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## 4. A NEW REGIONAL CENTRE OF ENDEMISM IN AFRICA

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### Abstract

Recent botanical surveys and the ongoing publication of further volumes of the *Flora of Tropical East Africa* and *Flora Zambesiaca* have provided much new floristic data on White's Zanzibar-Inhambane regional mosaic, which were not available at the time of publication of *The Vegetation of Africa*. The data from these floras, supplemented by additional data from checklists, taxonomic monographs and herbarium records, are now sufficient to present a representative and near-complete list of the endemic vascular plant species in the phytochorion, and indicate a far higher level of floristic endemism along the tropical eastern African coastal strip than had previously been realised. An examination of the patterns in this endemism confirm an earlier observation by White that most of the endemic vascular plant species of this phytochorion are concentrated in the region to the north of Moçambique town. These results challenge the existing classification of the area as a single regional mosaic, and suggest that the name 'Zanzibar-Inhambane' is also inappropriate. White's Zanzibar-Inhambane regional mosaic is therefore reclassified as two regions, the Swahilian regional centre of endemism in the north, and the Swahilian/Maputaland regional transition zone in the south.

### Introduction

The phytogeographical classification of the eastern African coastal zone has seen a plethora of different opinions as to whether this area should be delineated as a separate region/domain in its own right, or whether it should be considered as an outlier of another region (compare Brenan, 1978; Lebrun, 1960; Leroy, 1978; Lovett, 1993; Milne-Redhead, 1955; Monod, 1957). White (1976) eventually recognized the Zanzibar-Inhambane region as a regional mosaic, owing to its perceived depauperate flora containing 'a few hundred endemic species' and just four endemic genera (White, 1983a), two of which are now recognised as belonging to Lovett's Eastern Arc flora (Lovett, 1993). Estimates of the number of endemic vascular plant species and genera in the Zanzibar-Inhambane regional mosaic have subsequently been revised upwards to 450 species and 25 genera by Davis *et al.* (1994: 132), although a slightly earlier estimate reached 50 endemic genera (Vollesen, 1992). White however maintained the figure of "a few hundred endemic species and a few genera" in his final treatment on African phytogeography (White, 1993). This paper tests the integrity of White's classification of the Zanzibar-Inhambane region, based on real data, rather than on estimates.

### Method

The status of the Zanzibar-Inhambane domain was analysed by cataloguing as far as possible the entire endemic vascular plant flora of the region, using published floras (Thulin *et al.*, 1993; Turrill & Milne-Redhead *et al.*, 1952; Exell & Wild *et al.*, 1960),

supplemented by reviews of recent taxonomic literature (all volumes post 1950 of *Kew Bulletin*, all volumes of *Distributiones Plantarum Africanarum* (1969) and *Kirkia* (1975); selected issues of *Botanisk Notiser* and *Botanisk Tidskrift*), as well as published check-lists and monographs (Adams & Holland, 1978; Beentje, 1988, 1990 & 1994; Brenan & Greenway, 1949; Clarke, 1995; Dowsett-Lemaire, 1990; Drummond, in prep.; Faden, 1991; Friis, 1991; Friis & Vollesen, 1989; Goldsmith, 1976; Gomes e Sousa, 1966 & 1967; Greenway with Rodgers *et al.*, 1988; Haines & Lye, 1983; Hawthorne, 1984 & 1993; Iversen, 1991; Johansson, 1978; Kapuya, 1994 & 1995; Manktelow, 1996; Medley, 1992; Mwasumbi *et al.*, 1994; Mziray, 1992; Palgrave, 1977; Pennington, 1991; Robertson & Luke, 1993; Rodgers *et al.*, 1983; Ruffo, 1991; Seyani, 1991; Temu, 1990; Verdcourt, 1996; Vollesen, 1980; Vollesen & Bidgood, 1992; White, 1988), electronic databases (East African Herbarium (Nairobi) LEAPMASTER database) and the examination of a few herbarium specimens and notes (at the Royal Botanic Gardens, Kew, and the University of Dar es Salaam) where no other data sources were available.

Species endemic to the Zanzibar-Inhambane regional mosaic were identified through an iterative process based on their geographical and altitudinal distributions (as listed in the aforementioned floras and other taxonomic literature). An initial search was conducted for all species whose distribution is limited to those geographical divisions of the *Flora of Tropical East Africa* and *Flora Zambesiaca* which approximate to the extent of the Zanzibar-Inhambane *sensu lato* (to allow for the outlying satellites mapped in White 1983b), i.e. Southern Somalia; K7, marginally intruding into the K1 and/or K4 divisions of Kenya; T3, T6 and/or T8, marginally intruding into the T2 divisions of Tanzania; Zanzibar Island; Pemba Island; coastal divisions of Mozambique, including Maputo (formerly Lourenço Marques) Province and Natal for species which also occur to the north of these divisions; Eastern Zimbabwe (Mlsetter District) and southern Malawi. Within this geographical distribution a varying altitudinal limit was imposed (to 400 m in areas of high, regular rainfall, e.g. at the base of the East Usamabara mountains, Tanzania (contrary to White's classification of this area), going up to 1,000 m in areas with low, strongly seasonal rainfall, e.g. on the Rondo Plateau in south-eastern Tanzania), reflecting that the Zanzibar-Inhambane flora is essentially adapted to seasonal rainfall conditions and that a single altitudinal limit throughout its extent is unrealistic. Finally, collection localities were checked to determine whether these occurred within the limits of White's (1983b) Zanzibar-Inhambane regional mosaic, for which purpose a personal knowledge of the Tanzanian, Kenyan and southern Somali coastal districts (gained from spending five years in these areas) proved invaluable.

## Results

A total of 1,356 vascular plant species were found to be endemic to the Zanzibar-Inhambane regional mosaic *sensu lato* (full analysis of data and annotated species list published in Burgess & Clarke, in press), far exceeding previous estimates (e.g. Davis *et al.*, 1994; White 1983a & 1993), and well in excess of the required minimum of 1,000 species for the region to qualify as a regional centre of endemism *sensu* White (1979, 1983a & 1993). Further botanical surveys and taxonomic syntheses may raise this figure by at least 150 species (Clarke *et al.*, in press).

The distribution of these endemics is not however evenly spread throughout the mosaic: 940 species (69%) are restricted to the northern part of the mosaic, along the 1,440 km coastline length of southern Somali, Kenya and Tanzania, compared to just 149 species (11%) confined to the 2,480 km of the Mozambique coastline. Reanalysing the data to factor out the effect of the different floral divisions being of different size shows a strikingly consistent high number of Zanzibar-Inhambane regional endemics per unit of coastline length (or per unit of latitude) along the

Kenyan and Tanzanian coasts, compared to a low number along the Somali, Mozambique and Natal coasts (Figs. 1–6). Although differences in the intensity of botanical survey undoubtedly influence this pattern, the Somali, Natal and southern Mozambique coasts are comparatively well surveyed relative to south-eastern Tanzania (T8 division of the FTEA), which has the highest number of Zanzibar-Inhambane endemic species confined to it (187 species). Further botanical surveys in the less well known areas of the Zanzibar-Inhambane regional mosaic (i.e. in Niassa Province of Mozambique, and in south-eastern Tanzania) would both reinforce the observed patterns of endemism by increasing the number of regional endemics recorded from T8, and also significantly increase the number of Zanzibar-Inhambane regional endemics recorded from Niassa Province, and would thereby extend the area of high endemism south into Cabo Delgado Region of Mozambique. This pattern of floristic endemism confirms White's earlier findings that (a) most of the Zanzibar-Inhambane endemics are confined to the region north of Moçambique town (Moll & White, 1978), and (b) a floristically impoverished area (the 'Malawi Interval') exists south of Lake Malawi (White, 1990).

Patterns in endemic species are matched by the endemic genera: 33 genera were found to be endemic to the Zanzibar-Inhambane region *sensu lato*, of which 25 (76%) are confined to the area north of Moçambique town (Table 1). Only the coastal divisions of Kenya (K7), Tanzania (T3, T6 and T8) and Niassa and Zambesia Provinces of Mozambique contain endemic Zanzibar-Inhambane genera which are confined to a single division, with the highest concentration in T8 (six genera).

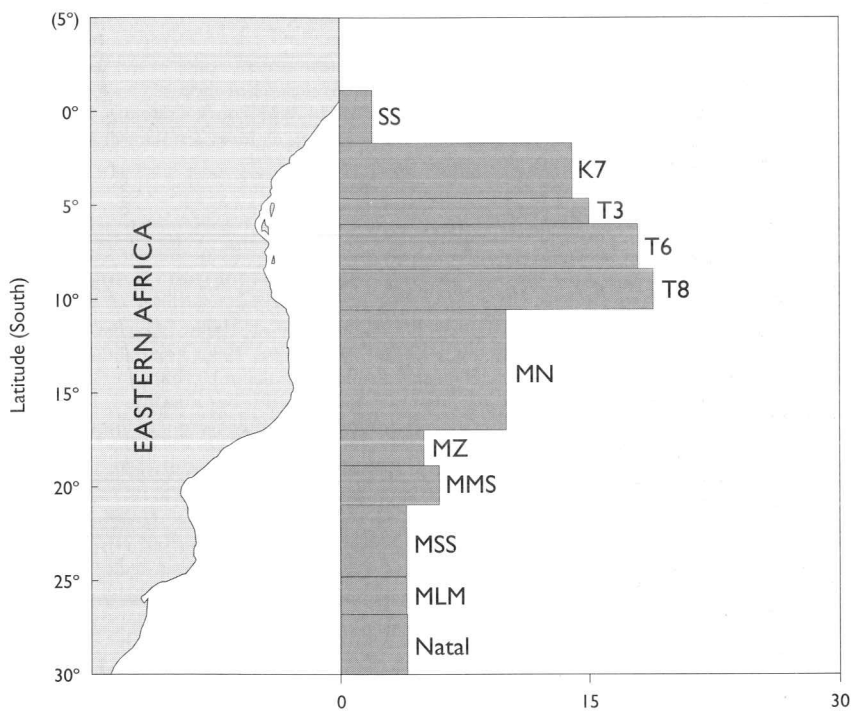


FIG. 1. Number of Zanzibar-Inhambane endemic genera present in each geographical division of the *Flora of Tropical East Africa* and *Flora Zambesiaca* plotted against the coastline of eastern Africa on the left.

TABLE 1. Vascular plant genera endemic to the Zanzibar-Inhambane regional mosaic *sensu lato*. Distributions as per the geographical divisions in the *Flora of Tropical East Africa* and *Flora Zambesiaca*.

Genus	Family	Distribution
<i>Aerisilvaea</i> <sup>1, c, §</sup>	Euphorbiaceae	T6 (Kimboza Forest)
<i>Asteranthe</i> <sup>a, §</sup>	Annonaceae	K7; T3,6,8; Z
<i>Baptorhachis</i> <sup>b, §</sup>	Poaceae	MN
<i>Burrtdivaya</i> <sup>a</sup>	Rubiaceae	T3,6,8; Z; MN, MT, MMS; S. Malawi
<i>Callopsis</i> <sup>a, □</sup>	Araceae	K7; T3,6 & possibly Cameroon
<i>Cladoceras</i> <sup>a, §</sup>	Rubiaceae	K7; T3,6,8; Mafia Island
<i>Dielsothammus</i> <sup>a</sup>	Annonaceae	T8; MN, MZ; Central Malawi
<i>Farrago</i> <sup>a, §</sup>	Poaceae	T8 (Nachingwea)
<i>Grandidiera</i> <sup>a</sup>	Flacourtiaceae	South Somalia; K7; T3,6,8; Z; MMS
<i>Hyalocalyx</i> <sup>2, d, §</sup>	Turneraceae	T8; MN
<i>Hystriophora</i> <sup>e, §</sup>	Asteraceae	T8 (Rondo)
<i>Lamprothamnus</i> <sup>a, §</sup>	Rubiaceae	Somalia; K1,7; T3,6,8; Mafia Island
<i>Lettowianthus</i> <sup>a, §</sup>	Annonaceae	K7; T3,6,8; Mafia Island
<i>Mkilua</i> <sup>a, §</sup>	Annonaceae	K7; T3,6,8; Z; P
<i>Ophrypetalum</i> <sup>a, §</sup>	Annonaceae	K7; T3,6,8
<i>Parancepsia</i> <sup>a, §</sup>	Euphorbiaceae	T6; MN
<i>Phellocalyx</i> <sup>a</sup>	Rubiaceae	T8; MN; South Malawi
<i>Pseudobersama</i> <sup>a</sup>	Meliaceae	K7; T3,6,8; MMS, MSS, MLM; Natal
<i>Sanrafaelia</i> <sup>f, §</sup>	Annonaceae	T3 (E. Usambaras at Kwangumi)
<i>Schlechterina</i> <sup>a</sup>	Passifloraceae	K7; T3,6,8; Z; MN, MZ, MMS, MSS, MLM; Natal
<i>Stephanostemma</i> <sup>g, §</sup>	Apocynaceae	T6 (Gongolamboto)
<i>Streptosiphon</i> <sup>h, §</sup>	Acanthaceae	T8 (Rondo & Litipo)
<i>Stuhlmannia</i> <sup>a, §</sup>	Fabaceae	K7; T3,8
<i>Thespesiopsis</i> <sup>b, §</sup>	Malvaceae	MN
<i>Trichaulax</i> <sup>i, §</sup>	Acanthaceae	K7; T3,6
<i>Vismianthus</i> <sup>a, i, §</sup>	Connaraceae	T8 (Rondo & Makonde Plateau)
<i>Zamioculcas</i> <sup>a</sup>	Araceae	K1,7; T3,6; Z; P; Moz; Zimbabwe; Malawi; Natal
gen. nov. <sup>j, §</sup>	Acanthaceae	K7 (Gongoni)
gen. nov. of FTEA <sup>a, §</sup>	Rubiaceae	T8 (Rondo)
gen. unknown of FZ <sup>b</sup>	Rubiaceae	MZ (Milange)
gen. indet. of FTEA <sup>a, §</sup>	Annonaceae	T6 (Kimboza)
gen. indet. <sup>k, §</sup>	Annonaceae	T6 (Pugu)
gen. indet. <sup>l, §</sup>	Fabaceae	T8 (Selous)

Sources: <sup>a</sup>Turrill & Milne-Redhead *et al.*, 1952–; <sup>b</sup>Exell & Wild *et al.*, 1960–; <sup>c</sup>*Kew Bull.* 45: 147–156; <sup>d</sup>Leroy, 1978; <sup>e</sup>*Kew Bull.* 43: 249; <sup>f</sup>Verdcourt, 1996; <sup>g</sup>Hawthorne, 1984; <sup>h</sup>*Kew Bull.* 49: 401–407; <sup>i</sup>Vollesen, 1992; <sup>j</sup>Robertson & Luke, 1993; <sup>k</sup>University of Dar es Salaam Herbarium; <sup>l</sup>Vollesen, 1980.

This list only includes the endemic genera which could be identified from existing publications; a full list of all disjunct genera awaits the publication of complete floras for East and south-central Africa.

<sup>1</sup> Considered by Lovett (1993) to be an Eastern Arc endemic. This species is however limited to *Pandanus rabaensis* swamp forest at 500 m altitude in Kimboza forest (Clarke & Dickinson, 1995: 98), which is similar to the swamp forest at Jozani on Zanzibar Island. It is therefore included as a Zanzibar-Inhambane endemic.

<sup>2</sup> Considered to be cultivated on Madagascar, where it is also recorded (see *Kew Bull.* 5: 335).

§ Genus endemic to the Swahilian regional centre of endemism (defined in this paper).

The genus *Cleistochlamys* (Annonaceae) has been cited as a Zanzibar-Inhambane endemic (e.g., in Vollesen, 1992; Davis *et al.*, 1994), but extends somewhat further inland (Distribution T6, 8; MN, MZ, MT, MMS, MSS; E. Zambia, N. Zambia; E. Zimbabwe, S. Zimbabwe; Malawi).

The genus *Primularia* (Melastomaceae) has been cited as a Zanzibar-Inhambane endemic (from the Rondo plateau in T8) but is now considered to be congeneric with *Cinnobotrys*.

The Asclepiadaceae gen. indet. in Robertson & Luke (1993) is now recognised to be a new species of *Dregea*. Likewise the Rubiaceae gen. nov. aff. *Coffea* in Vollesen (1980) is now recognised to be *Psilanthus semsei*.

All genera listed are monotypic except *Asteranthe* (3 spp.) and *Lettowianthus* (2 spp.).

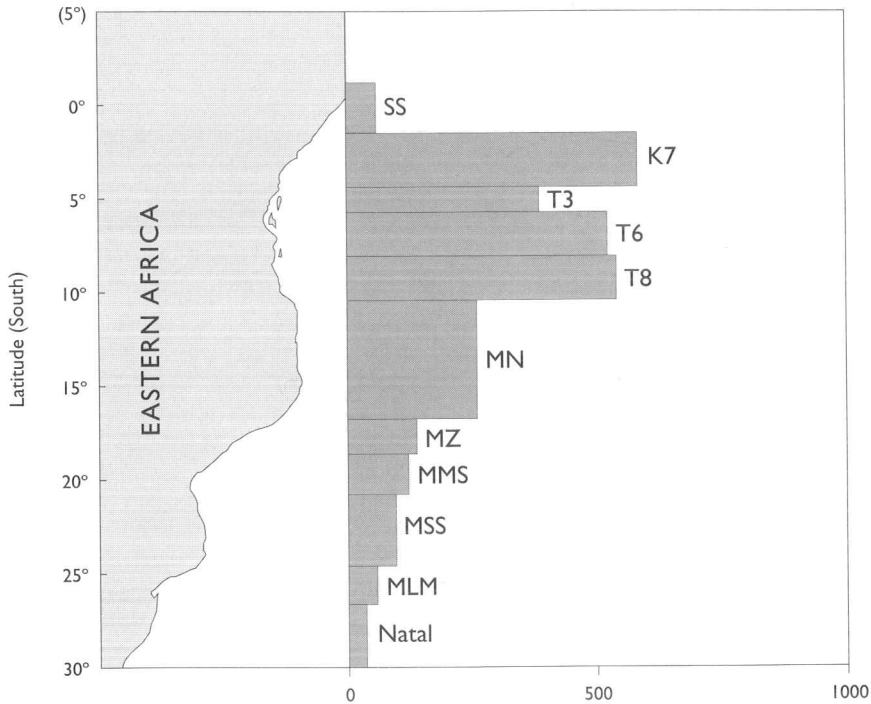


FIG. 2. Number of Zanzibar-Inhambane endemic species present in each geographical division of the *Flora of Tropical East Africa* and *Flora Zambesiaca* plotted against the coastline of eastern Africa on the left.

### Classification

Under White's chorological classification, a regional centre of endemism has more than 50% of its phanerogamic species confined to it and a total of more than 1,000 endemic or near-endemic species of phanerogam (White, 1979, 1983a, 1993). These criteria were nonetheless relaxed in the case of the Sudanian regional centre of endemism, where White's most recent estimate was for about 1,250 endemic species which accounted for about 33% of the total flora, and only a few endemic genera (White, 1993, but see Davis *et al.*, 1994 and Table 2 for a lower endemic species total). In addition, the most recent estimate for the Somalia-Masai regional centre of endemism gives 1,240 endemic vascular plant species, accounting for 31% of the flora (Davis *et al.*, 1994).

A sufficiently high number of endemic plant species is present both in the northern part of the Zanzibar-Inhambane, as well as throughout the regional mosaic to warrant its reclassification as a regional centre of endemism. Given the uneven distribution of these endemic species across the region, it is proposed to split the Zanzibar-Inhambane regional mosaic into two smaller regions: (1) a regional centre of endemism along the Kenyan, Tanzanian and northern Mozambique coasts, marginally intruding into southern Somalia, and (2) a regional transition zone between this regional centre of endemism and the neighbouring Maputaland-Pondoland regional mosaic (*sensu* van Wyk, 1994), occurring along the Mozambique coast and extending into southern Malawi and eastern Zimbabwe. An estimated 4,000 species are present in the regional centre of

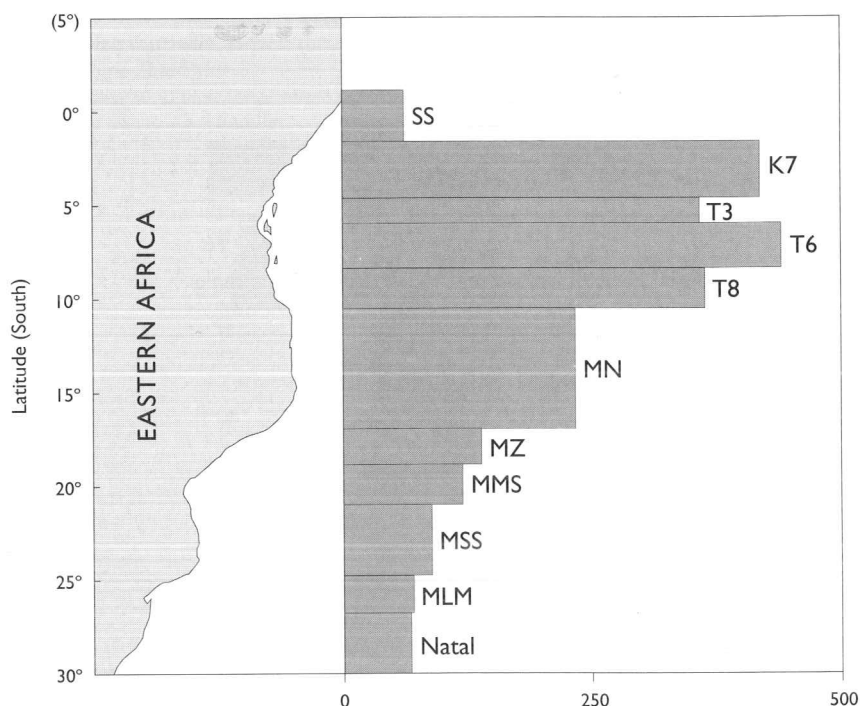


FIG. 3. Number of Zanzibar-Inhambane endemic species present in two or more geographical divisions of the *Flora of Tropical East Africa* and *Flora Zambesiaca*, i.e. excluding endemic species which are confined to a single geographical division; plotted against the coastline of eastern Africa on the left.

TABLE 2. Comparison of the regional centres of endemism in Africa, showing area, species richness, species endemism and percentage endemism of phanerogams.

Regional centre	Size (Km <sup>2</sup> ) <sup>a</sup>	Total no. of species <sup>b</sup>	No. of endemic species <sup>b</sup>	% endemism <sup>b</sup>
Guineo-Congolian	2,800,000	12,000	6,400	53 <sup>c</sup>
Zambeziian	7,770,000	8,500	4,590	54
Sudanian	3,731,000	2,750	960	35
Somalia-Masai excl. Arabia	1,873,000	4,000	1,250	31
Cape	71,000	8,600	5,870	68
Karoo-Namib	661,000	7,000	<3,500	35-50
Mediterranean excl. Eurasia	330,000	4,000	800	20
Afromontane	715,000	4,000	3,000	75
Swahilian	250,000 (est)	4,000	1,200	30

Sources: <sup>a</sup> White, 1983a; <sup>b</sup> Beentje with Adams *et al.*, 1994.

<sup>c</sup> On pages 106 and 115 of Beentje with Adams *et al.* (1994) a figure of 6,400 endemic species is given for the Guineo-Congolian regional centre of endemism, representing a 53% rate of endemism compared to the 80% species endemism rate given.

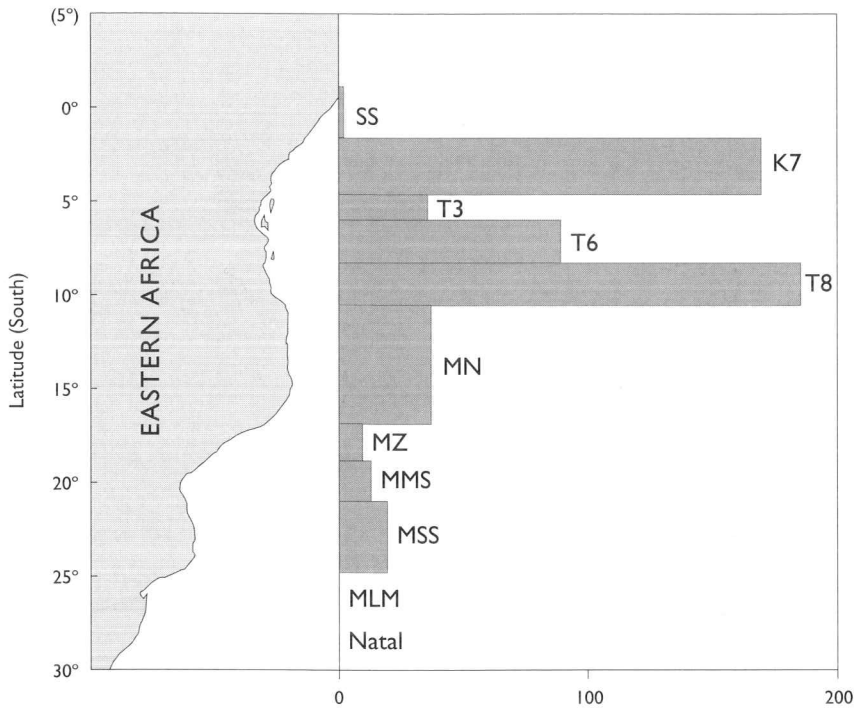


FIG. 4. Number of Zanzibar-Inhambane endemic species confined to a single geographical division of the *Flora of Tropical East Africa* and *Flora Zambesiaca* plotted against the coastline of eastern Africa on the left.

endemism, given Robertson & Luke's (1993) figure of 3,040 taxa present in non upland, coastal areas of the K7 geographical division (some of which belong to the neighbouring Somalia-Masai regional centre of endemism), together with the occurrence of a further 499 endemic species from the data which are neither found in the K7 geographical division, nor south of Moçambique town. Of these an estimated 1,200 species are endemic (given further botanical surveys and taxonomic syntheses over and above the 1,077 species identified in this study), giving an approximately 30% rate of endemism in the regional centre, or a 32% rate of endemism throughout the region *sensu lato*, assuming an additional 500 species are present in the southern part of the region.

The relatively low rate of endemism in the core area is probably a reflection of its comparatively small size (Table 2), such that edge effect interactions with its surrounding phytochoria will contribute large numbers of non-endemics species into this phytochorion. Furthermore, the long history of human settlement and cultivation in this area, a possibly even more ancient history of anthropic bush fires (Clarke & Karoma, in press), and its location on the eastern continental seaboard where trans-oceanic air and sea currents increase the opportunity for long-distance dispersals, mean that this area will contain a greater proportion of widespread and pan-tropical species than might be expected in the other regional centres of endemism. The requirement for 50% endemism can then be justifiably relaxed; it is even possible that this region would have recorded a 50% level of regional endemism prior to the large-scale extinctions of endemic species and colonisations of exotic species that are expected to have resulted from the extensive human modifications to the environment.

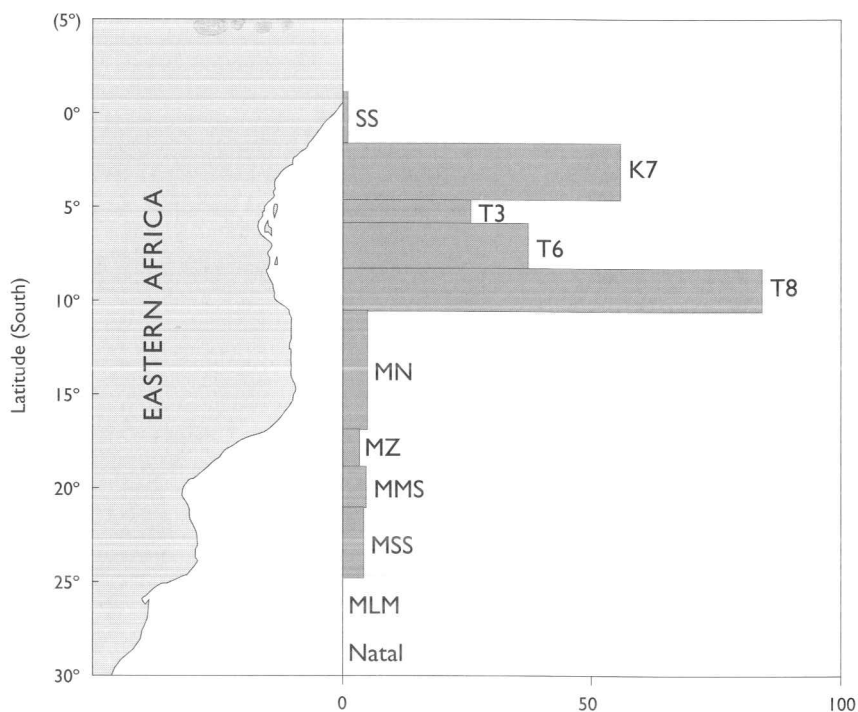


FIG. 5. Number of Zanzibar-Inhambane endemic species confined to a single geographical division of the *Flora of Tropical East Africa* and *Flora Zambesiaca*, divided by the number of degrees of latitude crossed by that division, plotted against the coastline of eastern Africa on the left.

### Nomenclature

No reason was given by White (in Moll & White, 1978) for his choice of 'Zanzibar-Inhambane' although this may have been influenced by the geographical location of Zanzibar Island and Inhambane town towards the respective northern and southern limits of the region. However, the data demonstrate that Zanzibar Island and Inhambane Province (Mozambique) together contain a mere 10% of the endemic flora of the Zanzibar-Inhambane regional mosaic, and 1.5% of this endemic flora is strictly confined to these areas. 'Zanzibar-Inhambane' is therefore a misleading and unrepresentative name for this region, and is additionally impossible to maintain given the proposal to split the region in recognition of the far higher levels of floristic endemism that are present in the northern part.

The Zanzibar-Inhambane domain will therefore be renamed as the 'Swahilian region' in recognition of the fact that the proposed regional centre of endemism in the northern part of this area (Fig. 7) is similar in extent to the area which flourished under the Swahili civilisation from 800 to 1500 AD (which stretched from the Querimba Islands in northern Mozambique to Mogadishu; maps 2 & 4 in de Vere Allen, 1993), and almost coincides with those areas where Swahili was spoken as the mother-tongue (as opposed to a second language) during the last century (map 7 in Nurse & Spear, 1985). Phytochorion XIII of White (1983a) is hereby split as follows :



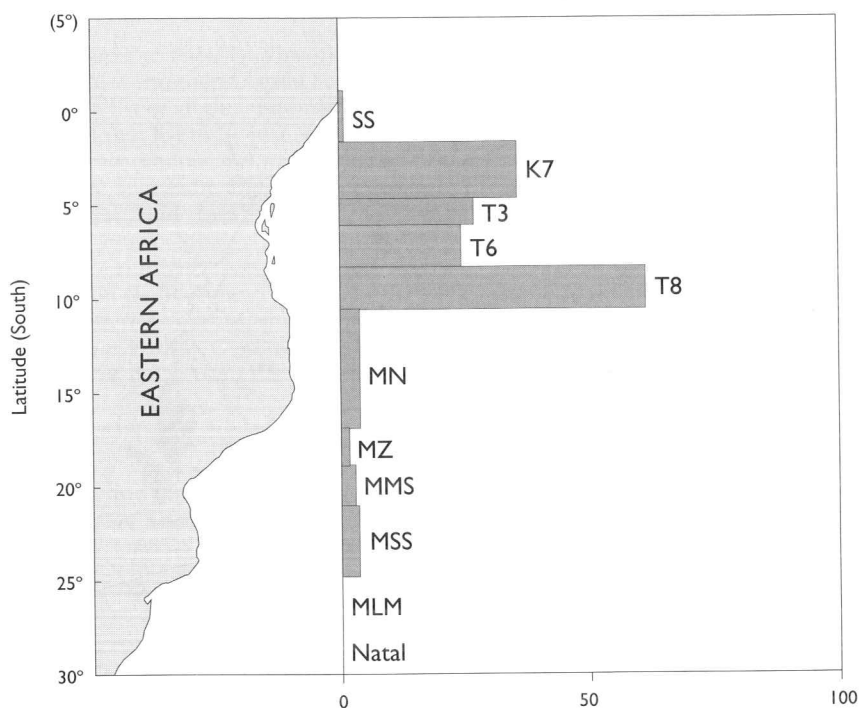


FIG. 6. Number of Zanzibar-Inhambane endemic species confined to a single geographical division of the *Flora of Tropical East Africa* and *Flora Zambesiaca*, divided by the coastline length of that division (per 100 km), plotted against the coastline of eastern Africa on the left.

### XIIIa. Swahilian regional centre of endemism

Northern part of White's Zanzibar-Inhambane regional mosaic (White, 1976, 1983a & 1993) to Moçambique Island (cf. Moll & White, 1978). This regional centre includes 4,000 vascular plant species, of which an estimated 1,200 are endemic and 25 endemic genera. A further 287 species and eight genera can be considered as near-endemics, extending into the neighbouring Swahilian/Maputaland regional transition zone, a few of which marginally intrude into northern Natal.

### XIIIb. Swahilian/Maputaland regional transition zone

Southern part of White's Zanzibar-Inhambane regional mosaic (White, 1976, 1983a & 1993) south of Moçambique Island (cf. Moll & White, 1978). This transition zone contains 3,300 species of which an estimated 100 are endemic (73 identified in the data). A further 40 species intrude into the Maputaland-Pondoland regional mosaic south to Natal. A single endemic genus (*Rubiaceae*, genus unknown of *Flora Zambesiaca* ined.) occurs in the extreme north of this regional transition zone.

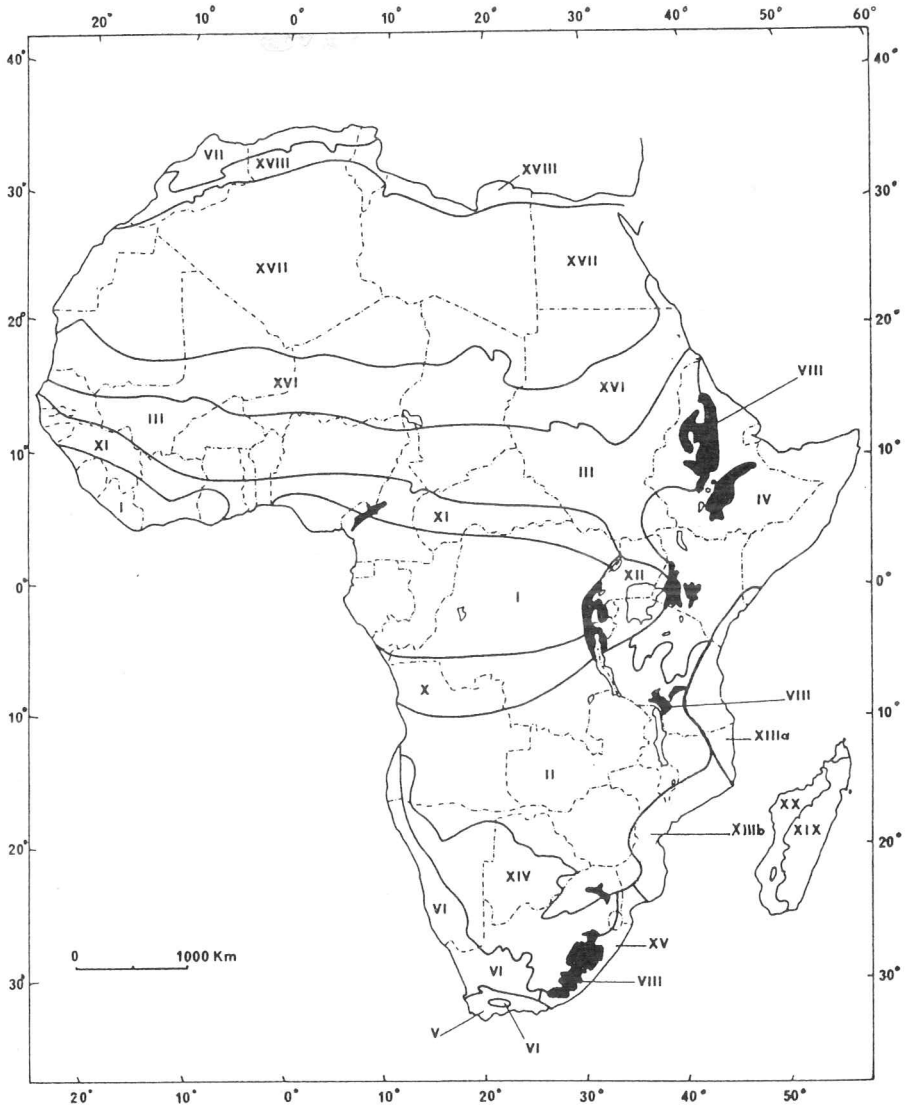


FIG. 7. The phytochoria of Africa (after White, 1983a), showing the extent of the proposed Swahilian regional centre of endemism (phytochorion XIIIa) and of the Swahilian/Maputaland regional transition zone (phytochorion XIIIb).

I. Guineo-Congolian regional centre of endemism. II. Zambezan regional centre of endemism. III. Sudanian regional centre of endemism. IV. Somalia-Masai regional centre of endemism. V. Cape regional centre of endemism. VI. Karoo-Namib regional centre of endemism. VII. Mediterranean regional centre of endemism. VIII. Afromontane archipelago-like regional centre of endemism, including IX, Afroalpine archipelago-like region of extreme floristic impoverishment (not shown separately). X. Guinea-Congolia/Zambezia regional transition zone. XI. Guinea-Congolia/Sudania regional transition zone. XII. Lake Victoria regional mosaic. XIIIa. Swahilian regional centre of endemism. XIIIb. Swahilian/Maputaland regional transition zone. XIV. Kalahari-Highveld regional transition zone. XV. Maputaland-Pondoland regional mosaic. XVI. Sahel regional transition zone. XVII. Sahara regional transition zone. XVIII. Mediterranean/Sahara regional transition zone. XIX. East Malagasy regional centre of endemism. XX. West Malagasy regional centre of endemism.

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Many thanks to Alex Dickinson who first suggested that I carry out a taxonomic analysis of the Tanzanian Coastal Forest flora, to Neil Burgess who later encouraged me to generate a list of all the endemic Zanzibar-Inhambane plant species (at a time when we expected that list to be just 500 species long!), to Jon Lovett who provided the use of his extensive library and for many discussions on the phytogeography of Africa, to Kaj Vollesen and Sally Bidgood for assistance during visits to the Royal Botanic Gardens, Kew, and for identifying a number of the species cited, to Leonard Mwasumbi, Frank Mbago and Haji Suleiman for assistance during visits to the herbarium of the University of Dar es Salaam, to G. Freeman-Grenville for references on the Swahili civilisation, to Braam van Wyk for suggesting the name for the Swahilian /Maputaland regional transition zone, and to Henk Beentje, Diane Bridson, David Goyder, Roger Polhill, Gerald Pope, Sylvia Phillips and Bernard Verdcourt for help in filling some of the gaps in the data.

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