Syst. Geogr. Pl. **71**: 575-584 (2001)

Diversity of Upper Katanga epiphytes (mainly orchids) and distribution in different vegetation units

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Abstract. *– Vascular epiphytism in Upper Katanga is approached for the first time. It concerns holoepiphytes and occasional epiphytes but not lianas. Some 127 taxa were encountered. Orchidaceae takes the top position with 79 species. Their distribution regarding the five main woody vegetation units (open forest or woodland, dry evergreen forest, gallery forest, mountain forest, swampy forest) has been recorded by a weekly survey made during twenty years. Regarding diversity, gallery forests take the pole position with 14 taxa restricted to this unit as well as 50 other taxa occurring in other units as well. This is tremendous, notably according to the heavy anthropogenic pressure on this ecosystem, of which the expanse is continuously reduced and which covers far below 1% of the country. Open forests or woodlands, mainly of wetter miombo type, occur in second position with respectively 7 and 48 taxa. Other main vegetation units take a tiny part regarding epiphytic orchid biodiversity. With 36 taxa, pteridophyte diversity is in second position, as in African rain forests. The flowering periods of orchids are tackled. The phenological spectrum is saturated, whilst the phenogram indicates seasonal trends, with a maximum in November-December. Finally, epiphytic diversity confirms to be a suitable information for forest vegetation monitoring.*

Key words: *Upper Katanga, epiphytism, orchids, vegetation unit, phenology.*

Résumé. **– Diversité des épiphytes (principalement des Orchidées) du Haut-Katanga et distribution en fonction des unités de végétation.** *Une étude des plantes vasculaires épiphytes du Haut-Katanga est effectuée pour la première fois. Elle concerne les holoépiphytes et les épiphytes occasionnels mais ne considère pas les lianes. Cent vingt-sept taxons furent dénombrés. Les Orchidaceae occupent la première position avec 79 espèces. Leur distribution en fonction des cinq unités majeures de végétation (forêts claires ou savanes boisées, forêts denses sèches, forêts galeries, forêts de montagne et forêts marécageuses) a fait l'objet d'une exploration hebdomadaire pendant une vingtaine d'années. Du point de vue de la diversité, les forêts galeries viennent en position de tête avec 14 taxons à distribution limitée à cette formation végétale et 50 autres taxons également présents dans d'autres unités. Ceci est remarquable, compte tenu de la pression anthropique que subit cet écosystème dont la superficie se réduit sans cesse et qui couvre aujourd'hui bien moins qu'un pour cent du territoire. Les forêts claires et savanes boisées occupent la deuxième position avec respectivement 7 et 48 taxons. Les autres unités majeures de végétation jouent un rôle mineur au point de vue de la*

E. Robbrecht, J. Degreef & I. Friis (eds.) *Plant systematics and phytogeography for the understanding of African biodiversity.* Proceedings of the XVIth AETFAT Congress, held in 2000 at the National Botanic Garden of Belgium.
 ISSN 1374-7886

diversité en Orchidées épiphytes. Avec 36 taxons, les Ptéridophytes viennent en seconde position, tout comme elles le font dans les forêts denses humides africaines. Les périodes de floraison des orchidées sont abordées. Le spectre phénologique est saturé, tandis que le phénogramme indique l'existence d'une saisonnalité, avec un maximum en novembre-décembre. La diversité des épiphytes se confirme être un outil performant pour le suivi de la dynamique des formations forestières.

1 Introduction

Epiphytism is a tremendous characteristic of most tropical forests. Several approaches may be distinguished regarding its study. First, from a taxonomic point of view, as far as vegetal kingdom is concerned, studies may be devoted to vascular plants, Bryophytes or Lichens. Secondly, richness in epiphytes can be expressed in several ways, namely, (i) the total number of epiphytic species occurring in a region, as documented from floras or extensive collections, (ii) the percentage of trees of a certain minimum height that carry epiphytes, (iii) the number of epiphytes on one tree (Johansson 1989). Thirdly, ecological studies consider (i) the zonal distribution on one tree according to sections corresponding to broad ecological units as already roughly used by Van Oye (1924) and emphasised by Johansson (1974) or (ii) the nature of phorophytes, including their bark characteristics (Kelly 1985). A survey of literature concerning vascular epiphytes has been given by Watson et al. (1987).

Studies devoted to epiphytism in tropical Africa are rare. The only two comprehensive works are the study of Johansson (1974) carried out in West African forests in the Nimba Mountains of Liberia and that of Biedinger & Fischer (1996) completed in mountain forests of Rwanda and compared to a mountain rainforest at Irangi (Dem. Rep. Congo). It should be noted that the whole Afro-Malagasy area exhibits a paucity of vascular epiphytes compared to the Neotropics or the Australo-Asia area. Whilst South American rain forests are rich in Orchidaceae, Pteridophyta, Bromeliaceae, Araceae, Piperaceae, Gesneriaceae and Opuntiaceae (Benzing 1989), and Indo-Malayan ones in Orchidaceae, Pteridophyta, Moraceae, Melastomataceae, Asclepiadaceae, Ericaceae and Rubiaceae (Wallace 1989), African epiphytic flora consists mainly of pteridophytes and orchids (Johansson 1989). The reason of this impoverishment has been related to bouts of aridity and the lack of refugia during the late Pleistocene (Johansson 1989).

The publication of studies related to orchids of Upper Katanga, as well as neighbouring territories, is relatively recent. Indeed, the publication of *Orchids of East Africa* by Piers took place in 1968; some 250 taxa are quoted in this book. Two studies offer a valuable information regarding our subject, namely *Epiphytic Orchids of Malawi* (Morris 1970) and *The Orchids of South Central Africa* (Williamson 1977). Based upon collections mainly carried out in Zambia and Northern Malawi, this last book is a tremendous source of documentation. A new step was reached in 1984 with the editing of the second volume of *Flora of Tropical East Africa* (Cribb 1984), as well as the first issue of Orchidaceae of the *Flore d'Afrique centrale* (Geerinck 1984). Later, four more recent contributions deal with the orchids concerning respectively Rwanda (Geerinck 1987), East Africa (Cribb 1989), Malawi (la Croix et al. 1991) and Central Africa (Geerinck 1992). Lastly, the recent publication of the Orchidaceae of *Flora Zambesiaca* (la Croix & Cribb 1995, 1998) should be mentioned. In conclusion, a key knowledge dealing with the orchids of South Central Africa is, at present, available and allows a more detailed analysis of their distribution.

Regarding the ecology of epiphytic orchids, information is scattered and of various levels. Most authors insist that orchids are restricted to certain pockets of country and confined to well defined ecological characters, some to very narrow ecological limits (Morris 1970; la Croix et al. 1983). Even more... "an impulse made the collector to stop and look around and the feeling that orchids should be about proved true" (Piers 1968)!

If the line between epiphytic and terrestrial orchids can be blurred (la Croix et al. 1991), all studies agree that distinction between them is both real and useful. The non parasitic growth form is also frequently underlined. Finally, epiphytic orchids imply trees, so that it is to woodlands and forests that one must look for them. *Xerophyta* spp. on rocky places is the only exception.

There is a general agreement on the highly adapted growth forms, including comments on comparative morphology. If a few delicate epiphytes do not tolerate strong light, most need fairly strong sunlight (Piers 1968); moreover they are generally faced to poor mineral nutrition availability so that the importance of the role of root systems in the process of nutrition becomes evident.

Regarding the phorophytes comments diverge. If some authors recognise "orchid-prone" tree species (Morris 1970) such as *Syzygium cordatum* along rivers and *Brachystegia spiciformis* in high rainfall areas, if some comments agree on marked idiosyncrasies (Piers 1968), other authors consider that there is no evidence for any consistent link between epiphyte and host (la Croix et al. 1991). Epiphytic orchids dislike trees which exude a latex juice as most *Ficus* (Piers 1968). Further more, texture of bark of phorophyte seems important. One example of stratification is figured on plate 2 by Morris (1970). Only some counts of orchid plants on group of trees are available for some places of Malawi, where 71% of the epiphytic orchids were recorded on five tree species (Morris 1970). In the same way little is known regarding orchids associations, even if narrow ecological limits give rise to it (one example can be found in Morris 1970).

If flowering times of each species are given in some books, general comments on phenology are scarce and generally insist on the wider amplitude of epiphytic species. In contrast with most terrestrial orchids which flower exclusively or more profusely if their habitat has been burnt in the previous season (Linder & Kurzweil 1999), no stimulating effect of fire is evoked concerning epiphytic orchids. On the contrary, if no clear inhibition effect is known, severe fires over several years can deplete or completely destroy the epiphytic orchid flora (Morris 1970). While in Malawi it is possible to find something in flower at any time of the year, certain species have erratic flowering dates (la Croix et al. 1991). In contrast, the flowering season of epiphytic orchids in Southern Africa lasts mainly from September to May (Linder & Kurzweil 1999).

When dry season effects are modified by frequent mist and low cloud, epiphytic orchid diversity rises (la Croix et al. 1991). Riverine forests, gallery forests, *Syzygium cordatum* swampy forests, mountain forest, as well as *Brachystegia* woodlands of high altitude are the best habitats to observe epiphytic orchid diversity (Piers 1968; Morris 1970; Williamson 1977; la Croix et al. 1983, 1991).

In the same way, studies devoted to Pteridophyta are presently available regarding Upper Katanga (Kornas et al. 2000), Zambia (Kornas 1979), *Flora Zambesiaca* (Schelpe 1970) and Southern Africa (Jacobsen 1983; Schelpe & Anthony 1986; Burrows 1990), while some comparisons of pteridophyte floras in tropical Africa have been published (Pichi Sermolli 1983; 1985; Jacobsen & Jacobsen 1989; Lwanga et al. 1998.

2 Milieu

The present paper deals with vascular epiphytes richness for a given territory, Upper Katanga. This is a well defined territory, currently quoted in *Flore d'Afrique centrale*. Its delimitation is artificial and results from the settling of the eastern, southern and western Congolese borders. On the other hand its northern limit is natural. It was first proposed and established by Robyns (1950); Ndjele (1988) later on suggested a more accurate limit regarding the Upemba depression.

Upper Katanga is definitely part of the Zambezian regional centre of endemism as defined by White (1983), but the need of differentiation within this territory rises repetitively. Duvigneaud (1958) first stresses the complexity of Upper Katanga flora and the junction area made up by this territory. Further the existence of differences between an eastern and a western part appears respectively in Symoens &

Ohoto (1973) and Malaisse (1996, 1997). Moreover the existence of a Katango-Zambian geo-element has been discussed and has led to the recognition of a Katango-Zambian or "bemba" domain (Malaisse 1996), which distribution has been mapped (Malaisse 1997).
Vegetation units of Upper Katanga have been studied by diverse authors (Schmitz 1962, 1963; White 1983; Malaisse 1997) and data are available on the net (Ruelle et al. s.d.). For Zambia and Malawi main sources concerning vegetation units have to be found in Fanshawe (1969) and Chapman & White (1970).

3 Material and methods

A preliminary list regarding epiphyte diversity in Upper Katanga has first been established from authors' field observations as well as several sources. The list of Upper Katanga epiphytic orchids arises from two main sources. First a survey carried out by the senior author during about twenty years furnishes the core of our knowledge with some 69 different taxa recognised, their respective vegetation unit(s) involved as well as their flowering period(s). Moreover data contained in the *Flore d'Afrique centrale* allow us to add some ten other taxa, whilst collections deposited at BR provide complementary information.

Comparisons with *Flora Zambesiaca* and *Flora of Tropical East Africa* allow to confirm several data, namely regarding their distribution and ecology. Of interest were also the studies of Kornas et al. (2000) regarding ferns and ferns allies, of Lecron & Malaisse (1999) for Araceae.

Five main woody vegetation units were recognised, namely open forest or woodland (mainly of wetter miombo type), dry evergreen forest (locally called "muhulu"), gallery forest (including fringing forest), high plateau or "mountain" forest and swampy forest (Malaisse 1997). Patches of *Xerophyta* spp. occur in diverse rocky situations and support some epiphytic orchids, they were not regarded as a well defined vegetation unit according to their very restricted and scattered distribution.

Table 1

Diversity of vascular epiphytes in Upper Katanga.

True = true epiphyte
Occ. = occasional epiphyte

Family	Genera	True	Occ.	Total
Pteridophyta				
Aspleniaceae	*Asplenium*	8	7	15
Davalliaceae	*Davallia*	1		1
Hymenophyllac.	*Hymenophyllum*	2		2
	Trichomanes	4		4
Lomariopsidac.	*Elaphoglossum*		1	1
	Lomariopsis	1		1
Nephrolepidac.	*Nephrolepis*	1	1	2
Oleandraceae	*Arthropteris*		2	2
Polypodiaceae	*Drynaria*	2		2
	Platycerium	1		1
	Pleopeltis	3		3
	Pyrrosia	1		1
Vittariaceae	*Haplopteris*	1		1
Magnoliophyta				
Araceae	*Remusiata*	1		1
Begoniaceae	*Begonia*		1	1
Euphorbiaceae	*Euphorbia*		1	1
Iridaceae	*Anomatheca*		1	1
Lamiaceae	*Coleus*		1	1
Moraceae	*Dorstenia*		1	1
	Ficus		4	4
Orchidaceae	*Acampe*	1		1
	Aerangis	6		6
	Ancistrorhynchus	1		1
	Angraecum	2		2
	Ansellia	1		1
	Bolusiella	2		2
	Bulbophyllum	14		14
	Calyptrochilum	1		1
	Chamaeangis	2		2
	Cyrtorchis	5		5
	Diaphananthe	5		5
	Graphorkis	1		1
	Microcoelia	5		5
	Nephrangis	1		1
	Polystachya	22		22
	Rangaeris	1		1
	Stolzia	1		1
	Summerhayesia	1		1
	Tridactyle	6		6
	Vanilla		1	1
Piperaceae	*Peperomia*	1		1
Total		**106**	**21**	**127**

Table 2. List of Upper Katanga epiphytic orchids according to distribution types.
λ: linking elements.

Gallery forests
Aerangis luteoalba (Kraenzlin) Schlechter
Aerangis stelligera Summerh.
Ancistrorhynchus metteniae (Kraenzlin) Summerh.
Angraecum stolzii Schlechter
Bulbophyllum fuscum Lindley var. *fuscum*
Bulbophyllum lupulinum Lindley
Chamaeangis odoratissima (Reichenb.f.) Schlechter
Cyrtorchis chailluana (Hooker f.) Schlechter
Microcoelia koehleri (Schlechter) Summerh.
Polystachya armeniaca la Croix & P.J.Cribb
Polystachya caloglossa Reichenb.f.
Polystachya galeata (Swarz) Reichenb.f. var. *galeata*
Polystachya odorata Lindley
Vanilla polylepis Summerh.

Open forests or Woodland
Aerangis verdickii (De Wild.) Schlechter
Bulbophyllum cochleatum Lindley var. *gravidum* (Lindley) J.J.Vermeulen
Bulbophyllum rugosibulbum Summerh.
Cyrtorchis neglecta Summerh.
Polystachya brassii Summerh.
Polystachya dendrobiiflora Reichenb.f.
Polystachya epiphytica De Wild.

Dry evergreen forests
Angraecum affine Schlechter

Mountain forests
Polystachya simplex Rendle

λ Swampy forests - Gallery forests
Aerangis calantha (Schlechter) Schlechter
Bolusiella iridifolia (Rolfe) Schlechter subsp. *iridifolia*
Tridactyle gentilii (De Wild.) Schlechter

λ Gallery forests - Open forests or Woodland
Acampe praemorsa (Roxb.) Blatter & McCann
Ansellia africana Lindley
Bolusiella maudae (Bolus) Schlechter
Bulbophyllum elliotii Rolfe
Bulbophyllum encephalodes Summerh.
Bulbophyllum expallidum J.J.Vermeulen
Bulbophyllum fuscum Lindley var. *melinostachyum* (Schlechter) J.J.Vermeulen
Bulbophyllum injoloense De Wild. subsp. *pseudoxypterum* (J.J.Vermeulen) J.J Vermeulen
Bulbophyllum maximum (Lindley) Reichenb.f.
Bulbophyllum oreonastes Reichenb.f.
Bulbophyllum scaberulum (Rolfe) Bolus var. *scaberulum*
Calyptrochylum christyanum (Reichenb.f.) Summerh.
Cyrtorchis arcuata (Lindley) Schlechter var. *variabilis* (Summerh.) Geerinck
Diaphananthe fragrantissima (Reichenb.f.) Schlechter
Diaphananthe xanthopollinia (Reichenb.f.) Summerh.
Microcoelia exilis Lindley
Microcoelia globulosa (Hochst.) Jonsson
Microcoelia hirschbergii Summerh.
Polystachya bennettiana Reichenb.f.
Polystachya golungensis Reichenb.f.
Polystachya imbricata Rolfe
Polystachya modesta Reichenb.f.
Polystachya parva Summerh.
Polystachya villosa Rolfe
Stolzia repens (Rolfe) Summerh.
Summerhayesia zambesiaca Cribb
Tridactyle bicaudata (Lindley) Schlechter
Tridactyle tridentata (Harvey) Schlechter

λ Gallery forests - Dry evergreen forests
Aerangis collum-cygni Summerh.
Microcoelia macrorrhynchia (Schlechter) Summerh.
Polystachya saccata (Finet) Rolfe

λ Gallery forests – Mountain forests
Chamaeangis vesicata (Lindl.) Schlechter
Tridactyle tridactylites (Rolfe) Schlechter

λ Open forests or Woodland - Dry evergreen forests
Nephrangis filiformis (Kraenzlin) Summerh.
Polystachya adansoniae Reichenb.f. var. *adansoniae*
Polystachya adansoniae Reichenb.f. var. *stuhlmannii* (Kraenzlin) Geerinck

λ Open forests or Woodland - Mountain forests
Bulbophyllum josephi (Kuntze) Summerh. var. *mahonii* (Rolfe) J.J.Vermeulen
Polystachya zambesiaca Rolfe var. *malilaensis* (Schlechter) Geerinck
Tridactyle tricuspis (Bolus) Schlechter

λ Swampy forests - Gallery forests - Open forests or Woodland
Aerangis kotschyana (Reichenb.f.) Schlechter
Diaphananthe pulchella Summerh.

λ Gallery forests - Open forests or Woodland - Dry evergreen forests
Cyrtorchis crassifolia Schlechter
Cyrtorchis praetermissa Summerh.
Diaphananthe rutila (Reichenb.f.) Summerh.
Graphorchis lurida (Swartz) Kuntze
Polystachya tessellata Lindley
Polystachya zambesiaca Rolfe var. *zambesiaca*
Rangaeris muscicola (Reichenb.f.) Summerh.
Tridactyle anthomaniaca (Reichenb.f.) Summerh.

λ Gallery forests - Open forests or Woodland - Mountain forests
Bulbophyllum cochleatum Lindley var. *cochleatum*
Diaphananthe kamerunensis (Schlechter) Schlechter
Polystachya greatrexii Summerh.

λ Gallery forests - Open forests or Woodland - Dry evergreen forests - Mountains forests
Polystachya fusiformis (Thou.) Lindl.

4 Results

Table 1 presents a preliminary list of vascular epiphytic taxa quoted in Upper Katanga. Only some 127 taxa were encountered. Two taxa take a main position, namely Orchidaceae (20 genera, 79 species) and Pteridophyta (9 families, 14 genera, 37 species). The importance of orchids in Upper Katanga vascular epiphytism is obvious. Indeed 79 species of the 313 orchids quoted in Upper Katanga (Geerinck et al. 1996) are epiphytic. Some of the other species are linked to good waterholding humus accumulations at the main trunk ramification; such is the case of *Begonia princeae* Gilg and *Remusiata vivipara* (Roxb.) Schott & Endl. Regarding drought resistance, ferns offer a wide range of variation from the poorly adapted filmy ferns, such as *Hymenophyllum* spp. and to a lesser degree *Trichomanes* spp. to some extremely resistant such as the truly deciduous fern, *Pleopeltis excavata* (Bory ex Willd.) Sledge.

Seventy nine epiphytic orchids have been listed for Upper Katanga (table 2). Their distribution regarding vegetation units was analysed (table 3). Twenty three species (29.1%) have been recorded from only one vegetation unit. Regarding diversity, gallery forests take the top position with 14 taxa restricted to them. They are followed up by open forests with seven taxa. The main ecological group is nevertheless constituted by orchids both observed in gallery forests and open forests; it concerns 28 species or 35.4 %! The relative richness of gallery forests is notably reduced according to the heavy anthropological pressure on this ecosystem of which the expanse is continuously reduced and which covers far below 1% of the country.

The distribution pattern of orchids observed in Upper Katanga (UK) is not a local endemic trend, but results from a more general character of the Zambezian region. Indeed a comparison with epiphytic orchids in neighbouring territories according to *Flora Zambesiaca* (FZ) and *Flora of Tropical East Africa* (FTEA) indicates that 52 taxa (65.8%) are common to three floras, only 3 taxa (3.6%) endemic to Upper Katanga, whilst 13 (16.5%) and 11 (13.9%) taxa are respectively common to UK-FZ and UK-FTEA. Accordingly Katanga and Flora Zambesiaca have some 65 (82.3%) taxa in common.

Table 3. Distribution of Upper Katanga epiphytic orchids according to vegetation units.
(number and relative %)

	swampy forest	gallery forest	open forest	dry evergreen forest	mountain forest	% of total species
	0					0.0
		14				17.7
			7			8.9
				1		1.3
					1	1.3
	3	3				3.8
		28	28			35.4
		3		3		3.8
		2			2	2.5
			3	3		3.8
			3		3	3.8
	2	2	2			2.5
		8	8	8		10.1
		3	3		3	3.8
		1	1	1	1	1.3
						(100%)
Total	5	64	55	16	10	79

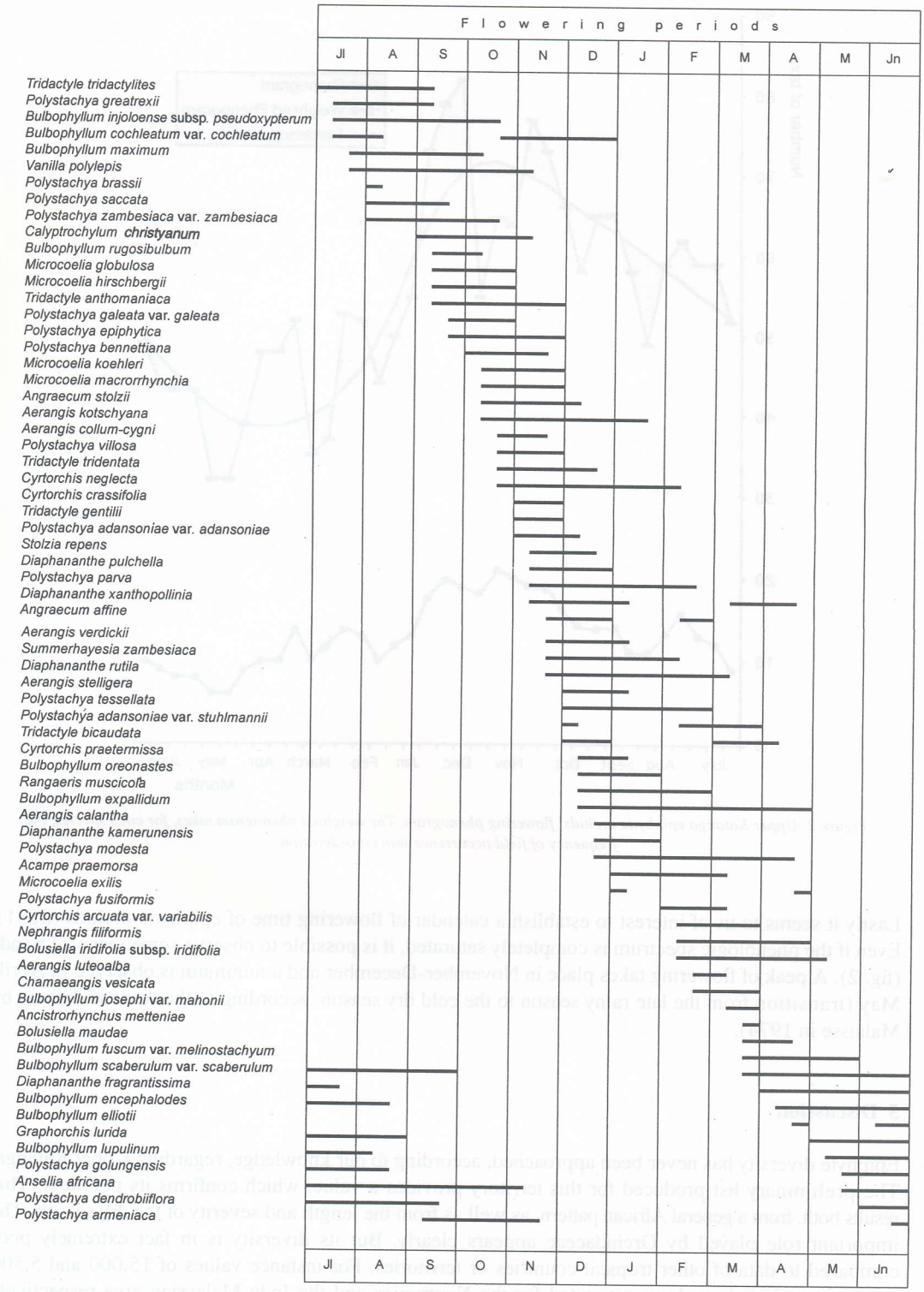

Figure 1. Upper Katanga epiphytic orchids' flowering phenological spectrum.

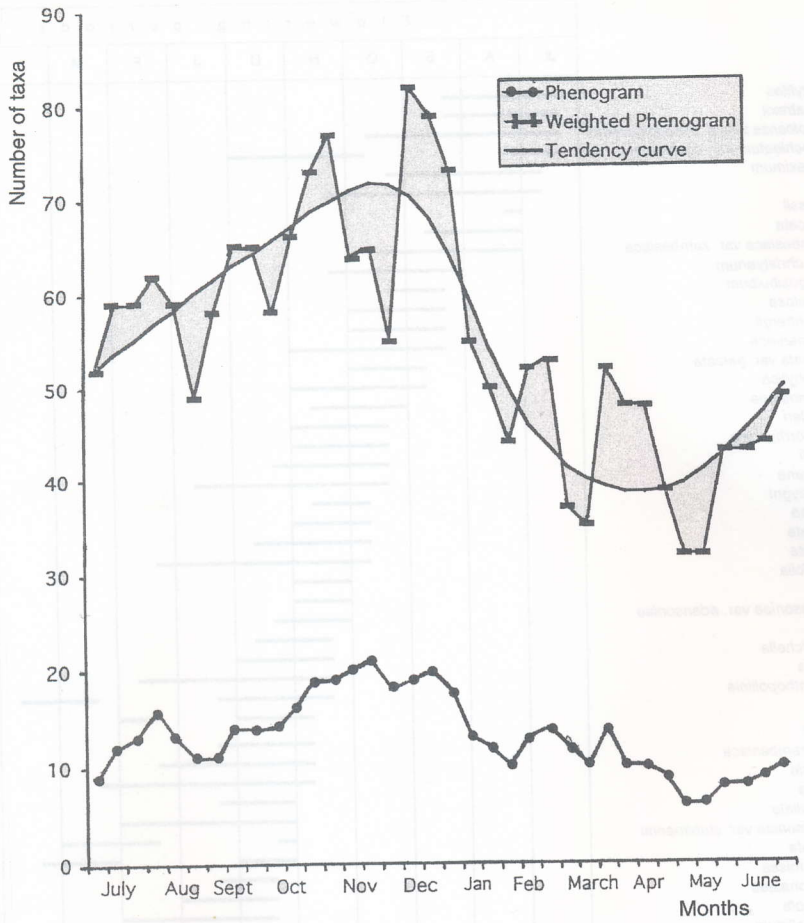

Figure 2. Upper Katanga epiphytic orchids' flowering phenogram. The weighted phenogram takes, for each species, the frequency of field occurrence into consideration.

Lastly it seems to us of interest to establish a calendar of flowering time of epiphytic orchids (fig. 1). Even if the phenologic spectrum is completely saturated, it is possible to observe some seasonal trends (fig. 2). A peak of flowering takes place in November-December and a minimum is observed in April-May (transition from the late rainy season to the cold dry season, according to the seasons defined by Malaisse in 1974).

5 Discussion

Epiphyte diversity has never been approached, according to our knowledge, regarding Upper Katanga. The preliminary list produced for this territory provides a value, which confirms its poorness. This results both, from a general African pattern, as well as from the length and severity of the dry season. The important role played by Orchidaceae appears clearly. But its diversity is in fact extremely poor compared to data of other tropical countries or territories. For instance values of 15,000 and 5,500 epiphytic orchids have been estimated for the Neotropics and the Indo-Malaysian area respectively

(Benzing 1989; Wallace 1989)! The same is true concerning epiphytic Pteridophyta with values of 2,703 (Neotropics) and 2,200 (Australo-Asia) respectively (Wallace 1989).

On the other hand, besides true epiphytes, the relative importance of hemiparasitic Loranthales (2 families, 10 genera and 34 species) has to be quoted (Polhill & Wiens 1998); this appears as a characteristic feature of forest ecosystems in Katanga.

Finally it is of interest to keep in mind that epiphyte diversity is a suitable information for vegetation monitoring. For instance, bryophytes have been used for altitudinal zonation of tropical rain forest (Frahm & Gradstein 1991) as well as vascular epiphytes for monitoring regressive succession and importance of degradation of diverse evergreen forests at Moheli, a Comoro island (Moulaert 1998). In Upper Katanga decrease in orchids epiphyte diversity in open forests appears as a fine information regarding annual fire intensity which in turn is related to the relative importance of savannah grasses in the herb layer, a response to human degradation increase. In fact, epiphytic orchid diversity offers, as far as Upper Katanga is concerned, a firm management aid for screening the state of forestry vegetation units and an useful tool for selecting suitable sites for conservation purposes, notably regarding biodiversity.

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Manuscript received May 2001; accepted in revised version January 2002.