

The *Cheilanthes hirta* complex and allied species (Adiantaceae/Pteridaceae) in southern Africa

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ABSTRACT

The very variable complex of plants until now ascribed to *Cheilanthes hirta* Swartz, together with some derived or allied species, is investigated. The type of the species as established by N. C. Anthony (1984), is accepted. Three new varieties are distinguished: *Cheilanthes hirta* Swartz var. **brevipilosa** W. & N. Jacobsen, var. **inferacampestris** W. & N. Jacobsen and var. **nemorosa** W. & N. Jacobsen. One new form of *Cheilanthes hirta* var. **brevipilosa** W. & N. Jacobsen is recognized: forma **waterbergensis** W. & N. Jacobsen. Var. *laxa* Kunze (1836) is given the new status of forma: *Cheilanthes hirta* var. **brevipilosa** W. & N. Jacobsen forma **laxa** (Kunze) W. & N. Jacobsen. Three allied species are discussed and included in the key to all taxa mentioned. Taxa are described and information given includes notes on distribution and ecology. Special attention is paid to spore morphology. Most taxa are illustrated by a habit photo, and all by line drawings and scanning electron micrographs (SEM) of the spores. Possible evolutionary conclusions, particularly on the nature of the spores and on frond dimensions in relation to geographical distribution and climate are discussed.

UITTREKSEL

Die hoogs variërende plantkompleks wat tot nou toe by *Cheilanthes hirta* Swartz ingesluit is, tesame met sommige afgeleide of verwante spesies, word ondersoek. Die tipe van die spesie soos deur N. C. Anthony vasgestel, word aanvaar. Drie nuwe variëteite word onderskei: *Cheilanthes hirta* Swartz var. **brevipilosa** W. & N. Jacobsen, var. **inferacampestris** W. & N. Jacobsen en var. **nemorosa** W. & N. Jacobsen. Een nuwe vorm van *Cheilanthes hirta* var. **brevipilosa** W. & N. Jacobsen word erken: forma **waterbergensis** W. & N. Jacobsen. Var. *laxa* Kunze (1836) word hier die nuwe status van forma gegee: *Cheilanthes hirta* var. **brevipilosa** W. & N. Jacobsen forma **laxa** (Kunze) W. & N. Jacobsen. Drie verwante spesies word bespreek en by die sleutel tot alle genoemde taksons ingesluit. Taksons word beskryf en inligting wat verskaf word, sluit aantekeninge oor verspreiding en ekologie in. Spesiale aandag word aan spormorfologie gegee. Die meeste taksons word geïllustreer met 'n foto van die groeiwyse, en almal met lyntekeninge en aftaselektronmikrogawe (SEM) van die spore. Moontlike evolusionêre gevolgtrekkings, veral oor die aard van die spore en oor blaarfmetings met betrekking tot geografiese verspreiding en klimaat, word bespreek.

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INTRODUCTION AND AIMS

Amongs the 24 currently accepted species of *Cheilanthes* Swartz (Anthony 1984) in southern Africa, the widespread *C. hirta* Swartz contains in its broader concept a number of rather different looking plants. In this respect it resembles the equally widespread *C. viridis* (Forssk.) Swartz complex which has been split into a number of varieties or separate species (Anthony 1984). This has so far not been done in the case of *C. hirta*. Since the first naming of the species by Swartz as *Adiantum caffrorum* in 1801 and its description by him in 1806 as *Cheilanthes hirta*, it has been referred to under a number of different specific epithets in different genera and with varying breadth of concept until as recently as 1983 (Jacobsen) and 1984 (Anthony).

The present paper deals with the varying forms, varieties and allied species which were at one time or another included in the species concept. The authors realize that, similar to the *C. viridis* complex, the various forms of *C. hirta* will propagate partly sexually and partly apogamously with the possibility of the more xerophytic ones being apogamous. Cytological studies might clarify in what way polyploidy and hybridization affect their evolution. This is at present being done with a number of cheilanthoid ferns of Europe, the Mediterranean and

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Macaronesia and it has led to the creation of a great number of hybrids, each with its own name. The authors are not equipped to do this, but they have made a thorough examination of morphological features, including those of the spores, and they conclude that their findings warrant separation of the *C. hirta* complex into a number of taxa.

HISTORY AND SYNONYMY

The typification of the species presents difficulties. It could either be based on a collection by Dr Groendal in Herb. Gastroemi of a plant from Mauritius in the Riksmuseet, Stockholm, or on a collection by Thunberg from the Cape of Good Hope in Herb. Thunberg, Uppsala. Certain entries by Wikstroem on the former sheet seem to indicate that this is indeed the specimen on which Swartz (1801: 85) based his *Adiantum caffrorum* and on which he himself changed the name to *Cheilanthes hirta* (Swartz 1806: 128, 329). Anthony (1984) accepts the sheet from Mauritius as the type of the species. Figure 1.

Professor N. Lundqvist of the Cryptogamic Section of the Riksmuseet (personal correspondence) is of the opinion that Swartz typified both his *Adiantum caffrorum* and his *Cheilanthes hirta* with material from South Africa and that the sheet from Mauritius is not the type. He also mentioned that it was not marked thus by Prof. Schelpe, who quotes it as the type (1969: 72). The sheet in the Thunberg Herbarium is, according to Lundqvist, not the type, as Swartz had not seen it. He did not comment on the possible locality of the type sheet. Thus the question of the whereabouts of the type sheet is not solved. It appears best, however, to follow Anthony (1984) and to accept the sheet from Mauritius at least as the lectotype. The specific epithet *hirtum* or *hirta* based on Swartz' material was combined by various authors with various genera, which are now included in *Cheilanthes*.

Kunze recognized the variability of the species in 1836 and distinguished four forms: α *contracta*, β *intermedia*, γ *laxa* and δ *parviloba*. The types of these names were housed in his herbarium in Leipzig and were destroyed during the last war in air attacks on the city. In later works, beginning with Pappe & Rawson (1858), and including those of Sim (1915), Jacobsen (1983) and

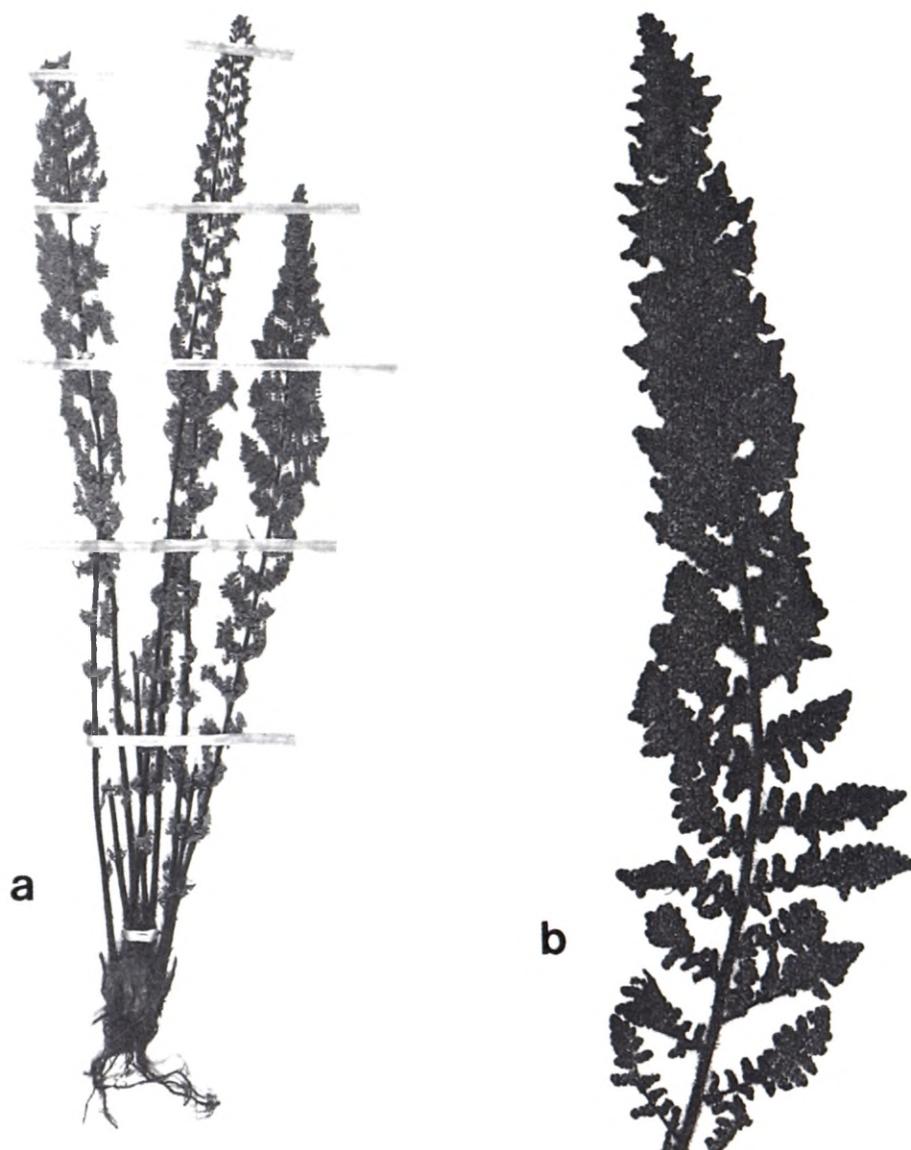


FIGURE 1.—a, a form of *C. hirta*, collected 30.4.1905 at Koedoespoort near Pretoria, Leendertz 622, $\times 0.5$; b, photostat of the lectotype of *Cheilanthes hirta* Swartz in Herb. Gastroemi, Riksmuseet, Stockholm, $\times 1$.

Anthony (1984), the forms of Kunze are referred to as varieties, a procedure in agreement with Article 35.3 of the Code. Anthony (1984) and Roux (1986) have investigated the typification of Kunze's forms. They have established the following:

1, var. *contracta* is synonymous with *C. contracta* (Kunze) Mett., a species on its own;

2, for var. *intermedia*, Anthony (1984) selects as lectotype a collection by Drège from the Witberg in the southern Cape, now in B under No. 000414 and determined by Kunze. A duplicate of this collection is in SAM. Roux (1986) also studied material from B but he states that he could not find any material listed by Kunze in his text and he concludes that the variety is untypified;

3, for var. *laxa*, Anthony (1984) selects a collection by Drège from near Bokpoort and Nieuweveld as lectotype in B under No. 000413, with a duplicate of this collection in SAM. Roux notes that the specimen *Drège s.n.* (BM) collected near Enon and Bontjes River, mounted on one sheet with some plants collected by Cooper can be identified with var. *laxa*, but they are not cited by Kunze and cannot be considered as syntypes;

4, var. *parviloba* is cited by Roux (1986) as synonymous with *Cheilanthes parviloba* Swartz.

The authors of this paper have investigated the duplicates of the lectotypes of var. *intermedia* and var. *laxa* in SAM as well as photostats of a probable syntype of var. *intermedia* and of an isosyntype of var. *laxa*. The lectotype of *C. hirta* var. *intermedia* is a frond without a rhizome, with a thick stipe and a contracted, narrowly linear lamina. Stipe, lamina and vestiture coincide with what the authors consider to be *C. hirta* Swartz var. *hirta* and they sink var. *intermedia* under it.

The photostat of a probable syntype of var. *intermedia* shows a small whole plant and a large stipe and lamina on the left and right sides of the sheet respectively, collected by Drège, Ecklon & Zeyher, s. n., s. d. The sheet is housed at the Museum at Leiden under *Morton 750*. The plant on the left is from the Paarl Mountain and the frond on the right from the Sneeuwbergen. They are obviously different species, the latter is *Cheilanthes contracta* (Kunze) Mett. ex Kuhn, the former in habit and size similar to what the authors describe as *C. hirta* Swartz var. *brevipilosa* W. & N. Jacobsen forma *laxa* (Kunze) W. & N. Jacobsen (see below).

The lectotype chosen by Anthony (1984) for *C. hirta* var. *laxa* consists of a rather damaged plant with thin stipes and rhachises and rather crumpled pinnae as well as part of a stipe and lamina of similar poor preservation. When Kunze described the forms of the *C. hirta* complex he had only material from the southern and eastern Cape at his disposal. The authors of this paper worked with much more material, including specimens from the Transvaal, the Orange Free State, Lesotho, Natal and the northern Cape Province. On account of shape, character of stipe and lamina and vestiture, they consider the lectotype to represent a form of their var. *brevipilosa*, so that

the correct name of the plant is now *C. hirta* Swartz var. *brevipilosa* W. & N. Jacobsen forma *laxa* (Kunze) W. & N. Jacobsen. The photostat of an isosyntype of *C. hirta* Swartz var. *laxa* Kunze shows six very damaged fronds, collected by Drège and now housed at the Museum in Leiden under *Morton 751*. The locality is not known. The habit of these plants is similar to the lectotype above and the plants are considered to be a good match of it.

Pappe & Rawson (1858: 252) described as *Cheilanthes glandulosa* a plant collected by the missionary R. Moffat, possibly from a locality near Kuruman. According to their text this appears to be a lax form of *C. hirta*. The whereabouts of the type are not known.

Anthony (1984) incorporated *C. nielsii* Jacobsen (1983) in her concept of *C. hirta* as a shade form.

MATERIALS AND METHODS

The authors have studied the large collection in the National Herbarium at Pretoria as well as their own collections. The following features were used to distinguish taxa: rhizome and basal stipe scales, lamina configuration, length to width ratio of lamina and largest pinna, vestiture of stipe, rhachis and lamina, angle setting of pinnae to rhachis, and sculpturing of the spores by means of electron microscope scanning. The latter was carried out by the Botanical Research Institute, Pretoria.

RESULTS

The authors have come to the conclusion that the complex of forms should be subdivided, that the obviously allied and consistently deviating forms without intermediates should be considered separate species and that the remaining forms of *C. hirta sensu lato* should be split into a number of forms or varieties.

As an allied species which might have evolved from a common ancestor, *Cheilanthes parviloba* (Swartz) Swartz was considered a separate species by its author, who had originally named it *Adiantum parvilobum* in 1800, but transferred it to *Cheilanthes* in 1806. Though later included as a variety of *C. hirta* by Kunze (1836), Pappe & Rawson (1858) and others up to Christensen's *Index filicum* (1906), Sim (1915) accepted it again at authors' level and this view is supported by the present authors. Due to its glabrous and viscid lamina surface it is immediately distinct from all other more or less hirsute members of the complex. It is therefore not discussed any further in this study.

The general essential features of all forms of the complex are set out by Jacobsen (1983: 261–263) and by Anthony (1984: 68–69). An important diagnostic feature is the presence of patent or adpressed multicellular, often gland-tipped hairs on stipe, rhachis and lamina surfaces. As gradations occur between a number of the taxa, separation at species level has been possible only in a few instances. Three of the hirsute members are separated at specific level, and four at varietal level. One of the varieties is split into two formae. The main differences are shown in the following key.

KEY TO THE TAXA

- 1a Fronds 2-pinnatifid to 2-pinnate, sometimes 3-pinnatifid at the extreme base, elliptic, not exceeding 175 mm in length, frail; rhizome very short, erect, almost like that of an annual herb..... 9. *C. nielsii*
- 1b Fronds 3–4-pinnatifid:
- 2a Lamina densely covered with translucent, hyaline glands..... 8. *C. hyaloglandulosa*
- 2b Lamina mainly hirsute, hyaline glands occasionally present:
- 3a Hairs on stipe and rhachis twisted and adpressed; fronds mostly strongly contracted, lamina on long stout stipes..... 1. *C. contracta*
- 3b Hairs on stipe and rhachis mainly patent:
- 4a Setting of pinnae to rhachis mainly at 45°–57°, pinnae crowded towards apex, pinnules more or less inrolled, hairs on upper surface of lamina long, thin, sparse, undersurface with sparse hairs along costae and costules only..... 2. *C. hirta* var. *hirta*
- 4b Setting of pinnae to rhachis mainly at more than 50°:
- 5a Hairs on lamina short, thick, often glandular, varying in length:
- 6a Hairs very short, glassy, occasionally glandular on upper side of lamina, very sparse, short, gland-tipped hairs on undersurface; fronds narrowly lanceolate to linear, often contracted, with pinnules strongly inrolled..... 3. *C. hirta* var. *brevipilosa*
- 6b More densely hirsute on both surfaces; fronds lanceolate, not contracted, pinnae spreading; plants small; stipe thin, fragile, reddish to purplish:
- 7a Hairs on rhachis 1.0–1.8 mm long, dense, mainly gland-tipped, 4–5-celled..... 4. *C. hirta* var. *brevipilosa* forma *laxa*
- 7b Hairs on rhachis mostly thin and fine, clear, hyaline, 0.4–1.4 mm long, mostly 2–3-celled, with characteristic pyramidal basal cell..... 5. *C. hirta* var. *brevipilosa* forma *waterbergensis*
- 5b Hairs on lamina long, thin, flexuous, only occasionally with a small glandular tip:
- 8a Fronds finely divided, up to 4-pinnatifid, ovate-lanceolate, broadest below the middle of the lamina; hairs on rhachis 1–2 mm long, fine and twisted, 5–6-celled..... 6. *C. hirta* var. *nemorosa*
- 8b Fronds lax, 3-pinnatifid, lanceolate, broadest in middle of the lamina; hairs on rhachis 1.5–2.8 mm long, very dense in basal part, 6–8(15)-celled..... 7. *C. hirta* var. *inferacampestris*

DESCRIPTION OF TAXA

1. ***Cheilanthes contracta* (Kunze) Mett. ex Kuhn**, *Filices Africanae*: 70 (1868); N. C. Anthony 11: 60, t. 12, fig. 14 A'–D' (1984). Type: Cape Province, Zwartkops River, *Drège* (LZ, syn.†; BM lecto.; K, L–BOL photo.; S, SAM). Figures 2b, 3, 4a–c.

Cheilanthes hirta var. *contracta* Kunze 10: 539 (1836); Pappe & Rawson: 35 (1858); Sim: 85 (1892); Sim: 229, t. 111, fig. 1 (1915), pro parte. *Myriopteris contracta* (Kunze) Fee: 149 (1852).

Cheilanthes hirta var. *contracta* sensu Sim in Jacobsen: 262 (1983), pro parte.

The species (Figures 2b, 3) has recently been described by Anthony (1984) so that only a few pertinent morphological features need be stressed here, which distinguish the species from all other taxa of the complex: the long creeping rhizome; the rhizome scales which are darker than those of other members of the complex; the dark green coloration of the ventral surface of the lamina (only common with *C. hirta* var. *hirta*) and especially the twisted 3–4(–6)-cellular hairs on stipe, rhachis and lamina surfaces, adpressed downwards along the rhachis (Figure 3c). The pinnae are mostly 12–15 mm apart, 9–28 × 2.5–10 mm, with up to 10 pinnules, spreading at an angle of 38°–52° (average 46°) from the rhachis, but curving upwards to run parallel or even towards it and touching the pinnae above (Figure 2 b). The pinnules may be very close together or more often well separated and alternate on the costae, about 4 × 2 mm where measurable, but often too contracted, especially when mature or drying out; the sori are dark brown, about 0.5

mm in diameter. The spores are globular, about 50 µm in diameter, rugulose with anastomosing rugae and a prominent trilete ridge (Figure 4a–c).

Vouchers: *Acocks 19081* (PRE); *Esterhuysen 25808* (PRE); *Liebenberg 7253* (PRE); *Louw 2* (PRE); *Taylor 5915* (PRE).

Distribution

The species is essentially southern, but has recently been found to occur in the eastern Transvaal, where it overlaps in its distribution with that of *C. hirta* var. *hirta* and of var. *brevipilosa*. In the Cape Province it extends from the Kamiesberg in Namaqualand along the Cape mountain ranges to the south-western, southern and south-eastern parts of the province, approximately as far as the Grahamstown area. Northwards it is found as far as the Swartberg. The species is quite frequent in the Cape, but rare in the Transvaal (Figure 5).

Ecology

C. contracta usually grows in shallow, sandy lithosols amongst rocks or even on sheetrock mats. Quartzite soils seem to be preferred. Aspect is of no importance, but plants at the foot of large boulders in half or part shade tend to be larger. In arid fynbos the stipe may be quite long, frequently as long as the lamina. In spite of the creeping rhizome the fronds are mostly only ± 3 mm apart, the stipes irregularly sprouting, young ones indiscriminately mixed with mature ones, so that large clusters of fronds develop.

The altitudinal range is large, according to Anthony (*l. c.*) between 60 and 1 830 m in the Cape, but apparently not below 1 000 m in the Transvaal. An herbarium sheet

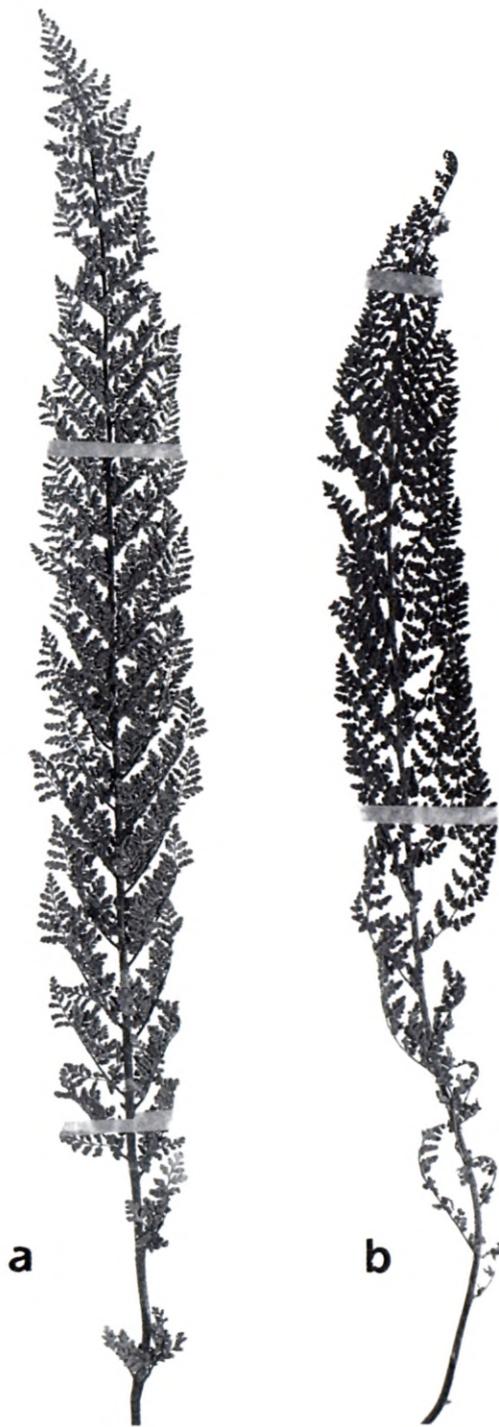


FIGURE 2.—a, *Cheilanthes hirta* Swartz var. *hirta*. Transvaal, 2530 (Lydenburg): on Old Kruger Road at Waterval Onder, amongst grass and herbs in sunlight (—CA), 13.1.1978, *Jacobsen 4907*, $\times 0.7$; b, *Cheilanthes contracta* (Kunze) Mett. ex Kuhn. Cape, 3323 (Willowmore): west end of Baviaanskloof, (—BD), *Jacobsen 5181*, $\times 0.7$.

from near Sabie bears the remark 'xerophytic on quartzite ridge'. This refers probably to the Pretoria Series quartzite. The other known Transvaal record is from Kaapsche Hoop, which lies well above 1 000 m. Conditions in the Cape are mostly fairly arid, the annual rainfall varying between 200 and 800 mm. The Transvaal localities, which fall in the summer rainfall area, receive more than 1 000 mm per year.

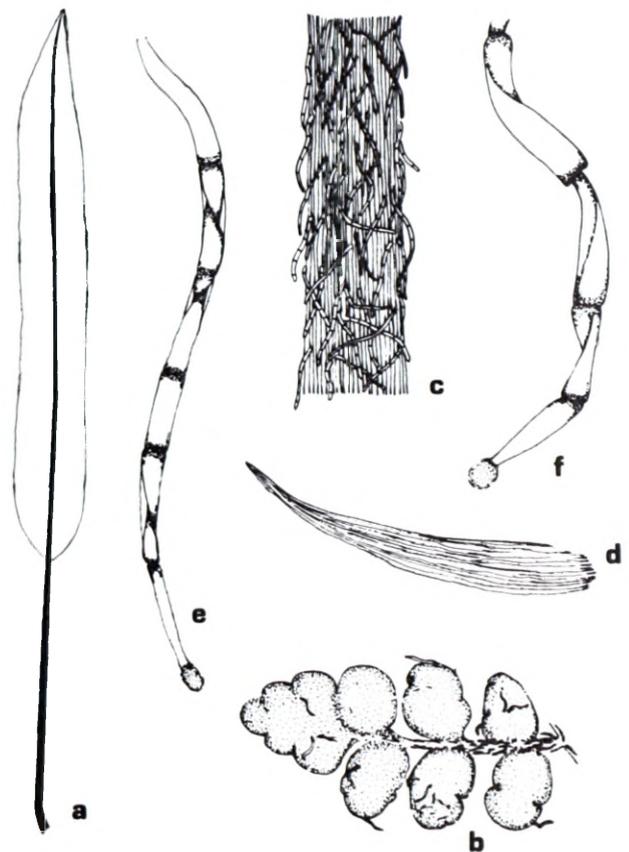


FIGURE 3.—*Cheilanthes contracta* (Kunze) Mett. ex Kuhn. Cape, 3321 (Ladismith): Sevenweekspoort (—AD), *Jacobsen 5177*. a, outline of frond, $\times 0.6$; b, pinnule, $\times 8$; c, portion of rachis (characteristic: the basiscopically adpressed long, multicellular hairs), $\times 32$; d, rhizome scale, $\times 48$; e & f, stipe and rachis hairs respectively, $\times 280$.

2. *Cheilanthes hirta* Swartz var. *hirta*. *Cheilanthes hirta* Swartz: 128, 329 (1806). Type: Mauritius, Groendal (S, lecto.—Herb. Jacobsen, photo.!). Figures 2a, 4d–f, 6, 7.

Adiantum hirtum (Swartz) Poir. in Lam.: 142 (1810). *Notholaena hirta* (Swartz) J. Sm.: 50 (1841). *Myriopteris hirta* (Swartz) J. Sm.: 174 (1866).

Notholaena capensis Sprengel: 32 (1828). Type: Cape Province. Uitenhage, *Zeyher 275* (B, iso.).

Cheilanthes hirta var. *intermedia* Kunze 10: 539 (1836); Roux: 370 (1986). *C. hirta* var. *intermedia* (Kunze) Pappe & Rawson: 35 (1858); Anthony 11: 69 (1984). (No type indicated; see discussion of lectotype under *History and synonymy* above).

Cheilanthes hirta var. *contracta* sensu Sim: 229, t. 111, figs 1 & 1 beta (1915), pro parte; Tardieu 1: 137, t. 19, figs 1–3 (1958); Jacobsen: 262, pro parte, fig. 66 (1983).

Icones: Tardieu-Blot: t. 19 (1958); Jacobsen: 101, fig. 66 (1983).

The lectotype is a rather contracted plant, of which only the upper part is preserved, not dissimilar to certain specimens from South Africa (Figure 1a, b). The conclusion that the South African populations agree with the lectotype is based on investigation of a photo of the type sheet and on the following observations: what is here considered to be var. *hirta* is, apart from var. *inferacampestris*, the only eastern representative of the complex, reaching the coast of South Africa in Transkei (Figure 7). Tardieu-Blot (1958) describes under *Cheilanthes hirta* Swartz var. *contracta* Kunze a plant with con-

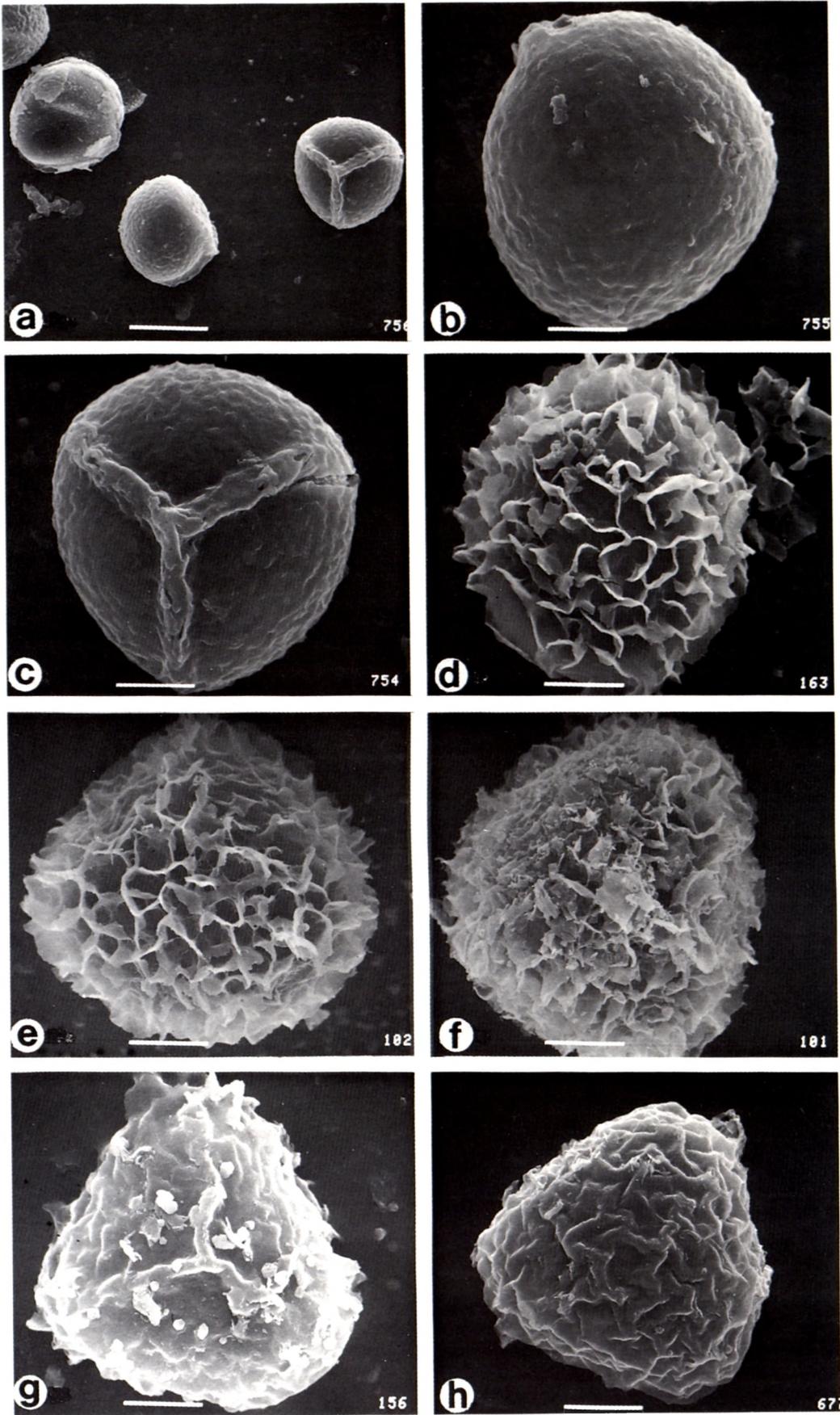


FIGURE 4.—*Cheilanthes contracta* (Kunze) Mett. ex Kuhn, *Jacobsen 5181*: a, several spores, $\times 380$; b, single spore, distal face, $\times 1160$; c, single spore, proximal face, $\times 1040$. *Cheilanthes hirta* Swartz var. *hirta*, *Jacobsen 4907*: d, single spore, side view, $\times 930$; e, single spore, distal face, $\times 730$; f, single spore, proximal face, $\times 730$. *Cheilanthes hirta* Swartz var. *brevipilosa* W. & N. *Jacobsen*: g, *N. Jacobsen 4522*, single spore, proximal face, $\times 1200$; h, *Jacobsen 5267*, single spore, distal face, $\times 870$.

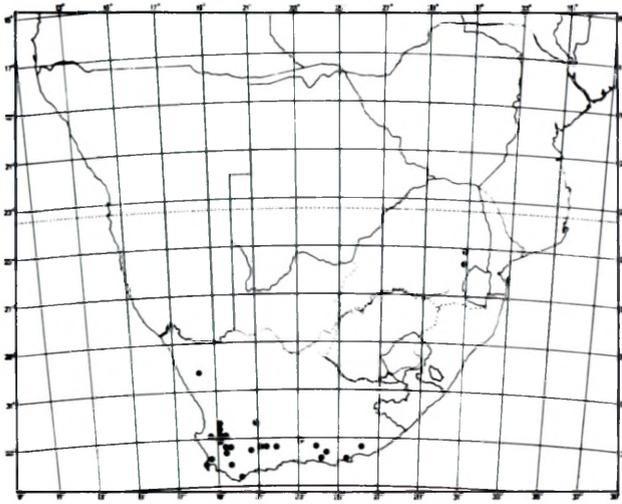
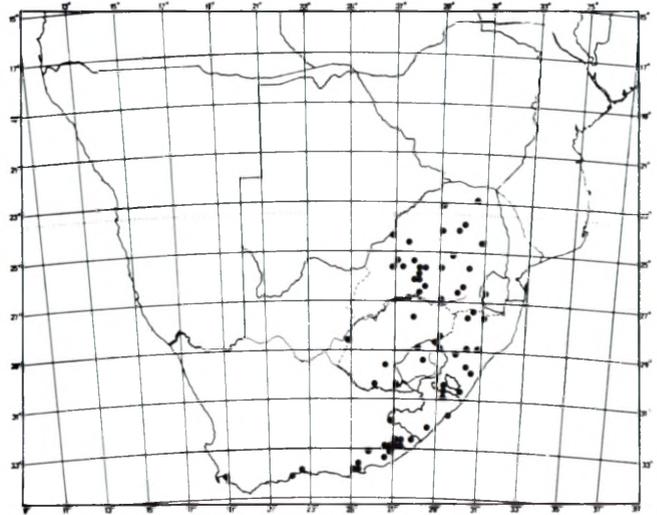
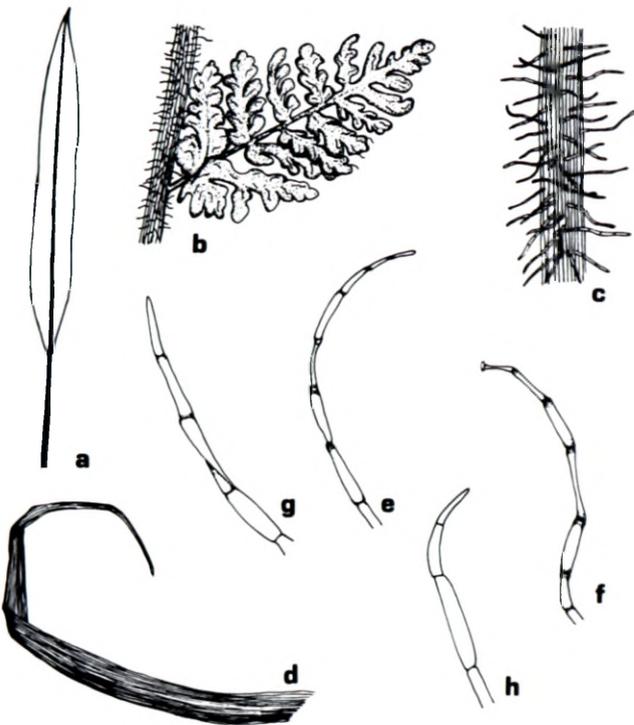
FIGURE 5.—Distribution of *Cheilanthes contracta*.FIGURE 7.—Distribution of *Cheilanthes hirta* var. *hirta*.

FIGURE 6.—*Cheilanthes hirta* Swartz var. *hirta*. Transvaal, 2530 Lydenburg (—CB), Jacobsen 4907. a, outline of frond, $\times 0,3$; b, portion of rhachis with right pinna, $\times 2$; c, portion of rhachis, $\times 5$; d, scale at base of stipe, $\times 12$; e, hair of stipe, $\times 35$; f, hair of centre of rhachis, $\times 35$; g, hair of underside of pinnule, $\times 46$; h, hair of upper surface, $\times 73$.

tracted, elongate fronds, with long, white, patent hairs and with globular trilete spores with convex faces and cristate-reticulate sporoderm. The senior author saw a contracted, elongate plant with long white hairs on the surfaces which he identified as a form of *Cheilanthes hirta* on Réunion in 1978. No other forms of the variable species are recorded from these localities. It is accepted therefore that the variety described here agrees with the Mauritian plant.

Rhizome creeping or shortly ascending with narrowly linear, subulate, flexuous scales, reddish brown with median dark stripe in the lower part, where they are $3-5 \times 0,2-0,5$ mm, uniformly reddish brown higher up, $8-11 \times 0,5$ mm. *Fronde*s erect, tufted or closely spaced,

slightly contracted to densely crumpled, pinnae slightly to tightly inrolled and twisted out of the plane of the frond. *Stipe* terete, stout, reddish brown to very dark brown, dull or shiny, 1–2 mm in diameter, basal scales 6–13 mm long, linear to narrowly lanceolate (Figure 6d), crowded at base, diminishing in frequency upwards and absent from about $\frac{2}{3}$ of the length of the stipe, becoming gradually replaced by grey to reddish patent hairs, 2,0–2,5 mm long (Figure 6e), protruding from a coat of deflexed or patent shorter hairs. *Lamina* very narrowly lanceolate (Figures 2a, 6a), $90-410 \times 5-55$ mm, averaging 200×24 mm, 2 to 3-pinnate; apex rounded to acute with pinnatifid terminal segment. *Pinnae* triangular with 6 to 7 pairs of pinnules, lowest of these often strongly basiscopically developed, pinnate to bipinnatifid at base, set at an average angle of $40^\circ-57^\circ$ (rarely up to 79°) to the rhachis, and then strongly bent upwards; 2 to 5 pairs of pinnae reduced towards base, lowest one 3–8 mm long, 15–28 mm distant from nearest above; centre pinnae (9–) $12-42 \times (3-7) 7-12$ mm, averaging 23×9 mm, 7–15 mm distant from each other; top pinnae crowded or up to 8 mm distant from the terminal segment; costae and larger costules winged. *Pinnules* triangular to oblong, lobed, not hairy at the margin, but with sparse, long, thin, simple or finely gland-tipped, 3–5-celled hairs 0,75–1,5 mm long on upper surface and along the costules on the undersurface (Figure 6g, h), elsewhere practically glabrous. *Rhachis* round, shiny or dull greyish to reddish brown, castaneous or dark brown, generally shaggy with patent reddish, occasionally gland-tipped 3–7-celled hairs (Figure 6f). *Sporangia* mostly barely visible under the inrolled lobes of the pinnules. *Spores* averaging $64 \mu\text{m}$ in diameter [Std Dev. (standard deviation) $\pm 2,71$], rounded though faintly triangular in outline with convex faces, trilete ridge not or weakly developed, reticulate-cristate, occasionally rugulose-cristate on a smoothly granulose base (Figure 4d–f).

Vouchers: Fourie 117/21 (PRE); Jacobsen 4521 (PRE); Lambrechts 45 (PRE); Leendertz 4047 (PRE); Theron 2469 (PRE).

Distribution

Apart from the type locality in Mauritius, the presence of the variety has been confirmed in Réunion, in Madagascar, Zimbabwe and southern Africa. Here it is known from the Transvaal Highveld, northern and western

Transvaal, Swaziland, the Orange Free State, Lesotho, Natal, Transkei and the eastern and southern Cape, with one occurrence as far west as the Somerset West area (Figure 7). The variety is frequent in the Transvaal, Natal, Transkei and the eastern Cape, rare in the OFS, Upper Karoo and southern Cape.

Ecology

The variety grows mostly in shallow sandy to loamy lithosols in rocky ground, amongst boulders and outcrops, often at the foot of boulders or cliffs, usually amongst some herbs and grass, but also in open bush country in sunlight or preferably in part shade. The altitude ranges from almost sea level in Natal, Transkei and the Cape to more than 2 000 m (almost 3 000 m in Lesotho in a deviating, dwarf, highly contracted form) at 400 to 1 000 mm annual rainfall, however, in the wetter areas not in forests, but always in open well drained positions. In the winter rainfall area of the Cape the plants dry and shrivel during the hot summer months, while on higher ground in the Free State, Lesotho and Transvaal they fade during the winter to develop new shoots at the onset of the summer rains. They may be evergreen, but are not soriferous during the winter in the coastal areas of higher rainfall.

Notes

It had initially been thought, that the fronds of *C. hirta* var. *hirta* were always highly contracted, corresponding to Kunze's (1836) var. *contracta*, but detailed investigations have shown that the essential differences between the taxa of the complex lie in the type of vestiture of rhachis and lamina and the spore characters. Contracted habit as well as more spread out fronds may occur in *C. contracta*, *C. hirta* var. *hirta* and var. *brevipilosa*. All three are well separated by the nature of the rhachis and surface hairs as well as by differences in the nature and size of the spores.

3. *Cheilanthes hirta* Swartz var. *brevipilosa* W. & N. Jacobsen, var. nova. Type: Transvaal, Mondeor, Johannesburg Jacobsen 5254 (PRE, holo.; Herb. Jacobsen, iso.) Figures 4g, h; 8 & 9.

A varietatibus et formis ceteris speciei pilis brevissimis glandulosis in superficiebus ambabus laminae difert.

Rhizome creeping with broadly based lanceolate, acuminate, light brown to reddish scales, 5–9 × 0,5–1,2 mm, basal ones shorter with black median stripe. *Fronde* erect, tufted, closely spaced. *Stipe* terete, dark brown, dull or shiny, 1,2–2,0 mm in diameter, stout, basal scales as those on rhizome, acuminate to linear, 5–10 × 0,4–0,8 mm, becoming less and smaller upwards and replaced about half way up by patent, twisted or shaggy light brown or reddish hairs up to 1 mm long protruding from a shaggy coat of shorter hairs. *Lamina* linear-lanceolate to lanceolate, often broadest above the middle (Figure 9a), 3-pinnatifid to 3-pinnate, slightly contracted to densely crumpled (Figure 8) with the pinnae flat or inrolled and twisted out of the plane of the frond; apex rounded or subacute with a tiny pinnatifid terminal segment 2–5 mm long. *Pinnae* mostly spreading at 63°–79° from the rhachis, but often at more acute angles, especially in contracted forms, otherwise pinnae and pinnales as in var. *hirta*, except for very short, glassy, occa-



FIGURE 8.—*Cheilanthes hirta* Swartz var. *brevipilosa* W. & N. Jacobsen. Transvaal, 2527 (Rustenburg): Rustenburg Nature Reserve, on rocky ground, in full sunlight, 1 460 m (–CC), Jacobsen 4522. This is an extremely contracted form as the variety is usually more open in habit than *C. hirta* var. *hirta*, × 1.

sionally glandular hairs, arranged flabelliform along the costules of the pinnules on the upper side (Figure 9f), and very sparse, short, gland-tipped hairs on the underside which may be almost glabrous. *Rhachis* densely covered by short and adpressed, 1–3-celled gland-tipped hairs 0,2–0,5 mm long, with occasional patent longer hairs of this type, up to 5-celled and 1,8 mm long (Figure 9d, e). *Spores* averaging 48 μm in diameter (Std Dev. ± 1,34), strictly triangular, trilete ridge prominent, essentially strongly and coarsely rugulose-cristate, especially on distal face, but with isolated short rugae and rare verrucae on proximal face (Figure 4g, h).

Vouchers: Jacobsen 5069 (PRE); Reid 462 (PRE); Repton 5335 (PRE); Thode A7877 (PRE); Westfall 905 (PRE).

Distribution

Known so far from South Africa and SWA/Namibia. In the former mainly in a strip trending north-south from the northern, eastern and western Transvaal through the Orange Free State and western Lesotho to the eastern Cape, with an isolated outlier in the northern Cape Province south of Vryburg and three north-south orientated occurrences in southern SWA/Namibia (Figure 10). A find allotted to this variety in the Natal Drakensberg is doubtful and may be a hybrid of var. *hirta* and var. *nemorosa* (Jacobsen 4628). The variety overlaps in its distribution to a large extent with that of var. *hirta*, but seems to be absent from Natal and the Transkei.

FIGURE 9.—*Cheilanthes hirta* Swartz var. *brevipilosa* W. & N. Jacobsen. Transvaal 2627 (Potchefstroom): Mondeor, Johannesburg (—BB), Jacobsen 5267: a, outline of frond, $\times 0,6$; b, portion of rhachis with right pinna, $\times 4$; c, portion of rhachis, $\times 15$; d, short glandular hair of rhachis, $\times 123$; e, multicellular hair of rhachis, $\times 123$; f, (same locality, but Jacobsen 5254) terminal segment of pinna with characteristic very short glandular hairs in fan-like orientation, $\times 23$.

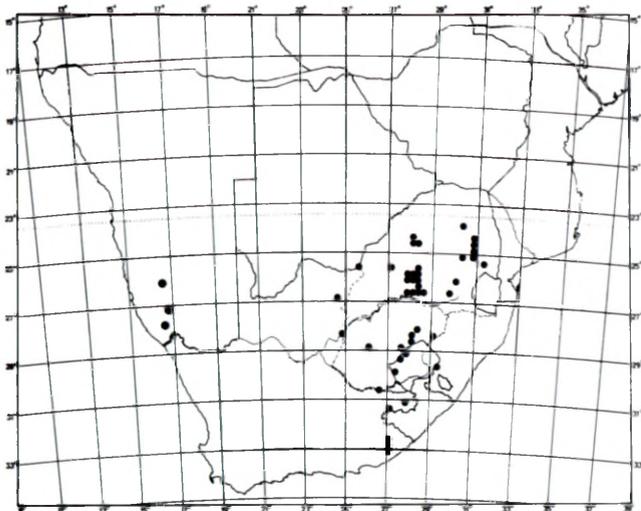
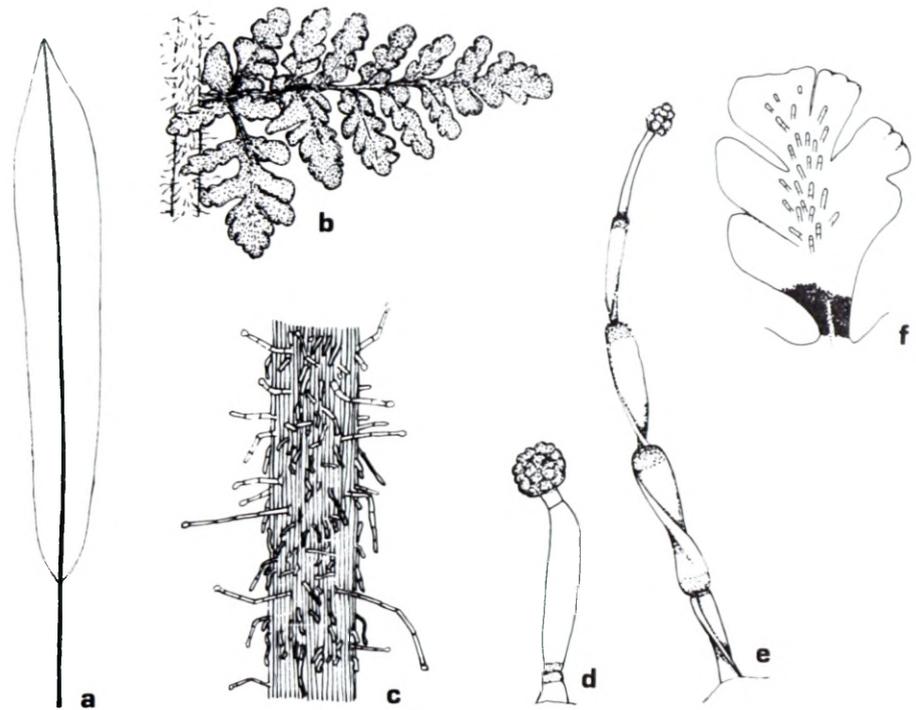


FIGURE 10.—Distribution of *Cheilanthes hirta* var. *brevipilosa*.

Ecology

Ecologically its requirements are similar to those of var. *hirta*. The altitudinal range also tends to be alike, probably from about 100–2 000 m. Highly alpine forms are missing. On the whole the variety prefers more xerophytic localities, yet has a broad moisture tolerance range, and occurs in both summer and winter rainfall areas with an annual precipitation ranging from as low as 100 mm to about 1 000 mm. It is common in the Transvaal and frequent in the OFS, but becomes rarer in the eastern Cape Province except for the Hogsback-Keiskamma area.

Notes

The variety is distinguished by its smaller, triangular spores from var. *hirta*, which has large, rounded spores. The original concept of a taxonomic separation on account of the generally more open and spreading lamina in var. *brevipilosa* could not be upheld, as some fairly

contracted forms with triangular spores (*N. Jacobsen* 4522, Figure 8) were seen. A subsequent study disclosed the different type of vestiture, which forms a most important additional criterion for differentiation and which was used in the key to the taxa of the complex.

4. *Cheilanthes hirta* Swartz var. *brevipilosa* W. N. Jacobsen forma *laxa* (Kunze) W. & N. Jacobsen, stat. nov. Type: near Bokpoort and Nieuweveld, *Drège s. n.* (B, lecto; SAM!; BOL, photo.). Figures 11a, 12 & 13a–c.

Cheilanthes hirta Swartz var. *laxa* Kunze in *Linnaea* 10: 540 (1836).

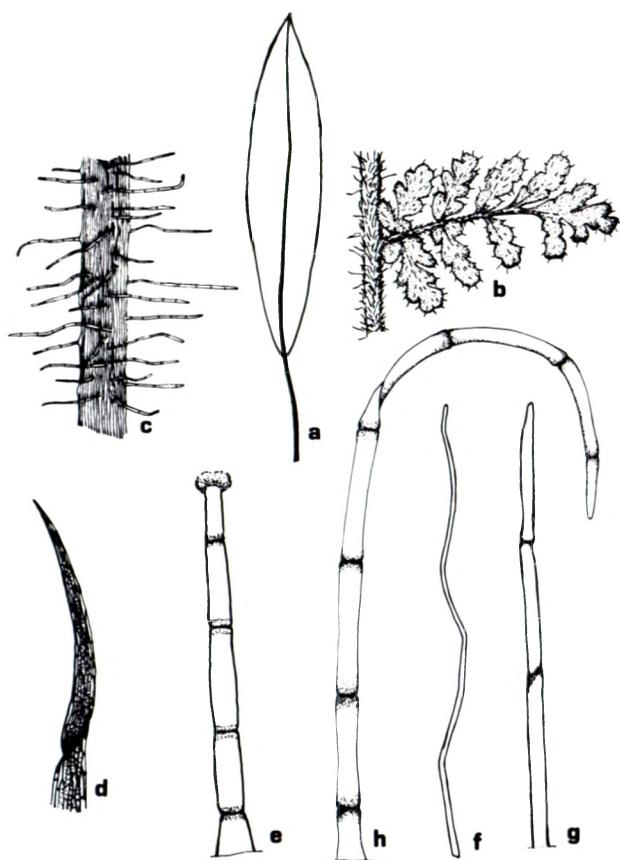
?*Cheilanthes glandulosa* Pappé & Rawson: 35 (1858). Type: ?Cape, nr Kuruman, *Moffat s. n.* (not found).

Icones: Anthony: t. 14A, B (1984).

Rhizome erect, small, with closely tufted fronds with scales lanceolate, acute, $4-5 \times 0,6-0,8$ mm, lower ones light brown with dark median stripe, upper ones light brown to foxy red, broader and larger. *Stipe* terete, reddish brown, more rarely dark brown to almost black, thin, reaching only rarely 1 mm in diameter, basal scales lanceolate-acuminate, $4 \times 0,6$ mm, pale brown to brown, replaced higher up by patent, occasionally gland-tipped, light brown hairs up to 2 mm long. *Lamina* lanceolate to oblong (Figures 11a, 12a), broadest in the middle, 3-pinnatifid to 3-pinnate, $60-250 \times 15-50$ mm, averaging 140×32 mm, about $4\frac{1}{4}$ times longer than broad, apex rounded, pinnatifid, terminal segment 7–8 mm long. *Pinnae* triangular, mostly with 3–4 pairs of pinnules, spreading at $70^{\circ}-90^{\circ}$ from the rhachis, 0–3 pairs slightly reduced towards base, lowest $8-15 \times 6-10$ mm, 13–27 mm distant from next above; centre pinnae $8-32 \times 5-14$ mm, 7–15 mm apart, apex rounded, slightly basicopically developed at the base (Figure 12b); top pinnae crowded or up to 5 mm distant from terminal segment. *Pinnules* oblong, lobed to pinnatifid, apex obtuse, terminal segment unequally pinnatifid, decurrent, some simple or gland-tipped hairs on the



FIGURE 11.—a, *Cheilanthes hirta* Swartz var. *brevopilosa* W. & N. Jacobsen forma *laxa* (Kunze) W. & N. Jacobsen. Cape, 3224 (Graaff-Reinet): Karoo Nature Reserve, under shrubs in shade amongst pillars of dolorite (-BB), Jacobsen 5185, $\times 0,6$; b, *Cheilanthes hirta* Swartz var. *brevopilosa* W. & N. Jacobsen forma *waterbergensis* W. & N. Jacobsen. Transvaal, 2328 (Baltimore): farm Ketting 368 LR, on south-facing slope, in crevices of sandstone cliff, 1 085 m (-BD), Jacobsen 5121 (holotype), $\times 0,6$.



upper side (Figure 12f), fairly thick, simple or gland-tipped 3–5-celled hairs on margins and underside (Figure 12e, g). *Rachis and costae* round, dull or shiny, red to reddish brown with a dense coat of often gland-tipped, patent, red, (2) 4–5 (10)-celled hairs, 1–2 mm long (Figures 12c, h). *Sporangia* discrete, marginal, under the lobes of the pinnules. *Spores* about $46 \mu\text{m}$ in diameter (Std Dev. $\pm 1,10$), triangular in outline with a faintly prominent trilete ridge, reticulate-cristate, the trilete ridge formed by reticulating cristae (Figure 13a–c).

Vouchers: Allardice 1504 (PRE); Giffen FH 1838 (PRE); Henrici 3966 (PRE); Jacobsen 5185 (PRE); Oliver & Mueller 6455 (PRE).

Distribution

The form extends from the south-western Transvaal into the northern Cape Province and south-eastern SWA/Namibia and southwards in a broad strip through the central Karoo, the OFS and part of Lesotho to the south-eastern Cape. A few finds of the form have been made in central SWA/Namibia (Figure 14).

FIGURE 12.—*Cheilanthes hirta* Swartz var. *brevopilosa* W. & N. Jacobsen forma *laxa* (Kunze) W. & N. Jacobsen. Cape, 3224 (Graaff-Reinet): Karoo Nature Reserve (-BB), Jacobsen 5185: a, outline of frond, $\times 0,5$; b, portion of rachis with right pinna, $\times 3$; c, portion of rachis, $\times 13$; d, basal stipe scale with sclerotic brown centre, $\times 38$; e, glandular hair of underside with russet-coloured interstices, $\times 102$; f, unicellular clear hair of upper surface, $\times 222$; g, clear hair of underside, $\times 102$; h, rachis hair, $\times 102$.

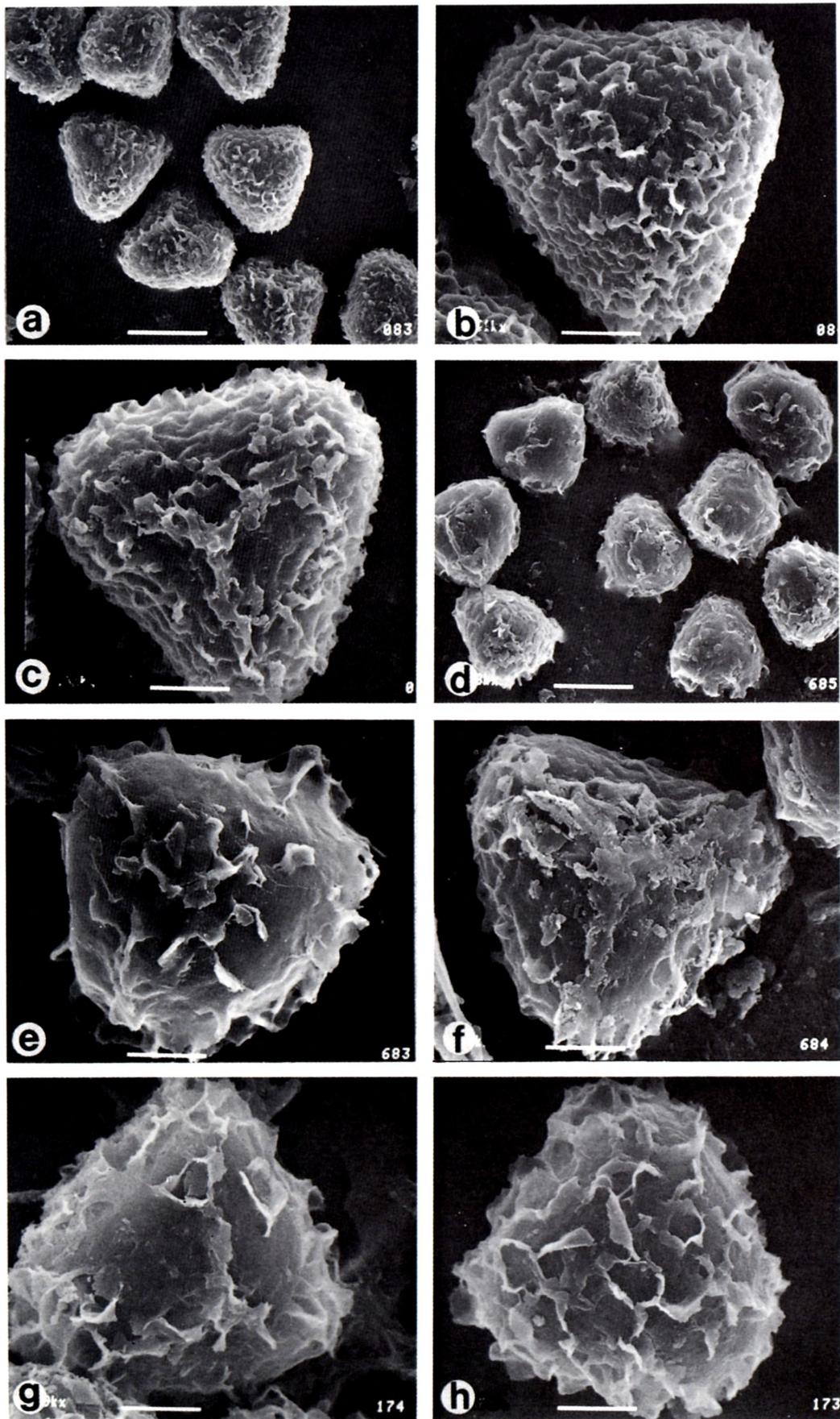


FIGURE 13.—*Cheilanthes hirta* Swartz var. *brevipilosa* W. & N. Jacobsen forma *laxa* (Kunze) W. & N. Jacobsen, Allardice 1504: a, several spores, $\times 380$; b, single spore, distal face, $\times 1040$; c, single spore, proximal face, $\times 1040$. *Cheilanthes hirta* Swartz var. *brevipilosa* W. & N. Jacobsen forma *waterbergensis* W. & N. Jacobsen, Jacobsen 5137: d, several spores, $\times 380$; e, single spore, distal face, $\times 1050$; f, single spore, proximal face, $\times 1050$. *Cheilanthes hyaloglandulosa* W. & N. Jacobsen, N. Jacobsen 5255: g, single spore, proximal face, $\times 925$; h, single spore, distal face, $\times 880$.

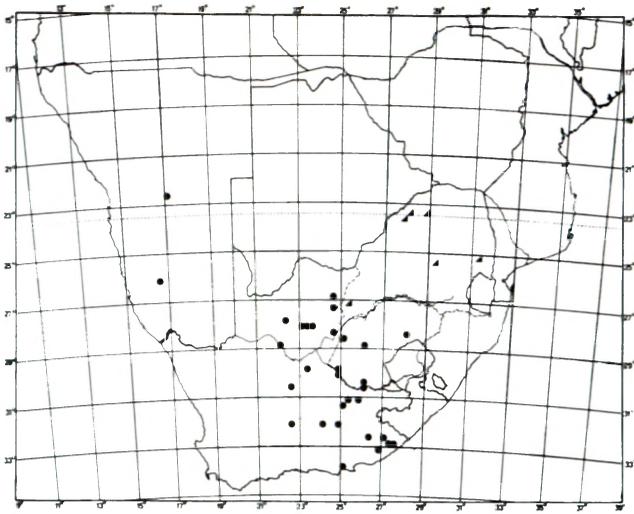


FIGURE 14.—Distribution of *Cheilanthes hirta* var. *brevopilosa* formae *laxa*, ●, and *waterbergensis*, ▲.

Ecology

It is a xerophytic representative of the *C. hirta* complex, growing mostly on stony slopes or amongst boulders or in rock crevices (very often of dolerite) under fairly arid conditions, never on north aspects, rarely on west-facing slopes, but frequently on east and south aspects. It shelters usually under boulders or overhanging krantzes or, if sufficient scrubby vegetation is available, as for instance in the Karoo Nature Reserve at Graaff-Reinet or in the south-eastern Cape, under shrubs, sometimes belonging to the genus *Euphorbia*. The habit of the plants is therefore not xeromorphic, but mesomorphic, with a small rhizome and frail stipes and rhachis.

The altitudinal range extends from practically sea level in the south-eastern Cape to about 2 000 m in western Lesotho in areas with the rainfall ranging from 200 to $\pm 1\ 000$ mm annually. Phenologically it follows the pattern of *C. hirta* var. *hirta* and var. *brevopilosa*. It is occasional to rare and mostly isolated.

Notes

C. hirta var. *brevopilosa* forma *laxa* probably corresponds with *C. glandulosa* of Pappe & Rawson (1858), the type of which was collected in Griqualand in 1857 by Moffat, but is now lost. According to the description it had purple stipes and rhachises with glandular hairs. Pappe & Rawson (1858: 36) remark that this species was 'very like *C. hirta* var. *laxa* of Kunze (1836)', which is obviously a lax variety of the species. It appears therefore that Baker, cited in Anthony: 70 (1984), erred in comparing a contracted form with the type specimen of *C. glandulosa* in Herb. Rawson.

C. hirta var. *brevopilosa* forma *laxa* differs from all other taxa of the complex, except *C. hirta* var. *brevopilosa* forma *waterbergensis* and *C. nielsii*, in the smaller size and fragile stipe. It differs from *C. hirta* var. *brevopilosa* forma *waterbergensis* in the 1–2 mm long hairs on the rhachis which are without long basal pyramidal cells, and from *C. nielsii* in the tripinnate fronds.

5. *Cheilanthes hirta* Swartz var. *brevopilosa* W. & N. Jacobsen forma *waterbergensis* W. & N. Jacobsen, forma nova. Type: north-western Transvaal, farm Ketting 368 LR, N. Jacobsen 5121 (PRE, holo.), Figures 11b, 13d–f & 15.

A taxis affinis praeter *C. hirtam* var. *brevilosam* forma *laxam* et *C. nielsii*, statura parva et stipite gracili differt. A *C. hirta* var. *brevopilosa* forma *laxa* cellulis basalibus pyramidalibus pilorum longiorum rhachidis et a *C. nielsii* fronde tripinnata differt.

All morphological features coincide with those of *C. hirta* var. *brevopilosa* forma *laxa*, but pinnae mostly with 5 pairs of pinnules. Pinnules triangular to oblong, deeply lobed, terminal segment lobed, apex rounded, margins not hairy (Figure 15b), but hirsute on both surfaces with short 1–3-celled, gland-tipped hairs (Figures 15f, g). Rhachis well covered with mostly thin and fine hairs, often gland-tipped, mostly 2- or 3-celled, but also with some longer ones with up to 6 cells, with a characteristic pyramidal long basal cell (Figures 15d, e). Spores about 51 μm in diameter (Std. Dev. $\pm 0,57$), triangular with faintly prominent trilete ridge; spore surface forming a network of irregular rugulose cristae, sparse on proximal face and on the trilete ridge.

Vouchers: Burt Davy 1670 (PRE); Galpin M 700 (PRE); Jacobsen 5137 (PRE); Rodin 4127 (PRE).

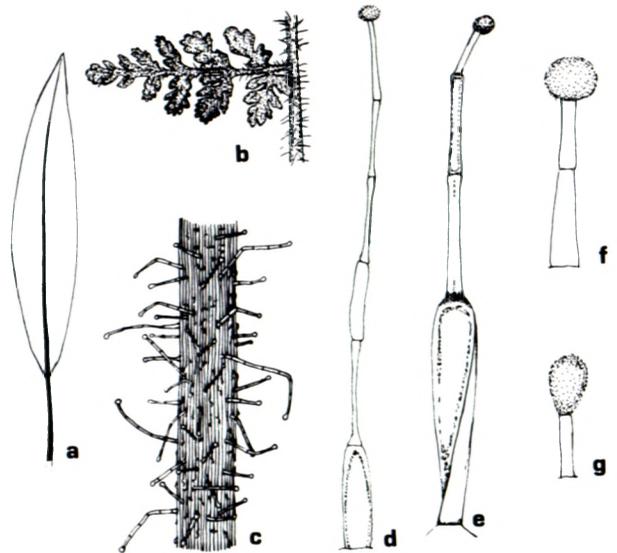


FIGURE 15.—*Cheilanthes hirta* Swartz var. *brevopilosa* W. & N. Jacobsen forma *waterbergensis* W. & N. Jacobsen. Transvaal, 2328 (Baltimore): Koedoesrand, farm Wemmersvlei 185 LR (–AC), Jacobsen 5137: a, outline of frond, $\times 0,7$; b, portion of rhachis with left pinna, $\times 3$; c, portion of rhachis, $\times 27$; d, rhachis hair, $\times 136$; e, stipe hair, $\times 136$; f & g, very short hairs of the lamina surfaces, $\times 406$ (both d & e show the characteristic pyramidal basal cell of these hairs).

Distribution

This form occurs to the north of the area of forma *laxa* in the western and north-western Transvaal with the northern limit north of the Waterberg. There are isolated finds from the Loskop Dam and from near Pretoriuskop in the Kruger National Park (see Figure 14).

Ecology

Forma *waterbergensis* is a xerophytic form of the drier areas of the Transvaal, where the annual rainfall does not

exceed 600 mm. Scarcity of material prevents an assessment of the altitudinal range. It may be between 700 and 1 100 m. Similar to forma *laxa*, the plants prefer south aspects, growing in shallow lithosols of sandstones, felsite or granite amongst and in shelter of boulders or in rock crevices. The form is rare and has been collected only a few times.

Notes

The form was separated from the similar and widespread forma *laxa* on account of the different nature of the hairs of the rhachis. It differs from *C. hirta* var. *brevipilosa* in the pyramidal basal cells of the rhachis hairs; in its small size and in the frail stipe and rhachis, which are very different from the robust stipe of the variety. The pinnae spread from the rhachis at almost 90° while those of var. *brevipilosa* are always ascending.

6. *Cheilanthes hirta* Swartz var. *nemorosa* W. & N. Jacobsen, var. nova. Type: eastern Transvaal, Mount Sheba Nature Reserve, Jacobsen 4443 (PRE, holo.; Herb. Jacobsen, iso.) Figures 16, 17 & 18a-c.

A taxis affinitibus aliis, praeter aliquas formas montanas, statura magna, fronde usque ad quadripinnatifida, ovato-lanceolata, latissime infra medium et sporis dense subtiliterque reticulato-cristatis differt.

Rhizome robust, erect, with densely tufted fronds and with linear, subulate, light brown to reddish brown scales 5–9 × 0,2–0,5 mm. *Stipe* terete, dark reddish brown to almost black, dull or shiny, stout, up to 2 mm in diameter, basal scales lanceolate to very narrowly linear, acuminate to subulate, 5–10 × 0,2–1,2 mm (Figure 17d), foxy red to brown, higher up replaced by

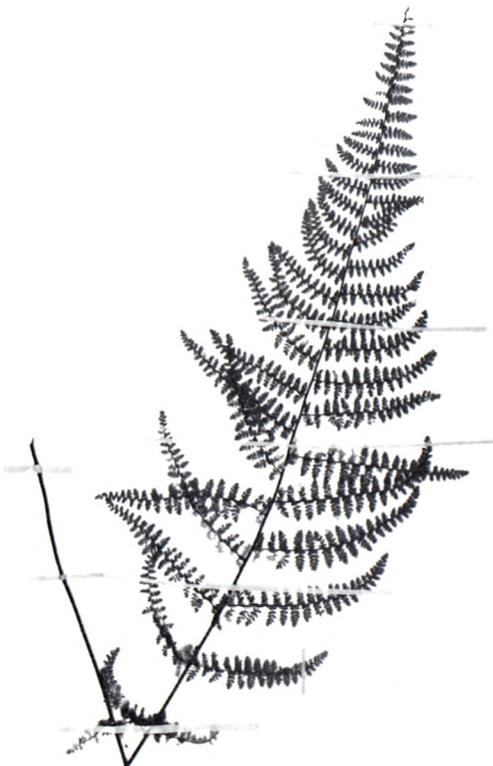


FIGURE 16.—*Cheilanthes hirta* Swartz var. *nemorosa* W. & N. Jacobsen. Transvaal, 2430 (Pilgrim's Rest): Mount Sheba Nature Reserve, on way to Gola Gola Waterfalls, in light scrubby forest, 1 660 m (—DB) Jacobsen 4443 (isotype), × 0,4.

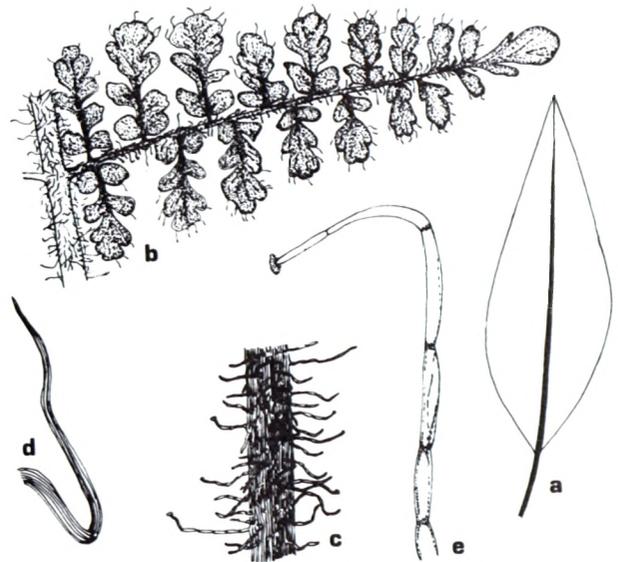


FIGURE 17.—*Cheilanthes hirta* Swartz var. *nemorosa* W. & N. Jacobsen. 2730 (Vryheid): Kwamadhlangampisi Mountain, near Dirkiesdorp, Transvaal (—AB), Jacobsen 5113: a, outline of lamina, × 0,2; b, portion of rhachis with right pinna, × 3; c, portion of rhachis, × 10; d, scale at base of stipe, × 38; e, rhachis hair, × 85.

patent, occasionally gland-tipped light brown to fox-red hairs up to 2 mm long. *Lamina* ovate-lanceolate to narrowly lanceolate, broadest below the middle (Figures 16, 17a), long tapering towards the apex, 3-pinnate to 4-pinnatifid, finely divided, apex rounded to acute with a minute terminal segment 3–5 mm long, base tapering with 1–4 pairs of pinnae reduced. *Pinnae* triangular to oblong, spreading at 61°–80° from the rhachis, in large specimens the lowest 20–28 × 5–20 mm, 35–44 mm distant from next above, largest below middle of frond 40–95 × 14–25 mm, 19–23 mm from each other, uppermost pinnae 1–3 mm from the terminal segment. *Pinnules* in (4)5–9 pairs, oblong, deeply pinnatifid to pinnate to a winged costule, upper ones, elliptic, slightly lobed (especially in the high altitude forms), lobes oblong-cuneate or rounded, apex obtuse (Figure 17b), terminal segment pinnatifid with apex rounded, margins and both surfaces with long, 4–5-celled non-glandular hairs. *Rhachis* round, shiny below, matt above, castaneous to dark brown with mostly non-glandular, 5 or 6(9)-celled, usually with fine and twisted hairs up to 2 mm long (Figure 17c, e). *Spores* on average 53 μm in diameter (Std Dev. ± 2,29), globular to faintly triangular in outline, trilete ridge not or only very faintly developed, loosely to densely and finely reticulate-cristate, rarely cristate-rugulose (Figure 18a–c).

Vouchers: Buitendag 1246 (PRE); Compton 30444 (PRE); Jacobsen 5113 (PRE); Strey 6167 (PRE); Wager 4595 (PRE).

Distribution

The variety is confined to the high rainfall areas of South Africa, following essentially the eastern escarpment and the mountains of the southern Cape. The distribution is somewhat patchy with isolated areas along the Soutpansberg-Woodbush escarpment, a long strip from The Downs in eastern Transvaal through Swaziland to the Louwsburg area and some isolated occurrences in the Witbank-Belfast and Ermelo areas. After a gap in the

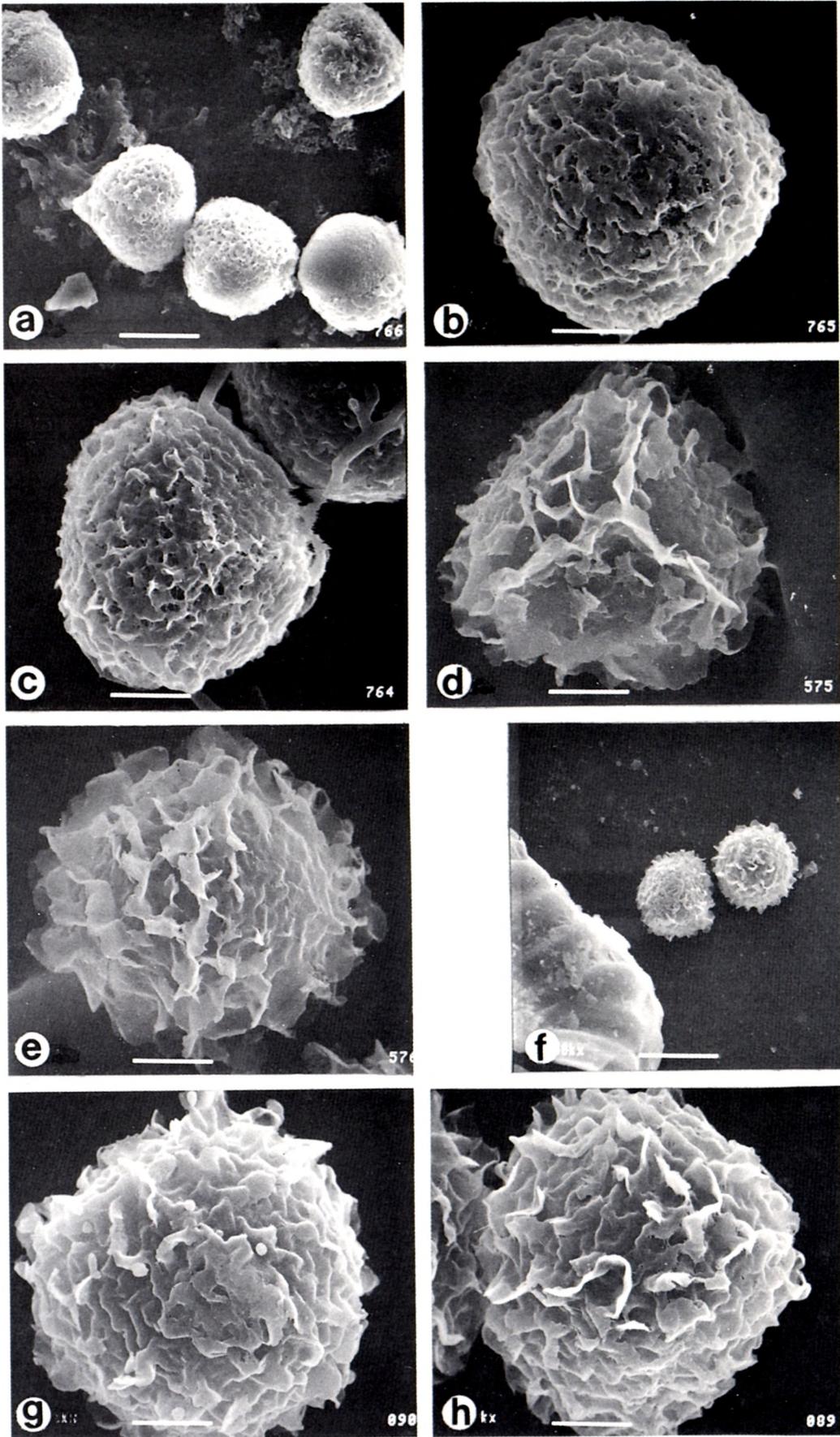


FIGURE 18.—*Cheilanthes hirta* Swartz var. *nemorosa* W. & N. Jacobsen, *Jacobsen 4443*: a, several spores, $\times 380$; b, single spore, distal face, $\times 890$; c, single spore, proximal face, $\times 840$. *Cheilanthes hirta* Swartz var. *inferacampestris* W. & N. Jacobsen, *V. d. Schiff 3990*: d, single spore, proximal face, $\times 1100$; e, single spore, distal face, $\times 1100$. *Cheilanthes nielsii* Jacobsen, *Jacobsen 5125*: f, several spores, $\times 380$; g, single spore, proximal face, $\times 1500$; h, single spore, distal face, $\times 1500$.

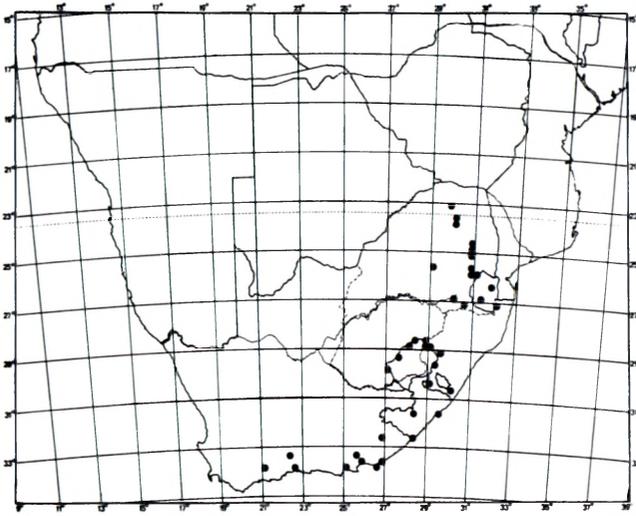


FIGURE 19.—Distribution of *Cheilanthes hirta* var. *nemorosa*.

Natal Midlands it is found again all along the OFS/Lesotho border, along the Drakensberg and into southern Natal and Transkei, ending in the Hogsback area of the eastern Cape. The southern Cape area extends from the Suurberg to the Grootvadersbos (Figure 19).

Ecology

The variety grows as a hemicryptophyte in shallow lateritic, humiferous soils of fersiallitic to ferallitic nature, mostly amongst boulders on mountain slopes or in gullies and ravines, as long as there is a certain amount of shade. It does not enter the wet forest of its environment, but prefers forest edges and scrub forest in areas of 800 to more than 1 200 mm annual rainfall. It was thought not to occur at greater altitudes than about 1 800 m, but a dwarf, typical montane form occupies elevations from 1 800 to about 2 300 m in the Witziesshoek-Sentinel area, either on scree slopes in the shelter of ericoid scrub or sometimes in company with *Polystichum alticola* Schelpe & N. C. Anthony or chasmophytic on basalt cliffs, again with *P. alticola* or *Cheilanthes eckloniana* (Kunze) Mett. These plants are usually between 150 and 200 mm, rarely up to 300 mm tall and about 50 mm broad.

Note

C. hirta var. *nemorosa* is morphologically an easily recognized type and its spores are rather different from the other members of the *C. hirta* complex. This might have justified specific rank, but some intermediates between it and var. *brevipilosa* or var. *inferacampestris* respectively were seen, so that varietal status is preferable.

7. *Cheilanthes hirta* Swartz var. *inferacampestris* W. & N. Jacobsen, var. nov. Type: Transvaal, Kruger National Park, V. d. Schiff 3990 (PRE, holo.). Figures 18d, e; 20 & 21.

A varietate typica pinnis patentibus laxis differt; a taxis ceteris complexi pilis longioribus laminae differt.

Rhizome black, robust, erect, with closely tufted fronds; scales practically absent except for a few very small, almost black scales low on the rhizome. **Stipe** terete, 1 mm in diameter, dark brown, dull, firm; basal

scales $5 \times 0,6$ mm, lanceolate, light brown, replaced upwards by patent light brown hairs up to 2 mm long (Figure 21d). **Lamina** slender, not contracted, delicately 3-pinnatifid to 3-pinnate, lanceolate to narrowly oblong, broadest in the middle (Figures 20, 21a), $180-360 \times 30-70$ mm, apex acute with a small terminal segment, base with only a few pairs of pinnae slightly reduced. **Pinnae** spreading at $60^\circ-78^\circ$ from the rachis, lowest 28 mm long, 35 mm distant from next above, largest coarsely serrate to bi-pinnatifid, $30-33 \times 20-23$ mm, 18 mm apart, triangular, subacute to obtuse (Figure 21b), upper ones crowded, about 4 mm distant from the terminal segment, which is pinnatifid or lobed. **Pinnules** elliptic in outline, apex lobed, margins and surfaces with scattered, straight, long, 4 or 5-celled hairs (Figure 21e), similar to those on the rachis. **Rhachis** cylindrical, castaneous or greenish brown in the upper part, hairs dense (Figure 21c), patent, (1-) 1,5–2,8 mm long, simple or only occasionally glandular, 6–8 (–15)-celled. **Spores** $41 \mu\text{m}$ in diameter (Std Dev. $\pm 0,97$), globular to rounded triangular, trilete ridge weakly developed, consisting of anastomosing cristae; distal face loosely, but strongly cristate, proximal face sparsely so, often only with some isolated rugose cristae on a rugulose base, so that the spores appear echinate with blunt projections in profile (Figure 18d, e).

Vouchers: Buitendag 1060 (PRE); Codd & De Winter 4895 (PRE); Van der Schijff 3745 (PRE); Vassilatos & Mantell 805 (PRE); Wager 1622c (PRE).

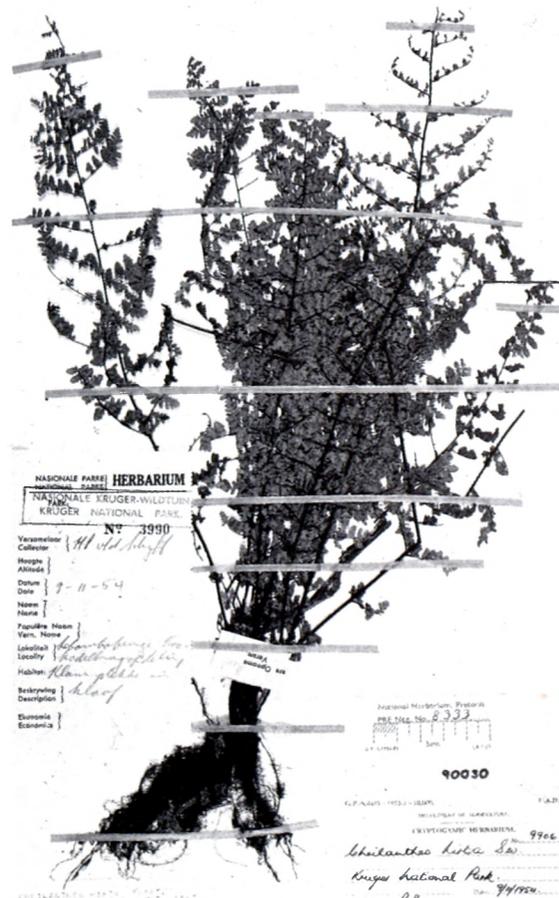


FIGURE 20.—*Cheilanthes hirta* Swartz var. *inferacampestris* W. & N. Jacobsen. Transvaal, 2531 (Komatipoort): Lebombo Mountains, Crocodile Bridge section of the Kruger National Park (–BD), H. P. v. d. Schiff 3990 (holotype), $\times 0,25$. The tall growth and very lax habit are characteristic.

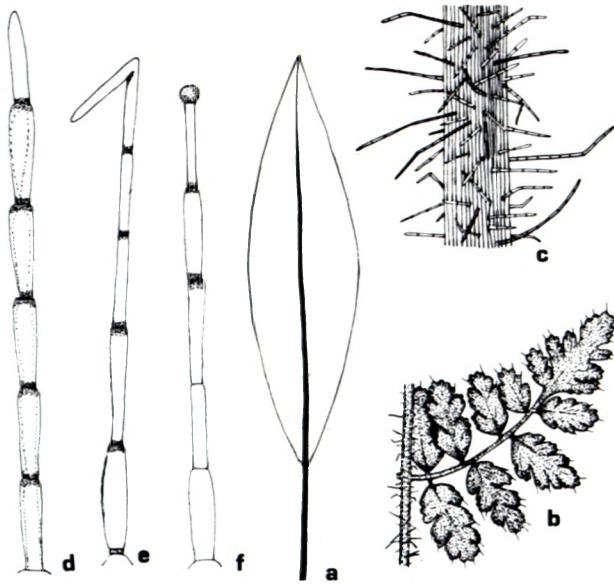


FIGURE 21.—*Cheilanthes hirta* Swartz var. *inferacampestris* W. & N. Jacobsen. Kruger National Park, H. P. v. d. Schijff 7743: a, outline of lamina, $\times 0.25$; b, portion of rhachis with right pinna, $\times 2$; c, portion of rhachis, $\times 13$; d, stipe hair, $\times 70$; e, lamina hair, $\times 70$; f, glandular rhachis hair, $\times 70$.

Distribution

Var. *inferacampestris* is found from the eastern Transvaal (southern Kruger National Park) through eastern Swaziland, Zululand and Natal, to the Port Shepstone area. One isolated specimen was seen from the Devuli Ranch in the Bikita District of Zimbabwe (Figure 22).

Ecology

The variety, although confined to low-lying hot areas is by no means typical of xerophytic habitats, but is usually found in sheltered shady localities, on south-facing rocky slopes with humiferous loamy soil. It may be found in scrub forest or in kloofs and ravines, in the shade of large boulders or amongst undergrowth. The annual rainfall varies between 600 mm (where the variety grows only in moist localities) and $\pm 1\ 000$ mm. The altitudinal range is between 50 and 600 m.

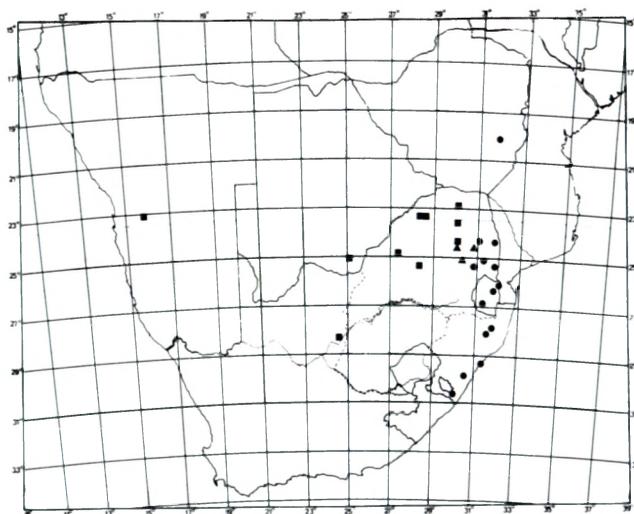


FIGURE 22.—Distribution of *Cheilanthes hirta* var. *inferacampestris*, ●; *C. nielsii*, ■; and *C. hyaloglandulosa*, ▲.

8. *Cheilanthes hyaloglandulosa* W. & N. Jacobsen in South African Journal of Botany 51: 145–148 (1985). Type: Transvaal, farm Wanhoop 78 JT, N. Jacobsen 5255 (PRE, holo.). Figures 13g, h; 23.

The species has been described recently, but it was felt that some supporting drawings and spore micrographs might be informative. As the spores have not yet been described a few words are necessary. Spores average $60\ \mu\text{m}$ in diameter, are roughly triangular with prominent cristate trilete ridge, the surface is loosely cristate with broad anastomosing cristae, up to $12\ \mu\text{m}$ high on a smooth base.

Vouchers: Jacobsen 5286 (PRE); Mogg 4894 (PRE).

Distribution and ecology

The species is known only from a few localities above 1 800 m altitude in the eastern Transvaal escarpment (Figure 22), where they grow in shallow lithosols over quartzite, along rocky shelves and amongst boulders on east and north-facing slopes in full sunlight. The fronds wither away during the cold season.

9. *Cheilanthes nielsii* W. B. G. Jacobsen, The ferns and fern allies of southern Africa: 252 (1983). Type: north-western Transvaal, Potgietersrus District, farm Goedgelegen 194 LR, Koperkop, Jacobsen 5126 (PRE, holo.). Figures 18f–h; 24.

Cheilanthes hirta sensu N. C. Anthony: t. 13F (1984).

Icones: Jacobsen: fig. 182a, b (1983).

This species was fully described by Jacobsen (1983) and merely a few line drawings of the species as well as micrographs of the spores are presented here. As the latter have not yet been described this is done in this paper.

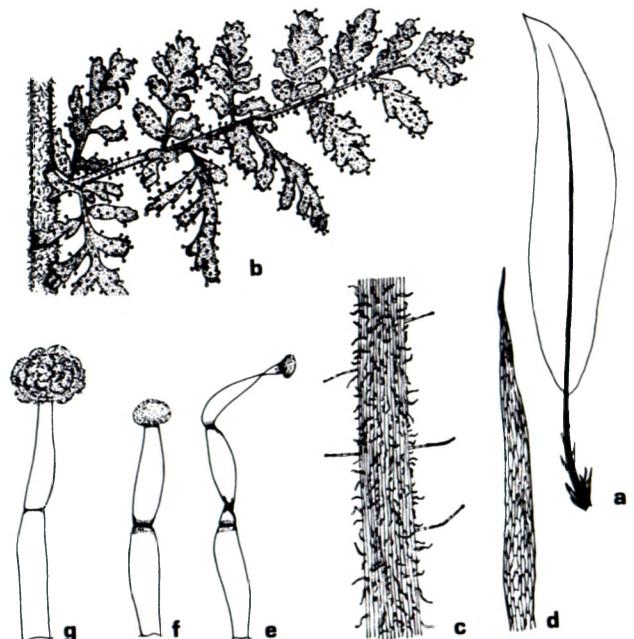


FIGURE 23.—*Cheilanthes hyaloglandulosa* W. & N. Jacobsen. Transvaal, 2530 (Lydenburg): Farm Wanhoop 78 JT, Dullstroom District (–AA), Jacobsen 5255: a, outline of frond, $\times 0.4$; b, portion of rhachis with right pinna, $\times 4$; c, portion of rhachis, $\times 10$; d, basal rhachis scale, $\times 13$; e & f, rhachis hairs, $\times 216$; g, stalked gland from the upper surface of the lamina, $\times 216$.

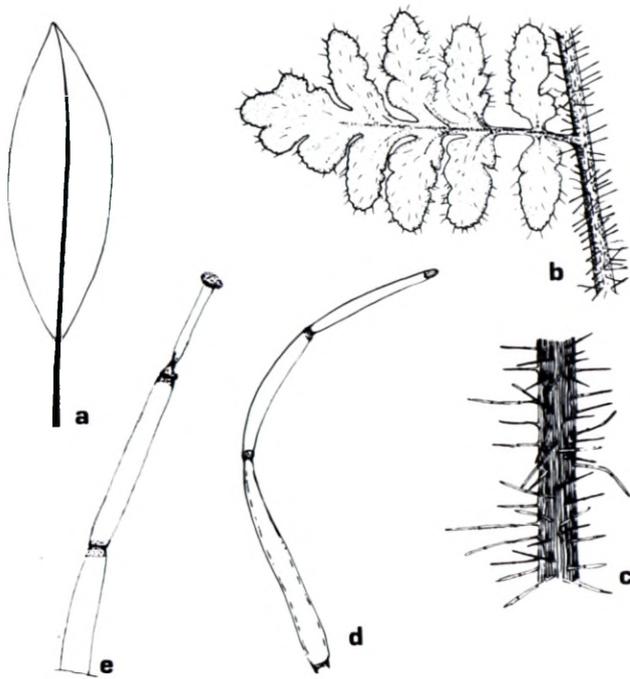


FIGURE 24.—*Cheilanthes nielsii* W.B.G. Jacobsen. Transvaal, 2328 (Baltimore); farm Goedgelegen 194 LR, Koperkop (–AD), Jacobsen 5126: a, outline of frond, $\times 0.9$; b, portion of rhachis and left pinna, $\times 5$; c, portion of rhachis, $\times 14$; d, hair at base of stipe, $\times 114$; e, hair at edge of pinnule, $\times 207$.

Spores average $36 \mu\text{m}$ in diameter (Std Dev. ± 0.52), are globular, the trilete ridge is not visible due to densely anastomosing, well developed cristae about $3 \mu\text{m}$ high (Figure 18f–h).

Vouchers: Jacobsen 5125 (K); 5207 (PRE); 5251 (PRE); Rang s.n. (PRE).

Distribution

The species is so far known with certainty from the northern and north-western Transvaal (because of poor preservation the few records from near Pretoria are dubious) and from a few isolated occurrences in the northern Cape and from one place in Botswana. A record from SWA/Namibia is doubtful, again due to poor preservation of the specimen (see Figure 22).

Ecology

The species inhabits very dry situations, growing on rocky hillsides or hilltops mostly in full sunlight amongst rock outcrops, on ledges and at boulder bases on north and west aspects, very much rarer on SSW-facing slopes and then in partial shade. Rainfall requirements are in the 400–600 mm range annually and the altitude lies between 700 and 1 100 m.

Notes

C. nielsii is included in this study merely because its indumentum has a certain similarity to that of the members of the *C. hirta* complex. Anthony (1984) declares that it is indeed a shade form of *C. hirta*. In view of the data given above, this view cannot be upheld. Anthony also states that the spores are indistinguishable from those of *C. hirta*. While it is true that some members of the *C. hirta* complex have similarly strongly cristate spores, as for instance *C. hirta* var. *hirta*, others within

the complex have deviating spores. The spores of *C. nielsii* are in fact not like any of the other members of the complex as they are very small, having an average size of $36 \mu\text{m}$ with very little variation. The smallest spores found within the complex are those of *C. hirta* var. *inferacampestris* with an average of $41 \mu\text{m}$, while those of var. *hirta* average $64 \mu\text{m}$. Morphologically *C. nielsii* is entirely different from var. *inferacampestris*, a form always growing in shade under fairly dry climatic conditions. As pointed out by Jacobsen (1983) the plants have morphologically a greater affinity to *C. inaequalis* (Kunze) Mett. var. *buchananii* (Bak.) Schelpe and to *C. leachii* (Schelpe) Schelpe as well as to *C. capensis* (Thunb.) Swartz than to *C. hirta*. Although the possibility of a derivation from the latter cannot be ruled out, it is felt that the specific status should be maintained because of the consistent morphological differences and lack of intermediates.

DISCUSSION

Spores and possible evolution

The separation of a complex of species on the basis of spores alone is debatable and the authors quote C. Wood (1973), that 'great caution must obviously be exercised when we assume that a character such as spore morphology is of prime importance in either taxonomy or phylogeny, when so little is known concerning the methods by which such sculpturing is produced' (this refers to the sculpturing of the sporoderm). He found that there was a great variation in the spores of the Thelypteridaceae. Bearing this in mind, as well as the tendency of xerophytic ferns to be apogamous and to produce hybrids, the authors have put emphasis on morphological characters, which are of immediate use to the botanist in the field, and used the nature of the spores only in a supporting function. Study of the spores has, however, revealed the existence of a distinct and separate taxon within the group of rather contracted members of the complex. Later morphological studies confirmed that the taxon differed also substantially in other respects. This variety was named *Cheilanthes hirta* var. *brevipilosa*.

The size of the spores of members of the complex varies greatly. The type variety, var. *hirta*, shows an average of $64 \mu\text{m}$, whereas spores of other members are as small as $41 \mu\text{m}$ (var. *inferacampestris*) and those of *C. nielsii* are consistently around the $36 \mu\text{m}$ mark. This agrees with R. M. & A. F. Tryon's (1973) findings for the entire cheilanthoid group. The large size of the spores of *C. hirta* var. *hirta* seems to point to an ancient type and its occurrence on Madagascar, Réunion and Mauritius may indicate that the variety existed already during the Miocene, if not the Oligocene periods. The rather large standard deviation (Std Dev.) of ± 2.71 confirms the noticeable irregularity in size and ornamentation, which would indicate apogamy and tendency to form hybrids.

Var. *brevipilosa* likewise seems to have separated from the ancestral form at a fairly early age as it is probably diploid (Prof. T. Reichstein, pers. comm.), but apparently originated later than the Miocene period. The spores are of average size ($48 \mu\text{m}$) with relatively little variation (Std Dev. ± 1.34). Var. *nemorosa* with its relatively large spores (average $53 \mu\text{m}$) and greater variability—the standard deviation here is ± 2.29 —is

TABLE 1.—Measurements of laminae and pinnae (in mm) of the *Cheilanthes hirta* complex and related species. Taxa are arranged from mesophytic (top) to xerophytic

Lamina	No. measurements	Min. length	Max. length	Range	Mean length	Min. width	Max. width	Range	Mean width	Ratio L:W min.	Ratio L:W Max.	Range	Mean ratio L:W
<i>C. hirta</i> var. <i>nemorosa</i>	23	185	600	415	362	40	170	130	93	2,66	7,89	5,23	4,23
<i>C. hirta</i> var. <i>inferacampestris</i>	11	185	360	175	280	30	70	40	54	4,07	8,00	3,93	5,18
<i>C. hyaloglandulosa</i>	4	170	255	85	233	20	52	32	45	4,42	8,50	4,08	5,18
<i>C. hirta</i> var. <i>hirta</i>	25	100	435	335	223	5	47	42	26	5,00	20,00	15,00	8,66
<i>C. contracta</i>	24	90	490	400	208	11	40	29	19	5,90	14,47	8,57	9,01
<i>C. hirta</i> var. <i>brevipilosa</i>	20	115	290	175	206	12	65	53	25	4,00	18,75	14,75	8,25
formae <i>laxa</i> and <i>waterbergensis</i>	21	60	250	190	143	14	50	36	32	2,90	8,46	5,56	4,73
<i>C. nielsii</i>	6	64	120	56	87	28	55	27	35	2,13	3,67	1,54	2,49

Largest pinna	No. measurements	Min. length	Max. length	Range	Mean length	Min. width	Max. width	Range	Mean width	Ratio L:W min.	Ratio L:W Max.	Range	Mean ratio L:W
<i>C. hirta</i> var. <i>nemorosa</i>	24	30	120	90	67	12	30	18	19	2,35	6,07	3,71	3,55
<i>C. hirta</i> var. <i>inferacampestris</i>	11	20	45	25	34	12	22	10	14,6	1,67	2,81	1,14	2,30
<i>C. hyaloglandulosa</i>	4	16	30	14	26	3,5	14	10,5	12	1,92	4,57	2,65	2,19
<i>C. hirta</i> var. <i>hirta</i>	21	12	40	28	22	6	14	8	9,6	1,08	4,00	2,92	2,26
<i>C. contracta</i>	24	9	38	29	18	2,5	11,5	9	5,8	2,20	4,67	2,47	2,63
<i>C. hirta</i> var. <i>brevipilosa</i>	16	9	40	31	17,5	4	13	9	8,3	1,54	3,33	1,79	2,10
formae <i>laxa</i> and <i>waterbergensis</i>	22	8	32	24	18	4,5	14	9,5	9	1,40	4,57	3,17	2,10
<i>C. nielsii</i>	6	14	28	14	18	8	22	14	12	1,25	1,79	0,54	1,49

Angle of pinna/rhachis	No. meas.	Min. de-grees	Max. de-grees	Range	Mean de-grees
<i>C. hirta</i> var. <i>nemorosa</i>	23	65	77,5	12,5	72,25
<i>C. hirta</i> var. <i>inferacampestris</i>	22	59,5	78	18,5	68,66
<i>C. hyaloglandulosa</i>	16	58,5	78	19,5	70,50
<i>C. hirta</i> var. <i>hirta</i>	17	39	79	40	55
<i>C. contracta</i>	12	37,5	51,5	14	45,75
<i>C. hirta</i> var. <i>brevipilosa</i>	16	45	79	34	54
formae <i>laxa</i> and <i>waterbergensis</i>	10	71	78	7	74
<i>C. nielsii</i>	22	67	81	14	76

probably also an older segregate. The sporoderm is generally consistently finely reticulate. With its lax growth and its spreading, finely divided pinnae, var. *nemorosa* is easily distinguished from all other members of the complex, even when unusually small, as in the montane forms.

The spores of var. *inferacampestris* are much smaller, averaging 41 μm . The variety has probably evolved from var. *nemorosa* in more recent times. This assumption is merely based on morphological similarity, as the sporoderm of the varieties is entirely different, being loosely and strongly cristate in *inferacampestris* and finely reticulate to reticulate-rugulose in var. *nemorosa*.

The spores of the two formae of var. *brevipilosa* with their distinctly triangular shape, prominent trilete ridge and rugulose-cristate sporoderm, are similar to the typical forma, which was the main reason for considering them as derivatives of it—even though their small and delicate, widely spreading fronds have little morphological affinity with it. The spores vary very little, having a standard deviation of only $\pm 1,10$ for forma *laxa* and $\pm 0,57$ for forma *waterbergensis*.

C. contracta has entirely different spores and is therefore thought to have originated from a non-related tribe, which developed in the southern Cape, and in a later

period extended its range to the Transvaal. Spore variation is minimal. *C. hyaloglandulosa* has large, strongly cristate spores ($\pm 60 \mu\text{m}$), similar to var. *hirta* and has probably evolved from it, but is considered to be a separate species because of its dense cover of unicellular glands on several-celled stalks. The tiny spores of *C. nielsii* are indeed superficially similar in their cristate, round sporoderm to those of *C. hirta* var. *hirta*, but they are almost only half as large. This fact and the consistent differences in habit exclude the plants from the *C. hirta* group. *C. nielsii* is therefore considered a distinct species, even though it may have derived from the *C. hirta* group. Cristate sporoderms are, according to Tryon & Tryon (1973), predominant in the cheilanthoid ferns, even if this is less pronounced amongst the South African species. Yet the spores of *C. marlothii* (Hieron.) Schelpe (= *Notholaena marlothii* Hieron.), a plant of very different habit, are very similar to those of certain types of the *C. hirta* complex [compare Anthony (1984), Plate 2, C–D with Plate 13, C–E].

Morphology, phytogeography and climate

The length and width of the lamina and of the largest pinnae were measured as well as the angle of the pinnae to the rhachis. These parameters show some correlation with the climatic conditions under which the plants grow. The results are summarized on Table 1 and the

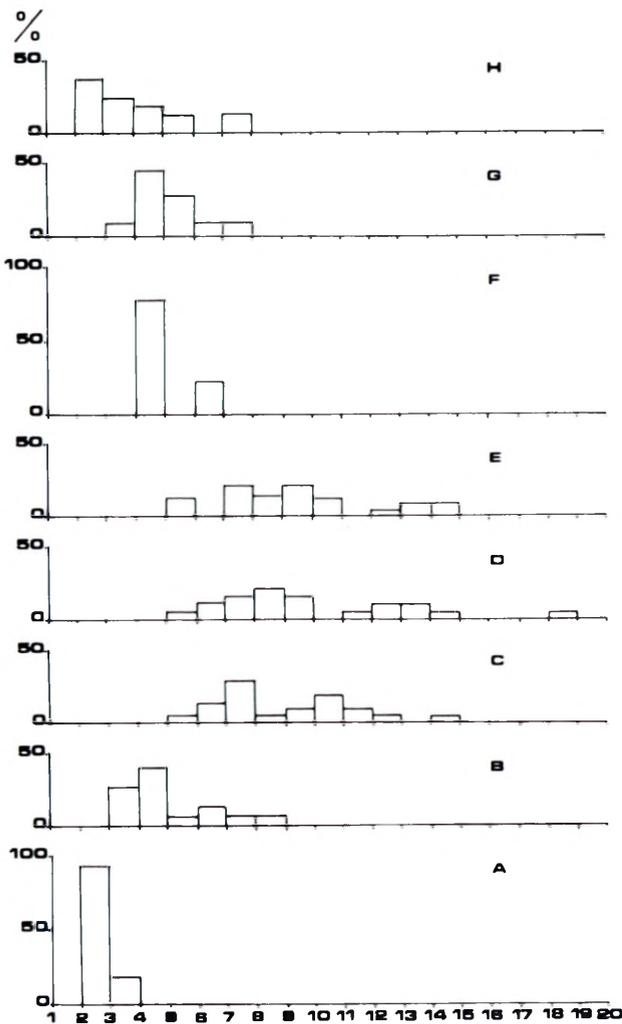


FIGURE 25.—Histograms of the ratio length to width of lamina of the members of the *Cheilanthes hirta* complex and some allied species. A, *C. nielsii*; B, *C. hirta* var. *brevipilosa* formae *laxa* and *waterbergensis*; C, *C. contracta*; D, *C. hirta* var. *brevipilosa*; E, *C. hirta* var. *hirta*; F, *C. hyaloglandulosa*; G, *C. hirta* var. *inferacampestris*; H, *C. hirta* var. *nemorosa*.

ratios of length to width of lamina and largest pinnae are depicted on the frequency histograms in Figures 25, 26 & 27.

It becomes evident that most of the members of the complex are typically associated with a certain type of climate. This is discussed in the sections on the ecology of the various taxa. The succession from east to west, i.e. from mesophytic to meso-xerophytic to xerophytic is reflected in the following sequence of the taxa:

C. hirta var. *nemorosa*—*C. hirta* var. *inferacampestris*—*C. hyaloglandulosa*—*C. hirta* var. *hirta*—*C. contracta*—*C. hirta* var. *brevipilosa*—*C. hirta* var. *brevipilosa* formae *laxa*/*waterbergensis*—*C. nielsii*.

The morphological changes parallel to this succession are: the lamina becomes narrower from the mesophytic environment towards the meso-xerophytic environment but broadens again as the xerophytic end is approached. The ratio maxima of length to width of the lamina moves from 2–3 times as long as wide (*C. hirta* var. *nemorosa*) to 20 times (*C. hirta* var. *hirta*) and decreases to 2–3 times (*C. nielsii*). The largest pinnae become shorter with the change to xerophytic conditions, being 2–6

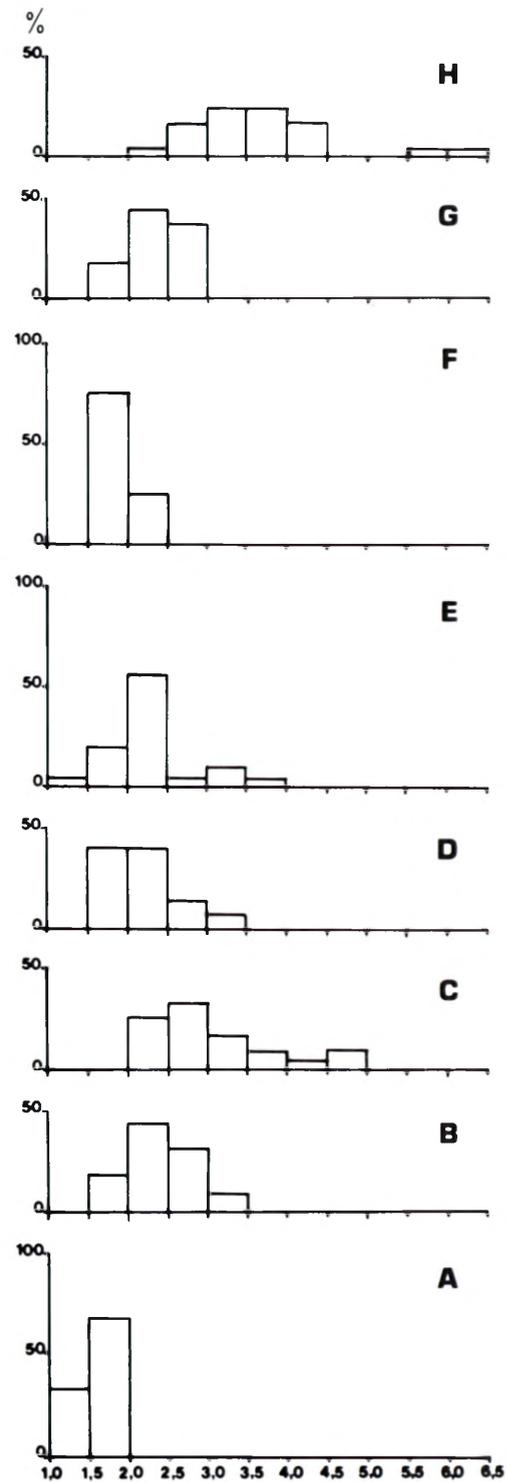


FIGURE 26.—Histogram of the ratio length to width of largest pinnae of the members of the *Cheilanthes hirta* complex and some allied species. A, *C. nielsii*; B, *C. hirta* var. *brevipilosa* formae *laxa* and *waterbergensis*; C, *C. contracta*; D, *C. hirta* var. *brevipilosa*; E, *C. hirta* var. *hirta*; F, *C. hyaloglandulosa*; G, *C. hirta* var. *inferacampestris*; H, *C. hirta* var. *nemorosa*.

times as long as wide in *C. hirta* var. *nemorosa* and only 1–2 times as long as wide in *C. nielsii*.

The angle of the pinnae to the rhachis becomes steeper towards the meso-xerophytic zone, but flattens out again towards the xerophytic end, averaging about 73° in *C. hirta* var. *nemorosa*, decreasing to between 46° and 55° in

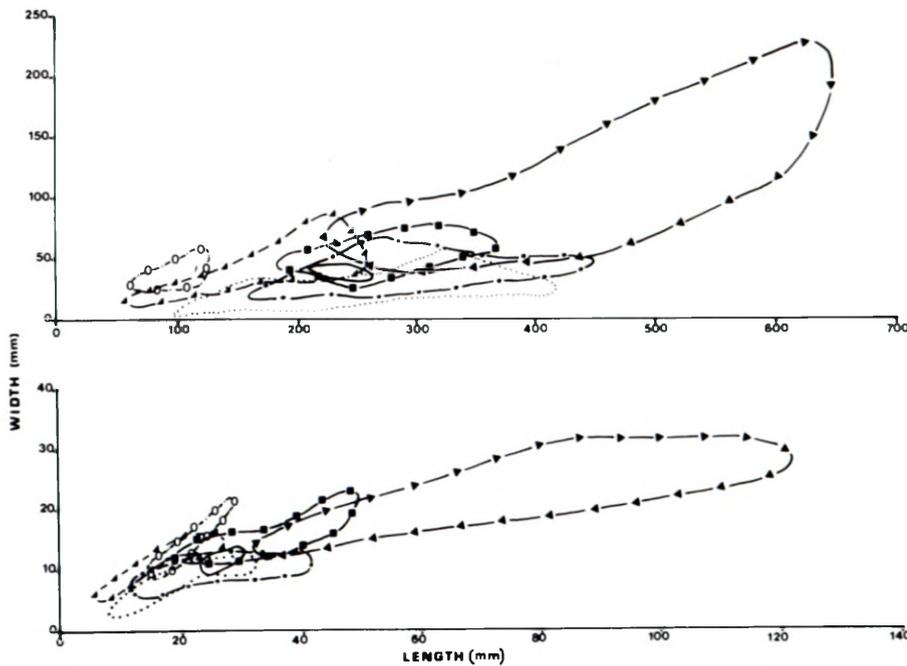


FIGURE 27.—Diagram of plotted measurements of lamina parameters of the members of the *Cheilanthes hirta* complex and some allied species: top, lamina; bottom, largest pinnae. —○—, *C. nielsii*; —■—, *C. hirta* var. *brevipilosa* formae *laxa* and *waterbergensis*; —●—, *C. hirta* var. *brevipilosa*; ·····, *C. hirta* var. *hirta*; —, *C. hyaloglandulosa*; —▲—, *C. hirta* var. *inferacampestris*; —▲—, *C. hirta* var. *nemorosa*.

C. contracta, *C. hirta* var. *hirta* and some forms of *C. hirta* var. *brevipilosa*, but reaching 74° in the xerophytic forms of the latter and 76° in *C. nielsii*.

The size and division of fronds decreases generally from wet to dry conditions.

The relatively tall mesomorphic habit with finely divided fronds which allows for maximum light exposure in *C. hirta* var. *inferacampestris* and *C. hirta* var. *nemorosa* gives way to the elongate meso-xeromorphic forms of the *C. hirta* var. *hirta*/*C. hirta* var. *brevipilosa*/*C. contracta* group with upwards directed, often contracted pinnae suited to cope with water loss. Towards the xerophytic end, however, no further contraction takes place and the formae *laxa* and *waterbergensis* escape desiccation by growing only in the shade of rocks, herbs or scrub on south-facing slopes, or wherever they are sufficiently protected from desiccation. They are small and delicate and not at all xeromorphic. *C. nielsii*, the most brittle of all, grows on fully exposed sites, in sunlight and frequently under very hot conditions. It is, however, entirely seasonal, being green only when the rainy season has fully set in and shrivelling rapidly when it gets too dry. In this respect and with its small rhizome and generally small size it resembles the small therophytes of arid areas. Its deviating position from the other members of the complex is well demonstrated in Figure 27, where its lamina ratios plot outside the general trend and where the ratios of the largest pinnae, although beginning within the trend, leave it at a steeper angle.

ACKNOWLEDGEMENTS

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SPECIMENS EXAMINED

All specimens listed are in the National Herbarium, Pretoria, unless stated otherwise. Those marked (Jac) are in the senior author's private herbarium.

Acocks 270 (4); 9160, 9825, 10810 (2); 19081 (1). *Allardice* 1504 (4). *Archibald* 5904, 5926 (5).

Balkwill & Cron 239 (2). *Bamps* 7017 (2). *Barnard* 2367 (2). *Baur* 136 (6). *Bosman* 2877 (3); *s.n.* (6). *Bottomley* 2779, 2878 (2). *Bottomley, Watson & Mogg* 2072 (3). *Bradfield* 132, 132a (3). *Brandmueller* 1987 (3); *s.n.* (2). *Bredenkamp* 449 (3). *Bremekamp & Schweickerdt* 386 (6). *Brown & Shapiro* 235 (2). *Brueckner* 385 (4). *Buitendag* 1060 (7); 1246 (6). *Burrows* 2121 (4). *Burt Davy* 1670 (5).

Codd & De Winter 4895 (7). *Coetzee* 978 (3). *Comins* 810 (2). *Compton* 30069 (7); 30444 (6). *Culverwell* 0050, 0664 (7).

Dahlstrand 2584 (4). *Daly* 54 (2); 725 (1). *De Beer* 177 (2). *De Joncheere* 292 (2); 294 (6); 303 (7). *Dieterlen* 264a (2); 264b (6); *CH* 6721 (3). *Dyer* 1698 (2).

Elliott 1506c (3). *Emdon* 85 (1). *Esterhuysen* 2053, 13157 (4); 15517 (6); 17082, 25808, 25917 (1); 26070 (6).

Fisher & Schweickerdt 540 (7). *Flanagan* 192c (2). *Fourie* 117/21, 791 (2); 903 (6).

Galpin M 700 (5). *Gibbs Russell* 3042 (2); 3127 BA, 4570 (3). *Giffen FH* 1838 (4); *FH* 1854, *s.n.* (3). *Grant* 3180 (2). *Griffin s.n.* (4). *Guillarmod* 176 (2); 808, 830 (3).

Hafstroem 858 (4); 921 (9); 1187 (4); 5117 (6). *Hafstroem & Acocks* 1950 (6). *Hanekom* 1432 (1). *Hardcastle* 2 (6); 274 (2). *Henrici* 1733 (2), 3966 (4). *Hilliard & Burt* 1713 (6). *Holub s.n.* (2). *Huntley* 1915 (2).

Jacobsen 5165, 5177, 5181, (1) Jac; 4269, 4521, 4525, 4907, 5062, 5318, (2) Jac; 4522, 4628, 5069, 5262, 5267, 5502 (3) Jac; 5254 (3) PRE, Jac; 5185 (4); 5121, 5137 (5); 2309, 4337, 4369, 5113, 5638,

5657, 5672 (6) Jac; 4443 (6); 5255 (8) FR, Jac, PRE; 5286 (8) PRE, Reichstein; 5125 (9) K; 5126, 5199, 5207, 5251 (9). *Jacobsz* 413 (3). *Jenkins* 910c, 914c (2). *Johnson* 643 (5). *Jooste* 193 (4).

Kluge 2179 (6). *Kotsokoane* 248 (6). *Krijt* 2311 (3).

Lambrechts 45 (2). *Lang* 5112 (6). *Leach & Bayliss* 12671 (2). *Leendertz* 856c, 980e, 1076, 2959 (2); 800 (3). *Leeuwenberg* 10912 (3). *Liebenberg* 7263 (1). *Lindstedt* 63 (4). *Louw* 2 (3).

Marloth 761 (2); 1077 (4); 4734, 6915 (1). *Marsh s.n.* (1). *Mauve, Reid & Wikner* 112 (1). *McLoughlin* 732 (6). *Meyer in Herb. Giess* 10775 (4). *Mitchell s.n.* (1). *Mogg* 600 (3); 1611 (2); 2282 (4); 2492 (2); 4210 (6); 4640 (3); 4894 (8); 7120 (2); 8882 (3); 11776, 15371, 18563 (2); 20729 (3). *Morris* 763 (7). *Moss & Rogers* 1169 (3). *Mott* 450 (2). *Mueller* 967 (4); 1559 (3). *Murray* 525 (3).

Nelson 464a (6).

Oliver & Mueller 6455 (4).

Paterson 794, 1734c (2). *Pegler* 269 (6). *Peplon* 6007 (7). *Pocock S* 181 (1). *Potgieter* 21830 (3). *Rang s.n.* (9). *Rauh & Schlieben* 9762 (3). *Reid* 124, 170 (2); 462, *s.n.* (3). *Repton* 5335 (3). *Roberts* 3228 (6). *Rodin* 1052 (2); 4127 (5). *Rogers* 990c (2); *s.n.* (3). *Rogers & Moss* 3583 (3). *Rose & Innes* 148 (2).

Scharf 1164 (1). *Scheepers* 434 (6), 1080 (2), *s.n.* (3). *Schelpel* 5912 (4), 5919 (1). *Schlechter* 16c (1), 995c (2). *Schlieben* 11045 (4). *Schmitz* 400 (6); 4204, 6471 (3); 6506 (6). *Schweickerdt s.n.* (2). *Sim* 193c, 194c (2); 345 *s.n.* (3); 1244c, 3678 (2). *Smith* 4408 (2). *Smook* 942 (2); 2019 (3). *Smook & Harding* 703 (4). *Snijman* 9 (3); 334 (1). *Stam* 83, 177 (3); 178 (4). *Story* 3390 (2). *Strey* 4254 (2); 6167, 7918 (6).

Taylor 5653 (3); 5915 (1); 7995 (6); 8009 (2). *Theiler s.n.* (2). *Theron* 856 (5); 2469 (2); 6475 (4). *Thode* A1877 (3). *Tyson* 136 (4).

Van der Schijff 53 (5); 604 (7); 3745, 3990 (7); 5338 (2); 5560 (6). *Van der Schijff & Schweickerdt* 5773 (1). *Van Hoepen* 1675 (2). *Van Wyk s.n.* (2). *Vassilatos & Mantell* 805 (7). *Venter* 1118 (2).

Wager 33 (3); 198 (6); 1480 (1); 1622 (7); 4595, *s.n.* (6). *Wasserfall* 12 (2). *Watson s.n.* (3). *Werdermann & Oberdieck* 1328 (9). *Werger* 141 (3). *West s.n.* (6). *Williams* 793c (6). *Wilman* 1507c (4).

Zeyde 159 (2).