Monopetalanthus exit.
A systematic study of *Aphanocalyx*, *Bikinia*, *Icuria*, *Michelsonia* and *Tetraberlinia* (Leguminosae, Caesalpinioideae)

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Jan Wieringa mounting *Tetraberlinia moreliana*. Photo J.A.C.M. van Oudenhoven.

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stellingen

I De klieren op de randnerf van de blaadjes zoals aanwezig in *Aphanocalyx heitzii, A. hedinii* en *A. libellula* zijn afkomstig van de gereduceerde distale blaadjeshelft.
(Dit proefschrift)

II In het Kongobekken hebben tenminste een aantal kleine glaciale laaglandbosrefugia bestaan in de vorm van rivierbegeleidend bos.
(Dit proefschrift)

III The absence of *Cynometra hedinii* or *Monopetalanthus hedinii* in the second edition of the Flora of West Tropical Africa (part 1(2), 1958) and the omission of *Monopetalanthus trapnellii* in the Flora of East Africa are the result of too locally focussed research, stimulated by artificial flora areas as present in some herbaria.
(This thesis)

IV Het verlengde epicotyl en de duidelijk afgegrensde bloei en vruchtzettingsperioden, zoals aanwezig in populaties van *Aphanocalyx microphyllus* in midden Congo (Kinshasa), zijn aanpassingen aan het leven in rivierbegeleidend bos.
(Dit proefschrift)

V The current algorithms for calculating bootstrap and mojo values are wrong because they are sensitive for instable trees. A new algorithm should be incorporated in programs that calculate these values.
(This thesis)

VI Het verdient aanbeveling heel goed naar de lokale bevolking te luisteren indien deze aangeeft dat een vermeend taxon uit verschillende eenheden bestaat.

VII Gezien de prioriteit die de mens steeds bij zichzelf blijkt te leggen is de beste garantie voor het behoud van biodiversiteit het door middel van genetische modificatie inbouwen van zoveel mogelijk vreemde genen in de mens zelf.

VIII Het is opmerkelijk dat men pas van gregair voorkomen van sprinkhanen spreekt als deze zich ook gregair verplaatsen, terwijl het gregair voorkomen van Caesalpinioideae juist (deels) veroorzaakt wordt door het relatieve onvermogen van deze bomen om zich te verspreiden.

IX De kabouter zit in ons, het is slechts een kwestie van selecteren.

X Gezien de trend van de afgelopen 10 jaar met betrekking tot de financiering van wetenschappelijk onderzoek valt te vrezen dat "WUR" een incorrecte spelling betreft van de past tense van "to be".

XI Een groot voordeel van stellingen bij een proefschrift tegenover een enkel citaat of een spreuk aan het begin van ieder hoofdstuk, is dat stellingen losbladig zijn en derhalve verwijderd kunnen worden.

Stellingen behorende bij het proefschrift "*Monopetalanthus* exit. A systematic study of *Aphanocalyx, Bikinia, Icuria, Michelsonia* and *Tetraberlinia* (Leguminosae, Caesalpinioideae)

Jan J. Wieringa
Wageningen, 22 oktober 1999

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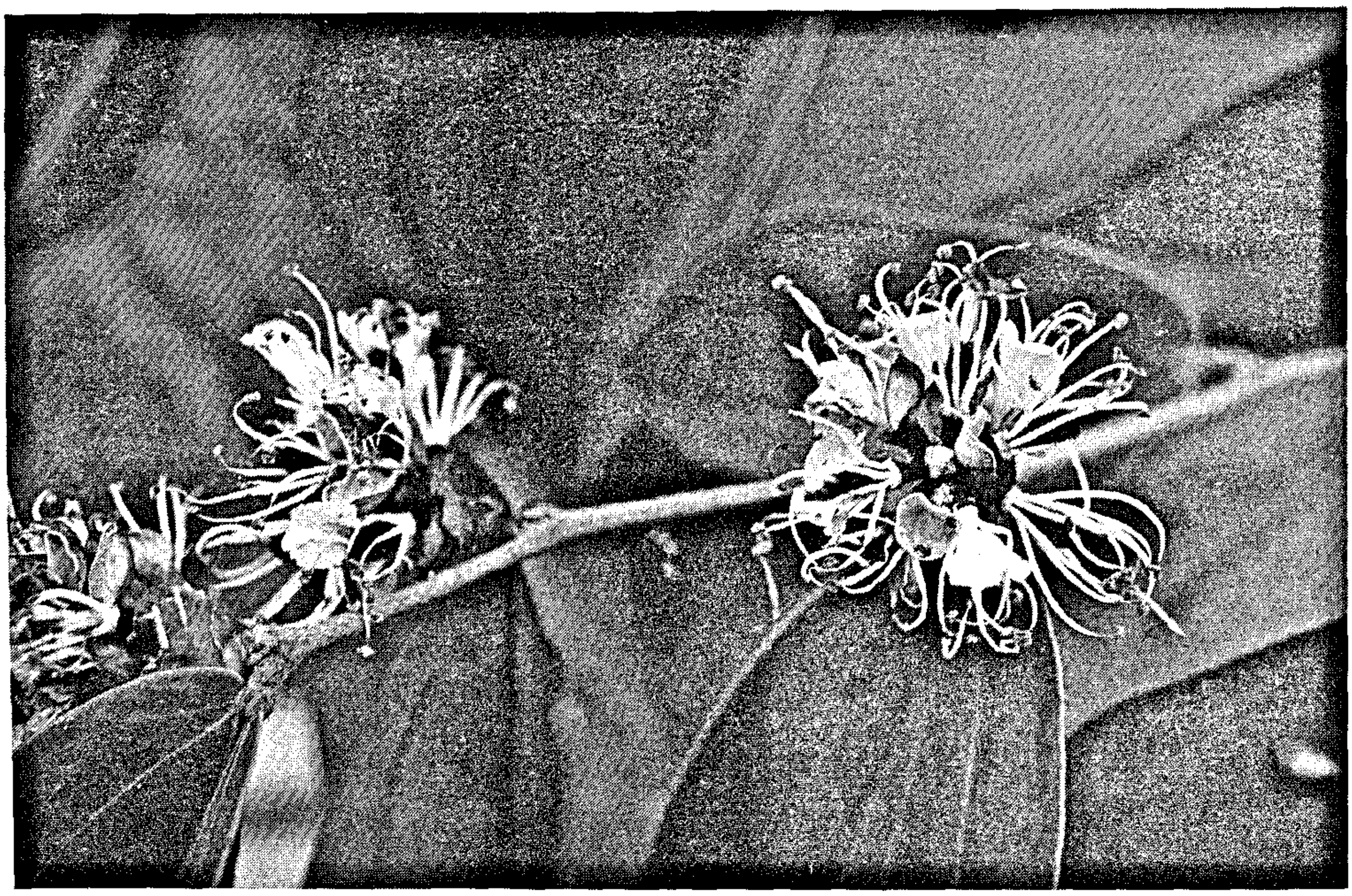
Aphanocalyx cynometroides Oliv., part of crown (*in situ*) with inflorescences (*Breteler, Wieringa & Nzabi 12868*).



Aphanocalyx cynometroides Oliv., detail of branch with inflorescences with all flowers flowering.

Summary

This dissertation deals with the ecology and the taxonomy of a group of dominant forest trees of the African high forest. Their size and inaccessibility has accounted for their comparative rarity in herbarium collections. Recently, due to various original collection methods, particularly special tree mounting techniques, quite a number of new collections from the canopy were obtained which provided a better insight into these taxa.

The core question at the start of this study was the generic and specific delimitation of *Monopetalanthus*, one of the most troublesome genera of African Caesalpinioideae. The genera *Aphanocalyx* and *Tetraberlinia* were supposedly closely related to or even congeneric with *Monopetalanthus*, so I have taken them into account as well. Since Aubréville had united *Michelsonia* with *Tetraberlinia*, that monotypic genus is dealt with as well. These genera are presently classified in the tribe Macrolobieae.

All available material belonging to these four genera has been studied in the major herbaria or was received on loan. A large number of macromorphological characters were studied and evaluated for their taxonomic potential. During this study nine new species and one new subspecies have been discovered. Of the original taxa all have been maintained, although one of them has been reduced to subspecific level, resulting in a total of 33 species. For all species concerned extensive descriptions have been made with distribution maps and most of them have been illustrated. Keys to the genera and to the species have been added.

In order to ascertain the phylogenetic history of these taxa and to see which characters are really indicating natural groups, a cladistic analysis was undertaken. To enhance resolution near the specific level some "minor" characters have been included as well. Characters that did not easily separate into discrete entities have also been used. They have been coded using a method similar to gap weighting. The resulting phylogeny proved to be strong on a number of points, but remains inconclusive on others. Since the stronger and most stable clades are those that are supported by several characters, these clades are the best to use for generic delimitation. When we treat the largest stable clades as genera, the species of the four old genera reshuffle into four new aggregates. *Michelsonia* remains a monospecific genus and *Tetraberlinia* hardly changes, only *Monopetalanthus longiracemosus* is now contained in it. *Aphanocalyx* engulfs the major part of *Monopetalanthus*, while for the remaining part of *Monopetalanthus* the name *Bikinia* is proposed. A new species from Mozambique, which seems to be related to this group, cannot be accommodated in any of these four genera and is described in the new genus *Icuria*. Three quite distinct species of *Aphanocalyx* are arranged in the new subgenus *Antherodontus*.

A small AFLP trial (DNA analysis) using only 7 ingroup samples resulted in a tree which is completely congruent with the tree based on morphological data. Moreover, the AFLP tree suggests that *Bikinia* is more closely related to *Tetraberlinia* than it is to *Aphanocalyx*, something which the morphological analysis was unable to prove.

Ethanol extracts with different colour compounds found in various species were analyzed by chromatography (TLC). The method has proved to be useful, but our analysis was biased too much by initial problems to include the results in the cladistic analysis.

The habitat of most species is dry-land evergreen forest. Only one species each of *Bikinia* and *Tetraberlinia* may be encountered in riverine forest as well, while a part of

Aphanocalyx has become adapted primarily to riverine and gallery forests. *Icuria* comprises pure stands of coastal evergreen forest, but remains present in woodland-like vegetation after degradation by logging.

Many trees of Macrolobieae have been recorded as growing gregariously. To assess such gregarious stands, the large trees in two 1-ha plots in Gabon have been mapped, and data from an existing line survey has been reanalysed. Several species of *Bikinia* and *Tetraberlinia* indeed grow in clusters. Most species of *Bikinia* occur in small clusters of only one or a few hectares, only *B. le-testui* and *B. pellegrinii* seem to form clusters with an area of a little less than 1 km^2. Four species of *Tetraberlinia* may become (co-)dominant over large areas, and such *Tetraberlinia* forests may extend over several square kilometres. Towards the margins of their distribution areas, the species tend to grow in smaller clusters or even singly. The gregarious nature of most Macrolobieae is considered the outcome of a rather complicated specialization process, including especially ectomycorrhizal relationships, but also factors of dispersal, germination and chemical defences. This set of ecological characters makes the species well adapted to life in a tropical evergreen forest.

The flowers of the species studied are pollinated by a variety of animals, most of them insects (like bees, beetles, flies and butterflies), but birds also seem to play a role in some species. The two species that were found to attract sunbirds both have 'strobiliform' racemes, which may be better suited for birds than 'umbelliform' or open and lax inflorescences. The 'umbelliform' inflorescences especially attract longhorn beetles. All different types of structures did attract large numbers of both medium-sized and small bees, probably the major pollinators. All species with yellow petals possess a deep hypanthium. However, an animal that appreciates these flowers is still unknown.

Flowering in most of the species is restricted to a definite period, often correlated with the rainfall pattern of the area. Most Gabonese species flower just before or during the main rainy season, a few (especially *Aphanocalyx heitzii* and *Tetraberlinia bifoliolata*) during the shorter rainy season. Only rarely was flowering recorded during dry periods.

The group is considered to be quite interesting for forestry, especially for plantation purposes. The trees are adapted to poor soils, they grow quite fast and produce tall, straight cylindrical boles. Moreover, the trees grow gregariously and are probably not much subject to diseases.

The distribution patterns of this group prove that one should be cautious in speaking about the location of glacial forest refuges. It depends on the requirements of a species whether a certain forested area during the ice ages could serve as a refuge or not. Within the Congo basin probably many riverine forests have existed during these periods, but they were only suited for species that could cope with inundation and other unstable conditions. Most species of *Bikinia* and *Tetraberlinia* were not adapted to these conditions, but several species of *Aphanocalyx* were and hence they still occur in the Congo basin.

Following the newest IUCN criteria, two of the treated species are possibly extinct, four classify as critically endangered and two as endangered.

Samenvatting

Dit proefschrift behandelt de taxonomie en de oecologie van een groep van meestal grote bomen uit het afrikaanse regenwoud. Door hun grootte zijn deze bomen altijd moeilijk verzamelbaar geweest, waardoor ze relatief slecht vertegenwoordigd zijn in herbaria. Dankzij speciale boomklimtechnieken zijn recentelijk veel nieuwe collecties bemachtigd, waardoor er nu een beter beeld gevormd kan worden van deze soorten.

Aanleiding voor deze studie waren de onduidelijke afbakening van het geslacht *Monopetalanthus* en de problemen die het op naam brengen van de soorten ervan opleverde. Daar *Aphanocalyx* en *Tetraberlinia* sterke verwantschappen vertoonde met *Monopetalanthus* zijn deze geslachten ook in het onderzoek betrokken. Omdat het monotypische geslacht *Michelsonia* door Aubréville bij *Tetraberlinia* gevoegd is, is ook deze ene soort bekeken. Volgens de meest recente classificatie behoren deze 4 geslachten tot het tribus Macrolobieae van de Peulvruchtenfamilie.

Al het beschikbare materiaal van deze geslachten uit de belangrijkste herbaria is te leen ontvangen of ter plaatse onderzocht. Dit herbariummateriaal is onderzocht op zoveel mogelijk morfologische kenmerken. Tijdens deze studie is het bestaan van 9 tot nog toe niet eerder beschreven soorten en 1 nieuwe ondersoort aan het licht gebracht. Alle bestaande taxa bleken inderdaad bestaansrecht te hebben, zij het dat 1 ervan nu als ondersoort wordt geclassificeerd. Het totaal aantal soorten komt daarmee op 33, waarvan er twee zijn opgesplitst in 2 ondersoorten elk. Van al deze taxa zijn uitgebreide beschrijvingen en verspreidingskaarten gemaakt, bijna alle soorten worden ook afgebeeld. Met behulp van determinatiesleutels tot de geslachten en de soorten kan zelfs het meeste steriele materiaal op naam worden gebracht.

Om de evolutionaire verwantschappen tussen de soorten op het spoor te komen werd een cladistische analyse uitgevoerd. Om het oplossend vermogen rond het soortsniveau te versterken zijn hierbij ook een aantal snel veranderende kenmerken toegevoegd. Ook kenmerken die niet netjes in duidelijke stappen waren in te delen zijn meegenomen, deze zijn gecodeerd met een methode die ongeveer overeenkomt met "gap weighting". Het resulterende cladogram bleek op een aantal punten stevig in elkaar te zitten, maar kon over een aantal andere verwantschappen geen duidelijke uitspraken doen. Omdat deze cladistische analyse gebruik maakt van morfologische kenmerken, zullen al die groepen, die stevig onderbouwd blijken te zijn in het cladogram, dit zijn omdat ze een aantal kenmerken gemeen hebben. Daarom zijn deze groepen bij uitstek geschikt om hogere taxa op te baseren. Als we de grootste, stevige groepen als geslacht classificeren, dan blijkt dat de oude 4 geslachten wat door elkaar gehutseld zijn en nu weer 4 geslachten vormen. *Michelsonia* blijft zijn ene soort behouden. *Tetraberlinia* verandert amper, het neemt alleen de soort *Monopetalanthus longiracemosus* in zich op. *Aphanocalyx* daarentegen verslindt het leeuwendeel van *Monopetalanthus*. Voor het groepje soorten dat overblijft wordt hier de naam *Bikinia* geïntroduceerd. Een nieuwe soort uit Mozambique die verwant lijkt te zijn aan de hier behandelde groep is niet in te delen bij één van deze 4 geslachten, en wordt derhalve in het nieuwe geslacht *Icuria* beschreven. Voor een drietal nogal afwijkende soorten van *Aphanocalyx* wordt het subgenus *Antherodontus* opgericht.

Een klein AFLP onderzoek (een DNA-techniek) dat slechts gebruik maakte van 6 soorten uit de groep, resulteerde in een cladogram dat volledig aansluit bij het cladogram gebaseerd op morfologische kenmerken. In tegenstelling tot de morfologische analyse, wist het AFLP onderzoek wel aan te tonen dat *Bikinia* meer verwant is aan *Tetraberlinia* dan aan *Aphanocalyx*.

Een chromatografie analyse (TLC) is uitgevoerd om een aantal in alcohol oplosbare kleuren uit de bloemen te kunnen scheiden. De methode blijkt hiervoor prima geschikt, maar ons onderzoek had te veel last van kinderziektes om het resultaat te kunnen toepassen in de fylogenetische analyse.

De meeste soorten van de behandelde groep komen voor in niet-onderlopend, niet-loofverliezend bos. Slechts één soort ieder van *Bikinia* en *Tetraberlinia* komen ook wel eens voor in rivierbegeleidend bos, terwijl een deel van *Aphanocalyx* juist vooral soorten van rivierbegeleidend of galerijbos betreft. *Icuria* vormt in zijn eentje een altijd-groen kustbos, maar kan ook nog worden aangetroffen in de boomsavannes die ontstaan zijn na het kappen van dit bos.

Van veel Macrolobieae bomen wordt vermeld dat ze gregair voorkomen. Om te zien hoe zo'n gregaire opstand eruit ziet, zijn twee 1-ha-plots in Gabon in kaart gebracht en zijn bestaande gegevens van een lijntransect opnieuw bewerkt. Een aantal soorten van *Bikinia* en *Tetraberlinia* blijken inderdaad in clusters te groeien. De meeste soorten *Bikinia* in kleine clusters van 1 of een paar hectares, slechts *B. le-testui* en *B. pellegrinii* vormen grotere opstanden met een oppervlakte van net onder de vierkante kilometer. Vier soorten *Tetraberlinia* kunnen (co-)dominant worden over grote gebieden, zulke *Tetraberlinia* opstanden kunnen meerdere vierkante kilometers beslaan. Aan de grens van het verspreidingsgebied van een soort blijken de bomen in kleinere clusters dan gebruikelijk of zelfs solitair te groeien. De oorzaak van het gregair voorkomen van veel Macrolobieae moet niet in een enkele factor gezocht worden. Het is het gevolg van een bepaalde levensstrategie die vooral gekenmerkt wordt door een symbiose met ectomycorrhiza's, grote zaden die zich niet ver verspreiden en een goede chemische bescherming tegen vraat. Dit pakket tezamen vormt een aangepassing aan het leven in tropisch regenwoud.

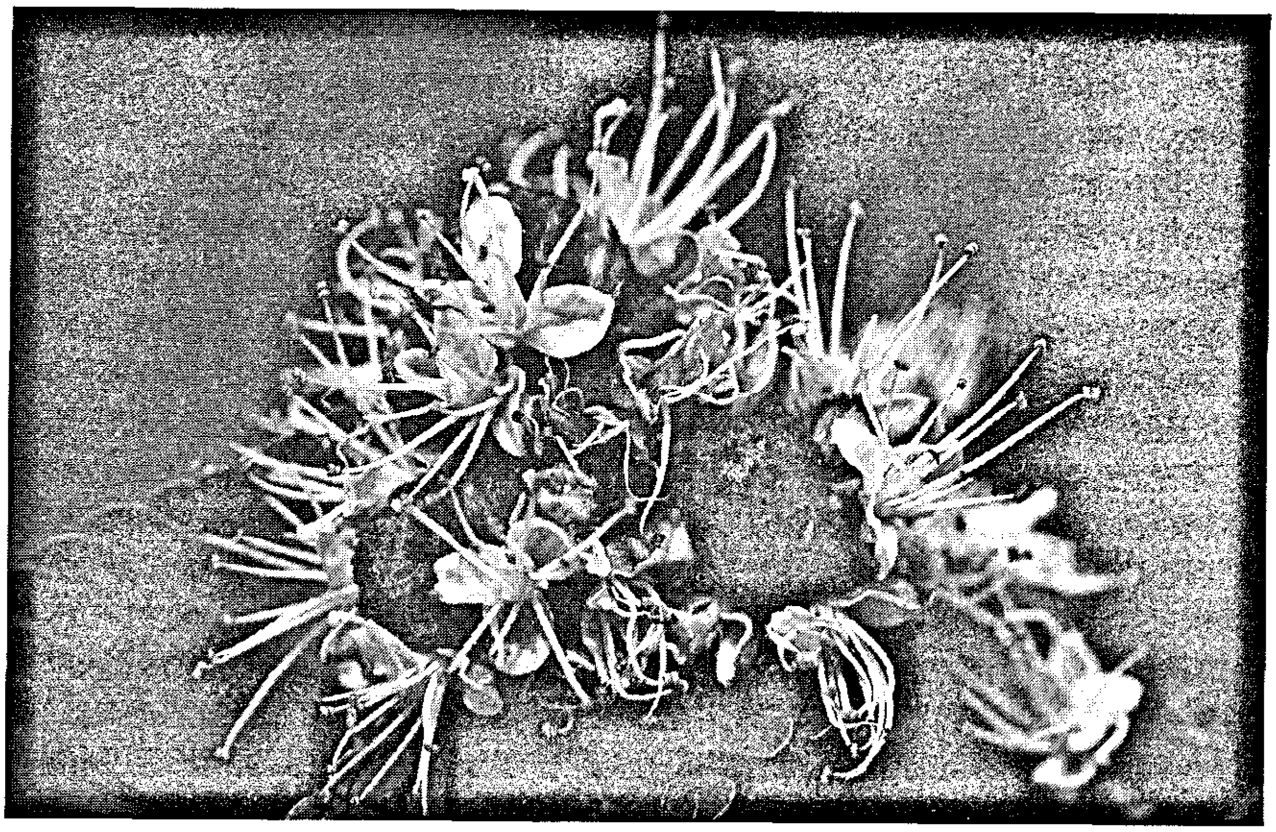
De bloemen worden bestoven door een groot verscheidenheid aan dieren. De meeste zijn insecten, met name bijen, kevers, vliegen en vlinders, maar ook vogels spelen een rol bij een aantal soorten. De twee soorten waarbij vogelbezoek is waargenomen bleken beide knotsvormige bloeiwijzen te hebben. Deze structuur is waarschijnlijk beter op vogels toegesneden dan de meer schermvormige of open bloeiwijzen van een aantal andere soorten. De schermvormige bloeiwijzen blijken speciaal ook boktorren aan te trekken. Op alle typen bloeiwijzen zijn kleine en middelgrote bijen aangetroffen. Waarschijnlijk zijn dit de belangrijkste bestuivers. Al die soorten die gele kroonbladen hebben, bleken ook een diep hypanthium te bezitten. Of er ook een bestuiver is die speciaal door deze combinatie wordt aangetrokken is nog niet vastgesteld.

Veel soorten blijken slechts gedurende een bepaalde periode te bloeien, meestal is deze periode te correleren aan de regenval in het betreffende gebied. De meeste soorten in Gabon bloeien net voor of tijdens de eerste natte tijd na de grote droge tijd, een paar soorten (vooral *Tetraberlinia bifoliolata* en *Aphanocalyx heitzii*) juist tijdens de tweede natte tijd. Slechts zelden werd bloei midden in de droge tijd waargenomen.

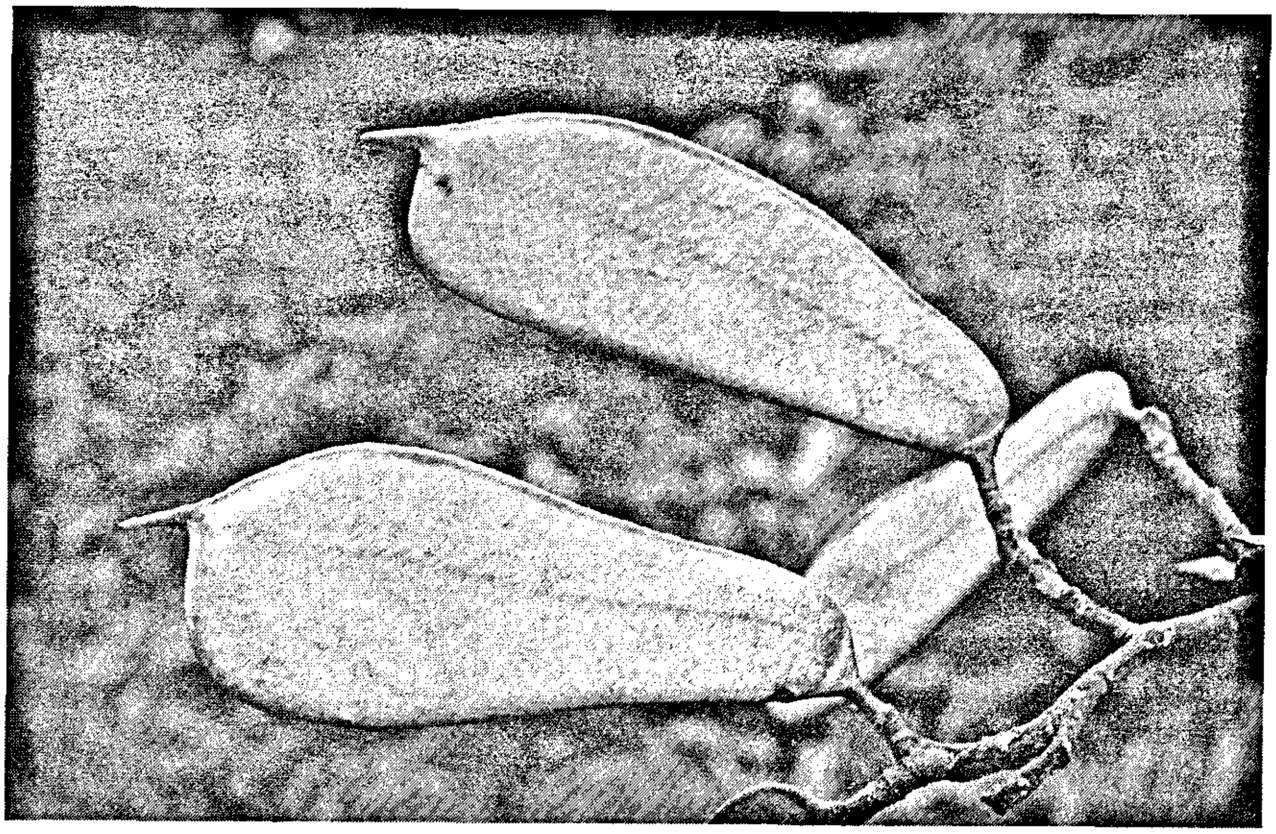
De onderzochte groep moet als erg interessant voor de bosbouw worden beschouwd. Vooral voor het aanleggen van plantages moet aan deze bomen gedacht worden, want ze zijn aangepast aan arme gronden, ze groeien snel en ze produceren lange, rechte, cylindrische stammen. Daar de bomen zijn aangepast aan het gregair groeien, zijn ze waarschijnlijk amper gevoelig voor ziekten die hierdoor de kop zouden kunnen opsteken.

Een analyse van de verspreidingspatronen toont aan dat men niet klakkeloos over de locaties van glaciale bosrefugia mag spreken. Het hangt van de oecologische eisen van de soort af of een bepaald bebost gebied tijdens de ijstijden als refugium dienst heeft kunnen doen. In het stroomgebied van de Kongo hebben gedurende de ijstijden waarschijnlijk veel rivierbegeleidende bossen bestaan, maar deze zijn slechts geschikt geweest voor soorten die waren aangepast aan een onstabiel milieu met overstromingen. De meeste soorten van *Bikinia* en *Tetraberlinia* waren hieraan niet aangepast en komen in dit gebied tegenwoordig dan ook niet voor. Een aantal soorten van *Aphanocalyx* waren wel aangepast en zij komen nog steeds voor in het Kongo stroomgebied.

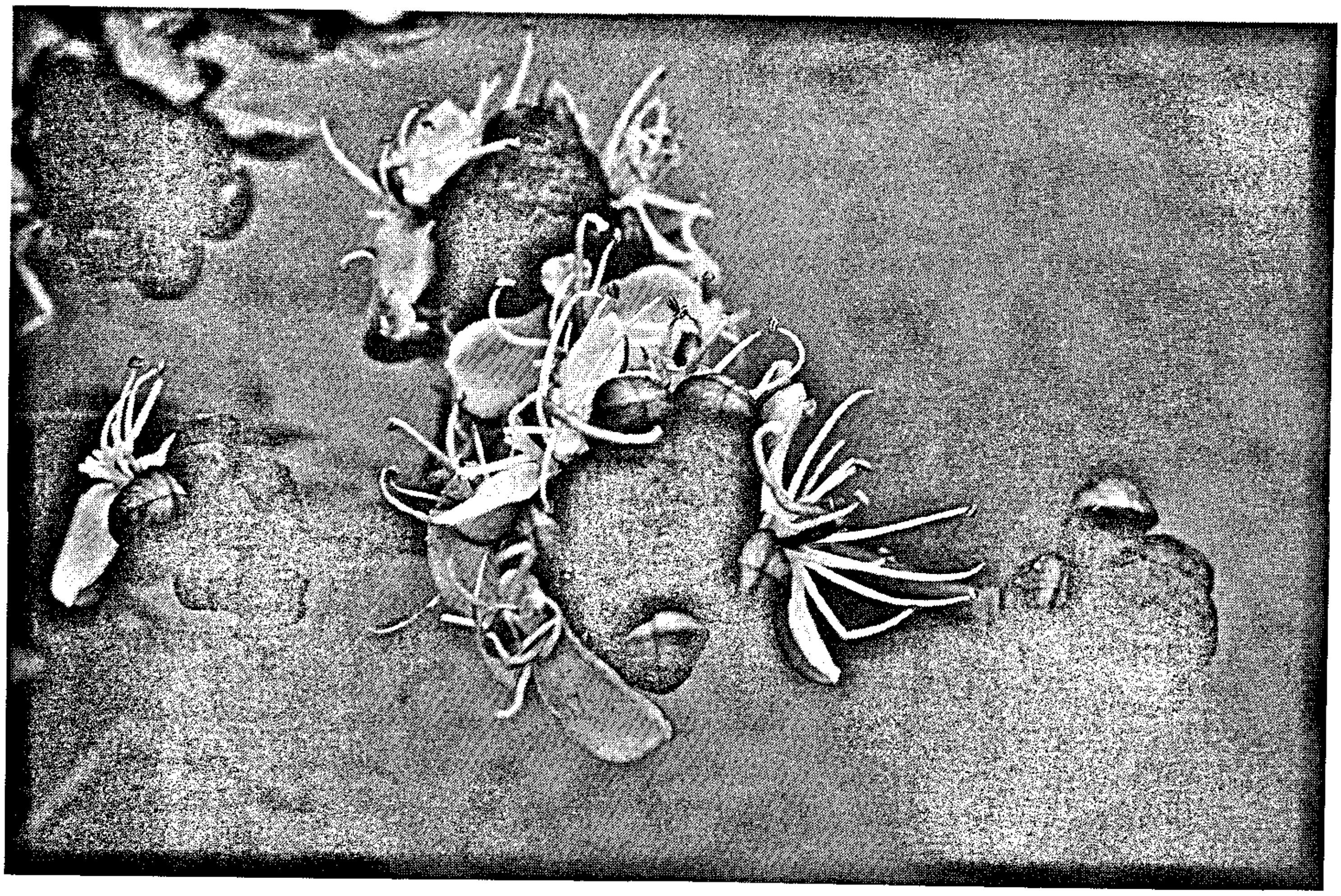
Volgens de nieuwste IUCN criteria zijn 2 van de behandelde soorten mogelijk uitgestorven, 4 zijn kritiek met uitsterven bedreigd en 2 met uitsterven bedreigd.



Inflorescence of *Aphanocalyx microphyllus* (Harms) Wieringa subsp. *microphyllus* (*Wieringa & v.d. Poll 1345*).



Pods of *Tetraberlinia polyphylla* (Harms) J. Léonard ex Voorh. (*Wieringa et al. 3151*).



Inflorescence of *Bikinia durandii* (F. Hallé & Normand) Wieringa (*Breteler, Wieringa & Nzabi 12820*).

Inflorescence of *Bikinia grisea* Wieringa (*Breteler, Wieringa & Nzabi 13334*).

Résumé

Cette thèse traite la taxonomie d'un groupe d'arbres dominant de la forêt haute africaine. Leurs dimensions et la difficulté d'accès ont, jusque maintenant, contribué à la rareté de matériel dans les collections d'herbiers. Récemment, grâce à de nouvelles méthodes de collection et en particulier des techniques pour escalader les arbres, un nombre important de nouveaux échantillons provenant de la canopée ont été obtenus, contribuant à une meilleure compréhension de ces taxons.

Cette étude a été abordée avec comme problème principal la délimitation générique et spécifique du genre *Monopetalanthus*, genre critique des Césalpinionideae africains. Les genres *Aphanocalyx* et *Tetraberlinia* étaient supposés être très proches, voire congénériques avec *Monopetalanthus*. Elles ont été inclues à ce titre dans l'étude. Le genre monotypique *Michelsonia* étant rassemblé avec *Tetraberlinia* par Aubréville l'a également été. Ces genres sont classés à présent dans la tribu des Macrolobieae.

Tout le matériel disponible dans les principaux herbiers appartenant à ces 4 genres a été étudié. Un nombre important de caractères macromorphologiques a été étudié et évalué en vue de son utilisation dans la délimitation taxonomique. Durant cette étude 9 nouvelles espèces et une nouvelle sous-espèce ont été découvertes. Tous les taxons originaux ont été maintenus, un seul ayant été ramené au niveau subspécifique. Le nombre total d'espèces s'élève à 33. Pour toutes ces espèces des descriptions détaillées sont données, des cartes de distribution établies. La plupart ont été figurées. Des clés d'identification des genres et des espèces ont été ajoutées.

Une analyse cladistique a été exécutée, permettant d'élucider l'histoire phylogénétique de ces taxons et d'établir des groupes naturels. Quelques caractères mineurs ont également été inclus dans cette étude, afin de réaliser cet objectif au niveau spécifique. Quelques caractères difficiles à représenter par des entités discrètes, ont été codés suivant une méthode similaire à celle du "gap weighting". La phylogénie obtenue s'est avérée excellente sur un nombre de points, mais reste incertaine pour d'autres. Etant donné que les clades les plus stables sont celles qui sont basées sur plusieurs caractères, celles-ci sont les meilleures pour être utilisées pour la délimitation générique. En considérant les plus grandes clades stables comme genres, les espèces des 4 anciens genres se déplacent dans 4 nouveaux agrégats. *Michelsonia* reste monospécifique, *Tetraberlinia* ne change guère, seulement *Monopetalanthus longiracemosus* y est ajoutée. *Aphanocalyx* reprend la plupart des *Monopetalanthus*, tandis que le nom de genre *Bikinia* est proposé pour les autres *Monopetalanthus*. Une nouvelle espèce du Mozambique, qui semble être proche de ce groupe, ne peut être affectée dans aucun de ces 4 genres et le nouveau genre *Icuria* est décrit pour cette espèce. Trois espèces assez bien différents de *Aphanocalyx* sont inclus dans le nouveau sous-genre *Antherodontus*.

Un essai AFLP (analyse de DNA) utilisant seulement 8 échantillons a fourni un arbre complètement congruent avec l'arbre basé sur des données morphologiques. En plus, l'arbre AFPL suggère que *Bikinia* est plus proche de *Tetraberlinia* que de *Aphanocalyx*, résultat non obtenu par l'analyse morphologique.

Pour quelques couleurs de fleurs dissolubles dans l'ethanol, une analyse chromatographique (TLC) a été faite en vue de les séparer. La méthode a prouvé d'être utile, mais l'analyse était fortement biaisée par des problèmes de départ et les résultats n'ont pas pu être utilisés dans l'analyse cladistique.

L'habitat de la plupart des espèces est constitué par la forêt sempervirente sèche. Seulement une espèce de *Bikinia* et une de *Tetraberlinia* peuvent également être rencontrées dans les forêts de rivière, tandis qu'une partie des *Aphanocalyx* habite principalement les bords de rivières ou la fôret de galerie. *Icuria* forme des peuplements pures de fôret sempervirente côtière, mais reste également présent dans des végétations secondaires après dégradation par coupe.

Beaucoup d'arbres de Macrolobieae ont été rapportés de former des peuplements en groupe. De telles formations ont été étudiées dans deux carrés de 1 hectare. Plusieurs espèces de *Bikinia* et de *Tetraberlinia* forment des groupes. La plupart des espèces de *Bikinia* forment de petits groupes d'une superficie de un ou de quelques hectares. Uniquement *B. le-testui* et *B. pellegrinii* semblent former des groupes avec une superficie d'un peu moins de 1 kilomètre carré. Quatre espèces de *Tetraberlinia* peuvent devenir (co-)dominantes sur de très grandes superficies, ces forêts pouvant s'étendre sur plusieurs kilomètres carrés. Aux confins de leur aire de distribution, les espèces tendent à former de plus petits groupes ou se trouvent isolées. La nature grégaire de la plupart des Macrolobieae est le résultat de certains caractères écologiques, qui, allant de pair avec une symbiose ectomycorrhizière, avec des dimensions importantes des grandes graines, qui réduisent la dispersion, et avec une certaine protection chimique. Tous ces facteurs ont contribué à une bonne adaptation à la forêt sempervirente tropicale.

Les fleurs des espèces considérées sont pollinisées par une variété d'animaux, dont la plupart sont des insectes (abeilles, coléoptères, diptères et lepidoptères). Dans certaines espèces les oiseaux semblent également jouer un rôle. Les deux espèces qui attirent des Souimangas ont des grappes strobiliformes, dont la structure semble être mieux adaptée pour les oiseaux que des inflorescences ombelliformes, ouvertes ou lâches. Les inflorescences ombelliformes attirent des coléoptères longicornes. Les pollinisateurs principaux sont probablement des abeilles de petite ou moyenne taille, qui visitent toutes les formes d'inflorescence. Toutes les espèces à pétales jaunes possèdent un hypanthium profond. Aucun animal attiré par cette structure n'est connu à ce jour.

La période de floraison de la plus grande partie des espèces correspond à une saison pluviométrique de la région concernée. La plupart des espèces gabonaises fleurissent peu avant ou pendant la longue saison des pluies, quelques unes (en particulier *Aphanocalyx heitzii* et *Tetraberlinia bifoliolata*) pendant la petite saison des pluies. La floraison en période sèche est rarement observée.

Le groupe est considéré d'être intéressant pour la sylviculture et plus particulièrement pour des plantations. Les arbres sont adaptés aux sols pauvres, grandissent relativement vite et produisent des troncs larges, cylindriques et droits. En outre, les arbres poussent en groupe et sont probablement peu sensibles aux maladies.

La distribution de ce groupe démontre la prudence que l'on doit avoir en délimitant les refuges glaciaires de forêt. Dans le bassin du Congo, il est probable qu'il en existait plusieurs, mais ceux-ci étaient adaptés uniquement aux espèces pouvant survivre aux inondations. La plupart des espèces de *Bikinia* et *Tetraberlinia* n'étaient pas adaptées à ces conditions, mais plusieurs espèces de *Aphanocalyx* l'étaient et sont encore présentes dans ce bassin.

D'après les derniers critères de l'UICN, deux espèces sont probablement éteintes, 4 sont classifiées gravement menacées d'extinction et deux menacées d'extinction.

1 Introduction

A large number of the tree species of African forests belong to the Leguminosae. Some of them produce major commercial timbers. In the most species rich forest type, the lowland evergreen rain forest, the legume family is mainly represented by the Caesalpinioideae subfamily. Although this subfamily is the smallest of the three legume subfamilies, it is by far the most important plant group in this forest type. According to Reitsma's (1988) "importance value" summed over 4 plots it ends up first, scoring 50% higher than the second most important group (Burseraceae). The diagrams of Caballé (1978) show an even larger supremacy of the Caesalpinioideae. Letouzey (1968: 112, 125–126) finds this dominance so striking that he even names a forest type after this subfamily. Other indications for its importance: over 25% of all tree species mentioned for Gabon by Saint Aubin (1963) belong to this subfamily, and in several forest inventories this group often figures as the largest in number of trees and/or species (Bie & Geerling, 1989; Valkenburg et al., 1998).

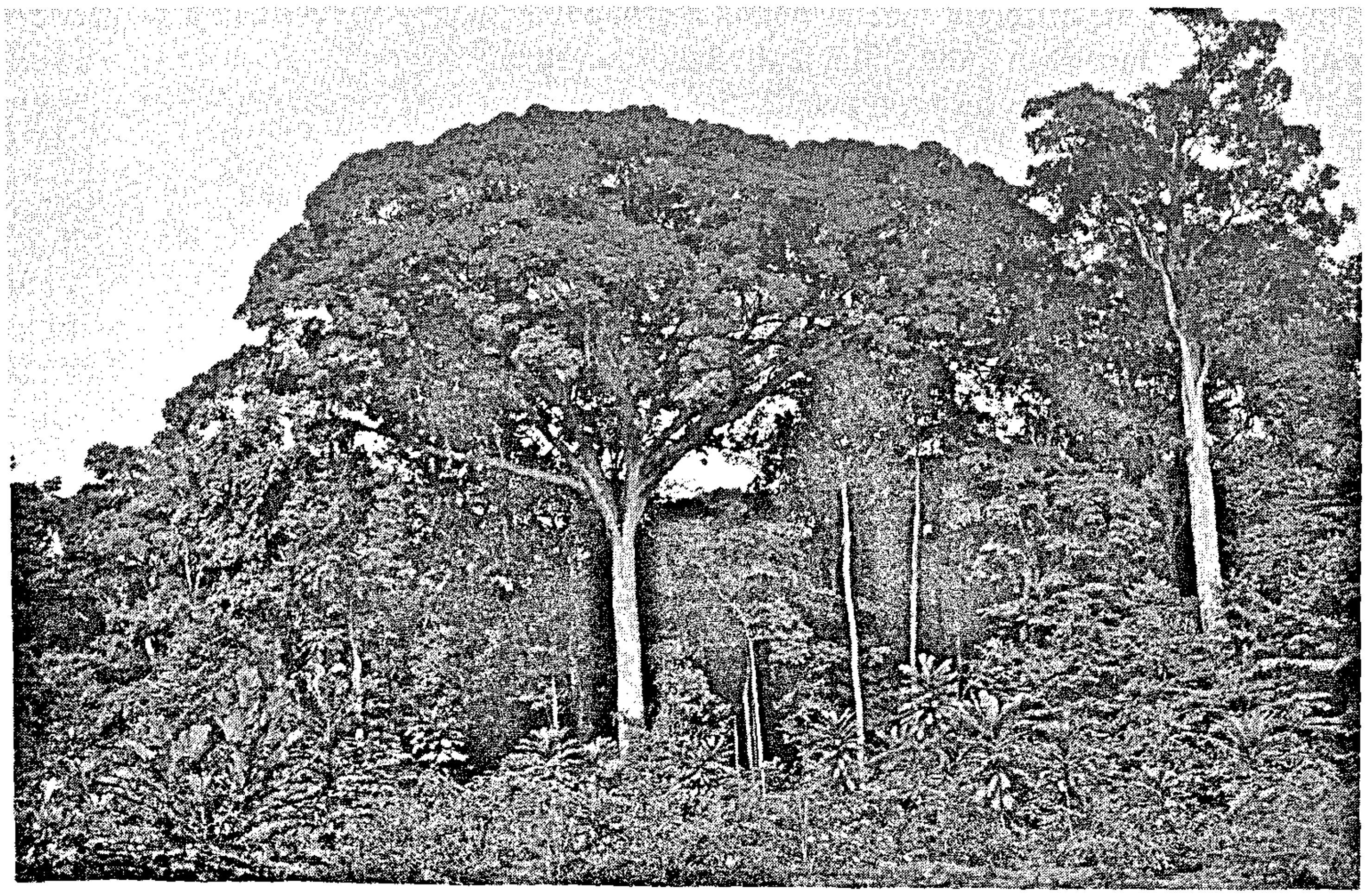
In Gabon, the richest part of the African rain forest (Breteler, 1992), the Caesalpinioideae reach a climax regarding the number of species and genera (70% of all central African Caesalpinioideae species occur in Gabon; pers. comm. Breteler, 1998). Among them are several narrow endemics. Typical for the distribution pattern of most Caesalpinioideae is that where a species occurs, it usually grows gregariously.

Partly caused by the wealth of species, foresters and even botanists have usually treated some groups of similar species as a single entity. Examples of such groups are "Abeum" for all *Gilbertiodendron* species, "Ngang" for most species of *Hymenostegia* and several species of *Monopetalanthus*, "Andoung" for some other species of *Monopetalanthus*, *Julbernardia*, *Tetraberlinia* and a *Didelotia*. For foresters such a generalization may seem convenient but the different species within a group may have different wood properties, resulting in groups with quite variable (and thus unreliable) wood properties. As a result timber of such groups is less appreciated than would have been the case if they had been considered at the species level.

Trees are always difficult to collect for botanists, who are generally not well equipped to collect samples from the canopy. For tree samples most botanists rely on the collecting efforts of forest-botanists prospecting the tropical forests for timber. Being foresters, they too have a tendency to group, as long as the leaves are similar, several species into a single entity, although not as strongly as the foresters, who merely consider bark and trunk characters. A disadvantage of gregarious species for botany is that on average they are more rarely encountered when compared to species that grow in comparable numbers but with a random distribution. Indeed, if gregarious species are located, one usually sights several trees, but in such cases the collector has the tendency to collect only one of them. The result is that these species are very poorly represented in herbaria, and are poorly known, even by foresters. The situation has changed a little for the better since Oldeman (1964) was struck by the extremely bad situation 35 years ago in *Didelotia*, but even now a lot remains to be done.

For almost all manner of people surveying or exploiting the tropical rain forests of Africa it is extremely important to be able to identify at least the tree species in the forest. Many ecological methods require numbers of species and number of individuals per species; both cannot be properly established when some species cannot be identified or when the individuals of different species are erroneously identified as a single one. If foresters would be able to identify Caesalpinioideae trees better, they might be able to find new markets for some of these species and be paid better for their timber, while the less suitable and less valuable species may be left in place, instead of logging all of them indiscriminately for low reward.

Since the Caesalpinioideae form such an important part of the forest, it is even more disappointing that the group contains so many problematic aggregates. One of the largest and most variable groups, probably the one with the greatest confusion with respect to species delimitation is the group of the "Andoung". The name is not confined to a single genus, but it encompasses several genera. For the purpose of this study we will use a more botanical definition of the group under study: all species considered to belong to the genera *Aphanocalyx*, *Michelsonia*, *Monopetalanthus* and *Tetraberlinia*. The boundaries between some of these genera have been questioned by botanists in the past (e.g. Voorhoeve, 1965: 215), although hardly anybody actually endeavoured to do something about it until the group could be studied more thoroughly. Such a detailed study forms the main body of this thesis: both specific and generic boundaries are investigated and changed where necessary. A second part of this thesis deals with the ecology of the species concerned: where they occur, whether they grow gregariously or not and if so, how these clusters should be characterized. The reason for this gregarious occurrence will also be discussed briefly.



Bikinia aff. *pellegrinii* (A. Chev.) Wieringa along a road at Rabi (Gabon) (*Wieringa & Epoma 1606*).

2 History

The present revision deals with the species until now included in the genera *Aphanocalyx*, *Michelsonia*, *Monopetalanthus* and *Tetraberlinia*. A chronological display of the publication of the species names and new combinations is presented in fig. 2.1. Most of the species involved have not been recombined very often. The only transfer of species among these four genera is from *Michelsonia* to *Tetraberlinia*. Since their histories do not coincide, the history of *Aphanocalyx* and *Monopetalanthus* is described separately from the other two.

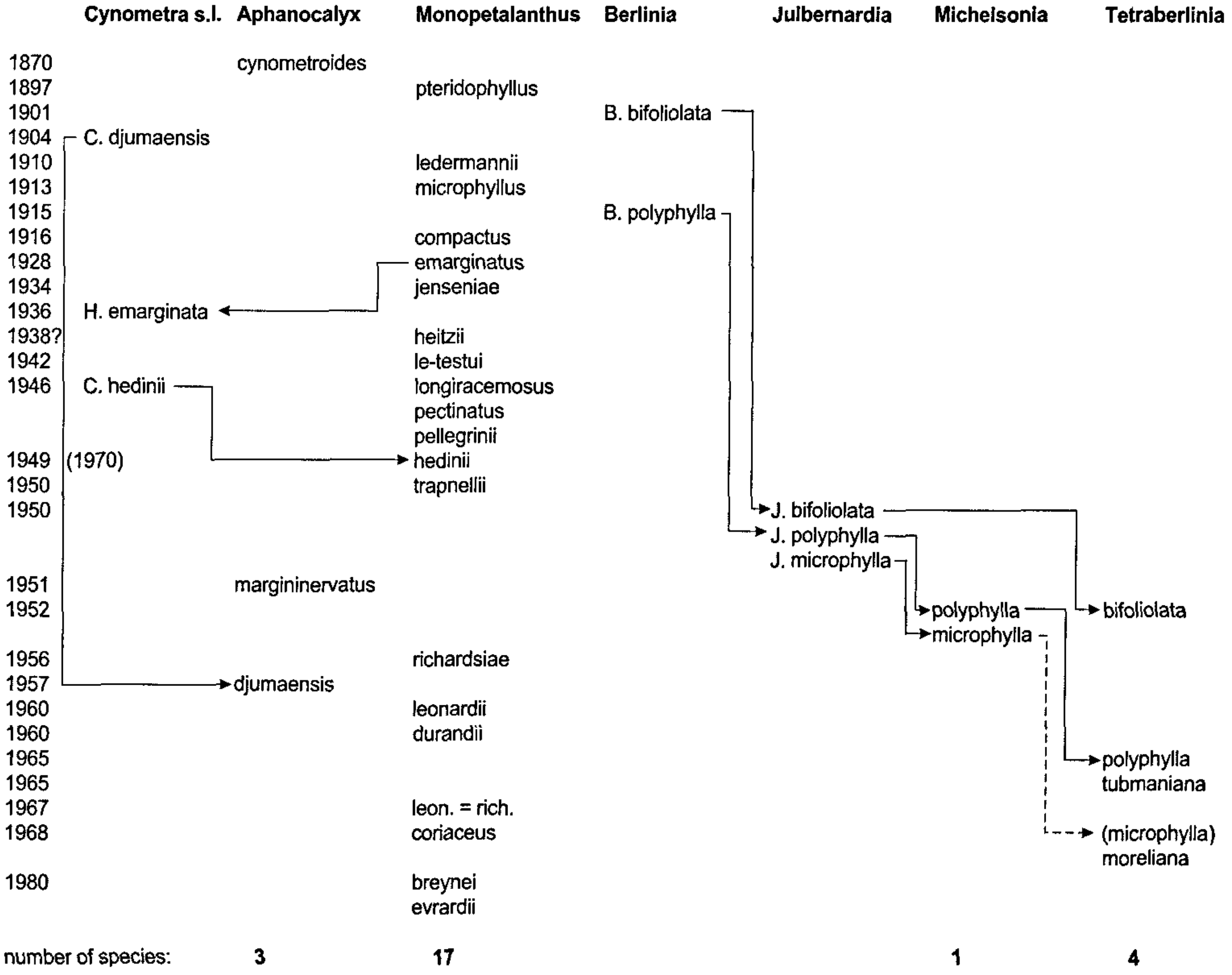


Figure 2.1: Chronological presentation of the description and recombination of the species that have at some time been considered to belong to *Aphanocalyx*, *Michelsonia*, *Monopetalanthus* or *Tetraberlinia*. Each column represents a genus. Arrows indicate recombinations. The transfer of *Michelsonia microphylla* to *Tetraberlinia* was never followed and is indicated by a dashed line. At the bottom of the columns of the treated genera the number of recognized species (as can be derived from the figure) is indicated. H = *Hymenostegia*, "leon. = rich." = *M. leonardii* is considered a synonym of *M. richardsiae*.

Of the 4 genera, *Aphanocalyx* was the first to be described. In 1870 Oliver publishes a plate and a description of this genus in which he proposes a single species: *A. cynometroides*. As to which other Caesalpinioideae this new genus is related, Oliver mentions that it should be sought in those genera that possess valvate bracteoles and a (nearly) obsolete calyx.

Taubert (1892: 132) places the genus in the Cynometreae (= Detarieae) next to *Sindora*.

The distinction with the Amherstieae is apparently solely made on basis of the free stipe (fused with the hypanthium in the latter). Such a distinction is already severely questioned by Taubert (1892: 126) himself.

In 1897 Harms describes *Monopetalanthus*, also with a single species (*M. pteridophyllus*). He considers the genus related to *Aphanocalyx*, but states it may be placed as well, or even better, close to *Brachystegia*. It is interesting to note that *Brachystegia* is classified both by Taubert and by Harms in the Amherstieae.

When describing the second species of *Monopetalanthus* (*M. ledermannii*), Harms (1910: 300) once more states that *Monopetalanthus* may be indistinguishable from *Brachystegia*. Because of this resemblance, Harms (1915a: 433, 481) transfers *Aphanocalyx* and *Monopetalanthus* to the Amherstieae and treats the genera *Brachystegia*, *Aphanocalyx* and *Monopetalanthus* one after another. Baker (1930) concurs and even unites the Cynometreae with the Amherstieae.

In 1928 a small error, regrettably with grave consequences, is made by Hutchinson and Dalziel. Based on pods and leaves only, they describe a new species from West Africa, *Monopetalanthus emarginatus,* with pods very similar to those of *M. pteridophyllus*, but with different, emarginate leaflets. In 1936 flowers have become available and the species is transferred to *Hymenostegia* by both Milne-Redhead (ex Hutchinson & Dalziel, 1936: 606) and Aubréville & Pellegrin in Aubréville (1936: 250). So far, the error had been corrected, although Aubréville (1936: 242) now mentions another species with emarginate leaflets as *Monopetalanthus* sp. (?). However, in 1942 Pellegrin comes to the curious conclusion that flowering material from western Africa should be named *Hymenostegia emarginata* Aubrév. & Pellegr., while material from Gabon with similar (emarginate) leaflets but different flowers should be named *Monopetalanthus emarginatus* Hutch. & Dalz. In the same publication he describes a second species with emarginate leaflets in *Monopetalanthus* and discusses the two types of leaflets in the genus (emarginate with a medial midrib versus not emarginate with a marginal midrib). Surprisingly Pellegrin mentions that this second type of leaflet also occurs in *Aphanocalyx,* although the only species included in that genus at that time does *not* show this character. According to Pellegrin these two genera are extremely closely related, but *Aphanocalyx* can be distinguished because it has only a single pair of leaflets. It is questionable whether Pellegrin would have described his two emarginate species in *Monopetalanthus* if he would not have been misled by the error of Hutchinson and Dalziel and consequently would not have considered emarginate leaflets to occur in that genus.

The erroneous continuation of the use of *Monopetalanthus emarginatus* for material not including its type is corrected by Chevalier (1946), who names such material *M. pellegrinii.* In the same publication he describes two additional new species of *Monopetalanthus*, one with a marginal midrib and one with a medial midrib but non-emarginate leaflets. Apparently Chevalier does not value the position of the leaflet's midrib as important, since he does not mention it in his descriptions. Moreover, he describes another new species showing a marginal midrib in *Cynometra*: *C. hedinii.* In his elaborate work on the legumes of Gabon, Pellegrin (1949) does esteem the value of this character and mentions that *C. hedinii* might better be at place in *Monopetalanthus.* Again he mentions that the species with a marginal midrib resemble *Aphanocalyx.* The only difference retained is the 1-jugate leaves of *Aphanocalyx.* Of this genus he cites material of *A. cynometroides*, *A. djumaensis* and *A. margininervatus*, but he fails to identify them as separate species.

The next work of importance does: Léonard (1957) recognizes all three species and places the genus together with *Monopetalanthus* in his redefined Amherstieae. Since he also includes a 1-jugate species in *Monopetalanthus*, he needs a new character in order to distinguish *Aphanocalyx*. The only clear difference Léonard uses is the presence of a lateral nerve on the pods in *Monopetalanthus*. Such a nerve is supposed to be absent in *Aphanocalyx* (in fact it runs at the upper suture, see anatomy and species descriptions). The same distinction is used by Aubréville (1968, 1970), who considers both genera very closely related. He also mentions the marginal midrib as an unique character, only found in some of the species of these two genera, but fails to use it except in his keys.

Finally, Cowan & Polhill (1981) group *Aphanocalyx* and *Monopetalanthus* together with *Brachystegia*, *Librevillea*, *Didelotia* and *Cryptosepalum* in their informal '*Brachystegia* group', part of the Amherstieae. Since Breteler (1995) excluded three genera (including *Amherstia*) from this tribe, it should now be called Macrolobieae.

The history of *Tetraberlinia* and *Michelsonia* starts with Harms (1915a: 472). He places *Berlinia bifoliolata* (Harms, 1901: 83) in a separate section (*Tetraberlinia*), together with *B. micrantha* and *B. polyphylla*. Baker (1930) transfers *B. micrantha* to *Oddoniodendron* and unites section *Tetraberlinia* (including the other two species) with *Berlinia* sect. *Neoberlinia*.

Troupin (1950: 288) excludes *B. bifoliolata* and *B. polyphylla* from *Berlinia* on basis of the presumed absence of a receptacle tube (apparently Troupin failed to make floral sections in order to verify this) and combines them into *Julbernardia*. In that genus he reinstalls sect. *Tetraberlinia* and includes a third (new) species: *J. microphylla*. Only two years later Hauman (1952a) raises *Tetraberlinia* to the generic level, including a single species only (*T. bifoliolata*), while the other two species are classified in the related new genus *Michelsonia*. The difference according to Hauman (and Léonard, 1957) is that *Tetraberlinia* in contrast to *Michelsonia* does have a receptacle tube (not true for *M. polyphylla*). In 1965 Léonard considers *M. polyphylla* as part of *Tetraberlinia* and describes a third species, *T. tubmaniana*, in this genus. *Michelsonia* can now be distinguished by the lack of a hypanthium, 5 subequal, glabrous petals, a hardly winged upper suture of the pod and some minor differences. Both Léonard (1957 & 1965) and Voorhoeve (1965) consider the genus *Microberlinia* as the closest relative of both genera.

In 1968 Aubréville unites *Michelsonia* with *Tetraberlinia*, but fails to adapt the generic circumscription. His arrangement is not being followed. On the contrary, Léonard (1996) explicitly rejects the fusion and, as far as necessary, reinstalls *Michelsonia*.

On tribal level these two genera have always been classified as part of the Amherstieae (Macrolobieae since 1995). Cowan & Polhill (1981) classify them in their informal '*Berlinia* group'.

As is clear from their independent histories, the two groups of two genera have rarely been considered as related, Cowan & Polhill (1981, followed by Yakovlev, 1991: 50–51) even place them in separate groups. However, a few references to a possible relationship between the two groups do exist: Normand (1950: 131) considers the wood of *Monopetalanthus* to partly resemble that of *Brachystegia* and partly that of two species later included in *Tetraberlinia*. It should be noted that some of his wood samples of *Monopetalanthus* belong to *Didelotia brevipaniculata*. In 1952 Normand explicitly states that the wood of *Tetraberlinia bifoliolata* is almost indistinguishable from that of *T. polyphylla*, *M. heitzii*, *M. microphyllus* and some species of *Brachystegia*. While describing the wood of *T. tubmaniana*, Normand (1958) again mentions it is very similar to that of

Monopetalanthus. Finally Normand & Paquis (1976: 99 & 105) call for a revision of the *Tetraberlinia-Monopetalanthus-Michelsonia* group, while they consider *Aphanocalyx* similar to a part of that group.

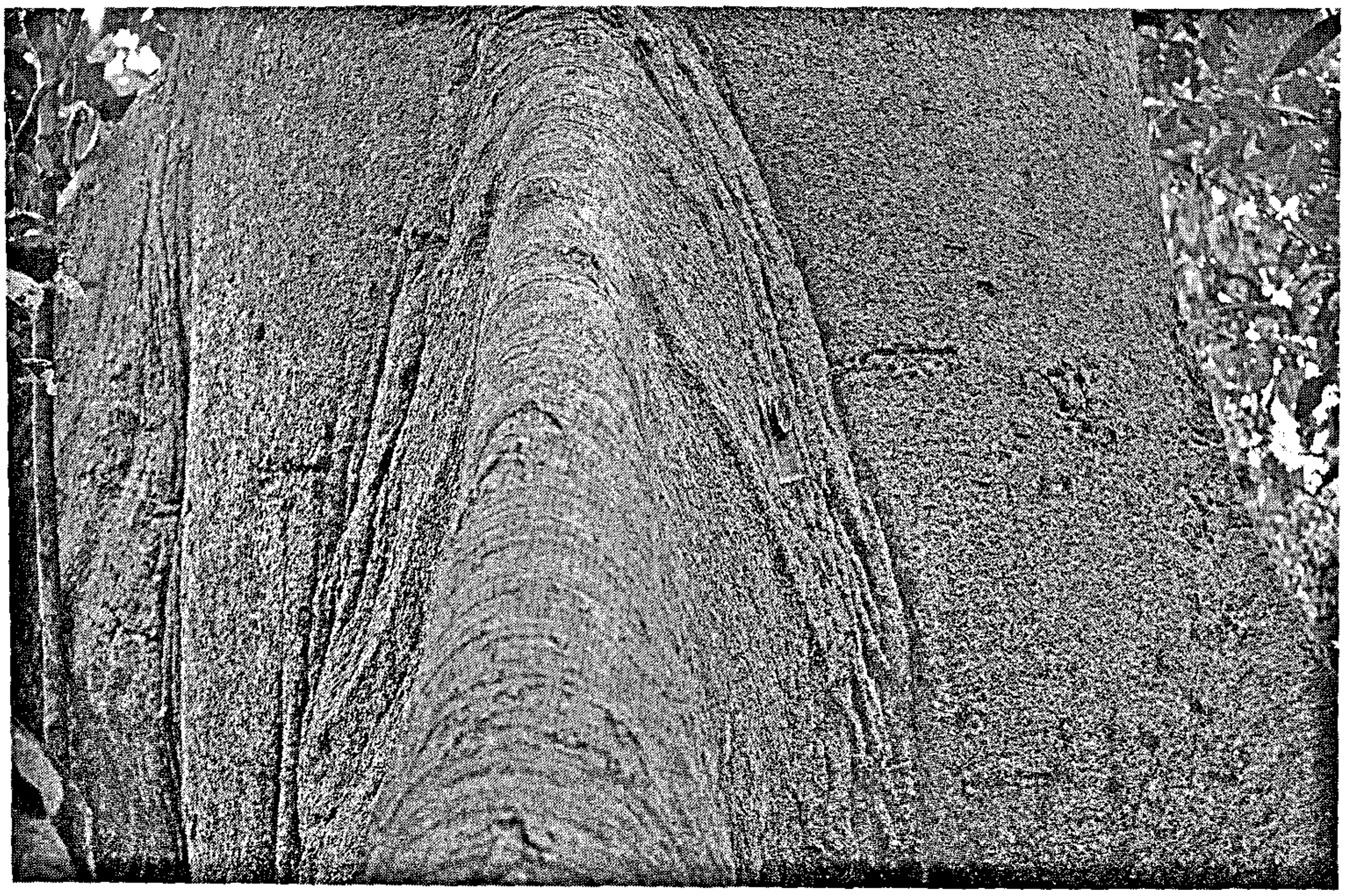
Léonard (1965: 104) merely states that the relation between *Tetraberlinia* and *Monopetalanthus* needs a better definition. Such a definition, however, has never been given to date. The difference as used by Aubréville (1968: 10) to key out the two genera (sepals short *versus* sepals rudimentary or absent) seems of no use.

Based on pollen characteristics Graham & Barker (1981) concluded that *Brachystegia* is distinct from all other Amherstieae genera, while *Tetraberlinia* and *Michelsonia* seem to differ slightly, but not enough to put them in different groups. Ferguson (1987) comes to similar conclusions except that he indicates that also *Julbernardia paniculata* may have distinctive pollen.

After a thorough analysis of the wood of 41 species of *Aphanocalyx*, *Brachystegia*, *Julbernardia*, *Monopetalanthus* and *Tetraberlinia*, Outer & Veenendaal (1996) conclude that *Brachystegia* differs from the other four genera. These other four genera can be considered as a single genus as far as the wood is concerned.

The present study reveals that one species of *Monopetalanthus* actually belongs to *Tetraberlinia*, while the remainder of *Monopetalanthus* consists of two parts, one closely related to (and here combined into) *Aphanocalyx*, the other part, probably related to *Tetraberlinia*, is here described as *Bikinia* (Fig. 2.2). The fact that *Monopetalanthus* actually consists of three different groups which show different affinities, explains why it has always been so difficult to delimit *Monopetalanthus* and why it was supposed to have affinities to several groups.

A new species from Mozambique that shows affinities to these genera is described in a new, monotypic genus: *Icuria*.

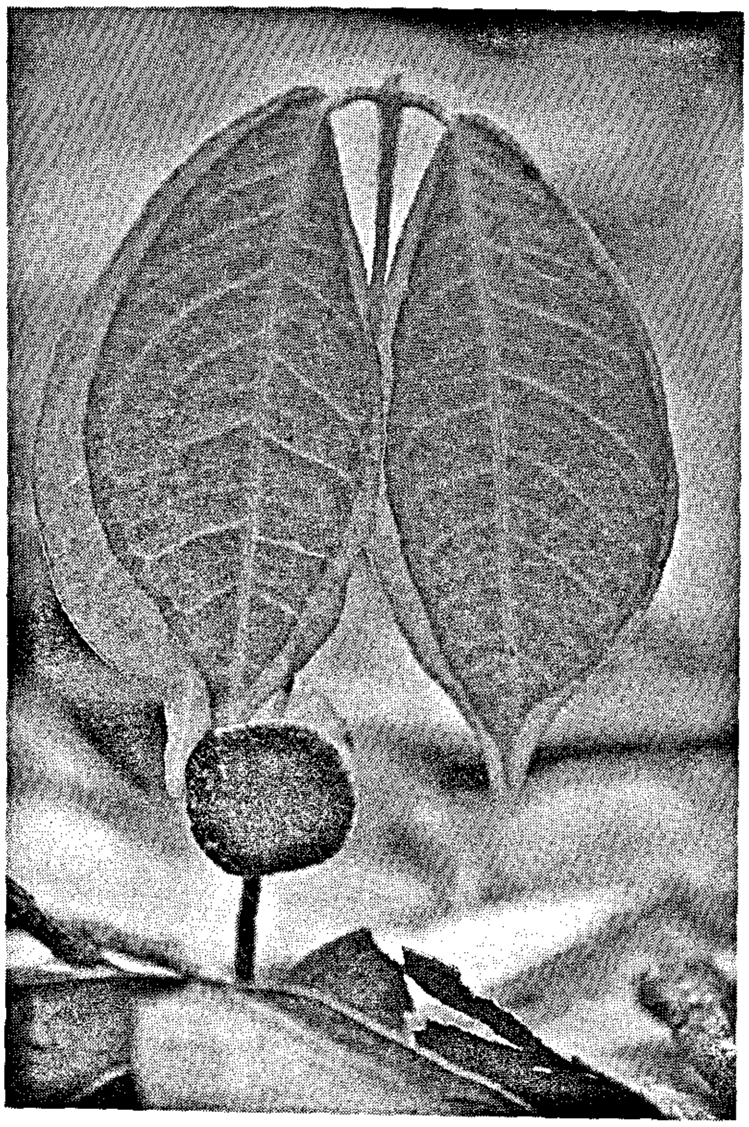


Base of trunk of *Bikinia* aff. *pellegrinii* (*Wieringa & Epoma 1606*). Photo J.J. Wieringa.

Old arrangement	New arrangement
Aphanocalyx	***Aphanocalyx* subg. *Aphanocalyx***
cynometroides	*cynometroides*
djumaensis	*djumaensis*
margininervatus	*margininervatus*
Monopetalanthus	
microphyllus	*microphyllus* subsp. *microphyllus*
compactus	*microphyllus* subsp. *compactus*
jenseniae	*jenseniae*
ledermannii	*ledermannii*
pectinatus	*pectinatus*
pteridophyllus	*pteridophyllus*
richardsiae	*richardsiae*
trapnellii	*trapnellii*
	obscurus
	subg. *Antherodontus*
hedinii	*hedinii*
heitzii	*heitzii*
	libellula
	Bikinia
breynei	*breynei*
coriaceus	*coriacea*
durandii	*durandii*
evrardii	*evrardii*
le-testui	*le-testui* subsp. *le-testui*
	le-testui subsp. *mayumbensis*
pellegrinii	*pellegrinii*
	aciculifera
	congensis
	grisea
	media
	Tetraberlinia
longiracemosus	*longiracemosa*
Tetraberlinia	
bifoliolata	*bifoliolata*
moreliana	*moreliana*
polyphylla	*polyphylla*
tubmaniana	*tubmaniana*
	baregarum
	korupensis
Michelsonia	***Michelsonia***
microphylla	*microphylla*
	Icuria
	dunensis

Figure 2.2: Diagram showing the old and the new generic and specific delimitation of the species of *Aphanocalyx*, *Bikinia*, *Icuria*, *Michelsonia*, *Monopetalanthus* and *Tetraberlinia*.

Seedling of *Tetraberlinia bifoliolata* with 2 pairs of leaflets in its first pair of leaves. Collection *Wieringa & Haegens 2529*. Photo J.J. Wieringa.



Young seedling of *Tetraberlinia bifoliolata* (*Breteler, Jongkind & Wieringa 11033*). Photo J.J. Wieringa.

3 Ecology

In this chapter a wide variety of ecological aspects of the treated tree species will be discussed. Most of these aspects have not been studied in detail, but since many of these issues are very poorly known, it is worthwhile to record what is known about them.

3.1 Habitat

In forest areas I distinguish between dry-land and riverine forest. Riverine forest is growing on periodically inundated ground adjacent to rivers, dry-land forest is growing on "terra-firma" and never becomes inundated. In savanna areas forests are sometimes present along rivers and streams. Some parts of these forests may become periodically inundated, whereas other parts will always remain dry. Because collectors in savanna areas usually do not distinguish between such parts, both are referred to as gallery forest.

The species of *Aphanocalyx*, *Bikinia*, *Icuria*, *Michelsonia* and *Tetraberlinia* are essentially species of primary evergreen rain forest, although *Icuria* remains present in woodland-like vegetations after degradation by logging. Most of the species require, or at least prefer, dry-land forest. However, a number of species of *Aphanocalyx* have adapted to riverine forest. Some of those species occur both in dry-land and riverine forest, a few are almost completely restricted to the latter habitat. Of the group of riverine species of *Aphanocalyx*, two were able to make the step from riverine rain forest to gallery forest. One other, poorly known, species of this genus (*A. libellula*) occurs in gallery forest as well, but its relatives are restricted to dry-land forest. It is not known whether or not the habitat of this species is subject to periodical inundation.

Most species of *Bikinia*, *Icuria*, *Michelsonia* and *Tetraberlinia* are strictly confined to dry-land forest. Only *T. bifoliolata* is rarely also encountered in riverine forest, while *B. evrardii* is often found near the transition between dry-land and riverine forest. Apparently these two species are capable of dealing with limited inundation for a short period. The habitat of *B. congensis* is described as gallery forest, without indication whether the species occurs in inundated parts or not.

Most species of the 5 genera occur in lowland forest. Only *Michelsonia microphylla* and *Tetraberlinia baregarum* seem to be restricted to slightly more elevated (650–1100 m) altitudes. However, since within their restricted area of distribution no lower altitudes are available, we cannot determine whether these species really require the altitudinal component.

Aphanocalyx pectinatus too has a tendency to occur at somewhat higher altitudes (650–850 m), but it is not confined to these.

Several species of *Bikinia* (*B. le-testui*, *B. media*, *B. pellegrinii*) occur up to 900 m altitude, but one has to realise that within the distribution area of *Bikinia* no suitable habitat is available at higher altitudes (all areas with altitudes over 1000 m are of volcanic origin).

Like most African Caesalpinioideae tree species all species of this group are restricted to relatively poor soils. Some species seem to be confined to sandy soils (e.g. *Aphanocalyx ledermannii*), others also occur on more loamy soils (e.g. *Bikinia durandii*), but there are no systematic records available to corroborate these findings. However, some very convincing records that the species of this group do *not* grow on rich soils are available. During all inventory work on the slopes of Mt. Cameroon (e.g. Cheek, 1992; Ndam, 1993; Cable & Cheek, 1998) not a single species of this group has been encountered so far (the only record in Ndam l.c. is based on a misidentification). In the adjacent sedimentary area of the Onge river, however, several species of this group are present (Cable & Cheek, 1998; distribution maps in taxonomic part of this study). The only difference between the two areas seems to be the presence of volcanic soils on the slopes of Mt. Cameroon.

Several species of this group are ectomycorrhizal (e.g. Newbery et al., 1988; Moyersoen et al., 1998). Ectomycorrhizal species will extract phosphorus from the litter more easily (Moyersoen et al, 1998), so they will have an advantage over vesicular-arbuscular mycorrhizal species in soils where phosphorus is the limiting factor and relatively a lot of P-rich litter is present. In P-rich soils this kind of symbiosis probably no longer provides sufficient advantage to remain a competitive species. If the volcanic soils of Mt. Cameroon are indeed rich in phosphorus, this might explain the absence of the treated species (and most other Macrolobieae) in that area.

3.2 Clustering

Many authors (e.g. Saint Aubin, 1963: 16; Aubréville, 1968 & 1970; Voorhoeve, 1964 & 1965; Letouzey, 1968: 126–127; Burg, 1977; Janzen, 1981; Vivien & Faure, 1985; Wilks, 1990: 14 & 189) mention that Caesalpinioideae, or at least certain species of this subfamily, occur gregariously. Although the phenomenon is well known, hardly anything is known about the extent (number of trees and area covered) of such clustered occurrences. Among the species dealt with in this study explicit records about the cluster size are available only for *Tetraberlinia tubmaniana* (Schäfer, 1970: 8), while Newbery et al. (1997: 369) mention that separate groves, consisting of *Microberlinia bisulcata*, *Tetraberlinia bifoliolata* and *T. moreliana* (in fact *T. korupensis*), form a single patch of 1.5 x 1 km. Aubréville (1968 & 1970) mentions that some species occur in small groups or in more extensive populations, but he is not explicit about these qualifications. Saint Aubin (1963) distinguishes three categories of clustering:

1) Small groups of only a few (large) trees.
2) Dense populations covering not more than 100 ha.
3) Less dense populations larger than 100 ha.

In a table (p. 18–19) summarizing inventories in western Gabon, he subsequently mentions 'Andoungs' (comprising mainly *Bikinia*, *Tetraberlinia* and *Aphanocalyx heitzii*) as belonging to category 2, while 'Ngangs' (comprising explicitly *Hymenostegia pellegrinii* and *Aphanocalyx microphyllus*) belong to category 1. Contrary to this first generalization of the 'Andoungs', Saint Aubin (1963: 53 & 57) specifies that *Bikinia le-testui* and *Tetraberlinia moreliana* only occur in small groups, while *Tetraberlinia longiracemosa*, *T. bifoliolata*, *Bikinia coriacea* and *B. durandii* (resp. p. 27, 62, 54 & 56) would form larger populations.

It should be noted that both more detailed records of *Tetraberlinia* stands (by Schäfer and Newbery et al.) do not fit any of Saint Aubin's categories: they are both dense and exceed 100 ha.

Whether a gregarious occurrence of a species concerns a dominant, co-dominant or even non-dominant stand is only rarely reported. In a few cases records from herbarium labels are available: *Aphanocalyx cynometroides* is supposed to be "quasi dominant" in the lower parts of valleys near Shabunda (*Michelson 826*); *Aphanocalyx libellula* constitutes gallery forest in Angola (see type label).

In order to obtain more detailed information on the shape of small gregarious clusters and the internal distributions of trees in such a cluster, the larger trees in two 1-ha plots have been mapped and identified. To get a rough estimate of the size of some larger clusters, data available from the Minkébé area (Valkenburg et al., 1998) have been used.

3.2.1 1-ha plots

The first plot is a permanent 1-ha plot in the Rabi area (western Gabon), which may serve as well for future studies of growth, mortality and succession. The second plot, situated in the CEB concession NE of Lastoursville (eastern Gabon), was used incidentally and not marked as such, the trees were only mapped in order to obtain an impression of their spatial arrangement.

Method

In 1992 in both the Rabi and the Lastoursville area a parcel of dry-land forest was selected that did not show recent damage caused by man. Both plots may be considered as primary forest; the trees show a normal distribution of diameter classes (partly shown in fig. 3.1) and there is no overabundance of lianas.

Table 3.1: Coordinates of corners of plot 1, Rabi. Port-Gentil datum. By Geometric Service Shell.

	easting	northing	alt.
NW	597197.90	9786908.87	48.51
NE	597297.37	9786923.74	46.08
SE	597309.28	9786824.22	39.59
SW	597208.24	9786809.52	39.78

The first plot is situated in the Rabi area at 1°55.7'S 9°52.5'E, 40–50 m alt. The surveying service of Shell-Gabon afterwards established detailed coordinates (table 3.1). The plot has been entered in the Shell geographical system as an experimental zone, hopefully aiding to its preservation. A small tree was selected as corner tree for the 1-ha plot and received coordinates (0, 0). With the aid of a compass and a topophyl the boundaries of the plot were demarcated to the (magnetic) south and to the east. To facilitate a fast and precise measuring of the position of the trees, topophyl lines were laid down every 10 metres in an east-west direction, with markers on every 10 metres. Of all trees with a DBH > 30 cm the position was determined as that of the nearest one metre grid point. To facilitate successive additions of diameter classes each class was numbered as a separate series (Z: 10–20, T: 20–30, S: 30–40, M: 40–50, G: ≥50 cm DBH). The Z and T classes have been checked only on species of our group. When other trees in these classes were collected (i.e. when they were flowering or when they could be collected while climbing a tree close to it) their position was recorded as well. Of all these trees the DBH was established by measuring the circumference at 1.3 m height and dividing it by 3.15 (and truncating the result). When the trunk was very irregular or when it had buttresses higher than 1.3 m, a diameter was measured at the lowest point above 1.3 m where a diameter could be properly established. Of some trees the height was estimated while climbing it.

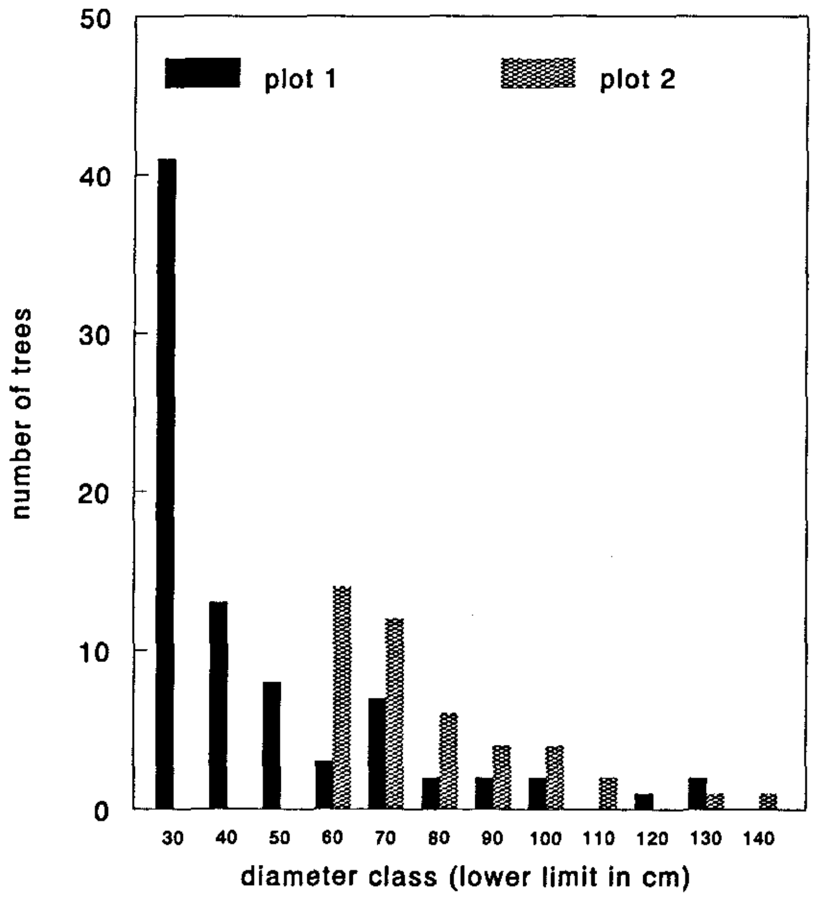


Figure 3.1: Distribution of diameter classes of all trees with a dbh ≥ 30 cm in plot 1 and with a dbh ≥ 60 cm in plot 2.

The trees were identified in as much detail as possible. For most of the larger trees (>40 cm) at least one voucher specimen per species was taken. For the interpretation of the results it is important to know that no insufficiently identified tree belongs to *Tetraberlinia*. Trees that could not be referred to a particular family are unlikely to be Leguminosae.

The plot NE of Lastoursville (Plot 2: 0°41'S, 12°56'E, alt. c. 300 m) was demarcated in the same way, except that it was anchored by a tree in the SE corner which received coordinates (100, 100). A slope is present, rendering (0, 0) the highest and (100, 100) the lowest point in the plot. Since in this area many large trees were present and time was limited, only trees with a dbh > 60 cm have been recorded. Of all these trees the position was established and a first identification was made by two tree spotters employed by the local forestry company (CEB) and by myself. Only the Caesalpinioideae were identified more thoroughly. Apart from the large trees, the plot was inventoried for trees belonging to one of the species treated here.

Results and discussion

The position, diameter, height, identification and voucher specimens of the measured trees are listed in Appendix 1. Their positions are plotted in map 3.1 and map 3.2. Data on the abundance of some Caesalpinioideae is summarized in table 3.2 and 3.3. Diameter distributions are figured in fig. 3.1–3.

Table 3.2. Abundance of Caesalpinioideae in 1-ha plot 1.

diameter class	≥70			≥50			≥40			≥30			≥10	
	#	b.a.	%	#	b.a.	%	#	b.a.	%	#	b.a.	%	#	b.a.
taxon														
T. moreliana	5	4.44	41	6	4.67	34	6	4.67	30	7	4.77	25	9	4.83
T. bifoliolata	1	0.38	3	4	1.00	7	9	1.79	11	16	2.38	12	27	2.75
Tetraberlinia	6	4.82	44	10	5.67	41	15	6.46	41	23	7.15	37	36	7.59
Librevillea	1	0.52	5	3	1.06	8	3	1.06	7	3	1.06	5		
Tetr. + Libr.	7	5.34	49	13	6.73	49	14	7.52	48	26	8.21	42		
Caesalpinioid.	9	6.88	63	16	8.49	62	23	9.54	61	42	11.31	58		
Total	16	10.93	100	27	13.69	100	40	15.71	100	81	19.40	100	>104	>20.13

= number of trees; b.a. = basal area; % is percentage of basal area; Tetr. + Libr. = *Tetraberlinia* + *Librevillea*.

Table 3.3. Abundance of Caesalpinioideae in 1-ha plot 2

diameter class	≥70			≥60		
	#	b.a.	%	#	b.a.	%
taxon						
J. pellegriniana	5	4.60	23	5	4.60	19
Caesalpinioideae	6	5.07	26	10	6.31	26
Total	30	19.74	100	44	24.06	100

For explanation of symbols see Table 3.2.

The plot at Rabi proved to be extremely rich in Caesalpinioideae: 59% of all trees with a DBH ≥ 50 cm belong to this subfamily, covering 62% of the basal area of that size class. For a DBH ≥ 30 cm these percentages are 52 and 58% respectively. The total of 16 trees with a DBH ≥ 70 cm totalling a basal area of 10.9 m^2 is fairly high when compared to some other inventories (e.g. Lejoly & Wilks (1995: 27): 12 trees with 7.1 m^2 / ha; Newbery & Gartlan (1996): 11 (Korup) and 15 (Douala-Edea) trees / ha; Valkenburg et al. (1998): 4 trees / ha). However, in the plot NE of Lastoursville these values (table 3.3) are even much

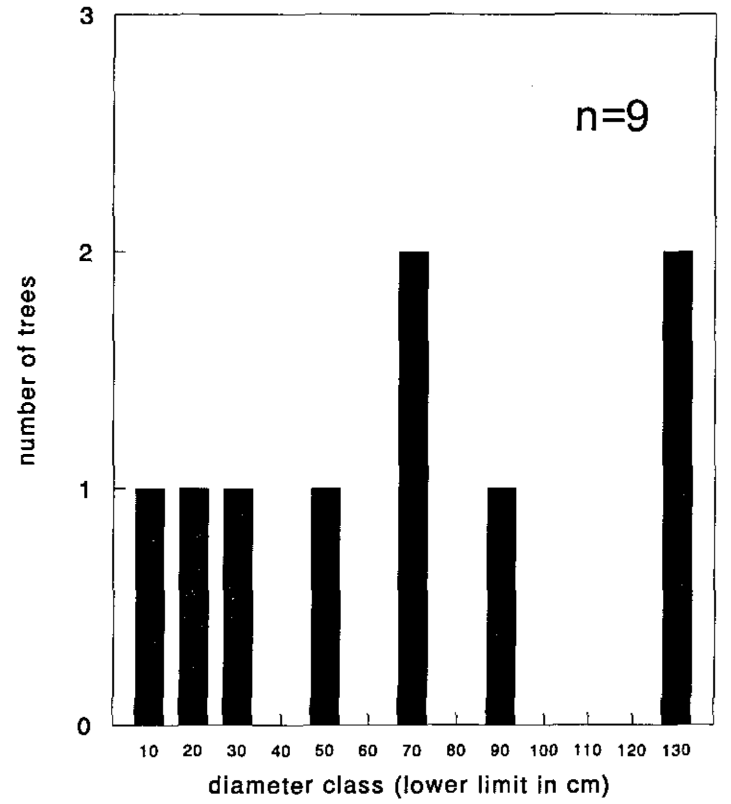


Figure 3.2: Plot 1, distribution of diameter classes of *Tetraberlinia moreliana.*

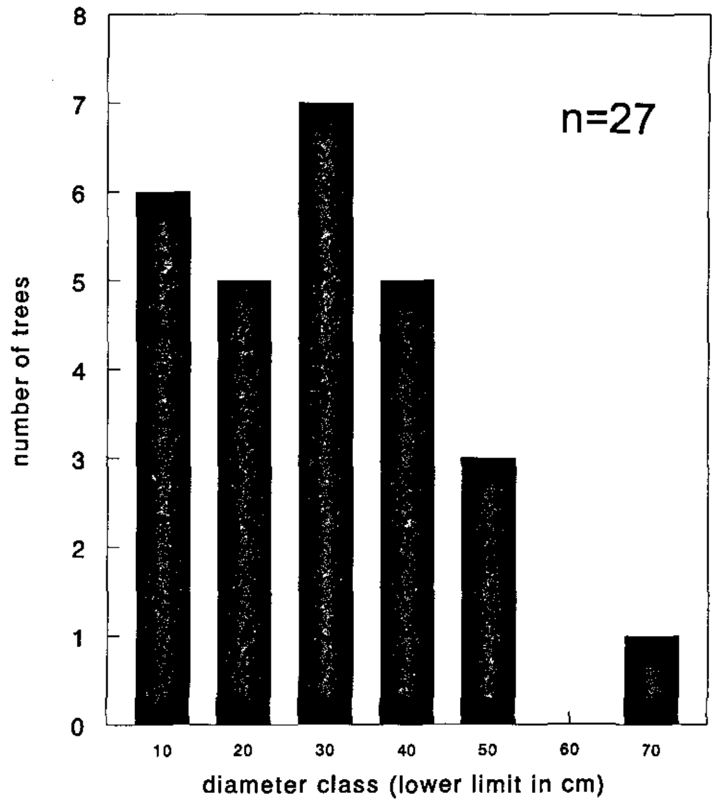
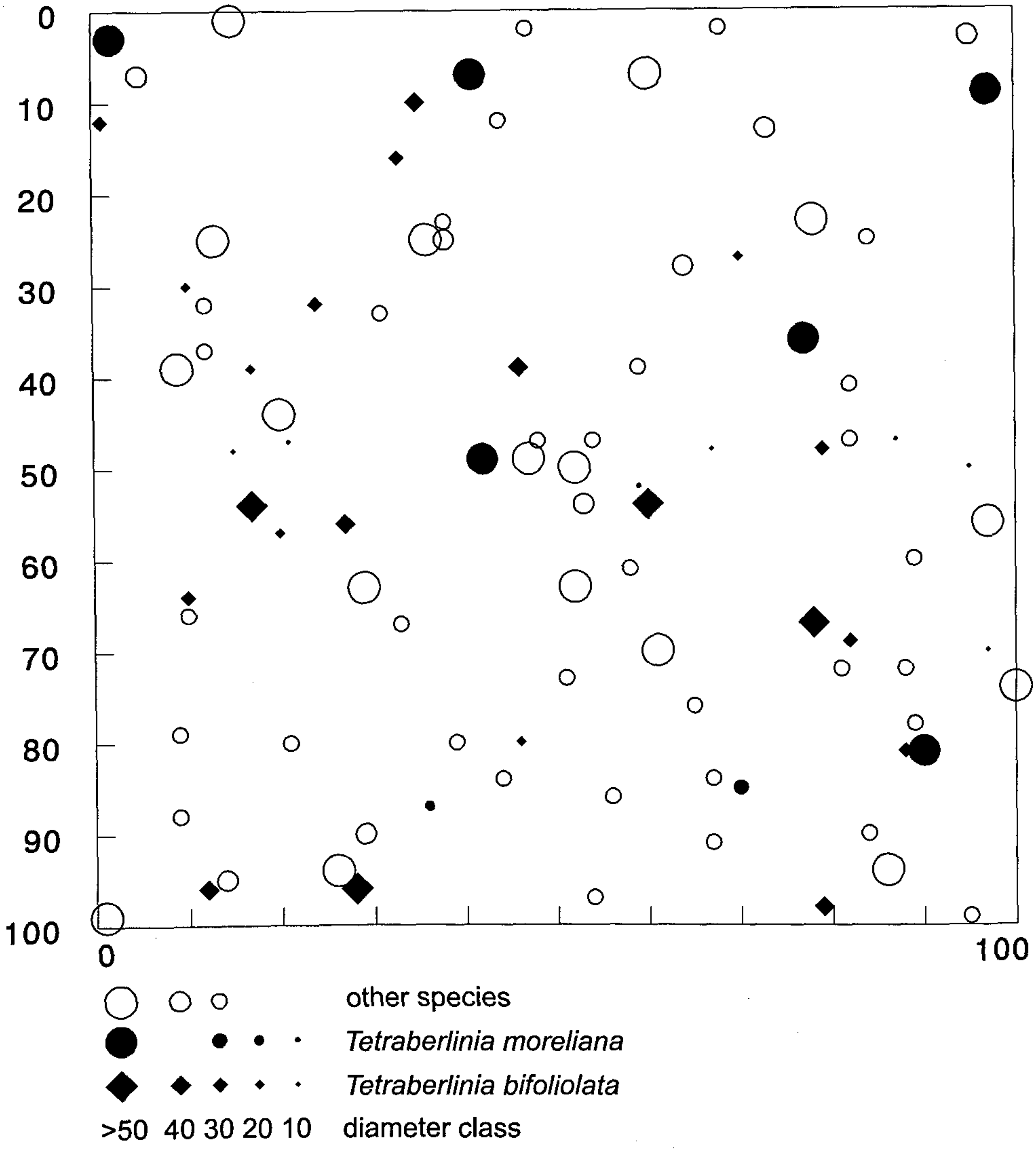


Figure 3.3: Plot 1, distribution of diameter classes of *Tetraberlinia bifoliolata.*

higher: 30 trees $\geq$ 70 cm DBH with a basal area of 19.7 m^2.

Newbery et al. (1997) distinguish between high abundance (HEM), low abundance (LEM) and very low abundance (VLEM) ectomycorrhizal caesalpiniaceous forests. In their study HEM forests were characterized by ectomycorrhizal trees covering 45–68% of the basal area for trees with a dbh > 9 cm. It is not known if all tree species occuring in my plots are ectomycorrhizal or not. However, all genera presently assigned to the Macrolobieae, of which records do exist according to Alexander (1989) and Onguene & Kuyper (submitted), are ectomycorrhizal. Therefore it is not unreasonable to assume that several other Caesalpinioideae (at least the Macrolobieae) present will be ectomycorrhizal as well. In this study (plot 1) *Tetraberlinia* trees (which are ectomycorrhizal) do not reach a percentage of over 45% basal area, but in combination with some of the other Caesalpinioideae present, this plot will prove to fall within the limits of HEM forest. The tree composition of the Rabi plot is comparable to the HEM forests in Korup. In both forests *Tetraberlinia bifoliolata* is co-dominant. In Rabi *T. korupensis* is replaced by its sibling species, *T. moreliana*, while the third co-dominant species of Korup (*Microberlinia bisulcata*) seems to be replaced by a series of Caesalpinioideae species of which *Librevillea klainei* is the most prominently present. Since *Microberlinia* presently does not regenerate itself in Korup, it may possibly not remain part of that forest in the long run, rendering the composition of both forests even more alike.

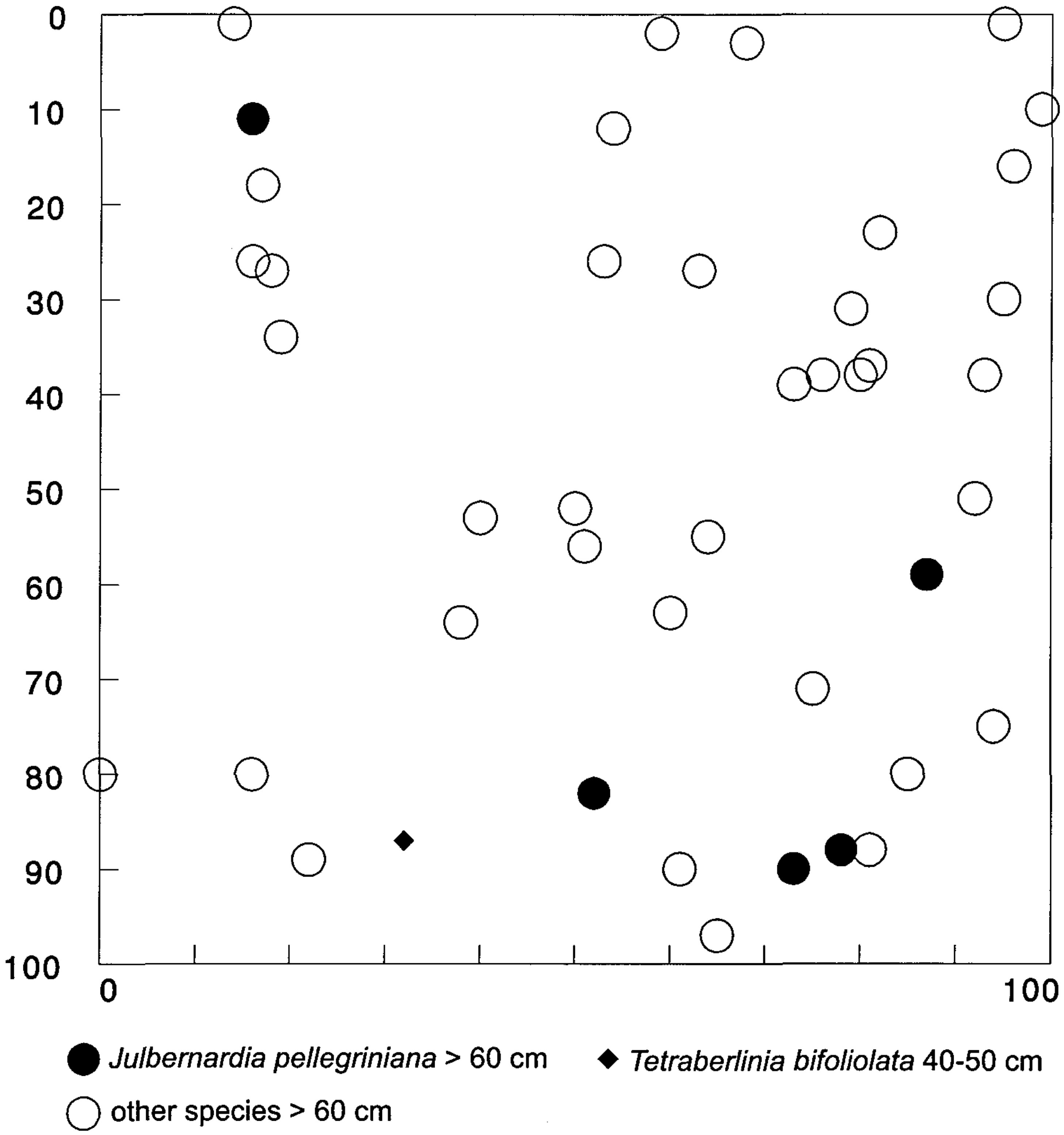
The diameter distribution of *T. moreliana* (fig. 3.2) does not show the usual pattern, i.e. decreasing numbers per class (compare to e.g. Newbery & Gartlan, 1996: fig 10). When the lower classes are underrepresented, this is usually interpreted as a lack of regeneration. However, in this forest the regeneration of *T. moreliana* is abundant. The forest floor is covered with seedlings and saplings. This distribution would be explained if this species were to start growing rapidly as soon as the trees reach sufficient light exposure (still with a dbh < 10 cm) and if those trees but rarely die in this phase. Necretion would only start after reaching class 80. The diameter distribution of *T. bifoliolata* (fig. 3.3) shows a fairly normal distribution, except that class 10 and 20 are slightly underrepresented. Maybe some trees in this class were overlooked during the survey, but a similar argument as for *T.*



Map 3.1: Plot 1. *Tetraberlinia* species are plotted from diameter class 10 and up, others from 30 and up.

moreliana might hold as well, except that growth gradually slows down and necretion sets in after reaching class 40.

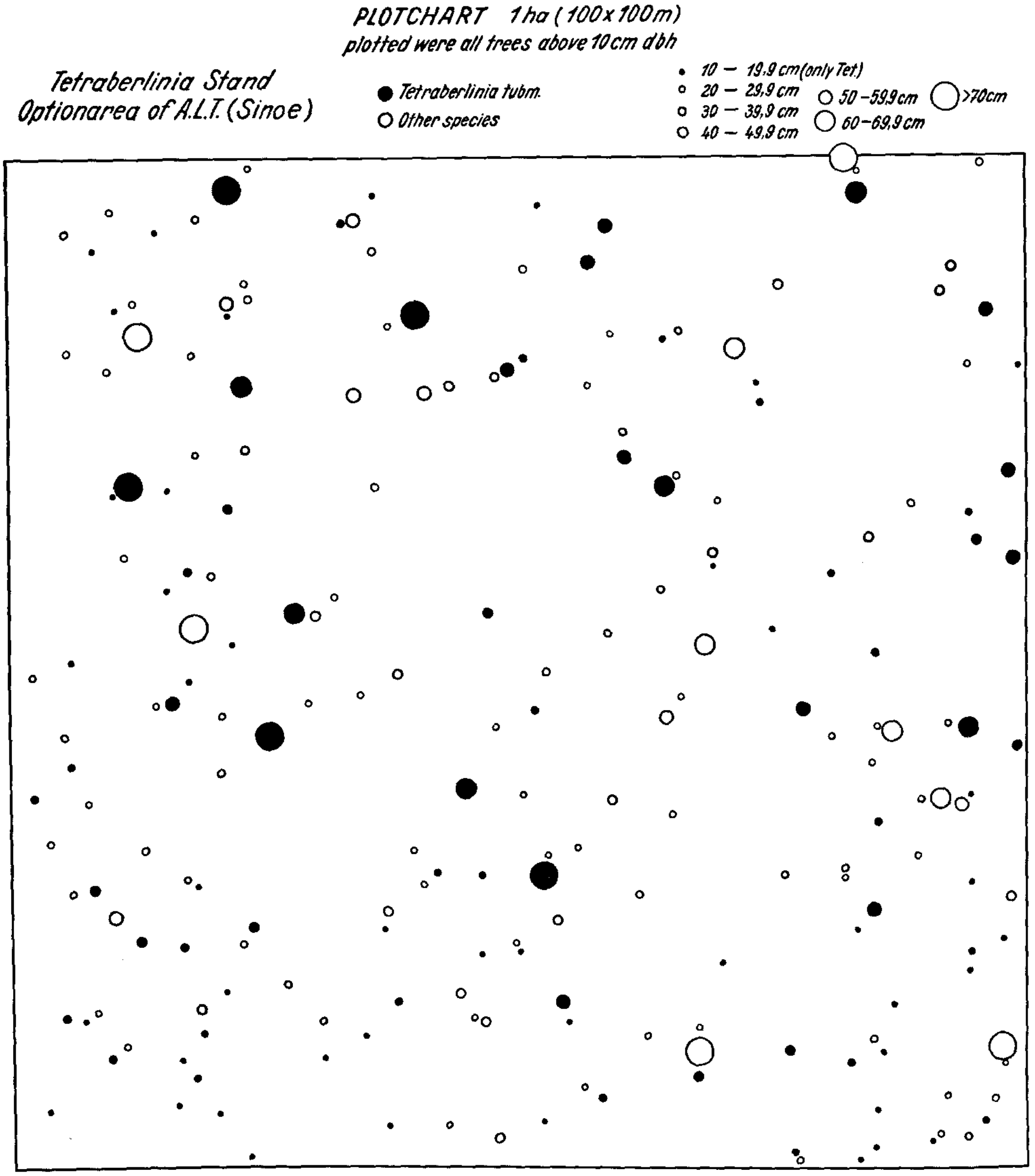
Since *Julbernardia pellegriniana* is ectomycorrhizal (Onguene & Kuyper, submitted), plot 2 constitutes a LEM plot. It is remarkable that in this plot *J. pellegriniana* has as many large trees with about the same basal area as *T. moreliana* has in plot 1. However, because the total basal area is much larger here and other mycorrhizal species are almost absent, it classifies as LEM forest. An interesting observation has been made on tree G22: its crown had completely died off, but its root system and lower trunk were still alive and taken over by G21 to which it was connected by one of its buttresses. Connection of root systems has been reported on several occasions for mono- or co-dominant trees (Leroy Deval, 1976: 286; Yasman, 1995), but such connections were realised by small roots or by way of mycorrhiza, not through the principal roots.



Map 3.2: Plot 2. All species except *Tetraberlinia* are plotted from diameter class 60 cm and up.

As will be clear from the plot-map (map 3.1), *Tetraberlinia bifoliolata* and *T. moreliana* do not grow in small monospecific clusters. They are both part of a forest type of which they constitute a major element, and this forest type may extend over large areas. In Rabi it seems to extend over an area of at least several square kilometres, intersected by riverine and swamp forest.

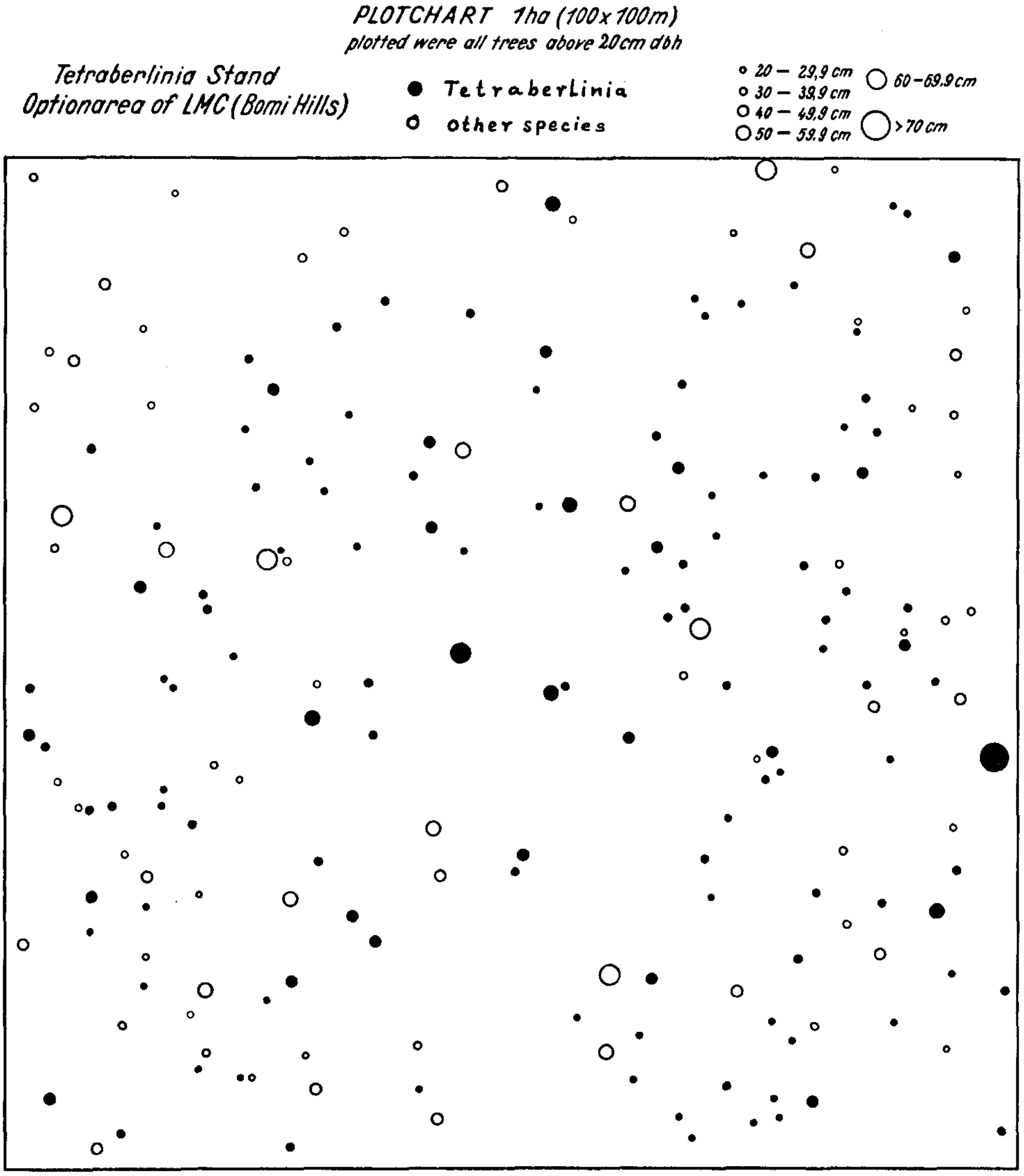
The *T. tubmaniana* forest in Liberia as described by Schäfer (1970) clearly constitutes HEM forest as well (if we assume this species to be ectomycorrhizal). The distribution of trees in two 1-ha plots in that forest (map 3.3 & 3.4, reproduced from Schäfer, 1970) is strikingly similar to that of plot 1. This means that all so far recorded (large) HEM-forests based on our group are formed by *T. bifoliolata*, *T. korupensis*, *T. moreliana* and *T. tubmaniana*. It can hardly be considered as mere coincidence that these four species form a clade (see chapter 6, phylogeny). It seems that the ability to form large HEM forests is an ecological speciality which developed in this clade. According to the PACER hypothesis of Newbery et al. (1997) this is highly beneficial for these species. By changing



Map 3.3: Plot at Sinoe with *Tetraberlinia tubmaniana*. Reproduced from Schäfer, 1970.

the soil properties these species create conditions in which they are competitively superior. Some other ectomycorrhizal Caesalpinioideae species may benefit from these conditions as well. In Gabon, where many Caesalpinioideae occur, this means that a variety of species will be found, in Korup apparently only *Microberlinia bisulcata* (and maybe *Didelotia africana*) is present to benefit, while in Liberia (which is again poorer in species) no other species seems present to join.

Outside the area where these four *Tetraberlinia*'s occur, some other dominant or co-dominant Caesalpinioideae forests have been reported in Africa. These involve *Cynometra alexandri* (Hamilton, 1981 ex Hart et al., 1989), *Gilbertiodendron dewevrei* (Gérard, 1960; Hart, 1995), *Julbernardia seretii* (Gérard, 1960; Hart, 1995), *Talbotiella gentii* (Ghana, pers. comm. Jongkind 1998). It is clear that the *Julbernardia-Gilbertiodendron* forest described by Gérard (1960) counts as HEM forest (89% of the basal area belongs to these two species). *C. alexandri* on the other hand is arbuscular mycorrhizal (pers. comm.



Map 3.4: Plot at Bomi Hills with *Tetraberlinia tubmaniana*. Reproduced from Schäfer, 1970.

T.W.M. Kuyper) and so is probably *T. gentii*. However, both species grow in a much dryer forest type which may not be comparable ecologically to the HEM forests. The same holds for the mono-dominant stands of *Icuria dunensis* (Lubke et al., in prep.), of which at least the environment (half-open dunes) is quite different from the primary rain forest of central and western Africa.

Ectomycorrhizal trees can also dominate woodlands which meet the HEM definition (at least 45% of the basal area constituted by ectomycorrhizal trees). However, these forests grow under much dryer conditions than the forests mentioned above. Contrary to the PACER hypothesis of Newbery et al. (1997), Munyanziza (1994) supposes that the symbiosis in these cases is a requirement to procure sufficient water as well.

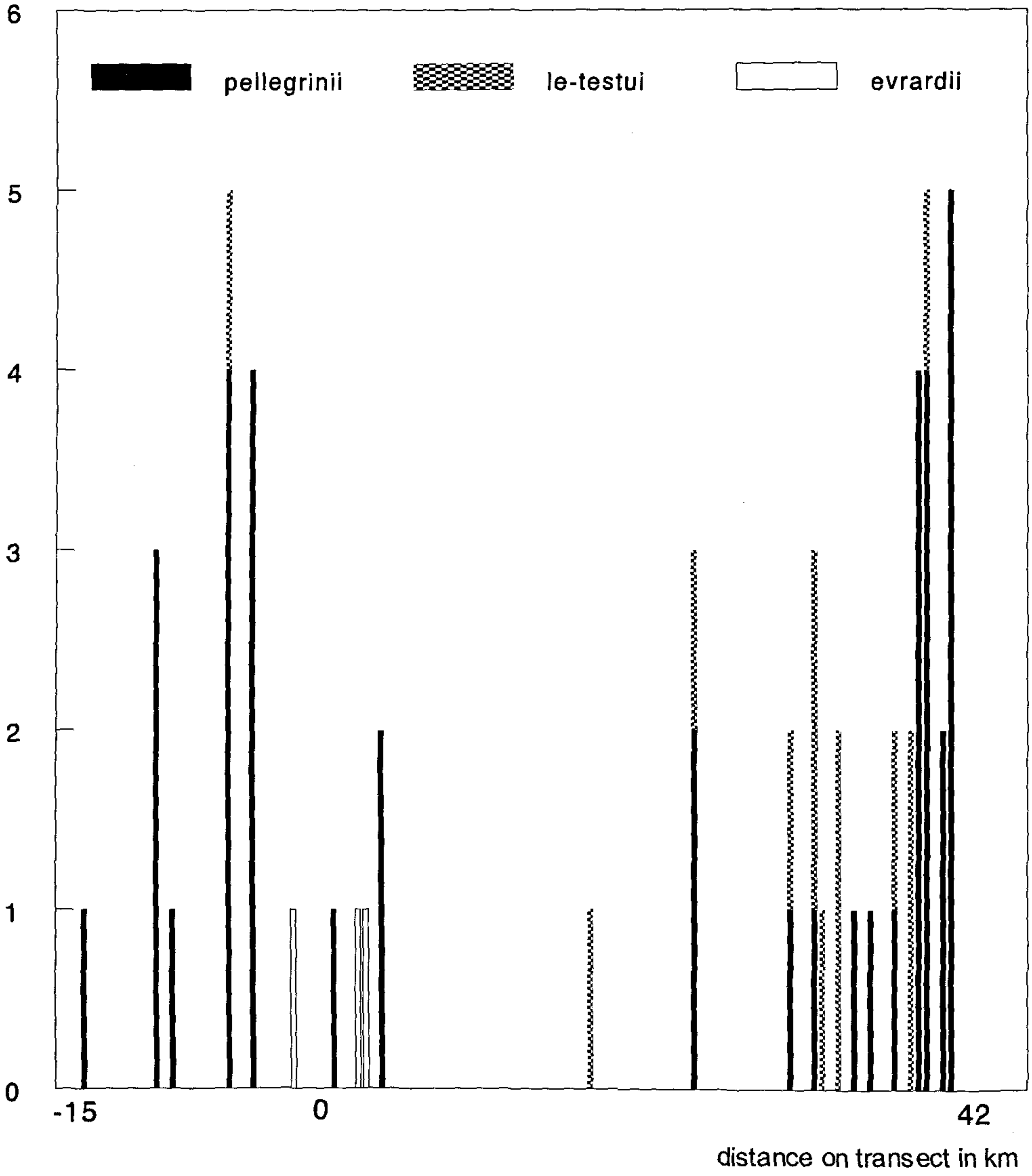


Figure 3.4: Numbers (stacked) of trees of 3 *Bikinia* species per 500 m line transect (50 m wide) from the Minkébé survey (see also Valkenburg et al., 1998). Transect A is presented as 0–42 km, transect B as -15–0 km (both transects started at the same point running in opposite directions).

3.2.2 Minkébé transect data

Another source for cluster size data can be extracted from the database of the forest inventory in the Minkébé area as described by Valkenburg et al. (1998). In fig. 3.4 the number of large trees (dbh ≥ 70 cm) in each 500 x 50 m plot along the transect of the three *Bikinia* species present are plotted. The method follows Valkenburg et al., but is amended by the reidentification of vouchered trees and by plotting the plots in geographical order. From these data the following patterns can be extracted:

- The three *Bikinia* species may occur fairly frequently along stretches of several kilometres while they may be absent the next 10–20 km before occurring again.
- If we assume the populations to be about circular and if at least some were intersected

close to their centre, we can endeavour to estimate the cluster size. The two largest *B. pellegrinii* clusters (at 37 & 39 km) are both 700 m in cross-section, so the actual cluster diameter most probably will not exceed 1 km. Within both these clusters about 40% of the large trees belongs to this species. The smaller clusters and individual sightings of this species may either represent individual trees or clusters that were intersected near their margins. *B. le-testui* occurs in smaller numbers, often associated with *B. pellegrinii.*

- *B. evrardii* was encountered only three times as a large tree, but all three times in areas in which the other two *Bikinia* species were absent. Moreover, all nine occurrences of this species in the inventory of smaller trees (dbh ≥ 10 cm) are in absence of the other *Bikinia* species, suggesting a different ecology. The species proves to be differential for vegetation type 1 of Valkenburg et al. (1998) with a frequency class of II in 1a and class III in 1b. The species was excluded in the analysis of Valkenburg et al. because its identity was not sure at the time of analysis. Type 1 is *Gilbertiodendron dewevrei - G. ogoouense* forest, where 1a is riverine forest and 1b somewhat drier adjacent forest. Both *G. dewevrei* and *B. evrardii* have their main distribution more to the east, rendering the occurence of an association in those areas plausible as well. Indeed Dowsett-Lemaire (1995: 20, *B. evrardii* as *Tetraberlinia polyphylla*) found both species present in the same riverine forest type.

3.2.3 Discussion on gregariousness

The 1-ha plots do not demonstrate small clusters of a Caesalpinioideae species. *Julbernardia pellegriniana* may seem to cluster in plot 2 (map 3.2), but the species continues outside the plot as a co-dominant. Using the inventory data and personal field observations, however, it is possible to put down some notes on the gregarious occurrence of most species.

Bikinia pellegrinii and possibly *B. le-testui* may become codominant in areas that cover less than 1 km^2. Most other species of *Bikinia* grow in small clusters, which do not seem to extend over an area wider than one or a few ha. So do several species of *Aphanocalyx*. Only some of the riverine species are able to become dominant over larger stretches in this habitat that is comparatively poor in species. Similarly, in the also relatively species poor forest of West Africa, *Aphanocalyx microphyllus* ssp. *compactus* appears to become gregarious over larger areas as well (Voorhoeve, 1965; Burg, 1977).

In the area of plot 2 *Tetraberlinia bifoliolata* reaches the most eastern limit of its distribution. The species does not form extensive stands here, but occurs merely scattered, as is exemplified by the single, medium large tree in plot 2. The other HEM-forest-forming *Tetraberlinia* species show the same pattern: (co-)dominant in the area were they meet their optimal conditions, solitary or in small groups outside that area. Burg (1977) reports the same phenomenon for *Gilbertiodendron preussii. T. longiracemosa* and *T. polyphylla* are usually encountered in small groups or solitary.

The monospecific genera *Michelsonia* and *Icuria* are both able to form fairly extensive monospecific stands (Pierlot, 1966; Lubke et al, in prep.).

The explanation for the gregarious nature of most Macrolobieae species is rather complicated and hard to unravel. The symbiosis with ectomycorrhiza certainly plays a role, as well as their seed dispersal mechanism. The pods explode, projecting the seeds up to 60 m away (Burgt, 1997). However, most seeds will fall much closer to the tree. Moreover, such seeds may have a higher chance of survival (Hart, 1995). The result of this seed dispersal mechanism is that the next generation of the tree is bound to grow in the vicinity of the mother tree. This locality will most likely be very suitable, especially when the mother tree made it suitable, as Newbery et al. (1997) suggest. Possibly the mother tree may even aid its seedlings by donating carbohydrates via mycorrhizas, as allegedly has been reported for Dipterocarpaceae by Yasman (1995) and has been demonstrated between seedlings of different species by Simard et al. (1997). Another way for such transfers may be by direct root connections similar to those observed on mature *Julbernardia pellegriniana* trees. In order to become a dominant, a tree should have good chemical defences against herbivores (Janzen, 1981); indeed at least the four HEM forest forming *Tetraberlinia* species and most *Bikinia* species do produce large amounts of dark red resin.

We should consider the gregarious nature of many Macrolobieae trees as the outcome of an ecological specialization process. During their evolution they have developed several characters and mechanisms that as a whole suit this special way of life, like the limited dispersal of seeds, large seeds with copious nutrients to realize initial growth under dark conditions, chemical protection and an ectomycorrhizal relationship. It is the combined effect of these characteristics that is responsable for the gregarious nature.

We can group the species which show a gregarious occurrence in a special guild (Root, 1967). If we do, it may be necessary to distinguish two groups or even separate guilds: the species that are able to form extensive HEM forest by themselves (the "constructors"), and the species that form only small clusters or occur in smaller numbers in HEM forest (the "profiteers").

3.3 Mycorrhizal status

Since the ability of Caesalpinioideae species to associate with ectomycorrhiza fungi appears to be of importance, it seems worthwhile to evaluate the existing ectomycorrhiza records against the new generic delimitation.

Since *Aphanocalyx microphyllus* is the only species previously classified in *Monopetalanthus* that occurs in Yangambi, the record of Fassi (1962) to an ectomycorrhizal *Monopetalanthus* spec. should refer to this species. Another reference to the ectomycorrhizal status of this species and to *A. margininervatus*, is found in Newbery et al. (1988). The reference to a 'M. sp. nov.' here may refer to an undescribed species of *Hymenostegia*, but such is doubtful given the arbuscular mycorrhizal status of that genus. *Aphanocalyx microphyllus* was also tested by Onguene & Kuyper (submitted) who find a high degree of colonization in this species. Moyersoen & Fitter (1999) report *A. cynometroides* as ectomycorrhizal, but since that record originates from outside its known distribution, it is a little questionable. It should be noted that so far no records exist on the mycorrhizal status of subgenus *Antherodontus*.

Both *Tetraberlinia bifoliolata* and *T. korupensis* (as *T. moreliana*) are reported ectomycorrhizal by Newbery et al. (1988) and Moyersoen & Fitter (1999). The first species has a very high colonization percentage according to Onguene & Kuyper (submitted), who also provide the first record for a *Bikinia* species: *B. le-testui* is heavily colonized by ectomycorrhiza fungi. Of *Icuria* and *Michelsonia* no records are available.

Of at least three species of *Julbernardia* records are available: *J. pellegriniana*: Onguene & Kuyper, submitted, *J. seretii*: Peyronel & Fassi, 1960; Fassi, 1961; Newbery et al., 1988; Onguene & Kuyper, submitted and *J. globiflora*: Munyanziza, 1994. Also in this genus the colonization level is very high.

For both *Tetraberlinia* and an unidentified species of *Monopetalanthus*, Moyersoen & Fitter (1999) report that in addition to high ectomycorrhiza colonisation also low percentages of colonisation by arbuscular mycorrhiza may be present. Most probably all ectomycorrhizal species will rarely be colonised by some arbuscular fungi as well.

Almost all seedlings (of *Aphanocalyx*, *Bikinia*, *Icuria* and *Tetraberlinia*) that were transported to the greenhouse in Wageningen performed very poorly and died within a period of a few months to three years. Only a single seedling of *A. obscurus* grows well. Mycelium has been observed in its pot, but whether these belonged to an ectomycorrhizal fungi was not established. It seems likely that the growth problems with these seedlings are related to the lack of the appropriate (ecto?)mycorrhizas.

3.4 Pollination

Nothing has been published on the pollinators of the species studied and only little on those of their relatives. According to Harms (1903: 250; as *Berlinia baumii* Harms) *Julbernardia paniculata* is visited by large numbers of bees. Yumoto (1992) observed that flowers of an *Anthonotha* species were visited by honey-bees (*Apis mellifera*), stingless bees (*Trigona* spp.), carpenter bees (*Xylocopa* sp.), some other bees (*Amegilla* sp. and 3 species of Halictidae), 2 species of hover-flies (Syrphidae), 3 species of blowflies (Calliphoridae) and one scarab-beetle species (Scarábaeidae). Most of them (except the beetles and most of the Calliphoridae) proved to bear *Anthonotha* pollen. According to Yumoto (l.c.) hardly anything is known about pollinators of African canopy trees.

During my fieldwork in Gabon the animals visiting the flowers of several species of this group were observed, using the climbing method as described in Wieringa (1996), and a few additional observations with the aid of binoculars from the forest floor. In some cases I was able to catch them as well. Not only insects were frequenting the flowers, also several species of sunbirds (*Nectarinia*) were observed on several species (more detailed information on the pollinators are given under the tree species concerned). Because of their high energy requirements, sunbirds most probably visit only those species that have a high concentration of easily accessible flowers. The two tree species of this group where these birds were observed (*Aphanocalyx microphyllus* and *Bikinia durandii*) both show 'strobiliform' racemes (see pag. XIV & plate 1a), each possessing several open flowers simultaneously. The birds land on the branch and hop from one strobilus to another. Several other species of *Bikinia* and *Aphanocalyx* subg. *Aphanocalyx* show the same type of inflorescences and may be visited by sunbirds as well. *Tetraberlinia* on the other hand has far more lax inflorescences and these flowers are probably not frequented by sunbirds. Whether the more 'umbelliform' inflorescences of some other species of *Bikinia* and *Aphanocalyx* subg. *Antherodontus* will be visited by sunbirds remains to be seen. Large flocks of sunbirds have been observed on the very large (1½ x 1½ m), flattened inflorescences of *Daniellia soyauxii* var. *pilosa* (*Wieringa & v.d. Poll 1462*) and on the smaller ones of var. *soyauxii* (*Wieringa & Sargeant 1112*), but their flowers are much larger than those of *Bikinia* and *Aphanocalyx*, and they contain large quantities of nectar. The internal structure of these inflorescences may in fact be more comparable to the 'strobiliform' racemes of some *Bikinia* and *Aphanocalyx* that also attracted sunbirds.

All three genera of which flower visitors have been observed (*Aphanocalyx*, *Bikinia* and *Tetraberlinia*) are visited by honey-bees (*Apis mellifera*) and small bees ("moucherons"), comprising both stingless bees (Apinae, Meliponini: e.g. *Trigona* spp.) and some Allodapini (Xylocopinae: e.g. *Braunsapis* spp.). These bees may occur in very large numbers, sometimes the humming of honey-bees in the canopy of the flowering tree is even audible on the forest floor. Carpenter bees (Xylocopinae: Xylocopini) were only observed on *Bikinia durandii*. This record might be coincidental, but as *B. durandii* does have the largest flowers of the genus, it renders them more suitable for such larger bees.

The special arrangement of the anthers in most species of *Bikinia* (see morphology, fig. 4.5) may be an adaptation to accommodate small bee species (like Meliponini). The two subadaxial anthers end up in the middle of the flower, placing all anthers and the stigma in a plane rather than a circle. Several small bees were observed to move over this plane of anthers, using the central anthers and the stigma as stepping stones in order to reach the other anthers of the outer ring (see photo 3.1). Since they only visited the anthers, they were apparently only collecting pollen.

Photo 3.1: Flowers of *Bikinia le-testui* ssp. *le-testui* visited by a small bee passing over the anthers and stigmas.

Honey-bees on the contrary visited both the anthers and the lower parts of the flowers. Since I did observe a liquid substance at the bottom of the hypanthium of *Bikinia* flowers, it is likely that the honey-bees were also collecting nectar.

As all these bees are collecting pollen, it is presumed that they operate as pollinators.

Also Lepidoptera (butterflies & moths) have been observed on all three genera. Since their numbers (at least during day-time) were low, they are not supposed to contribute substantially to the pollination of these trees. However, since Lepidoptera tend to move around more than bees, they might attribute to some extent to cross-pollination. The butterflies that were observed, were collecting nectar.

In *Bikinia* hoverflies (Syrphidae: Melanostomatini) have been observed to visit flowers. They probably do so to collect pollen, because they are unable to reach the nectar. Their numbers were large enough to have a considerable effect on pollination.

On *A. microphyllus* the pollen-eating leaf beetle *Barombiella marginata* has been observed (in coll. Wieringa). Since a few flowers will suffice for its food intake it is rather unlikely that this species will bring about cross-pollination. Its function as pollinator also will be marginal.

On two tree species a species of weevil (Curculionidae) has been collected while visiting the flowers. Most probably these beetles were visiting the ovaries to deposit eggs, but they may occasionally pollinate some flowers in the process.

Bikinia species with 'umbelliform' inflorescences attract yet another group of pollinators: longhorn beetles (Cerambycidae). Several species were observed (and some collected) on *B. pellegrinii*. Probably the other species of this genus with rather lax racemes that are arranged close enough to form a compound plane (*B. breynei*, *B. evrardii*, *B. le-testui*, *B. media* and maybe *B. grisea* and *B. congensis*, see photo 3.1, plate 2b & 4a) will most probably attract this group of pollen-eating beetles as well.

In order to attract sunbirds (and carpenter bees?) instead of small insects, trees have to invest more energy in large or numerous flowers with copious nectar. However, sunbirds will more easily cause cross-pollination because they tend to swap between trees more readily than most small bee species. Yumoto (1992) postulated that canopy trees with flowers exposed to direct sunlight should have the smallest flowers with the least amount of nectar [compared to lianas and sub-canopy plants]. This hypothesis seems to be falsified by several examples: e.g. *Aphanocalyx heitzii* and *Bikinia durandii* have fairly large flowers with copious nectar. If these examples are not sufficient to reject the hypothesis, the large-flowered canopy species of *Berlinia*, *Daniellia* and *Afzelia* certainly are.

Contrary to Yumoto (1992) and other authors he cites, canopy trees are not all pollinated exclusively by small opportunistic insects. It seems that most canopy trees indeed rely on bees, but several species also attract sunbirds, probably to have better chances for cross-pollination. This pollinating system is not yet very specialized, but it may be a start towards specialization. Also the development of a deep hypanthium (with nectar only within reach of a long tongue) as present in *Aphanocalyx heitzii*, *Bikinia durandii* and the species of *Tetraberlinia* is clearly a step towards serving a specialized group of pollinators.

In a recent study on pollination in Asian rain forest, Momose & Inoue (1997) found that most of the groups of pollinators they distinguish, also act as pollinators in canopy and emergent trees. Only vertebrates (birds and mammals) and solitary bees are almost absent. Their finds correspond fairly well with the pollinators found by me, except that in some of my trees also birds seem to play a role.

In all three tree species observed by Yumoto (1992) no nectar was recorded. This may account for the absence of butterflies and sunbirds. However, for sunbirds Yumoto's observation method seems inappropriate. Both a canopy raft and sled will scare away sunbirds. By using a free rope climbing technique, one stays hidden between the branches and can also observe birds from short distances.

The observations presented here are still incomplete. Since trees were only climbed during daytime, dawn, dusk or night-time pollinators if any, will have been missed. The subcanopy tree *Neochevalierodendron stephanii* is known to be visited by hawkmoths (Sphingidae) and sunbirds (*Nectarinia*) during the night and around dawn (Haegens, 1994). Also Noctuidae are good candidates for such visits, and may eventually prove to be important cross-pollinators.

Schrire (1989) lists many different aspects of pollination biology. He calls for a study of as many of these aspects as possible. Although my records are only occasional, it is worthwhile to note a few of Schrire's aspects that have not been discussed earlier.

- Synchrony of flowering within a species: Most species are gregarious. The mature trees in a gregarious cluster seem to have synchronized flowering. Other clusters in the same region often flower during approximately the same period as well. Contrary to this, one population of *Tetraberlinia longiracemosa* in the Rabi area flowered about a month later than two other populations in its vicinity.
- Synchrony of flowering within a single tree: Usually all inflorescences of a tree start flowering at about the same time. A tree rarely produces few inflorescences on a single

branch while it produces flushes at all its other branches.

- Patterns of flowering: Since in most species the flowers of a raceme flower one or a few at a time, flowering can last for several weeks. Only in a few species of *Aphanocalyx* almost all flowers of an inflorescence reach anthesis all at once (see pag. VIII) and thus flowering may last only a few days. In this period the trees become very conspicuous.
- Variation in flowering between years: Since no long-time observations are available little is known concerning this subject. Of at least two species (*Bikinia pellegrinii* and *Tetraberlinia longiracemosa*) records show that an individual tree flowered in two successive years. On the other hand mature trees have been observed to remain barren among others fully flowering or bearing fruits.
- Flower patch structure: All trees produce flowers on the outside of the canopy, so all flowers are fully exposed to sunlight and form a huge umbrella. The more detailed structure of these patches is already discussed above ('strobiliform' versus 'umbelliform' versus 'open' flower arrangements).
- Odour: Several species are recorded to have a sweet odour. Only of *Aphanocalyx jenseniae* an explicit record that it lacks odour is available.
- Colour: two groups developed yellow petals, while the other species all have pure whitish petals. The yellow colour is associated with a relative deep hypanthium, so both characters may be part of the same functional complex. It is at present unknown whether there exists a pollinator that is particularly attracted by this combination of characters.
- Other special features to enhance attractiveness: Most species have both bisexual and functionally male flowers. If we consider those male flowers as additional flowers, they increase the overall attractiveness of the inflorescence and the amount of pollen available.
- Nectar robbers: Although most species have a hypanthium, no traces of nectar robbing have been observed. The extra thick hypanthium wall (fused with the bracteoles) of this group is apparently very effective in preventing burglary.

3.5 Phenology

Most species of *Aphanocalyx*, *Bikinia*, *Icuria*, *Michelsonia* and *Tetraberlinia* have a definite flowering period. For the species with a fairly wide area of distribution it proved difficult to establish this period. Due to climatic differences over such wide areas, flowering dates cannot easily be compared. The available flowering data are discussed per region for such species but it has not been statistically tested. Only for species with a more limited area of distribution can flowering dates be compared within the species. However, such species are usually poorly collected, resulting in too few data to obtain definite answers. Still of several more restricted species enough data are available to test whether the observed flowering period deviates statistically from a random pattern. To perform this test the data from the specimens database have been exported to Faunist 2.3 (Veen, 1998). The distribution of the number of flowering collections per period of 10 days was compared to that of the non-flowering collections. Faunist provides two tests to compare these distributions: a Chi-square test for a difference in median and the Kolgomorov-Smirnov two-sample test. When the tests were performed using all material from Africa they failed, with only the Gabon material (fig. 3.6a) both the median test and the Kolgomorov-Smirnov test gave a significant ($p < 0.05$, $n=384$, $m=101$) result. This means that the two general flowering peaks as evident from fig. 3.6a most probably really exist as such, but they are not very clear and are partly due to the more intensive collecting activities during those periods.

The only species with ample data is *Tetraberlinia bifoliolata* (fig. 3.6j). Both tests

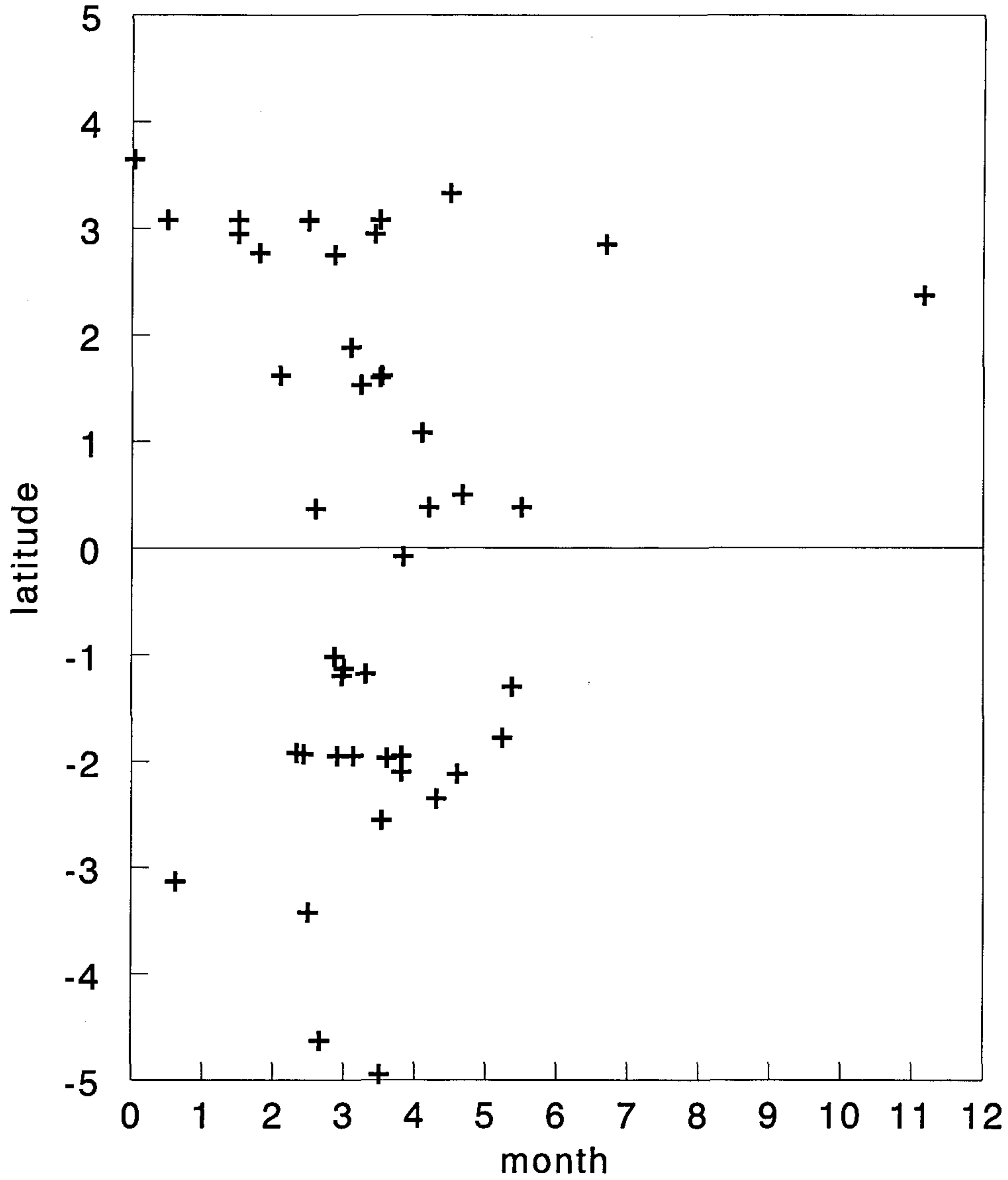
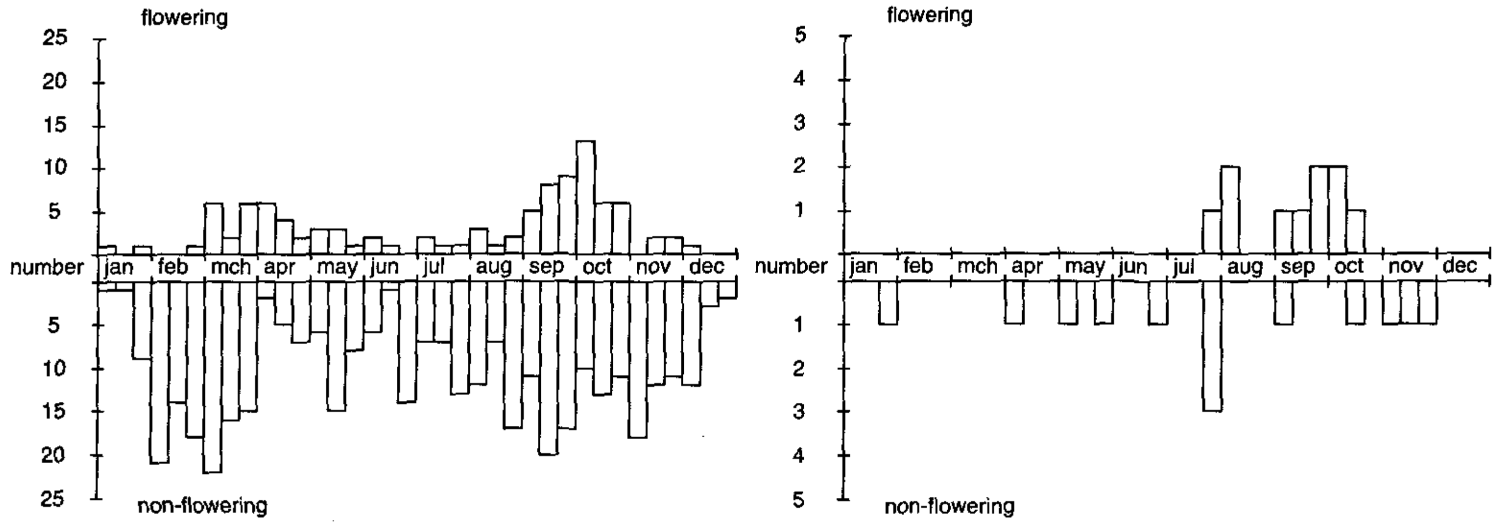


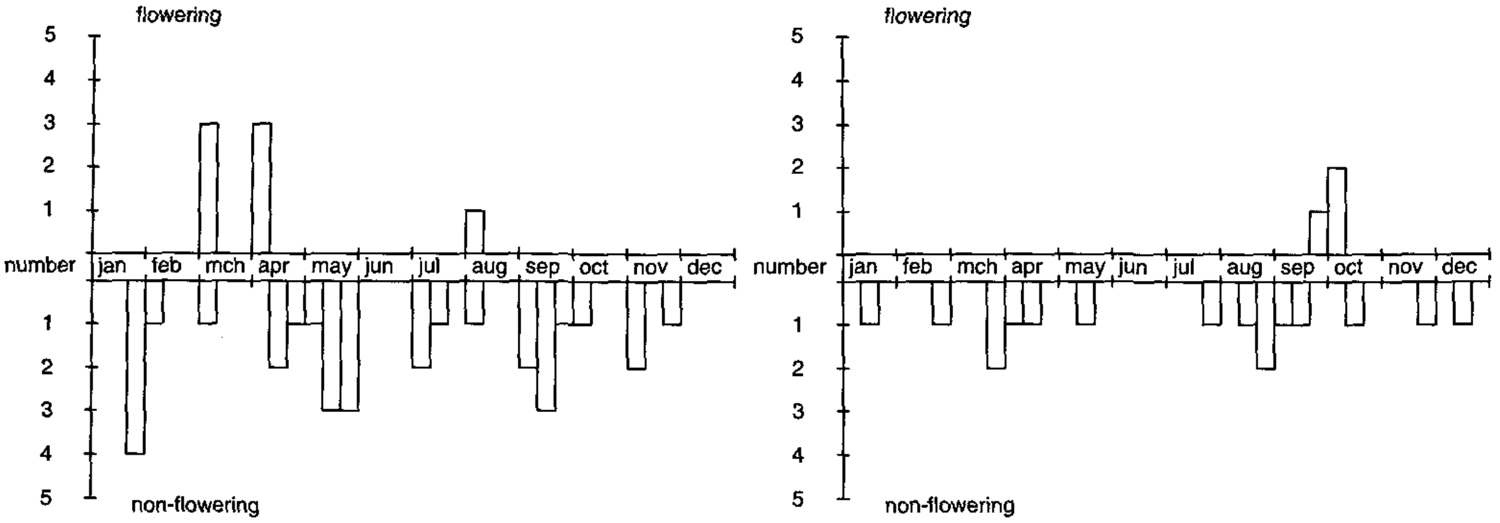
Figure 3.5: Latitude of flowering collections of *Tetraberlinia bifoliolata* growing in the wild plotted against collection date. Going from south to north flowering follows the rains that come from the south around March and April. Only around 3 ° N (Kribi area) flowering starts earlier while rains arrive later, which might be related to a climatic boundary in that area.

resulted highly significant, proving that this species possesses a distinct flowering period. Because this flowering period seems to be related to the lesser rainy season and the start of this season varies with latitude, the flowering collections have been plotted against the latitude (fig. 3.5). Some correlation seems present: south of the equator, the species starts flowering at the start of this rainy season, more to the north the species start flowering sooner, even when the rains arrive later. This phenomenon may be related to the climatic boundary around 3 ° N as described by Maley & Elenga (1993). In the most northern part of the distribution area of this species (around and north of Mt Cameroon) no clear dry season is present. From this area no flowering samples are available at present. Since it may demonstrate what triggers flowering in *Tetraberlinia bifoliolata*, it will be interesting



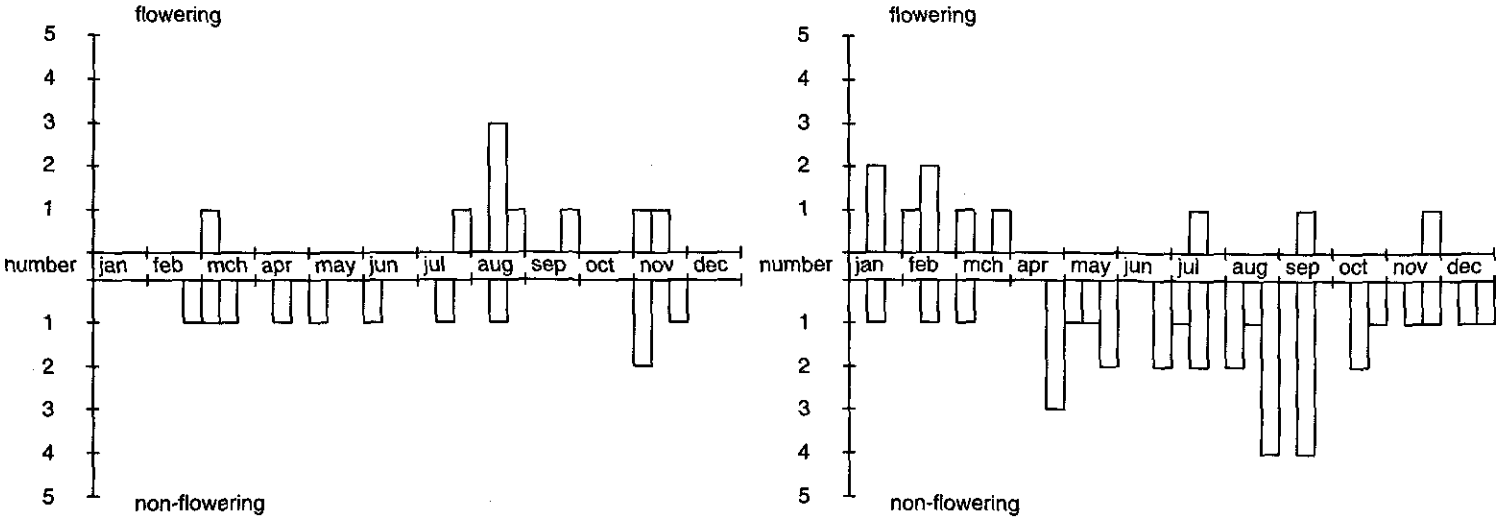
a: all material from Gabon

b: *Aphanocalyx djumaensis*



c: *Aphanocalyx heitzii*

d: *Aphanocalyx margininervatus*



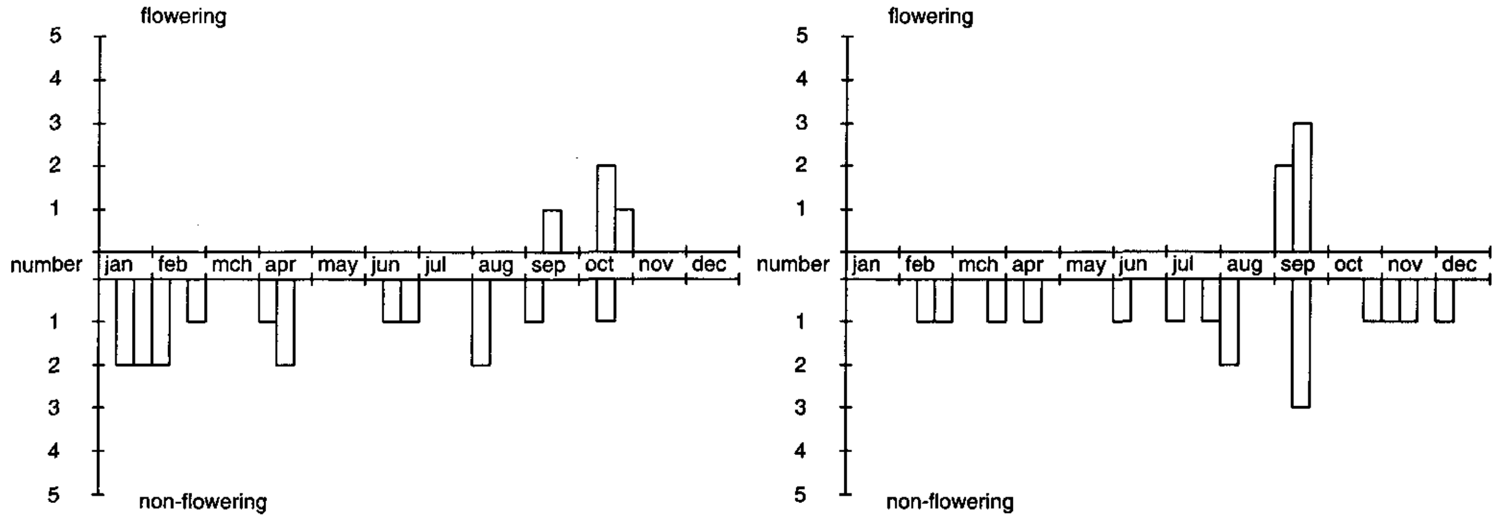
e: *Aphanocalyx pteridophyllus*

f: *Aphanocalyx richardsiae*

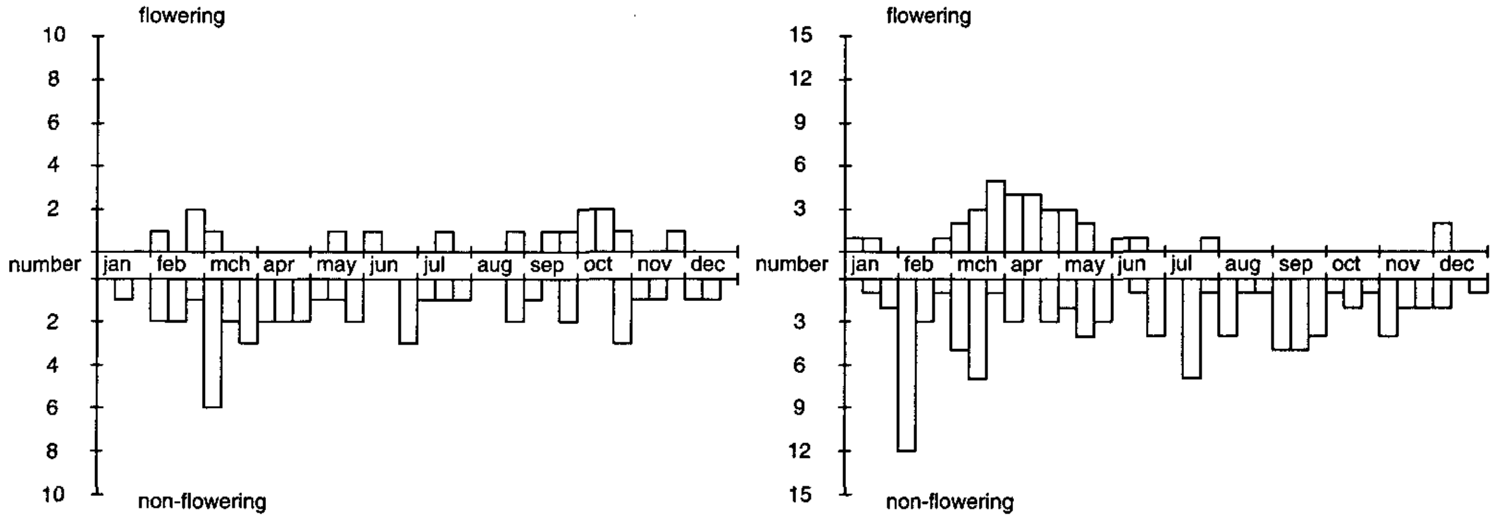
Figure 3.6: Numbers of collections per period of 10 days. Above flowering collections, below without flowers.

to know whether the flowering period becomes diffuse towards these latitudes or that it continues to be in the first months of the year.

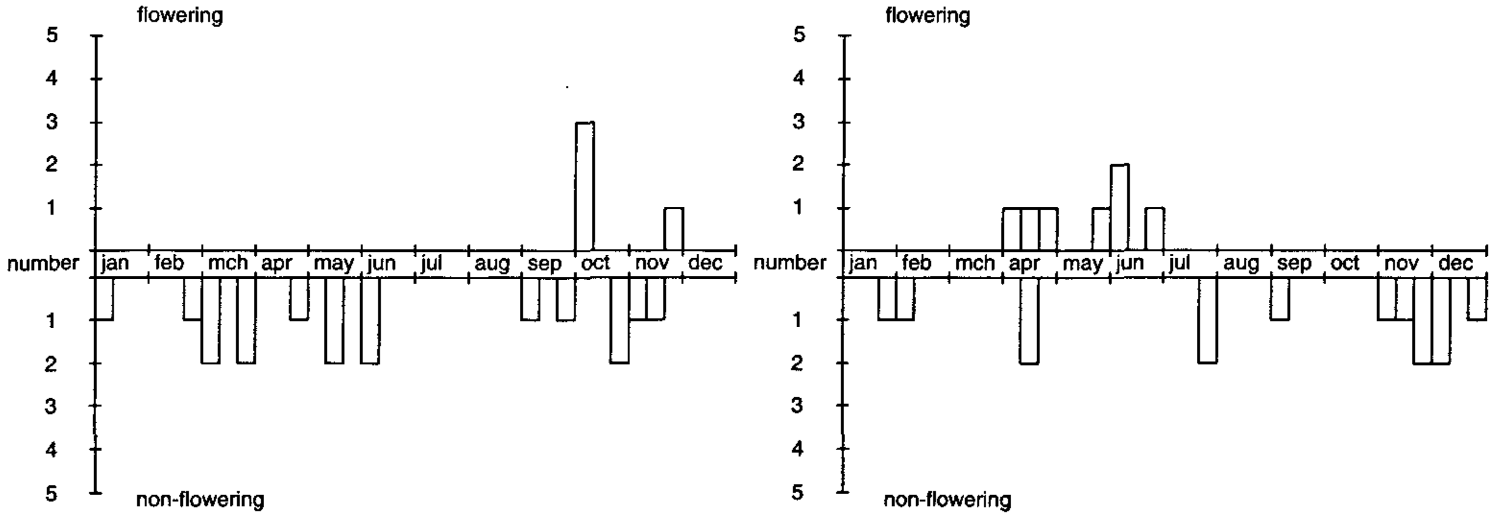
For other species much fewer data are available. However, if the flowering period of such species is sufficiently distinct, it may still prove to be tested as significant with the Kolgomorov-Smirnov test (p values calculated using Laan, 1983: table 16; after each p the number of flowering respectively non flowering collections is given). With so few data one should only be aware that 'not significant' does not always means that there is no distinct flowering period. As will be clear from the results, most species do prove to have a significant flowering period. The species with only 1 or 2 flowering collections as well as those with a wide distribution area are disregarded.



g: *Bikinia congensis* **h**: *Bikinia durandii*



i: *Bikinia pellegrinii* **j**: *Tetraberlinia bifoliolata*



k: *Tetraberlinia longiracemosa* **l**: *Tetraberlinia tubmaniana*

Figure 3.6: (continued).

Aphanocalyx djumaensis (fig. 3.6b): $p < 0.1$ (10, 13), pooled per month: $p < 0.05$ (10, 17).
Aphanocalyx heitzii (fig. 3.6c): $p < 0.025$ (7, 30)
Aphanocalyx margininervatus (fig. 3.6d): $p < 0.05$ (3, 16)
Aphanocalyx pteridophyllus (fig. 3.6e): $p < 0.1$ (9, 11)
Aphanocalyx richardsiae (fig. 3.6f): $p < 0.01$ (10, 33)
Bikinia congensis (fig. 3.6g): $p < 0.005$ (4, 16)
Bikinia breynei: $p < 0.1$ (4, 7)
Bikinia durandii (fig. 3.6h): not significant (5, 16), pooled per month: $p < 0.1$ (5, 18)
Bikinia le-testui: not significant (7, 66)
Bikinia pellegrinii (fig. 3.6i): not significant (16, 45)

Tetraberlinia bifoliolata (fig. 3.6j): $p < 0.001$ (34, 95)
Tetraberlinia longiracemosa (fig. 3.6k): $p < 0.05$ (4, 17)
Tetraberlinia moreliana: not significant (4, 24)
Tetraberlinia polyphylla: $p < 0.1$ (3, 9)
Tetraberlinia tubmaniana (fig. 3.6l): $p < 0.025$ (7, 14)

3.6 Growth rates

Actual growth rates of the species studied are not known. However, some circumstantial evidence on this issue is available.

Aphanocalyx heitzii: The trunk of *Wieringa & Haegens 2439* with a DBH of 96 cm, showed 87 growth-rings in cross-section. If each ring represents one year (conservative estimate as alternative for 2 rings per year), the mean annual diameter increment amount to a little more than 1 cm.

Bikinia le-testui: a small wood sample from the exterior part of a tree with a DBH of 180 cm (*Breteler, Jongkind & Wieringa 11192*) shows 38 mm over 6 growth rings. If each ring represents one year this indicates a 13 mm annual diameter increment.

Bikinia coriacea: A tree sampled in 1994 in the Sibang arboretum (Libreville) showed a DBH of 105 cm. The trees in this part of the arboretum were planted in 1947. The DBH of the trees at the time of planting cannot have exceeded a few cm, rendering the annual increment more than 2 cm.

Tetraberlinia moreliana: The trees in 1-ha plot 1 seem to grow fairly rapidly. Remeasuring of some trees in early 1994 showed an increment of nearly 2 cm (so 1 cm per year). However, measuring errors will be comparatively large over such a small period and we cannot rely on these values. Future research in plot 1 will provide more definite increment figures for this species.

The indications presented above lead to an annual increment of 1 to over 2 cm per year. More than 2 cm / year is rather much when compared to other large African forest trees, e.g. *Entandrophragma cylindricum* has a maximal annual increment of 1.7 cm (Redhead & Taylor, 1970).

3.7 Implications of the ecology for forestry

Several of the ecological characteristics of this group of legumes make it very interesting for forestry, especially for plantation purposes. Many tree species become vulnerable to diseases when they are planted too close together. Since these trees tend to grow in clusters, they already have a defence mechanism built in for such gregarious conditions. Another interesting property of these trees is that they are adapted to grow on poor soils. Their growth rate seems to be quite high, while most species produce perfectly cylindrical, tall boles. The wood is not very well appreciated yet, but this could be a result of the identification problems with this group. Several investigations of the wood properties and its applications (Anonymous, 1953; Gottwald, et al., 1968; Mathews, et al., 1993; Normand, 1952; Sachtler, 1968; Wagenführ, 1980) concluded that the wood of several species is very well suited for most purposes.

Most species of *Bikinia*, *Tetraberlinia* and *Aphanocalyx* subg. *Antherodontus* should be considered seriously for application in timber plantations in western and central Africa. Particularly *Aphanocalyx hedinii*, *A. heitzii*, *Tetraberlinia moreliana*, *T. tubmaniana*, *Bikinia aciculifera*, *B. coriacea*, *B. durandii*, *B. le-testui* and *B. pellegrinii* are of interest because of their more voluminous boles. At first propagation may prove difficult, but that problem should be easy to solve with some research on the ectomycorrhizal relationships of this group.

3.8 Biogeography

The distribution of several species does not fit the glacial forest refuges as proposed by Sosef (1994) from a study of terrestrial species of *Begonia*. An example of such a distribution concerns *Bikinia congensis*. The restricted range of this species might point to the existence of a riverine glacial forest refuge around Brazzaville and Kinshasa, maybe extending along some tributaries like the Kwango. This forest may even have been constituted (partly) by a monospecific stand of this species. Also the very restricted area of distribution of *B. breynei* in Congo (Kinshasa) points to such a refuge. The existence of such refuge areas has already been proposed by Colyn et al. (1991). The absence of such refuge areas in the *Begonia*-based study of Sosef might be due to the fact that a riverine forest is not very suitable for most *Begonia* species. Only few species, adapted to frequently disturbed environments, might be able to survive in such a habitat. In fact, some species of *Begonia* do occur in the Congo basin. Of the species included in the study of Sosef only *Begonia mildbraedii* Gilg has such a wide distribution. Its ecological requirements are not known to me, but of the adjacent section *Filicibegonia*, which follows the same distribution pattern as Sosef's sections, the only species living outside the refuge areas, *B. macrocarpa* Warb., is a species mainly occurring in disturbed habitats. Probably a number of riverine forest refuges have existed during the ice ages, but they might have been suitable for only a part of the earlier existing flora and fauna. Some species, like most of the vulnerable terrestrial *Begonia* species and some *Bikinia* and *Tetraberlinia* species that cannot withstand inundation, have not been able to survive in those small, often disturbed forest remnants, and have completely disappeared from the area. Less demanding species (e.g. several species of *Aphanocalyx*) might have coped, and probably never have left the Congo basin during the glacials at all. It is interesting to observe that especially those species that can live along rivers do occur in central Congo (Kinshasa), while those that cannot survive inundation are restricted to the coastal zone of central Africa (Cameroon, Gabon, coastal part of both Congo's).

In a later paper Sosef (1996) indeed accepts the possibility of the existence of these riverine forest refuges. Also Robbrecht (1996) mentions these riverine refuges and appreciates their distinct ecology.

Based on Rubiaceae data, Robbrecht (1996) extends both the number of forest refuge areas in tropical Africa as well as the actual size of some of these areas. One of his suggestions is that the Mayombe area of Sosef (1994: 118) would extend further to the east up to around Brazzaville and Kinshasa. I suggest that a separate refuge area might have been present in that region, most probably a riverine one. Such can be derived from the quite different species that indicate this part of the refuge. In the present study *Bikinia congensis* and *B. breynei* are indicators for this 'Kinshasa' refugium.

Some other 'new' refuges suggested by Robbrecht (1996) do correspond very well to the distribution areas of some Caesalpinioideae species. *Aphanocalyx libellula* for example was collected about 100 km S of the centre of his 'Golungo Alto' refuge in Angola. The distribution of *Bikinia evrardii* and *Aphanocalyx obscurus* in Congo (Kinshasa) matches his area C1 (Mai Ndombe Lake), whereas the second species together with *A. jenseniae* also (partly) support C4 (southern edge of Congo Basin). *B. evrardii* also occurs in Congo (Brazzaville); one of its sites is in the 'Kinshasa' area, the other (Odzala N.P.) would indicate yet another riverine refuge. Since rivers are present in most areas, (very) small riverine refuges can be expected to have been present in many areas in tropical Africa, resulting in a more or less closed distribution pattern of species that favour the riverine ecology of these former refuges.

The distribution pattern of *Aphanocalyx djumaensis* (map 10.3) suggests that this species spreads through transport by rivers. Especially the fact that the species occurs along the Ivindo and the Ogooué river below the confluence with the Ivindo but not above this confluence, points to a relatively recent introduction in the upper area of the Ivindo or one of its confluences. Harris (1993: 189, 196 & pers. comm.) discusses the case of *Irvingia smithii*, of which the distribution also follows river systems. Its fruits are eaten and subsequently transported to other river systems by elephant in savanna regions only. Hence this species was not able to reach the Ogooué river system, since non of its tributaries approach other systems in a savanna area. Apparently *Aphanocalyx djumaensis* was able to make this step, either by slow dispersal by its exploding pods or by a long distance dispersal of some kind. If it reached the Ogooué system by slow dispersal, the species is expected to be found along the Dja or another river of the Sangha system as well.

3.9 Extinction and threats

The majority of the species studied are definitely not extinct and are not likely to go extinct in the near future. This is mostly due to the fact that they grow in the best preserved parts of the African rain forest: Gabon and Liberia. However, for a few species the prospects are not so good, perhaps they are extinct already.

For many large mammals actual population sizes are known, so extinction can be recorded directly. For plant species it is hard to tell whether they are extinct or not. When evaluating extinction in New Caledonian plants, Bouchet et al. (1995) use as an initial criterion "not recorded for 100 years", but they assume that several plants meeting this criterion still exist, while some others that have been recorded far more recently, are already presumed extinct. Clearly every case will have to be evaluated separately.

Of my group only two species were known 100 years ago, so applying that criterion will not be very useful. When we consider their records, we have to conclude that two species are possibly extinct: *Aphanocalyx hedinii* and *Tetraberlinia baregarum*. *A. hedinii* is known from three areas in Cameroon. Two of these areas are deforestated and entirely used for crop plantations. The third area (between Bipindi and Kribi) is still mostly covered with (logged-out) forest. The species could not be traced in that area by me, but it is fairly possible that it still is growing in that area, or that it occurs in a yet undiscovered population elsewhere.

The situation of *T. baregarum* is worse. This species was collected only once in eastern Congo (Kinshasa). Apparently it was rare in *Michelsonia microphylla* populations, with which species it was confused, and as a result, simultaneously logged. *Michelsonia microphylla* was heavily exploited to provide wood for the mining industry and could not be traced recently (pers. comm. C.E.N. Ewango). Since *Michelsonia microphylla* occurred in a relatively large area, it is likely it is still growing in some less accessible areas of its range; this species should be considered severely threatened. Whether also *T. baregarum* will occur in those remote areas is far less sure.

Beside the two possibly extinct species, another 4 species classify as critically endangered when applying the IUCN criteria (Oldfield et al., 1998): *Aphanocalyx libellula*, *A. jenseniae*, *Bikinia breynei* and *Michelsonia microphylla*. At least two species classify as endangered: *Icuria dunensis* and *Tetraberlinia korupensis*.

4 Morphology

4.1 Introduction

A macro-morphological study has been undertaken of material so far classified as *Aphanocalyx*, *Michelsonia*, *Monopetalanthus* and *Tetraberlinia*. To a lesser extent most of the species of *Julbernardia* (including *Paraberlinia*) have been studied as well. This was done to delimit better the species already recognised, to look for new species and to find better characters to delimit the genera. Although morphology is the traditional taxonomic basis for studying taxa, many characters have never been studied in a systematic way and some had never been taken into account at all. This chapter will deal with the characters studied, their definition and measurement.

4.2 Material and methods

The material used for this study is based on the material of 49 herbaria. The following official herbaria (acronyms according to Index Herbariorum 1990) have been visited: AMS, B, BM, BR, BRLU, K, L, LBV, LG, P, SCA, U, W, WAG and WU. Parts of their collections have been received on loan. Also BOG and MT were visited, but possessed no relevant material. Some other institutes have been asked to send all their material on loan. A, C, E, EA, F, FHI, FHO, G, GH, GRA, HBG, IEC, LD, LE, LISC, LISJC, M, MA, MO, NY, PRE, S, SRGH, US, WRSL, YA and Z kindly made their material available. AAU, FI, IAGB, IFE, LY, OXF and UPS did not possess any material of this group, while from COI, LISU, LUA, LUAI and POZG no reply was received. UCJ replied they did possess material from *Monopetalanthus compactus* but this material has never been received. Material collected for the newly founded reference herbarium of the 'Faculté des Sciences Agronomiques, u.e.r. Sylviculture', Gembloux, Belgium is referred to as GEMBL since it is not the same institute as LFG. The reference herbarium of the 'Station d'Etudes des Gorilles et Chimpanzés' in the Lopé Reserve in Gabon is referred to as SEGC. For the reference and voucher-for-woodsample herbarium of CIRAD-forêt, Montpellier, France, the acronym CIRAF is used. Besides these official herbaria the private collection of C. Wilks, B.P. 13261, Libreville, Gabon has been visited and was partly sent on loan to WAG. For his collection the acronym WILKS will be used.

Recently, duplicates from WAG collections have been sent to G, IAGB, LY, UGDA and W, which material has also been included in the citations.

Some information from the herbarium material has been entered in a database: country, locality, date, altitude, tree height, diameter, herbaria and the condition (flower, fruit) of the material. The database has been used to make distribution maps and to check the phenology of the species.

Besides the herbarium specimens, much live material has been studied (and collected) in the field during three field trips to Gabon and Cameroon in 1992 and 1994. These field studies enabled me to study rarely recorded characters such as trunk shape, the presence, shape and size of buttresses and bark texture and colour. By applying a free-rope climbing technique (Wieringa, 1996) it became possible to collect better specimens of some of the poorly known species. For several species the first flower collections ever could be made in this way. Of the 33 species treated here, 20 have been collected by me, of which 14 were in flower. Collecting flowers allows the study of the colours of the floral parts and the observation of pollinators. Since the floral parts of this group are usually misinterpreted (one is inclined to call the bracteoles a calyx), label information is often unreliable.

In a few cases reference is made to zoological specimens (pollinators, pests, etc.). Those specimens are preserved in one of the following collections: the collection of the University of Amsterdam (referred to as ZMA = "Zoologisch Museum Amsterdam"), in collection Adlbauer (LMJ = "Steiermärkisches Landesmuseum Joanneum", Graz, Austria) or in my own private collection (Wieringa).

Most of the measurements taken from herbarium and spirit material were made using an electronic measure (Mitutoyo 500-311). All floral parts were measured this way using boiled or spirit material in combination with a binocular microscope.

The epidermis of the leaflets has been examined using the method of Jongkind (1989), except that usually samples were taken from both lower and upper surface. Of some species leaves fixed in FAA and preserved in 70% alcohol have been used instead of herbarium specimens. A list of samples of which epidermal photographs are available at WAG is given below. Other samples have been used as well, but they have not been used for the descriptions. FAA fixed specimens are marked (FAA).

Aphanocalyx cynometroides: Donis 3615.
Aphanocalyx djumaensis: Breteler & de Wilde 630 (FAA).
Aphanocalyx heitzii: Heitz 16.
Aphanocalyx margininervatus: Le Testu 7483, Wieringa & v.d Poll 1471.
Aphanocalyx microphyllus subsp. *microphyllus*: Wieringa & v.d. Poll 1345 (FAA).
Aphanocalyx obscurus: Wieringa & v.d. Poll 1544 (FAA).
Aphanocalyx pteridophyllus: Baldwin 11099.
Aphanocalyx richardsiae: Desenfans s.n. 1, Glover in Bredo 6124.
Bikinia le-testui subsp. *le-testui*: Mpom 5.
Bikinia pellegrinii: Wieringa & Epoma 1606 (FAA).
Julbernardia brieyi: Wagemans 376.
Michelsonia microphylla: Léonard 1710, Michelson 882.
Tetraberlinia bifoliolata: Le Testu 9304.
Tetraberlinia moreliana: Wieringa & Epoma 1608 (FAA).

4.3 Characters

4.3.1 Indumentum

Indumentum terminology has been based primarily on Hewson (1988). In accordance with Hewson 'long' is ≥ 0.5 mm, 'short' is < 0.5 mm. The term 'very long' has been used for hairs ≥ 1.0 mm, 'very short' for hairs < 0.1 mm. The indumentum terminology has been used as follows:

Chaffy = (very) short, flattened and usually matted hairs.
Puberulous = a somewhat dense cover of very short (<0.1 mm) hairs.
Pubescent = a somewhat dense cover of not straight but neither matted, short (<0.5 mm) and usually rather soft hairs.
Silky = densely covered with fine, soft, straight, appressed hairs, with a lustrous sheen and satin-like to the touch.

Tomentose = densely covered with matted, short (<0.5 mm) hairs.
Velvety = very densely covered with straight, fairly stiff, short hairs.
Villous = covered with long (≥0.5 mm) straight hairs, in general less stiff than velvety hairs.

The definition of villous is not strictly in accord with Hewson's terminology, but no better term seems to be available to describe this kind of frequently encountered hair. Also that of chaffy is not in line. The drawing of chaffy in Hewson (1988: 21 fig. 1A) covers the hairs encountered here quite well, only in the case shown by Hewson the hairs are probably much larger and may have a different origin. The main characteristic of my definition of chaffy hairs is that they are flattened. In this group chaffy hairs are frequently encountered and usually have some kind of sealing function. The margins of the valvate bracts are crowded with chaffy hairs which keep the bracts tightly closed until anthesis. These hairs have the same function on the margins of the valvate stipules of *Bikinia*.

If the length of the hairs differs from those stated above, it will be mentioned explicitly in the text. Also a less dense cover than defined above will be qualified by an explicit statement.

The term velvety will be used very often in combination with length and density statements. Such indumentum might not be velvety in the strict sense, but may consists of the same hairs, less dense and/or longer than the 'real' type. Only villous indumentum might be hard to differentiate from velvety when the hairs are very long. Because of their length such hairs will lose their stiffness, which is the major difference between the two. In a few cases involving very long hairs, the indumentum will be called 'very long villous', even when the hair type might not be essentially different from the shorter, velvety type.

Photo 4.1: Lower leaflet surface of *Aphanocalyx cynometroides* showing red (here dark) glands. Bar = 24 μm.

A special type of (glandular?) cells has been encountered on sun-exposed leaflets of *A. cynometroides*. In dry condition these cells are visible with a binocular microscope as tiny red dots. They are also visible in the microscopic preparations (see photo 4.1) in a density of c. 40 glands / mm^2. These cells are probably present in a few related species as well, but in far lower densities.

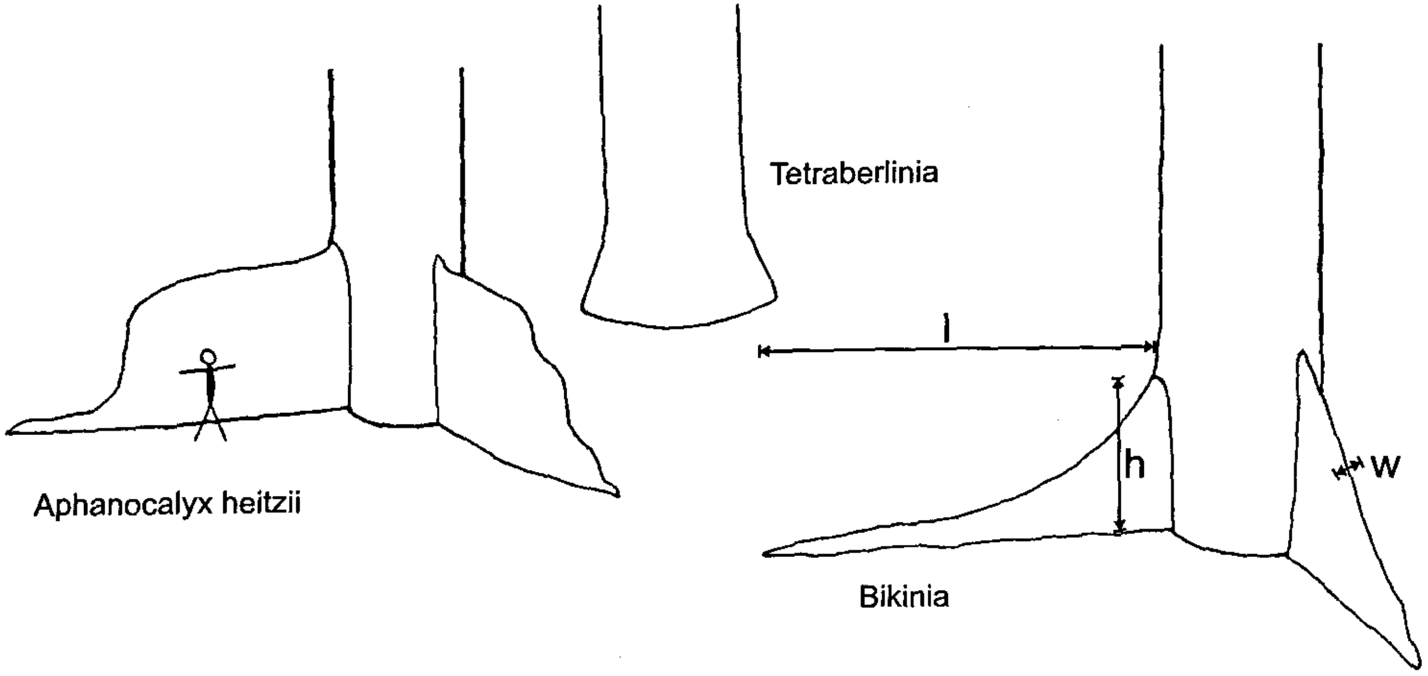


Figure 4.1. Trunk bases: *A. heitzii* showing the largest developed buttresses of that genus. A trunk of a *Tetraberlinia*, characteristic for most of the species of that genus. Finally a *Bikinia* trunk showing the relatively broad buttresses or feet of that genus. h = height, l = length, w = width.

4.3.2 Trunk

In accordance to custom in forestry the diameter of the trunk is measured as the "**D**iameter at **B**reast **H**eight" (DBH), where breast height is 1.3 m. When the buttresses are higher than 1.3 m, the diameter is measured directly above the buttresses. When very little information about height and/or DBH is available, these values are usually presented as "at least ...". When a range of fertile specimens is present, the range of height and DBH of these specimens (if available) is given. The lower measure of these ranges thus present the smallest known flowering or fruiting tree. This is an interesting characteristic because some species (e.g. *Tetraberlinia*) start flowering at a relatively young stage when conditions are favourable (enough light, i.e. in a gap or at a forest edge), while others (e.g. most *Bikinia* species) always wait until they have reached the canopy. Species that sometimes flower at a younger stage may have a far shorter generation cycle than species which flower only when large. As such the former may spread much faster and be the more effective recolonizers of old sites cropped by slash and burn.

Although all species have a single, 'normal' trunk, there is considerable variation present in more detailed features of the trunk. Since most of these details are only exceptionally noted on collection labels, it has been hard to obtain such data for species that were not observed in the field by myself. However, the collection labels made by foresters and people interested in identifying trees on trunk characters (mainly Voorhoeve and Wilks), do mention some of these features and their samples sometimes include pieces of bark. As a result trunk and bark features are available for most of the species, and some generalized characteristics can be drawn.

Buttresses (fig. 4.1). The height of a buttress is the height it reaches at the trunk, the length is the distance it reaches away from the trunk at ground level and its width is the tangential width (this last measure is only used relative to other buttresses). Most species of *Tetraberlinia* (and probably *Michelsonia*) do not have buttresses at all, but their trunk is often swollen at the base in a regular way. Sometimes small feet are present. The species of *Bikinia* do develop buttresses, although these only become clearly apparent at maturity. The more pronounced buttresses are present on trees with a DBH of at least 80 cm. These buttresses are remarkably wide. They are usually not very high (usually up to 1 m, although up to 2½ m does occur) and may reach lengths of several metres. The buttresses of the species of *Aphanocalyx* are always narrower than those of *Bikinia*. Some *Aphanocalyx* species hardly develop them, while in others buttresses of up to 1 or 2 m height occur regularly. The climax is found in *A. heitzii* (and probably also the other species of subg. *Antherodontus*) where real plank buttresses of up to 4 m high can be encountered.

Bark. The bark surface is smooth in most species of *Aphanocalyx*, rather smooth with many lenticels in *Aphanocalyx* subg. *Antherodontus*, *Michelsonia*, *Tetraberlinia* and a part of *Bikinia* or fissured or with pits and many lenticels in some other *Bikinia* species. Especially in some species of *Tetraberlinia* and *Bikinia* horizontal lines are present. In some species of *Aphanocalyx* subg. *Aphanocalyx* large pieces of bark may flake off.

The outer bark is always very thin (± 1 mm) and fairly hard (*Aphanocalyx*) to very hard (*Tetraberlinia*). In *Aphanocalyx* subg. *Aphanocalyx* a whitish to pale greyish layer is present at or just below the surface. The inner bark is always fibrous (in *Bikinia* often slightly granular to the exterior) and fairly thin (c. 0.5 cm in most *Aphanocalyx*) to thick (up to 2 cm in *Bikinia*). It shrinks considerably during drying, and becomes very hard. For this reason it was traditionally used to make boxes etc. (see e.g. Walker & Sillans, 1961).

Wood. The sapwood is creamy white to yellowish in fresh condition, but often turns pale pink when dry (especially in *Bikinia* and *Tetraberlinia*). The heartwood is fairly pale (pale brown, pinkish, etc.) in *Aphanocalyx* to rather dark, often with a reddish tone (red-brown, brown, orange-brown) in *Bikinia*, *Michelsonia* and *Tetraberlinia*.

No exudate is produced directly after slashing, but *Bikinia evrardii* fairly quickly exudes some clear yellow or greenish resin which turns white after a few minutes. Most species of *Tetraberlinia* and *Bikinia* will produce fairly large quantities of dark red resin over a period of several days.

The anatomy of the wood of many species of this group is treated by Outer & Veenendaal (1996). Regrettably it is difficult to compare or interpret their generic wood descriptions because those of *Monopetalanthus* and *Tetraberlinia* contain samples now considered to belong to *Bikinia*, while one species of *Monopetalanthus* belongs to *Tetraberlinia*, several to *Aphanocalyx* and an unvouchered (suspect) wood sample of *M. durandii* (BAC 17-2) is often responsable for extreme values in *Monopetalanthus*. On the other hand Outer and Veenendaal describe the wood of all these genera as very similar, so even if differences in wood anatomy between these genera do exist, they will be small.

4.3.3 Twigs

The twigs show few characters. As soon as radial growth starts, the same white layer present in the outer bark can be observed in branches of *Aphanocalyx* subg. *Aphanocalyx*. The indumentum can be studied in twigs before radial growth starts. In some species (e.g. *B. durandii* & *B. aciculifera*) the twigs are almost glabrous, in most species some kind of indumentum is present, while in *A. obscurus* and *A. pectinatus* a very dense tomentum can be present. Also the type of indumentum can be distinctive, like the golden-brown silky indumentum present in some species of *Bikinia*.

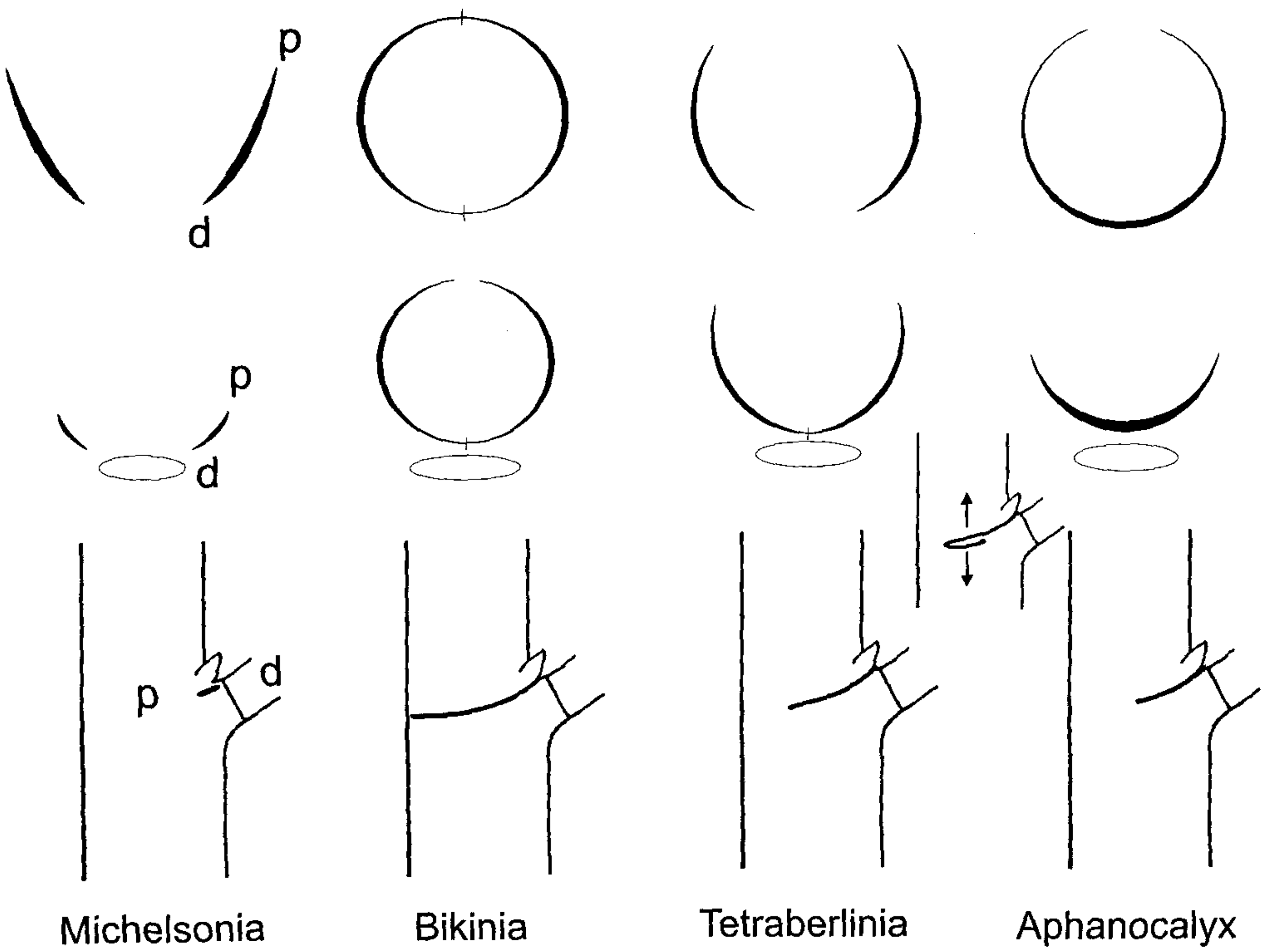


Figure 4.2. Stipules of *Michelsonia*, *Bikinia*, *Tetraberlinia* and *Aphanocalyx*. Those of *Icuria* agree with those of *Bikinia*. The lower row shows a lateral view of the stipule insertion. The situation with a folded stipule insertion pictured between *Tetraberlinia* and *Aphanocalyx* occurs in both these genera. The arrows indicate the growth direction of the stipule. The middle row schematically pictures the leaf insertion (open ellipse) and the stipules (black) at the level of insertion. The upper row pictures the stipules halfway along their length. d = distal, p = proximal.

4.3.4 Stipules

The stipules are described as if they were free, even if they are (partly) fused. Measurements are always given for a single stipule and terms as 'central line' hold for the central line of a single stipule. The stipules usually stand in line with the twig, the side adjacent to the twig is referred to as proximal, the side away from the twig and adjacent to the leaf as distal (fig. 4.2 & 4.3c).

The stipules possess several of the most pertinent characters for delimiting taxa in this group. The first important character is the position of the stipules (fig. 4.2). The stipules are always inserted next to the petiole. However, in most taxa (all genera but *Michelsonia*) their insertion extends between the petiole and the axillary bud, meeting the insertion of the other stipule of the pair. A second character concerns fusion of the stipules, and if so, how far. The stipules of *Tetraberlinia* (photo 4.2 & 4.3) are

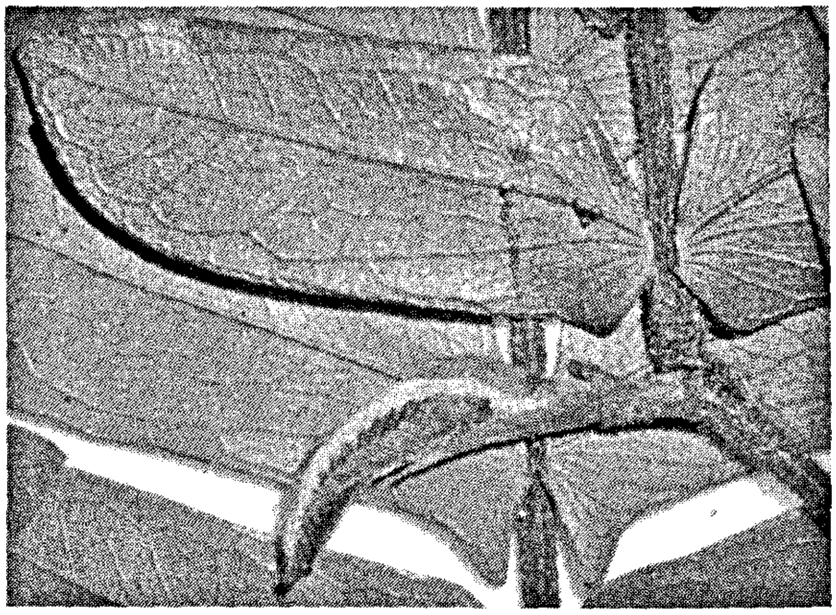


Photo 4.2: A basal leaflet and a developing twig of *Tetraberlinia polyphylla* (*Wieringa et al. 3164*). Photo J.J. Wieringa.

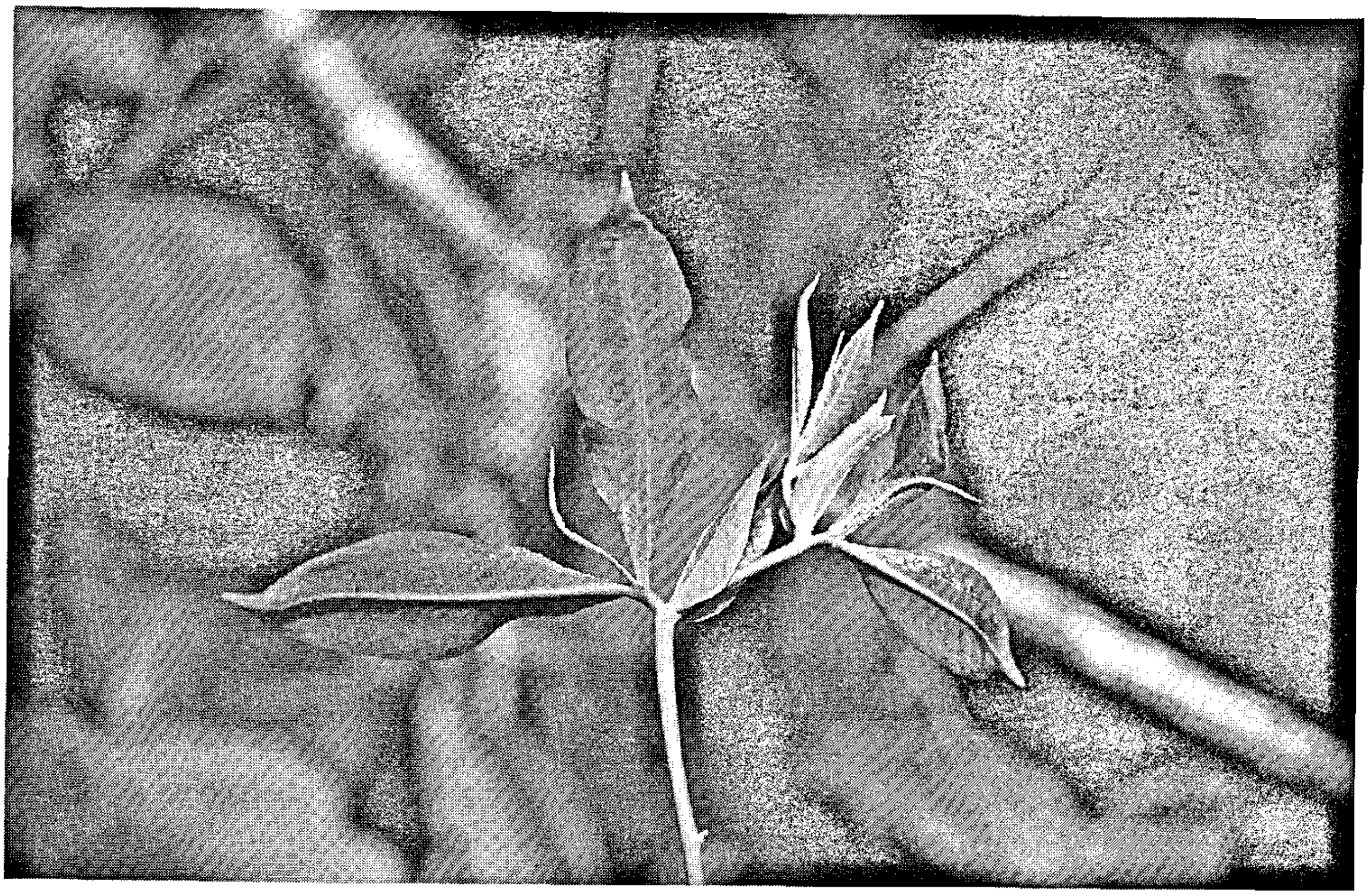


Photo 4.3: Developing twig of *Tetraberlinia bifoliolata* with stipules and young leaves showing a rudimentary leaf rachis (*Wieringa & Haegens 2527*). Photo J.J. Wieringa.

usually free and meet only at their base, only in *T. bifoliolata* they are sometimes fused for a short distance. Those of *Aphanocalyx* are fused for their entire length. The stipules of *Bikinia* are free, but the distal margins and most or all of the proximal margins are connivent and are usually connected by chaffy hairs (photo 4.4); this situation is indicated as valvate. The stipules of *Bikinia* cover the entire continuing twig, rendering them comparable to Russian dolls: opening two stipules reveals a short piece of twig, a leaf and the next two valvate stipules (see fig. 11.11:4). Those of *Tetraberlinia* cover the twig only partly and do not shield off the twig and leaves completely. In both genera leaves are produced one after another in a flush. Since flushes develop quickly, the difference in age of subsequent leaves is not much, but still evident (see fig. 11.11:2 & photo 4.3). New leaves of *Aphanocalyx* on the other hand develop all at the same time, the buds increase in size and finally start telescoping out into a flush. Since the stipules are open on the proximal side, the twig and the equally developed leaves are able to slide along and finally out of them (this is impossible in *Bikinia*) (see fig. 10.1:3 & 10.6:E).

The stipules of *Aphanocalyx* have many, closely spaced, prominent veins, rendering them rather striate. Oldeman (1964: 214) recorded this charac-

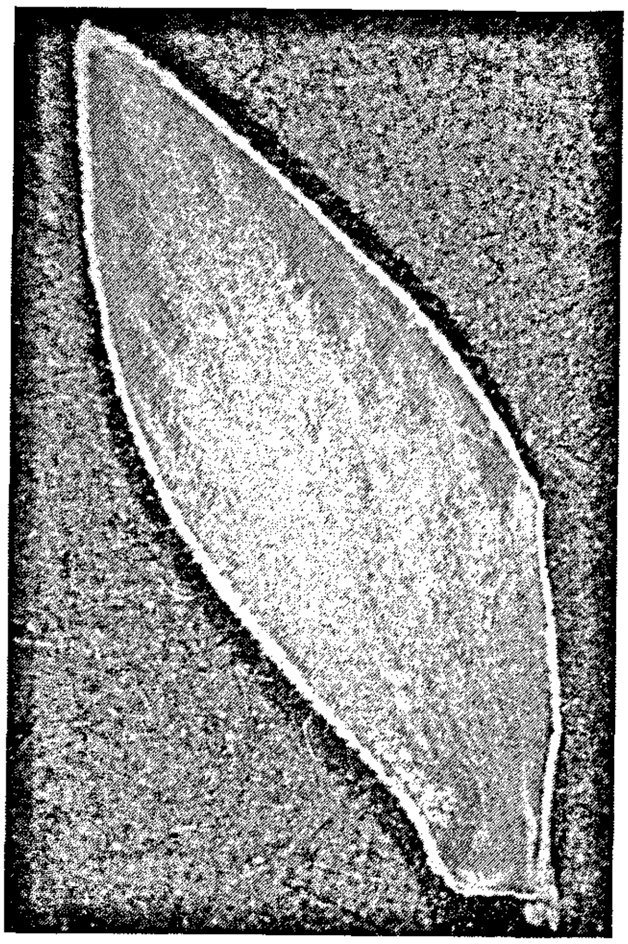


Photo 4.4: Stipule of *Bikinia breynei* adaxially (= inside) showing chaffy margins (*Breteler & Leal 14198*). Photo J.J. Wieringa.

ter, though less prominent, in *Didelotia*. In the other genera the veins are not as many, less prominent and not as dense. In both *Tetraberlinia* and *Aphanocalyx* some species have auriculate stipules. In both groups this is accomplished by the insertion line making a 180° turn, heading back to the leaf insertion (fig. 4.2). In this situation, the stipules are actually growing in two directions (arrows). A different situation occurs when the proximal margin produces a small auricle before ending in the still straight insertion line. This kind of auricle is usually very small and does not occur in all the stipules of a species or even in a single specimen. The first type of auriculation usually correlates with persistent stipules, but in two *Tetraberlinia* species the auriculate stipules are caducous in mature trees. However, in seedlings of this genus they are persistent for a longer period. The combination of auriculate and persistent stipules is most probably an adaptation to facilitate a symbiosis with ants. Indeed ants nests have been found between the stipules of these species, but no benefit for the tree has yet been proven.

Previous authors did not mention whether stipules were fused or not (e.g. Aubréville, 1968; Chevalier, 1946; Léonard, 1957; Pellegrin, 1949; Troupin, 1950), or merely mentioned whether they were 'intrapetiolar' or not (Voorhoeve, 1965: 204). Brenan (1967) tried to understand it, but he was not able to detect the distribution of this character, probably because he lacked material showing stipules and because he was supposed to treat only the species of eastern Africa. Voorhoeve (1965) does describe the stipules correctly, but since from this group only three species occur in Liberia, he failed to assess the importance of this character. The use of the term "intrapetiolar" for stipules is rather confusing. In its essence it tells us something about the position of the stipules (see also Jackson, 1928 & Gove, 1976: 1187). However, some authors (e.g. Voorhoeve, 1965: 214) apparently use it only in case the stipules are also fused! Moreover, even in intrapetiolar stipules the insertion continues laterally of the petiole. The insertion of the stipules is a continuum from strictly lateral to growing in between the petiole and the axillary bud and eventually meeting. In the last case the stipules may become partly or completely fused. I prefer to circumscribe to which extent in this continuum the stipules of a species have progressed, and desist from using the undifferentiating term intrapetiolar.

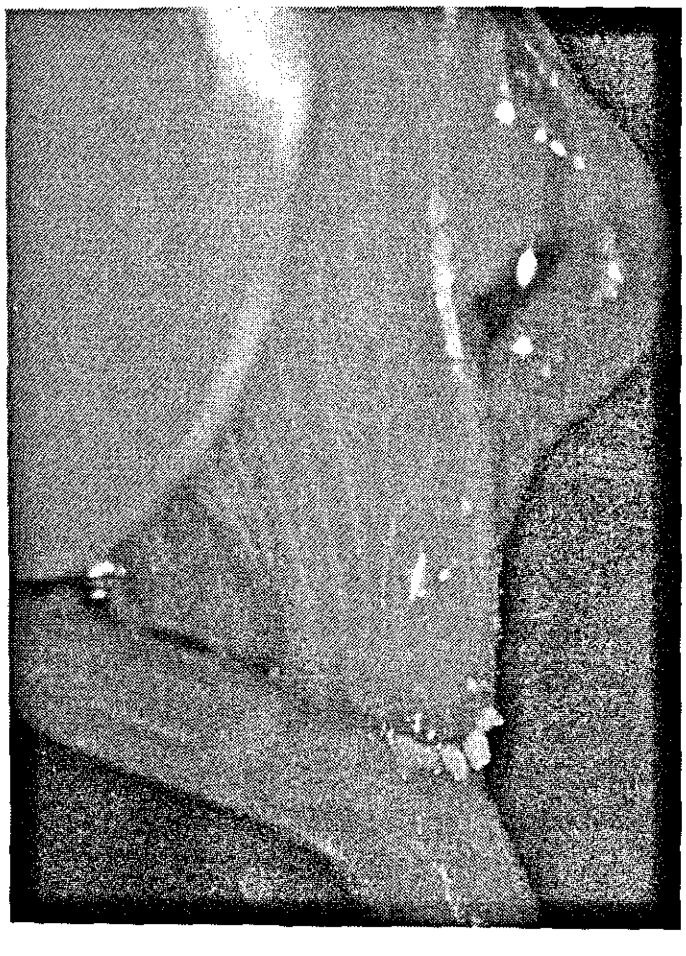


Photo 4.5 (left): Very young twig of *Bikinia breynei*. The apex of the shoot just emerges from between the valvate stipules. Photo 4.6 (right): detail of same stipule showing basal appendages (*Breteler & Leal 14198*). Photo J.J. Wieringa.

It has to be observed that it is not easy to establish whether stipules are fused or not, mainly because they are early caducous in most species. Additional confusion, however, is caused by the misleading nature of the bud scales. At the base of the shoot usually several bud scales are present. These bud scales are formed by reduced leaves and their stipules (see also Troll, 1959: 45). Of the leaf usually only a small part of the rachis is developed, which is fused to the distal margins of the stipules. The bud scale thus appears to consist of a fused pair of stipules without a leaf. The deceit reveals itself when the reduced leaf rachis continues over a short distance past the fused part, and produces reduced leaflets. This phenomena can best be observed in some malformed buds, probably caused by indecision between leaves and inflorescence in a new shoot (e.g. *Breteler, Wieringa & Nzabi 12957*, spirit material). It is also evident from bud scales like the one pictured in fig. 14.4:3. Since bud scales are often persistent longer than stipules, botanists may have taken them for stipules, and considered them fused in most of the taxa, at least in all those taxa formerly included in *Monopetalanthus* (bud scales of both *Bikinia* and *Tetraberlinia* are, at least partly, fused).

The most apical stipules of a shoot do not protect subsequent leaves or a continuing twig, and thus are much smaller than usual stipules. They may also deviate in some other respect and are best disregarded in the description (their measures are sometimes given separately). However, in a few species these stipules were the only ones available. Contrary to this in some species of *Aphanocalyx* with auriculate persistent stipules, the apical stipules are extra large and swollen (in the swollen area the striate venation turns into a reticulate pattern). Most probably this is related to the ant-housing function of these stipules.

Along the basal proximal margins of the stipules frequently some kind of appendages may be present (photo 4.5 & 4.6). These appendages differ in shape and colour. Some seem to be mere triangular extensions of the margin, others are distinctly separated and have the shape of sausage-like papillae or teeth. These appendages may very well be of a glandular nature, but such a function has not been demonstrated.

4.3.5 Leaves

Size, texture, number of leaflets and some surface properties of the leaves proved to be linked to the position of the leaves. In saplings, treelets and in a lesser extent in shade leaves of mature trees, the leaves often had more leaflets, which were larger and thinner than those of sun-exposed leaflets of the mature tree. A grey lower surface of the leaflets of some species is restricted, or most prominently expressed, in sun-exposed leaves. Therefore it is important to know whether a studied leaf was sun-exposed or not. Flowering or fruiting branches are usually sun-exposed, while the branches of immature trees are not.

Petiole. The petiole is defined here as the part between the leaf insertion and the first leaflets. In *Aphanocalyx margininervatus* and *A. cynometroides* the first pair of leaflets is often wanting, but it is still comparatively easy to denote their original position. In order to keep structures and sizes comparable within and between these two species, the length of the petiole and leaf rachis has been measured from the original position onward. The base of the petiole is always formed by a joint (pulvinus). In most species it continues after this joint with a part which is similar to the leaf rachis.

Leaf rachis. The leaf rachis shows some interesting characters, both structural and in indumentum. Structural characters, however, are hard to define and use because they depend strongly on the state (dry or fresh) of the material. Anatomical studies can probably overcome this problem, and are likely to reveal interesting differences between the genera.

In general *Aphanocalyx* has a terete rachis, but when dry either the upper or lower side may become flattened or may show some rather weak ribs. For *Tetraberlinia* a similar condition prevails, although ridges (or a grooved ridge) may be more distinct. In *Bikinia* the rachis may be terete when fresh, but several species already have a very pronounced grooved or flattened upper side when fresh. Also most of the terete rachides will develop grooves when dry. A flattened and glabrous upper side occurs in *B. le-testui*. This flat area often protrudes over the lateral sides into small wings. Also *Michelsonia* often shows small lateral wings on the rachis, but not in combination with a flattened upper side.

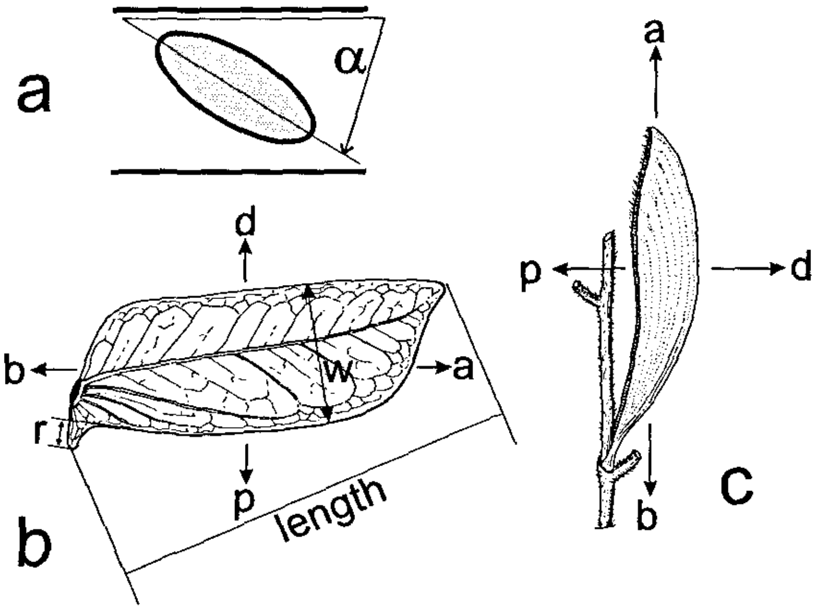


Figure 4.3. a: schematic lateral view of a part of the leaf rachis (base to the left) showing the scar of a leaflet insertion (grey area). b: leaflet showing measures and directions. c: two fused stipules showing directions. α = angle of leaflet insertion, a = apical, b = basal, d = distal, p = proximal, r = length of auricle, w = width.

Indumentum patterns can sometimes be used to distinguish species. For *Bikinia grisea* and *B. media* the indumentum and the groove of the leaf rachis proved to be the only dependable character to distinguish sterile material. These characters enabled correlation of pod characters with those of the flowering type specimens.

Leaflets. The insertion of the leaflets in this group is usually in one plane with the rachis. However, some leaflets (especially basal and apical ones) sometimes may be inserted almost perpendicular to this plane. This tendency towards perpendicular insertion is most strongly present in *Aphanocalyx* subg. *Antherodontus*. Outside this group leaflet insertions of over 90° are very frequent; in *Julbernardia* the leaflet insertion angle (fig. 4.3a) lies generally between 90 and 120°.

Sleep movements have been observed in a few species. In *Bikinia aciculifera* and *B. durandii* the leaflets fold together with their upper surfaces facing each other during the night. The rachis observes a pendent position and the folded leaflet pairs become directed downwards as well. In some other species (e.g. *Tetraberlinia moreliana* and *T. longiracemosa*) such movements could not be observed. This character may have systematic value, but the movement may be dependent as well on e.g. the age of the branch or its position in the tree.

In two species of *Aphanocalyx* the first two pairs of leaflets are inserted closely together, often on a swollen geniculate part of the rhachis. Since such a swollen part only bears a single pair of leaflets in related species, the first situation is considered as a 'doubling' of the first leaf pair.

Because some leaflets are rather asymmetric (e.g. banana-shaped), the length of the leaflets is defined as the diameter of the smallest encompassing circle. In normal shaped leaflets this will equal the mid-nerve length, in banana-shaped leaves it is the distance between the lower auricle and the apex. The width is measured on the widest part. The length of the auricle at the base of the proximal margin is measured as the perpendicular deviation from the imaginairy extension of that margin (see fig. 4.3b). Sometimes leaflets have a cordate base, this does not automaticly mean that they are auriculate as well, usually they are not! Descriptions are given for the basal leaflet, the apical leaflet and the largest leaflet of a leaf. The position of this largest leaflet may vary. In many species it is positioned close to the middle pair of leaflets, but in some species it is usually found to be more proximal or more distal in the leaf. Sometimes even one of the apical leaflets is the largest. Recording the position of the largest leaflet is one way to describe the overall leaf shape.

The side of the leaflet close to its insertion is called the basal side, the side close to its apex the apical side. When we consider the two leaflet parts that are divided by the midrib, the side closest to the twig is called proximal half, the side closest to the leaf apex the distal half (fig. 4.3b). In most species of *Aphanocalyx* the distal leaflet half is completely wanting or only represented by some small lobes, rendering the midrib to become a marginal vein.

In species where both leaflet halves are present, the shape of these halves is often described separately. Since usually no term for half-shapes are available, the term used refers to the shape as if the leaflet half was mirrored in the midrib (so ovate for a shape which is in fact half-ovate).

The lower surface of leaflets usually show some glands, which form an important character. They can be present on the proximal leaflet half, the distal half (e.g. photo 4.2) or on both. Their presence is dependent on the position of the leaflet. Basal leaflets usually have the highest number of glands, which number rapidly decreases towards the middle of the leaf, while their number (especially in the distal leaflet half) may increase again in the most apical leaflets. In the species of *Aphanocalyx* subg. *Antherodontus* the glands to be expected on the wanting distal leaflet half are found on the midrib of the leaflet.

In *A. margininervatus* (and in a lesser extent in *A. cynometroides*) a fairly large gland is often present at or near the apex of the leaflets (see fig. 10.4:2a & b). In the former species the apex is sometimes curved around this gland.

The lower surface of the leaflets in some species is remarkably dull and pale grey. This occurs in both *Aphanocalyx* subg. *Antherodontus* and two species of *Bikinia*, in the latter especially in sun-exposed leaves. This dull, greyish lower surface is caused by some stud-like micro-structure. All epidermis cells, except those cells associated with stomata, seem to have a conically protruding surface. In the *Bikinia* species the cells associated with stomata have a normal, flat surface, in *Aphanocalyx* subg. *Antherodontus* these cells are conically protruded as well, but the cones link up to form a kind of crater around the stomata. For the species that have such dull greyish surfaces, these have been investigated

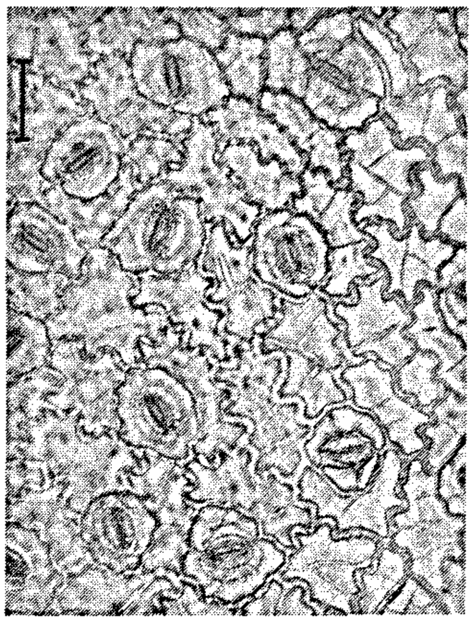


Photo 4.7: *Aphanocalyx djumaensis*, lower leaflet surface: strongly sinuous cell walls subdivided by straight walls. Bar = 31 µm.

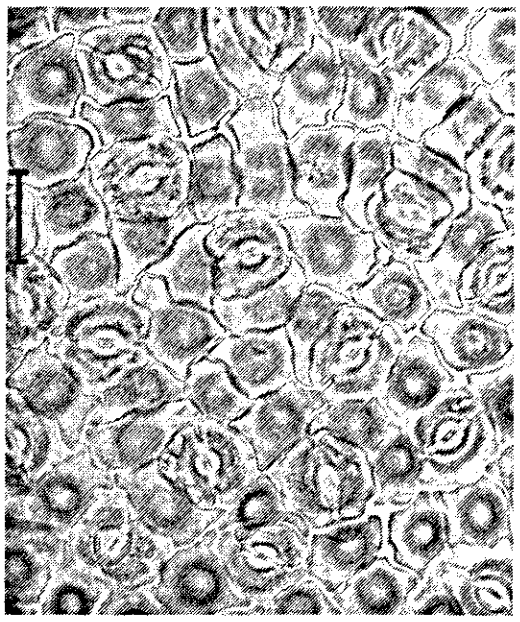


Photo 4.8: *Aphanocalyx heitzii*, lower surface: hardly sinuous walls, cells protruding in a cone (the dots out of focus). Bar = 24 µm.

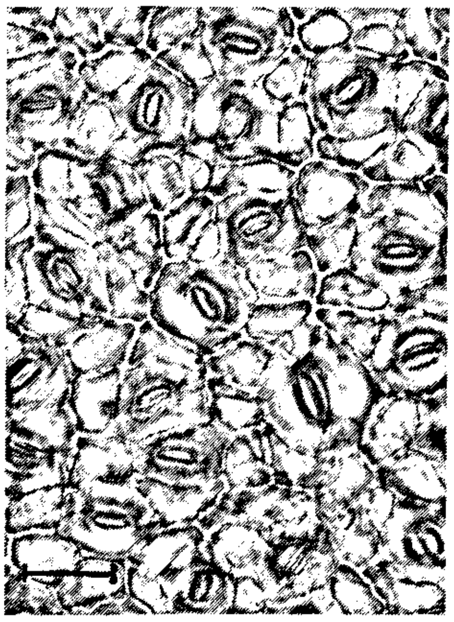


Photo 4.9: *Bikinia le-testui* ssp. *le-testui*, lower surface: densely set with stomata, walls slightly sinuous. Bar = 24 µm.

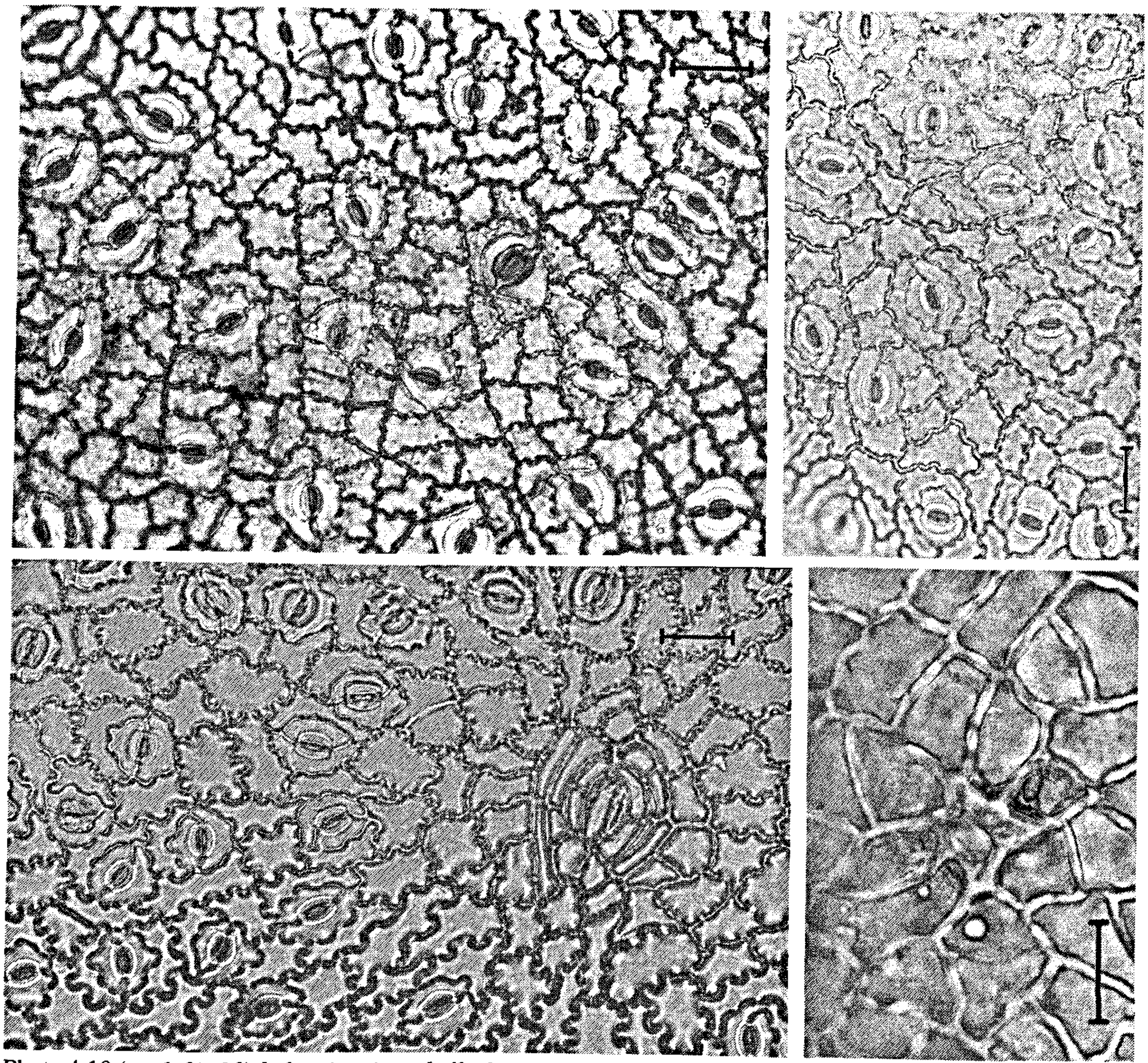


Photo 4.10 (top left): *Michelsonia microphylla*, lower surface: cells with sinuous walls. Photo 4.11 (bottom left): *Tetraberlinia bifoliolata*, lower surface: cells with sinuous walls, at the right showing an unusual cell pattern. Photo 4.12 (top right): *Tetraberlinia moreliana* lower surface: cells with sinuous walls. Photo 4.13 (bottom right): *Michelsonia microphylla*, upper surface: another unusual cell pattern. 10–12: Bar = 31 μm; 13: Bar = 15μm.

more closely by Gervais (1998 and pers. comm.). She recognizes two different types of surfaces of epidermis cells causing the dull appearance: 'véricule' and 'papillé'.

My (preliminary) research on leaflet epidermis revealed several other interesting characters:

- *Aphanocalyx* subg. *Aphanocalyx*: Lower surface with 280–600 stomata / mm^2. Upper surface rarely with stomata (*A. margininervatus*: 10–60 / mm^2). The cells of both surfaces have thick, strongly sinuous cell-walls. These thick-walled cells may be divided once or twice more by thinner, straight walls into 2–4 smaller cells (photo 4.7). Such additional straight walls may be universal (e.g. *A. obscurus*, *A. djumaensis*) or (very) rare (e.g. *A. cynometroides*, *A. margininervatus*, see photo 4.1).
- *Aphanocalyx* subg. *Antherodontus*: Lower surface with c. 600–700 stomata / mm^2, epidermis cells protruding in a cone (photo 4.8). Cell walls hardly sinuous. Upper surface without stomata, cells with sinuous walls, without additional straight subdivisions.
- *Bikinia*: Lower surface with 550–1050 stomata / mm^2, epidermis cells sometimes protruding in a cone (photo 4.9). Upper surface without stomata. Cell walls of both

surfaces a little sinuous to straight, cells not subdivided.

- *Julbernardia brieyi*: Lower surface with c. 300 stomata / mm^2. Upper surface with c. 15 stomata / mm^2. Cells of both sides with straight walls, without subdivisions.
- *Michelsonia microphylla*: Lower surface with 300–400 stomata / mm^2. Upper surface without stomata. Cells of both sides with sinuous walls, cells not subdivided (photo 4.10).
- *Tetraberlinia*: Lower surface with 200–450 stomata / mm^2. Upper surface without stomata. Cells of both sides with sinuous walls, cells not (or rarely?) subdivided (photo 4.11 & 4.12). See also Watson (1981: plate 2b & e).

The density of stomata on the lower surface of most species is fairly high, but within the limits given by Troll (1959: 264): 100–300(–700) and Denffer et al. (1971: 160): 18–860. Only the value of 1050 stomata / mm^2 of *Bikinia le-testui* is remarkably high and exceeds these values.

The sinuous cell walls probably have a function in strengthening the epidermis in the direction perpendicular to the surface. In the SEM photos in Gervais (1998) of dried leaflets these walls become evident because they remained upright while the surface had become impressed. On these photos the thin straight walls are not visible, hence the cells appear larger than they actually are. The same kind of sinuous (undulate) anticlinal walls have also been observed in *Dialium* (Sheteolu & Ayodele, 1997), but in that genus the cells have not become divided once more by thinner straight walls. So far these straight, secondary divisions seem to be characteristic for *Aphanocalyx* subg. *Aphanocalyx*. According to Watson & Dallwitz (1983) sinuous cell walls are quite common in Caesalpinioideae and at least present in 54 other genera. However, they already score a genus as potential sinuous if it has slightly sinuous cell walls (see Watson, 1981: pl. 2d). The degree of curving of the walls in the present group may be more rare than is apparent from their analysis.

In several species other structures (e.g. photo 4.11 & 13) appeared to be present in the epidermis. Since no transverse sections are available of these structures and far too few specimens have been sampled no conclusions can be drawn at present.

These epidermal characters may have potential for identification purposes or for further phylogenetic studies and deserve to be studied more thoroughly in the future.

4.3.6 Inflorescence

The basic inflorescence type for most Leguminosae is the simple raceme (Tucker, 1987a & 1987b). Also in this group the basic unit is a raceme. However, in the species treated the inflorescences consist of more than a simple raceme. In order to be able to understand the evolutionary line leading up to the present inflorescences we have to look outside this group. It starts with a branch, with in every leaf axil a simple raceme. This situation is present in *Macrolobium*. The next stage is that such a branch develops at the same time as the racemes in its leaf axils (possibly also present in *Macrolobium*). Subsequently the leaves start reducing. Examples of this stage are sometimes present in the treated group: *Michelsonia microphylla*, *Aphanocalyx heitzii* and some species of *Bikinia* and *Tetraberlinia* sometimes show small leaves in the (compound) inflorescence. When the leaves have completely disappeared, a main axis with lateral racemes is left, forming what is called here a compound raceme. This inflorescence fits the "Doppeltraube" (or "Dibotryum") of Troll (1959: 85) and Weberling (1981: 218). In theory it probably is a "homoeothetische Doppeltraube" (Weberling l.c.), but since in real plants the most apical raceme often has an apical orientation this type is very hard to separate from his "heterothetische Doppeltraube". This last type is called a panicle by Tucker (1987a &

1987b). However, she does not consider the possibility of a "homoeothetische Doppeltraube". Moreover, her definition of a panicle is quite different from what Weberling (l.c.) calls a panicle ("Rispe"). An interesting feature of the compound raceme is that in some species the lower lateral branches tend to branch once more (Weberling calls this a "Tribotryum").

In *Aphanocalyx* the compound raceme has continued to evolve. In a few species the compound raceme is still present, but in most species the lateral branches are suppressed. Only the highest lateral raceme develops and is preceded by dormant lateral buds. These inflorescences superficially appear to be simple racemes. That they are not, becomes clear when studying inflorescences of *A. microphyllus* and *A. richardsiae*, which usually seem simple, but in some inflorescences several lateral branches develop and the inflorescence becomes compound.

When confronted with the entire evolutionary line as explained above, it has become impossible to give a definition of the term inflorescence which is consistent with the way it is used in general. In *Macrolobium* one will call the simple racemes inflorescences. However, such structures are homologous with only a single lateral branch of the inflorescence of *Bikinia*. Since the situation as present in *Macrolobium* does not occur in our group, I will use the term inflorescence for the entire compound raceme, even if some reduced leaves are still present.

In a compound inflorescence two types of bracts are present: bracts that support a lateral branch and bracts that support a flower (bractella according to Oldeman, 1964). Both types find their origin in a fusion of stipules with a reduced leaf rachis (like bud scales), however, the first type only developed (in an evolutionary sense) that way during the transformation of simple to compound racemes, while the second type already developed during the development of racemes. Indeed both types of bracts often show some differences in shape, size or indumentum. Tucker (1987b) distinguishes first- and second-order bracts, but since in our group second-order bracts can be branch-supporting bracts as well, I will use the term floral bract (or short just bract) for bracts that support a flower. First order bracts will be called inflorescence bracts or bud scales. When neither a flower nor a lateral branch (but probably a not developed flower bud) is supported, 'bracts' may be used.

The floral bracts often possess some kind of glandular teeth at their margins. The glandular status of these teeth could not be demonstrated, but is very likely (van Veenendaal & den Outer, pers. comm.). The size, shape and colour of such teeth may vary between species. These teeth proved to be a very valuable character for identifying the type of *A. djumaensis*, which could not be definitely assigned to any species otherwise.

The bracts of *Aphanocalyx* possess the same closely spaced, prominent veins as the stipules do. The gene(s) responsible for this character may well be the same. Nevertheless, since in some genera (*Didelotia*) outside this group sometimes stipules occur with closely spaces veins while they are not so in the bracts, both characters have been coded separately (see phylogeny).

The apical bracts of a raceme are usually smaller than the preceding ones and support buds that will never fully develop. These bracts have been disregarded in the measurements.

4.3.7 Flowers

Several species have been reported to have sweet scented flowers. Only exceptionally it has been recorded that odour is absent (*Aphanocalyx jenseniae*).

Pedicel. A pedicel is always present, although it may be very short in some genera (*Michelsonia* and *Icuria*). The length is measured adaxially, from its insertion at the raceme rachis to the position where the bracteoles become free from each other (fig. 4.4). This measure may not coincide with the 'real' pedicel length (e.g. Velenovský, 1904), especially since the hypanthium cavity may in some cases extend below this point. However, as defined here, the length can be measured without having to dissect the flower. Moreover, this length will be about identical to that taken by an uniniated observer.

Bracteoles. Below the floral organs two valvate bracteoles are present. These bracteoles have a protective function, in other flowers usually effected by sepals. This feature is typical for the tribe (Breteler, 1995). The length of the bracteoles is measured from the point where they become free from each other (or from the hypanthium if that occurs lower, as in *Microberlinia*) to their apices. An interesting character of the bracteoles is the opening angle at anthesis. This is measured adaxially between the point where the bracteoles separate and both bracteole apices (see fig. 4.4b). Other characters concerning the bracteoles are the indumentum inside and the presence and the indumentum of a midrib outside.

In the flowers of most of the treated species the bracteoles are fused with the hypanthium. There are several ways of defining it. One could even say that the floral receptacle invaginates into the pedicel, or, in line with Velenovský (1904), that the bracteoles are fused with the pericladium and continue to be fused with the hypanthium. Whatever the definition, a transverse section of such a flower (fig. 4.4a) shows a tube formed by the bases of the bracteoles, the sepals, the petals and the stamens. A hypanthium is usually defined as a tube consisting of sepals, petals and stamens (e.g. Velenovský, 1904; Weberling, 1981). Since in this case the bracteoles are part of it as well, I call it a hypanthium s.l. The fusion with the bracteoles may be complete, or only partly so (as in most species of *Julbernardia*). In *Bikinia* the fusion is complete, except for the points of meeting of both bracteoles. Especially on the adaxial side the bracteoles are almost free here, resulting in a short zone were a real hypanthium s.str. can be observed. Since this zone continues into the adaxial sepals and the transition into them is indistinguishable from the outside, the length of these sepals is given both including and excluding the visible hypanthium part.

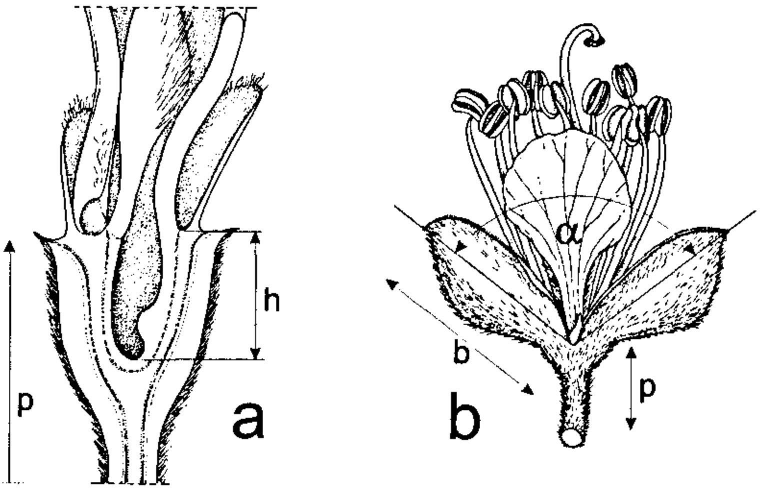


Figure 4.4. a: longitudinal section of a flower. b: adaxial view of a flower. p = pedicel length, h = hypanthium height, b = length of bracteole, α = angle of bracteoles at anthesis.

Hypanthium. The length of the hypanthium is defined as the distance from the bottom of the staminal tube to the point where the abaxial sepal becomes free, measured strictly parallel to the floral axis. If this sepal is not present, this point should be estimated from the point were the other sepals, petals or even the bracteoles become free.

Whether a hypanthium is present is sometimes hard to observe. In most species of *Julbernardia* the sepals, petals and the staminal tube are fused over a short length, but this part usually has a transverse orientation, rendering it hard to measure. In some species of *Aphanocalyx* subg. *Antherodontus*, *Bikinia* and *Tetraberlinia* the hypanthium can become quite large. Such deep hypanthia are probably an adaptation to protect the nectar at the bottom of them so it can be reached only by a few more specialized pollinators.

The length of the sepals, petals and stamens is always measured from the point where they separate from the hypanthium.

Sepals. The number of sepals for Leguminosae is usually 5. Since the bracteoles of this group have taken over the protective function, the sepals have become largely useless and may be reduced without serious consequences for the fitness of the species. Indeed most species have sepals that are strongly reduced or even absent. In general the lateral sepals are the smallest. In this group, and many other genera in the Macrolobieae, the two adaxial sepals are (partly) fused. When the fusion is substantial, these two sepals are often considered as one (this is how ***Tetra**berlinia* got its name). When these two sepals decrease in size the level of fusion often increases because their free apical parts are the first to reduce. In e.g. *Tetraberlinia moreliana* the adaxial sepals form a broad but not very high band and their two separate apices are only represented by two small teeth. When the two sepals continue to reduce the level of fusion may decrease again. In several species of *Bikinia* the adaxial sepals have become very small triangular teeth that are hardly fused. Since these sepals merge into the hypanthium, it is hardly possible to establish if the free lobes are still connected or not. In several species of *Aphanocalyx*, however, this is quite evident. Even within one individual larger adaxial sepals still may have a basal connection, while smaller ones tend to be free. Another phenomenon observed in that group is unequal development of the two sepals. One of them tends to grow fairly large while the other disappears (almost) completely, and as such presenting a non-fused situation. This demonstrates that the fusion of sepals may only be significant for specific or even generic delimitation when they are well developed.

The indumentum of the sepals shows some interesting variation, as do the margins: they may be glabrous, ciliate or even fimbriate (*Julbernardia*).

Petals. The usual number of petals in the Leguminosae is 5. In many Macrolobieae the petals have started to reduce as well. However, a general trend is that the adaxial petal does not reduce. It even tends to increase. As a result many lineages have (independently) resulted in species showing a single, large petal. Another, more rare, trend is that all petals reduce. It is not clear if this really is a separate trend, resulting from the gradual loss of all petals, or that it is a continuation of the first line, in which the adaxial petal finally reduces as well. Some evidence for the second scenario is presented in *Julbernardia pellegriniana*, where the adaxial petal may be almost absent in some flowers, while in others it is still fairly large.

The indumentum of the adaxial petal can be very distinctive. Especially in *Tetraberlinia* the patterns appear to be quite specific. In that genus also the shape is very important. The most complicated adaxial petal is found in *T. polyphylla*. The indumentum or shape of the other petals can be of importance as well. The species of *Aphanocalyx* subg. *Antherodontus* have very characteristic long hairs inside, while those of *Tetraberlinia* tend to become folded together and rotate for 90°, resulting in a double-layered petal.

The adaxial petals are usually white, but in most (if not all?) species of *Tetraberlinia* and *Aphanocalyx* subg. *Antherodontus* they are (lemon) yellow (plate 4 & 5). Within the Macrolobieae this colour is rare, *Dicymbe* is the only other genus in which yellow petals occur.

Stamens. The usual number of stamens is 10. In most species this number is still encountered, only in *Aphanocalyx heitzii* the adaxial stamen is lost, while in *Icuria dunensis* 2–4 stamens are missing. Since in the latter species the staminal ring is still closed it is not clear which ones are absent. In the species with 10 stamens the adaxial one is free (it is only fused to the hypanthium) while the others are united at their base. The length of the fusion is measured on the abaxial side of the flower, on the most abaxial filament. In some species the 3 filaments next to the abaxial one are fused over an additional distance. These stamens are called here the lateral stamens. Especially in most species of *Bikinia* the stamens next to the adaxial one tend to bend inwards, placing the anthers abaxial compared to those of their adjacent lateral stamens (fig. 4.5). Since the stamens form the innermost layer of the hypanthium, the inside surface of the hypanthium has staminal properties. The indumentum of the hypanthium can continue onto the stamens or not, and is described as such. Often the individual filaments are already visible in the hypanthium as ridges in the hypanthium wall. In some species of *Tetraberlinia* each filament grows inwards in the hypanthium, almost filling up the cavity. At the top of the hypanthium these ridges abruptly recede as to open up the cavity (fig. 4.6). At the bottom of the hypanthium cavity nectar has been observed in at least several species of *Bikinia*. It appeared that nectaries were present in the lowest part of the tube, but such was not tested.

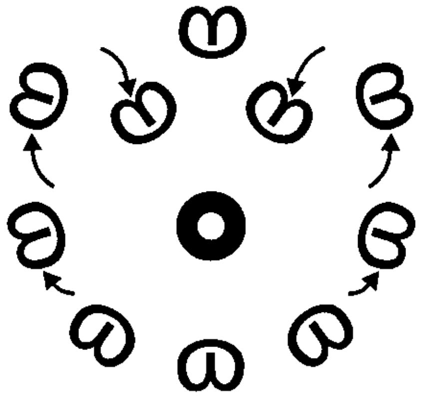


Figure 4.5. Position of the anthers (∞) and the basal position of their supporting filament (base of arrow) as found in *Bikinia*.

All species have a versatile anther attachment. The connective of the anthers of *Aphanocalyx* often shows a tooth on each side of the filament insertion. In the species of subg. *Antherodontus* these teeth are very pronounced, in the species of the typical subgenus they vary in size but never reach the size present in the other subgenus.

In many species from this group (except most species of *Aphanocalyx*) the connective is slightly extending at base and protrudes from between the two locules. Rarely a few hairs are present at the apex of the anthers.

An interesting character which has not been studied thoroughly is the angle between both locules of an anther. In *Aphanocalyx* both locules seem to be turned to the inside of the flower, resulting in both slits lying more or less in one plane. In the other genera such a rotation is less evident, and the locule slits are not lying in the same plane. A problem for studying this character in herbarium specimens is that dried anthers tend to curl in aberrant ways, losing their original orientation. The orientation of the locules may also vary with the age of the anthers. Future studies on spirit-preserved flower buds may demonstrate whether this character has any value.

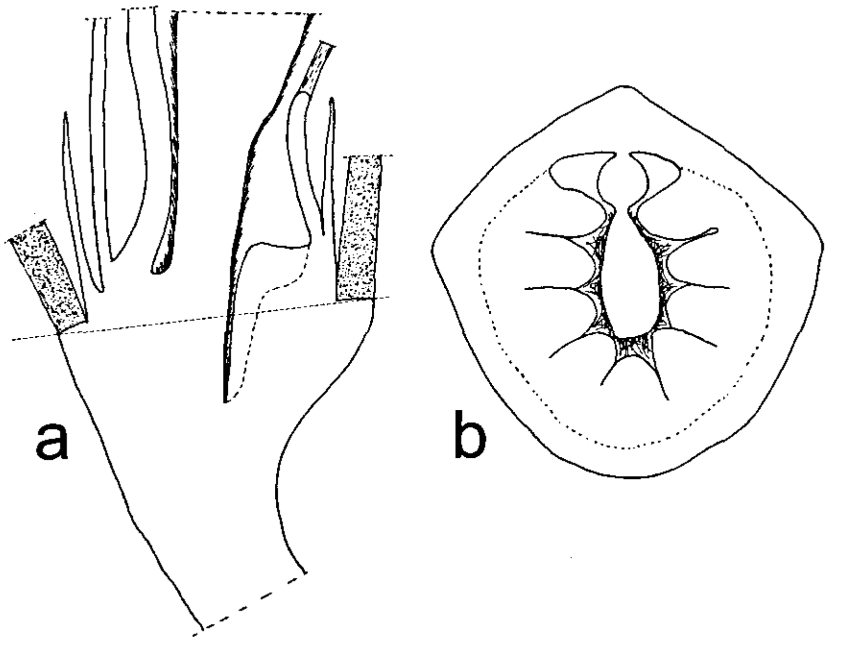


Figure 4.6. Schematized longitudinal- (a) and cross-section (b) of a flower of *Tetraberlinia moreliana*. The straight dashed line in (a) indicates where the cross-section was made. The curved dashed line indicates how far the staminal lobes inside the hypanthium remain free. The dashed line in (b) indicates a tissue transition, probably between real hypanthium and bracteole tissue.

Pistil. The pistil is supported by a gynophore, here called a stipe. The stipe is usually partly fused to the adaxial hypanthium wall (e.g. fig. 4.6a & b). If this fusion continues past the point were the adaxial stamen becomes free from the rest of the hypanthium, this stamen and the stipe are considered to be partly fused. The stipe is always hairy, only in *Aphanocalyx* the very base is glabrous.

The ovary is usually hairy, even in species that finally develop glabrous pods. In some species of *Tetraberlinia*, however, the indumentum is restricted to both sutures.

In most species depauperate ovaries have also been found. Depauperate ovaries can be recognized by their much shorter and usually still inrolled style. Even during anthesis these styles are shorter than those in bisexual flower buds. Depauperate ovaries are usually also smaller than functional ones, but the extent of reduction varies between the species. In most species these depauperate ovaries still possess distinct ovules, only in a few species they may become very small and amorphous. Since flowers with depauperate ovaries always drop a few days after anthesis, such flowers can be considered as functionally male. In descriptions they are referred to as male flowers, those with normal ovaries are called bisexual flowers.

The number of ovules varies from 1–6. The ovule number is surprisingly constant in the species of *Aphanocalyx* subg. *Aphanocalyx*, for which the usual number is 2, only in a few species individual flowers may vary a little. Other (sub)genera are far more variable in this character. In a few species hairs may be present inside the ovule cavity.

The style is always inserted at the apex of the ovary. Much variation may be observed in the angle of insertion. It may be placed centric or inserted at an angle of up to 140° to the adaxial side of the ovary, i.e. continuous to the axis of the ovary, deflexed or even reflexed up to an angle of 140°. In *Bikinia* the base is usually reflexed and conically thickened; at the end of this conical part the style is often geniculate, resulting in the apical part assuming a position more or less parallel to the ovary.

All stigmas are of the (wet) papillate type of Owens & Lewis (1996). The shape of the stigma as mentioned in the descriptions is always the projected shape as seen from above.

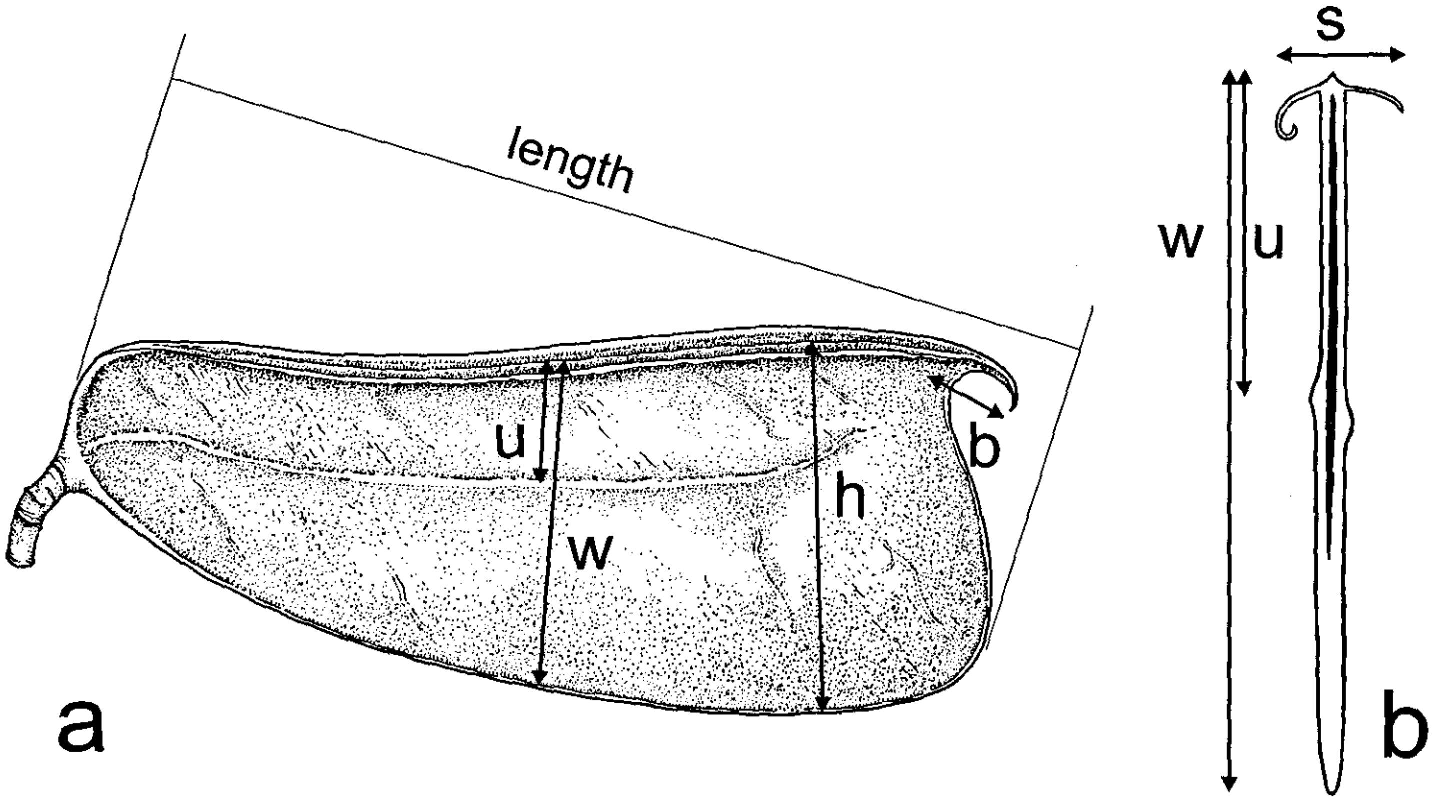


Figure 4.7. Pod. Lateral view (a) and cross-section (b). u = distance from lateral nerve to the upper margin, w = width of the pod in the middle, h = width ("height") of the pod, b = length of beak, s = width of upper suture.

4.3.8 Pods

Pod sizes are always reported as length x width x thickness (see fig. 4.7). The length is defined as the diameter of the smallest encompassing circle (this results in the largest possible length). The width (or height) is the diameter of the largest circle confined to the inside of the pod limits, where this circle cannot be constrained by the basal or apical margin (this method is supposed to result in the largest possible width perpendicular to the local central axis of the pod). The thickness of the pod is the largest thickness, excluding measures near the upper suture, the lateral nerve or at a seed position. The shape of the pod as reported is that of a lateral projection.

When the pods are still on the tree, they are positioned horizontally in such a way that the dorsal suture forms the upper side of the pod (same orientation fig. 4.7). This suture is referred to as upper suture. It is often extended into wings. The thickness of the pod at the upper suture is given separately as measurement for the size of the wings. It is referred to as the width of the upper suture (fig. 4.7b). The wings may be inrolled or curled upwards to form a groove (*Aphanocalyx hedinii*).

On the lateral surface of the pod a nerve is usually present (called the lateral nerve). This nerve usually runs more or less parallel to both sutures. In some groups the nerve runs fairly close to the upper suture (e.g. in some species of *Aphanocalyx*, where it was often overlooked or considered to be part of the wing of the upper suture), in others it runs about in or even below the middle of the pod. To be able to characterize the position of this lateral nerve its relative position is measured halfway along the length of the pod in relation to the upper edge. It is given as the *u/w* index (fig. 4.7), which stands for the distance of the nerve to the upper edge divided by the total width at the half-way point. Sometimes (in some species of *Tetraberlinia*) a second lateral nerve is present below the first one. The index for this second nerve is called *u2/w*.

The ultimate support of the pod is formed by two distinct structures: the pedicel and the stipe. Both structures may become elongated in fruit. The transition from the pedicel to the stipe is formed by the scars of the bracteoles and the hypanthium. When the transition is not straight, both lengths are measured from the centre of the scar-ellipse.

In most species a part of the style remains present in the pod: the beak. Most species of *Aphanocalyx* and *Michelsonia* have a rather small or even absent beak, while most species of *Bikinia* and *Tetraberlinia* have a rather stout beak.

4.3.9 Seeds

All species possess flattened ± lens-shaped seeds. In outline they are ovate, elliptic or obovate, which shape is given in the descriptions.

The testa is fairly thin in *Aphanocalyx* and *Michelsonia*, while it is very thin, membranous and easily detaches after seedshed in *Bikinia*, *Icuria* and *Tetraberlinia*. This character may prove to have a high systematic value, but this should be tested on more abundant comparable seed material. In all these genera the testa does not swell nor becomes slimy after being put in water, as was established for several other genera of Macrolobieae by Léonard (1957).

4.3.10 Seedlings

Léonard (e.g. 1957, 1996 & (with Doucet) 1997) values seedling characters as very important for generic delimitation. All seedlings of this group have similar seedlings according to Léonard's system: germination 'Type A' (epigeal with the cotyledons well above the soil), the first leaves opposite and 'Collet sans appendice'. However, this does not mean that there is no variation. The length of both epicotyl and hypocotyl is quite variable (see fig. 6.1). In *Aphanocalyx* the epicotyl is short to very short (both absolute and relative). In several species the cotyledons clasp the insertion of the first leaf pair. The epicotyl of *Bikinia* on the contrary is very long. Also the presence of indumentum on the epicotyl is of interest: in several species of *Tetraberlinia* and *Bikinia* it is almost glabrous, especially in the basal part.

I define the hypocotyl as the stem between the soil and the cotyledons. This definition conforms to that of Léonard (1957: 35) and implicitly used by Troll (1959: 37–40). The epicotyl I define as the stem part between the cotyledons and the first opposite leaf pair. If no opposite leaves are present and the first leaf (or scale) is solitary on its node, I consider that the epicotyl is not developed. This definition is quite different from that of Léonard (l.c.) and Troll (l.c.). Léonard defines the epicotyl in such cases as the stem between the cotyledons and the first leaf, that of Troll is not clear: either similar to Léonard or up to the first node (either a leaf or a scale).

In seedlings with an opposite leaf pair, stem development above this point is arrested for some time. Subsequently one or more shoots emerge from this point. The leaves of such shoots may be preceded by bud scales. These shoots are evidently homologous with the shoots emerging from between the cotyledons in seedlings without an opposite leaf pair (see also Breteler, 1973: 29 for a similar case in Dichapetalaceae). If one calls these shoots epicotyl in their lowest node(s), and compare them to the real epicotyl of the other group, one compares plant parts that are not homologous. Léonard (e.g. 1993) repeatedly stated that the seedlings of two groups differ on several points, because those of the one group possess both alternating first leaves and bud scales on the epicotyl, while in fact the other group also has bud scales, but on the shoot past the opposite leaf pair. The only real difference in such cases is the absence of the epicotyl with its opposite leaf pair.

The first leaves of the subsequent shoot usually possess distinctly fewer leaflets than mature leaves. Some species start branching fairly quickly, sometimes already from the axils of the opposite leaflets (e.g. *Tetraberlinia longiracemosa*), while others continue monopodially for a considerable distance.

4.4 Discussion

According to Léonard (1957, 1993, 1994, 1996, 1999a, 1999b & (with Doucet) 1997) some characters have 'generic value', others do not. To know which characters have this generic value, one should check this character in all species of the family (although for Caesalpinioideae Léonard (1996: 444) states the tribal level suffices as well) and see if it has generic value in other genera. This argument approaches circularity (genera that show variation in 'generic characters' are divided by Léonard until they are homogenous again).

Seen in an evolutionary light, one can interpret a character state present in several genera as developed in the common ancestor of those genera. However, the same argument holds for a character shared by several genera that does vary within a genus, only such characters might show a little more homoplasy. If a character shows variation in one genus, this does not mean it cannot be a perfect character of some other genus. This is demonstrated by the completely fused stipules of *Aphanocalyx*, which separate this genus neatly from *Tetraberlinia* and *Bikinia*, while the character is variable within *Julbernardia*.

The morphological study has revealed that even after a century of morphological studies still much can be learned. However, such a study has to be thorough and the characters measured should be defined unambiguously. The different application of terminology has, at least in the Caesalpinioideae, resulted in much confusion and errors. There is a great need for specific and generic descriptions that describe all characters in a systematic way and do so unambiguously. Only if such descriptions are available we might be able to unravel the complicated morphological patterns in the Macrolobieae and Detarieae.

5 Chromatography

J.J. Wieringa & G.Y.F. Gervais

5.1 Introduction

While preserving flowers of some species of *Aphanocalyx*, *Bikinia*, *Tetraberlinia* and *Julbernardia* one is confronted with a peculiar phenomenon: stored in ethanol for later study those flowers turn the liquid yellow, orange, red or dark brown-red after about a day. Also other plant parts (like pods and leaflets) cause this effect. Since colours and their intensities differ among species, it was difficult to define them properly and use this character in phylogenetic studies. However, it seems to be a very interesting phenomenon, which can be used to refer specimens to their proper genus. For instance, it has been used to demonstrate that the pods of *Michelson 520* did not belong to *Michelsonia* but to a hitherto unknown species of *Tetraberlinia.*

In order to be able to define the different colours, and use them in the phylogenetic study, Thin Layer Chromatography (TLC) has been applied to the ethanol samples. TLC separates the different components of the colours on the basis of their affinities with the solvent used. It may also reveal some other substances present in the ethanol which are only visible in UV-light.

5.2 Material and methods

Ethanol samples of different extraction ages have been used. The first kind were samples that had been prepared especially for extracting the colours. Flowers and flower buds from herbarium specimens were placed in 70% ethanol for at least 2 days. The second kind were samples made for the same purpose, but at least 1 year previously. Because in these the extraction lasted much longer, some additional products could be present in these samples. The third kind of samples consisted of ethanol samples used for conserving flowers for anatomical research. Although they were not made for this particular analysis, these samples had an extraction period of somewhere between 1 and 7 years, which might be an advantage over the first two kinds. The 79 samples used are listed in table 5.1, as control a blank (ethanol sample with a paper label extracted for 2 days) was added, resulting in a total of 80 samples. The substances that were dissolved in the ethanol were separated by TLC. TLC plates of 0.22 mm thick silica gel 60 F254, containing 20 samples each, were used with two different combinations of solvent. Solvent A contained 69% (volume) chloroform, 26% ethanol, 5% glacial acetic acid and 0.3% isoamyl. Solvent B contained 25% chloroform, 69% ethanol, 5% glacial acetic acid and 1% isoamyl.

The resulting bands were recorded by visual checking under visible light, and UV light, and both once more after spraying with NaOH.

5.3 Results and discussion

A total of 27 different bands were detected. Differences were determined by the (relative) position of a particular band in both solvent combinations, its colour in visible and UV light and the response to NaOH. A few bands proved to be unique for a single specimen or species.

Spraying with NaOH resulted in extra bands. However, it also obscured other bands. Most of the bands that were caused by the NaOH proved to disappear again (permanently) after about a day. As a result it became very hard to compare the separate TLC plates that received the same solvent treatment (mounting the samples on a TLC plate takes about one day, after which the TLC plates were put in the solvent immediately).

Since bands could not be compared over all plates, it was not always possible to establish whether two bands were identical or not. Such bands have been discarded from the final data matrix (see chapter 6). Another problem for comparing bands was that some bands appeared to have shifted slightly in position on successive plates. This may have been caused by selective evaporation of the solvent components resulting in changed composition. As the container with the solvent was supposed to be air-tight this should not have been possible, but apparently these containers were not. Since shifting of a band occurred in all samples of a plate, the identity of a shifted band could still be established in most cases by comparing colours and the NaOH response.

Samples of a species, or even a single herbarium specimen, did not always show the same bands. This may have been caused by differences in the concentration of the colour elements in the ethanol, but some of the factors described above may have contributed as well. The field treatment of some specimens also may have some influence. Some collectors initially preconserve their herbarium specimens in white spirit in the field and postpone drying until they reach home. This treatment will prematurely extract most of the colour components from such specimens. Also other methods to conserve material may provoke some differences in composition.

No obvious differences could be observed between the old (≥ 1 year) and young (2 day) samples; most of the bands present in the old samples were also present in at least some young samples. The few bands that did not show up in young samples were aberrant cases. Either the species showing such bands was not included in the young set or it concerned bands that had become incomparable in some way or other.

The results of this TLC analysis are not considered to be very reliable, hence they have not been used in the final cladistic analysis. However, to gain some insight in how these results do perform, they have been summarized as follows: A taxon was coded '1' if a band was present in at least half of the samples of that species. When more than 2 samples of a species were available and a band showed up in only one of them the character was coded '?'. Bands which were scored as doubtfully present in at least half of the samples were scored similarly. The resulting data matrix is part of table 6.1.

Nevertheless, TLC has proved to be a promising method. It may present some additional characters to clear up phylogenetic questions (i.e. internal topology of *Bikinia*). However, in order to be able to compare all bands it is recommended to prepare all plates initially and subsequently place them in the solvent combinations simultaneously. Before applying NaOH the plates should be scanned or photographed. Moreover it is recommended not to use too much ethanol solution because excessive colour may produces smears that may obscure bands. There seem to be no objections for the employment of samples extracted only two days before analysis, it might even be preferable.

It may be worthwhile to identify the most important components responsible for the observed colours. When the components are known, it will be possible to select the optimal extracting liquid as well as the optimal solvents. Ethanol was chosen because it proved to extract some colours, ethanol / chloroform solvent combinations were used on a trial and error base. When the chemical substances are known, their chemical pathway in combination with the evolutionary history of the group may be reconstructed, and explain their presence or absence in taxa.

Table 5.1: material used.

Aphanocalyx cynometroides: Breteler, Wieringa & Nzabi 12868, J. Louis 13815.
A. djumaensis: Breteler & de Wilde 630, Breteler & Breteler-Klein Breteler 13056, Evrard 4562.
A. hedinii: Mpom 1832 (2x: old & young extractions).
A. heitzii: Wieringa & Haegens 2439; Wilks 973.
A. jenseniae: Jense 25 (2x: flowers, flowers & leaflets).
A. ledermannii: Devred 2314, Dhetchivu 747, Dhetchivu 852b, Wieringa & Nzabi 2846.
A. libellula: Raimundo, Matos & Figuera 619.
A. margininervatus: Le Testu 8418 (2x: old & young extractions).
A. microphyllus ssp. *compactus*: v. Harten 343, Voorhoeve 1083.
A. microphyllus ssp. *microphyllus*: Letouzey 10332, Louis 14832, Wieringa & v.d. Poll 1345.
A. obscurus: Wieringa & v.d. Poll 1544.
A. pectinatus: Le Testu 6069.
A. pteridophyllus: Bos 2100 (2x: old & young extractions).
A. richardsiae: Barros de Machado s.n.(1), Fanshaw 4343, Leonard 5011.
A. trapnellii: Richards 19612.
Bikinia aciculifera: Wieringa et al. 2977.
B. breynei: Breyne 3155, Breyne 3183.
B. congensis: Kibungu Kembelo in Wieringa 3466 (flowers) & 3467 (pods).
B. coriacea: Morel 130.
B. durandii: Breteler, Jongkind & Wieringa 12820, de Saint Aubin 2003.
B. evrardii: Descoign 7627.
B. grisea: Breteler, Wieringa & Nzabi 13334.
B. le-testui ssp. *le-testui*: Wieringa & Nzabi 2775, Wieringa et al. 3130.
B. le-testui ssp. *mayumbensis*: Sita 4547.
B. media: Wieringa et al. 3180.
B. pellegrinii: Breteler, Wieringa & Nzabi 13195.
Brachystegia stipulata: Breteler 11824, Breteler 12000.
Icuria dunensis: Dold 3362.
Julbernardia brieyi: N. Hallé & Cours 5855, L. White 1595.
J. globiflora: Breteler 11805, Pardy 4597, SF 83.
J. hochreutineri: Le Testu 7184.
J. paniculata: Schmidt et al. 1435.
J. pellegriniana: Breteler, Wieringa & Nzabi 13285, Le Testu 7339.
J. seretii: Le Testu 7487, Troupin 4456.
Michelsonia microphylla: Leonard 1768 (pods), Michelson 882, Michelson 1068.
Microberlinia brazzavillensis: Wieringa 2516.
Oddoniodendron micranthum: Breteler 7653.
Tetraberlinia baregarum: Michelson 520b (pods).
T. bifoliolata: Breteler, Wieringa & Nzabi 12928 (pods), Sita 4137, Wieringa & Haegens 2328, Wieringa & Haegens 2458; J. de Wilde 8374.
T. korupensis: Thomas 4723.
T. longiracemosa: Chevalier 26935, Wieringa & Nzabi 3270.
T. moreliana: Wieringa & Epoma 1608.
T. polyphylla: Fleury in Chevalier 26690, McPherson 15436.
T. tubmaniana: Bos 1889, J. de Wilde & Voorhoeve 3836.

Table 6.1. Data matrix of morphological analysis and results from the TLC study.

	1	2	3	4	5	6	7	8	9	10		
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234	
Aphanocalyx margininervatus	2110210100	1010100120	02031?0010	10?2142100	2001105201	0110012033	3300000121	000000271?	000100?001	1501101040	1101	00000000000000
A. djumaensis	2110210100	1000000020	01031?0000	10??042100	2001005200	1110011032	3200??033?	0000?0?510	1001001001	1201000020	1113	00000000?00000
A. richardsiae	2110210100	1010000020	02031?0000	10?2031100	1001106200	11000?1032	3200001220	0000000310	?0?111?001	1301201010	0112	00000000000000
A. microphyllus microphyllus	2110210100	1011500021	01031?0000	0052031100	1001006200	2110012032	330?001330	0000002310	10?1011001	1101100010	0102	0000?0?0000000
A. microphyllus compactus	2110210100	1011500021	01031?0000	0042031100	1001106200	1110011032	320000133?	0000002320	10?101?001	1301200010	0102	00000000000000
A. trapnellii	2?10210100	1010400021	01031?0000	0052040100	1001104200	0110022032	330000033?	0000002320	000110?001	1201200010	1103	00000000000000
A. ledermannii	2110210200	1011400021	01031?0100	0062042100	1001106200	1110012021	32001?133?	0000002420	100101?001	1201100010	0102	100000000?0000
A. obscurus	2111221300	10015010?1	?1031?0100	0052040100	1001002200	411?011021	3200??133?	0000?00120	1001011001	1302200012	0102	00000000010000
A. pteridophyllus	?110221300	1002500021	00031?0100	0032042100	1001105200	511?011021	2200111331	0000002520	?001011001	1102200012	0102	00000000000000
A. pectinatus	2?11221300	1011501001	?1031?010?	0052041100	1001105200	211?011032	3200100230	0000000320	100100?001	1302?0???2	0101	00000000000000
A. jenseniae	??10220201	101130002?	01031?0100	10???40100	1001106200	311?011021	1100111130	0000000410	100101?001	140??0????	???1	00000000000000
A. heitzii	1120210102	1011500220	0203111000	0102010000	0001005200	9201025022	2100011120	0101100241	1111021003	1101200130	2101	00000000000001
A. hedinii	112021??02	10??600001	?203111000	0132040000	0001101200	5100026021	1100011220	010?100231	1??102?002	1001400020	3?01	00000000000001
A. libellula	??20?1??02	????400220	0203111100	0102?20000	0001103200	7201025022	2100011120	010?110341	111102?003	100??0????	???3	00000000000000
A. cynometroides	2110210100	1011100120	0101110110	10?2142100	2001104201	1110011033	330??0033?	0000002510	1001101101	1001001012	0112	00000000010000
Bikinia media	1120010100	0110400020	0001110000	1071022001	1000102210	2211014022	320110133?	0000?00421	0101002102	1911500152	7001	10010011000000
B. congensis	?120010100	0110400020	0001110000	1061020001	1000102210	2201013022	3201102220	0000000220	010210?102	1411400131	8001	10010011000010
B. grisea	1120010100	0111400020	1001110000	1041022001	1000104210	2201015022	3201101220	0100012220	0112102101	1712400140	7001	10000110000000
B. breynei	1020010100	0110000220	?101110000	10?0022001	1000101210	2211014022	320010133?	0110010421	011310?111	1511400151	8001	11000111000000
B. evrardii	1120010100	0111300021	0001100000	2212010001	1000102210	1211013022	3200101220	0110012220	110210?111	1512500052	7102	01001011000000
B. durandii	1120010100	0112400221	1101110000	2002020001	1000104210	6211016022	320211233?	0100012221	1113102101	1811400152	9001	10001011000010
B. le-testui le-testui	1120010100	0112500010	1101100000	2232020000	1000003210	3201014022	3200101330	0100012321	1111102102	1913500142	8101	01001011000010
B. le-testui mayumbensis	1120010100	01?2500010	1001100000	2042021000	1000004210	2211013022	320010133?	0100012321	011210?101	1813?00?52	???1	0?001011000000
B. pellegrinii	1120010100	0111500020	0001110000	2072022000	1000104210	0211013?22	3200101220	010000?421	0112002101	1712400041	7001	?0000011000000
B. coriacea	1120010100	0111500021	0101100000	1042010000	?000101210	2211014022	2200111120	0100012?21	111310?110	15?1500052	80?1	00001011000000
B. aciculifera	1120010100	0110500021	0101100000	1042010000	1000004210	2211016022	330?11133?	0100?12321	1113102100	1911400142	8001	00001011000010
Icuria dunensis	1?20010100	0112100010	0101100000	10?2020000	?00000????	?2110?????	??????????	??????????	???????1?2	1??13?01?2	????	00000000010010
Tetraberlinia longiracemosa	1120010300	0011500020	0001010000	0070021000	10?0001200	1211013011	1101001111	1111011310	1011001102	1101300030	5101	000010110000?0
T. bifoliolata	1020110101	00?0100020	01?1110000	10?1012011	0010011100	6201024020	1102?00111	0101010520	1012001102	0103410150	60?1	0100101?0?0010
T. tubmaniana	1020010100	0000300020	00?1010000	10?1020011	1110112200	3201024121	1002111111	0111010510	001200?101	0002400180	5111	00000011000010
T. polyphylla	1120010101	0010400020	0001010000	1041020001	10?0023200	4211014110	1001001112	112?010520	001100?103	0002400140	6??1	00001011000010
T. moreliana	1020020300	0011400020	0101110000	1032021000	1000023200	6200125112	2202?01111	0101011520	1011101102	1002310140	6101	01101011000010
T. korupensis	1020010301	0010400020	0101110000	1031010001	1000023200	2200124112	2102?01111	0100011320	101100?101	1002310060	61?1	01101011000010
T. baregarum	1?20?1???1	??0?400011	1001010?00	1041??????	?0????????	??????????	??????????	??????????	?????????2	???13001?0	???1	10001011000010
Michelsonia microphylla	1120010110	0000400012	?001010000	0050010001	0000100000	0111011021	1100000000	0000202510	100100?101	1601400040	???1	000000??000000
Julbernardia brieyi	1120110102	0001300021	?311110000	10?1020011	0000109100	4201022031	1110?01111	0000000321	?11100?102	1301001120	7102	00000000011100
J. globiflora	???0110102	0012300200	0301010101	0001021011	1000121110	42100?2031	1110??1010	0000000221	011110?102	1502001122	510?	0000101?0?00?0
J. seretii	1120010101	0000200021	?3111101?0	10?1021011	1000128000	82100220?1	1100?01110	0000000220	101110?002	1102?0?010	6002	000000?0?110??
J. pellegriniana	1120210101	0002000020	0301110110	00?1020011	1000026200	3201023031	1110012111	?000100321	0112101102	1512?0?120	5101	000000?00?000?
J. hochreutineri	1?20010101	001020002?	?311110000	10?0?20011	000012900?	9200022031	1100002111	000?000521	101100?102	1402?00120	???1	?0000000110001
Microberlinia brazzavillensis	?020010110	0000400011	?101010000	0000?20000	1010002000	42?0019021	1100001110	0000000120	0012001003	1201201140	5101	000000?0010000
Oddoniodendron micranthum	?120220102	000011000?	??01110100	20?0022001	1000004000	1000014?10	0000110000	0000100700	00?1001102	1011?00062	??03	000000000?0000
Brachystegia stipulata	??20120312	00?2300220	0211110101	0?01021010	1000101000	9000211?22	2200?033?0	????0??520	0001001104	01?2?00110	4?0?	000000?0010000
Berlinia bracteosa	?120210102	0002300000	?001110100	00?1030000	1000021001	9100015031	1100001000	0110000210	0001101113	12?2?00110	???2	??????????????

6 Phylogeny

6.1 Introduction

There are at least two reasons for trying to reconstruct the phylogeny of a group. The first is the purely scientific curiosity about the history of the development of a group. If we know this, we might be able to understand more about the historical background of the distribution of the species, or estimate whether or not certain features are homologous.

The second reason is that we need the phylogeny of a group for its classification. Modern classifications are supposed to be 'natural', i.e. based on the phylogenetic relationships of the group.

The morphological study of the genera *Aphanocalyx, Michelsonia, Monopetalanthus* and *Tetraberlinia* has produced answers to several questions. It revealed the existence of several so far undetected species and enabled the arrangement of species in several groups of closely related taxa. Within such groups resemblances are so striking that there was no doubt about the phylogenetic affinities of the species concerned. Of some of these groups it was evident that they were in some way related to each other, but the degree of 'kinship' was not clear.

The main problem lies with characters that point to different directions of kinship. Some characters seem to group species in a way that is contested by other characters. Apparently at least one of such characters does not reflect phylogenetic relationship, but it is hard to tell beforehand which one it is. In cases where most characters point in the same direction, one does not need many characters to establish a basic picture of the phylogeny of a group, nor is it difficult to establish such a phylogeny. In this case, however, the number of characters pointing in different directions is so large that it is almost impossible to extract a general pattern at first sight.

If two species share a certain character state, this can have three explanations. 1) The shared state is derived through a common ancestor, and thus the character tells us something about the phylogeny of the two species. 2) The two species have some kind of shared circumstance (i.e. ecology, pollination) which made the development of the same character state beneficial (convergence). 3) Mere chance.

Since we are interested in the phylogeny of the group, we need some method that considers only the characters which originate through explanation 1 and rules out those that originate by 2 and 3. By using many different characters, we can rule out the effect of 3. Since chance will have a random distribution, all those groupings based on a random process will cancel against each other. The effect of 2 is slightly more difficult to eliminate. However, as long as the circumstantial similarities between two unrelated species and the difference in that circumstance with other species is not too extreme, the effect on the number of shared states will probably also be not very extreme, and may be ruled out by using sufficient characters. In the group under study no extreme differences in ecology are present. Most species occur in rain forest, some species grow in savanna country, but are restricted to gallery forests. As described in chapter 3, some different lines of pollination biology seem to be developing. The amount of radiation, however, is not (yet) very large. If these circumstances will cause any effect, these will probably be limited to only a part of the characters (leaf characters for ecological factors, floral characters for pollinator adaptations). For the present group, we may assume that by utilizing sufficient characters, we will be able to obtain a fairly reliable picture of the phylogeny of the group.

Since we are trying to establish natural groups above the species level, a cladistic analysis seems most appropriate. The theoretical background of this method is the more adequate, even though phenetic approaches at least under some conditions seem to perform better when trying to reconstruct a phylogeny (Heijerman, 1995; Wieringa, 1991).

6.2 Outgroup

The morphological analysis provided no evidence that the group under study constitutes a monophyletic group. No shared apomorphic characters were found. On the other hand several characters seem to offer means to define a few groups of species. This implies that we are dealing with a number of, putatively monophyletic groups of which it is not clear whether they also form a monophyletic group as a whole.

Therefore choosing an outgroup is not easy. Some taxa chosen for this purpose might eventually prove to belong to the ingroup. Another problem in this particular case is the availability of a large number of genera as a potential outgroup. The lowest well-defined grouping, above the group-level mentioned above, is the tribal level. When Breteler (1995) erected the Macrolobieae he included 22 genera, to which he recently added the genus *Humboldtia* (pers. comm. Breteler, 1998). Since 4 of these genera are treated here, that leaves us with 19 genera as potential outgroups. Based on a morphological study, Wieringa (1997) considers *Julbernardia* as fairly closely related to *Tetraberlinia*, so that it is more likely to form an ingroup. Using molecular methods, Bruneau et al. (1997; pers. comm. 1998) have studied 13 of the 19 potential outgroup genera, together with a few taxa belonging to what is treated here as *Aphanocalyx*, *Tetraberlinia* and *Bikinia*, and many genera from other tribes. This study shows that a number of genera (*Anthonotha*, *Brachystegia*, *Julbernardia*, *Microberlinia* and *Oddoniodendron*) might either be an ingroup or an immediate outgroup to *Aphanocalyx*, *Bikinia* and *Tetraberlinia*. Genera more likely to constitute an outgroup are *Berlinia*, *Gilbertiodendron*, *Didelotia* and *Librevillea*. A problem that remains is that in the study of Bruneau et al. not only 6 outgroup Macrolobieae-genera have not been considered but also that *Michelsonia* was not included. *Michelsonia* has a rather primitive flower morphology, which might point to a fairly basal position of this genus in the tribe.

As a result of these considerations, several species of *Julbernardia* and one species each of *Berlinia*, *Brachystegia*, *Microberlinia* and *Oddoniodendron* have been selected and incorporated in the phylogenetic analyses. Since molecular data suggested that of these genera only *Berlinia* can be considered as a real outgroup, this taxon was always used to root the results of the analyses.

6.2.1 Rough descriptions of species used as potential outgroup.

The following descriptions are based on a limited amount of material, and should not be considered to be proper species descriptions. They do not include all the characters that have been coded. They show some characters of special interest for a species and the most important minimum and maximum values which are needed for several characters. Because most of these quantitative characters are not used in an absolute way but in an index (relative size), the sizes are given in rather precise values. This will prevent errors based on using rounded off values, but it does not necessarily merit the variation present in these species! Most characters not included can be derived from the data matrix.

All cited material refers to WAG specimens, unless stated otherwise. Other material that has been consulted as well, fell within the variation of the specimens cited.

Berlinia bracteosa Benth.

Stipules caducous, fused, 14–18 cm long, velvety outside, glabrous inside, leaving a ridge next to the petiole. Leaves 3–6-jugate.

Inflorescence axillary on the terminal 1–2 nodes. A simple raceme, rarely branched at base, 30–70-flowered. Pedicel 14–35 mm long. Bracteoles 39–88 mm long. Hypanthium 11–21 mm high. Sepals 5, free, both sides glabrous. Adaxial sepals 20–50 mm long. Lateral sepals 21–46 mm long. Abaxial sepals 24–48 mm long. Petals 5, white with greenish veins. Adaxial petal 53–98 mm long. Lateral petals 45–98 mm long, outside with indumentum along central axis only, inside glabrous. Abaxial petals 46–93 mm long, indumentum as in lateral petals. Stamens 10, filaments 54–100 mm long, 9 united for 3–7 mm, outside pubescent. Anthers 2.7–3.4 mm long. Ovary never depauperate, with 4–7 ovules, style 57–66 mm long, inserted at an angle of 30–40°, stipe 26–30 mm long.

Pods 4–6-seeded, 27–42 x 9–14 x 0.6–1.0 cm, upper suture winged, 13–22 mm wide, beak 4–8 mm long, stipe 25–35 mm long, pedicel c. 30 mm long.

Material studied: *Bos 4857, Breteler & de Wilde 258, Breteler, Jongkind & Wieringa 11138 & 11285, Gentry 33501, McPherson 16186, Reitsma, Reitsma, Breteler & Louis 1108, Satabie 672, Schoenmaker 386, Thomas 5715, Wieringa 1213, Wieringa & v.d. Poll 1456, Wilks 959 & 1192.*

Brachystegia stipulata De Wild.

Stipules persistent, fused at the very base of the distal side, linear, with reniform, auriculate base. Leaves 4–10-jugate. Leaflets slightly emarginate at the apex, proximal base not auriculate.

Pedicel 4–9 mm long. Bracteoles 13–20 mm long. Hypanthium 1.0–2.0 mm high. About 8 sepals present, it is difficult to establish whether the most adaxial one is fused or not: 2½–5 x 1½–4½ mm. The abaxial one is usual easy to find: 3½–6½ x 2–4½ mm. Since all other sepals could be considered as 'lateral sepals' it is hard to tell which is homologous with the two lateral sepals present in other species. However, all are about the same size: 2½–5 x 1½–3 mm. Adaxial petal wanting. Lateral petals often wanting, up to 5 x 1.0 mm. Abaxial petals sometimes wanting, up to 4 x 1.2 mm. Stamens 16–23, filaments 23–39 mm long, all united over 1.7–4.7 mm. Anthers 1.4–2.1 mm long. Ovary never depauperate, 6–8 x 2.0–2.5 x 0.8–1.3 mm, with 7–9 ovules, style 20–36 mm long, inserted at an angle of 0–40°, stipe 2–8½ mm long.

Pods c. 5-seeded, 10–14 x 3–4 cm, upper suture winged, c. 10 mm wide, beak 5–7 mm long, stipe 5–9 mm long, pedicel 7–14 mm long.

Seedlings not studied, phylogenetic coding based on Léonard (1957: 252).

Material studied: *Bingham, Chikuni & Zimba 11190, Breteler 11820, 11824, 11829, 11864, 11968 & 12000, Goldblatt 4559, Harder et al. 2216, Lisowski 92083 & 92089, Malaisse 13365 & 13365, Pawek 13600.*

Julbernardia brieyi (De Wild.) Troupin

Stipules partly fused along distal margin, not auriculate. Leaves 2–7-jugate. Leaflets in proximal half without an auricle at base.

Pedicel 7–13 mm long. Bracteoles 7–10 x 5–6½ mm. Hypanthium 1.1–1.4 mm high. Adaxial sepals free, 3.2–4.5 x 2.7–3.1 mm. Lateral sepals 3.4–4.1 x 2.2–3.1 mm. Abaxial sepal 3.8–5.2 x 2.5–3.9 mm. Adaxial petal 6½–7½ mm. Lateral petals rarely wanting, up to 3.4 x 2.0 mm. Abaxial petals sometimes wanting, up to 3.0 x 1.1 mm. Stamens 10, filaments 10–17 mm long, 9 united over 1.3–2.1 mm. Anthers 1.5–1.8 mm long. Ovary never depauperate, 2½–3½ x 1.3–2.0 x 0.7–1.4 mm, with 3–4 ovules, style 8–15 mm long, inserted at an angle of 20–60°, stipe 0.9–1.0 mm long.

Pods 9–16 x 3.2–6.0 x 0.4–0.6 cm, upper suture winged, 6–7 mm wide, beak 5–9 mm long, stipe 3–7½ mm long, pedicel 7–11 mm long.

Seedling: Hypocotyl 4–9 cm long. Epicotyl 5½–13 cm long. First pair of leaves opposite, (3–)4-jugate. Subsequent leaves alternate, gradually increasing in leaflet number.

Material studied: *Breteler, Jongkind & Wieringa 11249, Hallé & Cours 5855, Sita 4092 & 4823, Wieringa & v.d. Poll 1424, 1425, 1440, 1453 & 1459, White 1524 & 1595, Wilks 1924 & 2553.*

Julbernardia globiflora (Benth.) Troupin

Stipules partly fused along distal margin, not auriculate. Leaves 4–7-jugate. Leaflet margins shortly ciliate, apex usually emarginate, proximal base without an auricle.

Pedicel 2.3–4.8 mm long. Bracteoles 7–11 x 5–7½ mm, inside glabrous to pubescent. Hypanthium 0.6–1.2 mm high. Sepals outside glabrous to puberulous or pubescent, inside glabrous to pubescent or villous. Adaxial sepals free, 2.2–4.0 x 1.5–2.1 mm, 3.1–4.3 mm high including the hypanthium part. Lateral sepals 2.0–4.6 x 0.8–2.2 mm. Abaxial sepals 2.1–3.9 x 1.2–1.8 mm. Adaxial petal 5½–9 x 4–6 mm, glabrous, apex sometimes sparsely ciliate. Lateral petals 3–9 x 0.6–3.0 mm, apex often ciliate. Abaxial petals 2–8 x 0.4–2.2 mm, apex often ciliate. Stamens 10, filaments 9–16 mm long, 9 united over 1.6–3.9 mm, lateral ones sometimes additionally united over up to 1.2 mm. Anthers 1.4–2.1 mm long. Ovary 1½–4 x 1.2–2.0 x 0.7–1.5 mm, the smaller ones possibly depauperate, with (2–)4 ovules, style 4–12 mm, inserted at an angle of 30–90°, stipe 0.7–2.0 mm long.

Pods 4–7½(–11) x 1.5–2.6 x 0.2–0.3 cm, upper suture hardly winged, 1–2 mm wide, lateral nerve elevated up to 2 mm from the surface, running very close to the upper suture, u/w = 0.04–0.15, beak 3–6½ mm long, stipe 3–5½(–8½) mm long, pedicel 1½–7 mm long.

Seedling: Hypocotyl 2½–4 cm long. Epicotyl 1½–3½ cm long. First pair of leaves opposite, 2-jugate.

Material studied: *Bingham 7750, Boaler 852, Breteler 10043, Breteler 11794, Chapman & Chapman 9492, Lisowski 92494, Lovett & Kayombo 457, Lovett & Kayombo 4394, Macitela 56, Malaisse 12231, Pawek 9635, Veldhuizen 1427.*

Julbernardia hochreutineri Pellegr.

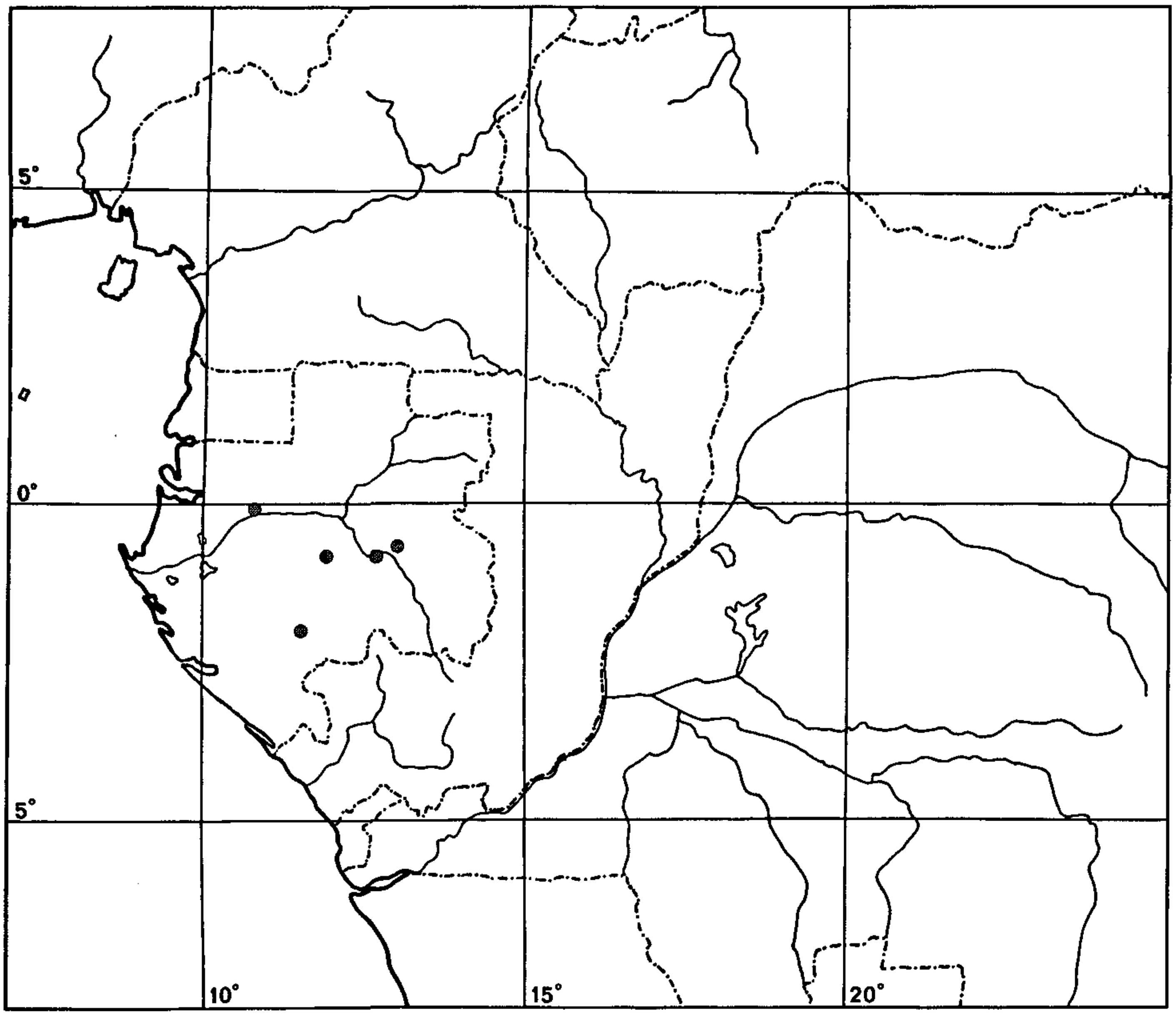
Stipules free. Leaves (1–)3–4-jugate. Rachis glabrous on both sides. Basal leaflet in the proximal half with 1 gland, in the distal half with 0–1 glands.

Pedicel 14–31 mm long. Bracteoles 14–16 x 7½–11 mm. Hypanthium 0.9–2.1 mm high. Adaxial sepals 4½–6½ x 4–5½ mm, including the part fused with the hypanthium 6–7 mm high. Lateral sepals 4½–7 x 3–4 mm. Abaxial sepals 4½–8 x 4–5 mm. Adaxial petal 9–11½ x 5–9 mm. Lateral petals 4½–7½ x 0.9–1.8 mm. Abaxial petals 3–4½ x 0.8–1.1 mm. Stamens 10, filaments 25–29 mm long, 9 united at base over 3.3–3.6 mm, adaxial one free, anthers 1.7–2.1 mm. Ovary never depauperate, 5–6½ x 2.2–3.1 x 1.3–1.6 mm, with 2–4 ovules. Style c. 15 mm long, inserted at an angle of 10–90°. Stipe 2.4–3.1 mm long.

Pods 1–4-seeded, 13–21 x 5–6½ 0.5–0.6 cm, glabrous, upper suture clearly winged, 9–14 mm wide, lateral longitudinal nerves absent, with many transverse nerves, beak 3–9 mm long. Stipe 4–16 mm long. Pedicel 15–29 mm long.

This species is rather poorly know, but since it is the type species of *Julbernardia* it has been included nevertheless. The pods are described here for the first time. Since some new records have become available, a map is presented here also (map 6.1).

Material studied: *Breteler & Breteler-Klein Breteler 13009, Breteler, Jongkind & Wieringa 11330, Dibata 1184, Le Testu 6543, 7184* (P, WAG) & *7556.*



Map 6.1. Distribution of *Julbernardia hochreutineri* Pellegr.

***Julbernardia pellegriniana* Troupin**

Stipules fused, caducous. Leaves 1-jugate.

Pedicel 4–8½ mm long. Bracteoles 6½–8½ x 6½–8 mm, inside very long villous. Hypanthium s. str. 1.1–1.9 mm. Sepals free, outside glabrous (sometimes a few hairs present at base), inside long pubescent, margins long ciliate. Adaxial sepals free, 3.0–4.2 x 2.5–4.0 mm, inflexed over adaxial stamen and petal like the wings of a swan. Lateral sepals 2.9–3.8 x 1.8–2.5 mm. Abaxial sepals 3.0–4.4 x 2.4–3.5 mm. Petals inside pubescent. Adaxial petal 1.3–5.7 x 1.1–4.4 mm, white. Lateral petals 1.2–2.1 x 0.4–0.9 mm. Abaxial petals 0.8–1.9 x 0.3–0.8 mm. Stamens 10, filaments 10½–13 mm long, 9 united over 1.0–1.5 mm, the lateral ones united over another 0.4–0.6 mm, glabrous, but inside the hypanthium part at base sometimes pubescent, the adaxial stamen free, in basal part geniculate, causing it to protrude from between the bracteoles adaxially, sparsely puberulous at base; anthers 1.2–1.9 mm. Ovary 2–5-ovulate, 2–4 x 1.1–2.1 x 0.6–1.2 mm (maybe some of these ovaries are depauperate), stipe 1.1–2.1 mm, style 6½–9½ mm, inserted at an angle of 30–90°.

Pods 11–14 x 3.6–4.4 x 0.4–0.7 cm, upper suture distinctly winged, 7–13 mm wide, beak obsolete to distinct, 1–10 mm, stipe 2½–5½ mm, pedicel 3–9 mm long.

Seedling: Hypocotyl 5½–13 cm long, long velvety. Epicotyl 4–9 cm long, velvety.

Material studied: *Breteler, Jongkind & Wieringa 11001, Breteler, Wieringa & Nzabi 13285, Breyne 578, Le Testu 7339* (P), *Leeuwenberg 9155a & 12443, Leeuwenberg & Berg 9833, Louis, Breteler & de Bruijn 640, Wieringa & Haegens 2278, 2284 & 2285, Wieringa & v.d. Poll 1469, 1547 1581 & 1582, Wilks 1487.*

***Julbernardia seretii* (De Wild.) Troupin**

Tree. Trunk straight, cylindrical.

Stipules free, margins tomentose. Leaves 2–3-jugate. Rachis on lower side hairy, glabrous above, with a grooved midrib above.

Pedicel 6–20 mm. Bracteoles 10–14½ x 7½–14 mm, not fused with the hypanthium, but bracteoles at base fused with one another over a small length. Hypanthium s. str. 1.2–1.8 mm. Sepals outside usually glabrous, sometimes hairy, inside glabrous, margins ciliate. Adaxial sepals 3½–6 x 2½–6½ mm, including the hypanthium part 4½–7½ mm high, usually free, sometimes almost completely fused. Lateral sepals 4–6 x 2–4 mm. Abaxial sepals 4–7½ x 2–5 mm. Petals white, glabrous. Adaxial petal 10–16 x 3½–7 mm. Lateral petals 2.3–4.2 x 0.5–1.3 mm. Abaxial petals 2.1–4.2 x 0.3–0.8 mm. Stamens 10, filaments 12–18 mm long, 9 united at base over 1.7–3.5 mm, adaxial one free, but fused at base with the stipe, anthers 1.7–2.5 mm. Ovary never depauperate, 3–6 x 1.9–2.8 x 1.5–1.9 mm, with (2–)3–4 ovules. Style 14–15 mm long, inserted at an angle of 0–40°. Stipe 1.1–2.2 mm long.

Pods up to 4-seeded, upper suture clearly winged, 6–16 mm wide, no lateral nerves present, beak fairly indistinct. Stipe 4½–6 mm long.

Seedling: Hypocotyl 5½–8 cm long. Epicotyl 6–10 cm long. First pair of leaves opposite, 1(–2)-jugate. Subsequent leaves alternate, also 1(–2)-jugate.

Material studied: *Le Testu 7487, Léonard 3331 ter* (BR), *Mpom 1796, Reitsma & Reitsma 1492, Reitsma, Reitsma & Mezui 2602, Thomas 5713, Troupin 4430, Wieringa 1700, J. de Wilde 8203, 8283A, Wilks 1580, de Winter 60.*

***Microberlinia brazzavillensis* A. Chev.**

Leaves 5–14-jugate. Leaflets in proximal half at base without an auricle, in proximal half without glands, in distal half usually with 1 gland.

Pedicel 2–5½ mm long. Bracteoles 7½–10 mm long, on the adaxial side united over most of its length. Hypanthium s. str. 3.9–4.6 mm high, on inside sparsely pubescent/velvety. Sepals both sides and margins glabrous. Adaxial sepals almost completely fused, 4.7 x 2.7–3.0 mm. Lateral sepals 4.2–4.8 x 1.2–1.3 mm. Abaxial sepals 4.7–5.1 x 1.5 mm. Adaxial petal 6.4–6.6 x 2.8–3.2 mm, outside glabrous, inside sparsely pubescent, margins glabrous. Lateral petals 6.3–6.8 x 1.9–2.2 mm. Abaxial petals 6.7–7.2 x 2.0–2.4 mm. Stamens 10(–12), filaments 8½–10½ mm long, 9(–11) united over 1.4–1.7 mm; anthers 1.2 mm long. Ovary c. 3.4 x 1.4 x 0.8 mm, with 5–6 ovules, stipe c. 5 mm. Style c. 7½ mm long, inserted at an angle of 20–40°.

Pods: stipe 9–11 mm long, pedicel 2–5 mm long.

Seedling: Hypocotyl 3–8½ cm long. Epicotyl 3–6½ cm long. First pair of leaves opposite, 8–11-jugate.

Material studied: *Wieringa & v.d. Poll 1326 & 1327, Wieringa 2516.*

***Oddoniodendron micranthum* (Harms) Baker f.**

Stipules distally fused, persistent (at least for a while), forming a small cap clasping the twig, glabrous. Leaves with 1–4 alternating leaflets.

Bracts very early caducous, inside glabrous. Pedicel 2½–4½ mm long. Bracteoles

5.1–6.0 x 3.8–4.4 mm. Hypanthium 1.0–1.5 mm high. Sepals outside puberulous, inside pubescent to villous. Adaxial sepals completely fused, 4.9–6.5 x 3.7–5.4 mm. Lateral sepals 6.0–7.9 x 2.6–3.8 mm. Abaxial sepal 5.4–6.6 x 3.2–5.1 mm. Petals glabrous outside, villous inside but glabrous along the margins. Adaxial petal 7.5–9.5 x 2.7–3.6 mm. Lateral petals 7.6–9.7 x 2.6–4.0 mm. Abaxial petals 7.7–10.1 x 2.8–3.6 mm. Stamens 10(–11), filaments 9–16 mm long, free; anthers 1.2–1.5 mm long. Ovary sometimes depauperate, with 2–3 ovules, stipe 1.5–2.9 mm long. Style 10–11 mm long, inserted at an angle of 0–30°.

Pods c. 11–15 x 4–5 cm, densely covered by silky hairs, beak 3–4 mm, stipe 8–10 mm long.

Seedling: Hypocotyl not developed, cotyledons at ground level. Epicotyl not definable because the first leaves alternate and no trace of an opposite pair is evident.

Material studied: *Breteler 7653, Breteler, Jongkind & Wieringa 11224, J. de Wilde 7668, 8205 & 8288A.*

Oddoniodendron contains one or a few new species (Breteler pers. comm.), at present often identified as *O. micranthum*. The description as given here is based on a limited amount of material, supposed to belong to the real *O. micranthum*. Only the seedlings (*11224*) have not been identified definitely, but are likely to belong to this taxon as well.

6.3 Coding

6.3.1 Continuous and discrete

Traditionally characters are divided into 'discrete' and 'continuous' ones. For the great majority of characters I find this division artificial, at least in case of an analysis at the species level. Only for a very limited number of characters can one really speak of a discrete variation. Such characters will usually be caused by the presence or absence of a single gene. Being based on a single gene does not make such a character a very good one, as such characters will be highly sensitive to changes caused by a single mutation, hence such characters may become quite variable within a species. Only in analyses at a high taxonomic level will one find 'discrete' characters which are based on numerous genes and which are very essential for the taxa under study (i.e. number of limbs, absence / presence of flowers or a spinal column). Such characters usually consist of many small characters (genes) forming one single system or structure. Each one of such smaller characters is essential for the entire structure and thus for the existence of the species and will be much less liable to mutation. Still, these kind of 'discrete' characters were the ones Hennig most probably had in mind when he developed the cladistic method. When analysing groups of related species, complexes of this kind of characters will not be variable within the group.

The fact that many characters can be coded discrete is often an artifact caused by the limited number of species used in such an analysis. Whenever new species are added to the analysis, gaps tend to be filled or 'new' intermediary states are discovered. A good example of such a 'nice' discrete character is provided by the dorsal teeth on the anthers of the three species of *Aphanocalyx* subg. *Antherodontus* (*A. heitzii*, *A. hedinii* and *A. libellula*). These teeth are really very pronounced and form a striking feature of these species. However, in other species of *Aphanocalyx* very small teeth may occur. Some species never show teeth at all, others always show small bumps or even small teeth, moreover there are species with small teeth in some specimens where they are absent in others. Apparently the evolution of this character was not instantaneous, but the teeth slowly developed with a lot of intermediary stages. This is not a surprise, it is exactly how most people usually perceive evolution (and is what the word means: characters evolve). Another example of a character which is usually considered to be solidly discrete: petal colour, particularly where yellow contrasts with not yellow. In the present study even this character proved to be less discrete than it is usually considered to be. In some species of *Tetraberlinia* the adaxial petal is yellow. However, in *Tetraberlinia moreliana* only the apical quarter of this petal is yellow. This character was scored as 'yellow present' or 'not present' in the petal, resulting in such partly yellow petals being coded as 'yellow'. However, when a species of *Tetraberlinia* would have shown a rather reduced, white, adaxial petal, one should have wondered whether this was caused by an absence of the possibility to produce the yellow colour, or by the absence of a developed apical part to show the character. In the latter case it has been scored already as a reduced adaxial petal.

As Thiele (1993) has pointed out, there are two types of 'discrete' character states. The first concerns true discrete character states such as booleans ('absent' and 'present') and states that are always integers (i.e. petal number). The second type consists of discrete quantitative states which are caused by a disjunction in a continuous variable ('leaves 1–4 cm' versus 'leaves 30–80 cm'). One can imagine that the second type of discrete characters will easily fall apart when species with intermediate ranges are found. However, the first type is also not immune to the occurrence of intermediate states. For example when a certain structure is only slightly developed or absent in some individuals of a species (the anther teeth in our case). Boolean states are likely to fail to be truely discrete when they are coded by more than one gene, or when a single gene is not fixed in some of the treated species. Also integer values can fail to be true discrete states because species (or even specimens for that matter) can possess a range of different integers for such a character. For instance the number of leaflet pairs is variable in most species studied here, but it is a very valuable character for separating species. If one considers that this character varies between species from 1 to 57 pairs it is likely to be informative about the phylogeny of a group as well.

In the present analysis many characters would have had apparently discrete states when only a few species would have been included or when only a limited amount of material per species would have been checked. Often one can solve these problems by reformulating the states (e.g. stipules: 'free or only partly fused' and 'completely fused' instead of three states), but this is closing one's eye to the reality of nature.

Ultimately (with sufficient species added) most characters will prove to be continuous in one way or another.

Some authors (i.e. Pimentel & Riggins, 1987 and Crisp & Weston, 1987: 67) argue that one should use discrete characters only in a cladistic analysis, and abolish the use of continuous ones. As I have argued above, I find the distinction arbitrary, and the discarding of continuous characters unacceptable. The more taxa one includes in an analysis, the more characters one needs to construct a cladogram. If the inclusion of extra taxa would imply loosing characters because they become continuous, this would have a devastating effect on the applicability of cladistic methods for larger groups of species.

6.3.2 Methods for coding continuous characters

A problem which continuous data does raise is that one needs a method to code it. Various methods have been proposed for coding continuous characters, e.g. coding according to

Almeida & Bisby (1984), generalized gap coding (Archie, 1985), segment coding (Chappill, 1989), gap weighting (Thiele, 1993), finite mixture coding (Strait, Moniz & Strait, 1996). Each of these methods has its merits but not to the same extent.

In all methods, except that of Thiele, the codes assigned to a species depend on the values found in other species. This means that for all these methods one has to re-assign codes after adding a further species. In gap weighting this only has to be done when the new species shows a value outside the range of values encountered so far. For a given character this happens on average only about once per doubling of the number of taxa. Code reassignment is not only a practical disadvantage, it also forms a theoretical problem: Why should the character state of one species be dependent on the situation in other species? In 'discrete' characters this is not the case. Only with gap weighting is the state assigned to a species more or less independent from other species. Only when the total range of a character changes (see above), differences between species become less pronounced, but because on the average this will happen with all characters, the eventual effect remains the same.

Another disadvantage of some methods is that different states might collapse into one with the inclusion of additional taxa. This is certainly true for the method of Almeida & Bisby, and might be true for finite mixture coding, although the latter method might also distinguish more states when more taxa are concerned. This kind of dependence of species upon each other, i.e whether species 'a' has the same state as species 'b' might depend on species 'c', is strange and undesirable, especially when species 'c' is hardly related to 'a' and 'b'.

A third disadvantage of some methods is that they rely on a dataset that has been sampled in a statistically accountable manner. Although this is not a fundamental problem, it forms a substantial practical problem when dealing with poorly known tropical taxa. When a taxonomic study is performed on herbarium specimens one cannot presume that measurements are taken from a random sample. Collectors tend to collect the odd things. When confronted with a population of over a thousand herbs, they will try to make a sample of it including the smallest and if possible the largest plant. A nice example from *Tetraberlinia* is a collection of several tens of pod valves of *T. moreliana* collected by v.d. Burgt (*76*). For this collection he checked several hundreds of valves, only one of these showed 6 seeds and was subsequently added to his collection sample. From the point of view of the traditional taxonomist this is a very good method: when studying herbarium material he wants to see the total amount of possible variation of a species to be able to delimitate it and he will make a description which presents the minimum and maximum observed value for a given character. As a result data taken from herbarium sheets will tend to have a larger degree of variation than a random sample of that species. Therefore the σ_{n-1}^2 of a herbarium data sample will not be a good, unbiased estimator for the actual variance of that character within a species. Only when one samples all species randomly in the field, or when all species can be checked on several accessions present in experimental fields, can one be more confident of having a sound statistical background. Methods which suffer from this practical draw-back using herbarium studies are that of Almeida & Bisby, generalized gap coding, finite mixture coding and to a lesser extent segment coding. In the last case, by taking a smaller constant *c* for herbarium studies, one can compensate for the effect.

A fourth disadvantage of some methods is that all gaps present in the total range are treated similarly. Some methods like that of Almeida & Bisby and finite mixture coding only code states as separate when they are sufficiently distinct in some way, but they code the difference between barely separable states as well as extremely disjunct ones invariably as a single step as long as no intermediary states are present. Generalized gap coding will code barely differing species with zero to up to two steps, whereas it will code gaps no matter how large, with two steps. Farris (1990) rightfully claims that such a coding procedure, in combination with rescaling of the total character range, will obscure the true gaps. Moreover, I think it will also obscure the size of such a true gap. Only segment coding and gap weighting do not suffer from this disadvantage. It has to be noted that some authors (e.g. Farris, 1990) do not see this feature as a disadvantage, since they see any gap, no matter how large, as a single one, albeit always assigned one step. However, if any species, whatever its relation, with a value in the middle of a very large gap, would be added to an analysis, one would see that the earlier transition over the large gap turns at once into two steps. A posteriori we should now conclude that the gap represented two steps from the start. By not valuing the gap-size in the first place, we make our coding method vulnerable to what is treated here as the first possible disadvantage: the dependence of the coding of one species to the value of others.

I want to make one remark on finite mixture coding: a premise of this method is that continuous characters are in fact a continuous perception caused by environmental and other influences, on a series of discrete theoretical statistical populations, which can be revealed by sampling sufficiently. Most probably this is a rather nonsensical approach to most continuous characters, because if one samples long enough one will probably find that eventally each population of a species has its own statistical population somewhere on the long continuous line of possible values. And even when this is not the case one should question what the value of such a statistical population is in a biological sense.

After coding there is one other problem to be considered: how should one weight the total range of steps produced by the chosen coding method? Methods that try to locate 'real gaps' such as that of Almeida & Bisby and finite mixture coding suppose that they have found real states, and use these states in the same manner as those of other multistate characters. However, methods like generalised gap coding can easily produce more (ordered!) states than there are taxa in an analysis, and it is clear that each step in such a large range does not deserve a weight equal to a step from absent to present in another character. One could suppress the effect of these artificial multistate characters by rescaling them to a total range of one step. This is how the problem is usually treated when using generalized gap coding or gap weighting. However, when the character which is treated in this way is very variable, i.e. has a large range, we might (rightfully) code it into several distinct states weighting one step each under other circumstances (e.g. with less taxa when it still seemed to be a discrete character or when using finite mixture coding). My biological instinct tells me that the presence of a single pair of leaflets as opposed to about 40 pairs tells more about the phylogeny of a group than the transition from 'sepals hairy outside' to 'glabrous'. Segment coding has tried to find a solution for this dilemma by taking the total range of a character in account compared to the pooled within-group standard deviation of that character.

Using the standard deviation per species to decide how heavy a character should be weighted seems a good idea. Only it does presume that per species less variable characters have a larger phylogenetic information content than more variable characters, i.e. also if their total range is equal. Winter (1992) proved that this correlation is not always true, as he was able to create non-overlapping distributions of a fairly invariable call character of a plant hopper by bi-directional artificial selection in only five generations. This means each selection lineage has shifted about 2 times the standard deviation in only five generations. It shows that one should be careful about looking only at standard deviation; maybe one should also consider the total range of the character, preferably using a logarithmic scale.

Of the five coding methods compared, gap weighting is the only method which does not suffer from any of the disadvantages mentioned above, except that it does not provide a way to weight wide-ranged characters differently from those with a narrow range. According to Levin (1997) gap weighting and finite mixture coding are the best methods for coding continuous characters. Finite mixture coding performed slightly better in his tests, but given the practical and theoretical disadvantages of this method, I prefer gap weighting.

Most coding methods, including gap weighting, do have an effect on the resulting trees that should not be disregarded. Because they create minor steps the final result of an analysis is likely to contain far less trees when compared to an analysis using exclusively steps of an equal weight. Other trees, that are disregarded, will not be at least 1 step longer, but they might have been only 0.1 step longer. The resulting tree(s) should thus be critically regarded, and only those branches that are supported by e.g. a bootstrap analysis should be valued.

6.3.3 Actual coding and weighting[1)]

For the coding of some of my morphological data I have used a technique similar to gap weighting. Gap weighting as it was described used the mean per species for establishing a code, but in a footnote Thiele (1993: 283) already mentions that one can also use other measures, preferably such with a central tendency. As my specific descriptions were already prepared, my raw data had been gathered specifically to make these descriptions, i.e. noting down only extreme values. This made my data far from a random sample and also their average is not an unbiased estimator for the sample- or species mean. Moreover one has the tendency to write down more often maximum extremes than minimum extremes. Resampling would have been a time consuming effort and as an alternative I chose to use the average of the minimum and maximum values from the species description, discarding the extreme values in brackets, as the values to be used for coding. An advantage of this method is that it can be readily used for analyses of other groups of which a revision is already published. Moreover, this technique can also be used when the sample size of some species is very low; both minimum and maximum values will have a tendency to be less extreme in such a species, rendering the average to be close to the actual mean and still being an unbiased estimator.

On mathematical grounds one could argue that for single sizes (not indexed ones) it would have been better to take averages of the log(min) and log(max). However, this will make the coding process of these species far less transparent. Since I estimate the effect of such a better coding procedure to be almost neglectable, I decided to leave out this log transformation. However, for characters showing a large total range I have used a log-based scale.

[1)] It should be noted that the entire matrix has been designed for analysis by Hennig86. In order to be able to rescale some characters, in the final calculations by Hennig86 all character weights are multiplied by 8. So, a character which I describe to have weight 1, receives weight 8, whereas each step discribed as ¼ will actually count for 2 steps during the analysis. However, in all discussions and arguments, the number of steps is given as if the multiplication would not have taken place. This explains how the tree can have a broken number of steps.

Thiele (1993: 282, 286) considers discrete characters, like boolean type characters, as a continuous character of frequency distributions. Going from absent to present a distribution of 100% / 0% changes to 0% / 100%. The latter distribution in such characters is given the maximum possible value for the state 'present'. In the present study such discrete characters were just coded with 1 state difference, while the gap weighted characters were rescaled. The ultimate effect, however, remains the same.

In this analysis in general character steps have been given a weight of 1. 'Discrete' multistate characters which are considered to be ordered thus have a total range of more than one step. Several discrete characters, however, have also intermediate states. Such characters have been coded in such a way that the transition between its states weights half a step, similar to the coding used by Sosef (1994). These intermediate states were created for characters which showed either real intermediate states ('present, but small') or for characters which were polymorphic in a part of the species. The polymorphic species received the intermediate code (Hennig86 cannot deal with polymorphic species). Some apparently polymorphic characters, however, were supposed to be so because the feature was often hard to observe or could vanish from the specimen although it had been present earlier. Such characters were scored as being present as soon as it was encountered in any specimen of a species.

Some continuous characters, such as the size of petals and sepals, have been coded in a rather conventional fashion, indicating whether they are of 'usual size', 'have started to reduce', 'have become quite tiny' or are 'completely absent'. Maybe gap weighting would have been better in these cases. However, the solution adopted was preferred for two reasons: 1) These characters are rather variable within species, and since sample size for flower collections is very limited, this might easily result in quite different codes, based only on pure chance. 2) I feel that the importance scale of these reductions is not linear. A major step is the initiation of reduction, the element may now vary in size (cost/benefit compromise) and this may result in it being almost lost and remaining present as a very small element. At this point the plant hardly has any investment in this element, so the pressure to loose it completely is almost nil. Ultimately the element can become truly absent. Tucker (1989: 74) even calls a loss far more significant than a reduction. Although I recognize such transformations as 'steps', I prefer to code them as half steps, resulting in a total transformation series weighting as 1½ and not 3 steps. Since all types of sepals and petals are coded separately, 3 steps would be over-proportional given the possibility that the genes that control the size of these separate elements are linked in some way (similar to the A-type homeotic genes that influence development of both sepals and petals (Weigel & Meyerowitz, 1994)). For a few other continuous characters also a few-step state series has been made, explanation follows after these characters.

Other continuous characters were coded according to the gap weighting method. Since the analysis was performed by Hennig86, the maximum number of states was 10. However, because some other characters had to be weighted down with a factor 0.5 or 0.25, the rescaling factor that has been used for these characters is 0.125 and not 0.111. This is a constraint of Hennig86: it only allows integers between 0 and 9 as weighting factor. In this light, the range of some characters was divided into 8, 9 or 10 states, the choice usually depended upon the possibility to break up the range into neat, rounded values. Of course this choice immediately has implications for the total weight of the character, now varying between 7/8 and 9/8, but these discrepancies are not considered to be of any significance.

As stated above, in few cases I find it quite reasonable to weight the total range of a character considerably more than with just 1 step. Such ranges should be large. As a rule for these cases each ^{4}log is 1 step. Of course this choice is very arbitrary, but for the present study it means these characters receive a slightly higher weight than all the other characters. I also believe that the ^{4}log is a reasonable estimate of what might have been taken as a separate step in the multistate coding of a 'discrete' character.

6.4 Characters used for coding

A total of 104 morphological characters have been used for the analysis. Characters which were only present in one species, such as the 9 stamens in *A. heitzii*, usually have not been coded. Only in two cases (16 & 42) an exception was made for characters which might be important in future studies, since either they may be present in other outgroups (16) or because the character state is still unknown in closely related, or potential new, species (42).

Characters which have been treated as ordered are marked by an '*'. The weight factor of a character is given between brackets when different from 1.

1 Trunk shape
1 = straight, cylindrical
2 = often contorted, not perfectly cylindrical

2 Buttresses:
0 = absent or very small
1 = present, although sometimes only distinct in larger trees

3 Bark, colour of outer layer
1 = white or pale grey, older twigs turn pale grey.
2 = usually brown or blackish

4 Twigs from the mature canopy persistently (very) dense tomentose-velvety?
0 = no
1 = yes

This character is defined as the kind of indumentum present in *A. pectinatus*. Some other species may show some indumentum as well, but this is always of another type or far less dense, except in *A. obscurus*.

5 * Stipules: (x½)
0 = free
1 = (sometimes) partially fused
2 = always completely fused

6 Stipules (persistence):
1 = caducous
2 = persistent

When only the basal part of the stipule is persistent, this is coded as caducous, the special basal feature is coded in character 10.

7 Stipules (inflation):
0 = not inflated
1 = inflated

8 * Stipule base (auriculate): (x½)
1 = without or with a very small auriculate appendage which does not surround the base of the stipule
2 = small auricle present which surrounds the base
3 = large auricle present which surrounds the base

9 Stipules

0 = not stalked
1 = stalked

The basally fused and auriculate stipules of *Brachystegia stipulata* have a short (fused) stalk under the auricle, so the auricle arises from the top of the stalk. Although it is not clear whether this stalk is homologous with the stalk of other species, it is still scored as 1.

10 * Stipules at base with a thicker, persistent part which is sometimes fused to the petiole: (x½)

0 = no
1 = only an indication of such a structure present
2 = yes

This character should be scored on canopy branches. In seedlings and saplings the persistent structure is often lacking, while it is present in mature specimens.

11 Stipules:

0 = with a few, not closely spaced, veins
1 = with many closely spaced veins

12 Stipule margins with chaffy hairs:

0 = no (other hairs may be present)
1 = yes, rendering the valvate stipules adnate

13 Stipules at base of proximal margin:

0 = without glandular appendages
1 = with some (glandular?) tooth-like or club-shaped appendages

Just like the glandular appendages of the bracts, these appendages have different shapes and sizes. In many species some of these glands are also present on the twig around the stipule base, facilitating scoring of this character even when the stipule itself is not available.

14 * Stipules outside (x½)

0 = (almost) glabrous
1 = partly velvety or varying from glabrous to velvety
2 = completely velvety outside

15 * Leaves on average: (x½)

0 = 1-jugate (strictly)
1 = 1¼–1½-jugate or 1-jugate with sometimes a reduced pair
2 = 2–3½-jugate
3 = 4–7½-jugate
4 = 8–15½-jugate
5 = 16–31½-jugate
6 = 32–63½-jugate

Note: when the first pair is reduced and usually only the second pair is present, this is scored as 1½-jugate! The missing first pair is scored in character 43. Please note that *Oddoniodendron micranthum* has 1–4 leaflets, which is comparable to ½–2-jugae, hence it is on average 1¼-jugate.

This character will be weighted with factor 4, resulting in each successive change being half a step and the total range of this character being 3 steps. I think 3 steps is a good weight for the enormous range of variation which is covered by this character. Each step (except the first) stands for about a doubling of the average number of leaflets. An in- or decrease by a factor 4 will be valued as one step compared to other characters and follows my directive for scaling multistate characters.

16 Leaflets:

0 = opposite
1 = alternate

17 First two pairs of leaflets inserted close together ('doubled'):

0 = no
1 = yes

18 First pair of leaflets of a leaf:

0 = present, petiole relatively short
1 = wanting, vestigial, scars present or other indications it is lost
2 = petiole relatively long, but not evidently caused by loss of a leaflet pair

State 1 means it is evident the first pair is wanting or nearly so. This can be because remnants are still visible or because seedlings show an extra pair before the otherwise first pair. State 2 can be caused by a well developed loss without any evidence of such a loss (so the next stage after 1) but also by a stretching of the petiole. Since both stages will be hard to distinguish because they will appear similar, they are scored as a single state, separate from state 1. The character should be treated as un-ordered to allow for a stretching of the petiole (0→2). *A. heitzii* most probably has a loss, but the remains are so obscure, that it is scored as 2. The 'relatively' long petiole of state 2 should be interpreted as being so long that it would have enough space to fit another pair of leaflets.

19 Leaf rachis

0 = without wings or ribs
1 = with fairly broad wings that extend beyond the lateral sides when viewed from above
2 = with ribs or narrow wings that do not extend beyond the lateral sides.

20 * Leaf rachis (x½)

0 = with same indumentum on both sides
1 = above with less dense indumentum than below
2 = glabrous above, with indumentum below
? = both sides glabrous

This indumentum of the upper side should be scored outside a possible groove. The indumentum of the groove is scored separately in character 21.

In *B. breynei* the leaf rachis characters are scored on the petiole part beyond the joint. In other species this part is generally the same as the rachis.

In the truly 1-jugate species with 2-jugate seedlings (*A. djumaensis* & *A. richarsiae*) this character could not be scored on the rachis present in the seedlings because *A. cynometroides* shows a difference between seedling and mature rachis indumentum, rendering seedling indumentum unreliable. Also for these species the character states were determined using the apical part of the petiole.

21 Leaf rachis inside of groove:

0 = with indumentum
1 = without indumentum, whereas upper side outside the groove does have indumentum
? = both inside and outside the groove glabrous or without such a groove.

22 * Angle between leaflet insertion and leaf rachis (see fig. 4.3b) (x½)

0 = 0–30°
1 = 30–60°
2 = 60–90°
3 = 90–120°

Some species (e.g. in *Julbernardia* and *Brachystegia*) are supposed to have twisted leaflet insertions. However, this character seems to be present to a smaller extent in some other species as well. Hence, it has been coded as a continuous character, were the rotation angle is the measure. Since, in the first place, it very hard to tell which angle should be measured (sometimes the leaflet insertion is almost circular), in the second place this measure is difficult to establish accurately and in the third place the measure is dependent on the position of the leaflet (basal pairs tend to be more twisted than apical pairs), it seemed unwise to distinguish more than 4 states. Since most species which are considered to have non-twisted leaflets are assigned state 1, and those that do receive state 3, the weight has been chosen such that the transition from 1 to 3 is 1 step.

23 Leaflets with translucent dots:

0 = no
1 = yes

24 Distal leaflet half:

1 = present
2 = (almost) absent

25 Basal leaflet in proximal half with glands:
0 = absent or rarely present
1 = present or usually present

26 Basal leaflet in distal half with glands:
0 = absent
1 = present or usually present

27 Glands of distal half present on primary nerve:
0 = no
1 = yes

28 Primary vein ending in hydratode, often also mucronate:
0 = no
1 = yes

29 Leaflet apex on lower side with a gland:
0 = no
1 = yes

30 Leaflets emarginate *at* the termination of the principal vein:
0 = no
1 = yes

31 * Proximal half of leaflets to the apex:
0 = not at all sinoid
1 = at least sometimes sinoid, so "apex emarginate" but *below* the termination of the principal vein
2 = usually very strongly sinoid, sometimes even angled

32 Lower side of sun-exposed leaflets:
0 = not greyish, usually glossy
1 = dull and greyish, caused by conical protruding epidermis cells. Cones show a strongly ornamented surface ('papillé'). Cones sometimes formed by several cells, i.e. the crater-shaped stomata.
2 = dull and greyish, caused by conical protruding epidermis cells ('vériculé'). Cones smooth. One cone per cell, stomata cells not protruding into a cone.

The species which do show a dull, grey surface have been coded according to Gervais (1998 and pers. comm.).

33 * Relative length of the auricle at the proximal leaflet base: average auricle height of largest leaflet / average width of largest leaflet: (x⅛)
0 = 0–0.025
1 = 0.025–0.05
2 = 0.05–0.075
3 = 0.075–0.1
4 = 0.1–0.125
5 = 0.125–0.15
6 = 0.15–0.175
7 = 0.175–0.2

Basal leaflets hardly ever have an auricle, if they do, it is a small one. The same often holds, though for a lesser extent, for apical leaflets. Leaves with only one or a few pairs of leaflets do not possess leaflets that are neither basal nor apical, therefore species with an average number of leaflet pairs of less than 5 are scored as "?". In species were the largest leaflet sometimes coincides with the apical leaflet, measurements from those apical leaflets have been excluded from the largest leaflet averages.

34 Leaflet margin (at least in young leaves):
0 = glabrous
1 = with short hairs
2 = with long to very long hairs

35 Very young leaflets on both sides densely tomentose, surface not or hardly visible? In full-grown young leaflets these hairs detach, for the naked eye forming a kind of powder:
  0 = no, at least on the upper surface only some (long) velvety hairs may be present.
  1 = yes

36 * Inflorescence: (x½)
  0 = young branch produces leaves and at the same time simple racemes
  1 = compound, sometimes still with reduced leaves on base of racemes
  2 = compound without leaf remains
  3 = both 2 and 4 present in species
  4 = reduced to 1 raceme (sometimes with not developed lateral buds)

For a more detailed discussion see the morphology chapter. State 0 does not occur in the present species selection. It is a hypothetical primitive condition, as may be present in *Macrolobium.*

37 * Number of inflorescences per node: (x½)
  0 = 1
  1 = sometimes more than 1 possible
  2 = usually several

38 Inflorescences:
  0 = only borne on the most terminal (usually up to 6 or less) nodes of a branch
  1 = borne on all nodes of the youngest generation branches and sometimes even on nodes of older branches.

39 Inflorescences:
  0 = all clearly axillary
  1 = at least some seem terminal since the flowering branch continues past the last leaf in producing several leafless nodes bearing inflorescences and finally becoming an inflorescence itself of which it is impossible to tell were it begins. (With this kind of inflorescences it is often hard to tell what is a single inflorescence and what are several)

40 Compound inflorescence tends to branch again at base ("double compound"):
  0 = no
  1 = yes

41 * Number of flowers open at one moment per raceme: (x½)
  0 = 1
  1 = a few
  2 = at least half of the raceme (see photos page VIII)

42 Racemes with flowers arranged:
  0 = spirally
  1 = in two rows

43 Bracts:
  0 = without a doubled midrib or broadened swollen midrib
  1 = usually with two ribs that usually fuse and end just before the apex which then becomes nosed. The area in between the ribs may become swollen creating one large inflated area.

44 Bracts:
  0 = veins not closely spaced and prominent
  1 = with many closely spaced prominent parallel veins

45 Bract margins with glandular hairs or dents:
  0 = no
  1 = yes, present

These glandular appendages seem to differ in shape among species. In some species dark, triangular teeth are present which are fairly easy to find, in others those teeth are also triangular, but more or less transparent or white, while sometimes they become more hair-like and club-shaped. It is hardly possible to draw a line between teeth and club-shaped hairs. For this reason this character is defined in a fairly broad sense, including all these structures. The character is only mentioned in the species description when it is easy to see or when it is essential for identification purposes. Since these teeth might easily break off, or be present in only a part of the bracts of an inflorescence, this character is scored as present as soon as some of these appendages were found in a species.

46 * Bracts inside: (x½)
0 = entirely glabrous
1 = only with a narrow pubescent (apical) marginal band
2 = at least the apical part pubescent or velvety

47 * Average length pedicel / average length bracteole: (x⅛)
0 = 0.2–0.3
1 = 0.3–0.4
2 = 0.4–0.5
3 = 0.5–0.6
4 = 0.6–0.7
5 = 0.7–0.8
6 = 0.8–0.9
7 = 0.9–1.0
8 = 1.0–1.1
9 = ≥ 1.1

48 * Bracteoles: (x½)
0 = not fused with hypanthium
1 = partly fused with hypanthium
2 = fused with hypanthium (at least in the middle completely) creating a hypanthium s.l.

49 Bracteoles adaxially incised creating a partial hypanthium s.str. at the adaxial sepals
0 = no hypanthium triangle
1 = hypanthium triangle present

50 Bracteoles:
0 = deciduous after flowering, usually together with petals and stamens
1 = (at least sometimes) deciduous during anthesis

51 * Average bracteole length (x⅛)
0 = 4–5 mm
1 = 5–6 mm
2 = 6–7 mm
3 = 7–8 mm
4 = 8–9 mm
5 = 9–10 mm
6 = 10–11 mm
7 = 11–12 mm
8 = 12–13 mm
9 = >13 mm

The bracteole length is the measure which best represents flower size in the Macrolobieae. Because the bracteoles have taken over the protective function from the calyx, it can be used as indication how large the bud is just before opening and for the growth potential of the pods. Since the bracteoles are also the most striking feature of the open flowers, it is also indicative for the flower size as seen by pollinators. In this character the flower size itself is coded, most other flower characters dealing with size will be coded relative to this bracteole size. Maybe one should use a log-scale for this character. However, first of all the total range of this character is not very large, secondly: what is used here is a single-dimension measure, while flower size actually is a three dimensional measure. The discarding of the use of a log scale compensates somewhat for this flower-volume effect.

52 * Bracteoles outside: (x½)
0 = without a rib

1 = with an indication of a rib (small ridge)
2 = with a prominent rib

53 Bracteoles outside on the midrib
0 = with the same indumentum as elsewhere on the outside
1 = with longer or otherwise different indumentum than rest of outside

54 Bracteoles: (x½)
0 = almost symmetrical
1 = midrib clearly present on the adaxial side

The bracteoles are never really symmetrical, this character only indicates whether the asymmetry is very pronounced or not. Since state '0' is already an intermediary state, this transition from 0 to 1 is weighted as half a step.

55 Bracteoles:
0 = at the apex not notably swollen and nosed
1 = at the apex notably swollen and nosed

56 Bracteoles inside:
1 = glabrous or with a few hairs along the margin
2 = hairy throughout

57 * Relative hypanthium height: average hypanthium height / average bracteole length (x⅛)
0 = 0–0.05
1 = 0.05–0.1
2 = 0.1–0.15
3 = 0.15–0.2
4 = 0.2–0.25
5 = 0.25–0.3
6 = 0.3–0.35
7 = 0.35–0.4
8 = 0.4–0.45
9 = 0.45–0.5

58 Filaments within the hypanthium markedly broadened towards the centre of the hypanthium, at the apex of the hypanthium abruptly receding towards the actual hypanthium (fig. 4.6):
0 = no
1 = yes

59 * Adaxial sepals: (x½)
1 = completely fused
2 = fused, but lobed or incised at the fusion
3 = free

60 * Adaxial sepals: (x½)
0 = longer than ⅔ of the bracteole length
1 = ⅓–⅔ of bracteole length
2 = less than ⅓ of bracteole length
3 = (usually) absent

61 * Lateral sepals: (x½)
0 = longer than ⅔ of the bracteole length
1 = ⅓–⅔ of bracteole length
2 = less than ⅓ of bracteole length
3 = (usually) absent

62 * Abaxial sepal: (x½)
0 = longer than ⅔ of the bracteole length
1 = ⅓–⅔ of bracteole length

2 = less than ⅓ of bracteole length
3 = (usually) absent

63 Adaxial sepals:
0 = not curved inwards and embracing the adaxial petal
1 = curved inwards and embracing the adaxial petal which base is bent outwards, protruding from between the sepals. Sometimes the adaxial sepals even touch each other inside the adaxial petal base.

64 * Lateral margins of abaxial sepal: (x½)
0 = not inrolled
1 = weakly inrolled
2 = strongly inrolled, rendering the sepal triangular with sometimes even concave margins

65 Sepals outside
0 = glabrous
1 = with some kind of indumentum

66 Sepals inside
0 = glabrous
1 = with some kind of indumentum

67 * Adaxial petal: (x½)
0 = longer than bracteoles (av. >130%)
1 = about equal in length to bracteoles
2 = smaller than bracteoles (av. < 70%)
3 = absent

68 * Lateral petals: (x½)
0 = about as large as adaxial petal
1 = smaller than adaxial petal (10% < av. < 70%)
2 = minute (av. < 10% adaxial petal), but usually present
3 = usually absent

The size of the lateral and abaxial petals is supposed to be related to that of the adaxial petal, so reductions should be compared to the adaxial petal size. In species where these petals are usually absent, while the average is still larger than 10% of the adaxial petal, this is scored as a 2.

69 * Abaxial petals: (x½)
0 = about as large as adaxial petal
1 = smaller than adaxial petal (10% < av. < 70%)
2 = minute (av. < 10% adaxial petal)
3 = usually absent

See comment under character 68.

70 * Lateral and abaxial petals: (x½)
0 = not folding lengthwise
1 = sometimes folding lengthwise and displaying some of the secondary features as in '2'
2 = usually folding lengthwise, this is usually correlated with a tendency to curve sideways, to have a slightly broadened apex and to have most of the cilia in the middle part of the lateral margin

71 Apical margin of adaxial petal:
0 = not folded inwards
1 = folded inwards

72 Adaxial petal:
0 = not suddenly broadened above a relative short claw, usually obovate
1 = with a short claw after which the petal suddenly broadens

note: *B. congensis* & *B. media* have very narrow adaxial petals, which do not really show this character, so they are given state 0. However, from the petals it is evident that this is based on an incompletely settled loss. *B. pellegrinii* has a variety of stages between presence and absence; it is scored as 1.

73 * Base of adaxial petal above the claw: (x½)
0 = not auriculate
1 = sometimes auriculate or auricle only with half a spiral coil
2 = with fully developed auricles of at least an entire spiral coil

74 Colour of adaxial petal:
0 = white
1 = yellow (at least in some parts)

75 Lateral and abaxial petals inside:
0 = glabrous
1 = with long hairs
2 = with short hairs, puberulous

76 Adaxial petal along basal lateral margin:
0 = glabrous on both sides
1 = at least inside with indumentum

77 Apical margin of adaxial petal:
0 = always glabrous
1 = sometimes with a single central hair (rarely 2)
2 = usually (sparsely) ciliate

State 1 has nothing to do with state 2, although a single hair might become obscured by a ciliate apical margin. However, in the species were such single hairs were found these hairs are much longer than the usual ciliate hairs.

78 * Relative length of stamens: average filament length / average bracteole length (x⅛)
0 = < 1
1 = 1.0–1.2
2 = 1.2–1.4
3 = 1.4–1.6
4 = 1.6–1.8
5 = 1.8–2.0
6 = 2.0–2.2
7 = 2.2–2.4

79 * Filaments fused for: (x¼)
0 = not fused at all
1 = less than 10% of their length
2 = 10–20% of their length
3 = 20–30% of their length
4 = 30–40% of their length

80 Fusion of lateral filaments:
0 = same as fusion of the more abaxial filaments
1 = extended compared to the more abaxial filaments

81 Adaxial filament:
0 = not fused to stipe
1 = fused to stipe at least over some distance

82 The stamens next to the adaxial one (sometimes) bend to abaxial side while the ones next to it bend outside around it to the adaxial side (see fig. 4.5)
0 = no
1 = yes

83 Filaments at base (where they become free from the hypanthium):
0 = go about straight up, or bent outwards
1 = distinctly (and often abruptly) bend inwards, sealing off the hypanthium cavity
The state in *Oddoniodendron micranthum*, where the filaments do bend inwards but at another level (higher), is scored as "?".

84 * Hypanthium and staminal tube on inside: (x½)
1 = glabrous
2 = hypanthium with indumentum, but staminal tube glabrous
3 = both hypanthium and staminal tube with indumentum

85 Adaxial filament: (x½)
0 = always glabrous
1 = sometimes or always with some hairs
This character is probably (partly) related to character 84, and could be seen as an additional step from any of the 3 states of character 84. Since each step in character 84 is weighted as ½, this step should be ½ as well. Moreover, this character is a rather poor one, which was rather doubtful to score for some species because the hairs were only present in a few flowers. Half a step is also a compromise between using it and discarding it completely.

86 * Anthers: (x½)
0 = without a tooth
1 = with a weak tooth
2 = with a fully developed tooth

87 Anther colour:
1 = yellow
2 = red-purple

88 Connective of anthers at base:
0 = not protruding into a small dent
1 = (usually) protruding into a small dent

89 Locules of anthers apically:
0 = without one or a few hairs
1 = often with one or a few hairs

90 * Ovules: number (x½)
0 = 1(–2)
1 = 2(–3)
2 = (2–)3–4(–5)
3 = 4–6 (on average)
4 = 7–10 (on average)
State 4 is only present in the outgroup. The variation left in the ingroup is valued important enough to merit it a total value of 1½ step.
The variation has been divided over only five states because in some of the species there really seems to be a near fixation on a certain ovule number (especially 2), rendering these figures for such species being discrete states. Also other states (like the variation described at state 2) are frequently encountered values, characteristic for several species.

91 Ovary lateral surface:
0 = at least partly glabrous
1 = hairy throughout

92 * Average angle between axis of ovary and style: (x⅛)
0 = 0–20°
1 = 20–30°
2 = 30–40°
3 = 40–50°

4 = 50–60°
5 = 60–70°
6 = 70–80°
7 = 80–90°
8 = 90–100°
9 = 100–115°

Because 0 is a limit value, which is (as an average) hard to reach in large series of flowering specimens, but easier in poorly known species, the first state consists of 20° instead of 10°. Since there is only one species which reaches 115°, this value is lumped into state 9.

93 Base of style conically widened at base:
0 = no
1 = yes

94 * Pod upper suture:
1 = not winged to weakly so and wings indistinct
2 = with distinct to wide wings but not inrolled
3 = with very wide and usually inrolled wings

Inrolled wings is seen as an evolutionary step of its own, however, the wings do need to be wide initially in order to be able to commence inrolling, so the character should be treated as ordered.

95 * Pod u/w index (see paragraph 4.3.8), average of min. and max. values: (x¼)
0 = < 10%
1 = 10–20%
2 = 20–30%
3 = 30–40%
4 = 40–50%
5 = 50–60%

This character has been divided into the 10 theoretical states of this index; only states 0–5 occur in the present species set. The weight of ¼ has been chosen to make the present range as close to 1 as possible.

96 Pod often with a second nerve present:
0 = no
1 = yes

97 Lateral nerve of the pod:
0 = never more than 1 mm emergent from the surface
1 = prominent and sometimes more than 1 mm emergent from surface

98 Pod beak:
0 = absent or indistinct
1 = distinct, at least 5 mm long in some specimens

99 * Relative length of stipe in fruit: average stipe / average bracteole length (x⅛)
0 = 0–0.25
1 = 0.25–0.5
2 = 0.5–0.75
3 = 0.75–1
4 = 1–1.25
5 = 1.25–1.5
6 = 1.5–1.75
7 = 1.75–2
8 = 2–2.25
9 = ≥2.25 (does not occur in present data set)

The stipe length is corrected for flower size. Maybe it would be better to correct it in this case for pod size. However, all other reproductive system sizes have been corrected using bracteole size as well, and correcting for pod size is also arbitrary. One can use pod length, width, thickness or a combination of these three. By correcting for flower size, the stipe length is corrected with a measure which is related to the starting potential of the stipe.

100* Mature pod: (x½)

0 = glabrous or with very few velvety hairs
1 = sparsely velvety and puberulous
2 = densely velvety and puberulous, pods soft to touch

Pods of *Oddoniodendron micranthum* are densely covered by a hair type not present in the other species. Since those hairs might be homologous with puberulous hairs, the species is scored as 2.

101* Position of cotyledons in a seedling: (x¼)
average epicotyl / (average epicotyl + average hypocotyl)

0 = 0–0.08
1 = 0.08–0.16
2 = 0.16–0.24
3 = 0.24–0.32
4 = 0.32–0.40
5 = 0.40–0.48
6 = 0.48–0.56
7 = 0.56–0.64
8 = 0.64–0.72
9 = 0.72–0.80

The value as calculated above gives the percentage of how far the cotyledons are positioned from the first pair of leaves in relation to the ground level. However, it can be read as well as the relative epicotyl length, since it is also the length of the epicotyl relative to the entire initial length of the seedling. The absolute values of the epicotyl length of the members of this group demonstrate that there exists much variation, i.e. the average epicotyl length ranges from 0.15–25.5 cm! However, large seeds will grow big seedlings with relatively long epicotyls. Indeed the species with the longest epicotyl also has the largest seeds, and has the largest elevation above ground for the first leaves. Because it is compensated for seed size the relative measure is a more perfect measure than the absolute epicotyl value. As is clear from an analysis of the relative values (fig. 6.1), the variation falls apart in two clearly separate distributions, but also within these distributions much variation is present. The largest relative value is more than 35 times larger than the smallest value! In my opinion breaking up the variation into 10 equal ranges values this variation in the best way, because it assigns a large value on the major difference between the two data groups, and a small value on the variation within these groups. By weighting these steps by a factor ¼ the total weight of this character becomes 2¼, which corresponds with a situation where the variation is broken up in 3 'evolutionary' states: epicotyl shorter, equal or longer than the hypocotyl and it is comparable to the weight given to character 15 (each ^{4}log is 1 step), although in this case the range is an index, not a log scale. Since the variation in epicotyl length is so large, I find it quite defendable to weight it heavier than other characters.

The outgroup genera *Oddoniodendron* and *Berlinia* are scored as a "?" since the epicotyl is not definable caused by a missing first opposite leaf pair.

102 Epicotyl:

0 = (usually or almost) glabrous
1 = not glabrous

103 Seedling; 2 first leaflets:

0 = with smaller or equal number of jugae than the mature tree
1 = with a higher number of leaflets than the mature tree

104* Ecology: (x½)

1 = dry-land rain forest
2 = both dry-land and riverine forest
3 = riverine forest and gallery forest
? = dunes & savanna.

The biotope of *I. dunensis* is open vegetation to dry-land forest on dunes. Since it is not clear whether this compares to the dry-land forest of central and western Africa this is coded as a "?". The savanna habitat of some of the outgroup species seems to be an ecological trend of its own, of which it is hard to say where it fits in the range from dry-land forest to gallery forest; savanna is dry like dry-land forest, but gallery forest on the other hand tends to penetrate into savanna areas. Since the other states should be considered as ordered, we cannot code savanna here as a separate state.

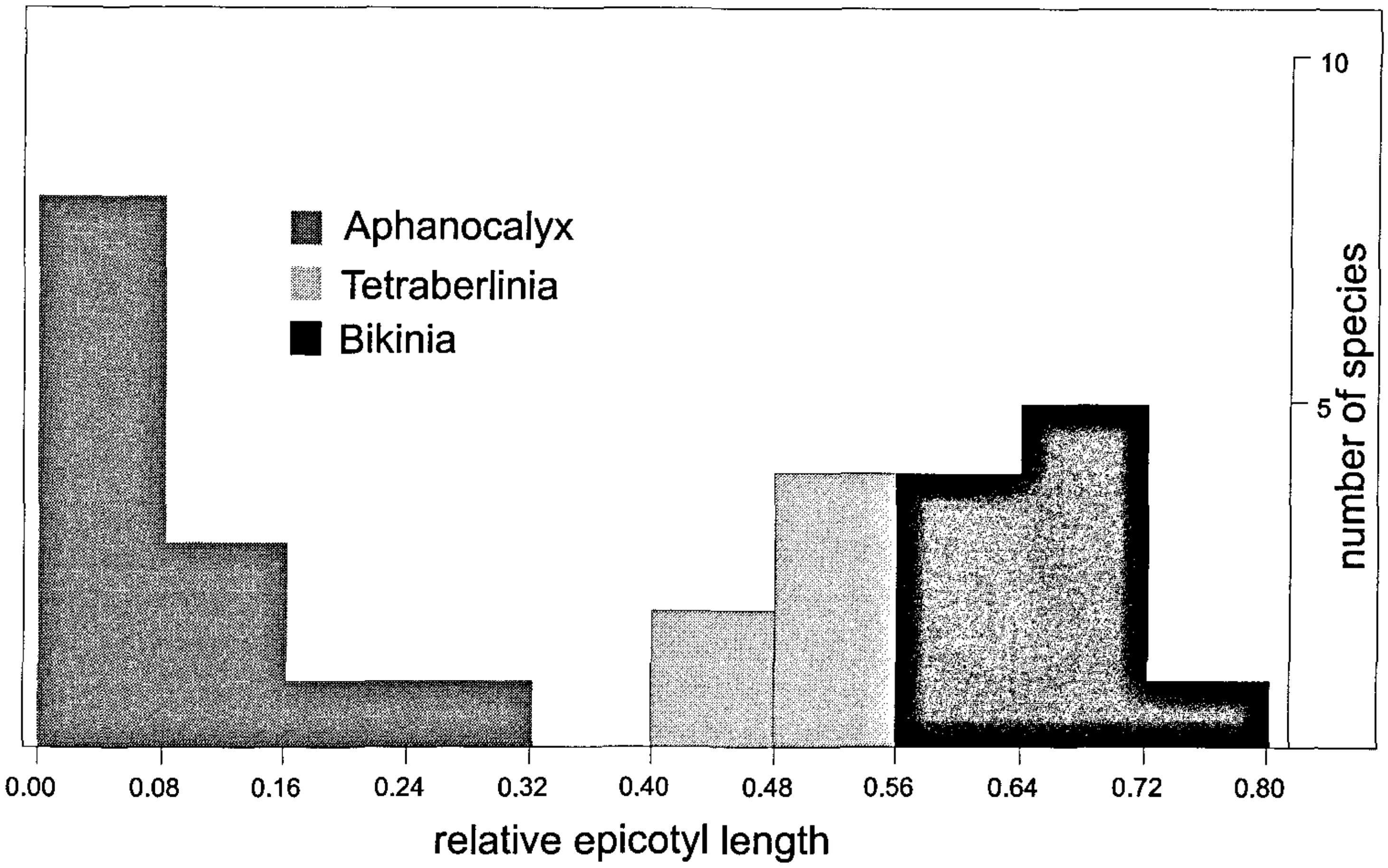


Figure 6.1. Analysis of distribution values for character 101: relative epicotyl length.

6.5 Data matrix

The data matrix (table 6.1, p. 54) shows all 104 morphological characters that were used for the calculations. The character states that were extracted from the chromatography study (see chapter 5) have been added at the end.

It has to be noted that *Icuria dunensis* has been coded based on all the material that was available in July 1998, hence not including the flowering specimen and the seedlings which became available several months later.

6.6 Analysis

The phylogenetic analysis has been performed with Hennig86 (Farris, 1988). Gap coded characters and other multistate characters of which the states are supposed to be related in an ordered way were ordered. All weights as described above were multiplied by 8 because Hennig86 can only calculate with integer weights and states. *Berlinia bracteosa* was used as outgroup. Trees were constructed using mhennig* followed by bb*.

To be able to present bootstrap values (Felsenstein, 1985, see also Hillis & Bull, 1993), the same analysis was performed using PAUP 3.1.1 (Swofford, 1993). The bootstrap analysis was performed with 1000 replicates, characters were selected with equal probability and with applying of weights. Shortest trees were calculated using a heuristic search with stepwise addition in a random sequence with 20 repeats. Branch swapping was performed using options TBR and MULPARS. Uninformative characters (= 2 characters) were excluded.

Two species, *Tetraberlinia baregarum* and *Icuria dunensis*, are so poorly known that about 50% of their codes are unknown. Since this might result in much lower bootstrap values for clades including these species, they have been excluded in the initial analysis. When these two species are excluded, there are three shortest trees: one is identical to the original tree with both species pruned, the other two have a quite different general

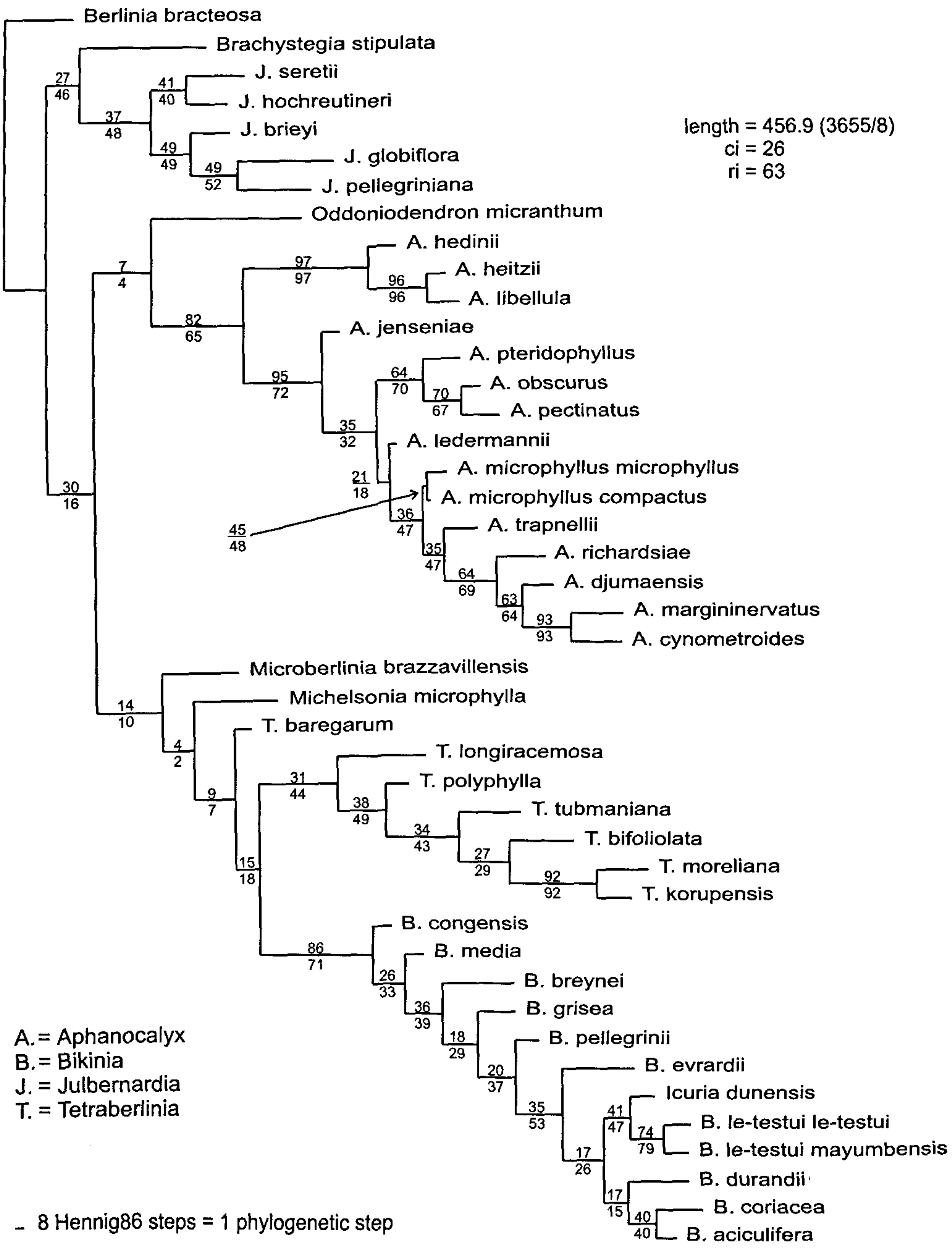


Figure 6.2. Shortest tree calculated on the entire morphological matrix. Relative branch lengths are shown on horizontal branches (see scale). Above each branch the bootstrap value (in % of 1000 replicates) of that branch is indicated, as is the mojo value (in % of 500 replicates) below that branch.

topology, with *Bikinia* and *Aphanocalyx* forming a clade with *Tetraberlinia* as sister group (similar to figure 6.5b). Since the first topology is shorter when all taxa are included, this tree was used to calculate bootstrap values, the other two trees are disregarded.

To test whether bootstrap values are actually much influenced by taxa with a lot of missing data, the analysis has also been performed with the inclusion of the two taxa. The

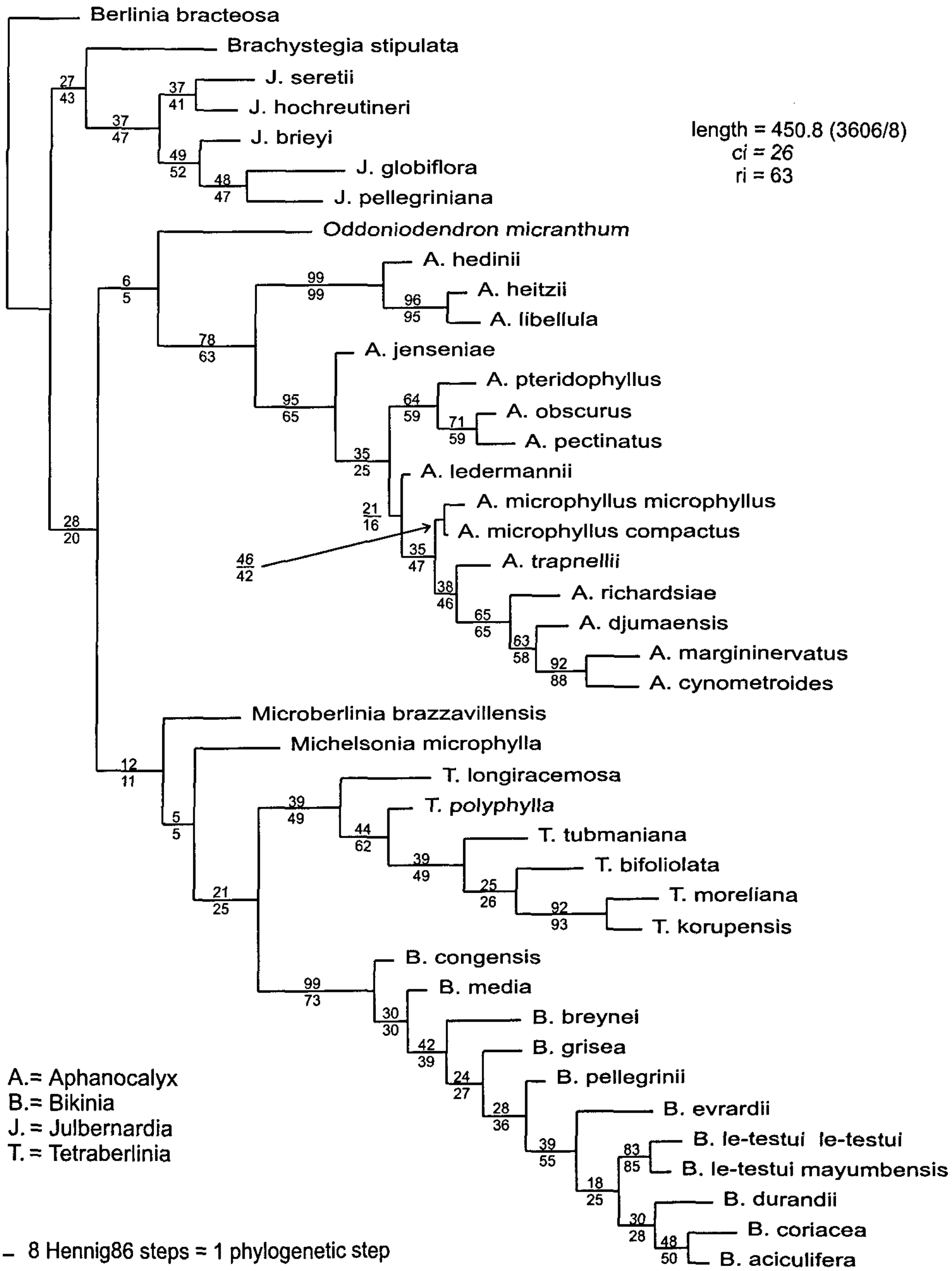


Figure 6.3. One of the three shortest trees calculated with the morphological matrix excluding *Icuria dunensis* and *Tetraberlinia baregarum*. Relative branch lengths are shown on horizontal branches (see scale). Above each branch the bootstrap value (in % of 1000 replicates) of that branch is indicated, as is the mojo value (in % of 500 replicates) below that branch.

results are presented in figures 6.2 & 6.3.

Another way of assessing the 'strength' of a branch is through calculating Mojo values. This method compares the shortest tree with trees calculated on a dataset with a part of the data substituted by noise or missing data. Mojo values have been calculated using

MOOTOO 1.1 from the Random Cladistics software package 4.0.3 (Siddall, 1997). Mojo values were calculated for both the entire data matrix (no species or characters deleted) and a matrix without *Icuria dunensis* and *Tetraberlinia baregarum*. In both analyses 20% of the data was substituted with '?' in 500 repeats. It might have been better to substitute 20% of the data with noise (random data), but the present MOOTOO program cannot distinguish between characters with a different number of possible states. Both the 500 repeats and the shortest tree were calculated in the same manner as described for the shortest tree in Hennig86. Similar to the bootstrap calculations, only the pruned 44-taxa tree has been used for the 42 taxa calculation.

The results from the TLC analysis (see chapter 5) are considered to be very unreliable. However, as an illustration of possible evidence in this data, trees have been calculated using the combined dataset from morphological data and the TLC analysis. Each TLC character received weight 8 (= 1 step).

In this analysis two shortest trees were calculated. The strict consensus tree is picturized in figure 6.5b.

As an illustration of how easily the relative position of the genera might change, a tree was calculated using the morphological dataset, but leaving out *Oddoniodendron*, *Microberlinia* and *Michelsonia*: At once the group under study becomes monophyletic (although we cannot say anything about *Michelsonia* now) and is derived from within *Julbernardia*! This tree is picturized in figure 6.5a.

6.7 Results from analyses

6.7.1 Resolution within the genera

Bikinia

The results of the analysis on morphological data are not very satisfactory as far as the internal resolution of *Bikinia* is concerned. The network of this group is linked to the other species next to *B. congensis*, resulting in most other branches appearing in a rather pectinate way. However, with shifting sister clades (e.g. as happens in the analysis including TLC-data, fig. 6.5b), the network of this genus is linked between *B. pellegrinii* and *B. evrardii*, dividing the genus into two groups. In order to obtain a more sound impression on the evolutionary relationships in *Bikinia*, I have also calculated the network of this group alone. It was subsequently rooted at the node which showed the largest amount of 'primitive' characters. I consider the following characters as 'primitive' for *Bikinia*: 18:0, 20:0, 21:0, 26:1, 31:1, 32:0, 36:1, 61:2, 62:2, 68:1, 69:2, 72:1, 89:0. In other characters either no variation is present or it is not easily established which state is primitive. The resulting network does not differ from the one based on the entire morphological analysis. However, the rooting is changed to the branch between the nodes with *B. breynei* and *B. grisea*, since both nodes equally have the largest amount of primitive characters.

A striking feature of this analysis is that both the ci (= 48) and ri (= 48) are fairly low. Since the ci is dependent on total number of taxa, it is not surprising that it is higher in this 12 taxa calculation than in the entire analysis of 44 taxa. But when it is compared to a separate analysis of the 15 taxa of *Aphanocalyx* (ci = 57, ri = 66) it is clearly lower. The ri is lower than that of both the entire analysis (ri = 63) and that of *Aphanocalyx* on its own. This indicates that this part of the tree is more difficult to reconstruct due to more homoplasy than the other parts, and that the results should be observed with much doubt.

As far as the internal evolution of *Bikinia* is concerned, it should be concluded that the available data are too limited to obtain a good picture. Several factors might be responsible for these results:

- At least *B. pellegrinii*, and possibly also *B. le-testui*, seem to cover not one but several, sibling species. Since they have been coded as one, this can account for some extra homoplasy in the group. Hennig86 does not support polymorphisms, so that variation is usually scored as either an intermediate step or as 'present' in case of doubt when no intermediate states are possible.
- Most probably hybridisation has occurred in this group. Maybe some species are of hybrid origin, which is bound to present problems when analyzing such a group with a cladistic method. Also introgression of genes might be responsible for low resolution. The hybridisation hypothesis is supported by the fact that two putative hybrids have been found in this group.
- The evolution of this group probably took place rather recently. In groups with rapid speciation, phylogenetic relationships may be difficult to trace because most branches have existed only for a short time, leaving hardly any character fixations as evidence.

In the present analysis *I. dunensis* ends up close to *B. le-testui*. It should be kept in mind that *I. dunensis* is poorly known, and that many of its characters are coded as "?". Its placement close to *B. le-testui* is thus based on a very limited amount of data in a group where relationships are already vague in the first place. In September 1998, after this analysis had been undertaken, mature flowers of this species were obtained, and these clearly indicate that the species does not belong in the *Bikinia* clade. When the flowers will be coded it is more likely that this species will take a basal position under *Bikinia* rather than the place it occupies in the present analysis (see also discussion in § 8.3 and notes in § 12.2).

Concerning the internal phylogenetic structure of *Bikinia* the main conclusion has to be that no firm statements can be made. There is only some indication that *B. evrardii*, *B. durandii*, *B. coriacea*, *B. aciculifera* and *B. le-testui* form a clade.

Aphanocalyx

The internal phylogenetic tree of *Aphanocalyx* shows some firmly supported clades and some weaker parts. The basal division into two clades, here treated as subgenera, is strongly supported. The internal topology of subgenus *Antherodontus*, where *A. libellula* and *A. heitzii* form a clade with *A. hedinii* as a sister clade, is strongly supported as well. An interesting test for this clade will be the petal colour (yellow in *A. heitzii*) of the other two species when this feature becomes known. The yellow petals might be a character for the entire subgenus, but it could be restricted also to the clade of *A. heitzii* and *A. libellula*, or even represent a character which opposes such a clade. Of course also all the other characters that are so far unknown for *A. libellula* (all stipule and pod characters!) and *A. hedinii* will provide a very interesting test of the present topology.

The internal topology of subgenus *Aphanocalyx* poses more problems. First of all this topology is dependent on the direct outgroup(s) of the genus *Aphanocalyx*. In some other analyses, e.g. the one which excludes *Oddoniodendron* etc., where *Bikinia* forms the direct outgroup of *Aphanocalyx* (fig. 6.5a), the division into subgenera remains in place, but *A. trapnellii* occupies the most basal position in subgenus *Aphanocalyx*. As the same analyses suggest that floral elements have re-developed after having been reduced to (almost) zero, this solution seems a questionable one. However, it does show that this part of the cladogram is sensitive to the choice of the outgroup. In order to tackle this problem, an analysis was made of subgenus *Aphanocalyx* with subgenus *Antherodontus* as outgroup (in all analyses subg. *Antherodontus* proved to be the sister clade of subg. *Aphanocalyx*). The result of this analysis (fig. 6.4) was exactly congruent with the structure of *Aphanocalyx* in the shortest tree, rendering that topology fairly well based.

Because during bootstrap and mojo analyses other outgroups will be joined regularly to *Aphanocalyx*, some of the internal nodes of subgenus *Aphanocalyx* will appear more weakly than they actually are. To see how stable the analysis of *Aphanocalyx* is on its own, without the disturbance caused by varying outgroups, a mojo and bootstrap analysis (same conditions as above) was performed on *Aphanocalyx* alone (fig. 6.4). The results suggest indeed that the instability was partly caused by the variable outgroups, although the difference is fairly moderate. Since the true outgroup for *Aphanocalyx* is unknown, and since it might very well be a group which was not even used in the present analysis (e.g. *Anthonotha*), it is to be preferred to use the topology, with the bootstrap and mojo support, of the separate analysis as far as the internal phylogeny is concerned.

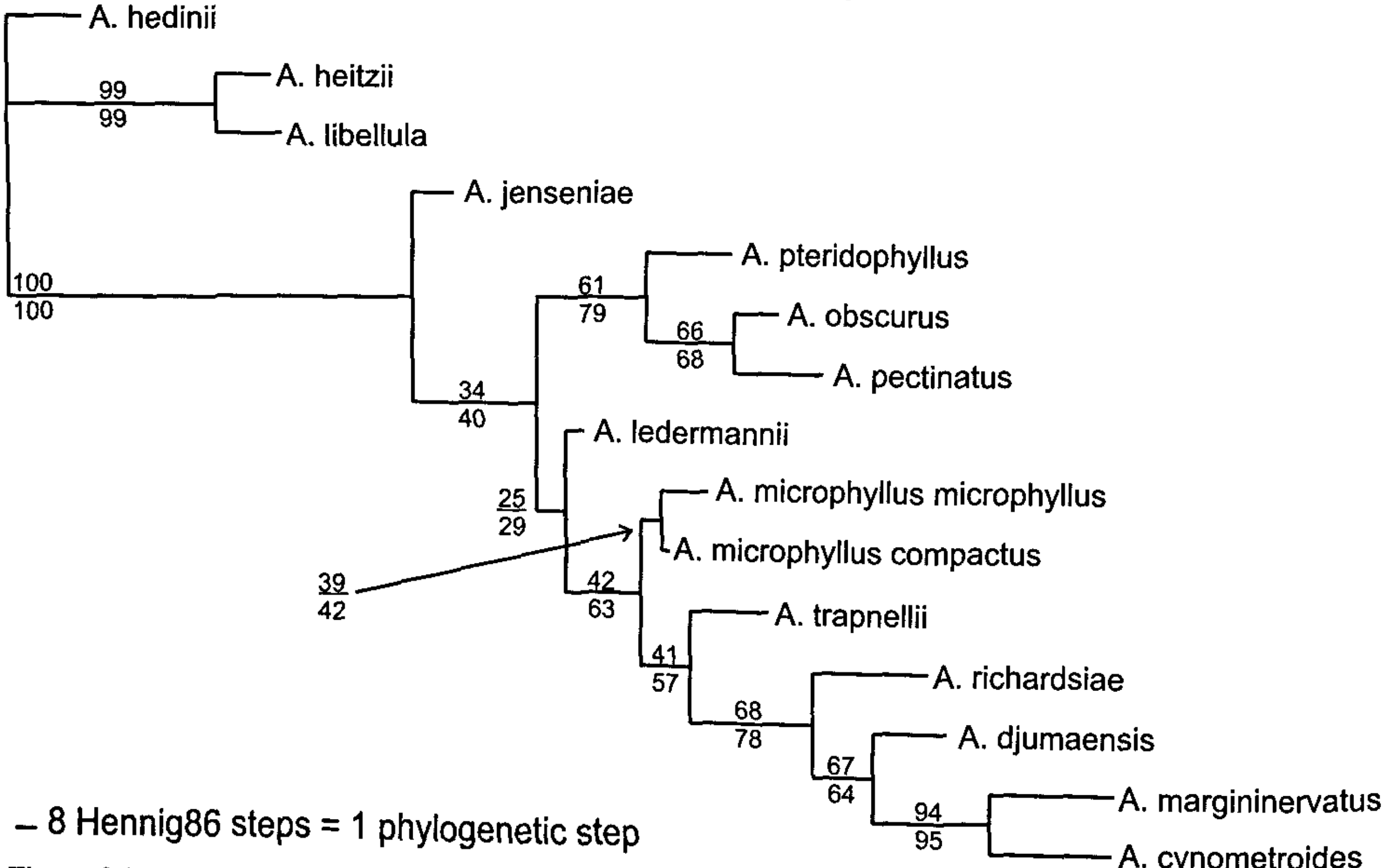
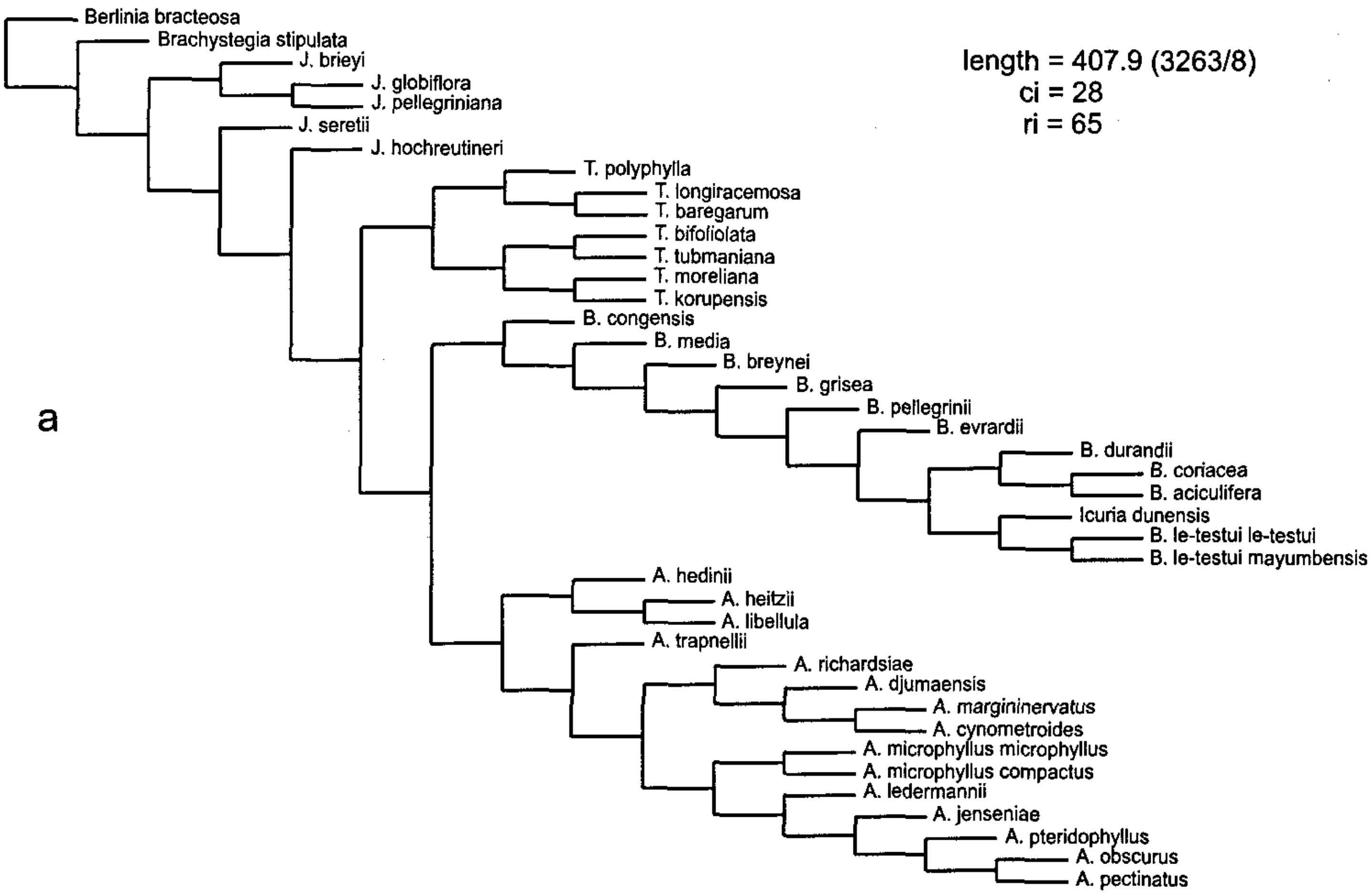


Figure 6.4. Shortest tree of *Aphanocalyx* leaving out other taxa. The tree is rooted with subgenus *Antherodontus*. Relative branch lengths are shown on horizontal branches (see scale). Above each branch the bootstrap value (in % of 1000 replicates) of that branch is indicated, as is the mojo value (in % of 500 replicates) below that branch.

A. jenseniae is either the most basal taxon of subgenus *Aphanocalyx*, or it is the sister clade of the '*Monopetalanthus*' clade which includes *A. pteridophyllus*, *A. obscurus* and *A. pectinatus* (e.g. fig. 6.5 a & b). As a matter of fact *A. jenseniae* has many primitive features, e.g. all flower parts still present, making either position plausible. The '*Monopetalanthus*' clade is a well established clade, which is characterized by some



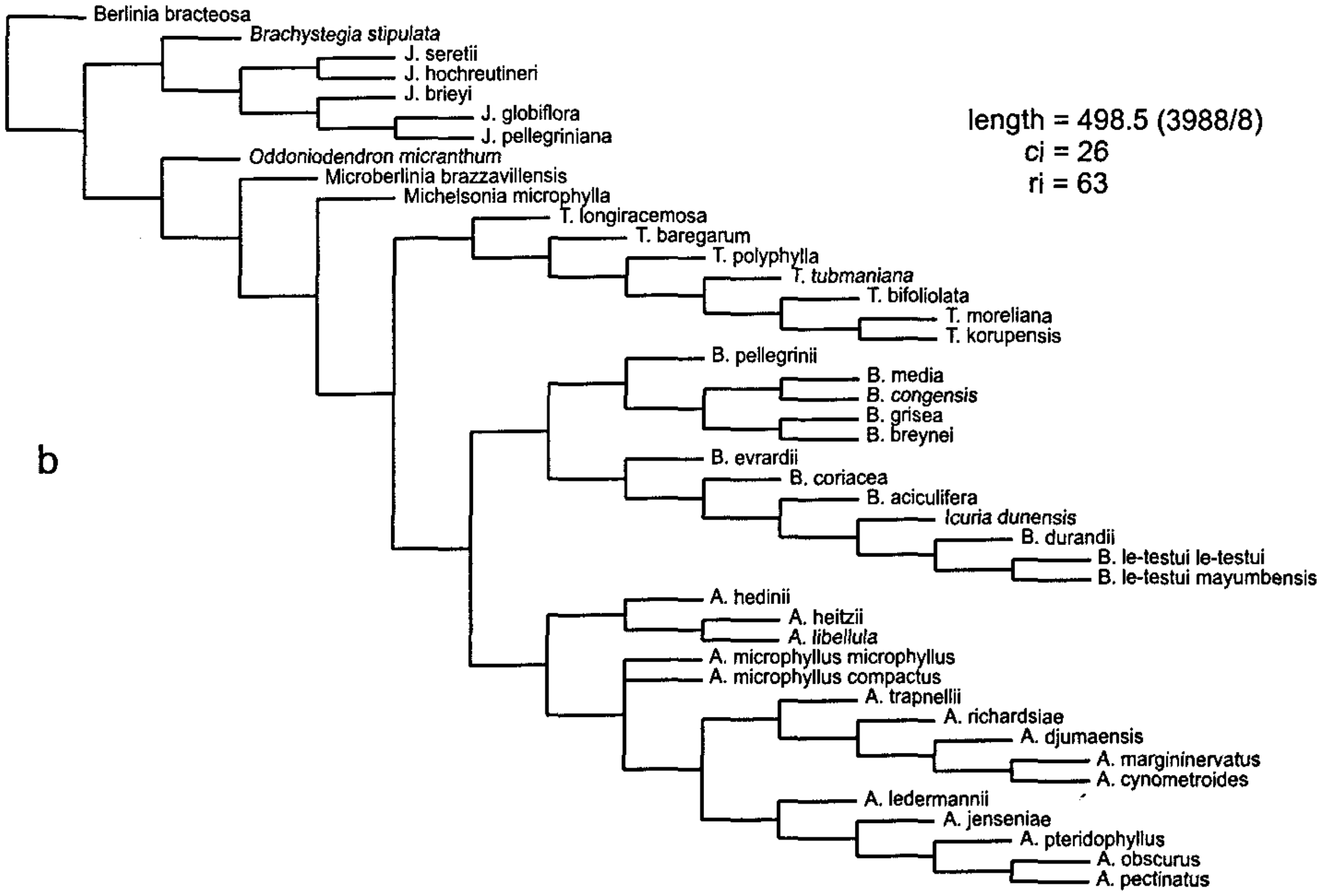


Figure 6.5a. Shortest cladogram resulting from the morphological matrix excluding *Michelsonia*, *Microberlinia* and *Oddoniodendron*.

Figure 6.5b. Strict consensus cladogram of the analysis of the entire morphological and TLC dataset.

remarkable features such as the persistent, inflated stipules housing ants and velvety pods with a well-developed wing on the upper suture.

The two subspecies of *A. microphyllus* are only weakly supported as a clade. However, given the very short length of this branch, its bootstrap and mojo values are not low at all. Since subspecies *compactus* has hardly any proper character changes, it could qualify as being ancestral to subspecies *microphyllus*.

A fairly firm clade (*Aphanocalyx* s.str.) is formed by *A. cynometroides*, *A. margininervatus*, *A. djumaensis*, *A. richardsiae* and possibly *A. trapnellii*. The first 4 species have only a single pair of leaflets. *A. trapnellii* is intermediate in this character; it has more than 1 pair, but less than most of the other species of the subgenus. Its general appearance is still very similar to *A. microphyllus*. On the other hand it does have a distinct lateral nerve on the pod (which is not evident in the coding since it was not yet 1 mm emergent!). An even more pronounced lateral nerve is present in most of the other species of this clade.

The fairly weakly supported clade containing *A. microphyllus* on one hand and the '*Aphanocalyx* s.str.' clade including *A. trapnellii* on the other hand does make sense. As stated above, *A. trapnellii* could be considered as intermediate between the multijugate *A. microphyllus* and the one-jugate species of *Aphanocalyx*. If *A. trapnellii* would not have had such distinct pods, I would have seriously considered lumping it into *A. microphyllus*. On the other hand, those pods come pretty close to some pods of *A. richardsiae*. One should note that the mojo support (63) for this clade is fairly high.

The definite topology between *A. ledermannii*, *A. jenseniae*, the '*Monopetalanthus*' clade and the extended '*Aphanocalyx* s.str.' clade remains uncertain.

Tetraberlinia

Although the internal phylogenetic structure of *Tetraberlinia* is only weakly supported by bootstrap and mojo-analysis, this structure is less unstable than it seems. There are actually only two parts of the topology which might alter when the direct outgroups of *Tetraberlinia* change due to different weighting or the exclusion of taxa. Such easy changes are most probably also the source for the lower bootstrap and mojo values.

The first alternative topology variant (e.g. fig 6.5a) places *T. tubmaniana* and *T. bifoliolata* in a clade, with *T. korupensis* and *T. moreliana* as its sister clade. There are a few characters which point in this direction, e.g. the double rib on the bracts and the (non coded!) tendency in some *T. bifoliolata* collections to have flowers arranged in two rows as well. Also the bootstrap support for such a topology would be higher, but apparently the total evidence for another topology, that of the shortest total tree (fig. 6.2), is stronger. The latter is also supported by some nice characters, such as the presence of a second lateral nerve on the pod. Still, this alternative topology should be seriously considered as being the true one, especially when one realizes that it would be the shortest option when the tree is calculated leaving out some other genera (figure 6.5a) or when the tendency in *T. bifoliolata* towards 'flowers in two rows' (character 42) would have been coded in some way. Half a step would have been sufficient to make both options equally short.

The second variant concerns the place of *T. baregarum*. In the shortest tree it is placed at the base of the genus just below the branching off of *Bikinia*. In some analyses, however, it settles before or after the branch with *T. polyphylla* (e.g. see figure 6.5b) or forms a clade together with *T. longiracemosa* and *T. polyphylla* (e.g. see figure 6.5a). Only in a few cases does it join up with *Michelsonia*, but this arrangement is opposed by the dark colouring in alcohol of this species, a character which was not coded in this analysis, and by the stipule scars which do meet up in the leaf axil. For these reasons it is discarded. One should note that the low bootstrap support for the clade *T. baregarum* with *Tetraberlinia* and *Bikinia* is partly caused by the low support of the *Bikinia* + *Tetraberlinia* clade. All trees which include *T. baregarum* in *Tetraberlinia* but exclude *Bikinia* as its sister, do not count for this bootstrap value!

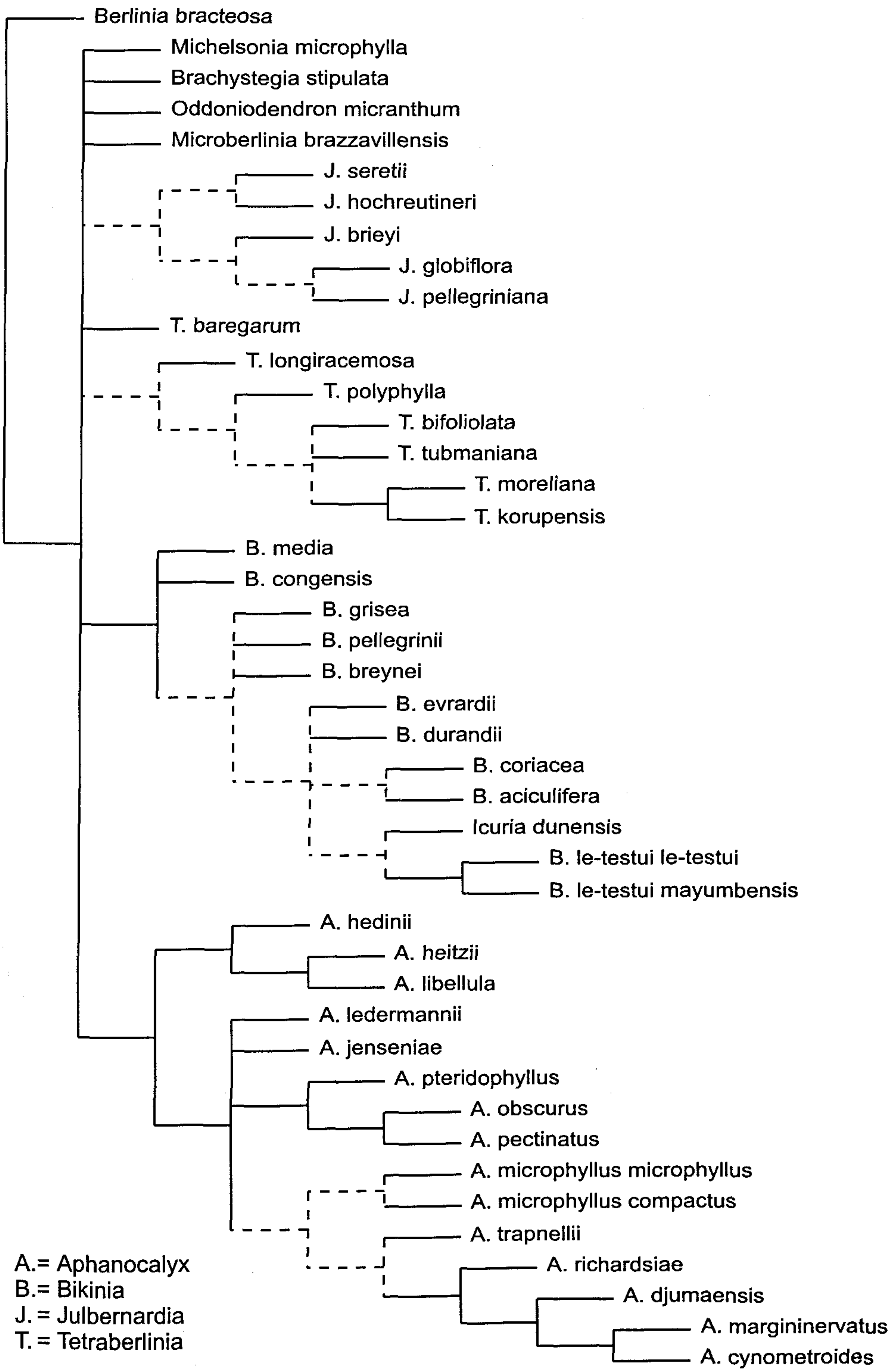


Figure 6.6. Conclusive cladogram, showing strongly supported branches (bootstrap > 60%) as solid lines and weakly supported clades (bootstrap between 40% and 50% or nearly 40% but with a higher mojo value) as dashed lines. Clades with less support are collapsed.

What we do know about *Tetraberlinia* is that *T. longiracemosa* and *T. polyphylla* are always found at the base of this genus (either pectinate or as a clade), whereas the four earlier mentioned species always form a more advanced part of the genus. *T. moreliana* and *T. korupensis* are indeed very closely related, and it is not surprising they form such a strongly supported clade.

Julbernardia

All internal nodes of *Julbernardia* are fairly weakly supported. The clustering of *J. seretii* with *J. hochreutineri* is most probably correct, both species indeed are very similar, and sometimes hard to tell apart. Interesting is the clustering in a clade of *J. pellegriniana* with *J. globiflora*. The species are quite different, but the clustering does show that there might not be much ground for the separation of the first species in a monotypic genus (*Paraberlinia bifoliolata* Pellegr.). It should be remarked that for *Julbernardia* not all of the species have been coded. *J. paniculata* was not coded because it is very similar to *J. globiflora* and would have received (almost) the same codes. Both species clearly form a clade. However, some other species do have cladistic characters of their own and might end up on distinct branches, or they might even quite change the present topology of the genus. In any case one should not value this topology too strongly: most coded characters were chosen because they occur (and vary) within the group studied initially. Only a few characters (22, 23, 30 & 63) were added because they showed some interesting features of *Julbernardia*. However, if we would want to solve the internal topology of *Julbernardia* we could probably find quite a number of additional interesting characters.

6.7.2 Phylogenetic relations between the genera

As discussed above, most of the genera are well supported. The next level of aggregation however, appears to be one big mess. At this level any topology is highly unstable and shows very low bootstrap and mojo values. The relationship between the genera therefore remains a complete mystery. Of course, there is a single, shortest tree, and that solution is our best guess. However, other possible solutions (e.g. fig. 6.5) are only negligibly longer and cannot be set aside on this ground alone. One could even argue about which tree is the 'better' one. The tree including the chromatography data (fig. 6.5b) is based on more data, and as such it could be valued higher. However, at present the chromatography data are not completely reliable (see chapter 5), and I rather tend to disregard it for that reason. Still, whichever choice would be made, any of these topologies is unreliable and yields low bootstrap supports for the branches that organize the various genera.

6.7.3 Overall phylogeny

In order to obtain a picture of which clades are supported and about which relationships actually nothing definite is known, the results of the discussions on clades as given above have been summarized in one figure (6.6). Branches with a bootstrap support of more than 50% (actually more than 60%, since the range of 50–60% does not occur) are depicted as solid lines. Branches with a bootstrap support between 40 and 50% or with a bootstrap support of almost 40% and strong mojo support are depicted as dashed lines. All other clades have been collapsed.

6.8 Character evolution and evolutionary trends

Figure 6.7 shows the characters which appear to have a high phylogenetic content. All characters with a RC ≥ 0.2 (Farris, 1989) were plotted (similar to Sosef, 1994: 103 who plotted characters with a RC ≥ 0.1). Some characters with a lower RC were added when they did not show too many changes in the tree or were of interest to the discussion. Character 71 (adaxial petal without or with the apical margin folded inwards) for instance has a RI (and so a RC) of 0: the distribution of this character can be explained by two autapomorphies as well as by a single development and a single reversal (plotted this way in 6.7a & c), while in a slightly different topology (e.g. that of fig. 6.5a) it would yield a RC of 1. Some of the gap-coded characters also performed fairly well, but since such characters consist of many states, resulting in many transitions, these characters have only been plotted when they reached a RC of 0.2. Reversals are marked by dotted lines; characters which change on the root branch have been plotted as a character of *Berlinia bracteosa*, so they do not cause reversals higher up in the tree. When characters could have been plotted in several ways on the tree, only one of those possibilities was chosen.

Some of the characters used fit the tree very well, and do not need any explanation: they just developed in that line and remained present. One could only argue about the reason for such a character to develop. A lot of 'minor' characters (e.g. indumentum characters) are not at all in line with the cladogram, but such characters were not supposed to be very good indicators for overall phylogeny. They were merely added to the analysis to obtain resolution around the specific level. Several 'major' characters, however, do not completely follow the cladogram either, and require some discussion.

One of such features is the absence of the distal half of the leaflet (character 24), resulting in the midrib becoming a marginal vein. As far as I know this character is unique in the Leguminosae. In *Brachystegia* there are one or two species where the distal half is very narrow but still present. Apparently this character does not develop easily and may be expected to have a strong phylogenetic background. Still, it shows a reversal in the present tree. If one considers such a reversal impossible, the alternative explanations are expensive. Either *A. cynometroides* becomes basal to the rest of the genus, or all other branches have developed the character (9 times) independently of each other. The reversal becomes more plausible when we consider the circumstances under which the character developed initially and its evolutionary advantage. The distal half of the leaflet disappeared in a species which was most probably growing in a rain forest and which had, according to the phylogeny, about 10 pairs of leaflets. In a rain forest (with optimal growth conditions) a tree will try to catch as much sunlight as possible with a minimal investment in leaflets. In a multijugate situation such an optimum can be attained when the leaflets tightly fit in the overall leaf shape, but do not overlap. One can easily imagine that in a compound leaf overlap is avoided more easily by tightly fitting leaflets that lack a distal half, than one provided with complete leaflets. Indeed, it is striking how well the leaflets fit to each other in most multijugate species of *Aphanocalyx*. This 'extent of fitting' is never achieved in other genera, although some species with very straight leaflet margins (e.g. *Bikinia coriacea*) do approach it.

However, part of the species of *Aphanocalyx* ('*Aphanocalyx* s.str.-clade') have developed leaves where only a single pair of leaflets is left. In such a group it is no longer an advantage to miss the distal half. It may even be a disadvantage because the leaflets

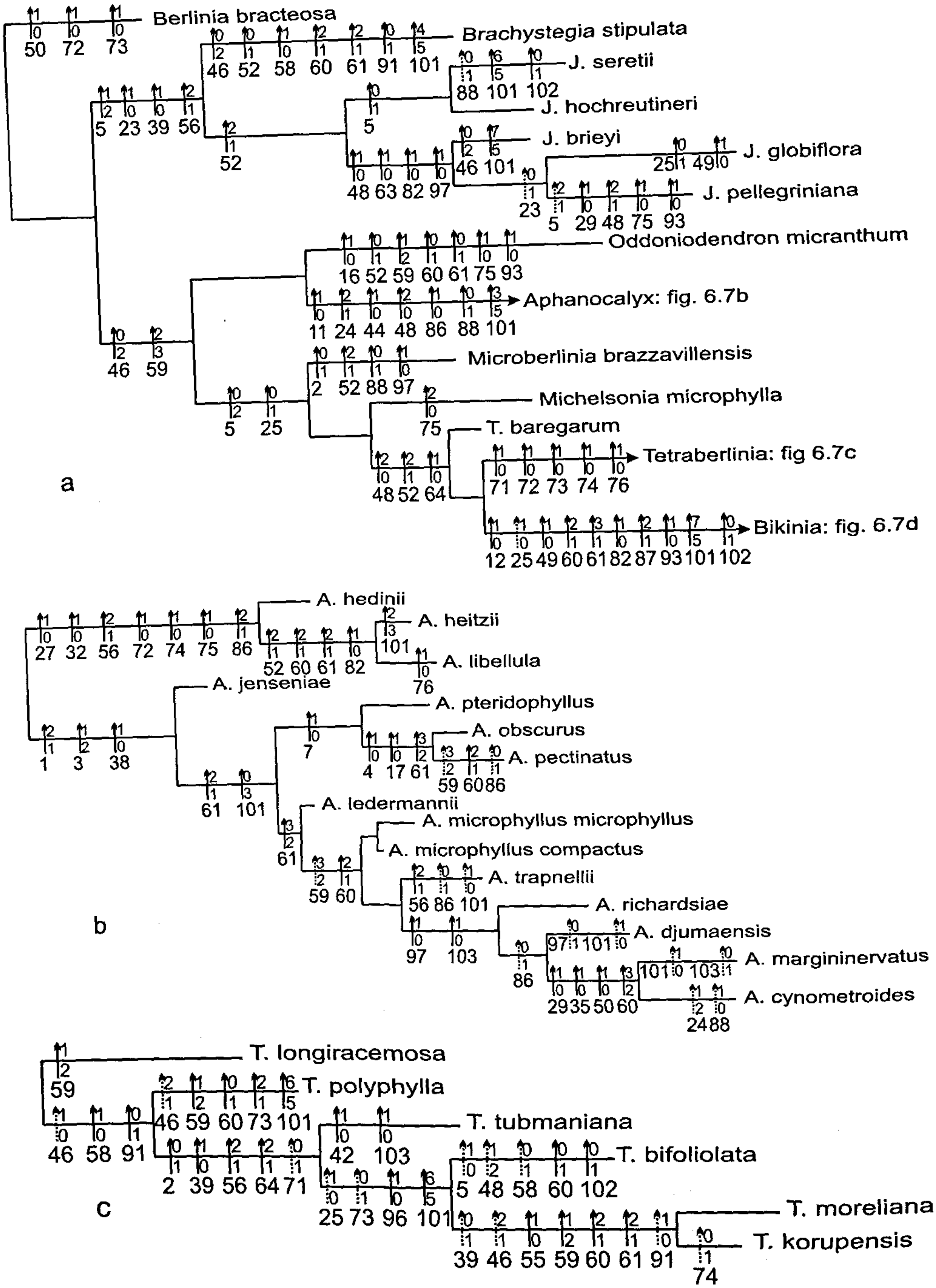


Figure 6.7. Shortest tree from 44 taxa analysis showing one of the possibilities for plotting the best characters on the branches. Reversals (counted for this tree) are indicated by dotted lines, except that the characters which change on the root branch are considered to have developed in the part leading to *Berlinia bracteosa*. Some characters could have been plotted in a different way as well, the pictured tree is just one of the possibilities.

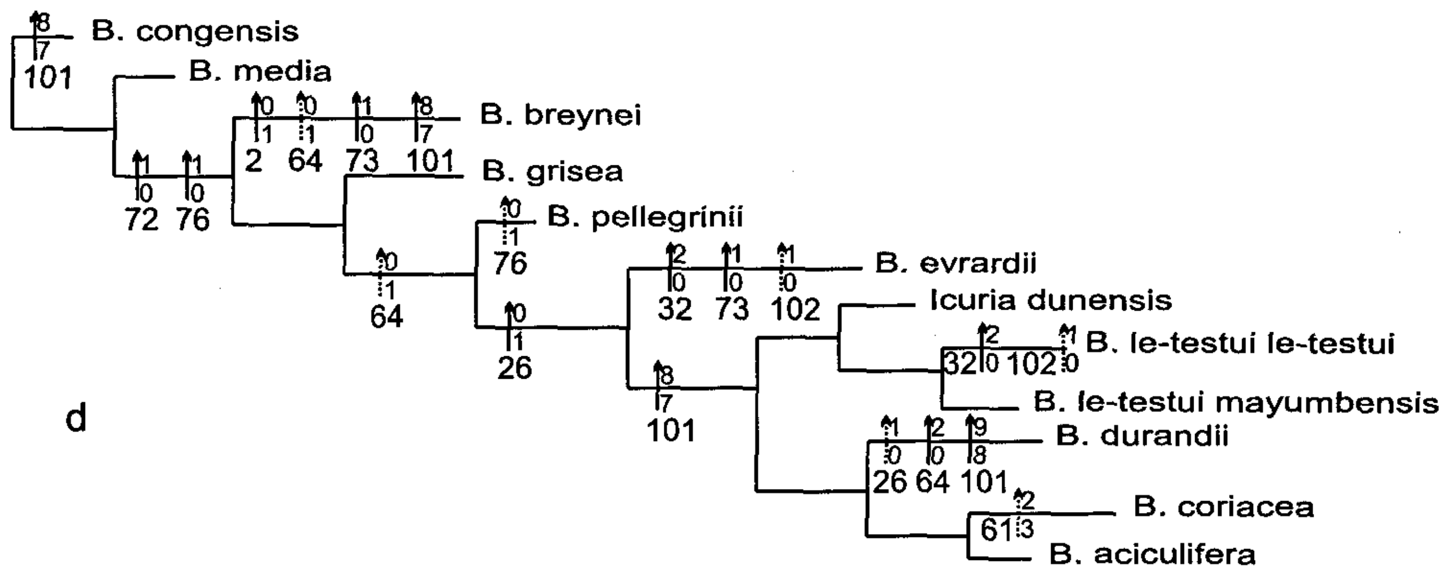


Figure 6.7: (continued) Figure b–d consist of pruned branches of figure a.

cannot fill the intermediate distal space between the leaflets. Under such circumstances one may imagine that a species rebounds into development of its distal half of the leaflet.

Another explanation of this phenomenon could be that *A. cynometroides* arose from hybridization between a species of *Aphanocalyx* and a species from another genus. One might point to the strange red glandular cells on the leaflet surface of *A. cynometroides* as another indication of alien genes present in this species. However, such cells are also present, although in much lower quantities, in some of the related species in *Aphanocalyx*. If *A. cynometroides* originated from intergeneric hybridization one would expect to find other unique characters, not present in other species of *Aphanocalyx*, as well. As this is not the case, this explanation becomes rather unlikely.

Another interesting character is the number of leaflet pairs (character 15). This character proved to be fairly variable, yielding a ci of only 0.17 (ri = 0.42), but it remains interesting to see how it varies. For instance in *Aphanocalyx* we see a base number of about 10 pairs, which increases in subgenus *Antherodontus*, finding its highest numbers in *A. hedinii*. An interesting bifurcation is present after the branching off of *A. ledermannii*. One clade (*A. microphyllus*) remains in the forest and starts developing more pairs, the ancestor of the other clade moves into a savanna-gallery forest environment and shows a reduction range ending up in a single pair.

A character which scores remarkably well is the position of the cotyledons in seedlings (101). For a character where the variation is divided into 10 states, the ci of 0.42 and ri of 0.85 are very high. First of all it proved possible to distinguish *Aphanocalyx*, *Bikinia* and *Tetraberlinia* on this character (remembering that the values refer to averages, individual seedlings cannot always be assigned to a genus unambiguously). Especially in *Aphanocalyx* this character is interesting to interpret. The cladogram indicates that in the common ancestor of this genus the cotyledons are already in a relatively elevated position, remaining so in subgenus *Antherodontus*, whereas they evolve into an even higher position (with the epicotyl nearly reduced to nil) in subgenus *Aphanocalyx*.

A character which initially puzzled me is character 32: lower surface of leaflets dull and greyish. An analysis with a light microscope showed this was caused by the presence of conical epidermal cells. The character seemed to occur in two groups (in *Aphanocalyx* subg. *Antherodontus* and in two species of *Bikinia*), but when Gervais (1998) discovered that the two concurrences were not homologous, this problem was solved. Since no anatomical research has been performed on the leaflet surface of *A. libellula*, this species has been coded '?'. The current cladogram predicts that this species will have state 1. Indeed the surface is dull and greyish, at least ruling out state 0.

The distribution of this character in *Bikinia* (state 2) is not very satisfactory. The present cladogram suggests it may have evolved twice, once in *B. evrardii* and once in *B. le-testui* ssp. *le-testui* (fig. 6.7d). Since this epidermis structure seems to be a quite unique character, this distribution appears strange. There are several plausible explanations:

- The cladogram is partly incorrect, because *B. evrardii* and *B. le-testui* are more closely related than is shown. This option is not unrealistic given the poor resolution in *Bikinia* in the first place.
- The character developed in a common ancestor of both *B. evrardii* and *B. le-testui*, but it became (nearly) fixed in those two species only, whereas it was lost in the other branches (parafixation, see Kornet & McAllister, 1993: 76 & 80).
- The character developed in one species (e.g. *B. evrardii*) and by hybridization and subsequent introgression ended up in the other species as well. Given the fact that some other putative hybrids were found in this genus, this explanation is not unlikely either.

A quite remarkable character state present in several species is an auriculate stipule base (8). At first sight such an auricle structure seems a good candidate for a uniquely derived state. However, half of the species with auriculate stipules have fused stipules, the other half not. The cladogram indicates that this character state indeed has developed several times in this group and that it is only indicative for small groups of species. If one considers the fact that auriculate stipules are present in many other Macrolobieae and even Detarieae, usually only in part of the species of a genus, it becomes clear that this character may not be so unique to develop after all. Apparently it concerns a trait that is easily attained in this corner of the Caesalpinioideae.

In a note below character 72 (adaxial petal abrubtly broadening beyond a relatively short claw) the state '0' in two species (*B. congensis* & *B. media*) is noted as being actually derived from state '1', whereas other species with state '0' are not supposed to have their state derived from '1'. In the present cladogram, however, the character distribution suggests that the two mentioned species really have a primitive state '0' instead of being derived from '1'. As discussed under *Bikinia* the topology within this genus is rather weak, as well as the position of its base, but if the present topology is true, then the tiny indications on which the presumption of a 'loss' were based are probably the first signs of the development of the character.

6.9 Features of bootstrapping and mojo analyses

6.9.1 Effect of poorly known taxa

As described in '6.6 Analysis' bootstrap and mojo values were calculated using separate datasets including and excluding two taxa with a high percentage of missing data (*T. baregarum* and *I. dunensis*). Theoretically one would expect that an incompletely known taxon is likely to end up in much more different as well as more extreme places in the tree during succesive replicates than a taxon with all data known. This will result in much lower bootstrap and mojo values for clades which include those poorly known taxa and in a lesser extent also for clades present at short distances. Such lower values do not indicate that a clade as such is likely to be wrong, only that there exists doubt whether the poorly known taxon is part of it or not.

When we compare the results from both analyses (fig. 6.2 & 6.3), it becomes clear that this expected effect is present. However, the effect on bootstrap values is much higher than it is on the mojo values. The largest effect is in the *Bikinia* clade, which is not surprising as one poorly known taxon is part of it and the second branches off near its base. The bootstrap value drops from 99 to 86%, whereas the mojo value drops from 73 to 71%. An expected effect on the *Tetraberlinia* clade is also present, although not as strong: the bootstrap drops from 39 to 31, the mojo value from 49 to 44. All bootstrap values inside *Bikinia* also decrease, but only by a small amount; mojo values do not change or they become either slightly higher or lower.

The different response of mojo and bootstrap analyses to the inclusion of taxa with missing data is interesting. In case of a mojo analysis only 10% of the data of a taxon with 50% informative data with be substituted with '?', because the other 10% already consisted of a '?'. On the other hand this 10% is still 20% of the informative data. More importantly: about the same argument holds true for a bootstrap analysis. The doubling or discarding of 50% of the characters will change nothing for these species. Maybe the explanation should be sought in the data-doubling or tripling which occurs in a bootstrap analysis: for a species with only 50% of the characters known, a doubled or tripled character has a far more important effect than for a species with all data present. In a mojo analysis such a doubling of data does not take place.

Whatever the real cause: in a mojo analysis the effect of taxa with missing data is very small, if not even negligible. In a bootstrap analysis it is present, and can be substantial.

6.9.2 Comparison of bootstrap with mojo analyses

It is interesting to compare the results of the bootstrap analyses with those of the mojo analyses. In this study these values point in the same direction[2)]. Only in a few cases do they deviate considerably. In the 42-taxon-analysis (fig. 6.3) both *Aphanocalyx* subgenus *Antherodontus* and *Bikinia* receive a bootstrap of 99%. The mojo values, however, are 99% and 73% respectively. The most striking difference between the two clades is that *Bikinia* is much larger (11 taxa) than *Antherodontus* (3 taxa). Possibly mojo values are likely to be lower for larger groups than for smaller groups. Indeed, the second highest bootstrap value (95%) for the large subgenus *Aphanocalyx*-clade (12 taxa) corresponds to a mojo value of 65%. An explanation for this phenomenon (partly?) may be that the amount of information in a mojo replicate is really 20% less, whereas the number of data points in the bootstrap analysis remains the same (only some are copies of each other). In clades with many taxa there is a larger chance that one of the taxa receives a relatively high percentage of missing data, so that it ends up at quite a different place in the tree, than in clades with only a few taxa. Since a single misplaced taxon already causes that the clade is discarded, such larger clades will yield lower mojo values compared to an equally strongly supported smaller clade. In a bootstrap analysis the number of characters which are doubled or discarded is always the same for all taxa.

The fact that mojo values for larger groups tend to be relatively lower, does not mean

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[2)] It should be noted that the absolute bootstrap values cannot be compared with the mojo values. It is an arbitrary choice to calculate mojo values with 20% replacement of data with '?', if the mojo values were calculated with e.g. 30% replacement, all the mojo values would have been lower. Only their relative values can be compared.

that these values are to be disregarded. Maybe the probability of larger clades to be really true is indeed less. To be really true, it should contain all taxa grouped in it. It is more likely that at least one taxon of a large clade is wrongly positioned, than that one of the taxa of a small clade is not a member of it. If one would like to use a mojo or bootstrap value as an estimator for the probability that a clade is true (like Hillis & Bull, 1993 try for bootstrap values), then mojo values might be more appropriate than bootstraps values. Whether this is really the case will have to be tested with simulation studies.

While calculating bootstrap values with PAUP, an interesting feature of bootstrap values revealed itself. After a bootstrap analysis, PAUP shows a tree with all clades which have a support of over 50%. In all three bootstrap analyses that include *Aphanocalyx* surprisingly two clades showed up with a support of about 52% which were not present in the shortest tree. The first is a clade consisting of the '*Monopetalanthus*-clade' and *A. jenseniae.* The second includes the first clade jointed to *A. ledermannii.* As already discussed in 6.7.1, the first clade is not considered impossible. However, the position of *A. ledermannii* at the base of such a group is unlikely since it would assume reduced floral elements to re-develop. Moreover, there exists a shorter solution for these taxa. So, from a phylogenetic viewpoint these clades are less likely and therefore they are disregarded. Still, it is interesting to know *why* such a group receives a bootstrap support which is higher than the support for the actual shortest tree. The reason probably is the following:

A tree which includes those 5 taxa as a single clade is only slightly longer than the shortest tree. So, it is likely that such a tree will become the shortest one or at least equally long in quite a number of the different bootstrap replicates. As soon as it is equally long, an interesting phenomenon can be observed: In the situation were those 5 taxa form a single clade, other taxa become unstable within *Aphanocalyx*, resulting in several equally shortest trees. Since for such a bootstrap replicate every shortest tree has an equal contribution to the bootstrap value, those two or more trees including the 5-taxon-clade will contribute more than the single tree where *A. jenseniae* is the most primitive species of the subgenus, and *A. ledermannii* is joined to the rest of the subgenus (3-taxon-clade solution). So, in all replicates where both options are equally short, the 5-taxon-clade yields a far higher bootstrap support than the 3-taxon-clade. Moreover, both Hennig86 and PAUP appeared to have more problems finding this 3-taxon-clade solution than in finding the 5-taxon-clade solutions. For PAUP this last problem is countered by running 20 repeats per replicate, but if the same problem occurred with the mojo values (which we do not know since only bootstrap values for clades present in the shortest tree were calculated) the inability of Hennig86 to find the 3-taxon-clade solution might have influenced these values as well (MOOTOO uses Hennig86 as a subroutine).

It should be considered a disadvantage of both bootstrap and mojo values that they are sensitive for a situation were two trees are equally short, but one is instable in some parts, whereas the other is not. Being unstable is not an argument for such a tree being more suitable, still such a solution receives a higher value than the other option. The more unstable, the stronger it scores! I think we need bootstrap and mojo programs that, in case of the presence of several equally short trees, only score whether a clade is present or not in any or all of these trees. If it is present in all trees, it should receive the value 1 (for that replicate), if it is present in at least one tree but not in all, it should receive the value 0.5.

7 AFLP analyses

J.J. Wieringa & M.J. Zevenbergen

7.1 Introduction

The AFLP technique (Vos et al., 1995) (often referred to as "amplified fragment length polymorphism", but see original publication) has proved to be a valuable instrument for phylogenetic analysis of fairly closely related species (Kardolus, 1998). To date taxonomic applications have been restricted to taxa for which fresh leaf material for DNA extraction was available. However, living material of many tropical plants is generally not readily available, and often these are difficult to cultivate. The *Aphanocalyx-Monopetalanthus* complex is a representative example of such tropical plants. Most of the species of *Aphanocalyx*, *Bikinia* and *Tetraberlinia* are large forest trees for which it is difficult to collect specimens. Furthermore, these species have proved extremely difficult to cultivate from seeds or seedlings. However, since 1994 samples of leaves dried in silica gel have been taken in the field for the majority of the species of this group.

Because the AFLP method produces DNA fragments of about 100–500 base pairs, the technique needs fairly high quality DNA. As silica gel dried leaves sometimes yield somewhat degenerated DNA (Chase & Hills, 1991), it was uncertain whether DNA obtained from silica gel dried leaves would be appropriate for AFLP applications. Furthermore, AFLP's are generally used at the infraspecific level (e.g. Eck et al., 1995) or for groups of closely related species (Folkertsma et al., 1996), the application of this technique on taxa considered to belong to different genera has not previously been tested. Kardolus et al. (1998) have shown that the technique is still applicable for taxa as different as *Solanum* sect. *Petota* Dumortier (potatoes) and *Solanum* sect. *Lycopersicum* (Mill.) Wettst. (tomatoes), but they doubted its suitability at the generic level in general.

To test whether or not the AFLP technique can be applied on DNA obtained from silica gel dried leaves, and to see if it can be applied at or above the generic level, a pilot study was conducted using a few taxa from the complex. A *Julbernardia* species considered as a close relative based on a morphological study (Wieringa, 1997) was added as a possible outgroup.

7.2 Material and methods

One species of *Julbernardia* and eight from the complex were sampled; two species of *Tetraberlinia*, three of *Aphanocalyx* and three of *Bikinia*.

Leaf samples of two *Aphanocalyx* species and *Julbernardia brieyi* (De Wild.) Troupin were obtained from plants growing in the tropical greenhouse at Wageningen. Of these plants about 0.5 g of leaf material was nitrogen-frozen. A total of 8 samples from the other 6 species examined were obtained from leaves dried in silica gel (table 7.1).

DNA was extracted using the CTAB-method of Bernatzky & Tanksley (1986), modified by replacing the precipitation steps by a precipitation with a high concentration of NH_4Ac as described by Doyle (1991), or (for the Montreal samples) using a CTAB-method modified from Doyle & Doyle (1987; A. Bruneau, pers. comm.). All accessions are listed in table 7.1; vouchers are deposited at WAG.

The AFLP analysis followed procedures described by Eck et al. (1995) and adapted by Kardolus et al. (1998) with the exception that 250 ng of DNA and half the amount of restriction enzymes were used, the dilution of the samples after restriction and ligation was 10-fold and a 0.35 mm sequence gel was used. Two different primer combinations (p.c.) were tested: EcoR1+ACA / Mse1+CTA (p.c. A) and EcoR1+ACA / Mse1+CAC (p.c. B).

After restricting, ligation of adapters and the first amplification (with a single selective nucleotide next to the adapter sequence), pcr products were tested for the presence of DNA of the right size. The final pcr was carried out with eight samples and two primer combinations.

On the resulting autoradiograms bands present in at least two accessions were scored and transferred to a matrix (0 = absent, 1 = present). Bands unique to particular accessions were counted over the same range for which shared bands had been scored. All bands scored ranged in size between 150–450 base pairs. Where a very dark, broad band did not permit unambiguous scoring of an adjacent narrow band, the narrow band was scored as "?". The data were analyzed by application of Wagner parsimony (Farris, 1970) using Hennig86 (Farris, 1988). The option ie* was used to obtain all shortest trees. The analyses were also performed using PAUP 3.1.1 (Swofford, 1993) in order to provide the cladogram with relative lengths and bootstrap values. For correct lengths the unique bands were added to the data matrix. Trees were calculated for the data of each primer combination separately as well as for the combined primer combinations. Bootstrap values (100 repeats) were calculated ignoring uninformative characters and using the branch-and-bound and furthest additional sequence options.

The data matrix including unique bands was also analyzed phenetically with TREECON 1.2 for Windows (Van de Peer & De Wachter, 1994), using Nei & Li's distance coefficient (= 1-Dice (1945) coefficient). As clustering method both neighbour-joining (bootstrap 100 repeats) and UPGMA were used. The group which showed the largest distance in the UPGMA analysis was used as the root for the neighbour-joining tree.

Table 7.1. Accessions used in this study. The last 3 columns show results of extraction and AFLP experiment.

Species	voucher[1]	leaf	extr.[2]	amp[3]	pcA[4]	pcB[4]
Aphanocalyx ledermannii (Harms) Wieringa	Wieringa 2400[5]	fresh	WAG	±	12+1?/16	21/7
Aphanocalyx microphyllus (Harms) Wieringa	Ewango 852	dry	WAG	+	-	21/11
Aphanocalyx obscurus Wieringa	Wieringa 1541[5]	fresh	WAG	-		
Bikinia breynei (Bamps) Wieringa	Breteler 14198	dry	WAG	-		
Bikinia grisea Wieringa	Breteler 13334	dry	MT	+	26+1?/10	16+1?/9
Bikinia le-testui (Pellegr.) Wieringa	Wieringa 2123	dry	MT	+	27+1?/14	17+2?/9
Julbernardia brieyi (De Wild.) Troupin	Wieringa 3348[6]	fresh	WAG	+		
Julbernardia brieyi (De Wild.) Troupin	Wieringa 3348[6]	fresh	WAG	+	6+1?/16	12/17
Tetraberlinia bifoliolata (Harms) Hauman	-	dry	WAG	±	28/10	21/14
Tetraberlinia bifoliolata (Harms) Hauman	Wieringa 3304	dry	MT	+	26+1?/11	18+1?/7
? *Tetraberlinia bifoliolata* (Harms) Hauman	-	dry	WAG	±		
Tetraberlinia moreliana Aubrév.	Wieringa 2124	dry	MT	+	19+1?/7	16/10
Total					46/84	46/84

[1] Only the first collector is cited here. For all collectors see the "studied material" in the taxonomic part. The non-voucher samples were collected by M.E. Leal in the Lopé Reserve, Gabon. Some leaflet material of the only sample actually used in the final analysis is preserved on sheet *Leal 39*.

[2] Laboratory where the DNA was extracted: MT= Montreal, WAG = Wageningen.

[3] Amount of high quality DNA after first amplification: - = nothing, ± = low quantities, + = high quantities.

[4] The number of shared bands (before the slash) and unique bands (behind the slash) is given per primer combination.

[5] Taken from a seedling of this collection growing in the greenhouse at Wageningen.

[6] These sample were taken from two different seedlings growing in the greenhouse, the voucher was made from some other seedlings, all grown from a seed sample of 1 tree.

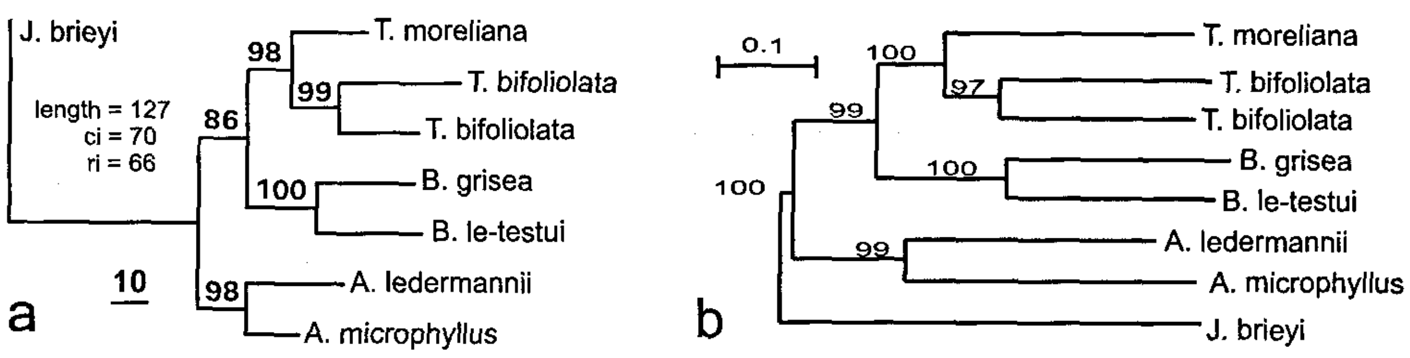

Figure 7.1: a) Single most parsimonious cladogram resulting from Hennig86 and PAUP including bootstrap values (100 repeats) calculated using only informative characters. For the branch lengths all characters are used, the bar represents 10 steps. b) Neighbour-joining dendrogram with bootstrap values (100 repeats). The bar represents 0.1 distance of Dice (1945) coefficient.

7.3 Results

For all samples from the group, dry or fresh, it proved to be difficult to extract reasonable amounts of DNA, when compared to lettuce (*Lactuca*) DNA that was extracted simultaneously. Some accessions (including some from fresh leaf material) had to be re-extracted using larger quantities of leaf material and relatively more CTAB solution to obtain enough DNA for this study.

Samples that yielded only small amounts of DNA amplification products after the first amplification, resulted nonetheless in scorable lanes on the final gel. With p.c. A *Aphanocalyx microphyllus* did not show any bands, while the other seven samples displayed a large number of bands. Bands were obtained for all eight samples with p.c. B. Since the *A. microphyllus* sample showed high quantities of DNA after the first amplification and performed well in p.c. B, the cause of its absence in the p.c. A lane is not related to the DNA quality, but likely is related to failure of one of the AFLP steps that followed the first amplification.

The number of bands (divided in unique bands and bands shared with at least one other accession) per primer combination of each accession is presented in table 7.1. Both p.c. A and p.c. B resulted in 46 shared bands. The datamatrix of these bands is given in table 7.2. *Julbernardia brieyi*, which was added to the analysis as putative outgroup, showed the smallest number of shared bands in both combinations and was used to root the cladogram. Analyses of the data for both primer combinations individually and that of the combined dataset resulted in the same, single most parsimonious tree (fig. 7.1a, in p.c. A *A. microphyllus* omitted because of missing data). Dendrograms resulting from the UPGMA analysis proved to have the same topology as the cladogram, as did the neighbour-joining tree (fig. 7.1b).

Table 7.2. Datamatrix of the shared bands. The first 46 characters concern pcA, the second 46 characters pcB.

J.brieyi	1001000000000000100000000000010000000?01010000	0010000100010000010010000010100000101001010100
B.grisea	001011100001111101000111001110101?111000110111	00100100100001000001000?0101000010110011110101
B.le-testui	0011101101011110010101110011101010011?00110111	1010000010?001100000000?0111001010110011010101
T.bifoliolata	1111000111110100111111101101001111000110010010	0110101001100010001111100000100011110000110110
T.bifoliolata	0111000010110111011110?01101001111100110011010	1110100000?00010001101100000100011110000110110
T.moreliana	0111000001010100000010101001001001?01101011110	1010100000100000001000100000101011110000110110
A.ledermannii	0111011000010000010000100001010010000001000000	0011010101111001110000011000010110001100011100
A.microphyllus	??	0011001010111001111010011000010110000100011100

7.4 Discussion

The extracted DNA and resulting AFLP bands from fresh and from silica gel dried leaflets are of equal quality in our analysis. It can be concluded that the AFLP method can be applied to silica gel dried leaf material as well as to fresh material. Furthermore, in our analysis of the group, shared bands were present for taxa included in different genera, suggesting that the AFLP technique may prove to be a good tool for establishing relationships at the generic level for some other groups as well. These two observations open ample possibilities for the application of the AFLP technique in systematics, especially extending it to groups for which fresh material is not readily available, such as most tropical plants. Because the AFLP technique is relatively inexpensive and fast, it may prove to be an excellent aid for classifying the large number of comparatively poorly known tropical species. Of course this technique cannot replace a classical morphological analysis, but it can be a useful tool for establishing evolutionary relationships. Such knowledge may speed up the morphological analysis.

The two primer combinations result in basically the same cladogram. The same topology also is obtained using distance methods. This topology also is congruent with the cladogram based on morphological characters for the same group (chapter 6, fig. 6.2). Both the AFLP and the morphological analyses recognize the clades of *A. ledermannii* / *A. microphyllus*, of *Tetraberlinia bifoliolata* / *T. moreliana* and of *B. le-testui* / *B. grisea.* However, in the morphological cladogram the relationships among those clades as well as the position of *Julbernardia* remained unclear (fig. 6.5 & 6.6). In contrast, the AFLP results strongly suggest that the *Bikinia* clade is more closely related to the *Tetraberlinia* clade than to the *Aphanocalyx* clade, containing the other species until now classified in *Monopetalanthus*. Apparently the AFLP data are much more informative than the morphological data at this taxonomical level.

This preliminary analysis was conducted to see if the AFLP method can be used on silica gel dried leaves and if it would be meaningful for species from different genera. Now that we know that both questions, at least for this group, can be answered with "yes", a follow-up analysis including as many samples as possible from the group has become desirable. For most of the species silica gel dried leaf material already is available, for the remaining taxa herbarium material should be tested. AFLP appears to be an excellent and efficient way to solve the phylogenetic relationships that could not be unravelled by the more classical methods of chapter 6.

8 Generic delimitation

As stated in chapter 6 (Phylogeny), the phylogenetic relationships within this group are not immediately obvious from the character state distributions. Because of contradicting character distributions, previous botanists (i.e. Léonard, 1957; Aubréville, 1968 & 1970) have been confused about such relationships and, as a consequence, they did not alter the existing classification substantially. At present the phylogeny has become clear, at least partly. Since most of the relationships are quite different from those that could be inferred from the old taxonomic grouping of the species, it is now opportune to reconsider the generic delimitation of the genera studied.

8.1 Monophyly and paraphyly

In modern systematics, systematic groupings (such as genera) are to reflect the phylogenetic relationships of such a group. According to some (e.g. Hennig, 1950 & 1966 & Wiley, 1981) this means we should only classify taxa that form a monophyletic group, while others (e.g. Sosef, 1997, Paton, 1997 & Brummitt, 1996 & 1997) also allow paraphyletic groups into a classification. However, taxa are never allowed to be polyphyletic.

As clearly established by for instance Sosef (1997) and Brummitt (1997), a Linnaean classification is not possible when one only recognizes monophyletic groups (the following arguments are valid for any supraspecific level, but for a matter of convenience I use the generic level as example). As soon as we want to classify species[1] (species i–l in fig 8.1) that are ancestral to several genera (a–c and d–h), these species are bound to end up in a paraphyletic genus unless all life on earth is classified in one genus, which is nonsensical. Some authors (e.g. Wiley, 1981: 223) argue that one should classify species that are ancestral to several genera in a monotypic genus of their own, but this still results in such genera being paraphyletic (although this is contested because monotypic genera cannot be paraphyletic by (some people's) definition, but such definitions only serve to prove wrong things right). Why bother to make such monotypic genera in the first place if it does not solve the problem? So, in principle we have to allow some (if not most) genera to be paraphyletic. However, in practice, we do not, because in most classifications we do not have to classify these ancestral species because they have not been found so far. The ancestral species that are still alive (c,d and f in fig. 8.1) are usually those of which the split with its daughter is still relatively young, and both species will be part of the same genus anyway. The only ancestral species which are giving us a hard time *in theory* are those (i–l) that are ancestral to at least two groups that we want to name as different genera. And those ancestral species are usually not alive at present. For theory it does not matter if the species is extant: we are sure such species *have* existed, and thus the problem exists (at least for species l we can calculate which characters it probably possesses).

Actual classifications only classify known species; usually the known extant species (a–h), with in addition sometimes a fossil one. Since some definitions for monophyly (like that of Farris, 1974; but see also Wiley, 1981 who cites Farris, but defines a monophyletic group as including *all* species descending from the ancestor) judge a group monophyletic as long as it solely consists of all *known* descendants of an ancestor (and if available, that ancestor itself) such classifications may indeed classify monophyletic groups (e.g. a–c &

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[1] For this discussion I use the composite species concept (Kornet, 1993).

d–f). It should be noted that such classifications do not classify all the descendants of that common ancestor, simply because they are unknown (e.g. o–t). However, implicitly, those missing taxa are included in the group, because they will (most probably) match its description (of the species o–t, t may fall out of the generic description because it developed a character state which may be described as absent).

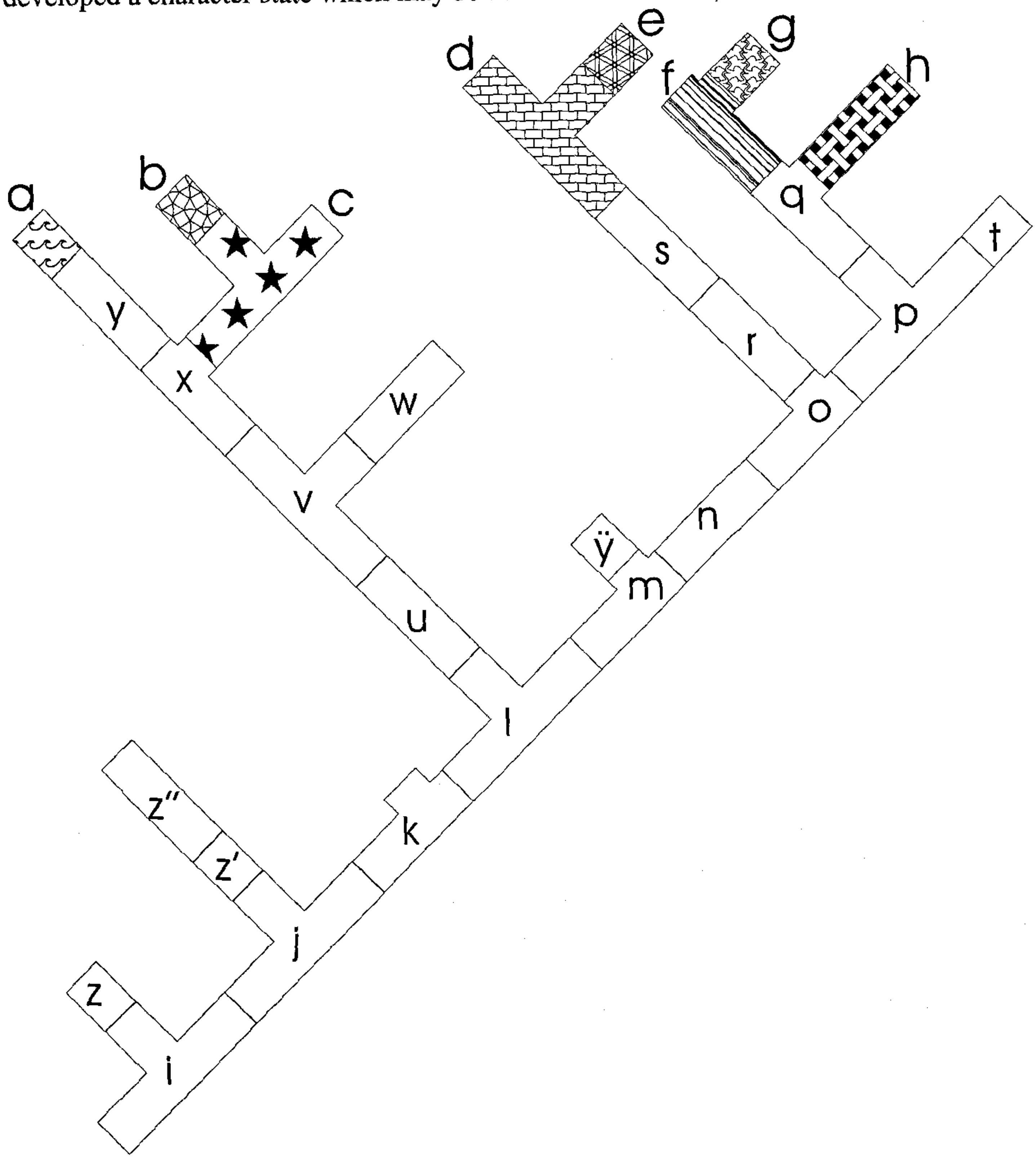


Fig. 8.1. Hypothetical phylogenetic tree. The extant species a–c are being classified in one genus, the extant species d–h in another. Whenever one of the ancestral species i–l is found (either as a fossil or extant) it cannot be classified in a monophyletic genus.

However, the implicit inclusion will not be the case for an ancestral species which linked this genus with its sister genus (e.g. l, but also m, n, u and v). Most probably this ancestral species will not match any of the generic descriptions, and thus actually rests unclassified. Practising taxonomists will hardly ever see this problem, because the ancestral species hardly ever exists and they do not consider the necessity of its existence at some time in history.

Linnaean classification is a perfectly nested system: all elements of a certain level fall into an element of a higher level. Present-day practising taxonomists make generic descriptions for all extant taxa, by which they leave some non-extant taxa unclassified. Actually this is against the principle of a perfectly nested system, but because we do not see such species, nobody notices.

To solve this problem we have two possibilities:

1. Allow only monophyletic groupings of known taxa (implicitly including all ancestral taxa within that clade) to which grouping a single line of ancestral taxa that preceded it may be added (e.g. d–h + i–t, also ij can be added when it is found). The ancestral taxa of two genera may thus be added to any of the two genera; that is a choice we should make as soon as such species are located. (Please note: In **practice** this solution is not different from monophyletic classification: only d–h will actually be classified.)

2. Since we have admitted that paraphyletic genera are inevitable, why make rules that we only like certain types of paraphyletic groupings (such as in solution 1)? If paraphyletic genera are allowed: allow all paraphyletic taxa. This would mean we have more freedom to lay generic boundaries. This will be seen by some as a disadvantage (the system has become more arbitrary), by others as an advantage (it has become easier to maintain stability in nomenclature and to lay a boundary such that it is easy to circumscribe the group). It is true that the system has become more arbitrary, but since it already was arbitrary where we were laying our generic level, I do not see why we cannot give the system a second degree of freedom. We should only use this freedom wisely. Over the past centuries botanists were not aware of cladistics or monophyletic groupings, and they have still been able to construct some very stable and sensible classifications. If we allow taxonomists to make this kind of paraphyletic genera, we can still judge their reasons for choosing their limits, and replace it by something better if we really think it is better, and not for the sole reason that the classification 'was not monophyletic', which was factually impossible in the first place.

In theory solution 1 is not a real solution: the single ancestral line will most probably possess an enormous amount of small sister lineages which all died out and of which we are completely unaware (all z-species). All those splitting off lineages should be classified as separate genera (one for z and one for z' & z"), even if they have hardly any distinguishing characters from the main ancestral line. However, as soon as we find such a fossil, we are likely to classify it as one of those ancestral taxa, and thus put it in the genus, which has now actually become paraphyletic in the sense of the second solution. If we would try to prevent this by putting all fossils (and putative ancestral extant taxa) in separate genera, we might find a real ancestral fossil (e.g. j), and by putting it in a separate genus we will make that genus paraphyletic. So, if we end up classifying things according to choice 2, why not allow such paraphyletic groups in the first place? In a paraphyletic classification it is no problem to erect a genus containing species i–n, ij and all z-species, either or not including u–w.

A way out of the dilemma would be to classify only extant species. If we have such a classification system, a–c and d–h can be perfectly monophyletic genera. Only when species k is discovered to be extant, we have to lump the two genera. The "snowball" or "telescoping" effect (Sosef, 1997 & Brummitt, 1996) will not occur because subsequent ancestral taxa will not be extant. In such a system, generic levels (at least its upper boundary) depend on the amount of extinction of ancestral taxa. As soon as species k does go extinct, we will be able to classify the remaining extant species in two genera again (or even five if we like). I, however, prefer a system that is capable of classifying both extant and extinct species. In a system classifying only extant species, species k would lose its right to a scientific name as soon as it becomes extinct; in such a system there is no place for the Dodo!

The only real solution if we want to classify only monophyletic taxa is to abandon the system of Linnaean classification. If we do, we will need a completely new system of classification rules. Outlines for such a system are given by Queiroz & Gauthier (1990, 1992) & Queiroz (1996), but since such a new classification system is not yet effective (in the form of a Nomenclatural Code), this option is not yet open. Moreover, such a system will have large problems classifying taxa with a hybrid origin (Sosef, 1997), while it has several other disadvantages compared to Linnaean classification (Lidén et al., 1997).

To delimitate my genera, I will preferably create monophyletic groups. If, however, a paraphyletic classification seems to make more sense or will probably result in a more stable classification, I will choose such a paraphyletic classification. My definition of a paraphyletic group is the temporary definition of Farris (1974: 550), conveniently worded by Wiley (1981: 84): 'A group that includes a common ancestor and some but not all of its descendants'. I explicitly do not accept the algorithm definition of Farris (1974: 554), where the decision on para- or polyphyly may depend on the order of branching off of the not included clades. As a result the most recent common ancestor may be group member, but the group be polyphyletic. In my opinion the inclusion of an ancestor in the group depends on the grouping criterion, most probably a set of characters. If the ancestor is supposed to possess them, then the group is paraphyletic.

Of course also my generic descriptions will most probably not include some of the ancestral taxa. As soon as a potential ancestral taxon is discovered (either extant or as fossils) it has to be decided (on the basis of its characters and on the amount of distortion it will give) if it can best be classified in one of the existing genera or in a separate (paraphyletic) genus.

8.2 Criteria for generic boundaries

Delimiting genera does not end with calculating a cladogram, it starts with it. Even when a completely solved and well supported cladogram is available for a group, the grouping of taxa into higher taxonomic units is still partly arbitrary: one is still free to choose at what level in the cladogram one sets a certain taxonomic level. With incompletely solved cladograms, the number of possible taxonomic groupings increases (the number of groups which are not necessarily polyphyletic is larger).

Especially the choice of the generic level is an important one, because it directly affects the naming of the species concerned, and thus the stability of nomenclature. Therefore, this choice should be well-considered and evaluated against several criteria. These criteria are:

1. **Robustness** (future stability). The grouping should last when new data (new species, other characters) become available. By choosing a robust group, we diminish the chance that future workers will be forced to change the classification again. Robust groups can in general be recognized by high bootstrap, decay and mojo values, although no linear relation is present between these values and the chance of such groups actually being clades. High support values are caused by relatively many characters supporting the clade compared to ones that contradict it.

2. **Nomenclatural stability** (compared to previous classifications). The choice should cause a minimal amount of name changes. This criterion usually includes something which we could call the 'tradition' of a group. In some families or subfamilies the generic level seems to be defined more or less by tradition at a certain level; the choice of another generic level might not serve any genuine purpose, but will cause an enormous amount of name changes, and such should be avoided if possible. A good example is the genus *Begonia*: one could also choose to value the present sections as genera (see Sosef, 1994: 11), but this would cause a transfer of over 1300 species (Doorenbos et al., 1998) to different genera.

3. **Recognition**. The new grouping should be based on some (or several) easily observed character(s). A clade can be very well-based (stable, with high bootstrap or other support) on several molecular characters. However, if these molecular characters do not concur with some readily observed morphological character, it will be much more convenient to lay *the generic level at a different, well-based level that is supported by some readily observed* morphological feature. This will ease the acceptance of the genus by botanists in general, especially those working in the field.

Clades are based on one or several character state changes. Since combined state changes are also responsible for high support values, we can partly trace well-recognizable clades by high support values in a morphological cladogram. However, some of the supporting characters may show reversals or may develop into a subsequent state in some part of the clade, which means that these characters can no longer be used to recognize the entire clade.

4. **Size**. Genera should have a convenient size. However, it is hard to define this size. Too many monotypic genera are to be avoided, as are genera with 1000 species. But splitting up a large genus (such as *Begonia*) leads to huge nomenclatural changes, and is to be dissuaded.

To me the earlier three criteria seem more important than this fourth one, so, this criterion may be attributed when the others are not conclusive.

8.3 Application of criteria to the cladogram

The cladistic analysis on the morphological data resulted in a single, most parsimonious tree (fig. 6.2). However, since several of the branches are hardly supported, these clades do not meet criterion 1 and are unlikely to meet criterion 3. The branches that do meet criterion 1 are those that are still present in fig. 6.6.

The first question to be tackled is: can all 'ingroup' taxa be classified as one group? If so, we could consider it for becoming a single genus. The answer is no. First of all fig. 6.2 suggests it is polyphyletic. Furthermore the group as such has hardly any supporting characters. The smallest group, supported by some good characters, which does contain all 'ingroup' taxa is the group nowadays classified as the tribe Macrolobieae. Merging all genera belonging to this tribe would cause an enormous amount of name changes and thus does not serve nomenclatural stability (criterion 2). Moreover, the new genus would contain several hundreds of species, which I find impractically large (criterion 4).

The next level of grouping that has a strong support (criterion 1) can be easily traced from fig. 6.6. The first well-supported group we can regard as a genus is the *Aphanocalyx*-clade. It encompasses all species previously classified as *Aphanocalyx* and a part of *Monopetalanthus* (including its type). Within this clade several smaller clades are also well-supported, and could be considered as genera as well. The most appealing clade in this respect is that comprising *A. hedinii*, *A. heitzii* and *A. libellula*. This clade is supported by a large number of synapomorphies (see fig. 6.7b), which makes it quite distinct from the rest of the *Aphanocalyx*-clade. If we consider the *Aphanocalyx*-clade as one genus, it can be easily distinguished (also in the field) by several characters, among which the striking feature of the missing distal leaflet half (although present in one species) and the closely parallel-veined stipules and bracts. On the other hand, if we would consider the *A. heitzii*-clade as a distinct genus, the missing leaflet half and the closely spaced veins of stipules and bracts become characteristic for two genera. The *A. heitzii*-clade can subsequently be separated by several characters, but only the floral ones are really striking. Since the number of names to be changed (criterion 2) is equal in either situation, and all groups are well-supported (criterion 1), but the *Aphanocalyx*-clade is easier to distinguish than its two sub-clades (criterion 3), I prefer to lay the generic level at the base of the *Aphanocalyx*-clade. Moreover, I also prefer one genus of 14 species over two with 3 and 11 (criterion 4). Since the *A. heitzii*-clade forms a very distinct entity, I decided to treat it as a distinct subgenus: *Antherodontus*.

For the record: I do not see any reason in this case to uphold a paraphyletic genus *Monopetalanthus* next to *Aphanocalyx*. The only possible ground for such a grouping could be the stability of nomenclature. However, the distinction between the two genera would be very difficult (maybe 1–2-jugate against 3–more-jugate; this would still cause *A. richardsiae* to change genus) and the delimitation might not be agreed upon by others, causing instability. A single genus *Aphanocalyx* will in the end be far more practical for workers in the field. According to the label of *Michelson 820* the bark and the trunk shape of *Aphanocalyx cynometroides* is almost identical to that of a *Monopetalanthus* (at that place it can only be *A. microphyllus*). Local tree spotters err if they do not check the crown.

The next clearly defined clade opting for distinction as a genus is the *Bikinia*-clade (excluding *Icuria dunensis*, see below). The internal branches are all weakly supported, so the generic level cannot be placed at a higher position in the tree. Nor does morphology give us a reason to do so because the species are all fairly similar. Since it remains uncertain to which other species or group of species this clade is related, there is no other option than to treat this well-supported and well-characterized group as a genus. The most striking characters of the group are the valvate free stipules which enclose the next leaf and branch bud, the fused and reduced adaxial sepals, and the hypanthium which is fused with the bracteoles except for a small adaxial part.

After the cladistic analyses were performed, a flowering sample of *Icuria dunensis* was collected. Its flowers are quite different from *Bikinia*: they show (almost) no hypanthium, usually no petals, only a very small abaxial sepal and indeed only 6–8 stamens. The grouping of this species with the species of *Bikinia* was mainly based on its stipule and pod characteristics, which indeed fit strikingly. Most of the character states that appear on the *Bikinia* branch (fig. 6.7a) are actually coded unknown for *I. dunensis*. Now that flowers are available, some of these characters remain unknown (most petal- and sepal-related characters cannot be coded), some fit, while others do not fit *Bikinia*. When a tree would be recalculated, *I. dunensis* most probably would appear at the base of the genus as was predicted in chapter 6. However, the first molecular results for this species (pers. comm. F. Gervais, Montreal) seem to indicate that the species might be more closely related to *Aphanocalyx* than to *Bikinia*. From my findings the stipules (and some other characters) do not fit *Aphanocalyx* at all, so the species cannot be classified there. Actually, the species possesses a quite unique set of characters, rendering a classification in a new, monotypic genus the best solution. Even if in the end *I. dunensis* would prove to be most closely related to *Bikinia*, the circumscription of a combined genus would be less coherent and much more difficult to make.

The type species of *Michelsonia* is not solidly grouped with any clade. Since the flowers and the stipules of this species are indeed quite unique, the recognition of a monotypic genus seems justified.

What remains are the species of the *Tetraberlinia*-clade. This clade is not very well-supported, although the situation is not as bad as it seems. As discussed in chapter 6, a part of the bad support is caused by the unstable position of *T. baregarum*. Moreover, in the morphological analysis the species seemed to form a well recognizable group. One of the distinguishing characters is formed by the adaxial petal, which shows complicated structures and indumentum patterns. However, since most of these structures and patterns differ from species to species, they were hard to code, and hence are not represented in the cladistic analysis.

When we apply the criteria of the previous paragraph, we have to conclude that this clade can best be regarded as a single genus. The robustness is not optimal, but neither is it for any other generic delimitation of these species, except one consisting of just monotypic genera and one for *T. moreliana* and *T. korupensis*, which hardly makes sense (it does not meet criterion 2 and 4). Nomenclatural stability is served very well: only one name has to be transferred, which is inevitable anyhow because the old genus (*Monopetalanthus*) ceases to exist. The last main criterion, recognition, is also met, although some of the 'typical' *Tetraberlinia* characters will be plesiomorphic.

The position of *T. baregarum* is rather doubtful. In the shortest tree it ends up basal to the *Tetraberlinia* and *Bikinia*-clade, rendering *Tetraberlinia* paraphyletic when included. However, in some other cladograms (e.g. fig. 6.5a) it shows up as an ingroup of the *Tetraberlinia*-clade. Since the scarce material of this species possesses several characters which are reminiscent of *Tetraberlinia* (such as the glabrous pods and the absence of glands in the proximal leaflet half) it is best classified within this genus for the time being. Pods soaked in alcohol produce a typical dark red-brown colour in the liquid, only found in *Bikinia*, *Tetraberlinia* and some species of *Julbernardia*. Also the stipule scars (fairly large, starting laterally and meeting above the petiole) point to these genera. Since *T. baregarum* seems to have glabrous pods which is aberrant for *Bikinia* and has, contrary to *Julbernardia*, a lateral vein running fairly low over the pod, *Tetraberlinia* is the obvious option for the moment. In case *Tetraberlinia* really becomes paraphyletic by the inclusion of this species (to be decided only when flowers will have been found), the decision whether this is acceptable depends on the amount of characters that will remain present to circumscribe *Tetraberlinia* (all good apomorphic characters of the *Tetraberlinia*-clade are unknown for *T. baregarum*).

As stated in the chapter on phylogeny, we should not rely too much on the position of the *Julbernardia* species in the cladogram. However, at present there is no reason to doubt

Table 8.1. Most important generic characters.

	Aphanocalyx	*Bikinia*	*Icuria*	*Michelsonia*	*Tetraberlinia*
stipules (see also fig. 4.2)					
position	meeting	meeting	meeting	lateral	meeting
free/fused	completely fused	free, connate by hairs	free, connate by hairs	free	free or fused only at base
both margins valvate	no	yes	yes	no	no
veins closely spaced	yes	no	no	no	no
leaflets					
number of pairs	1–57	1–36	1–2	10–16	1–34
distal half reduced	yes (usually)	no	no	no	no
inflorescence					
compound/simple	compound/simple	compound	compound	compound	compound
petals:					
number	1–5	1–5	0(–1)	5	5
large petals	1	1	0	5	1
colour	white or yellow	white	white	white	yellow (or white?)
adaxial petal	simple to complex	fairly simple	absent	simple	complex
sepals:					
number	0–5	(0–)2–5	0–1	5	3–5
adaxial free/fused	free/fused	free/fused	wanting	fused	fused
hypanthium					
size	small to large	small to large	almost absent	almost absent	large
including bracteoles	yes	yes	(yes)	no	yes
with adaxial 'triangle'	no	yes	no	no	no
stamens					
usual number	9–10	10	6–8	10	10
# fused at base	9	9	6–8	9	9
style					
insertion angle (roughly)	centric	eccentric	eccentric	eccentric	centric
pods					
indumentum	glabrous to velvety	puberulous to velvety	velvety	glabrous	glabrous (puberulous)
u/w index	0–0.48	0.34–0.67	0.23–0.44	0.39–0.56	0.24–0.62
upper suture winged	not to strong	hardly to strong	hardly	not	hardly to strong
beak	usually short	short to long	medium size	very short	short to long
seedlings					
epicotyl/hypocotyl	<< 1	> 1	> 1	?	≈ 1

that these species form a genus. The inclusion of *J. pellegriniana* in it seems well supported.

Léonard (1996: 448) refuted the separation of *Paraberlinia* because the genus was only based on a single character (reduction of the adaxial petal). Given the fact that *Paraberlinia* can be separated on a second character (completely fused stipules), Léonard and other botanists who prefer genera to have at least two distinguishing characters, might have to reconsider the recognition of *Paraberlinia*.

The most distinctive (and often traditionally used) characters of the genera as proposed are summarized in table 8.1.

8.4 Delimitation of the group within the Macrolobieae

8.4.1 Circumscription of the group

From the cladogram, but also as the result of a thorough morphological study, it has become clear that the genera studied here do not form a well-defined group. A few characters are shared by the entire group under consideration, while they are not present in all Macrolobieae. However, these characters may be plesiomorphic and are often shared with some other genera of the Macrolobieae. These characters are:

- Pods with a lateral nerve (although hard to observe in some *Aphanocalyx*).
- Leaflets opposite.
- Leaflets more or less sessile.
- Leaflet insertion not extensively twisted (hard to determine in 1-jugate species).
- Leaflets never emarginate *at* the apex.
- Hypanthium (partly) fused with the bracteoles or hypanthium absent (consequently never with a hypanthium which is completely free from the bracteoles).

Species of Macrolobieae which show all these characters belong either to this group, or to a 1-jugate species of *Didelotia*, that easily can be distinguished by the lower number of stamens (5 instead of 6–10).

Not all the above mentioned characters are always readily observed. To determine whether a certain Macrolobieae specimen belongs to the group here revised, the following key can be used. Vegetative characters have been used whenever possible.

The genera included in the Macrolobieae are those mentioned by Breteler (1995) with the addition of *Humboldtia* which he now considers a member of this tribe as well (pers. comm.). Breteler (1995) based his list on the genera accepted by Cowan & Polhill (1981); for synonyms please check there. The only genus not mentioned in the key is *Thylacanthus*. This genus is congeneric with *Julbernardia*; a proposal for conservation of the latter name is being prepared.

8.4.2 Partial key to the genera of the Macrolobieae

1 a Leaves unifoliolate .... *Cryptosepalum* p.p., *Didelotia* p.p.
  b Most leaves with more than 1 leaflet 2

2 a Leaflets alternate .... *Librevillea*, *Oddoniodendron*
  b Leaflets opposite or subopposite 3

3 a Leaflets with a distinct petiolule (when in doubt follow 4) .... *Anthonotha*, ... *Berlinia*, *Dicymbe*, *Englerodendron*, *Gilbertiodendron* p.p., *Humboldtia*, ... *Isoberlinia*, *Macrolobium*, p.p., *Polystemonanthus*, *Pseudomacrolobium*.
b Leaflets sessile 4

4 a Leaf 1-jugate 5
b Leaf 2–60-jugate 7

5 a Fertile stamens 3 or 5 .... *Didelotia* p.p., *Gilbertiodendron* p.p., *Pellegriniodendron*, *Macrolobium* p.p.
b Fertile stamens 6–10 6

6 a Bracteoles inside densely hairy. Leaflets sometimes with translucent dots. Sepals 5, adaxial ones (almost) free. Pods without a lateral nerve. .... *Julbernardia* p.p. (incl. *Paraberlinia*)
b Bracteoles inside glabrous or sparsely pubescent. Leaflets without translucent dots. Sepals 0–5, if 5, the adaxial ones fused over a considerable length. Pods usually with a lateral nerve (though sometimes close to upper suture). .... **group under study**

7 a Insertion of leaflets distinctly twisted (do not check this character on apical leaflets, and preferably neither on basal ones). .... *Cryptosepalum* p.p., ... *Gilbertiodendron* p.p., *Julbernardia* p.p., *Didelotia* p.p., ... *Brachystegia*, *Paramacrolobium*, *Macrolobium* p.p.
b Insertion not distinctly twisted. 8

8 a Leaflets emarginate **at** the very apex (were the midrib ends). .... *Cryptosepalum* p.p., *Didelotia* p.p., *Microberlinia* p.p.
b Leaflets not emarginate at the very apex, though the margin often sinoid and emarginate **below** the point were the midrib meets the apex. 9

9 a Hypanthium present, entirely free from the bracteoles. .... *Cryptosepalum* p.p., *Microberlinia* p.p.
b Hypanthium usually present, when present (almost) entirely fused with the bracteoles. .... **group under study**

8.5 Key to the treated genera and subgenera

This key summarizes the major differences between the newly circumscribed genera and subgenera. It can also be used for identification purposes.

1 a Stipules completely fused. Distal half of leaflets usually completely reduced. Inflorescences single or compound racemes, when compound then anthers usually with dorsal teeth. Stipules and bracts with many conspicuous closely spaced parallel veins. (*Aphanocalyx*) 2
b Stipules free, rarely fused at base. Distal half of leaflets always present. Inflorescences a compound raceme, anthers never with teeth. Stipules and bracts not with conspicuous closely spaced veins 3

2 a Midrib (= marginal vein) of the more apical leaflets usually with one to several glands in the basal half. Anthers with distinct dorsal teeth. Adaxial petal (always?) yellow. Lateral and abaxial petals long to very long villous inside. Hypanthium at least 2½ mm high. Inflorescences only developing on the most terminal nodes of a branch. .... ***Aphanocalyx* subg. *Antherodontus***

b Midrib of leaflets (= usually the marginal vein) without glands at base. Anthers without or with indistinct teeth. Adaxial petal white. Lateral and abaxial petals wanting or glabrous inside. Hypanthium less than 1½ mm high. Inflorescences (potentially) developing on all nodes of young branches and sometimes even on those of older branches .... ***Aphanocalyx* subg. *Aphanocalyx***

3 a Stipules lateral, not touching above the petiole, stalked. Petals 5, about equal in length.. ***Michelsonia***

b Stipules lateral, but at least their very bases (almost) touching above the petiole, not with a stalked base. Petals 0–1 large, others much smaller or absent........... **4**

4 a Petals wanting or rarely only a very small lateral petal present. Sepals wanting or only the abaxial sepal present. Stamens 6–8. Hypanthium absent or very small. . ***Icuria***

b At least the adaxial petal present. Usually at least the adaxial sepals present. Stamens 10. Hypanthium present. **5**

5 a Stipules valvate at both margins, margins at first connected by chaffy hairs. Style conical at base, geniculate and usually inserted at a distinctly eccentric angle ((10–)45–140°) on the ovary. Pods velvety, puberulous or almost glabrous, never with a second lateral nerve. Adaxial petals entirely white. Lateral and abaxial petals often wanting, when vestigial usually linear, sometimes slightly inrolled, but never folded, lateral margins not specifically ciliate in the middle. Adaxial sepals reduced to two small lobes at base of adaxial petal, continuing in a hypanthium-triangle between the receding bracteoles. Lateral filaments often fused over an additional distance and bending outwards, the sub-adaxial filaments bent inwards. Bracts inside glabrous. Anthers purple. .... ***Bikinia***

b Stipules at least at proximal margin not valvate, free, also in bud, margins with normal hairs. Style not conically thickened at base, not distinctly geniculate, inserted only slightly eccentric (angle 0–40°) on the apex of the ovary. Pods usually glabrous, rarely puberulous, but never velvety, sometimes with a second lateral nerve. Adaxial petals partly or entirely yellow (always?). Lateral and abaxial petals more or less spathulate and usually inrolled or folded, lateral margins often ciliate in the middle. Adaxial sepals fused forming a band or a triangular to ovate unit supporting the adaxial petal. Bracteoles not receding adaxially to show a triangular sepal continuation in the hypanthium. Lateral filaments not fused over an additional distance, bending inwards at base (except in *T. longiracemosa*), sub-adaxial filaments not bent inwards. Bracts inside often at least in a band along the apical margin pubescent or velvety. Anthers pink, yellow or creamy. .... ***Tetraberlinia***

8.6 Synoptic key using a few striking characters

Several species often show some striking features which may be very helpful for identification purposes. Species (sometimes) possessing such features are mentioned, so when the described feature is present, one is dealing with one of the these species. However, the opposite is not always true, e.g. a pod with only a single lateral nerve may also belong to *Tetraberlinia bifoliolata*.

Pods densely velvety but hairs not appressed: *Aphanocalyx cynometroides, A. obscurus, A. pectinatus*?, *A. pteridophyllus, Bikinia evrardii, B. le-testui*, (*Icuria dunensis*).
Pods densely appressed velvety: *Bikinia aciculifera, B. coriacea, B. durandii, B. media*?

Pod with a second lateral nerve: *Tetraberlinia bifoliolata, T. korupensis, T. moreliana*, (*Icuria dunensis*).

Pod with a distinctly widened upper suture: *Aphanocalyx obscurus, A. pectinatus, A. pteridophyllus, Bikinia evrardii, B. grisea, B. le-testui*, (*B. pellegrinii*), (*Tetraberlinia baregarum*), *T. bifoliolata, T. korupensis, T. moreliana*, (*T. polyphylla*), *T. tubmaniana*.

Leaves strictly 1(–2)-jugate: *Aphanocalyx cynometroides, A. djumaensis, A. margininervatus, A. richardsiae, Bikinia breynei, Icuria dunensis, Tetraberlinia bifoliolata*.
Leaves with 18 pairs of leaflets or more present: *Aphanocalyx hedinii, A. heitzii, A. microphyllus, A. obscurus, A. pectinatus, A. pteridophyllus, Bikinia aciculifera, B. coriacea, Bikinia le-testui, B. pellegrinii, Tetraberlinia longiracemosa*.

Distal margin of leaflet formed by the midrib: all *Aphanocalyx* species except *A. cynometroides*.
Midrib of leaflet not running along the distal margin: *Aphanocalyx cynometroides*, all *Bikinia* species, *Icuria dunensis, Michelsonia microphylla*, all *Tetraberlinia* species.

Apex of leaflets strongly sinoid just below the termination of the midrib, often even angled, rendering the apex apparently emarginate: (*Bikinia durandii*), *B. evrardii, B. le-testui, B. pellegrinii*.

Proximal half of the largest leaflets with a very large (> 2 mm) auricle at base: (*A. ledermannii*), *Bikinia congensis, B. grisea, B. media, Tetraberlinia moreliana, T. polyphylla*.

Stipules auriculate: *Aphanocalyx obscurus, A. pectinatus, A. pteridophyllus, Tetraberlinia korupensis, T. longiracemosa, T. moreliana*.

Adaxial petal (partly) yellow: *Aphanocalyx* subg. *Antherodontus* (all?), *Tetraberlinia* (all?).
Adaxial petal white: all others.

9 Introduction to the taxonomic part

The next chapters contain a taxonomic treatment of the genera recognized. A few issues and notes related to the treatments are presented below. All morphological terms have already been defined in the chapter on morphology (4).

Species concepts

Before delimiting species one should consider the species concept to be used. Many different species concepts are available, see Stuessy (1990) for an overview of the most important ones. In chapter 8 (Generic delimitation) I have used the fairly new "composite species concept" (Kornet & McAllister, 1993). This concept is the only formally defined and philosophically correct species concept presently available, and is most useful for theoretical discussions like those on generic boundaries. However, for practical purposes, e.g. delimiting species and assigning specimens to these species, it is not. A serious setback of this concept is that to implement it in the way it is defined, the genealogical network of parental relationships of all individuals belonging to the group under study should be known. Such is of course impossible. However, it may be possible to estimate these relationships and base one's conclusions on these estimates.

An important theoretical objection against the composite species concept as defined by Kornet (1993) is that in my opinion this concept does not define groups that biologists want to define as species. The problem is caused by the fact that those parts of the network that relatively rapidly die out do not have the opportunity to link up with other parts of the network later on, and thus can easily, when also "quality Q" is met, be recognized as species. Contrary to this those parts of the network that continue to exist for a longer period have a far larger chance to link up with other parts, and thus can constitute a separate species with much more difficulty. To illustrate this mechanism two examples: A human family of a father, a mother and their daughter, all having blue eyes (a possible "quality Q"), does not constitute a separate species, but as soon as they all die in a car accident, we have to conclude with hindsight that they were a separate species. Contrary to this, if some human in 2350 succeeds in mating and producing offspring with a chimpanzee, we have to conclude that humans and chimpanzees were one species all the time (except for the family that crashed, which still constitutes a separate species). In short: because there are so many humans, the chance that one of them breeds outside the species is relatively large (I say relatively, because the gap with chimpanzees is quite large, humans are not the best possible example), while a small group of individuals (i.e. a rare and nearly extinct species) does not have such a chance.

Especially in plants, hybridization between groups recognized as distinct species is quite common. The composite species concept would classify such groups as different populations of a single species. However, such groups may show very different properties such as distinct ecologies, and the hybridization events may be extremely rare, resulting in those groups to 'behave' in the same manner as other distinct species. Since I want to be able to classify such groups as distinct species, I cannot use the composite species concept. When some sort of hybridization could be allowed in the concept and not all tiny lineages with a single fixation have to be recognized as species, the composite species concept will definitely turn out to be a perfect species concept, both for practise and theory.

The species concept used here is: A species is a group of (potentially) mating individuals that do not hybridize with other such groups, or that succeed in remaining a distinct group (maintaining their properties) if they do hybridize. Of the concepts discussed by Stuessy (1990: 171–179) this concept most closely approaches the evolutionary species concept.

Of course it is not known which individuals are potentially genetically isolated from which other individuals, but I can use their properties (characters) to estimate this. In sympatrical populations of separate species stable combinations of characters are expected to be found. Such is not the case for populations with a considerable gene-flow present between them. For allopatric populations one has to compare the amount of divergence with that between sympatric species. Since "my" species are supposed to succeed in maintaining their distinctness from other species, they are expected to become 'composite species' in the future if they cannot be considered as such already. Using my definition tiny composite species (i.e. small dying-out groups with character fixation) which will be very hard to find in the first place, will not be recognized as species. They still have the potential to mate with the main population of which they branched off, while they would not remain a distinct group when they would have hybridized.

Subspecific taxa

In my concept, subspecies are restricted to their own separate geographical area or be ecologically isolated. If those geographical areas meet, the groups should hybridize in a narrow hybridization zone. If they do not meet, other features should be taken into account as whether they are likely to meet in the future and the amount of distinct characters they have developed.

I see no reason to recognize any taxonomic level below that of subspecies. When sympatric occurring individuals show small differences this is merely a matter of population genetics. These variations do not warrant taxonomic recognition.

Author citation

Abbreviations for authors of plant names are in accordance with Brummitt & Powell (1992). Only J. Morel and myself are not listed. Since already a "Morel", a "J.M. Morel" and a "J.F.N. Morel" exist, "J. Morel" is proposed as standard abbreviation for this French forester. I will use "Wieringa" for myself.

Type citation

Label information of types, as cited in between quotes, is always the literal text found on the *holotype* sheet(s) unless stated otherwise. If this is written in another language than English or French, a translated text may be given between square brackets.

Vernacular names

Vernacular names are followed by their language(s) between brackets. If the language is not known to me, the region from which the name originates is indicated. Beside vernacular names, also forestry names and trade names are mentioned; these are used as follows:

Forestry name = name commonly used by foresters to name a tree, usually for inventory purposes. This name may vary from one country to another, but is supposed to be standardized for one country. It is the name the French call 'nom pilot'. Its origin is often a local vernacular name, but it can also be a derivation of a name of a similar tree from a European language or an African vernacular name from quite another country.

Trade name = name used in international trade, is supposed to be standardized worldwide or at least in a region.

Distribution and citation

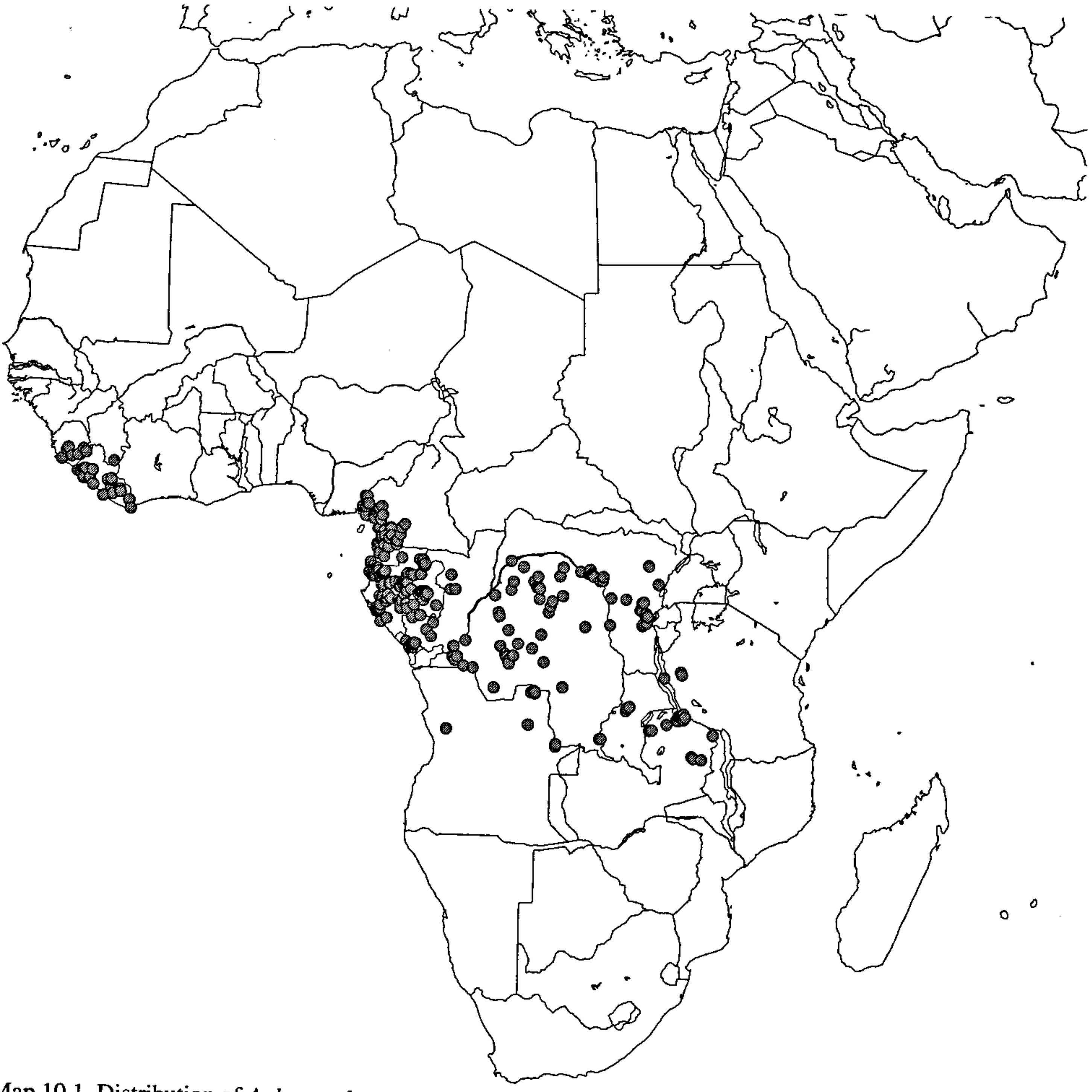
The records are mapped directly from the specimen database with an accuracy of 1 minute (as far as possible for such a record). The coordinates used for plotting the map are indicated after each locality in the 'specimens examined' listing. Specimens of which the identity is doubtful are plotted with an open symbol (usually a circle).

Some literature, not quoted elsewhere, that has been used to clarify the geographical origin of specimens is: Lecomte, 1894; Hallé, 1964; Hallé, 1978; Bamps, 1982; Polhill, 1988; Encarta World Atlas 1998 (cd-rom, Microsoft); gazetteers of the U.S. Board on Geographic Names and their database at website http://164.214.2.59/gns/html/index.html.

Herbarium material used is cited after the description of the relevant species. Collections that could not be referred to unambiguously, were renumbered in such a way that the reference became unique: mixed samples have been renumbered by adding 'a' or 'b' to the numbers, samples without a collection number (s.n.) have been given a s.n.-number series per collector, which number is cited between brackets after 's.n.' (e.g. *Jones s.n. (2)*). These new numbers are also printed on the identification slips.

If any of the sheets of a collection showed flowers and/or fruits this is indicated by subsequently 'fl' and 'fr'. If neither was encountered this is indicated by 'st'. Young pods are indicated as fruits and so are old pods found on the forest floor. Flower buds are considered as flowers.

Herbaria that only possess a photo or a sketch of a collection are followed by the indication 'picture only' or a more definite indication of the kind of picture. Samples preserved on spirit are indicated by '+alc' or 'alc only'.



Map 10.1. Distribution of *Aphanocalyx*.

10 *Aphanocalyx* Oliv.

10.1 ***Aphanocalyx*** **Oliv.** **Map 10.1**

Aphanocalyx Oliv.: Oliver 1870: 53 & Pl. 1066; Baillon, 1876: 233; Taubert, 1892: 132–133; Harms, 1915a: 481; Lemée, 1929: 327–328; Baker, 1930: 733; Pellegrin, 1949: 72; Léonard, 1952: 438; Léonard, 1957: 262–263; Aubréville, 1968: 274; Aubréville, 1970: 254–255; Normand & Paquis, 1976: 105; Watson & Dallwitz, 1983: 9; Gunn, 1991: 388–389. **Type** (= type of *Aphanocalyx cynometroides* Oliv.): *Mann 1810* (holo: K; iso: BR (frag.), P, W) — Equatorial Guinea: "W. Trop. Africa, Lat. 1 ° N. 1862" and "Mount John River Kongui, Septemb." (2 sheets).

Monopetalanthus Harms: Harms, 1897: 195; Harms, 1899: 265–266; Harms, 1915a: 481; Baker, 1930: 734 p.p.; Lemée, 1932: 541 p.p.; Pellegrin, 1942: 118–119 p.p.; Chevalier, 1946: 592–593 p.p.; Pellegrin, 1949: 73–74 p.p.; Léonard, 1952: 441–442 p.p.; Léonard, 1957: 255–256 p.p.; Brenan, 1967: 196 p.p.; Aubréville, 1968: 304–306 p.p.; Aubréville, 1970: 276–279 p.p.; Normand & Paquis, 1976: 105–106 p.p.; Watson & Dallwitz, 1983: 43 p.p.; Gunn, 1991: 386–387 p.p. **Type** (= type of *Monopetalanthus pteridophyllus* Harms): *Dinklage 1720* (holo: B†; lecto: K (fragments); sketch in BM) — "Grand Bassa, Liberia 1896".

Shrubs or small to large trees. Stipules completely fused, with many closely spaced veins. Leaves paripinnate, 1–57-jugate, rachis ± terete, sometimes with a poorly developed (grooved) rib on the upper side. Leaflets opposite, distal half usually completely absent, resulting in the distal margin being formed by the midrib, both halves (as far as present) with glands.

Inflorescence a compound raceme, in most species reduced to a single raceme. Bracts densely parallel-veined, inside glabrous. Bracteoles fused with petals, sepals and stamens into a hypanthium s.l., although this sometimes very short (0.2–5 mm high). Sepals 5, but all or a part usually wanting. Adaxial sepals in principle fused, but in very reduced state often free. Adaxial petal fully developed. Lateral and abaxial petals reduced and often wanting. Stamens generally 9–10, adaxial stamen free (or wanting in *A. heitzii*), 9 united at base. Anthers often with small or large dorsal teeth. Ovary hairy, with 1–6 ovules. Style insertion not hooked, angle 0–90°.

Pods with a (rarely indistinct) lateral nerve, usually running fairly high and sometimes fused to the dorsal wings, dorsal suture distinctly winged or not. Seeds with a thin testa, but not membranous.

Seedlings epigeal. Epicotyl fairly short, less than half as long as the hypocotyl, often almost lacking. First pair of leaves opposite.

Distribution: Map 10.1. Rain forest of western and central Africa, extending to the east and south in gallery forest as far as northern Zambia and central Angola.

Etymology and gender: *Aphanocalyx* means 'not visible calyx'.

Aphanocalyx has the masculine gender: calyx is masculine, and the first combination which expresses the gender, *A. margininervatus*, is also masculine.

10.2 Key to the species of *Aphanocalyx*.

1 a Leaves 1–2-jugate. (subg. *Aphanocalyx* p.p.) 2
  b Leaves 3–57-jugate.[1] 5

2 a Distal half of leaflet not developed, principle vein marginal. Pods glabrous or sparsely set with long hairs, not soft to the touch. 3
  b Distal half of leaflet present, midrib not marginal. Pods velvety, soft to the touch. .... ***A. cynometroides***

3 a 1–3 Inflorescences per axil. The most basal 1–2 glands of the leaflet imbedded in or very close to the most basal part of the proximal margin (fig. 10.2:2), apex without a gland. Leaves 1-jugate. Leaflets 1–13 cm long. Developing leaflets with at least the upper surface glabrous or sparsely villous to velvety. The two most distal nerves of a leaflet not running parallel at base, rarely running parallel for up to 3 mm. Usually riverine. 4
  b 1–10 Inflorescences per axil. The most basal glands of the apical leaflet at some distance from the proximal margin and not close to its base (fig. 10.4:1), at or just before the apex a gland is often present at the distal margin (fig 10.4:2a & b), the very tip of the apex is sometimes curved around it. Leaves in essence 2-jugate, but basal pair vestigial to absent. Apical leaflets 4½–24 cm long. Developing leaflets densely rusty tomentose. In most leaflets the two most distal longitudinal nerves running parallel or even fused over some distance (0–15 mm)(fig. 10.4:1). Usually in dry-land forest. .... ***A. margininervatus***

4 a Margin of the bracts with dark, minute (c. 0.05 mm long) teeth. Pods 2–3.8 cm long, lateral nerve usually very prominent. Eastern and southern Congo (Kinshasa), Angola, Zambia and Tanzania. .... ***A. richardsiae***
  b Margin of the bracts without teeth. Pods 4–7 cm long, lateral nerve indistinct to distinct, but hardly prominent. Gabon and central Congo (Kinshasa). .... ***A. djumaensis***

5 a Lateral and abaxial petals inside long to very long villous. Hypanthium at least 2½ mm high. Inflorescences only present on the 6 uppermost nodes of a branch. Anthers with two large teeth next to the filament insertion. Midrib (= marginal vein) of the leaflets (at least in some leaflets of the apical half of the leaf) with one or several glands in the basal half (fig. 10.13: 2 & 4)[2]. Adaxial petal (always?) yellow. (subg. *Antherodontus*) 6
  b Lateral and abaxial petals wanting or glabrous inside. Hypanthium less than 1½ mm high. Inflorescences may be present on all nodes of terminal branches and sometimes even on those of older branches. Anthers without or with indistinct teeth. Midrib of leaflets without glands in basal part. Adaxial petal white. (subg. *Aphanocalyx* p.p.) 8

6 a Leaves 10–11-jugate. Angola. .... ***A. libellula***
  b Leaves 20–57-jugate. Gabon, Equatorial Guinea & Cameroon. 7

7 a Leaves 20–32-jugate. Largest leaflet of a leaf 3–9(–13) mm wide. Inflorescence a

compound raceme. Stamens 9. Bracteoles 11–17 mm long. Pedicel (4–)8–14 mm long. Gabon & Equatorial Guinea. . . . . ***A. heitzii***

b Leaves 35–57-jugate. Largest leaflet of a leaf 1½–2½(–4) mm wide. Inflorescence a simple raceme. Stamens 10. Bracteoles 7–11 mm long. Pedicel 2–3½ mm long. Cameroon. . . . . ***A. hedinii***

8 a Leaves 3–5-jugate1). Largest leaflet of a leaf 3–4½ cm long. Central Congo (Kinshasa). . . . . ***A. jenseniae***

b Leaves 5–44-jugate1). When 5 or 6-jugate, then largest leaflet of a leaf only 0.3–1(–2) cm long. **9**

9 a Stipules persistent, at least not early caducous, auriculate at base, the more apical ones of a shoot inflated. Pods velvety. Abaxial sepals always present. **10**

b Stipules caducous, not auriculate, not inflated. Pods glabrous to sparsely villous. Abaxial sepals often wanting. **12**

10 a Full grown branches densely long brown velvety to tomentose. First two leaflet pairs inserted on a slightly inflated part of the rachis. Pedicel 2–5½ mm long. Stamens 7–13 mm long. Adaxial petal 5–11 mm long, glabrous both sides. Largest leaflet of a leaf 1½–10 mm wide. Central Africa. **11**

b Full grown branches nearly glabrous, only puberulous or velvety when young. Only the first leaflet pair inserted on the inflated part of the rachis. Pedicel 4½–9 mm long. Stamens 15–21 mm long. Adaxial petal 9–13 mm long, (very) sparsely pubescent on both sides. Largest leaflet of a leaf 4–13 mm wide. Liberia and Sierra Leone. . . . . ***A. pteridophyllus***

11 a Leaves (9–)11–23-jugate. Largest leaflet of a leaf 3–10 mm wide, 2.8–4.5 times as long as wide. Bracteoles 7–10 mm long. Adaxial sepals 2.3–4.3 x 2.2–3.8 mm. Anthers 1.6–1.9 mm long.3) South-eastern Gabon to western-central Congo (Kinshasa). . . . . ***A. obscurus***

b Leaves 19–34-jugate. Largest leaflet of a leaf 1½–4 mm wide, 4.4–6.1 times as long as wide. Bracteoles 5½–6½ mm long. Adaxial sepals 0.6–2.7 x 0.3–1.5 mm. Anthers 1.4–1.5 mm long.3) Southern Gabon and probably Bas-Congo (Kinshasa). . . . . ***A. pectinatus***

12 a Leaves 5–13(–17)-jugate. Young branches and leaf rachis usually sparsely set with hairs < 1 mm, not conspicuously so. Largest leaflet 2.1–4.0 times as long as wide. Pods 1.2–6½ cm long. Central and eastern Africa. **13**

b Leaves 13–44-jugate. Young branches and leaf rachis with long to very long (1–4 mm long) conspicuous hairs. Largest leaflet (3.5–)4.2–7.8 times as long as wide. Specimens with less than 16 jugae, a leaflet ratio of less than 3.8 and less conspicuous long hairs on branches and rachis always from western Africa. Pods 3½–7 cm long. Western and central Africa. . . . . ***A. microphyllus***4)

13 a Leaves (0.4–)0.6–2.8(–4.4) cm long, 5–13(–17)-jugate. Largest leaflet 3½–10(–18)5) x 1.2–3(–4½) mm, 3.0–4.0 times as long as wide. Bracts 1½–2½ mm long. Pods 1.2–3.8 cm long, lateral nerve usually distinct. Northern Zambia (& Tanzania?). . . . . ***A. trapnellii***

b Leaves (3–)4–11(–18) cm long, 7–13-jugate. Largest leaflet 11–34(–52)[5] x 3–13(–19) mm, 2.1–3.7 times as long as wide. Bracts 2½–5 mm long. Pods 3–6½ cm long, lateral nerve rather indistinct. Central Africa. . . . . ***A. ledermannii***

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[1] The number of leaflet pairs is usually counted from normally developed canopy leaves. The numbers between brackets usually refer to saplings; those of seedlings should not be used.

[2] These glands can be very hard to observe. When dealing with sterile material one should check several leaflets. Be aware that the glands may be obscured by fungi growing on the exudate or that they may be indicated only by a small lobe on the marginal vein or a lighter spot in it. Material that is wrongly supposed to lack glands will usually key out as *A. microphyllus*.

[3] The ranges of the floral characters of both these species are based on only one collection per species. New material is likely to surpass these values.

[4] Sterile material of *A. hedinii* or *A. heitzii* of which the glands in the marginal vein were not observed will key out here: when the material originates from Cameroon, Equatorial Guinea or Gabon, the lower leaflet surface is dull and light grey, and the leaflet apex rounded: be aware one of these two species may be at hand.

[5] The numbers between brackets represent extreme values, usually only present in saplings or other branches hanging in the shade.

10.3 *Aphanocalyx* subgenus *Aphanocalyx*

Trunk often slightly contorted or with other irregularities. Bark fairly thin, up to 10 mm thick, outer bark formed by a whitish layer, giving trunk a greyish appearance.

Inflorescence compound, but usually reduced to a single raceme, potentially present on all nodes of the youngest shoots or even on older branches. Bracteoles inside glabrous or sparsely pubescent to puberulous. Hypanthium s.l. fairly short (0.2–1.5 mm). Sepals often (partly) wanting. Adaxial petal white, inside glabrous or sparsely pubescent, without a distinct claw, gradually widening into the blade. Lateral and abaxial petals often wanting, inside glabrous. Anthers without or with weakly developed dorsal teeth. Ovary with 1–3(–4) ovules.

Pod glabrous to velvety, stipe not distinctly elongated.

Distribution: Identical to that of the genus, except it reaches less far south into Angola.

Aphanocalyx cynometroides Oliv. **Fig. 10.1, Map 10.2**

Aphanocalyx cynometroides Oliv.: Oliver, 1870: 53, pl. 1066; Baillon, 1876: 233; Taubert, 1892: 132–133; Baker, 1930: 733 p.p.; Pellegrin, 1949: 73 p.p.; Léonard, 1951a: 129 & fig. 32A; Léonard, 1952: 438–440; Léonard, 1957: 264; Lebacq, 1957: pl. 98; Walker & Sillans, 1961: 216; Aubréville, 1968: 274–276 & pl. 68; Aubréville, 1970: 256, 338 & pl. 60. **Type** (see notes): *Mann 1810* (holo: K; iso: BR (frag.), P, W) — Equatorial Guinea: "W. Trop. Africa, Lat. 1 ° N. 1862" and "Mount John River Kongui, Septemb." (2 sheets, in flower).

Small to large forest tree, 8–45 m high; crown irregular to hemispherical, but not very wide. **Bole** cylindrical to contorted, branchless for up to at least 17 m, DBH 50–130 cm: base with narrow but often long reaching, up to 2(–3) m high, greyish brown buttresses. **Bark** 3–10 mm thick, easily detaching from the wood: surface smooth to finely fissured with pockets of living bark emerging to the surface, grey to brownish grey with many ½–1 cm diameter brown spots and tiny horizontally stretched lenticels; outer bark up to ½ mm

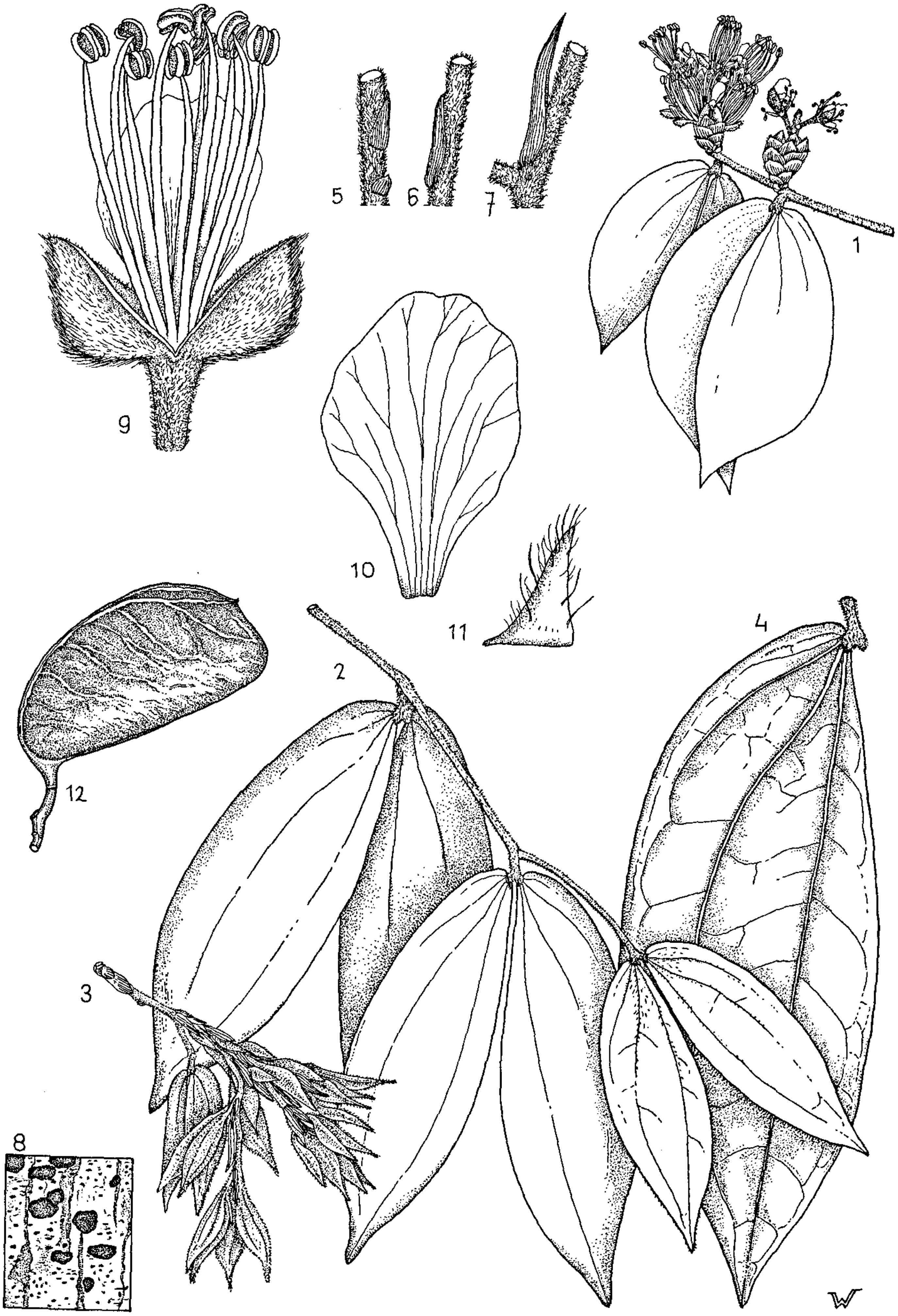


Figure 10.1. *Aphanocalyx cynometroides* Oliv. — 1: twig with leaves and inflorescences (x⅔); 2: twig with young leaves (x⅔); 3: young shoot with stipules and developing leaves (x⅔) 4: leaflet from below (x⅔); 5 & 6: budscales that precede leaves on a shoot (x2); 7: two fused stipules (x2); 8: bark surface (x⅔); 9: flower from abaxial side (x4); 10: adaxial petal (x4); 11: adaxial sepal (x8); 12: pod (x⅔). — 1, 8–11: *Breteler, Wieringa & Nzabi 12868*; 2–7: *Wieringa & Haegens 2355*; 12: *J. Louis 3814*.

thick, dirty white; inner bark fibrous, pinkish or pinkish purple to light brown, when exposed to air rapidly changing into red or orange-red, producing some clear, hardly sticky resin. Sapwood thick, creamy to pinkish white, heartwood small in diameter, light brown. Wood hard, very fibrous, showing growth-rings.

Twigs smooth or with small lenticels, pale grey to brownish grey, young twigs densely short to long red-brown tomentose-velvety, older twigs becoming whitish and glabrescent. **Stipules** fused, early caducous, obovate to spatulate (the most apical ones of a shoot narrowly triangular), 6–16 x 1–3 mm, with many, closely spaced, parallel veins, outside glabrous, but often short and long velvety along the fused distal margin, inside glabrous, margins short to long ciliate mixed with some glandular hairs. **Leaves** 4–25 cm long, 1-jugate (first pair wanting or represented by some hairs, second developed): **Petiole** 1–5 mm, densely long velvety, glabrescent. **Rachis** 1–10 mm long, densely long velvety, glabrescent, more or less terete, usually with a grooved ridge above. **Leaflets** leathery, upper surface glossy, dark green, lower side glossy, medium green, in sun-exposed leaves with (glandular?) cells appearing as tiny red dots (to a far lesser extent also present on upper side), both sides of immature leaves long brown velvety, usually soon glabrescent; margins long to very long ciliate, glabrescent; proximal half ovate to obovate, base cordate without an auricle; distal half narrow, obovate, broadest point always more to the apex than that of the proximal half, base cuneate; apex acute to acuminate, ending in a kind of gland. **Basal leaflet** only present in seedlings, in other plants wanting or only indicated by some hairs. **Apical leaflet** 3–25 x 1–10 cm. **Gland pattern**: Apical leaflet with 1–8 glands along the proximal margin and (1–)3–13 glands along the distal margin.

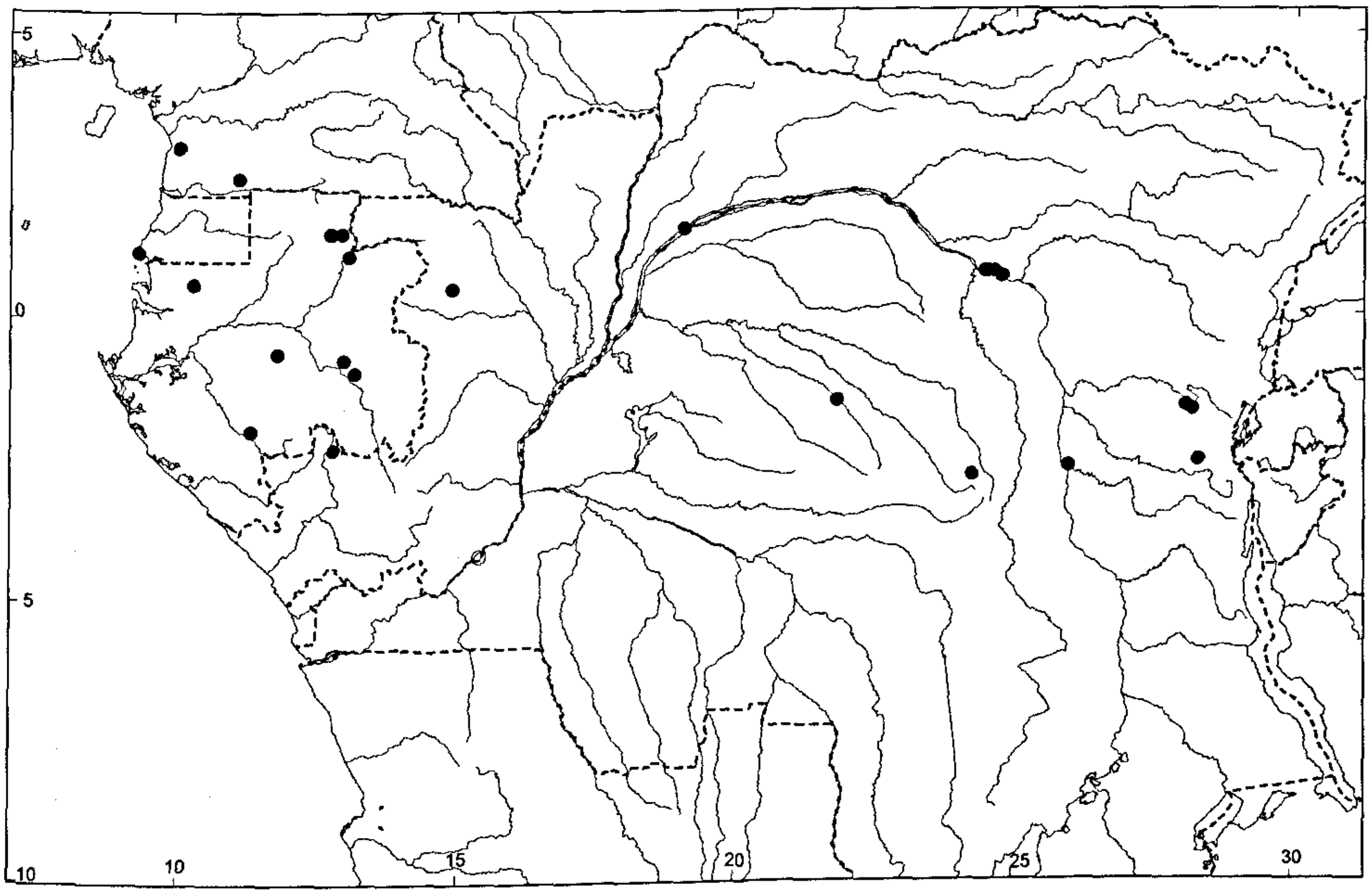
Inflorescence on the nodes of the most recent shoot (= up to 14 nodes) or in those of the previous growth phase, 1–6 per axil, a simple raceme, 1½–5½ cm long, (4–)10–30(-60) flowered. Most flowers flowering simultaneously (see photos p. VIII). **Rachis** 8–53 mm long, densely short to long tomentose-velvety. **Bracts** caducous, ovate to obovate, 3.0–4.9 x 3.4–5 mm, densely parallel-veined, outside short to long appressed velvety along the central axis, glabrous towards the margins, inside glabrous, margins shortly to long ciliate and often with some (glandular?) hairs/teeth. **Pedicel** 3–5 mm long, tomentose-velvety. Hypanthium s.l. 0.3–0.8 mm high. **Bracteoles** assuming a 90–120° wide angle at anthesis, caducous before the stamens and usually also before the petal, obovate, 5–6½ x 2½–4 mm, fairly limp, white, outside brown pubescent, long to very long velvety over a central line, midrib indistinct, inside glabrous, margins chaffy. **Flowers** white, fragrance as in violets (*Viola*). **Adaxial sepals** wanting, vestigial or sometimes more or less developed, usually free, rarely fused, free ones triangular to linear, 0.2–2.1 x 0.2–0.9, fused ones triangular to ovate, 0.4–2.4 x 1.0–1.4 mm, outside glabrous or sparsely pubescent, inside glabrous or with a few hairs towards the apex, margins glabrous to shortly ciliate. **Lateral** and **abaxial sepals** wanting. **Adaxial petal** obovate to spatulate, 5–9 x 3–5½(–7) mm, white, glabrous, margins glabrous, apical margin often emarginate, at the emargination often with a few hairs, claw indistinct, 1–4 mm long. **Lateral petals** wanting or vestigial, triangular, up to 0.7 x 0.3 mm, glabrous. **Abaxial petals** usually wanting, rarely vestigial, triangular, up to 0.2 x 0.3 mm, glabrous. **Stamens** 10: filaments (5–)8–13 mm long, white, 9 united over a length of 0.4–1.2 mm, glabrous or with a few hairs in the hypanthium part, adaxial one free, only the base slightly fused with the hypanthium, inside often pubescent, usually only at base, but sometimes over almost its entire length; anthers 1.2–1.5 mm long, pale brown. **Ovary** 2.0–3.6 x 0.9–1.9 x 0.4–1.1 mm, often depauperate and only 0.5–1.1 x 0.3–0.6 x 0.2–0.4 mm, green, long brown velvety, with 2(-3) ovules; stipe 1.1–1.6 mm long (0.7–1.3 mm long in depauperate ovaries), long velvety. **Style** 8–12 mm long in bisexual flowers, 0.3–1 mm in male flowers, inserted at an angle of 5–30(–90)° to the adaxial side of the ovary, at base with a few short to long hairs; stigma distinctly heart-shaped, brownish.

Pod (1–)2(–3) seeded, obovate to obovate-oblong, 4–7 x 2.2–2.9 x 0.2–0.4 cm, brown velvety with a few long hairs; beak 0–1 mm long; upper margin indistinctly winged, 1½–4½ mm wide (but often (partly) fused with the prominent nerve and seemingly distinct, up to 8½ mm wide); nerve running very close to the upper suture and often fused with it partially or over its entire length, u/w = 0–0.18 (for a definition see 4.3.8); stipe 1–3 mm long, pedicel 4–6 mm long. **Seeds** ovate to obovate, 13–16 x 8–13½ x 1½–3½ mm, 0.15–0.35 g in dry condition; testa thin, but not membranous, slightly glossy, dark brown.

Seedling: Germination epigeal. **Hypocotyl** 5–7 cm long (–10 cm acc. to Léonard, 1957: 264), long velvety. **Epicotyl** 0.1–0.2 cm long, long velvety. First pair of leaves opposite, 1–2(–5)-jugate. The rachis (or in 1-jugate leaves the petiole part after the joint) on the upper side glabrous, lower side long velvety. Stipules of these first two leaves free. Subsequent leaves alternating, 1(–5)-jugate, with fused stipules, at first preceded by persistent scales.

The two gatherings of seedlings studied originate from Gabon. They seem to concur well with the 4 samples described by Léonard from Congo (Kinshasa) which could not be studied.

Distribution: Map 10.2. The distribution of this species appears to be disjunct. On one hand it occurs in Gabon, Equatorial Guinea and the adjacent parts of Congo (Brazzaville) and southern Cameroon, on the other hand the species occupies a clear-cut area in central Congo (Kinshasa). The one dot on the distribution map from between both areas concerns a not definitely located sample site. Congo (Brazzaville) has been poorly collected, so the



Map 10.2. Distribution of *Aphanocalyx cynometroides* Oliv.

gap may be filled in that part by further collecting, however, Congo (Kinshasa) has been explored much better, so it is likely that at least the part of the gap in western-central Congo (Kinshasa) will prove to be an actual one making the species really disjunct.

Vernacular names: **Gabon**: Ngabi (Mitsogo). **Congo (Kinshasa)**: Bubalaka (Kirega), Kaabi (Lega), Kisanjabala (Kisongola), Yela (Turumba); (acc. to Tailfer (1989) also Kikumbukumbu (Kirega)).

Ecology: A solitary or gregarious tree, in Congo (Kinshasa) sometimes becoming dominant. Usually found in dryland, rarely riverine, forest on clayish, rarely sandy, soils, from 200–1400 m altitude. Both records from Cameroon relate to isolated hill tops, in Gabon the species occurs on hill sides, in valleys or on flat terrain, in Congo (Kinshasa) it is reported to be most abundant on lower hill slopes and on valley bottoms, but to occur as isolated trees on hill tops as well. Pierlot (1966: 144 & 154) also describes the species as abundant in submontane forest from 1200–1600 m.

Phenology: Congo (Kinshasa): In Yangambi flowering seems to be restricted to the period February to April, in Mukumari flowering occurs in July.

Gabon and Equatorial Guinea: all three flowering collections are from September.

According to Papadakis (1961) the rainy season in Yangambi starts in March and that of northern Gabon in September (for Mukumari no rainfall data are available), so all flowering records from Yangambi and Gabon concur with the beginning of the rainy season.

In Yangambi developing pods have been collected in March and May while almost mature ones were found in July. The July record concerns a tree that was flowering in February, which indicates a maturation time of 6–7 months. A record from Yongo, almost mature pods in August, corresponds with the Yangambi phenology.

In Ngoli mature pods were found in February; if Ngoli and Mukumari (same latitude) are comparable as far as seasonality is concerned, this points to a maturation time of 7 months.

Chemistry: flowers or leaves do not produce any colour in alcohol.

Diseases and pests: Sometimes a kind of gall is found on the twigs, that is similar, but not completely identical, to those of *A. djumaensis* and *A. richardsiae*. These galls are caused by an insect (probably a beetle) larva. Two collections from Yangambi (*Louis 3814* & *Gilbert 9478*) show very characteristic fruit galls (or actually, most likely it is the pedicel which is galled): these galls are 3–6 mm long and resemble acorns.

Uses: none reported.

Notes: In Oliver's publication no precise type specimen is mentioned, except for *Mann* and that the collection is present at Kew. Aubréville (1968) specifies this to *Mann 1810*, without mentioning a herbarium. Since *1810* is the only available Mann collection of this species and its location fits exactly the description, it is the only possible choice, and the Kew sheet should be considered as the holotype since at least the reference to Mann and the type locality was made in the protologue.

Specimens examined:

CAMEROON: *Letouzey 10203* (P, WAG, YA): 15 km NW of Ambam, near Akonékyé, Ongongondoé, 2°28'N 11°10'E (st, 23.03.1970); *Wieringa & Haegens 2355* (G, IEC, WAG): 1 km E of Bidou I, Mbengué mountain, 3°01'N 10°07'E (st, 26.02.1994).

EQUATORIAL GUINEA: *Mann 1810* (BR, K, P, W) type: Mount John, River Konqui, 1°10'N 9°25'E (fl, 09.1864).

GABON: *Breteler, Issembe, Moussavou & Pascal 15208* (WAG): c. 10 km NW Makandé, 0°37'S 11°51'E (st, 25.02.1999); *Breteler, Wieringa & Nzabi 12868* (UGDA, WAG (+alc)): Crystal Mountains, Tchimbélé, 0°36'N 10°23'E (fl, 15.09.1994); *Breteler, Wieringa & Nzabi 13291* (WAG (+alc)): 38 km SE Bambidie, left bank of Sebe-river, 0°58'S 13°13'E (fr, 14.10.1994); *Breteler, Wieringa & Nzabi 13292* (WAG): 38 km SE Bambidie, left bank of Sebe-river, 0°58'S 13°13'E (st, 14.10.1994); *Breteler, Wieringa & Nzabi 13345* (WAG): 7.5 km NE Bambidie, 0°44'S 13°02'E (st, 17.10.1994); *Dibata in MINKébé series C398* (WAG): Minkébé region, 2235m on transect A, 1°30'N 12°47'E (st, 09.03.1990); *Dibata in MINKébé series E206* (WAG): Minkébé region, 1260m on transect B, 1°30'N 12°49'E (st, 28.02.1990); *Eckendorf 118* (BM, P): Djoua, Mayébut savanna, 1°06'N 13°07'E (fl, 02.09.1945); *Wilks 1022* (WAG): 4 km SW of Bilengui, 1°59'S 11°23'E (st, 16.12.1984); *Wilks 1990* (WAG): Nouna-riverbank, 1°30'N 13°00'E (st, 24.07.1989).

CONGO (BRAZZAVILLE): *Dowset-Lemaire 1769* (BR): Odzala N.P., slope to the Diba river, 0°30'N 14°57'E (st, 24.08.1994); *Sita 3516* (IEC): near Mayoko, mount Lekoumou, 2°19'S 12°51'E (st, 13.03.1973).

CONGO (KINSHASA): *Y. Ankei & T. Ankei 79/1094* (BR): Ngoli, 2°41'S 25°57'E (fr, 11.02.1980); *Bolema 577* (BR): Yangambi, 0°46'N 24°27'E (fl, 04.04.1961); *Donis 3615* (BR): Yangambi, 0°46'N 24°27'E (fl, 11.02.1952); *Donis 3616* (BR, K): Yangambi, 0°46'N 24°27'E (fl, 11.02.1952); *Donis 3640* (BR, LISC): Yangambi, 0°46'N 24°27'E (fl, 13.02.1952); *Donis 3641* (BR, M, SRGH): Yangambi, 0°46'N 24°27'E (fl, 13.02.1952); *Donis 3642* (BR, K): Yangambi, 0°46'N 24°27'E (fl, 13.02.1952); *Evrard 4728* (BR, K): Yongo, on piste to the yenge, 1°31'S 21°49'E (fr, 14.08.1958); *Germain 7996* (BR, FHI, PRE): Mukumari, INÉAC-station, 2°51'S 24°14'E (fl, 14.07.1952); *Gilbert 7691* (BR): Yangambi, 0°46'N 24°27'E (st, ?); *Gilbert 8286* (BR): Yangambi, 0°46'N 24°27'E (fl, 194?); *Gilbert 8287* (BR, K): Yangambi, 0°46'N 24°27'E (fl, 194?); *Gilbert 9141* (BR): Yangambi, 0°46'N 24°27'E (st, ?); *Gilbert 9301* (BR): Yangambi, 0°46'N 24°27'E (st, ?); *Gilbert 9303* (BR): Yangambi, 0°46'N 24°27'E (st, 194?); *Gilbert 9427* (BR): Yangambi, 0°46'N 24°27'E (fl, 194?); *Gilbert 9459* (BR): Yangambi, 0°46'N 24°27'E (fl, ?); *Gilbert 9478* (BR): Yangambi, 0°46'N 24°27'E (fr, ?); *Gillardin s.n. (1)* (BR): Mubangu-Mukunza (= Mabanga to Makanza ?), 1°33'N 19°05'E (st, 193?); *J. Louis 3814* (BR, K): 6 km E of Yangambi, Yaosuka, 0°46'N 24°30'E (fr, 02.05.1937); *J. Louis 13815* (BM, BR, EA, K, LISC, P, PRE): Yangambi, Isalowe, 0°46'N 24°27'E (fl, 25.02.1939); *J. Louis 14328* (BR, K): Yangambi, Lusambila, 0°46'N 24°28'E (fl, fr, 17.03.1939); *J. Louis 14341* (BR): Yangambi, Babasites, Wilsorm?, 0°46'N 24°27'E (fr, 17.03.1939); *J. Louis 15188* (BR, BRLU, C, K, LG, LISJC, P): Yangambi, Isalowe, 0°40'N 24°45'E (fr, 15.07.1939); *Maudoux 3169* (P): Yangambi, 22 km, 0°45'N 24°37'E (st, 06.1954); *Michelson 268* (BR): riviere Luka, 1°37'S 28°02'E (st, ?); *Michelson 826* (BR): 263 km Costermansville-Shabunda, 2°35'S 28°15'E (st, 22.12.1948); *Terashima 192* (BR): Nyamakombola, 1°41'S 28°09'E (st, 27.10.1989).

Aphanocalyx djumaensis (De Wild.) J. Léonard Fig. 10.2, Map 10.3

Aphanocalyx djumaensis (De Wild.) J. Léonard: Léonard, 1957: 263–264; Aubréville, 1968: 274; Aubréville, 1970: 255; Léonard, 1994: 373; White & Abernethy, 1996: 25–26.

Cynometra djumaensis De Wild.: De Wildeman, 1904: 128 & Pl. 39, fig. 6; Durand & Durand, 1909: 181; De Wildeman, 1925: 94 & 97. **Type**: *Gillet 2800* (holo: BR, see notes) — Congo (Kinshasa): "Vallée de la Djuma, Juillet 1902".

Aphanocalyx cynometroides auct. non Oliv.: Baker, 1930: 733–734 p.p.; Staner, 1939: 135 p.p.; Pellegrin, 1949: 73 p.p.

Aphanocalyx margininervatus auct. non J. Léonard: Léonard, 1951a: 127–129 p.p.; Léonard, 1952: 440 p.p.; Aubréville, 1968: 276–277 p.p.

Aphanocalyx spec.: Lebrun, 1933: 302; Léonard, 1952: 440–441 p.p.

Shrub to medium-sized or sometimes large tree, 6–20(–35) m high; crown of shrubs and small trees usually irregular and overhanging a river. **Bole** usually irregular and contorted, occasionally cylindrical, DBH 15–100 cm: base cylindrical, in large trees with small buttresses. **Bark**: surface smooth becoming flaky with circular scales, grey to yellowish grey, fallen scales leaving brown-red spots; inner bark pinkish to wine-red.

Twigs smooth, with few lenticels, first medium green to greyish green, later red-brown to grey, glabrous, but in saplings and young trees fairly sparsely, short to very long, red-brown velvety. **Stipules** fused, early deciduous, obovate to spatulate, 12–26 x 2½–7 mm, those towards the apex of a shoot sometimes persistent at first, narrowly triangular and much narrower (usually also much smaller), 3–8(–16) x ½–1½ mm, all stipules with many closely spaced parallel veins, both sides glabrous, margins short and long ciliate. **Leaves** 2½–13 cm long, 1-jugate: **Petiole** 2–10 mm long, fairly densely very long velvety, glabrescent but in saplings and young trees indumentum often fairly persistent, for the major part consisting of the wrinkled joint, towards the apex usually smooth and the lower side there often with a slightly swollen, paler area in dry condition. **Rachis** wanting, but see seedling. **Leaflets** half-ovate to half-obovate, 21–127 x 9–47 mm, thick leathery (to papery in saplings), upper surface dark green, rather dull to glossy, lower surface medium green to pale green, dull to fairly glossy, in developing leaflets upper side fairly sparsely, long to very long villous, lower side fairly sparsely to densely so, both sides soon glabrescent; distal half completely reduced or composed of a small lobe near the apex; apex rounded to acute or acuminate, without a glandular mucro; base cordate to rounded, rarely cuneate, not auriculate. Young leaves red, later creamy. **Gland pattern**: 0–5 glands near the base of the leaflet and along the proximal margin, the most basal one sometimes imbedded in the margin.

Inflorescence in the terminal 2–12 axils of the most recent shoots, rarely some in those of the previous growth phase, 1–2(–3) per axil, a simple raceme (sometimes at least 6 undeveloped buds of lateral racemes may be present), 1½–5 cm long and 10–70-flowered. **Rachis** 7–45 mm long, brown tomentose to velvety, with 6–20(–50), sometimes persistent, scale-like 'bracts' below the flowers. **Bracts** caducous, triangular to ovate to obovate, 3½–6½ x 4–6½ mm, densely parallel-veined, outside short to very short appressed velvety along the central axis to completely velvety, inside glabrous, margins shortly (rarely long) ciliate. **Pedicel** 2–6½ mm long, short and long brown velvety. Hypanthium s.l. 0.3–0.6 mm high. **Bracteoles** assuming a 70–90(–150)° wide angle at anthesis, 4½–7½ x 2½–5 mm, white, outside pale brown pubescent, especially along the mid-axis also short to long, brown velvety, inside glabrous, margins chaffy. **Flowers** sweetly fragrant. **Sepals** both sides glabrous to fairly densely, long villous, margins long ciliate, more densely towards the apex. **Adaxial sepals** free, sometimes one or both wanting, triangular to ovate or obovate, up to 2.1 x 0.9 mm. **Lateral sepals** wanting. **Abaxial sepal** often wanting, oblong to linear, up to 0.7(–1.6) x 0.2(–0.4) mm. **Adaxial petal** spatulate, limb usually circular, 6–13 x 3–9 mm, white, outside glabrous, rarely sparsely pubescent, inside glabrous, margins glabrous but apical margin rarely ciliate, claw 1½–4½ mm long, with somewhat inrolled margins. **Lateral** and **abaxial petals** wanting, the lateral ones rarely indicated by a minute tubercle. **Stamens** 10 (sometimes 1 or 2 anomalous and petaloid): filaments 7–16 mm long, 9 united over a length of 0.4–1.1 mm, white, entirely glabrous; anthers 1.0–1.8 mm long, brownish yellow. **Ovary** 2–4 x 1.0–1.7 x 0.3–0.8 mm, rarely more or less depauperate and only 1–2 x 0.4–1.0 x 0.2–0.3 mm, short to long brown velvety, with 1–3 ovules; stipe 0.6–1.6 mm long, short (to long) velvety except for the base. **Style** 8–12 mm long in bisexual flowers, 1–2 mm long in male flowers, inserted at an angle of

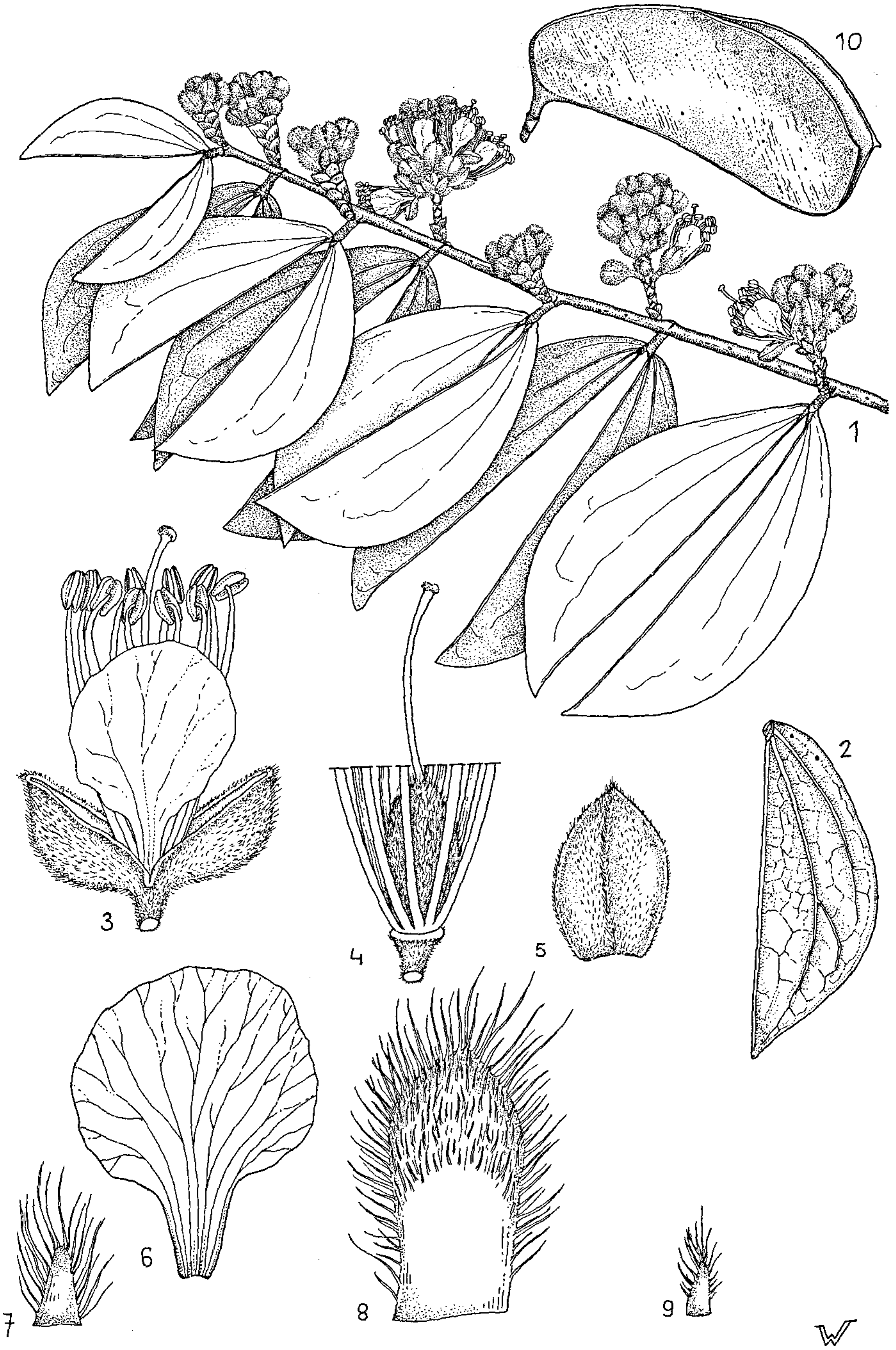


Figure 10.2. *Aphanocalyx djumaensis* (De Wild.) J. Léonard. — 1: twig with leaves and inflorescences (x⅔); 2: leaflet from below showing two glands (x⅔); 3: flower from adaxial side (x3); 4: flower with bracteoles, sepals and petal removed showing insertion of stamens and the ovary (x3); 5: bracteole from outside (x3); 6: adaxial petal (x4); 7 & 8: two forms of an adaxial sepal (x20); 9: abaxial sepal (x20); 10: pod, just splitting open along upper suture (x⅔). — 1–9: *Breteler & de Wilde 630*; 10: *Bolema 1808*.

10–50(–80)°, sparsely short to long velvety near the base; stigma heart-shaped.

Pods 1–2(–3)-seeded, oblong-obovate, 4–7 x 2.1–2.9 x 0.17–0.3 cm, surface granulate, dull, medium to pale green, becoming brown to grey when mature, glabrous to sparsely set with short to long hairs; beak 0–2 mm long; upper suture not or hardly winged, 2–3½ mm wide; nerve indistinct to distinct, running very close to the upper suture and therefore often hard to distinguish, u/w = 0.01–0.14; stipe 2–6 mm long; pedicel 3½–6½ mm long. **Seeds** obovate, 12–15 x 8–11 mm, margin slightly accrescent; testa papery, dull, medium brown, but darker along the margins.

Seedling: Germination epigeal. **Hypocotyl** 4–12 cm long, long to very long velvety. **Epicotyl** 1.1–1.7 cm long, long to very long velvety. First pair of leaves opposite, 2-jugate: rachis 4–10 mm long, upper surface glabrous to sparsely long velvety, lower side long to very long velvety, in dry condition more or less terete with on the upper side a grooved ridge, leaflets of about equal size. Subsequent leaves alternate, 1-jugate, preceded by leafless stipules.

Distribution: Map 10.3. Gabon: along the Ivindo river and some of its tributaries, and along the Ogooué river downstream its confluence with the Ivindo down to Ndjolé. Congo (Kinshasa): several areas in the Congo river system.

Vernacular names: Gabon: Nlighedi (Ndjolé region). Congo (Kinshasa): Ebaka (Bolia region), Mpeke (or Empeke or Impeke) (Lac Tumba region).

Ecology: An often gregariously growing tree of riverine forest, usually growing on the riverbank and overhanging the river. Several times found in *Gilbertiodendron dewevrei* forest. According to *Moureau s.n. (1)* the tree avoids areas where inundation levels may reach more than 50 cm. Altitudes range from 25–500 m.

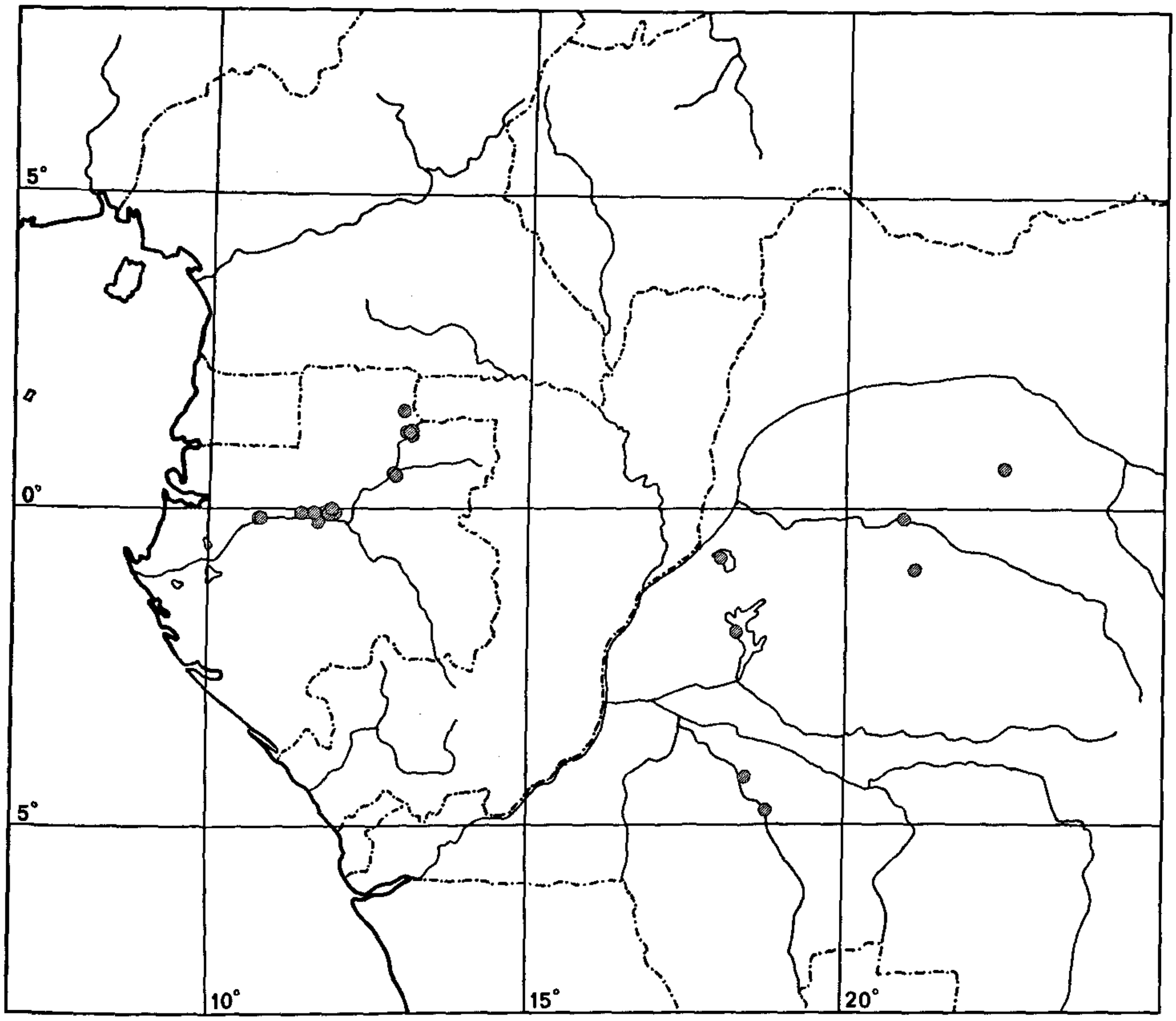
Phenology: In Gabon flowering from August to mid-October. White and Abernethy (1996: 25) observed in the Lopé Reserve (Gabon) abundant flushes and flowers at the end of the dry season (= August or September). They also report the presence of flowers throughout the rest of the year, but only in small numbers.

Developing pods have been reported twice in November. Almost mature pods have been collected at the end of January, which points to a maturation time of about 5 months. One mature pod was collected in July, but this could be the result of anomalous flowering as reported by White & Abernethy (l.c.).

Chemistry: Flowers produce no distinct colour in spirit.

Diseases and pests: Twigs may be swollen over a length of c. 1½–3 cm and become hollow with one or a few small holes in it. Often several such galls are present along the same twig. In one of the galls a woolly coccus was found, although these insects are known to produce galls in the temperate regions, it is not sure whether this species is responsible for the galls. These galls have been observed twice, both times from the Booué area in Gabon. The only other species of the genus which displays similar galls is *A. richardsiae*.

Evrard (*5277*) reports the trunk may be completely criss-crossed by tunnels left by large insect larvae.



Map 10.3. Distribution of *Aphanocalyx djumaensis* (De Wild.) J. Léonard.

Uses: none reported.

Notes: *Gillet s.n.* was originally designated as the type, but Léonard (1952: 441 & 1957: 263) corrected the '*s.n.*' in '*2800*' (BR, holo, no duplicates exist). The number 2800 is clearly present on the label, but it is not evidently the collection number since it is mentioned on the bottom just before "juillet".

This tree is usually reported as a widely branched shrub or medium-sized tree with an irregular and short bole. However, in the northern part of its distribution in Congo (Kinshasa) it is also recorded as a large tree with a cylindrical bole. The larger variation in forms in that area, may be an indication that the species originated from that area. This is supported by the more widespread distribution in Congo (Kinshasa); the distribution in Gabon is most easily explained by a single introduction somewhere upstream in the Ivindo drainage-area.

All seeds present in the collections are very thin (only the margin being slightly thicker) and do not seem to be fully matured. However, some of them originate from (almost) mature pods. To know for sure what ripe seeds look like, seeds collected from the forest floor are needed. Since those are not available, no values for thickness or weight are given here.

Specimens examined:

GABON: *Alers & Blom 69* (LBV, WAG): Lopé Reserve, 0°07'S 11°37'E (st, 23.06.1986); *Aubréville 73* (P):

near Ndjolé, 0°11'S 10°45'E (fl, 01.09.1945); *Breteler & Breteler-Klein Breteler 13056* (WAG (+alc)): border of Ogooué, 3-4 km downstream Ndjolé, 0°11'S 10°44'E (fl, fr, 28.09.1994); *Breteler & J. de Wilde 630* (BR, C, K, LBV, MA, MO, P, PRE, SRGH, WAG (+alc)): Ivindo River, between Mayibout I and II, 1°07'N 13°07'E (fl, 14.09.1978); *Breteler 14644* (WAG (+alc)): border of Ogooué river near Ndjolé, 0°11'S 10°46'E (st, 11.1998); *Breteler, Jongkind & Wieringa 11381* (WAG): road Ndjolé to Lopé, just before bridge crossing Ogooué, 0°06'S 11°24'E (st, 08.05.1992); *Florence 292* (P): 10 km S of Makokou, IPASSA station, 0°29'N 12°52'E (st, ?); *Florence 1607* (P): 10 km S of Makokou, IPASSA station, 0°29'N 12°52'E (fr, 25.01.1979); *Floret, A. Louis & Moungazi 1796* (LBV, P, WAG): Petit Okano, in riverbed near Nké ferry, 0°02'S 11°53'E (fl, 10.10.1983); *Floret, A. Louis & Moungazi 1805* (LBV, P, WAG): Petit Okano, viaduct transgabonais, 0°04'S 11°52'E (fl, 10.10.1983); *Floret, A. Louis & Moungazi 1921* (LBV, P, WAG): road to Lopé, 6 km after the Petit Okano ferry, 0°07'S 11°50'E (fl, 13.10.1983); *N. Hallé & Le Thomas 251* (P): Booué, Ogooué, 0°06'S 11°56'E (st, 30.07.1966); *Hladik 1536* (P): Makokou, Elephant island, middle of Ivindo, 0°31'N 12°50'E (fl, 21.09.1971); *A. Louis, Breteler & de Bruijn 584* (BR, WAG (+alc)): Offooué River, near Achouka, 0°06'S 11°46'E (fr, 10.11.1983); *Sita 4938* (LBV): Ogooué Ferry next to confl. petit Okano, 0°03'S 11°52'E (fl, 10.08.1983); *L. White 949* (WAG): Lopé reserve, Ogooué-Portes d'Okanda, 0°15'S 11°40'E (fl, 30.07.1993); *L. White 1092* (WAG): Lopé reserve, 0°15'S 11°40'E (fr, 16.10.1993); *J. de Wilde, v.d.Maesen, Bourobou & Moussavou 11458* (WAG): Lopé village, 0°06'S 11°36'E (fr, 27.11.1995); *Wilks in MINKébé series W 510* (WAG): Ogooué-Ivindo, Nsye-river bank, 1°10'N 13°02'E (st, 30.05.1990); *Wilks in MINKébé series W 549* (WAG): lower Nouna river, 1°12'N 13°07'E (st, 10.09.1990); *Wilks 1988* (WAG): Nouna-riverbank, 1°30'N 13°00'E (st, 24.07.1989); *Wilks 1994* (WAG): Nouna-riverbank, 1°10'N 13°05'E (fr, 25.07.1989).

CONGO (KINSHASA): *Bolema 1808* (BR): Djolu, 0°35'N 22°27'E (fr, 03.04.1976); *Evrard 4562* (BR, K, SRGH): Salonga (betw. Botoka-Ndjoku and Bamata), 1°01'S 21°03'E (fl, 08.08.1958); *Evrard 5277* (BR): Boende, Tshuapa river, 0°13'S 20°52'E (st, 14.11.1958); *Gilbert 14412* (BR): Lac Léopold II, 2°00'S 18°15'E (st, ?); *Gillet 2800* (BR) type: Djuma valley, 4°50'S 18°44'E (st, 07.1902); *Moureau s.n. (1)* (BR): Lac Tumba, 0°50'S 18°00'E (st, 0?.05.1958); *Sapin X* (BR): Madibi, 4°18'S 18°24'E (st, 05.1907).

Aphanocalyx jenseniae (Gram) Wieringa comb. nov. Fig. 10.8: 1–8, Map 10.4

Basionym: *Monopetalanthus jenseniae* Gram, Bot. Tidsskr. 42: 416 (1934).

Monopetalanthus jenseniae Gram: Gram, 1934: 416 & fig. 1 (as *M. Jenseni*); Pellegrin, 1942: 119 (as *M. Jenseni*); Léonard, 1952: 442–443 (as *M. Jensenii*). **Type**: *Jensen 25* (holo: C; iso (fragments): BR, WAG) — "Congo Belge: Lac Leopold II Distrikt", "Ved Landsbyen Bosango; Dekese territoriel. Lac Distriktet".

Medium-sized tree, 20 m high with a flat crown.

Twigs smooth but lenticellate, reddish brown, sparsely to fairly densely brown velvety, old twigs becoming pale grey and glabrescent. **Stipules** fused, more or less persistent, narrowly oblong to ovate, base not auriculate or with a very small auricle, distal halves not inflated, 16–25 x 2–4 mm, with many closely spaced parallel veins, outside glabrous but in the apical part usually puberulous, inside glabrous, margins shortly to long ciliate. **Leaves** 4–7 cm long, 3–5-jugate, largest leaflet situated at about the middle or at the apex: **Petiole** 1½–3½ mm long, sparsely velvety to glabrous, completely consisting of the wrinkled joint. **Rachis** 10–36 mm long, upper surface glabrous, but often the ridge (sparsely) velvety, lower surface glabrous or rarely very long appressed velvety, in dry condition semi-circular to triangular in cross-section, lower side flattened, upper side often with a (grooved) ridge. **Leaflets** thick leathery, upper side slightly glossy, glabrous, lower side dull, glabrous; margins glabrous; distal half completely reduced; proximal half not auriculate at base; apex acute to acuminate, with an up to 2.5 mm long glandular mucro. **Basal leaflet** half-obovate to half-elliptic, 16–34 x 4–11 mm: base of proximal half cuneate. **Apical leaflet** half-oblong-elliptic, 31–44 x 8–12 mm: base of proximal half truncate, angle with the lateral margin obtuse, rounded. **Largest leaflet** half-oblong-obovate to half-oblong-elliptic, 32–44 x 6–12 mm: base of proximal half truncate to rounded, angle with the lateral margin obtuse, rounded. **Gland pattern**: Basal leaflet with 1–3 glands. All other leaflets without glands.

Inflorescence in axils of the youngest shoots (= up to 8 nodes), a simple raceme, solitary, 1½–4 cm long and 15–35-flowered, without odour. **Rachis** 13–32 mm long, 1.0–1.5 mm thick, (long) pale brown velvety. **Bracts** caducous, ovate, 5–6 x 4½–6 mm, densely parallel-veined, outside mixed appressed velvety (long appressed velvety along the midrib) and puberulous, glabrous along the lateral margins, inside glabrous, margins shortly and long ciliate. **Pedicel** 5½–7 mm long, long brown velvety. Hypanthium s.l. 0.4.–1.0 mm high. **Bracteoles** assuming a 60–100° wide angle at anthesis, 6–8 x 3–4 mm, outside long brown velvety, along the midrib very long velvety, inside sparsely pubescent, especially along the margins, margins chaffy. **Sepals** outside fairly densely velvety, inside fairly densely pubescent, margins shortly and long ciliate. **Adaxial sepals** usually fused, then ovate to obovate or swallowtail-shaped, 3.6–4.0 x 2.4–3.0(–3.8) mm, apical margin usually emarginate, when free oblong-ovate, 2–3½ x 1 mm. **Lateral sepals** oblong-obovate to spatulate, often folded inwards, (0.7–)1.3–2.7 x (0.1–)0.3–0.8 mm. **Abaxial sepal** obovate to spatulate, 2.9–4.0 x 0.8–1.8 mm. **Adaxial petal** spatulate, 7–10 x 5½–7 mm, both sides glabrous, margins glabrous, apical margin often emarginate, claw 3½–5 mm long. **Lateral petals** linear, 0.3–1.9 x 0.1–0.2 mm, glabrous. **Abaxial petals** wanting. **Stamens** 10: filaments 11–13 mm long, 9 united over a length of 1.0–1.3 mm, entirely glabrous; anthers 1.3–1.5 mm long, each cell with a small dorsal tooth. **Ovary** 2.3–3.5 x 1.3–2.3 0.6–1.2 mm, never depauperate, long and very long very densely pale brown velvety, with 2 ovules; stipe 1.8–2.8 mm long, long velvety except for the base. **Style** 8–10 mm long, inserted at an angle of 30–80°, long velvety at the very base and in the lower half on the abaxial side; stigma heart-shaped.

Pods, seeds and **seedlings** unknown.

Distribution: Map. 10.4. Only known from the type collection from western central Congo (Kinshasa).

Vernacular names: none recorded.

Ecology: According to the protologue and the collection label the species is very common in the lake region. However, if this is true, it is a mystery why the species has not been collected more frequently. According to the collection label the species occurs most frequently at the forest edge.

Phenology: Flowering in June.

Chemistry: Flowers and leaves in spirit produce a pale yellow colour.

Diseases and pests: none recorded.

Uses: none reported.

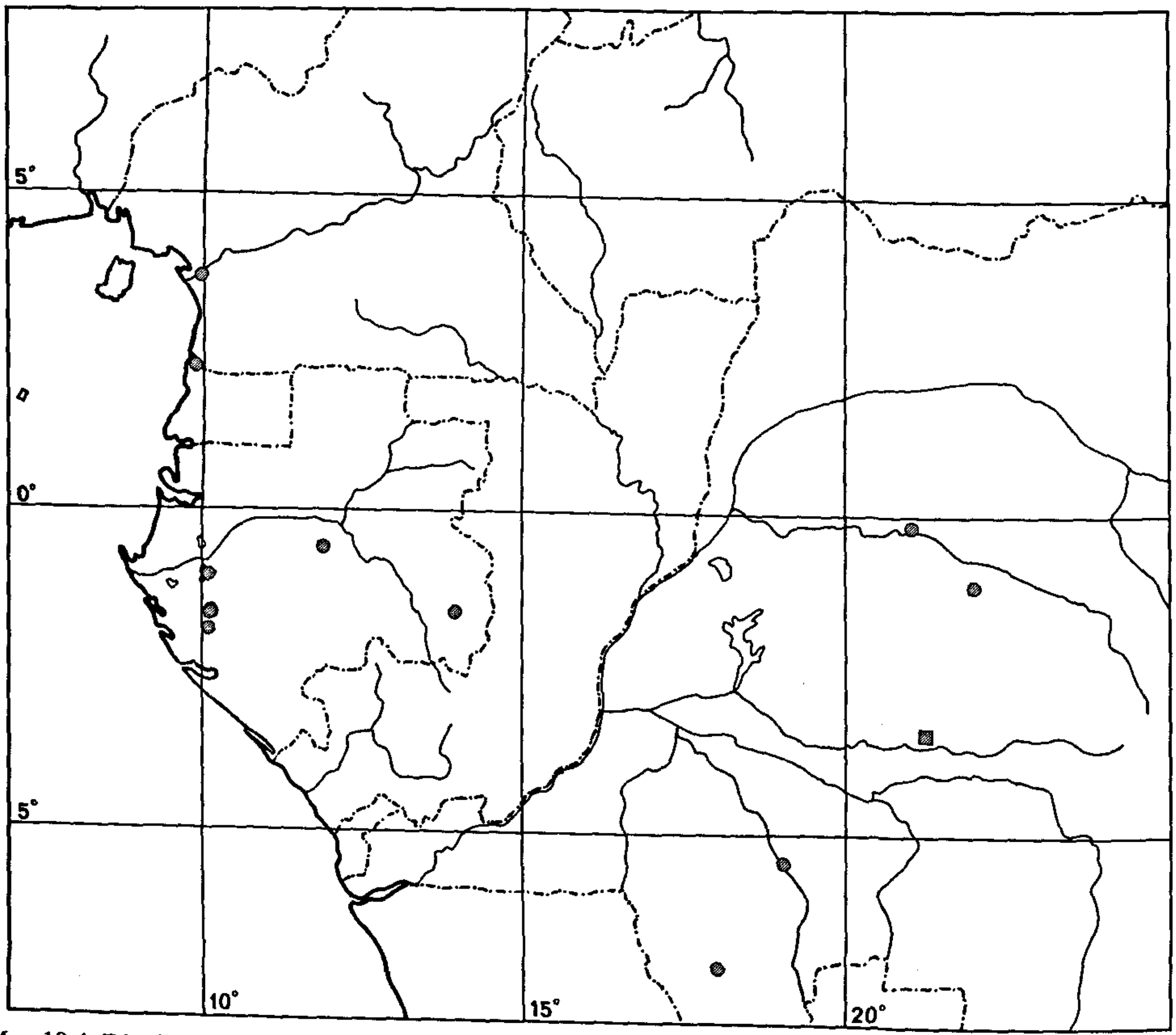
Notes: Up to now this species has always been called *M. jensenii* instead of *jenseniae*. As the collector of the holotype was a woman, as indicated on the holotype itself ("leg Fru K. Jensen") and by K. Gram in the protologue ("suivant Madame K. Jensen"), the latter is correct.

In the protologue the holotype is not specified by its number. However, since the description is accompanied by a photograph of the *Jensen 25* sheet from C, and the protologue states it was collected by Mrs. Jensen at Busangu, Dekese, no doubt can exist that this sheet should be treated as the holotype.

It is rather suspect that this species has only been collected once. Since it was usually distinguished from *A. pteridophyllus* only by the smaller number of leaflets, it may seem likely it represents merely a form of what is now known as *A. obscurus*. However, *A. jenseniae* is lacking the densely velvety to tomentose twigs and the broadly auriculate stipules of that species. Also many characters in the flowers distinguish the two (although one should be aware as both are only known from a single flowering specimen). Another explanation for the fact that the species has only been collected once in a fairly well explored region may be that it constitutes a hybrid. Contradictory to this hypothesis is the fact that its flowers still posses most perianth elements, whereas the potential parent species (*A. obscurus* or *A. ledermannii* on one hand, *A. djumaensis* on the other) all have further reductions. Another argument is that none of these species is known to occur near the type locality (the closest occurrences are at least 100 km away).

Specimens examined:

CONGO (KINSHASA): *Jensen 25* (BR, C, WAG) type: Lac Leopold II district, Dekese territories, Bosango, 3°28'S 21°12'E (fl, 23.06.1923).



Map 10.4. Distribution of *Aphanocalyx jenseniae* (Gram) Wieringa (square) and of *Aphanocalyx ledermannii* (Harms) Wieringa (circles).

***Aphanocalyx ledermannii* (Harms) Wieringa comb. nov.**

Fig. 10.3, Plate 1d, Map 10.4

Basionym: *Monopetalanthus ledermannii* Harms, Bot. Jahrb. Syst. 45b: 299–300 (1910).

Monopetalanthus ledermannii Harms: Harms, 1910: 299–300; Baker, 1930: 734–735; Aubréville, 1968: 308–310, pl. 78; Aubréville, 1970: 280, pl. 67. **Type**: *Ledermann 444* (holo: B†; sketch in BM) — "Kamerun: Campo, Dipika, Felsen in den Schnellen des Campoflusses, August 1908", flowering (copied from protologue). **Neotype** (designated here, see notes): *Wieringa & Haegens 2263* (WAG; duplicates: G, IAGB, IEC, LY, UGDA, W & 17 others to be distributed) — "Cameroon, Sud province, Campo, rapids in the Ntem (=Campo) river at Dipika, 2°13.6'N 9°53.4'E, 18.02.1994", with old pods.

Medium-sized to large tree, 10–40 m high; crown irregular or hemispherical. **Bole** cylindrical, sometimes somewhat contorted, branchless for up to 15 m, DBH up to 70 cm: base often with rather thin buttresses, these up to 1½ m high and 1 m wide, rarely transformed into a stilt-root. **Bark** thin, up to 6 mm thick: surface smooth or very fine fissured, with horizontally stretched lenticels which may join up into horizonal lines, pale grey to yellowish grey; outer bark very thin, 0.1 mm thick, when scratched a light green layer is exposed; inner bark fibrous, creamy pink to pinkish red when fresh, reddish brown when dry, innermost layer paler. Sapwood whitish.

Twigs smooth, with some lenticels, pale to dark grey, (sparsely) (long) velvety or pubescent. **Stipules** fused, early caducous, spatulate, the more apical stipules of a shoot triangular to linear, base often with a tiny auricle, 3–14(–25) x 0.5–3 mm, pale green to pinkish or brownish yellow, with many, closely spaced, parallel veins, outside (short) villous to pubescent along the central line, this pubescence often extending over the distal half and towards the apex over the total width, inside glabrous, margins ciliate. Sometimes flattened hairs or glandular teeth present along the base, the basal part of the proximal margin and at the base of the central line of hairs. **Leaves** (3–)4–11(–18) cm long, (3–)7–13-jugate, largest leaflet at about or just past the middle: **Petiole** (1–)2–5 mm long, sometimes glabrous or pubescent to sparsely velvety or villous, completely consisting of the wrinkled joint. **Rachis** (1–)3–13 cm long, glabrous to sparsely velvety, in young leaves the lower side with additional long villous hairs, terete to semi-circular in cross-section, upper side often with a medial ridge. **Leaflets** papery to firm leathery, upper side (somewhat) glossy, dark green, glabrous, lower side dull to glossy, medium to greyish green, often with medium to dark green secondary and tertiary veins, glabrous; margins often pale green, very long silvery ciliate, glabrescent; distal half completely reduced, rarely partly present in the most apical leaflet; apex more or less rounded, but the primary nerve ending in an up to 2.7 mm long mucro. Young leaflets red, becoming pink-red, pinkish brown, purplish brown and finally green, apical mucro with a greenish white gland and sometimes bearded at this stage, lower side sometimes sparsely very long villous. **Basal leaflet** half-elliptic to half-obovate, 6–21(–28) x 1½–9(–12) mm: base of proximal half cuneate, without an auricle. **Apical leaflet** half-oblong to half-obovate, 7–31(–43) x 2½–12(–17) mm: base of proximal half sharply angled, rarely with an up to 1.1 mm long auricle. **Largest leaflet** half-oblong to half-oblong-obovate, 11–34(–52) x 3–13(–19) mm: base of proximal half sharply angled, usually with an up to 2.6 mm long auricle. **Gland pattern**: basal leaflet with 1–4 glands, 2 of which often very close to the base. Second leaflet with 0–3 glands. Other leaflets, including the apical one, with 0–2 glands.

Inflorescence in the axils of the youngest shoots (= up to 10 nodes), sometimes a few on older shoots, a simple raceme, 1–4 per axil, 1–4 cm long and 5–30-flowered. **Rachis** (long) brown velvety. **Bracts** caducous, ovate to obovate, 2½–5 x 2–4½ mm, distinctly densely parallel-veined, outside pubescence varying from almost glabrous with only a narrow puberulous band over the middle (Congo (Kinshasa)) to almost completely densely long velvety mixed with puberulous (Gabon & Cameroon), inside glabrous, margins shortly ciliate. **Pedicel** 2½–7 mm long, short to long brown velvety. Hypanthium s.l. 0.5–0.9(–1.5) mm high. **Bracteoles** assuming a 70–120° wide angle at anthesis, 4½–7 x 3–5 mm, reddish, outside mixed (sparsely) short to very long velvety with pubescent, the longer hairs on the indistinct midrib, inside glabrous or silvery pubescent along the margin, margin chaffy, at least sometimes with (glandular?) teeth. **Sepals** outside (very) sparsely velvety, inside pubescent to glabrous, margins short to long ciliate. **Adaxial sepals** usually fused, together more or less rectangular to semi-circular or ovate, 0.8–2.8 x 0.7–2.2 mm, apical margin often emarginate, when not fused sepals ovate, 0.2–2.2 x 0.4–0.9 mm. **Lateral sepals** wanting. **Abaxial sepal** usually present, then obovate or ovate to triangular, 0.1–1.6 x 0.1–0.8 mm. **Adaxial petal** spatulate, 4½–10 x 3–6½ mm, white, glabrous, claw often distinct, sometimes inrolled, 1½–3 mm long. **Lateral petals** usually wanting, rarely vestigial, triangular, up to 0.1 x 0.2 mm. **Abaxial petals** usually wanting, very rarely vestigial, triangular, 0.2 x 0.3 mm. **Stamens** 10: filaments 6½–13 mm long, 9 united over a length of 0.3–1.7 mm, entirely glabrous; anthers 1.1–1.5 mm long. **Ovary** 1.4–4.1 x 1.0–2.1 x 0.5–1.0 mm, sometimes depauperate and only 1.1 x 0.6–0.8 x 0.3–0.5 mm, long brown velvety, with 2 ovules; stipe adaxially fused with the hypanthium and the very base of the adaxial filament, 0.4–2.5 mm long, velvety except for the very base. **Style** 6½–9½ mm long in bisexual flowers, 0–1½ mm in male flowers, inserted at an angle of 10–60°, glabrous or sparsely velvety at base; stigma heart-shaped.

Pods 1–2-seeded, oblong-obovate to trapezoid, 3–6½ x 1.6–2.6 x 0.2–0.3 cm, immature ones dull, red, later green, very sparsely set with very long hairs, mature surface granulate, brown, virtually glabrous; beak 0–2 mm long; upper suture not winged, 1½–3½ mm wide; nerve rather indistinct, running close to the upper suture, u/w = 0.06–0.30; stipe 1–2½ mm long, pedicel 3–6 mm long. **Seeds** unknown, impressions in pods 9–15 x 8–13 mm.

Seedling: Germination epigeal. **Hypocotyl** 7–11 cm long, long brown velvety. **Epicotyl** 0.1–0.4 cm long, long brown velvety. First pair of leaves opposite, 7–8(–10)-jugate. Subsequent leaves alternate, with the same number of or slightly fewer leaflets, then the number slowly increasing. Stipules somewhat longer persistent than those in mature trees, rather small, pale greyish brown.

Distribution: Map 10.4. Apparently disjunct. In Cameroon, Equatorial Guinea (only known from the border with Cameroon) and Gabon, especially the coastal regions. Also present on inland localities in Congo (Kinshasa). To be expected in Congo (Brazzaville), most likely in the riverine forests in the valleys of the Batéké plateau.

Vernacular names: Congo (Kinshasa): Bonkese (Lokundu), Wendjele (Boende region); both these names are used for *A. microphyllus* as well.

Ecology: A tree occurring scattered in riverine forest or forest on slopes close to riverine forest, sometimes several individuals growing fairly close together. Except for the tree that

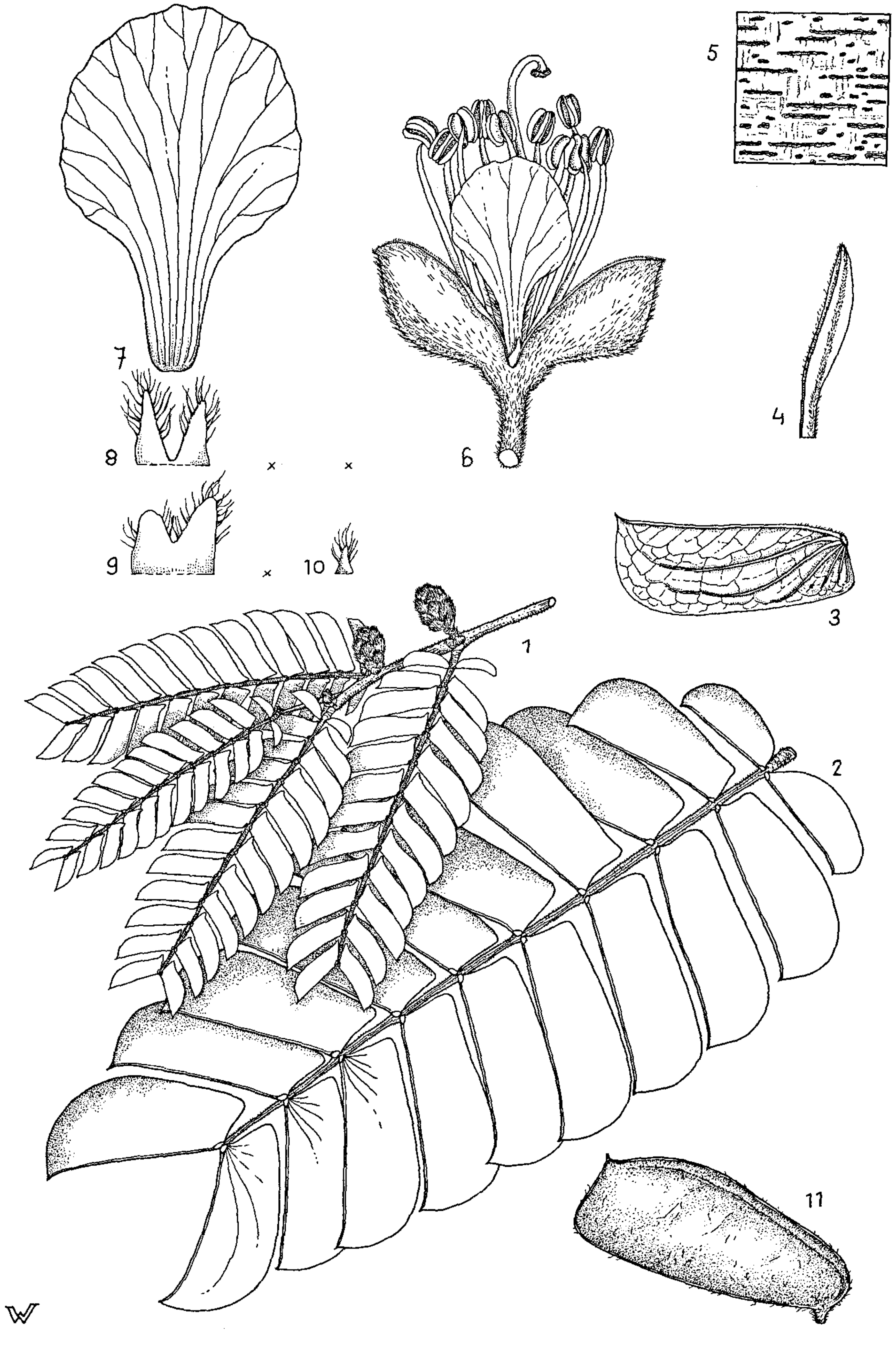


Figure 10.3. *Aphanocalyx ledermannii* (Harms) Wieringa. — 1: twig with leaves and inflorescence buds (x⅔); 2: large leaf from above (x⅔); 3: leaflet from below (x1); 4: two fused stipules (x2); 5: bark surface (x⅔); 6: flower from adaxial side (x4); 7: adaxial petal (x8); 8 & 9: two forms of the adaxial sepals (x8); 10: abaxial sepal (x8); 11: pod (x⅔). — 1, 5: *Wieringa & Haegens 2433*; 2, 3: *Wieringa & Haegens 2263*; 4: *Wieringa & Haegens 2400*; 6–10: *Dhetchuvi 853 B*; 11: *Wieringa & Haegens 2263 & Evrard 3890.*

provided the type specimens, this species has always (as far as mentioned) been collected from fine sandy or loamy soils. In the three areas in Gabon where I have collected the tree myself, this fine sand was often remarkably white and apparently nutrient-poor. The forest in such sites was lower than surrounding forest on other soils.

Phenology: In the Edea area of Cameroon flower buds were recorded in December. In southern Cameroon and Gabon flowering takes place in August and September. Rather fresh fallen pods have been recorded in February and March.

In Congo (Kinshasa) flowering probably differs between the various regions. In the area in which the Botsima and Boende record are situated, flowering starts by the end of February, full flowering was recorded early March. Young pods have been collected in April. In Kwango flowering was recorded in July.

Chemistry: Flowers and leaves produce no distinct colour in spirit.

Diseases and pests: No galls were observed, young leaves often bear traces of insect attacks.

Uses: No uses recorded.

Notes: Harms mentioned in his description of this species only one collection, *Ledermann 444*, which therefore automatically became the type. Since the holotype was destroyed at B and duplicate material could not be traced elsewhere, it becomes preferable to designate a neotype. Please note that the sketch in BM does not belong to the original material, since it was made only in 1926. The collection *Wieringa & Haegens 2263* has been made on precisely the same spot as the holotype and has most likely been collected from the same tree as the Ledermann collection (see locality data in 'type' description). Harms copies Ledermann's notes which read: "großer, überhängender Baum zwischen *Raphia*, mit weißen Blüten, junge Triebe rosa gefärbt" [large overhanging tree in between *Raphia*, with white flowers, young leaves pink]. The tree of the Wieringa & Haegens collection was growing on a rock in the rapids of the Ntem river and was surrounded by some *Raphia*'s. The young leaves were pink indeed, the only thing that did not seem to fit was the size of the tree, only 10 m, which is not supposed to be large in Cameroon. After examining the tree, Haegens and myself concluded, however, that the old tree had fallen over completely during the 20th century, with the old trunk still partly present in a horizontal position and that the 'new', now 10 m high tree represented the largest of the side-shoots from this trunk.

Since *Aphanocalyx ledermannii* seems to be a rather variable species (i.e. the pubescence of the bracts), preference is given to a specimen which certainly belongs to the same taxon as the holotype, over flowering material from other sites. The neotype does not bear any flowers, but was collected with old pods, which probably are characteristic to about the same extent as flowers are.

The inland populations, or maybe only those from Congo (Kinshasa), may constitute a distinct subspecies or even a distinct species. However, until good flowering material from the coastal Cameroonian and Gabonese populations as well as the inland Gabonese ones is collected, decisions with regard to this matter will have to be postponed. The description of the flowers is (almost) completely based on material from Congo (Kinshasa).

Very rarely the two leaflets of the apical pair are fused, creating a seemingly imparipinnate leaf.

The young leaves in flushes of this species remain bright red to pink for a considerable time. During this period the trees are very conspicuous and easy to locate in the forest.

Specimens examined:

CAMEROON: *Ledermann 444* (BM (sketch only)) type: Campo, Dipika, rocks in the Campo river rapids, 2°14'N 9°53'E (st, 08.1908); *Thomas 508* (K): Douala-Edea reserve, Lombe, 3°39'N 9°59'E (fl, 12.1978); *Wieringa & Haegens 2263* (G, IAGB, IEC, LY, UGDA, W, WAG (+alc)) neotype: Campo, rapids in Ntem river near Dipika, 2°14'N 9°53'E (fr, 18.02.1994).

GABON: *Breteler, Issembe, Moussavou & Pascal 15207* (WAG): c. 10 km NW Makandé, 0°37'S 11°51'E (st, 25.02.1999); *Gauchotte 1160* (LBV, P): Oguémoué, 1°04'S 10°03'E (st, 09.10.1953); *J. Reitsma OF 19-34* (WAG): Ofoubou, 1°40'S 10°06'E (st, 1991); *Wieringa & Nzabi 2806* (WAG): Rabi-area, NE of Divangui, 1°55'S 10°03'E (fl, fr, 29.09.1994); *Wieringa & Nzabi 2846* (WAG): Rabi-area, NE of Divangui, 1°55'S 10°03'E (fr, 02.10.1994); *Wieringa & v.d. Poll 1542* (LBV, WAG): 46 km on the road from Franceville to Lékoni, Boubou I, 1°37'S 13°55'E (fr, 31.08.1992); *Wieringa & v.d. Poll 1543* (LBV, WAG): 46 km on the road from Franceville to Lékoni, Boubou I, 1°37'S 13°55'E (st, 31.08.1992); *Wieringa 1309* (IEC, LBV, WAG): c. 20 km NE of Yeno, Ofoubou-area, 1°38'S 10°05'E (fr, 22.07.1992); *Wieringa 1310* (LBV, WAG): c. 20 km NE of Yeno, Ofoubou area, 1°38'S 10°05'E (st, 22.07.1992); *Wieringa & Haegens 2400* (WAG): c. 20 km NE Yeno/Coucal, Oufoubou area, 1°40'S 10°04'E (st, 05.03.1994); *Wieringa & Haegens 2433* (WAG): NE Divangui, 18 km E Rabi, 1°55'S 10°03'E (st, 10.03.1994).

CONGO (KINSHASA): *Devred 2314* (BR, K): Lutshima-Kahemba-Kwango, 5°30'S 19°00'E (fl, 22.07.1955); *Dhetchuvi 747* (BR, WAG): Botsima, 1°09'S 21°57'E (fl, 25.02.1991); *Dhetchuvi 853 B* (BR): Botsima, research station, 1°09'S 21°57'E (fl, 04.03.1991); *Evrard 3890* (BR, FHI): along Tshuapa river upstream from Boende, 0°13'S 21°00'E (fr, 02.04.1958); *Renier 15* (BRLU): Kwango, Mukue, 7°10'S 17°58'E (st, ?).

Aphanocalyx margininervatus J. Léonard

Fig. 10.4, Map 10.5

Aphanocalyx margininervatus J. Léonard: Léonard, 1951a: 127–129, fig. 32B p.p.; Léonard, 1952: 440 p.p.; Léonard, 1957: 263; Fasbender, 1959; Aubréville, 1968: 276–277, pl. 68 p.p.; Aubréville, 1970: 255–256 (p.p.?); Vivien & Faure, 1985: 156 (p.p.?); Léonard & Doucet, 1997: 214–216. **Type**: *Zenker 3751* (holo: BR, iso: BM, COI (n.v.), F, G, K, L, M, MO, P, PRE, S, US, W, WRSL, WU, Z) — 'Kamerun. Bipinde, Urwaldgebiet. 1908'

Aphanocalyx cynometroides auct. non Oliv.: Baker, 1930: 733 p.p.; Pellegrin, 1949: 73 p.p.

Small to large tree, 8–40 m high; branches comparatively high up the bole, crown compact. **Bole** cylindrical, contorted or channelled, DBH up to 70 cm: base sometimes slightly inflated or with relative thick, up to 0.5 m wide and up to 1.5(–3) m high buttresses. **Bark** fairly thin, up to 10 mm thick: surface rugose, brown-red to green-grey, sometimes with lines of c. 1 cm large, red spots; outer bark 0.2–0.6 mm thick, white to pale brown; inner bark fibrous, with a little exudate, pinkish to red, rapidly changing to yellow-orange upon exposure, in dry condition brown. Sapwood cream-coloured when fresh, in dry condition pale pinkish. Heartwood pink.

Twigs smooth, not or only faintly lenticellate, reddish brown to dark grey, at first densely appressed brown tomentose (in saplings also appressed villous) but soon glabrescent, old twigs becoming pale grey. **Stipules** fused, early caducous, triangular to ovate, 3–8 x ½–1½ mm, with closely spaced parallel veins, both sides glabrous, margins shortly ciliate mixed with some glandular hairs. **Leaves** 5–25 cm long, 1–2-jugate, the first leaflet wanting or vestigial: **Petiole** (see notes) 2–8 mm long, in young leaves brown tomentose but soon glabrescent, completely consisting of the wrinkled joint. **Rachis** 1½–6 mm long, in young leaves brown tomentose but soon glabrescent, more or less terete. **Leaflets** thick leathery, upper surface dull to somewhat glossy, dark green, lower surface dull, medium to somewhat greyish green, both sides of premature leaves mixed sparsely long velvety with densely rusty tomentum, soon glabrescent; margin glabrous or (in young trees) the distal margin of young leaves shortly to long ciliate but glabrescent; distal half completely reduced; apex acute to acuminate, the very tip with a gland and often incurved around it. **Basal leaflet** semicircular, half-elliptic or half-obovate, up to 24 x 8 mm: base of proximal half cuneate, not auriculate. **Apical leaflet** half-elliptic to half-obovate, 45–240 x 18–80 mm: base of proximal half rounded to cordate, not auriculate. **Gland pattern** (apical gland of leaflet, mentioned above, not included): basal leaflet (when present) with 1(–3) glands. Apical leaflet with 0–8 glands, arranged in a line running at some distance from the proximal margin, starting well away from the leaflet base.

Inflorescence in the terminal 1–9 axils of the most recent shoots, rarely some in those of the previous growth phase, 1–10 per axil, a simple raceme, 1½–5 cm long and (7–)10–50-flowered, most flowers (if not all) opening simultaneously. **Rachis** 10–40 mm long, brown tomentose-velvety. **Bracts** caducous, ovate or obovate to spatulate, 3½–4½ x 3–5 mm, densely parallel-veined, outside at base and along the central axis mixed appressed velvety and puberulous, inside glabrous, margins shortly ciliate. **Pedicel** 2½–5 mm long, pale brown velvety-tomentose. Hypanthium s.l. 0.3–0.7 mm high. **Bracteoles** assuming a 70–90° wide angle at anthesis, 3½–6 x 2–4 mm, greenish, outside mixed tomentose and puberulous, along the midrib also short to long velvety, inside glabrous, margin chaffy. **Adaxial sepals** usually wanting, when present free, triangular, up to 0.3 x 0.2 mm, both sides glabrous, margin shortly ciliate. **Lateral sepals** wanting. **Adaxial sepals** usually wanting, only represented by a few velvety hairs or rarely reduced to a minute scale, up to 0.05 x 0.1 mm. **Petals** white, outside glabrous or sparsely velvety, inside glabrous. **Adaxial petal** spatulate, 4–9 x 2–5½ mm, margins glabrous, apex usually emarginate to incised, often sparsely shortly ciliate, claw indistinct, 1–3 mm long. **Lateral petals** sometimes wanting, linear and folded together, 1.4–3.2 x 0.2–0.7 mm, margins shortly to long ciliate, apex truncate. **Abaxial petals** usually wanting, when present linear and folded together, up to 3.5 x 0.5 mm, margins especially at the apex shortly ciliate, apex truncate. **Stamens** 10(–12): filaments (5–)8–14 mm long, 9 united over a length of 0.6–1.3 mm, white, entirely glabrous; anthers 1.0–1.5 mm long. Pollen described by Fasbender (1959). **Ovary** 1.9–3.6 x 0.9–2.0 x 0.4–1.0 mm, sometimes depauperate and only 0.8–0.9 x 0.3–0.4 x 0.2–0.3 mm, long to very long pale brown velvety, with 2(–3) ovules; stipe 1.0–2.1 mm long (0.2–0.7 mm long in depauperate ovaries), (long) velvety except for the base. **Style** 6–10 mm long in bisexual flowers, 0.2–0.4 mm in male flowers, inserted at an angle of 30–90°, the basal ¼–½ short to long velvety; stigma heart-shaped. After flowering stamens and adaxial petal longer persistent than bracteoles.

Pods 1–2-seeded, oblong-obovate, (3–)5–7½ x (1.8–)2.4–3.8 x 0.2–0.4 cm, surface granulate, fairly dull to glossy, dark brown, glabrous; beak 0–4 mm long; upper suture indistinctly winged, 2–6 mm wide; nerve usually distinct, often even distinctly prominent and up to 1.4 mm elevated from the surface, at base running very close to the upper suture or merged with it, towards the middle usually running in the upper quarter, towards the

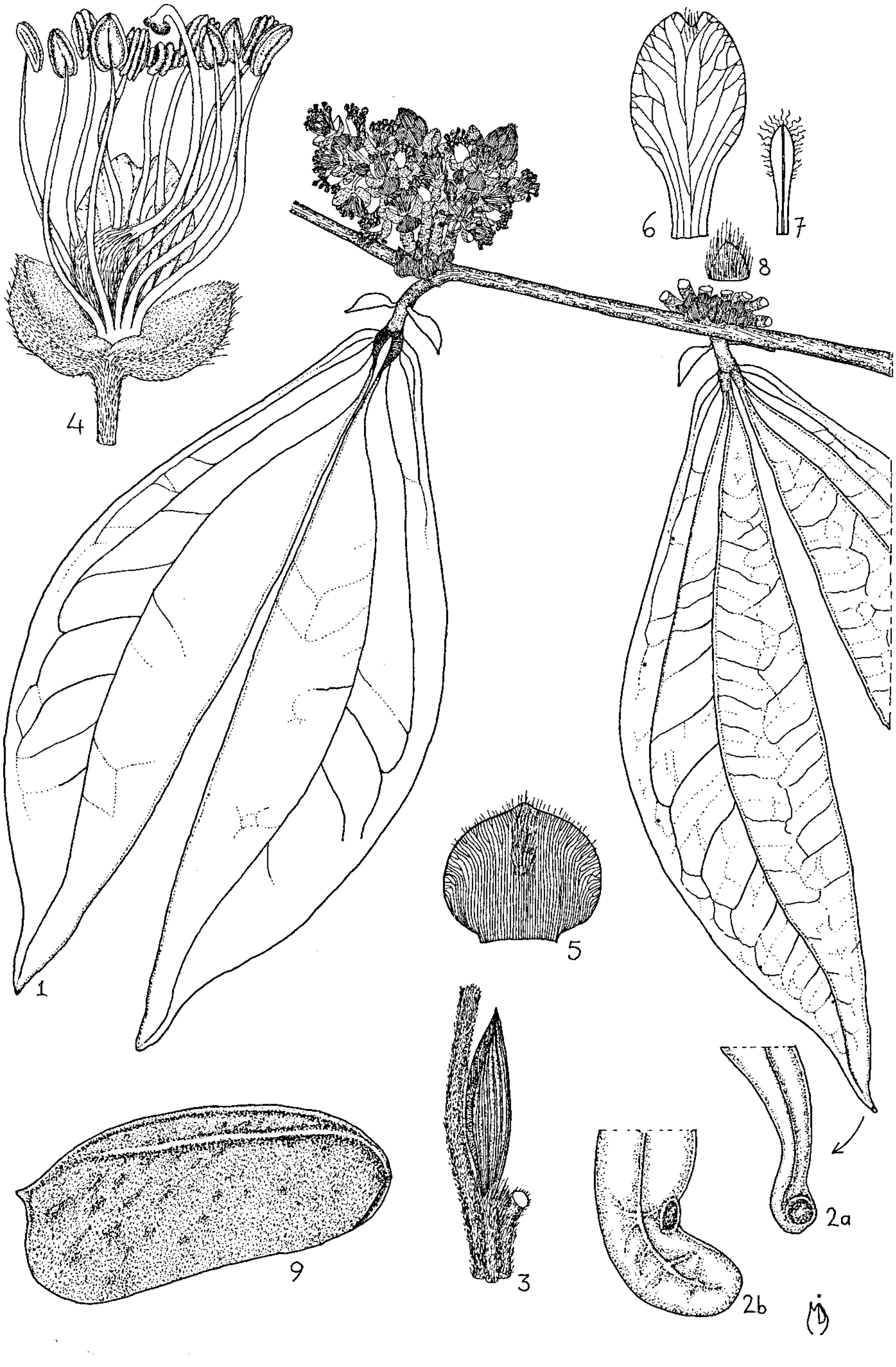
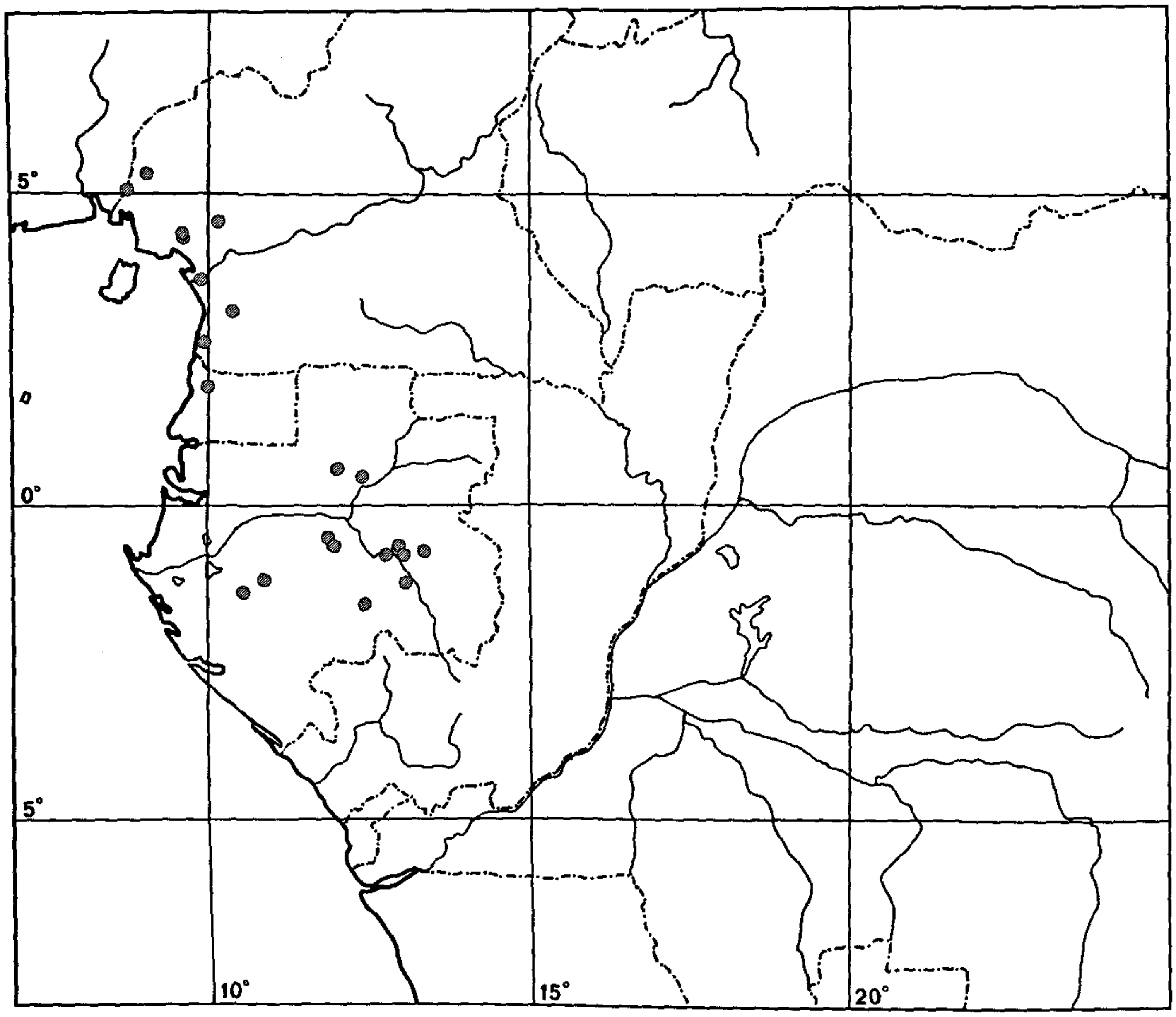


Figure 10.4. *Aphanocalyx margininervatus* (J. Léonard) Wieringa. — 1: twig with leaves and inflorescences (x⅔); 2a & b: detail of leaflet apex showing a gland (x12); 3: stipule (x4); 4: flower from abaxial side (x4); 5: bract from outside (x4); 6: adaxial petal (x4); 7: lateral petal (x4); 8: adaxial sepal (x4); 9: pod (x⅔). — 1: *Le Testu 7483* & *McKey & Gartlan 253*; 2a: *Letouzey 9239*; 2b: *McKey & Gartlan 253*; 3: *Breteler, Jongkind & Wieringa 9837*; 4, 6: *Le Testu 7483 & 8418*; 5: *Le Testu 7483*; 7, 8: *Le Testu 8418*; 9: *Thomas, Mambo & Namata 7633*.



Map 10.5. Distribution of *Aphanocalyx margininervatus* J. Léonard.

apex becoming less distinct, running at various positions, u/w = 0.04–0.25; stipe c. 5 mm long, pedicel in fruit unknown. **Seeds** obovate, 14–21 x 9–12 x c. 4 mm, weight unknown; testa fairly thin, brown.

Seedling: Germination epigeal. **Hypocotyl** 6–13 cm long, fairly densely to densely, long to very long velvety. **Epicotyl** 1–2 cm long, long to very long velvety. First pair of leaves opposite, 1(–2)-jugate with the first pair varying between vestigial to completely reduced. Subsequent leaves alternate, 1-jugate.

Distribution: Map 10.5. Coastal Cameroon, Equatorial Guinea and central Gabon. Apparently the species is absent from the Crystal Mountains, resulting in a gap between the coastal distribution in the north and the more inland populations in the south of its range. According to Sita & Moutsambote (1988) this species also occurs in Congo (Brazzaville), but that record is most probably based on a misidentified sample of *A. cynometroides* (*Sita 3516*).

Vernacular names: Equatorial Guinea: Efas Mekeañ. Gabon: Eko-Abia, Eko-Abinga (Fang).

Ecology: In primary dry-land rain forest, rarely also in riverine forest on riverbanks, from sea-level to 650 m altitude, on clay soils.

Phenology: In Gabon flowering takes place in September and October. Since fairly fresh pods and young seedlings were found in April, seed fall is probably in March, indicating a maturation time of 5–6 months. In Cameroon flowering might take place in February or March.

Chemistry: Flowers produce no distinct colour in spirit.

Diseases and pests: The glandular leaflet tips are often eaten away, apparently some animal likes these glands not only for its excretion.

Uses: None reported.

Notes: When the first pair of leaflets is wanting, it is still comparatively easy to denote their original position. The length of the petiole and leaf rachis has been measured from this position onward.

The fused apical leaflets pictured in fig. 1 by Léonard & Doucet (1997) is most probably an anomaly. Apparently is was only present in one of the four samples of Doucet, and it was not present in any of the seedlings I studied. Although Léonard and Doucet describe the first two leaves as unijugate, there figure clearly demonstrates that a smaller leaflet pair near the base may be present. In a note they do mention the additional leaflet pair, but apparently they refuse to count it as such. In the same note they state the adult leaves are always really unijugate, which is also incorrect.

Specimens examined:

CAMEROON: *Alleizette 1972* (L): Lolodorf region, false record! not located (fl); *Leeuwenberg 9157* (BR, WAG, YA): 2 km N of km 17 on road Yingui to Yabassi, 4°30'N 10°11'E (st, 11.01.1972); *Letouzey 1440* (P, YA): 33 km on road Bonaberi to Nkongsamba, Maleke, chant. Gibely, 4°15'N 9°38'E (st, 24.07.1950); *Letouzey 1848* (YA): Maleke, near Mbanga, 4°19'N 9°37'E (st, ?); *Letouzey 9239* (BR, P, WAG, YA): Mamelles hills, 30 km NNE Campo, 40 km SSE Kribi, 2°35'N 9°57'E (fr, 28.03.1968); *Mckey & Gartlan 253* (E, K): near Lake Tissongo, strip C, Douala-Edea reserve, 3°35'N 9°54'E (st, 18.08.1976); *Thomas 1199* (K): Korup reserve, transect P, 5°02'N 8°47'E (st, 12.1979); *Thomas, Mambo & Namata 7633* (MO, WAG, YA): Korup nat. parc, 6 km W of Ikenge, 5°17'N 9°05'E (fr, 03.04.1988); *Zenker 3751* (BM, BR, F, G, K, L, M, MO, P, PRE, S, US, W, WRSL, WU, Z) type: Bipinde, Mimfia mountain, 3°04'N 10°23'E (fl, 03.1908).

EQUATORIAL GUINEA: *Issembe 21* (WAG): c. 32 km on road Bata-Niefang, just W of Mikan (Machinda), 1°52'N 10°00'E (st, 19.05.1998).

GABON: *Alleizette 1972 a* (L): Lastoursville region, false record! not located (fl); *Breteler & Breteler-Klein Breteler 12346* (WAG): c. 30 km E of Lastoursville, 0°50'S 13°00'E (st, 25.11.1993); *Breteler, Issembe, Moussavou & Pascal 15161* (WAG (+alc)): Makandé, *0°41'S 11°55'E* (st, 22.02.1999); *Breteler, Jongkind & Wieringa 9837* (WAG): c. 20 km ENE of Lastoursville, CEB-exploitation, 0°45'S 12°55'E (fr, 11.04.1990); *Breteler, Leal, Moussavou & Nang 13965 a* (WAG): W of Yombi, Koumounabouali massif, 1°25'S 10°30'E (st, 18.09.1997); *Breteler, Wieringa & Nzabi 13311* (WAG): road Lastoursville to Okondja, 19 km E Ndambi, 0°46'S 13°19'E (st, 15.10.1994); *Dibata 548* (WAG): ?, not located (fl, ?); *Doucet 24* (GEMBL, WAG): Forêt des Abeilles, camp de la Makandé, 0°40'S 11°54'E (st, 15.12.1993); *Le Testu 7483* (A, BM, BR, FHO, K, MO, P, S, WAG): Maçoukou, 0°50'S 12°43'E (fl, 03.10.1929); *Le Testu 8418* (B, BM, BR, L, WAG): Lastoursville, Lébèla, 1°37'S 12°23'E (fl, 08.10.1930); *Leal 75* (WAG): E side of Lopé reserve, along the Offoué river, 0°33'S 11°49'E (st, 10.09.1998); *Leeuwenberg, Persoon & Nzabi 13604* (BR, WAG): SE of Sindara, right bank of Ngounié R., 17 km W Camp Waka, 1°13'S 10°49'E (fl, fr, 22.09.1985); *Wieringa & v.d. Poll 1471* (LBV, WAG): 28 km NE of Lastoursville, 0°41'S 12°56'E (st, 24.08.1992); *Wieringa & v.d. Poll 1501* (WAG): 75 km on the road Lastoursville to Moanda, 3 km for Pouby, 1°16'S 13°02'E (st, 27.08.1992); *Wilks 1460* (WAG): 40 km NNE of Koumameyong, 0°33'N 11°59'E (st, 24.03.1987); *Wilks 1927* (WAG): 7 km E of Agnang, 0°25'N 12°22'E (st, 05.1989).

Aphanocalyx microphyllus (Harms) Wieringa comb. nov.
Figure 10.5 & 10.6: A–F, Plate 1a & b, Map 10.6

Basionym: *Monopetalanthus microphyllus* Harms, Bot. Jahrb. Syst. 49: 424 (1913).

Key to the subspecies:

1 a Leaves 3½–14(–21) cm long, with (9–)16–44 pairs of leaflets. Largest leaflet (3.8–)4.2–7.8 times as long as wide. Very long hairs of young branches and leaf rachis conspicuous. Stipules 20–50 mm long. Compound racemes 4½–8 cm long; simple racemes 1–4(–7½) cm long, 13–45(–110)-flowered. Bract margins without glandular teeth. Hypanthium (0.3–)0.5–1.2 mm, anthers 1.1–1.8 mm long. Pod with the nerve often close to the upper suture: u/w = 0.09–0.29. Central Africa (Cameroon to Congo (Kinshasa)) .... **subsp. *microphyllus***

b Leaves 2–9 cm long, with (8–)13–24(–26) pairs of leaflets. Largest leaflet 3.5–5.2 times as long as wide. Hairs of young branches and leaf rachis often not very conspicuous. Stipules 6–25 mm long. Compound racemes 1½–4½ cm long; simple racemes 1–3½ cm long, 5–25-flowered. Bract margins often with glandular teeth. Hypanthium 0.2–0.6 mm, anthers 1.0–1.4 mm long. Pod with the nerve generally running lower: u/w = 0.22–0.36. Western Africa (Sierra Leone, Liberia, Ivory Coast) .... **subsp. *compactus***

subsp. *microphyllus* **Fig. 10.5, Plate 1a & b, Map 10.6**

Monopetalanthus microphyllus Harms: Harms, 1913: 424; Baker, 1930: 734–735; Staner, 1938: 37; Pellegrin, 1942: 120 p.p.; Pellegrin, 1949: 75; Léonard, 1952: 444–445 & fig. 37; Lebacq, 1957: pl. 99; Saint Aubin, 1963: 51 & 96; Aubréville, 1968: 310–312 & pl. 79; Aubréville, 1970: 284–286, 338 & pl. 68; Thirakul, 1983: 243 p.p. (not the photo's). **Type:** *Mildbraed 6141* (holo: B†; lecto (designated here): HBG; iso: P, WAG (alc. coll. only); drawing: BM) — 'Südkameruner Waldgebiet: Bez. Kribi, Vorland bis ca. 100 m ü. M., etwa 25 km östl. Gr. Batanga, Eduduma-Bidue'.

Monopetalanthus heitzii auct. non Harms: Wilks, 1987: photo Andoung.
Monopetalanthus pectinatus auct. non A. Chev.: Pellegrin, 1949: 75 p.p.
Monopetalanthus sp.: Letouzey & Mouranche, 1952: 62 & Pl. 17 (also as "Ekop «d»").
Monopetalanthus sp. C.: Keay, 1958: 478 p.p.

Small to large tree, 7–45 m high; crown hemispherical or irregular. **Bole** often contorted but sometimes cylindrical, branchless for up to 15 m, DBH 10–100(–160) cm: base of large trees often with rather thin, sometimes branching buttresses or plank roots (or even stilt-roots?), these up to 2(–6) m high and 3(–8) m wide. **Bark** thin, up to 8 mm thick: surface smooth, crowded with tiny lenticels to fine rugose to scaly, in large trees even with large flakes, pale grey to grey-brown or also somewhat pinkish or yellowish tinged, sometimes white or greenish marbled or spotted; outer bark 0.2–0.5 mm thick, pale grey to greenish grey; inner bark fibrous, in fresh condition pale purple-red to pinkish orange or yellow-pinkish, getting creamy inwards, in dry condition pale orange-brown to brown. Sapwood whitish to creamy, in dry condition creamy to pale brown or pale violet-brown. Heartwood pale red-brown. Wood with indistinct growth-rings.

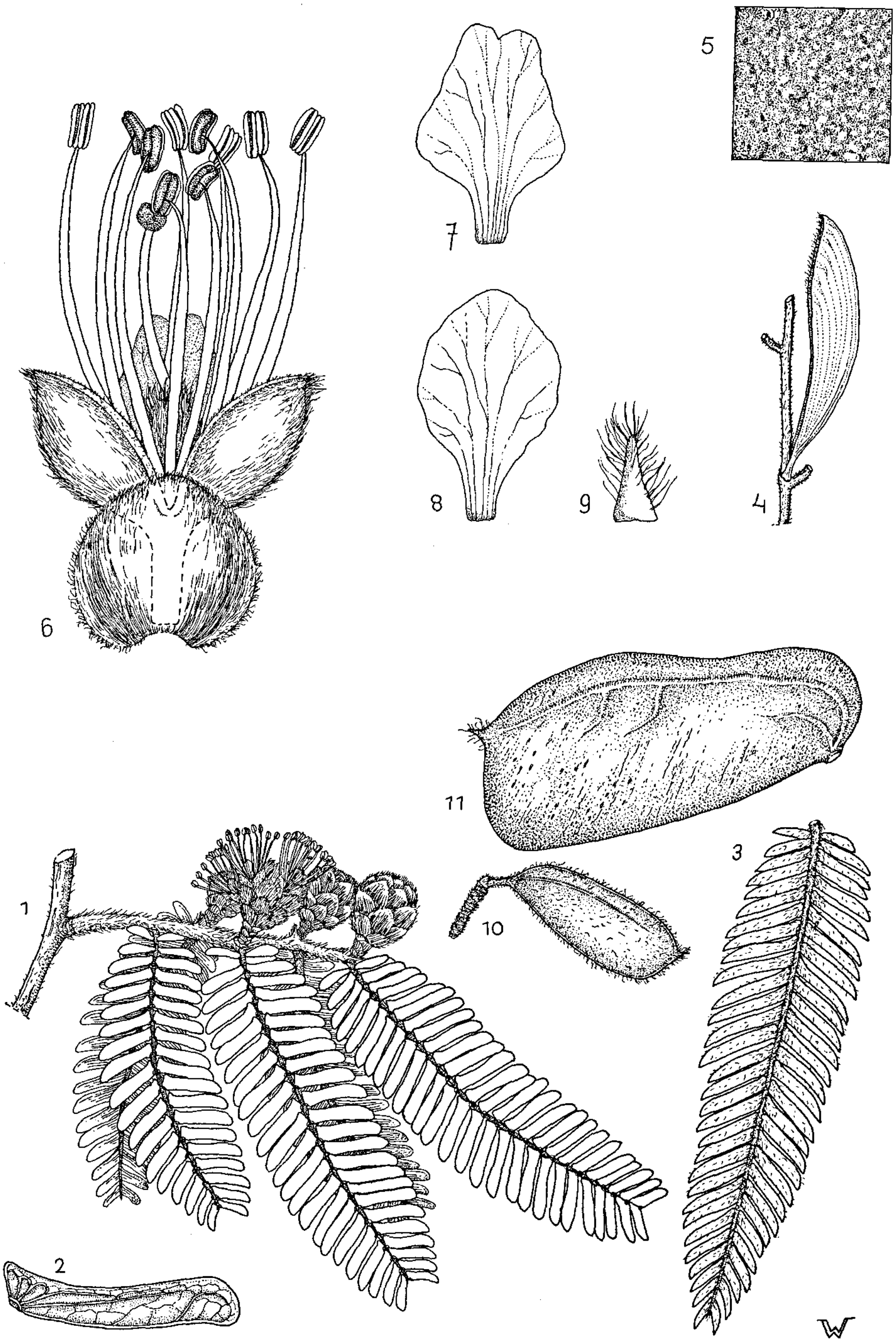


Figure 10.5. *Aphanocalyx microphyllus* (Harms) Wieringa subsp. *microphyllus*. — 1: twig with leaves and inflorescences (x⅔); 2: leaflet from below (x2); 3: leaf with acute leaflets from below (x⅔); 4: twig with two fused stipules (x1); 5: bark surface (x⅔); 6: flower and its supporting bract from abaxial side (x4); 7 & 8: two forms of the adaxial petal (x4); 9: adaxial sepal (x14); 10: young pod (x⅔); 11: pod (x⅔). — 1, 2: *Wieringa & v.d. Poll 1345 & Wieringa & Epoma 1628*; 3: *Evrard 4042*; 4: *Breteler, Jongkind & Wieringa 11243 A*; 5: *Wilks in MINKébé series W 80*; 6, 7: *Wieringa & v.d. Poll 1345*; 8, 9: *Pierlot 244*; 10: *Wieringa & Epoma 1628*; 11: *Wilks 1332*.

Twigs smooth or with tiny lenticels, grey to grey-brown, very long brown villous, glabrescent or sparsely puberulous on old twigs. **Stipules** fused, early caducous, obovate to spatulate, the most apical ones of a shoot usually linear, base usually straight, rarely with a tendency to develop an auricle, 20–50 x 2–13 mm, in bud (dark) red to purple-red, later pink, pale purple or pale brown, with many, closely spaced, parallel veins, outside very shortly puberulous to the apex and mixed villous with pubescent at base and often over a central line which sometimes expands towards the apex over the total width, inside glabrous, margins shortly to long ciliate, often also with a few glandular hairs, apex bearded. **Leaves** 3½–14(–21) cm long, (9–)16–44-jugate, largest leaflet situated at about ⅓: **Petiole** 1–2½(–3½) mm long, long villous but glabrescent, completely or at least for the major part consisting of the wrinkled joint. **Rachis** 2½–13(–18) cm long, (sparsely) pubescent or tomentose or velvety, on the lower side mixed with very long hairs, upper side with a tuft of long hairs in between the paired leaflet-insertions, in fresh condition terete, in dry condition semi-circular in cross-section, upper side flattened with a medial ridge. **Leaflets** (thick) leathery, upper side glossy, dark green, glabrous or sparsely stiff pubescent, lower side somewhat glossy, medium green to greyish green, glabrous or sparsely brown (stiff) villous; margins glabrous to shortly or long brown ciliate, often glabrescent; distal half usually completely reduced, sometimes very narrowly indicated, especially towards the apex; apex rounded to acute or even acuminate. Young leaflets whitish, greenish pink, dark red or pale green. **Basal leaflet** semi-circular to oblong to half-obovate or narrowly so, 3½–12(–20) x 1–4(–6½) mm: base of proximal half rounded, without an auricle. **Apical leaflet** rectangular to half-obovate or triangular or narrowly so, 3–13(–20) x 1–3(–4½) mm: base of proximal half sharply angled, sometimes with an auricle, auricle up to 0.2(–0.6) mm long. **Largest leaflet** more or less rectangular with the widest point above the middle to narrowly triangular, 6–20(–33) x 2–4(–7) mm: base of proximal half sharply angled, usually with an auricle, auricle up to 0.9 mm long. **Gland pattern**: basal leaflet with 0–2(–11) glands. Second leaflet with 0–3(–8) glands. Apical leaflet without glands. Other leaflets with 0–2(–3) glands, the highest number in the more proximal leaflets, decreasing towards the apex.

Inflorescence a simple or compound raceme, in the axils of the youngest shoots (= up to 21 nodes), sometimes even a few on older shoots, 1(–2) per axil: simple racemes (see notes) 1–4(–7½) cm long and 13–45(–110)-flowered; compound racemes 4½–8 cm long, with 3–12 lateral branches which are 1–4 cm long and 20–50-flowered. **Rachis** short to very long brown velvety. **Bracts** (early) caducous, ovate to obovate, 4–8 x 3–8 mm, distinctly densely parallel-veined, brown, outside mixed puberulous with short to very long brown velvety hairs, puberulous or glabrous towards the lateral margins, inside glabrous, margins shortly (to long) ciliate, without glandular teeth, apex shortly bearded. **Pedicel** 3–8½ mm long, long brown velvety. Hypanthium s.l. (0.3–)0.5–1.2 mm. **Bracteoles** assuming a 70–110(–180)° wide angle at anthesis, 5–8 x 3–5 mm, outside creamy white, mixed puberulous and pubescent with sparsely to somewhat densely long brown velvety, along the indistinct midrib denser and longer (sometimes very long) velvety, inside white, glabrous, sometimes at base or along the margins white puberulous to pubescent, margins chaffy. **Sepals** usually absent, when present glabrous on both sides, margins short to long ciliate. **Adaxial sepals** often absent, sometimes one or both present, in case both are well developed then usually partly to completely fused, fused ones ovate to obovate or semi-circular, 1.2–2.8 x 1.8–3.0 mm, outside sometimes with a few hairs indicating the fused margins, apex rounded to emarginate, free ones ovate, 0.1–2.2 x 0.3–1.0 mm. **Lateral**

sepals usually wanting, very rarely vestigial, 0.1 x 0.2 mm. **Abaxial sepal** usually wanting, rarely vestigial, 0.1–0.5 x 0.1–0.5 mm. **Adaxial petal** obovate, spatulate or trullate to obtrullate, 4½–10 x 2½–6½ mm, white, glabrous, claw indistinct, ½–3 mm long, apical margin sometimes ciliate. **Lateral petals** usually wanting, sometimes vestigial, linear to lanceolate or triangular, up to 2.3 x 0.5 mm, glabrous. **Adaxial petals** usually wanting, very rarely vestigial, linear to lanceolate, up to 3.0 x 0.5 mm, glabrous. **Stamens** 10: filaments 7–13 mm long, 9 united over a length of 0.5–1.4 mm, white, only in the part fused with the hypanthium brownish (or purple?), entirely glabrous; anthers 1.1–1.8 mm long, purple with creamy ridges. **Ovary** 1.9–4.7 x 0.9–2.3 x 0.4–1.6 mm, often depauperate and only 0.6–1.4 x 0.3–0.5 x 0.15–0.3 mm, very pale pink, pale brown villous, with 2(–4) ovules; stipe adaxially fused with the hypanthium and the very base of the adaxial filament, 1.0–2.3 mm long (0.4–0.9 mm long in depauperate ovaries), very base usually glabrous, remainder villous. **Style** 5–11½ mm long in bisexual flowers, ½–2 mm long in male flowers, inserted at an angle of 0–50°, white, base villous, remainder glabrous; stigma heart-shaped to circular, sticky.

Pods (0–)1–2(–3)-seeded, oblong-obovate, 3½–7 x 1.9–3.3 x 0.2–0.5 cm, immature ones dull, wine-red, later yellow, sparsely (very long) villous, mature surface granulate, rather dull, brown, very sparsely villous; beak ½–3 mm long; upper suture not to indistinctly winged, 2–4 mm wide; nerve usually distinct, running close to the upper suture, u/w = 0.09–0.29; stipe 1–4½ mm long, pedicel 2½–10 mm long. **Seeds** obovate, 13–21 x 10–14 x 2–3½ mm, 0.25–0.39 g in dry condition, margin slightly accrescent; testa papery, glossy, dark brown.

Seedling: Germination epigeal. **Hypocotyl** 6½–16 cm long, green, long brown velvety. Cotyledons clasping the base of the first leaf pair, green. **Epicotyl** 0.1–0.4(–3) cm long (see notes), very densely long brown velvety. First pair of leaves opposite, (11–)16–24-jugate. Subsequent leaves alternate, at first with a decreasing number of leaflets. First subsequent leaf 11–18-jugate. Leaflets papery, darker than in mature trees. Stipules smaller than in mature trees, 8–13 x 1–2½ mm, linear to narrowly triangular.

Distribution: Map 10.6. From just east of the Nigerian-Cameroonian border across Cameroon, Equatorial Guinea (Rio Muni), Gabon and Congo (Brazzaville) southwards to northern Angola and eastward to the most eastern parts of Congo (Kinshasa). The only record from Nigeria (seedlings, *FHI 1362*) is doubtful since the locality is not mentioned (the record could originate from the British Cameroons), but occurrence within the country is very likely. Regarding the comparatively low collection density in Cabinda and the occurrence of this taxon nearby, the taxon is to be expected in this area. One should also not exclude the possible occurrence of this taxon in Burundi, Rwanda or Uganda, since it has been found in Congo (Kinshasa) not far from the border, but if it does occur in one of these countries it will be rare and local, otherwise it would have been collected already.

Vernacular names: Cameroon: Abaij (Kribi region). Gabon: Eko-Abinga (Fang, Makokou), Kogo (Mitsogho), Ndoungou (Bakota), Ngabi (Masango), Ngabo (Mitsogho), Ngang (Fang). Congo (Kinshasa): Bonkese (Lokundu), Efembe (Kibila), Lotiko (Moma region), Lusassa (Lopori, Kirega), Lusere, Lusheshe, Luseke or Lusele (Kitembo, Kirega, see notes), Mualankisi (Ngoli region), Mukobi (Tshiluba), Mwemfo (Popokabaka region), Ose or Osse (Kinyanga), Osengele (Turumbu), Ufimbu (Kisangani region), Wendzélei (Bofungi region).

Ecology: In Cameroon to Congo (Brazzaville) and eastern Congo (Kinshasa) in primary and older secondary, dry-land rain or semi-deciduous forest, sometimes reaching the forest-edge, in central Congo (Kinshasa) usually in swampy to riverine rain forest (see notes). In savanna areas (both Congo's, Angola) also in gallery forest. The taxon is usually reported from sandy soils.

In Cameroon, Gabon and Congo (Brazzaville) it is found in lowland and sub-montane forest, in Congo (Kinshasa) also in transitional forest, ranging from 0–1400 m altitude (acc. to Pierlot (1966: 144) up to 1500 m in (sub-)montane forest).

Pollination takes place by a wide variety of animals. On a tree in Gabon (*Wieringa & v.d. Poll 1345*) sunbirds (*Nectarinia* spec.), several bees among which the honeybee, several species of butterflies (i.e. Pieridae and Nymphalidae) and *Barombiella marginata*, a pollen eating leaf beetle (Chrysomelidae), were observed.

Seedlings were found up to 51 m from the parent tree.

Phenology: In Cameroon flowering has only been recorded in July, which is in the wet season. In Gabon flowering trees have been observed almost throughout the year, e.g in February, March, May, June, August, September and November. In Congo (Brazzaville) flowering was recorded at the end of July, in September and in October. July is in the dry season, while September and October are at the start of the wet season.

In central Congo (Kinshasa) (Mbandaka to Kisangani) flowering seems to be restricted to a distinct period from March to the beginning of June, also the collections with young fruits match this pattern. In eastern Congo (Kinshasa) flowering occurs in the same period, but continues up to August. In central Congo (Kinshasa) well-developed pods are present in June, seed-shed occurred in September, pointing to a maturation time of 3 to 6 months. Of one tree which flowered at the beginning of April (*Louis 3561*), old pods were collected in October (*Louis 6333*), indicating a maturation time of about 5 months. In the Ituri forest, the most north-eastern part of its distribution, the species flowers in May, while almost shedding pods were collected in October; seed shed occurred from early November until mid December (pers. comm. C.E.N. Ewango) pointing to a maturation time of 6 months.

For southern and western Congo (Kinshasa) nor for Angola flowering records are available. In southern Congo (Kinshasa) well developed fruits were collected in November.

Chemistry: Flowers and leaves usually produce no colour at all or very rarely give a weak yellow coloration in spirit.

Diseases and pests: Rarely galled pods are present of the same type that is common in *Tetraberlinia bifoliolata*. The leaves usually seem very healthy, the leaflets without traces of galls, only sometimes with a few leaf-miners, but this damage is not extensive. The leaf rachis, however, may be galled.

Uses: The wood has been used for house-construction, firewood and axe-handles (Terashima et al., 1991), also for carpentry, 'menuiserie' and railway sleepers (*v.d. Meieren 50*).

Notes: Collections from the surroundings of Yangambi (Congo (Kinshasa)) often show compound inflorescences. In the same collections or in other ones from that region simple inflorescences are usually much longer than in those from other regions. Such simple inflorescences seem to be compound inflorescences with undeveloped lateral branches.

Their peduncle has a large sterile basal part which often shows non-developed axillary buds. The measurements of these long simple racemes are given between brackets in the description of the simple racemes.

The seedling collection *Michelson 531* much resembles this species. Also the bark and pods going with it are not unusual for this species. However, the epicotyl is 2–3 cm long which is about 10 times as much as usual for this species. Also Léonard (1952: 445; 1957: 261) reports the epicotyl being this long. His measure is based on *H.P.Y. 3793* and *H.P.Y. 81*, both collections I could not trace (probably in the inaccessible Yangambi herbarium). According to Léonard (1957: 261) the first is grown from seeds of *Gilbert 8670*, the origin of the second is unknown. The origin of *Michelson 531* is also unknown, but could be the same as one of the H.P.Y. numbers (maybe Michelson did not mention a locality because he collected the seedlings in the Yangambi garden). Some surrounding collection numbers from Michelson, however, concern collections from the southern hemisphere (2–4° S, c. 27°E) which may indicated that his collection 531 does not originate from Yangambi. If the above three collections prove to be independent of each other, the length of the epicotyl might be an interesting feature to study in relation to the above mentioned, rather aberrant inflorescences present in some parts of Congo (Kinshasa). Maybe one should give some taxonomic status to these populations. To make such a relation now would be too speculative since the origin of only one of the seedlings is known.

The main problem with delimiting the aberrant trees in Congo (Kinshasa) lies in the fact that there exists a lot of variation within this species in Congo (Kinshasa). Most collections from Congo (Kinshasa) have acute leaflet apices, while those from countries bordering the Gulf of Guinea usually have rounded apices. However, this character is not 100% indicative for the region. Moreover, it might be influenced by the seemingly different ecology in Congo (Kinshasa) (swamp forest) compared to the more coastal populations (dry-land forest). The compound inflorescence trees from Yangambi and surroundings seem to grow mixed with trees with normal simple inflorescences, but all these inflorescences have large, rather short and not so densely velvety, not early caducous bracts characteristic for the region. However, I would not dare to base a taxon on these bracts only. Only when more is known about the distribution of the populations with long epicotyls and the value of this character, one might be able to delimit a species or subspecies.

The difference in ecology between central Congo (Kinshasa) on one side and Cameroon, Gabon, Congo (Brazzaville) and eastern Congo (Kinshasa) on the other, is strange at first sight. However, as discussed in the ecology chapter (3.8 biogeography) it is likely that the forest species in central Congo (Kinshasa) survived the last glacial in gallery and riverine forests. If they are correct, only *A. microphyllus* populations adapted to riverine or swampy sites will have survived in that region, and apparently they have kept to that custom since. The distinct flowering and fruiting period in this region and the elongated epicotyl may well be adaptions to life in riverine forest.

Damaged parts of the flower become purple.

The vernacular name Lusere (and probably the other orthographic variants as well) is also used for *Cynometra hankei* Harms (see *Pierlot 1084* BR).

Specimens examined:

NIGERIA?: *Forest Herbarium Ibadan 1362* (FHI): ?, not located (st, ?).

CAMEROON: *Brigade d'Inventaire, Edea 918* (CIRAF): Edea region, Mamba camp, 4°10'N 10°05'E (st, 31.08.1968); *v.d. Burgt 335* (WAG): c. 11 km ENE Mvie, 2°55'N 10°39'E (st, 20.01.1998); *Endengle 67* (P, YA): 26 km on road Yaounde to Mbal-Mayo, 3°39'N 11°31'E (fr, 01.05.1958); *Floret 552* (YA): Mamfe, forest reserve

Ejagham, 5°46'N 8°58'E (st, 11.1972); *Forest Herbarium Ibadan 12029 a* (FHI, FHO, K): Br. Cameroons, not located (st, ?); *Leeuwenberg & Berg 9763* (BR, WAG, YA): 11 km on road Loum to Solé, Dibombé river, 4°41'N 9°48'E (st, 27.04.1972); *Leeuwenberg 9928* (BR, P, PRE, WAG, YA): 3 km E of Eboné (=11 km road Nkongsamba-Loum), Bakaka forest, 4°50'N 9°54'E (st, 30.05.1972); *Letouzey 1434* (P, WAG, YA): 45 km on road Yaounde-Akono, 3°54'N 11°43'E (st, 20.10.1950); *Letouzey 9242* (P, YA): 20 km NNE of Campo, 2°32'N 9°51'E (st, 28.03.1968); *Letouzey 9980* (BR, HBG, P, WAG, YA): 20 km SSE of Ebolowa on road to Evindisse, near Nkolemvon, 2°44'N 11°13'E (st, 03.02.1970); *Letouzey 10250* (P, YA): 15 km S of Ebolowa, SE of Ndengue, 2°45'N 11°09'E (st, 26.03.1970); *Letouzey 10332* (P, YA): 60 km E of Campo, W of Ebianemeyong, Nkolemenlong, 2°25'N 10°20'E (st, 10.04.1970); *Letouzey 10334* (P, YA): 60 km E of Campo, W of Ebianemeyong, Nkolemenlong, 2°25'N 10°20'E (st, 10.04.1970); *Letouzey 11416* (P, YA): 10 km N of Ngoulemakong, near Bènébalot, 3°11'N 11°25'E (st, 30.06.1972); *Letouzey 12533* (P, WAG, YA): 55 km WSW of Eseka, Lisouk, 3°26'N 10°20'E (fr, 31.12.1973); *Letouzey 12755* (K, P, WAG, YA): 20 km SE Lolodorf, SW of Mébandé, 3°06'N 10°50'E (st, 23.01.1974); *Letouzey 13273* (P, WAG, YA): 10 km SW of Bafang, near Mounko, 5°05'N 10°07'E (st, 21.11.1974); *Letouzey 13700* (P, YA): betw. Tabo & Akoumayip river on Ossidinge-Agborkem road, 5°46'N 9°06'E (st, 02.06.1975); *Letouzey 15257* (P, WAG, YA): road Meyo Ntem to Evouzok, 75 km W Ambam, 2°17'N 10°37'E (st, 28.11.1979); *Mildbraed 6141* (BM (drawing only), HBG, P, WAG (alc only)) type: Kribi, 25 km E of Groß Batanga, Eduduma-Bidue, 2°49'N 10°07'E (fl, 07.1911); *Nemba, Thomas & Bromley 764* (MO): 5 hrs walk N of Mundemba, Meta, 5°03'N 9°01'E (fr, 05.02.1988); *Sonké 1236* (BR): Dikoumbe Barondo Forest, 4°27'N 9°01'E (st, 05.05.1994); *Thomas 590* (K (+alc), WAG): Korup reserve, transect Q, 5°04'N 8°47'E (fr, 02.1979); *Thomas 8012* (MO): on footpath from Esukutang to Ekogate, 5°25'N 9°04'E (st, 30.05.1988); *Thomas 8250* (MO): Baro, 5°16'N 9°13'E (st, 04.1988); *Thomas, Mambo & Namata 7535* (MO): Korup National Park, betw. Baro and Ikenge, 5°15'N 9°09'E (st, 01.04.1988); *de Wit 9418* (WAG): Loum region, SE of N'Kongsamba, 4°57'N 9°56'E (fr, 20.12.1957).

EQUATORIAL GUINEA: *Wilks 3514* (WAG, WILKS): Monte Alen, 1°39'N 10°19'E (fr, 11.04.1998).

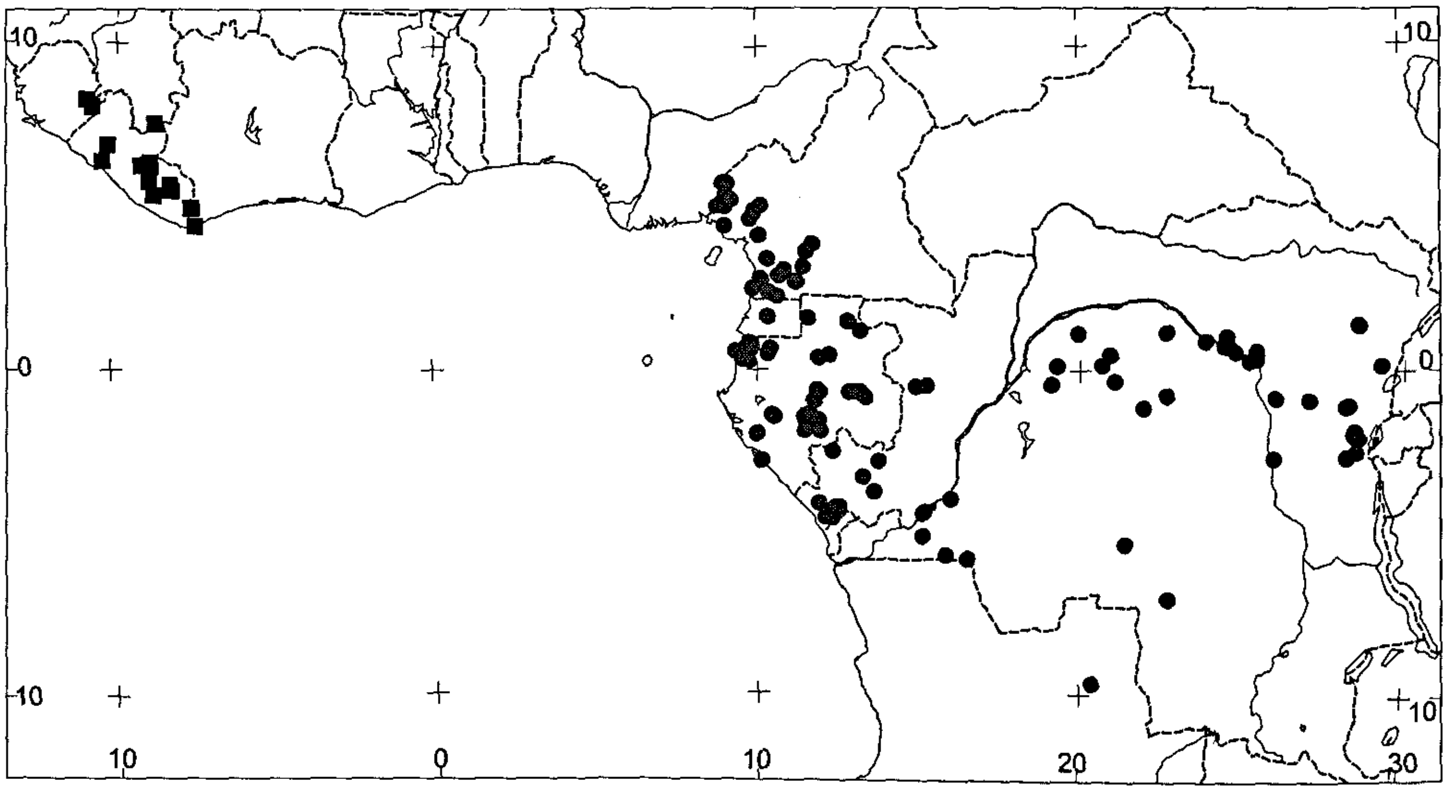
GABON: *Bernard & Boislouveau 909* (LBV): Mondah, Liby, 0°35'N 9°20'E (st, 25.09.1952); *de Boislouveau 1032* (LBV, P): Noya-Mvomenzork, 0°50'N 9°49'E (st, 13.03.1956); *Breteler & Jongkind 10693* (WAG): c. 30 km E of Lastoursville, 0°40'S 13°00'E (st, 23.11.1991); *Breteler & Jongkind 10765* (WAG): c. 30 km E of Lastoursville, 0°40'S 13°00'E (st, 26.11.1991); *Breteler, Issembe, Moussavou & Pascal 15171* (WAG): Makandé, 0°41'S 11°55'E (st, 22.02.1999); *Breteler, Issembe, Moussavou & Pascal 15196* (WAG): c. 10 km NW Makandé, 0°37'S 11°51'E (st, 24.02.1999); *Breteler, Jongkind & Wieringa 11243* (WAG (+alc)): c. 50 km E of Lastoursville, 0°40'S 13°10'E (fl, fr, 02.05.1992); *Breteler, Jongkind & Wieringa 11243 a* (WAG): c. 50 km E of Lastoursville, 0°42'S 13°10'E (st, 02.05.1992); *Breteler, Wieringa & Nzabi 12865* (WAG): Crystal Mountains, Assok, 0°40'N 10°24'E (st, 14.09.1994); *Breteler, Wieringa & Nzabi 13239* (WAG): Lastoursville region, 17 km WNW Bambidie, 0°41'S 12°50'E (st, 12.10.1994); *Corbet 772* (LBV): ?, not located (st, 07.05.1952); *Dibata 1207* (WAG, WILKS): Bambidie, CEB road B3, 0°40'S 13°00'E (st, 1997); *Dibata in MINKébé series C 146* (WAG): Minkébé region, 698 m on transect A, 1°30'N 12°48'E (st, 10.02.1990); *Dibata in MINKébé series C 175* (WAG): Minkébé region, 819 m on transect A, 1°30'N 12°48'E (fr, 11.02.1990); *Doucet 276* (BR, WAG): Parcel 32 of Leroy Gabon. 0°46'-1°09'S 11°30'E-Offoué, 0°57'S 11°45'E (st, 06.12.1995); *Durand 1584* (LBV): station Ikoy, 0°20'N 9°33'E (st, 08.1955); *Gauchotte 1838* (LBV): Nkoulounga, 0°42'N 9°50'E (st, 08.1957); *N. Hallé 3115* (P): Belinga, 1°13'N 13°10'E (st, 10.11.1964); *Ibinga in MINKébé series C 97* (WAG): Minkébé region, 437 m on transect A, 1°30'N 12°48'E (st, 06.02.1990); *I.N.E.F. s.n. (1)* (P, WAG): Libreville, 18 km, 0°22'N 9°33'E (st, 25.11.1968); *J. de Wilde & de Wilde-Bakhuizen 11635* (LBV, WAG): Koumounabouali massif, 1°23'S 10°27'E (fr, 04.12.1996); *Le Testu 5251* (A, BM, BR, FHO, K, P, WAG): Ht Ngounyé, Pounga, 1°32'S 11°28'E (fl, 26.02.1925); *Le Testu 5741* (BM, BR, EA, HBG, MO, NY, P, PRE, WAG): Ipoungou (Masungo), 1°33'S 11°53'E (fl, 14.11.1925); *Le Testu 8824* (BM, P): Mbigou, 1°53'S 11°56'E (fl, 22.05.1931); *Le Testu 9171* (A, BM, BR, FHO, K, MO, P, S, WAG): Oyem, 1°36'N 11°34'E (fl, 08.06.1933); *Morel 109* (P): Ntoum Rogolié, 0°18'N 9°45'E (fl, fr, 29.03.1950); *Morel 132* (P, WAG): middle Mbei valley, 0°30'N 10°20'E (fr, 26.10.1950); *Morel 180* (LBV): surroundings of Nkan-Noya, 0°43'N 9°40'E (st, 24.11.1948); *Morel 715* (LBV): ?, not located (st, 1950); *de Saint Aubin 2079* (P): 18 km from Libreville, 0°23'N 9°37'E (fr, 10.1961); *Sota s.n. (1)* (WILKS): c. 70 km E Lastoursville, CEB concession, 0°50'S 13°20'E (st, 21.07.1996); *team of Wilks s.n. (2)* (WILKS): Bambidie, transect BN 3, tree 10-B-2-1, 0°40'S 13°00'E (st, 1997); *Wieringa & Epoma 1628* (IAGB, LBV, WAG (+alc), WILKS): Divangui savanna, 1°57'S 10°00'E (fl, fr, 23.09.1992); *Wieringa & v.d. Poll 1345* (IEC, LBV, UGDA, WAG (+alc)): 9 km E of Gamba airport, 2°48'S 10°08'E (fl, 04.08.1992); *Wieringa & v.d. Poll 1346* (LBV, WAG): 9 km E of Gamba airport, 2°48'S 10°08'E (st, 04.08.1992); *Wieringa & v.d. Poll 1399* (LBV, WAG): 5 km NNW of Bembodie, Koumounabwali massive, 1°26'S 10°31'E (st, 15.08.1992); *Wieringa & Haegens 2558* (WAG): Rabi area, W side of Divangui-savanna, 1°58'S 10°00'E (st, 23.03.1994); *Wieringa & Haegens 2559* (WAG): Rabi area, W side of Divangui-savanna, 1°58'S 10°00'E (st, 23.03.1994); *Wieringa, van Nek & Moussavou 3103* (WAG): 13 km on road Etéké to Ovala, Nyongué, 1°26'S 11°26'E (st, 08.11.1994); *Wilks in MINKébé series S 81* (WAG): Minkébé region, 10x10 m plot (plot S), 360 m on transect A, 1°30'N 12°48'E (st, 11.03.1990); *Wilks in MINKébé series S 226* (WAG): Minkébé region, 10x10 m plot (plot S), 360 m on transect A, 1°30'N 12°48'E (st, 19.03.1990); *Wilks in MINKébé series W 80* (WAG): Minkébé region, 100 m S of 1100 m on transect A, 1°30'N 12°47'E (fr, 30.03.1990); *Wilks 1332* (WILKS): 20 km NNE of Koumameyong, 0°23'N 11°53'E (fr, 13.02.1987); *Wilks 1412* (WAG, WILKS): 20 km NNE of Koumameyong, 0°23'N 11°53'E (st, 04.03.1987); *Wilks 1934* (WAG): 19 km N of Ovan, 0°29'N 12°13'E (fr, 20.05.1989); *Wilks 1936* (WAG): 19 km N of Ovan, 0°29'N 12°13'E (fr, 20.05.1989); *Wilks 1961* (WAG): Chaillu massif, 8 km N of Massima, 1°22'S 11°36'E (st, 28.06.1989); *Wilks 1981* (WAG): Chaillu massif, 5 km SE of junction Ogoulou and Ogoudou r., 1°53'S 11°28'E (st, 08.07.1989).

CONGO (BRAZZAVILLE): *Bouquet & Sita 2242* (IEC, P): road to M'Bila, forest left of road after Mouyabi, 3°18'S 13°16'E (st, 11.01.1968); *Constant 65* (CIRAF): Mokila, 2°48'S 13°44'E (st, 19.05.1972); *Descoings 8403* (BR, IEC, P, WAG): road Alima-Likouala, near Fort-Rousset, 56 km on road to Ewo, 0°30'S 14°55'E (fl, fr, 22.07.1961); *Dowset-Lemaire 1390* (BR): Niari, Mayombe at col de Bamba, 4°14'S 12°31'E (st, 07.12.1990); *Dowset-Lemaire 1455* (BR): Kouilou, Mayombe betw. Béna and Zavanga, 4°07'S 11°54'E (fr, 22.12.1990); *Farron 4544* (P): 35 km ESE of Sibiti, chant. Moussomo, 3°45'S 13°35'E (st, 28.08.1965); *Farron 5294* (IEC): Djoumouna forest, 4°23'S 15°10'E (st, 05.01.1967); *Foresta 1878* (BR): Mayumbe, Les Saras, 4°14'S 12°31'E (st, 07.1989); *Makany 1150* (P): 22 km on the road from Brazzaville to Linzolo, Djoumana for., 4°25'S 15°08'E (st, 03.12.1969); *Normand 80* (P): central Mayombe, env. Dimonika, near M'Vouti, 4°14'S 12°25'E (fr, 15.06.1947); *Normand 395* (P): Mayombe, near Boku N'Situ, 4°32'S 12°06'E (st, 25.09.1959); *Normand 402* (P): Mayombe, Federal road between 85 and 91 (km), M'bubangu reg., 4°20'S 12°20'E (fl, fr, 29.09.1959); *Normand s.n. (2)* (P): forestry station Buku N'Situ, original from Kugni, 4°33'S 12°19'E (st, 09.07.1947); *Sita 2618* (IEC, P, WAG): near Brazzaville, Plateau de Cataractes, Djoumouna, 4°23'S 15°10'E (fr, 07.10.1968); *Sita 4933* (BR, IEC, P, WAG): Chaillu, Divenié, Bibaka valley, Moudounga, 2°30'S 12°18'E (fl, 29.07.1983); *Trochain 8434* (IEC, P, WAG): road to Ewo (Fort Rousset), 0°29'S 15°15'E (fl, fr, 15.10.1951); *J. de Wilde & v.d. Maesen 11061* (WAG): 13km on road Les Saras (Mboulou) to Pointe Noire, 4°21'S 12°15'E (st, 11.02.1993).

ANGOLA: *Gossweiler 11675* (BM, M, MO): Lunda, Vila Henrique de Carvalho, near Luachima river, 9°39'S 20°24'E (st, 04.1937).

CONGO (KINSHASA): *Y. Ankei & T. Ankei 79/ 1118* (BR): Ngoli, 2°41'S 25°57'E (st, 12.02.1980); *Babault 497* (P): Kiwu, Lukando, 2°03'S 28°31'E (fl, 08.?); *Babault 641* (P): Kiwu, W of Butembo, 0°09'N 29°17'E (st, 2?.08.1935); *Bequaert 6834* (BR): Lubutu - Kirundu, 0°50'S 26°00'E (st, 05.02.1915); *Bombali 1795* (MO): Yangambi, 0°46'N 24°27'E (fl, fr, 05.04.1961); *Butaye s.n. (1)* (BR): Nsele river basin, 5°08'S 15°06'E (st, 10.1900); *Butaye s.n. (2)* (BM, BR): ?, not located (st, 1902); *Dhetchuvi 563* (BR, WAG): [Botsima] research station, 1°09'S 21°57'E (st, 19.02.1991); *Dhetchuvi 1040* (BR): Botsima, 1°09'S 21°57'E (fl, 26.03.1991); *Evrard 2263* (BR, K, L, NY, PRE, SRGH): Isangi, Ligusa - Mangala, 0°55'N 23°53'E (fl, fr, 21.03.1957); *Evrard 4042* (BR, FHI, K, PRE, SRGH): Befale, Maringa, Ikelemba river, 0°10'N 20°40'E (fl, 07.05.1958); *Evrard 4092* (BR, K, PRE, SRGH): Bolomba, Djoa, 0°08'N 19°16'E (fr, 17.05.1958); *Evrard 4158* (BR, FHO, LISC, M, WAG): Befale, road Befale to Tolongote, 0°30'N 20°56'E (fl, fr, 01.06.1958); *Evrard 6241* (BR, L): Ikela, Yongo, 0°46'S 22°40'E (fr, 05.05.1959); *Ewango 852* (BR, WAG): Ituri forest, near Epulu, 1°23'N 28°36'E (fl, fr, 16.10.1997); *Germain 2666* (BR): Kwango, Lufuna river, 3°58'S 15°59'E (st, 05.08.1944); *Germain 7320* (BR): Itia, Yalokombe, 0°35'N 24°47'E (fl, 12.05.1952); *Ghesquière 712* (BR, C, K): Ht Lopori, Lokolenge, 1°11'N 22°40'E (st, 06.1927); *Gilbert 8108* (BR): Yangambi, 0°46'N 24°27'E (st, ?); *Gilbert 8553* (BR): Yangambi, 0°46'N 24°27'E (fl, fr, ?); *Gilbert 8571* (BR): Yangambi, 0°46'N 24°27'E (fl, ?); *Gilbert 8670* (BR): Yangambi, 0°46'N 24°27'E (fr, ?); *Gilbert 8890* (BR): Yangambi, 0°46'N 24°27'E (fr, ?); *Gilbert 9407* (BR): Yangambi, 0°46'N 24°27'E (st, ?); *Gilbert 9801* (BR): Yangambi, 0°46'N 24°27'E (st, ?); *Gilbert 9802* (BR): Yangambi, 0°46'N 24°27'E (fr, ?); *Gutzwiller 1396* (BR): Kaliki, Bunyakidi, 2°04'S 28°34'E (st, 11.09.1957); *Hart 285* (BR, K, MO, PRE): Ituri, Epulu, 1°25'N 28°35'E (fl, 29.05.1982); *Hulstaert 1556* (BR, K): Iambo near Flandria, 0°26'S 19°06'E (st, 15.07.1951); *Jespersen 1911* (BR): Moma, Watzi, 0°19'S 21°04'E (st, 11.1914); *Lejoly 806* (BRLU): ?, not located (st, 04.12.1976); *Lejoly 856* (BRLU): Kivu, Maiko N.P., N of Ubukala, Lubutu riverbank, 0°54'S 27°03'E (st, 07.01.1977); *A. Léonard 4685* (BR, K, LISC, P, WAG): Walikale, Umpi, 1°05'S 28°16'E (fr, 06.1959); *Liben 2588* (BR, K): Luisa, Elkasai-concession, 7°01'S 22°44'E (fr, 27.02.1957); *Lisowski 40440* (BR, WAG): 15 km NE of Kisangani, Tshopo river, 0°36'N 25°26'E (st, 09.04.1975); *Lisowski 52426* (BR, K, WAG): 45km Kisangani to Rukula, 4km NE Batikalola, Amumyala falls, 0°20'N 25°24'E (st, 13.05.1979); *J. Louis 3561* (B, BM, BR, K, NY, P, PRE): Yangambi, 5 km N of the river, 0°46'N 24°27'E (fl, 09.04.1937); *J. Louis 4208* (B, BM, BR, EA, K, NY, P): Yangambi, 5 km N of the river, 0°48'N 24°28'E (fr, 21.06.1937); *J. Louis 6333* (BM, BR, K, PRE): Yangambi, 5km N of river, 0°48'N 24°28'E (fr, 08.10.1937); *J. Louis 6363* (BR): Yangambi, 0°46'N 24°27'E (fr, 08.10.1937); *J. Louis 14832* (BM, BR, EA, K, PRE): N'Gazi, 1°03'N 24°31'E (fl, 15.05.1939); *J. Louis 16113* (BR, C, K): Yangambi, Lubilu riverine forest, 0°44'N 24°36'E (fr, 23.09.1939); *Lynes 194* (BR, FHO): Luebo, 5°20'S 21°24'E (fr, 02.11.1933); *Van der Meiren 50* (BR): km 25 railroad Kisangani-Ubundu, 0°18'N 25°13'E (st, 22.02.1939); *Michelson 199* (BR): near Eke river, 1°56'S 28°26'E (st, ?); *Michelson 531* (BR): ?, not located (fr, end 1943); *Michelson 819* (BR, K): N of Kimbili, 264 km

Costermansville - Shabunda road, 2°39'S 28°12'E (st, 21.12.1948); *Michelson 825* (BR, K, Z): Kimbili, 264 km Costermansville - Shabunda road, 2°41'S 28°12'E (st, 22.12.1948); *Michelson 955* (BR): ?, not located (st, 07.1949); *Nannan 52* (BR, K): near Bofungi, 1°08'N 19°56'E (st, 24.10.1913); *Paquay 8* (BR): Shabunda, Kimbili, 2°41'S 28°12'E (st, 04.10.1937); *Pauwels 1748* (BR): Popokabake, Kingunba - Lona, 5°50'S 16°30'E (st, 19.02.1959); *Pauwels 3016* (BR, WAG): Popokabaka, Nto Mbombo, 5°43'S 15°51'E (st, 13.05.1959); *Pierlot 244* (BR): Mingazi, 2°00'S 28°25'E (fl, 25.03.1952); *Pierlot 717* (BR (+alc)): Kalehe, 79 km road Kavumu to Walikale, 2°03'S 28°28'E (fl, 16.08.1955); *Pierlot 2186* (BR): Walikale, 153 km road Sake-Walikale, Kembe, 1°07'S 28°10'E (st, 10.06.1958); *Rossignol 25* (BR): Maniema, 2°30'S 28°30'E (st, ?); *Troupin 4542* (BR, K, WAG): Kalehe, 110 km road Kavumu to Walikale, Irangi, 1°53'S 28°27'E (st, 17.10.1957); *Troupin 7772* (BR (+alc), K, LG, NY): Kalehe, 110 km road Kavumu to Walikale, Irangi, 1°52'S 28°28'E (fl, 30.07.1958); *Troupin 9316* (BR): Kalehe, 110 km road Kavumu to Walikale, Irangi, 1°53'S 28°27'E (st, 19.12.1958); *Yafunga 136* (BR, WAG): Yangambi, flora-reserve of Luweo-river, 0°46'N 24°27'E (fl, fr, 08.04.1961).



Map 10.6. Distribution of *Aphanocalyx microphyllus* (Harms) Wieringa. The records from western Africa (squares) represent subsp. *compactus* (Hutch. ex Lane-Poole) Wieringa, those from central Africa (circles) represent subsp. *microphyllus*.

subsp. *compactus* (Hutch. ex Lane-Poole) Wieringa comb. & stat. nov.

Fig. 10.6: A–F, Map 10.6

Basionym: *Monopetalanthus compactus* Hutch. ex Lane-Poole, Trees, shrubs, etc. Sierra Leone: 64 (1916).

Monopetalanthus compactus Hutch. ex Lane-Poole: Lane-Poole, 1916: 64 (as *M. compactum*); Hutchinson & Dalziel, 1928a: 342 & fig. 133; Hutchinson & Dalziel, 1928b: 397; Baker, 1930: 734–735; Pellegrin, 1942: 120; Pellegrin, 1949: 75; Keay, 1958: 478 & fig. 153; Voorhoeve, 1965: 204–208 & fig. 34: A–F; Kunkel, 1965: 142–143 & pl. 52; Fox, 1967: 64; Burkill, 1995: 138–139. **Type**: *Aylmer 30* (holo: K; drawing: BM) — "Sierra Leone, Falaba 3/4/14. Mapavi M."

Monopetalanthus heitzii auct. non Pellegr.: Borota & Supin (1989: obr. 1)

Much resembling the nominal subspecies. Only sizes and aberrant characters are given.

Small to medium-sized, rarely large, tree, 10–35 m high. DBH up to 80 cm, according to Voorhoeve (1965) rarely over 100 cm.

Stipules 6–25 x ½–6 mm. **Leaves** 2–9 cm long, (8–)13–24(–26)-jugate, largest leaflet situated at about the middle. **Petiole** ½–2 mm long. **Rachis** on upper side glabrous or sparsely velvety. **Leaflets**: upper and lower side glabrous. **Basal leaflet** 3–8(–10) x 1–2½ mm. **Apical leaflet** 4–12 x 1–3 mm: base of proximal half rarely with an auricle, auricle up to 0.2 mm long. **Largest leaflet** 6–16(–18) x 1½–3½ mm: base of proximal half often with an auricle, auricle up to 0.6 mm long. **Gland pattern**: basal leaflet with (0–)1–2(–3) glands. Second leaflet with 0–2 glands. Apical leaflet without glands. Other leaflets without or only in the more basal ones sometimes with 1 gland.

Inflorescence a simple or compound raceme, 1(–2) per axil: simple racemes 1–3½ cm long and 5–25-flowered; compound racemes 1½–4½ cm long, with 2–6 lateral branches which are 0.8–2.3 cm long and 8–16-flowered. **Bracts** 3½–5½ x 2–5½ mm, margins often with glandular teeth. **Pedicel** 3–7 mm long. Hypanthium s.l. 0.2–0.6 mm long. **Bracteoles** assuming a 85–200° wide angle at anthesis, 4½–7 x 2½–4 mm. **Adaxial sepals** fused or free, rarely one wanting, fused ones 0.6–2.0 x 1.2–2.2 mm, free ones 0.1–2.2 x 0.1–1.0 mm. **Lateral sepals** wanting. **Abaxial sepal** sometimes wanting, 0.5–1.8 x 0.2–0.8 mm. **Adaxial petal** 4–7½ x 3–5½ mm, claw ½–2½ mm long. **Lateral petals** usually wanting, sometimes vestigial, up to 1.7 x 0.4 mm. **Adaxial petals** usually wanting, very rarely vestigial, up to 0.2 x 0.1 mm. **Stamens** 10: filaments 6–11 mm long, 9 united over a length of 0.8–1.8 mm; anthers 1.0–1.4 mm. **Ovary** 2.0–4.9 x 1.0–2.7 x 0.4–1.0, often depauperate and only 0.8–1.1 x 0.3–0.5 x 0.15–0.3 mm, with 2 ovules; stipe 1.2–1.9 mm long (0.4–1.1 mm in depauperate ovaries). **Style** 5–8½ mm long in bisexual flowers, ½–1½ mm in male flowers, inserted at an angle of 10–80°.

Pods 1–2-seeded, 3½–6 x 1.8–2.6 x 0.2–0.4 cm; beak ½–2 mm long; upper suture not to indistinctly winged, 1½–4 mm wide; nerve usually distinct, u/w = 0.22–0.36; stipe 1–3 mm long, pedicel 4–6 mm long. **Seeds** 9–16 x 7–12 x 1–2 mm.

Seedling: Germination epigeal. **Hypocotyl** 5–11 cm long. **Epicotyl** 0.1–0.2 cm long. First pair of leaflets (10–)14–20-jugate. Subsequent leaves alternate, at first with a decreasing number of leaflets, first subsequent leaf 8–13-jugate.

Distribution: Map 10.6. From southern Sierra Leone across Liberia to south-western Ivory Coast. Since the species occurs on the Liberian side of Mt. Nimba, it might be occurring on the Guinean side of the mountain as well.

The subspecies occurs over a rather narrow band, on average c. 100 km inland, only reaching the coast at Tabou (doubtful record!) and coming close to it at Harbel. Also from the data presented by Kunkel & Voorhoeve (1964), who walked along a transect going inland in Liberia close to the border with Sierra Leone, this band can be reconstructed. Outside this band exists an isolated population on Mt. Nimba. This pattern might indicate that the subspecies is restricted to evergreen rain forest with an annual rainfall between 2000 and 3000 mm (compare with maps from Bongers et al., 1999).

Vernacular names: Sierra Leone: Mapavi, Nelleh, Neyeh (Mende, see notes). Liberia: Fian (Gio), according to Voorhoeve (1965: 204) also: Gbang (Kpelle) and K'pai (Gola).

Ecology: This subspecies is very regularly reported as being gregarious. According to Voorhoeve (1965: 208) it constitutes single dominant forest of vast extension in slightly rolling areas. Since some secondary forest might consist completely of this subspecies, Voorhoeve wonders if the single dominant forests might be relics from shifting cultivation. On more rocky terrain the subspecies does occur as well, but not so clearly gregarious.In drier areas with semi-deciduous forest it only occurs in riverine forest.

Altitudinal records range from sea-level to 300 m, but around Mt. Nimba it occurs also over 500 m.

Regeneration can be so massive that the entire forest floor is covered by seedlings that have grown to a height of c. 1 m.

Phenology: Flowering is from February to April, just before the rainy season. The first mature pods are present in October, indicating a maturation time of c. 7 months. Young seedlings have been collected in March.

The tree probably produces flushes twice a year: in April to May and in October.

Chemistry: Flowers produce no colour on spirit.

Diseases and pests: No diseases have been observed, only some flowers were damaged by small caterpillars.

Uses: No uses were recorded, but it most probably can be used like the nominal subspecies. Mayer (1951: 66) classified this taxon as a "Class III" species, meaning it had at that time no commercial value, but was considered promising.

Notes: The type specimen (*Aylmer 30*) was collected, according to the label, in Falaba. In the gazetteer 6 Falaba's are cited. One of those is a relative large town also cited in The Times Atlas of the World. However, this location does not match the distribution pattern of the species and that of most of Aylmer's collections. Two other species that were collected at Falaba by Aylmer, *Strychnos icaja* Baill. and *Eriocoelum racemosum* Baker seem to have a forest distribution as well (for the first species this is confirmed by Dr Leeuwenberg) and are not likely to be collected at this northerly situated Falaba. Therefore I have interpreted the Falaba record as the Falaba at 8°02'N 10°42'W, which lies in the region where Aylmer has been collecting.

The vernacular names from Sierra Leone mentioned on the collections of Aylmer are all followed by an M. I have interpreted these words as vernacular names from the language Mende. This is coherent with remarks made by Fox (1967: 64 & 96).

Also in this subspecies both compound and simple racemes occur. In this case a geographical factor seems to be present as well: trees in Sierra Leone and possibly north-western Liberia have compound racemes, trees from the other regions have simple ones.

Specimens examined:

SIERRA LEONE: *Aylmer 30* (BM (drawing only), K) type: Falaba, 8°02'N 10°42'W (fl, 03.04.1914); *Aylmer 226* (K): Giehun (Gambui), 8°15'N 10°54'W (fl, 09.04.1918).

LIBERIA: *Harley 1485* (K, WAG): Harbel, Firestone plantation, 6°22'N 10°20'W (fl, 09.04.1947); *van Harten 343* (K, WAG): Krahn Bassa forest, 5°45'N 8°50'W (fl, 06.02.1964); *Leeuwenberg & Voorhoeve 4927* (B, BR, FHI, HBG, K, L, MO, P, PRE, WAG): Bong Range, 32 km N of Kakata, 6°52'N 10°10'W (fr, 11.08.1962); *Mayer 121* (US): Eastern prov., Sinoe River drainage, near Wllebateh, 5°20'N 8°40'W (fr, 15.05.1948); *Voorhoeve 298* (WAG): 35 km SW of Tapeta, LITICO-concession, 6°15'N 9°05'W (fr, 26.05.1961); *Voorhoeve 548* (WAG): Gbi National Forest, 6°20'N 8°48'W (st, 10.1961); *Voorhoeve 587* (WAG): South side Gbi nat. forest, 6°12'N 8°48'W (fr, 10.1961); *Voorhoeve 801* (WAG): Putu-area, 5°40'N 8°10'W (st, 25.01.1962); *Voorhoeve 939* (WAG): Bong range, 6°52'N 10°10'W (st, 04.03.1962); *Voorhoeve 1013* (WAG): Kanweake, 5°30'N 8°06'W (st, 25.03.1962); *Voorhoeve 1083* (BR, WAG): Nimba Mountains, West Nimba nat. forest, 7°32'N 8°42'W (fl, 10.04.1962); *Voorhoeve 1145* (WAG): Bonge range, 6°52'N 10°10'W (fr, 20.06.1962); *Voorhoeve s.n. (1)* (WAG): Bong Range, 6°52'N 10°10'W (st, 10.07.1960); *J. de Wilde & Voorhoeve 3659* (A, B, BR, K, MO, S,

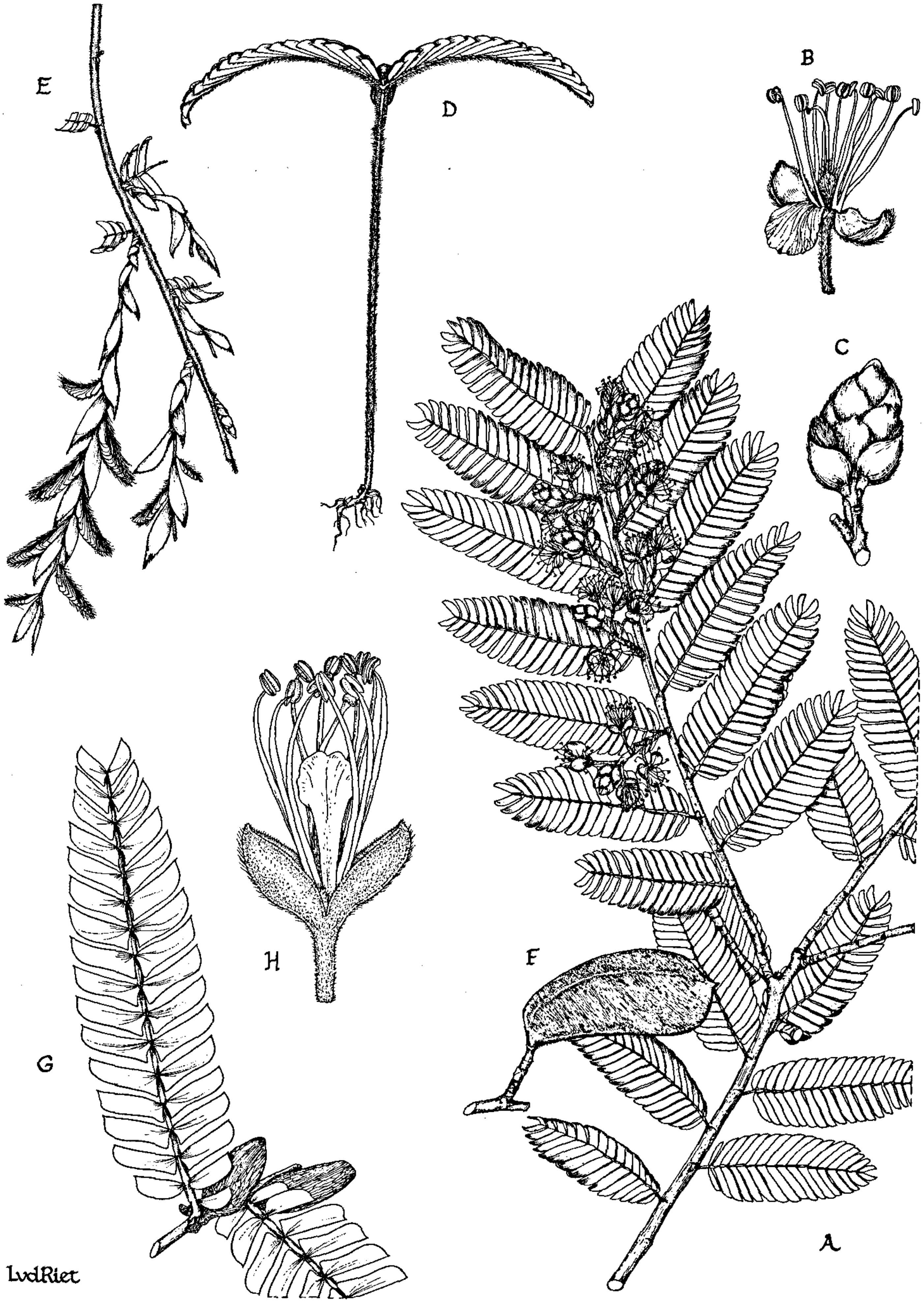


Figure 10.6. *Aphanocalyx microphyllus* (Harms) Wieringa subsp. *compactus* (Hutch. ex Lane-Poole) Wieringa (A–F) and *Aphanocalyx pteridophyllus* (Harms) Wieringa (G & H). — A: branch with leaves and inflorescences (x½); B: flower (x2); C: inflorescence bud (x2); D: seedling (x½); E: young shoots with stipules and developing leaves (x½); F: pod (x½); G: part of twig with leaves and stipules (x½); H: flower (x1½). — A–C: *J. de Wilde & Voorhoeve 3659*; D: *Voorhoeve 939*; E: *Voorhoeve 548*; F: *Leeuwenberg & Voorhoeve 4927*, G, H: *Voorhoeve 1194*. A–G: published earlier in Voorhoeve, 1965, H: drawn by W. Wessel-Brand.

WAG (+alc)): Putu district, 70 km S Chiehn, near Kanweake, Zwedru village, 5°30'N 8°08'W (fl, 26.03.1962).

IVORY COAST: *Albers 47* (WAG): NE of Grabo, lower slopes of Mt. Kopé, 4°58'N 7°28'W (st, 28.01.1990); *Breteler 13356* (WAG): Abidjan, Botanical garden, not located (st, 22.04.1995); *Breteler 13378* (WAG): N of Grabo, Mount Kopé, at foot of slope, 4°57'N 7°30'W (fr, 30.04.1995); *Guillaumet 1833* (BR, WAG): Mt Kopé, 3.5 km N of Grabo, 4°57'N 7°30'W (fl, fr, 16.04.1964); *de Wit s.n. (1)* (WAG): ?, not located (st, ?); *Yapi & Tehe 914* (BR): Botanical garden of Adiopodoumé, origin: Tabou forest, 4°25'N 7°21'W (fl, 12.04.1969).

General notes on the species:

Leaves from treelets are usually larger and bear more leaflets than those of mature trees. Their measures are given in between brackets.

Voorhoeve (1965: 207) already mentions that *M. compactus* is hard to distinguish from *M. microphyllus*. He notes that the latter species has a larger epicotyl. This character, however, was based on Léonard (1952), which observation in its turn was based on the aberrant material from Congo (Kinshasa). The only other difference Voorhoeve mentions is the slightly larger flowers of *M. microphyllus*. This character alone, however, does not merit in my opinion the status of a distinct species, especially not since the difference is only visible as a trend and not an absolute difference. The West African population, however, differs on several size characters, though none of them is absolute. One more discrete character seems to be present in the bracts: the margins of *compactus* often bear glandular teeth, while such teeth were not observed in *microphyllus*. The combination of these characters makes it possible to distinguish good sampled material from West Africa from that of Central Africa. For this reason, in combination with the fact that there exists a 1800 km wide gap between the populations rendering them genetically strongly isolated, I have chosen to give the West African population the status of subspecies.

Aphanocalyx obscurus Wieringa spec. nov. **Fig. 10.7, Plate 1c, Map 10.7**

Type: *Wieringa & van de Poll 1544* (holo: WAG, incl. spirit coll.; iso: LBV and 16 others to be distributed) — "Gabon, Haut-Ogooué, c. 46 km on the road from Franceville to Lékoni, Boudou I. Alt. 400 m 1°37'S 13°55'E, 31.08.1992".

Monopetalanthus pteridophyllus auct. non Harms: Baker, 1930: 734–735 p.p.; Pellegrin, 1942: 119 p.p.; Léonard, 1952: 443–444, fig. 37 A & B p.p.; Aubréville, 1968: 308 p.p.; Tailfer, 1989: 796–799 (p.p.?).

Diagnosis: Arbor *A. pteridophyllo* (Harms) Wieringa similis, sed ramulis indumento densiore et persistenti. Legumina sutura alato lato venaque laterali obscuro vel absenti. Flos apertus pedicello tantum 2–5 mm longo. Petalum adaxiale tantum 5–11 mm longum glabrumque. Stamina tantum 7–13 mm longa. *Aphanocalyx pectinato* (A. Chev.) Wieringa foliolis latioribus, jugorum numero parvo (9–23) sepalisque adaxialis connatis distincta.

Small to medium-sized tree, 14–25 m high; crown hemispherical or irregular. **Bole** straight or contorted, DBH 30–120 cm: base sometimes with buttresses (for a photo see Tailfer l.c.). **Bark** thin, up to c. 6 mm thick, odour of slash described as reminiscent of a gherkin: surface finely rugose, scaly, pale grey with red-brown lenticels, grey-brown underneath the scales; outer bark 0.3–0.5 mm thick, brown; inner bark fibrous, in dry condition red-brown.

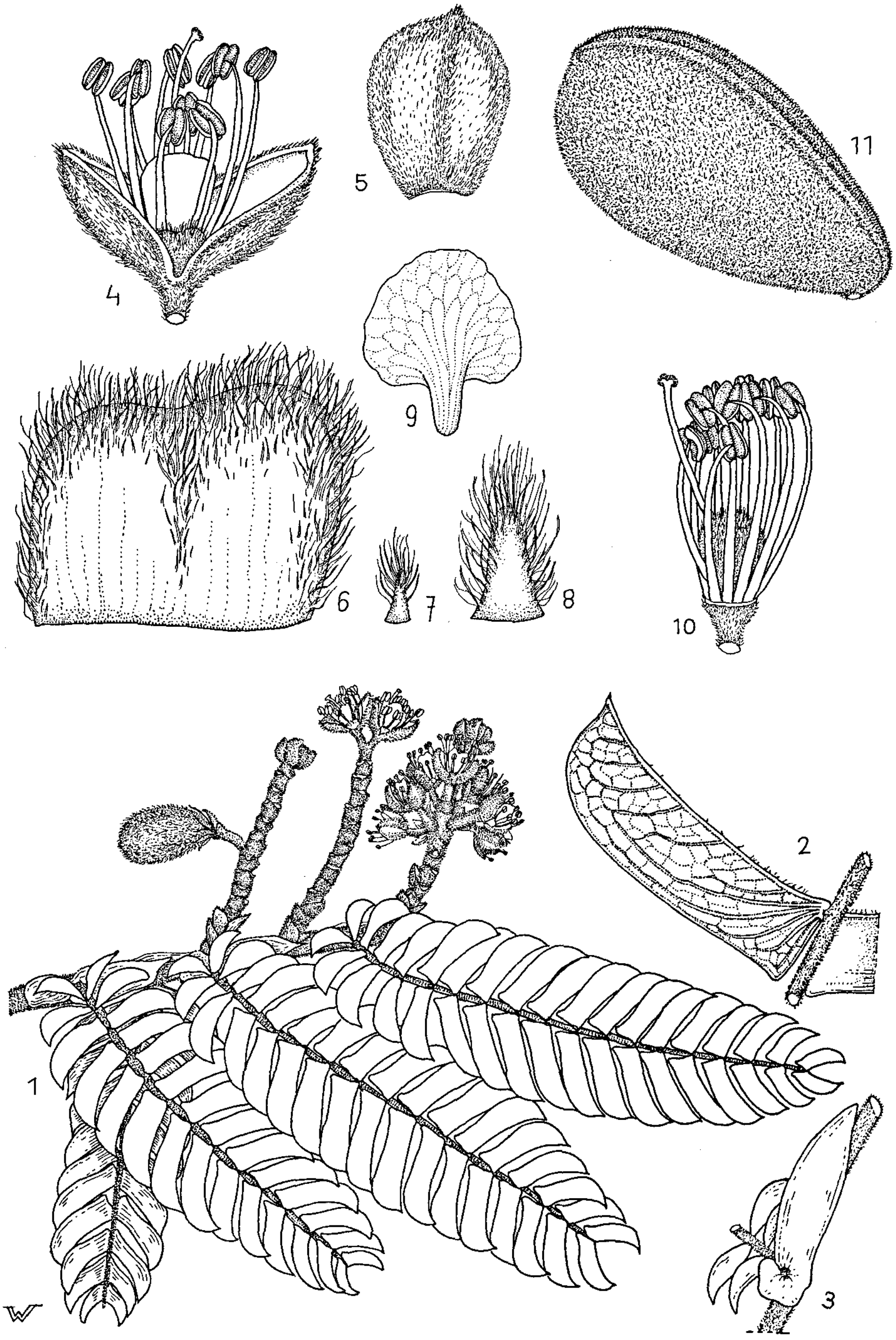


Figure 10.7. *Aphanocalyx obscurus* Wieringa. — 1: twig with leaves and inflorescences (x⅔); 2: leaflet from below (x2); 3: leaf insertion with two fused stipules (x1); 4: flower from adaxial side (x3); 5: bracteole from outside (x3); 6: fused adaxial sepals (x10); 7: lateral sepal (x10); 8: abaxial sepal (x10); 9: adaxial petal (x3); 10: flower with bracteoles, sepals and petal removed showing insertion of stamens and the ovary (x3); 11: pod (x⅔). — 1–10: *Wieringa & v.d. Poll 1544*; 11: *Wieringa & v.d. Poll 1540*.

Twigs smooth but lenticellate, reddish brown, fairly densely to very densely long brown velvety to tomentose, old twigs becoming pale grey and glabrescent. **Stipules** fused, persistent, obovate with an auriculate base, of the more distal stipules of a shoot the distal halves enlarged and appearing inflated, 12–38 x 3–10 mm, purple-red but soon becoming brown, most parts only with parallel veins, especially around the base often also with a branching pattern, outside sparsely to densely puberulous to (long) pubescent, the longer hairs especially present on the distal half, the apical part and along the mid-axis, inside sparsely pubescent, often becoming glabrous towards the apex, margins shortly ciliate. **Leaves** 4½–18(–22) cm long, (9–)11–23-jugate, largest leaflet situated at about the middle: **Petiole** 1½–4 mm long, fairly densely (shortly to) long velvety, almost completely consisting of the wrinkled joint. **Rachis** 3–16(–20) cm long, upper surface glabrous to sparsely velvety, often with a tuft of soft hairs in between each pair of leaflets, lower side shortly, long and very long, sometimes appressed, velvety, more or less terete in both fresh and dry condition, often geniculate and slightly inflated on the transition between petiole and rachis, this part usually with two pairs of leaflets, ratio 1st internode : 4th internode = 0.22–0.55. **Leaflets** thick leathery, upper surface (slightly) glossy, dark green, glabrous, lower surface dull, pale greyish green, in young leaflets sparsely (long) velvety, glabrescent; margins shortly and long ciliate, glabrescent, but often persistent along the distal margin; distal half completely reduced or composed of a minute lobe near the base, sometimes anomalously present in the apical leaflet; apex rounded, but the primary nerve often ending in a conspicuous, up to 1.7 mm long glandular mucro. Young leaflets pale yellow with purple margins. **Basal leaflet** with its distal margin at right angles to the rachis to up to 90° reflexed, the proximal margin often aligned with the petiole or even covering it and overlapping the other basal leaflet, half-obovate, (4–)6–21 x (1–)2–8 mm: base of proximal half cuneate, not auriculate. **Apical leaflet** half-oblong-obovate (to half-oblong-ovate), 6–23 x 2–7 mm: base of proximal half sharply angled, sometimes auriculate, auricle up to 0.7 mm long. **Largest leaflet** half-oblong-obovate, 10–37 x 3–10 mm: base of proximal half rectangular to sharply angled, often auriculate, auricle up to 1.7 mm long. **Gland pattern**: basal leaflet with 1–2(–3) glands. Second leaflet with 1–3 glands. Third leaflet with 0–2 glands. Apical leaflet with 0–2 glands. Other leaflets with 0–1 gland.

Inflorescence in the axils of the youngest shoots (= up to 14 nodes), or in those of the previous growth phase, a simple raceme, solitary, 2–7 cm long and 15–50-flowered. **Rachis** 16–63 mm long, 1.4–2.2 mm thick, shortly, long or very long brown velvety. **Bracts** caducous, ovate, 3½–6½ x 3–5 mm, densely parallel-veined, outside mixed puberulous and velvety or rarely long appressed velvety, becoming glabrous towards the lateral margins, inside glabrous, margins shortly ciliate. **Pedicel** 2–5 mm long, long brown velvety-tomentose. Hypanthium s.l. 0.6–1.0 mm high. **Bracteoles** assuming a 35–70° wide angle at anthesis, 7–10 x 4–6 mm, white, outside shortly and long brown velvety, along the midrib also very long velvety, inside glabrous, margin chaffy. **Sepals** white, margins long to very long ciliate. **Adaxial sepals** fused, together hemi-circular, obovate or rectangular, 2.3–4.3 x 2.2–3.8 mm, apical margin emarginate, outside glabrous but velvety-pubescent along the margins, inside sparsely pubescent, especially on upper half. **Lateral sepals** wanting or vestigial, triangular, up to 0.3 x 0.4 mm, both sides glabrous. **Abaxial sepal** triangular, 0.9–1.9 x 0.5–0.8 mm, outside glabrous or with a few hairs near the apex, inside glabrous, apex bluntly acute. **Adaxial petal** spatulate, 5–11 x 4–9½ mm, white, both sides glabrous, margins glabrous, those of the claw inrolled, claw 2–4 mm long. **Lateral** and **abaxial petals** wanting. **Stamens** 10: filaments 7–13 mm long, 9 united over a length of 0.9–1.6 mm, white to pale pink, entirely glabrous; anthers 1.6–1.9 mm long, yellow.

Ovary 2.2–3.5 x 1.4–2.3 x 1.1–1.7 mm, sometimes depauperate and only 0.6–0.7 x 0.5–0.6 x 0.3–0.5 mm, very long very densely pale brown velvety, with 2 ovules; stipe 1.7–2.6 mm long (0.3–0.9 mm long in depauperate ovaries), long velvety except for the base. **Style** 6–10½ mm long in bisexual flowers, 0.3 mm in male flowers, inserted at an angle of 30–50°, white, with a few long hairs near the base; stigma heart-shaped.

Pods 1–2-seeded, oblong-obovate to obovate, 3–7½ x 1.8–3.8 x 0.2–0.6 cm, reddish brown to brown, fairly densely to densely brown velvety, sparsely mixed with some (very) long brown hairs; beak 0–2 mm long; upper suture winged, 4–10 mm wide; nerve wanting or indistinct and running at about ¼ of the width from the upper suture, u/w = 0.17–0.39; stipe 1½–4½ mm long, pedicel 3–8 mm long. **Seeds** obovate, 13–21 x 9–16 x 3–4½ mm, 0.4–0.6 g in dry condition; testa rather thin but not membranous, slightly glossy, dark brown.

Seedling: Germination epigeal. **Hypocotyl** 7–13 cm long, fairly densely, appressed or not, very long velvety. **Epicotyl** 0.1–0.3 cm long, long to very long velvety. First pair of leaves opposite, 8–12-jugate, with the first (or first two?) pair of leaflets wanting (the first pair present is not inserted directly after the rachis joint). Subsequent leaves alternate, at first with a decreasing or equal number of leaflets.

Chromosome number: 2n = 24 + 1 B-chromosome.

Distribution: Map 10.7. From south-eastern Gabon to western central Congo (Kinshasa), but not yet found in Congo (Brazzaville).

Vernacular names: Gabon: Ngang (Ouzo, a Batéké dialect). Congo (Kinshasa): Mtuna (Patambalu region), Wenseie Bang (Illongonga region); acc. to Tailfer (1989: 797) also Bontuna (?), Lusere (Maniéma), Ufimbu (Kisangani).

Ecology: An often gregariously growing tree, usually of riverine forest, often growing along the river, Lebrun & Gilbert (1954: 41) even mention it as a characteristic species for riverine forest. More rarely found in dryland forest on plateaux. A tree of sandy soils.

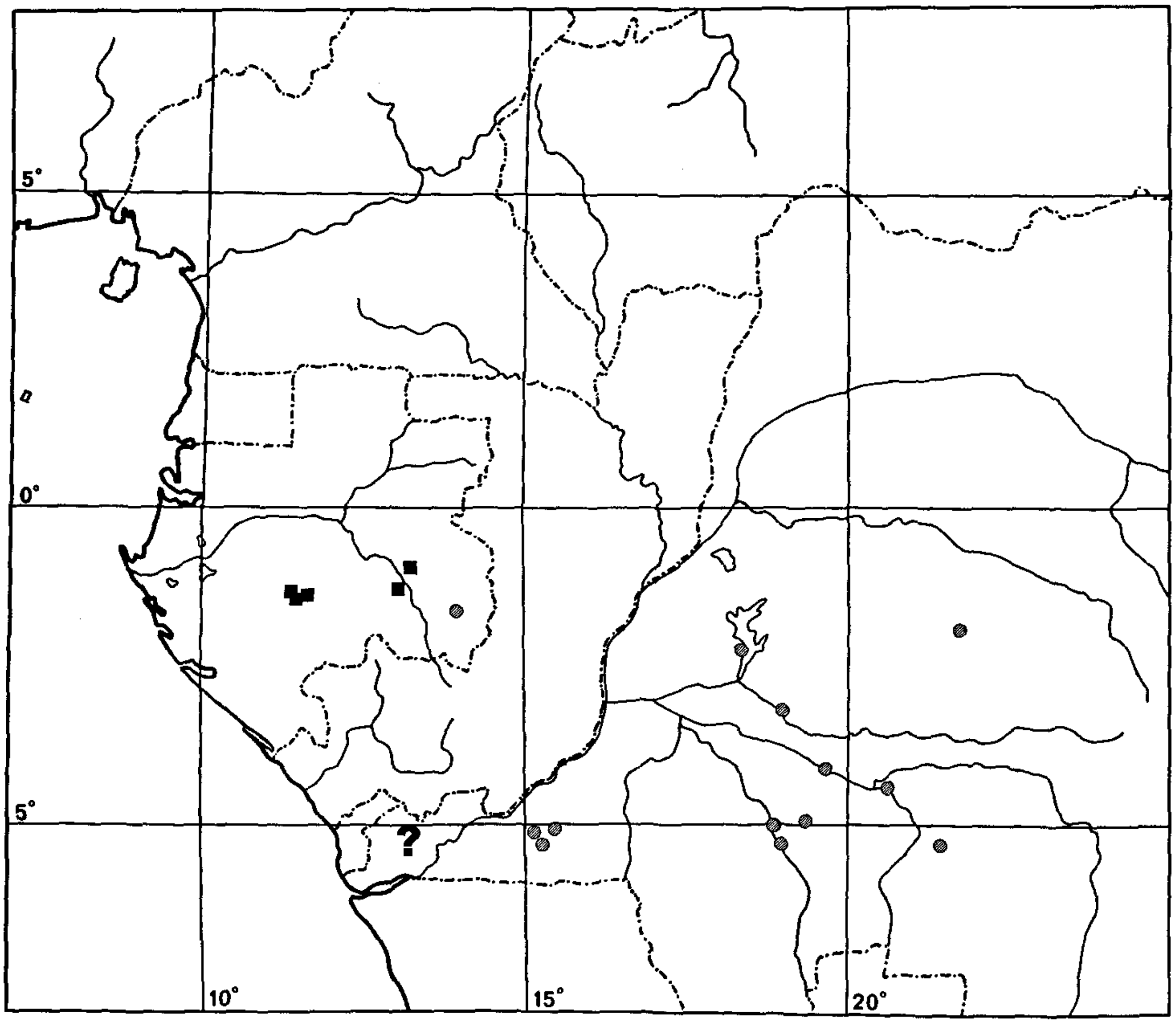
Compère (*2171*) found the species as a small (12 m) dominating tree in old secondary forest with *Piptadeniastrum africanum* (Hook. f.) Brenan and *Millettia laurentii* De Wild. Flamigni (*8077 bis*) reports it as a very common tree with large numbers of seedlings and saplings underneath it.

Between the persistent stipules ants build their nests.

Phenology: Flowering has only been observed once: end of August in south-eastern Gabon, being just before the start of the rainy season. In Congo (Kinshasa) almost mature pods were found in December, while mature pods have been reported from December and February.

Chemistry: Flowers produce a weak yellow colour in spirit.

Diseases and pests: Flowers seem to suffer considerably from caterpillar attacks. Also a weevil species (same species as found on *Bikinia le-testui*, in coll. Wieringa) has been collected on the flowers, most probably laying eggs in the ovary. However, such attacked trees still seem to produce pods. For the tree as a whole no major pests were observed.



Map 10.7. Distribution of *Aphanocalyx obscurus* Wieringa (circles) and of *Aphanocalyx pectinatus* (A. Chev.) Wieringa (squares), the question-mark indicates another area where *A. pectinatus* may be occuring.

Uses: None reported.

Etymology: The species is named "obscurus" since it is obscure in several ways. The lateral nerve on the pod is more obscure than in *A. pteridophyllus*. The flowers are relatively obscure because the adaxial petal and the stamens are much shorter than in that species. After discovering the tree that provided specimen *1540*, it took me more than an hour to observe that only 15 m away another, smaller, tree was growing that was full in flower (*1544*, the type). Finally, the differences with *A. pteridophyllus* are rather subtle, the new species has long been "obscured" by its resemblance to it.

Notes: Renier (*121 B*) calls this tree "one of the largest and most beautiful trees of the forest of Kikwit", which makes it likely that it does grow taller than the maximum of 25 m reported so far, especially since the height of the tree with a reported DBH of 1.20 m was not mentioned.

Already Léonard (1952: 444) wondered whether the Congolese material of *M. pteridophyllus* might be distinct from that of West Africa. However, he reached the conclusion that the sterile and fruit-bearing material of this new taxon was identical to the material from Liberia. Indeed, the two species really closely resemble each other and it was not until after a detailed investigation that I was able to separate them. The most striking vegetative character, the persistent indumentum on the twigs, is easily overlooked as a difference because one might interpret the densely hairy twigs as being young twigs, which are hairy in *A. pteridophyllus* as well. The presence of an extra leaflet closer to the leaf insertion has not been noted by anyone before. The distinguishing characters of the pod, i.e. a more prominently winged upper suture and a more obscure or even wanting lateral nerve, show some overlap with *A. pteridophyllus*. Léonard did not have any flowers at his disposal. Some very clear differences are present in the flower: the smaller pedicel, smaller stamens, smaller and glabrous adaxial petal and some minor other ones. However, these characters all have to prove their value when more flowering material from this species becomes available.

How strange it may sound after these observations, this new species is probably even more closely related to *A. pectinatus* than it is to *A. pteridophyllus* (this observation is based on the morphological study, not on the cladistic analysis, which indeed seems to corroborate it). For the distinctions see the notes under *A. pectinatus*.

Specimens examined (except the type all paratypes):

GABON: *Wieringa & v.d. Poll 1540* (LBV, WAG): 46 km on the road from Franceville to Lékoni, Boubou I, 1°37'S 13°55'E (fr, 31.08.1992); *Wieringa & v.d. Poll 1541* (LBV, WAG): 46 km on the road from Franceville to Lékoni, Boubou I, 1°37'S 13°55'E (st, 31.08.1992); *Wieringa & v.d. Poll 1544* (LBV, WAG (+alc)) type: 46 km on the road from Franceville to Lékoni, Boubou I, 1°37'S 13°55'E (fl, fr, 31.08.1992).

CONGO (KINSHASA): *Anonymous s.n. (2)* (BR): ?, not located (fr, ?); *Callens 135* (BR): near Kisantu, 5°08'S 15°06'E (st, ?); *Callens 148* (BR, K): Kinkasi, forest on plateau, 5°20'S 15°14'E (fr, 08.02.1953); *Compère 2171* (BR): Madimba, Kinkoko, 5°05'S 15°25'E (st, 20.04.1960); *Devred 2760* (BR, K): Kiyaka, Kwango, Kwilu forest, 5°19'S 18°56'E (fr, 04.11.1955); *Evrard 4659* (BR, K, SRGH): piste Yongo-Yenge, riverine forest Eeko river, 1°55'S 21°42'E (fr, 13.08.1959); *Flamigni 8077 bis* (BR, K): Popompo, Lukénie (river), 3°12'S 18°57'E (fr, 10.1942); *Huet 85* (BR): Ilebo, towards source of the Mishibu, 4°25'S 20°35'E (st, 28.12.1951); *Lynes 193* (BR, FHO): Luebo, 5°20'S 21°24'E (fr, 02.11.1933); *Renier 86 A* (BR): Kikwit, bank Kwilu river, 5°02'S 18°48'E (st, 16.06.1946); *Renier 121 B* (BR): Kikwit, 5°02'S 18°49'E (st, ?); *Sapin s.n. (2)* (BM, BR, K): Illongonga, 4°57'S 19°18'E (fr, 12.1907); *Tailfer 73* (BR, K): Patambalu, 2°15'S 18°19'E (fr, 10.05.1958); *Vanderijst 10356* (BR, WAG): Ipamu, 4°07'S 19°37'E (st, 08.1921).

Aphanocalyx pectinatus (A. Chev.) Wieringa comb. nov. Fig. 10.8: 9–17, Map 10.7

Basionym: *Monopetalanthus pectinatus* A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 26: 593 (1946).

Monopetalanthus pectinatus A. Chev.: Chevalier, 1946: 593, pl.14A; Pellegrin, 1949: 75 p.p.; Aubréville, 1968: 310, pl. 79. **Type**: *Le Testu 6069* (lecto (see notes): P; iso-lecto: B, BM, BR, K, MO, WAG) — "Gabon (Haute Ngounyé) Comi Mavaco. 9 Septembre 1926".

Monopetalanthus spec.: Harms, 1897: 195.
Monopetalanthus microphyllus auct. non Harms: Pellegrin, 1942: 120 p.p.

Medium-sized (or large?, see notes) tree, at least up to 20 m tall. **Bole** in young trees cylindrical, irregular when mature but cylindrical at base, DBH up to at least 30 cm. **Bark** thin, up to 8 mm thick: surface in young trees smooth, in older ones scaly, pale grey to grey-brown; outer bark c. ½ mm thick, creamy brown; inner bark fibrous, pinkish with reddish rays, innermost layer creamy. Sapwood in dry condition creamy.

Twigs smooth but lenticellate, reddish brown, fairly densely to very densely, short to long, brown velvety to tomentose, old branches becoming whitish, glabrescent. **Stipules**

fused, persistent, obovate, with an auriculate base, the distal halves (at least of the most distal stipules of a shoot) enlarged and appearing inflated, 14–31 x 2½–13 mm, first wine-red, rapidly turning medium to reddish green with a red apex, soon becoming entirely brown, most parts with parallel veins, inflated areas and the auricle with a reticulate venation, outside glabrous to sparsely pubescent but more densely pubescent, puberulous or even villous at the apex and along the central-axis of the individual stipules, inside glabrous, margins shortly ciliate. **Leaves** 4–13 cm long, 19–34-jugate, largest leaflet situated at about the middle: **Petiole** ½–2 mm long, velvety, completely consisting of the joint. **Rachis** 3–12 cm long, upper side glabrous to fairly densely tomentose-velvety, often with a tuft of long hairs in between each pair of leaflets, lower side very densely velvety, usually mixed with very long hairs, broadly elliptic to rounded triangular in cross-section, often geniculate and slightly inflated on the transition between petiole and rachis, this part often with two pairs of leaflets, ratio 1st internode : 4th internode = 0.32–0.67. **Leaflets** leathery, upper surface glossy, medium to dark green, glabrous; lower surface dull to fairly glossy, greyish green, in young leaflets fairly sparsely, long to very long, white villose, glabrescent; margins very long pale brown ciliate, glabrescent but sometimes partly persistent on the distal margin; distal half completely reduced or composed of a minute lobe near the base; apex rounded to acute, usually acuminate in an up to 1.4 mm long glandular mucro. Young leaflets pink with a pale green primary nerve. **Basal leaflet** with its distal margin at right angles to the rachis to up to 100° reflexed, the proximal margin often aligned with the petiole or covering it and overlapping the opposite leaflet, half-elliptic to half-obovate, 4½–10(–12) x 1½–3½(–4½) mm: base of proximal half cuneate, not auriculate. **Apical leaflet** half-oblong-obovate to narrowly oblong, (3–)5–10(–16) x (0.7–)1–2½(–3½) mm: sometimes auriculate, auricle up to 0.6 mm long. **Largest leaflet** narrowly half-oblong, 7–17(–21) x 1½–4 mm, usually auriculate, auricle up to 0.8 mm long. **Gland pattern**: basal leaflet with 0–3 glands. Second leaflet with 0–4 glands. Third leaflet with 0–1(–3) glands. Apical leaflet with 0–4 glands. Other leaflets with 0–1(–2) glands, those with glands always close to the base or to the apex.

Inflorescence in the axils of the youngest shoots (= up to 16 nodes), a simple raceme, 1(–2) per axil, 2–4½ cm long and 10–40-flowered. **Rachis** 16–38 mm long, very densely, long brown velvety, with up to 18, often persistent, scale-like 'bracts' below the flowers. **Bracts** caducous, ovate, 4–6 x 2½–5 mm, densely parallel-veined, outside mixed long and very long appressed velvety with pubescent and puberulous, but becoming glabrous towards the lateral margins, inside glabrous, margins shortly ciliate. **Pedicel** 4–5½ mm long, long brown velvety-tomentose. Hypanthium s.l. 0.3–0.7 mm high. **Bracteoles** assuming a 80–95° wide angle at anthesis, 5½–6½ x 3–4 mm, outside fairly densely shortly and long velvety, along the midrib also very long velvety, at the apex bearded, inside glabrous, margin chaffy. **Sepals** outside fairly densely velvety-pubescent, inside glabrous, margins shortly (rarely long) ciliate. **Adaxial sepals** free, oblong to ovate, 1.1–2.3 x 0.3–1.5 mm. **Lateral sepals** wanting, rarely present and then only 0.1 x 0.1 mm or indicated by some hairs. **Abaxial sepal** oblong to obovate, 0.6–2.7 x 0.3–1.5. **Adaxial petal** spatulate, 6½–9½ x 4½–7 mm, both sides glabrous, margins glabrous, apex usually deeply emarginate, claw 2–3½ mm long. **Lateral petals** usually vestigial, rarely developed or wanting, linear, rarely spatulate, up to 7 x 2½ mm, glabrous. **Abaxial petals** wanting. **Stamens** 10: filaments 7–10½ mm long, 9 united over a length of 0.8–1.1 mm, entirely glabrous; anthers 1.4–1.5 mm long. Pollen described by Fasbender (1959). **Ovary** 2.3–3.5 x 1.3–1.7 x 0.8–1.3 mm, never depauperate, long to very long, very densely velvety, with

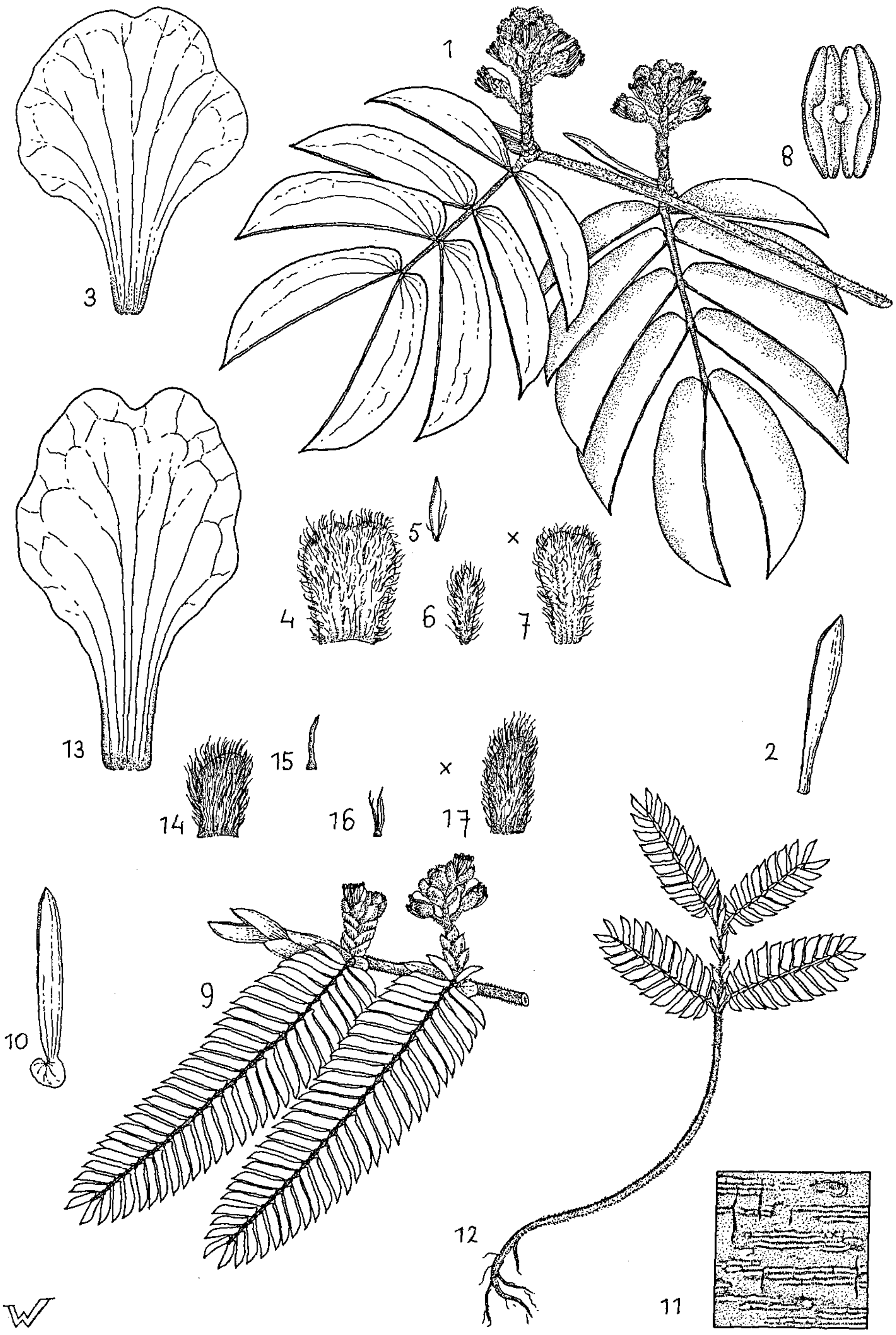


Figure 10.8. *Aphanocalyx jenseniae* (Gram) Wieringa (1–8) and *Aphanocalyx pectinatus* (A. Chev.) Wieringa (9–17). — 1: twig with leaves and inflorescences (x⅔); 2: two fused stipules (x1); 3: adaxial petal (x4); 4: fused adaxial sepals (x4); 5: lateral petal (x4); 6: lateral sepal (x4); 7: abaxial sepal (x4); 8: anther from outside (x12); 9: twig with leaves and inflorescences (x⅔); 10: two fused stipules (x1); 11: bark surface (x1); 12: seedling (x⅔); 13: adaxial petal (x6); 14: adaxial sepal (x6); 15: lateral petal (x6); 16: lateral sepal (x6); 17: abaxial sepal (x6). — 1–8: *Jensen 25*; 9, 10: *Breteler, Wieringa & Nzabi 13282 & Le Testu 6069*; 11: *Wieringa & v.d. Poll 1500*; 12: *Wilks 1965*; 13–17: *Le Testu 6069*.

2 ovules; stipe 1.3–1.8 mm long, long velvety except for the glabrous base. **Style** 6–8 mm long, inserted at an angle of 30–50°, long velvety in the lower half on the abaxial side; stigma heart-shaped.

Pods (see notes) most probably densely velvety; upper suture winged (ovary already winged). **Seeds** unknown.

Seedling: Germination epigeal. **Hypocotyl** 6–8 cm long, fairly dense, long to very long velvety. **Epicotyl** 0.1–0.4 cm long, long to very long velvety. First pair of leaves opposite, 11–18-jugate, with the first pair of leaflets wanting (the first pair present is not inserted directly after the rachis joint). Subsequent leaves alternate, at first usually with a decreasing number of leaflets.

Distribution: Map 10.7. Possibly restricted to the southern interior part of Gabon. However, the collection *Camp s.n. (1)*, which probably also belongs to this species, originates from "Congo", which is in the case of captain J.H. Camp usually interpreted as Congo (Kinshasa). Another collection of Camp has been referred to as from Bas-Congo (Léonard, 1952: 326).

According to Maley et al. (1990: 352) and Sita & Moutsambote (1988) this species occurs also at Kouyi (Congo (Brazzaville), near the border with Gabon). Although this record fits well the known distribution of the species, this record is probably based on *Sita 4933*, which in fact belongs to *A. microphyllus* subsp. *microphyllus*.

Vernacular names: Gabon: Kogo (Mitsogho) (see notes).

Ecology: A tree of primary lowland or sub-mountain rain forest at 300 to 840 m altitude. Aubréville (1968: 305; 1970: 278–279) claims this species is exclusively riverine, however, all records so far are from dry-land forest. It has never been reported as growing gregariously.

Between the persistent stipules ant nests have been observed.

Phenology: Flowering has only been observed once: at the beginning of September in Gabon, that is just before or at the start of the rainy season.

Chemistry: Flowers produce after some time a weak yellow colour in spirit.

Diseases and pests: None reported.

Uses: None reported.

Notes: At first sight it seems that Chevalier only cites one specimen in his protologue. However, he writes: "Hte Ngounié Comi Mavaco (G. Le Testu, n° 6069), Lastourville (Le Testu)" and thus in fact cites **two** collections, but forgets to give the number for the second one. It is not hard to determine that the second collection concerns *Le Testu 8824*, the only collection of Le Testu from around Lastoursville that has been (mis-)identified in the past as belonging to this species. However, since Chevalier cites two collections, they both qualify as syntypes. Aubréville (1968: 310) is the first to choose a type when he mentions *Le Testu 6069* (P) as holotype, and we should consider this as a lectotypification.

Harms's (1897: 195) reference to material of the Congo he has seen in Brussels of another species probably belonging to *Monopetalanthus* can only apply to *Camp s.n. (1)*. This specimen indeed bears notes in his handwriting.

No record of the height and diameter was made for the only flowering collection of this species. The only values that are available are from saplings and probably immature trees. The species may well prove to become considerably taller and thicker as may be apparent from the description. According to the field notes of Camp (*s.n. (1)*) "the tree has a large size". The largest known values for this species (and notes about the pods and the vernacular name) were copied from the field-book notes belonging to *Wilks 1964*. The material matching these notes has not been studied: Wilks has sent it to P, where it could not be traced. The sample, together with the seedlings found below the tree (*Wilks 1965*), was identified as *Monopetalanthus microphyllus* by J.J. Floret. However, since it concerned poor material, and the seedlings are now considered to belong to *A. pectinatus*, it is almost certain that *1964* belongs to this species as well. The identity of the collection of J.H. Camp (*s.n. (1)*) is less certain. Although it will perfectly key out as *A. pectinatus*, this rather poor sample has some minor tendencies towards *A. obscurus*. Most suspicious, however, is its apparent origin from Congo (Kinshasa).

Shoots of this species first bear some leafless stipules at the base which do not possess an auriculate base, followed by reduced leaves with sometimes as few as only 4 jugae. Such leaves and stipules are not included in the description.

Shade leaves of young trees tend to be larger than supposed sun leaves. Sizes from such leaves are put between brackets.

A. pectinatus is in many aspects very similar to *A. obscurus*. The main difference is found in the leaflets: *A. pectinatus* has in general more pairs of and much narrower leaflets than *A. obscurus*. Also the flowers show some differences: *A. pectinatus* has free adaxial sepals, and lateral petals are usually present, whereas *A. obscurus* has fused adaxial sepals and lacks lateral petals. However, since flowers of both species are only known from one collection each, no hard conclusions may be drawn from these observations.

Specimens examined:

GABON: *Breteler, Wieringa & Nzabi 13282* (WAG): 34 km SE Bambidie, 0°56'S 13°13'E (st, 14.10.1994); *Le Testu 6069* (B, BM, BR, K, MO, P, WAG) type: Ht Ngounyé, Comi Mavaco, betw. sous-Tounelei and Ipsnugou, 1°19'S 11°21'E (fl, 09.09.1926); *Wieringa & v.d. Poll 1500* (LBV, WAG): 75 km on the road Lastoursville to Moanda, 3 km for Pouby, 1°16'S 13°02'E (st, 27.08.1992); *Wieringa, van Nek & Moussavou 3102* (WAG): 13 km on road Etéké to Ovala, Nyongué, 1°26'S 11°26'E (st, 08.11.1994); *Wilks 1965* (WAG): Chaillu massif, 8 km N of Massima, 1°22'S 11°36'E (st, 28.06.1989).

CONGO (KINSHASA): *Camp s.n. (1)* (BR) id. doubtful: ?, not located (st, 189?).

Aphanocalyx pteridophyllus (Harms) Wieringa comb. nov.

Fig. 10.6: G & H, Map 10.8

Basionym: *Monopetalanthus pteridophyllus* Harms in Engl. & Prantl, Pflanzenfam. Nachtr. 1 (II–IV): 195 (1897).

Monopetalanthus pteridophyllus Harms: Harms, 1897: 195 (as *M. Pteridophyllum*); Harms, 1899: 265–266; Stapf, 1906: 600; Hutchinson & Dalziel, 1928a: 342; Baker, 1930: 734–735 p.p.; Dalziel, 1937: 198; Pellegrin, 1942: 119 p.p.; Léonard, 1952: 443–444 p.p.; Keay, 1958: 447–478; Voorhoeve, 1965: 206–208 & fig. 34.G; Kunkel, 1965: 142–143; Aubréville, 1968: 308 p.p.; Fox, 1967: 64; Burkill, 1995: 139 p.p. **Type:** *Dinklage 1720* (holo: B†; lecto (designated here): K (fragments); sketch in BM) — "Grand Bassa, Liberia 1896".

Small to medium-sized tree, 6–30 m high, often overhanging when along a river; crown broad, but irregular due to early branching trunk. **Bole** DBH up to 45(–75) cm: sometimes with small buttresses. **Bark**: surface grey.

Twigs smooth with lenticels, reddish brown to pale grey, glabrous, rarely sparsely puberulous or fairly densely velvety; young shoots velvety. **Stipules** fused, persistent, ovate with an auriculate base, especially in the more distal stipules of a shoot the distal half enlarged, especially from just above the base to about the middle, the fused stipules thus appear inflated, 20–56 x 4–18 mm, brown to greyish brown, the parallel veins somewhat spaced at base with distinct tertiary venation in between, towards the apex with many closely spaced parallel veins, outside puberulous to pubescent, the longer hairs more frequent near the base and on the veins, slowly glabrescent, inside glabrous to sparsely pubescent, especially near the base, margins sparsely shortly or long ciliate. **Leaves** 6–24(–28) cm long, (9–)12–22-jugate, largest leaflet situated at or just before the middle: **Petiole** 3–7 mm long, velvety, almost completely consisting of the wrinkled joint. **Rachis** 5–21(–25) cm long, dark brown, velvety, lower side usually slightly denser velvety and sometimes also with appressed long hairs, terete, in dry condition sometimes flattened above and with a grooved ridge, on the transition between petiole and rachis often geniculate and slightly inflated, this part with a single pair of leaflets, ratio 1st internode : 4th internode = 0.45–0.90. **Leaflets** (thick) leathery, upper surface rather dull, bright to dark green, glabrous, lower surface dull, pale or light green, glabrous but young leaflets often sparsely pubescent or sparsely villous on both sides (especially near the base); margins short and long ciliate, glabrescent; distal half completely reduced, however, sometimes anomalously present in the apical leaflet; apex rounded, but the primary nerve often ending in a conspicuous, up to 1.9 mm long glandular mucro. **Basal leaflet** with its distal margin at right angles to the rachis to up to 30° reflexed, half-obovate, 8–22 x 2½–12 mm: base of proximal half cuneate, not auriculate. **Apical leaflet** half-obovate to half-oblong-obovate, 8–26(–37) x 2½–9(–11) mm: base of proximal half sharply angled, sometimes auriculate, auricle up to 0.3 mm long. **Largest leaflet** half-oblong-obovate, 13–43 x 4–13 mm: base of proximal half rectangular to sharply angled, often auriculate, auricle up to 0.9(–1.6) mm long. **Gland pattern**: basal leaflet with (1–)3–11 glands. Second leaflet with 0–3(–7) glands. Apical leaflet with 0–2 glands. Other leaflets with 0–2 glands.

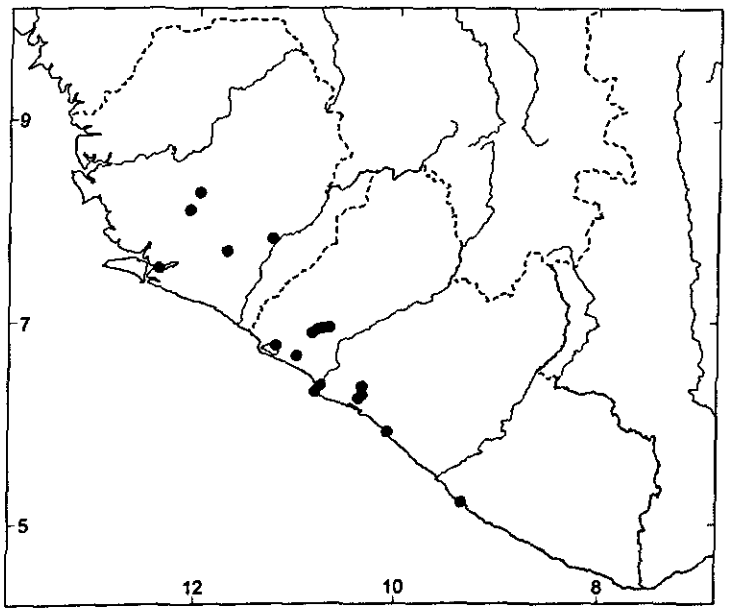
Inflorescence in the axils of the youngest shoots (= up to 12 nodes), often also on older shoots, a simple raceme, 1–4 per axil, 2–7 cm long and 15–50-flowered. **Rachis** 16–66 mm long, 1.6–2.7 mm thick, brown velvety. **Bracts** caducous, ovate, 4–7 x 3½–7 mm, densely parallel-veined, outside mixed (appressed) velvety and puberulous, becoming glabrous towards the lateral margins, inside glabrous, margins shortly ciliate. **Pedicel** 4½–9 mm long, brown velvety. Hypanthium s.l. 0.5–1.3 mm high. **Bracteoles** assuming a 40–70° wide angle at anthesis, 7½–11 x 4–6 mm, whitish, outside short and long brown velvety and especially along the midrib very long velvety, inside glabrous to sparsely white pubescent, especially along the margin, margin chaffy. **Sepals** outside short, long or very long velvety to pubescent, inside pubescent, margins long to very long ciliate. **Adaxial sepals** usually fused, together rectangular to heart-shaped or swallowtail-shaped, 2.6–4.9 x 2.2–4.8 mm, apical margin emarginate to incised to about halfway, rarely not fused and then those sepals ovate or triangular, c. 3 x 1½ mm, apex acute. **Lateral sepals** variable, slightly reduced to wanting, obovate, oblong or spatulate, up to 3.7 x 1.7 mm, when very small the pubescence reduced to the bearded apex, apex rounded. **Abaxial sepal** always present, but very variable in size, triangular or obovate to oblong, 0.1–4.5 x 0.1–1.6 mm, the smallest sizes coincide with wanting lateral sepals. **Adaxial petal** spatulate, 9–13 x 4–10½ mm, white, both sides (very) sparsely pubescent, margins glabrous but at the apex often with a few hairs, claw inrolled into a tube, 4–6 mm long. **Lateral petals** usually wanting, sometimes vestigial, linear, up to 3.5 x 0.5 mm, glabrous. **Abaxial petals** usually wanting, rarely vestigial, linear to triangular, up to 1.7 x 0.4 mm, glabrous. **Stamens** 10: filaments 15–21 mm long, 9 united over a length of 1.4–2.7 mm, white, *entirely glabrous*; anthers 1.6–2.1 mm long, yellow. **Ovary** 2.7–4.5 x 1.4–2.5 x 0.8–1.7 mm, never depauperate, very long brown velvety, with 2 ovules; stipe 1.9–3.5 mm long, velvety except for the very base. **Style** 10–13 mm long, inserted at an angle of 0–45°, white, long velvety at the very base and in the lower half on the abaxial side; stigma heart-shaped.

Pods 1–2-seeded, oblong-obovate or obovate, 4–6½ x 2.0–3.1 x 0.3–0.5 cm, green to reddish brown, short to long brown velvety, sparsely mixed with some very long (pale) brown hairs; beak 0–2 mm long; upper suture winged, but often indistinct, 3–5½ mm wide; nerve usually distinct, running at about ¼ of the width from the upper suture, u/w = 0.20–0.38; stipe 2½–5 mm long, pedicel 4–9 mm long. **Seeds** (broadly) obovate to oblong, 13–19 x 9–18 x 3–5 mm, 0.28–0.82 g in dry condition; testa rather thin but not membranous, dull, dark brown.

Seedling: Germination epigeal. **Hypocotyl** 10–12 cm long, fairly densely long to very long velvety. Cotyledons *clasping the base of the first leaf pair*. **Epicotyl** 0.2–0.5 cm long, very long velvety. First pair of leaflets opposite, 10–13-jugate, with the first pair of leaflets wanting (the first pair present is not inserted directly after the rachis joint and has the gland pattern and shape of the second pair).

Distribution: Map. 10.8. Sierra Leone to Liberia, mostly along the coast. In Sierra Leone the species occurs also quite far inland, but further to the south-east it seems more restricted to the coast. An explanation for this may lie in a restriction by altitude; the north-eastern limit of the distribution range shows a remarkable resemblance to the 200 m altitude line.

Vernacular names: Sierra Leone: Ansas (Temne), Gumni, Neyei (Mende).



Map 10.8. Distribution of *Aphanocalyx pteridophyllus* (Harms) Wieringa: Sierra Leone and Liberia.

Ecology: A tree of riverine forest, often along and hanging over a river, occurring even along river with brackish water. On sandy soils. According to Voorhoeve (1965: 208) also occurring in small groups in evergreen (dryland?) forest. Ranging from 0–150 m altitude.

In between the persistent stipules ants build their nests.

Phenology: Flowering takes place during the rainy season in July and August. Very young pods were collected in September, many immature pods have been collected in November, while mature pods have been observed in February and were collected in early March. Maturation time of the pods is hence about 7 months.

Chemistry: Flowers produce no or a weak yellow-brown colour in spirit.

Diseases and pests: None were observed.

Uses: According to *Deighton 1209* (also copied by Fox, l.c. and Burkill, l.c.) the seeds are edible, the pulverised bark is used as a poultice for a skin disease (craw-craw) and canoes are being made from the trunk. According to Kunkel (1984) *Monopetalanthus* is being eaten; he does not cite which species or which part, possibly this reference also refers to the remark of Deighton. Mayer (1951: 66) classifies this species as a "Class III" species, meaning it had at that time no commercial value, but was considered promising.

Notes: The type-label as mentioned in the header is that from the Kew specimen. The label on the holotype reads according to Harms (1899: 266): "Liberia: Grand Bassa; St. Johnsriver, Flussufer in der Brackwasserzone, 16. August 1896". In the actual protologue (Harms, 1897: 195; descriptio generico-specifica, see article 42.1 of ICBN) Harms does not fully cite the type. However, he does state it was collected by Dinklage, which reference I consider to be enough to recognize *Dinklage 1720* (B) as holotype.

Stapf (1906: 600) cites *Dinklage 1700* and not *1720*. I interpret this as a typographical error.

According to Voorhoeve (l.c.) the larger bole diameters of up to 75 cm occur when the trees do not grow along rivers.

The inflorescences of this species are simple, but are in fact compound racemes reduced to a single branch. In some inflorescences dormant buds of side axes can be found towards the base of the peduncle.

There are two independent records of the trunk being spiny. First Hutchinson & Dalziel (1928a: 342) state this in their very brief description. However, their source is not clear since on neither of the two exsiccatae cited (at least not on the Kew sheets) this character is mentioned. Another possibility could be that the feature was mentioned on the destroyed holotype sheet from B, however, since a duplicate was present in K, and Harms does not mention this character in either of his two descriptions, this seems unlikely. The second time it is mentioned is on the label of *Small 836* (collected after 1928). This collection, however, merely consists of some pods picked from the forest floor and was at first identified as *Hymenostegia emarginata*. Voorhoeve identified the pods correctly as belonging to *M. pteridophyllus*, but stated that the "note refers to *Plagiosiphon emarginatus*", which does have a spiny trunk (at least in West Africa). Since no spiny trunks have been observed in other species of the genus, it is unlikely that this species would possess this character.

According to Harms (1897: 195; 1899: 266) the ovary may also have 3 ovules. However, in the 25 flowers from 8 different specimens studied for this character always 2 ovules have been observed, nor did any of the studied pods show any sign of a third ovule.

Specimens examined:

SIERRA LEONE: *Anonymous s.n. (1)* (BR) id. doubtful: Njala (seeds ex BRLU), 8°07'N 12°05'W (st, 16.03.1955); *Dawe 562* (K): Njala, Taia River, 7°32'N 12°23'W (st, 08.1923); *Deighton 1209* (BM, BM, K, MO): Njala, 8°07'N 12°05'W (fl, 14.08.1928); *Deighton 6150* (B, BR, EA, K): Njala, Kori, 7°43'N 11°42'W (fr, 30.11.1954); *Small 735* (B, K, MO, P): Gola forest, Pewa, 8°17'N 11°59'W (st, 03.06.1952); *Small 836* (K): Kambui Hills South, 7°50'N 11°15'W (fr, 05.11.1952).

LIBERIA: *Adam 21724* (MO, PRE): Monrovia, Firestone, 6°22'N 10°20'W (st, 13.07.1965); *Baldwin 11099*

(K, MO, US): Montserrado Co., Harbel, by Farmington River, 6°17'N 10°20'W (fl, fr, 01.03.1948); *Bos 2100* (BR, K, WAG): NE of Bomi Hills, Gola Nat. Forest, bank of Budula creek, 6°57'N 10°40'W (fl, 23.07.1966); *Dinklage 1720* (BM (drawing only), K) type: St. John's River, Grand Bassa, 5°55'N 10°05'W (fl, fr, 16.08.1896); *Dinklage 2924* (A, B, BR, P, Z): Monrovia, King's Farm, muddy bank of branch Mesurado river, 6°23'N 10°45'W (fl, fr, 11.11.1923); *van Harten 205* (K, WAG): Bomi Hills, near Mahe river, 6°56'N 10°47'W (fr, 08.11.1963); *J.W.A. Jansen 979* (BR, WAG): Goodrich bridge, 6°40'N 11°00'W (fl, fr, 26.09.1968); *J.W.A. Jansen 2244* (WAG): Bendu, along road to Lake Piso, 6°46'N 11°13'W (fl, fr, 04.11.1970); *Mayer 99* (MO, US): Eastern province, near Sangwin, Sangwin river drainage, 5°13'N 9°21'W (st, 01.05.1948); *Straub 866* (US): Monrovia, 6°19'N 10°48'W (st, 01.1894); *Voorhoeve 60* (BR, FHO, LG, MO, P, WAG): Bomi Hills, Gola nat. forest, 6°57'N 10°44'W (fl, 20.08.1960); *Voorhoeve 831* (P, WAG): Bomi Hills, 6°54'N 10°50'W (st, 25.02.1962); *Voorhoeve 1042* (WAG): 12 km NE Bomi Hills, on border of Maher river, 6°56'N 10°47'W (st, 15.04.1962); *Voorhoeve 1194* (B, BR, G, K, LG, LISC, M, MO, SRGH, WAG (+alc)): Robertsfield airfield, 6°15'N 10°22'W (fl, 21.08.1962); *Voorhoeve s.n. (2)* (WAG): ?, not located (st, 14.08.1960); *Voorhoeve s.n. (4)* (WAG): from seeds from Bomi Hills, 6°54'N 10°50'W (st, 03.03.1962); *Voorhoeve s.n. (5)* (WAG): ?, not located (fr, 1961).

***Aphanocalyx richardsiae* (J. Léonard) Wieringa comb. nov. Fig. 10.9, Map 10.9**

Basionym: *Monopetalanthus richardsiae* J. Léonard in Exell & Mendonça, Consp. Fl. Angolensis: footnote p. 204 (1956).

Monopetalanthus richardsiae J. Léonard: Léonard, 1956; Exell & Hillcoat, 1956: 204; Léonard, 1957: 257–260 & photo 22; Devred & Bamps, 1960: 114, fig. 18E; White, 1962: 126; Brenan, 1967: 196–198 & fig. 42; Gunn, 1991: 386–387. **Type**: *Richards 4483* (holo: K, iso: B, BM, BR, EA (n.v.), LISC, SRGH) — Zambia: "Northern Rhodesia. Abercorn district: Inono stream, close to Mpulungu road. 1200 m."

Monopetalanthus leonardii Devred & Bamps: Devred & Bamps, 1960. **Type**: *A. Léonard 3331* (holo: BR, iso: C, K, YBI (n.v.)) — Congo (Kinshasa): "6/3/59 Altitude: 1.000 M. Bunyakiri Terr. Kalehe. Forêt à Julbernardia et Staudtia.".

Aphanocalyx sp.: Léonard, 1952: 441 p.p.

Shrub or small to medium-sized tree, 3–25 m high; crown large, spreading. **Bole** contorted, branchless for up to 3 m (or more?), DBH 20–65 cm: base with small buttresses. **Bark** up to 7 mm thick: surface smooth to irregular, scaly, yellow-brown to light grey, sometimes with horizontal lines; outer bark very thin; inner bark brownish pink, smells like rosewood (*Dalbergia* or *Pterocarpus*).

Twigs smooth, with few to many lenticels, dark grey, later pale to dark grey or greyish brown, usually glabrous, sometimes, especially in saplings and young trees, sparsely to fairly densely brown velvety. **Stipules** fused, early caducous, ovate or obovate to spatulate, 6–11 x 0.8–2.5 mm, with many parallel veins, outside glabrous or rarely velvety to pubescent along the (fused) distal margin, inside glabrous, margin shortly to long ciliate. **Leaves** 1–13 cm long, 1-jugate: **Petiole** 1½–7 mm long, glabrous to fairly densely velvety (similar to the indumentum of twigs), glabrescent, for the major part consisting of the wrinkled joint, towards the apex usually smooth and on the lower distal side often with a slightly swollen, paler area in dry condition. **Rachis** absent (but see seedling). **Leaflets** half-ovate, 9–130 x 5–41 mm, thin to thick leathery, upper surface dark green, glossy to dull?, lower surface pale green, fairly dull, both sides glabrous but in saplings lower side often sparsely velvety, especially on the veins, glabrescent; margins glabrous or shortly to long ciliate, glabrescent but along the distal margin the indumentum sometimes persistent; distal half completely reduced or composed of a small lobe near the apex; apex rounded to acute or acuminate, sometimes terminating in a black dot, possibly a hydathode; base cordate, rounded or cuneate, rarely auriculate, auricle up to 0.4(–0.6) mm long. Young leaves whitish to pinkish, later pale green. **Gland pattern**: 0–6(–10) glands along the proximal margin of the leaflet of which the first 1 or 2 are often proximate to or are even imbedded in the margin.

Inflorescence in the terminal 1–11 axils of the youngest shoots, rarely some in those of the previous growth phase, 1–2(–3) per axil, a (rarely) compound or a simple raceme with up to 4 branches, 1–4 cm long and 8–40-flowered. **Rachis** 5–34 mm long, brown velvety; "peduncle" when developed usually more or less glabrous, with 4–20 scale-like 'bracts' below the flowers. **Bracts** caducous, ovate, 2½–5 x 2½–5½ mm, densely parallel-veined, outside usually only in a distinct central band short (rarely long) appressed velvety, rarely completely so, inside glabrous, margins shortly (rarely long) ciliate and with c. 0.05 mm long teeth (glandular cells?). **Pedicel** 3–6½ mm long, short to long brown tomentose-velvety. Hypanthium s.l. 0.2–0.6 mm high. **Bracteoles** assuming a 110–140° wide angle at anthesis, 4–7½ x 3–5 mm, white, outside short to long brown velvety, usually mixed with pubescent or tomentose indumentum, inside glabrous or sparsely pubescent, margins chaffy. **Flowers** sweet fragrant. **Sepals** outside usually glabrous, sometimes sparsely pubescent, inside glabrous, rarely sparsely pubescent, margin glabrous to long ciliate. **Adaxial sepals** free or fused, sometimes one or both wanting, fused ones 0.5–2.3 x 1.0–1.8 mm, free ones triangular or ovate to obovate, 0.05–3.0 x 0.1–1.7. **Lateral sepals** wanting. **Abaxial sepals** sometimes wanting, when present elliptic, oblong, triangular or linear, 0.1–2.9 x 0.2–1.3 mm. **Adaxial petal** spatulate, limb usually circular, 4½–7 x 3½–6½ mm, white, outside usually glabrous, sometimes sparsely pubescent, inside glabrous, very rarely with some short hairs, margins glabrous, claw 1–2 mm long, with somewhat inrolled margins. **Lateral petals** wanting or vestigial, triangular or oblong to linear, up to 1.1 x 0.3 mm, glabrous. **Abaxial petals** usually wanting, rarely vestigial, triangular, up to 0.1 x 0.2 mm, glabrous. **Stamens** 10 (–12, anomalous and petaloid): filaments 5½–11 mm, 9 united over a length of 0.3–1.0 mm, adaxial one free, at base fused with the stipe, entirely glabrous or outside with a few short hairs, adaxial one sometimes with a few hairs inside; anthers 0.9–1.5 mm long, often with remains of dorsal teeth. **Ovary** 1.5–3.2 x 1.0–1.8 x 0.5–0.8 mm, rarely depauperate and only c. 0.8 x 0.4 x 0.3 mm, green, long to very long brown velvety, with 2(–3) ovules; stipe 0.9–1.7 mm long in bisexual flower, 0.7 mm long in male flowers, shortly to long velvety except for the very base. **Style** 7–9½ mm long in bisexual flowers, ½ mm long in male flowers, inserted at an angle of 20–70°, at base long velvety becoming sparser to the apex, very apex glabrous; stigma broadly elliptic.

Pods 0–2(–3)-seeded, oblong-obovate, rarely ovate, 2.0–3.8 x 1.2–2.2 x 0.15–0.4 cm, surface granulate, dull to glossy, green when immature, becoming brown to reddish brown or blackish when mature, sparsely long to very long velvety, glabrescent; beak 0–2½ mm long; upper suture not to obscurely winged, 1–4 mm wide; nerve distinct, usually prominent and up to 1.5 mm elevated from the surface, running in upper half of the pod, u/w = 0.17–0.41, very rarely with a second, indistinct nerve above the main one, u/w = 0.15; stipe 1–3(–5) mm long; pedicel 1½–8 mm long. **Seeds** obovate, 7½–14 x 5–12 x 1.4–2.7 mm, 0.1–0.2 g in dry condition, margin slightly accrescent; testa papery, fairly dull to glossy, brown.

Seedling: Germination epigeal. **Hypocotyl** 3–9 cm long, long to very long velvety. **Epicotyl** 0.05–0.3 cm long, long to very long velvety. First pair of leaves opposite, 2-

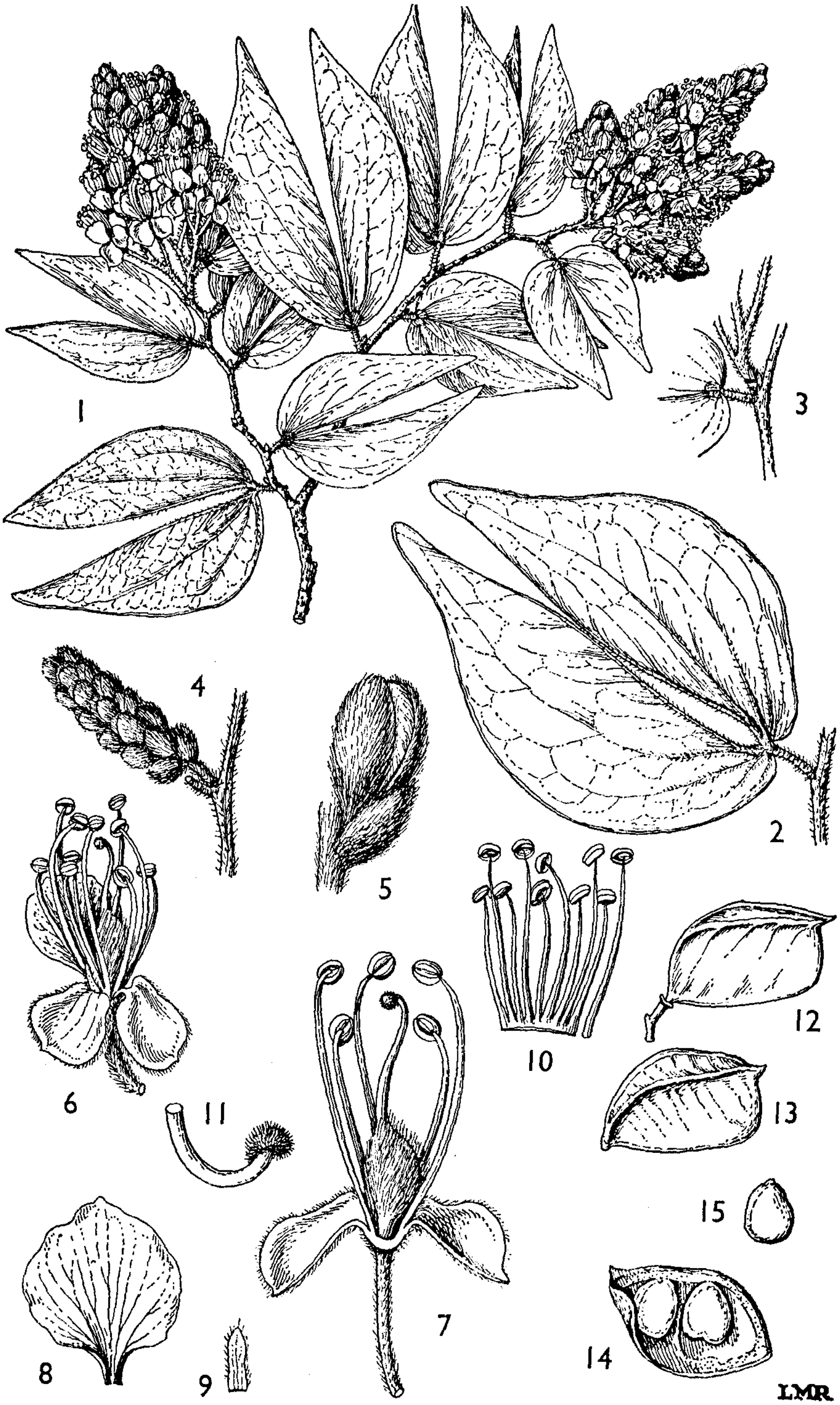


Figure 10.9. *Aphanocalyx richardsiae* (J. Léonard) Wieringa. — 1: twig with leaves and inflorescences (x⅔); 2: leaf of young shoot from below (x⅔); 3: leaf and inflorescence insertion (x2); 4: inflorescence bud (x⅔); 5: just opening flower bud and its supporting bract (x4); 6: flower from abaxial side (x2); 7: longitudinal section of flower (x3); 8: adaxial petal from inside (x3); 9: abaxial (?) sepal (x3); 10: 9 basally fused and 1 free stamens (x2); 11: stigma (x8); 12 & 13: pods (x⅔); 14: inside of a pod valve showing seeds (x⅔); 15: seed (x⅔). — 1, 3, 5–11: *Richards 4483*; 2: *Richards 10203*; 4: *Lawton 150*; 12: *Glover in Brédo 6124*; 13–15: *Burtt 5995*. — Drawing by L.M. Ripley, reproduced from Brenan, 1967: 197 with permission of the Royal Botanic Gardens Kew.

jugate: rachis 4–8 mm long, upper surface sparsely velvety, lower side long velvety, in dry condition more or less terete with on the upper side a grooved ridge, leaflets of about equal size. Subsequent leaves alternate, 1-jugate, at first preceded by leafless stipules.

Distribution: Map 10.9. Southern and eastern Congo (Kinshasa), north-eastern Angola, northern Zambia and south-western Tanzania.

Vernacular names: Angola: Mukuzuma (Luachimo region). Congo (Kinshasa): Kambaraka (Kirega).

Ecology: Along rivers and permanent streams in savanna, often gregarious and dominant in riverine forests or becoming co-dominant next to *Syzygium* species. Also as a tree in dryland forest with *Julbernardia seretii*, *Staudtia gabonensis*, *Cynometra alexandri* and *Grossera multinervis* (around Shabunda, Congo (Kinshasa)). Altitudes range from 700–1500 m.

According to Grandvaux Barbosa (1970: 89) the species is characteristic for vegetation type 8.1: densely riverine rain forest.

Phenology: In Angola flowering is from November to December, whereas developing and nearly mature pods were recorded from March to May. In Tanzania, Zambia and near the border in S.E. Congo (Kinshasa) flowering is in January and February, developing and nearly mature pods were recorded from April to August, whereas mature pods were collected in September; young seedlings have been collected in October.

Around Shabunda, Congo (Kinshasa), flowering was observed in July, young pods in December and almost mature pods in February and March; young seedlings in March.

All these records point to a maturation time of about 8 months.

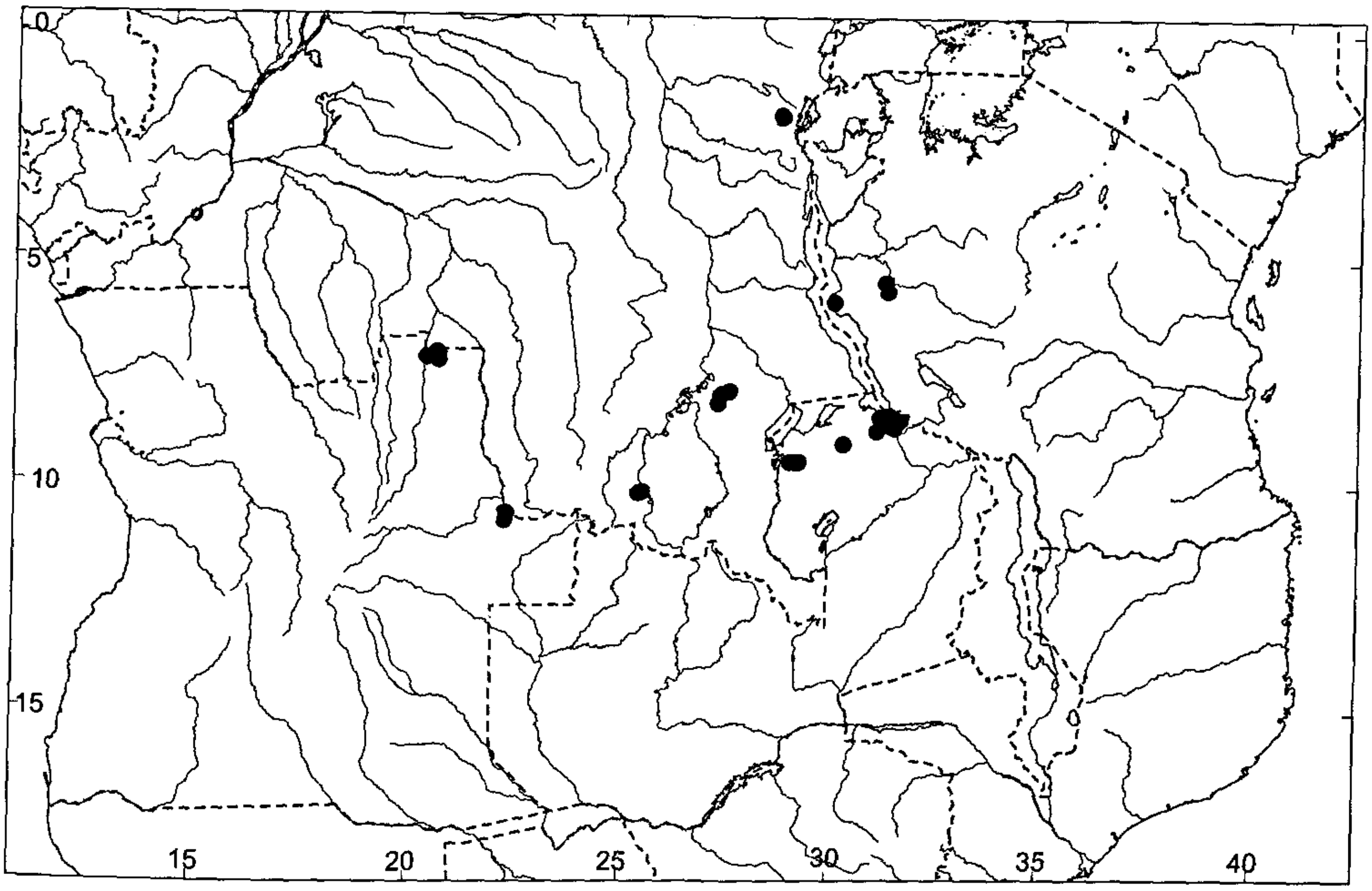
The flowering data seem to coincide with the rainy season.

Chemistry: Flowers produce no or a weak yellow-brown colour in spirit.

Diseases and pests: This species has similar galls (swollen twigs) as described for *A. djumaensis*.

Flower buds are attacked by weevils (Curculionidae), a hatching weevil (Rhynchaeninae?) was found in an old flower bud of *Léonard 2897* that had failed to open. Strikingly frequently nymphal jumping plant lice (Psyllidae) are being encountered in the flowers.

Notes: **1.** In a sterile state this species is not distinguishable from *A. djumaensis*, whereas in flowering condition they are also hard to tell apart. The only obvious characters are the nerve and the size of the pods. The oldest name available for these two taxa is *A. djumaensis*, so its type (*Gillet 2800*) becomes crucial for deciding which of both species should bear that name. Unfortunately the type consists of a leafless twig with a few very immature inflorescences, accompanied by a bag with some leaflets. The specimens of both species that *can* be identified (with pods) suggest that the two species are vicariants: one in the north-west and one in the south-east of Central Africa. Identifying the type by its provenance, however, is impossible since it originates from in between the two areas. If one had to guess to which of both species this type would probably belong, the more south-eastern species looks a little more likely based on the geography of the river-systems and the indumentum of the bracts. This would, however, have serious consequences for the



Map 10.9. Distribution of *Aphanocalyx richardsiae* (J. Léonard) Wieringa: Angola, Congo (Kinshasa), Zambia and Tanzania.

present nomenclature, as it would then belong to a species for which already two other names are available, leaving the other species nameless.

Fortunately, it proved to be possible to distinguish both species on the basis of the teeth on the margin of the bracts. All 9 gatherings of *A. richardsiae* that were checked show such teeth, whereas all 8 samples from *A. djumaensis* from its 'core-area' do not. *Gillet 2800* does not have toothed bracts, so it belongs to the north-western species. One might object that the teeth develop only in full-grown bracts, however, the bracts of the young inflorescence buds of *Lawton 979* **do** already show the teeth. Still, for a definite settlement of this question it is desirable that gatherings from the Kwilu valley with pods become available.

Léonard (1957: 260) gives some characters by which he claims to have been able to distinguish *Monopetalanthus richardsiae* from the type of *Aphanocalyx djumaensis*. Some of these observations are just wrong (*A. richardsiae* does have glands on its leaflets) whereas in other described characters the type of *A. djumaensis* is even more similar to *A. richardsiae* than to other *A. djumaensis* specimens (the indumentum of the bracts is strikingly similar to that of *Barros Machado s.n.* as cited by Léonard and the cuneate base of the leaflets is more typical for *A. richardsiae* than for *A. djumaensis*). I also cannot confirm the difference in nervation. On the basis of all the characters mentioned, Léonard could not have been able to distinguish the type of *A. djumaensis* from *A. richardsiae*. Hence it is remarkable that he even placed *A. richardsiae* in a different genus!

2. *Richards 10198* may represent a hybrid between this species and *A. trapnellii*, see notes below the latter.

3. The inflorescence of this species is usually a much reduced compound raceme resulting in a virtually simple raceme. The supporting "peduncle" has become very short and condensed. In some gatherings, however, it is still clearly present, often showing undeveloped buds of or more rarely true lateral branches. This character is especially

obvious in the collections formerly assigned to *M. leonardii* from eastern Congo (Kinshasa). However, it also appears in northern Angola (*Barros Machado s.n. 1*).

Specimens examined:

ANGOLA: *Barros Machado in Gossweiler 14223* (B, BM, P): Dundo, near Luachimo river, 7°24'S 20°50'E (fr, 03.1949); *Barros Machado 35* (LISC): Dundo, Foz of Dundundo river, 7°30'S 20°50'E (fr, 26.04.1949); *Barros Machado s.n. (1)* (BM, BR, K, P): Lunda, Dundo, Luachimo river, 7°24'S 20°50'E (fl, 30.11.1955); *Barros Machado s.n. (2)* (BM): junction of Luachima with Dundundo-river, 7°20'S 20°47'E (fr, 1954); *Fontinha in Gossweiler 14223 b* (BM): Dundo, 7°24'S 20°47'E (fr, 04.1949); *Sanjinje 48* (LISC): Luachimo post, Caluembe river, afl. do Chicapa, 7°26'S 20°34'E (st, 02.08.1961); *Sanjinje 442* (LISC): Dundo, Buena-Mai island in the Luachimo river, 7°30'S 20°50'E (st, 14.09.1954); *Sanjinje 443* (LISC, WAG): Dundo, Buena-Mai island in Luachimo river, 7°30'S 20°50'E (fr, 05.1954).

CONGO (KINSHASA): *Bamps & Malaisse 8180* (BR, WAG): 11 km road Nzilo to Kyamasumba, Luilu riverine forest, 10°30'S 25°24'E (fr, 19.01.1986); *Bamps 711* (BR): seedlings of Leonard 3331, 2°04'S 28°34'E (st, 15.09.1959); *Desenfans 3888* (BRLU, WAG): gallery of Kalumengongo on road Mandwe, 8°30'S 27°12'E (fr, 10.08.1953); *Desenfans s.n. (1)* (BRLU): Mitwaba, Mwema-Kalumengongo, 8°13'S 27°28'E (fr, ?); *Duvigneaud 4561* (BRLU): Katanga, betw. Nzilo and Delcommune, gallery forest with *Monopetalanthus*, 10°29'S 25°29'E (st, 13.12.1959); *Duvigneaud & Timperman 2451 M1* (BRLU): 29 km S of Dilolo, 10°56'S 22°21'E (st, 23.08.1956); *Duvigneaud & Timperman 2451 M2* (BRLU): 29 km S of Dilolo, 10°56'S 22°21'E (st, 23.08.1956); *Duvigneaud & Timperman 2453* (BRLU): Katanga, 50 km S of Dilolo, Katende, 11°06'S 22°19'E (st, 23.08.1956); *Huart 138* (BR, K, WAG): Mwema, Kalumengongo river, 8°13'S 27°28'E (fl, 20.01.1960); *A. Léonard 2227* (B, BM, BR, FHO, K, LISC, M, NY, P, SRGH): Tshabunda, 2°02'S 28°32'E (fr, 29.12.1958); *A. Léonard 2897* (BR, K): Kalehe, Bunyakiri, 2°04'S 28°34'E (fl, fr, 08.02.1959); *A. Léonard 3331* (BR (+alc), C, K) type of *M. leonardii*: Bunyakiri, 2°04'S 28°34'E (fl, fr, 06.03.1959); *A. Léonard 3331 bis* (BR): Kalehe, Bunyakiri, 2°04'S 28°34'E (st, 06.03.1959); *A. Léonard 5011* (A, BR, FHI, K, MO): Bunyakiri, 2°04'S 28°34'E (fl, 18.07.1959); *Malaisse & Robbrechts 2220* (BR, K): 25 km NNW Kolwezi, Luila valley, 10°30'S 25°24'E (st, 16.02.1982); *Pierlot 2913* (BR, K, WAG): 70 km road Kavumu to Walikale, Kando, Luhoho valley, 2°05'S 28°33'E (fr, 26.05.1959); *Schmitz 6664* (BR): Manda falls, 8°18'S 27°16'E (fr, 11.09.1959).

ZAMBIA: *Brenan & Greenway 8169* (FHO, K): 10 mls on road Mbala (Abercorn) to Mpulungu, 8°48'S 31°12'E (st, 20.10.1947); *Breteler 11923* (WAG): 10 km W Kawambwa, Ntumbachushi Falls, 9°48'S 28°53'E (st, 20.11.1992); *Bullock 3874 bis* (K): Lunzua river, 19 mls W of Mbala (Abercorn), 8°50'S 31°03'E (fr, 14.05.1953); *Burtt 5994* (BM, BR, K): Mbala (Abercorn), along Inono river on road to Mpulungu, 8°53'S 31°12'E (st, 07.05.1936); *Burtt 5995* (BM, BR, EA, K): Mbala (Abercorn), on way to Kambole mission, 8°46'S 30°55'E (fr, 30.05.1936); *Fanshawe 4343* (BR, FHO, K): Kawambwa, 9°47'S 29°05'E (fl, 12.01.1958); *Fanshawe 4919* (BR, K): Mporokoso, 9°22'S 30°06'E (st, 11.10.1958); *Fanshawe 5023* (BR, K): Kitwe, nursery. Orig. Kawambwa, 9°47'S 29°05'E (st, 25.11.1958); *Fanshawe 5148* (K): Kitwe, nursery. Orig. Kawambwa, 9°47'S 29°05'E (st, 29.08.1959); *Fanshawe 5208* (K): Kitwe, nursery. Orig. Kawambwa, 9°47'S 29°05'E (st, 12.09.1959); *Glover in Brédo 6124* (BM, BR, K): Mpulungu-road on Inono river, 8°53'S 31°12'E (fr, 13.07.1948); *Hornby 1015* (EA): Mbala (Abercorn), 8°50'S 31°22'E (fl, 30.03.1939); *Lawton 150* (K): Lunzua-Mishitu, Tiger point, 8°44'S 31°09'E (fl, 01.1955); *Lawton 161* (K): Lunzua Mushitu, Tiger point, 8°44'S 31°09'E (fr, 02.1955); *Lawton 964* (FHO): Kawambwa, 9°47'S 29°05'E (st, 15.08.1962); *Lawton 979* (FHO): Mbala (=Abercorn), 8°50'S 31°22'E (fl, 14.09.1962); *Michelmore 470* (K): near Mbala (Abercorn), Mwami river, 9°04'S 30°52'E (fr, 03.07.1933); *Procter 1879* (EA, K): Mbala, Lunzua river, 9°00'S 31°15'E (st, 06.1961); *Richards 1544* (BR): Inono stream, 8°53'S 31°12'E (st, 27.04.1952); *Richards 1547* (K): Inono stream, 8°53'S 31°12'E (st, 27.04.1952); *Richards 4483* (B, BM, BR, K, LISC, SRGH) type: Inono stream, close to Mpulungu road, 8°53'S 31°12'E (fl, 14.02.1955); *Richards 10203* (K): Mbala(Abercorn) distr., riv. for. of Lunzua river above fall, 8°57'S 31°09'E (st, 24.06.1957); *Richards s.n. (1)* (BR): Mbala (Abercorn) district, lake Tanganyika, near Mpulungu, 8°46'S 31°07'E (fr, 1955); *Richards s.n. (2)* (K): ?, not located (st, 195?); *Richards s.n. (3)* (K): Abercorn distr., Lake Tanganyika, Lunzua gulf, Tiger point, 8°44'S 31°09'E (fr, 1955); *Stevenson 156 /30* (BR, FHO): ?, not located (st, 1930); *Trapnell 1750* (B, BR, K): Mbala (Abercorn), 8°50'S 31°22'E (fl, fr, 04.1937); *Vesey Fitzgerald s.n. (1)* (EA, FHO, K, SRGH): Mbala (Abercorn), 8°50'S 31°22'E (fr, 13.07.1948); *F. White 3556* (BR, FHO, K, PRE): 10 miles W of Kawambwe Boma, 9°47'S 28°59'E (st, 31.10.1952).

TANZANIA: *Hoyle 1052* (BRLU, EA): 85½ mls on road Uvinsa to Mpanda, Nyamansi river bank, 5°46'S 30°58'E (fr, 30.06.1949); *Procter 479* (EA): 25 mls N of Mpanda, 5°57'S 31°02'E (st, 07.1956); *Procter 1948* (BR, EA, K, PRE): 25 mls N of Mpanda, Nyamansi river, 5°57'S 31°02'E (fr, 09.1961); *Takahatu 416 a* (K): Mahale mountains, Kasoje, 6°12'S 29°50'E (fl, 16.02.1984).

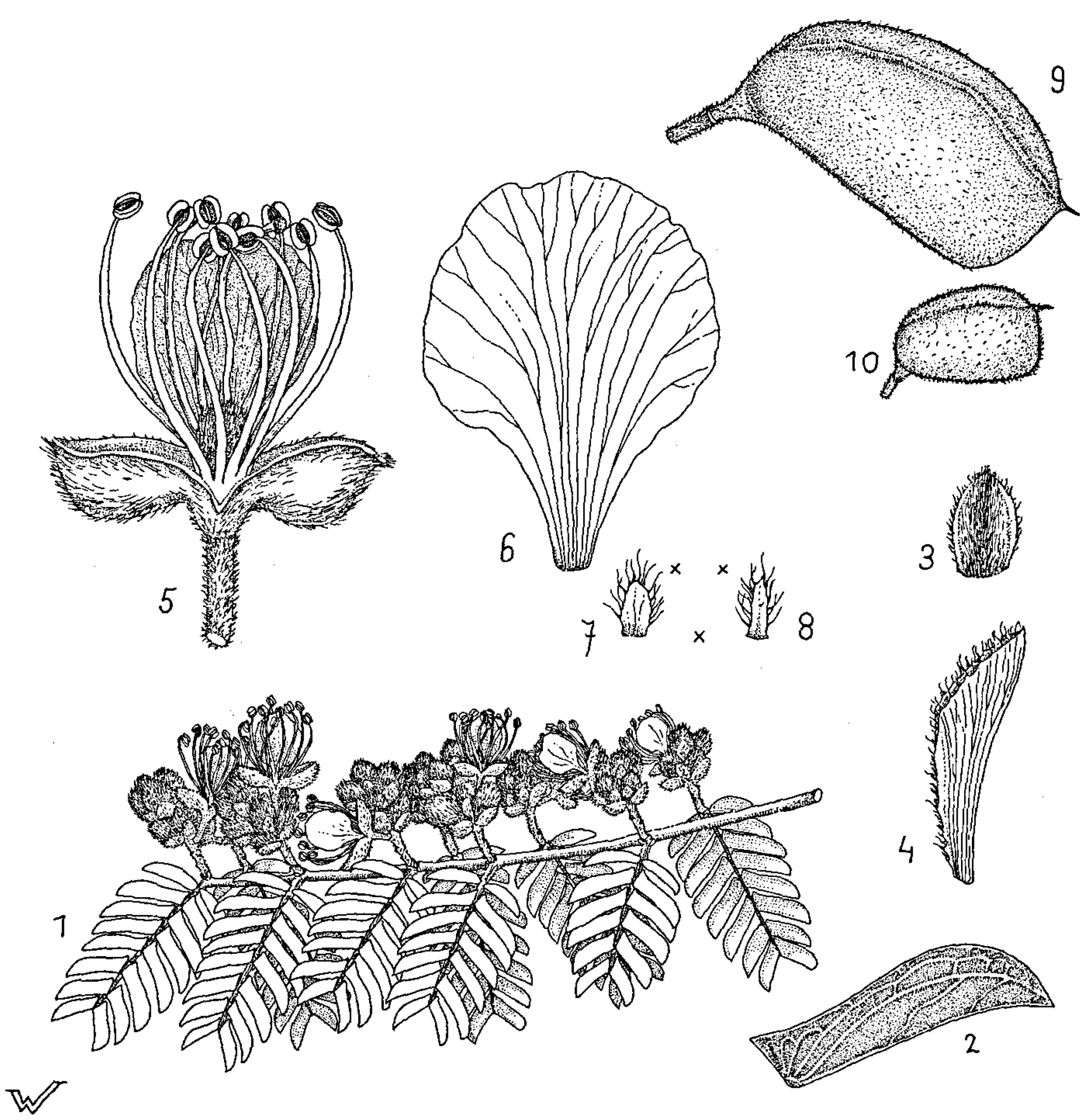


Figure 10.10. *Aphanocalyx trapnellii* (J. Léonard) Wieringa. — 1: twig with leaves and inflorescences (x1); 2: leaflet from below (x4); 3: bract (x4); 4: two fused stipules (x4); 5: flower from abaxial side (x4); 6: adaxial petal (x6); 7: adaxial sepal (x6); 8: abaxial sepal (x6); 9 & 10: pods (x1). — 1–3, 5–8: *Richards 19612*; 4: *Breteler 12001*; 9: *Greenway & Trapnell 5580*; 10: *Richards 10060.*

***Aphanocalyx trapnellii* (J. Léonard) Wieringa comb. nov. Fig. 10.10, Map 10.10**

Basionym: *Monopetalanthus trapnellii* J. Léonard, Bull. Jard. Bot. Brux. 21: 133–137 (1951).

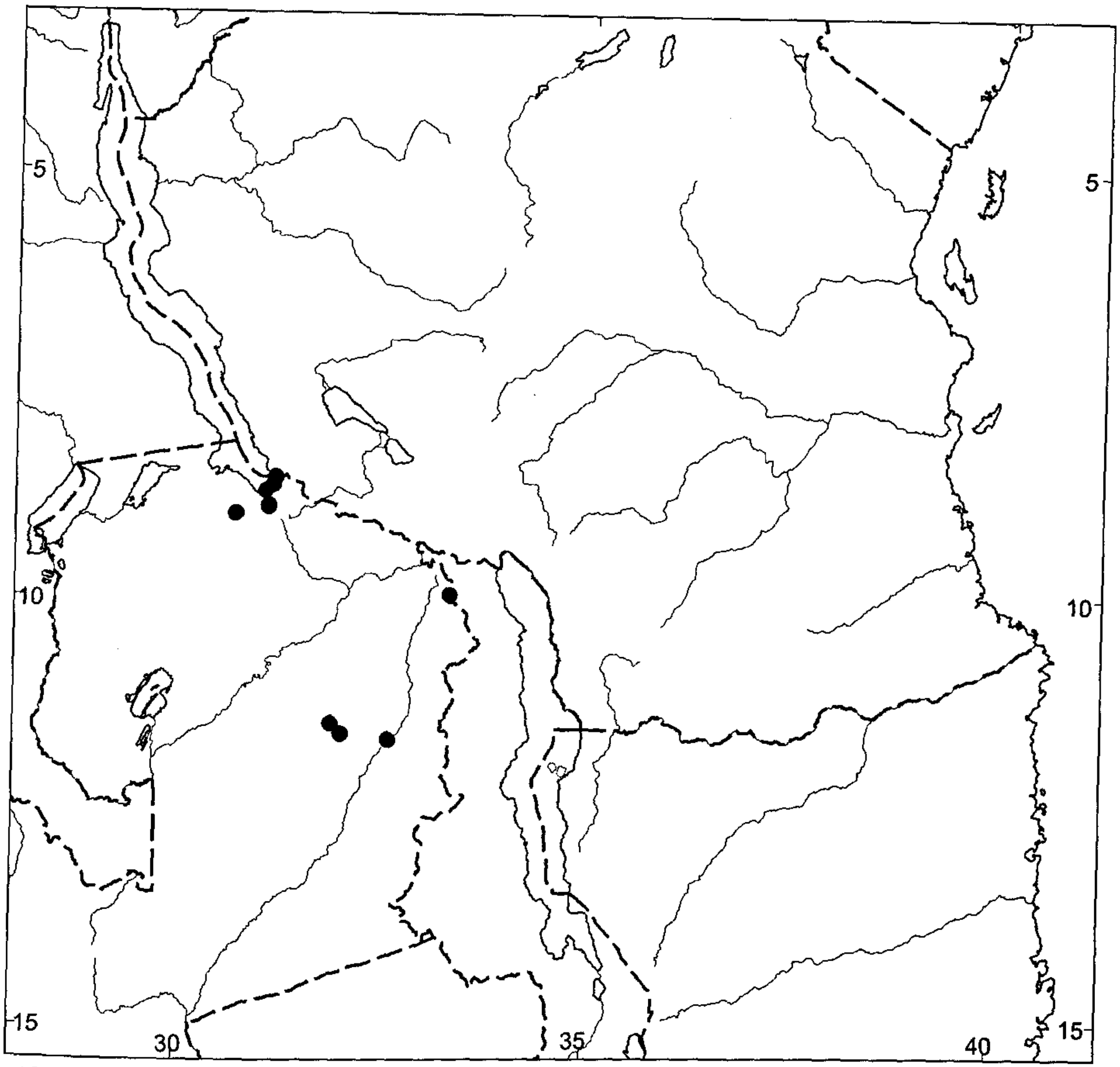
Monopetalanthus trapnellii J. Léonard: Léonard, 1951a: 133–137, fig. 34 & 35; White, 1962: 126; Gunn, 1991: 386–387. **Type**: Greenway & Trapnell 5580 (holo: K; iso: BR, EA, FHO, WAG) — Zambia: "N. Rhodesia. Lufila River, 4500ft. alt., 10/8/1938".

Small to medium-sized tree, 8–20 m high; crown spreading. **Bole** cylindrical, DBH up to 60 cm. **Bark**: surface smooth, grey; slash reddish.

Twigs smooth, grey or grey-brown, older ones with some red-brown lenticels, mixed villous with pubescent, glabrescent. **Stipules** fused, early caducous, rectangular or obovate to spatulate, sometimes with a lobe near the base, 2½–7 x 0.2–2.1 mm, the smallest ones at the end of a shoot, light green, with many parallel veins, outside along the base of the fused distal margin white villous, rest of outside and inside glabrous, margins long white ciliate, at base with a few glandular hairs, apex not bearded. **Leaves** (0.4–)0.6–2.8(–4.4) cm long, (1–)5–13(–17)-jugate, largest leaflet situated at about the middle: **Petiole** ½–1½ mm long, sparsely (long) velvety, completely consisting of the wrinkled joint. **Rachis** (0–)0.4–2.6(–3.9) cm long, sparsely white pubescent, especially on the lower side mixed with (long) brown velvety hairs, upper side usually with a small tuft of hairs in between the paired leaflet-insertions, cross-section in dry condition more or less terete to semicircular with the upper side flattened, with a grooved medial ridge. **Leaflets** leathery: upper side somewhat glossy, dark green, glabrous; lower side rather dull, medium green, glabrous or sparsely long or short villous; margins long silvery brown ciliate; distal half usually completely reduced, sometimes indicated by a narrow rim towards the apex; apex acute or bluntly acute. Young leaflets brownish. **Basal leaflet** half-obovate, 1½–7(–13) x 0.7–3(–5) mm: base of proximal half rounded, without an auricle. **Apical leaflet** oblong to half-obovate, 1½–6(–14) x 0.7–2½(–4½) mm: base of proximal half sharply angled, usually without an auricle, auricle up to 0.2 mm long. **Largest leaflet** oblong to half-obovate, 3½–10(–18) x 1.2–3(–4½) mm: base of proximal half sharply angled, usually with an auricle, auricle up to 0.6 mm long. **Gland pattern**: basal leaflet with 0–2(–3) glands. Second leaflet with 0–2 glands. Apical leaflet without glands. Other leaflets without glands, or rarely one present on the third leaflet.

Inflorescence a raceme, in the axils of the youngest shoots (= up to 15 nodes), 1 per axil, 0.8–1.7 cm long, 4–11-flowered. **Rachis** mixed brown velvety and sparsely puberulous. **Bracts** caducous, ovate to circular, 1½–2½ x 1–2 mm, distinctly densely parallel-veined, outside mixed long brown velvety and puberulous, becoming glabrous towards the lateral margins, inside glabrous, margins shortly ciliate, apex shortly bearded. **Pedicel** 2–4 mm long, (long) brown velvety. Hypanthium s.l. 0.5–0.8 mm high. **Bracteoles** assuming a 100–210° wide angle at anthesis, 4–5½ x 2½–4 mm, outside mixed puberulous and pubescent with long brown velvety, along the indistinct midrib more densely velvety, inside puberulous, specially in the apical half, margins chaffy. **Sepals** outside glabrous or sparsely velvety at base, inside glabrous, margins short to long ciliate. **Adaxial sepals** usually present, sometimes (partly) fused, ovate, 0.3–1.9 x 0.2–0.8 mm. **Lateral sepals** usually wanting, when present up to 0.4 x 0.3 mm. **Abaxial sepal** usually wanting, when present oblong, up to 1.2 x 0.3 mm. **Adaxial petal** obovate, 5½–7 x 3–6 mm, white, inside and outside glabrous, apical margin in the middle usually sparsely ciliate, claw rather indistinct, 1½–2½ mm long, sometimes with inrolled margins. **Lateral petals** usually wanting, rarely vestigial, triangular, up to 0.3 x 0.3 mm, outside glabrous or velvety, inside glabrous. **Adaxial petals** wanting. **Stamens** 10: filaments 6–9 mm long, 9 united over a length of 0.7–1.2 mm, glabrous, adaxial one free, usually glabrous but sometimes inside with short and long hairs; anthers 0.8–1.1 mm long. **Ovary** 1.5–2.1 x 1.1–1.7 x 0.5–0.7 mm, (very) long brown villous, with 2(–3)-ovules; stipe 0.9–1.4 mm long, villous, only the very base glabrous. **Style** 6–7 mm long, inserted at an angle of 10–60°, base long villous; stigma circular.

Pods 1–2(–3)-seeded, obovate, 1.2–3.8 x 0.8–1.9 x 0.1–0.3 cm, immature ones dull, red, later green, sparsely (very long) villous, mature surface granular, glossy, brown, very sparsely villous or glabrous; beak ½–3½ mm long; upper suture not winged, 1–2½ mm broad; nerve distinct, usually running close to the upper suture, u/w = 0.09–0.35; stipe 1–2½ mm long, pedicel 2–7 mm long. **Seeds** obovate, 8–11 x 5–9 mm; testa thin, glossy, brown.



Map 10.10. Distribution of *Aphanocalyx trapnellii* (J. Léonard) Wieringa: Zambia.

Seedling: Germination epigeal. **Hypocotyl** 3–5 cm long, (very) long brown velvety. **Epicotyl** 0.2–0.5 cm long, long brown velvety. First pair of leaves opposite, 9–12-jugate. Subsequent leaves alternate, with an increasing number of leaflets.

Distribution: Map 10.10. Endemic to northern Zambia. However, as the species has been collected at the Zambian side of the Kalambo river which forms the border with Tanzania, the species is expected to occur in Tanzania as well.

Vernacular names: Zambia: Mpandala (Chiwemba), Mwamba, Ugarati (Kilungu), Mutende (Lungu).

Ecology: The species is always found in gallery forest from 800–1500 m altitude.

Phenology: Flowering was observed in early February. Very young pods were present collected in late February, developing pods in June and mature pods in August (see notes), which points to a maturation time of about 6 months. Old pods and seedlings have been collected in November.

Chemistry: Flowers do not produce any colour in spirit.

Diseases and pests: All material seems very healthy.

Uses: No uses have been recorded.

Notes: Leaves of saplings and immature trees tend to be larger and have a larger number of leaflets. These numbers and measurements are cited in between brackets in the description. *Richards 10198*, also an immature tree, shows very large leaflets combined with only 2–6 pairs of leaflets. This specimen might represent a hybrid between *A. richardsiae* and *A. trapnellii*. It has not been used for any of the two descriptions. *Richards 10199* is already closer to *A. trapnellii*, maybe it contains some introgression, however, this sample has been used for the description of *A. trapnellii*.

White (1962) has interpreted the collection date of *Greenway & Trapnell 5580* as 8th October. However, according to Paul Smith (Kew), based on the collecting notebooks, the date should be read as 10th of August.

Specimens examined:

ZAMBIA: *Bingham 8688* (MO): Mpika District, Mwaleshi River, Mala Wildlife camp, 11°37'S 32°02'E (st, 24.11.1992); *Breteler 12001* (WAG): c. 40 km SE Shiwa Ngandu, Mwalishi River, fringing forest, 11°30'S 31°55'E (st, 24.11.1992); *Breteler 12004* (WAG): c. 40 km SE Shiwa Ngandu, Mwalishi River, fringing forest, 11°30'S 31°55'E (st, 24.11.1992); *Glover in Brédo 6260* (BR): Abercorn District, Ulungu, Uchinda, 8°46'S 31°07'E (st, 11.11.1948); *Glover s.n. (1)* (BR, K): 15 mls NW Abercorn, Mshinda river gorge near Mkoma, 8°42'S 31°12'E (fr, 25.02.1948); *Greenway & Trapnell 5580* (BR, EA, FHO, K, WAG) type: Lufila river, 11°41'S 32°36'E (fr, 10.08.1938); *Richards 10060* (K): Abercorn District, Kambole escarpment, 9°02'S 30°46'E (fr, 07.06.1957); *Richards 10198* (K) id. doubtful: Mbala (Abercorn) district, Lunzua river above falls, 8°56'S 31°09'E (st, 24.06.1957); *Richards 10199* (BR, K): Abercorn District, Lunzua river, riverine forest above falls, 8°57'S 31°09'E (st, 24.06.1957); *Richards 19612* (B, BR, K, MO): Abercorn District, Kalambo Falls, 8°36'S 31°14'E (fl, 09.02.1965); *Trapnell 1822* (BR, K): Isoka district, Mafinga Mts, 10°00'S 33°20'E (st, 14.01.1938).

10.4 *Aphanocalyx* subgenus *Antherodontus* Wieringa subgen. nov.

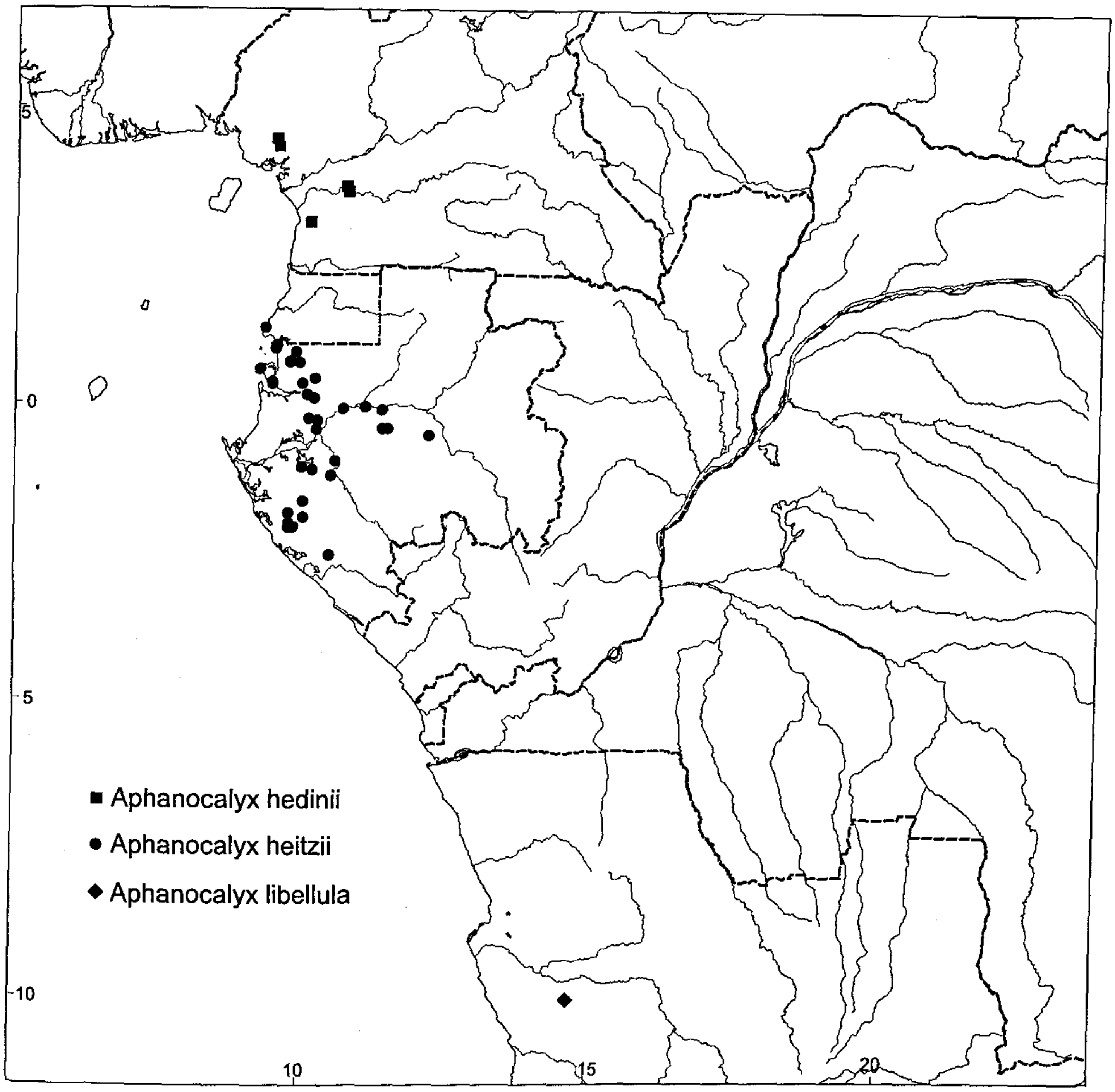
Type (= type of *Monopetalanthus heitzii* Pellegr.): *Heitz 16* (holo: P; iso: A, BR, K, WAG) — "GABON: région de Sibang", most isotypes: "Gabon - Ht Ramboué".

Diagnosis: Arbores trunco cylindraceo. Foliola (imis exeptis) parte basali costae marginalis glandulifera subtus opaca. Bracteolae intus longe vel longissime velutinae vel villosae. Hypanthium bene evolutum (2½–5 mm altum). Petalum adaxiale (semper?) luteum, intus minimum pro parte villosum. Petala lateralia et abaxialia reducta sed semper praesentia intus pilis longis. Antherae dentibus dorsalibus bene evolutis.

Trunk cylindrical. Bark up to 14 mm thick, the outer bark is formed by a dark grey to blackish layer.

Leaflets (excepts the most basal ones) with glands on the basal part of the marginal midrib, the lower surface dull, caused by conically protruding epidermis cells with a papillose surface and crater shaped stomata.

Inflorescences only present on the most terminal (up to 6) nodes of a shoot. Bracteoles long to very long velvety or villous inside. Hypanthium well developed (2½–5 mm high). All 5 sepals always present, (always?) pinkish red. Adaxial petal (always?) yellow, inside at least partly villous, with a distinct claw above which the petal abruptly widens. Lateral and abaxial petals reduced but always present, inside with long hairs. Anthers with strongly



Map 10.11. Distribution of *Aphanocalyx* subgenus *Antherodontus*: *Aphanocalyx hedinii* (A. Chev.) Wieringa (squares), *Aphanocalyx heitzii* (Pellegr.) Wieringa (circles) and *Aphanocalyx libellula* Wieringa (diamond).

developed dorsal teeth. Ovary with 4–6 ovules.

Pod glabrous, stipe distinctly elongated.

Distribution: Map 10.11. Restricted to western central Africa: Cameroon, Gabon and Angola.

Etymology and gender: Named after anther (ανθερα, anthera) and teeth (οδοντεσ, odontes), referring to the two characteristic teeth on the back of each anther in this subgenus. This new subgenus has the male gender.

***Aphanocalyx hedinii* (A. Chev.) Wieringa comb. nov.** **Fig. 10.11, Map 10.11**

Basionym: *Cynometra hedinii* A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 26: 599–600 (1946).

Cynometra hedinii A. Chev.: Chevalier, 1946: 599–600 & Pl. 21A (as *C. hedini*); Normand, 1947: 145–146; Pellegrin, 1949: 108–109; Léonard, 1951b: 399–400. **Type:** *Hédin Muj 1* (holo: P; iso: BR) — "Cameroon, Mujuka. Oct 1927".

Monopetalanthus hedinii (A. Chev.) Aubrév.: Pellegrin, 1949: 109 (invalid); Léonard, 1951b: 399–400 (invalid); Léonard, 1957: 256 (invalid); Aubréville, 1968: pl. 79 (invalid); Aubréville, 1970: 283–284 & pl. 68; Vivien & Faure, 1985: 133–135.

Monopetalanthus sp. C.: Keay, 1958: 478 p.p.

Large tree, up to at least 35 m high. **Bole** branchless for at least up to 15 m, diameter above buttresses up to 330 cm: base with plank buttresses. **Bark** scaly, brown. (Bole and bark characteristics after Aubréville, 1968.)

Twigs smooth, with red-brown lenticels, dark grey, long villous, often mixed with sparsely puberulous indumentum. **Stipules** early caducous, sapling bud scales fused, 10–26 x 1–2 mm, both sides glabrous, margins sparsely ciliate, apex outside bearded. **Leaves** 7–13 cm long, 35–57-jugate, largest leaflet situated proximal from the middle: **Petiole** 2–5 mm long, very long villous, completely consisting of the joint. **Rachis** terete, 6–12 cm long, upper side velvety, lower side very long appressed villous. **Leaflets** papery to leathery, upper side somewhat glossy, glabrous, lower side dull, glabrous; margins very long pilose but glabrescent; distal half completely reduced; apex rounded to truncate, end of marginal vein sometimes with some indication of a hydratode, rarely minutely mucronate. **Basal leaflet** narrowly half-ovate to half-obovate, 4–10(–11) x 0.8–1.6(–2.3) mm: base of proximal half cuneate, without an auricle. **Apical leaflet** narrowly rectangular, 4–9(–14) x 1.2–1.8(–2.9) mm: base of proximal half angled, without an auricle. **Largest leaflet** narrowly rectangular, 10–17(–27) x 1.6–2.3(–3.8) mm: base of proximal half right-angled, sometimes with an auricle, auricle up to 0.3 mm long. **Gland pattern**: basal leaflet with 1–4 glands; second leaflet with (0–)1–3(–4) glands; other leaflet without glands, only third leaflet rarely with up to 2 glands. Most leaflets, but never the basal ones, with 0–2 glands along the upper edge of the marginal vein or in a small leaf blade-like lobe protruding from the vein.

Inflorescence a raceme, axillary on the terminal 4 nodes, solitary, 1–4 cm long and 10–25-flowered. **Rachis** brown velvety. **Bracts** caducous, ovate to obovate, 5–7½ x 4–6½ mm, with many parallel veins, outside mixed appressed (long) velvety and pubescent but glabrous along the lateral margins, inside glabrous, margins ciliate. **Pedicel** 2–3½ mm long, appressed (long) brown velvety. Hypanthium 2½–3 mm high, abaxially near the bottom with an inward boss. **Bracteoles** 7–11 x 3–5½ mm, outside long appressed velvety, inside for a part long appressed velvety, margin chaffy. **Sepals** outside glabrous, inside for a part long to very long villous, margin densely long ciliate. **Adaxial sepal** almost completely fused, more or less rectangular, 4–4½ x 2½–3 mm, inside villous along the lateral margins, apex emarginate to truncate. **Lateral sepals** rectangular, 3½–4 x 1–1½ mm, inside villous except for the very base and the apex, apex truncate to rounded. **Adaxial sepal** rectangular, 4–4½ x 1½–2 mm, inside villous except for the very base and the apex, apex truncate. **Adaxial petal** 6–8½ x 2½–3½ mm, true claw 0.7–1.1 mm long, blade narrowly obtriangular to obovate but with a triangular lobe at base on each side, the latter part maybe inrolled in open flowers: outside glabrous; inside glabrous except for the (sparsely) villous centre of the basal part. **Lateral** and **abaxial petals** vestigial, triangular to ovate, apex blunt, outside glabrous, inside and margins long villous, lateral petals 0.2–0.4 x 0.1–0.2 mm, abaxial petals 0.2–0.3 x 0.1–0.2 mm. **Stamens** 10: filaments apparently more than 10 mm long, adaxial one shorter, 9 others united over a length of 2–4 mm, glabrous; anthers 1.2–1.5 mm long, each cell with a dorsal tooth. **Ovary** c. 2.8

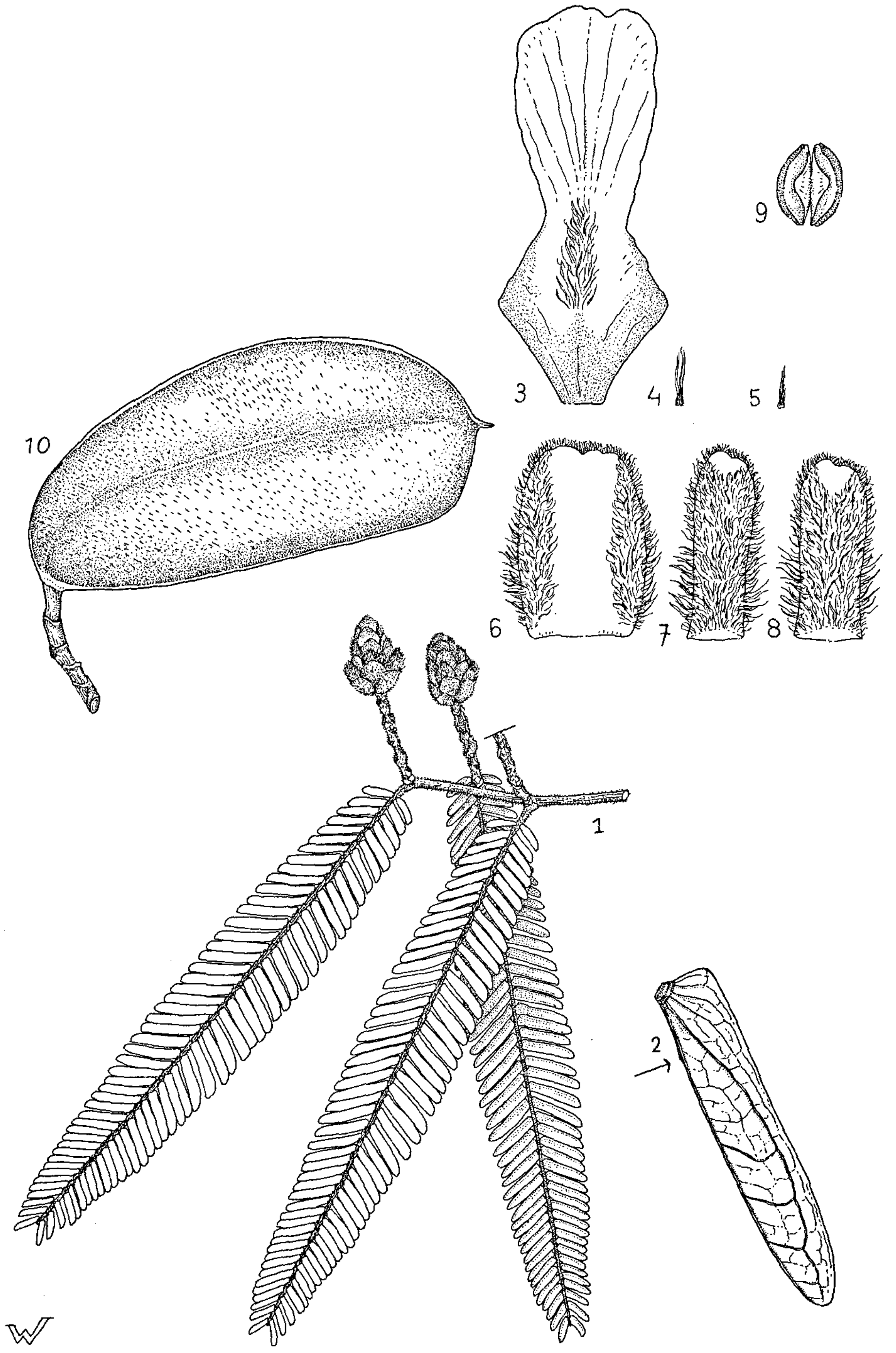


Figure 10.11. *Aphanocalyx hedinii* (A. Chev.) Wieringa. — 1: twig with leaves and inflorescences (x⅔); 2: leaflet from below, showing a tiny gland on the distal margin (arrow) (x4); 3: adaxial petal from inside (from bud) (x6); 4: lateral petal from inside (from bud) (x6); 5: abaxial petal from inside (from bud) (x6); 6: fused adaxial sepals from inside (from bud) (x6); 7: lateral sepal from inside (from bud) (x6); 8: abaxial sepal from inside (from bud) (x6); 9: anther from outside (x10); 10: pod (x⅔). — 1: *Mpom 1832 & Letouzey s.n. (1)*; 2–9: *Mpom 1832*; 10: *Letouzey s.n. (1) & Hédin muj 1.*

x 1.2 x 0.5 mm, very long brown villous, with 3 ovules, stipe adaxially fused with the hypanthium, free part 2–2½ mm long, fused part and base of free part glabrous, remaining free part densely, very long villous or woolly. **Style** up to at least 7 mm long, placed central on the ovary, base long villous, remainder glabrous; stigma heart-shaped.

Pods 2–3-seeded, oblong-obovate to somewhat kidney-shaped, 7–10½ x 2.9–4.4 x 0.3–0.6 cm, glabrous, during development dull, mature surface finely rugose with small diagonally arranged pits, more glossy, brown: beak 1–4½ mm long; upper suture with small wings, 4–6½ mm wide; nerve distinct to obsolete, running above the middle, u/w = 0.39–0.48; stipe 4–8 mm long, pedicel 3–6 mm long. **Seeds** elliptic to obovate, 11–20 x 9–16 x 3 mm, c. 0.5 g in dry condition; testa thin, glossy, brown.

Seedling: Germination epigeal. **Hypocotyl** c. 4½ cm long. **Epicotyl** c. 2 cm long. First pair of leaves opposite (only scars seen). Subsequent leaves with 30–37 pairs of leaflets observed (probably lower numbers are possible).

Distribution: Map 10.11. Endemic to Cameroon where it occurs very locally in three small areas: One just east of Mt. Cameroon, one between Kribi and Bipindi and one near Eséka.

So far, the species has not been found elsewhere and despite a search for it by me in the Kribi area, it has not been collected recently. The two other sites lie in heavily logged and cultivated areas. The species may therefore be extinct or is at least severely threatened.

Vernacular names: Cameroon: Mimbamilé (Ngoumba), Zoélé (Fang, Yaoundé), Mangona (Maleke area, probably erroneously as this name is also used for *Khaya ivorensis*), Nom Alen (Maleke area, means "not true Alen", Alen = *Detarium macrocarpum* Harms).

Forestry name: none in use.

Ecology: Primary dry-land rain forest. Restricted to the lowland, ranging from 0–200 m altitude. According to Letouzey (1968) and Aubréville (1970) it grows in clusters.

Phenology: The only flowering collection is without a collecting date. Young pods were found in July, ripening ones in September and October. These records point to a flowering season somewhere between April and June, which coincides with the beginning of the wet season.

Chemistry: Flowers produce a weak yellow colour in alcohol.

Diseases and pests: The open flowers of the only flowering specimen are all destroyed by insects, probably caterpillars.

Use: None recorded. As the species is closely related to the probably fast growing *A. heitzii* which yields good quality timber, and trees can grow to enormous diameters, *A. hedinii* may prove very interesting as a plantation tree or for enrichment planting.

Notes: In the past the author citations of *Monopetalanthus hedinii* has always been incorrect. In 1949 Pellegrin cites the species as *Cynometra hedini* Chev. but in a note he states that it might be better called *Monopetalanthus hedini*. Since he does not use this new combination it should be considered a provisional name and it is hence invalid. Léonard in his turn (1951b) cites *Cynometra hedinii* A. Chev. under "Species excludendae" from

Cynometra. Under other excluded species he gives the correct name in his opinion preceded by an "=" sign, however, in this case he first gives a description and cites Pellegrin as having proposed *Monopetalanthus hedinii*. Léonard at that time apparently did **not** have an opinion about the correct generic position of this species, which renders this publication also invalid. Further references to the species (Léonard, 1957 & Aubréville, 1968) are without basionym, so they are invalid. The first place where the name is mentioned with its basionym is in Aubréville, 1970: 283–284, who therefore becomes the correct author of the name. Thanks are due to Dr. Brummitt (K) who helped sort out this problem.

Leaflets of seedlings are larger than those of canopy leaves. The sizes of seedling leaves have been given between brackets.

Open flowers of this species were not available for study. The flower description is based on buds and flowers partly destroyed by caterpillars.

The specimen *Forest Herbarium Ibadan 12029* proved to be a mixture: the pods belong to *A. hedinii*, the branches with leaves to *A. microphyllus* subsp. *microphyllus*. I have added an "a" to the branches and a "b" to the pods to separate the two parts.

It is remarkable that this species has been omitted from the second edition of the Flora of West Tropical Africa. The species was described 12 years earlier (this publication is even cited, i.e. for *Microberlinia*) and the type originates from just east of the border between British and French Cameroon (Mujuka is the French counterpart of the British Muyuka). If Keay would have checked the material of this species in Paris, he might have been able to identify the pods of his *Monopetalanthus* sp. C.

Specimens examined:

CAMEROON: *Forest Herbarium Ibadan 12029 b* (FHI, FHO, K): British Cameroons, not located (fr, ?); *Hédin muj 1* (BR, P) type: Mujuka, 4°27'N 9°34'E (fr, 10.1927); *Letouzey 1460* (P, WAG, YA): 30 km on road Kribi to Lolodorf, 3°03'N 10°10'E (fr, 14.07.1950); *Letouzey 1463* (P, YA): Maleke, chantier Gibely, 4°19'N 9°37'E (fr, 24.07.1950); *Letouzey s.n. (1)* (BR): Eseka, 3°39'N 10°46'E (fr, ?); *Mpom 1832* (BR, HBG, K, P, WAG, YA): Gibely, Maleke, 4°19'N 9°37'E (fl, 1952); *Normand s.n. (1)* (P): chantier Vetter (= c. 10 km S Eséka, Soc. Bois du Cameroun), 3°34'N 10°48'E (st, 1953).

Aphanocalyx heitzii (Pellegr.) Wieringa comb. nov. Fig. 10.12, Map 10.11

Basionym: *Monopetalanthus heitzii* Pellegr., Bull. Soc. Bot. France 84: 642–643 (1938?).

Monopetalanthus heitzii Pellegr.: Pellegrin, 1938?: 642–643; Pellegrin, 1942: 119; Heitz, 1943: 118–120 & Pl. 35; Normand, 1947: 147–149 p.p.; Pellegrin, 1949: 74 & Pl. IV: 1; Anonymous, 1953; Walker & Sillans, 1961: 234–235 & fig. 79; Saint Aubin, 1963: 50 & 52; Aubréville, 1968: 306–308 & pl. 78; Aubréville, 1970: 282–283 & pl. 67; Bolza & Keating, 1972: 457; Gunn, 1991: 386–387. **Type**: *Heitz 16* (holo: P; iso: A, BR, K, WAG) — "GABON: région de Sibang", most isotypes: "Gabon - Ht Ramboué".

Baillon, 1865: 207 (as "Habeian" or "Owala du Boquoé").

Medium-sized to large tree, up to 45 m high, crown hemispherical. **Bole** cylindrical, branchless for up to 25 m, DBH or diameter above buttresses up to 200 cm: base of large trees often with thick plank buttresses, these up to 4 m high and 4½ m wide. **Bark** up to 13 mm thick: surface smooth, becoming fine rugose with vertical lines of lenticels, finally rough and scaly with depressions left by the fallen scales, grey, brown or reddish brown;

outer bark less than 1 mm thick, schistose, brown in dry condition; inner bark fibrous, in fresh condition purple to stone red, but yellow adjacent to the sapwood, in dry condition purple-brown to brown, producing a little purplish resin. Sapwood whitish. Heartwood cream-coloured. Wood showing clear growth-rings.

Twigs smooth, dark grey-brown, long pale brown villous, glabrescent or sparsely puberulous on old twigs, with red-brown lenticels. **Stipules** fused, caducous, obovate to spatulate, 8–31 x 0.9–3.6 mm, light green, outside glabrous to sparsely villous with a mixed villous and puberulous band along the (fused) distal margin, inside glabrous, margin mixed long and very short ciliate, apex often bearded. **Leaves** 7–25(–31) cm long, 20–32-jugate, largest leaflet situated proximal from or at the middle: **Petiole** 4–10(–11½) mm long, very long silvery to pale brown villous, basal half consisting of the wrinkled joint, remainder similar to the rachis. **Rachis** 6–24(–28) cm long, pale green, mixed very long appressed villous and velvety, the villous indumentum drops with age, cross-section in dry condition semi-circular, upper side flattened with a median ridge. **Leaflets** papery to leathery, upper side glossy, dark green, glabrous, lower side dull, pale greyish green, glabrous but in very young leaves very long silvery pilose; margins very long silvery pilose but glabrescent, only the distal margin next to the joint persistent velvety; distal half usually completely reduced, sometimes vestigial remains present near the apex; apex rounded to bluntly acute. Young leaflets light green. **Basal leaflet** half-obovate, 3½–20(–26) x 1–6(–8) mm: base of proximal half rounded, without an auricle. **Apical leaflet** half-obovate to rectangular, 4½–18(–28) x 1½–5(–8½) mm: base of proximal half usually angled, without an auricle. **Largest leaflet** rectangular, usually widest point above the middle, 13–36(–57) x 3–9(–13) mm: base of proximal half angled, usually without an auricle, rarely the auricle up to 0.2 mm long. **Gland pattern**: basal leaflet with 1–5(–10) glands. Second leaflet with 0–2(–6) glands. Apical leaflet with 0–1 gland. Other leaflets with 0–1(–4) glands. Most leaflets, but never the basal ones, with 0–2(–6) glands along the upper edge of the marginal vein.

Inflorescence a compound raceme, axillary on the terminal 6 nodes, 1 per node, 3½–12(–19) cm long, with 1–8 lateral branches which are 1–7 cm long and 6–30(–40)-flowered. **Rachis** greyish brown but lateral branches pale green, long silvery to pale brown (appressed) velvety. **Bracts** caducous, obovate, 4–5½ x 3–6 mm, densely parallel-veined, outside long and short velvety but glabrous along the lateral margins, inside glabrous, margins long ciliate. **Pedicel** (4–)8–14 mm long, pale green, long golden to silvery velvety. Hypanthium 2½–5 mm high, abaxially near the bottom with an inward lobe. **Bracteoles** assuming a 160–270° wide angle at anthesis, 11–17 x 7½–13½ mm, strikingly thick (0.5–0.9 mm), both side dark pinkish red to pale reddish brown, densely long golden to silvery velvety, margins chaffy. **Sepals** (dark) pinkish red, outside glabrous or very sparsely villous, inside long villous but often glabrous along the margins, margins densely ciliate. **Adaxial sepals** fused for ½ to ⅔, rounded triangular to ovate, 3.1–5.3 x 3.0–5.0 mm, apices rounded to bluntly acute. **Lateral sepals** ovate- to obovate-oblong, 3.1–5.2 x 1.6–2.5 mm, apex rounded. **Abaxial sepal** ovate-oblong, 3.9–6.4 x 2.3–3.6 mm, apex rounded. **Adaxial petal** spatulate, 10–15 x 3–6 mm, true claw 0.5–1.2 mm long, whitish, the base of the blade inrolled forming a 6–8 mm long, pale yellow secondary claw, the rest of the blade almost circular to obovate, yellow, apex rounded or emarginate; outside glabrous except the basal half of the lateral margins of the secondary claw which are villous, inside of secondary claw except along its margins and the base and centre of the limb villous. **Lateral** and **abaxial petals** linear, outside glabrous to sparsely villous, inside

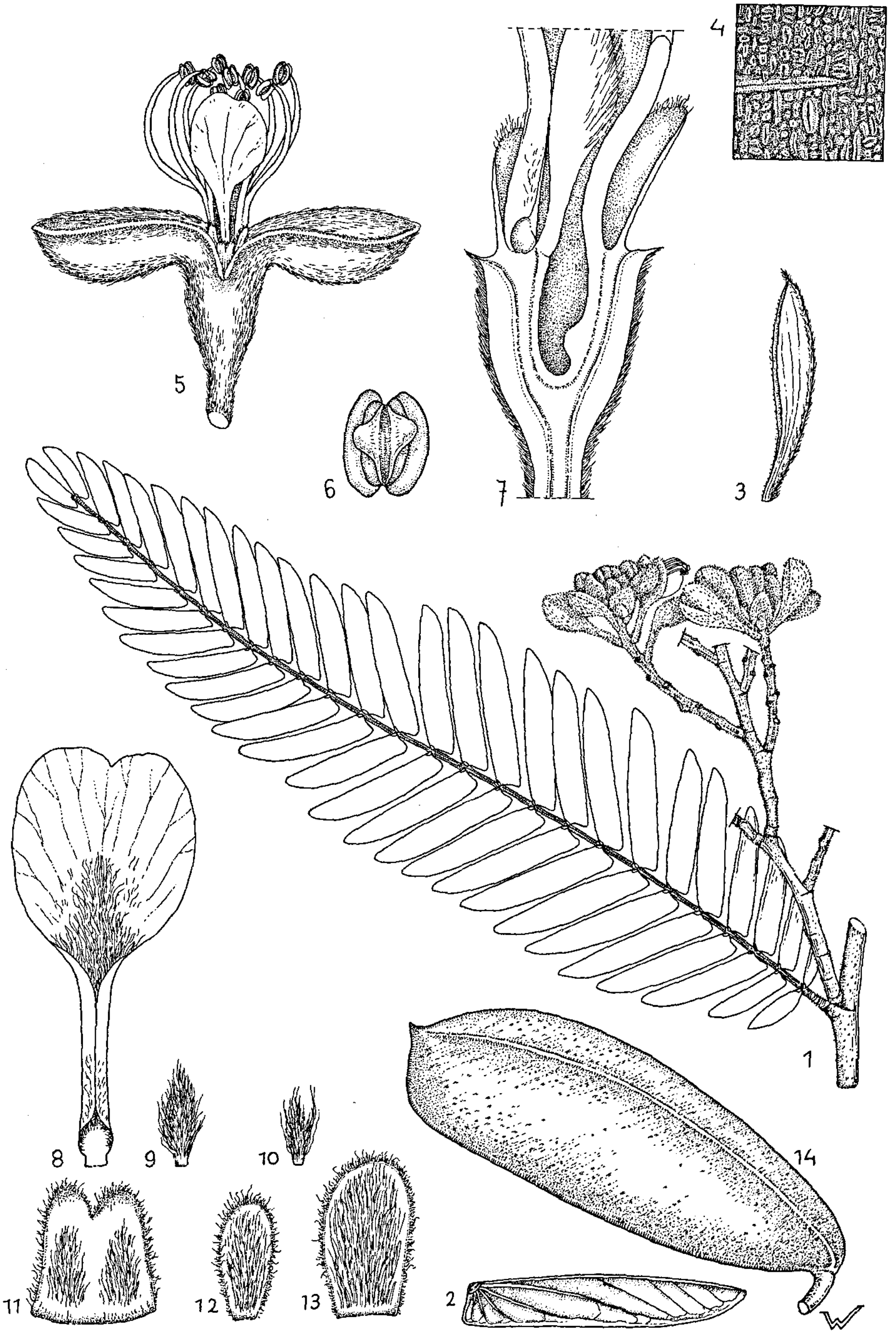


Figure 10.12. *Aphanocalyx heitzii* (Pellegr.) Wieringa. — 1: part of twig with a leaf and an inflorescence (x⅔); 2: leaflet from below (x1); 3: two fused stipules (x1); 4: bark surface (x⅔); 5: flower from adaxial side (x2); 6: anther from outside (x6); 7: longitudinal section of flower showing the hypanthium cavity (adaxial side to the left), bracteoles are left out from point where they become free (x6); 8: adaxial petal from inside (x4); 9: lateral petal from inside (x4); 10: abaxial petal from inside (x4); 11: two fused adaxial sepals from inside (x4); 12: lateral sepal from inside (x4); 13: abaxial sepal from inside (x4); 14: pod (x⅔). — 1, 2, 4, 7: *Wieringa & Haegens 2439*; 3: *Wieringa, v. Nek, Hedin & Moussavou 3016*; 5, 6, 8–13: *Wieringa & Haegens 2409*; 14: after Heitz (1943: pl. 35) and *Wieringa & v.d. Poll 1587.*

very long villous, lateral petals 1.3–3.4 x 0.4–1.0 mm, abaxial petals 0.7–1.7 x 0.2–0.7 mm. **Stamens** 9: filaments 16–21 mm long, adaxial one wanting, 9 united over a length of 4–7 mm, lateral ones united for an additional 0.4–1.0 mm, white, glabrous; anthers 2.2–2.9 mm long, each cell with a dorsal tooth, greenish to brownish yellow. **Ovary** 3.2–6.0 x 1.8–2.6 x 1.0–1.4 mm, often more or less depauperate and only 1.8–2.9 x 0.8–1.7 x 0.6–1.2 mm, pale green, densely very long white villous, with 3–6 ovules; stipe adaxially fused with the hypanthium, free part 2–3½ mm long, fused part and base of free part glabrous, remaining free part densely very long villous. **Style** 7–13 mm long in bisexual flowers, 1½–5 mm long in male flowers, inserted at an angle of 0–40(–80)°, white to pale pink, very base very long villous, remainder of style glabrous; stigma heart-shaped.

Pods 1–6-seeded, oblong-elliptic, 10–19 x 3.6–5.5 x 0.6–0.9 cm, during development dull (wax-layer), yellow-green to brown, sparsely villous, glabrescent, mature surface granulate, glossy, dark to medium brown, glabrous: beak 2–9 mm long; upper suture not winged, 3–7 mm wide; nerve distinct to rather indistinct, running comparatively close to the upper suture, u/w = 0.20–0.37; stipe (8–)10–16 mm long, pedicel 6–14 mm long. **Seeds** elliptic, 16–24 x 11–18 x 3–4 mm, 0.5–0.8 g in dry condition; testa thin, glossy, dark brown.

Seedling: Germination epigeal. **Hypocotyl** 6–12 cm long, mixed pubescent with long to very long villous. **Epicotyl** 1½–3½ cm long, mixed pubescent or tomentose with villous, often denser than in hypocotyl. First pair of leaves opposite, 8–15-jugate. Subsequent leaves alternate, with increasing numbers of leaflets.

Distribution: Map 10.11. Endemic to Equatorial Guinea and Gabon, where it occurs in the sedimentary basin with an intrusion eastward along the Ogooué valley up to the 'Forêt des Abeilles'.

Vernacular names: Gabon: Andoung (Pahouin), Evel-Andoung (Fang), Andoung Rouge (French?), Habeian, Owala du Boquoé (see Baillon (1865), language unknown).

Besides these names, reported on herbarium labels, Walker & Sillans (1961) mention the following names: Eréré z'ingówè (Mpongwè), Okorwè (Galao, Nkomi, Orungu), Mukuru (Echira, Bavarama, Bavungu, Ngowè, Balumbu), Dikuru (Bapunu), Mondungu (Masangu, Mitsogo, Bavové), Kogo (Mitsogo, Bavové, Ivéa), Indungu (Bakota), Undjunghu (Béséki), Mutsóngè (Bavili), Pavola (Apindji), Ugogwa (Benga), Bendongho, Landongho (Bakèlè).

Forestry name: Andoung de Heitz.

Ecology: Primary and older secondary dry-land rain forest, sometimes reaching the forest-savanna margin. Restricted to the lowland, ranging from 0–200 m altitude (according to Anonymous (1953) rarely up to 500 m). It usually occurs in small clusters of about 5 trees.

Seedlings have been found up to 60 m from the parent tree.

The mean annual diameter increment may be more than 1 cm (see Chapter 3, Ecology).

Phenology: Flowering takes place from the start of March to mid-April with the main peak in March. Flowering out of the normal season was recorded in June and August. Maturation of the pods takes 10 months. Main seed fall is in January.

Chemistry: Flowers produce a yellow to yellow-orange colour in alcohol.

Diseases and pests: All observed trees appeared to be very healthy. Galls were never encountered and the trunks showed no evidence of beetle attacks.

Use: Wood properties and application described in Anonymous, 1953. Borota & Supin (1989) discuss the suitability of the wood for veneer production, however, I have some doubts on the precise identification of their material. According to Walker & Sillans (1961) the bark is used to make boxes for religious purposes and to construct beehives.

Notes: Pellegrin's publication most probably dates from 1938 and not 1937, since it concerns the printed text of a meeting on 10 december 1937. In his diagnosis he mentions the leaves as c. 35-jugate, which is an over-estimation; even the P-sheet contains at the most 32-jugate leaves.

According to Pellegrin the type was collected in February 1935. However, the first material already arrived in Paris at 22 January 1935, rendering the collection date unknown, even though Heitz himself (1943) says the species flowers in February (erroneous copy of Pellegrin?). The sheets at P and WAG state the material was collected near Sibang / Libreville. However, other duplicates and the protologue state the material comes from the Ht. Rambоué. I presume that at first the newly arrived specimens at P were supposed to have come from around Libreville, which was only corrected later. The new data was subsequently used for duplicate labels and the protologue.

Normand's (1947) description of the wood is most probably based on a mixture. He used two samples. One, the type specimen, is without doubt, but the other is said to have come from Congo (Brazzaville). As long as *A. heitzii* is not known from Congo (Brazzaville), Normand's remark that it probably concerns the same species has to be doubted seriously.

Specimens examined:

EQUATORIAL GUINEA: *Issembe 22* (WAG): near Yanaboté, chantier SOFOGE, 1°16'N 9°25'E (fr, 20.05.1998).

GABON: *de Boislouveau 857* (LBV): Mondah, Liby, 0°35'N 9°20'E (st, 15.09.1952); *de Boislouveau 940* (LBV): Mondah, Liby, 0°35'N 9°20'E (fr, 30.09.1952); *Breteler 10878* (WAG): c. 30 km road Bifoun-Lambaréné, Mbiné, 0°26'S 10°18'E (fr, 03.03.1992); *Breteler 12150* (WAG (alc only)): c. 18 km S of Ekouk, 0°17'S 10°19'E (fr, 26.05.1993); *Breteler 12151* (WAG): c. 18 km S of Ekouk, 0°17'S 10°19'E (st, 26.05.1993); *Breteler 12154* (WAG): c. 30 km on road Bifoun to Lambaréné, Mbiné, 0°26'S 10°18'E (st, 27.05.1993); *Breteler, Jongkind & Wieringa 9742* (WAG (+alc)): S of Shell expl. Rabi-Kounga, near Echira river, 2°05'S 9°55'E (fl, 02.04.1990); *Breteler, Jongkind & Wieringa 10914* (WAG): 5-30 km NNW of Ndjolé, 0°05'S 10°45'E (st, 19.04.1992); *Breteler, Jongkind & Wieringa 11139* (WAG): 5-30 km NNW of Ndjolé, 0°05'S 10°45'E (fr, 27.04.1992); *Breteler, Jongkind & Wieringa 11373* (WAG): road Ndjolé to Lopé, just before bridge crossing Ogooué, 0°06'S 11°24'E (st, 08.05.1992); *Breteler, Jongkind, Nzabi & Wieringa 11543* (WAG): Rabi-Kounga, 1 km SE of "Checkpoint Charlie", 1°51'S 9°50'E (fr, 19.05.1992); *Breteler, Jongkind, Nzabi & Wieringa 11544* (WAG): Rabi-Kounga, 1 km SE of "Checkpoint Charlie", 1°51'S 9°50'E (st, 19.05.1992); *Breteler, Wieringa & Nzabi 12970* (WAG): Crystal Mountains, 5 km S of Kinguélé, 0°25'N 10°16'E (st, 20.09.1994); *v.d. Burgt 94* (WAG): road Rabi to Koumaga, 3 km past Echira bridge, 2°05'S 9°52'E (fl, 08.04.1994); *Dibata 708* (WAG): Ezanga, transect B east, 1°07'S 10°14'E (fr, 02.1991); *Dibata 876* (WAG, WILKS): Ofoubou, 1°39'S 10°05'E (fr, 1991); *Griffon du Bellay 160* (P): probably: Bokoué, 0°05'N 10°15'E (st, 1864); *Groulez 699* (LBV): Bokoué, 0°09'N 10°08'E (fl, fr, 06.03.1952); *Groulez 1076* (LBV): Nkoulounga, 0°43'N 9°50'E (st, 16.07.1953); *Groulez 1267* (LBV): Sibang arboretum, not plotted (st, 01.08.1953); *N. Hallé 1028* (P): Nkoulounga, 0°42'N 9°50'E (st, 31.01.1961); *Heitz 16* (A, BR, K, P, WAG) type: Ht Ramboué, 0°15'S 10°10'E (fl, fr, 193?); *I.N.E.F. s.n. (2)* (P): Libreville, km 18, 0°22'N 9°33'E (st, 03.02.1969); *McPherson 13849* (MO): Lopé reserve, S of Ayem, chantier SOFORGA, 0°25'S 11°30'E (fl, fr, 03.04.1989); *Morel 19* (P): Cocobeach, Nkan on the Noya, downstream Noya-Adughe junction, 0°41'N 10°00'E (st, 24.11.1947); *Morel 52* (P): E of Cocobeach, Atia river bassin, 0°59'N 9°38'E (fr, 06.09.1948); *Normand 219* (P): right bank of Ngounie, N of Sindara, near the Davo, 0°58'S 10°37'E (fr, 17.09.1947); *Olom C.T.F.T. 2128* (LBV, WAG): Mbelaléne, not located (fl, 06.1963); *J. Reitsma, B. Reitsma*

& Wilks 3282 (MA, MO, NY, WAG): 50 km SW of Doussala, 2°33'S 10°32'E (fr, 16.04.1987); *Schoenmaker 367* (WAG): Rabi-Kounga, S of Echira, 2°05'S 9°50'E (fr, 25.01.1992); *S.R.F. s.n. (1)* (BR, P): S of Cocobeach, 0°55'N 9°36'E (st, 30.01.1949); *L. White 12* (SEGC): Lopé reserve, 0°25'S 11°25'E (st, ?); *Wieringa & v.d. Poll 1587* (LBV, WAG): c. 25 km on the N3 from Alèmbé, 0°03'S 11°07'E (fr, 05.09.1992); *Wieringa & Haegens 2409* (WAG (+alc)): road Rabi to Echira, 2°01'S 9°50'E (fl, 07.03.1994); *Wieringa & Haegens 2439* (G, IAGB, IEC, LY, UGDA, W, WAG (+alc)): NE Divangui, 23 km E of Shell-camp Rabi, 1°55'S 10°05'E (fl, fr, 10.03.1994); *Wieringa, van Nek, Hedin & Moussavou 3016* (WAG): NW of Fougamou, 5km on forestry road following Bendolo river, 1°12'S 10°33'E (st, 01.11.1994); *J. de Wilde & v.d. Maesen 10964* (WAG): Rabi, c. 1 km SE of Checkpoint Charlie, 1°51'S 9°50'E (st, 25.01.1993); *Wilks 122* (WILKS): Lake Oguemwe, 1°04'S 10°03'E (fl, fr, ?); *Wilks 737* (WILKS): N of road Lastoursville to Ofoué, near ouboué, 0°32'S 12°12'E (fr, 04.10.1982); *Wilks 973* (WAG): 3 km N of Ndouaniang, 0°20'N 10°03'E (fl, 05.08.1984); *Wilks 1143* (LBV, WILKS): 7 km SSW of confluent Mitemboni & Lona, 0°52'N 9°56'E (fr, 06.11.1985); *Wilks 2523* (WAG): Ofoubou-area, path between line 6 and 4, 1°39'S 10°05'E (fr, 06.07.1991); *Wilks 2524* (WAG): Ofoubou-area, path between line 6 and 4, 1°39'S 10°05'E (st, 06.07.1991).

Aphanocalyx libellula Wieringa spec. nov. Fig. 10.13, Map 10.11

Type: *F. Raimundo, C. Matos & Figueira 619* (holo: LISC) — "Angola, CUANZA SUL, Próximo de Munenga na estrada velha para o Dondo, Alt: ca. 400m, 23/1/1971" (in flower) [close to Munenga, on old road to Dondo].

Diagnosis: Arbor 8–10 m alta, foliis (10–)11-jugatis inflorescentiisque thyrsoideis. Hypanthium bracteis connatum minime 2.5 mm altum. Sepala 5, extus glabra, intus longissime villosa. Sepala adaxialia circiter 3/4 connata. Petala 5; petalum adaxiale minime 9 x 4 mm; petala alia vestigialia intus villosa. Stamina 10; antherae dentibus 2 dorsalibus.

Tree, 8–10 m high, with a globose crown.

Twigs greyish brown, densely set with pale brown lenticels, sparsely pubescent. **Stipules** caducous, so far unknown. **Leaves** rectangular, up to 17 cm long, (10–)11-jugate, largest leaflet situated in about the middle: **Petiole** 4–9 mm long, silvery white villous. **Rachis** 82–136 mm long, sparsely white villous, on upper side with a ridge, which is very clear after each leaflet-pair but diminishes towards the next pair. **Leaflets** leathery, upper side somewhat glossy, glabrous, lower side dull, greyish, in young leaves villous, but glabrescent, the hairs only more persistent near the base; distal margin long ciliate, glabrescent, near the base also persistently velvety; distal half completely reduced; apex rounded, rarely acute, end of marginal vein often with a gland which is usually assimilated in the distal margin but rarely mucronate. **Basal leaflet** half-ovate to half-obovate, 13–29 x 4–10 mm: base of proximal half cuneate, without an auricle; **Apical leaflet** oblong, 13–28 x 3½–7½ mm: base of proximal half cordate, without an auricle. **Largest leaflet** oblong to triangular, 17–37 x 4.3–11 mm: base of proximal half slightly cordate to truncate, without an auricle. **Gland pattern** (excluding apical gland): basal leaflet with a line of 2–4 glands more or less central through the leaflet. Other leaflets with 0–1(–2) glands. Most leaflets with 1–6 glands against the upper edge of the base of the marginal vein.

Inflorescence a compound raceme, axillary on the terminal 5 nodes, 1 per node, up to 3½ cm long (but will be longer in a completely developed inflorescence), with up to 3–7 lateral branches which are up to 2½ cm long and 15–20-flowered. **Rachis** up to 15 mm long, pale brown appressed velvety, at base with scars of bud scales. **Bracts** early caducous, ovate to obovate contracted into a bowl, 5.6–7.2 x 6.4–8.2 mm, inside glabrous, outside long and shortly appressed velvety, becoming shorter to the lateral margins, finely

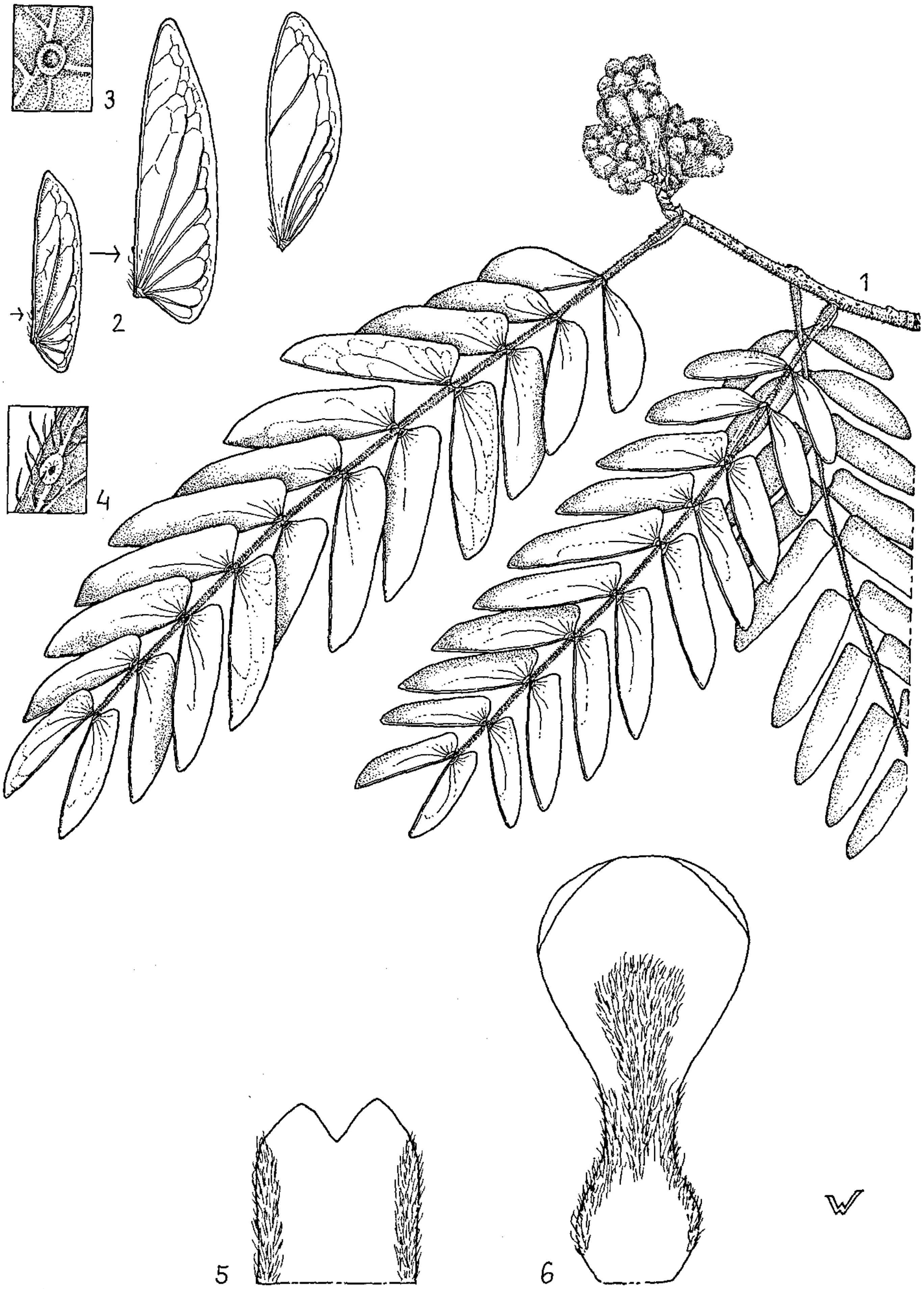


Figure 10.13. *Aphanocalyx libellula* Wieringa. — 1: part of twig with leaves and an inflorescence (x⅔); 2: leaflets from below, the arrows indicate glands on the midrib (x1); 3: gland of lower leaflet surface (x16); 4: gland on the midrib of a leaflet, from distal-above (x16); 5: adaxial sepals from inside (x6); 6: adaxial petal from inside (x6) (5 & 6 are derived from floral buds and a damaged flower). — 1–6: *Raimundo, Matos & Figueira 619.*

ridged by densely set nerves, apex rounded. **Pedicel** c. 5.5 mm long, long pale brown velvety. Hypanthium s.l. at least 2½ mm high. **Bracteoles** c. 11 x 7 mm, outside densely long pale brown appressed velvety, inside fairly densely long to very long white villous, margin chaffy. **Flowers** poorly known, in the type specimen only one flower is present, which is partially demolished and mounted under gummed tape, the following description is therefore partially based on buds. **Sepals** outside glabrous except sometimes some hairs along the margins and top, inside very long villous in different patterns. **Adaxial sepals** fused for about 3/4, ovate, 3.5–3.8 x 3.0–3.5 mm, on the inner side along the margin a strip of very long hairs, apices bluntly acute. **Lateral sepals** lanceolate, 3.2–3.3 x 1.0–1.2 mm, on the inside very long villous except for a narrow strip along the margins and the apex which are glabrous. **Abaxial sepal** lanceolate, often broadening to the base, 3.5–4.1 x 1.3–1.6 mm, hair pattern same as in lateral sepals. **Petals** 5. **Adaxial petal** at least 9 x 4 mm, seems to consist of 3 parts. Basal part wide, broadening to base, with on both sides a villous area along the margins. Central area narrower, probably forming a claw in developed flower, outside glabrous, inside villous. Apical part forming the blade, more or less circular, glabrous on both sides. **Lateral petals** much reduced, lanceolate, up to 2 x 0.4 mm, outside glabrous, inside villous in lower half. **Abaxial petals** very much reduced, rounded triangular, up to 0.5 mm long, outside glabrous, inside villous. **Stamens** 10: filaments up to 17 mm long, adaxial one free, others fused over a length of c. 6 mm, completely glabrous; anthers elliptic to oblong, 1.6–2.0 x 1.1–1.2 mm, each cell with a dorsal tooth. **Ovary** c. 6 x 1.5 x 1 mm, very long white villous, with 4 ovules, stipe adaxially fused with the hypanthium, very long villous but glabrous at base. **Style** c. 5 mm long, placed more or less central on the ovary, glabrous; stigma ovate.

Pods & seeds unknown.

Distribution: Map 10.11. So far this species is only known from the type specimen, collected in Munenga (central Angola).

Vernacular names: No names known at present.

Ecology: The species forms a rather densely gallery forest along the Muconga river.

Phenology: The type specimen, collected 23 January was just about to flower. The rainy season in this area is from September to April, with a small peak in November, a dip in December and January and a major peak in March and April. Flowering apparently occurs just before the major rains.

Chemical: Flowers produce an orange-yellow colour in alcohol.

Diseases and pests: As is evident from the type collection, this tree is host of a woolly coccus. The inflorescence contains some eggs, probably of a Lepidoptera species.

Etymology: This species is named after the dragonfly genus *Libellula*. The shape and position of leaflets of this tree are reminiscent of dragonfly wings.

Specimen examined:

ANGOLA: *Raimundo, Matos & Figueira 619* (LISC) type: Cuanza Sul, near Munenga, 10°04'S 14°41'E (fl, 23.01.1971).

11 *Bikinia* Wieringa

11.1 *Bikinia* Wieringa gen. nov. **Map 11.1**

Type (= type of *Bikinia media* Wieringa): *Wieringa, van Nek, Hedin & Moussavou 3180* (holo: WAG; iso: LBV, UGDA & 51 other duplicates to be distributed) — 'Gabon, Ogooué-Lolo, 22 km on road Lastoursville to Koulamoutou. Alt. 280 m 0°56.6'S 12°37.4'E'.

Monopetalanthus auct. non Harms: Pellegrin, 1942: 118–119 p.p.; Chevalier, 1946: 592–593 p.p.; Pellegrin, 1949: 73–74 p.p.; Léonard, 1952: 441–442 p.p.; Léonard, 1957: 255–256 p.p.; Aubréville, 1968: 304–306 p.p.; Aubréville, 1970: 276–279 p.p.; Normand & Paquis, 1976: 105–106 p.p.; Gunn, 1991: 386–387 p.p.

Diagnosis: Arbores trunco cylindraceo. Stipulae liberae valvatae utroque latere connatae pilis. Foliola opposita. Inflorescentia racemis composita. Bracteolae hypanthio connatae latere adaxiali parte parva hypanthii liberae. Sepala minima vel absentia. Petalum adaxiale magnum album. Petala lateralia et abaxialia minima vel absentia. Stamina 10, 9 connata. Antherae purpureo-rubrae. Legumina pubescentia, saepe eliam velutina.

Trees, usually large. Trunk straight and cylindrical, at base with fairly low, broad buttresses that may become a few metres long. Bark usually greyish to brown, with many lenticels, in slash outer bark very thin (up to 1 mm thick), dark brown, inner bark fibrous, to the exterior slightly granular. Sapwood creamy to pinkish in dry condition.

Stipules caducous, free, both lateral margins valvate, connate by chaffy hairs, the stipules covering the entire continuing branch in bud. Leaves paripinnate, 1–36-jugate. Leaflets opposite, never emarginate at the apex, but proximal margin often sinoid (even angled) just below the apex. Basal leaflet in proximal half usually with one or more glands, in distal half glands present only in some species.

Inflorescences compound racemes, sometimes branching once more, axillary on the terminal nodes, 1–5 per node. Bracts inside glabrous. Flowers with a distinct pedicel, some flowers functionally male, others bisexual. Bracteoles fused with the hypanthium, only adaxially and to a lesser extent abaxially partly giving way resulting in a part of the hypanthium becoming visible. Sepals reduced, brown velvety outside. Adaxial sepals rarely wanting, usually consisting of two triangular or hemicircular lobes that are usually (just) fused at base. Since both lobes are a non-demarcated continuation of the free hypanthium, the point where they become free (and whether or not they are fused) is only visible from behind. Lateral sepals often wanting. Abaxial sepals rarely wanting. Adaxial petal large, usually only slightly smaller than the bracteoles, with a short claw, after which the petal usually widens abruptly, inside often pubescent along the basal part of the lateral margins. Lateral and abaxial petals strongly reduced or even wanting. Stamens generally 10, adaxial stamen free, 9 united at base, the lateral ones often united for an additional part, the two filaments next to the adaxial one often bending inwards while the lateral ones bend outwards around it. Hypanthium inside often with indumentum, sometimes extending on to the staminal tube. Anthers purple-red, without dorsal teeth, connective at base protruding slightly past the thecae. Ovary with 1–4 ovules, stalked, stalk and ovary velvety. Style insertion angle usually strikingly eccentric (up to 140°) to the adaxial side of the ovary, base usually conical, at the end of the conical part often geniculate. In male flowers ovary present but depauperate, with a very short style.

Pods at least puberulous, often also velvety, lateral nerve present, running about central over the valve, wings of upper suture indistinct to distinct, when very pronounced usually inrolled. Seeds with a very thin membraneous testa, 'overgrown', should germinate immediately after seed shed.

Seedlings epigeal. Hypocotyl generally shorter than epicotyl. Epicotyl often glabrous at base. First pair of leaves opposite.

Distribution: Confined to the tropical rain forest and gallery forest of western central Africa.

Diseases and pests: Several species of galls are observed on *Bikinia* species, some of these galls are present on several species, but they were never encountered outside the genus. The same might apply to several species of Longhorn beetles (Cerambycidae), e.g.

Map 11.1. Distribution of *Bikinia*.

Xystrocera similis Jordan was collected by me only twice, but both times in association with a *Bikinia* species. However, since the distribution of *Xystrocera similis* outreaches that of *Bikinia* (pers. comm. K. Adlbauer) this longhorn beetle should have at least one other tree genus as its host (*Julbernardia* would be sufficient to fill the gap) or else *X. similis* comprises more than one species.

Etymology and gender: This new genus is named after the two-piece bathing suit 'bikini', which in its turn is named after the Pacific island Bikini. The name refers to the fused adaxial sepals which consist of two pieces: the basal piece is part of the hypanthium and becomes visible because the bracteoles are in that part not completely fused to the hypanthium, its shape is triangular or half-moon-shaped. The second piece consists of the part which is free from the hypanthium. Because it is formed by two partly fused sepals, it is usually bilobed. Both parts seen separately form some sort of bikini; models vary between the species.

The only disadvantage of this new generic name is, that none of its species occur on Bikini. Since all life was blasted from that island by atomic testing, the chances of finding some new plant genus on that island has become nil, so there is hardly a need to keep this name free for in case someone does. Now life has returned to Bikini, it might be nice to plant a *Bikinia* tree on the island as well, although it is highly questionable whether it will grow there (probably too dry).

Bikinia has the female gender.

11.2 Key to the species of *Bikinia*

1 a Leaves 1-jugate. Congo (Kinshasa) & Gabon. . . . . **B. breynei**
  b Leaves (5–)6–39-jugate[1]. 2

2 a Proximal leaflet half cuneate at base, not or hardly auriculate, midrib running obliquely (fig. 11.1a). Largest leaflet 3–11 cm long. Inflorescence 5–22 cm long. Hypanthium 2–4 mm high. Adaxial sepals including the hypanthium triangle 2.1–4.1 mm, lower surface of leaflets glossy. Gabon. . . . . **B. durandii**
  b Proximal leaflet half rounded to truncate or angular at base, the corner usually extended into an auricle, midrib running symmetrically or a little asymmetrically, but not oblique (fig. 11.1b–e). Largest leaflet 0.8–8 cm long. Inflorescence 1½–16 cm long. Hypanthium 0.5–2.5 mm high. Adaxial sepals including the hypanthium part 0–3.4 mm high, if more than 2.1 mm high than lower surface of leaflets dull and pale greyish. 3

3 a Largest leaflets 2–4 times as long as wide, distal half strongly widened at base, proximal half widest near apex, so that the midrib runs asymmetrically (fig. 11.1b & c). Leaves (5–)6–16-jugate. Largest leaflet at or above the middle. 4
  b Largest leaflets relatively narrow, 3–7½ times as long as wide[2], distal leaflet half not strongly widened at base, margins symmetrical relative to midrib (fig. 11.1d & e). Leaves (9–)13–39-jugate. Largest leaflet in or below the middle. 7

4 a Lower surface of leaflets pubescent (rarely glabrous in saplings), in sun-exposed leaves dull and pale greyish. The proximal leaflet base often rounded, auricle often not or hardly developed (fig. 11.1b). Pods velvety with a distinctly winged (6–14 mm

wide) upper suture. . . . . ***B. evrardii***

b Lower surface of leaflets glabrous (or sparsely pubescent only in young, basal leaflets), glossy and greenish. Proximal leaflet base always with a distinct auricle (fig. 11.1c). Pods sparsely puberulous and pubescent or velvety, when velvety then upper suture hardly winged. 5

5 a Leaf rachis on upper side always grooved, groove (almost) glabrous, at least distinctly less hairy than rest of rachis (fresh fig. 11.1i, dry fig. 11.1j). Bracts 5½–8 mm long. Adaxial petal broad, 2.7–3.6 mm wide, inside puberulous along the basal part of the lateral margins. Upper suture of pods 3–10 mm wide. Gabon. . . . . ***B. grisea***

b Leaf rachis almost terete in fresh condition (fig. 11.1f), when dry upper side grooved (fig. 11.1g), this groove with indumentum (if sparse, the lower side of the rachis with even less indumentum or glabrous, fig. 11.1h). Bracts 3–5 mm long. Adaxial petal narrow, 0.9–2.4 mm wide, inside along the basal part of lateral margins glabrous. Upper suture of pods 2–4 mm wide. Gabon to Congo (Brazzaville) 6

6 a Inflorescence 1½–4 cm long. Flowers crowded, bracts persistent. Pods at first sight glabrous, but in fact puberulous. Leaves (6–)8–10(–11)-jugate. Leaflets 2½–3½ times as long as wide. Central Congo (Brazzaville) and Congo (Kinshasa). . ***B. congensis***

b Inflorescence 2–10 cm long. Individual flowers easily recognizable, bracts dropping before anthesis. Pods short and long velvety. Leaves 8–16-jugate. Leaflets 3–4 times as long as wide. Gabon and possibly western Congo (Brazzaville). . . . . . ***B. media***

7 a Leaflets almost needle-like, (3.8–)5.0–7.6 times as long as wide, proximal margin not or hardly sinoid towards the apex (fig. 11.1e). 15–39-jugate. Developed ovaries 1-2-ovulate. Gabon 8

b Leaves not needle-like: less narrow, 2.8–5.2(–5.7) times as long as wide, proximal margin usually clearly sinoid towards the apex (fig. 11.1d). 13–24-jugate. Developed ovaries 2–3(–4)-ovulate. Cameroon to Congo (Brazzaville) 9

8 a Bracts 3–6 x 2–4 mm, caducous before anthesis. Lateral and abaxial sepals and petals wanting. Blade of adaxial petal centrally outside glabrous or only with a few short hairs at base. . . . . ***B. aciculifera***

b Bracts 7–10 x 5–8 mm, persistent until anthesis. Only abaxial petal sometimes wanting, other floral part always present. Blade of adaxial petal outside with a velvety triangle at base. . . . . ***B. coriacea***

9 a Leaf rachis terete when fresh, in dry condition above usually grooved, the edges run fairly close to each other, groove tomentose or velvety, sometimes mixed with very short hairs (see fig. 11.9). Proximal leaflet margin sinoid towards the apex, but often not very sharply angled. Largest leaflet 8–26 mm long. Bracteoles 3–6½ mm long. Adaxial petal 1.4–2.8 mm wide, often at least with some hairs along or at the lateral margins. Adaxial sepals including the hypanthium part (0–)0.1–0.8(–1.8) high. Sun-exposed leaves slightly glossy and medium green beneath. From Cameroon to border Gabon with Congo (Brazzaville). Pods usually only sparsely velvety, upper suture rather narrowly winged, 2–6½ mm wide. . . . . ***B. pellegrinii***

b Leaf rachis both in fresh and dry condition flattened above, the flat area is (almost) glabrous and may even extend into narrow lateral wings (so the 'groove' is very

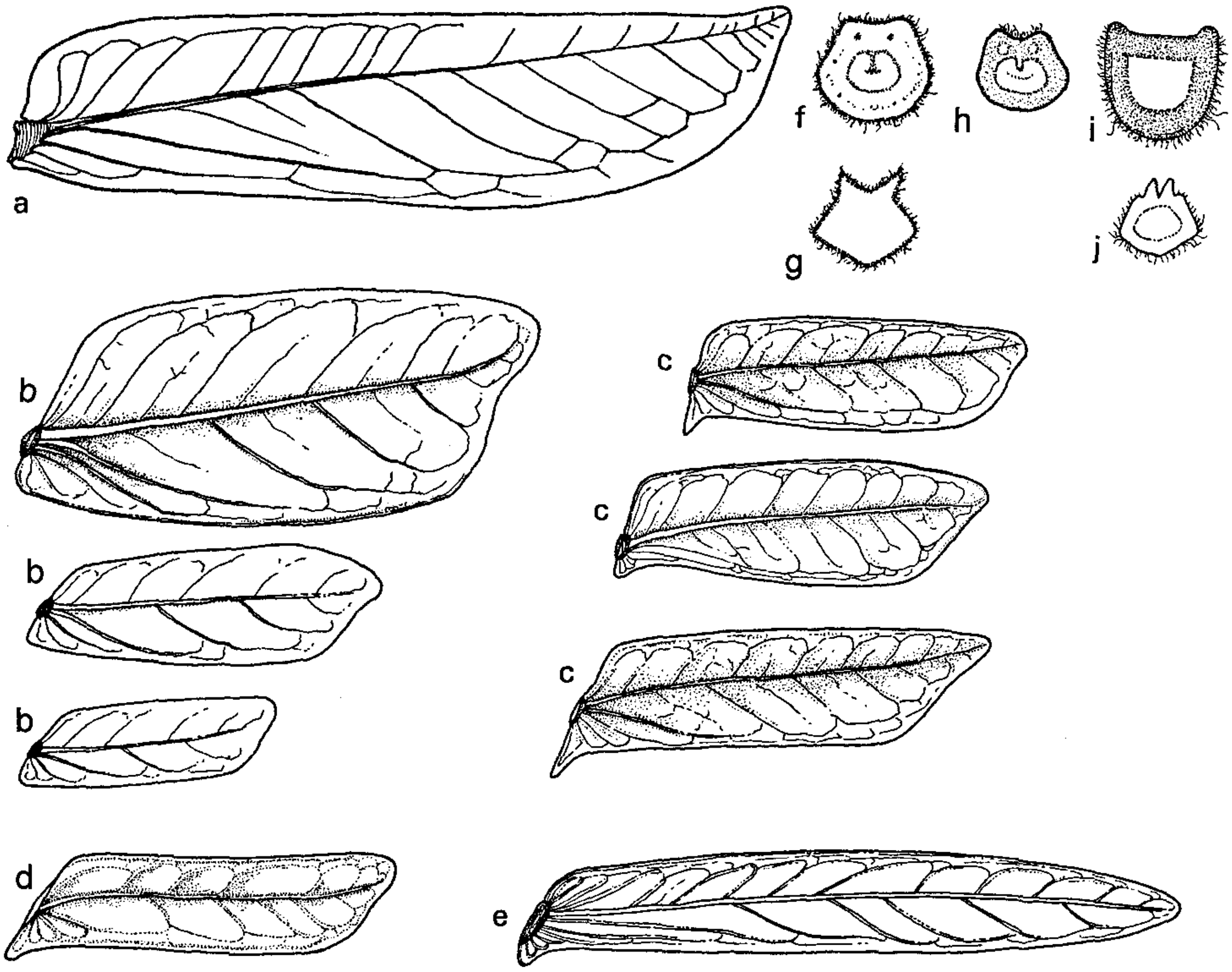


Figure 11.1. Illustrative aid to the key of *Bikinia*. — a–e: leaflets (not apical or basal); f, h, i: cross section of fresh leaf rachis; g, j: cross section of dry leaf rachis.

shallow and at least as wide as the rachis, see fig. 11.9). Proximal leaflet margin often conspicuously angled sinoid towards the apex. Largest leaflet 13–37 mm long. Bracteoles 5–10 mm long. Adaxial petal 3–8 mm wide, usually completely glabrous. Adaxial sepals including the hypanthium part (0.8–)1.1–3.4 mm high. Sun-exposed leaves dull and pale grey or glossy leaved tree from Congo (Brazzaville). Pods usually densely velvety, upper suture usually broadly winged, 8–20 mm wide. ***B. le-testui***

[1] The key uses numbers found on mature branches. Leaflet numbers of treelets and shade leaves may deviate from these values. It is advisable to count several leaves of a sample.

[2] Leaflets of saplings and shade leaves tend to be relatively wider. When in doubt with such a specimen, choose the narrower range or use the other characters.

11.3 Descriptions of the species

Bikinia aciculifera Wieringa spec. nov. Fig. 11.2, Plate 3, Map 11.4

Type: *Wieringa, van Nek, Hedin & Moussavou 2977* (holo: WAG (also alcohol); iso: G, IAGB, IEC, LBV, LY, UGDA, W & 15 duplicates, to be distributed) — "Gabon, Ngounié, Fougamou, 12 km on forestry road following Bendolo river. Alt. 180 m 1°13.0'S 10°30.7'E 29.10.1994".

Diagnosis: Arbor altus, foliolibus acerosis, *Bikinia coriaceae* (Aubrév.) Wieringa fortiter affinis sed bracteae minores, sine sepalis lateralibus et abaxialibus, et sine petalis lateralibus et abaxialibus.

Large tree, up to 45 m high, crown hemispherical to rather irregular. **Bole** cylindrical, up to at least 25 m high, diameter up to 165 cm: base with large buttresses of up to 2½ m high and radiating for up to 8 m. **Bark** surface greyish brown.

Twigs grey, older ones striate, glabrous, but brown puberulous in seedlings and saplings. **Stipules** free (but fused in stipules transformed into bud scales), early caducous, obovate, base not auriculate, 17–60 x 1–9 mm (in saplings), the terminal stipule of a shoot less caducous, triangular, c. 7 x 2 mm, very pale green: outside glabrous except for a few long hairs at base; inside glabrous; margins chaffy, at apex long bearded. **Leaves** (5–)9–19 cm long (–27 cm in saplings and small trees), 15–39-jugate, largest leaflet at 30–40% of the total number of pairs: **Petiole** 4–7 mm long (2–5 mm in seedlings), entirely consisting of the wrinkled, (sparsely) velvety to pubescent joint. **Rachis** (4½–)7–18 cm (–25 cm in saplings), in fresh condition terete, in dry condition upper side flattened or even grooved, (long) brown velvety or sparsely so, often sparser or even glabrous on upper side. **Leaflets** linear, straight or slightly curved in proximal direction, firm leathery, folding together at dusk, re-opening the next morning: upper side glossy, dark green, glabrous; lower side somewhat glossy, greyish green, glabrous, margin long ciliate; apex bluntly acute to rounded; leaflets pinkish to greenish white when young, later medium green above, pale green beneath; in saplings and treelets papery to thin leathery, on lower side glossy, medium to dark green. **Basal leaflet** 5–27 x 1.5–5.2 mm: base never auriculate. **Apical leaflet** 5–21 x 1.3–5.2 mm: auricle 0–0.4 mm. **Largest leaflet** 12–44 x 2.7–7.8 mm, (3.8–)5.1–7.6 times as long as wide; auricle 0–1.3 mm. Largest sizes and smallest length ratio occur only in saplings and treelets. **Gland pattern**: basal leaflet in proximal half with 1–4 glands, in distal half without glands. Second leaflet without glands. Apical leaflet in proximal half without, in distal half with 0–2 glands. Other leaflets in proximal half without glands, in distal half with 0–2 glands in the more distal leaflets.

Inflorescence axillary on the terminal four nodes, a compound raceme, sometimes primary axis with slightly reduced leaves present, 11–16 cm long, with 5–9 lateral branches which are 17–35 mm long and c. 10–25-flowered. **Rachis** light green, (long) brown velvety. **Bracts** early caducous, oblong or pentagonal, i.e. obtrullate to house-shaped, 3.8–6.0 x 2.3–4.0 mm, greenish white: outside mixed brown velvety and white pubescent, along the lateral margins glabrous; inside glabrous; margins short ciliate, towards the apex denser and sometimes also long ciliate. **Pedicel** 2.1–6.0 mm long, greenish white, brown velvety. Base of bracteoles, sepals, petal and filaments united in a 1.5–2.4 mm high hypanthium s.l. **Bracteoles** obovate, 5.0–7.0 x 3.6–6.0 mm, assuming a 140–260(–310)° wide angle at anthesis in bisexual flowers, 60–110(–160)° in male flowers, white: outside with an asymmetric running ridge, white pubescent, along and on the ridge mixed with long brown velvety indumentum; inside glabrous, but puberulous at the very base; margins chaffy. **Adaxial sepals** fused at base, 0.4–1.0 x 1.9–2.5, including the hypanthium triangle 1.2–2.1 mm high, light green: outside (long) dark brown velvety; inside white pubescent. **Lateral** and **abaxial sepals** wanting. **Adaxial petal** 4.3–6.1 x 2.6–4.0 mm: claw 0.6–0.9 mm long, white; blade obovate, lateral margins straight diverging, outside glabrous or with a few short soft white hairs at base, both sides with a narrow white pubescent band along the lateral margins, more distally reducing into cilia and finally fading, remaining inside parts glabrous, apical margin shortly ciliate. **Lateral** and **abaxial petals** wanting. **Stamens**

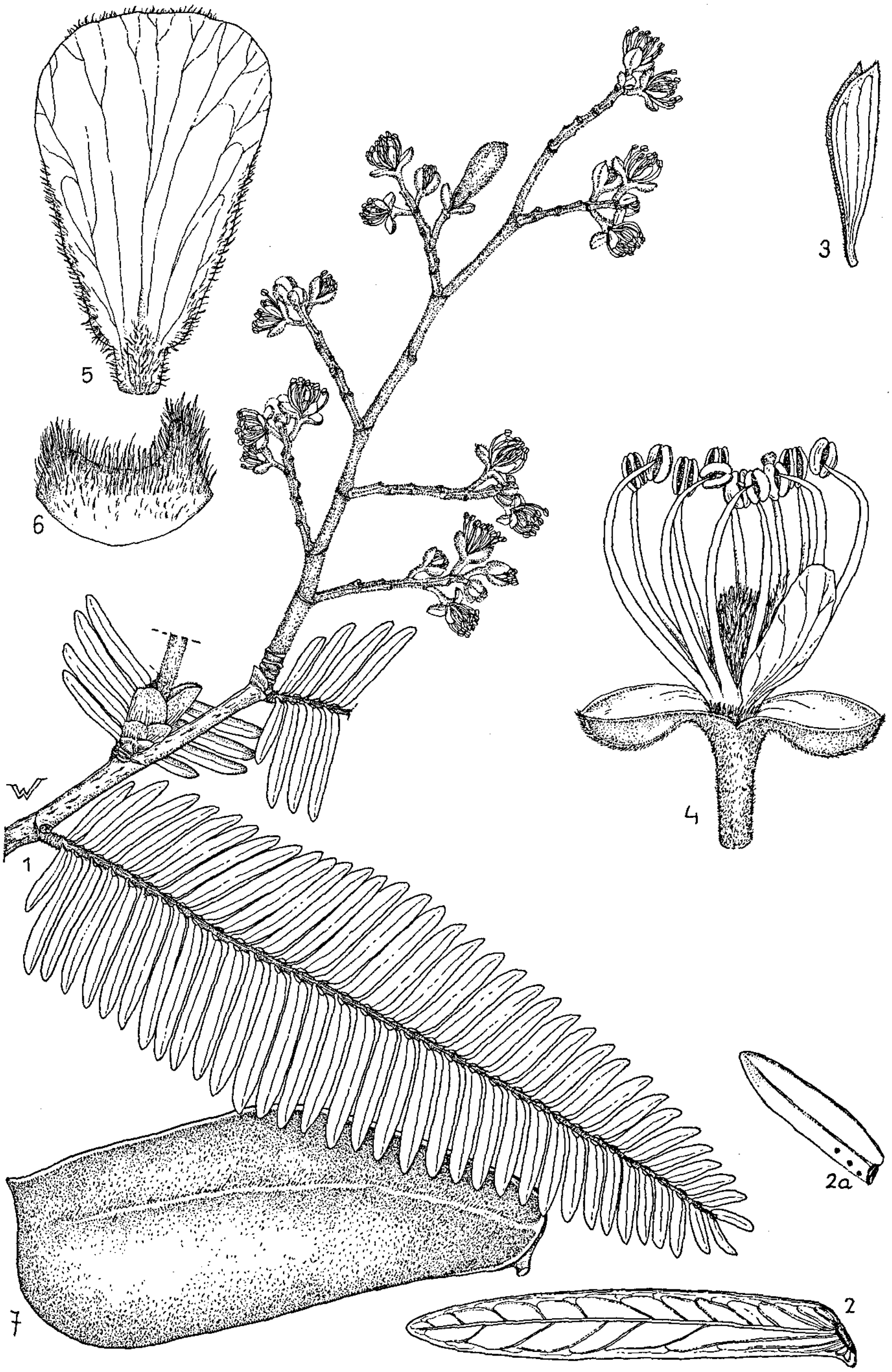


Figure 11.2. *Bikinia aciculifera* Wieringa. — 1: part of twig with leaves and inflorescence (x⅔); 2: medial leaflet, lower surface (x2); 2a: basal leaflet, lower surface with glands indicated by black dots (x2); 3: stipules (x⅔); 4: flower from adaxial side (x4); 5: adaxial petal from outside (x8); 6: adaxial sepals from outside, including the part fused with the hypanthium (x8); 7: pod (x⅔). — 1, 2, 4–6: *Wieringa, v. Nek, Hedin & Moussavou 2977*; 3, 4, 7: *Wieringa, v. Nek, Hedin & Moussavou 2920.*

10: filaments in apical half tapering to the apex, spreading in male flowers, curved to each other in bisexual flowers, 7–11 mm long, white (within the hypanthium red), 9 fused for 1.0–2.1 mm, the three stamens on each side of the abaxial one fused for 1.2–2.3 mm, base of adaxial filament fused on one side with the hypanthium and with the stipe of the ovary on the other, especially the three most adaxial filaments sparsely white pubescent at base, all filaments appressed brown velvety inside the hypanthium; anthers 1.3–1.6 mm long, medium to dark purple. **Ovary** in male flowers depauperate, in bisexual flowers 2.3–4.0 x 1.6–2.4 x 1.2–1.5 mm, pinkish, long brown and white velvety, with 1–2 ovules, stipe 2.8–3.6 mm long, long velvety; in male flowers ovary strongly reduced, 0.4–0.6 x 0.1–0.3 x 0.1–0.2 mm, without ovules, stipe 2.1–2.6 mm long. **Style** 6–9 mm long, inserted 90–130° eccentric on the adaxial side of the ovary, white, base conical, geniculate at the apex of the conical part, conical part long velvety, becoming glabrous towards apex; stigma heart-shaped, yellow.

Pod poorly known: 1-seeded, obovate, c. 9–11 x 3½–4½ x 0.5 cm, dull, brown velvety; beak c. 3–5 mm long; upper suture obscurely winged, 3–4½ mm wide; nerve ± in the middle, u/w = 0.46–0.49; stipe 7–8 mm long; pedicel 6–6½ mm long. **Seeds** unknown, but impression in pod c. 33 x 28 mm.

Seedling: Germination epigeal. **Hypocotyl** 5–5½ cm long, glabrous? **Epicotyl** 9–18 cm long, glabrous at base, sparsely velvety towards the apex. First pair of leaves opposite, 14–17-jugate, largest leaflet at about ⅓ of total number of pairs. Subsequent leaves alternate, with an increasing number of leaflets, the leaflets of the first of these leaves smaller than in the first pair.

Distribution: Map 11.4. Gabon: endemic to the mountain chain starting west of Fougamou, continuing up to the Doudou mountains north-west of Tchibanga.

Vernacular names: None recorded.
Forestry name: Gabon: no unique name in current use, but 'Andoung de Morel' has been used in the past.

Ecology: Canopy species or emergent of primary rain forest at c. 200 m altitude. The tree that provided the type collection was standing at the bottom of a valley close to a small stream, but was probably never or hardly ever inundated, some neighbouring trees were standing on a hill-side. The tree standing above the seedlings of *Wieringa et al. 2920* was growing almost at the summit of a hill. The species probably prefers dry-land forest. It grows gregariously in small groups of up to c. 10 individuals.

Phenology: Flowering in October, the flowering seems synchronized within gregariously growing groups.

Chemistry: Flowers, but in a lesser extent also leaves, produce a yellow (urine-like) colour in alcohol.

Diseases and pests: Many flowers of the type collection are galled. The attacked ovary becomes globose with a diameter of c. 7 mm, other flower parts (up to the bract) may or may not be deformed. The galls are caused by a fly, possibly an Agromyzidae. The same kind of galls is sometimes present on *B. le-testui* subsp. *le-testui*.

With a resin sample of this species (*Wieringa et al. 2920*), kept in a closed vial, a moth, probably belonging to the Tineidae (in coll. ZMA), was found which apparently hatched out of this resin. It is not clear whether this moth feeds on the resin, on old insect remains contained in it, or on the wood and pupates in the resin.

Use: At present not in use.

Notes: This species closely resembles *B. coriacea* and is hard to tell apart when sterile. Whether there exists a real difference in the indumentum of the twigs is not yet clear. Also the shape of the leaflets is not really helpful.

Because of the very small amount of, especially fertile, material present of both species, all differences observed here will have to be tested by further collecting. At the moment the best diagnostic characters seem to be: *B. aciculifera* has smaller bracts that drop earlier than in *B. coriacea*, in the latter species they usually develop a very strong central rib towards the apex (carinate), which is hardly present in the first. The flowers in the latter species are more densely packed than in the first. The reduction of the perianth has gone further in *B. aciculifera* than in *B. coriacea* since only the adaxial sepals and petal are left, while in the latter all elements are usually present. The outside of the adaxial petal of *B. coriacea* bears a velvety triangle, while that of *B. aciculifera* is only sparsely pubescent, with less stiff hairs. The anthers of *B. aciculifera* are in general somewhat larger.

Since no distinguishing vegetative characters are present, the collections from the Lopé area (including fôret des Abeilles) could not be identified at present. They are treated here as belonging to *B. coriacea*, since the area fits most closely to the distribution of that species.

Specimens examined (except the type all paratypes):

GABON: *Breteler, Leal, Moussavou & Nang 14015* (WAG): Koumounabouali massif, Dikaki chantier, Bendolo river basin, 1°20'S 10°28'E (fr, 20.09.1997); *Wieringa, van Nek, Hedin & Moussavou 2920* (WAG): W of Fougamou, 7 km on forestry road following Bendolo river, 1°12'S 10°32'E (fr, 26.10.1994); *Wieringa, van Nek, Hedin & Moussavou 2977* (G, IAGB, IEC, LY, UGDA, W, WAG (+alc)) type: W of Fougamou, 12 km on forestry road following Bendolo river, 1°13'S 10°31'E (fl, fr, 29.10.1994); *Wilks 1513* (MO, WAG, WILKS): expl. of CEB, 50 km W of Doussala, 2°20'S 10°25'E (st, 18.04.1987).

Bikinia breynei (Bamps) Wieringa comb. nov. Fig. 11.3, Map 11.2

Basionym: *Monopetalanthus breynei* Bamps, Bull. Nat. Plantentuin Belg. 50: 512–514 (1980).

Monopetalanthus breynei Bamps: Bamps, 1980: 512–514, fig. 2. **Type**: *Breyne 3183* (holo: BR) — Congo (Kinshasa): 'Maluku, lac Ngaenke ou "lac bleu". Forêt autour du lac. 30/12/76'.

Medium-sized to large tree, 15–45 m high. **Bole** cylindrical, branchless for up to at least 15 m, DBH up to more than 200 cm, base without buttresses, sometimes with small feet. **Bark** up to 12 mm thick: surface finely fissured, rough through large lenticels, grey or green with grey spots and bands; outer bark up to 1 mm thick, very hard, dark grey-brown; inner bark fibrous, more granular towards the exterior, yellow-brown when fresh, in dry condition pinkish brown to reddish brown, paler towards the interior. Bark producing red-brown to yellow resin. Sapwood whitish; heartwood red-brown.

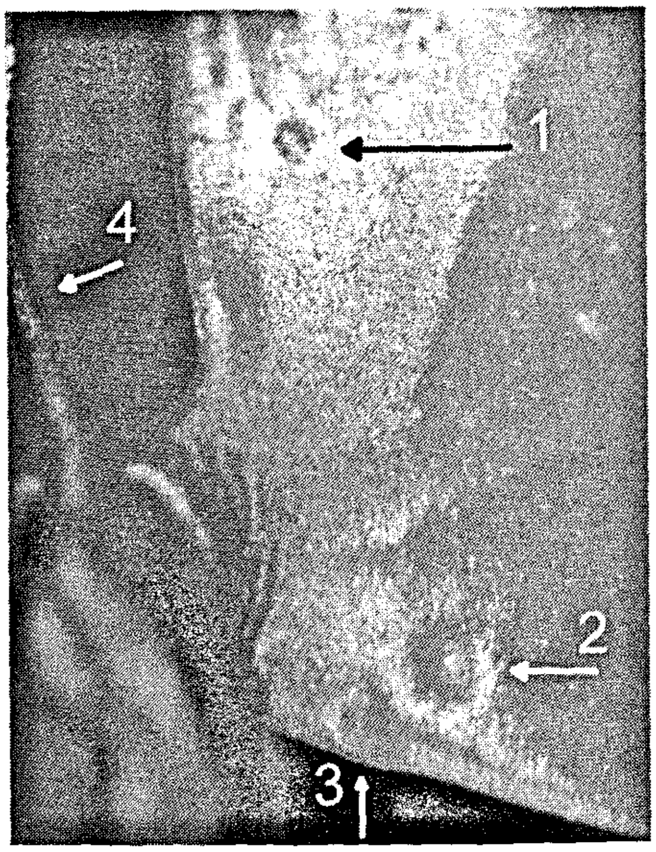


Photo 11.1. *B. breynei*, petiole and base of leaflet from below. 1–3: glands, 4: rudimentary rachis.

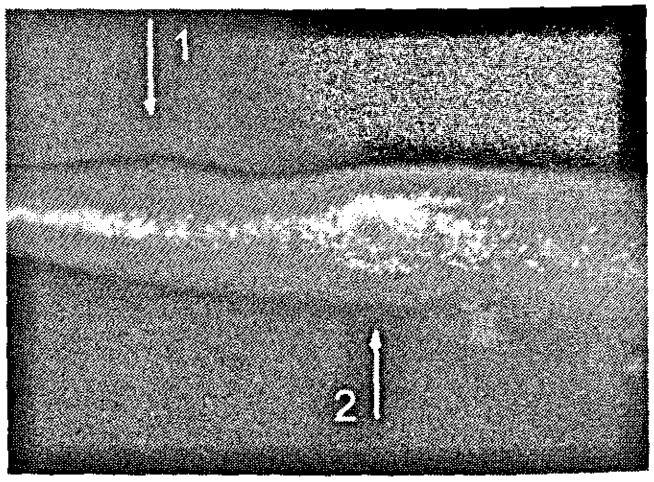


Photo 11.2. *B. breynei*, proximal margin of leaflet. 1: gland in proximal half, 2: gland on the margin.

Twigs greyish brown to grey with pale brown lenticels, glabrous. **Stipules** free, caducous, ovate to obovate, 11–29 x 4–12 mm, the last one of a shoot only 4–6 x 1½–2 mm, proximal side truncate to slightly auriculate at base, both sides glabrous, margins chaffy, proximal side also shortly ciliate at base and often with some small ovate to trullate (glandular?) appendages (photo 4.4–6). **Leaves** 1-jugate. **Petiole** 7–28 mm long, glabrous or rarely sparsely tomentose above in very young leaves, basal 3–9 mm consisting of the wrinkled joint. **Rachis** wanting or up to 2 mm long (photo 11.1→4). **Leaflets** 60–190 x 25–82 mm, leathery, both sides glossy, dark green, glabrous, margins glabrous: proximal half ovate to heart-shaped, base not auriculate, margin sinoid towards the apex; distal half narrowly obovate; apex bluntly acuminate. **Gland pattern**: leaflet in proximal half with 0–1(–2) glands (photo 11.1→2, 11.2→1), in distal half with 0–2(–4) glands (photo 11.1→1), at the very base a gland is often present **on** the proximal margin (photo 11.1→3, 11.2→2).

Inflorescence a compound or double-compound raceme, axillary on the terminal 4 nodes, 1–3 per node, 4½–13 cm long, with 6–16 lateral branches which are 5–27 mm long and densely 15–45-flowered, lower branches sometimes branched once more or even forming compound inflorescences of their own. **Rachis** mixed pubescent and fairly sparsely velvety, lateral branches velvety. **Bracts** caducous, obtrullate, 3.7–5.2 x 2.1–4.4 mm, outside appressed white puberulous with (especially on ribs when present) some slightly longer brownish hairs, a strip along the lateral margins usually more sparsely set with hairs or even glabrous, inside glabrous, margins shortly ciliate, apex sometimes with a few long hairs. **Pedicel** 1.6–2.6 mm long, appressed brown pubescent. Hypanthium s.l. 0.9–1.6 mm high in bisexual flowers, 0.7–1.0 mm high in male flowers. **Bracteoles** assuming a 60–100° wide angle at anthesis, ovate, 5–7½ x 3–5 mm, with a fairly asymmetrically positioned midrib, white, outside appressed white and pale brown puberulous to pubescent, especially along the midrib also appressed shortly to long brown velvety, inside glabrous, margin chaffy-tomentose. **Sepals** outside appressed pubescent-velvety, inside glabrous, margin shortly ciliate. **Adaxial sepals** fused into a boomerang-shaped band, 0.4–0.8 x 1.6–2.6 mm, including the hypanthium part 1.2–1.7 mm high. **Lateral sepals** wanting. **Abaxial sepal** triangular or narrowly so, 0.2–2.0 x 0.3–0.9 mm, apex rounded. **Adaxial petal** 4–6 x 1.9–2.9 mm, white: claw very short, only 0.2–0.4 mm long, glabrous; blade obovoid, towards the margins curved inwards, outside glabrous, inside glabrous except for a narrow tomentose strip along the lateral margins, lateral margins tomentose ciliate. **Lateral petals** usually wanting, rarely vestigial, up to 0.4 x 0.1 mm, glabrous but apex sometimes with

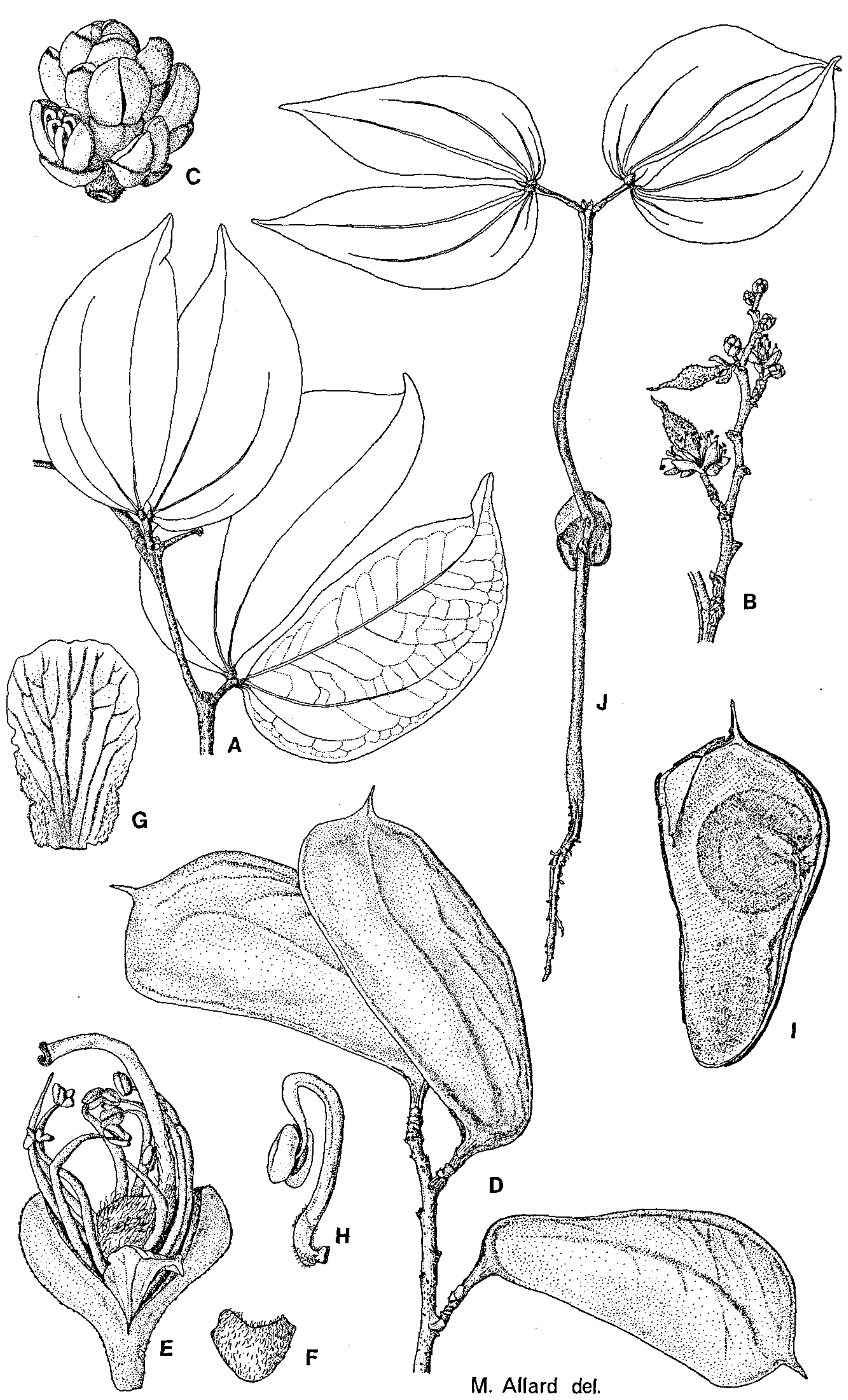


Figure 11.3. *Bikinia breynei* (Bamps) Wieringa. — A: twig with leaves (x½); B: inflorescence (x½); C: single raceme with flower buds (x2); D: infructescence (x½); E: bisexual flower from adaxial side (x3); F: adaxial sepals from outside, including the part fused with the hypanthium (x6); G: adaxial petal from inside (x6); H: adaxial stamen (x6); I: pod valve from inside (x½); J: seedling (x½). — A, B, E–H: *Breyne 3183*; C: *Breyne 3155*; D: *Breyne 3268*; I: *Breyne 3648*; J: *Breyne 3311*. Published earlier in Bull. Nat. Plantentuin Belg. 50: 511.

a few short hairs. **Abaxial petals** wanting. **Stamens** 10: filaments comparatively broad, flattened, 8–13 mm long, 9 united over a length of 0.5–2.6 mm, the lateral stamens often fused for up to another 1.0 mm, glabrous, but pubescent in the hypanthium part and the lower edge of the fused part, adaxial filament free, on inner or both sides at base usually with some short hairs; anthers 0.9–1.2 mm long, connective at base protruding in a small dent, thecae often with one or a few hairs at apex. **Ovary** often depauperate and only 0.8–0.9 x 0.4–0.7 x 0.2–0.5 mm in male flowers, in bisexual flowers 3.1–3.5 x 1.7–2.0 x 0.8–1.2 mm, with 2 ovules, very densely, shortly to very long velvety, upper suture indistinct, stipe 2.0–2.8 mm long in bisexual flowers, 1.1–1.4 mm long in male flowers, shortly to long velvety. **Style** 10–12 mm long, inserted at an angle of c. 40–90°, base conical, often geniculate at the apex of the conical part, shortly to long velvety, becoming glabrous towards apex; stigma heart-shaped.

Pod (0–)1–2-seeded, obovate, 7½–13 x 3.7–5.9 x 0.3–0.5 cm, green, brown at maturity, glossy, mixed appressed pubescent and puberulous, usually also sparsely set with long hairs; beak 2–9 mm long, often directed somewhat upwards; upper suture hardly winged, 1½–4 mm wide; nerve at or just above the middle, u/w = 0.42–0.51, sometimes some additional diagonal lines present in upper half; stipe 6–10 mm long; pedicel 2–4 mm long. **Seeds** 21–32 x 17–22 x 6–7½ mm, weight 2–3 g in dry condition; testa thin, brown.

Seedling: Germination epigeal. **Hypocotyl** 3–9 cm long, densely velvety. **Epicotyl** 6½–15 cm long, glabrous, rarely with a few short hairs near the apex. First pair of leaves opposite, 1-jugate. Subsequent leaves alternate, 1-jugate.

Distribution: Map 11.3. Known from only two localities: the borders of Lake Ngaenke in Congo (Kinshasa) and the Bambidie area, c. 30 km E of Lastoursville in Gabon.

Vernacular names: None recorded.

Ecology: Occurs abundant and dominant around lake Ngaenke, alternating with *Gilbertiodendron breynei* stands, in the narrow strip of forest around the lake. Regeneration in this area was at the time very abundant (Bamps, 1980: 514).

In Gabon some scattered large trees were found in dry-land forest.

Phenology: Flowering in Congo (Kinshasa) occurs from December to January. Almost mature pods have been found in March.

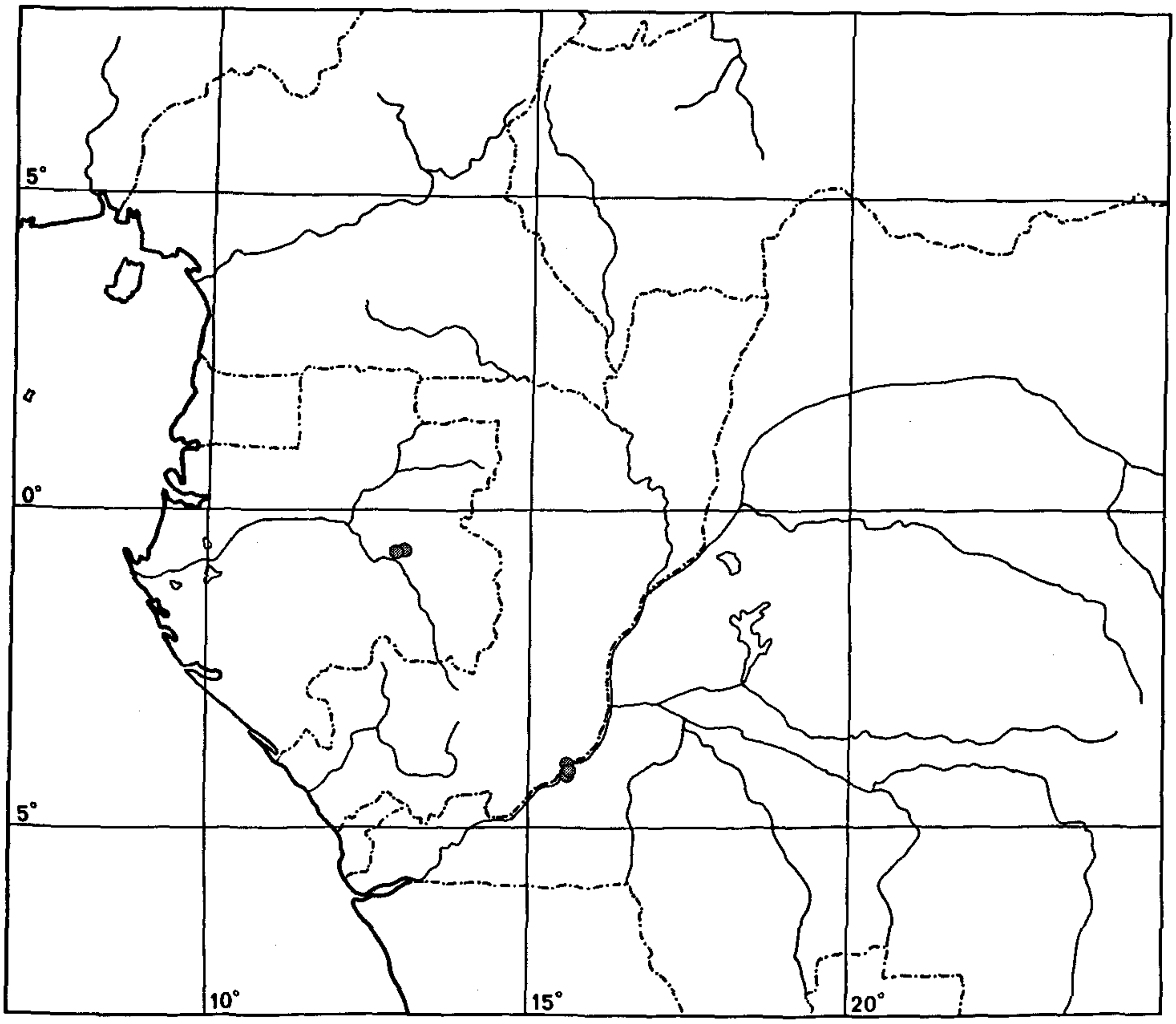
In Gabon fairly fresh pods and young saplings were collected in July.

Chemistry: Flowers produce an orange-yellow colour in alcohol.

Diseases and pests: Leaves are very often damaged by leaf-miners and galls: also the gland present on the margin may be galled, creating a tooth at the leaflet base.

Use: The wood is used for the production of charcoal. Possibly young trees are also used for house-construction and as poles. The wood is supposed to be very hard (Bamps, 1980: 514).

Notes: This species possesses truly functionally male flowers. These have a small ovary with the normal number of ovules but a very small style. Flowers with a normally



Map 11.2. Distribution of *Bikinia breynei* (Bamps) Wieringa.

developed ovary and style are functional bisexual, since the anthers possess developed pollen. The anther slits already open in bud. It seems as if some trees are entirely male, as *Breyne 3155 & 3508* show only reduced ovaries. Moreover, the latter is already in the final phase of flowering, but does not show any development of pods. No trees with exclusively bisexual flowers were detected: *Breyne 3183 & 3984* show both male and bisexual flowers.

Several characters, like the very compact inflorescence, the dense and persistent appressed hairs on the ovary, the long beak already present in the flower, the shape and number of sepals and petals and the filaments which are fused over a considerable distance *seem to point to a close affinity with B. durandii.* However, such a close link is not evident from the phylogenetic analysis.

Specimens examined:

GABON: *Breteler & Leal 14198* (WAG (+alc)): c. 30 km NE Lastoursville, c. 10 km NW Bambidie, 0°42'S 12°52'E (fr, 04.10.1997); *Deckoussoud 3* (WAG): c. 30 km E Lastoursville, N of Bambidie, 0°40'S 13°00'E (fr, 07.07.1997).

CONGO (KINSHASA): *Breyne 2921* (BR): Lac Ngaenke, Nsele, 4°14'S 15°33'E (fr, 02.03.1976); *Breyne 3155* (BR (+alc), K, WAG): Lac Ngaenke, Maluku, 4°03'S 15°33'E (fl, 16.12.1976); *Breyne 3183* (BR (+alc)) type: Lac Ngaenke, 4°09'S 15°35'E (fl, 30.12.1976); *Breyne 3208* (BR): Lac Ngaenke, Maluku, 4°09'S 15°35'E (fr, 17.03.1977); *Breyne 3268* (BR): Lac Ngaenke, Maluku, 4°09'S 15°35'E (fr, 25.01.1978); *Breyne 3311* (BR): Lac Ngaenke, 4°09'S 15°35'E (st, 05.06.1978); *Breyne 3508* (BR, MO): Lac Ngaenke, 4°09'S 15°35'E (fl, 06.12.1978); *Breyne 3648* (BR): Lac Ngaenke, 4°09'S 15°35'E (fr, 30.03.1979); *Breyne 3984* (BR): Lac Ngaenke, 4°09'S 15°35'E (fl, 24.01.1980).

Bikinia congensis Wieringa spec. nov. **Fig. 11.4, Map 11.3**

Type: *A.O. Kibungu Kembelo in J.J. Wieringa 3466* (holo: WAG; iso: some duplicates to be distributed) — "Congo (Kinshasa), Kisantu botanic garden. Introduced from Zongo, Inkisi falls".

Hymenostegia longituba auct. non (Harms) Baker f.: Germain, 1949: 15 & fig. 9.
Tetraberlinia polyphylla auct. non (Harms) J. Léonard ex Voorh.: Pauwels, 1993: 116 (excl. Pl. 53).

Diagnosis: Arbor usque ad 30 m alta. Stipulae liberae gemma valvata. Folia (6–)8–10(–11)-jugata; foliola auriculis conspicuis. Inflorescentia thyrsoidea, solitaria condensatissima, tantum 1½–4 cm longa ramis lateralibus tantum 5–14 mm longis floribusque 7–12. Flores aggregati inter bracteas persistentes. Sepala adaxialia connata; sepala lateralia absentia; sepalum adaxiale vestigiale. Petalum adaxiale magnum sed paulo angustum; petala alia absentia sed vestigialia. Legumen seminibus 1–3, 7–11 x 3.3–4.4 x 0.2–0.5 cm, puberulum et pilis longis paucis additiciis; rostrum 3–9 mm longum; sutura superna non vel anguste alata, 2–4½ mm lata.

Small to medium sized tree, up to 30 m high, crown hemispherical. **Bole** up to 10 m tall, DBH up to 100 cm: base with small, up to 1 m high, buttresses. **Bark** up to 10 mm thick, with the odour of nutmeg: surface finely rugose, brown; inner bark reddish brown.

Twigs pale to dark grey with pale brown lenticels, glabrous or puberulous. **Stipules** free, valvate in bud, early caducous, linear to narrowly obovate, 15–65 x 1½–18 mm, on one side with a small auricle: both sides glabrous; margins glabrous, tomentose or chaffy, sometimes sparsely ciliate towards the apex. **Leaves** (5–)7–20 cm long, (6–)8–10(–11)-jugate, largest leaflet the apical pair or just distal of the middle pair: **Petiole** 2–6 mm long, glabrous or puberulous, completely consisting of the wrinkled joint. **Rachis** terete but in dry condition the upper side usually with a grooved ridge, (4–)5–14 cm long, (sparsely) puberulous to tomentose but lower side often glabrous. **Leaflets** leathery: upper side glossy, glabrous, sometimes pubescent at base and on the midrib; lower side somewhat glossy, glabrous; margins glabrous to sparsely shortly ciliate, rarely that of the basal leaflet tomentose; proximal half obovate, base except in basal leaflet distinctly auriculate, margin towards the apex often somewhat sinoid; distal half rounded trullate; apex rounded. **Basal leaflet** 7–32 x 2½–13 mm: base of proximal half usually angled, often very faintly auriculate, auricle 0–0.3 mm long. **Apical leaflet** 18–63 x 6–23 mm: auricle 0.2–2.4(–3.8) mm long. **Largest leaflet** 18–46(–63) x 7–17(–23) mm, 2.4–3.5 times as long as wide: auricle 0.7–2.8(–4.4) mm long. **Gland pattern**: basal leaflet in proximal half with 1–3, in distal half with 0–1(–2) glands. Second leaflet usually without glands, very rarely one present in distal half. Apical leaflet in distal half with 0–1 glands. Other leaflets usually without glands, only the one but last leaflet rarely in the distal half with 1 gland.

Inflorescence axillary on the terminal 5 nodes, solitary, a compound raceme, 1½–4 cm long, with 1–7 lateral branches which are 5–14 mm long and 7–12-flowered, lowest branch rarely branched once more. **Rachis** brown velvety. **Bracts** finally deciduous to persistent in flower, ovate to circular, 3.6–4.8 x 2.4–5.6 mm, probably whitish or yellowish brown: outside silky to puberulous or sometimes only at base and in the centre; inside glabrous; margins short ciliate. Flowers crowded in between the bracts. **Pedicel** 1½–4 mm long, puberulous to tomentose or velvety. Hypanthium s.l. 0.5–1.8 mm high. **Bracteoles** ovate,

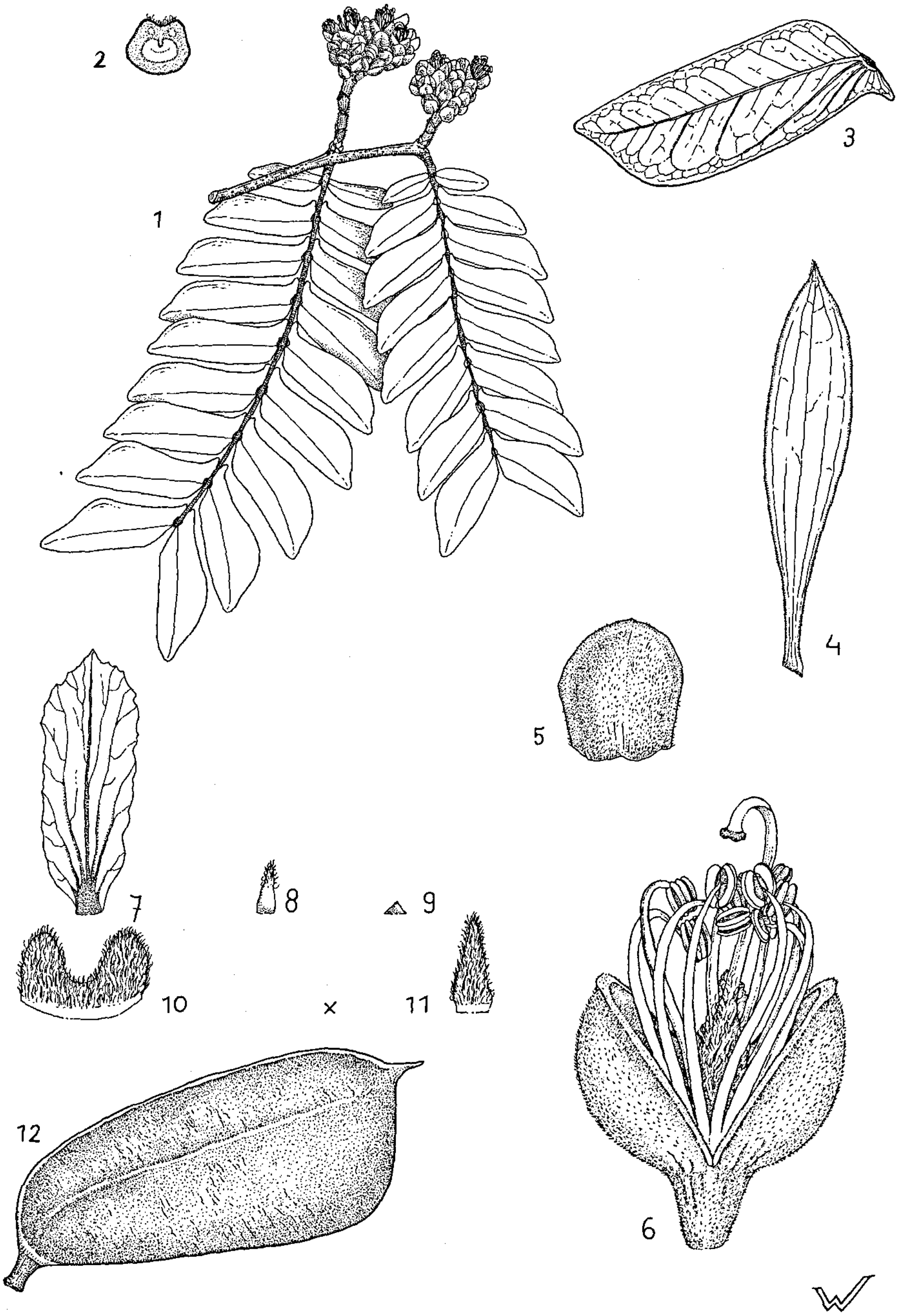


Figure 11.4. *Bikinia congensis* Wieringa. — 1: twig with leaves and inflorescences (x⅔); 2: cross section of leaf rachis (x6); 3: medial leaflet, lower surface (x⅔); 4: stipule (x⅔); 5: bract from outside (x4); 6: flower from abaxial side (x4); 7: adaxial petal (x6); 8: lateral petal (x6); 9: abaxial petal (x6); 10: adaxial sepals from outside, part fused to hypanthium indicated by a dotted line (x6); 11: abaxial sepal from outside (x6); 12: pod (x⅔). — 1–3, 5–11: *Kibungu Kembelo in Wieringa 3466*; 4: *Pauwels 5615 & Kibungu Kembelo in Wieringa 3468*; 12: *Kibungu Kembelo in Wieringa 3467.*

5.8–7.6 x 3.5–5.1 mm, assuming a 40–55(–90?)° wide angle at anthesis: outside appressed whitish puberulous, at base mixed with velvety hairs; inside glabrous, rarely sparsely pubescent at base or along the margins; margins chaffy. **Sepals** outside velvety, inside glabrous, margins ciliate. **Adaxial sepals** fused into a two-lobed band, 0.4–1.4 x 1.5–2.9 mm, including the part fused with the hypanthium 0.9–1.9 mm high. **Lateral sepals** wanting. **Abaxial sepal** (narrowly) triangular to ovate, 0.8–2.7 x 0.4–0.9 mm, base sometimes fused over a distance of up to 0.5 mm with the staminal tube, apex acute. **Adaxial petal** oblong, 3.4–5.1 x 0.9–2.1 mm, indistinctly clawed, claw 0.3–0.8 mm long, white: both sides glabrous but outside sometimes sparsely puberulous at the centre near the base; margins glabrous, undulate; apex acute. **Lateral petals** generally very small, rarely wanting, ovate or triangular to linear, 0.1–0.8 x 0.1–0.4 mm: outside velvety to glabrous; inside glabrous. **Abaxial petals** often wanting, when present triangular to linear, 0.1–1.0 x 0.1–0.5 mm: outside glabrous to sparsely velvety; inside glabrous. **Stamens** 10(–11): filaments 5½–12 mm long, 9 united over a length of 0.5–1.6 mm, the three stamens on each side of the abaxial one sometimes united for up to an additional 0.4 mm, adaxial filament free, the three most adaxial filaments usually pubescent outside in lower part, other stamens only pubescent on inner side of hypanthium; anthers 1.3–1.8 mm long, purple. **Ovary** in bisexual flowers 2.9–4.0 x 1.5–1.9 x 0.8–1.4 mm, in male ones 1.3–2.0 x 0.7–1.1 x 0.5–0.6 mm, long pale brown velvety, with 3–4 ovules; stipe 1½–3 mm long in bisexual flowers, 0.8–1½ mm in male flowers. **Style** 7–11 mm long in bisexual flowers, 1–2 mm in male flowers, inserted at an angle of 10–90°, long velvety up to more than half its length: base conical, often geniculate at the apex of the conical part; stigma heart-shaped.

Pod 1–3-seeded, oblong-obovate, 7–11 x 3.3–4.4 x 0.2–0.5 cm, dull or somewhat glossy, puberulous and with a few additional long hairs: beak 3–9 mm long; upper suture not to narrowly winged, 2–4½ mm wide; nerve rather indistinct, in or slightly above the middle, u/w = 0.34–0.55; stipe 4–9 mm long; pedicel 3–6 mm long. **Seeds** 17–27 x 13–22 x 3–6 mm, weighing 0.5–1.5 g in dry condition; testa thin, brown; cotyledons purplish brown.

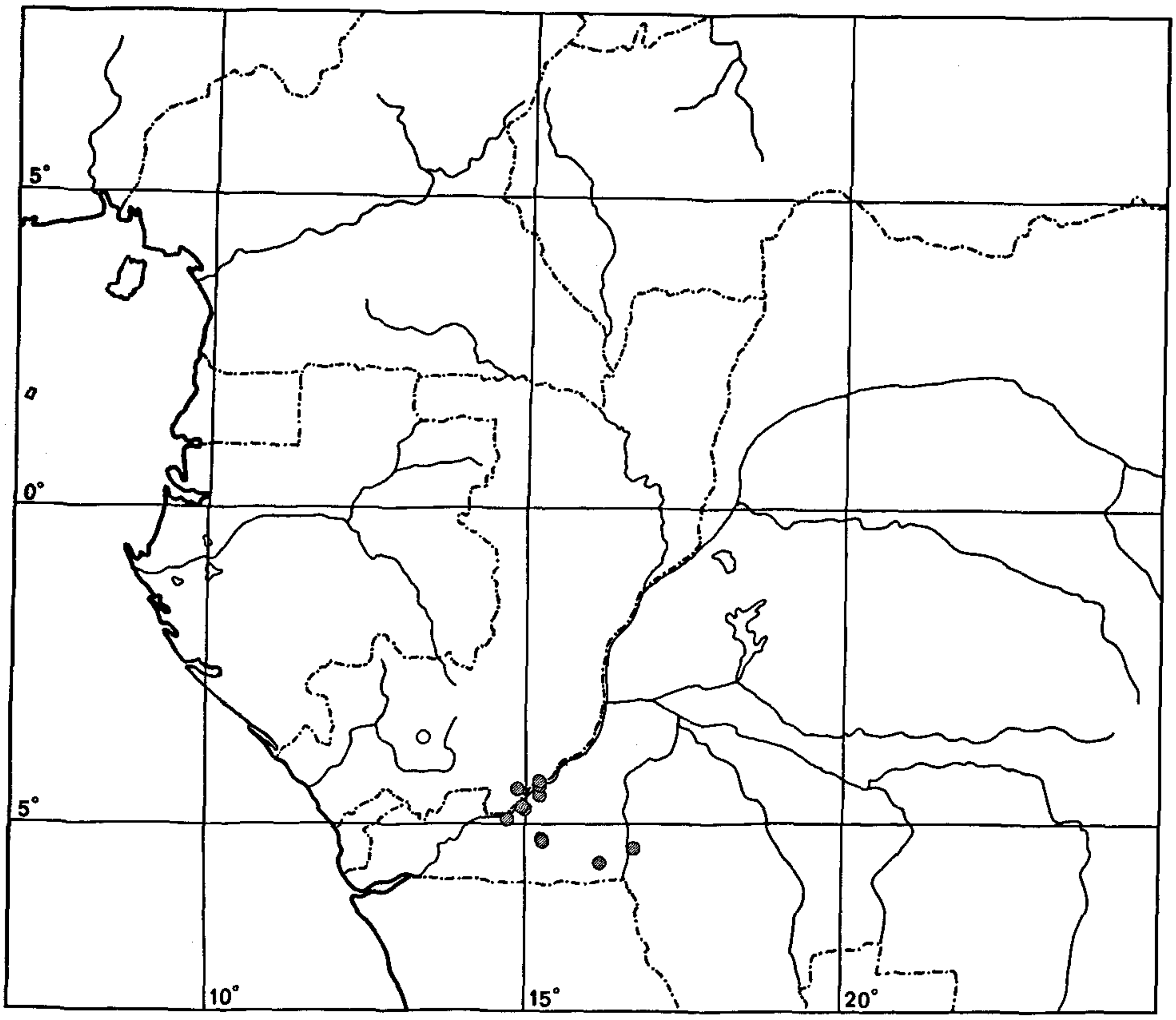
Seedling: Germination epigeal. Hypocotyl 4½–6 cm long, velvety. Epicotyl 6–10 cm long, sparsely pubescent, denser towards the apex. First pair of leaves opposite, 5–7-jugate, largest leaflet apical or in the middle of the leaf. Leaflets small, basal leaflet c. 12–18 x 6–8 mm without an auricle, apical and largest leaflet c. 19–30 x 6–11 mm, auricle 0.5–2.7 mm long. Subsequent leaves alternate, with an increasing number of leaflets.

Distribution: Map 11.3. Endemic to a rather small area ranging from the surroundings of Brazzaville (Congo) to those of Popokabaka (Congo (Kinshasa)). Possibly the distribution extends across the Angolan border.

Vernacular names: Congo (Kinshasa): Ngansi (Popokabaka area), Kubi (Kiyaka), Mabwati (Kisantu area).

Forestry name: none recorded.

Ecology: Tree of riverine and dry-land rain forest at low altitudes (probably 200–600 m). Grows gregariously; Germain (1949: 15) even reports a monospecific stand with abundant regeneration.



Map 11.3. Distribution of *Bikinia congensis* Wieringa.

Phenology: In the botanical garden of Kisantu, which lies within the natural range of the species, flowering seems to be restricted to September and October. Pods were subsequently collected at the start of February, a seedling in April. In the wild, pods have been collected in January and February, seedlings in April. Maturation of the pods takes about 4 months.

Chemistry: Pods and flowers produce a deep orange-yellow to orange-brown colour in alcohol.

Diseases and pests: Seeds are being infected by beetles (probably weevils, Curculionidae). Leaflets sometimes bear some small galls.

Use: Bark used as medicine against worms. Wood suitable for joinery. It has been reported that white edible mushrooms grow on the trunk of this species.

Notes: Through the very kind cooperation of A.O. Kibungu Kembelo, director of the botanic garden of Kisantu, rich samples of a tree growing in that garden were received. It includes the flowering material here selected as type, pods preserved in alcohol and a seedling. Since this important material was devoid of a collector and collection number, I have given it numbers in my own series, presuming Mr Kibungu Kembelo was the actual collector, and as such permitting unambiguous recognition of iso- and paratypes.

Specimens examined (except *Constant & Bertault 261* and the type all paratypes):

CONGO (BRAZZAVILLE): *Bouquet 376* (P): right bank of Foulakari river, 4°30'S 14°50'E (st, 03.08.1964); *Constant & Bertault 261* (CIRAF) id. doubtful: Sibiti, 3°41'S 13°21'E (st, 24.06.1972); *Sita 1540* (P, WAG): env. of Brazzaville, Djoumouna forest, 4°23'S 15°10'E (fr, 27.01.1967).

CONGO (KINSHASA): *Kibungu Kembelo in Wieringa 3466* (WAG (+alc)) type: Kisantu botanic garden, introduced from Zongo, Inkisi falls, 4°47'S 14°54'E (fl, fr, 15.09.1995); *Kibungu Kembelo in Wieringa 3467* (WAG (alc only)): Kisantu botanic garden, introduced from Zongo, Inkisi falls, 4°47'S 14°54'E (fr, 02.02.1996); *Kibungu Kembelo in Wieringa 3468* (WAG (+alc)): Kisantu botanic garden, introduced from Zongo, Inkisi falls, 4°47'S 14°54'E (st, 19.04.1996); *Breyne 3338* (BR): Madimba, Kisantu, botanic garden, not located (fr, 15.06.1978); *Breyne 3466* (BR): Madimba, Kisantu, botanic garden, not located (fl, 19.10.1978); *Breyne 3534* (BR): Kisantu, Kasangula, botanic garden (intr. from Zongo falls), 4°47'S 14°54'E (fr, 19.01.1979); *Breyne 4488* (BR): Kisantu, botanic garden, not located (fl, 22.10.1982); *Butaye in Gillet 3494* (BR): Lemfu, 5°18'S 15°13'E (st, 10.1903); *Callens 148 bis* (BR): Kinkasi, forest on plateau, 5°20'S 15°14'E (fr, 08.02.1953); *Callens 2849* (BR): Zongo, Inkisi falls, 4°47'S 14°54'E (st, 10.09.1951); *Callens 4542* (BR): Zongo, gallery forest of the Inkisi, 4°49'S 14°57'E (fr, 02.1954); *Compère 1270* (BR): Gombe Lutete, Tombe river (terr. Thysville), 4°59'S 14°41'E (fr, 22.01.1960); *Germain 2554* (BR): betw. Kwango and Wamba river, Wusi (=Wusu) valley, 5°27'S 16°40'E (st, 01.08.1944); *Laurent 480* (BR): Sabuka near Leopoldville, 4°27'S 15°10'E (fr, 27.02.1905); *Nsimundele 462* (BR): Bot. garden of Kisantu, not located (fl, 15.10.1978); *Nsimundele 463* (BR): Bot. garden of Kisantu, not located (st, 15.10.1978); *Nsimundele 470* (BR): Kasangula, 4°36'S 15°10'E (fr, 14.01.1979); *Pauwels 2300* (BR): Mpangu (Popok.), 5°41'S 16°08'E (st, 13.04.1959); *Pauwels 5615* (BR, WAG): Madimba, Kisantu, botanic garden (orig.: Zongo), 4°47'S 14°54'E (st, 01.04.1967).

Bikinia coriacea (J. Morel ex Aubrév.) Wieringa comb. nov. Map 11.4

Basionym: *Monopetalanthus coriaceus* J. Morel ex Aubrév., Fl. Gabon 15: 318–320 (1968).

Monopetalanthus coriaceus J. Morel ex Aubrév.: Aubréville, 1968: 318–320 & Pl. 81; Aubréville, 1970: 291; Bolza & Keating, 1972: 455. **Type**: *Morel 134* (holo: P) — Gabon: "Secteur d'inventaire de la Moyenne Mbei 28 octobre 1950".

Monopetalanthus sp. nov. (de Morel): Saint Aubin, 1963: 50, 54 & photo's opposite p. 54 (based on *de Saint Aubin CTFT-G 1935*).

Large forest tree, up to 53 m high, crown broad, hemispherical. **Bole** cylindrical, up to 26 m tall (probably even more), diameter up to 100 cm: base with up to 2 m high buttresses. **Bark** up to 17 mm thick: surface smooth to fissured, grey to greyish brown with red-brown lenticels; inner bark fibrous, towards exterior slightly granular, in dry condition orange-brown; outer bark up to 1 mm thick, dark brown. Sapwood in dry condition pinkish. Heartwood pink-brown.

Twigs grey to greyish brown, with brown lenticels, golden-brown (in older twigs white) silky. **Stipules** free (stipules modified as bud scales completely fused), early caducous, obovate or narrowly so, base not auriculate, 3–7 x 0.2–2 cm, outside completely appressed long velvety to only so in the lower half along the middle, inside glabrous, margins chaffy. **Leaves** 6–22 cm long (–28 cm in saplings), 19–36-jugate, largest leaflet at 25–50% of the total number of leaflets: **Petiole** 2–7 mm long, entirely consisting of the wrinkled, velvety joint. **Rachis** 5–20 cm long (–25 cm in saplings), in dry condition flattened or grooved above, (long) velvety to glabrous, but sparser on upper side. **Leaflets** linear, often curved in proximal direction, thickly leathery: upper side shiny, dark green, glabrous; lower side somewhat glossy, medium green, glabrous, but in very young leaves sparsely villous; margins long ciliate; apex bluntly acute. **Basal leaflet** 5–33 x 1.5–5.8 mm: base never auriculate. **Apical leaflet** 4–23 x 1.0–4.9 mm: base rarely auriculate, auricle up to 0.3 mm.

Largest leaflet 15–52 x 3.2–7.7 mm, (4.0–)5.0–7.4 times as long as wide: base usually auriculate, auricle up to 1.1 mm. Leaves of saplings and treelets usually larger and relatively broader than those in mature trees (all sizes included in this description). **Gland pattern**: basal leaflet in proximal half with 2–3 glands (usually arranged along a diagonal line from the leaf base to the apex), distal half without glands. Second leaflet in proximal half usually without, rarely with 1 gland, distal half without glands. Apical leaflet in proximal half without, in distal half with 0–2 glands. Other leaflets in proximal half without, in distal half with 0–1 gland (glands only present in more distal leaflets).

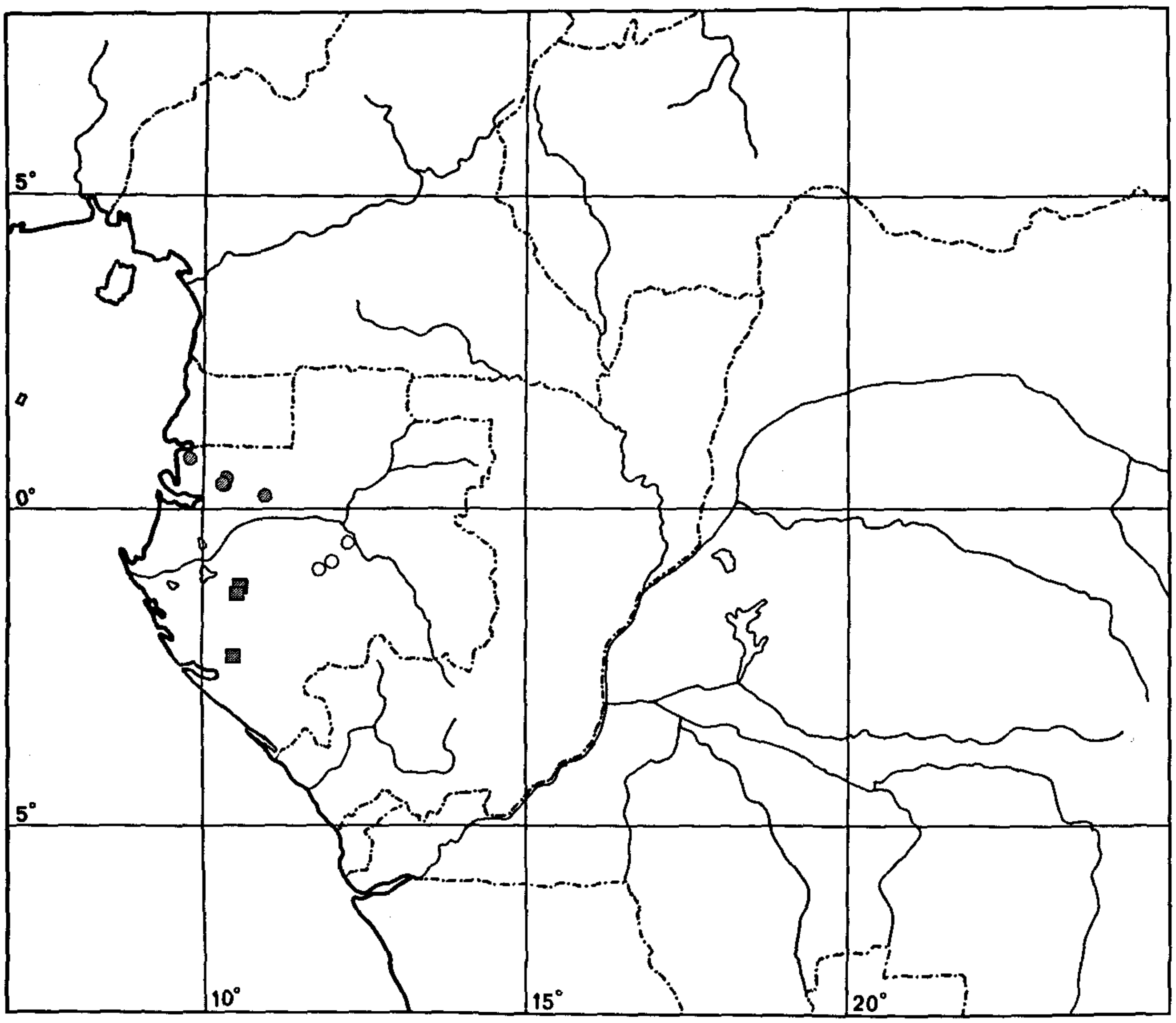
Inflorescence axillary on the terminal three nodes, a compound raceme, 3–8 cm long, with 1–6 lateral branches which are up to 15 mm long and c. 25-flowered, sometimes primary axis with leaves and lateral floral branches reduced. **Rachis** (long) brown velvety. **Bracts** falling late, ovate, 7–10 x 5–8 mm: outside tomentose, long velvety on the (often hardly developed) mid-ridge, glabrous along the margins; inside glabrous; margins long ciliate. **Pedicel** 0.5–4 mm long, velvety. Bracteoles, sepals, petals and filaments at base united in a c. 1.5 mm high hypanthium. **Bracteoles** ovate, 5½–8 x 3½–6 mm: outside with an asymmetric running ridge, along the ridge (long) velvety, becoming silky towards the margins; inside glabrous; margins chaffy. **Sepals** outside (long) velvety, inside sparsely pubescent. **Adaxial sepals** fused into a two-lobed band, 0.5–0.9 x 2.0–2.7 mm, including the hypanthium triangle 1.8 mm high. **Lateral sepals** triangular, 0.4–0.5 x 0.4–0.6 mm. **Abaxial sepal** ovate, 0.2–0.4 x 0.8 mm, including the part fused with the hypanthium 0.6–0.7 mm high. **Adaxial petal** c. 4–6 x 3 mm: claw c. 0.5 mm long; blade rounded obtriangular to fiddle-shaped, outside with a velvety basal triangle, both sides with a very narrow pubescent band along the lateral margins, otherwise glabrous, apical margin long ciliate. **Lateral petals** linear, 0.6–1.0 x 0.1–0.3 mm, glabrous, margins sometimes sparsely ciliate. **Abaxial petals** wanting or elliptic, up to 0.8 x 0.3 mm, margin at apex ciliate. **Stamens** 10: filaments tapering to the apex, over 5 mm long, 9 fused for 0.6–1.0 mm, the three stamens on each side of the abaxial one fused for 1.8 mm, adaxial filaments only fused with the hypanthium, the more adaxial ones outside pubescent at base, all filaments velvety inside the hypanthium; anthers 0.9–1.4 mm long. **Ovary** long velvety, with 1–2 ovules, stipe c. 2 mm. **Style** over 5 mm long, inserted at an angle of 40–80°, base velvety, towards the apex becoming glabrous; stigma heart-shaped.

Pod 1–2-seeded, obovate, 10–14 x 4–6 x 0.4–0.6 cm, dull, mixed velvety and papillose; beak ½–4 mm long; upper suture narrowly winged, 2–8 mm wide; nerve just above or about in the middle, u/w = 0.41–0.60; stipe 5–12 mm long; pedicel 3–7 mm long. **Seeds** unknown, prints in pods c. 33 x 30 mm.

Seedling: Germination epigeal. **Hypocotyl** 6–8½ cm long, fairly densely velvety. **Epicotyl** 15–19 cm long, glabrous at base, towards the apex becoming fairly densely tomentose-velvety. First pair of leaves opposite, 14–16-jugate. Subsequent leaves alternate, with a lower or equal number of leaflets.

Distribution: Map 11.4. Endemic to Gabon. From the lower southern slopes of the Crystal Mountains to the 'Forêt des Abeilles'.

Vernacular names: Nothing more than the general denomination 'Andoung' (Fang) is known.
Forestry name: Gabon: Andoung de Morel.



Map 11.4. Distribution of *Bikinia aciculifera* Wieringa (squares) and *Bikinia coriacea* (J. Morel ex Aubrév.) Wieringa (circles).

Ecology: Emergent of dry-land rain forest at altitudes of up to c. 300 m; solitary, but according to Saint Aubin (1963: 54) it also grows in important stands.

Phenology: Flowers have been found in July and October, developing pods in January. The inflorescence collected in October consists of a single suppressed inflorescence, that only produced a single lateral branch with normally developed leaves on the other nodes.

Chemistry: Flowers, but to a lesser extent also leaves, produce a strong dark brownish red colour in alcohol.

Diseases and pests: Galls are sometimes present on the leaflets at the position of a gland. According to Saint Aubin (1963: 54) the outer bark is sometimes scratched off by some rodent.

Use: As for most 'Andoungs', this tree is not being logged at present, but as soon as 'Andoungs' will be considered, also this species might be exploited, provided that the extensive stands mentioned by Saint Aubin still exist. The wood is suitable for many purposes including joinery, veneer, plywood and pulp.

The seedlings as described here are from the Sibang arboretum in Libreville, the provenance of these trees is not sure, but it is very likely the Crystal Mountains.

Specimens examined:

GABON: *Bernard 282* (LBV): Sibang arboretum, not mapped (fr, 29.10.1951); *Bernard 283* (LBV) id. doubtful: Sibang arboretum, not mapped (st, 29.10.1951); *Breteler & Leal 13925* (WAG): Libreville, Sibang arboretum, not mapped (fr, 12.09.1997); *Breteler, Wieringa & Nzabi 12972* (WAG): Crystal Mountains, 5 km S of Kinguélé, 0°25'N 10°16'E (st, 20.09.1994); *Dibata & Wilks 1141* (BR, WAG) id. doubtful: Forêt des Abeilles, SE of confl. Gongué-Offoué, 0°50'S 11°57'E (st, 29.07.1993); *Doucet 278* (BR) id. doubtful: Parcel 32 of Leroy Gabon. 0°46'-1°09'S 11°30'E-Offoué, 0°57'S 11°45'E (st, 06.12.1995); *Groulez 1263* (LBV): Sibang-arboretum, not mapped (st, 01.08.1953); *Morel 130* (P): inventarisation sector middle M'Bei-valley, near M'Foa, 0°24'N 10°18'E (fl, 07.1950); *Morel 133* (LBV): side of Mbeba-river (affl. of Mbei), 0°30'N 10°20'E (st, 26.10.1950); *Morel 134* (P): inventarisation sector at middle Mbei-valley, 0°24'N 10°18'E (fl, 28.10.1950); *de Saint Aubin 1935* (LBV, P): 24 km SE of Cocobeach, 0°49'N 9°46'E (fr, 01.08.1958); *Wieringa 3309* (WAG (+alc)): Libreville, Sibang forest, Andoung-plot, not mapped (fr, 01.12.1994); *Wilks & Dibata 2554* (WAG): Otouma, 0°13'N 10°55'E (fr, 27.01.1992); *Wilks 237* (WILKS) id. doubtful: N of road from Lastoursville to Ofoué, near Vouboué, 0°32'S 12°12'E (st, 29.06.1979); *Wilks s.n. (1)* (WILKS): ?, not located (st, ?).

Bikinia durandii (F. Hallé & Normand) Wieringa comb. nov.

Fig. 11.5 & 11.6, Map 11.5

Basionym: *Monopetalanthus durandii* F. Hallé & Normand, Notul. Syst. (Paris) 16: 136–140 (1960).

Monopetalanthus durandii F. Hallé & Normand: Hallé & Normand, 1960; Saint Aubin, 1963: 50, 56 & photo opposite 56; Aubréville, 1968: 313–314 & cover; Bolza & Keating, 1972: 456; Gunn, 1991: 386–387. **Type**: *de Saint Aubin 2003* (holo: P; iso: LBV, WAG) — Gabon: "le 6/9/59 aux environs de N'Kane (Mts de Cristal)", on additional sheets later additions read: "Nkane entre Etsam et Méla au Sud de Méla".

Large tree, up to c. 60 m high, crown usually rather narrow and irregular. **Bole** cylindrical, up to c. 30 m tall, diameter up to 1.3 m: base with small or rather broad up to 2½ m high buttresses, that may radiate several metres. **Bark** up to c. 10 mm thick, exuding red-brown resin: surface rugose with up to 1 cm wide pits, greyish brown to reddish brown; inner bark fibrous, towards the exterior slightly granular, in fresh condition brownish yellow, especially in interior half changing to purple, in dry condition in interior half pale, slightly purplish brown, exterior half purplish brown with pale brown granules; outer bark less than 1 mm thick, dark brown. Sapwood whitish in fresh condition, dry pale pinkish. Heartwood pink-brown.

Twigs comparatively stout, grey to greyish brown, with few pale brown lenticels and distinct stipular scars which are usually accompanied by short hairs, glabrous except for the basal part of the shoot which is golden-brown silky and shows numerous bract scars, shoots in young trees often completely silky. **Stipules** free, touching at base and often sticking together, early caducous, narrowly obovate (strikingly resembling a hare-ear), base not auriculate, 3–6 x 1.2–1.6 cm in mature trees to 15–21 x 2.3–2.7 cm in saplings, thin succulent, outside purple-brown to dark brown, appressed velvety, inside pinkish green to purplish brown, glabrous, margins chaffy. **Leaves** 8–31 cm long (–48 cm in saplings), (6–)9–16-jugate, largest leaflet in any one of the three or four median pairs: **Petiole** 7–24 mm long, the glabrous to sparsely appressed velvety, wrinkled basal joint occupying more than half of its length, remaining part similar to rachis. **Rachis** 7–23 cm long (up to 36 cm in saplings), terete with a grooved ridge above (all in dry condition), appressed velvety, but sparser on upper side, almost glabrous in the groove. **Leaflets** leathery to thickly so, folding together at dusk: upper side glossy dark green, glabrous; lower side glossy medium green, glabrous; young leaflets reddish; margins with some appressed long and short hairs; both sides sometimes with a pale green primary nerve; proximal half obovate, base rarely auriculate, margin towards the apex not to strongly sinoid; distal half obovate to rounded obtrullate; apex truncate or rounded to bluntly acute, sometimes slightly emarginate. **Basal leaflet** (7–)14–79 x (2½–)6–25 mm: base never auriculate. **Apical leaflet** (12–)28–70 x (4–)7–29 mm: auricle 0(–0.2) mm. **Largest leaflet** 32–105 x 8–37 mm: auricle 0–0.6 mm. Leaflets of saplings and treelets usually larger than those in mature trees (all sizes included). **Gland pattern**: basal leaflet in proximal half with (0–)1–4(–6), in the distal half with 0–2 glands. Second leaflet in proximal half with 0–3, in distal half with 0(–2) glands. Apical leaflet in proximal half with 0(–2), in distal half with 0–2(–5) glands. Last but one leaflet in proximal half with 0(–1), in distal half with 0–1(–3) glands. Other leaflets in proximal half with 0(–1), in distal half with 0(–2) glands.

Inflorescence a compound raceme, lower branches may branch once more, axillary on the 5 terminal nodes (often the terminal leaf not developed and the last internode very short, causing the terminal two inflorescences seemingly inserted on the same node), 5–22 cm long, with 4–12 lateral branches which are 1.0–4.5 cm long and c. 20–60-flowered. **Rachis** pale brown silky, lateral branches more velvety. **Bracts** caducous, obovate (basal ones) to obtrullate (higher up along rachis), 6.0–11.1 x 4.7–12.2 mm, outside dark brown, at base and margins whitish, (long) appressed velvety, inside pale green to whitish, glabrous, margins chaffy. **Pedicel** 4–8 mm long, white, brown velvety. The base of bracteoles, sepals, petals and filaments united in a 2–4 mm high hypanthium s.l., all subsequent lengths measured from point where bracteoles become free. **Bracteoles** ovate, 6½–13 x 5–9 mm, assuming a 170–230° wide angle at anthesis: outside with an asymmetric ridge, white, appressed brown velvety, towards apex long velvety, particularly along the ridge, the overall colour pale brown with a dark brown ridge; inside white, glabrous, but tomentose at base, sometimes extending along the central axis; margins chaffy. Between the bracteoles on the adaxial side and to lesser extent also on the abaxial side a part of the real hypanthium is visible. **Sepals** white, brown velvety outside, white tomentose inside, margins ciliate. **Adaxial sepals** fused into a two-lobed band or consisting of two hardly connate triangles, 0.7–2.0 x 1.7–3.4 mm, but including the hypanthium triangle 2.1–4.1 mm high. **Lateral sepals** usually wanting, rarely vestigial: up to 1.6 x 0.4 mm. **Abaxial sepal** triangular or narrowly so, 0.5–3.2 x 0.4–0.8 mm, apex acute. **Adaxial petal** 5.0–7.4 x 3.1–5.2 mm, white: claw 0.7–1.4 mm long, sparsely pubescent; blade obovate, broadest near the apex, from this point tapering to base and inrolled, apical part recurved, outside pubescent at base, becoming sparser and finally glabrous towards the apex, inside pubescent along the lateral margins, apical margin ciliate. **Lateral petals** wanting or vestigial, up to 2.0 x 0.3 mm, outside glabrous or very sparsely pubescent, inside glabrous, margins shortly to long ciliate. **Abaxial petals** wanting. **Stamens** 10: filaments tapering to the apex, 9–15 mm long, white (within the hypanthium dark purple-red), 9 united over a length of 1.5–2.6 mm, with a smaller diameter than within the hypanthium, the three stamens on each side of the abaxial one united over a length of 2.0–3.8 mm, this occasionally producing a thin extra filament-like threat, adaxial filament apart from the fusion with the hypanthium free, velvety inside basally, all filaments inside short or long velvety in fused part and the hypanthium, sometimes at base of the free part as well; anthers 1.4–1.8 mm long, purple. **Ovary** in some flowers depauperate, in bisexual flowers 3.5–5.3 x 1.6–2.4 x 0.7–1.2 mm, white, with long, brown and white, velvety indumentum, with (1–)2(–3) ovules, upper suture obscure, stipe 3–5 mm long. **Style** 9–11

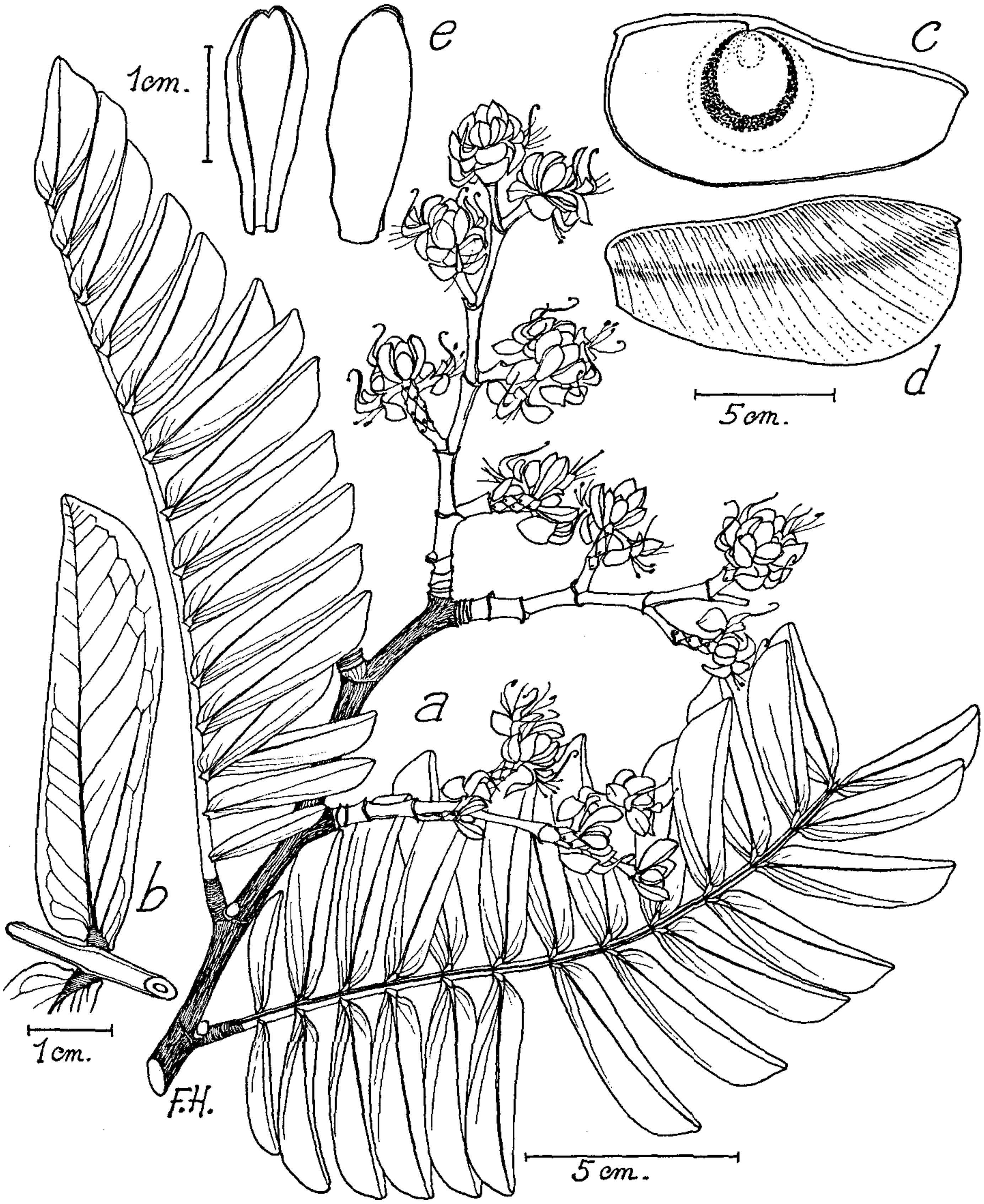


Figure 11.5. *Bikinia durandii* (F. Hallé & Normand) Wieringa. — a: branch with leaves and inflorescences; b: leaflet, lower surface; c: inner side of a pod valve; d: pod from outside; e: bud scale of inflorescence. — a, b, e: *de Saint Aubin 2003*; c, d: probably the pod cited by Hallé & Normand (1960) as CTFT/N 12061. Earlier published in Not. Syst. Paris 16: 137, used with permission of F. Hallé.

mm long, inserted 70–110° eccentric on the adaxial side of the ovary, base conical, often geniculate at the apex of the conical part, long velvety, becoming glabrous towards apex; stigma heart-shaped to broadly elliptic, pale yellow to pale green.

Pod 1–2-seeded, obovate, 9–21 x 3½–8½ x c. 0.9 cm, dull or with a silky sheen, light green during maturation, mixed long and short brown velvety with papillae; beak 8–16 mm long; upper suture very narrowly winged, c. 4 mm wide; nerve just above the middle, u/w = 0.39–0.43, often some additional diagonal lines present above the nerve; stipe 12–17 mm long. **Seeds** 31–38 x 26–28 x 6-9 mm, 4.3–4.6 g in dry condition; testa thin, dark brown; cotyledons purple, pale green in cross-section.

Seedling: Germination epigeal. Hypocotyl 8–11 cm long, velvety. Epicotyl 21–30 cm long, glabrous. First pair of leaves opposite, 4–6 jugate, largest leaflet median or apical. Subsequent leaves alternate, with increasing numbers of leaflets.

Distribution: Map 11.5. Endemic to Gabon. Seems to be confined to the older geological regions. Extends from the Mbei-valley in the Crystal Mountains via Ndjolé and Boué to the 'Forêt des Abeilles'. An apparently isolated population is present in the mountain chain west of Fougamou.

Schwartz et al. (1990) reported subfossil roots of this species at the coast of Congo (Brazzaville). As the wood of this species is not different from that of for instance *B. letestui*, I sincerely doubt this identification.

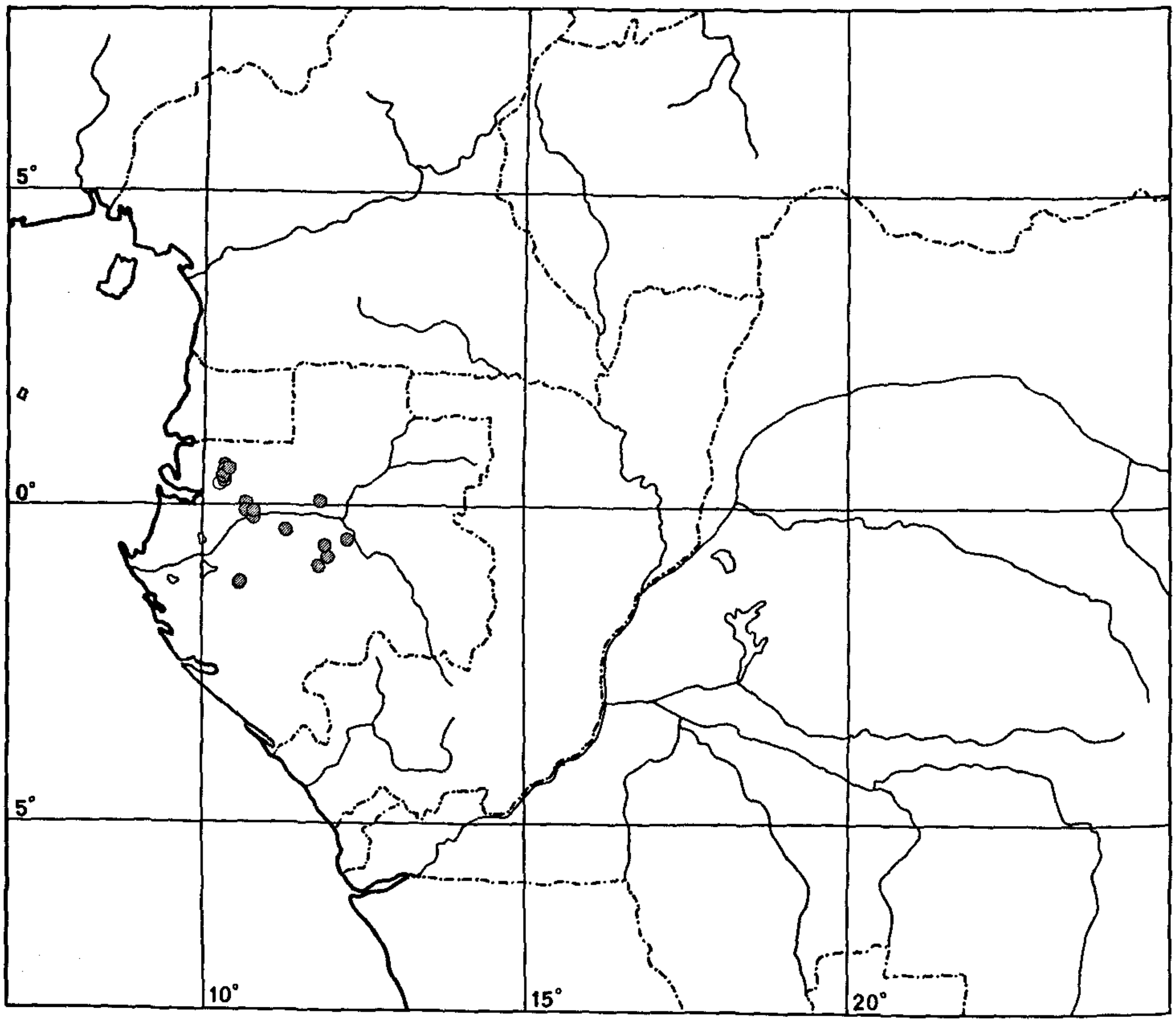
Vernacular names: Gabon: Mundunga (Mitsogo).

Forestry name: Gabon: Andoung de Durand.

Ecology: Canopy tree of dry-land rain-forest at altitudes of 180–600 m; usually growing in groups of c. 10 mature trees.

The flowers are visited by honey-bees (*Apis mellifera*), carpenter bees (Xylocopinae) and sunbirds (*Nectarinia* spec.).

Phenology: Flowering in September, maybe already starting at the end of August, i.e. at



Map 11.5. Distribution of *Bikinia durandii* (F. Hallé & Normand) Wieringa.

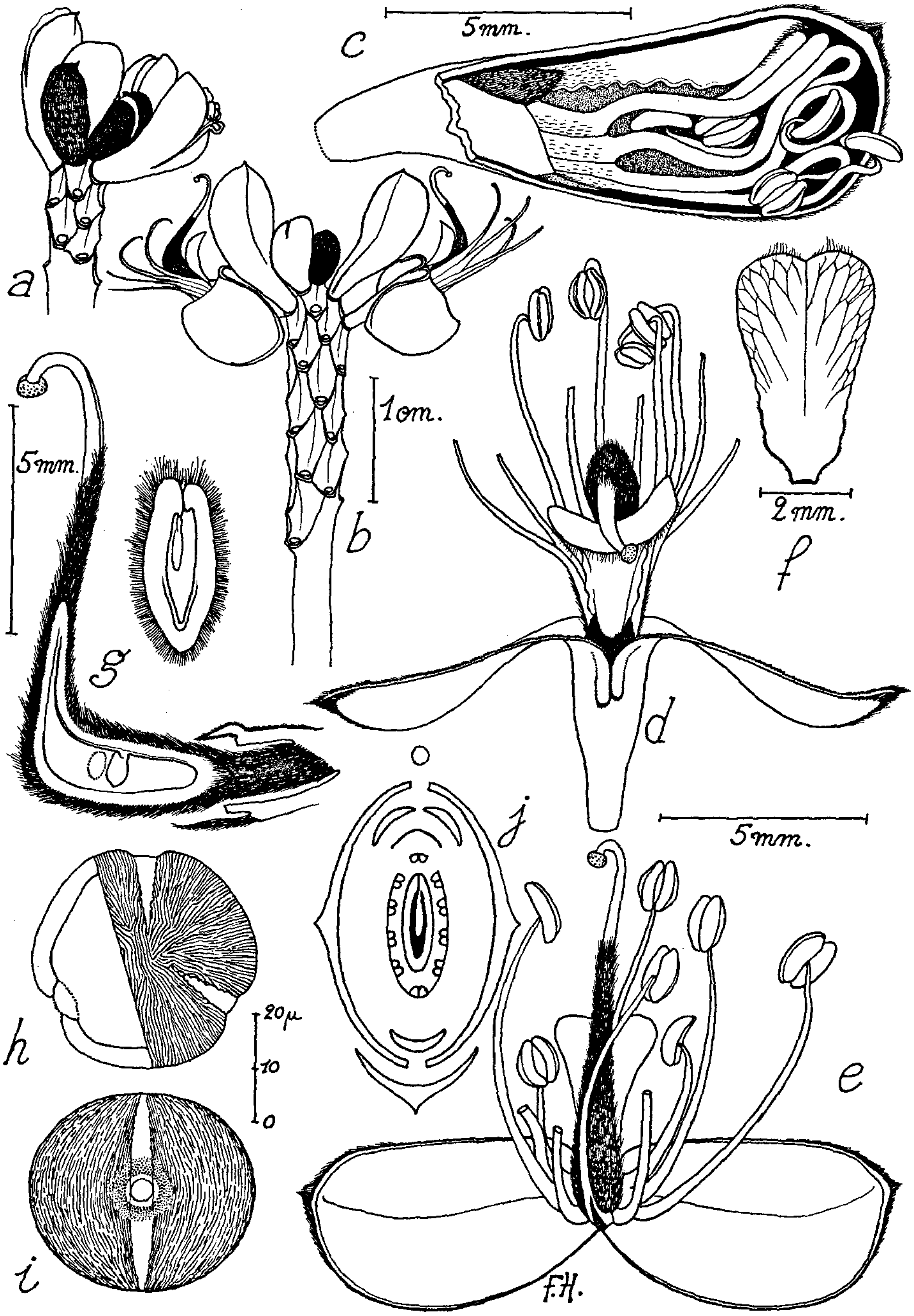


Figure 11.6. *Bikinia durandii* (F. Hallé & Normand) Wieringa. — a, b: racemes showing buds and flowers, bracts are depict in black; c: lateral view of a flower bud with one bracteole removed, including the part that was fused with the hypanthium, adaxial sepals depicted in black; d: flower from adaxial side; e: flower, central view; f: adaxial petal; g: ovary, cross- and transverse section, the latter also showing the hypanthium cavity; h: pollen grain, polar view; i: pollen grain, lateral view; j: floral diagram. — a–j: *de Saint Aubin 2003*. Earlier published in Not. Syst. Paris 16: 138, used with permission of F. Hallé.

the very start or even in the advent of the rainy season. Shedding of seeds is recorded in February, hence maturation of the pod takes about 5 months.

Chemistry: Flowers produce a brownish red colour in alcohol.

Diseases and pests: Galls are sometimes present on the leaflets at the site of a gland.

A recently felled trunk of this species (*Breteler, Jongkind & Wieringa 10907*) was found to attract many individuals of the longhorn beetle *Ptycholaemus maculipes* Thoms. (Cerambycidae: in coll. LMJ and Wieringa). Another longhorn beetle (*Xystrocera similis* Jordan, coll. LMJ) has been collected on the high branches of *Breteler, Wieringa & Nzabi 12899* where it displayed a rather successful mimicry of an ant, both in appearance and behaviour. It is likely that these beetles lay their eggs in these branches or in the trunk of this species.

Use: At present this tree is not being logged, but has economic potential as soon as the 'Andoungs' will be considered for exploitation. Wood suitable for several purposes, including plywood, veneer, joinery and pulp (Bolza & Keating, 1972: 456).

Notes: The collections *Durand 1369 & 1370*, at LBV (but originally from CTFT/G as cited by Hallé & Normand (1960)) proved to be mixtures of *B. durandii* and *Julbernardia brieyi* (De Wild.) Troupin. One leaflet of *Durand 1370* has been moved by me to *Durand 1369*, and the flowers from *Durand 1369* have been moved to *Durand 1370*. This results in *Durand 1369* being *B. durandii* and *Durand 1370* being *J. brieyi*. Both specimens were cited by Hallé and Normand (l.c.), but I do not consider them as paratypes because they were excluded from the material cited as "Matériel examiné". *Durand 1369* bears a label from Normand dated August 1959, stating the flowers do not belong to *B. durandii*, probably to a *Julbernardia* ("Ces fleurs ne sont pas celles du Monopetalanthus de Durand ... 3 folioles figurent ci-dessus mais les fleurs de Julbernardia"). *Durand 1370* does not bear any additional labels.

The LBV isotype of *M. durandii* contains an old pod that was collected under another tree. This pod should not be considered part of the isotype.

Breteler, Wieringa & Nzabi 12899 is a specimen showing some characters of *B. le-testui*. The proximal margin of the leaflet makes an angle near the base, the petioles are smaller, the inflorescence axis also bears longer hairs, the fewer and less crowded flowers are rather small, show a smaller hypanthium, the filaments are practically glabrous at base, etc. These characters suggest recent hybridization between the two species. The collected tree might belong to the F1 but more likely to the F2 (back-cross to *B. durandii*) since it shares most characters with *B. durandii*. Also the flowering period coincides with that of the latter species, while *B. le-testui* from the same region was long past flowering. Because of its putative hybrid origin this material has not been used for the description.

Specimens examined:

GABON: *Breteler & Jongkind 10483* (WAG): 5-15 km NNW of Ndjolé, 0°05'S 10°45'E (st, 14.11.1991); *Breteler, Issembe, Moussavou & Pascal 15210* (WAG): c. 10 km NW Makandé, 0°37'S 11°51'E (st, 25.02.1999); *Breteler, Jongkind & Wieringa 10907* (WAG): 5-30 km NNW of Ndjolé, 0°05'S 10°45'E (st, 19.04.1992); *Breteler, Wieringa & Nzabi 12806* (WAG): Crystal Mountains, 3 km NE Kinguélé, 0°28'N 10°18'E (st, 11.09.1994); *Breteler, Wieringa & Nzabi 12820* (UGDA, WAG (+alc)): Crystal Mountains, 3 km NE Kinguélé, 0°28'N 10°18'E (fl, fr, 11.09.1994); *Breteler, Wieringa & Nzabi 12880* (WAG (+alc)): Crystal Mountains, Tchimbélé, 0°36'N 10°23'E (fl, 15.09.1994); *Breteler, Wieringa & Nzabi 12899* (UGDA, WAG (+alc)) id.

doubtful: c. 18 km S of Kinguélé, 0°21'N 10°14'E (fl, 16.09.1994); *Breteler, Wieringa & Nzabi 12967* (WAG): Crystal Mountains, near Kinguélé dam, 0°28'N 10°17'E (st, 20.09.1994); *Dibata 279* (WILKS): 16 km SW of Koumameyong, 0°05'N 11°47'E (fr, ?); *Doucet 269* (BR): Parcel 32 of Leroy Gabon, 0°46'-1°09'S 11°30'E-Offoué, 0°57'S 11°45'E (st, 06.12.1995); *Durand 1369* (LBV): Ndjolé, 0°11'S 10°45'E (st, 05.07.1954); *Groulez 1268* (LBV): Sibang arboretum, not mapped (st, 01.08.1953); *Guigonis 795* (LBV) id. doubtful: route CGC km 100, not mapped (st, 03.08.1952); *Hallé & Villiers 5390* (P): Kinguélé falls, 0°28'N 10°17'E (fr, 18.02.1968); *N. Hallé 2363* (P, WAG): Abanga, chantier CETA, 0°03'N 10°38'E (st, 08.06.1963); *Morel 100* (LBV, P): near Mfoa, moyenne Mbei, 0°24'N 10°18'E (st, 02.1950); *de Saint Aubin 1991* (P): feet of the Crystal Mountains, 0°34'N 10°18'E (st, 01.1959); *de Saint Aubin 2003* (LBV, P, WAG) type: Crystal Mountains, near N'kan, 0°39'N 10°19'E (fl, fr, 06.09.1959); *Wieringa & v.d. Poll 1596* (WAG): 18 km NW of Ndjolé, 0°04'S 10°38'E (fl, 06.09.1992); *Wieringa, van Nek, Hedin & Moussavou 2984* (WAG): W of Fougamou, 10km on forestry road following Bendolo river, 1°13'S 10°31'E (fr, 30.10.1994); *Wieringa, van Nek, Hedin & Moussavou 3021* (G, IAGB, IEC, WAG (+alc)): W of Fougamou, 8 km on forestry road following Bendolo river, 1°12'S 10°32'E (fr, 01.11.1994); *Wilks & Dibata 2693* (BR, WAG): Foret des Abeilles, 9 km S of confluence Gongué-Offoué, 0°48'S 11°54'E (st, 28.07.1993).

Bikinia evrardii **(Bamps) Wieringa comb. nov.** **Fig. 11.7, Map 11.6**

Basionym: *Monopetalanthus evrardii* Bamps, Bull. Nat. Plantentuin Belg. 50: 512–513 (1980).

Monopetalanthus evrardii Bamps: Bamps, 1980: 512–513. **Type**: *Evrard 6014* (holo: BR (+ alc.); iso: K, P, WAG) — Congo (Kinshasa): "Route Kalamba - Ingende, km 20. (Terr. Bikoro). 27 Mars 1959."

Tetraberlinia polyphylla auct. non (Harms) J.Léonard ex Voorh.: Steel, 1992: 65; Dowsett-Lemaire, 1995: 36.

Forest tree, up to 50 m high, with a hemispherical crown. **Bole** cylindrical, up to at least 20 m tall, DBH up to 200 cm: base with feet or small buttresses up to 1 m height. **Bark** up to 15 mm thick, exuding clear yellow or greenish resin which turns white and thickens after a few minutes: surface finely fissured to rugose with lenticels, grey to grey-brown; inner bark fibrous, towards the exterior sometimes slightly granular, in fresh condition pinkish, pale brown or yellowish, in dry condition pale pinkish brown to brown, the most interior part darker, often purplish brown; outer bark very thin, dark brown. Sapwood in fresh condition whitish, dry pale pinkish.

Twigs grey, glabrous but brown velvety when young, sometimes with velvety stipule-scars. **Stipules** (see notes) free, early caducous, ovate to triangular, base not auriculate, 3–20 x 0.9–4½ mm, outside glabrous or appressed velvety, inside glabrous, margins chaffy, sometimes also puberulous or tomentose, apex often bearded. **Leaves** 3–27 cm long, (5–)6–9(–10)-jugate, largest leaflet one below middle pair to middle pair, rarely apical pair: **Petiole** 1–6 mm long, velvety to glabrous in older leaves, entirely consisting of the wrinkled joint. **Rachis** (1.4–)4–21 cm long, upper side often somewhat flattened or grooved, mixed dark brown velvety and puberulous, upper side sparsely so or only puberulous. **Leaflets** leathery, in saplings papery: upper side glossy, dark green, glabrous or rarely sparsely pubescent near base, midrib puberulous to pubescent; lower side dull (but glossy in some shade leaves!), greyish green, pubescent, rarely glabrous in saplings; margin long ciliate, sometimes glabrous on old leaflets; proximal half obovate, obtrullate or trapezoid, margin towards the apex distinctly sinoid; distal half ovate, trullate or trapezoid; apex rounded; young leaflets red. **Basal leaflets** (5–)8–35 x 3–18 mm: proximal half at base rounded, not auriculate. **Apical leaflet** 18–72 x 8–32: proximal half at base truncate, sometimes auriculate, auricle up to 1.2 mm. **Largest leaflet** 23–79 x 8–31 mm, 2.2–3.4(–3.9) times as long as wide: proximal half at base truncate, often auriculate, auricle up to 1.0 mm. **Gland pattern**: basal leaflet in proximal half with (0–)1 rather large, crater-like, often prominent, gland, distal half without glands. Second leaflet in proximal half rarely with one gland, distal half without glands. Apical leaflet in proximal half without, in distal half with 0–1 gland. Other leaflets usually without glands, sometimes one gland present in distal half of the last but one leaflet.

Inflorescence a compound raceme, axillary in terminal six leaves, sometimes small leaves present in inflorescence at base of the lateral branches, 2½–10 cm long, with 3–12 lateral branches which are 5–40 mm long and c. 10–50-flowered, lowest branch rarely branched once more. **Rachis** mixed velvety with tomentose. **Bracts** caducous, obovate to obtrullate, 3.3–5.0 x 3.2–4.0 mm, outside mixed (long) appressed velvety with puberulous, an area on each side of the base with less or no velvet coverage, inside glabrous, margin ciliate. **Pedicel** 1.3–4.1 mm long, velvety. A small, 0.6–1.3 mm high hypanthium s.l. is present. **Bracteoles** ovate, 4.7–6.5 x 3.3–4.0 mm, angle at anthesis 130–180°: outside with a slightly asymmetrically running ridge at c. 2/5 from the adaxial side, puberulous, especially in abaxial half mixed with rather short appressed velvety hairs, at base velvety as continuation from the pedicel, midrib usually, especially at the apex somewhat velvety; inside glabrous; margins chaffy. **Sepals** outside velvety, inside glabrous, margins ciliate. **Adaxial sepals** fused into a two-lobed band, 0.3–2.1 x 1.4–2.9 mm, including the hypanthium triangle 0.5–2.6 mm high. **Lateral sepals** wanting. **Abaxial sepal** sometimes wanting, (narrowly) triangular, up to 1.5 x 0.7 mm, apex acute. **Adaxial petal** 3.8–5.9 x 2.8–5.0 mm: nail very short, 0.2–0.8 mm long; blade obovate to rounded obtriangular or spatulate, lateral margins somewhat inrolled, both side glabrous except a very narrow strip along the base of the lateral margins with short bristle-like hairs, sometimes on outside a few hairs present at the base of the mid-axis, apical margins often emarginate, sometimes sparsely ciliate. **Lateral petals** wanting or vestigial, up to 2.2 x 0.3 mm, in larger ones lateral margins ciliate. **Abaxial petal** wanting or vestigial, up to 2.8 x 0.6 mm, in larger ones lateral margins ciliate. **Stamens** 10: filaments in the upper part tapering to the apex, 6–9 mm long, 9 united over a length of 0.5–1.7 mm, this staminal tube hardly narrower than in hypanthium, glabrous but the hypanthium part usually puberulous to pubescent, adaxial filament almost free, only its very base connected to the stipe of the ovary and to the hypanthium, at base and in the middle usually with some (very) short hairs; anthers 0.9–1.6 mm long. **Ovary** sometimes depauperate, but these ovaries hardly reduced, only the style not well developed, in bisexual flowers 2.6–3.8 x 1.4–2.2 x 0.9–1.1 mm, long velvety, with 2–3 ovules, upper suture rather indistinct, stipe c. 1½ mm long. **Style** c. 6–8 mm long, inserted at an angle of 45–90°, base slender conical, geniculate at the apex of the conical part, long velvety, towards apex becoming glabrous; stigma heart-shaped.

Pod 1–2-seeded, oblong to obovate, 4–12 x 2.3–5.7 x 0.3–0.6 cm, dull, yellowish green, mixed brown velvety and puberulous, very soft to the touch; beak 0.6–2.1 mm long; upper suture broadly winged, 6–14 mm wide; nerve about in the middle, u/w = 0.42–0.64; stipe 4–10 mm long, pedicel somewhat elongated in fruit, 2–6 mm long. **Seeds** 16–24 x 15–21 x c. 6 mm, c. 1.7 g in dry condition; testa thin, dark purple-brown.

Seedling: Germination epigeal. Hypocotyl 4½–8½ cm long, (long) velvety. Epicotyl 6–11½ cm long, villous to long rather sparsely velvety. First pair of leaves opposite, 5–6 jugate, largest leaflet in middle or apical, dimensions within the range of those of trees,

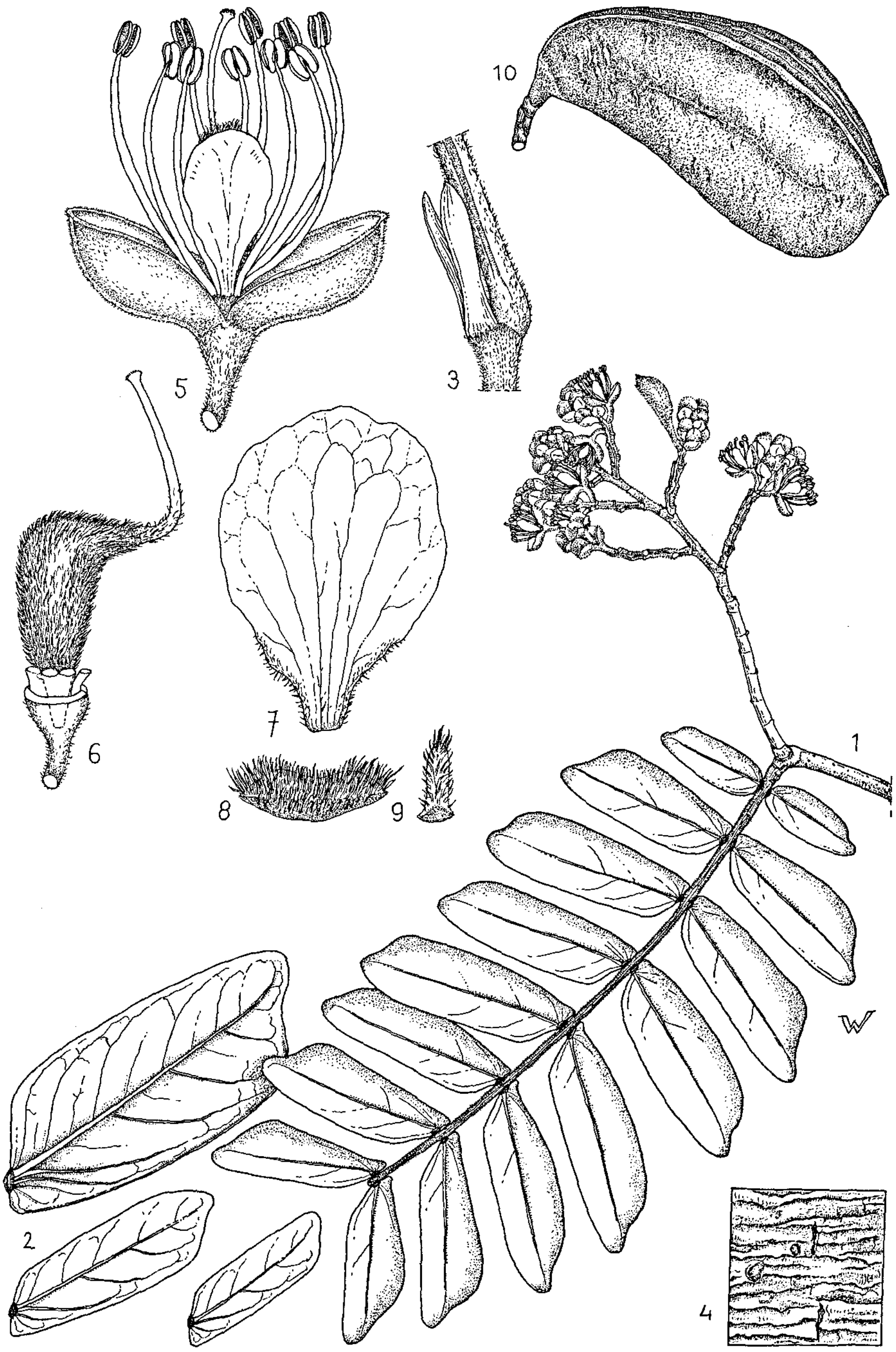
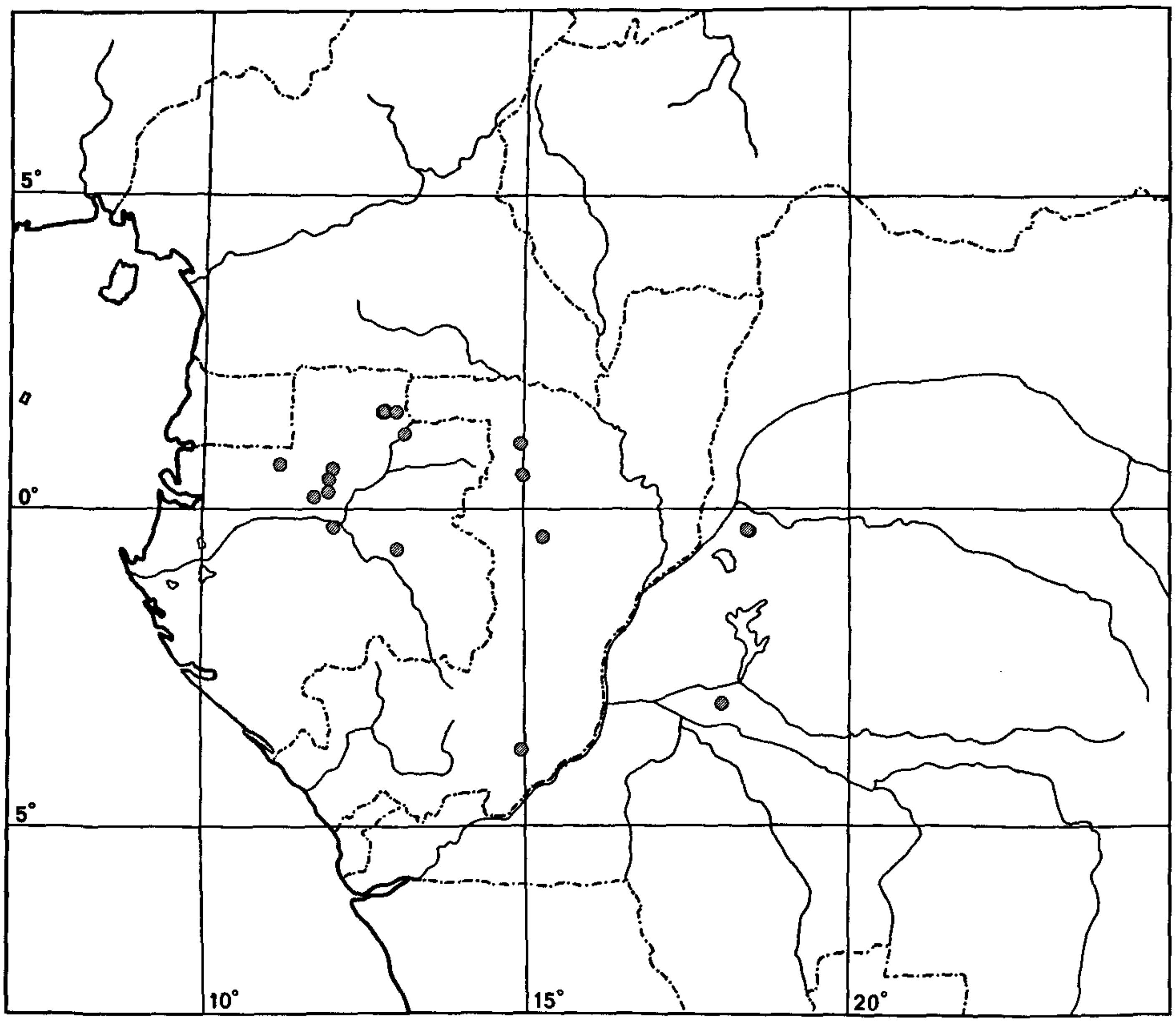


Figure 11.7. *Bikinia evrardii* (Bamps) Wieringa. — 1: twig with leaf and inflorescence (x⅔); 2: several medial leaflets showing variation, lower surface (x⅔); 3: twig with insertion of most apical leaf of a shoot showing two small stipules (x4); 4: bark surface (x⅔); 5: flower from adaxial side (x4); 6: lateral view of a partly dissected flower showing the ovary and its insertion (x4); 7: adaxial petal from outside (x8); 8: adaxial sepals from outside, part fused to hypanthium indicated by dotting (x8); 9: abaxial sepal, part fused to hypanthium indicated by dotting (x8); 10: pod (x8). — 1, 5–9: *Jans 1005*; 2: *Wilks 286, Wieringa & Nzabi 1689 & Descoings 7627*; 3: *Wieringa & Nzabi 1690*; 4, 10: *Wieringa & Nzabi 1689.*



Map 11.6. Distribution of *Bikinia evrardii* (Bamps) Wieringa.

although mainly towards the minor values. Subsequent leaves alternate, 4–6 jugate, this number slowly increasing, leaflets rather small, sometimes smaller than those of the tree.

Distribution: Map 11.6. Central part of the central-african rain forest belt, ranging from the north-eastern half of Gabon, over central Congo (Brazzaville) to western central Congo (Kinshasa). This distribution fits the 'marginal intruder' type of Rietkerk (1993, et al. 1995). The records of *T. polyphylla* in the Minkébé area (Steel, 1992) and Odzala N.P., Congo (Brazzaville) (Dowsett-Lemaire, 1995) and of *M. aff. durandii* (Aubréville, 1967: 107) refer to this species.

Vernacular name: None recorded.
Forestry name: Gabon: Andoung de Dibata.

Ecology: *B. evrardii* is a canopy tree often found in the transition from periodically inundated riverine forest to dry-land (hill-side) forest (Aubréville (1967: 107), pers. comm. C. Wilks and own observations), but may also be found in real dry-land forest on the top of a hill. Altitudes range from 150 to 550 m. The species has been recorded to grow gregariously (i.e. Aubréville, 1967: 107), but it is also, if not mostly, found solitary. Apparently the species is associated with *Gilbertiodendron dewevrei* forest (see chapter 3, ecology).

Phenology: Flowering in northern-central Congo (Brazzaville) (and probably Gabon) occurs in June. Developing pods were found in Gabon in September and October, just germinated seedlings in May.

In South-central Congo (Brazzaville) and adjacent Congo (Kinshasa) flowering has been recorded from February to April, also the more northern record from Congo (Kinshasa) (*Evrard 6014*, young pods end of March) seem to fit this pattern.

So far no clear pattern is obtainable from the few records present. However, it seems clear that flowering occurs during the dry season, which is rather unusual for *Bikinia*.

Chemistry: Flowers produce a light yellowish orange to brownish orange colour in alcohol.

Diseases and pests: Besides the usual damage on flowers by caterpillars and some galled leaf-glands nothing is recorded.

Use: This tree has never been considered for logging, since it occurs only locally in larger numbers and was, in these cases, so far always wrongly identified (usually as *Tetraberlinia polyphylla*).

Notes: Only stipules of the (one but) last leaf of a shoot and stipules from rudimentary leaves at the base of a shoot are known, those of other leaves are probably larger.

Specimens examined:

GABON: *Dibata 286* (WILKS): 19 km WSW of Koumameyong, 0°09'N 11°42'E (st, 08.08.1987); *Dibata in MINKébé series C 87* (WAG) id. doubtful: Minkébé region, 381m on transect A, 1°30'N 12°48'E (st, 04.02.1990); *Dibata in MINKébé series D 18* (WAG): Minkébé region, 381m on transect A, 1°30'N 12°48'E (st, 04.02.1990); *Dibata in MINKébé series D 19* (WAG, WILKS): Minkébé region, 381m on transect A, 1°30'N 12°48'E (st, 04.02.1990); *Dibata in MINKébé series D 23* (WAG): Minkébé region, 1150m on transect A, 1°30'N 12°48'E (st, 08.02.1990); *Dibata in MINKébé series E 16* (WAG): Minkébé region, 214m on transect B, 1°30'N 12°48'E (st, 19.02.1990); *Dibata in MINKébé series E 69* (WAG): Minkébé region, 470m on transect B, 1°30'N 12°48'E (st, 21.02.1990); *Dibata in MINKébé series E 139* (WAG): Minkébé region, 976m on transect B, 1°30'N 12°49'E (st, 24.02.1990); *Dibata in MINKébé series E 167* (WAG): Minkébé region, 1055m on transect B, 1°30'N 12°49'E (st, 25.02.1990); *Dibata in MINKébé series E 182* (WAG): Minkébé region, 1186m on transect B, 1°30'N 12°49'E (st, 26.02.1990); *N. Hallé & Le Thomas 112* (P): Bélinga airstrip, inundatable forest near savanne, 1°09'N 13°07'E (st, 07.1966); *Ibinga 33* (WILKS): 45 km NNE of Koumameyong, 0°36'N 12°00'E (fr, ?); *Mokagna in MINKébé series B 43* (WAG): Minkébé region, 1650m on transect B, 1°31'N 12°49'E (st, 09.03.1990); *Mondjo 269* (WILKS): Forêt des Abeilles, 12828 m on transect A, 0°20'S 12°00'E (fr, ?); *Pageix 9* (WAG): eastern Crystal Mountains, 0°40'N 11°10'E (st, 06.1999); *team of Wilks s.n. (1)* (WAG, WILKS): Bambidie, transect BN 2, tree 48-A-2, 0°40'S 13°00'E (st, 1997); *team of Wilks s.n. (3)* (WAG): Bambidie, transect BN 10, tree 29-A-19, 0°40'S 13°00'E (st, 1997); *team of Wilks s.n. (4)* (WILKS): Bambidie, transect BN 10, tree 23-B-2-11, 0°40'S 13°00'E (st, 1997); *team of Wilks s.n. (5)* (WILKS): Bambidie, transect BN 10, tree 26-B-1-9, 0°40'S 13°00'E (st, 1997); *Tengué in MINKébé series A 50* (WAG): Minkébé region, 1150m on transect A, 1°30'N *12°48'E (st, 03.02.1990)*; *Wieringa & Nzabi 1667* (G, IAGB, IEC, LBV, WAG): 25 km NNE of Koumameyong, 0°26'N 11°56'E (fr, 30.09.1992); *Wieringa & Nzabi 1689* (G, IAGB, IEC, LBV, WAG): 6 ENE of Koumameyong, 0°14'N 11°55'E (fr, 02.10.1992); *Wieringa & Nzabi 1690* (WAG): 6 km ENE of Koumameyong, 0°14'N 11°55'E (st, 03.10.1992); *Wilks in MINKébé series C 27* (WAG): Minkébé region, 150m on transect A, 1°30'N 12°48'E (st, 02.02.1990); *Wilks in MINKébé series C 279* (WAG): Minkébé region, 1311m on transect A, 1°30'N 12°47'E (st, 15.02.1990); *Wilks in MINKébé series C 286* (WAG): Minkébé region, 1347m on transect A, 1°30'N 12°47'E (st, 15.02.1990); *Wilks in MINKébé series S 41* (WAG): Minkébé region. 10x10 m plot (plot S), 360 m on transect A, 1°30'N 12°48'E (st, 10.03.1990); *Wilks in MINKébé series W 438* (WAG): Minkébé region, just S of transect point A2050, 1°30'N 12°47'E (fr, 22.05.1990); *Wilks 1673 B* (WILKS): 45 km NNE of Koumameyong, 0°36'N 12°00'E (fr, 1988); *Wilks 1991* (WAG): Nouna-riverbank, 1°30'N 13°00'E (st, 24.07.1989).

CONGO (BRAZZAVILLE): *Descoings 7627* (IEC, P, WAG): *Fort Rousset region, 30km road to Makoua, Loko* river forest, 0°29'S 15°15'E (fl, 15.06.1961); *Dowset-Lemaire 1770* (BR): Odzala N.P., near the Diba, 0°30'N

14°57'E (st, 24.08.1994); *Dowset-Lemaire 1899* (BR): Odzala N.P., lower Mambili river, 1°00'N 14°55'E (st, 02.02.1995); *Koechlin 5747* (P): Mayama forest, 3°51'S 14°54'E (fl, 02.1959); *Lebrun 11308* (BR): Mayana, forest de Mayana, 3°51'S 14°54'E (fr, 22.07.1958).

CONGO (KINSHASA): *Evrard 4115* (BR, K): Coquilhatville, Kalamba - Ingende, Beke-Bokala, 0°23'S 18°24'E (fr, 20.05.1958); *Evrard 6014* (BR, K, P, WAG) type: Bikoro, 20 km Kalamba - Ingende, 0°24'S 18°26'E (fl, fr, 27.03.1959); *Jans 1005* (BR, WAG): Nsontin, 3°08'S 18°00'E (fl, 01.04.1954).

Bikinia grisea Wieringa spec. nov. **Fig. 11.8, Map 11.7**

Type: *Breteler, Wieringa & Nzabi 13334* (holo: WAG; iso: LBV & 14 other duplicates to be distributed) — "Gabon, Ogooué-Lolo, near Bambidie, east of Lastoursville. In forest. Alt. 300 m 0°44'S 13°01'E ".

Monopetalanthus le-testui auct. non Pellegr. 1942: Pellegrin, 1949: 75–76 p.p.; Aubréville 1968: 314–316 p.p.

Tetraberlinia polyphylla auct. non (Harms) Voorhoeve: Aubréville, 1968: 298–300 p.p.

'*Andoung 1966*': Saint Aubin, 1963: 50, 58 (as *T. polyphylla* in 2nd ed. (1984)).

Diagnosis: Arbor magna cortice griseo. Folia 7–13(–15)-jugata rhachidi supero sulco fere glabro. Foliola saepe proxime basi auriculata. Inflorescentiae racemae compositae usque ad quattor nodo locatae. Bracteae deciduae. Hypanthium bracteola connata potius altum intus pilosa. Sepala adaxialia vestigialia. Sepala lateralia absentia. Sepalum abaxiale absens vel vestigiale. Petalum adaxiale panduratum usque ad obovatum. Petala lateralia et abaxialia absentia vel vestigialia. Stamina plerumque 10 de 9 basi unita, intus parte connata pilosa parteque libera glabra. Ovarium ovula 2–3 continens in floribus aliquis depauperatum. Legumina sparse pubescentia puberulaque matura fere glabra distincte rostrata sutura supera alis angustis extensa.

Large tree, up to 50 m high, crown hemispherical or irregularly so. **Bole** cylindrical, branchless for up to 30 m, DBH up to 200 cm: base with up to 2 m high, broad buttresses. **Bark** up to 23 mm thick: surface smooth with fine horizontal fissures, sometimes scaly, brown-grey to grey or pale grey, with red-brown lenticels; outer bark less than 1 mm thick, dark grey-brown; inner bark fibrous, creamy pink to orange, innermost part cream-coloured, turning pale yellow upon exposure. Sapwood creamy white to pale pinkish white. Resin drying dark red-brown to black.

Twigs smooth, glabrous to puberulous, grey, with some small brown lenticels. **Stipules** free, but the ones modified into bud scales at the base of a shoot almost completely united, early caducous, ovate or obovate to spatulate, 4–41 x 1½–8 mm, proximal side at base often with tiny remains of an auricle, very pale green to red, glabrous inside, outside glabrous or (partly) villous, especially along the central ridge when present, margin ciliate to chaffy. **Leaves** (4–)7–18 cm long, 7–13(–15)-jugate, largest leaflet usually situated at the middle or directly distal or proximal from the middle: **Petiole** 3–6 mm long, glabrous or puberulous to pubescent, completely comprised of the wrinkled joint. **Rachis** 5–15 cm long, green, in young leaves pale red, glabrous or mixed puberulous and pubescent, sometimes also with a few long hairs, in fresh as well as in dry condition above with a grooved ridge, groove (almost) glabrous, when with some hairs then distinctly less hairy than rest of rachis. **Leaflets** leathery, upper side glossy, dark green, glabrous, lower side glossy, medium green, sometimes base of midrib pale green, glabrous, sometimes sparsely

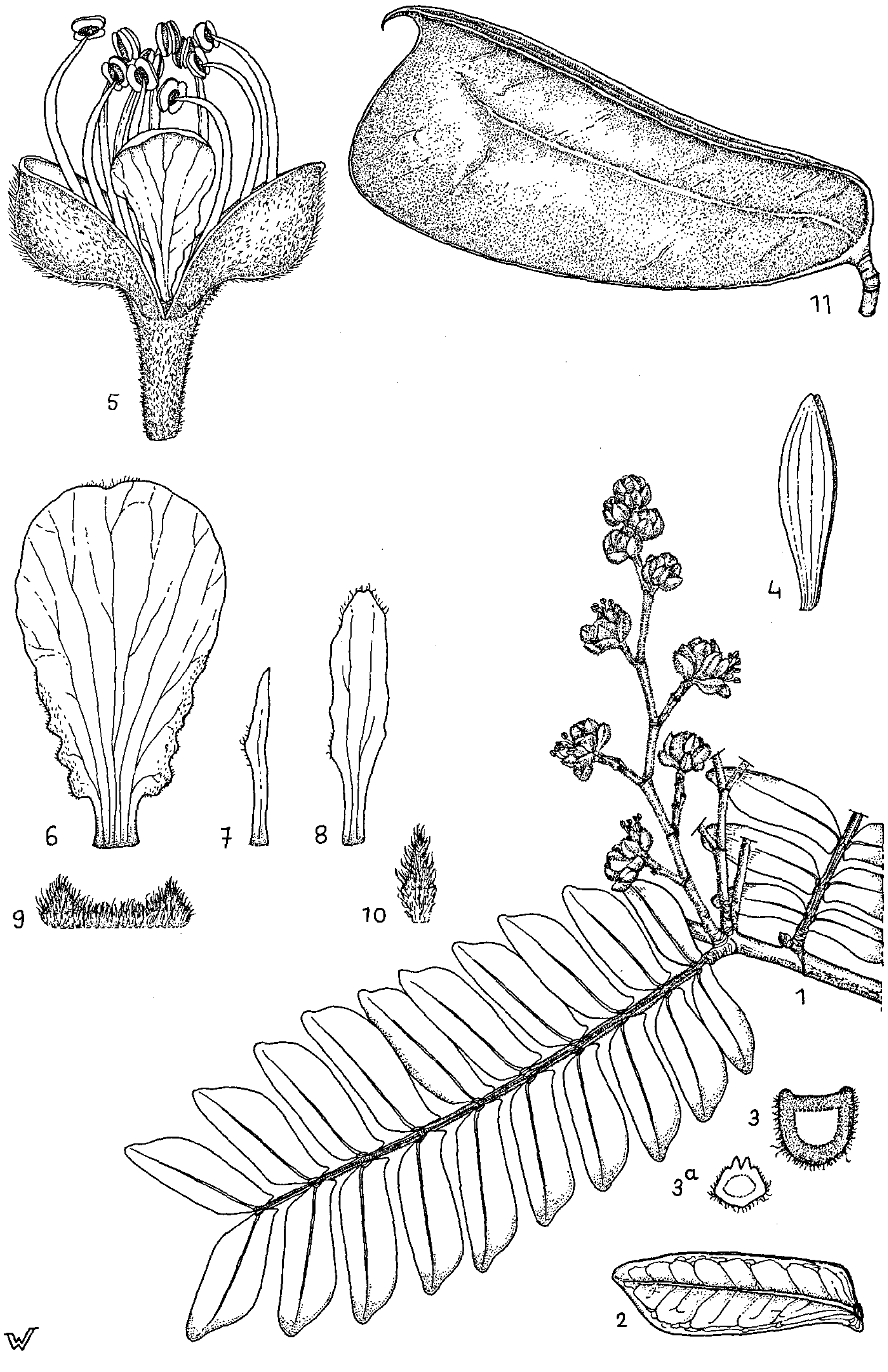


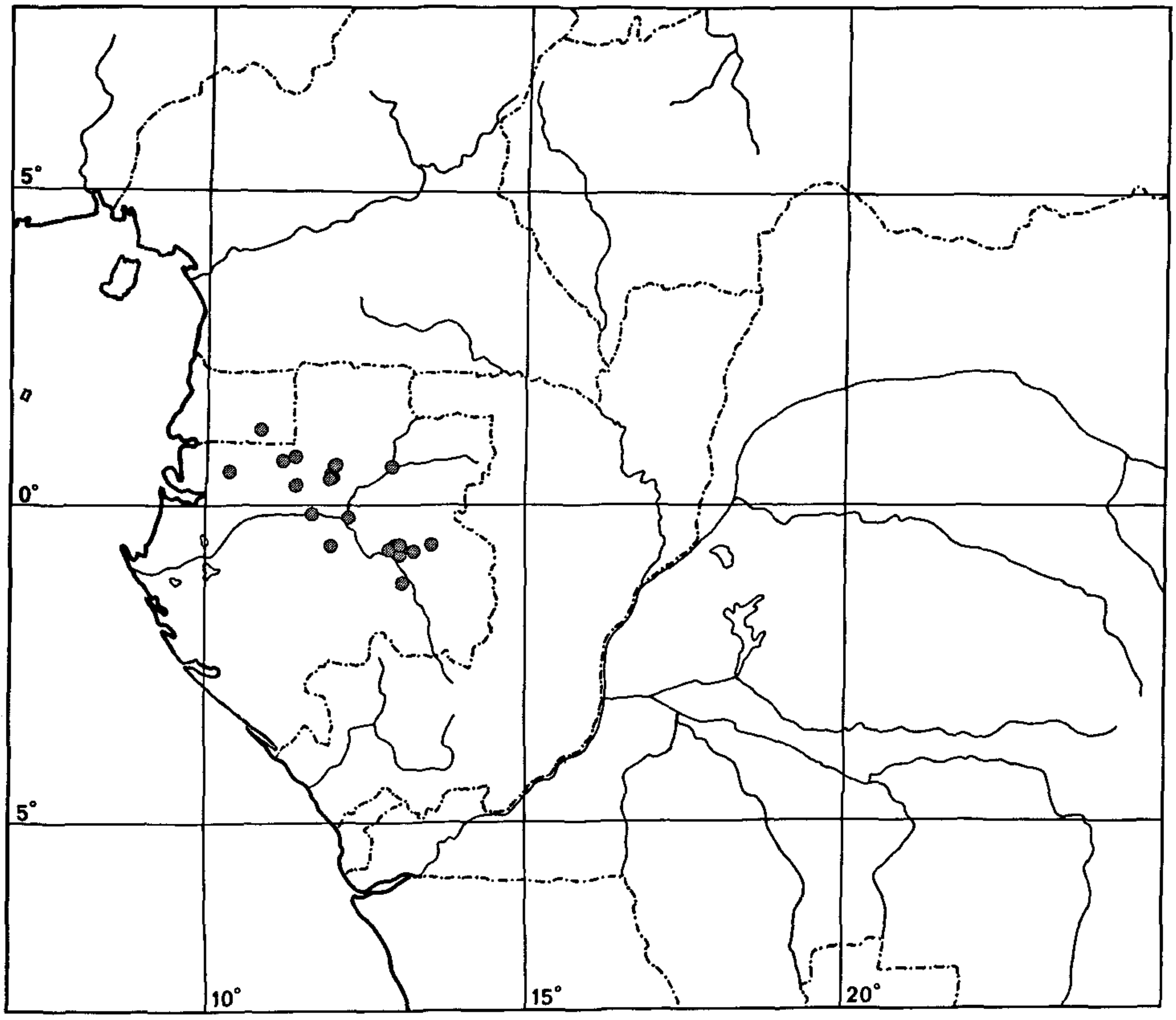
Figure 11.8. *Bikinia grisea* Wieringa. — 1: twig with leaves and inflorescences (x⅔); 2: medial leaflet, lower surface (x1); 3: cross section of leaf rachis in fresh condition (x8); 3a: idem, in dry condition (x8); 4: stipules (x1); 5: flower from adaxial side (x4); 6: adaxial petal from outside (x8); 7: lateral petal (x8); 8: abaxial petal (x8); 9: adaxial sepals from outside, part fused to hypanthium indicated by a dashed line (x8); 10: abaxial sepal, part fused to hypanthium indicated by a dashed line (x8); 11: pod (x⅔). — 1: *Breteler, Wieringa & Nzabi 13334* & *Wieringa & Nzabi 1681*; 2, 3: *Wieringa & Nzabi 1681*; 4: *Breteler, Wieringa & Nzabi 13189*; 3a, 5–10: *Breteler, Wieringa & Nzabi 13334*; 11: *Breteler, Wieringa & Nzabi 13189* & *Wieringa & v.d. Poll 1494*.

pubescent in young basal leaflets; margins shortly ciliate; proximal half obovate, base often auriculate, margin towards the apex usually sinoid; distal half ovate to trullate to rectangular, sometimes excessively widened at base rendering the distal margins concave; apex bluntly acute. Young leaflets very pale green. **Basal leaflet** 9–38 x 3–15 mm: auricle usually absent, when present up to 0.3 mm long. **Apical leaflet** 11–41 x 4–17 mm: auricle 0–1.7 mm long. **Largest leaflet** 16–55 x 6–18 mm, 2.3–3.7 times as long as wide: auricle 0.2–2.2 mm long. **Gland pattern**: basal leaflet in proximal half with 1–3, in distal half with 0–1 glands. Second leaflet in proximal half with 0–1, in distal half with 0(–1) glands. Apical leaflet in distal half with 0–2 glands. Other leaflets usually without glands, leaflets near the apex sometimes with 1 gland in the distal half.

Inflorescence a compound raceme, axillary on the terminal 4 nodes, up to 4 per node, 2–10 cm long, with 2–10 lateral branches which are 5–17(–27) mm long and 9–13-flowered, lowest branch rarely branched once more. **Rachis** pale green, mixed brown velvety and tomentose. **Bracts** caducous, ovate, 5½–8 x 3–5 mm, pale green, outside mixed velvety and puberulous, inside glabrous, margin with some chaffy hairs. **Pedicel** 2.9–6.2 mm long, velvety. Hypanthium s.l. 1.3–2.4 mm high. **Bracteoles** ovate, 5.8–7.9 x 3.5–5.2 mm, assuming a 100–170° wide angle at anthesis, white: outside mixed brown velvety and white puberulous, inside glabrous but along the lateral margins somewhat chaffy-like pubescent; margins chaffy. **Flowers** slightly fragrant. **Sepals** greenish white, brown velvety outside, glabrous inside, upper margin sparsely ciliate. **Adaxial sepals** including the hypanthium part 0.8–1.8 x 1.3–2.2 mm, the two triangular free lobes 0.3–1.0 mm high. **Lateral sepals** wanting. **Abaxial sepals** triangular 0.2–3.5 x 0.1–1.9 mm, apex acute. **Adaxial petal** fiddle-shaped to oblong-obovate, 4.4–6.2 x 2.7–3.6 mm, white, claw 0.3–1.0 mm long, outside with a central pubescent line over the basal half, inside with puberulous bands along the basal part of the lateral margins, these margins somewhat inrolled, apical margin rounded-truncate, sparsely ciliate in the centre. **Lateral petals** and **abaxial petals** wanting or vestigial, spatulate to very narrowly obovate, white, glabrous, margins sometimes sparsely ciliate; lateral petals up to 3.0 x 0.4 mm; abaxial petals up to 4.0 x 1.0 mm. **Stamens** 10, rarely an anomalous number of 11 or 12: filaments 8–11 mm long, 9 united over a length of 1.0–2.7 mm, adaxial filament free, all white, glabrous except for the part fused with the hypanthium and to a lesser extent the fused parts which are velvety and pubescent, adaxial filament sometimes inside basally with some hairs; anthers 0.9–1.1 mm long, red, turning brown. **Ovary** in some flowers depauperate, 1.3–1.7 x 0.8–1.2 x 0.6–0.7 mm, in bisexual flowers 2.8–4.0 x 1.5–2.0 x 0.8–1.0 mm, very long brown and white velvety, with 2–3 ovules, stipe 1–3½ mm long, adaxially slightly united with the hypanthium at base. **Style** 7–9 mm long, inserted at an angle of 70–90°, base only slightly conically thickened, white, long velvety over almost the whole length; stigma heart-shaped.

Pod 1–2(–3?)-seeded, oblong, slightly widening towards the apex, 7–12½ x 3–5½ x 0.3–0.5 cm, glossy, glabrous or with very few (long) hairs, during development also sparsely pubescent and puberulous; beak 1–8 mm long; upper suture hardly to narrowly winged, 3–10 mm wide; nerve usually running just above the middle, u/w = 0.39–0.55; stipe 6–9 mm long; pedicel somewhat elongated in fruit, 5–7 mm long. **Seeds** insufficiently known, c. 16–20 x 15–17 x 4 mm, probably also larger.

Seedling: Germination epigeal. Hypocotyl 4–8 cm long, velvety. Epicotyl 5–11 cm long, fairly sparsely tomentose. First pair of leaves opposite, 6–12-jugate. Subsequent leaves alternate, with an increasing number of leaflets.



Map 11.7. Distribution of *Bikinia grisea* Wieringa.

Distribution: Map 11.7. Endemic to Gabon and southern Equatorial Guinea. Ranges from the Crystal Mountains to Makokou and via the "forêt des Abeilles" to the area east and south of Lastoursville. Its main distribution is on the right bank of the Ogooué river. However, since it does occur as well in the area north of Moanda and S of Booué, it is apparently not entirely constrained by that river.

Vernacular name: Gabon: not known, however: Ekô (Fang) and Kogo (Mitsogo) according to Morel. The first name is generally used for *Tetraberlinia bifoliolata*. A problem with the second name is that *B. grisea* does not occur in the Mitsogo area. However, the very similar looking *B. media* does, and is named Kogo as well in Mitsogo.

Forestry name: Gabon: Andoung 66 or Andoung 1966.

Ecology: Tree of primary dry-land rain forest from 200–650 m altitude. In the Crystal Mountains it seems to be rare, around Koumameyong and Lastoursville it is more common, but never seen to occur gregariously.

Phenology: Flowering in October, maybe already end of September. Young pods in November, fairly recently dropped pods in February, March, August and October (see notes). Young seedlings in March. Maturation of pods probably takes about 4 months.

Chemistry: Pods and flowers produce a yellow to orange colour in alcohol or water.

Diseases and pests: Most trees seem pretty healthy, leaves sometimes show some galls, and some flowers were attacked by insect larvae.

Use: No use recorded. However, its large cylindrical bole would make it an interesting species for exploitation, if the wood properties prove to be favourable.

Etymology: The species is called 'grisea' after its greyish trunk.

Notes: As such is marked on the sheet, Gunn studied *de Saint Aubin 1966* (identified as *T. polyphylla*) but apparently did not use it for his description of *Tetraberlinia* (Gunn 1991: 336) since he cited and says to have studied only the other 3 species of the 4 species known.

The pods found in August and October may have fallen in April or even earlier and may not have rotted too much because they have been on the ground during the dry season. Etymology: The species is named 'grisea' since its trunk is usually strikingly grey.

Specimens examined (except the type all paratypes):

EQUATORIAL GUINEA: *Mondjo s.n. (1)* (WILKS): c. 20 km SW Ngon, 6970m on transect C-west, 1°10'N 10°50'E (fr, 1994).

GABON: *Breteler & Breteler-Klein Breteler 12176* (WAG): c. 30 km E Lastoursville, 0°50'S 13°00'E (fr, 19.11.1993); *Breteler, Issembe, Moussavou & Pascal 14723* (WAG): Makandé, 0°41'S 11°55'E (fr, 21.01.1999); *Breteler, Wieringa & Nzabi 13189* (WAG (+alc)): E of Lastoursville, near Bambidie, 0°42'S 12°59'E (st, 09.10.1994); *Breteler, Wieringa & Nzabi 13211* (WAG): road Lastoursville to Okondja, 3-5 km E Ndambi, 0°46'S 13°13'E (st, 11.10.1994); *Breteler, Wieringa & Nzabi 13334* (WAG (+alc)) type: E Lastoursville, near Bambidie, 0°44'S 13°01'E (fl, fr, 16.10.1994); *Dibata 1206* (WAG, WILKS): Bambidie CEB road B3, crest D, 0°40'S 13°00'E (st, 13.08.1996); *Le Testu 9090* (BM, BR, P): Amréné, 0°17'N 11°23'E (fl, 26.10.1933); *Leal 168* (WAG): NE part of Lopé reserve south of forest-savanna mosaic, 0°11'S 11°38'E (st, 08.06.1999); *Morel 102* (LBV, P): middle Mbei valley, 0°30'N 10°20'E (st, 02.1950); *J. Reitsma & B. Reitsma 1556* (NY, WAG): Oveng, c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 23.09.1985); *Pageix 5* (WAG): eastern Crystal Mountains, 0°40'N 11°10'E (st, 06.1999); *de Saint Aubin 1966* (P): Makokou, 0°34'N 12°52'E (fr, 08.1958); *team of Wilks s.n. (6)* (WILKS): Bambidie, 0°45'S 12°50'E (st, 1997); *team of Wilks s.n. (7)* (WILKS): Okondja area, CEB concession, transect OK 5, 0°40'S 13°30'E (st, 1996); *Wieringa & Nzabi 1681* (LBV, WAG): 18 km N of Koumameyong, 0°23'N 11°54'E (st, 02.10.1992); *Wieringa & v.d. Poll 1466* (LBV, WAG): 28 km NE of Lastoursville, 0°41'S 12°56'E (st, 23.08.1992); *Wieringa & v.d. Poll 1487* (LBV, WAG): c. 25 km E of Lastoursville, 0°43'S 12°53'E (fr, 26.08.1992); *Wieringa & v.d. Poll 1488* (LBV, WAG): c. 25 km E of Lastoursville, 0°43'S 12°53'E (st, 26.08.1992); *Wieringa & v.d. Poll 1494* (WAG): 75 km on the road Lastoursville to Moanda, 3 km for Pouby, 1°16'S 13°02'E (fr, 27.08.1992); *Wieringa & v.d. Poll 1495* (LBV, WAG): 75 km on the road Lastoursville to Moanda, 3 km for Pouby, 1°16'S 13°02'E (st, 27.08.1992); *Wilks 676* (WILKS): ?, not located (fr, ?); *Wilks 849* (WILKS): Forêt des Abeilles, 10 km SSE of Ogooué-Ivindo confluent, 0°14'S 12°12'E (fr, 14.02.1984); *Wilks 1359* (WILKS): c. 23 km NNE of Koumameyong, 0°24'N 11°57'E (st, ?); *Wilks 1396* (WAG, WILKS): 30 km NNE of Koumameyong, 0°27'N 11°55'E (fr, 28.02.1987); *Wilks 1450* (WAG): 40 km N of Koumameyong, 0°34'N 11°58'E (fr, 23.03.1987); *Wilks 1451* (WAG): 40 km N of Koumameyong, 0°34'N 11°58'E (st, 23.03.1987); *Wilks 1673* (WAG, WILKS): 45 km NNE of Koumameyong, 0°36'N 12°00'E (fr, 11.02.1988).

Bikinia le-testui **(Pellegr.) Wieringa comb. nov.** **Fig. 11.9, Map 11.8**

Basionym: *Monopetalanthus le-testui* Pellegr., Bull. Soc. Bot. France 89: 120 (1942).

Key to the subspecies:

1a Lower surface of sun-exposed leaves dull, pale grey. Leaflets relatively narrow: largest leaflet (3.1–)3.5–5.0(–5.7) times as long as wide. Inside of hypanthium glabrous or sometimes pubescent. Cameroon, Equatorial Guinea & Gabon. . . . **subsp. *le-testui*** b Lower surface of sun-exposed leaves glossy, pale to medium green. Leaflets relatively broad: largest leaflet 2.8–4.4 times as long as wide. Inside of hypanthium fairly densely velvety. SW Congo (Brazzaville) .... **subsp. *mayumbensis***

subsp. *le-testui*

Monopetalanthus le-testui Pellegr.: Pellegrin, 1942: 120; Letouzey & Mouranche, 1952: 46-49 p.p. (as "Mayo", see notes under *B. pellegrinii*) and 61 (as "Ekop «b»"); Saint Aubin, 1963: 50, 53 & photos opposite p. 53; Aubréville, 1968: 314–316 & Pl. 80 p.p.; Aubréville, 1970: 287–288 & Pl. 69 p.p.; Bolza & Keating, 1972: 458; Thirakul, 1983: 240–241 p.p.? (at least not the photo of the leaves); Vivien & Faure, 1985: 132–133. **Type**: *Le Testu 9314* (holo: P; iso: A, B, BM, BR, FHO, K, WAG) — "Gabon, entre Ogooué et Cameroun, Oyem. 5 Octobre 1933.".

Berlinia polyphylla auct. non Harms: Harms, 1915b: 466 p.p.
Monopetalanthus microphyllus auct. non Harms: Thirakul, 1983: 242–243 p.p.? (at least a part of the photo's).

Large tree, up to 55 m high, crown hemispherical. **Bole** cylindrical, branchless for up to 30 m, DBH up to 200(–262 ?, see notes) cm: base with up to 2 m high, broad buttresses. **Bark** up to 2 cm thick: surface smooth or rugulose with small pits, grey-red to red-brown, with reddish lenticels; outer bark up to 1½ mm thick, dark brown to purple-brown; inner bark fibrous, yellow to yellow-brown or pale orange in fresh condition, orange-brown to brown in dry condition. Sapwood white to yellowish in fresh, brownish pink in dry condition. Hardwood brown to pink-brown. Growth rings present. Resin drying dark red-brown to black. Sometimes (partial) rings of large resin-vessels are present in the wood.

Twigs smooth, greyish brown or greyish green, from very long brown villous in saplings and on the lower branches to glabrous or puberulous in the canopy, with brown lenticels. **Stipules** free, early caducous, ovate to obovate, 4–55 x 1–16 mm (apical ones in a shoot much smaller than the basal ones), pink to red, outside appressed velvety, glabrous inside, margin chaffy, apex bearded. **Leaves** (5–)6–17(–24) cm (see notes), (9–)13–24(–28)-jugate, largest leaflet situated proximal from or at the middle: **Petiole** 2–7 mm long, long brown villous sometimes mixed with tomentose indumentum, rarely glabrous, completely composed of the wrinkled joint. **Rachis** (4–)5–15(–21) cm long, flattened above in both fresh and dry condition, slightly winged towards the apex, pale green to greyish green, sparsely to densely long villous, sometimes mixed with tomentose indumentum, but usually (almost) glabrous above. **Leaflets** leathery, upper side glossy, dark green, glabrous but the paler primary nerve puberulous, lower side dull and greyish green in canopy leaves to glossy and medium green in other leaves, glabrous to sparsely villous, especially on the primary nerve; margins long ciliate; proximal half rectangular to narrowly obovate, base usually auriculate, margins towards the apex strongly sinoid; distal half narrowly ovate to rectangular; apex blunt. Young leaflets pink. **Basal leaflet** 4–18(–24) x 2.0–6(–10) mm: without an auricle. **Apical leaflet** (4½–)6–23(–35) x (1.4–)2.0–8(–11) mm: auricle up to 0.7 mm long, often absent. **Largest leaflet** 13–37(–54) x 3.4–9(–14) mm, (3.1–)3.5–5.0(–5.7) times as long as wide: auricle 0.1–1.0(–1.9) mm long. **Gland pattern**: basal leaflet in proximal half with 0–1(–2), in distal half with 0(–1) glands. Second leaflet in proximal half with 0(–1), in distal half without glands. Other leaflets (including apical) without glands.

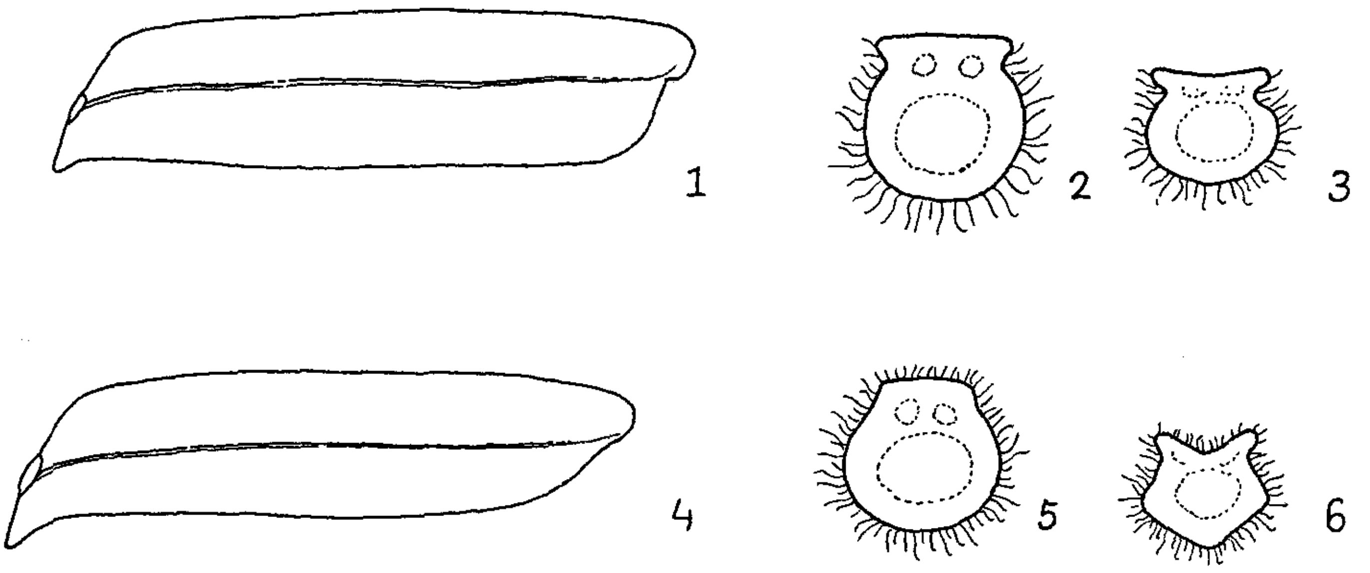
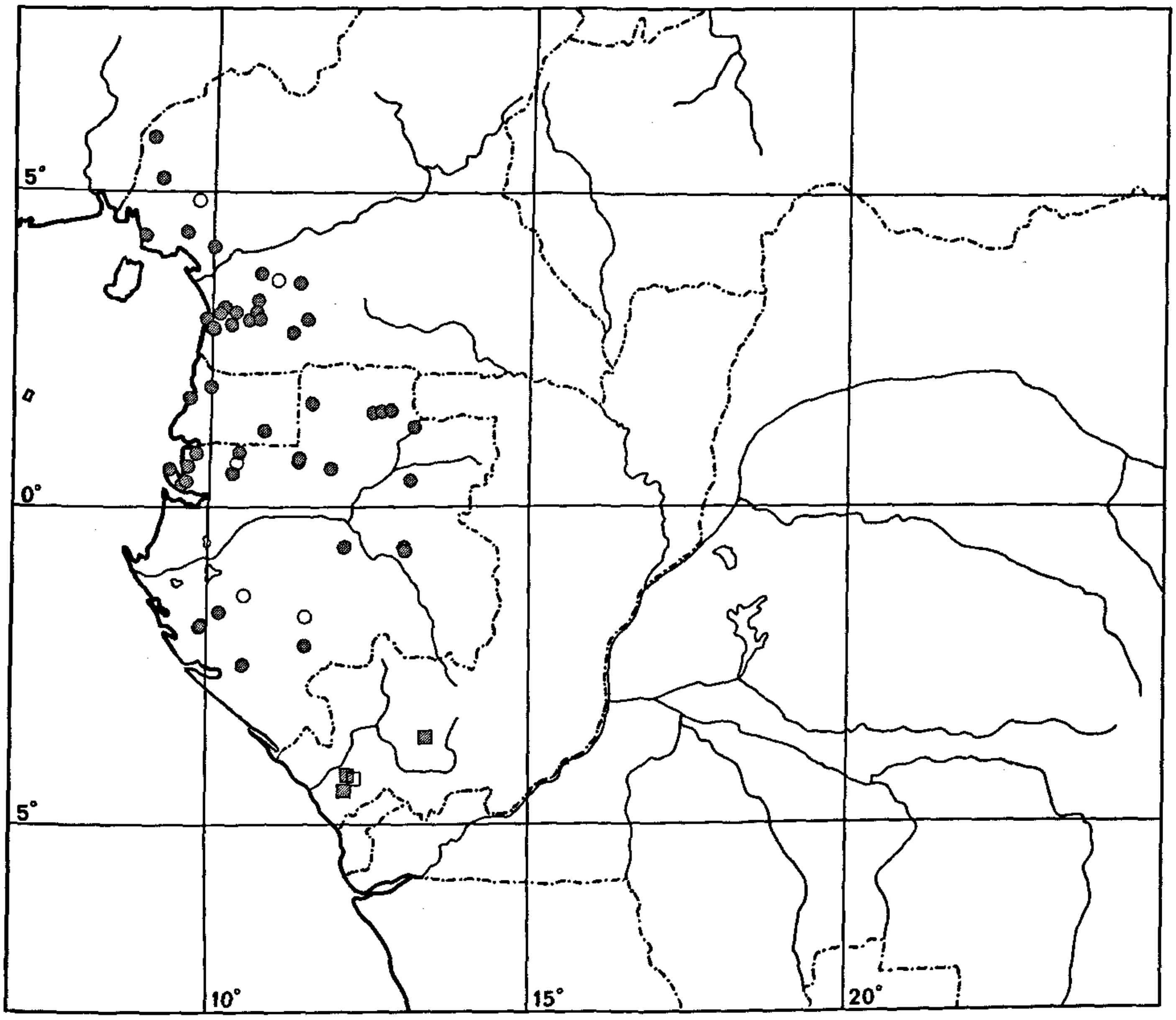


Figure 11.9. *Bikinia le-testui* (Pellegr.) Wieringa subsp. *le-testui* (1–3) and *Bikinia pellegrinii* (A. Chev.) Wieringa (4–6). — 1: leaflet (x1½); 2: cross section of leaf rachis in fresh condition (x12); 3: cross section of leaf rachis in dry condition (x12); 4: leaflet (x3); 5: cross section of leaf rachis in fresh condition (x24); 6: cross section of leaf rachis in dry condition (x24). — 1–2: *Wieringa & Nzabi 2775*; 3: *Wieringa, van Nek, Hedin & Moussavou 3130*; 4–6: *Breteler, Wieringa & Nzabi 13195*.

Inflorescence a compound raceme, axillary on the terminal 4 nodes (but the last 1 or 2 nodes often contracted and the leaves not developed), 1 per node, 2–9 cm long, with 1–10 lateral branches which are 11–28 mm long and c. 20–35-flowered. **Rachis** greyish brown, branches greenish white, mixed (long) dark brown velvety and tomentose. **Bracts** caducous, obovate to obtrullate, 4–6 x 3–5½ mm, greenish white, outside mixed long brown velvety and puberulous, inside glabrous, margin chaffy, apex acute to acuminate. **Pedicel** 1½–7 mm long, white to pinkish white, mixed velvety and puberulous. Hypanthium s.l. (0.6–)0.9–2.4 mm high. **Bracteoles** obovate, 4.8–10.1 x 3.0–6.1 mm, with an asymmetrically running ridge, angle at anthesis 50–140°, white: outside mixed sparsely to densely brown velvety with puberulous; inside glabrous; margin chaffy. **Flowers** sweet fragrant. **Sepals** white to pink-red: (long) brown velvety outside, often mixed with white tomentose indumentum; glabrous inside; margins ciliate? **Adaxial sepals** reduced, including the hypanthium part (0.8–)1.1–3.4 x (1.3–)2.1–3.2 mm, the two lobes triangular to ovate, usually just jointed at base, 0.2–1.1(–1.5) mm high. **Lateral sepals** usually wanting, up to 0.5 x 0.6 mm. **Abaxial sepal** reduced, rarely wanting, triangular, 0.3–2.2 x 0.1–1.4 mm. **Adaxial petal** obtriangular, 4.6–9.6 x 2.9–7.7 mm, white: claw indistinct, 0.4–1.2 mm long; outside glabrous, but often with a velvety median line; inside glabrous; lateral margins in lower half often short ciliate, sometimes accompanied by some short bristle-hairs along the margins on both sides, apical margin often short ciliate; apex often emarginate, sometimes rounded or truncate. **Lateral petals** usually wanting, sometimes vestigial, 0.2–1.1 x 0.1–0.4 mm, outside brown velvety, inside glabrous. **Abaxial petals** usually wanting, sometimes vestigial, 0.2–1.2 x 0.1–0.3 mm, glabrous. **Stamens** 10: filaments 8–14 mm long, white but purple-red to dark purple in the part fused in the hypanthium, glabrous but sometimes pubescent in hypanthium part, the adaxial filament often slightly short to long velvety basally on the inside, 9 united over a length of 0.8–2.8, the three stamens on each side of the adaxial one rarely united for another 0.5 mm, the two next to the adaxial one bent inwards, adaxial filament free; anthers 1.0–2.0 mm long, purple, older ones dark purple, pollen yellowish white. **Ovary** in some flowers depauperate, 0.9–1.4 x 0.6–0.8 x 0.3–0.6 mm, white, in bisexual flowers 2.5–5.5 x 1.4–2.9 x 0.7–1.9 mm, pink, long brown and white velvety, with 2–3(–4) ovules, stipe 0.8–1.9 mm long in male flowers, 1.4–4.2 mm in bisexual flowers. **Style** 0.3–1.0 mm long in male flowers, 6–11 mm in bisexual flowers, inserted at an angle of (60–)80–140°, white, base slightly conically thickened and long velvety, end of conical part sometimes geniculate; stigma heart-shaped to circular, pale yellow.

Pod 0–2-seeded, oblong-obovate to narrowly obtriangular, 7–14 x 3.1–5.9 x 0.4–0.7 cm, dull, pale green to yellow-green, mixed (long) brown velvety, puberulous and pubescent; beak 1–10 mm long; upper suture broadly winged, 8–20 mm wide; nerve usually prominent, running approximately at the middle or more often just below the middle, u/w = 0.40–0.60; stipe 7–11 mm long; pedicel 2–6 mm long. **Seeds** (22–)25–34 x (17–)20–29 x 5–8 mm, c. 2½ g in dry condition; testa thin, glossy, brown.

Seedling: Germination epigeal. Hypocotyl 2½–8 cm long, velvety. Epicotyl 6–17 cm long, sparsely to fairly densely (long) velvety. First pair of leaves opposite, 9–14(–16)-jugate. Subsequent leaves alternate, with about the same number of leaflets, the number gradually increasing higher up.



Map 11.8. Distribution of *Bikinia le-testui* (Pellegr.) Wieringa subsp. *le-testui* (circels) and subsp. *mayumbensis* Wieringa (squares).

Distribution: Map 11.8. From Cameroon near the Nigerian border (possibly in south-eastern Nigeria as well) to southern Gabon. Maybe this subspecies reaches Congo (Brazzaville) as well, Maley et al. (1990) mention the species from Kouyi (close to Gabonese border), but since no material from that site has been studied it is hard to say to which subspecies it belongs.

The most extensive stands probably occur in southern Cameroon (and Equatorial Guinea?), where it is present closer to the coast than *B. pellegrinii*, although both species are also found mixed. In Gabon the species is not rare but is usually not found in large numbers. Here it is found much further inland. Its apparent absence from south-eastern Nigeria is probably due to the low collecting density in that area.

Vernacular names: Cameroon: Ekop Even. Gabon: Eko-Andoung (Fang).

Forestry name: Cameroon: Mayo and "Ekop «b»", nowadays not further identified and sold as one of the "Ekop rouge". Gabon: "Andoung de Le Testu".

Ecology: Canopy tree of primary and old secondary dry-land rain forest at 0–900 m altitude. It usually occurs in small clusters of less than 10 mature trees (own observations). The tree often grows on hillcrests (especially obvious in southern Cameroon), but does occur on hill sides and in level places as well. The trees in Bongolo (Gabon) grow next to the river, but since they stand on a steep slope, their bases will not be reached by the water.

For the Minkébé area in N.E. Gabon Valkenburg et al. (1998) found the species always in association with *B. pellegrinii*. Here it is restricted to the *Monopetalanthus pellegrinii - Cylicodiscus gabonensis* forest type, where *B. pellegrinii* was found in this type most abundantly, but also in other forest types.

Flowers were observed to be visited by several species of bees (Apidae) among which honey-bees (*Apis mellifera*), two species of *Trigona* and two species of *Braunsapis* (det. H. Wiering, specimens in ZMA), by some butterflies (i.e. Lycaenidae) and one species of hover fly (Syrphidae: Melanostomatini, in ZMA). The bees forage specifically on the anthers which are arranged in a circle of 8 with 2 (and the stigma) in the centre (fig. 4.5), providing a kind of platform and ample opportunities to reach the pollen.

Phenology: In (southern) Cameroon flowering takes place in March, in the northern half of Gabon from March to April and in the southern half of Gabon from August to October.

In Cameroon freshly fallen pods have been recorded in February and August (maybe also in September), in northern Gabon in January and February. Therefore, the maturation period is either almost a year or 5 months. In southern Gabon, however, seedfall may already occur in February or March, which would point to a maturation period of half a year.

In South-West Cameroon the shedding of seeds occurs probably in June.

Chemistry: Flowers produce an orange-red colour in alcohol.

Diseases and pests: Glands on the leaves are often transformed into galls. Also flowers may become galled (probably the same gall as found on *B. aciculifera*).

It is not clear whether the dark brown rings in the wood are caused by injuries or a disease, or that they represent a natural characteristic of the species.

A weevil species has been found on the flowers of this species, most probably laying eggs in the ovary.

Use: The larger logs of this species are well appreciated for carpentry, especially on the Asian market (see also the notes). Probably because of transport problems (it sinks, see notes) it is only harvested in areas close to the coast where it can be rafted or transported by trucks.

The wood is suitable for many purposes, including carpentry, plywood, veneer and pulp.

Notes: It is remarkable that this timber species which is common in northern Gabon and southern Cameroon has only been described in 1942. Especially the fact that it seems to have been 'missed' by the Germans needs an explanation. This is partly due to the fact that G. Zenker has apparently never collected the tree, although it was growing on the top of Mimfia Mountain, being his property. Maybe because the flowers are all situated on top of the crown he never saw it flowering. Mildbraed, however, did collect the tree twice, but his material was sterile and one collection was described by Harms as a syntype of *Berlinia polyphylla*.

This subspecies sometimes resembles *B. evrardii* (both show dull sun-exposed leaflets). Besides the shape of the leaflets one can also use the indumentum on the lower side of the leaflet: pubescent in *B. evrardii*, glabrous to sparsely villous in *B. le-testui*.

A french forester, Mr Descazeaux, communicated that in March 1991, he logged a *B. le-testui* near Kachilere (Gabon, between Kafele and Woubele, c. 0°05'N 10°07'E) of which the first log of 7 m long had a diameter of 262 cm at base. This log comprised 40 m^3 of wood and has been sold for 22.000 CFA/m^3 (then c. $ 80/m^3) to Korea. It proved to sink and had to be rafted to the coast.

Shade leaves are generally markedly larger than canopy leaves that are exposed to the sun. The measurements given in the description refer to both types of leaves, the upper values between brackets occurring in shade leaves only. Also the number of leaflets per leaf usually increases a little in shade leaves. The same accounts for the other subspecies.

The amount of variation in this species is rather high, just like that in the closely related *B. pellegrinii*. However, at the moment no further conclusions can be drawn with the material available. Flowering material from Cameroon, where the core area of this species seems to be situated, is badly needed.

Once (*Wieringa & Nzabi 2775*) an inflorescence has been found that sprouted directly from a c. 30 cm thick branch.

Medou 1767 has been disregarded for the descriptions because it may represent a hybrid with *B. pellegrinii*. Collections from a tree in the Sibang arboretum near Libreville (*Wieringa 3307 & Breteler 13501*) are disregarded as well because they cannot be attributed to this species definitely.

Specimens examined:

CAMEROON: *Anonymous 7* (BR): Eseka, 3°39'N 10°46'E (st, 10.1957); *Bos 6542* (WAG): SE Kribi, summit Mt. Elephant, 2°48'N 10°00'E (st, 13.03.1970); *Breteler 12015* (WAG): 30 km SE of Bipindi, 2°55'N 10°35'E (fr, 26.02.1993); *v.d. Burgt 160* (WAG): c. 20 km SE Kribi, summit of Mt. Elephant, 2°48'N 10°01'E (st, 24.08.1997); *v.d. Burgt & Laan 208* (WAG): c. 20 km SE Kribi, summit of Mt. Elephant, 2°48'N 10°01'E (st, 01.10.1997); *v.d. Burgt, van Gemerden, Laan & Ek 212* (WAG): Mt. Elephant, 6 km S of Bidou III, 2°48'N 10°01'E (st, 24.10.1997); *v.d. Burgt, van Gemerden, Laan & Ek 213* (WAG): Mt. Elephant, 6 km S of Bidou III, 2°48'N 10°01'E (st, 24.10.1997); *van Gemerden 278* (WAG): Nkolebunde (Mt. Elephant), summit, 2°48'N 10°01'E (st, 01.08.1998); *Letouzey 1280* (P, YA): 14 km on the road Mbalmayo to Akono, chantier Tabourel, 3°30'N 11°23'E (fl, 19.03.1950); *Letouzey 1280 a* (P): 14 km on road Mbalmayo to Akono, chantier Tabourel, 3°30'N 11°23'E (st, 05.04.1949); *Letouzey 1408* (P, WAG, YA): 36 km on road Kribi to Lolodorf, chantier CIFA, 3°07'N 10°13'E (st, 14.07.1950); *Letouzey 1417* (P, WAG, YA): 34 km on road Kribi-Lolodorf, chantier CIFA, 3°07'N 10°12'E (st, 18.07.1950); *Letouzey 1443* (P, WAG, YA): 33 km on road Bonaberi-Nkongsamba, Maleke, chantier Gibely, 4°19'N 9°37'E (st, 24.07.1950); *Letouzey 1458* (P, WAG, YA): Bonepoupa (CFC 12 km), 4°05'N 10°02'E (st, 02.08.1950); *Letouzey 13709* (K, P, YA): 20 km WNW Mamfe, near cote 212 on track to Tabo-Agborkem, 5°49'N 9°07'E (st, 02.06.1975); *Letouzey s.n. (2)* (BR): Eseke, 3°39'N 10°46'E (st, ?); *Maley & Mezili s.n. (2)* (WAG): c. 25 km SE Ebolowa, Ako'okas, summit of Ako-Akas hill, 2°43'N 11°16'E (fl, 06.03.1995); *Médou 1767* (P, WAG, YA) id. doubtful: near Makak, Nyong forest, 3°33'N 11°02'E (fl, 17.02.1954); *Médou 1807* (P, WAG, YA): Eseka, chantier LBC, near "Beach no 52", 3°39'N 10°46'E (st, 25.08.1952); *Médou 1813* (WAG, YA): 12 km on road of CFC Bonepoupa, 4°05'N 10°02'E (st, 01.10.1952); *Médou 1827* (P, WAG, YA): 4 km from Zingui, near Mintofik, 2°57'N 9°55'E (st, 26.01.1953); *Mildbraed 5549*

(BM (picture only), HBG): between Ebolowa and Sangmelima, 2°55'N 11°30'E (st, 06.1911); *Mildbraed 6062* (HBG): Besou 45 km E of Gross Batanga, 2°51'N 10°18'E (st, 22.07.1911); *Mpom 5* (=SRFK 1671) (P, WAG, YA): ?, not located (fl, 1952); *Mpom 1682* (WAG, YA): Maleke, Gibely, 4°19'N 9°37'E (st, 1952); *Mpom 1684* (WAG, YA): ?, not located (st, 1952); *Mpom 1685* (WAG, YA): Kribi, Picard, 2°57'N 9°55'E (st, 1952); *Mpom 1688* (WAG, YA): Kribi, Picard, 2°57'N 9°55'E (fr, 1952); *Mpom 1691* (P, WAG, YA) id. doubtful: carbonnier Manengonteng, 4°49'N 9°48'E (st, 1952); *Staudt 229* (BM, W): "Urwald" (Lolodorf), 3°14'N 10°44'E (st, 189?); *Tchouto Mbatchou 614* (SCA) id. doubtful: Limbe, Onge/Mokoko river area, 4°16'N 8°59'E (st, 22.03.1993); *Thomas 8179* (MO) id. doubtful: 15 km W of Manyemen, around Banyu, 5°10'N 9°15'E (fr, 29.06.1988); *Thomas 8181* (MO, WAG, YA): 15 km W of Manyemen, around Banyu, 5°10'N 9°15'E (st, 29.06.1988); *Thomas 9816* (SCA): ?, not located (st, 1993); *Thomas 9960* (SCA): Limbe, Onge river area, 4°16'N 8°59'E (fr, end.1993); *Wieringa & Haegens 2123* (WAG): 24 km SE of Kribi, just SE of Mt. d'Elephant, 2°47'N 10°02'E (fr, 06.02.1994); *Wieringa & Haegens 2199* (WAG): 2½ km on a forestry road to S, 33 km on road Kribi to Bipindi, 3°02'N 10°08'E (fr, 13.02.1994); *Wieringa & Haegens 2300* (WAG): Bipindi, Mimfia mountain, 3°03'N 10°23'E (st, 22.02.1994); *Wieringa & Haegens 2301* (WAG): Bipindi, Mimfia mountain, 3°03'N 10°23'E (fr, 22.02.1994); *de Winter 45* (WAG): c. 15 km S of Lolodorf, near Ebom II, 1000m on transect 9B, 3°04'N 10°42'E (st, 05.10.1995); *de Winter 94* (WAG): Nyangong, 2000 m on transect *2, 2°56'N 10°45'E (st, 24.04.1996).

EQUATORIAL GUINEA: *Carvalho 5265* (WAG): 22-23 km on road Bata to Bolondo, 1°42'N 9°40'E (st, 19.03.1993); *Issembe 17* (WAG): c. 32 km on road Bata-Niefang, just W of Mikan (Machinda), 1°52'N 10°00'E (st, 19.05.1998); *Mondjo s.n. (3)* (WILKS): c. 20 km SW Ngon, 2690 m on transect C-west, 1°10'N 10°50'E (st, 1994).

GABON: *Bernard 262* (LBV) id. doubtful: Sibang arboretum, not mapped (st, 06.09.1951); *Bernard 285* (LBV): Sibang arboretum, not mapped (st, 19.10.1951); *Breteler 10864* (WAG (+alc)): Libreville, Sibanga arboretum, not mapped (fr, 29.02.1992); *Breteler 13501* (BR, WAG) id. doubtful: Libreville, Sibang arboretum, not mapped (fr, 17.03.1996); *Breteler, Jongkind & Wieringa 11192* (WAG): c. 30 km E of Lastoursville, 0°40'S 13°00'E (st, 30.04.1992); *Breteler, Wieringa & Nzabi 12857* (WAG) id. doubtful: Crystal Mountains, 10 km on road Tchimbélé to Assok, 0°40'N 10°24'E (fr, 14.09.1994); *Breteler, Wieringa & Nzabi 12957* (WAG (+alc)): Crystal Mountains, c. 20 km on road Assok to Medouneu, 0°50'N 10°26'E (st, 19.09.1994); *Breteler, Wieringa & Nzabi 13264* (WAG): Lastoursville region, 6 km E Bambidie, 0°44'S 13°01'E (st, 13.10.1994); *Dibata 789* (WAG): Atem, 1109 m on transect Z, 0°37'N 9°39'E (fr, 24.02.1991); *Dibata 865* (WAG, WILKS): Ofoubou, 1°42'S 10°08'E (fr, 30.06.1991); *Dibata 866* (WAG, WILKS): Ofoubou, 1°42'S 10°08'E (fr, ?); *Durand 1684* (LBV): Crystal Mountains, CFN, not located (fl, 04.1956); *Estasse 199* (LBV): Mondah (Elloy), 0°34'N 9°22'E (st, 06.1951); *Estasse 571* (P): Mondah, 0°34'N 9°22'E (st, 18.10.1951); *Gauchotte 1768* (P): Ikoy, 0°20'N 9°33'E (st, 01.1957); *Groulez 1266* (LBV): Sibang arboretum, not mapped (st, 01.08.1953); *N. Hallé & Le Thomas 82* (P, WAG): Bélinga, 1°13'N 13°10'E (st, 19.07.1966); *Le Testu 9314* (A, B, BM, BR, FHO, K, P, WAG) type: Oyem, 1°36'N 11°34'E (fl, 05.10.1933); *Nkogno in MINKébé series N 1* (WAG): Minkébé region, 1°29'N 12°48'E (fr, 29.01.1990); *Normand 280* (P): Sibang arboretum, original from Mbei-valley, 0°30'N 10°20'E (st, 30.10.1947); *Obiang 24* (WILKS): ?, not located (st, 09.06.1983); *Olom C.T.F.T. 2127* (WAG): Mbelaléne, not located (st, 06.1963); *J. Reitsma & B. Reitsma 725* (C, MA, NY, WAG): along forest road Oveng to Mintsic, 0°41'N 11°22'E (fl, 28.03.1985); *J. Reitsma & B. Reitsma 1195* (NY, WAG): Oveng, 0°44'N 11°22'E (fr, 23.06.1985); *J. Reitsma & B. Reitsma 1213* (NY, WAG): Oveng, 0°44'N 11°22'E (st, 24.06.1985); *J. Reitsma & B. Reitsma 1433* (C, MA, NY, WAG): 35 km SW of Doussala, Doudou Mountains, 2°32'S 10°30'E (fl, 27.08.1985); *J. Reitsma & B. Reitsma 1463* (NY, WAG): Oveng, 25 km SW of Mintsic, 0°44'N 11°22'E (st, 19.09.1985); *J. Reitsma & B. Reitsma 1480* (WAG): Oveng, c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 20.09.1985); *J. Reitsma & B. Reitsma 1559* (WAG): Oveng, c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 23.09.1985); *J. Reitsma & B. Reitsma 1583* (NY, WAG) id. doubtful: Oveng, c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 24.09.1985); *J. Reitsma & B. Reitsma 2953* (WAG): Oveng, 25 km WSW of Mintsic, 0°44'N 11°22'E (st, 09.02.1987); *J. Reitsma & B. Reitsma 3070* (NY, WAG): 50 km SE of Makokou, near Ekobakoba, 0°23'N 13°06'E (st, 18.02.1987); *de Saint Aubin 1937* (P): 24 km SE of Cocobeach, 0°49'N 9°46'E (fr, 01.08.1958); *de Saint Aubin 2011* (LBV) id. doubtful: Crystal Mountains, not located (st, 01.1960); *Schoenmaker 401* (WAG) id. doubtful: Rabi-Kounga, 1°55'S 9°50'E (st, 01.03.1992); *Tengué in MINKébé series A 360* (WAG): Minkébé region, 16634m on transect A, 1°28'N 12°39'E (fr, 22.02.1990); *Tengué in MINKébé series A 609* (WAG): Minkébé region, 30875m on transect A, 1°27'N 12°31'E (fr, 16.03.1990); *Tonnelle 1457* (P): Ikoy (km 18), 0°23'N 9°37'E (st, 01.02.1955); *Wieringa & Nzabi 2775* (G, IAGB, IEC, LY, UGDA, W, WAG (+alc)): Rabi, next to well 10, 1°54'S 9°51'E (fl, fr, 24.09.1994); *Wieringa & v.d. Poll 1400* (LBV, WAG) id. doubtful: 5 km NNW of Bembodie, Koumounabwali massif, 1°26'S 10°31'E (st, 15.08.1992); *Wieringa & v.d. Poll 1428* (LBV, WAG): Lebamba, Bongolo, along Loetsi river near protestant mission, 2°14'S 11°28'E (fr, 20.08.1992); *Wieringa & v.d. Poll 1429* (WAG): Lebamba, Bongolo, near protestant mission, 2°14'S 11°28'E (st, 20.08.1992); *Wieringa 3307* (WAG) id. doubtful: Libreville, Sibang forest, Andoung-plot, not mapped (fr, 01.12.1994); *Wieringa, van Nek, Hedin & Moussavou 3130* (WAG): Bongolo, hillside along Louétsi river nr protestant hospital, 2°14'S 11°28'E (fr, 10.11.1994); *Wieringa, van Nek, Hedin & Moussavou 3222* (WAG): c. 34 km E of Lastoursville, 1 km on CEB road "Moumba", 0°44'S 13°02'E (fr, 17.11.1994); *Wilks 646* (WILKS): Forêt des Abeilles, hill crest past Omvong, 0°40'S 12°05'E (st, 09.06.1983); *Wilks 1042* (WAG) id. doubtful: 8 km NNE of Egoumbi, 1°46'S 11°28'E (fr, 06.02.1985); *Wilks 1430* (WAG, WILKS): 40 km N of Koumameyong, 0°34'N 11°52'E (fr, 20.03.1987).

subsp. *mayumbensis* Wieringa subsp. nov. Map 11.8

Type: *Sita 4547* (holo: WAG, iso: IEC, P) — Congo (Brazzaville): "Plaine de SANGALA. Forest et Savane. 29-05-81."

Diagnosis: Arbor mediocris usque magna. Folia (11–)13–19(–22)-jugata. Foliola potius lata. Foliorum sole expositorum subtus nitida.

Only measurements and characters in which this subspecies differs from the typical one are given. Tree, up to 25 m, but probably also much larger. Leaves 7–19 cm long, (11–)13–19(–22)-jugate. Leaflets in general rather broad, **lower surface also in sun-exposed leaves glossy**. Basal leaflet 4–16(–22) x 1½–6(–8½) mm. Apical leaflet 8–29(–33) x 3–9(–10) mm, auricle 0–1.3 mm long. Largest leaflet 15–37(–49) x 4½–10(–12) mm, 2.8–4.4 times as long as wide, auricle 0–1.5 mm long. Only 1(–2) glands present on the proximal half of the basal leaflet.

Inflorescence 4–8 cm long, 1(–2) per node. Lateral branches 7–27 cm. Bracts c. 5 x 3 mm. Pedicel 3–6 cm long. Hypanthium s.l. 0.8–1.6 mm high. Bracteoles 5½–8 x 3–5 mm. Adaxial sepals 0.8–1.3 x 1.6–2.0 mm, free lobes 0.2–0.5 mm long. Lateral sepals usually wanting, up to 0.2 x 0.2 mm. Abaxial sepal 0.05–0.8 x 0.1–0.4 mm. Adaxial petal 5½–7 x 3½–4 mm, claw 0.5–0.6 mm. Lateral and abaxial petals wanting. Stamens 10: filaments c. 10 mm long, 9 united over a length of 1.1–1.7 mm, in the hypanthium part fairly densely velvety, adaxial one with some hairs inside basally; anthers 1.2–1.4 mm long. Ovary 2-ovulate, stipe 2.4–3.1 mm long. Style c. 9 mm long, inserted at an angle of 80–110°.

Ripe pods, seeds and seedlings unknown. Young **pods** already with a broadly winged upper suture, a stipe of c. 10 mm and a pedicel of c. 7 mm.

Distribution: Map 11.8. So far only known from a restricted area in the Mayombe forest range, Congo (Brazzaville). The reference of Schwartz et al. (1990) to the species might concern this subspecies, but remains questionable since wood samples are not identifiable down to the species level.

Phenology: Flowers were observed in May and inflorescence buds were present at the end of July.

Chemistry: Flowers produce an orange-red colour in alcohol.

Specimens examined (except the type and the "id. doubtful" specimens all paratypes):

CONGO (BRAZZAVILLE): *Constant & Bertault 286* (CIRAF): Sibiti, 3°41'S 13°21'E (st, 08.07.1972); *Groulez 614* (P) id. doubtful: Mayumbe, around 90 km, 4°20'S 12°15'E (fr, 02.1965); *Marteau 619* (P) id. doubtful: Mayumbe, Noyette chantier, near M'Boku N'Situ, 4°32'S 12°06'E (fl, 27.07.1965); *Marteau 620* (P): Mayombe, Noyette chantier, near M'Boku N'Situ, 4°32'S 12°06'E (fl, 27.07.1965); *Sita 4547* (IEC, P, WAG) type: Plaine de Sangala, not located (fl, fr, 29.05.1981); *Sita 5956* (WAG): ?, not located (fl, ?); *J. de Wilde & v.d. Maesen 11088* (WAG): 11 km on road Louvoulou to Kakamoéka, 4°17'S 12°09'E (st, 13.02.1993).

Bikinia media **Wieringa spec. nov.** **Fig. 11.10, Plate 4a, Map 11.9**

Type: *Wieringa, van Nek, Hedin & Moussavou 3180* (holo: WAG; iso: LBV, UGDA & 51 other duplicates to be distributed) — "Gabon, Ogooué-Lolo, 22 km on road Lastoursville to Koulamoutou. Alt. 280 m 0°56.6'S 12°37.4'E".

Tetraberlinia polyphylla auct. non (Harms) Voorhoeve: Aubréville, 1968: 298–300 p.p.

Diagnosis: Arbor staturae mediocrem. Folia 8–16-jugata rhachide vivo tereti sicco super saepe sulco piloso. Foliola saepe proxime basi auriculata. Inflorescentiae racemae compositae usque ad 3 nodo locatae. Bracteae deciduae. Hypanthium bracteola connata mediocre alta intus glabrum. Sepala adaxialia vestigialia basi connata. Sepala lateralia absentia. Sepala abaxialia vestigialia triangularia. Petalum adaxiale anguste obovatum usque ad anguste spathulatum. Petala lateralia et abaxialia absentia. Stamina 10 de 9 basi connata glaberrima. Ovarium ovula 3–4 continens rare depauperatum. Legumina longe breviterque velutina distincte rostrata sutura supera vix alata.

Medium-sized tree, up to 30 (or 40?) m high. Crown irregular. **Bole** cylindrical, branchless for up to c. 20 m, DBH up to 100 cm: base with small feet up to 1 m high, maybe also with larger buttresses up to 2 m high and 4 m long. **Bark** up to c. 15 mm thick: surface smooth, grey to brownish grey with reddish spots or horizontal lines; outer bark less than 1 mm thick, dark brown; inner bark fibrous, brownish pink but innermost part creamy to pale yellow rapidly changing to yellow or orange. Sapwood creamy white, in dry condition pale pinkish brown, with a flavour of apples. Resin dark red-brown.

Twigs smooth, grey, glabrous or velvety to appressed pubescent, with red-brown lenticels. **Stipules** free, in bud valvate, caducous, ovate c. 18 x 3 mm, green, both sides glabrous, margin chaffy, towards the apex and at the proximal base sometimes ciliate, apex bearded. **Leaves** 6–16 cm long, 8–16-jugate, largest leaflet situated at or distal from the middle: **Petiole** 2–6 mm long, mixed tomentose, puberulous and sometimes sparsely velvety. **Rachis** 3–12 cm long, mixed tomentose, puberulous and sometimes velvety, in fresh condition more or less terete, in dry condition often with a grooved ridge above. **Leaflets** leathery, upper side glossy, dark green, glabrous, lower side glossy, medium green, glabrous; margins ciliate or glabrous; proximal half obovate, base often auriculate, margin towards the apex usually sinoid; distal half ovate to trullate; apex bluntly acute to acute. Young leaflets light green. **Basal leaflet** 6–26 x 3–9(–10) mm: auricle usually absent, when present up to 0.3 mm long. **Apical leaflet** 17–38(–44) x 5–12(–14) mm: auricle 0.5–2.2 mm long. **Largest leaflet** 20–40(–44) x 6–12(–17) mm, 3.0–4.1 times as long as wide: auricle 1.0–2.4 mm long. **Gland pattern**: basal leaflet in proximal half with 1–3 glands, in distal half with 0–1(–2) glands. Second leaflet without glands. Apical leaflet in proximal half very rarely with 1 gland, in distal half with 0–1(–2) glands. Other leaflets usually without glands, or in leaflets near the apical one rarely with 1 gland in the distal half.

Inflorescence a compound raceme, axillary on the terminal 6 nodes, up to 3 per node, 2–10 cm long, with 2–10 lateral branches which are 6–22 mm long and 10–20-flowered, lowest branch rarely branched once more. **Rachis** brown (lateral branches very pale green), mixed brown velvety and pubescent. **Bracts** caducous, obtrullate to obovate, 3–4½ x 2–4 mm, pale green, outside almost glabrous to puberulous or tomentose, inside glabrous, apical margin ciliate, apex acute to acuminate. **Pedicel** 2–4 mm long, white, white

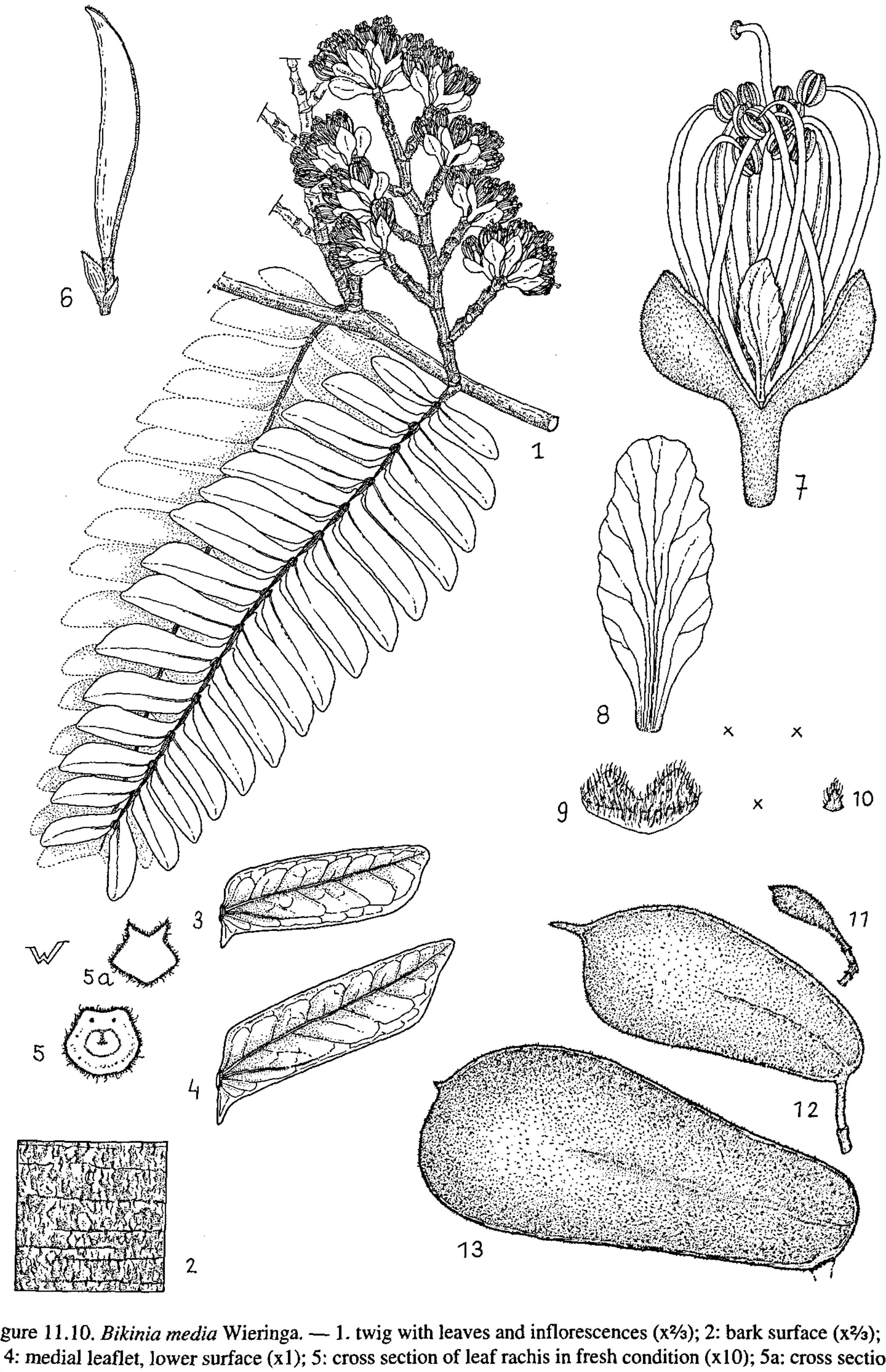


Figure 11.10. *Bikinia media* Wieringa. — 1. twig with leaves and inflorescences (x⅔); 2: bark surface (x⅔); 3 & 4: medial leaflet, lower surface (x1); 5: cross section of leaf rachis in fresh condition (x10); 5a: cross section of leaf rachis in dry condition (x10); 6: bud scales on a young shoot, most apical bud scale resembles a pair of stipules (x2); 7: flower from adaxial side (x4); 8: adaxial petal from outside (x8); 9: adaxial sepals from outside, part fused to hypanthium indicated by a dotted line (x8); 10: abaxial sepal (x8); 11: very young pod (x⅔); 12: developing pod (x⅔); 13: mature pod (x⅔). — 1–3, 5, 5a, 7–11: *Wieringa, v. Nek, Hedin & Moussavou 3180*; 4, 12: *Wieringa, v. Nek, Hedin & Moussavou 3125*; 6: *Wieringa & v.d. Poll 1445*; 13: *Wieringa & v.d. Poll 1554.*

puberulous to tomentose or velvety. Hypanthium s.l. 1.1–1.6 mm high. **Bracteoles** assuming a 70–120° wide angle at anthesis in bisexual flowers, in male flowers up to 210°, 5.0–7.1 x 3.2–5.3 mm, white: outside white puberulous to tomentose, sometimes mixed with sparsely brown velvety indumentum, especially at base and along the ridge; inside glabrous; margin chaffy. **Flowers** with a sweet, somewhat daffodil-like fragrance. **Sepals** white, outside brown pubescent, inside glabrous. **Adaxial sepals** including the hypanthium part 0.7–1.8 x 1.4–1.9 mm, the two triangular to rounded lobes 0.5–1.1 mm high, fused at base. **Lateral sepals** wanting. **Abaxial sepal** triangular, 0.2–1.1 x 0.1–0.5 mm, apex acute. **Adaxial petal** narrowly obovate to spatulate, 3.9–5.7 x 1.4–2.4 mm, white, outside glabrous or with a central pubescent line, inside glabrous, margins glabrous, claw 0.5–0.9 mm long, apex acute to rounded. **Lateral** and **abaxial petals** wanting. **Stamens** 10: filaments 9–12 mm long, 9 united over a length of 1.1–1.9 mm, the three filaments on each side of the abaxial one usually united for another 0.1–0.4 mm, adaxial filaments free, all filaments white, but part fused with the hypanthium purple-red and widened, entirely glabrous; anthers 0.9–1.5 mm long, dark purple-brown. **Ovary** in bisexual flowers 2.2–4.3 x 1.2–2.3 x 0.6–1.3 mm, rarely depauperate and only c. 1.6 x 0.8 x 0.5 mm, white to very pale green, long pale greyish brown velvety, with 3–4 ovules, stipe 1.9–2.7 mm in bisexual flowers, c. 1.8 mm in male flowers. **Style** 8–11 mm long, inserted at an angle of 100–130°, base somewhat conically thickened, end of conical part geniculate, white, often pink towards the apex, basal half long velvety; stigma heart-shaped, pale yellow.

Pod 1–2-seeded, obovate, 6–10 x 3.4–3.9 x 0.3–0.4 cm, dull, during development medium green, long and short brown velvety: beak 3–8 mm long; upper suture hardly winged, 2–4 mm wide; nerve rather indistinct, running approximately at the middle, u/w = 0.46–0.60; stipe 4–12 mm long, pedicel 2½–5 mm long. **Seeds** insufficiently known, 16–21 x 14–16 x c. 4 mm: cotyledons red.

Seedling: Germination epigeal. Hypocotyl (3–)6–8 cm long, velvety. Epicotyl (2–)8–13 cm long, sparsely tomentose. First pair of leaves opposite, 6–9-jugate. Subsequent leaves alternate, with an increasing number of leaflets.

Distribution: Map 11.9. Occurring in the interior of Gabon. All records come from the (lower) mountainous area of Gabon, none from the sedimentary basin. The species may be present in similar areas in western Congo (Brazzaville) as well (*Foresta 1980, 1981, 1982*), but these collections could not be identified with certainty.

Vernacular names: Gabon: Andoung (Fang), Kogo (Mitsogho), Ndala-à-benga (Bavoungou).

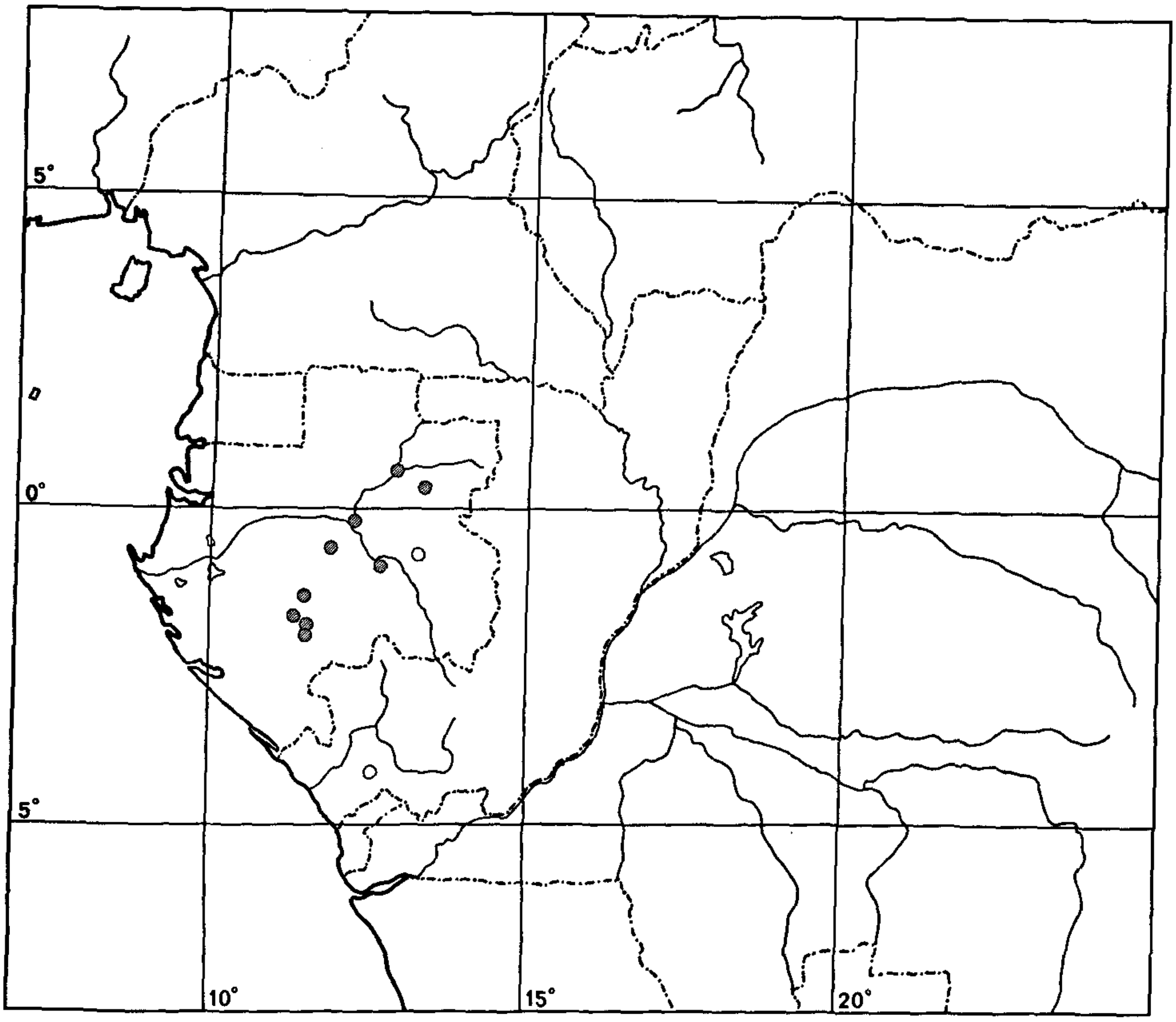
Forestry name: Gabon: in the past 'Andoung 66' may have been used.

Ecology: (Sub-)canopy tree of primary and old secondary dry-land rain forest at 200–900 m altitude. It occurs solitary or in small groups (up to 3 trees recorded).

Phenology: Flowering in October and November. A young seedling was found in May.

Chemistry: Flowers produce an orange colour in alcohol.

Diseases and pests: Except for some galled leaf glands, no diseases were observed or recorded. On the tree that provided the type specimen the longhorn beetle *Prosopocera*



Map 11.9. Distribution of *Bikinia media* Wieringa.

aristrocratica (Thoms.) (Cerambycidae, in coll. Wieringa) was collected, which might constitute a possible threat to the wood.

Use: None recorded.

Etymology: The species is called 'media' since it holds the middle between *B. grisea* and *B. congensis*. Its inflorescence and general leaf shape it shares with *B. grisea*, while its flowers and the leaf rachis are similar to those of *B. congensis*. Besides this, the species is only of medium height, compared to most other species of this group which are taller. Also the distribution is 'medial'. It does not reach the coast, nor the eastern border of Gabon.

Notes: Sterile collections of this new species closely resemble *T. polyphylla* and *B. grisea*. It is easy to distinguish from the first by a different gland pattern of the leaflets. *T. polyphylla* lacks glands in the proximal half, while *B. media* has at least one on the basal leaflet. From *B. grisea* it can be told apart with much more difficulty. In dried as well as fresh condition *B. grisea* has an (almost) glabrous groove on the upper side of the leaf rachis, while *B. media* shows a groove in dried condition only which has a mixed indumentum.

When sterile, this new species is also very hard to distinguish from a fourth species, *B. congensis*. Leaves of *B. congensis* have a slightly lower average number of leaflets.

However, these two species do not seem to occur sympatrically. The flowers of the two species are also extremely similar, but the inflorescence of *B. media* is much more elongated and the flowers are not crowded between the bracts. The pods of *B. media* are long velvety, while those of *B. congensis* are puberulous with a few long hairs.

Specimens examined (except the type and the "id. doubtful" specimens all paratypes):

GABON: *Breteler, Wieringa & Nzabi 13295* (WAG) id. doubtful: road Lastoursville to Okondja, 6 km E Ndambi, 0°46'S 13°13'E (fl, 15.10.1994); *Dibata 516* (WAG, WILKS): probably: Foret des Abeilles, 0°40'S 11°50'E (fr, 1989); *Hallé & Cours 5949* (P): Ovala (near Etéké), 1°25'S 11°26'E (st, 16.05.1963); *de Saint Aubin 670* (LBV, P): Ngounié, not located (fr, 03.1952); *de Saint Aubin 1945* (LBV, P, WAG): Makokou, 0°34'N 12°52'E (st, 08.1958); *Wieringa & v.d. Poll 1444* (WAG): 22 km on the road from Lebamba to Yéno, 2°03'S 11°27'E (st, 21.08.1992); *Wieringa & v.d. Poll 1445* (WAG): 22 km on the road from Lebamba to Yéno, 2°03'S 11°27'E (st, 21.08.1992); *Wieringa & v.d. Poll 1554* (WAG): road Okondja to Makokou, 0°18'N 13°19'E (fr, 01.09.1992); *Wieringa, van Nek, Hedin & Moussavou 3125* (WAG (+alc)): 23 km on road Lebamba to Yeno, 2°03'S 11°27'E (fr, 09.11.1994); *Wieringa, van Nek, Hedin & Moussavou 3180* (UGDA, WAG (+alc)) type: 22 km on road Lastoursville to Koulamoutou, 0°57'S 12°37'E (fl, fr, 15.11.1994); *Wilks 849 a* (WILKS): Forêt des Abeilles, 10 km SSE of Ogooué-Ivindo confluent, 0°14'S 12°12'E (st, 14.02.1984); *Wilks 1015 bis* (WAG): 28 km NE Mouila, 1°45'S 11°16'E (st, 09.11.1984); *Wilks 1976* (WAG): Chaillu massif, 5 km SE junction of Ogoulou and Ogoudou r., 1°53'S 11°28'E (st, 08.07.1989).

CONGO (BRAZZAVILLE): *Foresta 1980* (BR) id. doubtful: Les Saras, Kouilou, 4°14'S 12°31'E (st, 07.1989); *Foresta 1981* (BR) id. doubtful: Les Saras, Maymbe, 4°14'S 12°31'E (st, 07.1989); *Foresta 1982* (BR) id. doubtful: Les Saras, 4°14'S 12°31'E (st, 07.1989).

***Bikinia pellegrinii* (A. Chev.) Wieringa comb. nov.**

Fig. 11.9 & (11.11), Plate 2, Map 11.10

Basionym: *Monopetalanthus pellegrinii* A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 26: 593 (1946).

Monopetalanthus pellegrinii A. Chev.: Chevalier, 1946: 593 & Pl. 17 A p.p.; Letouzey & Mouranche, 1952: 46-49 p.p. (see notes); Saint Aubin, 1963: 50 & 54; Aubréville, 1968: 316–317 & Pl. 80; Aubréville, 1970: 288, 290 & Pl. 69; Bolza & Keating, 1972: 459; Salard-Cheboldaeff, 1982: 133–134 & pl. IV; Vivien & Faure, 1985: 134–135 p.p.?; Letouzey, 1985: 112. **Type**: *Le Testu 6024* (holo: P; iso: BM, BR, K, LISC, MO, WAG) — Gabon: "Moucouna 28 août 1926".

Monopetalanthus emarginatus auct. non Hutch. et Dalz.: Pellegrin, 1942: 120–121.
Monopetalanthus le-testui auct. non Pellegr.: Thirakul, 1983: 240–241 p.p.? (at least the photo of the leaves).

Large tree, up to 50 m high, crown hemispherical. **Bole** cylindrical, branchless for up to 30 m, DBH up to 200 cm: base with c. 1 m high, broad buttresses that continue horizontally for up to 10 m. **Bark** up to 2 cm thick: surface smooth, greyish to reddish brown with brown lenticels; outer bark less than 1 mm thick, dark brown; inner bark fibrous, pale brown to yellow in fresh condition, orange-brown in dry condition, the inner quarter turning purple upon exposure. Sapwood creamy white in fresh, pink-brown to orange-brown in dry condition. Resin drying dark red-brown to black.

Twigs smooth, grey to brown, mixed sparsely velvety and puberulous, in young twigs rarely also villous, with brown lenticels. **Stipules** free, in bud valvate, only low in a shoot the stipules are fused with a rudimentary leaf rachis into bud scales, caducous, obovate to spatulate, 16–25 x 3½–7 mm, bright red, outside glabrous or very sparsely villous or mixed velvety and villous, glabrous inside, margin chaffy, sometimes with a rudimentary

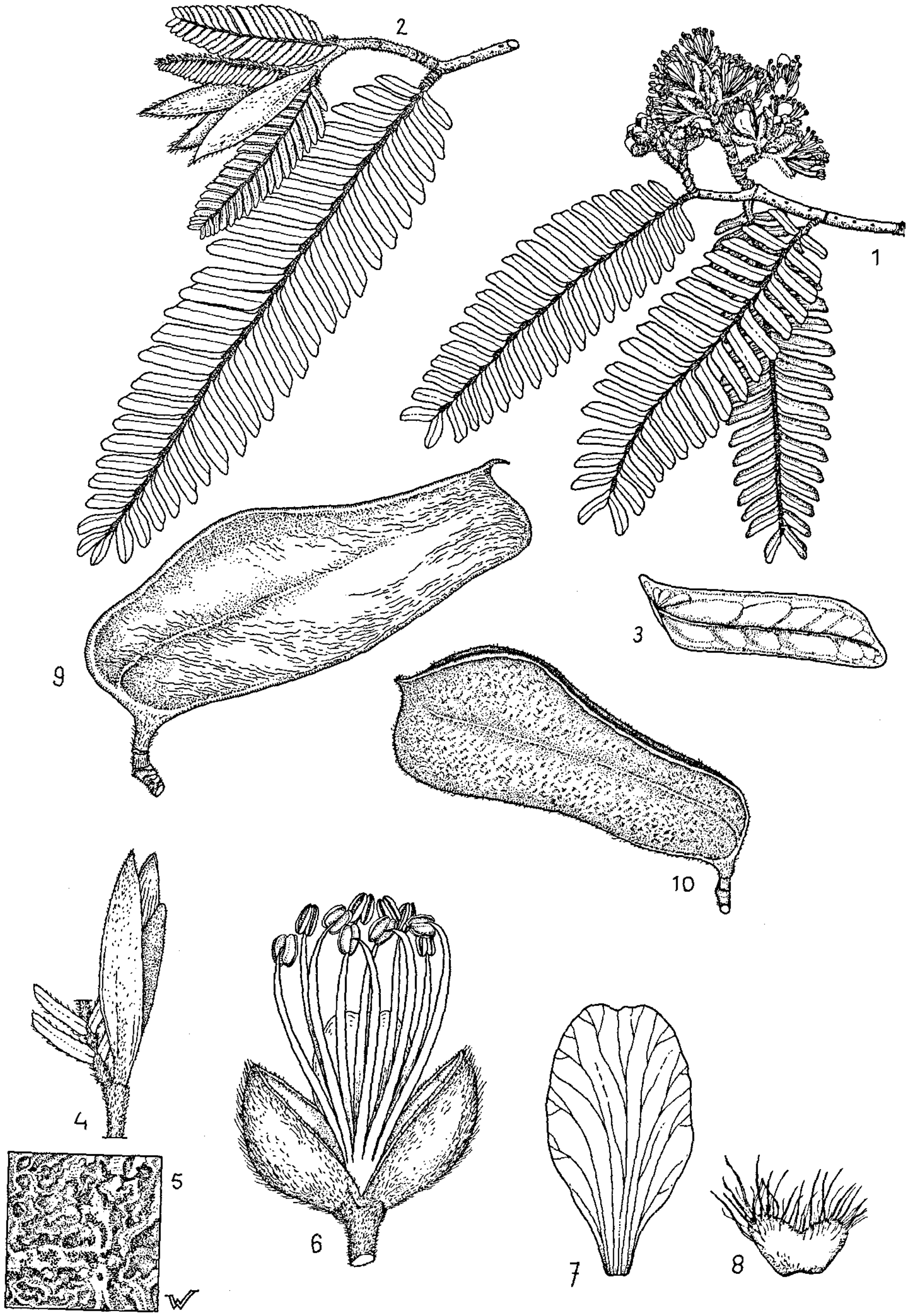


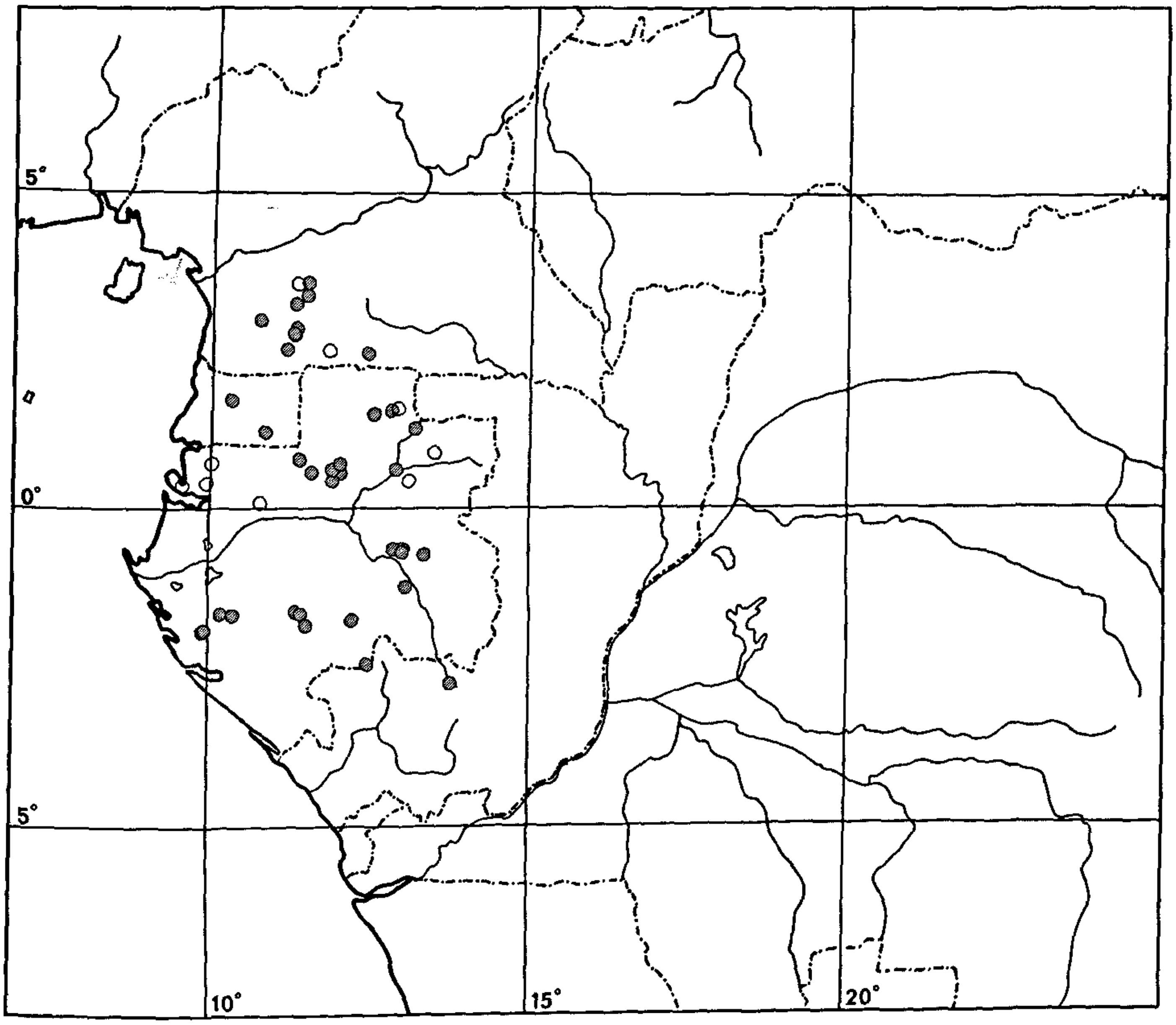
Figure 11.11. *Bikinia* aff. *pellegrinii* (A. Chev.) Wieringa (possible hybrid with *B. le-testui*). — 1. twig with leaves and inflorescences (x⅔); 2: twig with a developing new flush including stipules (x⅔); 3: medial leaflet, lower surface (x2); 4: stipules on a young shoot (x1); 5: bark surface (x2); 6: functionally male flower from abaxial side (x4); 7: adaxial petal from outside (x6); 8: adaxial sepals from outside (x14); 9: developing pod (x⅔); 10: mature pod (x⅔). — 1–8: *Wieringa & Epoma 1606*; 9: *von Asmuth & Vosmeer s.n. (1)*; 10: *Wieringa & Nzabi 2828.*

velvety auricle proximal at base. **Leaves** 3–12 cm long, (6–)13–23(–28)-jugate, largest leaflet situated proximal from or at the middle: **Petiole** (1–)2–4 mm long, tomentose or puberulous usually mixed with velvety indumentum, often glabrescent, (almost) completely comprised of the wrinkled joint. **Rachis** 2½–11 cm long, green, tomentose or velvety sometimes mixed with puberulous indumentum, in fresh condition terete, in dry condition with a groove or grooved ridge above. **Leaflets** leathery, upper side glossy, dark green, glabrous, lower side slightly glossy, medium green, glabrous but midrib rarely villous; margins long ciliate but glabrescent; proximal half rectangular to narrowly obovate, base usually auriculate, margins towards the apex usually sinoid; distal half narrowly ovate to triangular or rectangular; apex blunt. **Basal leaflet** (2½–)4–18 x (0.9–)1.2–5(–7) mm: without an auricle. **Apical leaflet** 5–19 x 1.4–4½(–6) mm: auricle up to 0.9 mm long, rarely absent. **Largest leaflet** 8–26 x 1.7–6(–8) mm, 3.0–5.2 times as long as wide: auricle 0.1–1.4 mm long. **Gland pattern**: basal leaflet in proximal half with 0–2(–3), in distal half with 0–2 glands. Second leaflet in proximal half with 0(–1), in distal half without glands. Apical leaflet rarely with one small gland in distal half. Other leaflets without glands.

Inflorescence a compound raceme, axillary on the terminal 4 nodes, up to 5 per node, 2–8 cm long, with 1–11 lateral branches which are 4–24 mm long and 12–35-flowered. **Rachis** whitish green, brown velvety usually mixed with tomentose indumentum. **Bracts** caducous, ovate or obovate to obtrullate, 2–6 x 1½–4½ mm, white, outside white puberulous usually mixed with sparsely to rather densely brown velvety indumentum, inside glabrous, margin chaffy, apex rounded or bluntly acute to acuminate. **Pedicel** (1–)2–4(–5½) mm long, (long) brown velvety. Hypanthium s.l. 0.5–1.3 mm high. **Bracteoles** obovate, 2.9–6.4 x 2.3–5.2 mm, with an asymmetrically running ridge, angle at anthesis 50–150° in functionally male flowers, 70–340° in bisexual flowers, white to whitish green: outside white puberulous, sometimes mixed with sparsely brown velvety indumentum especially at base and along the ridge; inside glabrous; margin chaffy. **Flowers** slightly fragrant. **Sepals** white: brown velvety outside; glabrous inside; margins glabrous. **Adaxial sepals** strongly reduced, rarely wanting, including the hypanthium part (0–)0.1–0.8(–1.8) x 0.4–2.0 mm, the two triangular free lobes usually very small or wanting, rarely more developed, 0–0.4(–0.8) mm high. **Lateral sepals** wanting. **Abaxial sepal** rarely wanting, semicircular to narrowly triangular, 0–0.8(–1.6) x 0.2–0.8 mm; apex acute to rounded. **Adaxial petal** rarely doubled (monstrosity), narrowly rounded obtriangular, 3.2–6.6 x 1.4–2.8 mm, white: claw indistinct, 0.2–0.9 mm long; glabrous outside; glabrous inside; margins glabrous, apex sometimes rarely with a few hairs; apex rounded. **Lateral petals** usually wanting, sometimes vestigial, rarely more developed, linear to spatulate, 0.2–2.5(–4.7) x 0.1–0.5(–1.2) mm, white, glabrous, apex rounded to acute. **Abaxial petals** usually wanting, rarely vestigial, linear to spatulate, 0.2–1.7 x 0.1–0.7 mm, white, glabrous, apex rounded to acute. **Stamens** 10(–11), rarely the adaxial one doubled together with the adaxial petal: filaments 5½–11 mm long, 9 united over a length of 0.6–2.1, adaxial filament free, white and glabrous but violet-red in the part fused in the hypanthium and velvety at its very base; anthers 0.8–1.2(–1.3) mm long, purple. Pollen described by Salard-Cheboldaeff (1982). **Ovary** in some flowers depauperate, 0.4–1.5 x 0.3–1.0 x 0.2–0.6 mm, in bisexual flowers 1.8–3.3 x 1.2–1.7 x 0.5–0.9 mm, long brown and white velvety, with 2(–3) ovules (0–2(–3) in depauperate ovaries), stipe 0.5–1.5 mm long in male flowers, 1.3–2.2 mm long in bisexual flowers. **Style** 3–8 mm long, inserted at an angle of 40–120°, base slightly conically thickened and long velvety, end of conical part usually not geniculate; stigma heart-shaped.

Pod 1–2(–3)-seeded, obovate, 4–9 x 2.2–4.2 x 0.2–0.4 cm, dull, sparsely long and shortly appressed velvety, green during development, maturing brown; beak ½–4 mm long; upper suture moderately winged, 2–6½ mm wide; nerve often rather obscure, running approximately at the middle, u/w = 0.36–0.67; stipe 3–8 mm long; pedicel 2–5½ mm long. **Seeds** insufficiently known, c. 13–22 x 10–19 x 3–4 mm.

Seedling: Germination epigeal. Hypocotyl 2½–9 cm long, velvety. Epicotyl 5–13 cm long, sparsely tomentose. First pair of leaves opposite, (8–)13–18(–24?)-jugate. Subsequent leaves alternate.



Map 11.10. Distribution of *Bikinia pellegrinii* (A. Chev.) Wieringa.

Distribution: Map 11.10. From Cameroon to Gabon and in a small area in Congo (Brazzaville) (Chaillu Massif). The fossil record from Schwartz et al. (1990) has to be doubted since wood identification of *Bikinia* is not possible at species level. Maley et al. (1990), however, refer to the only area in Congo (Brazzaville) where the presence of the species is confirmed by herbarium material.

The species seems to avoid the coastal regions, most of its occurrence being more inland. Saint Aubin (1963: 54) already noted that the species is very rare in Gabon's sedimentary basin. All records from the Estuaire province are doubtful (see notes). Only the records from the Rabi and Ofoubou area seem to be reasonably trustworthy. An explanation for this distribution may lay in the evasion of the wettest areas. The 'solid' records all come from places with a precipitation of less than 2200 mm.

Vernacular names: Cameroon: Ekop (Yaoundé-Boulou); Abaye (Boulou). Gabon: Evel-Andoung, Eko-Andoung (Fang); Mbazé (maybe misinterpretation), Ndoungou (maybe misinterpretation, Bakota).

Forestry name: Cameroon: Mayo, wood sold as Ekop Rouge. Gabon: Andoung de Pellegrin.

Ecology: Canopy tree of primary dry-land rain forest at 0–900 m altitude. It occurs usually in small clusters of less than 10 mature trees (own observations), but the Minkébé data as presented in chapter 3 seems to indicate the existence of larger stands as well. Also Letouzey (1985: 112) is probably describing larger groupings.

Letouzey (1985: 112–113) based a vegetation type on this species. He notes that this species occurs further East than most other Caesalpinioideae and constitutes the 'Taches de *Monopetalanthus pellegrinii*' vegetation type in that region (approximately the zone from Mbalmayo to Ebolowa), but he says the species also occurs along the Cameroonian coast between Campo and Edea as an element of the 'Forêts atlantiques biafréennes à Caesalpiniaceae'. However, from this region, as well as from the also mentioned Mundemba-Ndian region, no material is known to me and his records are probably the result of misidentifications.

The flowers are visited by several groups of insect; besides hoverflies (Syrphidae: Melanostomatini), stingless bees (Meliponini) and honey-bees (*Apis mellifera*, in coll. ZMA) also some beetles like *Cordylomera heimi* Teocchi, *Hypargyra* spec. and *Philomeces* cf. *albicrus* Aur. (Cerambycidae, in coll. Wieringa) were collected while visiting the flowers.

Phenology: Flowering in Cameroon from the second half of February to March. The northern populations in Gabon and Equatorial Guinea will probably prove to flower in this period as well. In the remainder of Gabon a distinct flowering season exists from the end of August to October. However, flowering has also been recorded in May and July, both in the Chaillu Massif. This corresponds with the flowering reported in June just across the border in Congo (Brazzaville) in the same mountains.

In Gabon developing pods have been recorded in June (north), July (Chaillu) and October (Estuaire). Fresh fallen pods in September, November, February and March (north) and February (east). No firm conclusions can be drawn from these records about the time necessary for maturation. However, the suspected hybrid tree (i.e. *Wieringa & Epoma 1606*, see notes) flowered in September and shed its seeds around March, which points to a maturation time of 6 months, while the population east of Lastoursville, which flowers in October, sheds its seeds in February, 4 months after flowering.

Chemistry: Flowers produce an orange-red colour in alcohol.

Diseases and pests: Observations on a (barely) surviving tree c. 20 km E of Rabi revealed lots of holes in its trunk, probably caused by longhorn beetles (Cerambycidae); one such beetle has been collected from its trunk and proved to be *Xystrocera similis* Jord. (in coll. Wieringa).

Leaf glands are sometimes transformed into galls.

Use: Together with the closely related *B. le-testui* and probably confused with it, this species will be logged and sold as one of the 'Ekop Rouge' species from southern

Cameroon.

The wood is suitable for several purposes including carpentry, plywood, veneer and pulp.

Notes: Letouzey & Mouranche (1952: 46–49) describe under the name "Mayo" (which they identify as *Monopetalanthus* aff. *pellegrinii* on page 16a) a mixture of *B. le-testui* and *B. pellegrinii* by referring to *Letouzey 1280* and *1278, 1279 & 1281* (cf.) respectively. The photos are most probably based on *Letouzey 1280* and thus show *B. le-testui*. Vivien & Faure (1985) describe for a part true *B. pellegrinii*, but considering their distribution map it has been confused with some other species, probably *B. le-testui* but maybe also with non-Macrolobieae genera such as *Hymenostegia*. Maybe their distribution map is based on Letouzey (1985: 112) who describes the same kind of distribution pattern.

B. pellegrinii, as presented here, comprises quite some variation in leaves, flowers and pods. The core of the material (collections from Cameroon, north and east Gabon) seems fairly constant in appearance. Flowering material from other regions (mainly Chaillu Massif), unfortunately including the type, do have most characters in common, but are aberrant in some others. However, each of these collections is aberrant in its own way. It has not been possible to relate other specimens without fruits or flowers from these regions to the various kinds of flowering material. Another problem arises with the material collected in the Estuaire province (Gabon) which is internally fairly coherent but does not really compare with the eastern and northern populations. Unfortunately no flowering collections from this region are known so far.

At present it is hard to draw any lines. Additional fertile material may well prove that several distinct species are involved. Maybe also the use of new techniques, such as DNA analyses, may illuminate some of the problems that arise from the macromorphological studies.

Partly because of the large variation in this taxon, it is sometimes hard to separate this species from *B. le-testui*. Typical *B. le-testui* trees have dull greyish lower sun-leaflet sides, these leaflets are larger and are more distinctly emarginate. Also the flowers and pods are notably larger than those of *B. pellegrinii*, while the adaxial petal is much broader and the velvety pods have broad wings. Saplings and leaves not exposed to the sun however, may already cause problems. One tree and its saplings from Rabi (*Wieringa c.s. 1050, 1051, 1606 & 2828, von Asmuth & Vosmeer s.n. (1) & van Nek 702*) possesses leaves which closely resemble *B. pellegrinii*, its pods look like those of *B. le-testui*, while its flowers are intermediate between the two. This tree is considered to be a possible hybrid, and all collections from it have not been included in the given measures, however it has been used for figure 11.11. Another sample, *Medou 1767*, may be such a hybrid as well, but it is tentatively placed under *B. le-testui*.

Specimens examined:

CAMEROON: *Koufani 164* (P, WAG, YA): S of Ebolowa, near Akonetye, Ngongonjie hill, 2°28'N 11°10'E (fr, 30.08.1978); *Letouzey 1278* (P, YA): S of Mbalmayo, Adzab, near Soo-bridge, chantier Restany, 3°19'N 11°29'E (fr, 11.04.1949); *Letouzey 1279* (P, YA): S of Mbalmayo, Adzab, near Soo-bridge, chantier Restany, 3°19'N 11°29'E (st, 11.04.1949); *Letouzey 1281* (P, YA) id. doubtful: Mbalmayo to Akono, chantier Tabourel, 3°30'N 11°20'E (st, 05.04.1949); *Letouzey 8235* (P, YA): 20 km E of Oveng, near Nkono, 2°24'N 12°26'E (fr, 28.10.1966); *Letouzey 8235 bis* (P, YA): 20 km E of Oveng, near Nkono, 2°24'N 12°26'E (st, 28.10.1966); *Letouzey 9846* (P, WAG, YA): 25 km ESE Ebolowa, road Biwong Boulou-Koungoulou, Nkolomeya, 2°48'N 11°19'E (st, 17.01.1970); *Letouzey 10012* (BR, P, WAG, YA): 25 km SE Ebolowa on road to Evindissi, Ako' Akas, 2°42'N 11°17'E (fl, 04.02.1970); *Letouzey 10115* (BR, HBG, K, P, WAG, YA) id. doubtful: 25 km SE Mvangan, 5 km SW Ekowong, 2°27'N 11°50'E (fl, 08.03.1970); *Letouzey 11394* (P, YA): 12 km SE Ngomedzap, near Mébomézoa, Nkol Emana, 3°11'N 11°18'E (st, 27.06.1972); *Maley & Mezili s.n. (1)* (WAG): c. 25 km SE Ebolowa, Ako'okas, summit of Ako-Akas hill, 2°43'N 11°16'E (st, 06.03.1995); *Médou 1829* (FHO, P, WAG, YA): 4 km SSW of Sieba, Mbalmayo, 3°31'N 11°30'E (fl, 26.02.1953); *Médou 1830* (P, WAG, YA): 4 km SSW of SIEBA-sawmill, near Mbalmayo, 3°31'N 11°30'E (fl, 27.02.1953); *Mpom 1675* (WAG, YA): Restany Mbalmayo, 3°31'N 11°30'E (st, 1952); *Mpom 2673 a* (YA) id. doubtful: ?, not located (st, ?); *de Winter 96* (WAG): Nyangong, 2000 m on transect *2, 2°56'N 10°45'E (st, 24.04.1996); *de Winter 100* (WAG): Nyangong, 2000 m on transect *2, 2°56'N 10°45'E (st, 24.04.1996).

EQUATORIAL GUINEA: *Mondjo s.n. (2)* (WILKS): c. 20 km SW Ngon, 10114m on transect C-west, 1°10'N 10°50'E (st, 1994); *Wilks 3523* (WAG): Monte Alen, Moka, 1°40'N 10°18'E (fr, 02.05.1998).

GABON: *von Asmuth & Vosmeer s.n. (1)* (WAG) id. doubtful: Rabi, c.1 km SE Shell-camp, 1°57'S 9°53'E (fr, 10.1992); *Bernard 284* (LBV): Sibang arboretum, not mapped (st, 29.10.1951); *Bois 981* (P) id. doubtful: Kougouleu, 0°22'N 9°55'E (fl, 24.10.1952); *Breteler & Breteler-Klein Breteler 13103* (WAG) id. doubtful: c. 20-30 km NNW Ndjolé, 0°03'N 10°45'E (st, 30.09.1994); *Breteler, Wieringa & Nzabi 13195* (UGDA, WAG (+alc)): c. 30 km E Lastoursville, 0°41'S 12°59'E (fl, fr, 10.10.1994); *Breteler, Wieringa & Nzabi 13244* (WAG (+alc)): Lastoursville region, 17 km WNW Bambidie, 0°41'S 12°50'E (fl, 12.10.1994); *Breteler, Wieringa & Nzabi 13305* (UGDA, WAG (+alc)): road Lastoursville to Okondja, 19 km E Ndambi, 0°46'S 13°19'E (fl, 15.10.1994); *Dibata 882* (WAG, WILKS): Ofoubou, 1°42'S 10°08'E (fr, 1991); *Dibata 1274* (WAG): Bambidie, 0°44'S 12°58'E (fr, 20.02.1997); *Durand 1656* (LBV): Crystal Mountains, chantier CFN, not located (st, 04.1956); *Gauchotte 1718* (P) id. doubtful: Station Ikoy, 0°20'N 9°33'E (fr, 10.1956); *Gauchotte 1720* (LBV, P) id. doubtful: station Ikoy, 0°20'N 9°33'E (fr, 10.1956); *Gauchotte 1738* (LBV) id. doubtful: station Ikoy, 0°20'N 9°33'E (fr, 10.1956); *N. Hallé 3142* (P, WAG) id. doubtful: Bélinga, 1°13'N 13°10'E (fr, 12.11.1964); *N. Hallé & Le Thomas 83* (P): Belinga, 1°13'N 13°10'E (st, 19.07.1966); *Le Testu 6024* (BM, BR, K, LISC, MO, P, WAG) type: Moucouna, 1°40'S 11°18'E (fl, 28.08.1926); *Le Testu 8820* (B, BM, BR, K, LISC, P, WAG): betw. Moucombo & Cambamongo, 1°48'S 12°11'E (fl, 15.05.1931); *Morel 23* (P) id. doubtful: Cocobeach, Nkan on the Noya, downstream Noya-Adughe junction, 0°41'N 10°00'E (fl, 23.11.1947); *van Nek 702* (WAG) id. doubtful: Rabi-Kounga, 1°57'S 9°53'E (fr, 05.03.1991); *J. Reitsma & B. Reitsma 1194* (NY, WAG): Oveng, 0°44'N 11°22'E (fr, 23.06.1985); *J. Reitsma & B. Reitsma 1197* (NY, WAG): Oveng, 0°44'N 11°22'E (fr, 23.06.1985); *J. Reitsma & B. Reitsma 1563* (NY, WAG) id. doubtful: Oveng, c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 23.09.1985); *J. Reitsma & B. Reitsma 1982* (MO, NY, WAG): c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 02.03.1986); *J. Reitsma & B. Reitsma 1990* (MO, NY, WAG): c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 02.03.1986); *J. Reitsma & B. Reitsma 1991* (MO, NY, WAG) id. doubtful: c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 02.03.1986); *J. Reitsma & B. Reitsma 2727* (NY, WAG) id. doubtful: 50 km SE Makokou, near Ekobakoba, 0°24'N 13°04'E (st, 09.12.1986); *J. Reitsma & B. Reitsma 2894* (LBV, NY): 25 km WSW of Mitsic, Oveng, 0°44'N 11°22'E (fr, 07.02.1987); *J. Reitsma, B. Reitsma & Mezui 2495* (MO, NY, WAG): c. 25 km WSW of Mintsic, Oveng, 0°44'N 11°22'E (st, 06.11.1986); *de Saint Aubin 1964* (LBV, P): Makokou, 0°34'N 12°52'E (fl, fr, 09.1958); *Tengué in MINKébé series A 596* (WAG): Minkébé region, 29420m on transect A, 1°27'N 12°32'E (fr, 07.03.1990); *Tengué in MINKébé series A 610* (WAG): Minkébé region, 30912m on transect A, 1°27'N 12°31'E (fr, 16.03.1990); *Tengué in MINKébé series B 244* (WAG) id. doubtful: Minkébé region, 10265 m on transect B, 1°32'N 12°54'E (fr, 06.04.1990); *Thomas & Wilks 6512* (BR, MO, P, WAG): road Mouila to Yeno, around Kembele, 1°42'S 11°23'E (fl, fr, 20.07.1986); *Wieringa & Epoma 1606* (IAGB, LBV, W, WAG (+alc), WILKS): Rabi, 1 km SE of Shell camp, 1°57'S 9°53'E (fl, 17.09.1992); *Wieringa & Epoma 1651* (WAG (+alc)): Rabi, well 13, 1°58'S 9°51'E (fl, 27.09.1992); *Wieringa & Nzabi 1050* (WAG): Rabi, 1 km E of Shell-camp, 1°57'S 9°53'E (st, 26.05.1992); *Wieringa & Nzabi 1051* (LBV, WAG): Rabi, 1 km E of Shell-camp, 1°57'S 9°53'E (st, 26.05.1992); *Wieringa & Nzabi 2828* (G, IAGB, IEC, LY, UGDA, W, WAG (+alc)): Rabi, 0.8 km SE of Shell-camp, 1°57'S 9°53'E (fl, fr, 01.10.1994); *Wieringa & v.d. Poll 1495 A* (WAG): 75 km rd Lastoursville-Moanda, 3 km before Tsotanzala-Pouby, 1°16'S 13°02'E (st, 27.08.1992); *Wieringa & v.d. Poll 1568* (WAG) id. doubtful: c. 73 km ENE of Makokou, Mont Sassamongo, 0°50'N 13°29'E (fr, 02.09.1992); *J. de Wilde, v.d. Maesen & Maley 11591 A* (WAG): c. 9 km along the road from Mandji to Mbari, 1°43'S 10°19'E (st, 13.12.1995); *Wilks in MINKébé series A 17* (WAG): Minkébé region, 647m on transect A, 1°30'N 12°48'E (fr, 01.02.1990); *Wilks 1109* (LBV, WILKS): 24 km N of Sougalam, 0°31'N 12°00'E (fr, 28.07.1985); *Wilks 1342* (WILKS): 22 km N of Koumameyong, 0°24'N 11°53'E (fr, 18.02.1987); *Wilks 1429* (WAG, WILKS): 40 km N of Koumameyong, 0°34'N 11°52'E (fr, 20.03.1987); *Wilks 1447* (MO, WAG, WILKS): 40 km N of Koumameyong, 0°34'N 11°56'E (fr, 22.03.1987); *Wilks 1448* (MO, WAG, WILKS): 40 km N of Koumameyong, 0°34'N 11°56'E (st, 22.03.1987); *Wilks 1470 a* (MO, WAG, WILKS): 35 km N of Koumameyong, 0°32'N 11°33'E (fr, 27.03.1987); *Wilks 1679* (WILKS): 53 km NNE of Koumameyong, 0°40'N 12°00'E (fr, 21.02.1988); *Wilks 1980* (WAG): Chaillu massif, 5 km SE junction of Ogoulou and Ogoudou r., 1°53'S 11°28'E (st, 08.07.1989).

CONGO (BRAZZAVILLE): *Constant 24* (CIRAF): Mokila, 2°48'S 13°44'E (st, 16.05.1972); *Sita 4575* (IEC, P, WAG): Chaillu Massif, Enclavie de Missanda, 2°30'S 12°25'E (fl, 01.06.1981).

12 *Icuria* Wieringa

12.1 *Icuria* Wieringa gen. nov. Map 13.1

Type (= type of *Icuria dunensis* Wieringa): *C.F. Johnson & A.M. Avis 694* (holo: WAG; iso: GRA (n.v.) and other duplicates still at GRA (n.v.)) — Mozambique: "Moma Region, BHP Concession area, Nampula Prov., N. Mozambique, 13-18/Sept/98".

Diagnosis: Arbores. Stipulae liberae valvatae. Inflorescentiae racemi compositi. Flores fere sessiles. Sepala absentia vel solum adaxiale vestigiale adest. Petala plerumque absentia. Stamina 6–8 omnia basi breviter unita. Ovarium 1–3 ovula gerens. Legumina nervo laterali ordinationeque reticulata.

Small to large trees. Trunk straight and cylindrical, base without buttresses. Bark pale grey, in slash outer bark very thin, inner bark fibrous.

Stipules free, both margins valvate. Leaves paripinnate, 1–2-jugate. Leaflets opposite, never emarginate at the apex. Basal leaflet only with glands in the proximal half.

Inflorescences compound racemes, sometimes branching once more, axillary on the terminal nodes, 1 per node. Bracts inside glabrous. Flowers almost sessile, some flowers functionally male, others bisexual. Bracteoles fused over a short distance at base. Hypanthium very short or absent, when present fused with the bracteoles. Sepals reduced, only the adaxial one sometimes present and often fused to the bracteoles. Petals usually wanting, rarely a vestigial lateral petal present. Stamens 6–8, all shortly fused at their bases. Anthers relatively large, purple-pink, without dorsal teeth, connective protruding at base past the thecae. Ovary with 1–3 ovules, shortly stalked, stalk and ovary completely velvety. Style inserted strikingly eccentric, base slightly conical, usually distinctly geniculate both near the base and near the apex, stigma ± mushroom-shaped.

Pods puberulous to velvety, lateral nerve present, running clearly above the middle of the pod, additionally with a reticulate pattern, wings of upper suture fairly narrow, with a distinct beak. Seeds with a very thin membraneous testa.

Seedlings epigeal. Hypocotyl shorter than epicotyl. First pair of leaflets opposite.

Distribution: Map 12.1 & 13.1. Confined to an area along the coast of central Mozambique.

Etymology and gender: *Icuria* is derived from one of the (fairly similar) vernacular names that are known for its single species. It seems that the name Icurri is used as well for *Monodora junodii* Engl. & Diels in an other part of Mozambique (Koning, 1993: 46 & 226), but this usage is most probably very restricted and based on a single herbarium label. The other vernacular name (Ungari) seems to be unique (not recorded by Koning, 1993) but has as severe disadvantage that it might be confused with *Uncaria* or *Ungeria*. *Icuria* on the other hand is a very distinct name not to be confused easily with any other generic name. Since single or double r's are not considered to be very important in Mozambican languages (pers. comm. J. de Koning) I rather use a single r to evade possible links to the Indian dish spelled and pronounced with a double r.
Icuria has the female gender.

12.2 Description of the species

Icuria dunensis Wieringa spec. nov. Fig. 12.1, Map 12.1

Type: *C.F. Johnson & A.M. Avis 694* (holo: WAG, incl. spirit coll.; iso: GRA (n.v.) and other duplicates still at GRA (n.v.)) — Mozambique: "Moma Region, BHP Concession area, Nampula Prov., N. Mozambique, 13-18/Sept/98".

Gen. nov. sp. nov.: Dold, 1998.

Diagnosis: Arbor parva usque magna trunco cylindraceo. Folia 1–2-jugata. Bracteolae porphyro-roseae. Petalorum lateralia rariter adsunt. Stamina alba intus velutina parte hypanthii. Legumina puberula usque ad velutina rostrata sutura que superna angustata.

Tree, up to 40 m tall. **Bole** cylindrical, up to 10 m long, DBH reaching over 100 cm: base without buttresses, sometimes with small feet. **Bark** relatively thin, producing black exudate: surface smooth, pale grey; outer bark very thin, from inside to outside subsequently whitish, greenish, red-brown and whitish; inner bark fibrous, pale brown. Sapwood in dry condition pale yellow to pale pink.

Twigs smooth, grey, white pubescent and puberulous, with red-brown lenticels. **Stipules** free, valvate in bud, caducous, ovate, 7–16 x 1½–4 mm, outside mixed pubescent and puberulous, inside glabrous, apex bearded, margins chaffy-papillose and ciliate, at proximal base often with glandular (?) appendages, sometimes with a tiny auricle. **Leaves** (2–)4–10 cm long, 1–2-jugate, when 2-jugate the apical leaflet the largest: **Petiole** 2–7 mm long, white pubescent, (almost) completely composed of the wrinkled joint, in longer petioles the apical part resembles the rachis. **Rachis** 7–22 mm long, almost glabrous to white pubescent, on the lower side also sparsely velvety, in dry condition upper side at base with two ribs which diverge to the apical leaflets and become wings. **Leaflets** leathery, upper side shiny, glabrous, lower side somewhat glossy, glabrous; margins sparsely shortly to long ciliate but glabrescent; proximal half ovate to obovate, base rounded, margins towards the apex rarely weak sinoid; distal half narrowly obovate to linear-rectangular; apex blunt. **Basal leaflet** (14–)30–98 x (4–)8–26 mm. **Apical leaflet** 25–74 x 5½–15 mm. **Gland pattern**: basal leaflet in proximal half with 0–1(–2) glands close to base, in distal half without glands; apical leaflet sometimes with 1 gland in the distal half about halfway along its length.

Inflorescence a compound raceme, lower branches may branch themselves, axillary on the terminal 6 nodes, 1 per node, 1½–12 cm long, with 2–10 lateral branches which are 3–15 mm long and 3–14-flowered. **Rachis** light green, mixed brown-yellow velvety and whitish pubescent. **Bracts** early caducous, circular to obovate or obtrullate, 2.0–2.4 x 2.1–2.5 mm, outside whitish to golden-yellow velvety or pubescent, towards the base mainly with puberulous hairs, inside glabrous. **Pedicel** 0.8–1.1 mm long, golden-yellow velvety or pubescent. Hypanthium absent or very small, when present fused with bracteoles, 0–0.4 mm high. **Bracteoles** circular to obovate, 3.5–4.4 x 2.3–3.4 mm, assuming a 60–100° wide angle at anthesis, margins on both sides very shortly fused at base: outside with a slightly asymmetrical running ridge, purplish pink, mixed whitish pubescent and puberulous, along the ridge also yellow-brown velvety; inside pale pink, glabrous; margins chaffy. **Sepals** 0–1, only the abaxial sepals often present. **Abaxial sepal** absent or very small, when present often partly fused to the bracteoles, free part linear to

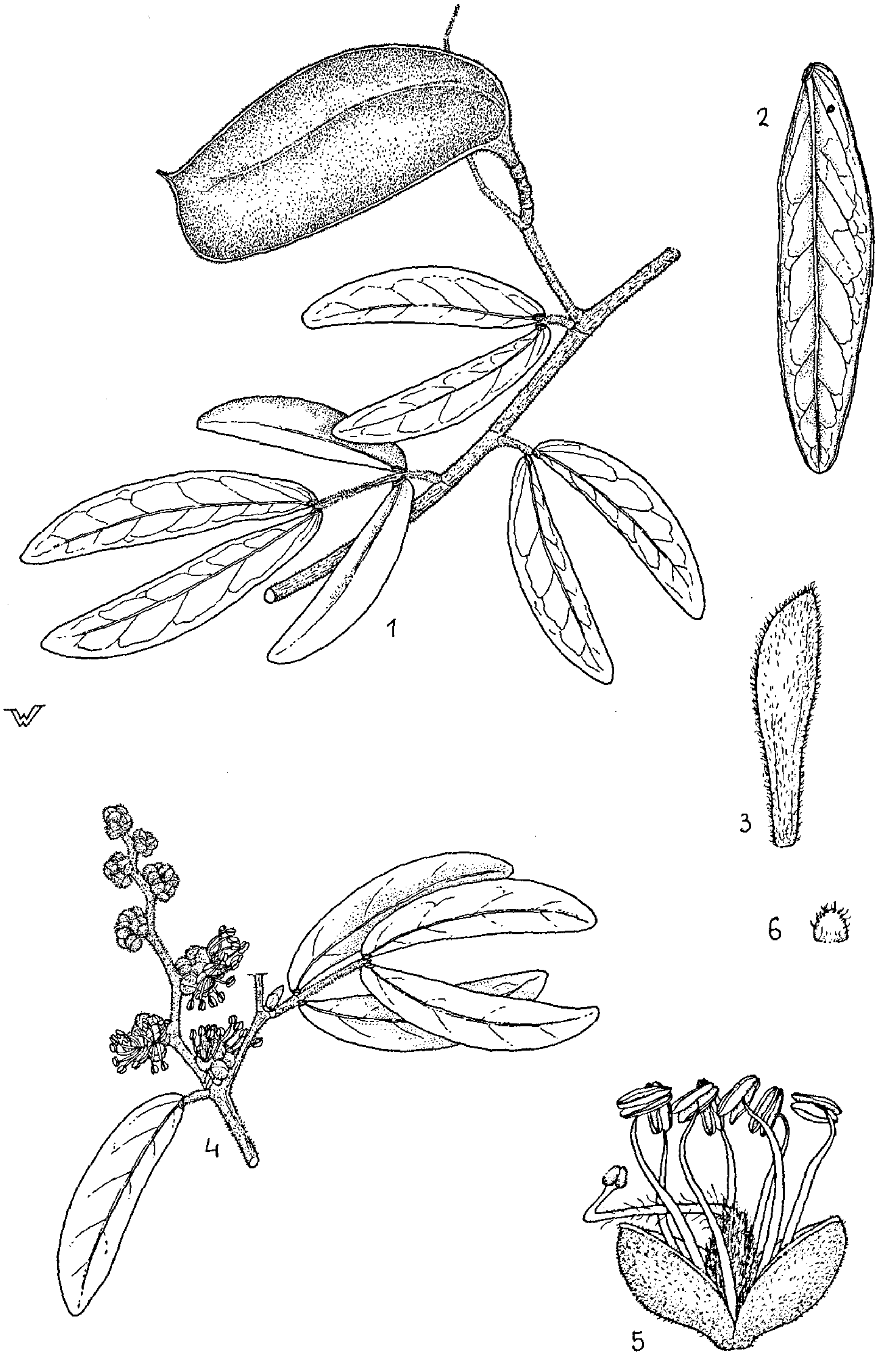


Figure 12.1: *Icuria dunensis* Wieringa. — 1: twig with leaves and infructescence (x⅔); 2: basal leaflet from below showing a gland (x⅔); 3: stipule from outside (x2); 4: twig with an inflorescence (x1); 5: flower (x4); 6: abaxial sepal (x20). — 1, 2: *Gomes e Sousa 4865*; 3: *Dold 3362*; 4–6: *Johnson & Avis 694.*

ovate, up to 0.2 x 0.2 mm, with a few short bristle-like hairs, mostly inserted at the margins. **Petals** usually all wanting, rarely a lateral petal developed. **Lateral petals** usually wanting, rarely vestigial, ovate-triangular, 0.4 x 0.2 mm, glabrous. **Stamens** 6–8: filaments 6–8 mm long, all fused at their very base over a length of 0.1–0.3 mm, white, inside sparsely set with some short to long hairs, velvety inside the hypanthium part; anthers relatively large and conspicuous, 1.9–2.3 mm long, pink-purple. **Ovary** in some flowers depauperate and only 0.4–0.7 x 0.4 x 0.4 mm, in bisexual flowers 1.6–2.1 x 0.9–1.3 x 0.5–0.9 mm, short and long velvety, with (1–)2(–3) ovules, stipe 0.8–1.0 mm long, in male flowers c. 0.5 mm long. **Style** 5–7 mm long, in male flowers c. 0.3 mm long, inserted at an angle of 70–100° to the adaxial side of the ovary, base slightly conically thickened, geniculate at the end of the conical part and at some distance before the apex, sparsely long velvety; stigma mushroom-shaped, sometimes bilobed, surface rather tuberculate.

Pod 1–3-seeded, obovate, 6–11 x 3.6–5.1 x 0.2–0.3 cm, dull, stiff puberulous to velvety; beak 3–6 mm long; upper suture narrowly winged, 2–5 mm wide; nerve running above the middle, u/w = 0.23–0.44, besides the lateral nerve with a distinct reticulate pattern, sometimes (accidentally?) resulting in a second (or even more) lateral nerve(s), u2/w = 0.64–0.80; stipe 6–12 mm long, mixed puberulous and short to long velvety with a few very long hairs, glabrescent; pedicel 1–4 mm, pubescent or velvety, glabrescent. **Seeds** elliptic with a protruding base, 25–28 x 20–23 mm. Testa very thin membraneous, silverish, purple-brown at the margins.

Seedling: Germination epigeal. Hypocotyl 1–8 cm long, glabrous (?). Epicotyl 8–21 cm long, glabrous (?). First pair of leaves opposite. Subsequent leaves alternate, 1-jugate.

Distribution: Map 12.1. Limited to a stretch of about 200 km along the Mozambican coast between Angoche (Antonio Enes) and Moebase.

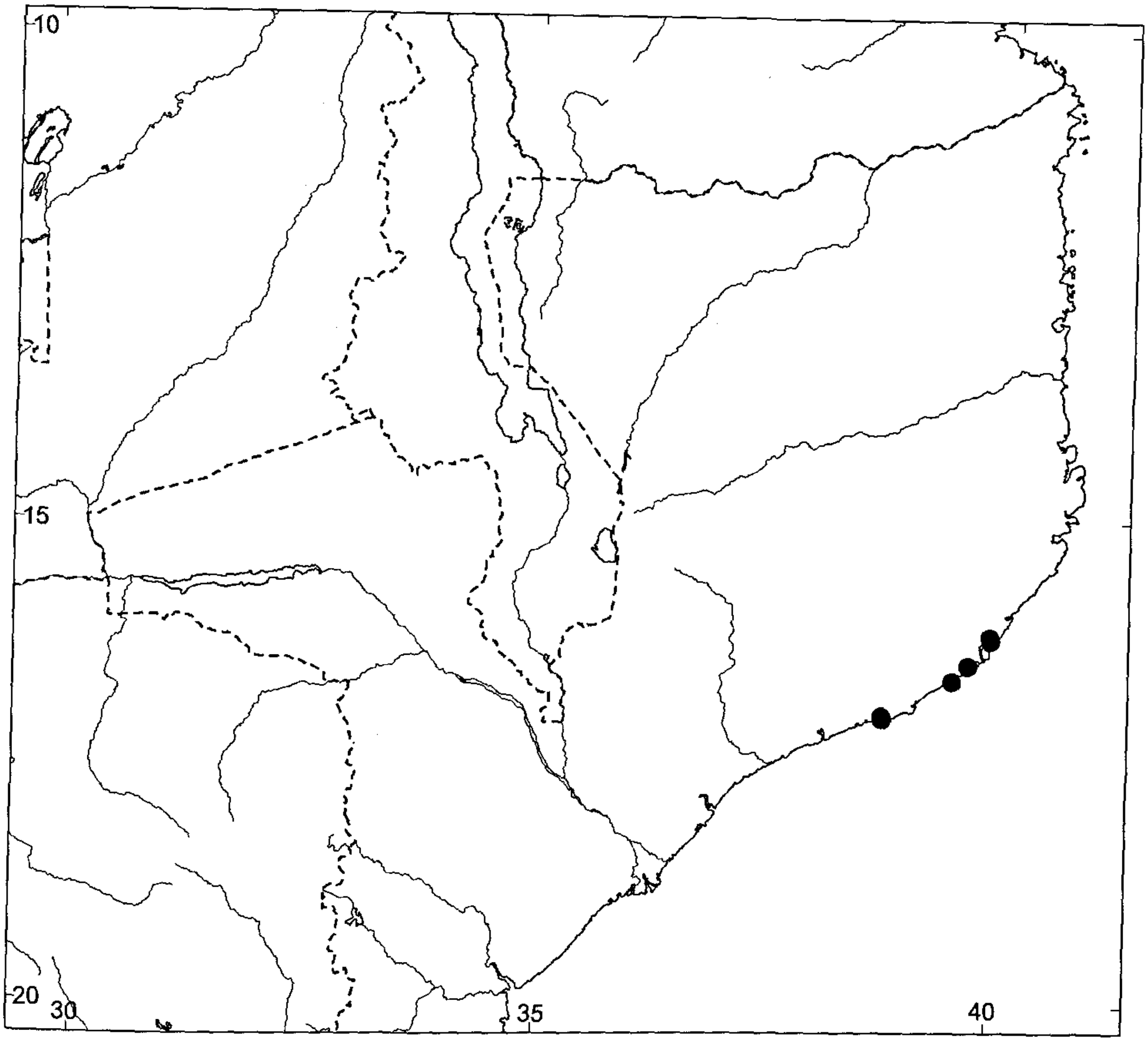
Vernacular names: Mozambique: Icurri (also as Ncurri or Ngurri) (Makhuwa), Unguri (Parapato).

Ecology: In large communities in sandy dunes. Forming nearly monospecific forests in the older dunes, on dry-land. It seems to occur only in the areas which are indicated as 'Littoral thicket and forest of recent dunes' on the vegetation map of Wild & Grandvaux Barbosa (1967–1968). They mention that in this vegetation type sometimes 'open littoral forest of *Trachylobium verrucosum*' occur. Since *Icuria dunensis* was also confused with that species (as *Hymenaea verrucosa*) when it was first located by the team of Lubke, Avis and Dold, it seems fairly well possible that also the reference of Wild & Grandvaux Barbosa (1967: 17), or at least a part of it, refers to *Icuria dunensis* forest.

Phenology: Flowering has been recorded in September, but probably starts already at the end of July, since young inflorescences were recorded early in July. Young pods and full grown but immature pods have been collected in mid-October, almost mature ones in December. Seedfall probably occurs around January.

Chemistry: Leaflets and flowers produce an weak orange colour in alcohol.

Diseases and pests; Some of the pods were transformed into galls by a gall wasp. These



Map 12.1. Distribution of *Icuria dunensis* Wieringa: Mozambique.

galls are encountered frequently. More rarely (different) galls are present on branches. The leaflets show traces of leaf miners.

Use: According to *Mogg 32309* the timber is valuable, but *Dold 3362* records the wood is not durable and used for firewood only, with the exception of saplings which are used for house construction. The bark is stripped to make canoes. Since the wood anatomy (see below) suggests a good quality, this wood could have several applications.

Notes: When the first specimens of this species were encountered in the herbaria of Kew and Harare, it seemed to fit very well within *Bikinia*. Especially the pod with the distinct nerve, the correct shape and indumentum, the beak and the presence of a stalk placed it almost without doubt in that genus, although the reticulate pattern on the pods is a rare feather for this group (*B. breynei* & *B. aciculifera* show it as well, although faintly). It is aberrant from *Julbernardia* since it does not possess transparent dots in the leaflets and it does have a nerve running over the side of the pod.

When the species was re-discovered recently by the team of Lubke, Avis and Dold, this relationship was confirmed by the stipules which were part of their gathering. These stipules are valvate, a character so far exclusively encountered in *Bikinia*. However, in September 1998 Johnson and Avis have collected flowers of this species which confirm the tribal placement of this species within the Macrolobieae, but which contradicts a placement in *Bikinia*. The flowers do not fit any known genus. Moreover, a first DNA analysis (pers. comm. F. Gervais) places the species closer to *Aphanocalyx* than to *Bikinia*, rendering the erection of a new genus the best option to accommodate this species.

The reference in Dold (1998) that the diameter of the stem often exceeds 2.8 m is based on an error, it should read circumference.

Specimens examined (except the type all paratypes):
MOZAMBIQUE: *Dold 3362* (GRA, K, WAG): betw. Beira and Angoche, 17°02'S 38°45'E (fr, 05.12.1997); *Dold, Avis & Lubke 3312* (GRA): 220 km E Quelimane, Moebase to Molocue, 17°02'S 38°45'E (fl, 05.07.1997); *Gomes e Sousa 4865* (WAG): Antonia Enes, coast, in dunes betw. village and the beach, 16°12'S 39°54'E (fr, 15.10.1965); *Johnson & Avis 556* (WAG): Nampula prov., Moma region, in NW of BHP concession area, 16°30'S 39°40'E (st, 15.09.1998); *Johnson & Avis 660* (WAG): Nampula, Moma region, BHP concession area, c.40km SW Angoche, 16°30'S 39°40'E (st, 16.09.1998); *Johnson & Avis 694* (WAG (+alc)) type: Nampula, Moma reg., in SW of BHP concession, 68km SW Angoche, 16°40'S 39°30'E (fl, 17.09.1998); *Lubke & Avis 3090* (WAG): betw. Beira and Angoche, 7 km E of Moebase river, 17°04'S 38°45'E (st, 12.08.1995); *Mogg 32309* (SRGH): Angoche (=Antonio Enes), Matangula forest near sea front, 16°14'S 39°54'E (fr, 17.10.1965).

12.3 Wood anatomy of *Icuria dunensis* Wieringa **Photo 12.1–4**

by R.W. den Outer & W.L.H. van Veenendaal

Since the description of the wood anatomy of this group (Outer & Veenendaal, 1996), treating the wood of species now considered to belong to *Aphanocalyx*, *Bikinia*, *Brachystegia*, *Julbernardia* and *Tetraberlinia*, also a wood sample of *Icuria* has become available. This wood sample, *Johnson & Avis 660* (WAG), is described below. Of the genera treated, only the wood of *Michelsonia* remains unknown.

Growth ring boundaries distinct, marked by marginal parenchyma.

Storied structure absent.

Vessels diffuse, solitary, in short radial multiples of 2–4, and infrequently in clusters; usually surrounded by parenchyma, sometimes in contact with libriform fibres; round to oval; (12–)18(–22) per square mm; tangential diameter (35–)77(–125) μm; thickness of walls c. 5 μm. Vessel member length (110–)200(–305) μm; perforations exclusively simple, slightly oblique; intervessel pits bordered, vestured, alternate, 5–6 μm; vessel-ray and vessel-axial parenchyma pits rather numerous, both similar to intervessel pits but half-bordered.

Vessels, libriform fibres, axial parenchyma and rays comprise about 8, 60, 13 and 19% respectively of the total cross-sectional area.

Libriform fibres c. 540 μm long, thin- to thick-walled, wall thickness 3–4 μm, diameter of lumina 5–6 μm; non-septate; with simple to minutely bordered pits with longitudinal, slit-like inner apertures, very numerous, confined to the radial walls; intercellular spaces absent.

Axial parenchyma lozenge-aliform or vasicentric (regularly not entirely surrounding the vessels), and in long marginal bands of 2–5 cells wide. Strands 4(–5) celled; end cells with conical-ends in tangential section; length (360–)410(–450) μm. Brown cell content present.

Rays 12 per mm, uniseriate, sometimes locally biseriate; homocellular, predominantly composed of procumbent cells, marginal cells heigher to square or sometimes upright; height (40–)200(–300) μm or (2–)12(–20) cells. Brown contents present.

Crystals rare, prismatic, solitary; in chambered axial parenchyma cells.

Pit flecks present.

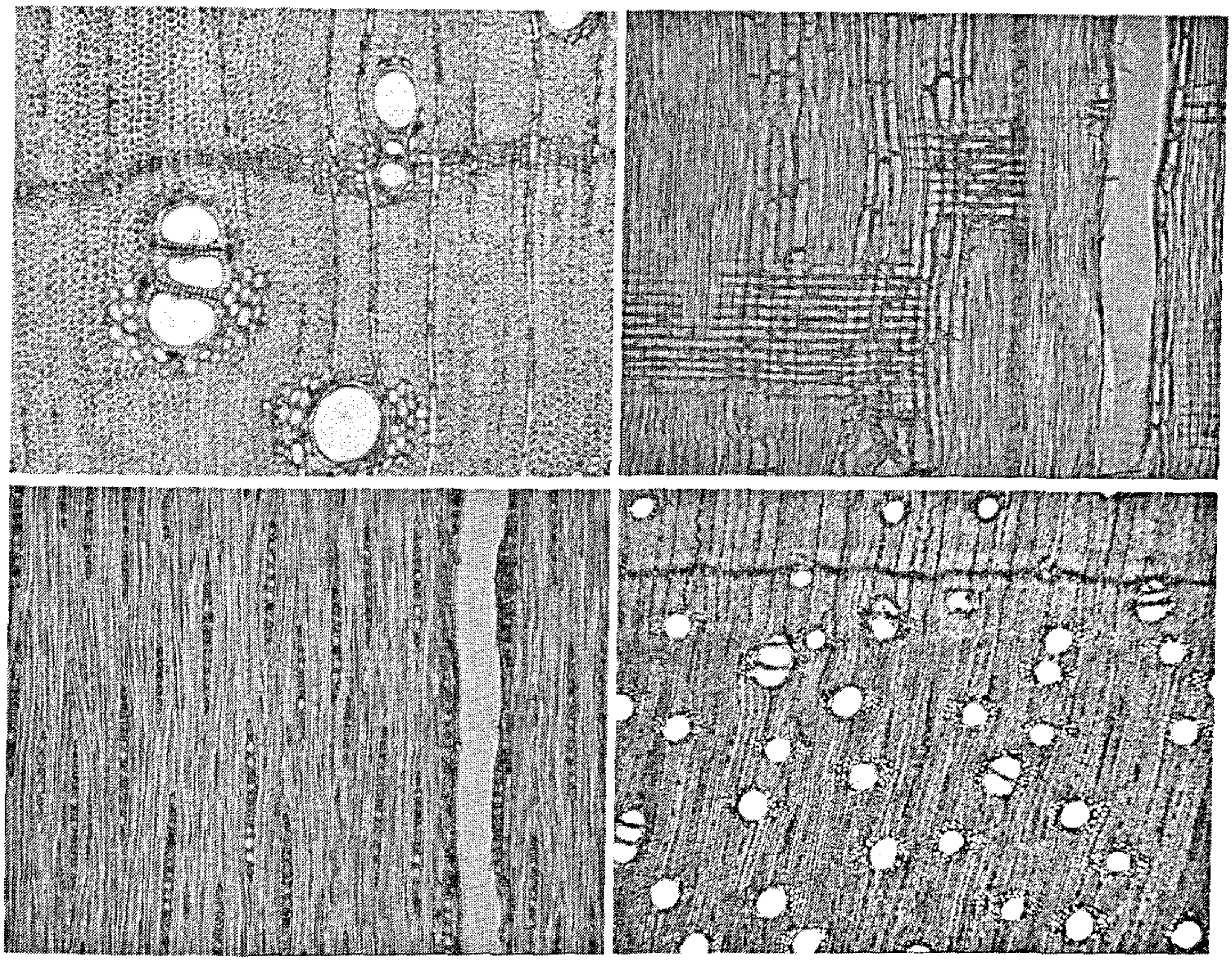
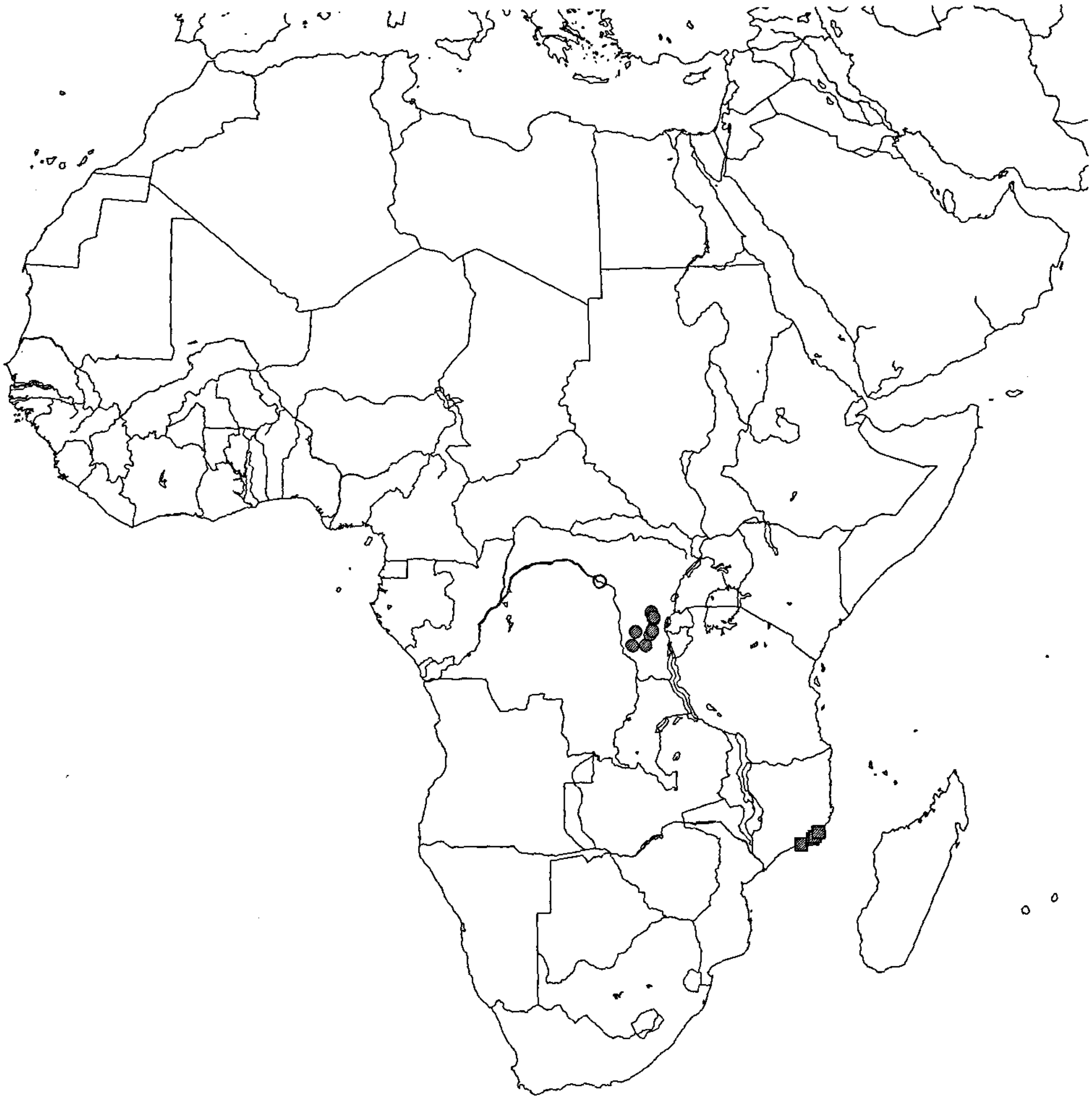


Photo 12.1–4. Wood of *Icuria dunensis*: 1 (top left): cross-section, cambium situated above this photo (82x); 2 (top right): radial section (74x); 3 (bottom left): tangential section (74x); 4 (bottom right): cross-section (29x).



Map 13.1. Distribution of *Icuria* (solid squares) and *Michelsonia* (circles, the open circle refers to a tree that was probably planted).

13 *Michelsonia* Hauman

13.1 *Michelsonia* Hauman

Map 13.1

Michelsonia Hauman: Hauman, 1952a: 478 p.p.; Hauman, 1952b: 406 p.p.; Léonard, 1965: 104 & 107; Normand & Paquis, 1976: 100; Watson & Dallwitz, 1983: 42 p.p.; Gunn, 1991: 334–335 (excl. fig. A); Léonard, 1996: 447–448. **Type** (= type of *Julbernardia microphylla*): *Michelson 882* (holo: BR; iso: BRLU, FHO, SRGH, WAG) — Congo (Kinshasa): "Nzibi-Belanzovi, petit ravin après le passage de la Lulumbe. Altitude 680 m. 28 janvier 1949" in flower.

Tetraberlinia auct. non (Harms) Hauman: Aubréville, 1968: 295 p.p.; Aubréville, 1970: 272 p.p..

Large trees. Trunk cylindrical, at base without or with small buttresses.

Stipules free, lateral, not meeting each other at any point. Leaves paripinnate, 10–16-jugate. Leaflets opposite, apex not emarginate. Basal leaflet in proximal half usually without glands, in distal half usually with glands.

Inflorescences compound racemes, sometimes branched once more, axillary on the terminal nodes, one per node, nodes sometimes with leaf remains. Bracts inside glabrous. Flowers nearly sessile, some functional male, others bisexual. Bracteoles not fused with the hypanthium. Hypanthium very short, nearly non existent. Sepals 5, of about equal size. Adaxial sepals partly fused. Petals 5, of about equal length. Stamens generally 10, adaxial stamen free, 9 united at their very base, at first radiating, all entirely glabrous. Anthers without dorsal teeth. Ovary with 2 ovules, velvety, with a short stipe. Style insertion slightly to strinkingly eccentric.

Pods glabrous, with a distinct lateral nerve running near the centre, upper suture not to very indistinctly winged. Seeds with a thin but not membraneous testa.

Distribution: Limited to the sub-mountane area of eastern Congo (Kinshasa).

Etymology and gender: This genus is named after the Belgium forester A. Michelson who collected several samples of its type species, among which its type.
Michelsonia has the female gender.

13.2 Description of the species

Michelsonia microphylla (Troupin) Hauman

Fig. 13.1, Map 13.2

Michelsonia microphylla (Troupin) Hauman: Hauman, 1952a: 478 p.p.; Hauman, 1952b: 406–407 p.p.; Normand & Paquis, 1976: 100; Bamps & Champluvier, 1990: 386 p.p.; Bamps & Champluvier, 1991 p.p.; Gunn, 1991: 334–335 (excl. fig. A).

Julbernardia microphylla Troupin: Troupin, 1950: 320–321 & fig. 30 p.p. **Type**: *Michelson 882* (holo: BR; iso: BRLU, FHO, SRGH, WAG) — Congo (Kinshasa): "Nzibi-Belanzovi, petit ravin après le passage de la Lulumbe. Altitude 680 m. 28 janvier 1949" in flower.

Tetraberlinia microphylla (Troupin) Aubrév.: Aubréville, 1968: 295.

Tree, up to 30 m high (but probably also higher, see notes), with a spreading crown. **Bole** branchless for up to at least 12 m, DBH up to 80 cm (or to 120 cm?, see notes): base without or with small buttresses, sometimes slightly conical. **Bark**: surface smooth except for the abundant lenticels, dark grey to blackish (like the bark of *Copaifera* according to *Michelson 520*) or light grey, sometimes even whitish (like a birch (*Betula* spec.) according to *Michelson 882*); outer bark black to dark grey; inner bark very tough, fibrous, its outer half light pink, its inner half light yellow. Sapwood in fresh condition white but quickly darkening to dark yellow upon exposure. Heartwood brown with blackish veins. Wood hard, though easy to saw, fibres cross-grained. Wood anatomy described by Normand & Paquis (1976: 100).

Twigs dark grey to greyish brown with reddish brown lenticels, whitish tomentose-pubescent sometimes sparsely mixed with short or long velvety indumentum. **Stipules** free, caducous, narrowly trullate to triangular, with a distinct central vein, asymmetric, the distal half narrower than the proximal half, with stalked base, 6½–13 x 1.4–2.6 mm, green, both sides glabrous: apex acute to acuminate; margins short ciliate or sparsely so; stalk 0.4–1.3 mm long, velvety. **Leaves** 2½–10 cm long, (5–)10–16-jugate, largest leaflet situated 1–2 pairs proximal from or at the middle: **Petiole** 2–3½ mm long, velvety. **Rachis** 2–8½ cm, semicircular in cross-section, lower side tomentose-velvety sometimes mixed with long velvety indumentum, upper side flattened, usually furrowed, slightly winged, glabrous, at the insertion of the leaflets the wings are slightly constricted and a tassel or a line of hairs is present. **Leaflets** leathery, both sides rather dull, glabrous, shape more or less oblong or oblong-obovate: proximal half elliptic to obovate, often auriculate at base; distal half trullate-oblong to ovate-oblong; margins glabrous; apex acute or occasionally rounded. **Basal leaflet** (3½–)8–16 x 2–5 mm: generally without or with a 0–0.1(–0.4) mm long auricle. **Apical leaflet** 5–15 x 1½–5 mm: auricle absent to small, 0–0.4 mm long. **Largest leaflet** (6–)10–22 x (2–)3–5(–8) mm: auricle present, 0.1–0.9 mm long. **Gland pattern**: the proximal half of all leaflets without glands or the basal leaflet very rarely with 1 gland. Basal leaflet in distal half with (0–)1–2(–3) glands. Second leaflet in distal half with 0–1(–3) glands. Apical leaflet in distal half with 0(–1) gland. Other leaflets without glands or rarely the third leaflet with 1 gland.

Inflorescence axillary on the terminal 6(–9) nodes, 1 per node, a compound raceme, 1–9 cm long, with (1–)4–13 lateral branches, rarely the more basal ones branched once more, branches 5–30 mm long and 5–30-flowered. **Rachis** mixed densely creamy pubescent-tomentose with sparsely, short to long, velvety. **Bracts** early caducous, hemi-circular to ovate with truncate base, 1.5–2.1 x 1.7–2.3 mm, inside glabrous, outside densely appressed pubescent, usually with a midrib which is prominent especially towards the apex, apex sometimes mucronate. **Pedicel** very short, 0.2–1.9 mm long, densely pubescent sometimes mixed with velvety indumentum. Hypanthium s.str. 0.2–0.4 mm high. **Bracteoles** assuming a c. 90–180°? wide angle at anthesis, circular to obovate, 3–5 x 3–4 mm, outside densely appressed white pubescent, midrib slightly prominent without a different indumentum, inside glabrous, margins chaffy. **Sepals** 5, the adaxial ones fused, others free or fused at their very base, all almost equal in length only the adaxial ones generally slightly smaller, both sides glabrous, margins densely shortly ciliate, apex rounded. **Adaxial sepals** fused only at the very base to up to ⅔ of their length, oblong or obovate to obtriangular, when largely fused the free parts often partly overlap, when shortly fused the sepals generally diverging without any overlap, 1.1–1.6 x 1.2–2.8 mm (individual sepals 0.5–0.9 mm wide). **Lateral sepals** obovate, 1.4–1.8 x 0.7–0.9 mm. **Abaxial sepal** ovate to obovate, 1.4–1.9

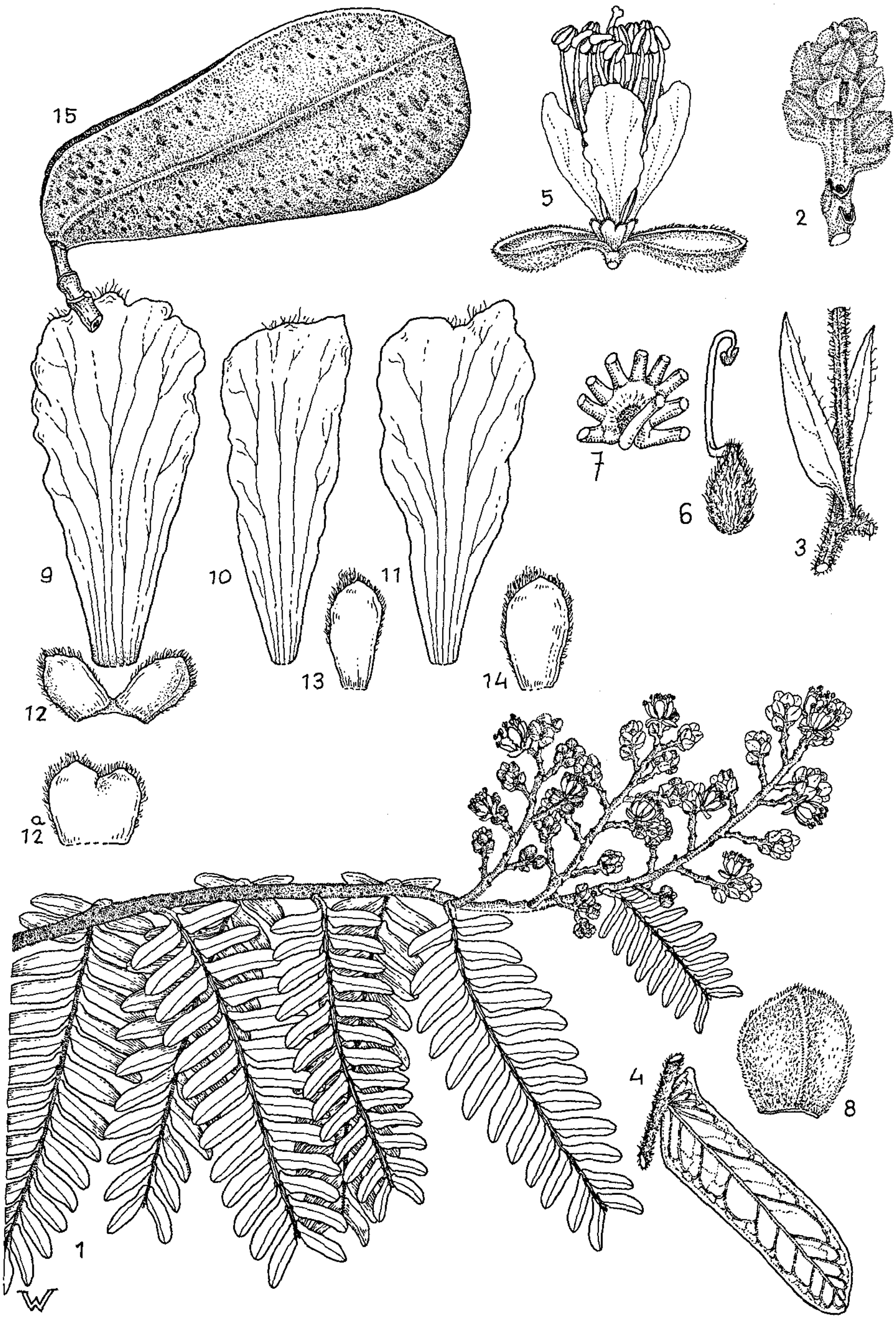


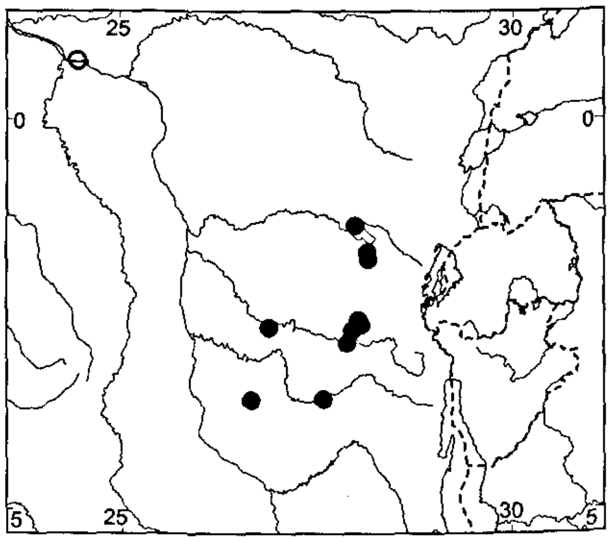
Figure 13.1. *Michelsonia microphylla* (Troupin) Hauman. — 1: branch with leaves and inflorescences (x⅔); 2: lateral branch of inflorescence (raceme) in bud (x2); 3: twig with a pair of stipules (x2); 4: leaflet, lower surface (x2); 5: flower from adaxial side (x4); 6: ovary with style (x4); 7: basal insertion of filaments (x4); 8: bract (x4); 9: adaxial petal (x8); 10: lateral petal (x8); 11: abaxial petal (x8); 12 & 12a: two variants of the adaxial sepals (x8); 13: lateral sepal (x8); 14: abaxial sepal (x8); 15: pod (x⅔). — 1,4: *Lisowski 15302 & A. Léonard 1800*; 2, 5–14: *A. Léonard 1800*; 3: *Michelson 520a*; 15: *A. Léonard 1768.*

x 0.7–1.1 mm. **Petals** 5, almost equal in size and shape (only the adaxial petal often slightly larger), spathulate to narrowly obtriangular, white, glabrous (but see notes), apex rounded, acute or emarginate, often with an irregularly incised margin, apical margin in centre often slightly ciliate. **Adaxial petal** 4.2–5.6 x 1.9–3.3 mm. **Lateral petal** 3.1–5.5 x 1.2–2.4 mm. **Abaxial petal** 3.3–5.9 x 1.4–2.7 mm. **Stamens** 10(–12, see notes): filaments 5–9½ mm long, 9 connected at their very base over a length of 0.4–0.6 mm, adaxial one completely free, all entirely glabrous; anthers elliptic to broadly elliptic, 0.8–1.3 x 0.6–0.9 mm, without dorsal teeth. **Ovary** 1.1–2.5 x 0.6–1.3 x 0.3–0.8 mm, sometimes depauperate and only c. 1 x 0.7 x 0.5 mm, fairly densely, short to long, velvety, with 2 ovules; stipe 0.4–0.9 mm long, glabrous to velvety. **Style** 5½–7½ mm long in bisexual flowers, c. 0.5 mm in male flowers, placed 30–120° eccentric on the adaxial side of the ovary, glabrous, only near the base with a few long hairs; stigma ± hemispherical thus becoming mushroom-shaped.

Pod 2-seeded, obovate to rounded obtriangular, 7–10½ x 3.2–4.3 x 0.3–0.5 cm, heavy (dry pods sink in water), surface granulate, fairly glossy, brown, glabrous; beak 0–1 mm long; upper suture not to very narrowly winged, 2–4 mm wide; nerve distinct, running along or just above the centre of the pod, u/w = 0.39–0.56; stipe 3–5 mm long; pedicel 1–2 mm long. **Seeds** elliptic to obovate, 17–20 x 13–17 mm; testa papery, fairly glossy, medium brown.

Seedling: unknown.

Distribution: Map 13.2. Eastern Congo (Kinshasa). The collection from Yangambi (*Lisowski 15302*) is most probably from a cultivated individual, as it was collected within the forest reserve belonging to the institute. Within this reserve many trees have been planted amidst the natural occuring vegetation (pers. comm. S. Lisowski). According to C.E.N. Ewango (pers. comm.) the species has also been found in the Maiko National Park (c. 0°40'S 28°E), but in general the species has become very rare and could not be traced recently. This may have been caused by extensive logging in the 40's and 50's.



Map 13.2. Distribution of *Michelsonia microphylla*. The open circle represents a record of a (most probably planted) tree in Yangambi.

Vernacular names: Congo (Kinshasa): Kasisi (Kirega, Ulindi-river), Musisi (Kirega, Shabunda region).

Ecology: This species grows mainly on hill tops and slopes. It is also found in valleys and small canyons, but never in swampy conditions. It occurs in primary forest at an altitude of 650–1100 m. Although its distribution area is quite restricted, locally this species may become common and may even form almost pure stands.

Pierlot (1966: 163–164) classifies forest dominated by *M. microphylla* as a distinct forest type, the *Michelsonia microphylla* forest.

Phenology: Flowers have been recorded in November (3x), January (1x), April (2x) and May (1x), young developing pods in April and November, almost mature pods in November, mature ones in May and fallen pods in January.

Chemistry: Flowers or leaves produce no or a weak yellow to weak orange-yellow colour in alcohol.

Diseases and pests: *Michelson 520* describes a gum-disease for this species, but he most probably misinterpreted *Tetraberlinia baregarum* as a diseased *Michelsonia* (see notes).

Use: According to Terashima et al. (1992) and Yumoto (1990) this species may have several local uses. However, these records may be based on misidentifications since no vouchers of this species could be traced at BR (where they are supposed to be deposited). In the 1940's and 50's the species was logged extensively for its good quality wood that was easy to process.

Notes: The height of the trees is only stated in 5 collections, of which *A. Léonard 1768* was the highest with 30 m, but according to *Michelson 882* this species grows in the middle Belanzovi valley with perfect trunks reaching magnificent heights, making larger heights likely. The DBH was stated only once (80 cm), however, the trees can most probably reach larger diameters, because Normand & Paquis (1976) say it can exceed 1 m and Tailfer (1989: 791) states it reaches 120 cm. However, since the species apparently is confused with *Tetraberlinia baregarum*, we can not be sure to which species these records refer, although *Michelsonia* is the most likely candidate since it is the most common one.

With a normal handlens the petals of dry herbarium material appear glabrous, but at a larger magnification they seem to be very finely (<0.05 mm long) appressed puberulous, especially on the inner side. However, I am not sure whether these microscopical structures really represent tiny hairs, or are tiny ridges in the surface, possibly caused by drying.

Some flowers of *A. Léonard 1800* possess 11 or 12 stamens, in such flowers one or both stamens next to the abaxial stamen are doubled, the most inner one of each pair being much smaller and sterile.

Michelson 520 represents a mixture of *M. microphylla* and a hitherto unknown *Tetraberlinia* species. The pods of this collection have been used by several authors to describe the pods of *M. microphylla*, but they actually belong to this *Tetraberlinia* species. They differ from true *M. microphylla* pods in having a distinctly winged upper suture and a strong beak. They also sometimes possess 3 seeds (a number never encountered in pods nor in ovaries of *M. microphylla*) and have relatively large fruiting pedicels. Also the seed cavities are smaller than those in *M. microphylla*. One branch of this collection (present in BR) with leaves and stipules really is *M. microphylla*, the other branches, with most leaves dropped, belong to the other species. The latter leaflets are shiny on both sides, have a ciliate margin and do sometimes also posses a gland in the 4–7th leaflet. When put in alcohol for a day, these leaflets and the pods produce a distinct red colour to the alcohol. Without any doubt these glossy leaflets and the pods of *Michelson 520* represent a previously unknown species that is described here as *T. baregarum*. See also the notes under that species.

It is remarkable that Michelson writes on the long label accompanying *Michelson 520* that locals from the Barega tribe (language: Kirega) distinguish two species, Mulende and Kasisi. Michelson agrees that the two entities have quite different trunks, but since the leaves and pods are equal (acc. to Michelson) he concludes it is just one species of which some are ill and therefore have a different bole, although the locals persist that they are different. If Michelson had looked more closely and listened better to the locals, he might have found the differences and we would have better material now for describing *T.*

baregarum. Michelsons notes about the "diseased" trees most probably concern the new species, the notes on the healthy trees *Michelsonia.*

Specimens examined:

CONGO (KINSHASA): *A. Léonard 1710* (BR, K, P, WAG): Walikale, Ibondo, 1°47'S 28°09'E (fl, 17.11.1958); *A. Léonard 1768* (BM, BR, C, MO, WAG): Walikale, Kabunga, 1°42'S 28°09'E (fr, 19.11.1958); *A. Léonard 1800* (BR, K, WAG): 10 km road Walikale to Stanleyville, 1°21'S 27°59'E (fl, fr, 20.11.1958); *A. Léonard 3744* (BR, K, P, WAG): Shabunda, Bulumbu, 2°42'S 27°57'E (fl, 09.04.1959); *A. Léonard 3782* (BR, C, MO, NY, WAG): Shabunda, Kitoko, 2°52'S 27°53'E (fl, fr, 10.04.1959); *Lisowski 15302* (BR, WAG): Yangambi, 0°46'N 24°27'E (st, 26.11.1972); *Michelson 520 a* (BR): middle Ulindi riverbank, Moka-Symétain Sud-camp, 2°40'S 26°53'E (st, 1943); *Michelson 654* (BR): Kampene, 3°36'S 26°40'E (fl, fr, 05.1944); *Michelson 844* (BR, BRLU, P): 10km N Kigulube, Nzibi-valley, 2°34'S 28°01'E (st, 10.01.1949); *Michelson 882* (BR, BRLU, FHO, SRGH) type: Nzibi-Belanzovi, after Lulumbe-passage, 2°38'S 28°03'E (fl, 28.01.1949); *Michelson 1068* (BR): 30km Kamituga-Kasongo, Mikélo for. res., 3°35'S 27°35'E (fl, 11.1959).

Map 14.1. Distribution of *Tetraberlinia.*

14 *Tetraberlinia* (Harms) Hauman

14.1 *Tetraberlinia* (Harms) Hauman — Map 14.1

Tetraberlinia (Harms) Hauman: Hauman, 1952a: 477; Hauman, 1952b: 398; Léonard, 1957: 186–187; Léonard, 1965: 105–106; Aubréville, 1968: 295–296 p.p.; Aubréville, 1970: 272–273; Normand & Paquis, 1976: 99–100; Watson & Dallwitz, 1983: 57; Gunn, 1991: 336–337.
Berlinia sect. *Tetraberlinia* Harms: Harms, 1915a: 472 p.p.. Type (= type of *Berlinia bifoliolata*, species selected by Hauman, 1952a): *Zenker 2275* (holo: B†; lecto: E; iso: A, BM, K, P, S, W, WU) — "Flora von Kamerun. Bipinde, Urwaldgebiet. 1900".
Julbernardia sect. *Tetraberlinia* (Harms) Troupin: Troupin, 1950: 319 p.p..

Berlinia sect. *Neoberlinia* auct. non Harms: Baker, 1930: 680–691 p.p..
Michelsonia auct. non Hauman: Hauman, 1952a: 478 p.p.; Léonard, 1957: 187–188 p.p..

Small to large trees. Trunk straight and cylindrical, usually without buttresses but often swollen at base. Bark dark grey, fairly smooth with horizontal lines and lenticels, in slash outer bark very hard, blackish, inner bark fibrous, to the exterior slightly granular.

Stipules caducous or persistent, free or rarely fused at base, distal margins meeting at base in leaf axil. Leaves 1–34-jugate, leaflets opposite. Leaflets never emarginate at the apex, but proximal margin often sinoid just below the apex.

Inflorescences compound racemes, sometimes branching once more, axillary on the terminal nodes or terminal, 1–3(–5) per node. Bracts hairy in apical part or glabrous. Bracteoles fused with the hypanthium which is usually well developed. Sepals usually 5, slightly or considerably reduced, not fully covering the inner elements in bud, lateral sepals sometimes wanting. Adaxial sepals partly to completely fused. Petals 5. Adaxial petal large, usually at least in the apical part yellow, maybe sometimes completely white, central axis usually inrolled, margins expanding laterally again, both sides with specific indumentum patterns. Lateral and abaxial petals reduced, usually inrolled or folded together lengthwise. Stamens usually 10, adaxial stamen free, 9 united at base, usually glabrous but sometimes velvety in the hypanthium part. Ovary velvety, lateral sides often glabrous, with 1–5(–6) ovules, rarely depauperate. Style insertion fairly centric on the apex of the ovary.

Pods usually glabrous, more rarely sparsely puberulous to pubescent, with 1–2 lateral nerves, upper suture usually distinctly winged, sometimes wings become very pronounced and inrolled, rarely (*T. longiracemosa*) wings poorly developed. Seeds with a very thin membraneous testa, 'overgrown', should germinate immediately after seed shed.

Seedlings epigeal. Hypocotyl about as long as epicotyl. First pair of leaves opposite.

Distribution: Confined to the tropical evergreen rain forest of western and central Africa.

Etymology and gender: *Tetraberlinia* was erected as a section of *Berlinia* to accommodate the species showing only 4 (greek: tetra) sepals (true if one counts the fused adaxial sepals as a single sepal).

Tetraberlinia has the female gender.

14.2 Key to the species of *Tetraberlinia*

1 a Leaves 1(–2)-jugate. Adaxial petal 10–20 mm long, at least 2 times as long as wide, lateral margins at base widened forming a triangular dent. Pods often with a second lateral nerve or one which is broken up into small diagonal lines. Cameroon to western Congo (Kinshasa) .... ***T. bifoliolata***

b Leaves (1–)3–34-jugate[1]. Adaxial petal 4–11 mm long (unknown in *T. baregarum*), only rarely more than twice as long as wide, lateral margins never with a triangular tooth. Second lateral nerve on the pod only present in some species with more than 4 pairs of leaflets. **2**

2 a Leaf rachis above extended into small lateral wings. Leaves 14–17-jugate. Poorly known species from eastern Congo (Kinshasa). .... ***T. baregarum***

b Leaf rachis above not extended into small lateral wings, a grooved ridge may be present on the upper side. Leaves (1–)3–34-jugate. Liberia and Cameroon to Gabon. **3**

3 a Hypanthium 0.7–1.1 mm high. Largest leaflet 5½–19 x 1½–5[1] mm. Leaves (6–)13–34-jugate. Pods 5–8 cm long. Stipe 3–7 mm long. Stipules auriculate, caducous (not in saplings and treelets). Adaxial sepals together longer than broad. Gabon. .. .. ***T. longiracemosa***

b Hypanthium 1.2–3.3 mm high. Largest leaflet 15–90 x 5–38 mm. Leaves (1–)3–15-jugate, if more than 8-jugate pods (6–)8–23 cm long. Stipe (5–)8–23 mm long. Stipules caducous or persistent, auriculate or not, if auriculate the adaxial sepals much broader than long. **4**

4 a Stipules auriculate, persistent to caducous. Adaxial sepals much broader than long. Leaves (4–)8–15-jugate. Leaflets of a typical shape: the margins parallel for most of the length, then suddenly with a sinoid curve in the proximal margin resulting in an acuminate apex and proximal half of basal leaflet with (0–)1–5 glands. Bracteoles notably swollen at the apex, 'nosed'. Pods often with a second lateral nerve or with diagonal lines below the first nerve. **5**

b Stipules not auriculate, caducous. Adaxial sepals longer than broad. Leaves (1–)3–13-jugate. Leaflets not with parallel margins followed by a sudden narrowing into an acuminate apex or proximal half of basal leaflet without glands. Bracteoles not notably swollen at the apex, not 'nosed'. Pods never with a second lateral nerve. **6**

5 a Hypanthium 2.1–3.3 mm high. Bracts 10–13 mm long, apex acute to acuminate. Bracteoles 8–12½ mm long. Adaxial petal 7–11 mm long. Filaments (11–)15–23 mm long. Anthers 1.8–2.3 mm long. Stipules more or less persistent. Largest leaflet 30–90 x 8–25 mm. Gabon, probably southern Cameroon (near Kribi) and Congo (Brazzaville). .... ***T. moreliana***

b Hypanthium 1.2–1.8 mm high. Bracts 4–7 mm long, apex bluntly acute. Bracteoles 5½–8 mm long. Adaxial petal 5½–7 mm long. Filaments 8–13 mm long. Anthers 1.0–1.4 mm long. Stipules caducous (persistent in saplings). Largest leaflet (17–)20–46 x 5–12 mm. South-western Cameroon (Korup). .... ***T. korupensis***

6 a Apical part of adaxial petal suddenly widened, transversally elliptic, bilobed, 6–8 mm

wide, its apex often in-folded. Sepals outside glabrous to sparsely pubescent towards the apex. Leaves (3–)6–13-jugate. Upper suture of pods narrowly winged, 3–6 mm wide, stipe 8–11 mm long. Gabon. .... ***T. polyphylla***

b Apical part of adaxial petal very gradually widened, not broader than wide, 2½–3½ mm wide, often reflexed. Sepals outside fairly densely pubescent-velvety to velvety. Leaves (1–)3–6(–7)-jugate. Upper suture of pods distinctly winged, 5–12 mm wide, stipe 10–23 mm long. Liberia. .... ***T. tubmaniana***

[1] Always count and measure several leaves of a collection to ensure that the right choice for a range is taken in the key.

14.3 Description of the species

Tetraberlinia baregarum Wieringa spec. nov. Fig. 14.1, Map 14.2

Type: *Michelson 520 b* (holo: BR; iso (fragm.): BRLU, FHO) — Congo (Kinshasa): "Camp de Moka-Symétain Sud. Alt. 650m env. Forêt des bords de l'Ulindi cours moyen."

Julbernardia microphylla auct. non Troupin: Troupin, 1950: 320–321 p.p. & fig. 30 H.
Michelsonia microphylla auct. non (Troupin) Hauman: Hauman, 1952a: 478 p.p.; Hauman, 1952b: 406–407 p.p.; Bamps & Champluvier, 1990: 386 p.p.; Gunn, 1991: 334–335 p.p.

Diagnosis: Arbor magna. Folia 14–17-jugata, foliolis utroque latere lucentibus margine breviter ciliato, dimidium proximale sine glandulis. Legumen seminibus 2–3, fere glabrum, sutura brevi alata, utroque latere prope medium leguminis vena lateralis prominens apice manifeste rostrato basi longe stipitata.

Large tree. Trunk swollen at base. Bark yellowish, scaly.

Twigs medium to dark grey with reddish brown lenticels, mixed puberulous, pubescent-tomentose and sparsely short to long velvety. **Stipules** unknown. **Leaves** 7–13 cm long, 14–17-jugate, largest leaflet situated at or just proximal from the middle: **Petiole** 3–5 mm long, mixed tomentose with sparsely long velvety. **Rachis** 6–11 cm long, semi-terete in cross-section, the flattened upper side widening into small wings, sparsely tomentose, lower side mixed tomentose with velvety. **Leaflets** leathery: upper side glossy, glabrous; lower side glossy, glabrous to very sparsely velvety, especially along the midrib; margins shortly ciliate; proximal half obovate, base often auriculate, margin towards the apex usually sinoid; distal half ovate to trullate to rectangular; apex rounded. **Basal leaflet**

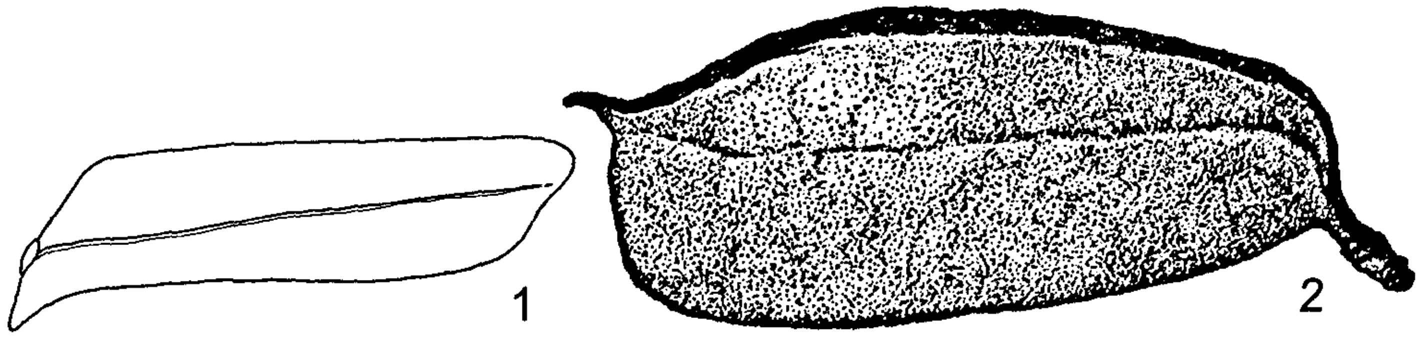


Figure 14.1. *Tetraberlinia baregarum* Wieringa. — 1: leaflet, lower surface (x3); 2: pod (x1). — 1, 2: *Michelson 520 b*. The leaflet is drawn by W. Wessel, the pod is adapted from Troupin, 1950.

11–14 x 3–5 mm: auricle absent. **Apical leaflet** 8–17 x 3–6 mm: auricle 0–0.6 mm long. **Largest leaflet** 18–29 x 4–8 mm: auricle 0.4–1.0 mm long. **Gland pattern**: All leaflets in proximal half without glands. Basal leaflet in distal half with 2–3 glands. Second leaflet in distal half with 1 gland. Apical leaflet without glands. Other leaflets with 0–1(–2) glands, especially present in more basal leaflets, glands observed up to the 7th leaflet.

Inflorescence unknown. Rachis attached to pod (a complete lateral branch) c. 15-flowered, velvety.

Pod 2–3-seeded, obovate-oblong to obovate, 6–10 x 2.5–3.5 x 0.2–0.4 cm, glossy, glabrous, but along the upper suture sometimes a few long hairs present; beak 4–6 mm long; upper suture with a distinct wing, also present in the beak, 3½–6½ mm wide; nerve running in or just above the middle, u/w = 0.42–0.50; stipe 4–6½ mm long; pedicel 3–5 mm long. **Seeds** poorly known, ovate, 10–16 x 8½–13 mm; testa glossy, reddish brown.

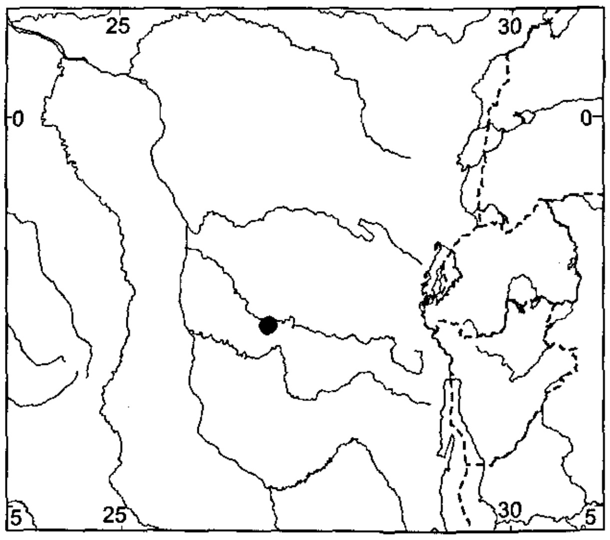
Seedling: unknown.

Distribution: Map 14.2. Only known from eastern Congo (Kinshasa).

Vernacular name: Congo (Kinshasa): Mulenda (Kirega, Ulindi-river).

Ecology: Dominant (or codominant with *Michelsonia microphylla*?) in small populations on hill tops and slopes. Altitude c. 650 m.

Phenology: No data available.



Map 14.2. Distribution of *Tetraberlinia baregarum* Wieringa: eastern Congo (Kinshasa).

Chemistry: The pods and leaves produce a strong red colour in alcohol.

Diseases and pests: According to Michelson these trees suffer from a gum disease, however, it is not clear if the trees really suffer, or that they only appear so when compared to *Michelsonia microphylla*.

Uses: According to Michelson these trees were logged in large numbers around 1943 for its good quality wood that was easy to process.

Notes: The only collection known so far (*Michelson 520)* was a mixture with *Michelsonia microphylla*. I have divided the material in *Michelsonia microphylla* as *520a* and the type as *520b* (see also notes under *Michelsonia microphylla*). The species may well be more common than is evident from its rareness in herbaria, because it has been confused with the supposedly "well known" *Michelsonia microphylla*, and hence it was not collected.

The species is named after the people that live in the area where *Michelson 520* was collected (the Barega, a plural name), who kept insisting to Michelson that this species was not the same as *Michelsonia microphylla*.

Specimens examined:

CONGO (KINSHASA): *Michelson 520 b* (BR, BRLU, FHO) type: middle Ulindi riverbank, Moka-Symétain Sud-camp, 2°40'S 26°53'E (fr, 1943).

Tetraberlinia bifoliolata (Harms) Hauman **Fig. 14.2, Plate 4b, Map 14.3**

Tetraberlinia bifoliolata (Harms) Hauman: Hauman, 1952a: 477; Hauman, 1952b: 398–399; Normand, 1952; Torre & Hillcoat, 1956: 208 & 210; Saint Aubin, 1963: 63; Aubréville, 1968: 296 & 298 & Pl. 75; Aubréville, 1970: 273–274 & Pl. 65 (excl. *Mpom 1672*); Bolza & Keating, 1972: 652; Thirakul, 1983: 260–261; Newbery et al., 1988 (in table 6 accidentally as *Microberlinia bifoliolata*); Détienne, 1991; White & Abernethy, 1996: 176–177.

Berlinia bifoliolata Harms: Harms, 1901: 83; De Wildeman, 1925: 132; Baker, 1928: 143; Baker, 1930: 682 & 690; Pellegrin, 1949: 62 p.p. (excl. *Zenker 3763*); Letouzey & Mouranche, 1952: 17–20 & Pl. I (= "Ribi"). **Type**: *Zenker 2275* (holo: B†; lecto: E (designated here); iso: A, BM, K, P, S, W, WU) — "Flora von Kamerun. Bipinde, Urwaldgebiet. 1900", on the lost holotype sheet probably also "April" was mentioned.

Westia bifoliolata (Harms) Macbride: Macbride, 1919: 21.

Julbernardia bifoliolata (Harms) Troupin: Troupin, 1950: 319.

Photo 14.1. *Tetraberlinia bifoliolata* trunk (*Wieringa & Haegens 2328*). Photo Wieringa.

Small to large forest tree, 5–50 m high; crown rather open and narrow, broader in large trees. **Bole** cylindrical, branchless for up to 20 m, DBH 5–100(–150) cm: base without buttresses, sometimes widening at the very base (but see notes). **Bark** up to 2½ cm thick: surface smooth, dark brownish grey with pale to red-brown lenticels arranged in horizontal lines or with horizontal wrinkles; outer bark up to 1 mm thick, very hard, slate-like, dark brown; inner bark: inside fibrous, becoming increasingly granular outwards, innermost layer of up to 2 mm creamy white when fresh, rapidly changing to brown-yellow surrounded by a thin purple ring, the rest of the inner bark creamy pink to dirty orange becoming darker (orange-red) outwards, light brown after drying, cambium turning brown within seconds upon exposure. Sapwood white to yellowish, in dry state pink to yellowish, heartwood pinkish brown to dark brown, wood with distinct growth rings.

Twigs grey-brown to dark grey, glabrous, sparsely pubescent when young, with small lenticels or longitudinal fissures. **Stipules** free, usually touching at base, sometimes fused in basal part, early caducous but often persistent in saplings (photo 4.3), narrowly triangular, 5–36 x 1–7 mm, greyish green or light to medium green, 6–10-veined, base at proximal side cuneate to sharply angled and slightly auriculate, margins tomentose. **Leaves** with 1 pair or very rarely 2 pairs of leaflets, in the latter case both pairs about equal in size: **Petiole** 3–8 mm long, glabrous, sparsely pubescent in young leaves. **Rachis** generally absent, when present ½–2½ cm long, in saplings sometimes present as an up to 4 cm long thin tail, in cross-section upper side flattened and slightly winged or with the wings forming a usually grooved ridge, sparsely pubescent, glabrescent. **Leaflets** thick papery to thick leathery, papery in saplings: upper side glossy, dark green with a pale yellow-green to medium green primary and pale to medium green secondary veins, glabrous; lower side glossy, medium to pale or yellowish green with a pale yellow to medium green primary vein, glabrous; proximal half ovate to elliptic, base not auriculate, margin rarely sinoid towards the apex; distal half obovate to pear-shaped; apex acute to long-acuminate. Young leaflets above purple-pink to light green, very pale green to pale purple-pink beneath; margins sometimes shortly ciliate, especially in basal half. **Basal leaflet** 4–35 x 1.0–10 cm (larger values only in saplings). **Apical leaflet** 4–15 x 2–5 cm. **Gland pattern**: Basal leaflet in proximal half near the base with 1–7 glands, more or less arranged in a line starting at the very base, distal half with 0–10 glands in a line from the base to the centre. Apical leaflet in proximal half with 2–7 glands, distal half with 0–2 glands. Especially in old leaves the glands are often very hard to observe.

Inflorescence a compound raceme, terminal or axillary on the terminal 4(–6) nodes, 1–3(–5) per axil, 3–10 cm long, sometimes primary axis with small leaves, with 1–6(–10) lateral branches which are 0.5–7 cm long and 2–17-flowered, branches often branched once more. **Rachis** pale green, tomentose-velvety. **Bracts** ovate to obovate, 4–9 x 3½–7½ mm, white to greenish white or pale pinkish, outside usually with one central and two lateral, indistinct ribs, which often fuse just below the apex and are truncated into a nose, area in between the ribs slightly swollen, white puberulous to pubescent, often near the base or sometimes all over mixed with brown velvety hairs, inside glabrous except a narrow tomentose-pubescent band along the margins, margins shortly ciliate. **Pedicel** 1½–4½ mm long, pale greenish white, velvety. Hypanthium s.l. 1.5–2.7 mm high. **Bracteoles** assuming a 30–80° wide angle at anthesis, oblong to ovate, 7–13 x 5–8 mm, asymmetric, the adaxial half about half as wide as the abaxial half, white to pale pinkish, outside mixed white puberulous to pubescent with sparsely to fairly densely brown velvety, inside glabrous or sparsely pubescent. **Sepals** white to pink, sometimes somewhat greenish near the base, outside glabrous to appressed brown pubescent, inside glabrous, lateral margins more or less inrolled, shortly ciliate, often glabrous towards the apex, apex variably rounded and often slightly fimbriate or acute. **Adaxial sepals** fused, together triangular to ovate, 4.9–9.4 x 2.3–5.0 mm, apex bidentate. **Lateral sepals** narrowly triangular, 2.0–8.0 x 0.3–2.3 mm. **Abaxial sepal** triangular, often concave at base, 3.8–8.9 x 1.7–3.2 mm. **Petals 5. Adaxial petal** 10–20 x 2.8–7.4 mm, lemon-yellow (see notes) with a whitish to pink base, outside paler than inside, in older flowers turning white, consisting of three parts: true claw 1.4–3.1 mm long, glabrous; basal part of limb (together with claw) furled into half a tube, basally the margins abruptly widened into a usually triangular tooth, rarely somewhat auriculate (see notes) or more rounded and sometimes reduplicate around the adaxial sepals, above the tooth gradually narrowing, outside glabrous or pubescent, especially on the teeth, inside pubescent except across the usually glabrous central axis, margins sometimes shortly ciliate; the apical part of the limb reflexed in older flowers, gradually widening towards the apex, outside glabrous, inside glabrous or pubescent at base, margins glabrous, apex often mucronate, rarely rounded or emarginate. **Lateral petals** usually inrolled, thus becoming linear, rarely vestigial, (0.7–)2.3–8.5 x (0.1–)0.4–1.2 mm, often curved to the abaxial side, glabrous, pale yellow to white. **Abaxial petals** usually inrolled and linear, usually smaller than lateral petals, (0.3–)1.5–5.0 x (0.1–)0.3–0.8 mm, often curved to the adaxial side, glabrous, pale yellow to white. **Stamens** 10: filaments 14–23 mm long, 9 united over a length of 1.0–3.3 mm, white but pink or pale violet towards the apex, glabrous but the hypanthium part basally usually velvety, above the hypanthium the staminal tube curving inwards; adaxial stamen fused with the stipe at base, entirely glabrous. **Anthers** 1.6–2.0 mm long, whitish to pink, margins of the slits purple. **Ovary** 3–6 x 1.8–2.5 x 1.1–1.7 mm, (rarely depauperate and

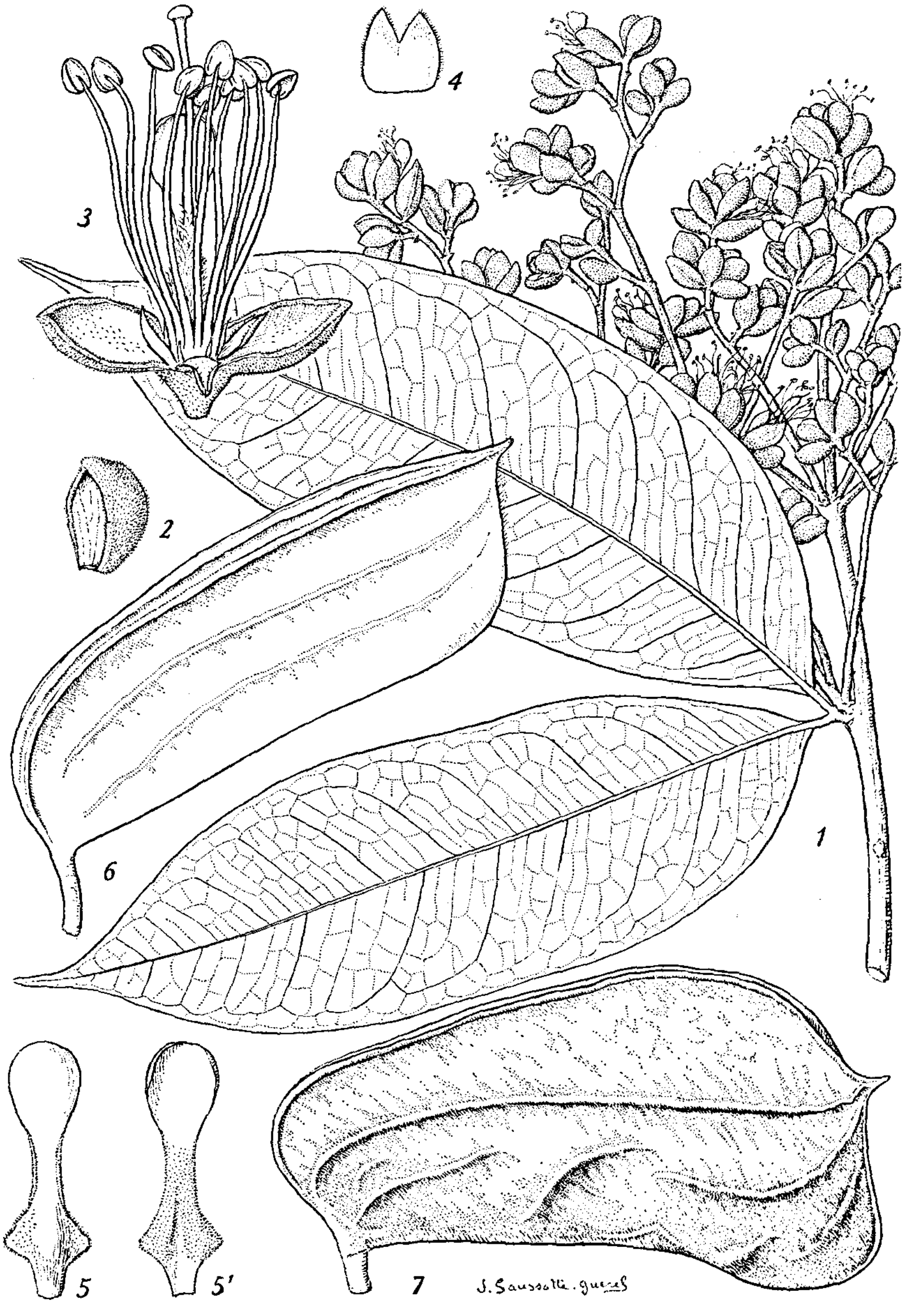
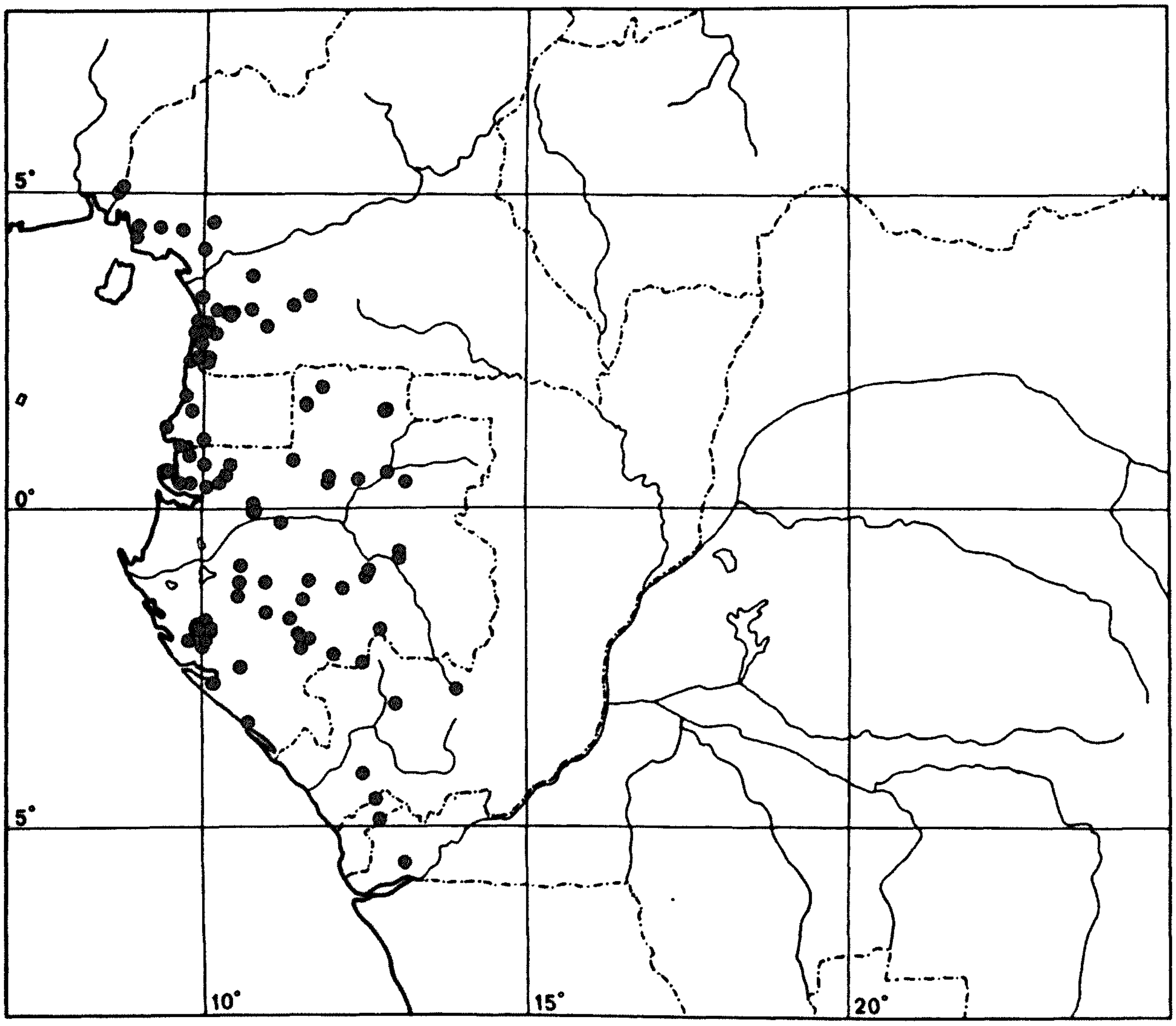


Figure 14.2. *Tetraberlinia bifoliolata* (Harms) Hauman. — 1: twig with a leaf and inflorescences (x⅔); 2: bract (x2); 3: flower from abaxial side with bracteoles and abaxial sepal pushed aside to show interior elements (x2); 4: adaxial sepals (x2); 5: adaxial petal from outside (x2); 5': adaxial petal from inside (x2); 6: young pod showing two lateral nerves (x⅔); 7: pod showing some diagonal lines (x⅔). — Reproduced from Aubréville, 1968.

only c. 2½ x 1.3 x 0.8 mm), with 2–5 ovules, light green, both sutures and base long to very long dark brown velvety, other parts glabrous or rarely long velvety (see notes), upper suture distinctly winged; stipe 2½–4½ mm long, robust, short to long brown velvety, sometimes sparser towards the base, both ovary and stipe sometimes with some tomentose hairs. **Style** 12–19 mm long, inserted at an angle of 0–40°, white to pinkish at base, pink towards the apex, glabrous except for a few long hairs at base; stigma heart-shaped, pale yellow or red.

Pod (0–)1-2(–5)-seeded, oblong to obovate, 6–15 x 2.9–6.9 x 0.2–0.8 cm, medium green to pale greenish yellow, brown when mature, glabrous or rarely (see notes) appressed puberulous to pubescent mixed with some long hairs: beak (1–)3–8 mm long; upper suture usually broadly winged, (4–)7–19(–27) mm wide, broadest part in apical half, broad wings often with some ridges and reflexed; nerve distinct, usually just above the middle of the pod, u/w = 0.34–0.62, often a second nerve present at about ⅔ of the pod, u2/w = 0.54–0.88, but this second nerve may be broken up into several diagonal lines; stipe 6–22 mm long; pedicel 1½–4 mm long. **Seeds** more or less obovoid, flattened, (17–)20–30 x (12–)14–27 x (3–)5–7 mm. Weight (0.35–)0.8–2.7 g. Testa thin, dark brown. Cotyledons dark purple.

Seedling: Germination starts immediately after seedfall, epigeal. **Hypocotyl** 2½–11 cm long, fairly densely to densely velvety. **Epicotyl** 4–13 cm long, distinctly narrower than hypocotyl, glabrous to very sparsely velvety. First pair of leaves opposite, 1–2-jugate, in leaves with 2 pairs of leaflets the apical pair is usually larger than the basal one or the basal pair is even wanting, rendering it seemingly 1-jugate again: petiole 2–4 mm, rachis 4–18 mm; basal leaflet 1½–6½ x 0.5–2.3 cm; apical leaflet 6½–11 x 2.3–4.4 cm. Subsequent leaves 1-jugate, preceded by some bud scales.



Map 14.3. Distribution of *Tetraberlinia bifoliolata* (Harms) Hauman.

Distribution: Western and central part of the lower guinean forest: SW Cameroon, Equatorial Guinea (Rio Muni), Gabon, SW Congo (Brazzaville), Angola (Cabinda) and W Congo (Kinshasa). Considering the (even common) presence in Cameroon close to the

Nigerian border, this species will probably occur in the Cross-river delta in Nigeria as well.

Excluded distribution reference: Ndam, 1993 (concerns *Oxystigma mannii* (Baill.) Harms, see *Wieringa 2011 & 2013*).

Vernacular names: Cameroon: Ekop-Osoé (Bou), Ehindi-Ekop-Ribi or Ekop-Ribi (Yaoundé region), Ekop naga rouge (Bipindi region), Ekop noir (Campo region), according to Vivien & Faure (1985) also: Kaka (Pygmy bagielli). Gabon: Eko or Eko-Andoung (Fang), Lokaba (Ntoum region), Moudoungou (Bapounou), according to Pellegrin (1949) also Mugangeri (Bapounou), Mukuru (Echira), Payola (Apindji).

Forestry names: Ekaba, Ribi or Ekop Ribi (Cameroon), Ekaba or Ekop (Gabon), Ekaba (Equatorial Guinea).

Commercial name: Ekaba (Normand, 1952).

Note: In Cameroon the name Ekop is used for a wide range of Caesalpinioideae species, but in Gabon it refers to this species only.

Ecology: In the central area of its distribution this species occasionally occurs very commonly and may even become the most important tree species over large forest areas (for instance in the Rabi area). To the margins of its distribution area the tree becomes rare and is often found solitary.

The species favours dry-land rain forest, but is sometimes found in riverine forest where the temporary inundations do not last very long. It occurs only on nutrient-poor soils. Altitudes range from sea level to 900 m.

Grandvaux Barbosa (1970: 49 & 51) treats this species as one of the characteristic species of his "evergreen guinean lowland rain forest" vegetation type, following Gossweiler & Mendonça (1939) who mention the species for their "High mayombe rain forest" (i.e. 100–500 m).

Phenology: *Tetraberlinia bifoliolata* flowers during the small rainy season (fig. 3.5 & 3.6j): in Congo (Brazzaville), Congo (Kinshasa) and Cabinda from January to April, in Gabon and Equatorial Guinea between March and June, in Cameroon from February to May (flower buds in January). Pods are found all year round; in Gabon seedfall occurs between November and March, which agrees with a maturation period of about 9 months. In Cameroon mature pods have been found on flowering trees, which may point to a maturation period of about 1 year.

The only dissonant for Gabon is a flowering tree found in the Sibang Arboretum near Libreville on 1 December (*Wieringa 3304*). The arboretum lies within the natural distribution area of the species, but the tree was not flowering profusely (only some lower branches) and the provenance of the tree is not known. A similar case of scarce flowering was observed on 5 December in southern Cameroon. For Cameroon the only real exception is *J. de Wilde 8374*, found on 21 July. This tree might not be following usual flowering patterns due to a different (wetter) climate in its habitat at 860 m.

Chemistry: Flowers produce a strong red-brown colour in alcohol.

Diseases and pests: Coccids are frequently encountered. Very characteristic for *Tetraberlinia bifoliolata* are galled inflorescences which form a rugose, cratered, broadly ovate, woody head of c. 1½–3 x 1–2 cm. It is probably made by a gall-wasp (Hymenoptera). The holoparasitic *Pilostyles aethiopica* Welw. (Rafflesiaceae) has been found once

(*Breteler, Jongkind & Wieringa 9773 & 9773A*) on its branches.

Especially the sapwood seems vulnerable to insect attacks (Wagenführ, 1980).

Use: The wood has many potentials, i.e. joinery, parquetry, veneer and plywood (Normand, 1952; Wagenführ, 1980). At the moment it is mainly sawn for the local market. The logs sometimes sink (pers. comm. Da Costa, contrary to Normand, 1952). Locally the wood is used as construction wood (*Ndoum 110*).

If one considers that this species is fairly closely related to *T. tubmaniana* (the wood of which has excellent properties for peeling and pulp), and that wood anatomists consider their wood very similar (e.g. Normand, 1958), this species could become an important timber for Gabon and Cameroon. Exploitation might be facilitated by the occurrence in large and dense stands, while regeneration may be fast because trees of all stages are usually present and growth is fast.

Notes: In collections from the southern part of the distribution area that have pods or flowers (*Flamigni 10107*, *Gossweiler 7068* and *Bouquet & Sita 2366*), the ovaries and pods are completely hairy instead of only so at the sutures. The adaxial petals of the two flowering collections show a more auriculate limb base instead of the typical tooth, but this difference is small, and hard to circumscribe. The (English) label of the BM specimen (copied by Baker, 1928) of *Gossweiler 7068* mentions purplish red petals and stamens. The LISJC label (in Portuguese) mentions gigantic buttresses and a polygonal trunk. Both characters are aberrant in *T. bifoliolata*. Purplish red petals have not been observed at all in any of the species treated in this monograph and therefore Gossweiler's comment has to be doubted. Flamigni refers to the trunk base as having only small feet, which renders the presence of large buttresses doubtful as well.

One could consider to distinguish the southern population as a distinct subspecies, but since so far it only seems to be based on a single or maybe two characters, appearing at the edge of its area (marginal population effects), without ecological or other implications, I prefer not to. However, if the hairy ovary and the auriculated limb bases prove consistent with the purplish red petals I would prefer to consider this taxon as a separate species. As long as no better and well-described material becomes available from the Cabinda area, it might be the best to preserve the present situation. Whatever this phenomenon taxonomically will prove to be, it probably points to an isolated position of this southern population during some stage in history.

Seedlings with two pairs of leaflets on their first opposite leaves are not rare (photo p. 8). For full-grown trees, however, it has only been found in *Breteler, Wieringa & Nzabi 12846*.

Le Testu (*7998*) describes the calyx as violet-purple. He probably refers to the bracteoles, but in all other descriptions the bracteoles are described as white or pale pinkish with a brown indumentum. Sita (*4137*) described the petals and stamens as being violet.

The vernacular name Kogo (Mitsogo) as mentioned on *Morel 102* was probably an incorrect copy of the label of *Morel 103* (= *Bikinia grisea* and easy to confuse with *B. media*, the real Kogo).

Specimens examined:

CAMEROON: *Bullock 651* (YA): vicinity (within 5 km) of Nkoelon, 2°23'N 10°03'E (fr, 02.04.1977); *Bunougou s.n. (1)* (BR): plantules Yaoundé, not located (st, ?); *v.d. Burgt & Amombo 313* (WAG): c.7 km NNW of Ngoulemakong, 1 km N Obégué, 3°10'N 11°24'E (fr, 27.12.1997); *Ejiofor FHI 29313* (K): southern Bakundu forest, 4°25'N 9°21'E (fr, 04.04.1951); *Ejiofor FHI 29322* (K): southern Bakundu forest, 4°25'N 9°21'E (st, 07.04.1951); *van Gemerden 38* (WAG): Ebimimbang, 1700 m on transect 2, 3°02'N 10°26'E (st, 07.03.1997); *van Gemerden x 733* (WAG): Mvila, Ebom, Minwo-catchment, 3°07'N 10°45'E (st, 10.09.1998); *F. Hallé 4318* (WAG): Campo reserve, camp Akok, 2°22'N 9°55'E (fl, 05.12.1991); *Hoshino 30* (YA): 7 km E of Nko'elon, Campo reserve, 2°18'N 10°05'E (st, 09.02.1981); *Hoshino 32* (YA): 7 km E of Nko'elon, Mvini, 2°18'N 10°05'E (st, 10.02.1981); *Hoshino 34* (YA): 7 km E of Nko'elon, Mvini, 2°18'N 10°05'E (st, 10.02.1981); *Hoshino 38* (YA): 7 km E of Nko'elon, Mvini, 2°18'N 10°05'E (st, 10.02.1981); *Hoshino 43* (YA): 7 km E of Nko'elon, Mvini, 2°18'N 10°05'E (st, 10.02.1981); *Hoshino 50* (YA): 7 km E of Nko'elon, Mvini, 2°18'N 10°05'E (st, 20.02.1981); *Hoshino 47814 HNC* (YA): 7 km E of Nko'elon, Mvini, 2°18'N 10°05'E (st, 10.02.1981); *Hoshino 1/84* (WAG, YA): 30 km E of Campo, 2°22'N 10°06'E (st, 23.08.1984); *Kaji 274* (P, YA): 35 km E of Campo, Mvini, 2°18'N 10°05'E (fr, 18.10.1983); *Leeuwenberg 9155* (WAG): 2 km N of km 17 on road Yingui to Yabassi (mixture with *Julbernardia pellegriniana*: 9155a), 4°30'N 10°11'E (st, 11.01.1972); *Letouzey 1319* (P, YA): Kribi, Adjab, chantier Picard, 2°57'N 9°55'E (fl, fr, 13.04.1949); *Letouzey 1407* (P, WAG, YA): 36 km on road Kribi to Lolodorf, chantier CIFA, 3°07'N 10°13'E (fr, 14.07.1950); *Letouzey 1415* (P, WAG, YA): 26 km on road Kribi to Adjap, chantier Otzmann, 2°54'N 10°05'E (fr, 17.07.1950); *Letouzey 1416* (P, YA): 26 km on road Kribi to Adjab, chantier Otzmann, 2°54'N 10°05'E (fr, 17.07.1950); *Letouzey 1445* (P, WAG): Bonépoupa, 4°05'N 10°02'E (st, 02.08.1950); *Letouzey 1455* (P, YA): 25 km on road Kribi to Adjap, Engale (Chantier Otzmann), 2°55'N 10°04'E (st, 13.07.1950); *Letouzey 14771* (K, P, YA): 35 km N Douala, near Bamwen, 4°23'N 9°42'E (fr, 30.04.1976); *Letouzey 14771 bis* (K, P, YA): 35 km N Douala, near Bamwen, 4°23'N 9°42'E (st, 30.04.1976); *Letouzey s.n. (3) (BR): Yaoundé, seedlings from garden, not located (st, 1959)*; *McKey 75* (P, YA): Akpasang river camp, 4°58'N 8°42'E (fr, 09.02.1976); *McKey C91 4/34* (K): Campo forest reserve, 20 km ENE of Ebodie, 2°36'N 9°59'E (st, end.1991); *Médou 1756* (BR, K, P, WAG, YA): Chantier LBC near Eseke, 3°39'N 10°46'E (fl, 01.01.1954); *Médou 1825* (P, WAG, YA): Kribi, 1½ km from Sieba-sawmill at Zingui, 2°57'N 9°55'E (st, 24.01.1953); *Médou 1828* (P, WAG, YA): Kribi, Zingui, SIEBA-sawmill, 2°57'N 9°55'E (st, 28.01.1953); *Mitani 71* (YA): Mvini near Campo, 2°18'N 10°05'E (st, 10.1983); *Mitani 72* (YA): Mvini near Campo, 2°18'N 10°05'E (st, 10.1983); *Mpom 261* (P, WAG, YA): 3 km of Zingui, 2°45'N 10°12'E (fl, 26.03.1957); *Mpom 1669* (P, WAG, YA): ?, not located (fl, 1952); *Mpom 1681* (WAG, YA): Mangombe, 3°19'N 11°39'E (fr, 1952); *Mpom 1792* (FHO, P, WAG, YA): Kribi, edge of town on road to Ebolowa, Picard sawmill, 2°57'N 9°55'E (fl, 02.1952); *Ndoum 110* (WAG): 5 km N of Ebimimbang, 3°05'N 10°28'E (st, 10.09.1996); *Sonké 1194* (BR): Dikoumbe Barondo Forest, 4°27'N 9°01'E (st, 04.05.1994); *Thomas 418* (K): Korup reserve, transect Q, 5°04'N 8°47'E (st, 02.1979); *Thomas 9857* (SCA): Limbe, Onge river area, 4°16'N 8°59'E (fr, end.1993); *Wieringa & Haegens 2109* (WAG): 23 km SE of Kribi, 2°47'N 10°02'E (st, 05.02.1994); *Wieringa & Haegens 2130* (WAG): Kribi, E slope of Mt Elephant, 2°48'N 10°02'E (fr, 07.02.1994); *Wieringa & Haegens 2328* (G, WAG (+alc)): 22 km on road Kribi to Campo, 2°46'N 9°53'E (fl, fr, 24.02.1994); *J. de Wilde 8374* (BR, WAG, YA): east face of Zingui Hill, 2°51'N 10°59'E (fl, 21.07.1975); *Zenker 577* (A, AMD, B, BR, LD, P, U, WAG): Bipindi, 3°05'N 10°25'E (fl, 03.1914); *Zenker 2275* (A, BM, E, K, P, S, W) type: Bipinde, 3°05'N 10°25'E (fl, 04.1900); *Zenker 2675* (BM, BR, E, F, K, P, S, W, WAG, WU): Bipinde, 3°05'N 10°25'E (fl, 02.1903); *Zenker 2949* (B, BM, BR, E, K, P, S, W, WAG, WU): Bipinde, 3°05'N 10°25'E (fl, 1904); *Zenker 4164* (BR, E, F, K, L, MO, P, S, W, WU): Bipindihof, Mimfia, 3°04'N 10°23'E (fl, 03.1911); *Zenker 4511* (BM, BR, E, GH, K, LE, P, S, W, WU): Bipinde, 3°05'N 10°25'E (fl, fr, 1912); *Zenker s.n. (1)* (F): Res. Njong, Njabi, 3°20'N 10°00'E (fl, 05.1900); *Zenker s.n. (2)* (F): Njabi, Ntegstigamba, not located (fl, 03.1903); *Zenker s.n. (3)* (F): Bipindi, 3°05'N 10°25'E (fl, 01.1903); *Zenker s.n. (4)* (F): Lokimdje, not located (st, 09.1909); *Zenker s.n. (5)* (F): ?, not located (fl, ?); *Zenker s.n. (6)* (P): Bipinde, 3°05'N 10°25'E (fr, 03.1900).

EQUATORIAL GUINEA: *Carvalho 4750* (WAG): 15 km on road Bata-Bolondo, near Macomo village, 1°46'N 9°44'E (fr, 25.06.1991); *Issembe 33* (WAG): near Yanaboté, chantier SOFOGE, 1°16'N 9°25'E (fr, 22.05.1998); *McPherson 14014* (A, B, BR, MO, NY, P, PRE, US, WAG): chantier E of Logo, near Gabonese border, 1°05'N 10°00'E (fl, 03.05.1989); *Obama 840* (WAG): Rio Muni, Mbini, Mitom, 1°32'N 9°49'E (fl, 07.04.1998); *Tessmann 592* (K): Bebai, Campo-area, 2°19'N 9°48'E (st, 23.10.1908).

GABON: *Breteler & Breteler-Klein Breteler 12547* (WAG (alc only)): c. 30 km E of Lastoursville, 0°50'S 13°00'E (fr, 06.12.1993); *Breteler & Breteler-Klein Breteler 13081* (WAG): c. 20-30 km NNW Ndjolé, 0°03'N 10°45'E (st, 29.09.1994); *Breteler & Jongkind 10279* (WAG): Rabi-Kounga, 1°55'S 9°55'E (fr, 01.11.1991); *Breteler 13496* (WAG (+alc)): c. 10 km NNW of Ndjolé, 0°04'S 10°47'E (st, 16.03.1996); *Breteler, Jongkind & Wieringa 9563* (WAG): Ogooué-Maritime, Shell expl. Rabi-Kounga, just S. of camp, 1°57'S 9°52'E (fl, fr, 27.03.1990); *Breteler, Jongkind & Wieringa 9773* (WAG (+alc)): Rabi-Kounga, 1°57'S 9°53'E (fl, 04.04.1990); *Breteler, Jongkind & Wieringa 11033* (WAG (+alc)): 11 km N of Ndjolé, 0°05'S 10°46'E (fr, 23.04.1992); *Breteler, Jongkind & Wieringa 11099* (WAG (+alc)): 5-30 km NNW of Ndjolé, 0°05'S 10°45'E (fl, 25.04.1992); *Breteler, Jongkind, Nzabi & Wieringa 11431* (WAG): Rabi-Kounga, 1°55'S 9°55'E (fr, 14.05.1992); *Breteler, Jongkind, Nzabi & Wieringa 11459* (WAG): between Rabi-Kounga and Yeno, 1°48'S 10°00'E (fr, 15.05.1992); *Breteler, Jongkind, Nzabi & Wieringa 11460* (WAG): between Rabi-Kounga and Yeno, 1°48'S 10°00'E (st, 15.05.1992); *Breteler, Jongkind, Nzabi & Wieringa 11525* (WAG (+alc)): Rabi-Kounga, road from Niunga to

Echira, 2°07'S 10°00'E (fl, fr, 18.05.1992); *Breteler, Leal, Moussavou & Nang 13969* (WAG): W of Yombi, Koumounabouali massif, 1°25'S 10°30'E (fr, 18.09.1997); *Breteler, Leal, Moussavou & Nang 13970* (WAG): W of Yombi, Koumounabouali massif, 1°25'S 10°30'E (st, 18.09.1997); *Breteler, Wieringa & Nzabi 12846* (WAG): 10 km S Kinguélé, 0°23'N 10°14'E (fr, 13.09.1994); *Breteler, Wieringa & Nzabi 12928* (WAG (+alc)): Crystal Mountains, 10 km road Tchimbélé to Assok, 0°40'N 10°24'E (fr, 18.09.1994); *Breteler, Wieringa & Nzabi 13171* (WAG (+alc)): E of Lastoursville, near Bambidie, 0°43'S 13°00'E (fr, 09.10.1994); *v.d. Burgt 17* (WAG): Rabi, near well Rabi 25, 1°55'S 9°52'E (st, 03.02.1994); *v.d. Burgt 58* (WAG): Rabi, near well Rabi 7, 1°55'S 9°51'E (st, 26.02.1994); *v.d. Burgt 107* (WAG): 10 km SE Divangui, 1°58'S 10°05'E (fl, 18.04.1994); *Dibata in MINKébé series C 82* (WAG): Minkébé region, 363m on transect A, 1°30'N 12°48'E (fr, 04.02.1990); *Dibata in MINKébé series C 447* (WAG): Minkébé region, 1763m on transect A, 1°30'N 12°47'E (st, 11.03.1990); *Dibata in MINKébé series C 483* (WAG): Minkébé region, 1951m on transect A, 1°30'N 12°47'E (st, 13.03.1990); *Dibata in MINKébé series E 287* (WAG): Minkébé region, 1720m on transect B, 1°31'N 12°49'E (st, 02.03.1990); *Estasse 589* (LBV, P): Mondah, 0°34'N 9°22'E (st, 18.10.1951); *Gavage s.n. (1)* (BR): Mondah forest, road Libreville km 28, 0°34'N 9°22'E (st, 28.09.1971); *Gavage s.n. (2)* (BR): Mondah forest, road Libreville km 28, 0°34'N 9°22'E (st, ?); *Gouteix 1056* (CIRAF): southern Gabon, not located (st, 14.07.1975); *Groulez 1265* (LBV): Sibang arboretum, not located (st, 01.08.1953); *Le Testu 5432* (BM, BR, P): Iméno Toumbidi, 2°21'S 11°59'E (fl, 09.05.1925); *Le Testu 5463* (BM, BR, K, P, WAG): Dibwangui, 2°06'S 11°36'E (fl, 24.04.1925); *Le Testu 5899* (BM, BR, K, P, WAG): Mimongo, 1°11'S 11°36'E (fl, 09.04.1926); *Le Testu 5941* (BM, BR, P): Maghoungha, 1°47'S 11°18'E (fl, 07.06.1926); *Le Testu 7987* (BM, BR, P): Roungassa, 1°01'S 12°32'E (fl, 26.03.1930); *Le Testu 7998* (B, BM, BR, P, S): Koulamotou, 1°08'S 12°29'E (fl, 30.03.1930); *Le Testu 8850* (BM, BR, P, WAG): Maghoundama, 1°18'S 12°07'E (fl, 11.06.1931); *Le Testu 9073* (BM, BR, P, WAG): Acom, 1°53'N 11°50'E (fl, 03.04.1933); *Le Testu 9082* (BM, BR, K, P): Oyem, 1°37'N 11°35'E (fl, 16.04.1933); *Le Testu 9504* (A, BM, BR, HBG, P, WAG): Oyem, 1°37'N 11°35'E (fl, 03.03.1934); *Le Testu s.n. (1)* (BM): Coundou, 1°12'S 10°56'E (fl, 29.03.1926); *Le Testu s.n. (2)* (BM): Oyem, 1°36'N 11°35'E (fl, 04.1934); *Lecomte s.n. (1)* (P): Mayomba, 3°25'S 10°39'E (fl, 03.1894); *A. Louis & Oberson 2255* (WAG): c. 30 km S Otoumbi, along a forestry road, 0°15'S 11°10'E (fr, 01.03.1987); *v.d. Maesen & de Bruijn 5968* (WAG): Malibé I embarcadère, 0°33'N 9°23'E (fr, 04.12.1988); *Mondjo 17* (WILKS): c. 30 km NNE of Koumameyong, 0°28'N 11°55'E (st, ?); *Morel 10* (LBV, P): Cocobeach, Nkan on the Noya, downstream Noya-Adughe junction, 0°41'N 10°00'E (st, 25.11.1947); *Morel 20* (P): Cocobeach, Nkan on the Noya, downstream Noya-Adughe junction, 0°41'N 10°00'E (fr, 26.11.1947); *Morel 53 A* (LBV, P): E of Cocobeach, Atia river basin, 0°59'N 9°38'E (fr, 06.09.1948); *Morel 53 B* (P): E of Cocobeach, Atia river bassin, 0°59'N 9°38'E (fr, 06.09.1948); *Morel 103* (P): middle Mbei, 0°30'N 10°20'E (st, 02.1950); *Morel 185* (LBV): middle Mbei-valley, 0°30'N 10°20'E (fl, 20.05.1950); *Moungazi in MINKébé series C 299* (WAG): Minkébé region, 1416m on transect A, 1°30'N 12°47'E (st, 16.02.1990); *van Nek 725* (WAG): Rabi-Kounga, Rabi to N'Goumbi 6.4km from pipe-track junction, 2°07'S 9°45'E (fr, 16.03.1991); *van Nek 727* (WAG): Rabi-Kounga, road Rabi-N'Goumbi 9.1km from pipeline junction, 2°07'S 9°44'E (fr, 16.03.1991); *Normand 205* (P, WAG): Moudoungou, on the Ngoungé between l'Ikoi and le Davo, 0°56'S 10°33'E (st, 18.09.1947); *Pauly 126* (BR, K): Ntoum, 0°23'N 9°47'E (fl, fr, 06.05.1985); *J. Reitsma & B. Reitsma 1234* (LBV): Oveng, inventory tree 364, 0°44'N 11°22'E (fr, 25.06.1985); *J. Reitsma & B. Reitsma 1557* (LBV, NY, WAG): Oveng, c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 23.09.1985); *J. Reitsma & B. Reitsma 1601* (LBV, NY, WAG): c. 25 km NNW of Oveng, 0°44'N 11°22'E (st, 25.09.1985); *J. Reitsma & B. Reitsma 1992* (LBV, MO, NY, WAG): c. 25 km SW of Mintsic, 0°44'N 11°22'E (st, 02.03.1986); *J. Reitsma & B. Reitsma 2201* (LBV, NY, WAG): c. 15 km NE of Oveng, 0°44'N 11°22'E (st, 10.05.1986); *J. Reitsma & B. Reitsma 3107* (LBV, NY, WAG): near Ekobakoba, 0°23'N 13°06'E (st, 20.02.1987); *J. Reitsma, B. Reitsma & Mezui 2501* (LBV, MO, NY, WAG): Oveng, c. 25 km WSW of Mintsic, 0°44'N 11°22'E (st, 06.11.1986); *J. Reitsma, B. Reitsma & Wilks 3271* (LBV, MA, NY, WAG): c. 50 km SW of Doussala, 2°33'S 10°32'E (fl, 16.04.1987); *de Saint Aubin 1916* (LBV): 18 km road Libreville to Kango, 0°23'N 9°37'E (fl, 06.1958); *de Saint Aubin 1938* (P): 24 km SE of Cocobeach, 0°49'N 9°46'E (fr, 01.08.1958); *Schoenmaker 157 B* (WAG): Rabi, 1°52'S 9°52'E (fr, 18.11.1991); *Thomas & Wilks 6354* (MO, P): on road from Libreville to Cap Esterias, 0°35'N 9°25'E (fr, 14.07.1986); *Villiers 148* (P) id. doubtful: Maliba river, mangrove border, 0°34'N 9°27'E (st, 30.06.1969); *Walker s.n. (1)* (P): mission de St. Martin, 1°41'S 10°56'E (st, 01.1939); *Wieringa & Nzabi 1191* (LBV, WAG): Rabi, N of airport, 1°56'S 9°52'E (st, 23.06.1992); *Wieringa & v.d. Poll 1432* (WAG): Lebamba, Bongolo near protestant mission, 2°15'S 11°28'E (st, 20.08.1992); *Wieringa 1305* (LBV, WAG): Rabi, N of airport, 1°56'S 9°52'E (st, 20.07.1992); *Wieringa 1318* (LBV, WAG): 48 km on the road from Koumaga to Rabi, 2°13'S 9°57'E (fr, 27.07.1992); *Wieringa 3304* (WAG (+alc)): Libreville, Sibang forest, Andoung-plot, not located (fl, fr, 01.12.1994); *Wieringa & Haegens 2376* (WAG): Rabi, 1 km NW of Rabi 7, 1°55'S 9°51'E (fr, 02.03.1994); *Wieringa & Haegens 2441* (WAG): NE Divangui, 23 km E of Shell-camp Rabi, 1°55'S 10°05'E (fl, 10.03.1994); *Wieringa & Haegens 2458* (WAG): Rabi, ha-plot, 1°56'S 9°52'E (fl, fr, 13.03.1994); *Wieringa & Haegens 2527* (WAG): Gamba, Mossomala, edge of cassava field, 2°48'S 10°06'E (fr, 19.03.1994); *Wieringa & Haegens 2529* (WAG): Gamba, Mossomala, 2°48'S 10°07'E (st, 19.03.1994); *Wieringa & Haegens 2589* (WAG): Rabi, ha-plot, 1°56'S 9°54'E (st, 27.03.1994); *Wieringa, van Nek & Moussavou 3078* (WAG): 8 km on road Etéké to Massima, 1°29'S 11°30'E (st, 06.11.1994); *Wieringa, van Nek, Hedin & Moussavou 3023* (WAG): W of Fougamou, 8 km on forestry road following Bendolo river, 1°12'S 10°32'E (st, 01.11.1994); *Wieringa, van Nek, Hedin & Moussavou 3157* (WAG): 23.7 km on road Lebamba to Yeno, 2°03'S 11°27'E (st, 12.11.1994); *Wilks in MINKébé series W 439 B* (WAG): Minkébé region, close to 2200m on transect A, 1°30'N 12°47'E (fr, 22.05.1990); *Wilks 447* (WILKS): Makokou, IRET-station, 0°32'N 12°49'E (st, ?); *Wilks 642* (WILKS): ?, not located (st, ?); *Wilks 984* (WAG): N of Ndouaniang, next to "Sogacel" plantation, 0°19'N 10°02'E (fr, 06.08.1984); *Wilks 1046* (LBV, WAG): 5km SSE of Bilengui village, 2°01'S 11°26'E (fr, 07.02.1985); *Wilks 1423* (MO, WAG, WILKS): 20 km N of Koumameyong, 0°22'N 11°54'E (fl, fr, 18.03.1987); *Wilks 1925* (WAG): 7 km E of Agnang, 0°25'N 12°22'E (st, 11.05.1989).

CONGO (BRAZZAVILLE): *Bouquet & Sita 2366* (IEC, P, WAG): 45 km on road Komono to Mossendjo, near Nyanga, 3°08'S 12°56'E (fl, 19.01.1968); *Constant 115* (CIRAF): Ingoumina, 2°54'S 13°52'E (st, 25.05.1972); *Dowset-Lemaire 1589* (BR): Kouilou, Mayombe near Dimonika, 4°14'S 12°25'E (st, 12.1990); *Normand 9* (P): central Mayombe, env. Dimonika near M'Vouti, 4°14'S 12°25'E (st, 15.06.1947); *Sita 4137* (P, WAG): Moungoundou-Sud, near Dziba-Dziba river, 1°57'S 12°42'E (fl, 24.04.1977); *Sita 4802* (BR): Chaillu Massif, Kouyi, Bowal de Mboumba, 2°29'S 12°25'E (st, 05.1983).

CABINDA (ANGOLA): *Gossweiler 7068* (BM, LISJC): Belize, 4°38'S 12°37'E (fl, 20.03.1917).

CONGO (KINSHASA): *Flamigni 10107 a* (BRLU): Koiko Tsbanga (Lubolo mayombe), 4°57'S 12°41'E (fl, 04.1953); *Flamigni 10107 b* (BR, BRLU): Koiko Tsbanga (Lubolo mayombe), 4°57'S 12°41'E (fr, 06.1953); *Hombert 419* (BR, WAG): Luki, Bloc H50-V14/15, 5°38'S 13°04'E (st, ?); *Wagemans 190* (K): Luki-forest, 5°38'S 13°04'E (st, 07.09.1951).

Tetraberlinia korupensis **Wieringa spec. nov.** **Fig. 14.3, Map 14.4**

Type: *D.W. Thomas 4723* (holo: WAG; iso: BR, MO, NY, P, PRE, YA) — Cameroon: "Mature rain forest in the Korup National Park, collected between Ndian River at PAMOL field 69 and 2.5 km on transect P. 5°01'N 8°50'E; elev. 50 m. 12-21 Apr. 1985".

Tetraberlinia moreliana auct. non Aubrév.: Newbery et al., 1988.
Tetraberlinia polyphylla auct. non (Harms) J. Léonard ex Voorh.: Vivien & Faure 1985: 152 & map on p. 153 p.p. (see notes).

Diagnosis: Arbor silvatica altus. Truncus cylindraceus sine anteridibus et cortice laevi. Folia (4–)10–15-jugata, foliolis basalibus subtus utraque latere costae glandulosis. Bracteae ovatae. Bracteolae oblongae vel ovatae apice basi crassiore. Sepala adaxialia fere usque ad apicem connata. Sepala lateralia parvissima vel absentia. Sepalum abaxiale triangulare margine involuto. Petalum adaxiale magnum. Petala lateralia et abaxialia multo minora. Stamina decem quorum novem basi connata. Dicimum alteris liberum. Antherae 1.0–1.4 mm longae. Ovarium stipitatum 2–3 ovulis. Legumen sutura alata, utraque latere venis unicis vel duobis suffultum.

Large forest tree, up to 55 m high. **Bole** cylindrical, DBH up to 150 cm: base without buttresses, sometimes slightly swollen at base. **Bark** smooth to finely rugose, surface reddish brown to brownish grey.

Twigs grey to grey-brown, glabrous to shortly to long velvety, sometimes mixed with pubescent hairs, with pale brown-red lenticels when older. **Stipules** free, caducous but persistent in saplings, ovate, with a completely auriculate base, 12–39 x 3–13 mm, both sides glabrous, margins shortly ciliate. **Leaves** (4–)6–22 cm long, (4–)10–15-jugate, largest leaflet situated approximately at the middle: **Petiole** 2–5 mm long, consisting for the major part of the wrinkled joint, glabrous to velvety, sometimes with some long bristle-like hairs.

Rachis (2½–)5–19 cm long, terete, upper side sometimes with a grooved ridge, velvety, usually mixed with some long, persistent, bristle-like hairs. **Leaflets** leathery, upper side glossy to fairly dull, glabrous, sometimes the mid-vein set with a few short hairs, lower side somewhat glossy, glabrous, margins shortly, rarely to long appressed ciliate: **basal leaflet** 9–25 x 4–11 mm, in seedlings as small as 2.5 x 6 mm: proximal half obovate, base not auriculate, margin usually sinoid towards the apex; distal half ovate to trullate; apex obtuse; **apical leaflet** 19–42 x 6–14 mm, in seedlings as small as 12 x 4 mm, its axis strongly to weakly curved distally: proximal half obovate, base not to distinctly auriculate, auricle 0–1.7 mm, margin often somewhat sinoid towards the apex; distal half trullate; apex bluntly acute to emarginate; **largest leaflet** (17–)20–46 x 5–12 mm, axis curved distally: proximal half narrowly obovate, base auriculate, auricle 0.2–1.5 mm, margin not or slightly sinoid towards the apex; distal half triangular to trullate; apex bluntly acuminate. **Gland pattern**: basal leaflet in proximal half with (0–)1–3, in distal half with 1–3(–7) glands; second leaflet in proximal half with 0–1, in distal half with 0–2 glands; apical leaflet in proximal half without glands, in distal half with (0–)1–3 glands; other leaflets in proximal half with 0(–1), in distal half with 0–2(–3) glands.

Inflorescence a compound raceme, axillary in the terminal 4 nodes (terminal internodes sometimes very short), 1(–4) per axil, 6–19 cm long, sometimes primary axis with small leaves, with 2–10 lateral branches which are 1–4½ cm long and 15–35-flowered, lower branches sometimes branched once more. **Rachis** mixed velvety and pubescent. **Bracts** ovate, 4–7 x 3–4½ mm, outside appressed tomentose-pubescent, inside glabrous at base, appressed pubescent towards the apex, apex bluntly acute. **Pedicel** 3–5 mm long, tomentose. Hypanthium s.l. 1.2–1.8 mm high. **Bracteoles** assuming a 30–80° wide angle at anthesis, oblong to ovate, 5½–8 x 3½–5 mm, apical part notably swollen and nosed, outside tomentose, inside mixed pubescent and sparsely tomentose. **Adaxial sepals** fused into a broad band, 1.0–1.8 x 2.6–4.3 mm, both sides glabrous to sparsely tomentose, lateral margins ciliate, upper margin with a small dent at each corner, sparsely ciliate in the centre. **Lateral sepals** vestigial or wanting, ovate to triangular, up to 1.2 x 0.8 mm, both sides glabrous, margins ciliate. **Abaxial sepal** triangular, 2.4–3.5 x 1.2–1.7 mm, outside sparsely tomentose, inside glabrous, margins inrolled, ciliate, apex acute. **Adaxial petal** 5½–7 x 3–4 mm, white (?): claw 0.5–0.8 mm, glabrous; blade obovate, its central part inrolled but the lateral margins slightly reflexed again, outside glabrous except for an ovate tomentose-pubescent area at the base and sometimes with a few hairs along the basal part of the margin, inside with pubescent to villous bands along the lateral margins, apex mucronate. **Lateral petals** obovate to spathulate, 1.2–2.1 x 0.4–0.8 mm, both sides glabrous, lateral margins somewhat inroled, ciliate in the middle, apex rounded. **Abaxial petals** oblong to obovate, 0.6–1.4 x 0.3–0.6 mm, both sides glabrous, lateral margins sometimes slightly inrolled, usually ciliate in the centre, apex rounded. **Stamens** 10: filaments 8–13 mm long, completely glabrous or rarely the filament on either side of the adaxial one with a line of hairs on the outside, 9 united at base over a length of 1.4–2.0 mm, within the hypanthium filaments markedly broadened towards the centre of the hypanthium, suddenly retreating again at the apex of the hypanthium, above the hypanthium bending inwards; adaxial filament free except for the base which is fused with the stipe of the ovary; anthers 1.0–1.4 mm long. **Ovary** 3–4 x 1.6–2.7 x 0.7–1.0 mm, never depauperate, with 2–3 ovules, mixed tomentose-pubescent and long to very long velvety, upper suture indistinctly winged; stipe 3.0–4.1 mm long, short to very long velvety, at base the hairs arranged in bands filling the gaps in between the stamens. **Style** 8–11 mm long, inserted straight on the ovary, basal half short to long velvety, especially on the abaxial side, glabrous towards the apex; stigma heart-shaped.

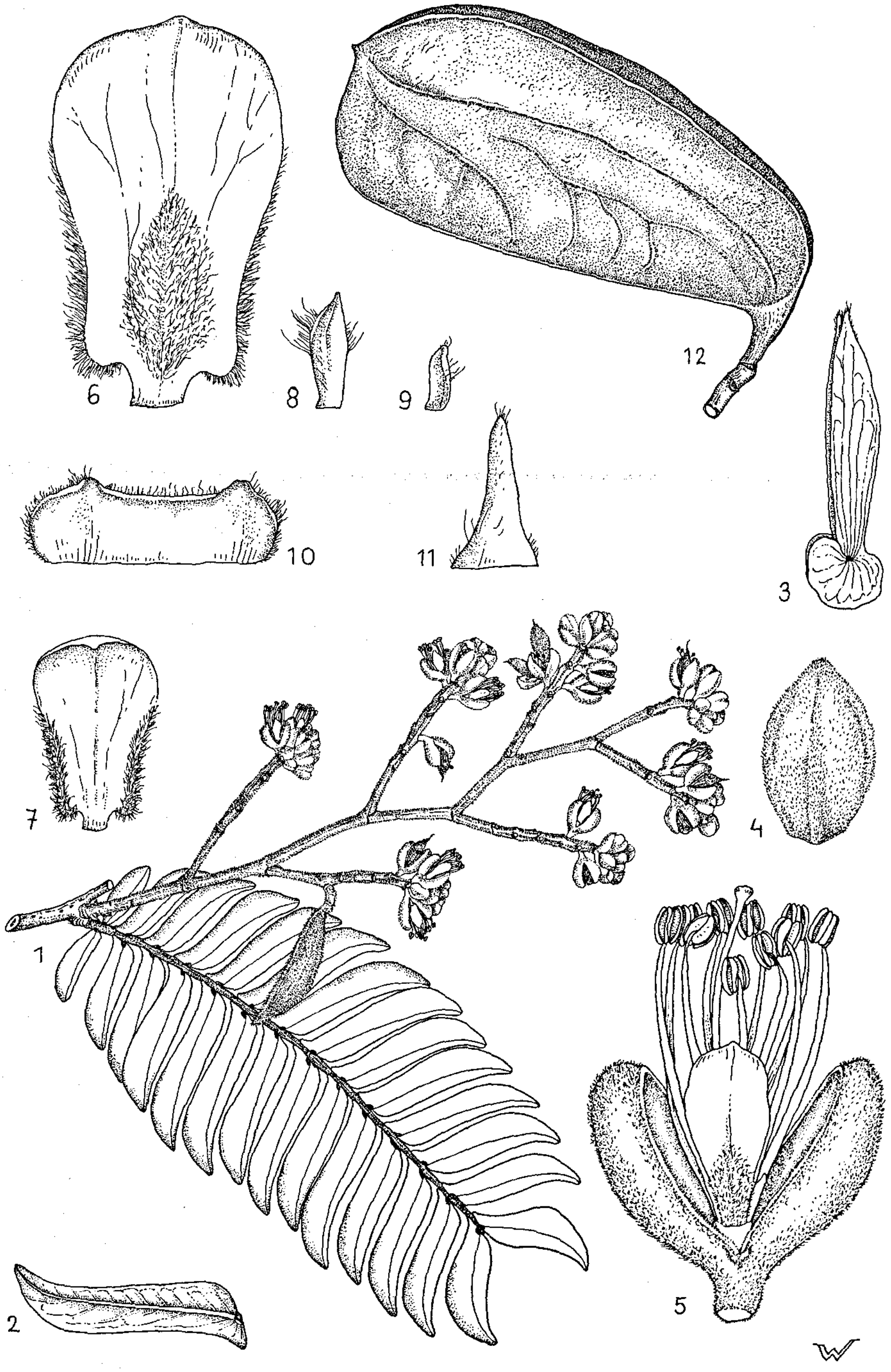


Figure 14.3. *Tetraberlinia korupensis* Wieringa. — 1: twig with a leaf and an inflorescence (x⅔); 2: leaflet from below (x1); 3: pair of stipules, the accompanying leaf (not shown) is positioned at the left (x1); 4: bract from outside (x4); 5: flower from adaxial side (x4); 6: adaxial petal from outside (x8); 7: adaxial petal from inside (x4); 8: lateral petal (x8); 9: abaxial petal (x8); 10: adaxial sepals (x8); 11: abaxial sepal (x8); 12: pod (x⅔). — 1, 2, 4–11: *Thomas 4723*; 3: *Thomas 2276*; 12: *Thomas 411*.

Pod 2-seeded, obovate to pear-shaped, 7–10 x 3½–4½ x 0.3–0.5 cm, sparsely to fairly densely tomentose-pubescent mixed with a few long to very long velvety hairs; beak 2–4 mm; upper suture distinctly winged, 5–12 mm wide, broadest point at or just behind the middle; nerve at about ⅓ of the pod-width, u/w = 0.33–0.43, usually a second nerve present below the middle, u2/w = 0.53–0.64, in the area below the second nerve some diagonal nerves present merging with the second nerve; stipe 11–12 mm long, short to long velvety; pedicel 2–5 mm long. **Seeds** unknown, impressions in pods 20–25 x 16–18 mm.

Seedling (data from older seedlings only): **Hypocotyl** 9½–10 cm long, glabrescent. **Epicotyl** 8½–9½ cm long, shortly to long velvety. First pair of leaves opposite (only scars observed). Subsequent leaves alternate, 5-jugate, increasing in leaflet number upwards. Seedlings have smaller leaves than mature trees.

Distribution: Map 14.4. Only known from the Korup National Park and its vicinity in South-West Cameroon.

Vernacular names: Unknown.

Ecology: Primary and secondary lowland rain forest (atlantic Caesalpinioideae forest) on sandy soils, at altitudes from 50–170 m. In its restricted area the tree is said to occur very abundantly with abundant regeneration. The species is subject of several ecological studies (e.g. Newbery et al., 1988 & 1997).

Phenology: The only flowering material available dates from April, the start of the rainy season in Korup. The only collection with an almost mature pod (*Thomas 411* in spirit at K) dates from April as well.

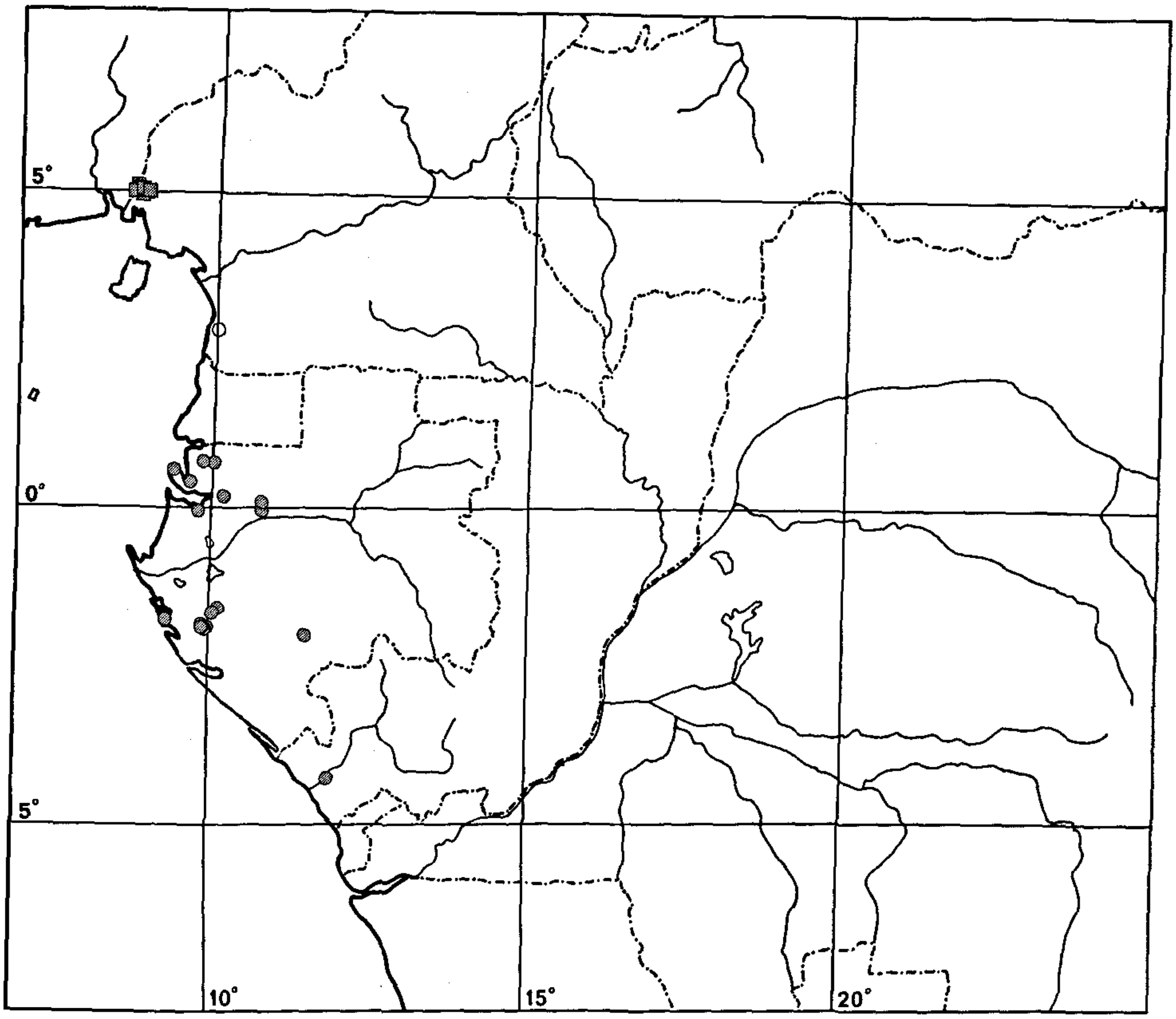
Chemistry: Flowers produce a red-brown colour in alcohol.

Diseases and pests: Some leaf miners are observed, but the damage does not seem to be extensive.

Use: Unknown.

Notes: This species is closely related to *T. moreliana*. It differs mainly in floral characters: the bracts, bracteoles, and most flower parts are considerably smaller than in *T. moreliana*. Also the leaves are generally somewhat smaller than in most *T. moreliana* samples. In most *T. moreliana* samples the stipules are persistent for some time at least, while in samples of canopy branches of *T. korupensis* they seem to drop during leaf development. This character, however, might not be reliable, since only two collections of mature trees could be studied; in saplings the stipules are persistent for a longer period (as in most *Tetraberlinia* species).

The rather large difference in bract, bracteole and flower sizes, combined with the, though weaker, other characters mentioned, provides sufficient evidence to justify describing the Korup population as a distinct species. Further collections of both species, especially of the *T. moreliana* population in southern Cameroon, will help to test the reliability of this segregation.



Map 14.4. Distribution of *Tetraberlinia korupensis* Wieringa (squares) and *T. moreliana* Aubrév. (circles).

In Vivien & Faure 1985, the drawing C on p. 153 is a true *T. polyphylla*, whereas the distribution record from between Ebolowa and Sangmelima points to the syntype of *T. polyphylla*, *Mildbraed 5549*, which, however, belongs to *Bikinia le-testui* subsp. *le-testui*. The description seems mainly based on that in Flore du Gabon. The distribution record from Korup and the remark about the abundance near Mundemba are probably the only references to *T. korupensis*.

Specimens examined (except the type all paratypes):

CAMEROON: *v.d. Burgt 548* (WAG): 2 km N Mundemba, along road to Fabe, 4°59'N 8°56'E (fr, 10.12.1998); *Gartlan 5* (K): Korup reserve, 5°00'N 8°45'E (fr, 1978); *Letouzey 15112* (K, P, YA): Korup Nat. Park, betw. Mundemba and Erat Ekong II, 5°04'N 8°45'E (fr, 10.06.1976); *Letouzey 15118* (K, P, YA): Korup Nat. Park, betw. Mundemba and Erat Ekong II, 5°04'N 8°45'E (st, 10.06.1976); *McKey 66* (P, YA): Korup Nat. Park, Akpasang river camp, near Esrat, 4°58'N 8°42'E (st, 07.02.1976); *Thomas 411* (K (alc only)): Korup reserve, 5°00'N 8°50'E (fr, 04.1979); *Thomas 2276* (MO, P, YA): South Korup Reserve, Buea-Douala, 4°55'N 8°50'E (st, 11.07.1983); *Thomas 4119* (MO): Korup Nat. Park, 5°01'N 8°50'E (st, 10.12.1984); *Thomas 4723* (BR, MO, NY, P, PRE, US, WAG, YA) type: Korup Nat. Park, betw. Ndian river at PAMOL 69 and 2.5km P-transect, 5°01'N 8°50'E (fl, 16.04.1985); *Thomas 6812* (F, MO, NY, YA): vic. of Mundemba, Ndian division, 4°57'N 8°54'E (st, 27.03.1987).

***Tetraberlinia longiracemosa* (A. Chev.) Wieringa comb. nov.**

Fig. 14.4, Plate 5c, Map 14.5

Basionym: *Monopetalanthus longiracemosus* A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 26: 593–594 (1946).

Monopetalanthus longiracemosus A. Chev.: Chevalier, 1946: 593–594, Pl. XVII B. (as *M. longeracemosus*); Pellegrin, 1949: 76; Saint Aubin, 1963: 50, 55; Aubréville, 1968: 317–318, Pl. LXXXI (p.p.); Aubréville, 1970: 290. **Type**: *Chevalier 26935* (holo: P; iso: BR, FHO, K, WAG) — "Gabon: Agonenzorck, sur le Haut-Komo. 6 octobre 1912"

Monopetalanthus emarginatus auct. non Hutch. & Dalz.: Pellegrin, 1942: 120–121 p.p.
Monopetalanthus pellegrinii auct. non A. Chev.: Chevalier, 1946: 593 p.p.

Large tree, 25–42 m high. Crown rather broad and flattened. **Bole** cylindrical, branchless for up to at least 16 m, DBH 55–115 cm: base somewhat swollen with small buttresses. **Bark** up to 10 mm thick: surface smooth with very fine horizontal stripes, grey or purple-grey to greyish brown, sparsely to densely set with reddish brown lenticels; outer bark thin, less than 1 mm thick, very hard, dark brown to black; inner bark fibrous, orange, turning purple a few minutes after exposure, in dry condition orange-brown, with creamy white granules to the exterior. Sapwood very pale pinkish white, hard; heartwood orange-brown.

Twigs dark grey to dark greyish brown, mixed tomentose and fairly sparsely shortly to long velvety. **Stipules** free, caducous, but persistent in saplings and treelets, narrowly triangular to ovate with a completely auriculate base, 5–19 x 1–4½ mm, purplish brown, medium green or medium green with purplish brown margins, when young pale purple to purple-green, outside with some long velvety hairs along the primary nerve, sometimes puberulous around the base, apex sometimes bearded, inside glabrous or rarely puberulous around the base, margins shortly, somewhat curled, ciliate, sometimes also with a few long velvety hairs. **Leaves** 3–13 cm long, (6–)13–34-jugate, largest leaflet at ¹/₅ to about the middle. **Petiole** 1–3 mm long, mixed pubescent and short to long velvety. **Rachis** (0.7–)2.5–12 cm long, broadly elliptic in cross-section, in dry leaves upper side flattened and with a grooved rib, greenish brown to dark brown, upper side tomentose-velvety, sometimes with a few long velvety hairs, lower side pubescent mixed with some long to very long brown velvety hairs. **Leaflets** papery to leathery, upper side glossy, glabrous, dark green, lower side glossy, glabrous, medium green, nerves sunken in fresh condition, margins glabrous, in very young leaflets rarely with a few short hairs and at the apex usually 1, sometimes a few, short to long hairs are present which may become plumose, apex rounded to acute, young leaflets pale to dark purple, later light to medium green above, pale green beneath: **basal leaflet** 2.8–13 x 1.0–4.6 mm: proximal half obovate, base not auriculate, not sinoid towards apex; distal half ovate to obovate; apex rounded; **apical leaflet** 3.2–15 x 0.9–5.0 mm, axis curved distally: proximal half obovate to oblong, usually distinctly auriculate, auricle 0–0.8(–1.3) mm, not sinoid towards the apex; distal half oblong to obovate; apex rounded; **largest leaflet** 5.8–19 x 1.7–5.0 mm, main nerve sometimes curved in distal direction at the apex: proximal half oblong, base auriculate, auricle 0.2–1.1 mm, not sinoid towards the apex; distal half oblong; apex rounded. **Gland pattern**: basal leaflet in proximal half with 0(–1), in distal half with 0–2 glands; second leaflet in proximal half with 0(–1), in distal half with 0–2(–3) glands; apical leaflet in proximal half without, in distal half with 0–1(–2) glands; other leaflets in proximal half without, in distal half with 0–2(–3) glands (essentially only in more basal ones, others hardly ever with glands).

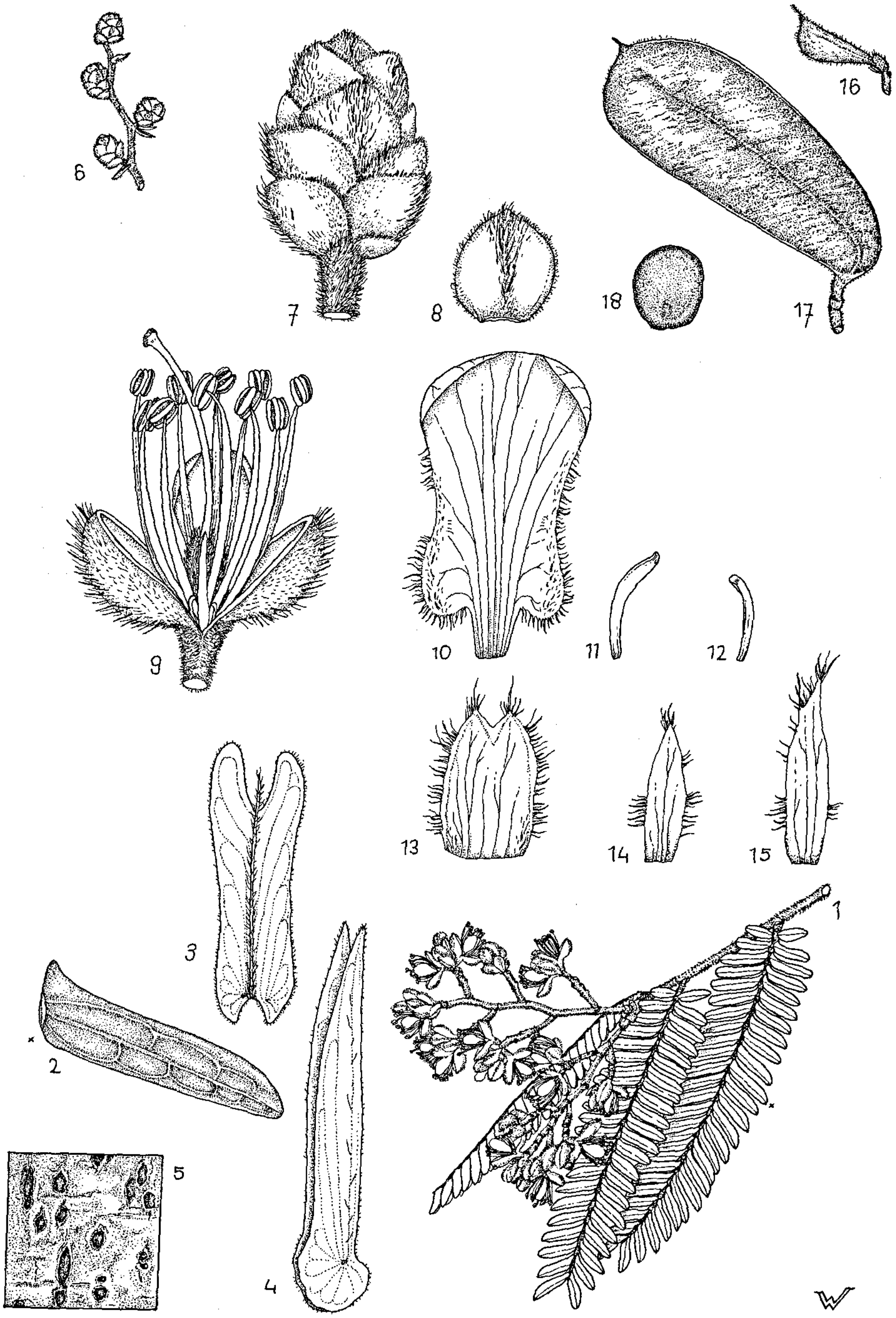


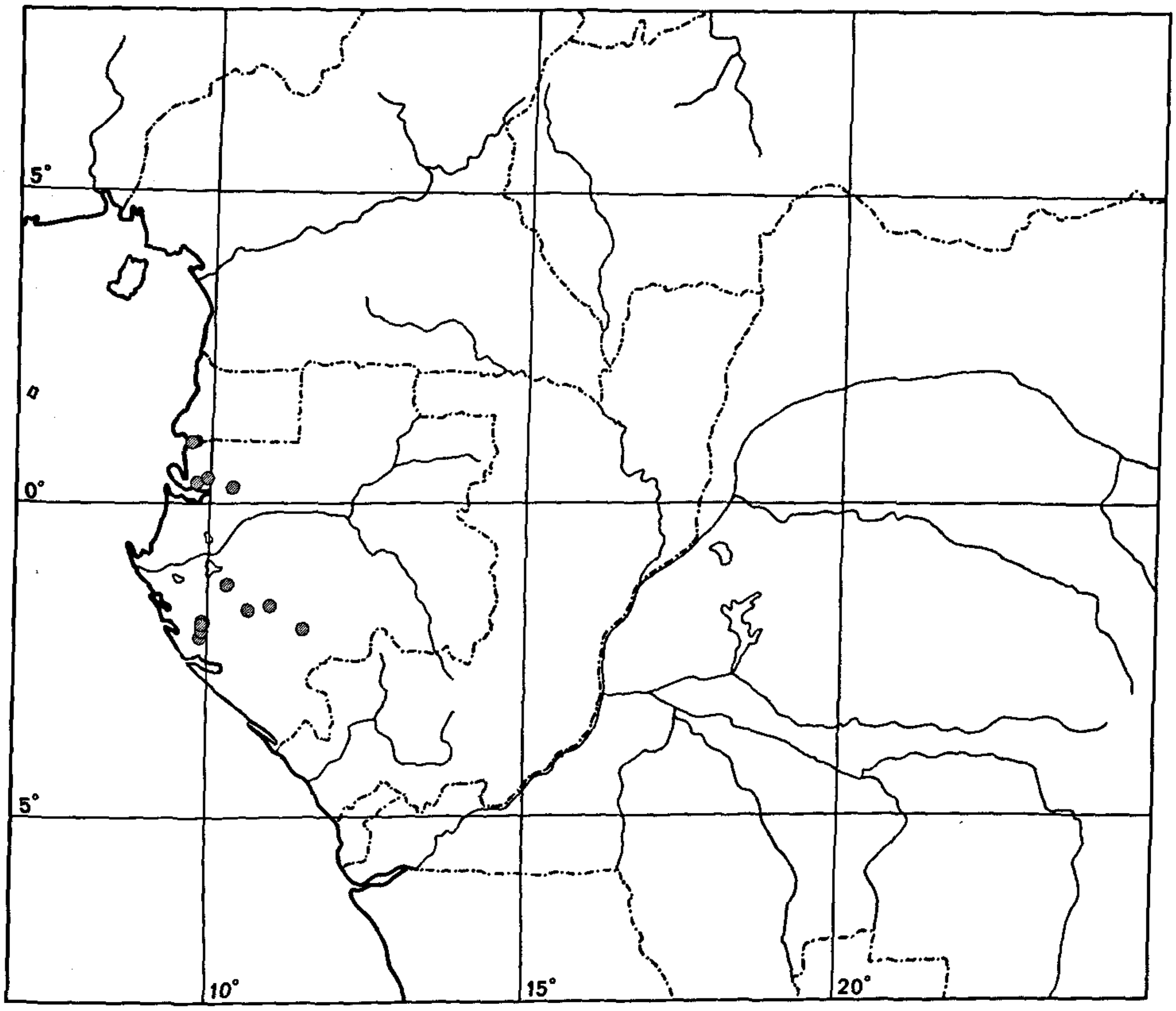
Figure 14.4. *Tetraberlinia longiracemosa* (A. Chev.) Wieringa. — 1: twig with leaves and inflorescences (x⅔); 2: leaflet from below (x4); 3: budscale that preceeds the leaves on a shoot, consisting of a reduced leaf and its stipules (x3); 4: two stipules (x3); 5: surface of bark (x⅔); 6: young inflorescence (x⅔); 7: lateral branch of an inflorescence (raceme) in bud (x4); 8: bract from outside (x4); 9: flower from abaxial side (x4); 10: adaxial petal from inside (x8); 11: lateral petal from outside (x8); 12: abaxial petal from outside (x8); 13: two adaxial sepals from outside (x8); 14: lateral sepal from outside (x8); 15: abaxial sepal from outside (x8); 16: developing pod (x⅔); 17: mature pod (x⅔); 18: seed (x⅔). — 1–3, 9–15: *Wieringa & Haegens 3270*; 4: *Wieringa & Haegens 2386*; 5: *Wieringa 1114*; 6–8: *Wieringa & Nzabi 2850*; 16: *Haegens & v.d. Burgt 223*; 17, 18: *Wieringa & Haegens 2385.*

Inflorescence a compound raceme, axillary on the terminal 5 nodes, 1(–2) per node, (1–)4–11 cm long, with 2–10 lateral branches which are 3–22 mm long and 3–23 flowered. **Rachis** green to brown, fairly densely, short to long brown velvety often mixed with whitish tomentose hairs, lateral branches green, mixed brown velvety with white pubescent. **Bracts** ovate to obtrullate, margins clasping the flower bud, 3–4½ x 2½–4 mm, (greenish) white: outside with an indistinct midrib which is usually broadened and somewhat swollen and truncated just before the apex into a nose, white puberulous, usually mixed with white velvety hairs, except a glabrous area at each side just above the base, in an area along the central axis, which broadens to the apex also long brown velvety, inside glabrous, margins shortly ciliate. **Pedicel** 1.5–2.6 mm long, greenish white to cream-coloured, mixed short to very long brown velvety with white pubescent. Hypanthium s.l. 0.7–1.1 mm high. **Bracteoles** assuming a 70–120° wide angle at anthesis, ovate to obovate, 4½–6 x 3–4 mm, white, outside white velvety (hairs of different length, from very short to 0.5 mm), especially along the midrib mixed with short to very long brown velvety hairs, inside glabrous, margins chaffy. **Sepals** yellowish to greenish white, both sides glabrous or the outside near the base with a few hairs, margins irregularly shortly white ciliate. **Adaxial sepals** fused, ovate to triangular, 2.1–2.8 x 1.4–2.1 mm, apex clearly to slightly bifid. **Lateral sepals** narrowly triangular to oblong, 1.7–2.4 x 0.5–0.8 mm, apex acute. **Abaxial sepal** narrowly triangular to oblong, 2.1–3.4 x 0.5–0.9 mm, lateral margins often inrolled, apex acute. **Petals** 5. **Adaxial petal** 4.4–5.6 x 2.5–3.5 mm, lemon-yellow, pinkish white at base: claw 0.3–0.8 mm long, glabrous on both sides; blade rectangular to oblong-obovate, towards the margins curved inwards and then slightly reflexed again, rounded to slightly auriculate at base, upper ⅓ widening into the circular to broadly elliptic apical part, apical margin often deflexed, often emarginate and often with a single (rarely 2) central hair, outside glabrous except for a few velvety hairs in the basal corners, inside more extensively velvety in basal corners, velvet area extending in a narrow strip along the lateral margins, lateral margins shortly ciliate. **Lateral petals** oblong to spathulate, folded and thus becoming linear, 1.1–1.8 x 0.2–0.4 mm, both sides glabrous, yellowish white to lemon-yellow, lateral margins sometimes ciliate in the middle, apex rounded. **Abaxial petals** oblong to spathulate, slightly inrolled to folded, 0.8–1.4 x 0.1–0.2 mm, both sides glabrous, yellowish white to lemon-yellow, lateral margins sometimes with a few hairs in middle part, apex rounded to acute. **Stamens** 10: filaments 5½–10 mm long, white to pinkish white, entirely glabrous, 9 united at base over a length of 0.3–0.7 mm, base of the adaxial filament fused to the stipe of the ovary; anthers 0.9–1.3 mm long, pink to pinkish orange with pale grey to purple slits. **Ovary** 1½–3 x 0.9–1.5 x 0.3–0.5 mm, never depauperate, with 1–3 ovules, light green, very long brown villous, upper suture not winged; stipe 1.7–2.4 mm long, villous but glabrous at base. **Style** 6–9 mm long, inserted at an angle of 10–30°, villous at base, white, pink to the apex: stigma heart-shaped to circular, white.

Pod 0–3-seeded, obovate to oblong, lower apical corner sometimes slightly protruding, 5–8 x 2.3–3.4 x 0.2–0.5 cm, during development light purple-green with some brown long hairs, medium brown and glabrous when mature; beak 1–3 mm long; upper suture only slightly widened, 1–3 mm broad; nerve indistinct, usually above the pod middle, u/w = 0.24–0.52; stipe 3–7 mm long; pedicel 1½–3 mm long, velvety. **Seeds** 13–20 x 11–17 x 3.1–4.5 mm, weight 0.3–0.6 g in dry condition; testa thin, pale to medium brown; cotyledons purple.

Seedling: Germination epigeal. **Hypocotyl** 2–5½ cm long, mixed puberulous with velvety. **Epicotyl** 2–4½ cm long, mixed puberulous with sparsely long velvety. First pair of leaves opposite, 19–30-jugate. First stipules 1½–3 mm long. Always (?) branching after the first leaf pair. Subsequent leaves alternate, preceded by bud scales, first alternate leaf only 10–21-jugate, subsequent ones with slowly increasing number of leaflets. Leaflets papery, pink at first.

Saplings of this species are easily distinguishable from those of *Bikinia le-testui* and *B. pellegrinii* by the characteristic, persistent, stipules.



Map 14.5. Distribution of *Tetraberlinia longiracemosa* (A. Chev.) Wieringa.

Distribution: Map 14.5. Endemic to Gabon. Only found west of the Crystal Mountains and Chaillu Massif: in the coastal plains and at the lower mountain feet. A northern part of the distribution area lies around Libreville, a second, more extensive one extends from Rabi over Mandji to Lebamba.

Maley et al. (1990) say they have found the species in Congo (Brazzaville) as well, close to the Gabonese border. This location (Kouyi) is close to the known Gabonese distribution and fits well in the observed pattern, but the altitude (600–700 m) causes doubt. Although the material from IEC has been seen, no material from Kouyi was encountered. Dowsett-Lemaire (1995) also reports the species for Congo (Brazzaville), but her collection (*1865*) is in fact *Hymenostegia pellegrinii.*

A sterile collection (*Constant & Bertault 228*) from central Congo (Brazzaville) resembles this species, but has different stipules. It may represent another (so far unknown) species of *Tetraberlinia.*

Vernacular names: Gabon: Mussinga (Bapunu, Mouila region), N'Dala (Bavoungou), Ndala (Echira), Ndaa (Mitsogo), Evel-Andoung, N'Sour-Andoung (Fang).

Ecology: Always found in dry-land rain forest at altitudes of 0–250 m. Usually occurring single or in small (<10 large trees) groups, often with abundant regeneration. According to Saint Aubin (1963: 27) larger populations occur in the Tandous Mountains.

The flowers are visited by honeybees (*Apis mellifera*), small stingless bees (Meliponini) and some moths.

Phenology: Flowering occurs during the large rainy season: beginning of October to the end of November. Seedfall occurs during February and the beginning of March. Hence maturation of the pods takes 3–4 months.

Chemistry: Flowers produce a red-brown colour in alcohol.

Diseases and pests: Small galls are sometimes present on the leaflets on the position where one would expect a gland.

Use: Unknown.

Notes: The BR isotype contains a pod which does not belong to this species.

Walker (s.n. 2) states the tree flowers in January. His specimen, however, consists of two branches of saplings (since they possess persistent stipules) and a bag with stipules not belonging to this species (probably of *Bikinia le-testui* or *B. pellegrinii*), hence the identification of the observed flowering tree is to be doubted.

Specimens examined:

GABON: *Bois 984* (LBV): Kougouleu, SBM, 0°22'N 9°55'E (st, 24.10.1952); *Bois 985* (P): Kougouleu, 0°22'N 9°55'E (st, 24.10.1952); *Breteler, Jongkind, Nzabi & Wieringa 11505* (WAG (+alc)): Rabi-Kounga area, near Rabi 53, 1°55'S 9°51'E (fr, 17.05.1992); *Breteler, Jongkind, Nzabi & Wieringa 11506* (WAG): Rabi-Kounga area, near Rabi 53, 1°55'S 9°51'E (st, 17.05.1992); *v.d. Burgt 55* (WAG (alc only)): Rabi, near well Rabi 53, 1°55'S 9°51'E (fr, 24.02.1994); *v.d. Burgt 109* (WAG): grown out of seeds from Rabi 7, 1°55'S 9°51'E (st, 25.04.1994); *Chevalier 26935* (BR, FHO, K, P, WAG) type: Ht Komo, Agonenzorck, 0°13'N 10°19'E (fl, 06.10.1912); *Haegens & v.d. Burgt 223* (WAG): Rabi-Kounga, near Rabi 13, 1°58'S 9°51'E (fr, 01.01.1994); *Morel 51* (LBV, P, WAG): E of Cocobeach, Atia-river bank, 0°57'N 9°40'E (st, 06.09.1948); *Morel 107* (LBV, P): Ntoum Rogolié, 0°18'N 9°45'E (st, 29.03.1950); *Morel & Gauchotte 89* (P): Ntoum Rogolié, 0°18'N 9°45'E (st, 01.1950); *Morel & Gauchotte 90* (LBV, P): Ntoum Rogolié, 0°18'N 9°45'E (st, 01.1950); *van Nek 215* (WAG): Rabi, just E of Pechaud-camp, 1°57'S 9°53'E (st, 07.11.1990); *de Saint Aubin 2022* (P): Tandous Mountains, 1°45'S 10°35'E (fr, 04.1960); *de Saint Aubin 2025* (LBV, P, WAG): upper Obangué river, 1°20'S 10°15'E (st, 04.1960); *Walker s.n. (2)* (P): mission de St. Martin, 1°41'S 10°56'E (st, 02.1939); *Wieringa & Epoma 1626* (LBV, WAG, WILKS): 1 km S of Rabi 13, 1°58'S 9°51'E (st, 22.09.1992); *Wieringa & Nzabi 2850* (G, IAGB, IEC, LY, UGDA, W, WAG (+alc)): Rabi, c. 1 km S platform Rabi 13, 1°59'S 9°51'E (fl, 03.10.1994); *Wieringa & van Nek 3270* (G, IAGB, IEC, LY, UGDA, W, WAG (+alc)): Rabi, W of platform 53, at crossing to Rabi platform 78, 1°55'S 9°51'E (fl, fr, 24.11.1994); *Wieringa, Haegens & v.d. Burgt 2601* (WAG): Rabi, just N of Shell-camp, 1°57'S 9°53'E (st, 31.03.1994); *Wieringa 1114* (WAG): Sounga, 2°11'S 9°49'E (fr, 09.06.1992); *Wieringa 1115* (LBV, WAG): Sounga, 2°11'S 9°49'E (st, 09.06.1992); *Wieringa 2863* (WAG): near Echira oilfield, next to Echira bridge, 2°05'S 9°51'E (fl, 05.10.1994); *Wieringa & Haegens 2385* (WAG): Rabi, W of platform 53, 1°55'S 9°51'E (fr, 03.03.1994); *Wieringa & Haegens 2386* (WAG): Rabi, W of platform 53, 1°55'S 9°51'E (st, 03.03.1994); *Wieringa, van Nek, Hedin & Moussavou 3154* (WAG): 23.7 km on road Lebamba to Yeno, 2°03'S 11°27'E (st, 12.11.1994).

Tetraberlinia moreliana Aubrév. Fig. 14.5, Plate 5a & b, Map 14.4

Tetraberlinia moreliana Aubrév.: Aubréville, 1968: 302–304, Pl. 77; Burgt, 1994; Burgt, 1997. **Type**: *de Saint-Aubin 1993 SRF* (holo: P) (= CTFT wood sample 11646) — "Gabon: Est-Libreville, 18 km. janvier 1959."

Monopetalanthus macrophyllus J. Morel (MS name, see notes): Normand, 1958: 302 (without diagnosis & type).
Tetraberlinia sp. nov.: Saint Aubin, 1963: 50, 57 & photo's opposite p. 57.

Large tree, 12–51 m high, with a hemispherical crown. **Bole** straight, cylindrical, branchless for up to c. 30 m, DBH 60–210 cm: base often widening in lower metre, sometimes with small (< 1 m high) buttresses, in large trees usually with some tumours. **Bark** up to c. 3 cm thick: surface smooth to finely fissured, dark grey to grey-brown with red-brown lenticels, surface of large branches with small scales; outer bark up to 1 mm thick, very hard, brown; inner bark fibrous, to outside slightly granular, creamy pink or yellowish, reddish brown when dry; old wounds with dark red-brown resin. Sapwood whitish; heartwood pale pink, rapidly turning to brownish pink or pale yellow-brown upon exposure.

Twigs grey-brown, glabrous to fairly densely velvety to very long villous, sometimes mixed with puberulous hairs. **Stipules** free, persistent, ovate, with an auriculate base, 11–50 x 2–13 mm, papery to leathery, green to pinkish brown when young, later brown, outside glabrous, sparsely tomentose or short to long velvety (see notes), inside glabrous, sometimes velvety at base, margins shortly ciliate. **Leaves** 9–29 cm long, (4–)8–13 jugate, largest leaflet usually in the middle but varying from the pair right before the middle pair to the apical pair: **Petiole** 2–7(–10) mm long, consisting for the major part of the wrinkled joint, glabrous or pubescent, often with a few additional long hairs; **Rachis** 6–23 cm long, terete with a grooved ridge above, pale brown, upper side tomentose to pubescent with some sparse long hairs, lower side glabrous to tomentose, but often more sparse than upper side, slowly glabrescent; **Leaflets** thickly papery to leathery, upper side glossy, glabrous, dark to medium green with a light green primary nerve, after drying dark grey, lower side rather dull, glabrous, medium to pale green, after drying brown to grey-brown, margins (short to) long ciliate. Young leaflets on upper side pale greenish yellow with pinkish margins, later yellowish green, lower side pale pink. **Basal leaflet** 14–60 x 5–27 mm (in saplings 8–24 x 3–12 mm): proximal half obovate to elliptic, base not auriculate, margin usually sinoid towards the apex; distal half ovate to trullate or triangular, basal corner rounded; apex obtuse to bluntly acute. **Apical leaflet** 20–74 x 6–30 mm (in saplings 15–52 x 5–17 mm), asymmetric, its axis curved to the distal side: proximal half obovate, base not to distinctly auriculate, auricle 0–2.7 mm, margin not or slightly sinoid towards the apex; distal half obovate to elliptic; apex bluntly acute to acuminate. **Largest leaflet** 30–90(–100) x 8–25(–32) mm, main vein often curved in distal direction at the apex: proximal half obovate, base slightly to distinctly auriculate, auricle 0.1–2.5 mm, margin slightly to distinctly sinoid towards the apex; distal half trullate; apex bluntly acuminate. **Gland pattern**: Basal leaflet in proximal half with (0–)1–5, in distal half with (0–)1–5(–7) glands. Second leaflet in proximal half with 0–1(–3), in distal half with 0–1 glands. Apical leaflet in proximal half with 0–2, in distal half with 0–5 glands. Other leaflets in proximal half with 0–1(–3), in distal half with 0–2(–3) glands.

Inflorescence a compound raceme, axillary on the terminal 5 nodes, 1 per axil, 7–16 cm long, with 2–10 lateral branches which are 1½–5 cm long and 6–19-flowered. **Rachis** very pale green, shortly to long brown velvety usually mixed with pubescent hairs. **Bracts** ovate with an acute apex, shaped like the head of a crown nib, 10–13 x 5–7½ mm, very pale green, outside velvety, inside velvety except for the glabrous basal part. **Pedicel** 4–8 mm long, whitish, mixed brown tomentose and shortly to long velvety. Hypanthium s.l. 2.1–3.3 mm high. **Bracteoles** assuming a 15–45° wide angle at anthesis, but adaxially the margins are often pressed together and appear to be fused at base, oblong, 8–12½ x 5–8 mm, apical part notably swollen and nosed, outside pink to pale red, brown tomentose, especially at base also velvety, inside whitish to pale pink, fairly densely pubescent-velvety. **Sepals** white with a more or less pale red central spot of variable size, outside glabrous or especially in the centre pubescent, inside glabrous to very sparsely pubescent, margins shortly ciliate. **Adaxial sepals** fused, forming a band at the base of the adaxial petal, 1.4–3.5 x 3.7–6.0 mm, upper margin with two lobes or small dents near the edges. **Lateral sepals** vestigial or sometimes wanting, triangular to semi-circular, up to 2.2 x 2.9 mm, apex acute or rounded. **Abaxial sepal** triangular, 1.8–4.6 x 1.5–2.6 mm, lateral margins inrolled, apex acute. **Adaxial petal** 7–11 x 4–6½ mm, white, apical ¼ yellow: claw 0.8–1.5 mm long, glabrous; blade oblong-obovate, outside brown velvety along the margins and in an area of variable size at the base and in the centre, inside velvety in broad bands along the margins, these bands widening towards the apex but ending before the apex, the central part of the blade inrolled whereas the margins are reflexed again especially at the abruptly widened, rarely even slightly auriculate base, apex usually rounded. **Lateral** and **abaxial petals** narrowly oblong-obovate to spathulate, white, glabrous, lateral margins often in-rolled (sometimes slightly so) or folded, brown ciliate in or just above the middle over a short distance, apex rounded. **Lateral petals** 0.7–3.8 x 0.5–1.5 mm. **Abaxial petals** 0.5–3.2 x 0.3–1.2 mm. **Stamens** 10(–11): filaments (11–)15–23 mm long, white with a pinkish apex, completely glabrous or sometimes the adaxial filament or one of its neighbours with a line of hairs on the outside, 9(–10) united at base over a length of 0.9–3.0 mm, towards the adaxial side usually united over a slightly larger length, within the hypanthium filaments markedly broadened towards the centre of the hypanthium, suddenly retreating again at the apex of the hypanthium, above the hypanthium filaments bending inwards; adaxial filament free except for its base which is fused with the stipe of the ovary; anthers 1.8–2.3 mm long, front creamy white with brown slits, back pinkish. **Ovary** 2½–6 x 1.5–2.9 x 0.7–1.5 mm, never depauperate, with 2–5(–6) ovules, pale green but upper suture sometimes pinkish, mixed appressed long to very long brown velvety with puberulous, upper suture indistinctly to slightly winged; stipe 3.3–5.3 mm long, short to very long velvety, at base the hairs arranged in vertical bands filling the gaps in between the stamens. **Style** 10–17 mm long, inserted at an angle of 0–30°, long to very long velvety at base, glabrous towards the apex; stigma heart-shaped.

Pod (0–)1–4(–6)-seeded, oblong to narrowly obovate, (6–)10–23 x (2.5–)3.5–6.8 x 0.3–0.6 cm (see notes), light green, brown at maturity, sparsely appressed puberulous with a few long bristle-like hairs; beak 2–7 mm long; upper suture broadly winged, (4–)8–12 mm wide, broadest near the apex; nerve at about ⅓ of the pod width, u/w = 0.27–0.39, sometimes a second nerve present at or just below the middle, u2/w = 0.49–0.59, often in the lower half some diagonal or vertical veins present, arising from the second nerve if present; stipe (5–)8–14 mm long; pedicel 3½–6½ mm long. **Seeds** 19–30 x 19–26 x 5.8–7.7 mm, 2.7–3.2 g when fresh, 1.6–2.3 g in dry condition; testa thin, dark brown; cotyledons purple.

Figure 14.5. *Tetraberlinia moreliana* Aubrév. — 1: twig with a leaf and inflorescences (x⅔); 2: bark surface (x1); 3: stipule (x1); 4: bract from outside (x2); 5: flower from about the abaxial side (x3); 6: adaxial petal from outside (x4); 7: lateral petal from outside (x4); 8: abaxial petal from outside (x4); 9: abaxial sepal from outside, the dotted line indicates the part fused to the hypanthium but left free by the bracteoles (x4); 10: adaxial sepals from outside (x4); 11: lateral sepal from outside (x4); 12: pod (x⅔). — 1, 3–11: *Wieringa & Epoma 1608*; 2: *Wieringa & Haegens 2366*; 12: *v.d. Burgt 76.*

Seedling: Germination epigeal, starting immediately after seed shedding. **Hypocotyl** 2½–9½ cm long, fairly dense, shortly to long velvety. **Epicotyl** 3–8½ cm long, fairly densely, long to very long velvety. Stipules smaller than in mature trees, the lowest ones 5–7 x 1½–2½ mm. First pair of leaves opposite, 5–7 jugate. Leaflets papery, young ones pink. Subsequent leaves alternate, with an increasing number of leaflets and larger stipules.

Distribution: Map 14.4. Coastal regions of Gabon and southern Cameroon. Seems to be restricted to some areas where it is common: c. 20 km SE of Kribi around Mount Elephant, the coastal plain at the western flanks of the Crystal Mountains and the sedimentary basin between the Ndougou lagoon and the Ogooué river. Some collections of isolated, more inland localities attributed to this species are regrettably always sterile.

The species may be occurring as well in Congo (Brazzaville), see notes.

Vernacular names: Gabon: Beniamam (Fang), Kakaka (?, Mondah region), Okorwé (Nkomi). Congo (Brazzaville) ?: Dikuru (Bapunu).
Forestry name: Beniamam (Gabon).

Ecology: The species is only found in dry-land rain forest at 0–200 m altitude. In the area between the Ndougou lagoon and the Ogooué River it may occur dominant in extensive stands.

The seed dispersal has been described by Burgt (1994 & 1997).

Phenology: Flowering in Gabon coincides with the first rains after the long dry season: mid-September to October. Flowering is very well-synchronized, all trees at a site start flowering within a period of a few days. Sometimes a single branch mistakenly flowers instead of producing new leaves in March (*v.d. Burgt 66* and own observations). Seedfall occurs from December to March, although some pods may stay on the tree longer if they do not explode. Hence pod maturation takes 3–6 months.

If *Ledermann 821* indeed concerned this species (see notes under *T. polyphylla*), flowering in Cameroon occurs in October as well.

de Saint Aubin 1993, collected in January in Gabon, contains both disconnected flowers and recently fallen pods. I therefore assume the flowers and pods were not collected simultaneously.

Chemistry: Flowers, leaves and pods produce a strong dark red-brown colour in alcohol.

Diseases and pests: Large boles very often display tumour-like swellings, especially near the base. Resin secreting holes, probably made by longhorn beetles (Cerambycidae), are often present.

Young leaves are eaten by monkeys and are also attacked by caterpillars (possibly Tortricidae). The damage can be considerable.

Use: No use is known so far. It can probably be used in a similar way to *Tetraberlinia bifoliolata*. The wood is relatively light, even fresh logs float (*Bernard 1330*).

Notes: Based on *Morel 8 SRF* (P, BR) — "Gabon: District de Coco-Beach. Environs de NKAN sur la Noya en aval du confluent Noya Adughe. 23 Novembre 1947.", J. Morel made a full latin description of *Monopetalanthus macrophyllus*, dated "17 decembre 1947" and sent it to Paris. His letter, however, was never published, but mounted on the sheet. Only Normand (1958) used the name in a publication.

Collections from the area around Rabi are distinct by their long persistent, firm, short to long velvety stipules. The saplings from this area however, have, as usual, glabrous stipules. I consider these characteristics merely as the fixation of a single character within this population, not demanding any taxonomic status. Further research though, especially of the other populations, may reveal additional characters, in which case a separate taxon should be considered.

Morel 8 shows one very small pod which is probably a seedless, but non-aborted one.

As is evident from Normand (1958: 302) two separate collections from the Mayumbe region should exist: *Bernard 1450* from "près Mayoumba, Doussa, sur chantier SFM, 21/XII/1954" and *Soc. For. Niari (s.n.)* from "confins du Gabon et du Moyen-Congo, Bas-Kouilou, 2/06/1948". In P a single sheet is present with according to the label the material of *Bernard 1450* (including "Doussa" and the right date). However, the only material on that sheet is a leaf (of *T. moreliana*) in a folded paper, in the same envelope a small piece of paper is included saying "Feuille de Dikuru (S.F.N.) Moyen Congo, env. Bas-Kouilou, Mr Mounter.", which clearly refers to the second collection mentioned by Normand. Moreover, above the Bernard label, an additional label is attached which says the collections resembles *Cynometra* (= *Plagiosiphon*) *longituba* but that in this specimen the nervation is less clear and the leaflets have emarginate apices. Both this description and the drawing of the leaflet apex clearly point to a species of *Plagiosiphon*, most probably *P. gabonensis* (A. Chev.) J. Léonard. Apparently no material of *Bernard 1450* is preserved in P, possibly a wood sample is still available in Montpellier (CIRAD). Wherever Doussa is, it should be excluded from the distribution area of *T. moreliana*. The leaflets of *Mounter s.n. (1)*, however, do belong to that species, rendering it likely the species is occurring in coastal Congo (Brazzaville) as well.

The branch showing aberrant flowering in March (*v.d. Burgt 66*, see phenology) has a morphology which is a mixture of a new branch and an inflorescence, it has been disregarded for the description of the inflorescence structure.

Specimens examined:

CAMEROON: *v.d. Burgt 207* (WAG) id. doubtful: 22 km SE Kribi, 10½ km along road to HEVECAM, 2°47'N 10°02'E (st, 01.10.1997); *Wieringa & Haegens 2105* (WAG) id. doubtful: 23 km SE of Kribi, 2°47'N 10°02'E (st, 05.02.1994); *Wieringa & Haegens 2124* (G, IEC, WAG) id. doubtful: 23 km SE of Kribi, 2°47'N 10°02'E (st, 06.02.1994); *Wieringa & Haegens 2322* (WAG) id. doubtful: 23 km SE of Kribi, = 10 km on road to Hevecam, 2°47'N 10°02'E (st, 23.02.1994); *Wieringa & Haegens 2366* (WAG) id. doubtful: 23 km SE Kribi, 10 km along road to HEVECAM, 2°47'N 10°02'E (st, 27.02.1994).

GABON: *Bernard 1330* (P): Fernan Vaz, Lagune Iguila (2 km from cirque Bongowé), 1°48'S 9°16'E (st, 30.04.1954); *Breteler & Breteler-Klein Breteler 13097* (WAG): c. 20-30 km NNW Ndjolé, 0°03'N 10°45'E (st, 30.09.1994); *Breteler, Jongkind & Wieringa 9455* (WAG): Rabi-Kounga, near Shell-camp, 1°57'S 9°53'E (fr, 24.03.1990); *Breteler, Jongkind & Wieringa 9786* (WAG): Rabi-Kounga, 1°57'S 9°53'E (st, 04.04.1990); *Breteler, Jongkind & Wieringa 11057* (WAG): 5-30 km NNW of Ndjolé, 0°05'S 10°45'E (st, 23.04.1992); *Breteler, Jongkind, Nzabi & Wieringa 11439* (WAG): Rabi-Kounga, 1°55'S 9°55'E (fr, 14.05.1992); *Breteler, Jongkind, Nzabi & Wieringa 11479* (WAG): Ofoubou, c 40 km NE of Rabi-Kounga, 1°38'S 10°05'E (fr, 16.05.1992); *Breteler, Jongkind, Nzabi & Wieringa 11492* (WAG): Yeno, 1°42'S 10°00'E (fr, 16.05.1992); *v.d. Burgt 9* (WAG): Rabi, 1°55'S 9°51'E (st, 01.02.1994); *v.d. Burgt 66* (WAG): Rabi, near platform 78, 1°55'S 9°50'E (fl, 06.03.1994); *v.d. Burgt 75* (WAG (alc only)): south and central Rabi, 1°55'S 9°50'E (st, 1994); *v.d. Burgt 76* (WAG (alc only)): south and central Rabi, 1°55'S 9°50'E (fr, 1994); *Corbet 742* (P): Bokoué, 0°09'N 10°09'E (st, 03.1952); *Estasse 662* (LBV, P): Mondah, 0°34'N 9°22'E (st, 05.02.1952); *Morel 8* (BR, P): Cocobeach, Nkan on the Noya, downstream Noya-Adughe junction, 0°41'N 10°00'E (fr, 23.11.1947); *Morel 179* (LBV): ?, not located (st, ?); *de Saint Aubin 1993* (P): 18 km E of Libreville, on road Ikoy to Bandja, 0°23'N 9°37'E (fl, fr, 10.01.1959); *de Saint Aubin 2016* (BR, LBV, P): N'Koulounga, 0°42'N 9°50'E (st, 02.1960);

Schoenmaker 7 (WAG): Rabi-Kounga, opposite Shell restaurant, 1°57'S 9°53'E (fl, 12.10.1991); *Schoenmaker 351* (WAG): Rabi-Kounga, near well Rabi 10, 1°53'S 9°50'E (fr, 16.01.1992); *Schoenmaker 405* (WAG): Rabi-Kounga, 1°53'S 9°50'E (st, 01.03.1992); *team of Wilks s.n. (8)* (WILKS): between Bilangone and Remboué rivers, transect DW 12, 0°05'S 9°45'E (st, 1997); *Wieringa & Epoma 1608* (IAGB, LBV, W, WAG (+alc), WILKS): Rabi, 4 km N of Shell-camp, 1°55'S 9°52'E (fl, 18.09.1992); *Wieringa & Nzabi 1181* (WAG): Rabi, N of airport, 1°56'S 9°52'E (st, 19.06.1992); *Wieringa & v.d. Poll 1442* (LBV, WAG): 22 km on the road from Lebamba to Yéno, 2°03'S 11°27'E (st, 21.08.1992); *Wieringa, Haegens & v.d. Burgt 2372* (WAG): Rabi, 1 km NW Rabi 7, 1°55'S 9°51'E (fr, 02.03.1994); *Wieringa, Haegens & v.d. Burgt 2373* (WAG): Rabi, 1 km NW Rabi 7, 1°55'S 9°51'E (fr, 02.03.1994); *Wieringa, van Nek, Hedin & Moussavou 3165* (WAG): 23 km on road Lebamba to Yeno, 2°03'S 11°27'E (st, 12.11.1994).

CONGO (BRAZZAVILLE): *Mounter s.n. (1)* (P): env. Bas-Kouilou, chantier Soc. For. du Niari, 4°20'S 11°50'E (st, 02.06.1948).

Tetraberlinia polyphylla (Harms) J. Léonard ex Voorh. Fig. 14.6, Map 14.6

Tetraberlinia polyphylla (Harms) J. Léonard ex Voorh.: Voorhoeve, 1965: 215 (1 March 1965); J. Léonard, 1965: 106–107 (31 March 1965, see notes); Aubréville, 1968: 298–300 p.p. & pl. 76; Aubréville, 1970: 274–276 & pl. 66; Vivien & Faure, 1985: 153, drawing C (not the text on p. 152!); Pauwels, 1993: pl. 53 (not text on p. 116!).

Berlinia polyphylla Harms: Harms, 1915a: 472 (Febr.–Sept. 1915); Harms, 1915b: 466 p.p. (19 October 1915); Chevalier, 1916: 168 & Pl. XI; De Wildeman, 1925: 148; Baker, 1930: 682 & 691 p.p.; Chevalier, 1946: 587 & pl. 14B; Pellegrin, 1949: 61 p.p.; Walker & Sillans, 1961: 218 (p.p.?); Wieringa, 1999. **Type**: Conserved type (see notes), *Fleury in Chevalier 26690* (P) — "Gabon: Plantation de Ninghé-Ninghé sur la Bokoué, près du poste de Kango sur le Komo. 6 octobre 1912" (in flower).

Julbernardia polyphylla (Harms) Troupin: Troupin, 1950: 320.

Michelsonia polyphylla (Harms) Hauman: Hauman, 1952a: 478.

Small to large forest tree, 10–30 (–40?) m high. **Bole** straight, fairly cylindrical, branchless for up to 20 m, DBH at least attaining 70 cm: base sometimes with small feet. **Bark** thin, up to 8 mm thick: surface rugose, dark grey to grey-brown; outer bark c. 1 mm thick, stony, dark grey-brown; inner bark fibrous, in fresh condition pale pinkish brown, in dry condition orange-brown with creamy granules in outer half; old wounds with red to brownish red resin. Sapwood creamy white, in dry condition pale pinkish brown.

Twigs grey to brownish grey with brown lenticels, puberulous, finally glabrescent, young twigs also erect and appressed pubescent. **Stipules** free, early caducous, narrowly ovate, 6–10 x 1.3–2.5 mm, green, both sides glabrous or sparsely pubescent outside at base, with 6–10 veins that run parallel below, apex rounded to acuminate, margins sparsely shortly ciliate mixed with some glandular hairs. **Leaves** 5–22 cm long, (3–)6–13-jugate, largest leaflet situated approximately at the middle, occasionally the apical pair largest: **Petiole** 2–7 mm long, puberulous, consisting for about ⅔ of the wrinkled joint; **Rachis** (2–)4–19 cm long, puberulous to short velvety, in dried condition approximately semi-circular in cross-section, with an, often furrowed, ridge over the flattened upper side, in fresh condition likewise with more rounded edges to almost circular; **Leaflets** leathery: upper side glossy, dark green, sometimes with a medium green primary vein, glabrous; lower side glossy, medium green, glabrous; margins shortly ciliate, glabrescent; proximal half usually obovate, base often auriculate, margin sometimes slightly sinoid towards the apex; distal half trullate, rarely ovate; apex rounded to bluntly acuminate. **Basal leaflet** 7–45 x 3–19 mm: proximal half sometimes ovate, lower corner usually rounded, auricle

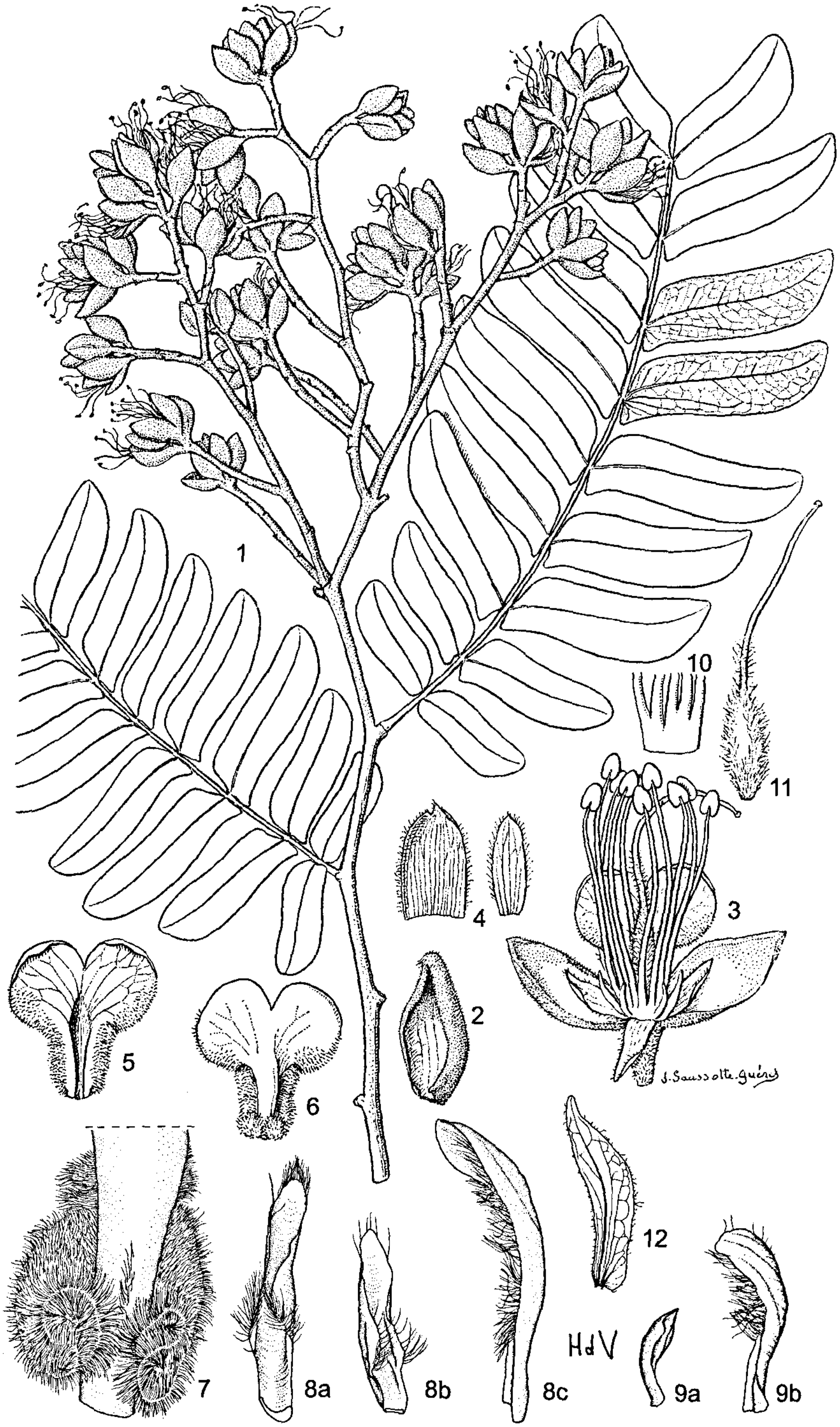


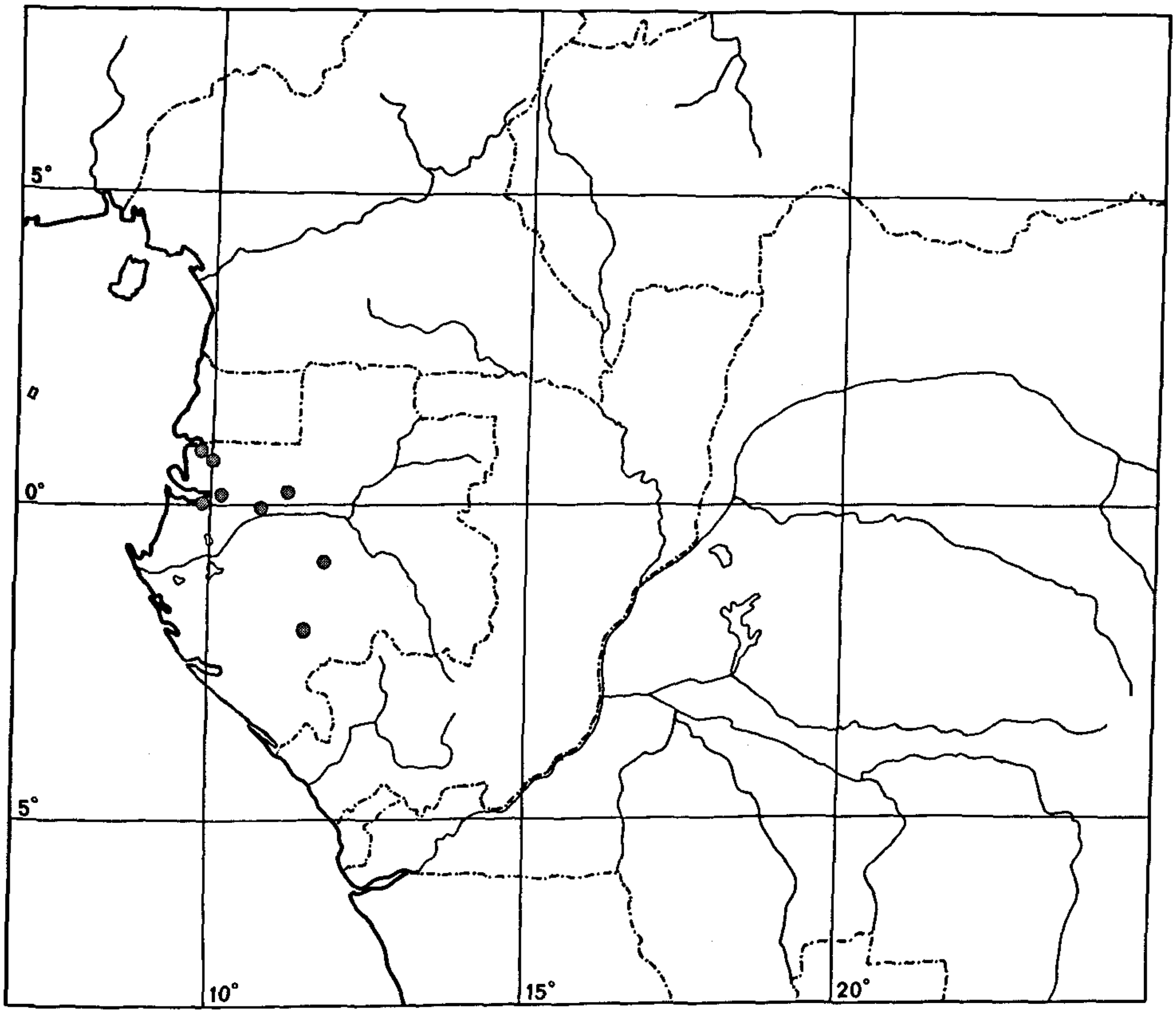
Figure 14.6. *Tetraberlinia polyphylla* (Harms) J. Léonard ex Voorh. — 1: twig with leaves and inflorescences (x⅔); 2: bract (x2); 3: flower from abaxial side with bracteoles and abaxial sepal pushed aside to show interior elements (x2); 4: two fused adaxial sepals (left) and a lateral or abaxial sepal (right) (x2); 5: adaxial petal from inside (x2); 6: adaxial petal from outside (x2); 7: base of adaxial petal from outside (x9); 8a–c: lateral petals (x9); 9: abaxial petals (x9); 10: base of the filaments (x2); 11: ovary and style (x2); 12: stipule from outside (x3). — 1–6 & 10–11 are reproduced from Aubréville, 1968: at least the flowering twig, but probably all elements are based on *Fleury in Chevalier 26690*; 7–9 & 12 drawn by H. de Vries: 7: *Fleury in Chevalier 26690*; 8a, 8c, 9b: *Le Testu 9338*; 8b, 9a: *McPherson 15436*; 12: *Breteler, Jongkind & Wieringa 11035*.

0(–0.4) mm long. **Apical leaflet** 11–54 x 5–20 mm, asymmetric, its axis curved to apical side: lower corner with a sharp angle (sagittate), 40–75°, auricle 0–1.4 mm long. **Largest leaflet** 16–58 x 6–19 mm: auricle (0.1–)0.3–2.3 mm long. **Gland pattern**: glands only present in the distal half along the midrib close to the base on the lower surface (see photo 4.2, p. 36). Basal leaflet with (0–)1–4(–5) glands, second leaflet with 0–2(–5) glands, third leaflet and second last leaflet with 0(–1) glands, apical leaflet with 0–1(–2) glands, other leaflets without glands.

Inflorescence a compound raceme, axillary on the terminal 4(–6) nodes, 1 per axil (terminal node sometimes very short!), 6–12 cm long, with 2–8 lateral branches which are 1–4 cm long and 10–20-flowered, lower branches rarely branched once more. **Rachis** brown velvety. **Bracts** early caducous, ovate, 6–10 x 4–6 mm, outside very short to short velvety all over or (in *McPherson 15436*) partly glabrous in the basal half, inside glabrous at base becoming pubescent towards the apex, margin short and long ciliate. **Pedicel** 2½–6½ mm long, velvety. Hypanthium s.l. 1.2–2.3 mm high. **Bracteoles** assuming a 40–80° wide angle at anthesis, ovate, 5½–11 x 4–8 mm, asymmetric, the adaxial half about half as wide as the abaxial half, greenish, outside very short to short velvety, long velvety along midrib, inside pubescent in apical half and along the margins, margins chaffy. **Sepals** inside glabrous, margins long ciliate, becoming very dense towards the apex. **Adaxial sepals** completely or almost completely fused, ovate to obovate, 5.4–8.1 x 3.1–4.0 mm, outside often sparsely pubescent towards the apex, apex often emarginate, the one or two tops acute to rounded. **Lateral sepals** oblong or rarely ovate, 3.9–6.6 x 1.1–1.9 mm, outside glabrous, apex acute. **Abaxial sepal** oblong, 5.4–8.5 x 1.4–2.4 mm, sometimes with a weak midrib, outside sometimes sparsely pubescent at the apex, lateral margins sometimes a little inrolled, apex acute. **Petals** 5. **Adaxial petal** 7½–11 x 6–8 mm, consisting of 3 parts: the true claw only 0.5–1.1 mm long, glabrous; about the half of the remaining part consist of a broad rectangular part which is glabrous but densely velvety on both sides along it margins, sometimes also with a few hairs outside along the central axis, its centre is furled into an tube (horse-shoe-shaped in cross-section) that encloses the free stamen, the velvety marginal areas close this tube by becoming a kind of flaps and bears 2 auricles which are inrolled into at least a whole whorl before folding back to the claw with a s-shaped curve, the auricle overlaps the true claw on the outside; the apical part is formed by a abruptly expanding, transversally elliptic, bilobed blade, glabrous but velvety along the lower and lateral margins, apical parts of the lobes often reflexed by a fold, apical margin glabrous. **Lateral petals** folded lengthwise to form a linear, laterally flattened tube, 3.0–5.3 mm long, 0.4–1.2 mm wide in unfolded condition, generally curved to the abaxial side of the flower, both sides glabrous, margins usually long ciliated except at base. **Abaxial petals** similar to the lateral petals, but shorter, 1.6–4.0 x 0.4–0.8 mm, usually curved towards the adaxial side. **Stamens** 10: filaments 10–22 mm long, 9 united over a length of 0.6–3.3 mm, completely glabrous, within the hypanthium filaments markedly broadened towards the centre of the hypanthium, at the apex of the hypanthium suddenly retreating towards the actual hypanthium again, above the hypanthium these filaments bending inwards; adaxial filament free, glabrous; anthers 1.6–2.0 mm long, locules without a dorsal tooth. **Ovary** 3–5 x 1.4–2.5 x 0.4–0.9 mm (rarely depauperate and only c. 1.3 x 0.7 x 0.4 mm), with 4–5 ovules, long to very long velvety along both sutures, remainder almost glabrous; stipe 2.0–3.8 mm long, long velvety. **Style** 12–14 mm long, inserted straight on the ovary, basal third, long velvety especially on abaxial side; stigma heart-shaped to nearly circular.

Pod 1–4-seeded, oblong to oblong-obovate, 8–12 x 2.9–3.9 x 0.2–0.4 cm, glossy, light green, glabrous but for a few brown hairs along upper suture; beak 6–12 mm long; upper suture narrowly winged, 3–6 mm wide; nerve distinct, running approximately at the middle of the pod, u/w = 0.45–0.54; stipe 8–11 mm long; pedicel 3–6 mm long. See photo p. XIII. **Seeds** ovate, 16–20 x 14–16 mm (only immature ones known, mature ones may be slightly larger); testa very thin, glossy, brown.

Seedling: Germination epigeal. **Hypocotyl** 6–7 cm long. **Epicotyl** 7–8 cm long. First pair of leaves opposite, not observed. Subsequent leaves 10–11-jugate at first, leaflets increasing in number upwards.



Map 14.6. Distribution of *Tetraberlinia polyphylla* (Harms) J. Léonard ex Voorh.

Distribution: Map 14.6. Endemic to Gabon, where it occurs at the western and southern feet of the Crystal Mountains, the adjacent Gabon Estuary, and in the western and northern parts of the Chaillu Massif.

Many records in literature to *T. polyphylla* actually concern *Bikinia* species (i.e. Dowsett-Lemaire, 1995: *B. evrardii*; Pauwels, 1993: *B. congensis*; Aubréville, 1968 & Saint Aubin, 1963(1984): *B. grisea & B. media*). All records to *T. polyphylla*, especially those outside the presently known distribution area should be doubted until they can be checked on voucher specimens.

Vernacular names: Gabon: Andoung ben Voughsene (Fang), Nsout Ngang (Fang), according to Walker & Sillans (1961: 218) also Abèm-éli (Fang) and Lébémbé (Bakèlè), but it is doubtful whether these names really apply to this species, as it has been commonly misidentified.

Trade name: Andoung 66 (partially).

Ecology: A tree of dry-land rain forest, at 0–250 m altitude. Not typically gregarious, but several small trees or at least treelets may be found in the proximity of a larger one.

Since *McPherson 15436* (WAG) contains a hind leg of *Apis mellifera*, the flowers are in any case visited by honeybees.

Phenology: All three flowering collections were made in October, which is at the start of the raining season. Rather young and some half-mature pods both date from November, indicating that flowering might at least already start in September.

Chemical: Flowers and leaves produce a strong red-brown colour in alcohol.

Diseases and pests: Apart from some woolly aphids and damage caused by caterpillars no real pests were encountered.

Use: According to Walker & Sillans (1961: 218) the bark is used medicinally against worms and the wood is used for carpentry (but see notes).

The wood of this species should have about the same properties as that of *Tetraberlinia bifoliolata* (Normand on *Morel 11* and Normand (1950: 132) notes it wood is similar). Fresh boles are reported to sink (*Morel 11*).

Notes: Up to now the combination *Tetraberlinia polyphylla* was attributed to Léonard. However, Voorhoeve (1965) published his book 30 days earlier, and complies with all necessary provisions. Voorhoeve, however, does credit J. Léonard as the author of the combination, so the correct author citation is "J. Léonard ex Voorh.".

Harms mentions in his (inadvertent) protologue no collections, however, his intended protologue published a few months later cites three collections: *Ledermann 821*, *Mildbraed 5549* and *Fleury in Chevalier 26690*. These three collections clearly constitute also the 'original material' used for the first publication. These three collections probably concern three different species. The first collection, *Ledermann 821*, is lost (B†). On the location were it was collected (Nkolebunde, = Mt. Elephant, ESE of Kribi) no *Tetraberlinia polyphylla* seems to be present and it lies well outside the presently known range of that species. It may concern *Bikinia le-testui* subsp. *le-testui* or *Tetraberlinia moreliana*, which are both present near the type locality (i.e *Wieringa & Haegens 2123*, *v.d Burgt 160* & *Stoffers in v.d. Burgt 208* and subsequently *Wieringa & Haegens 2105*, *2124* & *2322* & *v.d. Burgt 207*). It is unlikely that it was the first as that species has only 1–3 obscure sepals and one petal, while Harms described his species as having 4 sepals and 5 petals. He only states that the flowers of *Fleury in Chevalier 26690* are slightly larger than those of *Ledermann 821*. The second specimen mentioned, *Mildbraed 5549* concerns a sterile specimen of *Bikinia le-testui*. It has in general more jugae than is mentioned in the diagnosis, so it was probably not really used for it. Troupin (1950: 320) cited *Ledermann 821* as holotype (a valid lectotypification). However, the third specimen, *Fleury in Chevalier 26690*, is referred to as holotype by Aubréville (1968), which contravenes Art. 9.11 of the Code and cannot be accepted as such. The name *Tetraberlinia polyphylla* has been used since to refer to trees more or less alike *Fleury 26690*, whereas the already recognized but so far undescribed remaining part of the material has been named *T. moreliana*. For the stability of the nomenclature it is preferable the epithet *polyphylla* remains connected to *Fleury in Chevalier 26690*. To effect such a typification, a proposal has been submitted to conserve the name *Berlinia polyphylla* with *Fleury in Chevalier 26690* as its conserved type (Wieringa, 1999). Pending the final decision my taxonomy assumes it will be accepted.

The label on *Morel 11* reports that the species attains large dimensions but this apparently concerns hearsay of a tree which has been confused with others in those days. The sapling of *Breteler, Jongkind & Wieringa 11035*, however, was found under a large tree of at least 40 m height with a wide crown.

Walker & Sillans (1961: 218) briefly describe this species, but the identity of the material on which they based this description remains dubious. Their record about the medical uses of this species should therefore be doubted as well.

Specimens examined:

GABON: *de Boislouveau 1031* (LBV, P): Noya-Mvomenzork, 0°50'N 9°49'E (st, 13.03.1953); *Breteler, Jongkind & Wieringa 11035* (WAG): 5-30 km NNW of Ndjolé, 0°05'S 10°45'E (st, 23.04.1992); *Doucet 233* (WAG): Parcel 32 of Leroy Gabon. 0°46'-1°09'S 11°30'E-Offoué, 0°57'S 11°45'E (st, 06.12.1995); *Doucet 238* (GEMBL, WAG): Parcel 32 of Leroy Gabon, 0°46'-1°09'S 11°30'E-Offoué, 0°57'S 11°45'E (st, 06.12.1995); *Fleury in Chevalier 26690* (P) type: Kango, Ninghé-Ninghé plantation along the Bokoué river, 0°08'N 10°08'E (fl, 06.10.1912); *Le Testu 9338* (B, BM, BR, K, P, WAG): Bengwi, 0°10'N 11°10'E (fl, 24.10.1933); *McPherson 15436* (BR, WAG): along Remboué river, along road to British Gaz drill-hole 2, 0°00'N 9°50'E (fl, 23.10.1991); *Morel 11* (P): Cocobeach, Nkan on the Noya, downstream Noya-Adughe junction, 0°41'N 10°00'E (fr, 25.11.1947); *Wieringa, van Nek, Hedin & Moussavou 3122* (WAG): 26.8 km on road Lebamba to Yeno, 2°01'S 11°27'E (fr, 09.11.1994); *Wieringa, van Nek, Hedin & Moussavou 3123* (WAG): 26.8 km on road Lebamba to Yeno, 2°01'S 11°27'E (st, 09.11.1994); *Wieringa, van Nek, Hedin & Moussavou 3151* (G, IAGB, IEC, WAG (+alc)): 23.7 km on road Lebamba to Yeno, 2°03'S 11°27'E (fr, 12.11.1994); *Wieringa, van Nek, Hedin & Moussavou 3164* (WAG): 26.8 km on road Lebamba to Yeno, 2°01'S 11°27'E (st, 12.11.1994).

Tetraberlinia tubmaniana J. Léonard — Fig. 14.7, Map 14.7

Tetraberlinia tubmaniana J. Léonard: Normand, 1958: 301 (without latin diagnosis & type); Kryn & Fobes, 1959: 116–117 (without latin diagnosis & type) p.p.?; Voorhoeve, 1964 (without latin diagnosis & type); Voorhoeve, 1965: 212–217 & fig. 36 (1 March 1965, without latin diagnosis); J. Léonard, 1965: 98–102 & fig. 16 (31 March 1965); Kunkel, 1965: 194–195; Sachtler, 1968; Gottwald et al., 1968; Schäfer, 1970; Bolza & Keating, 1972: 653; Burkill, 1995: 177. **Type**: *Voorhoeve 310* (holo: BR; iso: BRLU? (not traced), K, LG, WAG) — "Africa, Liberia. Gola Forest, Loma District, Bomi Hills. 4-6-1961", in flower.

Didelotia ? sp.: Keay, 1958: 481 p.p.
Hymenostegia gracilipes auct. non Hutch. & Dalz.: Keay, 1958: 464 p.p.

Small to large tree (rarely a shrub: *Bos 2092*), 9–30(–42) m high; crown rather open, rarely reaching at least 75 m in diameter. **Bole** straight, branchless for up to 21 m, DBH up to 8–90(–110) cm: base without buttresses but often somewhat swollen or with up to 50 cm high root swellings. **Bark** up to 15(–20?) mm thick, exuding a dark brown gum (or resin?): surface smooth with lenticels and some horizontal lines, shallowly fissured in older trees, grey to bright brown; outer bark very thin; inner bark fibrous, bright brown, yellowish brown or pink-brown. Sapwood slightly pinkish pale brown, heartwood reddish brown, wood showing distinct growth rings.

Twigs greyish brown to reddish brown with pale brown lenticels, short to long pubescent, glabrescent. **Stipules** free, but sometimes touching at the very base, caducous but often persistent in saplings and treelets, ovate, slightly falcate, 5–14 x 1½–4 mm, greenish, with 5–10 veins, outsides glabrous or slightly velvety at base on the midrib, inside glabrous or pubescent at the very apex, apex acuminate, margins shortly ciliate. **Leaves** 4–16 cm long, (1–)3–6(–7)-jugate, the apical leaflet usually largest, but sometimes the middle pair or any pair from the apical half: **Petiole** 2–6 mm long, pubescent to velvety, consisting for $^{2}/_{5}$ to ¾ of the wrinkled joint; **Rachis** (0–)3–8(–13) cm long, pubescent to velvety, in fresh condition circular in cross-section, in dried condition obtriangular with a usually furrowed ridge on the upper side to 5-angular. **Leaflets** leathery, glabrous: upper side shiny, dark green with a light green primary vein; lower side pale green; margins shortly ciliate; proximal half usually elliptic to obovate, base usually rounded, rarely slightly angled and with a small auricle, margin usually sinoid towards the apex; distal half usually ovate; apex usually shortly acuminate. Young leaves red. **Basal leaflet** 8–50 x 4½–27 mm: proximal half sometimes ovate, basal corner rounded. **Apical leaflet** 12–71 x 4½–31 mm, sometimes asymmetric, its axis curved to the distal side: proximal half at base rounded, cordate or rarely sagittate, without or with a small, up to 0.6 mm long, auricle; distal half rarely obovate. **Largest leaflet** 15–83 x 6–38 mm, shape similar to the apical leaflet, auricle 0–0.6 mm long. **Gland pattern**: Usually only glands present in the distal leaflet half on the lower surface. Basal leaflet with 1–3(–4) glands, second leaflet with 0–3 glands, others with 0–1–(–2) glands (the 2 especially in the apical leaflet). Rarely 1–2 glands present in the proximal half of the basal leaflet.

Inflorescence a compound or double-compound raceme, terminal and axillary on the terminal 6(–9) nodes, one per axil, 3–8 cm long, with 2–7 branches, which are ½–3½ cm long and (2–)4–14-flowered, lower branches often branched once more. **Rachis** brown velvety-pubescent, branches laterally slightly flattened, bearing flowers in two rows. **Bracts** early caducous, ovate, circular or obovate, 2½–5 x 2½–4 mm; outside with two ribs that fuse just before the apex and are subsequently usually truncated into a nose, the entire area in between the ribs sometimes thickened, creating a swollen triangle, white and pale brown pubescent, often also brown appressed velvety in between the ribs and along the basal part of the margins, glabrous along the apical part of the margins; inside glabrous except a narrow pubescent band along the apical margin; margins shortly ciliate. **Pedicel** short, 2–4(–5) mm long, pubescent-velvety. Hypanthium s.l. 1.4–1.8 mm high. **Bracteoles** assuming a 30–100° wide angle at anthesis, ovate, 6–9 x 4½–6 mm, asymmetric, the adaxial half about half as wide as the abaxial half, greenish white, outside white and pale brown, often appressed, pubescent-velvety, midrib prominent, continuing into the pedicel, inside glabrous or pubescent, margins chaffy. **Sepals** white to greenish white, outside fairly densely to densely appressed pubescent-velvety to velvety, inside rather sparsely puberulous to pubescent, margins shortly, rarely long, ciliate. **Adaxial sepals** usually almost completely fused, rarely only at base, ovate to triangular, 3.9–5.4 x 2.5–3.9 mm, when almost free the free parts 2.0–2.7 mm wide, the two tops rounded to acute. **Lateral sepals** ovate, 3.5–4.4 x 1.3–2.0 mm, apex acute. **Abaxial sepal** triangular to oblong, 5.0–6.2 x 1.9–3.0 mm, with a distinct mid-rib, lateral margins inrolled, apex boat-shaped, rounded to subacute. **Petals** 5. **Adaxial petal** 6–8½ x 2.5–3.5 mm, medium to pale yellow, consisting of 3 parts: claw 0.5–2.0 mm long, glabrous or sparsely pubescent outside; basal

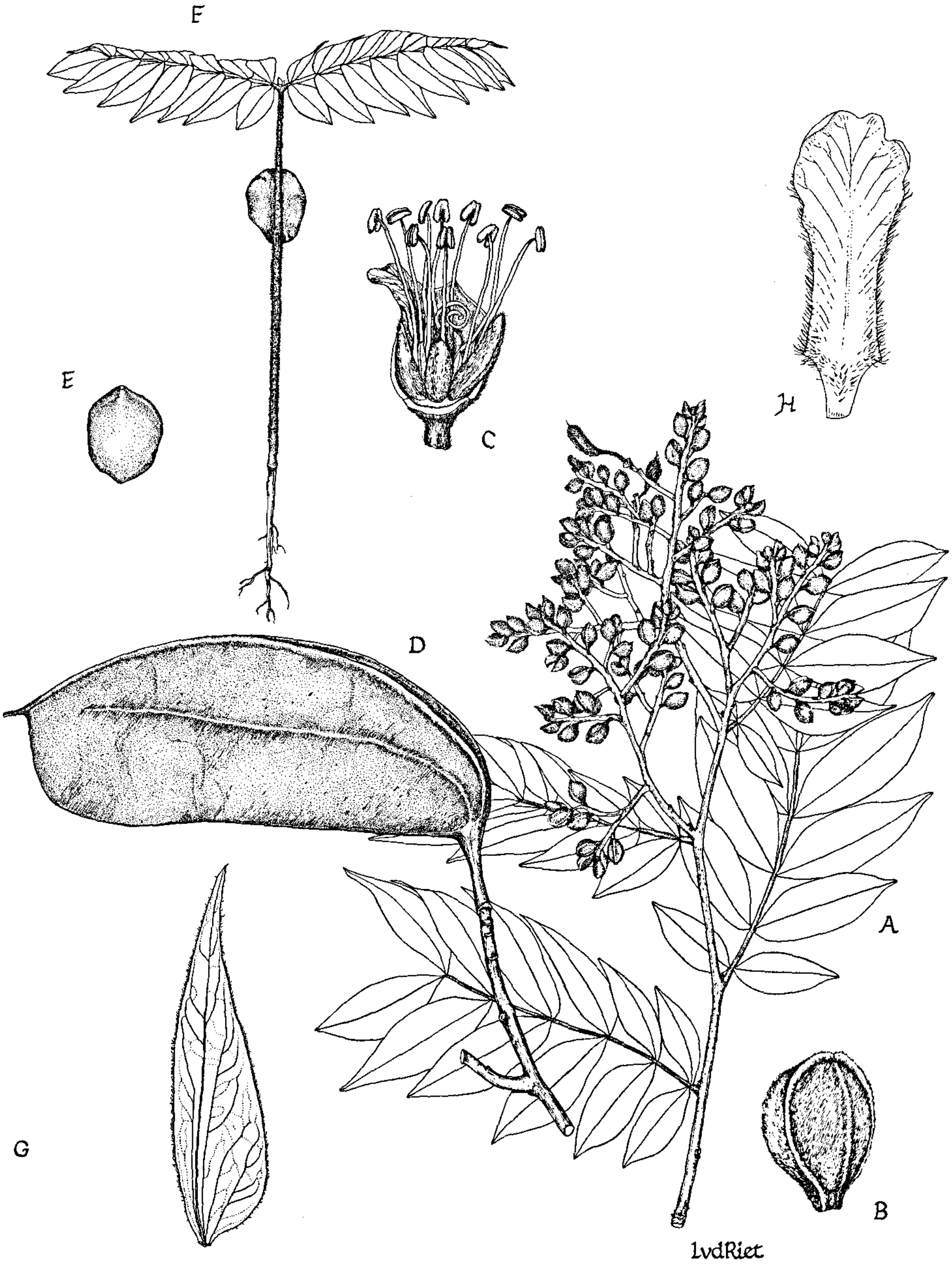


Figure 14.7. *Tetraberlinia tubmaniana* J. Léonard. — A: twig with leaves and inflorescences (x½); B: floral bud enclosed by bracteoles (x2); C: flower from lateral side with one bracteole removed (x2); D: pod (x½); E: seed (x½); F: seedling (x½); G: stipule (x8). — A: *Voorhoeve 310*; B, C: *Voorhoeve 1115*; D, E: *Voorhoeve 446*; F: *Voorhoeve 1043*; G: *Adam 16214*. A–F: published earlier in Voorhoeve, 1965; G: drawn by H. de Vries.

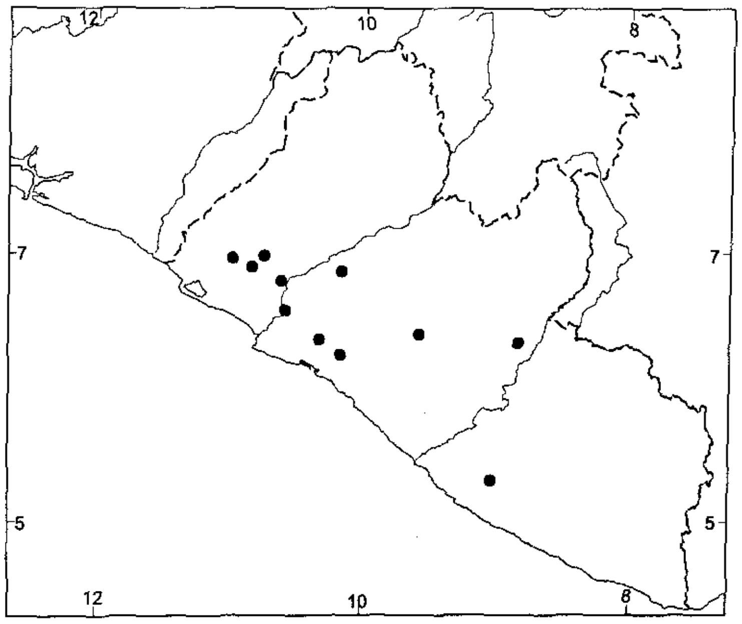
part of limb rectangular, the base sometimes auriculate, velvety on both sides along the margins, especially in basal half, and outside sometimes along the axis, margin shortly (rarely also long) ciliate; apical part of limb comparatively small, only slightly wider than basal part, more or less circular, reflexing over the supporting sepals, lateral margins shortly ciliate. **Lateral petals** linear, sometimes slightly broadening at apex, 2–4½(–8) x 0.3–0.8(–2.1) mm, glabrous, sometimes with a few hairs halfway up the lateral margins. **Abaxial petal** similar in shape and indumentum to the lateral petals but usually somewhat smaller, 1½–4½ x 0.2–0.8 mm. **Stamens** (9–)10: filaments 12–15 mm long, (8–)9 united at base over a length of 0.1–1.5 mm, white, glabrous, but base of hypanthium part fairly densely velvety, within the hypanthium filaments broadened towards the centre but at the apex of the hypanthium suddenly retreating again, above the hypanthium these filaments bending inwards; adaxial filament free, glabrous; anthers 1.7–2.0 mm long, without dorsal teeth, pollen grey to pale yellow. **Ovary** 2–4 x 1.1–1.9 x 0.4–1.0 mm, never depauperate, with 2–3 ovules, long velvety, especially along the sutures, lateral parts sometimes somewhat sparser, locule with long hairs at the dorsal side; stipe 1.4–3.8 mm long, long velvety. **Style** 7–11 mm long, inserted at an angle of 0(–30)°, glabrous except for the long velvety base; stigma heart-shaped.

Pod 1–3-seeded, oblong to oblong-obovate, 6–13 x 2.8–5.2 x 0.3–0.7 cm, glossy, finely striate-granular, during development very light green, brown to grey-brown when mature, glabrous or very sparsely set with some long hairs, especially along the sutures; beak 1½–6½ mm long; upper suture distinctly winged, 5–12 mm wide; nerve distinct, running just above or at the middle of the pod, u/w = 0.37–0.53; stipe 10–23 mm long, fairly densely long brown velvety; pedicel 2–4 mm long. **Seeds** elliptic to obovate, 16–27 x 15–20 x 4–6 mm, 0.6–1.9 g in dry condition; testa thin, fairly glossy, dark brown; cotyledons purple-brown.

Seedling: Germination epigeal. **Hypocotyl** 6–11 cm, long velvety. **Epicotyl** 3–9 cm, fairly densely short to long velvety. First pair of leaves opposite, 6–9-jugate, rachis velvety. Subsequent leaves usually 5–6-jugate.

Distribution: This species is only known from Liberia, although maps like that of Sachtler (1968) (reprinted in Schäfer (1970: 6a) and Rompaey (1993: fig. 20)) and certainly that of Bongers et al. (1999), suggest that it might grow just across the border near Grabo in Ivory Coast or maybe in small numbers just across the border with Sierra Leone. Sierra Leone has not been explored very thoroughly, so botanists might well have missed small populations. However, according to Ishmael S. Jah (Sierra Leonean forest ranger, pers. comm.) it has never been found despite extensive specific searches for it. Burkill (l.c.) states that the species occurs in Sierra Leone, but he assumes that the tradename 'Gola' refers to the Gola district in Sierra Leone, where it actually refers to the Gola country around Bomi Hills, Liberia.

The south-eastern part of the distribution of the above mentioned maps, based on forest inventories, is not confirmed by any herbarium material, but it should be considered that this corner of Liberia has hardly been visited by botanists. Still, it is remarkable that from the area (Krahn-Bassa & Sapo National Forest), in which according to Sachtler (1968: 106) and Gottwald et al. (1968) the largest stands of this species (7 million m^3 exploitable wood, compared to only 300,000 m^3 in NW Liberia!) occurs, no botanical vouchers exist. According to Schäfer (1970: 11) the most south-eastern stands occur in the western part of the Grebo National Forest, close to the border with Ivory Coast.



Map 14.7. Distribution of *Tetraberlinia tubmaniana* J. Léonard: Liberia.

Vernacular names: Liberia: Small leaf African Pine (English), according to Voorhoeve (1965: 212) also: Ho (Bassa, Gio, Gola & Kpella), according to Sachtler (1968: 107) also Sikon (Krahn-Bassa region).

Forestry name: Gola.

Trade name: Gola, but wood also traded as Ekop (Mathews et al., 1993; Kunkel, 1965) or Sikon (i.e. Bolza & Keating, 1972).

Ecology: A tree of dry-land rain forest, at 0–100 m altitude. It seems to occur mainly, if not only, gregariously. According to Schäfer (1970: 8) all *T. tubmaniana* stands in the Krahn-Bassa National Forest count about 30 trees per ha with a DBH > 40 cm, only such stands become more rare and smaller to the north and north-east. Some of the forests in Liberia (such as Krahn-Bassa N.F.) are dominated by *Tetraberlinia tubmaniana* for hundreds of square kilometres, only intersected by non-suitable areas.

The species is confined to evergreen rain forest with a precipitation of over 2300 mm/year. Data from Bongers et al. (1999) suggest that the species might be most specifically limited by a dry season of over 4 months. It will only grow on flat to slightly undulate terrain with deep soils. The terrain should not be inundated nor have a high water-table.

Phenology: Flowering occurs from mid April until mid June; withered, old inflorescences are found until July. For Bomi Hills (were most of the flowering collections came from) flowering coincides with the start of the rainy season (according to Voorhoeve (1964) and Schäfer (1970) the main rainy season lasts from May to December, but Bomi Hill receives already c. 150 mm of rain per month in March and April (Schäfer, 1970)).

Developing pods were found in July, full-grown but not yet exploding pods in September and November. Exploding pods have been collected or are reported from December to February, while seedlings and old pods were found in January and April. According to Schäfer (1970) the fruiting period lasts from November to January. The complete maturation of the pods thus takes approximately 8 months.

Flowering and fruiting is reported to occur in all years (Schäfer, 1970). The trees start flowering already at a comparatively young stage (*Voorhoeve 446*, possessing fully developed pods, concerns a tree of 8 m high, 10 cm DBH).

Young leaves are present at least in January and February, but maybe also during a second period.

Chemistry: Flowers and pods produce a strong red-brown colour in alcohol.

Diseases and pests: Some flowers appear to be attacked by some kind of insect larvae, probably of a moth species. The trees seem rather healthy: according to Schäfer (1970) heart rot of a major extent has never been found.

Uses: *T. tubmaniana* yields a medium-weight wood of 590–770 kg/m^3 at 14 % moisture content. It can be sawn as well as peeled. It is easy to saw and to process. According to Sachtler (1968: 107) the wood is good for sawing, excellent for peeling and supplies an extraordinary good pulp. Locally it is used for general construction and carpentry and also used for canoes (*Baldwin 10449*).

The species is especially interesting for forestry because of the high densities in which it occurs. According to Gottwald et al. (1968: 9) in old stands the exploitable timber per hectare can be as high as 70 m^3.

Notes: According to Voorhoeve (1964 & 1965) this species can be up to 42 m tall and attain a DBH of just over 1 m (in the 1964 publication such a tree is even drawn in a forest profile). These values have been put between brackets because they exceed the measures that are backed up by labels on voucher material. Kryn & Fobes (1959: 116) state the trees might even reach 150 feet height and 4 feet diameter, but very likely they have been misidentifying some trees, especially the larger ones, since Voorhoeve (1965: 216) states they also misidentified the photo which they published as belonging to *Tetraberlinia tubmaniana*.

Some more specific forestry measures (like bole-shape and stand densities) of this tree can be obtained from Sachtler (1968).

One flower of this species was present in the alcohol sample of *Voorhoeve 1194* which otherwise represents *Aphanocalyx pteridophyllus*. This flower was probably part of another spirit sample of Voorhoeve, which was not properly separated. Therefore, the measures of this flower have been included in the description, but the locality of this collection is **not** added to the distribution because: a) it lies just outside the known distribution of the species, b) also the collection date (21.VIII = outside flowering period) is suspect for *Tetraberlinia tubmaniana*.

Specimens examined:

LIBERIA: *Adam 16179* (MO, P, PRE): Blazie, 6°24'N 9°35'W (st, 27.11.1958); *Adam 16214* (P): Zokatown, not located (st, 28.11.1958); *Adam 16257* (MO, P, PRE): Queentown, not located (fr, 04.12.1958); *Anonymous s.n. (3)* (WAG): ?, not located (fl, fr, ?); *Baldwin 10449* (K): Boporo district, Mecca, 6°48'N 10°37'W (st, 19.11.1947); *Baldwin 10841* (BR, K): Grand Cape Mount, Mecca, 6°58'N 10°59'W (fr, 24.12.1947); *Bos 1889* (BR, K, WAG (+alc)): Bomi Hills, Gola Nat. Forest, 6°54'N 10°50'W (fl, 21.04.1966); *Bos 2092* (WAG): NE of Bomi Hills, Gola Nat. Forest, sawmill depot, 6°54'N 10°50'W (fr, 23.07.1966); *Fobes LF 1* (BR, FHO, P): Bomi-Hills, 6°54'N 10°50'W (st, 02.1954); *Harley 1496* (K): Harbel, firestone plantations, 6°22'N 10°20'W (fl, 10.04.1947); *Jones s.n. (1)* (FHO): 20 mls N of Greenville, Vanply concession, 5°19'N 9°02'W (st, 01.1971); *Jones s.n. (2)* (FHO): 20 mls N of Greenville, Vanply concession, 5°19'N 9°02'W (fl, April-May.1971); *Voorhoeve 31* (WAG): Bong Range, 6°52'N 10°10'W (fr, 23.07.1960); *Voorhoeve 310* (BR, K, LG, WAG) type: Bomi Hills, Gola Forest, 6°54'N 10°50'W (fl, 04.06.1961); *Voorhoeve 446* (BR, K, LG, MO, WAG, Z): 12 km NE of Bomi Hills, 6°54'N 10°50'W (fr, 02.09.1961); *Voorhoeve 621* (WAG): Gbi Nat. For., 6°20'N 8°50'W (fr, 04.11.1961); *Voorhoeve 690* (WAG): Bassa no III, Siga, 6°15'N 10°10'W (fr, 02.12.1962); *Voorhoeve 850* (WAG): Bomi Hills, nat. forest, 6°54'N 10°50'W (st, 06.02.1962); *Voorhoeve 851* (WAG): Bomi Hills, 6°54'N 10°50'W (st, 28.01.1962); *Voorhoeve 1043* (WAG): Yoma-Gola National Forest, Bomi-Hills, Matu-river, 6°54'N 10°50'W (st, 15.04.1962); *Voorhoeve 1115* (WAG (+alc)): Bomi Hills, 6°54'N 10°50'W (fl, 28.05.1962); *Voorhoeve s.n. (3)* (WAG (alc only)): ?, not located (fr, ?); *J.A. White A1557* (BR): Mont Serrado country, 6°35'N 10°35'W (fl, 22.06.1957); *J.A. White s.n. (1)* (BR): Bomi Hills, 6°54'N 10°50'W (fl, 07.1957); *J.A. White s.n. (3)* (BR): Bomi Hills, 6°54'N 10°50'W (fr, 17.04.1958); *J. de Wilde & Voorhoeve 3836* (A, B, BR, K, MO, P, PRE, S, WAG): c. 15 km NE of Bomi Hills, Gola Nat. Forest, 6°59'N 10°45'W (fl, 17.04.1962); *Wright 1* (WAG): Gola National Forest, Bomi Hills, 6°54'N 10°50'W (fl, fr, 03.06.1961).

15 Excluded species, names and material

excluded species:

Monopetalanthus emarginatus Hutch. & Dalziel: Hutchinson & Dalziel, 1928a: 342; Hutchinson & Dalziel, 1928b: 397. Type: *Unwin & Smythe 42* (holo: K, n.v.).
Hymenostegia emarginata (Hutch. & Dalziel) Milne-Redhead ex Hutch. & Dalz.: Hutchinson & Dalziel, 1936: 606.
Tripetalanthus emarginatus (Hutch. & Dalziel) A. Chev.: Chevalier, 1946: 597–598.
= *Plagiosiphon emarginatus* (Hutch. & Dalziel) J. Léonard: Léonard, 1951b: 426.

excluded names:

Monopetalanthus sp. (?): Aubréville, 1936: 242 (= *Didelotia brevipaniculata* J. Léonard).
Monopetalanthus sp.: Aubréville, 1970: 339 (= sterile specimen of a Mimosoideae species).
Monopetalanthus sp. A: Keay, 1958: 478 (= *Didelotia brevipaniculata* J. Léonard).
Monopetalanthus sp. B: Keay, 1958: 478 (= probaly a new species of *Hymenostegia*).

unidentified material:

The collection *Medou 1468*, identified by Letouzey as *Monopetalanthus ledermannii*, is aberrant with that species and has been discarded for its description. The leaflets do not bear an apical gland and the twigs and leaf rachis are much hairier than is usual for that species. Also leaflet shape, number and size are not within the limits of that species. For *Aphanocalyx margininervatus* it posseses too many leaflets and the nervation is not correct either. This specimen might belong to an undescribed species or be aberrant juvenile material of an existing species. Medou describes the mature tree (not unlike *A. ledermannii* or other *Aphanocalyx* subg. *Aphanocalyx*), but apparently was only able to collect sapling material.
CAMEROON: *Médou 1468* (YA): Maleke, chantier SAFA, 4°19'N 9°37'E (st, 12.1952).

The sterile collection *Constant & Bertault 228* from central Congo (Brazzaville) seems to belong to *Tetraberlinia*. It much resembles *T. longiracemosa* but has different stipules. It may represent another (so far unknown) species of *Tetraberlinia*.
CONGO (BRAZZAVILLE): *Constant & Bertault 228* (CIRAF, WAG): Sibiti, 3°41'S 13°21'E (st, 14.06.1972).

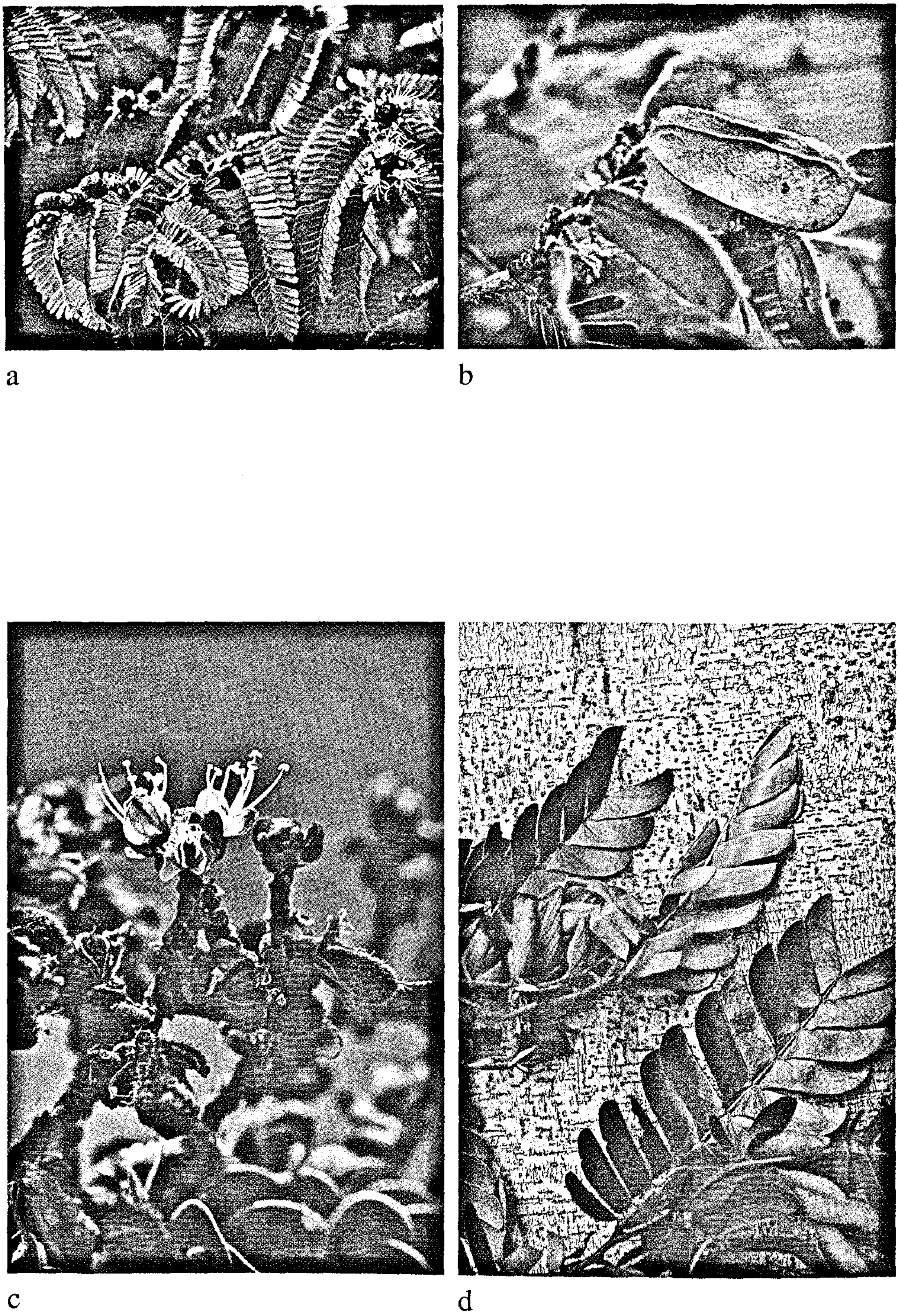


Plate 1. a & b: *Aphanocalyx microphyllus* (Harms) Wieringa subsp. *microphyllus*, a: flowering branches (*Wieringa & v.d. Poll 1345*); b: young pods (*Wieringa & Epoma 1628*); c: *Aphanocalyx obscurus* Wieringa, racemes with flowers and very young pods (*Wieringa & v.d. Poll 1544*); d: *Aphanocalyx ledermannii* (Harms) Wieringa, trunk with leaves of varying age (*Wieringa & Haegens 2433*). Photos J.J. Wieringa.

16 Literature

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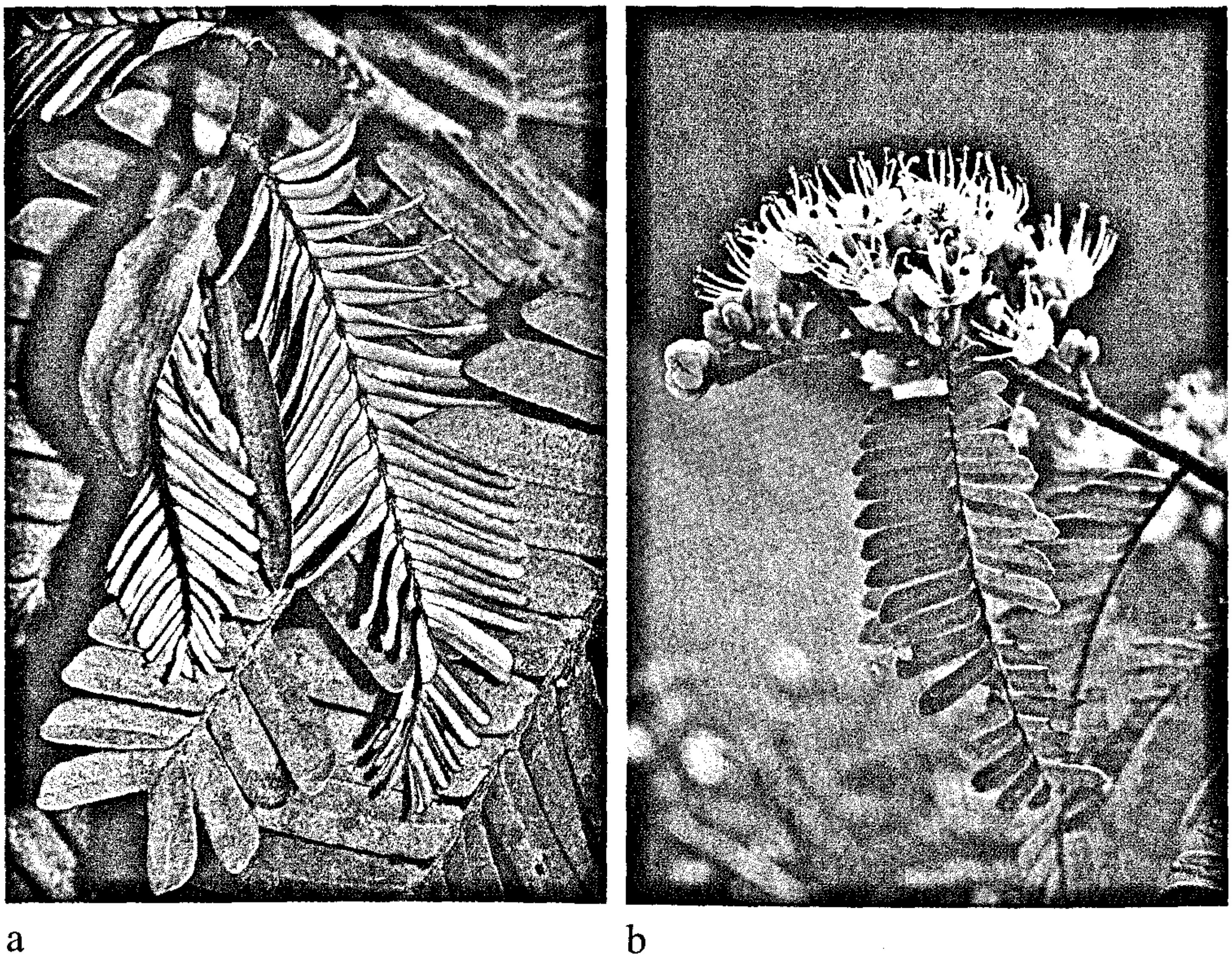

Plate 2. *Bikinia pellegrinii* (A. Chev.) Wieringa. a: flush with blood-red stipules (*Wieringa & Epoma 1606*, aff.); b: umbelliform inflorescence (*Breteler, Wieringa & Nzabi 13195*). Photos J.J. Wieringa.

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Behind each collection the identification is indicated by a code. The codes are explained in the list presented below. Doubtful identifications are indicated by a (?).

Acy = *Aphanocalyx cynometroides*
Adj = *Aphanocalyx djumaensis*
Ahd = *Aphanocalyx hedinii*
Aht = *Aphanocalyx heitzii*
Aje = *Aphanocalyx jenseniae*
Ale = *Aphanocalyx ledermannii*
Ali = *Aphanocalyx libellula*
Ama = *Aphanocalyx margininervatus*
Amc = *Aphanocalyx microphyllus* subsp. *compactus*
Ami = *Aphanocalyx microphyllus* subsp. *microphyllus*
Aob = *Aphanocalyx obscurus*
Ape = *Aphanocalyx pectinatus*
Apt = *Aphanocalyx pteridophyllus*
Ari = *Aphanocalyx richardsiae*
Asp = *Aphanocalyx* spec.
Atr = *Aphanocalyx trapnellii*

Bac = *Bikinia aciculifera*
Bbr = *Bikinia breynei*
Bcn = *Bikinia congensis*
Bcr = *Bikinia coriacea*
Bdu = *Bikinia durandii*
Bev = *Bikinia evrardii*
Bgr = *Bikinia grisea*
Ble = *Bikinia le-testui* subsp. *le-testui*
Blm = *Bikinia le-testui* subsp. *mayumbensis*
Bme = *Bikinia media*
Bpe = *Bikinia pellegrinii*

Idu = *Icuria dunensis*

Mmi = *Michelsonia microphylla*

Tba = *Tetraberlinia baregarum*
Tbi = *Tetraberlinia bifoliolata*
Tko = *Tetraberlinia korupensis*
Tlo = *Tetraberlinia longiracemosa*
Tmo = *Tetraberlinia moreliana*
Tpo = *Tetraberlinia polyphylla*
Tsp = *Tetraberlinia* spec.
Ttu = *Tetraberlinia tubmaniana*

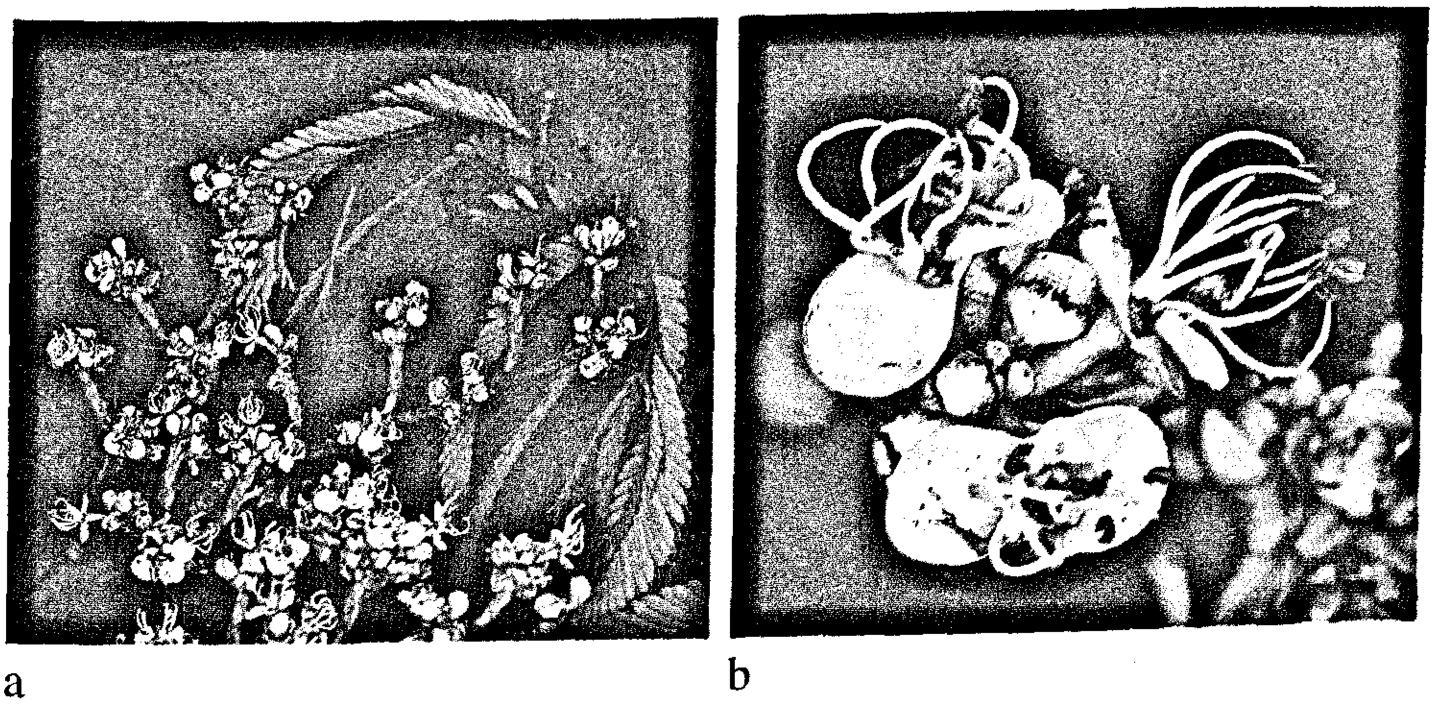

Plate 3. *Bikinia aciculifera* Wieringa (*Wieringa et al. 2977*), a: inflorescences and a branch with pending leaves (during the night); b: lateral branch (single raceme) with three flowers. Photos J.J. Wieringa.

Adam, J.-G. 16179: Ttu; 16214: Ttu; 16257: Ttu; 21724: Apt. — **Albers, P.** 47: Amc. — **Alers, M.P.T. & Blom** Lope 69: Adj. — **Alleizette, Ch. d'** 1972: Ama; 1972a: Ama. — **Ankei, Y. & T. Ankei** 79/1094: Acy; 79/1118: Ami. — **Anonymous** 7: Ble; s.n. (1): Apt(?); s.n. (2): Aob; s.n. (3): Ttu. — **Asmuth, J.R. von & Vosmeer** s.n. (1): Bpe(?). — **Aubréville, A.** 73: Adj. — **Aylmer, G.** 30: Amc; 226: Amc. — **Babault, G.** 497: Ami; 641: Ami. — **Baldwin, J.T. jr.** 10449: Ttu; 10841: Ttu; 11099: Apt. — **Bamps, P.** 711: Ari. — **Bamps & Malaisse** 8180: Ari. — **Barros Machado, A. de** 35: Ari; s.n. (1): Ari; s.n. (2): Ari. — **Barros Machado in Gossweiler** 14223: Ari. — **Bequaert** 6834: Ami. — **Bernard** 262: Ble(?); 282: Bcr; 283: Bcr(?); 284: Bpe; 285: Ble; 1330: Tmo. — **Bernard & Boislouveau** 909: Ami. — **Bingham, M.G.** 8688: Atr. — **Bois** 981: Bpe(?); 984: Tlo; 985: Tlo. — **Boislouveau, de** 857: Aht; 940: Aht; 1031: Tpo; 1032: Ami. — **Bolema, D.** 577: Acy; 1808: Adj. — **Bombali, J.** 1795: Ami. — **Bos, J.J.** 1889: Ttu; 2092: Ttu; 2100: Apt; 6542: Ble. — **Bouquet** 376: Bcn. — **Bouquet & Sita** 2242: Ami; 2366: Tbi. — **Brenan & Greenway** 8169: Ari. — **Breteler, F.J.** 10864: Ble; 10878: Aht; 11923: Ari; 12001: Atr; 12004: Atr; 12015: Ble; 12150: Aht; 12151: Aht; 12154: Aht; 13356: Amc; 13378: Amc; 13496: Tbi; 13501: Ble(?); 14644: Adj. — **Breteler & Breteler-Klein Breteler** 12176: Bgr; 12346: Ama; 12547: Tbi; 13056: Adj; 13081: Tbi; 13097: Tmo; 13103: Bpe(?). — **Breteler, Issembe, Moussavou & Pascal** 14723: Bgr; 15161: Ama; 15171: Ami; 15196: Ami; 15207: Ale; 15208: Acy; 15210: Bdu. — **Breteler & Jongkind** 10279: Tbi; 10483: Bdu; 10693: Ami; 10765: Ami. — **Breteler, Jongkind, Nzabi & Wieringa** 11431: Tbi; 11439: Tmo; 11459: Tbi; 11460: Tbi; 11479: Tmo; 11492: Tmo; 11505: Tlo; 11506: Tlo; 11525: Tbi; 11543: Aht; 11544: Aht. — **Breteler, Jongkind & Wieringa** 9455: Tmo; 9563: Tbi; 9742: Aht; 9773: Tbi; 9786: Tmo; 9837: Ama; 10907: Bdu; 10914: Aht; 11033: Tbi; 11035: Tpo; 11057: Tmo; 11099: Tbi; 11139: Aht; 11192: Ble; 11243: Ami; 11243 a: Ami; 11373: Aht; 11381: Adj. — **Breteler & Leal** 13925: Bcr; 14198: Bbr. — **Breteler, Leal, Moussavou & Nang** 13965a: Ama; 13969: Tbi; 13970: Tbi; 14015: Bac. — **Breteler, Wieringa & Nzabi** 12806: Bdu; 12820: Bdu; 12846: Tbi; 12857: Ble(?); 12865: Ami; 12868: Acy; 12880: Bdu; 12899: Bdu(?); 12928: Tbi; 12957: Ble; 12967: Bdu; 12970: Aht; 12972: Bcr; 13171: Tbi; 13189: Bgr; 13195: Bpe; 13211: Bgr; 13239: Ami; 13244: Bpe; 13264: Ble; 13282: Ape; 13291: Acy; 13292: Acy; 13295: Bme(?); 13305: Bpe; 13311: Ama; 13334: Bgr; 13345: Acy. — **Breteler & de Wilde** 630: Adj. — **Breyne, H.** 2921: Bbr; 3155: Bbr; 3183: Bbr; 3208: Bbr; 3268: Bbr; 3311: Bbr; 3338: Bcn; 3466: Bcn; 3508: Bbr; 3534: Bcn; 3648: Bbr; 3984: Bbr; 4488: Bcn. — **Brigade d'Inventaire, Edea** 918: Ami. — **Bullock, A.A.** 651: Tbi; 3874 bis: Ari. — **Bunougou** s.n. (1): Tbi. — **Burgt, X.M. v.d.** 9: Tmo; 17: Tbi; 55: Tlo; 58: Tbi; 66: Tmo; 75: Tmo; 76: Tmo; 94: Aht; 107: Tbi; 109: Tlo; 160: Ble; 207: Tmo(?); 335: Ami; 548: Tko. — **Burgt, v.d. & Amombo** 313: Tbi. — **Burgt, v.d. & Laan** 208: Ble. — **Burgt, v.d., van Gemerden, Laan & Ek** 212: Ble; 213: Ble. — **Burtt, B.D.** 5994: Ari; 5995: Ari. — **Butaye, R.P.** s.n. (1): Ami; s.n. (2): Ami. — **Butaye in Gillet** 3494: Bcn. — **Callens, H.** 135: Aob; 148: Aob; 148bis: Bcn; 2849: Bcn; 4542: Bcn. — **Camp, J.H.** s.n. (1): Ape(?). — **Carvalho** 4750: Tbi; 5265: Ble. — **Chevalier** 26935: Tlo. — **Compère, P.** 1270: Bcn; 2171: Aob. — **Constant, J.P.** 24: Bpe; 65: Ami; 115: Tbi. — **Constant & Bertault** 228: Tsp(?); 261: Bcn(?); 286: Blm. — **Corbet** 742: Tmo; 772: Ami. — **Dawe, M.J.** 562: Apt. — **Deckoussoud** 3: Bbr. — **Deighton** 1209: Apt; 6150: Apt. — **Descoings, B.** 7627: Bev; 8403: Ami. — **Desenfans, R.** 3888: Ari; s.n. (1): Ari. — **Devred, R.** 2314: Ale; 2760: Aob. — **Dhetchuvi, M.M.** 563: Ami; 747: Ale; 853 B: Ale; 1040: Ami. — **Dibata** 279: Bdu; 286: Bev; 516: Bme; 548: Ama; 708: Aht; 789: Ble; 865: Ble; 866: Ble; 876: Aht; 882: Bpe; 1206: Bgr; 1207: Ami; 1274: Bpe. — **Dibata in MINKébé series** C 82: Tbi; C 87: Bev(?); C 146: Ami; C 175: Ami; C 398: Acy; C 447: Tbi; C 483: Tbi; D 18: Bev; D 19: Bev; D 23: Bev; E 16: Bev; E 69: Bev; E 139: Bev; E 167: Bev; E 182: Bev; E 206: Acy; E 287: Tbi. — **Dibata & Wilks** 1141: Bcr(?). — **Dinklage, M.** 1720: Apt; 2924: Apt. — **Dold, T.** 3362: Idu. — **Dold, Avis & Lubke** 3312: Idu. — **Donis, C.** 3615: Acy; 3616: Acy; 3640: Acy; 3641: Acy; 3642: Acy. — **Doucet, J.L.** 24: Ama; 233: Tpo; 238: Tpo; 269: Bdu; 276: Ami; 278: Bcr(?). — **Dowset-Lemaire** 1390: Ami; 1455: Ami; 1589: Tbi; 1769: Acy; 1770: Bev; 1899: Bev. — **Durand** 1369: Bdu; 1584: Ami; 1656: Bpe; 1684: Ble. — **Duvigneaud** 4561: Ari. — **Duvigneaud & Timperman** 2451 M1: Ari; 2451 M2: Ari; 2453: Ari. — **Eckendorf** 118: Acy. — **Ejiofor FHI** 29313: Tbi; 29322: Tbi. — **Endengle, E.** 67: Ami. — **Estasse** 199: Ble; 571: Ble; 589: Tbi; 662: Tmo. — **Evrard, C.** 2263: Ami; 3890: Ale; 4042: Ami; 4092: Ami; 4115: Bev; 4158: Ami; 4562: Adj; 4659: Aob; 4728: Acy; 5277: Adj; 6014: Bev; 6241: Ami. — **Ewango, C.E.N.** 852: Ami. — **Fanshawe, D.B.** 4343: Ari; 4919: Ari; 5023: Ari; 5148: Ari; 5208: Ari. — **Farron, C.** 4544: Ami; 5294: Ami. — **Flamigni** 8077 bis: Aob; 10107a: Tbi; 10107b: Tbi. — **Fleury in Chevalier** 26690: Tpo. — **Florence, J.** 292: Adj; 1607: Adj. — **Floret, J.J.** 552: Ami. — **Floret, Louis & Moungazi** 1796: Adj; 1805: Adj; 1921: Adj. — **Fobes, E.W.** LF 1: Ttu. — **Fontinha, M. in Gossweiler** 14223b: Ari. — **Forest Herbarium Ibadan** 1362: Ami; 12029 a: Ami; 12029 b: Ahd. — **Foresta, H. de** 1878: Ami; 1980: Bme(?); 1981: Bme(?); 1982: Bme(?). — **Gartlan, J.S.** 5: Tko. — **Gauchotte** 1160: Ale; 1718: Bpe(?); 1720: Bpe(?); 1738: Bpe(?); 1768: Ble; 1775: Aht; 1838: Ami. — **Gavage** s.n. (1): Tbi; s.n. (2): Tbi. — **Gemerden, B.S. van** 38: Tbi; 278: Ble; x 733: Tbi. — **Germain, R.**

2554: Bcn; 2666: Ami; 7320: Ami; 7996: Acy. — **Ghesquière, J.** 712: Ami. — **Gilbert, G.** 7691: Acy; 8108: Ami; 8286: Acy; 8287: Acy; 8553: Ami; 8571: Ami; 8670: Ami; 8890: Ami; 9141: Acy; 9301: Acy; 9303: Acy; 9407: Ami; 9427: Acy; 9459: Acy; 9478: Acy; 9801: Ami; 9802: Ami; 14412: Adj. — **Gillardin** s.n. (1): Acy. — **Gillet** 2800: Adj. — **Glover, P.E.** s.n. (1): Atr. — **Glover in Brédo** 6124: Ari; 6260: Atr. — **Gomes e Sousa, A.** 4865: Idu. — **Gossweiler, J.** 7068: Tbi; 11675: Ami. — **Gouteix** 1056: Tbi. — **Greenway & Trapnell** 5580: Atr. — **Griffon du Bellay** 160: Aht. — **Groulez, J.** 614: Blm(?); 699: Aht; 1076: Aht; 1263: Bcr; 1265: Tbi; 1266: Ble; 1267: Aht; 1268: Bdu. — **Guigonis** 795: Bdu(?). — **Guillaumet, J.L.** 1833: Amc. — **Gutzwiller, R.** 1396: Ami. — **Haegens, R.M.A.P. & v.d. Burgt** 223: Tlo. — **Hallé, N.** 1028: Aht; 2363: Bdu; 3115: Ami; 3142: Bpe(?). — **Hallé, N. & Cours** 5949: Bme. — **Hallé, N. & Le Thomas** 82: Ble; 83: Bpe; 112: Bev; 251: Adj. — **Hallé, N. & Villiers** 5390: Bdu. — **Hallé, F.** 4318: Tbi. — **Harley, W.J.** 1485: Amc; 1496: Ttu. — **Hart, T.B.** 285: Ami. — **Harten, A.M. van** 205: Apt; 343: Amc. — **Hédin** muj 1: Ahd. — **Heitz** 16: Aht. — **Hladik** 1536: Adj. — **Hombert** 419: Tbi. — **Hornby, H.L.** 1015: Ari. — **Hoshino, J.** 30: Tbi; 32: Tbi; 34: Tbi; 38: Tbi; 43: Tbi; 50: Tbi; 47814 HNC: Tbi; 1/84: Tbi. — **Hoyle** 1052: Ari. — **Huart, A.** 138: Ari. — **Huet, J.** 85: Aob. — **Hulstaert, R.P.** 1556: Ami. — **Ibinga** 33: Bev. — **Ibinga in MINKébé series** C 97: Ami. — **Issembe** 17: Ble; 21: Ama; 22: Aht; 33: Tbi. — **I.N.E.F.** s.n. (1): Ami; s.n. (2): Aht. — **Jans, E.** 1005: Bev. — **Jansen, J.W.A.** 979: Apt; 2244: Apt. — **Jensen, Mrs. K.** 25: Aje. — **Jespersen** 1911: Ami. — **Johnson, C.F. & Avis** 556: Idu; 660: Idu; 694: Idu. — **Jones, B.E.** s.n. (1): Ttu; s.n. (2): Ttu. — **Kaji, M.** 274: Tbi. — **Kibungu Kembelo, A.O. in J.J. Wieringa** 3466: Bcn; 3467: Bcn; 3468: Bcn. — **Koechlin, J.** 5747: Bev. — **Koufani, A.** 164: Bpe. — **Laurent, M.** 480: Bcn. — **Lawton, R.M.** 150: Ari; 161: Ari; 964: Ari; 979: Ari. — **Le Testu, G.** 5251: Ami; 5432: Tbi; 5463: Tbi; 5741: Ami; 5899: Tbi; 5941: Tbi; 6024: Bpe; 6069: Ape; 7483: Ama; 7987: Tbi; 7998: Tbi; 8418: Ama; 8820: Bpe; 8824: Ami; 8850: Tbi; 9073: Tbi; 9082: Tbi; 9090: Bgr; 9171: Ami; 9314: Ble; 9338: Tpo; 9504: Tbi; s.n. (1): Tbi; s.n. (2): Tbi. — **Leal, M.** 75: Ama; 168: Bgr. — **Lebrun, J.** 11308: Bev. — **Lecomte, H.** s.n. (1): Tbi. — **Ledermann** 444: Ale. — **Leeuwenberg, A.J.M.** 9155: Tbi; 9157: Ama; 9928: Ami. — **Leeuwenberg & Berg** 9763: Ami. — **Leeuwenberg, Persoon & Nzabi** 13604: Ama; — **Leeuwenberg & Voorhoeve** 4927: Amc. — **Lejoly, J.** 806: Ami; 856: Ami. — **Léonard, A.** 1710: Mmi; 1768: Mmi; 1800: Mmi; 2227: Ari; 2897: Ari; 3331: Ari; 3331 bis: Ari; 3744: Mmi; 3782: Mmi; 4685: Ami; 5011: Ari. — **Letouzey, R.** 1278: Bpe; 1279: Bpe; 1280: Ble; 1280a: Ble; 1281: Bpe(?); 1319: Tbi; 1407: Tbi; 1408: Ble; 1415: Tbi; 1416: Tbi; 1417: Ble; 1434: Ami; 1440: Ama; 1443: Ble; 1445: Tbi; 1455: Tbi; 1458: Ble; 1460: Ahd; 1463: Ahd; 1848: Ama; 8235: Bpe; 8235 bis: Bpe; 9239: Ama; 9242: Ami; 9846: Bpe; 9980: Ami; 10012: Bpe; 10115: Bpe(?); 10203: Acy; 10250: Ami; 10332: Ami; 10334: Ami; 11394: Bpe; 11416: Ami; 12533: Ami; 12755: Ami; 13273: Ami; 13700: Ami; 13709: Ble; 14771: Tbi; 14771 bis: Tbi; 15112: Tko; 15118: Tko; 15257: Ami; s.n. (1): Ahd; s.n. (2): Ble; s.n. (3): Tbi. — **Liben, L.** 2588: Ami. — **Lisowski, S.** 15302: Mmi; 40440: Ami; 52426: Ami. — **Louis, A.M., Breteler & de Bruijn** 584: Adj. — **Louis, A.M. & Oberson** 2255: Tbi. — **Louis, J.** 3561: Ami; 3814: Acy; 4208: Ami; 6333: Ami; 6363: Ami; 13815: Acy; 14328: Acy; 14341: Acy; 14832: Ami; 15188: Acy; 16113: Ami. — **Lubke & Avis** 3090: Idu. — **Lynes, H.** 193: Aob; 194: Ami. — **Maesen, v.d. & de Bruijn** 5968: Tbi. — **Makany, L.** 1150: Ami. — **Malaisse & Robbrechts** 2220: Ari. — **Maley & Mezili** s.n. (1): Bpe; s.n. (2): Ble. — **Mann, G.** 1810: Acy. — **Marteau** 619: Blm(?); 620: Blm. — **Maudoux, E.** 3169: Acy. — **Mayer, K.R.** 99: Apt; 121: Amc. — **McKey, D.** 66: Tko; 75: Tbi; C91 4/34: Tbi. — **Mckey & Gartlan** 84: Tpo(?); 253: Ama. — **McPherson, G.** 13849: Aht; 14014: Tbi; 15436: Tpo. — **Médou, J.** 1468: Asp; 1756: Tbi; 1767: Ble(?); 1807: Ble; 1813: Ble; 1825: Tbi; 1827: Ble; 1828: Tbi; 1829: Bpe; 1830: Bpe. — **Meiren, J.J. van der** 50: Ami. — **Mercier?** s.n. (1): Ami. — **Michelmore** 470: Ari. — **Michelson, A.** 199: Ami; 268: Acy; 520a: Mmi; 520b: Tba; 531: Ami; 654: Mmi; 819: Ami; 825: Ami; 826: Acy; 844: Mmi; 882: Mmi; 955: Ami; 1068: Mmi. — **Mildbraed** 5549: Ble; 6062: Ble; 6141: Ami. — **Mitani, M.** 71: Tbi; 72: Tbi. — **Mogg** 32309: Idu. — **Mokagna in MINKébé series** B 43: Bev. — **Mondjo, J.-P.** 17: Tbi; 269: Bev; s.n. (1): Bgr; s.n. (2): Bpe; s.n. (3): Ble. — **Morel** 8: Tmo; 10: Tbi; 11: Tpo; 19: Aht; 20: Tbi; 23: Bpe(?); 51: Tlo; 52: Aht; 53A: Tbi; 53B: Tbi; 100: Bdu; 102: Bgr; 103: Tbi; 107: Tlo; 109: Ami; 130: Bcr; 132: Ami; 133: Bcr; 134: Bcr; 179: Tmo; 180: Ami; 185: Tbi; 715: Ami. — **Morel & Gauchotte** 89: Tlo; 90: Tlo. — **Moungazi in MINKébé series** C 299: Tbi. — **Mounter** s.n. (1): Tmo. — **Moureau, J.** s.n. (1): Adj. — **Mpom, B.** 5: Ble; 261: Tbi; 1669: Tbi; 1675: Bpe; 1681: Tbi; 1682: Ble; 1684: Ble; 1685: Ble; 1688: Ble; 1691: Ble(?); 1792: Tbi; 1832: Ahd; 2673a: Bpe(?). — **Nannan** 52: Ami. — **Ndoum, D.** 110: Tbi. — **Nek, F.I. van** 215: Tlo; 702: Bpe(?); 725: Tbi; 727: Tbi. — **Nemba, Thomas & Bromley** 764: Ami. — **Nkogno in MINKébé series** N 1: Ble. — **Normand, D.** 9: Tbi; 80: Ami; 205: Tbi; 219: Aht; 280: Ble; 395: Ami; 402: Ami; s.n. (1): Ahd; s.n. (2): Ami. — **Nsimundele** 462: Bcn; 463: Bcn; 470: Bcn. — **Obama, C.** 840: Tbi. — **Obiang** 24: Ble. — **Olom C.T.F.T.** 2127: Ble; 2128: Aht. — **Pageix** 5: Bgr; 9: Bev. — **Paquay, L.** 8: Ami. — **Pauly** 126: Tbi. — **Pauwels, L.** 1748: Ami; 2300: Bcn; 3016: Ami; 5615: Bcn. — **Pierlot, R.** 244: Ami; 717: Ami; 2186: Ami; 2913: Ari.

— **Procter, J.** 479: Ari; 1879: Ari; 1948: Ari. — **Raimundo F., Matos & Figueira** 619: Ali. — **Reitsma, J.M.** OF 19-34: Ale. — **Reitsma, J.M. & B. Reitsma** 725: Ble; 1194: Bpe; 1195: Ble; 1197: Bpe; 1213: Ble; 1234: Tbi; 1433: Ble; 1463: Ble; 1480: Ble; 1556: Bgr; 1557: Tbi; 1559: Ble; 1563: Bpe(?); 1583: Ble(?); 1601: Tbi; 1982: Bpe; 1990: Bpe; 1991: Bpe(?); 1992: Tbi; 2201: Tbi; 2727: Bpe(?); 2894: Bpe; 2953: Ble; 3070: Ble; 3107: Tbi. — **Reitsma, J.M., B. Reitsma & Mezui** 2495: Bpe; 2501: Tbi. — **Reitsma, J.M., B. Reitsma & Wilks** 3271: Tbi; 3282: Aht. — **Renier, M.** 15: Ale; 86 A: Aob; 121 B: Aob. — **Richards, M.A.E. (H.M.)** 1544: Ari; 1547: Ari; 4483: Ari; 10060: Atr; 10198: Atr(?); 10199: Atr; 10203: Ari; 19612: Atr; s.n. (1): Ari; s.n. (2): Ari; s.n. (3): Ari. — **Rossignol** 25: Ami. — **Saint-Aubin, G. de** 670: Bme; 1916: Tbi; 1935: Bcr; 1937: Ble; 1938: Tbi; 1945: Bme; 1964: Bpe; 1966: Bgr; 1991: Bdu; 1993: Tmo; 2003: Bdu; 2011: Ble(?); 2016: Tmo; 2022: Tlo; 2025: Tlo; 2079: Ami. — **Sanjinje** 48: Ari; 442: Ari; 443: Ari. — **Sapin** s.n. (2): Aob; X: Adj. — **Schmitz, A.** 6664: Ari. — **Schoenmaker, J.** 7: Tmo; 157 B: Tbi; 351: Tmo; 367: Aht; 401: Ble(?); 405: Tmo. — **Sita, P.** 1540: Bcn; 2618: Ami; 3516: Acy; 4137: Tbi; 4547: Blm; 4575: Bpe; 4802: Tbi; 4933: Ami; 4938: Adj; 5956: Blm. — **Small, D.** 735: Apt; 836: Apt. — **Sonké** 1194: Tbi; 1236: Ami. — **Sota, D.** s.n. (1): Ami. — **S.R.F.** s.n. (1): Aht. — **Staudt** 229: Ble. — **Stevenson, D.** 156/30: Ari. — **Straub, F.C.** 866: Apt. — **Tailfer** 73: Aob. — **Takahatu, Y.** 416 a: Ari. — **Tchouto Mbatchou, G.P.** 614: Ble(?). — **Team of C. Wilks** s.n. (1): Bev; s.n. (2): Ami; s.n. (3): Bev; s.n. (4): Bev; s.n. (5): Bev; s.n. (6): Bgr; s.n. (7): Bgr; s.n. (8): Tmo. — **Tengué in MINKébé series** A 50: Bev; A 360: Ble; A 596: Bpe; A 609: Ble; A 610: Bpe; B 244: Bpe(?). — **Terashima** 192: Acy. — **Tessmann** 592: Tbi. — **Thomas, D.W.** 411: Tko; 418: Tbi; 508: Ale; 590: Ami; 1199: Ama; 2276: Tko; 4119: Tko; 4723: Tko; 6812: Tko; 8012: Ami; 8179: Ble(?); 8181: Ble; 8250: Ami; 9816: Ble; 9857: Tbi; 9960: Ble. — **Thomas, Mambo & Namata** 7535: Ami; 7633: Ama. — **Thomas & Wilks** 6354: Tbi; 6512: Bpe. — **Tonnelle** 1457: Ble. — **Trapnell, C.G.** 1750: Ari; 1822: Atr. — **Trochain, J.** 8434: Ami. — **Troupin, G.** 4542: Ami; 7772: Ami; 9316: Ami. — **Vanderijst** 10356: Aob. — **Vesey Fitzgerald** s.n. (1): Ari. — **Villiers** 148: Tbi(?). — **Voorhoeve, A.G.** 31: Ttu; 60: Apt; 298: Amc; 310: Ttu; 446: Ttu; 548: Amc; 587: Amc; 621: Ttu; 690: Ttu; 801: Amc; 831: Apt; 850: Ttu; 851: Ttu; 939: Amc; 1013: Amc; 1042: Apt; 1043: Ttu; 1083: Amc; 1115: Ttu; 1145: Amc; 1194: Apt; s.n. (1): Amc; s.n. (2): Apt; s.n. (3): Ttu; s.n. (4): Apt; s.n. (5): Apt. — **Wagemans** 190: Tbi. — **Walker** s.n. (1): Tbi; s.n. (2): Tlo. — **White, F.** 3556: Ari. — **White, J.A.** A15-57: Ttu; s.n. (1): Ttu; s.n. (3): Ttu. — **White, L.** 12: Aht; 949: Adj; 1092: Adj. — **Wieringa, J.J.** 1114: Tlo; 1115: Tlo; 1305: Tbi; 1309: Ale; 1310: Ale; 1318: Tbi; 2863: Tlo; 3304: Tbi; 3307: Ble(?); 3309: Bcr. — **Wieringa & Epoma** 1606: Bpe; 1608: Tmo; 1626: Tlo; 1628: Ami; 1651: Bpe. — **Wieringa & Nzabi** 1050: Bpe; 1051: Bpe; 1181: Tmo; 1191: Tbi; 1667: Bev; 1681: Bgr; 1689: Bev; 1690: Bev; 2775: Ble; 2806: Ale; 2828: Bpe; 2846: Ale; 2850: Tlo. — **Wieringa & van de Poll** 1345: Ami; 1346: Ami; 1399: Ami; 1400: Ble(?); 1428: Ble; 1429: Ble; 1432: Tbi; 1442: Tmo; 1444: Bme; 1445: Bme; 1466: Bgr; 1471: Ama; 1487: Bgr; 1488: Bgr; 1494: Bgr; 1495: Bgr; 1495 A: Bpe; 1500: Ape; 1501: Ama; 1540: Aob; 1541: Aob; 1542: Ale; 1543: Ale; 1544: Aob; 1554: Bme; 1568: Bpe(?); 1587: Aht; 1596: Bdu. — **Wieringa & van Nek** 3270: Tlo. — **Wieringa, Haegens *& van der Burgt*** *2372: Tmo; 2373: Tmo; 2601: Tlo.* — **Wieringa, J.J. & Haegens** 2105: Tmo(?); 2109: Tbi; 2123: Ble; 2124: Tmo(?); 2130: Tbi; 2199: Ble; 2263: Ale; 2300: Ble; 2301: Ble; 2322: Tmo(?); 2328: Tbi; 2355: Acy; 2366: Tmo(?); 2376: Tbi; 2385: Tlo; 2386: Tlo; 2400: Ale; 2409: Aht; 2433: Ale; 2439: Aht; 2441: Tbi; 2458: Tbi; 2527: Tbi; 2529: Tbi; 2558: Ami; 2559: Ami; 2589: Tbi. — **Wieringa, van Nek & Moussavou** 3078: Tbi; 3102: Ape; 3103: Ami. — **Wieringa, van Nek, Hedin & Moussavou** 2920: Bac; 2977: Bac; 2984: Bdu; 3016: Aht; 3021: Bdu; 3023: Tbi; 3122: Tpo; 3123: Tpo; 3125: Bme; 3130: Ble; 3151: Tpo; 3154: Tlo; 3157: Tbi; 3164: Tpo; 3165: Tmo; 3180: Bme; 3222: Ble. — **Wilde, J.J.F.E. de** 8374: Tbi. — **Wilde, J.J.F.E. de & v.d. Maesen** 10964: Aht; 11061: Ami; 11088: Blm. — **Wilde, J.J.F.E. de, v.d. Maesen, Bourobou & Moussavou** 11458: Adj. — **Wilde, J.J.F.E. de & Voorhoeve** 3659: Amc; 3836: Ttu. — **Wilde, J.J.F.E. de & de Wilde-Bakhuizen** 11635: Ami. — **Wilde, J.J.F.E. de, v.d. Maesen & Maley** 11591 A: Bpe. — **Wilks, C.** 122: Aht; 237: Bcr(?); 447: Tbi; 642: Tbi; 646: Ble; 676: Bgr; 721: Bdu; 737: Aht; 849: Bgr; 849 a: Bme; 973: Aht; 984: Tbi; 1015 bis: Bme; 1022: Acy; 1042: Ble(?); 1046: Tbi; 1062: Bdu; 1109: Bpe; 1143: Aht; 1332: Ami; 1342: Bpe; 1359: Bgr; 1396: Bgr; 1412: Ami; 1423: Tbi; 1429: Bpe; 1430: Ble; 1447: Bpe; 1448: Bpe; 1450: Bgr; 1451: Bgr; 1460: Ama; 1470 a: Bpe; 1513: Bac; 1673: Bgr; 1673 B: Bev; 1679: Bpe; 1925: Tbi; 1927: Ama; 1934: Ami; 1936: Ami; 1961: Ami; 1965: Ape; 1976: Bme; 1980: Bpe; 1981: Ami; 1988: Adj; 1990: Acy; 1991: Bev; 1994: Adj; 2523: Aht; 2524: Aht; 3514: Ami; 3523: Bpe; s.n. (1): Bcr. — **Wilks in MINKébé series** A 17: Bpe; C 27: Bev; C 279: Bev; C 286: Bev; S 41: Bev; S 81: Ami; S 226: Ami; W 80: Ami; W 438: Bev; W 439 B: Tbi; W 510: Adj; W 549: Adj. — **Wilks & Dibata** 2554: Bcr; 2693: Bdu. — **Winter, A.J. de** 45: Ble; 94: Ble; 96: Bpe; 100: Bpe. — **Wit, H.C.D. de** 9418: Ami; s.n. (1): Amc. — **Wright, M.C.** 1: Ttu. — **Yafunga, F.** 136: Ami. — **Yapi & Tehe** 914: Amc. — **Zenker, G.** 577: Tbi; 2275: Tbi; 2675: Tbi; 2949: Tbi; 3751: Ama; 4164: Tbi; 4511: Tbi; s.n. (1): Tbi; s.n. (2): Tbi; s.n. (3): Tbi; s.n. (4): Tbi; s.n. (5): Tbi; s.n. (6): Tbi.

18 Index

The pages where a species or genus is described and those where the distribution map and illustration can be found are listed in bold. Synonyms are listed in *italics*.

Appendix 1. Trees of the two 1-ha plots

number		E	S	dbh	h.	family	genus	epithet	coll
Plot:		**1**							
G	1	2	3	79	-	LEGCAES	Tetraberlinia	moreliana	-
G	2	15	1	90	-	LEGMIM	Calpocalyx	heitzii	-
G	3	41	7	134	-	LEGCAES	Tetraberlinia	moreliana	-
G	4	60	7	53	-	LEGCAES	Hymenostegia?		-
G	5	97	9	134	-	LEGCAES	Tetraberlinia	moreliana	-
G	6	13	25	73	-	LEGMIM	Calpocalyx	heitzii	-
G	7	36	25	68	-	BURSERA	Dacryodes ?	igaganga ?	-
G	8	78	23	107	-	IRVINGI	Klainedoxa	gabonensis	1184
G	9	9	39	63	-	BURSERA	Dacryodes	igaganga	-
G	10	77	36	79	-	LEGCAES	Tetraberlinia	moreliana	-
G	11	20	44	100	-	SIMAROU	Odyendyea	gabonensis	-
G	12	42	49	55	-	LEGCAES	Tetraberlinia	moreliana	1181
G	13	47	49	81	-	LEGCAES	Librevillea	klainei	1193
G	14	52	50	120	-	LEGCAES	Erythrophleum	ivorense	1191
G	15	17	54	50	-	LEGCAES	Tetraberlinia	bifoliolata	-
G	16	60	54	50	-	LEGCAES	Tetraberlinia	bifoliolata	1192
G	17	97	56	54	-	OLACACE	Coula	edulis	-
G	18	29	63	72	30	LEGCAES	Crudia	gabonensis	2585
G	19	52	63	83	-	SIMAROU	Odyendyea	gabonensis	1194
G	20	78	67	70	31	LEGCAES	Tetraberlinia	bifoliolata	-
G	21	61	70	70	-	SIMAROU	Odyendyea	gabonensis	-
G	22	100	74	70	38	LAURACE	Beilschmidtia		2463
G	23	90	81	90	35	LEGCAES	Tetraberlinia	moreliana	-
G	24	1	99	66	35	LEGCAES	Librevillea	klainei	1382
G	25	26	94	56	28	EBENACE	Diospyros	rabiensis	2590
G	26	28	96	53	-	LEGCAES	Tetraberlinia	bifoliolata	-
G	27	86	94	51	30	LEGCAES	Librevillea	klainei	2461
M	1	5	7	48	40	VOCHYSI	Erismadelphus	exsul	2584
M	2	35	10	47	-	LEGCAES	Tetraberlinia	bifoliolata	1305
M	3	95	3	40	-	LEGCAES	Neochevalierodendro	stephanii	1642
M	4	73	13	47	21	OLACACE	Diogoa	zenkeri	1185
M	5	38	25	41	-	LEGCAES	Hymenostegia	ngounyensis	-
M	6	64	28	43	-	LAURACE	Beilschmidtia		1200
M	7	46	39	43	-	LEGCAES	Tetraberlinia	bifoliolata	-
M	8	27	56	43	-	LEGCAES	Tetraberlinia	bifoliolata	-
M	9	29	90	42	-	OLACACE	Coula	edulis	-
M	10	12	96	46	30	LEGCAES	Tetraberlinia	bifoliolata	2589
M	11	14	95	46	8	OLACACE	Coula	edulis	3295
M	12	79	98	45	29	LEGCAES	Tetraberlinia	bifoliolata	2458
M	13	53	54	46	-	EUPHORB	Klaineanthus	gaboniae	1196
S	1	47	2	37	-	?			-
S	2	68	2	30	-	?			-
S	3	1	12	35	-	LEGCAES	Tetraberlinia	bifoliolata	-
S	4	33	16	34	-	LEGCAES	Tetraberlinia	bifoliolata	-
S	5	44	12	31	-	?			-
S	6	38	23	35	16	OLACACE	Strombosiopsis	tetrandra	3300
S	7	84	25	33	-	OLACAC?			-
S	8	12	32	34	-	LEGCAES			-
S	9	12	37	32	-	OLACAC?	Coula ?	edulis ?	-
S	10	24	32	33	-	LEGCAES	Tetraberlinia	bifoliolata	-
S	11	31	33	30	-	LEGMIM	Calpocalyx	heitzii ?	-
S	12	59	39	36	-	?			-
S	13	48	47	38	-	LEGCAES	Hymenostegia ?		-
S	14	54	47	34	-	OLACAC?	Coula ?	edulis ?	-
S	15	79	48	32	-	LEGCAES	Tetraberlinia	bifoliolata	-
S	16	82	47	34	-	SIMARO?	Odyendya ?	gabonensis ?	-
S	17	82	41	33	-	?			-
S	18	10	66	34	-	?			-
S	19	10	64	34	-	LEGCAES	Tetraberlinia	bifoliolata	-
S	20	33	67	33	16	OLACACE	Diogoa	zenkeri	2586
S	21	58	61	38	-	SAPINDA			1195
S	22	82	69	32	-	LEGCAES	Tetraberlinia	bifoliolata	-
S	23	89	60	39	-	LEGCAES			-
S	24	9	79	34	-	LEGCAE?	Gilbertiodendron?		-
S	25	21	80	32	-	EUPHOR?			-
S	26	51	73	30	-	LEGCAES			-
S	27	65	76	30	-	LEGCAES			-
S	28	81	72	33	-	LEGCAES	Gilbertiodendron ?		-
S	29	88	72	38	-	LEGCAES	Hymenostegia ?		-
S	30	89	78	34	-	?			-
S	31	9	88	35	23	LEGCAES	Gilbertiodendron	ogoouense	1316
S	32	39	80	32	-	ANISOPH	Anisophyllea		-
S	33	44	84	33	-	?			-
S	34	56	86	37	-	LEGCAES			-

number	E	S	dbh	h.	family	genus	epithet	coll
S 35	67	84	39	-	LEGCAE?			-
S 36	70	85	35	-	LEGCAES	Tetraberlinia	moreliana	-
S 37	88	81	30	-	LEGCAES	Tetraberlinia	bifoliolata	-
S 38	54	97	32	-	?			-
S 39	67	91	34	-	ANNONA?			-
S 40	84	90	34	30	FLACOUR	Casearia	stipitata	1317
S 41	95	99	31	-	OLACACE	Coula ?	edulis ?	-
T 1	70	27	24	-	LEGCAES	Tetraberlinia	bifoliolata	-
T 2	17	39	29	-	LEGCAES	Tetraberlinia	bifoliolata	-
T 3	10	30	22	-	LEGCAES	Tetraberlinia	bifoliolata	-
T 4	20	57	28	-	LEGCAES	Tetraberlinia	bifoliolata	-
T 5	46	80	29	-	LEGCAES	Tetraberlinia	bifoliolata	-
T 6	36	87	25	-	LEGCAES	Tetraberlinia	moreliana	-
T 7	79	93	26	23	LEGCAES	Dialium	guineense	2454
T 8	13	98	24	25	LEGCAES	Crudia	gabonensis	2595
T 9	47	86	29	22	ROSACAE	Dactyladenia	campestris ?	3256
T 10	56	81	25	-	ROSACAE	Dactyladenia	campestris ?	-
Z 1	87	47	14	-	LEGCAES	Tetraberlinia	bifoliolata	-
Z 2	67	48	13	-	LEGCAES	Tetraberlinia	bifoliolata	-
Z 3	21	47	15	-	LEGCAES	Tetraberlinia	bifoliolata	-
Z 4	15	48	14	-	LEGCAES	Tetraberlinia	bifoliolata	-
Z 5	59	52	13	-	LEGCAES	Tetraberlinia	moreliana	-
Z 6	97	70	15	-	LEGCAES	Tetraberlinia	bifoliolata	-
Z 7	74	25	12	11	LEGCAES	Gilbertiodendron	stipulaceum	1644
Z 8	95	50	14	-	LEGCAES	Tetraberlinia	bifoliolata	-
Z 9	81	91	12	16	SAPINDA			2453
Z 10	97	77	13	15	SAPINDA			2464
Z 11	18	94	17	18	MELASTA	Warneckea		2591
Z 12	31	4	13	15	GUTTIFE	Garcinia		1303
Z 13	28	8	14	15	LEGCAES	Crudia	gabonensis	1304
Plot:	**2**							
G 1	100	100	62	-	BURSERA	Dacryodes	buetneri	-
G 2	81	88	100	-	SAPINDA			-
G 3	85	80	65	-	LEGCAES	Hymenostegia?	pellegrinii	-
G 4	87	59	92	-	LEGCAES	Paraberlinia	bifoliolata	-
G 5	92	51	79	-	MYRISTI	Sorro 1		-
G 6	93	38	77	-	LEGCAES	Gossweilerodendron	balsamiferum	1481
G 7	95	30	109	-	MYRISTI	Sorro 1		-
G 8	82	23	97	-	MYRISTI	Sorro 2		-
G 9	95	1	115	-	BURSERA	Okoumea	klaineana	-
G 10	99	10	83	-	VERBENA	Vitex		-
G 11	96	16	78	-	?			-
G 12	68	3	131	-	MELIACE	Entandrophragma		-
G 13	79	31	81	-	MYRISTI	Sorro 1		-
G 14	80	38	84	-	?			-
G 15	81	37	61	-	LEGMIMO		spec 1	-
G 16	76	38	60	-	LEGCAES	Gossweilerodendron	balsamiferum	-
G 17	73	39	69	-	?			-
G 18	63	27	60	-	?			-
G 19	64	55	63	-	MYRISTI	Sorro 1		-
G 20	75	71	61	-	MYRISTI	Sorro 1		-
G 21	73	90	117	-	LEGCAES	Paraberlinia	bifoliolata	-
G 22	78	88	144	-	LEGCAES	Paraberlinia	bifoliolata	-
G 23	65	97	61	-	SAPINDA			-
G 24	61	90	76	-	EUPHOR?			-
G 25	52	82	91	-	LEGCAES	Paraberlinia	bifoliolata	-
G 26	94	75	80	-	MYRISTI	Sorro 1		-
G 27	60	63	66	-	LEGCAES	Hymenostegia	pellegrinii	-
G 28	51	56	96	-	?	baya		-
G 29	40	53	76	-	MYRISTI	Sorro 2		-
G 30	50	52	61	-	LEGCAES	Gossweilerodendron	balsamiferum	-
G 31	53	26	106	-	LEGMIMO		spec 1	-
G 32	54	12	73	-	MYRISTI	Sorro ....?		1483
G 33	59	2	71	-	?			-
G 34	17	18	76	-	STERCUL	Cola		-
G 35	16	11	86	-	LEGCAES	Paraberlinia	bifoliolata	-
G 36	14	1	63	-	MYRISTI	Sorro 3		-
G 37	16	26	74	-	MYRISTI	Sorro 1		-
G 38	18	27	71	-	MYRISTI	Sorro 1		-
G 39	19	34	74	-	MYRISTI	Sorro 1		-
G 40	38	64	65	-	LEGMIMO		spec 2	-
G 41	16	80	73	-	ANNONA?			-
G 42	22	89	100	-	MYRISTI	Sorro 3 (=AKBA?)		-
G 43	27	100	80	-	MYRISTI	Sorro 3		-
G 44	0	80	60	-	ANACARD			-
M 1	32	87	43	-	LEGCAES	Tetraberlinia	bifoliolata	-

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Mark van Veen always immediately responded when problems arose with Faunist and he usually was able to solve them within a day, a better help-desk was never encountered. Eddy Dijkstra (Animal taxonomy) allowed the use of his Apple computer to run PAUP.

Of course the entire staff of the Planttaxonomy group provided much assistance and back-up when needed. Especially the field trips required much extra work of Judith van Medenbach, Marina Wassink and the herbarium staff. Although exploding pods made such work sometimes risky, the 'herbarium guys' were always willing to mount some additional specimens on short notice when these became available.

Last but not least I find it appropiate to thank all collectors who gathered the various specimens on which this book is based. It is upon their sweat that the major part of it is based. Without it, I could not even have started the study.

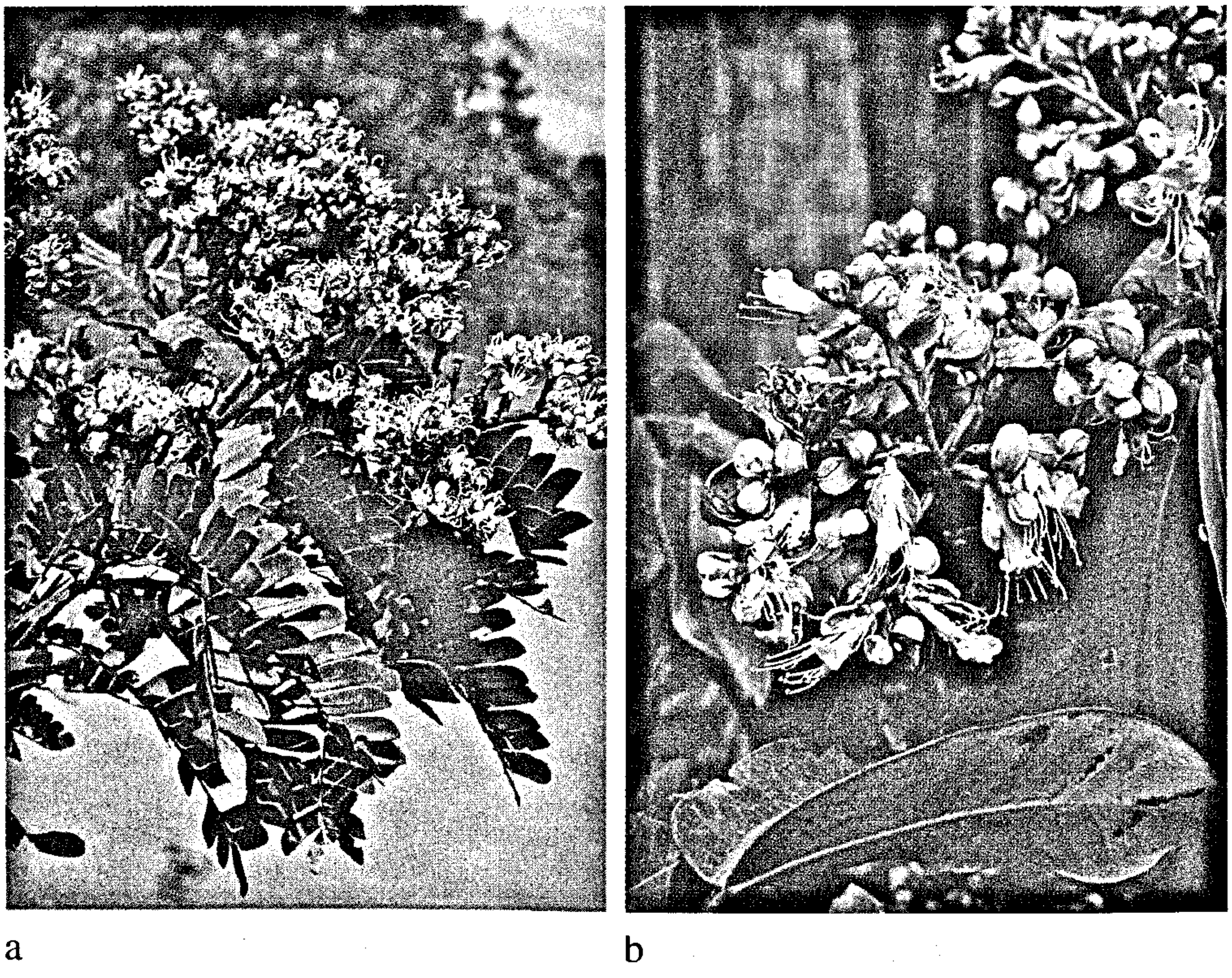

Plate 4. a: Flowering branches of *Bikinia media* Wieringa (*Wieringa et al. 3180*); b: Inflorescences of *Tetraberlinia bifoliolata* (Harms) Hauman showing yellow adaxial petals (*Wieringa & Haegens 2328*). Photos J.J. Wieringa.

Plate 5. a, b: *Tetraberlinia moreliana* Aubrév. (*Wieringa & Epoma 1608*), a: inflorescence, b: single raceme; c: inflorescence of *Tetraberlinia longiracemosa* (A. Chev.) Wieringa (*Wieringa & van Nek 3270*). Photos JJW.

Curriculum vitae

Jan Johannes Wieringa werd op 15 juli 1967 geboren te Naarden. In 1985 behaalde hij aan het Willem de Zwijger College te Bussum het VWO-diploma en begon met de studie Biologie aan de Landbouwhogeschool in Wageningen. Zijn belangrijkste afstudeervak bestond uit een systematische revisie van *Begonia* sectie *Filicibegonia*, terwijl hij zich meer in theoretische aspecten van fylogeniereconstructie verdiepte tijdens een kleiner afstudeervak bij diertaxonomie. Als stage bracht hij een half jaar in Gabon door alwaar hij de bestuiving bij *Begonia* onderzocht. In augustus 1991 studeerde hij met lof af aan de (inmiddels) Landbouwuniversiteit. Meteen daarna volgde een aanstelling van vier jaar als AIO om de systematiek van een aantal Afrikaanse bomen te bestuderen. Tijdens deze aanstelling bracht hij totaal één jaar in Afrika door. De resultaten van dit onderzoek, dat in de jaren na de aanstelling werd voortgezet, worden in dit boek gepresenteerd.

In 1999 was hij gedurende 3 maanden in dienst als toegevoegd docent bij de Landbouwuniversiteit.

Publicaties betrekking hebbende op dit proefschrift:

Wieringa, J.J., 1996. Tree-climbing on a free rope. In: L.J.G. van der Maesen et al. (eds), The Biodiversity of African Plants: 819–821. – Kluwer Academic Publishers, The Netherlands.

Bruneau, A., F.J. Breteler & J.J. Wieringa, 1997. Phylogenetic relationships in tribes Amherstieae and Detarieae (Caesalpinioideae) based on chloroplast DNA sequences. – Am. J. Botany 84 (6) suppl.: 179. (abstract)

Wieringa, J.J., 1997. A macromorphological and phylogenetic study on *Aphanocalyx*, *Julbernardia*, *Michelsonia*, *Monopetalanthus* and *Tetraberlinia* (Leguminosae: Caesalpinioideae: Macrolobieae) – Am. J. Botany 84 (6) suppl.: 245. (abstract)

Wieringa, J.J., 1999. (1395) Proposal to conserve the name *Berlinia polyphylla* (Leguminosae) with a conserved type. – Taxon 48: 167–168.