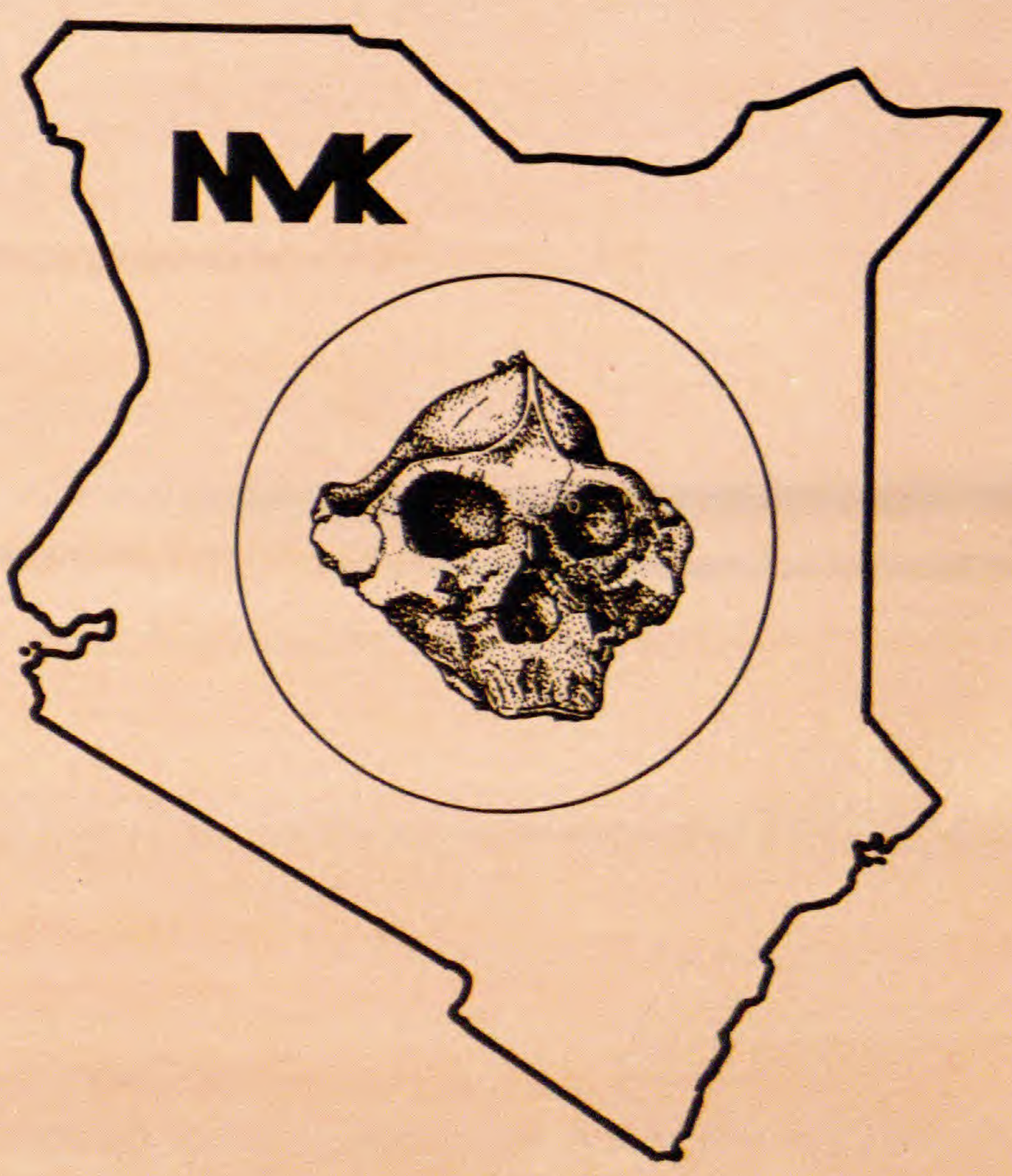
UTAFITI

OCCASIONAL PAPERS OF THE NATIONAL MUSEUMS OF KENYA



NATIONAL MUSEUMS OF KENYA

VOLUME 1 NUMBER 1 JUNE 1988

MISSOURI BOTANICAL
GARDEN LIBRARY

Utafiti, Vol. 1, No. 1, pp. 1 to 22, 1988

MISSOURI BOTANICAL GARDEN LIBRARY AUG 22 1989

Vegetation and Modern Pollen Rain at Olorgesailie, Kenya

Joseph Mworia,[1] Agnes Dallmeijer,[2] and Bonnie Jacobs[3]

(Received November 1985)

Abstract-----Vegetation studies based on two transects of 100 metres each have been analysed in their relative percentage coverage and the occurrence frequency. Eight surface soil samples taken from the two transects were analysed for their pollen contents. A comparison was made between the relative percentages of the taxa common in both the vegetation and pollen samples. A trap sample obtained through a period of one year was analysed for pollen content and compared with pollen spectra from soil samples. Three types of artificial pollen traps were used to obtain one month pollen records to establish the most useful type of trap.

INTRODUCTION

Pollen grains deposited on the ground surface, and in lake and bog sediments bear a relationship to the surrounding vegetation (Birks 1979; Bradshaw 1981; Ibe 1984; Jacobs 1982). This relationship serves as the basis for interpreting the fossil pollen record.

Pollen released from the anthers finds its way to the stigma of the same species in various ways. Transport is carried out over long or short distances either by animals or through the forces of wind and water current. Understanding what can happen during dispersal is essential, in order to interpret the origin of a pollen assemblage at a certain site. Studies of contemporary pollen rain and its relationship to modern vegetation are necessary for correct interpretation of fossil pollen spectra. Two main approaches have been used for such studies: the analysis of surface samples of soil, peat, and lake sediments, and trapping air-borne pollen in specially constructed traps.

The study reported here was undertaken to determine the relationship between the present vegetation and modern pollen rain in the area around Olorgesailie archeological site. To achieve this, two vegetational transects were studied and from the same transects eight surface soil samples were taken and their pollen contents analysed. Three types of pollen traps were used to obtain one month pollen records. A one year pollen record was obtained from one trap.

STUDY AREA

The site is situated in the Eastern Rift Valley (1°30° S and 36°30° E) at the altitude of 990 m above sea level. The mean annual rainfall is 600 mm.

The vegetation around Olorgesailie archeological site is composed of *Acacia* -- *Commiphora* bushland. According to Trump (1967) and Isaac (1968) the area around Olorgesailie can be characterised as semi-arid, with evaporation far exceeding precipitation. The dominant tree species in the bushes are *Acacia tortilis, Acacia senegal, Commiphora africana* and *Commiphora campestris*. *Delonix elata* occurs with scattered distribution throughout the area. Common amongst the low shrubs are species of *Sericocomopsis, Barleria, Aerva* and *Indigofera*. *Acacia mellifera* is one of the most frequent bush constituents, while other common bushes and small trees are *Terminalia* spp., *Balanites* spp., *Grewia* spp., *Boscia coriacea* and *Salvadora persica*. Most of the trees are deciduous, coming into leaf only after rain.

MATERIALS AND METHODS

Vegetation study

Two transects each of 100 m. length were studied. The transects were established in a place where the vegetation appeared to be representative of the area and rather homogeneous in its floral composition. As shown on the map (Fig. 1) the two transects were laid across one another with their mid points intersecting at right angles. The centimeter coverage was recorded for each plant encountered along the transect. The height of each plant above ground level was estimated using a 2 m. pole. The 2 m. pole was used for tall plants as well but heights were estimated by a person standing at a distance from the plant. Plants were collected, given numbers and pressed for identification in the herbarium. A profile sketch was made on graph paper in the field.

For each transect the total coverage by plants was summed in centimetres. The same was done for each species present along the transect. From this the relative percentage cover per species was established. Absolute

[1]Palynology Department, National Museums of Kenya, P.O. Box 40658, Nairobi.
[2]I.T.C., Private Mail Bag 14, Banjul, Gambia.
[3]Shuler Museum of Paleontology, Institute for the Study of Earth and Man, Southern Methodist University, Dallas, Texas 75275.

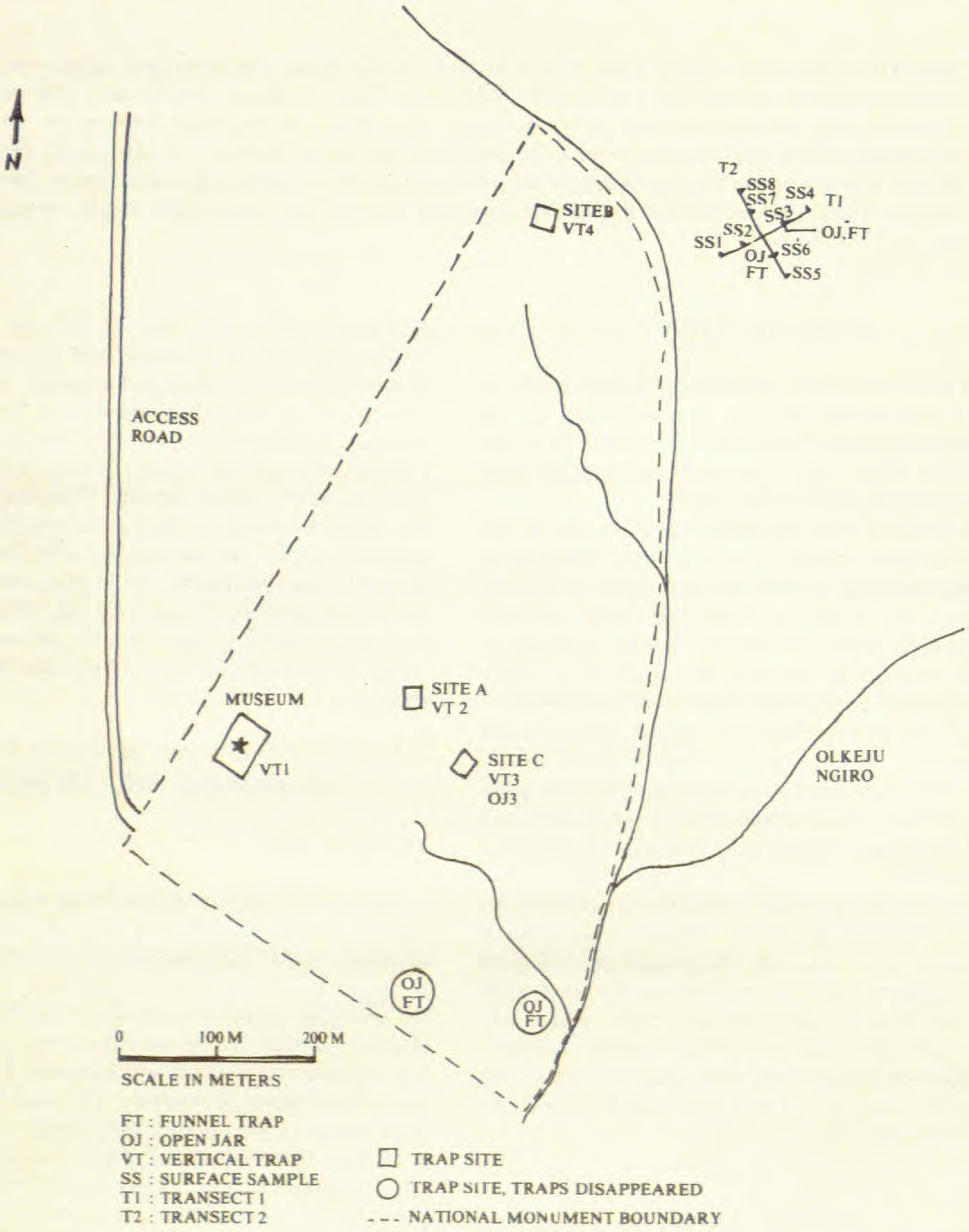


Figure 1. Study area: Olorgesailie National Monument

cover in centimetres and relative percentages were also calculated for genera to facilitate comparison with pollen taxa. The plants were grouped into trees, shrubs, herbs and grasses plus sedges according to descriptions made by Dale and Greenway (1961) and Agnew (1974). Further percentage coverage within these groups were calculated to show species dominance in each category.

Pollen traps

Three types of pollen traps were constructed for use in sampling (Fig. 2). The funnel trap consisted of a large (approximately 1 litre) jar with an infitting upright plastic funnel lined with cotton gauze soaked in a mixture of glycerine and phenol.

An open jar measuring 7 cm high and 8 cm diameter, with a small amount of glycerine with phenol was used as the open jar trap.

The vertical trap was made of a 20 cm sided square wood frame, 2.5 cm thick, and with a one metre wood support from the middle of one side. Cotton gauze was taped on the frame covering the square space and smeared with a mixture of glycerine and phenol.

The traps were placed at various spots in the study area, (Fig. 1). All the vertical traps were placed under the roofs of excavation sheds to avoid washing off by rain. Eight surface soil samples (four from each transect) were collected for pollen analysis. The soil samples were collected within intervals of 25 m. along the transects. A month later samples from nine o the traps (4 vertical, 3 funnel and 2 open jar traps), were collected. The other traps unfortunately disappeared.

Laboratory processing and pollen analysis

The samples were prepared for pollen analysis using the method described by Faegri and Iversen (1975). The method includes KOH treatment and acetolysis for samples with apparently high organic contents, which was the case in trap samples. Soil samples were treated with HCl and HF in addition to KOH and acetolysis, as they contained sand and siliceous material. The full preparation procedure is in Appendix I. Identification of pollen grains was based on comparison with the reference slides from the National Museums of Kenya and published pollen floras, (Bonnefille 1969, 1971, Bonnefille & Riollet 1980. Caratini & Guinet 1974, Hamilton 1976, Heusser 1971, Kingham 1976, Moore and Webb 1978, Senesse 1980, Ferguson and Strachan 1982). New reference slides were prepared from herbarium material, to cover as many of the species present in Olorgesailie area as possible.

Pollen grains were identified at various taxonomic levels. In many cases identification was made at the generic level such as *Grewia*, while in other cases only the family level was distinguishable e.g. in Compositae. In one case pollen could only be identified as belonging to either of two families i.e. Amaranthaceae or Chenopodiaceae. The results of the analysis of the different samples are presented in figures 3 and 4.

Pollen and vegetation comparison

To compare the percentages of taxa present in the vegetation with percentages of the same taxa in the pollen counts of the soil samples the data were treated as follows.

Mean of percentages per taxa were calculated for each pollen type from the four soil samples in each transect. A mean was also calculated for the eight soil samples of the two transects together. Relative percentages for taxa encountered in both vegetation and pollen samples are shown in figure 5.

RESULTS

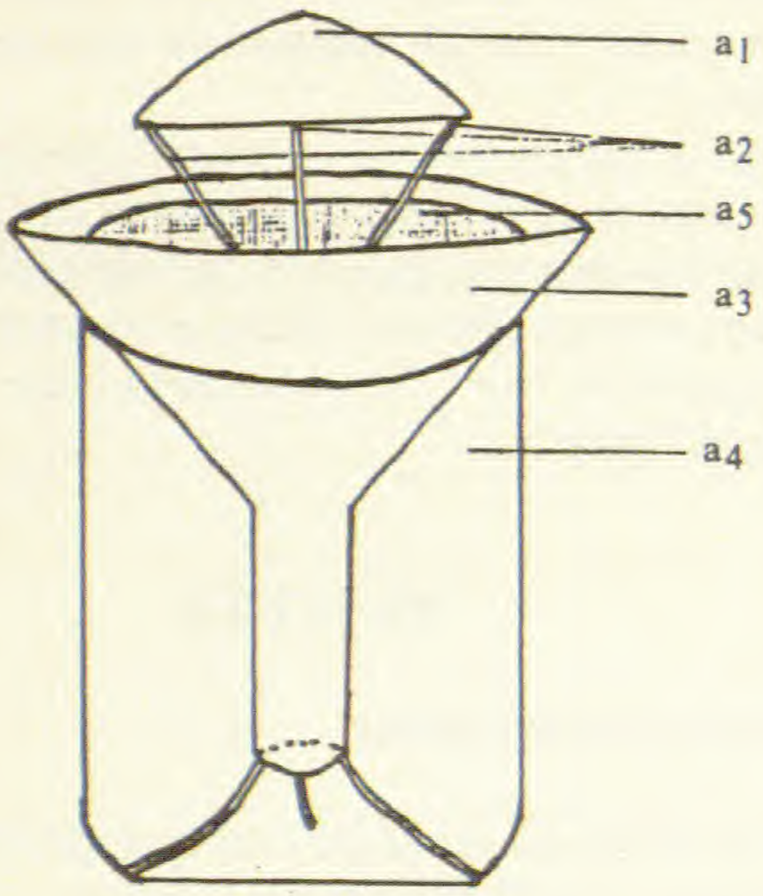
Vegetation transect studies

Some of the results of the transects studies are shown in Tables 1 and 2 (transects 1 and 2). The column farthest to the left represents all the plant species encountered along the transects; shrubs, herbs and grasses together with sedges. In each of the four columns with numbers, the values for a species is on the left and values for a genus is on the right. The first column with numbers shows the coverage in centimetres in the transect. Column 2 shows the number of individual plant counts (frequency). It was not possible to obtain the frequencies for the herbs, grasses and sedges because of their nature. The next two columns represent relative percentages of cover within each structural component and within the whole transect. For example, 3 *Acacia tortilis* trees were encountered along 1480 cms. of the transect. This species comprises 27.1% of all tree coverage and 8.7% of coverage for the transect. The percentage values of the genera present in the vegetation are given to facilitate comparison with pollen percentages, many of which could only be identified to the generic level. Vegetation profile drawings of the transects are given in figures 6a, 6b, 7a and 7b.

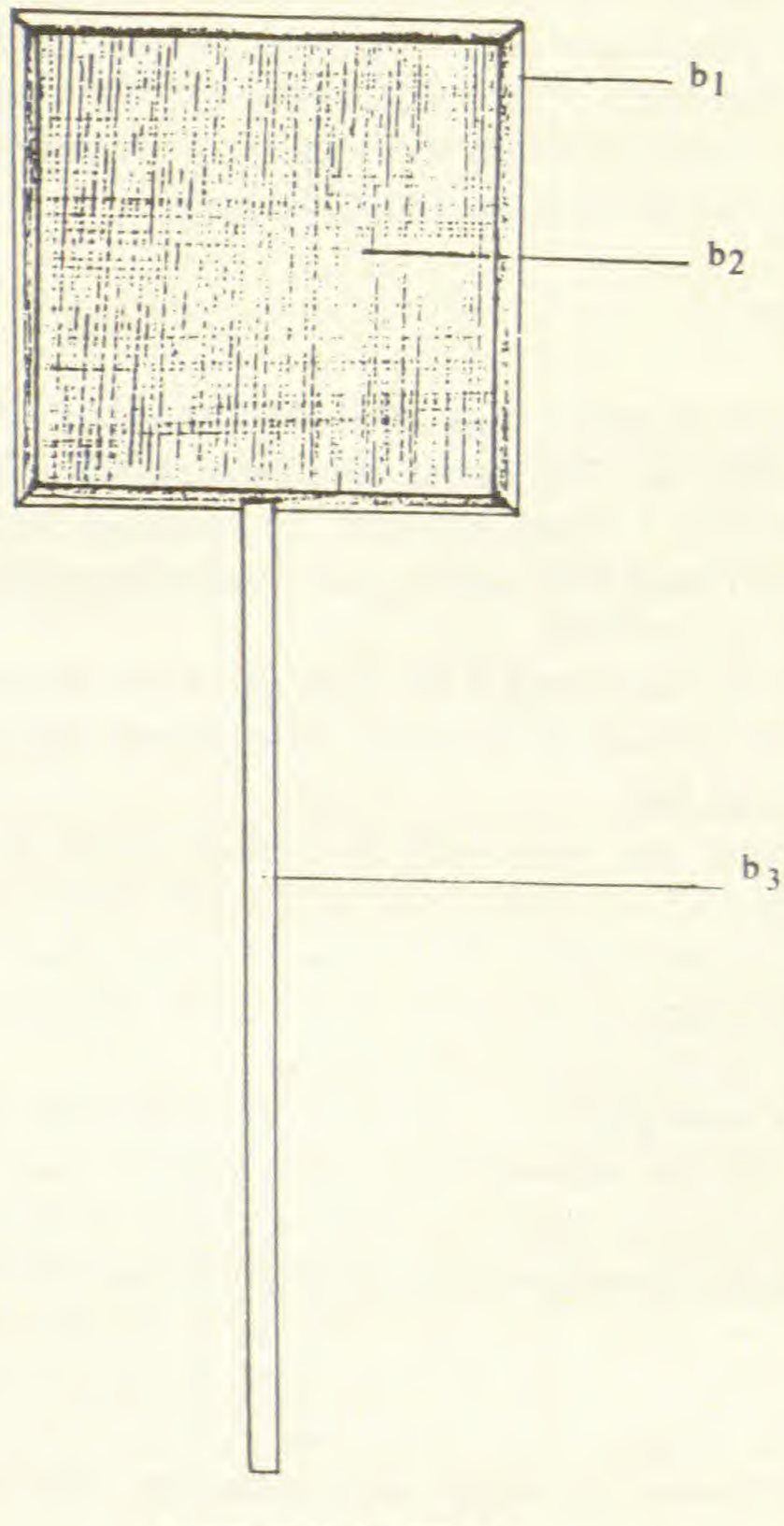
Pollen study: Soil surface samples

Results of the soil surface sample analyses are shown in Figure 3. This histogram shows the percentages of each pollen taxon found in the eight surface soil samples, SS_1 - SS_4 from transect 1, SS_5 - SS_8 from transect 2, and in two trap samples (OJ_3 1983 and OJ_3 1984). OJ_3 is open jar trap No. 3; the OJ_3 1983 pollen sample was collected over one month (6th May 1983 to 9th June 1983). The OJ_3 1984 pollen sample was collected over a period of one year (9th June 1983 to 17th June 1984).

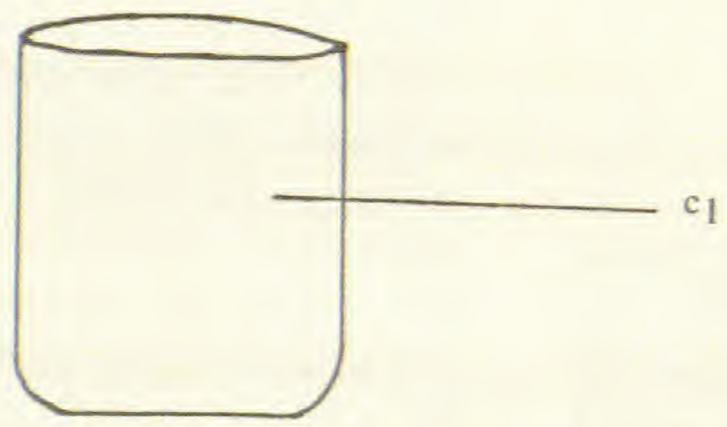
Gramineae and Cyperaceae are the first and second most abundant pollen types, respectively, in all the samples. Soil sample number SS_4 had the lowest Gramineae percentage but had highest number of pollen taxa among all the soil samples. Soil sample number SS_1, which had the highest Gramineae pollen percentage, had the lowest number of pollen taxa. In the soil surface samples, pollen from the following plant taxa were well



a) FUNNEL TRAP



b) VERTICAL TRAP



c) OPEN JAR TRAP

a1 funnel cap (plaster)
a2 metal wires
a3 plastic funnel
a4 plastic jar
a5 cotton gauze

b1 wooden square frame
b2 cotton gauze
b3 wooden supporting frame

c1 open jar

Figure 2. Atmospheric pollen traps.

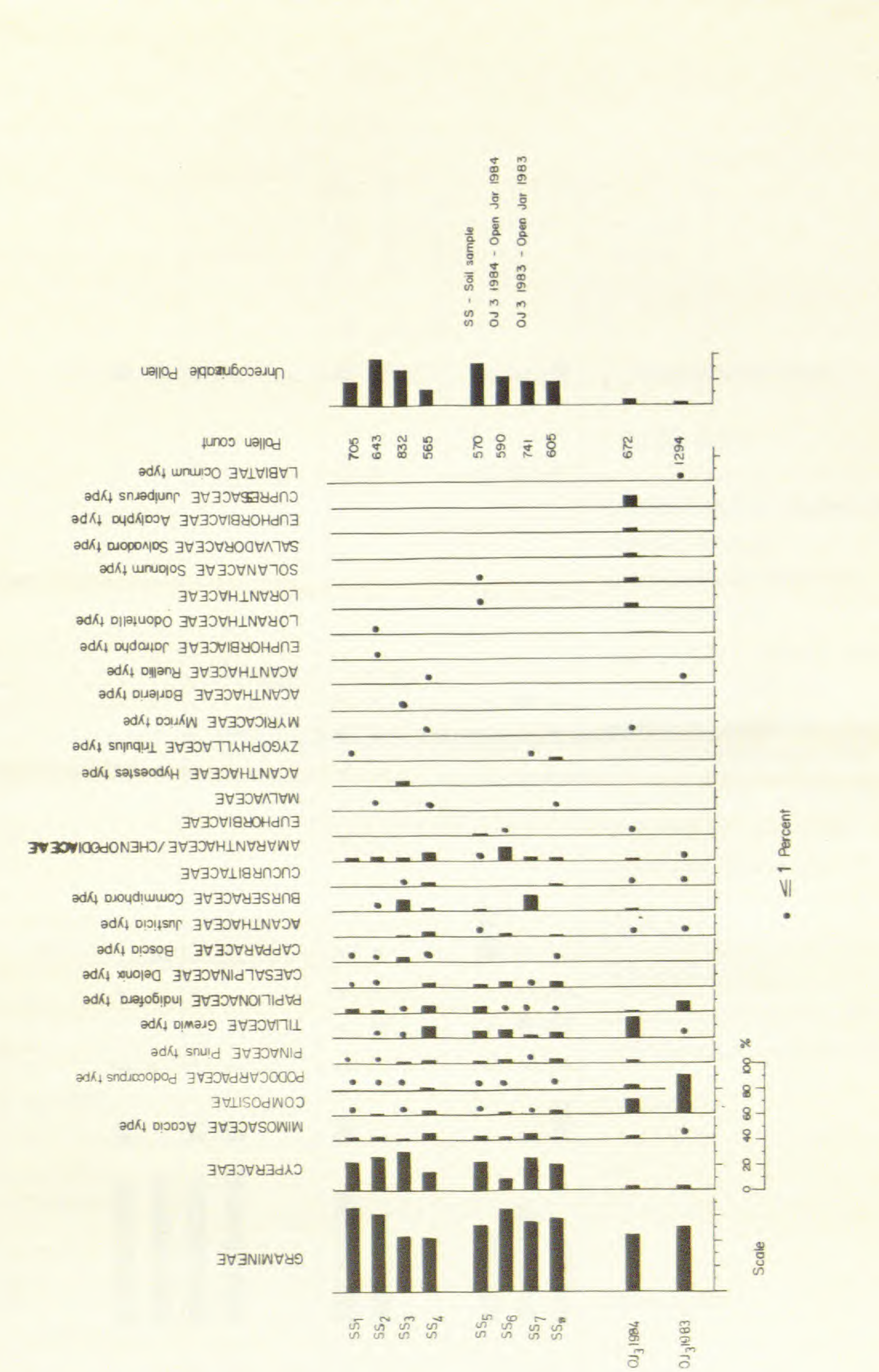


Figure 3. Pollen percentage histograms from 8 surface soil samples. One trap annual record and a one month sample from the same trap.

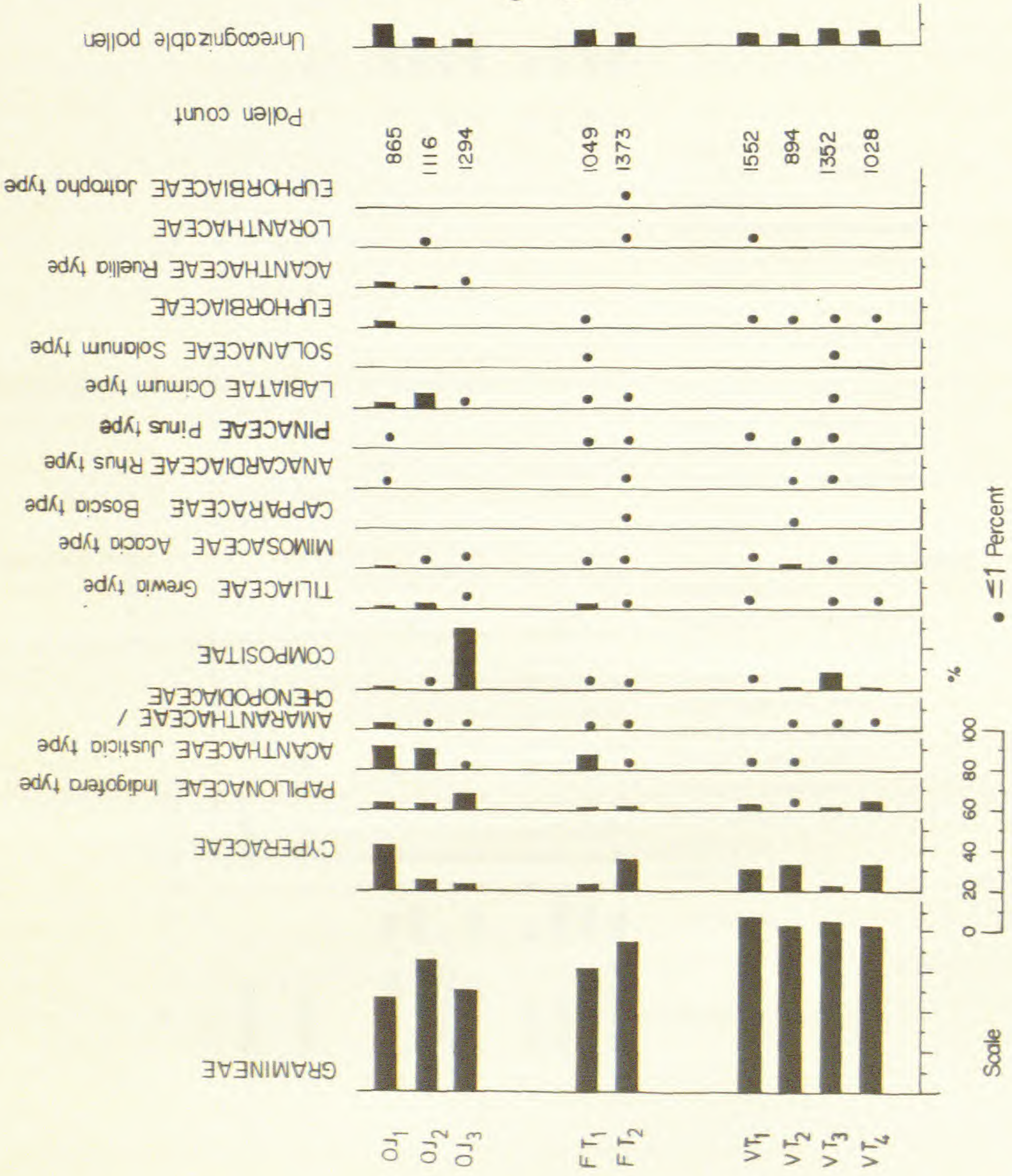


Figure 4. Pollen percentage histograms from the trap samples.

Table 1. Transect 1

	Coverage in centimeters		Frequency		Percentage canopy		Percentage transect	
	Species	Genus	Species	Genus	Species	Genus	Species	Genus
TREES								
Mimosaceae								
Acacia tortilis	1480		3		27.1		8.7	
Acacia senegal	1370		4		25.1		8.1	
Acacia sp.	610		1		11.2		3.6	
Acacia		3460		8		63.3		21.6
Burseraceae								
Commiphora campestris	175		3		32.0		10.3	
Commiphora africana	255		2		4.7		1.5	
Commiphora		2005		5		36.7		11.8
SHRUBS								
Tiliaceae								
Grewia tembensis	1615		13		22.9		9.5	
Grewia (unspecified)	1040		6		14.7		6.1	
Grewia bicolor	650		3		9.8		4.1	
Grewia villosa	292		3		4.1		1.7	
Grewia		3637		25		51.5		21.4
Triumfetta flavescens	20		1		0.3		0.1	
Triumfetta		20		1		0.3		0.1
Papilionaceae								
Indigofera spinosa	899		20		12.7		5.3	
Indigofera		899		20		12.7		5.3
Acanthaceae								
Barleria acanthoides	650		16		9.2		3.8	
Barleria eranthemoides	70		1		1.0		0.4	
Barleria		720		17		10.2		4.2
Justicia odora	170		2		2.4		1.0	
Justicia		170		2		2.4		1.0
Ecbolium revolutum	105		2		1.5		0.6	
Ecbolium		105		2		1.5		0.6
Ruellia sp.	12		2		0.2		0.07	
Ruellia		12		2		0.2		0.07
Capparaceae								
Boscia coriacea	380		3		5.4		2.2	
Boscia		380		3		5.4		2.2

Table 1 (cont'd)

	Coverage in centimeters		Frequency		Percentage canopy		Percentage transect	
SHRUBS (Cont.)								
Mimosaceae								
Acacia mellifera	210		1		3.0		1.2	
Acacia		210		1		3.0		1.2
Euphorbiaceae								
Euphorbia sp.	210		1		3.0		1.2	
Euphorbia		210		1		3.0		1.2
Malvaceae								
Hibiscus micranthus	185		2		2.6		1.1	
Hibiscus		185		2		2.6		1.1
Pavonia patens	75		2		1.1		0.4	
Pavonia		75		2		1.1		0.4
Compositae								
Vernonia cinerascens	180		2		2.6		1.1	
Vernonia		180		2		2.6		1.1
Labiatae								
Capitanya otostegioides	112		2		1.6		0.7	
Capitanya		112		2		1.6		0.7
Balanitaceae								
Balanites aegyptiaca	80		1		1.1		0.5	
Balanites		80		1		1.1		0.5
Solanaceae								
Solanum taitense	60		1		0.9		0.4	
Solanum		60		1		0.9		0.4
HERBS								
Agavaceae								
Sansevieria robusta	400				28.6		2.4	
Sansevieria		400				28.6		2.4
Scrophulariaceae								
Craterostigma sp.	330				23.6		1.9	
Craterostigma		330				23.6		1.9
Amaranthaceae								
Pupalia lappaceae	155				11.1		0.9	
Zaleya pentandra	35				2.5		0.2	
Amaranthaceae		190				13.6		1.1
Labiatae								
Becium sp. A	135				9.7		0.8	
Becium		135				9.7		0.8
Asclepiadaceae								
Diplostigma canescens	120				8.6		0.7	
Diplostigma		120				8.6		0.7
Papilionaceae								
Tephrosia lortii	105				7.5		0.6	
Tephrosia		105				7.5		0.6

Table 1 (cont'd)

	Coverage in centimeters	Frequency	Percentage canopy	Percentage transect
Commelinaceae				
Commelina bengalensis	45		3.2	0.3
Commelina albescens	20		1.4	0.1
Commelina	65		4.6	0.4
Boraginaceae				
Heliotropium somalense	25		1.8	0.1
Heliotropium	25		1.8	0.1
Vitaceae				
Cissus rotundifolia	20			
1.4	0.1			
Cissus	20		1.4	0.1
Acanthaceae				
Blepharis linarifolia	15		1.1	0.09
Belpharis	15		1.1	0.09
Nyctaginaceae				
Boerhavia erecta	13		0.9	0.08
Boerhavia	13		0.9	0.08
GRASSES AND SEDGES				
Grasses (undifferentiated)	1709		56.9	10.1
Sporobolus jacquemontii	5		0.2	0.03
Enneapogon cendroides	15		0.5	0.09
Grasses	1729		57.1	10.2
Grasses and Sedges	1048		34.6	6.2
Kyllinga welwitschii	249		8.2	1.5
Grasses plus sedges	3026		100	17.9

Table 2. Transect 2

	Coverage in centimeters		Frequency		Percentage canopy		Percentage transect	
	Species	Genus	Species	Genus	Species	Genus	Species	Genus
TREES								
Mimosaceae								
Acacia tortilis	2050		2		48.6		16.5	
Acacia senegal	310		2		7.3		2.5	
Acacia		2360		4		55.9		20.4
Papilionaceae								
Delonix elata	1640		1		38.9		13.2	
Delonix		1640		1		38.9		13.2
Burseraceae								
Commiphora africana	155		1		3.7		1.2	
Commiphora campestris	65		1		1.5		0.5	
Commiphora		220		2		5.2		1.8
SHRUBS								
Tiliaceae								
Grewia (unspecified)	1145		6		21.8		9.2	
Grewia tembensis	785		7		15.0		6.3	
Grewia bicolor	105		1		2.0		0.8	
Grewia		2035		14		38.8		16.4
Triumfetta flavescens	69		3		1.3		0.6	
Triumfetta		69		3		1.3		0.6
Papilionaceae								
Indigofera spinosa	1423		28		27.1		11.5	
Indigofera cufodontii	60		1		1.1		0.5	
Indigofera		1483		29		28.3		11.9
Acanthaceae								
Barleria acanthoides	322		8		6.1		2.6	
Barleria eranthemoides	100		2		1.9		0.8	
Barleria		422		10		8.0		3.4
Ecbolium revolutum	180		2		3.4		1.4	
Ecbolium		180		2		3.4		1.4
Justicia odora	65		3		1.2		0.5	
Justicia		65		3		1.2		0.5
Capparaceae								
Boscia coriacea	425		3		8.1		3.4	
Boscia		425		3		8.1		3.4
Malvaceae								
Hibiscus micranthus	130		5		2.5		1.0	
Hibiscus		130		5		2.5		1.0
Pavonia patens	110		2		2.1		0.9	
Pavonia		110		2		2.1		0.9

Table 2 (cont'd)

	Coverage in centimeters		Frequency		Percentage canopy		Percentage transect	
SHRUBS (Cont.)								
Mimosaceae								
Acacia mellifera	170		2		3.2		1.4	
Acacia		170		2		3.2		1.4
Solanaceae								
Solanum taitense	100		1		1.9		0.8	
Solanum		100		1		1.9		0.8
Loranthaceae								
Odontella ugogensis	55		1		1.0		1.0	
Loranthaceae		55		1		1.0		1.0
HERBS								
Agavaceae								
Sansevieria robusta	600				41.8		4.8	
Sansevieria		600				41.8		4.8
Papilionaceae								
Tephrosia lortii	298				20.8		2.4	
Tephrosia		298				20.8		2.4
Labiatae								
Plectranthus sp.	150				10.4		1.2	
Plectranthus		150				10.4		1.2
Becium sp. A	127				8.8		1.0	
Becium		127				8.8		1.0
Asclepiadaceae								
Diplostigma canescens	90				6.3		0.7	
Diplostigma		90				6.3		0.7
Vitaceae								
Cissus quadrangularis	50				3.5		0.4	
Cissus		50				3.5		0.4
Amaranthaceae								
Pupalia lappacea	43				3.0		0.3	
Amaranthaceae		43				3.0		0.3
Scrophulariaceae								
Craterostigma sp. C	33				2.3		0.3	
Scrophulariaceae		33				2.3		0.3
Euphorbiaceae								
Euphorbia acalyphoides	20				1.4		0.2	
Euphorbia		20				1.4		0.2
Commelinaceae								
Commelina bengalensis	20				1.4		0.2	
Commelina		20				1.4		0.2
Nyctaginaceae								
Boerhavia erecta	5				0.3		0.04	
Boerhavia		5				0.3		0.04
GRASSES AND SEDGES								
Grasses	1465				96.2		11.8	
Grasses and Sedges	58				3.8		0.5	
Total grasses & sedges		1523				100		12.3

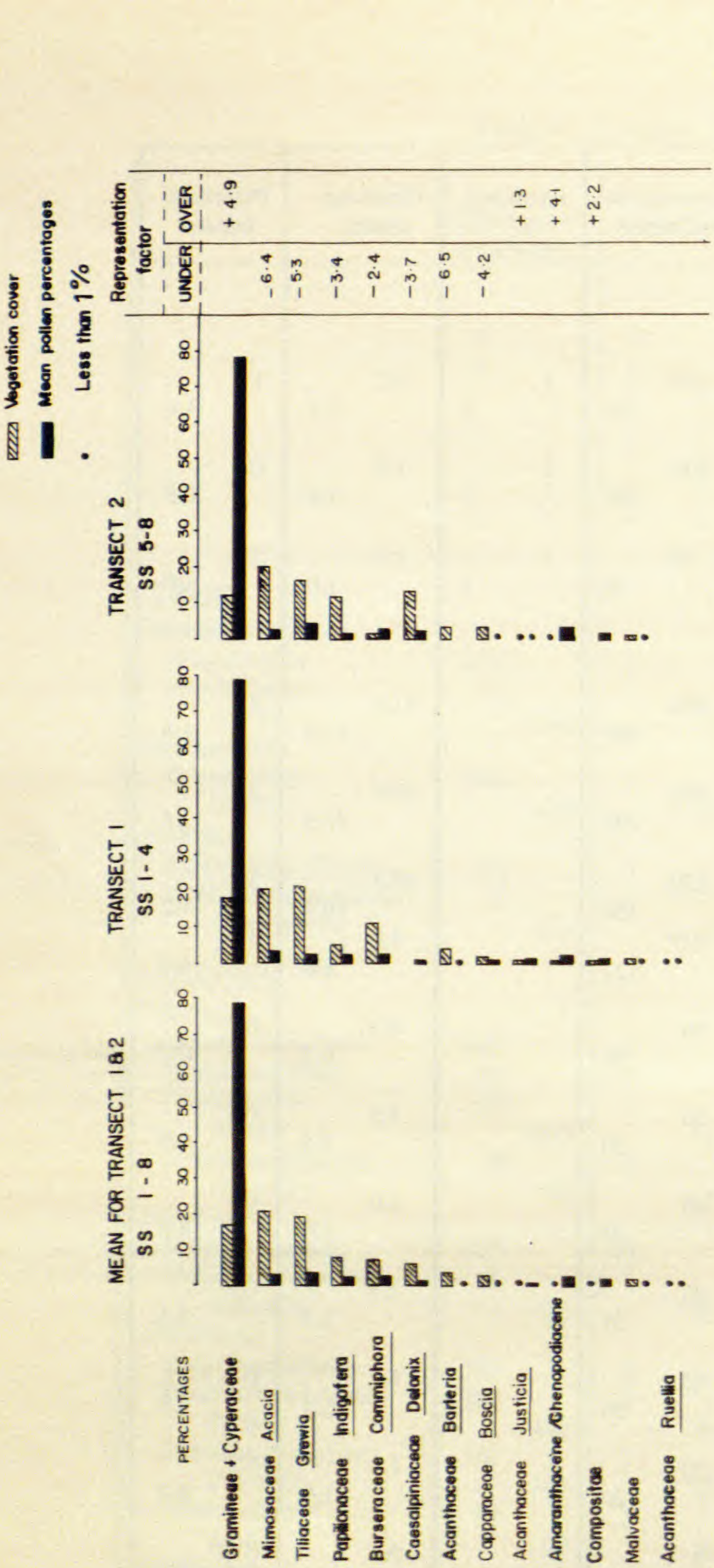


Figure 5. Pollen percentages of taxa present in surface soil samples compared with percent cover in the vegetation transects.

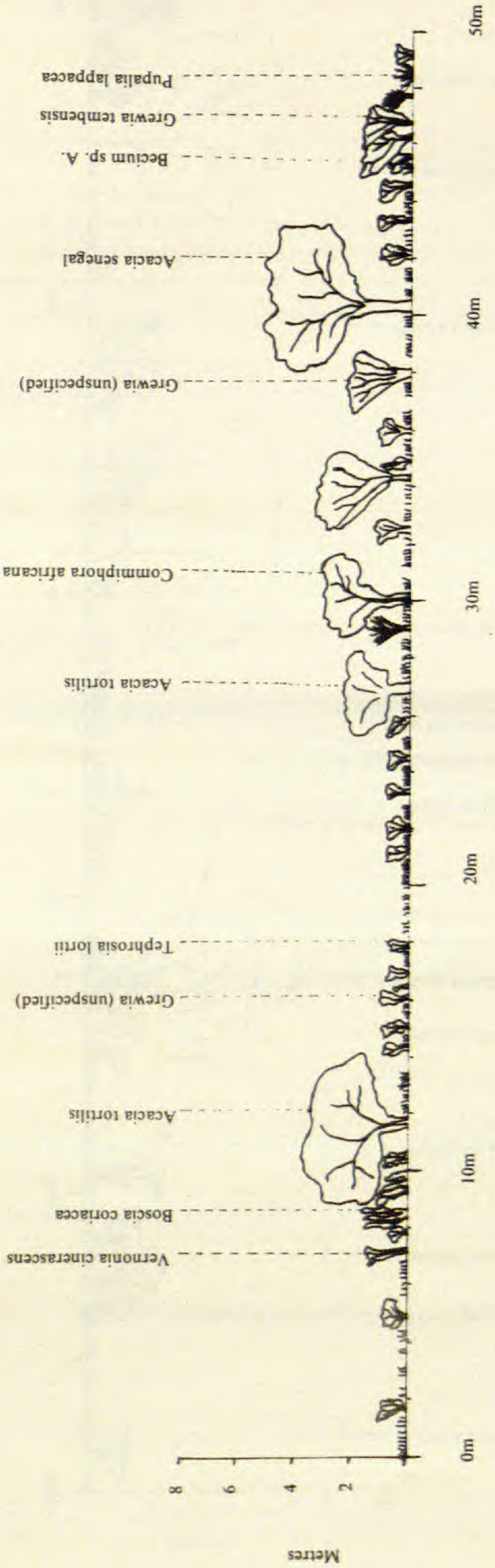


Figure 6a. Transect 1 (0-5m).

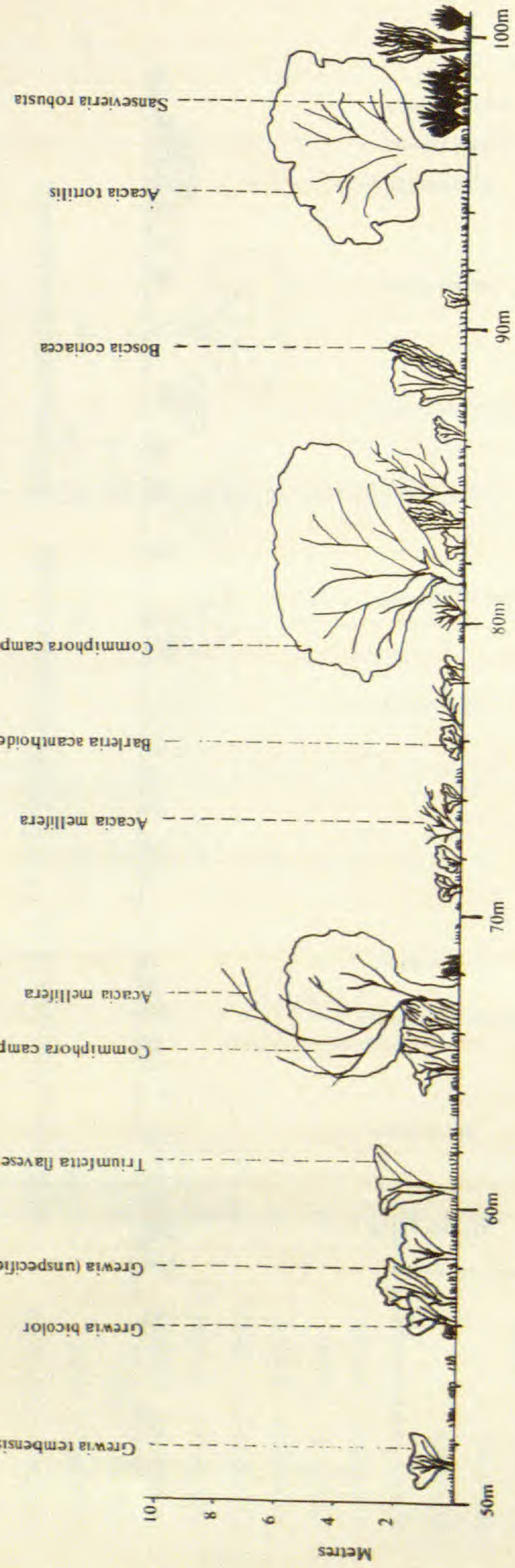


Figure 6b. Transect 1 (50-100 m).

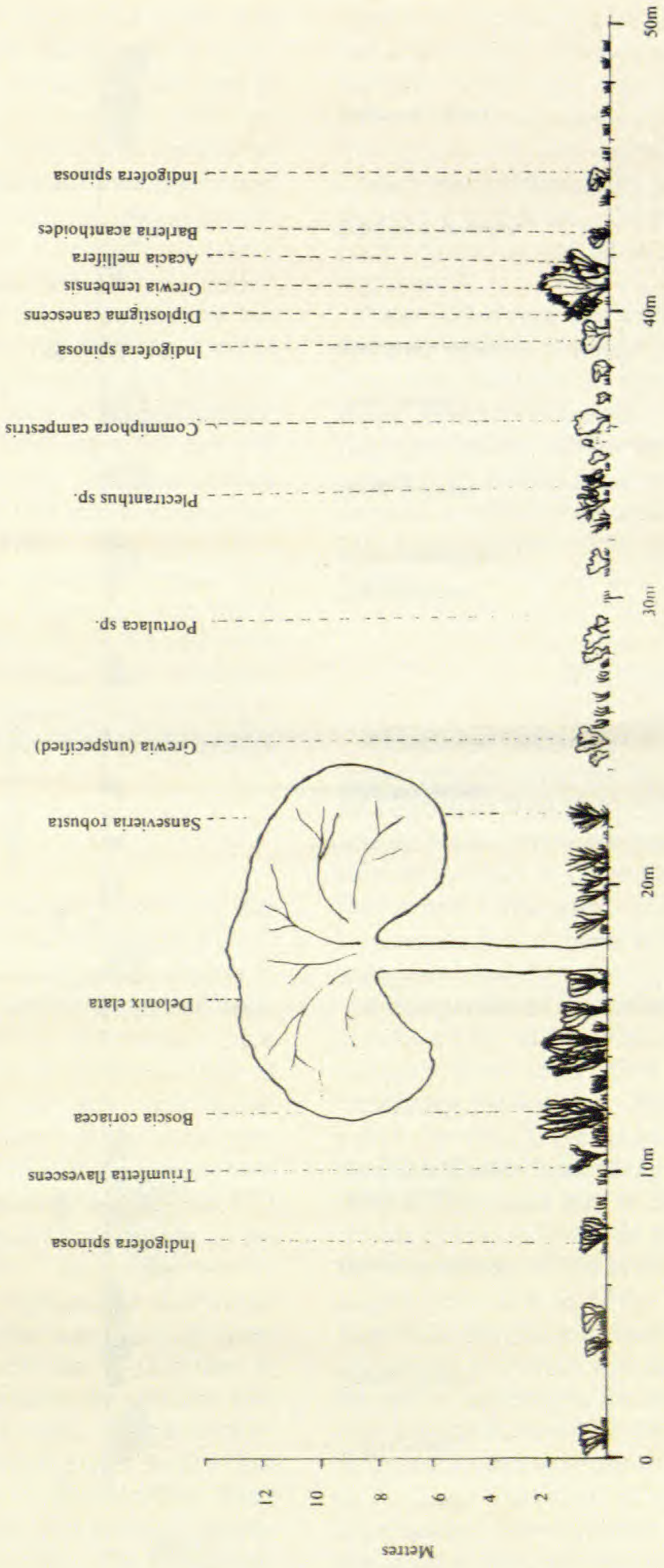


Figure 7a. Transect 2 (0-50 m).

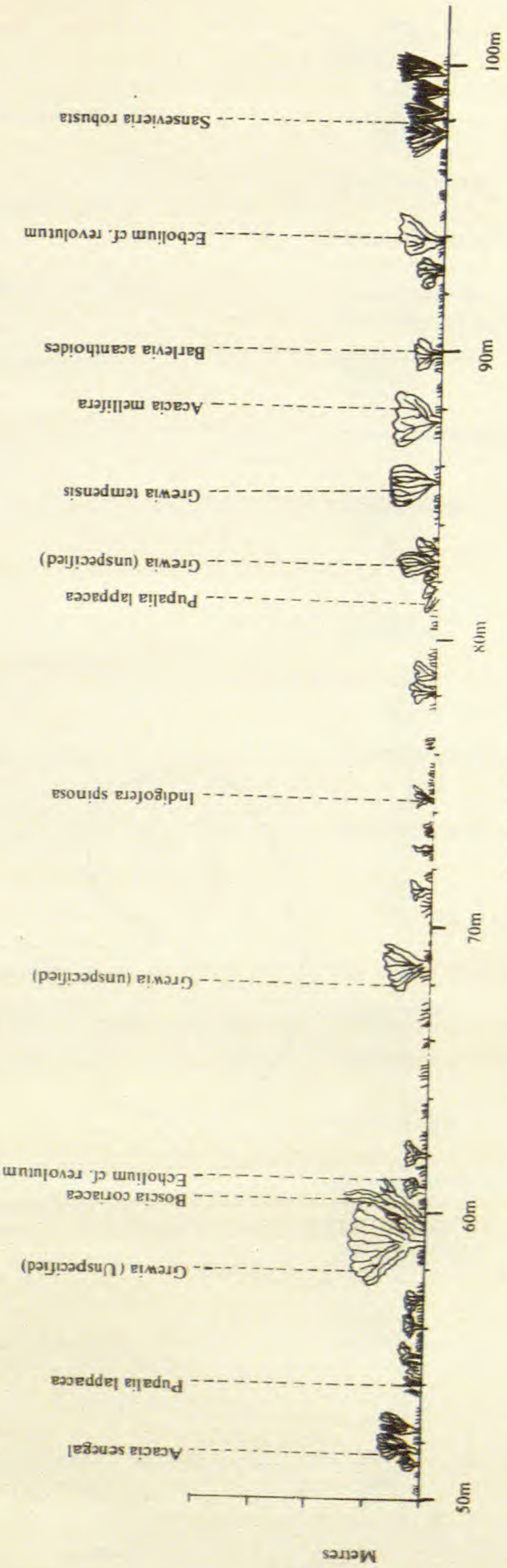


Figure 7b. Transect 2 (50-100 m).

represented: Gramineae, Cyperaceae, Amaranthaceae/Chenopodiaceae, *Acacia*, *Grewia*, *Indigofera*, *Delonix*, Compositae, *Commiphora*, *Boscia* and *Justicia*. Well represented means that pollen was found in at least four of the eight soil surface samples. *Pinus* pollen was found in all surface samples and in relatively higher percentages than those of *Podocarpus*. *Pinus* and *Podocarpus* pollen are the only well represented allochthonous pollen in the analysis. The percentage values of *Commiphora* were very variable throughout the samples. In SS7, there was 12% *Commiphora* pollen while neighbouring samples had none. *Boscia* pollen was present in all the samples from transect one but absent in three out of four surface samples from transect two. The percentage of unrecognizable pollen found in trap samples were much lower than in the soil surface samples. OJ3 1984 and OJ3 1983 have 4% and 2% unrecognizable pollen respectively. The soil surface sample SS4 had the lowest with 13% of unrecognizable pollen and SS_2 the highest (37%). SS_4 also had a relatively low percentage of grass pollen while other taxa were present in relatively higher percentages than found in other samples. The trap samples OJ3 (1983 and 1984) showed high percentages of Compositae pollen compared to the surface soil sample. Cyperaceae pollen percentages were much lower in the trap samples than in soil surface samples.

Pollen trap samples

Relative pollen percentages for taxa from nine trap samples collected over a period of one month (6th May to 9th June 1983) are shown in a histogram in Figure 4. To compare the results of three different types of traps, open jar (OJ's), funnel traps (FT's), and vertical traps (VT's), the analysis from samples of individual traps of the same type are placed next to each other in the diagram. OJ1 and FT1, were placed on the same spot, and their contents show similarities in the percentages of *Indigofera*, *Justicia*, *Grewia* and *Acacia*. OJ_2 and FT_2 were also placed together and showed similarities in the pollen percentages of *Indigofera*, Amaranthaceae/Chenopodiaceae, Compositae, *Acacia* and Loranthaceae types. *Ocimum* pollen was relatively more abundant in OJ_1 than in FT_1 and also in OJ_2 than in FT_2. Among the traps placed outside the transect, OJ3 and VT3 were placed beside one another. The percentages of *Compositae* pollen type was much higher in OJ3 than in VT3 and *Gramineae* higher in VT3 than in OJ3. *Rhus* type and *Pinus* type were the two allochthonous pollen types found in VT3 but absent in OJ3. The annual trap sample OJ3 1984 shown in Fig. 3 had more pollen taxa than any of the one month trap samples.

Vegetation and pollen rain comparisons

In Fig. 5 pollen percentages of genera/taxa present in the soil surface amples are shown in histograms next to the histograms of the percentages of these taxa as they occur in the vegetation. The pollen percentages of Gramineae and Cyperaceae were added together for the purpose of comparing with the vegetation percentages.

The pollen of Gramineae plus Cyperaceae was the most over-represented, being 4.9 times more than its vegetation percentage in the transects. The other pollen types over-represented were Acanthaceae-*Justicia* type Amaranthaceae/ Chenopodiaceae and Compositae. *Barleria* pollen type was the most under-represented followed by *Acacia* and *Grewia* pollen types. None of the tree species was over-represented. Among the shrubs, *Grewia* was predominantly present in the vegetation and also in the pollen rain. Genera and families found in the pollen record as well as in the vegetation are listed in Appendix II.

Pinus pollen type was present in both the soil samples and trap samples although *Pinus* does not occur in the local semi-arid type of vegetation. The same applies to *Rhus* (Anacardiaceae). Though *Tribulus* (Zygophyllaceae) pollen was found in the soil surface samples, no *Tribulus* was recorded in the floral survey. *Tribulus terrestris* does occur in Nairobi District and the Rift Valley (Agnew 1974), and Olorgesailie borders this region.

DISCUSSION

Gramineae pollen was a dominant feature in all the pollen samples analysed for this study. On comparing the vegetation plant taxa percentages with the surface soil and air borne pollen samples, grasses and sedges were over-represented in the pollen rain by a factor of about five times. The great quantities of Gramineae and Cyperaceae pollen found in the modern pollen rain may exaggerate their importance in the vegetation.

A comparison of the surface soil pollen spectra shown in this study with pollen spectra from surface soil samples from other sites in Kenya reveals some interesting similarities. For example, the Gramineae pollen percentages for the soil samples in this study (Fig. 5), resemble the Gramineae pollen percentages in surface samples from Alia Bay at Lake Turkana (Bonnefille & Vincens 1977). Gramineae pollen percentages from Alia Bay ranged from 47.6% to 65.4% and at Olorgesailie they ranged from 42% to 66%. Surface soil samples from Laga Tulu Bor (Bonnefille et Vincens 1977) show close similarities to surface soil samples from Olorgesailie in the pollen percentages for the taxa: Gramineae, *Acacia* and Amaranthaceae/Chenopodiaceae. In the Alia Bay record no *Acacia* was found but the percentages of *Acacia* in the Laga Tulu Bor samples resembled those from Olorgesailie. The vegetation profile sketch of Laga Tulu Bor transect was more similar to that at Olorgesailie than that at Alia Bay. The Alia Bay profile sketch showed no trees. The vegetation in the Turkana areas was characterized as a bushed grassland with *Acacia* and *Commiphora* (Bonnefille et Vincens 1977), and at Olorgesailie the vegetation was characterized as *Acaia-Commiphora* bushland (see 1.2.). Though *Acacia* pollen percentages in the soil samples from Olorgesailie did not differ very much from samples taken at Laga Tulu Bor, there was a clear difference in the *Commiphora* percentages. At Olorgesailie *Commiphora* pollen percentages ranged from 0-11%, but at Laga Tulu Bor

	A Number of pollen taxa present	B Number of taxa with value > 1%	C Number of taxa with value ≤ 1%
OJ_1	13	11	2
OJ_2	11	7	4
OJ_3	10	4	6
OJ average	11.3	7.3	4
FT_1	12	5	7
FT_2	14	3	11
FT average	13	4	9
VT_1	10	3	7
VT_2	11	4	7
VT_3	12	4	8
VT_4	7	4	3
VT average	10	3.8	6.3

Table 3. A comparison of the pollen taxa in trap samples.

percentages did not exceed 0.6%. Since no detailed data about the vegetation in Laga Tulu Bor are available it is not known whether the absence of *Commiphora* pollen is due to an absence of these plants in the vegetation or to anything else. The quite remarkable differences in percentages of *Commiphora* pollen in the different soil samples from Olorgesailie and its near absence in the Turkana area may suggest that *Commiphora* pollen are only very locally dispersed. The fact that many of the *Commiphora* pollen found in the Olorgesailie samples were in relatively bad shape may indicate that *Commiphora* pollen deteriorate relatively easy.

Surface soil sample number SS_4 had the highest number of pollen taxa. It also had the lowest percentage of unrecognizable pollen and the lowest Gramineae pollen percentage. More likely the high grass percentages in the other samples depressed (or constrained) the percentages of other pollen taxa. Among the soil surface samples the unrecognizable pollen percentage ranges from 13% in SS_4 to 37% in SS_2. In the annual trap sample OJ_3 1984 the percentage of unrecognizable pollen was clearly lower than in the soil samples (5%). In addition the diversity in OJ_3 was higher as were the relative amounts of the less common pollen types. This may indicate better pollen preservation in the trap than in the soil samples. Establishing the efficiency of the different trap types presented us with difficulties. It was not possible to compare all the results from the trap samples with the soil surface, because all of the traps (except OJ3 1984) had been collecting pollen over too short a period (one month). The disappearance of pollen traps while in the field reduced the number of trap samples. The results from one annual sample were not adequate for satisfactory explanations.

Table 3 shows that the total number of pollen taxa was quite low. Some taxa might have been included in the unrecognizable pollen count. Whether a pollen trap is an efficient instrument to record modern pollen rain, one has to establish whether the pollen sampled by the trap are representative of the pollen rain of the area. Establishing the pollen rain does have its problems. Pollen preservation is poor in surface soil samples from semi-arid regions like Olorgesailie. Traps seem to be preferable because of the better preservation, but their disadvantage is that pollen in the immediate area of the traps is over-represented. From this study we were not able to establish the true value of the traps, but they appeared to have the advantage of containing better preserved pollen. Since the results of modern pollen studies are meant to be an aid in the interpretation of fossil pollen data, we think that though the preservation in the soil surface samples is poorer than in the trap samples, surface soil samples are preferable over trap samples because they approach the most natural situation.

ACKNOWLEDGEMENTS

We would like to thank the Kenya Museum Society for providing the funds which enabled us to do the field work. We are also thankful to Mr. David Nyakundi of the East African Herbarium, National Museums of Kenya, for assistance in the field and with the identification of plants.

REFERENCES

Agnew, A. D. 1974. Upland Kenya Wild flowers Oxford University Press, 827 p.

Birks, H. J. 1979. Modern pollen assemblages and vegetational history of the moraines of the Klutlan Glacier and its surroundings, Yukon Territory, Canada Quart. Res. 14: 101-129.

Bonnefille, R. 1969. Analyse pollinique d'un Sediment Recent: Vases Actuelles de la Riviere Aouache (Ethiopie). Pollen et Spores Vol. XI - No. 1.

Bonnefille, R. 1971. Atlas des Pollens D' Ethiopie: Principales Especes des Forets de Montagne. Pollen et Spores Vol. XIII - No. 1.

Bonnefille, R. et Vincens, A. 1977. Representation pollinique environments arides a l'est du Lac Turkana (Kenya). Recherches Francaises sur le Quarternaire INQUA 1977 Supplement au Bulletin AFEQ 1977-1, No. 50.

Bonnefille, R., et Riollet, G. 1980. Pollens des Savanes d'Afrique Orientale. Editions du Centre National de la Recherche Scientifique, 140 p., 113 pl.

Bradshaw, R. H. W. 1981. Modern pollen presentation factors for wood in southeast England. J. Ecol. 69: 45-70.

Caratini, Cl., and Guinet, Ph. 1974. Pollen et spores d'Afrique tropicale. Centre d'etudes des geographie tropicale. Talence France.

Dale, I. R., and Greenway, P. J. 1961. Kenya Trees and Shrubs. Buchanans Estates, 654 p.

Faegri, K., and Iversen, J. 1975. Textbook of pollen analysis. Blackwell Oxford, 3rd ed., 195 p.

Ferguson, I. K., and Strachan, R., 1982. Pollen morphology and taxonomy of the Tribe Indigofereae *(Leguminosae: Papilionoideae)* Pollen et Spores, Vol. XXIV No. 2.

Hamilton, A. C. 1976. Identification of East African Urticales pollen. Pollen et Spores Vol. XVIII - No.1.

Heusser, C. J. 1971. Pollen and spores of Chile. The University of Arizona Press, Tucson, Arizona.

Ibe, R. A. 1984. Modern pollen rain -- vegetation relations at four different elevations on Slide Mountain, Catskill Mountains, New York. Bull. Torrey Bot. Club Vol. 3 No. 1: 96-102.

Isaac, G. L. 1968. The Acheulian site complex at Olorgesailie, Kenya: A contribution to the Interpretation of Middle Pleistocene Culture in East Africa. Ph.D. Thesis Cambridge.

Jacobs, B. F. 1982. Modern pollen spectra from surface soil samples, Northern Nayarit, Southern Sinaloa, Mexico. J. Arizona Nevada Acad. Sc. 17: 1-14.

Kingham, D. L. 1976. A study of the pollen morphology of Tropical African and certain other Vernonia (Compositae:). Kew Bull. Vol. 31(1): 9-26.

Moore, P. D., and Webb, J. A. 1978. An illustrated guide to pollen analysis. Hodder and Stoughton, 133, pp.

Senesse, S. 1980. *Fam. Caesalpiniaceae*. Pollen et spores, Vol. XXXI No.3-7: 355-423.

Trump, E. C. 1967. Vegetation. In: Nairobi City and Region ed. W. T. W. Morgan, Nairobi, Oxford University Press.

APPENDIX I

Laboratory Treatment

The method followed in the treatment of samples for pollen analysis is that described by Faegri and Iversen (1975), which can be outlined as follows:-

A. *Trap samples*

-- Samples were put in centrifuge tubes
-- 6 ml. of 10% KOH was added to each sample, and put in hot water bath for about 3 minutes.
-- Samples were sieved using a 250 microns aperture diameter sieve and washed through with distilled water. Materials retained by the sieve were discarded.
-- Centrifuged at 3000 R.P.M. for 3 minutes and decanted by pouring the supernate.
-- Samples were water washed twice using distilled water.
-- About 6 ml. of glacial acetic acid was added to each sample.
-- Centrifuged and decanted.
-- About 6 ml. of acetolysis mixture was added. The acetolysis mixture was prepared to consist 9 parts acetic anhydride and 1 part concentrated sulfuric acid. The samples in acetolysis mixture were put in hot water bath for a minute.
-- Centrifuged and decanted.
-- 6 ml. of glacial acetic was added.
-- Centrifuged and decanted.
-- Two water washes.
-- Transferred into vial tubes.
-- Added 2-3 drops of glycerine.
-- Water was evaporated by putting the samples in the oven at about 40`C overnight.
-- Samples were accessioned into the pollen residue collection, and slides were prepared.

B. *Surface soil samples*

-- Approximately 15 grams from each sample was put in centrifuge tubes.
-- 10% HCl was added to each sample, until there were no further effervescence.
-- Centrifuged and decanted.
-- 10 ml. of 10% KOH was added to each sample and put in hot water bath for about 3 minutes.
-- Samples were sieved using a 250 microns aperture diameter sieve and washed through with distilled water. Materials retained by the sieve were discarded.
-- Two water washes (putting distilled water in the samples, centrifuging and decanting in each of the water washes).
-- The samples were transferred to polythene centrifuge tubes.
-- About 6 ml. of 40% of hydrofluoric acid (HF) was added to each sample and placed in hot water bath for 30 minutes (for some samples the 30 minutes period was extended to 1 hour or more due to presence of undissolved sand particles).
-- 6 ml. of 10% HCl was added to each sample and warmed a little (not boiling).
-- Two water washes.
-- 6 ml. of acetolysis mixture (prepared as in the case of the trap samples), was put in every sample place in hot water bath for 1 minute.
-- Centrifuged and decanted.
-- 6 ml. of glacial acetic acid was added.
-- Centrifuged and decanted.
-- Two water washes.
-- Added about 2-3 drops of glycerine.
-- Water was evaporated by putting the samples in the oven at about 40`C overnight.
-- Samples were accessioned into the pollen residue collection, and slides were prepared.

APPENDIX II

Below is a list of plant species found in Olorgesailie archeological site area during fieldwork. Representation in the pollen rain is shown by asterisk(*) in the appropriate level (genus/family) of pollen identification.

ACANTHACEAE
**Barleria acanthoides* Vahl
**Barleria eranthemoides* C.B.Cl.
Blepharis linariifolia Pers.
Dicliptera sp. "C" of Upland Kenya Wild Flowers
Ecbolium revolutum (Lindau) C.B.Cl.
**Justicia odora* (Forssk.) Vahl
**Ruellia prostata* (Nees) T. Anders.

ADIANTACEAE
Actiniopteris radiata (Swartz) Link

AGAVACEAE
Sansevieria robusta N.E. Br.

AIZOACEAE
Corbichonia decumbens (Forssk.) Exell
Trianthema triquetra Willd.
Zaleya pentandra (L.) Jeffrey

*AMARANTHACEAE
Pupalia lappacea (L.) Juss.

APOCYNACEAE
Catharanthus roseus (L.) G. Don (exotic)

ASCLEPIADACEAE
Caralluma gracilipes K. Schum.
Cynanchum tetrapterum (Turcz.) R. A. Dyer
Diplostigma canescens K. Schum.

BALANITACEAE
Balanites aegyptiaca (L.) Del.

BORAGINACEAE
Heliotropium somalense Vatke
Heliotropium strigosum Willd.

BURSERACEAE
**Commiphora africana* (A. Rich.) Engl.
**Commiphora campestris* Engl.

CAPPARACEAE
**Boscia coriacea* Pax
Cadaba farinosa Forssk.

COMMELINACEAE
Commelina albescens Hassk.
Commelina benghalensis L.
Commelina imberbis Hassk.

*COMPOSITAE
Vernonia cinerascens Sch. Bip.

*CUCURBITACEAE
Kedrostis gijef (J.F.Gmel.) C. Jeffrey

*CYPERACEAE
Kyllinga alba Nees
Kyllinga welwitschii Ridley

*EUPHORBIACEAE
Dalechampia scandens Benth.
Euphorbia acalyphoides Boiss.
Euphorbia agowensis Boiss.
Euphorbia scheffleri Pax
Euphorbia tirucalli L.
**Jatropha fissispina* Pax
Phyllanthus maderaspatensis L.
Phyllanthus rotundifolius Willd.

GERANIACEAE
Monsonia senegalensis Guill. & Perr.

*GRAMINEAE
Chloris roxburghiana Schult.
Dactyloctenium bogdanii S. M. Phillips
Enneapogon cenchroides (Roem & Schult) C. E. Hubb.
Eragrostis cilianensis (All.) F. T. Hubb.
Sporobolus jacquemontii Kunth
Tetrapogon cenchriformis (A. Rich.) W.D. Clayton

LABIATAE
Becium sp. 'A' of Upland Kenya Wild flowers
Capitanya otostegioides Guerke
**Ocimum lamiifolium* Benth.

LILIACEAE
Asparagus sp. = P.E. Glover & Samuel 2812
Chlorophytum tenuifolium Bak.

*LORANTHACEAE
**Odontella ugogensis* Engl.

*MALVACEAE
Abutilon grandiflorum G. Don
Hibiscus micranthus L.f.
Pavonia patens (Andr.) Chiov.

MIMOSACEAE
**Acacia mellifera* (Vahl) Benth.
**Acacia nubica* Benth.
**Acacia senegal* (L.) Wild.
**Acacia tortilis* (Forssk.) Hayne
Albizia sp.

NYCTAGINACEAE
Boerhavia erecta L.

PAPILIONACEAE
Crotalaria laburnifolia L.
**Indigofera cufodontii* Chiov.
**Indigofera microcharoides* Taub.
**Indigofera spinosa* Forssk.
**Tephrosia lortii* Bak.
Vigna macrorhyncha (Harms) Milne-Redhead

POLYGALACEAE
**Polygala amboniensis* Gurke
**Polygala senesis* Klotzsch

PORTULACECEAE
Portulaca sp.
Talinum portulacifolium (Forssk.) Schweinf.

RUBIACEAE
Pentanisia ouranogyne S. Moore

SCROPHULARIACEAE
Craterostigma sp. "C" of Upland Kenya Wild Flowers
Cycnium veronicifolia (Vatke) Engl.

SOLANACEAE
**Solanum taitense* Vatke

STERCULIACEAE
Hermannia uhligii Engl.
Sterculia stenocarpa H. Winkler

TILIACEAE
**Grewia bicolor* Juss.
**Grewia tembensis* Fresen. var. *kakothamnos* (K. Schum.) Burret
**Grewia villosa* Willd.
Triumfetta flavescens A. Rich.

VERBENACEAE
Lantana viburnoides (Forssk.) Vahl

VITACEAE

Cissus quadrangularis L.

Cissus rotundifolia (Forssk.) Vahl

Cyphostemma sp. "C" of Upland Kenya Wild Flowers.

Printed in Kenya by,
Kenya Litho Ltd., Changamwe Road,
P.O. Box 40775,
Nairobi Kenya.

UTAFITI Volume 1 Number 1

JUNE 1988

VEGETATION AND MODERN POLLEN RAIN AT OLORGESAILIE, KENYA

by Joseph Mworia, Agnes Dallmeyer and Bonnie Jacobs

p. 1-22

Abstract: vegetation studies based on two transects of 100 m each have been analysed in their relative percentage cover and the occurrence frequency of species. Eight surface soil samples taken from the two transects were analysed for their pollen contents. A comparison was made between the relative percentages of the taxa common in both the vegetation and the pollen samples. A pollen trap sample obtained through a period of one year was analysed for pollen content and compared with pollen spectra from soil samples. Three types of artificial pollen traps were used to obtain one month pollen records to establish the most useful type of trap. A checklist of the plants occurring at the site is given.

UTAFITI is published several times a year, and incorporates original research papers on work carried out at the National Museums of Kenya.
Every paper is peer-reviewed by professionals from outside the Museums.

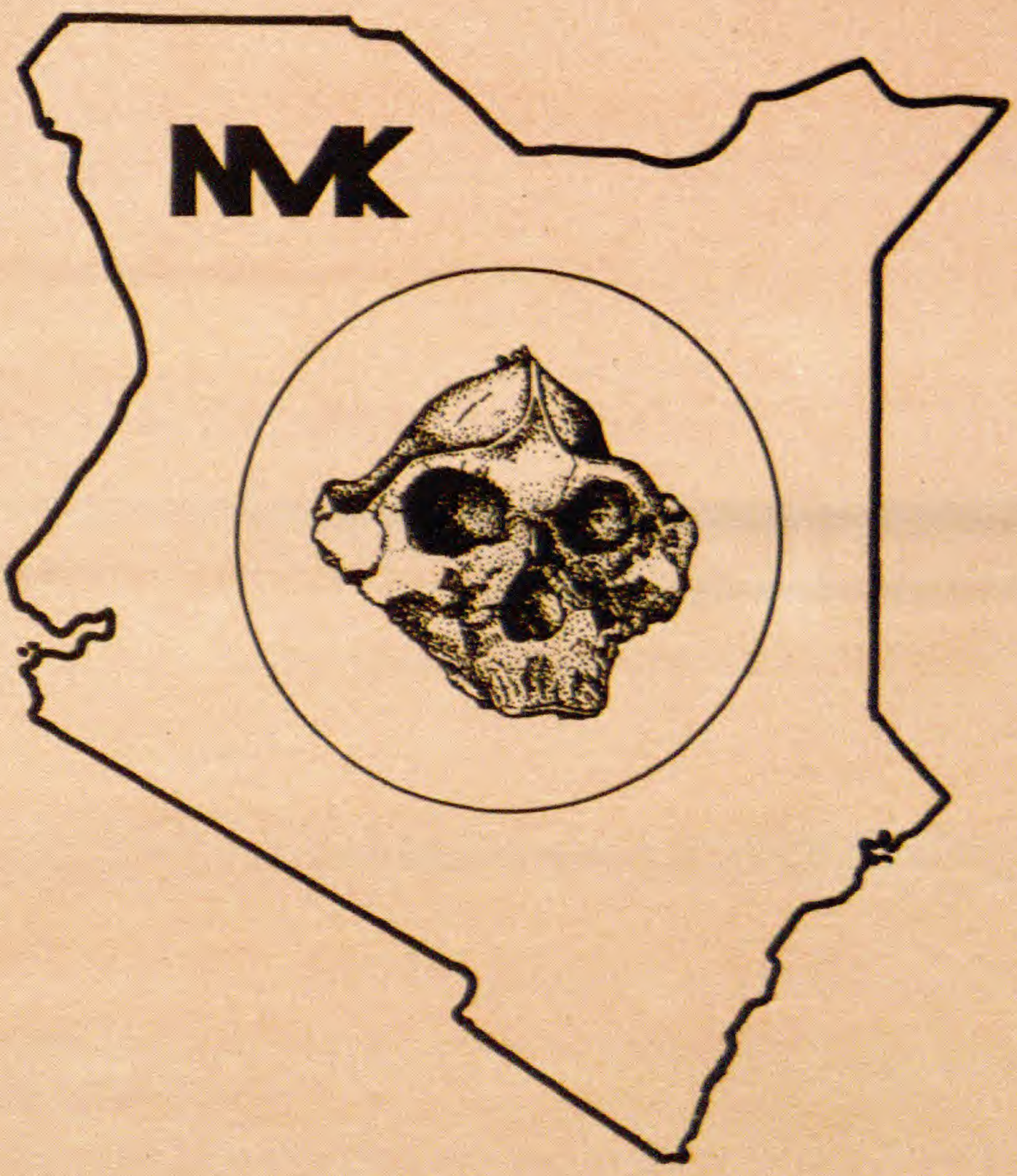
Editor Dr. H.J. Beentje
Editorial Committee Dr. H. Adan
Dr. R. Bagine
Dr. M. Issahakia
Miss C.H.S. Kabuye
Dr. M. Leakey
Mr. A. MacKay
Dr. S. Wandibba

Typesetting and layout done at the Southern Methodist University, Dallas, Texas, U.S.A.
Produced by the National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya

Printed by Kenya Litho Ltd., Changamwe Road, P.O. Box 40775, Nairobi.

UTAFITI

OCCASIONAL PAPERS OF THE NATIONAL MUSEUMS OF KENYA



NATIONAL MUSEUMS OF KENYA

VOLUME 1 NUMBER 2 JULY 1988

MISSOURI BOT
AUG 22 19
GARDEN LIBRARY

AN ECOLOGICAL AND FLORISTIC STUDY OF THE FORESTS OF THE TAITA HILLS, KENYA

EDITED BY H.J. BEENTJE

1. ECOLOGY OF THE FORESTS

H.J. Beentje & Ndegwa Ndiang'ui

INTRODUCTION

The strategy conference for management and protection of Kenya's plant communities, held in August 1984, identified the Taita Hills forests as one of the habitats in urgent need of inventarization (Anon. 1984). As a follow-up to the recommendations of this conference the National Museums of Kenya organized a multidisciplinary expedition to these hills, in the period May 6-June 7, 1985.

The aim of the expedition was to assess the extent of the remaining indigenous forest patches, to assess their status and threats thereto; to attempt an ecological survey, and to list the species occurring in the forests.

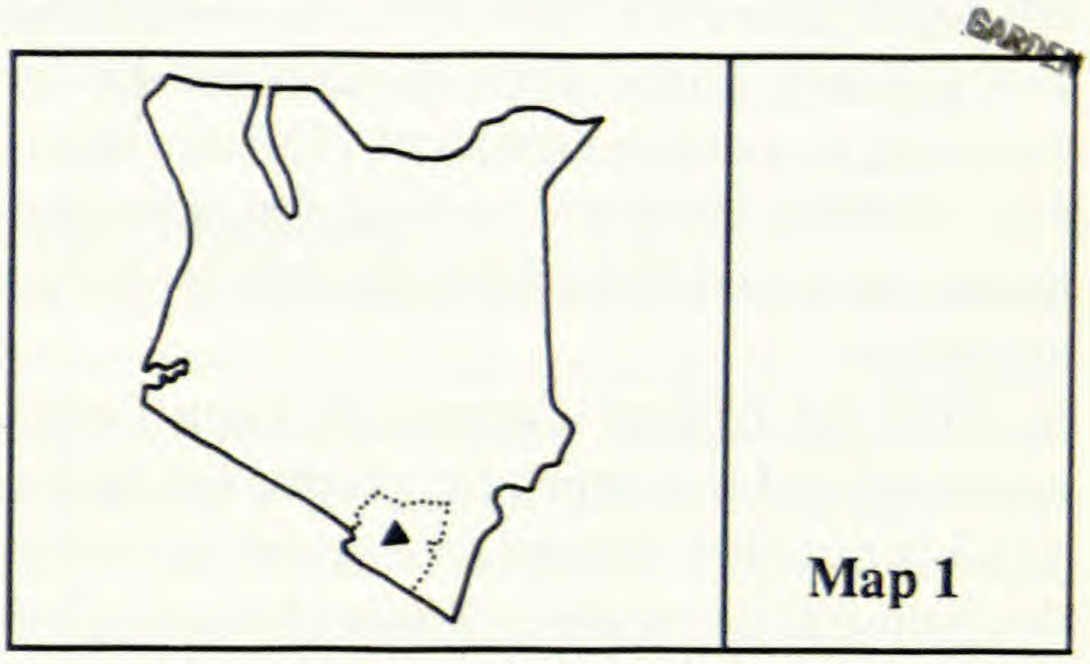
The gazettement of the Taita Hills forests has dragged on for years. During this time the once extensive forests have been encroached upon, leaving only small remnants on hilltops, while formerly denuded hilltops have been reforested with exotic trees. What is left of the indigenous forest is small remnants on the peaks and ridges of Ngangao, Chawia, Vuria, Mbololo and Sagalla. It was on these peaks that the expedition concentrated their efforts.

METHODS

Before the research team left for the study area, old aerial photographs were studied in order to reconstruct a picture of the past vegetation of the hills. Once in the field the extent of the remaining forests was established by ground survey. About 1200 plant specimens were collected; birds were studied by mistnetting and observation; small mammals were trapped with baited traps; other collections were mainly casual.

Seven vegetation transects (each of 100 x 20 m) were studied in Ngangao and Mbololo forests.

A check-list of the forest plant species was compiled from the collections of the expedition, as well as from the collections made in earlier years and held in the East African Herbarium. An unpublished check-list by R.B. Faden, who collected several hundred specimens in the forests between 1969 and 1977, was incorporated.



Map 1

STUDY AREA

The Taita Hills are located in south-east Kenya, 25 km west of Voi in the Taita-Taveta District, at approximately 03º 20' S, 38º 15' E (see map 1). The surrounding plains have a general altitude of 600-700 m above sea level; the Taita Hills rise abruptly from these plains to a series of ridges, culminating in Vuria peak at 2228 m. The steepness of the rocks is due to the hardness of a quartzite cap overlaying soft metamorphic rocks.

The soils are composed of a high-humic A-horizon overlaying a pinkish acid sandy loam. These sandy loams are generally deep, with high infiltration rates, a low pH (3-4), a low water-holding capacity, and they are low in nutrients due to excessive leaching. The soils are also characterized by the presence of high aluminium levels, low calcium levels, and unavailable potassium, causing a low cation exchange capacity.

The climate of the area is under the influence of the intertropical convergence zone, with a bimodal rainfall incidence. Of great significance to the hills are the moisture-laden clouds which blow in from the coast, to which the hills form the first large barrier: precipitation from trapped moisture accounts for the almost permanently humid conditions observed in the forests. While rainfall at Mwatate, at the base of the southern footslopes of the hills, is 600 mm per year, that at Wundanyi (alt. 1463 m) is 1329 mm per year (Met. Dept. 1966). Peaks in the rainfall occur in April and November, but mist and cloud precipitation is a year-round phenomenon. The southeastern slopes are the most humid, and precipitation in the forests on this side is proba-

bly well over 1500 mm annually, although there are no records from the forests.

Most of the land under agriculture is on the hillslopes, and this land falls in ecoclimatic zones 2 and 3 (see Pratt & Gwynne 1977), receiving an average rainfall of 1250 mm annually. Coffee, mangoes, cassava, tomatoes, bananas, maize and beans form the main crops that are grown.

In 1973 the County Council of Taita-Taveta approved 22 forest areas for gazettement and a year later another 10 areas were added ,all within the Taita Hills complex. Some of the original areas included for gazettement were Ngangao (139 ha.), Mbololo (370 ha.), Sagalla (1280 ha.) and Chawia (86 ha.). These forests and all the others within the Taita Hills have been placed under the jurisdiction of the Forest Department, but have not yet been gazetted.

RESULTS

Extent of the forests

The former extent of the forest is difficult to assess. Photographs taken in the early 1920s by Dr. V.G.R. van Someren indicate that at least Vuria was clothed in extensive forest. Study of aerial photographs from the early 1960s indicates a forest cover of Vuria of ca. 145 ha. The present extent of the forest is estimated from the expeditions ground survey (and covers indigenous forest only):

Mbololo	168 ha
Ngangao	92 ha
Chawia	17 ha
Sagalla	5 ha
Ronge	unknown, estimated at less than 10 ha
Wundanyi	less than 1 ha
Vuria	less than 1 ha

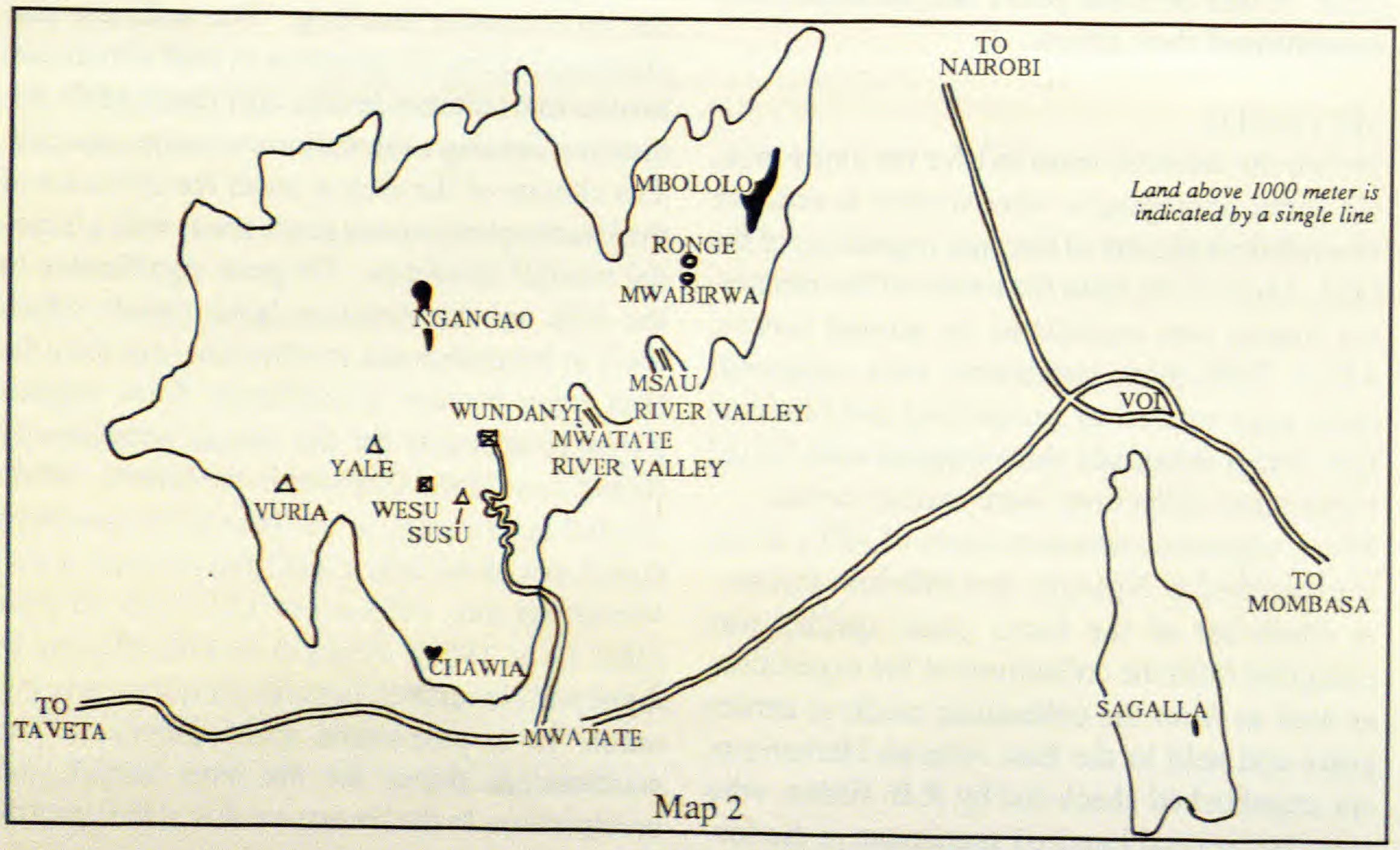
(see map 2 for localities)

Forest formerly reported from Yale, Wesu and Susu has now disappeared completely. The former existence of these forests is indicated by collections or sight records by Drummond and Hemsley (Yale, 1953), Gardner (Wesu, 1941), Gillett (Susu, 1961) and Dale (Susu, 1937).

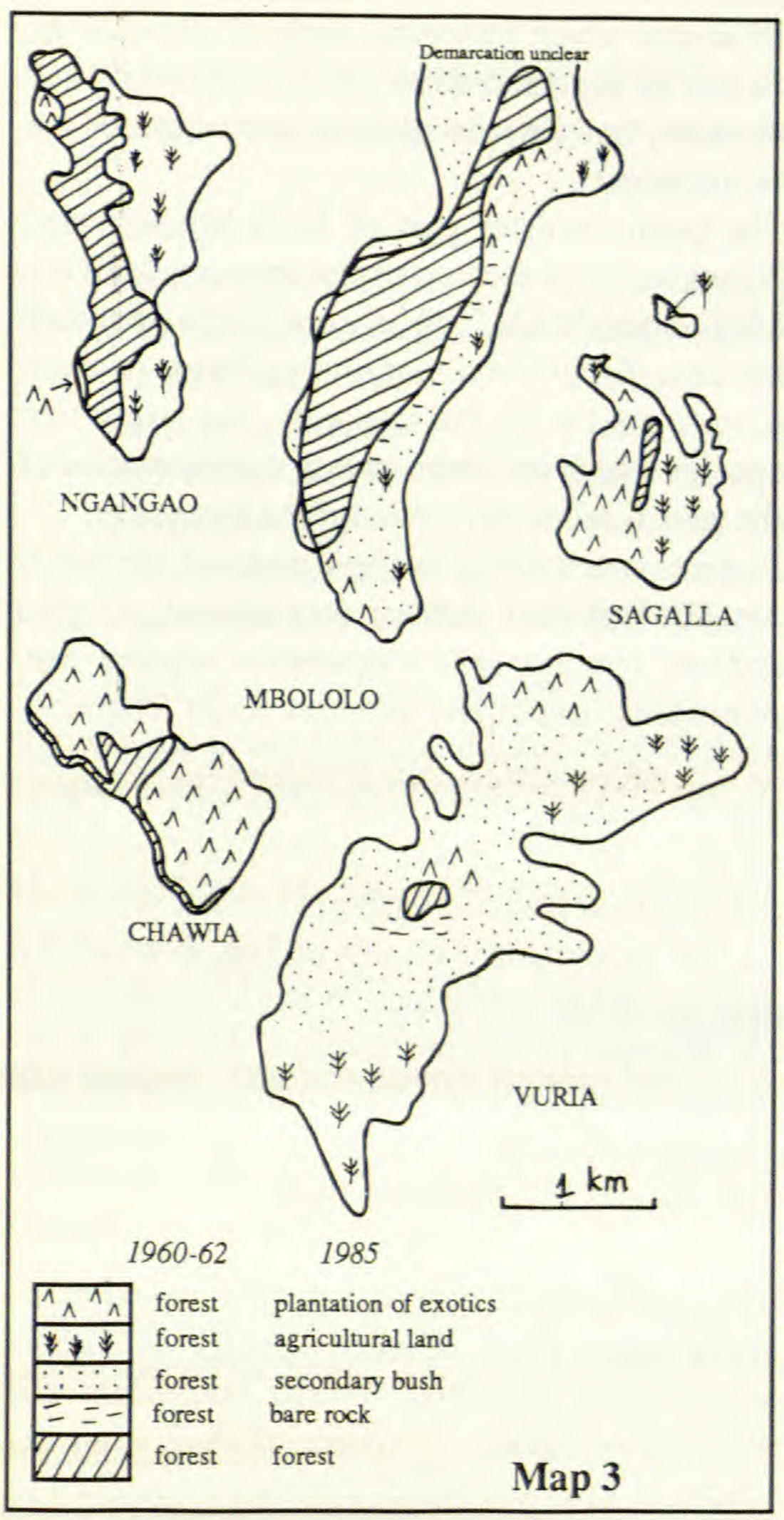
Conversion of the forests

Map 3 gives the extent of indigenous forest cover in the early 1960s (from aerial photographs) and 1985 (from ground survey by the expedition). In this figure the conversion of former forest into plantation of exotic trees, cultivated area or other types of vegetation is also given.

Clearing of forests for purposes of cultivation seems to have occurres for a long time. It is estimated that the Taita Hills were occupied by the Kitaita in the 17th-18th century; before their arrival, Wanderobo (known to the Kitaita as Wambisha) were present, probably in small numbers (Prins, 1952). Hildebrandt (1877)



Map 2



Map 3

mentions that on Sagalla cultivated areas were bordering the forest.

Plantations of exotic trees are a more recent phenomenon. The oldest plantation forest in the hills is the one on Sagalla, consisting of *Pinus elliottii*, which was started by the Forest Department in 1955 (Forest Officer, Wundanyi, pers. comm.). In some cases, such as that of Chawia, the Forest Department has cleared the original forest to make way for exotic trees; in other cases plantations replaced original forest where this had disappeared due to forest firest, such as in north-east Mbololo and near the summit of Ngangao. A relatively recent practice is the planting of exotic tree saplings within Ngangao forest; this seems to have occurred on a Tree Planting Day, when patches of undergrowth were cleared to make way for exotic *Cupressus* and *Pinus* species. Many other plantation forests have been started on eroded hillsides, where cultivation, following the clearing of the original vegetation, was unsuccessful, either because of the shallow soil or because of wrong agricultural practice, such as cultivation of steep slopes.

Forest vegetation

The forest vegetation can be classified as upland moist forest or upland mist forest. There are many affinities with other "Eastern Arc" forests (see White 1981, Lovett 1985), especially with the forests of the Usambaras in Tanzania (see Rodgers & Homewood 1982). Se Appendix 1 and 2 for a listing of these affinities. These affinities suggest former links with the other Eastern Arc forests; these links have now disappeared due to a drier climate, so that these forests are now isolated from one another. The result of this rather recent isolation is the evolution of endemic taxa (at the level of varieties, subspecies or vicarious species) in the various forests.

At leats 13 taxa of plants are endemic to the Taita Hills forests. Most of these occur in more than one of the forest patches, but *Zimmermannia ovata* and *Psychotria sp. B* are restricted to northern Ngangao, which is relatively dry; *Ypsilopus sp. nov.* and *Saintpaulia teitensis* are restricted to the wetter parts of Mbololo. The endemics, the rare species and the Eastern Arc species are listed in Appendix 2.

The vegetation of the forests has been influenced by man. Apart from the disturbances of the forest margins caused by firewood collecting, and that caused by paths running through the forests, the vegetation inside the forests has been influenced by selective logging in the past. Dale (1939) and Faden (data from collecting labels, 1971, and pers. comm.) record *Ocotea usambarensis* as one of the dominant species on Mbololo; in 1985 less than 10 individuals of this species could be found. *Podocarpus spp.*, which should be common in this type of forest, could only be found as saplings; not a single mature tree was found.

In Ngagao and Mbololo we observed over thirty old pitsaws, which were used to saw the logged trees. It is likely that these only fell into disuse after the Presedential Decree of 1977 banning the cutting of indigenous trees without a licence. Only in Sagalla and on Vuria we observed signs of recent tree-poaching.

Trees common to nearly all forests, and playing an important role in these forests, are:

Tabernaemontana stapfiana, Strombosia scheffleri, Phoenix reclinata, Newtonia buchananii, Chrysophyllum gorungosanum, Albizia gummifera, Cola greenwayi, Macaranga conglomerata, Xymalos monospora and *Syzygium sclerophyllum*

In the understorey some of the more common trees and shrubs are:

Pauridiantha paucinervis, various *Psychotria spp., Dracaena steudneri* and *Dichapetalum eickii.*

Common herbs are:

Piper capense, Culcasia falcifolia, Asplenium holstii and *Blotiella stipitata.*

Common epiphytes are:

Lycopodium holstii, Streptocarpus montanus, S. kirkii.

Discussion of individual forests

Mbololo

Altitude 1400-1700 m; area 168 ha.

Ngangao

Altitude 1730-1900 m; area 92 ha.

Tables 1 and 2 list the common species of respectively the larger trees and the undergrowth species encountered in the seven transects laid in these forests. A more complete list of the species found in the transects can be found in appendix 3.

Of course seven transects, each of 100 x 20 m, cannot be representative for two forests of 260 hectares, but they do give an indication of the vegetation.

The main, moister part of both Mbololo and Ngangao is represented by the transects MBO-1, MBO-3 and NGA-2. While one of the dominant species, *Tabernaemontana stapfiana*, is common to nearly all the transects, the larger tree species which are more or less representative of the moist, relatively undisturbed forest are:

Endemics occurring in these parts of the forest are *Diphasiopsis fadenii* (occasional), *Coffea fadenii* (occasional), *Impatiens engleri ssp. pubescens, Impatiens teitensis* (both frequent), *Memecylon teitense* (occasional) as well as the species already mentioned (*Psychotria, Chassalia*). In the moist, undisturbed parts of Mbololo *Saintpaulia teitensis* occurs; we found ca. 700 specimens in an area of 3 ha, to which the species seems restricted. What is surprising is the absence of *Ocotea* suckers; this tree is reported to sucker freely from stumps, but no such suckers were seen by us. In the early 1970s this species was still common here.

Where the forest has been disturbed, mass occurrence takes place of such species as *Tabernaemontana stapfiana, Maesa lanceolata* and *Phoenix reclinata*. Transect NGA-3 is an example of this, and MBO-2 shows a tendency in

TABLE 1

Common trees of more than 10 cm diameter found in the transects.
Per species the number of trees in each transect is given. This number is printed **bold** when it constitutes more than 10 % of the total number of trees of that transect.

transect	m-1	m-2	m-3	m-4	n-1	n-2	n-3	all
Total number of trees	120	147	131	80	109	83	113	783
Tabernaemontana stapfiana	**20**	**40**	1	**13**	**29**	8	**29**	140
Albizia gummifera	6	**22**	2	3	**15**	---	**16**	64
Cola greenwayi	5	3	1	**10**	**37**	---	---	56
Phoenix reclinata	5	**43**	---	---	---	---	7	55
Macaranga conglomerata	**13**	3	3	2	---	**17**	7	45
Newtonia buchananii	**14**	2	7	**11**	---	5	---	39
Strombosia scheffleri	7	2	7	**11**	---	5	---	32
Craibia ? zimmermannii	5	---	3	3	**19**	*	---	30
Xymalos monospora	10	8	3	2	---	---	---	23
Syzygium sclerophyllum	5	---	11	2	---	4	---	23
Chrysophyllum gorungosanum	7	---	4	8	---	1	---	19
Millettia oblata	---	----	---	---	9	---	9	18

*: common as sapling

TABLE 2

Species of the undergrowth common in most transects

Com = common, loc = locally common, fre = frequent, occ = occasional, rar = rare

	Mbololo				Ngangao		
Transect	**1**	**2**	**3**	**4**	**1**	**2**	**3**
Culcasia falcifolia	com	com	com	com	---	fre	com
Pauridiantha pauciflora	com	com	com	fre	---	com	fre
Blotiella stipitata	com	---	com	occ	---	com	com
Dracaena steudneri	com	rar	rar	com	loc	fre	com
Asplenium holstii	fre	com	com	fre	---	rar	---
Chassalia spp.	rar	rar	com	fre	rar	com	fre
Dichapetalum eickii	fre	occ	rar	rar	com	com	fre
Piper capense	loc	com	rar	rar	---	com	fre

this direction. Numbers of tree species per transect are lower than in undisturbed transects (resp. 15 and 17 spp. as opposed to 22-29 spp. in MBO-1, MBO-3 and NGA-2) while the number of individuals of the disturbance-indicators rises.

Transect MBO-2 represents, besides being rather disturbed, the lowermost forest vegetation present. Due to a stream flowing here such species as *Elatostema* and *Calanthe* occur, as well as two species of *Dorstenia*, one of which is thought to be new to science. Tree species include *Mitragyne rubrostipulata* and *Celtis gomphophylla,* both of which are not found in other parts of the forest. They might represent an element of lower montane vegetation which formerly was more widespread. (See also "other forest patches").

At lower altitudes, at the southern end of Mbololo, *Cynometra sp. A* often occurs in large numbers, a fact not reflected in any of the transects.

Transects MBO-4 and NGA-1 represent the northern, drier parts of the forests. This relative dryness is presumably caused by their locality in the rainshadow of the forested ridges comprising the main part of the forests. Both these transects show a preponderance of *Cola greenwayi. Craibia ? zimmermannii* and *Albizia gummifera* are present in both transects, although in larger numbers in Ngangao than in Mbololo. It is suspected that the northern end of Ngangao is drier than the northern end of Mbololo, especially as north Ngangao has some endemics: *Zimmermannia ovata* and *Psychotria sp. B. Acokanthera oppositifolia, Croton sylvaticus, Croton megalocarpus, Erythroxylum emarginatum* and *Psychotria alsophila* are only found in Ngangao north. Species which are well represented in the moister parts of the forests are conspicuous by their absence in NGA-1: all the other species of *Psychotria*; *Pauridiantha, Tabernaemontana, Macaranga, Phoenix,* and *Newtonia.*

In the early 1970s there was a part of the forest, now disappeared, which was situated on the lower western side (ergo, also in the rainshadow), which is thought to have had a composition very similar to that at the northern end (R.B. Faden, pers. comm.).

Sagalla

Altitude 1350-1450 m; area ca. 5 ha.

This is a narrow strip of forest with signs of recent disturbance (tree cutting). Epiphytes occur in larger numbers than in any of the other forests: mosses, *Asplenium spp., Lycopodium spp., Streptocarpus montanus*, orchids, *Peperomia spp.* occur in profusion. This might infer that Sagalla receives more obscure precipitation (cloud and mist) than the other forests.

The dominant tree species are *Newtonia buchanii, Macaranga conglomerata, Syzygium sclerophyllum* and *Xymalos monospora. Phoenix* and *Strombosia* are frequent. *Cola greenwayi* saplings are numerous, but this species is rarely seen as a mature tree.

Common understorey species are *Pauridiantha paucinervis, Dracaena laxissima, Impatiens pseudoviola* and *I. walleriana, Asplenium friesiorum, Blotiella stipitata* and *Selaginella kraussiana.*

Chawia
Altitude 1500-1550 m; area ca. 17 ha.
This forest mainly consists of exotic, planted trees under a canopy of mature *Albizia gummifera* and *Tabernaemontana stapfiana*. Along Bura Bluff there is a long, narrow ridge of forest where many indigenous species are found, but this strip is at the most 100 m wide and rather disturbed. Along a stream in a central valley there is some disturbed remnant forest dominated by *Albizia* and *Tabernaemontana*, with *Polyscias fulva* and *Cyathea manniana* as common species.

Vuria
Altitude 1950-2228 m; area < 1 ha.
Only small remnants of the former forest remain. Species such as *Dracaena afromontana* and *Dombeya goetzenii* occur here, presumably because of the high altitude. Near the top of the hill there is a closed-canopy forest of 7-9 m high, dominated by *Philippia pallidiflora ssp. usambarensis, Prunus africana* and *Maesa lanceolata*. In this low forest there is a rich epiphytic flora, mainly consisting of mosses and lichens.

Yale
Altitude 1680-1950 m; area nil.
Only remnants of the original forest (visited by Drummond & Hemsley in 1953) remain. Isolated trees of *Philippia, Dracaena, Myrica* and *Xymalos* are found near the summit, while on the lower slopes there are some isolated *Ficus thonningii, Cyathea manniana* and *Lepidotrichilia*.

Wesu
Altitude 1670-1750 m; area nil.
Only isolated trees of *Maesa, Xymalos, Agauria* and *Nuxia congesta* were found.

Ronge
Altitude 1230-1300 m; area estimated at 5-10 ha.
This is a plantation forest stocked with exotics, but along streams there are strips of riverine or swamp forest. *Anthocleista grandiflora* seems to be dominant, and common species include *Pauridiantha, Keetia gueinzii, Phoenix reclinata, Macaranga capensis* and *Aframomum angustifolium*.

Mwabirwa
Altitude ca. 1200 m; area less than 1 ha.
Rather similar to Ronge. The rare *Cyathea dregei* occurs here.

Other forest patches
On the southern access road to Mbololo, south of Mwabirwa, at an altitude of 1200 m, there is a "sacred grove" which might well be a remnant of the original forest. There is a large *Ficus exasperata*, as well as specimens of *Blighia unijugata* and *Celtis gomphophylla*. These might indicate that a former forest at this altitude had a different composition than the hilltop forests now present; the occurrence of *Celtis gomphophylla* at the lower edge of Mbololo forest confirms this. Ronge and Mwabirwa, although at a similar low altitude, owe their existence to streams and so have a different composition.
Along rivers such as the Mwatate R. and Msau R. there are species which are confined to the riverine forest habitat. *Sorindeia madagascariensis, Celtis durandii, Diospyros zombensis, Cremaspora triflora, Adiantum hispidulum, A. incisum* and *Doryopteris concolor* are such species.
Such is the general picture of the forest vegetation. Most sites are more or less disturbed, except for some inner parts of Mbololo and Ngangao, where only *Ocotea* trees have been extracted. Places which have been disturbed are indicated by the mass presence of *Tabernaemontana, Phoenix* and *Maesa*. On the other hand, there are a few places in Mbololo and Ngangao where the vegetation seems completely undisturbed, with a high closed canopy, a deep humus

FOREST FAUNA

Mammals
There is an endemic race of the Sykes' monkey, *Cercopithecus mitis kima* (Heller), which has been observed in Mbololo, Ngangao and Chawia. Other species observed and caught are listed in Appendix 4.

Birds
Endemics of the forests are:
Bar-throated apalis (*Apalis thoracica fuscigu-*

laris): occasional in forest margins.
Taita white-eye (*Zosterops poliogastra silvanus*): common in forest margins.
Taita white-starred forest robin (*Pogonocichla stellata helleri*): common in forest.
Orange ground trush (*Turdus gurneyi raineyi*): moderately common in forest.
Other species observed and caught are listed in Appendix 4.

Reptiles

The back-fanged snake *Amblyodipsas teitana* is endemic to Mbololo forest.

Amphibians

The Taita cecilian, *Afrocaecilia teitana*, occurs in sites where the wild banana (*Ensete*) is found.
The toad *Bufo teitensis* is endemic to Mbololo.
The frogs *Arthroleptis adolfifrederici* and *Callulina kreftii* are endemic to the Usambaras and the Taitas. The latter species is a new record for Kenya.
The chameleon *Cameleo fischeri tavetanus*, a rare species, was found on Mbololo by the expedition.

Invertebrates

A large number of collections was made by the expedition, but identification of the collections will take a long time. A giant fly turned out to be a new species (*Prosoeca* sp. nov.)
Three taxa of butterfly are endemic to the forest (edges):
Taita swallowtail (*Papilio desmondi teita*)
Taita charaxes (*Charax xiphares desmondi*)
Taita glider (*Cymothoea teita*).
For details, see Collins & Clifton (1984) and Mathias in Tetlow (1987).

DISCUSSION AND RECOMMENDATIONS

The remaining forest remnants of the Taita Hills are unique within Kenya, and unique in the world, in the fact that at least 13 plants and 9 animals are restricted to these forests and occur nowhere else. These endemics include a species of wild coffee which was only recently described. Furthermore, 22 species of plants and at least 3 species of animals represent the rare "Eastern Arc" type of flora and fauna, which is only known from Kenya and Tanzania; and 37 more species of plants occurring in these forests can be termed rare, both for Kenya and in a world sense.
These forests, therefore, deserve protection, because of their uniqueness and their value as in-situ biological genebanks.
Factors which threaten the remnant forests are the same that contributed to the encroachment upon the forests in the past: clearfelling for agricultural purposes, and for the establishment of exotic softwood plantations, firewood collection and tree poaching. Everywhere, except for in Mbololo and Ngangao forests, these factors are still operating; in Ngangao and Mbololo there is only some firewood collecting, with a few exceptions: in 1984/5 one of the best parts of Ngangao forest was clearfelled to make way for a large vegetable plot for the local Polytechnic; and the planting of exotic trees within Ngangao forest is a definite and serious threat to the future of this forest.
In Mbololo, a water pipeline has been constructed from a site near the crest to the valley on the western side. This has caused some disturbance, but does not seem to be dangerous to the forest in general. The road constructed along the length of the crest ridge, however, has opened the forest to potential disturbance since the late 1970s.
The main reason for the continuation of the threats to the forests is the continuing growth of population within the Taita Hills. Already nearly all land suitable for agriculture has been utilized; since the approval of the County Council of several forests for gazettement, about 15 % of the area approved has been placed under cultivation. Felling of the remaining forest areas would make a tiny contribution to the land already available for cultivation, while causing an enormous loss to the biological richness of the Taita Hills, of Kenya, and of the world.
A second reason for not felling these forests is that they are situated on steep slopes; removal of the forest will, most likely, result in the loss of soil on these slopes, as has happened on Susu (see also Brown, 1981).
A third reason to protect these forests is their function as a water catchment area. The amount of so-called obscure precipitation (resulting

from mist or cloud) of moisture over a given area depends on the surface of that area; the surface of a forest, with its enormous number of branches and leaves, is immensely larger than that of any other type of vegetation; therefore, the removal or disappearance of these forests would cause a large decrease of the water supply to the area. Already, the destruction of much of the formerly extensive forests has caused the drying up of a number of streams in the area, and the Voi river carries less water than it used to (information from local people). Further destruction of, for example, ·Mbololo forest would result in the almost complete loss of the water supply to the people of Wongonyi, Ndile and Tausa.

Protection of Mbololo and Ngangao forests is strongly recommended. The area involved is relatively small, respectively 168 and 92 hectares. Protection of Sagalla forest is also recommended, but this will probably come too late as this forest is heavily disturbed by tree-poaching and cutting of firewood.

The removal of the exotic saplings planted in Ngangao is strongly recommended. The planting of trees *outside* the forests, especially when indigenous trees are used, is an excellent method of reducing the threat to the forest as it forms both a buffer zone and a source of forest products; the planting of fast-growing exotics can be a valuable addition to the firewood supply.

Any protection measures would need to be accompanied by a campaign to involve the local people. Without their understanding and support, any measure taken would lose its meaning. The people we spoke to do seem to realize that these forests are important, both as water catchment areas and as a source of medicines and small forest products; without this local feeling, these small forests, and especially Ngangao, would have disappeared already.

But the slow encroachment which affects the forest margins, or even large parts of the forest (as in the case of the felling of forest to provide a vegetable plot) should be made impossible by legal measures. What shape should this protection take? The areas concerned seem to be too small for National Park status, and the status of National or Forest Reserve does not provide enough safety. The designation of Mbololo, Ngangao and possibly Sagalla forests as *Sites of special scientific interest* would seem the best solution. This category has been proposed in Endangered Resources for Development (Anon. 1984 & 1985) for small areas. There is certainly an enormous scientific interest in forests with such a diversity and such a large number of rare and endemic species of plant and animal.

ACKNOWLEDGEMENTS

The Expedition was funded by the World Wildlife Fund/International Union for the Conservation of Nature and the East African Wildlife Society. The publication of the final paper was made possible through a grant from DANIDA. To these organizations we express our sincere thanks.

We would also like to thank the co-members of the expedition:

from the Herbarium: Joseph Mutangah, David O. Nyakundi and Christopher N. Maikweki.

From the Ornithology Department: Cecilia Gichuki and James Wacira.

From the Mammology Department: Issa Aggundey, Joseph Kwambai and Paul Githinji.

From the Herpetology Department: Bw. Lorobuini.

From the Entomology Department: Joseph Muhangani.

Our drivers: Charles Maina and Paul N. Mulinge.

Our cook: Mzee Kilonzo.

Mr. G.R. Cunningham van Someren joined the expedition for ca. 2 weeks, and we would like to thank him for his companionship and his contributions to almost all fields of research.

Dr. Robert B. Faden introduced us to the forests and their flora, and we would like to thank him for this, as well as for his generous permission to use his data.

The administration officers of the Taita-Taveta district were very helpful, and we would like to thank them all, and specifically the District Commisioner for permitting us to camp in the Chief's compound at Weruga and in the District Officers compound at Voi; the Clerk to the County Council, the District Forestry Officer, the District Agricultural Officer and the Land Adjudication Officer who were very helpful and gave us much useful information.

We thank Mr. G.R. Cunningham van Someren,

Mr. J.B. Gillett and Dr. R.B. Faden for their critical reading of a draft of this paper.
Miss Queen Chiuli and Mrs. Jane Nzioki retyped this paper several times, and we would like to thank them for their patience and hard work.

REFERENCES

ANONYMOUS. 1984. Endangered resources for development: proceedings of a workshop on the status and options for management of plant communities in Kenya. NES/ETMA, Nairobi.

ANONYMOUS. 1985. Endangered resources for development 3: report on the strategy conference for the management of Kenya's plant communities. NES/ETMA, Nairobi.

BROWN, L. 1981. Conservation of forest islands in areas of high human density. *Afr. J. Ecol.* 19: 27-32.

COLLINS, N.M. & CLIFTON, M.P. 1984. Threatened wildlife in the Taita Hills. *Swara* 7, 5: 10-14.

DALE, I.R. 1939. The woody vegetation of the Coast Province of Kenya. Imp. For. Inst., Oxford.

HILDEBRANDT, J.M. 1877. Von Mombassa nach Kitui. *Zeits. Gesellsch. Erdk.* 14: 321-350.

LOVETT, J. 1985. Moist forests of Eastern Tanzania. *Swara* 8, 5: 8-9.

METEOROLOGICAL DEPARTMENT. 1966. Monthly and annual rainfall in Kenya during 1931-1960. Met. Dept., Nairobi.

PRATT, D.J. & GWYNNE, M.D. (Eds.) 1977. Rangeland management and ecology in East Africa. Hodder & Stoughton, London.

PRINS, A.H.J. 1952. The coastal tribes of the north-eastern Bantu. Int. Afr. Inst., London.

RODGERS, W.A. & HOMEWOOD, K.M. 1982. Species richness and endemism in the Usambara mountain forests. *Biol. J. Linn. Soc.* 18, 3: 197-242.

TETLOW, S. (Ed.). 1987. Cambridge conservation study1985: Taita Hills, Kenya. I.C.B.P. study report 18, Cambridge.

WHITE, F. 1981. The history of the afromontane archipelago and the scientific need for its conservation. *Afr. J. Ecol.* 19: 33-54.

APPENDIX 1

Forest trees of the Taita Hills Forests.
This list enumerates all forest trees which reach a height of at least 10 m. Endemic species are marked with *; species confined to the Eastern Arc forests are marked with @.

ANACARDIACEAE
Sorindeia madagascariensis DC.
APOCYNACEAE
Tabernaemontana stapfiana Britten
AQUIFOLIACEAE
Ilex mitis Radlk. *var. mitis*
ARALIACEAE
Cussonia spicata Thunb.
Polyscias fulva (Hiern) Harms
Polyscias stuhlmannii Harms *var. stuhlmannii* @
Scheffera myriantha (Bak.) Drake
BORAGINACEAE
Ehretia cymosa Thonn. *var. sylvatica* (Guerke) Brenan
CAESALPINIACEAE
Cynometra sp. A of F.T.E.A. *
CAPPARACEAE
Ritchiea albersii Gilg
CELASTRACEAE
Elaeodendron buchananii (Loes.) Loes.
Maytenus acuminata (L.f.) Loes.
Mystroxylon aethiopicum (Thunb.) Loes.
EBENACEAE
Diospyros abyssinica (Hiern) White
ERICACEAE
Agauria salicifolia (Lam.) Oliv.
Philippia pallidiflora Engl. *ssp. usambarensis* (Alm.&Th.Fr.)Ross
EUPHORBIACEAE
Croton macrostachyus Del.
Croton megalocarpus Hutch.
Croton sylvaticus Hochst.
Drypetes gerrardii Hutch.
Macaranga capensis (Baill.) Sim
Macaranga conglomerata Brenan @
Margaritaria discoidea (Baill.) Webster *var. discoidea*
Neoboutonia macrocalyx Pax
FLACOURTIACEAE
Aphloia theiformis (Vahl) Benn
Dasylepis integra Warb. @
GUTTIFERAE
Garcinia volkensii Engl.
ICACINACEAE
Apodytes dimidiata Arn. var. *acutifolia* (A. Rich.) Boutique
LAURACEAE
Ocotea kenyensis Robyns & Wilczek
Ocotea usambarensis Engl.
LOGANIACEAE
Anthocleista grandiflora Gilg
Nuxia congesta Fresen.
Nuxia floribunda Benth.
Strychnos henningsii Gilg

Strychnos cf. mitis S. Moore
MELASTOMATACEAE
Memecylon teitense Wickens *
MELIACEAE
Ekebergia capensis Sparrm.
Lepidotrichilia volkensii (Guerke) Leroy
Turraea holstii Guerke
Turraea robusta Guerke
MIMOSACEAE
Albizia gummifera (J.F. Gmel.) C. Sm. *var. gummifera*
Newtonia buchananii (Baker) Gilg & Bened.
MONIMIACEAE
Xymalos monospora (Harv.) Warb.
MORACEAE
Ficus exasperata Vahl
Ficus sur Forssk.
Ficus thonningii Bl.
MYRSINACEAE
Maesa lanceolata Forssk.
Rapanea melanophloeos (L.) Mez.
MYRTACEAE
Syzygium guineense (Willd.) DC. ssp. afromontanum
Syzygium sclerophyllum Brenan @
OCHNACEAE
Ochna holstii Engl.
Ouratea schusteri Gilg @
OLACACEAE
Strombosia scheffleri Engl.
OLEACEAE
? Chionanthus mildbraedii (Gilg & Schellenb.) Stearn
PALMAE
Phoenix reclinata Jacq.
PAPILIONACEAE
Craibia aff. zimmermannii (Harms) Dunn
Millettia oblata Dunn ssp. teitensis Gillett *
PODOCARPACEAE
Podocarpus latifolius (Thunb.) Mirb.
Podocarpus usambarensis Pilg. *var. usambarensis* @
Podocarpus sp. (T 388)
ROSACEAE
Prunus africanus (Hook. f.) Kalkman
RUBIACEAE
Aulacocalyx diervillioides (K. Schum.) Petit
Coffea fadenii Bridson *
Cremaspora triflora (Thonn.) K. Schum. ssp. triflora*
Galiniera coffaeoides Del.
Keetia gueimzii (Sond.) Bridson
Oxyanthus speciosus DC. *ssp. stenocarpus* (K. Schum.) Bridson
Psychotria crassipetala Petit *
Psychotria cf. hemsleyi Verdc. *
Psychotria petitii Verdc.
Psydrax parviflora (Afz.) Bridson *ssp. rubrocostata* (Robyns) Bridson
Rytigynia eickii (K. Schum & K. Krause) Bullock
Rytugynia uhligii (K. Schum. & K. Krause) Verdc.
RUTACEAE
Diphasiopsis fadenii Kokwaro
Fagaropsis angolensis (Engl.) Dale
Teclea nobilis Del.
Teclea simplicifolia (Engl.) Verdoorn
Teclea trichocarpa Engl.
Vepris sp. (T 480)
SAPINDACEAE
Allophylus abyssinicus Radlk.
Blighia unijugata Bak.
Filicium decipiens (Wight & Arn.) Thwaites
Haplocoelum foliolosum (Hiern) Bullock
SAPOTACEAE
Aningeria adolfi-friederici (Engl.) Robyns & Gilbert *cf. ssp. usambarensis* Hemsley
Bequaertiodendron natalense (Sond.) Heine & Hemsley
Chrysophyllum gorungosanum Engl.
STERCULIACEAE
Cola greenwayi Brenan *var. greenwayi* @
Dombeya goetzenii K. Schum.
Leptonychia usambarensis K. Schum.
ULMACEAE
Celtis africana Burm. f.
Celtis gomphophylla Bak.
Trema orientalis (L.) Bl.
VERBENACEAE
Vitex keniensis Turrill

APPENDIX 2

Rare plant species

1. Species endemic to the Taita Hill forests

After the species name, its family name is abbreviated; then follow the abbreviated forest names where the species is found; then follows its status (assuming that the Taita Hills forests are not in danger, otherwise these all have to be upgraded).

Chassalia discolor ssp. teitensis (Rubi.)-MBO, NGA, CHA-rare
Coffea fadenii (Rubi.)-MBO, NGA-rare
Dorstenia sp. nov. (Mora.)-MBO-vulnerable
Impatiens engleri ssp. teitensis (Bals.)-MBO, NGA-rare
Impatiens teitensis ssp. teitensis (Bals.)-MBO, NGA, VUR-rare
Memecylon teitense (Mela.)-MBO, NGA-vulnerable
Millettia oblata ssp. teitensis (Papi.)-MBO, NGA, RON, YAL)-rare
Psychotria crassipetala (Rubi.)-MBO, NGA, CHA-rare
Psychotria petitii (Rubi.)-MBO, NGA, SAG, VUR-rare
Psychotria sp. B (Rubi.)-NGA-feared extinct
Saintpaulia teitensis (Gesn.)-MBO-vulnerable
Ypsilopus sp. nov. (Orch.)-MBO-vulnerable
Zimmermannia ovata (Euph.)-NGA-vulnerable

NOTE: species occurring in low numbers have

been assigned the status "vulnerable". Any further threat would make them "endangered". *Psychotria sp. B* has been searched for intensively in all likely areas.

2. Species endemic to Eastern Arc forests

Acridocarpus scheffleri (Malp.)-NGA
Aningeria adolfi-friederici ssp. usambarensis (Sapo.)-MBO, NGA, SAG
Carex castanostachyus (Cype.)-MBO
Clematis dolichopoda (Ranu.)-NGA
Coccinia grandiflora (Cucu.)-MBO, NGA
Cola greenwayi var. greenwayi(Ster.)-MBO, NGA, SAG
Crotalaria lukwangulensis (Papi.)-MBO, NGA, VUR
Cynometra sp. A of F.T.E.A. (Caes.)-MBO
Cyphostemma braunii (Vita.)-SAG
Dasylepis integra (Flac.)-MBO, NGA, SAG
Dichapetalum eickii (Dich.)-MBO, NGA, SAG, CHA
Dicranolepis usambarica (Thym.)-MBO, NGA
Euphorbia usambarica (Euph.)-MBO, NGA
Galium brenanii (Rubi.)-VUR
Gymnosiphon usambaricus (Burm.)-MBO, NGA, SAG
Leptonychia usambarensis (Ster.)-NGA, CHA
Lycopodium holstii (Lyco.)-MBO, NGA, SAG
Lycopodium ophioglossoides (Lyco.)-MBO, SAG, VUR (YAL 1953)
Macaranga conglomerata (Euph.)-MBO, NGA, SAG, CHA
Ouratea schusteri (Ochn.)-MBO, NGA
Pentas hindsioides var. hindsioides (Rubi.)-MBO, NGA, YAL
Podocarpus usambarensis var. usambarensis (Podo.)-MBO, NGA
Polyscias stuhlmannii (Aral.)-MBO, NGA
Polystachya albescens (Orch.)-VUR
Psychotria alsophila (Rubi.)-NGA
Psychotria pseudoplatyphylla (Rubi.)-MBO, NGA
Senecio mirabilis (Comp.)-MBO
Streptocarpus kirkii (Gesn.)-MBO, SAG, CHA
Syzygium sclerophyllum (Myrt.)-MBO, NGA, CHA
Tridactyle cruciformis (Orch.)-MBO

NOTE: at this time it is not possible to assign a status such as "rare", "vulnerable" etcetera to these species; information on numbers and distribution patterns in other Eastern Arc forests is necessary for that.

3. Species endemic to Kenya

Diphasiopsis fadenii (Ruta.)-MBO, NGA. Rare; also occurs on Kasigau and near Murka.
Ocotea kenyensis (Laur.)-MBO, NGA. Also occurs around Mt. Kenya, Nyandarua (Aberdares), Marsabit and Kulal.
Streptocarpus caulescens (Gesn.)-MBO, NGA, SAG, VUR, CHA, YAL, Wesu. Rare; also in the Chyulu Hills, on Nzaui and near Thika.

4. Species possibly rare in world sense

Angraecum cf. sacciferum (Orch.)-NGA. Only known from a few scattered sites in Kenya and Tanzania.
Cyathea humilis (Cyat.)-MBO, NGA, SAG. Known from the Eastern Arc forests, Kilimanjaro and Mt. Kenya.
Oplismenus undulatifolius (Gram.)- MBO, NGA, VUR. Known from a few East African localities.
Oxyanthus goetzei ssp. keniensis (Rubi.)-NGA. Known from the Usambaras and a few Kenyan localities.
Platylepis glandulosa (Orch.)-MWA. Known from a few scattered localities in East Africa.
Streptocarpus montanus (Gesn.)-MBO, NGA, SAG, VUR, YAL. Known from a few mountain forests in Tanzania and Kenya.
Zehneria oligosperma (Cucu.)-NGA. Known from a few sites in Tanzania and Kenya.

APPENDIX 3
Transects

1. Four transects were laid in Mbololo and three in Ngangao (see for location map 4, p. 36). Each transect measured 100 by 20 meters; the two halves (each 50 x 20 m) were inventoried sparately, to check whether differences would occur over the length of the transect.

2.Every tree over 10 cm diameter (at breast height) was classified according to the following categories:

A - diameter 10-30 cm, height less than 15 m
B - diameter 10-30 cm, height over 15 m
C - diameter 30-100 cm, height less than 15 m
D - diameter 30-100 cm, height over 15 m
E - diameter over 100 cm

For each of the tree species falling in one of these categories, the frequency of saplings is also given, on a scale -(none)/ rare/ occasional/ frequent/ common.
The five most common species of each transect are underlined.
In each transect all undergrowth was also inventoried; these data are present at the East African Herbarium; for reasons of space only the more common species are listed here.

Ngangao - transect 1

Location: northern end of forest. Altitude 1800 m. Orientation NNE-SSW, uphill on a gentle slope.

	NORTH HALF						SOUTH HALF					
	nr. of trees	*A*	*B*	*C*	*D*	*sapl.*	*nr. of trees*	*A*	*B*	*C*	*D*	*sapl.*
Albizia gummifera	6	-	-	5	1	-	9	1	1	1	6	rar
Cola greenwayi	25	8	-	4	13	co	12	2	-	2	8	co
Craibia?zimmerman	18	10	-	5	3	co	1	1	-	-	-	co
Croton megalocarpus	1	-	-	-	1	-	1	-	-	1	-	ra
Croton sylvaticus	1	-	-	-	1	-	-	-	-	-	-	-
Cussonia spicata	3	1	-	-	2	-	2	-	-	-	2	-
Drypetes gerrardii	1	1	-	-	-	oc	-	-	-	-	-	oc
Ehretia cymosa	-	-	-	-	-	-	2	-	-	1	1	-
Millettia oblata	-	-	-	-	-	-	9	1	-	8	-	fr
Podocarpus latifolius	1	1	-	-	-	ra	-	-	-	-	-	ra
Polyscias fulva	-	-	-	-	-	-	1	-	-	1	-	-
Psydrax parviflora	2	-	-	1	1	ra	3	1	-	-	2	-
Ritchiea albersii	4	1	1	2	-	-	3	2	-	1	-	-
Rytigynia albersii	3	3	-	-	-	fr	-	-	-	-	-	fr
Turraea holstii	1	1	-	-	-	-	-	-	-	-	-	-
	66	**26**	**1**	**17**	**22**		**43**	**8**	**1**	**15**	**19**	

TOTAL 15 species

Common undergrowth species: *Asplenium linkii, Dichapetalum eickii, Dracaena steudneri, Erythroxylum emarginatum, Euphorbia engleri, Justicia sp., Loxogramme lanceolata, Oplis menus undulatifolius, Setaria plicatilis, Zimmermannia ovata.*
No clear distiction in the undergrowth of the two transect halves.

Ngangao-transect 2

Location: south-central part. Altitude 1850 m. Orientation SE-NW, the eastern half sloping to the southeast (being dense, undisturbed forest), the western half sloping to the northwest (being more open with signs of former logging such as treestumps and a pitsaw, and with more undergrowth).

	EAST HALF						WEST HALF					
	nr.of trees	*A*	*B*	*C*	*D*	*sapl.*	*nr.of trees*	*A*	*B*	*C*	*D*	*sapl.*
Aningeria adol.	2	-	-	-	2	oc	2	2	-	-	-	rar
Canthium oligo.	1	-	-	1	-	ra	-	-	-	-	-	-
Cyathea mann.	-	-	-	-	-	-	1	1	-	-	-	-
Dasylepis int.	1	1	-	-	-	oc	-	-	-	-	-	-
Macaranga con.	8	4	-	-	4	ra	9	3	-	5	1	co
Maesa lanceol.	3	1	1	-	1	-	-	-	-	-	-	-
Neoboutonia m.	-	-	-	-	-	-	5	3	-	-	1	co
Newtonia buc.	2	1	-	-	1	fr	3	-	-	-	3	oc
Ochna holstii	-	-	-	-	-	-	1	1	-	-	-	-
Polyscias fulva	1	-	-	-	1	-	3	-	-	2	1	-
Polyscias stuh.	4	-	-	-	4	ra	-	-	-	-	-	-
Psychotria pet.	3	3	-	-	-	oc	1	1	-	-	-	-
Psychotria pse.	-	-	-	-	-	-	1	1	-	-	-	-
Psydrax parvif.	3	3	-	-	-	-	-	-	-	-	-	-
Ritchiea alb.	2	2	-	-	-	oc	-	-	-	-	-	ra
Strombosia sch.	3	1	-	-	2	fr	2	-	-	-	2	-
Syzygium scl.	4	-	-	-	4	oc	-	-	-	-	-	-
Tabernaemont.s.	7	5	1	1	-	fr	1	1	-	-	-	-
Trema orient.	-	-	-	-	-	-	2	-	1	1	-	-
Vitex kenien.	-	-	-	-	-	-	8	7	-	-	1	-
	44	**21**	**2**	**2**	**9**		**40**	**21**	**1**	**9**	**9**	

TOTAL 22 species

Common undergrowth species: *Blotiella stipitata, Craibia zimmermannii, Culcasia falcifolia.*
Common in west half only: *Pauridiantha paucinervis, Piper capense, Dracaena steudneri.*
Common in east half only: *Asplenium erectum, A. inaequilaterale, Chassalia spp., Dichapetalum eickii, Diphasiopsis fadenii, Senecio syringifolius.*

Ngangao - transect 3

Location: in a rather narrow "tongue" of forest, about halfway between the N and S ends of the forest, pointing E. Altitude 1800 m. Orientation E-W, on a very gentle slope rising to the W. Presumably rather disturbed; canopy 20-25 m high, which is lower than the main forest, with some emergent *Albizia*.

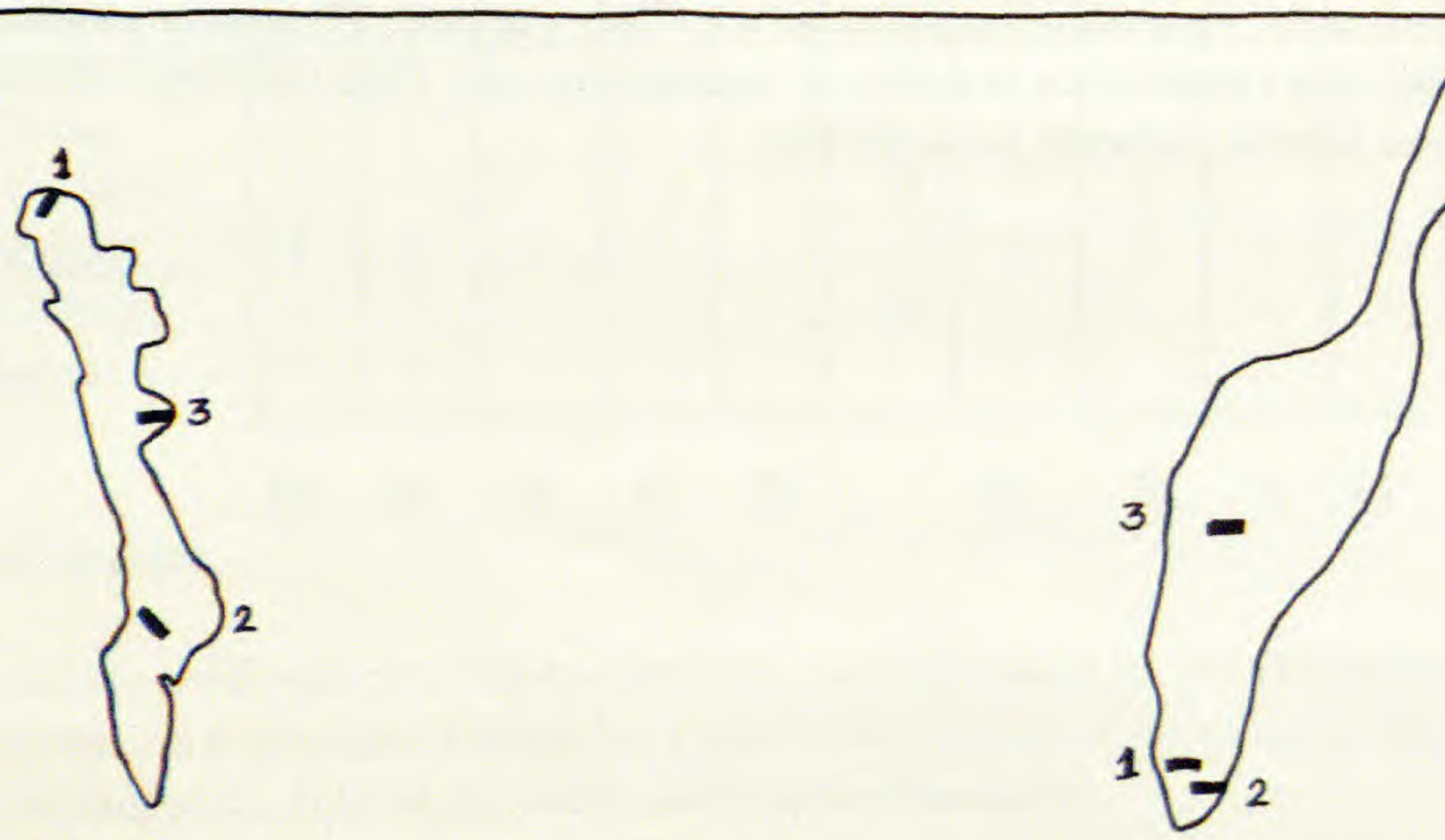
	EAST HALF							WEST HALF					
	nr.of trees	*A*	*B*	*C*	*D*		*sapl.*	*nr. of trees*	*A*	*B*	*C*	*D*	*sapl.*
Albizia gummifera	13	1	-	2	9	E1	ra	3	-	-	-	3	ra
Cussonia spicata	1	1	-	-	-		-	-	-	-	-	-	-
Ficus sur	-	-	-	-	-		-	2	-	-	1	1	-
Lepidotrichilia volk.	3	3	-	-	-		co	1	1	-	-	-	-
Leptonychia usamb.	1	1	-	-	-		oc	1	1	-	-	-	oc
Macaranga conglom.	3	-	1	1	1		ra	4	1	-	2	1	oc
Maesa lanceolata	4	-	2	2	-		ra	26	19	2	4	1	ra
Millettia oblata	9	5	-	4	-		fr	-	-	-	-	-	co
Neoboutonia macr.	-	-	-	-	-		-	1	1	-	-	-	-
Phoenix reclinata	-	-	-	-	-		oc	7	6	-	1	-	co
Polyscias fulva	-	-	-	-	-		-	2	-	-	-	2	-
Psychotria petitii	1	1	-	-	-		oc	-	-	-	-	-	oc
Rapanea melano.	1	-	-	1	-		ra	-	-	-	-	-	-
Tabernaemontana s.	15	11	-	1	3		fr	14	13	-	-	1	co
unidentified sp.	1	1											
	52	**24**	**3**	**11**	**13**	**E1**		**61**	**42**	**2**	**8**	**9**	

TOTAL 15 species

Common undergrowth species: *Culcasia falcifolia, Oplismenus undulatifolius, Psychotria pseudo-platyphylla, Pteris catoptera.*

Common in the E half: *Blotiella stipitata, Chassalia discolor, Dichapetalum eickii, Dracaena steudneri, Pauridiantha paucinervis.*

Common in the W half: *Piper capense.*



MAP 4

Location of the transects within Ngangao and Mbololo forests

Mbololo - transect 1

Location: S part of forest, near the crest. Altitude 1500-1600 m. Orientation W-E. on a steep slope downhill to the E.

	WEST HALF						EAST HALF					
	nr of trees	*A*	*B*	*C*	*D*	*sapl.*	*nr.of trees*	*A*	*B*	*C*	*D*	*sapl.*
Albizia gummifera	3	1	-	-	2	ra	3	1	-	-	2	-
Chrysophyllum gor.	1	-	-	-	1	ra	6	1	3	-	2	ra
Cola greenwayi	2	-	-	1	1	fr	3	-	-	-	3	ra
Craibia zimmerm.	4	-	1	2	1	co	1	1	-	-	-	co
Cussonia spicata	-	-	-	-	-	-	1	1	-	-	-	-
Dasylepis integra	-	-	-	-	-	-	1	-	-	1	-	1
Ekebergia capensis	3	2	-	-	1	-	1	1	-	-	-	-
Lepidotrichilia vol.	1	-	-	1	-	oc	-	-	-	-	-	oc
Leptonychia usam.	-	-	-	-	-	-	1	1	-	-	-	1
Macaranga congl.	5	1	-	2	2	1	8	-	-	1	7	oc
Newtonia buch.	10	1	-	5	4	oc	4	1	-	-	3	fr
Ochna holstii	2	2	-	-	-	-	-	-	-	-	-	oc
Ouratea schusteri	1	1	-	-	-	ra	-	-	-	-	-	1
Phoenix reclinata	-	-	-	-	-	ra	5	5	-	-	-	1
cf. Pleiocarpa sp.	-	-	-	-	-	1	1	1	-	-	-	-
Psychotria cras.	3	3	-	-	-	-	1	1	-	-	-	-
Psychotria petitii	2	2	-	-	-	-	-	-	-	-	-	ra
Rapanea melanop.	2	-	-	1	1	co	-	-	-	-	-	co
Strombosia schef.	5	1	-	3	1	ra	2	-	-	1	1	oc
Strychnos cf. henn.	-	-	-	-	-	oc	1	-	-	-	1	oc
Syzygium scler.	3	1	-	1	1	-	2	-	-	1	1	ra
Tabernaemontana s.	3	3	-	-	-	co	17	12	-	5	-	ra
?Teclea sp.	-	-	-	-	-	-	2	1	1	-	-	-
Xymalos monosp.	4	2	-	1	1	oc	6	3	-	3	-	ra
	54	**20**	**1**	**17**	**16**		**66**	**30**	**4**	**12**	**20**	

TOTAL 24 species

Common undergrowth species: *Asparagus falcatus, Asplenium holstii, Culcasia falcifolia, Di - chapetalum eickii, Pauridiantha paucinervis.*

Common in the W half: *Cissus oliveri, Cyphostemma T 386, Cynometra sp. A, Dracaena steudneri, Piper capense, Tiliacora funifera.*

Common in the E half: *Blotiella stipitata, Coffea fadenii, Pteris usambarensis.*

Mbololo - transect 2.

Location: S part of the forest, in valley near stream. Altitude ca. 1430 m. Orientation W-E, on a medium steep slope going uphill to the E. Canopy relatively low, 20-25 m, with some larger trees near the stream.

	WEST HALF						EAST HALF					
	nr. of trees	A	B	C	D	sapl.	nr. of trees	A	B	C	D	sapl.
Albizia gummifera	9	1	-	6	1 E1	-	13	-	-	5	8	fr
Allophylus abyss. -	-	-	-	-	-		1	-	-	1	-	ra
Cola greenwayi	1	1	-	-	-	oc	-	-	-	-	-	fr
Cussonia spicata	3	2	-	-	1	2	4	1	-	3	-	-
Ekebergia capensis	-	-	-	-	-	2	1	1	-	-	-	ra
Ficus sp.	1	1	-	-	-	-	1	-	-	-	1	-
Ficus sp.	1	1	-	-	-	-	-	-	-	-	-	-
Lepidotrichilia vol.	1	1	-	-	-	co	1	1	-	-	-	co
Macaranga cong.	1	-	-	-	- E1	co	2	1	-	-	1	oc
Maesa lanceolata	1	1	-	-	-	-	5	4	-	-	1	-
Neoboutonia macr.	3	2	-	-	1	co	-	-	-	-	-	-
Newtonia buchananii	-	-	-	-	-	fr	2	2	-	-	-	fr
Phoenix reclinata	33	26	-	7	-	co	10	6	-	4	-	co
Psydrax parviflora	2	1	-	1	-	co	-	-	-	-	-	ra
Tabernaemontana s.	15	10	-	3	2	co	25	17	2	6	-	co
Turraea holstii	2	1	-	1	-	-	1	1	-	-	-	1
Xymalos monospora	1	1	-	-	-	oc	7	5	-	2	-	fr
	74	**49**	**-**	**18**	**5 E2**		**73**	**39**	**2**	**21**	**11**	

TOTAL 17 species

Common undergrowth species: *Asplenium holstii, Culcasia falcifolia, Desmodium repandum, Dorstenia sp. nov., Pauridiantha paucinervis, Piper capense.*

Common in the W half: *Calanthe volkensii, Ctenitis cirrhosa, Elatostema orientale, Marattia fraxinea, Pteris catoptera.*

Common in the E half: *Cissus oliveri, Drypetes gerrardii (young), Keetia gueinzii, Leptonychia usambarensis, Oplismenus undulatifolius.*

Mbololo - transect 3

Location: central part of the forest, near the crest of the ridge. Altitude 1650 m. Orientation E-W, on a gentle slope uphill to the W, with a small valley in the W half.

	WEST HALF						EAST HALF					
	nr.of trees	A	B	C	D	sapl.	nr.of trees	A	B	C	D	sapl.
Albizia gummifera	2	-	-	1	1	-	-	-	-	-	-	-
Aningeria adolfi-fr.	1	-	-	-	1	-	-	-	-	-	-	-
Bequaertiodendron n.	1	1	-	-	-	-	1	1	-	-	-	1
Chrysophyllum gor.	3	-	-	3	-	co	1	1	-	-	-	co
Cola greenwayi	2	1	-	1	-	oc	1	1	-	-	-	1
Craibia zimm.	1	1	-	-	-	co	2	1	-	1	-	co
Cussonia spicata	1	1	-	-	-	-	-	-	-	-	-	-
Drypetes gerrardii	1	-	-	-	1	-	-	-	-	-	-	ra
Garcinia volkensii	3	3	-	-	-	co	-	-	-	-	-	fr
Ilex mitis	2	-	-	2	-	-	-	-	-	-	-	-
Lepidotrichilia vol.	4	3	-	-	1	-	-	-	-	-	-	-
Leptonychia usam.	1	1	-	-	-	-	-	-	-	-	-	-
Macaranga conglom.	3	-	-	2	1	ra	-	-	-	-	-	1
Maytenus acuminata	1	-	1	-	-	1	-	-	-	-	-	1
Newtonia buchananii	2	1	-	1	-	fr	5	1	-	3	1	ra
Ochna holstii	2	-	-	1	1	-	2	2	-	-	-	-
? Pleiocarpa sp.	-	-	-	-	-	co	3	3	-	-	-	ra
Polyscias stuhlmannii	1	-	-	-	1	1	6	2	-	3	1	ra
Psychotria crassipet.	1	1	-	-	-	ra	3	3	-	-	-	ra
Psychotria petitii	4	4	-	-	-	-	4	4	-	-	-	ra
Psychotria pseudopl.	1	1	-	-	-	1	-	-	-	-	-	ra
Psydrax parviflora	2	1	1	-	-	-	-	-	-	-	-	-
Rapanea melanophl.	-	-	-	-	-	-	1	1	-	-	-	oc
cf. Ritchiea albersii	2	-	-	2	-	-	1	1	-	-	-	-
Strombosia scheffleri	16	5	-	6	5	co	31	12	-	14	5	ra
Strychnos sp.	1	-	-	-	1	oc	-	-	-	-	-	ra
Syzygium scleroph.	1	-	-	-	1	ra	10	1	-	4	5	oc
Tabernaemontana st.	1	-	-	-	1	ra	-	-	-	-	-	-
Xymalos monospora	1	-	-	-		E1 ra	-	-	-	-	-	oc
	61	**24**	**2**	**19**	**15**	**E1**	**70**	**34**	**-**	**25**	**12**	

TOTAL 29 species

Common undergrowth species: *Asplenium holstii, Blotiella stipitata, Chassalia spp., Culcasia falcifolia, Dicranolepis usambarica, Pauridiantha paucinervis.*

Common in the W half: *Crossandra tridentata.*

Common in the E half: *Asplenium erectum, Clerodendrum johnstonii, Dracaena laxissima, Diphasiopsis fadenii.*

Mbololo - transect 4

Location: N part of forest. Altitude 1620 m. Orientation S-N, on a gentle slope downhill to the S; the N half is rather open in places.

	SOUTH HALF						NORTH HALF					
	nr. of trees	A	B	C	D	sapl	nr.of trees	A	B	C	D	sapl.
Albizia gummifera	3	-	-	1	1 E1	ra	-	-	-	-	-	-
Aningeria adolfi-f.	-	-	-	-	-	-	1	-	-	1	-	-
Chrysophyllum goru.	6	3	-	2	1	ra	2	-	-	-	2	oc
Cola greenwayi	6	6	-	-	-	co	4	-	-	-	3 E1	co
Craibia zimmerm.	1	-	-	-	1	co	2	1	-	-	1	co
? Hunteria sp.	1	1	-	-	-	ra	1	1	-	-	-	oc
Lepidotrichilia vol.	2	2	-	-	-	co	2	2	-	-	-	co
Leptonychia usamb.	2	2	-	-	-	oc	-	-	-	-	-	ra
Macaranga congl.	-	-	-	-	-	-	2	1	-	1	-	-
Maesa lanceolata	2	1	-	1	-	-	-	-	-	-	-	-
Newtonia buchananii	7	5	-	1	1	co	3	1	-	1	1	fr
Ocotea kenyensis	-	-	-	-	-	-	1	-	-	-	1	-
Polyscias fulva	-	-	-	-	-	-	1	-	-	1	-	-
Psychotria petitii	-	-	-	-	-	-	2	2	-	-	-	ra
Strombosia scheffleri	2	2	-	-	-	co	8	2	-	5	1	fr
Strychnos sp.	-	-	-	-	-	-	1	1	-	-	-	-
Syzygium scleroph.	1	-	-	-	1	-	1	-	-	-	1	-
Tabernaemontana st.	10	7	-	-	3	-	3	3	-	-	-	oc
Teclea nobilis	-	-	-	-	-	-	2	-	-	2	-	-
	43	**29**	**-**	**5**	**8 E1**		**36**	**14**	**-**	**11**	**10 E1**	

TOTAL 19 species

Common undergrowth species: *Clerodendrum johnstonii, Culcasia falcifolia, Dracaena steudneri, Pauridiantha paucinervis, Scadoxus multiflorus.*

Common in the S half: *Asplenium trifolium.*

Common in the N half: *Asplenium holstii, Chassalia discolor, Chlorophytum comosum, Crossandra tridentata, Garcinia volkensii.*

APPENDIX 4
Forest Fauna

Mammals

The following mammals were trapped in Ngangao and Mbololo forests:

Epaulet fruit bat	*Epemophorus wahlbergi*	Chiroptera: Pteropodidae
Angolan fruit bat	*Rousettus angolensis*	Pteropodidae
	Rousettus lanosus	Pteropodidae
Egyptian slit-faced bat	*Nycteris thabaica*	Nycteridae
Greater long-fingered bat	*Miniopterus inflatus*	Vespertilionidae
Cape hairy bat	*Myotis tricolor*	Vespertilionidae
Greater bushbaby	*Galago crassicaudatus*	Primates: Galagidae
Sykes monkey	*Cercopithecus mitis kima (= C. albogularis)*	Cercopithecidae
Large spotted genet	*Genetta tigrina*	Carnivora: Viverridae
Black-legged mongoose	*Bdeogale nigripes jacksoni*	Viverridae
Slender mongoose	*Herpestes sanguineus*	Viverridae
Giant rat	*Cricetomys gambianus*	Rodentia: Muridae
Taita forest rat	*Praomys delectorum*	Muridae

Birds

The following birds were sighted and/or trapped and/or ringed in Ngangao and Mbololo forests:

African goshawk	*Accipiter tachiro*	
Augur Buzzard	*Buteo rufofuscus*	
Mountain buzzard	*Buteo oreophilus*	
Crowned eagle	*Spizaetus coronatus*	
Ayres eagle	*Hieratus ayresii*	
Kenya crested guineafowl	*Guttera pucherani*	Mbololo only
Lemon dove	*Aplopelia larvata*	common
Tambourine dove	*Turtur tympanistra*	frequent
Hartlaub's turaco	*Tauraco hartlaubi*	frequent
African wood owl	*Strix woodfordii*	
White bellied tit	*Parus alboventris*	
Stripe-cheeked greenbul	*Andropadus milanjensis striifacies*	common in forest
Mountain greenbul	*Andropadus tephrolaemus usambarae*	common
Olive mountain greenbul	*Phyllastrepus placidus*	common
Yellow-vented bulbul	*Pycnonotus barbatus*	common in forest margins
Robin chat	*Cossypha caffra*	common at forest edges
Ruppels robin chat	*Cossypha semirufa*	uncommon
White-starred forest robin	*Pogonocichla stellata helleri*	common in forest
Orange ground trush	*Turdus gurneyi raineyi*	frequent in forest
Taita trush	*Turdus helleri*	frequent in forest
Hill babbler	*Alcippe abyssinica*	
Bar-throated apalis	*Apalis thoracica fuscigularis*	occasional in forest
Yellow-breasted apalis	*Apalis flavida golzii*	
Evergreen forest warbler	*Bradypterus barrattii usambarae*	forest margins
Grey-backed camaroptera	*Camaroptera brachyura*	frequent in forest
Brown woodland warbler	*Phylloscopus umbrovirens*	
Yellow-throated woodland warbler	*Phylloscopus ruficapilla minulla*	common in forest canopy

Dusky flycatcher	*Muscicapa adusta*	common in forest margins
Olive sunbird	*Nectarinia olivacea*	common in forest
Taita white-eye	*Zosterops poliogastra silvana*	common in forest margins

Observations are by C. Gichuki, J. Wachira, G.R. Cunningham van Someren and F. N'gweno.

C. McGuigan reports (in Tetlow 1987) the following species for Ngangao forest (margin) not seen on the NMK expedition:

African hawk eagle	*Hieratus spilogaster*
Moustached green tinkerbird	*Pogoniulus leucomystax*
Pale flycatcher	*Bradornis pallidus*
Black-backed puffback	*Dryoscopus alba*
Violet-backed starling	*Cinnyriclincus medioris*

McGuigan also gives in-depth reports on several of the (near-)endemic taxa (see Tetlow 1987).

APPENDIX 5
Botanical Exploration of the Taita Hills forests

1877 Hildebrandt collects on Ndara (= Sagalla) and Ndi (= Mbololo) in february.
1931 Napier collects at Wesu.
1932 Percher makes a small collection at Bura Bluff/Chawia.
1932 Gardner collects at Ngangao and Mbololo.
1934 Bally collects at Ndara (= Sagalla).
1937 Dale collects at Chawia, Susu and Mwangozi forest (The last locality has not been traced).
1938-39 Joana and Opiko, collecting information on butterflies for van Someren, also make extensive plant collections at Mbololo and Wundanyi.
1941 Gardner collects at Susu and Wesu.
1953 Bally collects at Sagalla, Ngerenyi (near Ngangao), Wesu and Wundanyi.
Drummond and Hemsley collect at Ngangao, Yale and Chawia.
1960 Polhill and Verdcourt collect on Vuria.
1964 Osborn collects on Vuria.
1966 Gillett, Burtt and Osborn collect at Susu and Vuria.
1969 Gillett, Burtt and Osborn collect at Susu and Vuria.
1969-77 Faden collects, during many safaris and with different companions, at Mbololo, Ngangao, Sagalla, Ronge and Vuria.
1970-s several orchid collectors visit the hills to collect live orchids (no collections deposited at any herbarium).
1985 National Museums expedition visits Mbololo, Ngangao, Sagalla, Chawia, Vuria, Yale, Wesu and Ronge.

Literature on these collections, flora and vegetation is absent, except for a brief mention of the floristic composition by Dale (1939).

2. CHECKLIST OF THE FOREST PLANT SPECIES

Robert B. Faden[1], H.J. Beentje[2] & D.O. Nyakundi[2]

All plants known to occur in the forests of the Taita Hills are listed. Species from outside the forests have not been taken into account.

The families have been arranged according to the system of Hutchinson, as in use at the East African Herbarium. An index will be found at the end of the paper.

Collections are vouchered by one or two collections, present at the East African herbarium. Collectors have been abbreviated as follows:

DH - Drummond & Hemsley
F - R.B. Faden
T - Taita Hills expedition of the National Museums

All other collectors are named in full. A star * indicates a sight record.

Apart from the higher plants, the NMK expedition collected 62 fungi, 9 lichens, 24 hepatics and 49 bryophytes. These have not yet been identified.

Identifications of the higher plants have been done at the East African Herbarium. Some Rubiaceae and Euphorbiaceae were re-identified at the Royal Botanic Gardens, Kew.

Localities of collections are abbreviated as follows:

CHA - Chawia forest; altitude 1500-1550 m.
MBO - Mbololo forest; altitude 1400-1750 m; this includes Mraru ridge.
MWA - Mwabirwa, a forest patch near the forest station; altitude ca. 1200 m.
NGA - Ngangao forest; altitude 1730-1900 m.
RON - Ronge plantation; altitude 1230-1300 m.
SAG - Sagalla forest; altitude 1350-1450 m.
VUR - Vuria forest remnants; altitude 1950-2228 m.
YAL - Yale forest remnants; altitude 1680-1950 m.

PTERIDOPHYTA

LYCOPODIACEAE

Lycopodium cernuum L. — F 70/508, T 1135
Plant of disturbed ground. Frequent at MBO, MWA, VUR.

L. clavatum L. — F 70/504
Plant of forest edges. Rare at VUR.

L. dacrydioides Bak. — F 70/478, T 963
Forest epiphyte. Occasional at CHA, MBO, NGA, SAG.

L. sp. aff. dacrydioides — F 71/1025
Forest epiphyte. MBO.

L. holstii Hieron. — F71/55, T 772
Forest epiphyte. Occasional at MBO, NGA, SAG. Taita Hills and Kasigau are the only Kenyan localities; also rare in Tanzania; not known elsewhere.

L. ophioglossoides Lam. — DH 4321, T 108
Forest epiphyte. Occasional at MBO, VUR; YAL in 1953. Taita Hills only Kenyan locality.

L. verticillatum L.f. — F 71/53
Forest epiphyte. Rare at MBO.

SELAGINELLACEAE

Selaginella kraussiana (Kunze) A. Br. — DH 4320, T 75
Forest floor herb. Locally common at NGA, SAG, VUR.

[1].National Museum of Natural History, Smithsonian Institution, Washington DC, U.S.A.
[2] East African Herbarium, National Museums of Kenya, Nairobi.

OPHIOGLOSSACEAE

Ophioglossum vulgatum L. F 71/240, 72/245
Tiny terrestrial of forest edges. Locally common at MBO, VUR.

MARATTIACEAE

Marattia fraxinea Sm. F 70/515, T 806
Large terrestrial, to 2.5 m; locally common near streams at MBO; rare at CHA, MWA; occasional at SAG.

OSMUNDACEAE

Osmunda regalis L. T 1152
Large terrestrial. Rare at VUR.

SCHIZAEACEAE

Mohria caffrorum (L.) Desv. F 69/833, Gardner 2982
Small terrestrial on forest edges. Rare at MBO, VUR.

GLEICHENIACEAE

Dicranopteris linearis (Burm. f.) Underw. T 419, 1041
Common scrambler in steep roadside banks just below MBO and at RON.

HYMENOPHYLLACEAE

Hymenophyllum capillare Desv. F 71/1022
Small pendent epiphyte. Rare at MBO.

H. kuhnii C. Chr. F 70/705, T 443
Small creeping epiphyte. Occasional at MBO.

H. sibthorpioides (Willd.) Kuhn F 69/848, T 974
Small creeping epiphyte. Occasional at MBO.

Trichomanes borbonicum v.d. Bosch F 70/702
Small creeper on mossy rocks. Rare at MBO.

T. chevalieri Christ. T 59
Small creeper on rocks. Rare at Wesu.

T. erosum Willd. F 70/718
Small creeper on rocks, or epiphytic on treeferns. Rare at MBO.

T. melanotrichum Schlechtend. F 69/847, T 972
Small epiphytic creeper, occasionally found on wet rocks. Rare at SAG, VUR; occasional at CHA; frequent at MBO, NGA.

T. ramitrichum Faden F 70/524
Small creeper on rocks. Rare at MWA.

T. rigidum Swartz F 70/571
Small terrestrial along stream. Rare at MWA.

T. sp. T 406
Small epiphytic creeper. Occasional at MBO.

DENNSTAEDTIACEAE

Blotiella hironymii (Kumm.) Faden DH 4355, T 421
Terrestrial. Rare at MBO.

B. stipitata (Alston) Faden ssp. *angustata* F 69/844, T 815
Terrestrial to 2.5 m. Common at MBO, abundant in parts of NGA, SAG.

Hypolepis sparsisora (Schrad.) Kuhn F 70/469, T 469
Terrestrial to 1.5 m of forest clearings. Occasional at CHA, MBO, NGA.

H. sp. aff. rugulosa (Labill.) J. Sm. var. *africana* C. Chr. T 401
Terrestrial to 1.2 m of forest clearing. Locally coomon at MBO.

Pteridium aquilinum (L.) Kuhn F 69/814, 70/522
Terrestrial of disturbed forest margins at MBO, MWA, SAG, VUR, YAL.

ADIANTACEAE

Cheilanthes bergiana Schlechtend. F 69/867, T 550
Terrestrial to 50 cm. Rare at NGA.

Cheilanthes farinosa (Forssk.) Kaulf. F 70/476, T 513
Terrestrial to 2 m in rock crevices and forest edges. Local at CHA, NGA, Wesu.

Cheilanthes multifida (Swartz) Swartz F 70/476, T 513
Terrestrial to 2 m, in rock crevices and forest edges. Local at CHA, NGA, Wesu.

Doryopteris concolor (Langsd. & Fisch.) Kuhn T 538
Terrestrial at forest edge; occasional at NGA.

Pellaea quadripinnata (Forssk.) Praentl F 70/514, T 1128
Terrestrial to 60 cm. Rare at MBO, MWA, SAG, VUR, YAL.

Pteris catoptera Kunze F 69/827, T 892
Terrestrial to 1.7 m; occasional at CHA, MBO, NGA, SAG, YAL.

Pteris dentata Forssk. ssp. *flabellata* (Thunb.) F 69/861, T 58
Terrestrial to 1 m. uncommon at NGA, SAG, Wesu.

Pteris pteroides (Hook.) Ballard F 71/1006, T 781
Terrestrial of streamsides; rare at MBO.

Pteris usambarensis Hieron. F 70/729, T 274
Terrestrial. Common at MBO, NGA, SAG.

DAVALLIACEAE

Arthropteris orientalis (Gmel.) Posth. DH 4393, T 315
Epilithic to 40 cm. Local at MBO, NGA.

CYATHEACEAE

Cyathea dregei Kunze F 70/531, T 1166
Treefern to 5 m. Rare at MBO, NGA. Rare within Kenya.

Cyathea humilis Hieron. F 70/531, T 970
Treefern to 2 m. Rare at MBO, NGA; occasional at SAG. Rare within Kenya.

Cyathea manniana Hook. F 70/716, T 147
Treefern to 6 m. Locally common at CHA, MBO, NGA, SAG, VUR, YAL.

ASPIDIACEAE

Arachnioides foliosa (C.Chr.) Schelpe F 70/502, T 1153
Terrestrial to 40 cm. Occasional at MBO, VUR.

Ctenitis cirrhosa (Schum.) Ching F 70/549, T 792
Terrestrial to 1.2 m at streamsides. Frequent at MBO, MWA.

Ctenitis lanuginosa (Kaulf.) Copel F 70/549, T 792
Terrestrial to 1.8 m. Occasional at MBO, NGA; rare at SAG.

Didymochlaena truncatula (Swartz) J. Sm. F 70/472, T 787
Terrestrial of streamsides. Occasional at CHA, MBO.

Dryopteris pentheri (Krasser) C. Chr. F 70/477, T 422
Terrestrial to 1.3 m. Rare at YAL, occasional at Wesu, common at MBO, NGA, VUR.

Dryopteris kilimensis (Kuhn) O. Kuntze F 70/498, T 164
Terrestrial to 1 m. Common at VUR, occasional at SAG.

Dryopteris manniana (Hook.) C. Chr. F 77/340, T 391
Terrestrial to 1 m. Frequent at MBO, NGA, SAG.

Polystichum fuscopaleaceum Alston F 72/255, T 162
Terrestrial to 1 m. Occasional at MBO, NGA, VUR.

Tectaria gemmifera (Fee) Alston F 69/872, T 825
Terrestrial to 1 m. Locally common at CHA, MBO, NGA, YAL.

LOMARIOPSIDACEAE

Elaphoglossum acrostichoides (Hook. & Grev.) Schelpe F 71/1018
Epiphyte. Rare at MBO.

Lomariopsis warneckei (Hieron.) Alston F 69/823, T 319
Epilithic or epiphytic creeper. Rare at MBO, NGA; occasional at SAG.

THELYPTERIDACEAE

Amauropelta bergiana (Schlechtend.) Holtt. F 70/499, T 1150
Terrestrial to 50 cm. Occasional at VUR.

Amauropelta oppositiformis(C. Chr.) Holtt. F 72/249
Terrestrial. Rare at VUR.

Christella chaseana (Schelpe) Holtt. F 71/243
Terrestrial creeper. Rare at MBO.

Christella dentata (Forssk.) Holtt. F 71/222, T 830
Terrestrial to 2 m. Occasional at CHA, NGA.

Christella gueinziana (Mett.) Holtt. F 69/828
Terrestrial of disturbed sites. Rare at MBO.

Christella hilsenbergii (Presl.) Holtt. F 70/550
Terrestrial. Rare at MBO.

Christella sp. F 70/449
Terrestrial. Rare at MBO

Cyclosorus interruptus (Willd.) H. Ito F 70/519
Streamside terrestrial. Rare at MWA.

Pneumatopteris unita (Kuntze) Holtt. F 70/468, T 471
Streamside terrestrial. Frequent at CHA, MBO, NGA.

Pseudophegopteris cruciata (Willd.) Holtt. F 71/236, T 925
Terrestrial of moist sites. Rare at MBO, VUR.

Pseudocyclosorus pulcher (Willd.) Holtt. F 71/236, T 925
Streamside terrestrial to 3 m. Common at MBO, YAL.

Stegnogramma pozoi (Lag.) K. Iwats F 72/242
Rare at VUR.

ATHYRIACEAE

Diplazium hylophilum (Hieron.) C. Chr. F 70/756
Swamp fern to 1.2 m. Rare at MBO.

Diplazium zanzibaricum (Bak.) C. Chr. F 70/495
Terrestrial to 1.5 m. Rare at VUR.

Dryoathyrium boryanum T 937
Streamside terrestrial to 2.5 m. Rare at YAL.

BLECHNACEAE

Blechnum attenuatum (Swartz) Mett. F 70/732
Terrestrial. Occasional at MBO, VUR.

Blechnum ivohibense C. Chr. F 70/752
Terrestrial. Rare at MBO.

ASPLENIACEAE

Asplenium adiantum-nigrum L. F 70/471, 72/250
Terrestrial to 25 cm in dense shade. Rare at CHA, SAG, VUR.

Asplenium aethiopicum (Burm. f.) Becherer F 69/838, T 924
Terrestrial or epiphytic to 60 cm. Occasional to locally common at MBO, NGA, SAG, YAL, Wesu.

Asplenium albersii Hieron. F 70/530, T 424
Terrestrial to 40 cm. Occasional at MBO.

Asplenium sp. aff. albersii F 70/556, T 959
Rare at MBO.

Asplenium sp. aff. barteri Hook. T 782, 1126
Terrestrial. Locally common at MBO, SAG.

Asplenium boltonii Schelpe F 69/874, 70/465
Terrestrial. Occasional at CHA, NGA, VUR.

Asplenium sp. aff. boltonii F77/327, T 312
Epiphytic or epilithic to 70 cm. Locally common at NGA.

Asplenium buettneri Hieron. F 70/526, T 316
Terrestrial or in shallow soil on rocks. Uncommon at MWA, NGA.

Asplenium christii Hieron. F 77/321, T 1091
Terrestrial to 50 cm. Locally common at MBO, NGA, SAG.

Asplenium elliottii CH Wright F 69/826, T 156

Asplenium erectum Willd. var. *usambarense* (Hieron.) Schelpe — F 69/866, T 1090
Terrestrial to 35 cm. Occasional to common at MBO, NGA, SAG.

Asplenium sp. near *erectum* Willd. — T 267, 818
Locally common at NGA.

Asplenium friesiorum C. Chr. — F 69/821, T 968
Epiphytic to 1 m. Frequent to common at MBO, NGA, SAG, VUR.

Asplenium holstii Hieron. — F 70/555, T 966
Terrestrial or epiphytic to 1 m. Frequent to common at CHA, MBO, NGA, SAG.

Asplenium hypomelas Kuhn — F 69/820, T 1083
Epiphytic on treeferns or rarely terrestrial. Locally common at MBO, SAG, VUR.

Asplenium inaequilaterale Willd. — F 69/863, T 409
Usually on streamsides. Occasional at MBO, NGA, YAL.

Asplenium linckii Kuhn — DH 4340, T 410
Terrestrial or epiphytic. Occasional at MBO, NGA.

Asplenium macrophlebium Bak. — F 70/754, T 906
Terrestrial to 35 cm. Rare to occasional at MBO, NGA.

Asplenium mannii Hook. — F 70/488
Epiphyte. Rare at CHA.

Asplenium megalura Hieron. — F 71/49, T 965
Epiphytic or terrestrial to 40 cm. Rare at MBO, SAG.

Aspenium normale D. Don — F 69/829, T 375
Locally common at MBO.

Asplenium paucijugum Ballard — F 70/561, T 366
Terrestrial. Rare to locally common at MBO.

Asplenium sandersonii Hook. — DH 4374, Joana 8844
Epiphytic. Rare at CHA, MBO.

Asplenium simii Schelpe — F 70/520, T 833
Epiphytic. Rare at CHA, MWA, NGA.

Asplenium theciferum (Kunth) Mett. var. *concinnum* (Schrad.) Schelpe — F 70/480, T 826
Epiphytic. Occasional at CHA, MBO, NGA, SAG.

Asplenium unilaterale Lam. — F 70/540, 71/245
Streamside terrestrial. Rare at CHA, MBO.

POLYPODIACEAE

Loxogramme lanceolata (Swartz) Presl — F 69/873, T 9
Epiphyte or epilithic. Locally common at CHA, NGA, SAG, VUR, Wesu.

Pleopeltis excavata (Willd.) Sledge — F 70/551, T 1151
Epiphyte. Occasional at CHA, locally common at MBO, NGA, SAG, VUR, Wesu.

Pleopeltis macrocarpa (Willd.) Kaulf. — DH 4395, T 7
Epiphyte. Rare at CHA, MBO, NGA, SAG, Wesu.

Pleopeltis schraderi (Mett.) Tard. — F 72/212
Epiphyte. Rare at MBO.

GRAMMITIDACEAE

Grammitis nanodes (Peter) Ching — F 69/846, T 964
Epiphyte. Rare at MBO.

Xiphopteris strangeana Pic. Ser. — F 69/850
Epiphyte. Rare at MBO.

VITTARIACEAE

Vittaria isoetifolia Bory — F 71/1023, T 962
Epiphyte. Rare at MBO.

Vittaria guineensis Desv. var. *orientalis* Hieron. — Joana CM 8842
Epiphyte. Locality uncertain ("Bura Hills").

Vittaria volkensii Hieron. — F 71/1024
Epiphyte. Rare at MBO.

GYMNOSPERMAE

PODOCARPACEAE

Podocarpus latifolius (Thunb.) Mirb. — DH 4353, T 387

Tree; in 1985 only young trees up to 12 m high were observed. Occasional at MBO, NGA.

Podocarpus usambarensis Pilg. var. *usambarensis* — T 540

Tree; only young trees to 6 m high were seen. Occasional at MBO, NGA. Endemic to the Taitas, Ngulia, and Tanzanian Eastern Arc forests.

Podocarpus sp. — T 388

Tree to 12 m at MBO. Might be a new species.

ANGIOSPERMAE: DICOTYLEDONES

8. ANNONACEAE

Uvaria lucida Benth. — F 71/1008

Scandent shrub. Frequent at MBO, NGA.

10. MONIMIACEAE

Xymalos monospora (Harv.) Warb. — Joana CM 9026, T 372

Understorey tree. Occasional at CHA, MBO, NGA, SAG, VUR, YAL, Wesu.

11. LAURACEAE

Cryptocarya liebertiana Engl. — T 957

Small tree to 3 m. Rare at MBO. New record for Kenya.

Ocotea kenyensis (Chiov.) Robyns & Wilczek — F 71/48, T 212

Canopy tree. Rare (in 1985) at MBO, NGA. Endemic to Kenya.

Ocotea usambarensis Engl. — F 70/746, 72/267

Canopy tree. Rare (in 1985) at MBO, NGA.

15. RANUNCULACEAE

Clematis brachiata Thunb. — T 365.

Climber in forest edge. Occasional at MBO.

Clematis dolichopoda Brenan — T 239, 1047

Climber in forest edge. Occasional at NGA. New record for Kenya.

Thalictrum rhynchocarpum Dillon & A. Rich. — T *

Herb. Common in *Philippia* forest at VUR.

23. MENISPERMACEAE

Cissampelos pareirera L. var. *orbiculata* (DC.) Miq. — T 592

Herbaceous twiner. Occasional at NGA north end.

Tiliacora funifera (Miers) Oliv. — F 71/238, T 510

Woody climber. Occasional at CHA, MBO, NGA, SAG.

28. PIPERACEAE

Peperomia abyssinica Miq. — F 70/710, T 82

Semi-succulent herb, epilithic or epiphytic. Locally common at CHA, MBO, NGA, VUR.

Peperomia retusa (L.f.) Dietr. var. *mannii* (Hook.) Duell. — Gillett et al. 17149, T 218

Semi-succulent herb on rocks. Locally common at CHA, MBO, NGA, YAL.

Peperomia tetraphylla (Forssk.) Hook. & Arn. — F 70/711, T 246

Semi-succulent herb on rocks. Locally common at CHA, MBO, NGA, YAL.

Piper capense L. — DH 4377, T 427

Woody herb. Occasional at MBO, VUR; frequent at NGA, SAG.

36. CAPPARACEAE

Ritchiea albersii Gilg — F 72/208, T 1123

Tree to 15 m in forest (margin). Occasional at CHA, NGA.

39. CRUCIFERAE

Cardamine africana L. — T 151, 332

Perennial herb of disturbed sites. NGA, VUR.

40. VIOLACEAE

Rinorea angustifolia (Thou.) Baill. ssp. *ardisiiflora* (Oliv.) Grey-Wilson — T 476, Beentje 2188
Shrub to 2 m. Rare at NGA and possibly (T 956) at MBO. Rare in Kenya.

Viola abyssinica Oliv. — DH 4314, T 106
Herb of forest clearings. Common at VUR.

Viola eminii (Engl.) RE Fries — T *
Herb. Rare at VUR.

45. CRASSULACEAE

Crassula alsinoides (Hook. f.) Engl. — Gillett & Burtt 17066, T 899
Succulent herb of forest margins. Locally common at NGA, YAL. In 1966 found on Susu by Gillett.

53. CARYOPHYLLACEAE

Drymaria cordata (L.) Roem. & Schultes — Beentje2141, T 40
Creeping herb of disturbed sites. MBO, NGA, VUR, Wesu.

59. PHYTOLACCACEAE

Phytolacca dodecandra L'Herit. — Bally 8760, T 343
Climber of forest margins. Rare at NGA.

63. AMARANTHACEAE

Celosia anthelmintica Asch. — T 534
Twining herb of forest edge. Common at NGA north.

Celosia sp. — T 352, 402
Scrambling herb at forest adge. Local at MBO, NGA.

Celosia sp. — T 130, 432
Scrambling herb in disturbed sites. Occasional at MBO, VUR.

64. BASELLACEAE

Basella alba L. — T 562, 847
Climber in forest margin. Occasional at NGA, frequent at CHA.

67. GERANIACEAE

Geranium arabicum Forssk. ssp. *arabicum* — F 70/506, T 6
Creeping herb of forest margins. Occasional at VUR, Wesu.

71. BALSAMINACEAE

Impatiens engleri Gilg ssp. *pubescens* Grey-Wilson — DH 4356, T 767
Herb to 70 cm. Frequent at MBO, NGA. Endemic to Taita Hills.

Impatiens pseudoviola Gilg — Bally 8699, T 1
Herb to 40 cm in forest margins. Occasional at CHA, MBO, NGA, SAG, VUR, YAL, Wesu.

Impatiens sodenii Engl. — Joana CM 9051, T 289
Herb to 1.5 m. Occasional at MBO, NGA, VUR, Wesu.

Impatiens teitensis Gilg ssp. *teitensis* — Opiko CM 8775, T 1051
Herb to 2 m. Occasional at MBO, NGA, VUR; in 1939 collected at Wundanyi. Endemic to Taita Hills.

Impatiens walleriana Hook. f. — Bally 8700, T 1065
Herb to 75 cm in forest margins. Occasional at SAG.

81. THYMELEACEAE

Dicranolepis usambarica Gilg — Joana CM 9000, T 945
Shrub to 3 m. Occasional to locally common at MBO, NGA. Endemic to Taita Hills and Tanzanian Eastern Arc forests.

93. FLACOURTIACEAE

Aphloia theiformis (Vahl) Benn. — Joana B 8939, T 249
Tree to 16 m. Occasional at CHA, MBO, MWA, NGA. Formerly also near Wundanyi (Joana). Taitas only Kenyan locality.

Dasylepis integra Warb. — DH 4341, T 242
Tree to 12 m. Occasional at MBO, NGA, SAG. Endemic to Taitas and Tanzanian Eastern Arc forests.

Dovyalis abyssinica (A. Rich.) Warb. — DH 4285, T 242
Shrub to 2 m at forest or thicket edges. Rare at NGA and (in 1953) at YAL.

Trimeria grandifolia (Hochst.) Warb. ssp. *tropica* (Burkill) Sleumer — T 327
Shrub to 2.5 m in forest margin; 2 seen at NGA.

101. PASSIFLORACEAE

Passiflora edulis Sims — T 479
Naturalized climber, found in forest margin at MBO.

103. CUCURBITACEAE

Coccinea grandiflora Cogn. — Bally 13759, T 799
Herbaceous climber. Rare at CHA, MBO, NGA. Rare in Kenya.

Gerrardanthus grandiflorus Cogn. — T 1216
Climber. Rare at MBO.

Gerrardanthus lobatus (Cogn.) C. Jeffrey — T *
Climber. 1 seen at NGA north.

Momordica sp. — T *
Herbaceous twiner. Rare at MBO, NGA.

Oreosyce africana Hook. f. — T 95, 926
Climber to 2 m in disturbed forest. Common at VUR, rare at YAL.

Peponium vogelii (Hook. f.) Engl. — T 221, 463
Herbaceous climber. Rare at NGA.

Zehneria emirnensis (Bak.) Keraudren — T 259
Forest edge climber. Rare at NGA. 2nd record for Kenya.

Zehneria oligosperma C. Jeffrey — DH 4333
Climber to 3.5 m. Rare at NGA. Rare in Kenya.

Zehneria scabra (L.f.) Sond. — DH 4326
Climber in forest margin. At YAL in 1953.

Zehneria sp. — T 553, 1117
Climber. Rare at MBO, occasional at NGA north. Possibly a new species.

Unidentified — T 121

104. BEGONIACEAE

Begonia johnstonii Oliv. — F 71/215
Herb. Rare in lower parts of MBO, SAG.

107. CACTACEAE

Rhipsalis baccifera (J. Mill.) Stearn — F 71/1013, T 450
Fleshy epiphyte. Occasional at CHA, MBO, NGA.

114. OCHNACEAE

Ochna holstii Engl. — F 71/51, T 250
Tree to 22 m. Frequent at MBO, NGA; occasional at CHA, SAG.

Ouratea schusteri Gilg — DH 4342, T 952
Tree to 10 m. Occasional at MBO, NGA. Endemic to Taitas, Kasigau and Tanzanian Eastern Arc forests.

118. MYRTACEAE

Syzygium guineense (Willd.) DC. ssp. *afromontanum* F. White — Dale CM 13529
Large tree. CHA, in 1937.

Syzygium sclerophyllum Brenana — Bally 7811, T 335
Tree to 30 m. Occasional to common at CHA, MBO, NGA, RON, SAG. Kabuye 82/126 is from Mbale, and probably indicates former forest at that site. A form approaching *S. guineense* occurs on MBO. Rare; only known from Taitas, Ngulia and Tanzanian Eastern Arc forests.

120. MELASTOMATACEAE

Memecylon teitense Wickens — DH 4363, T 303
Tree to 8 (22?) m. Occasional at MBO, NGA. Endemic to Taitas.

126. GUTTIFERAE

Garcinia volkensii Engl. DH 4344, T 400
Shrub or tree to 20 m. Rare at CHA, frequent at MBO, NGA.

130. STERCULIACEAE

Cola greenwayi Brenan cf. var. *greenwayi* F 71/975, T 771
Tree to 30 m. Uncommon at CHA, locally common at MBO, NGA, SAG. Taitas are the only Kenyan locality.

Dombeya goetzenii K. Schum. T 81
Small tree of disturbed forest. Occasional at VUR.

Leptonychia usambarensis K. Schum. F 69/882, T 868
Tree to 12 m. Uncommon at CHA, occasional at NGA. Endemic to Kenya and North Tanzania.

132. MALVACEAE

Pavonia urens Cav. var. *tomentosa* (Urbr.) Brenan T 8, 932
Woody herb to 1.5 m. Locally common at Wesu, rare at NGA, YAL.

Sida rhombifolia L. T 520
Woody herb to 40 cm, of forest edges. Common at NGA.

Sida schimperana A. Rich. T 533, 1157
Woody herb. 1 seen at forest margin at NGA north.

133. MALPHIGIACEAE

Acridocarpus scheffleri Engl. DH 4331, T 525
Liana. Locally common at NGA north. Endemic to Taitas and Usambaras; the Taita population might represent a new taxon (see Launert in Fl. Trop. E. Afr. Malphigiaceae: 9).

135. ERYTHROXYLACEAE

Erythroxylon emarginatum Schum. & Thonn. T 516
Shrub or tree to 5 m. Common at NGA north.

136. EUPHORBIACEAE

Acalypha volkensii Pax T 30, Beentje 2144
Creeping herb of forest margins. Occasional at NGA and Wesu.

Argomuellera macrophylla Pax Gardner 2949, T 1043
Shrub to 3 m. Rare at MBO, NGA.

Clutia abyssinica Jaub & Spach var. *usambarica* Pax & K. Hoffm. T 318
Shrub to 2 m in forest edge. Occasional at MBO, NGA.

Croton macrostachyus Del. T 852
Sapling in forest margin at CHA.

Croton megalocarpus Hutch. T 527
Tree to 25 m. Occasional at NGA north.

Croton sylvaticus Hochst. T 546
Tree to 25 m. Occasional at NGA north. Rare in Kenya.

Drypetes gerrardii Hutch. T 326, 1070
Tree to 32 m. Occasional at CHA, MBO, NGA, RON; rare at SAG, YAL.

Euphorbia engleri Pax DH 4359, T 557
Woody herb to 2 m. Locally common at MBO, NGA.

Euphorbia usambarica Pax Bally 8776, T 1000
Woody herb to 1.5 m, in forest edges or secondary forest. Occasional at MBO, SAG. Taitas are the only Kenyan locality.

Macaranga capensis (Baill.) Sim F 70/515, T 1183
Tree to 5 m, more (and with spiny trunk) at Ronge. Occasional at MBO, MWA, RON.

Macaranga conglomerata Brenan DH 4372, T 1097
Tree to 30 m. Locally common at CHA, MBO, NGA, RON, SAG. Endemic to Taitas and Usambaras.

Margaritaria discoidea (Baill.) Webster var. *discoidea* T 486
Tree to 25 m in forest edge. Rare at NGA.

Neoboutonia macrocalyx Pax Gillett 17244, T 500
Tree to 20 m in wetter forest edges. Occasional at MBO, NGA, YAL.

Zimmermannia ovata Bruce Gardner 2909, T 524
Shrub or tree to 5 m. Frequent at NGA north and endemic to this locality.

Unidentified shrub (NGA) T 568

143. ROSACEAE

Prunus africana (Hook. f.) Kalkm. F 72/201, T 306
Tree to 21 m, often on forest edges. Occasional to frequent at CHA, NGA, SAG, VUR, YAL.

Rubus rosifolius Sm. T 347
Scrambler in forest edge. 2 seen at NGA; naturalized.

Rubus pinnatus Willd. T 403
Scrambler in forest margin. Occasional at MBO.

144. DICHAPETALACEAE

Dichapetalum eickii Ruhl DH 4330, T 324
Liana to 6 m. Occasional to frequent at MBO, NGA, SAG. Endemic to Taitas, Usambaras and Ulugurus.

146. CAESALPINIACEAE

Cassia didymobotrya Fres. T 475
Shrub or small tree in forest edge. Occasional at NGA.

Cynometra sp. A of FTEA F 70/564, T 783
Tree to 40 m. Locally dominant at MBO. Endemic to Taitas and E Usambaras.

147. MIMOSACEAE

Albizia gummifera (JF Gmel.) CA Sm. F 71/1003, T 328
Tree to 30 m. Common to locally dominant at MBO, NGA; rare at RON (seedlings only), SAG, VUR, YAL.

Newtonia buchananii (Baker) Gilb. & Bout. T 1078
Tree to 25 m. Dominant at SAG, common in parts of MBO, NGA; rare at CHA.

148. PAPILIONACEAE

Amphicarpa africana (Hook. f.) Harms DH 4288, T 117
Twining herb in forest edges. Occasional at VUR, YAL.

Antopetitia abyssinica A. Rich. T 110
Annual herb of forest clearing; locally common at VUR.

Craibia ? zimmermannii (Harms) Dunn F 71/970, T 877
Tree to 25 m. Common at MBO, NGA; rare at CHA, SAG (young ones only). Taitas are the only Kenyan locality; R.B. Faden believes that this is not true *zimmermannii*, as the calyx is hairy. Flowers and fruit will be necessary to identify this species properly; it might be a new taxon.

Crotalaria axillaris Ait. T 188
Shrub to 2.5 m in forest margin. Occasional at NGA.

Crotalaria lukwangulensis Harms DH 4358, T 129
Climber to 4 m in forest edges. Rare at MBO, NGA, VUR. Endemic to Taitas and Tanzanian mountain forests.

Crotalaria natalitia Meissn. var. *rutshuruensis* De Wild. DH 4300, T 883
Woody herb to 1.5 m in forest margins. 1 seen at CHA, locally common at YAL.

Dalbergia lactea Baker Hildebrandt 2439, T 425
Climbing shrub to 2 m. Occasional at MBO, NGA, and in 1877 at SAG.

Desmodium repandum Harms Napier 1112, T 132
Perennial herb to 80 cm in forest edges. Common at MBO, NGA, VUR, Wesu.

Eriosema montanum Bak. f. Hildebrandt 2445, T 907
Scrambling herb to 1 m in forest edges. Rare at MBO, YAL and in 1877 at SAG.

Eriosema sp. (= Plaizier 1335) T 837
Woody herb to 1.5 m in forest edges. Occasional at CHA.

Indigofera arrecta A. Rich. T 123
Woody herb to 1 m. Locally common at VUR.

Indigofera atriceps Hook. f. ssp. *kaessneri* (Bak. f.) Gillett Napier 1087, T 124
Woody herb to 2 m. Occasional at VUR, in 1931 at Wesu.

Kotschya africana Endl. var. *bequaertii* (De Wild.) Verdc. T 885
Woody herb to 50 cm in forest edges. Occasional at CHA.

Kotschya aeschynomenoides (Bak.) Dewit & Duvign. DH 4328
Shrub. NGA (1953).

Millettia oblata Dunn ssp. *teitensis* Gillett Dale FD 3781, T 872
Tree to 23 m. Occasional at CHA, MBO, NGA, RON, YAL; in 1937 at Wesu, in 1966 at Wundanyi. Endemic to the Taitas.

Vigna parkeri Bak. ssp. *maranguensis* (Taub.) Verdc. Napier 1110, T 32
Twining herb. Rare at Wesu.
Vigna unguiculata (L.) Walp. ssp. *dekindtiana* (Harms) Verdc. T 841
Scrambling herb. 2 seen in forest edge at CHA.
Unidentified climber at MBO T 1004

159 MYRICACEAE
Myrica salicifolia A. Rich. Gardner 2947, T 79
Tree, either in or outside forest. Occasional to locally common at MWA, MBO, NGA, SAG, YAL. In 1932 "very common all over the hills" (Gardner).

165. ULMACEAE
Celtis africana Burm. f. T 528
Tree to at least 7 m. Occasional at NGA.
Celtis gomphophylla Bak. F 71/58, T *
Tree in small sacred forest patch S of Mbololo (altitude 1200 m); also at lower edge of MBO.
Trema orientalis (L.) Blume T 398, 940
Tree to 10 m in disturbed forest. Uncommon at MBO, NGA, SAG, YAL.

167. MORACEAE
Dorstenia brownii Rendle F 70/224, T 763
Herb along stream; local at MBO. Rare in Kenya.
Dorstenia denticulata Peter F 70/483
Herb. CHA.
Dorstenia sp. T 765
Herb near stream. Locally common at MBO. Presumed to be a new species.
Ficus exasperata Vahl Bally 8773, T 805
Tree to 16 m in riverine forest. 1 seen at MWA, in 1953 at Wesu, 1 in small sacred forest patch S of Mbololo.
Ficus sur Forssk. F 71/217, T 902
Tree to 25 m. Uncommon at MBO, NGA.
Ficus thonningii Blume T 15, 337
Tree to 15 m. Locally common at MBO, NGA, YAL, Wesu.

169. URTICACEAE
Elatostema orientale Engl. Gillett et al. 17165, T 773
Herb along forest streams. Locally common at MBO, NGA.
Pilea johnstonii Oliv. T 41
Fleshy herb on seepage area. Locally common at Wesu.
Pilea rivularis Wedd. T 348
Herb near forest stream. Locally common at NGA.
Pilea cf. usambarensis Engl. Dale 7119, F 72/275
Herb. MBO, YAL (in 1953) and Mwangozi forest (Dale, in 1937, locality not traced).
Pilea veronicifolia Engl. Verdcourt & Polhill 2723, T 98
Fleshy herb in disturbed forest. Locally common at VUR; NGA (1969).
Pouzolzia parasitica (Forssk.) Schweinf. T 13
Woody and/or fleshy herb to 2 m in relict forest patches. Locally common at Wesu.
Urera hypselodendron Wedd. T 200
Fleshy shrub or climber to 1.5 m in forest edges. Rare at CHA, NGA, locally common at VUR.

171. AQUIFOLIACEAE
Ilex mitis (L.) Radlk. var. *mitis* F 71/976, T 1102
Tree to 20 m. Occasional at SAG, frequent at MBO.

173. CELASTRACEAE
Elaeodendron buchananii (Loes.) Loes. T 544
One sapling seen at NGA north.
Hippocratea goetzei Loes. F 71/1011, T 474
Liana of forest (edges). Occasional at CHA, MBO, NGA.
Maytenus acuminata (L.f.) Loes. DH 4357, F 71/52
Shrub to 9 or tree to 20 m; rare at MBO, NGA.

Maytenus senegalensis (Lam.) Excll — T122
Tree to 6 m. Common at VUR.

Maytenus sp. — T 508, 1089
Shrub or tree. Rare at NGA, SAG.

Mystroxylon aethiopicum (Thunb.) Loes. — T 543
Tree to 25 m in remnant forest patches. 2 seen at NGA.

179. ICACINACEAE

Apodytes dimidiata Arn. var. acutifolia (A. Rich.) Boutique — T 840, 1113
Tree to 6 m in forest margin. Rare at CHA.

182. OLACACEAE

Strombosia scheffleri Engl. — DH 4354, T 233
Tree to 25 m. Common at MBO, NGA, SAG, occasional at CHA, RON.

183. OPILIACEAE

Opilia amentacea Roxb. — T 559
Twiner. Rare at NGA north.

185. LORANTHACEAE

Englerina sp. cf. near kagehensis (Engl.) Balle — F 71/999
Hemi-parasite. Rare at RON.

Erianthemum dregei (Eckl. & Zeyh.) van Tieghem — F 70/516, T 336
Hemi-parasite in forest remnant. 1 seen at NGA.

190. RHAMNACEAE

Gouania longispicata Engl. — Gardner FD 2979, T 1063
Canopy liana. Rare at MBO, NGA.

Maesopsis eminii Engl. — T *
1 seen at NGA, in forest edge; but this species is cultivated at Mwabirwa, and the NGA tree was probably bird-dispersed.

193. VITACEAE

Cissus oliveri (Engl.) Gilg — DH 4382, T 800
Climber in forest edges. Occasional at CHA, MBO, MWA, NGA.

Cyphostemma braunii Gilg & Brandt — T 1081
Climber to 8 m. Occasional at SAG. New record for Kenya; formerly only known from the Usambaras.

Cyphostemma nodiglandulosum (Th. Fr. jr.) Desc. — T 160
Trailing herb with discolorous leaves. 1 seen at VUR.

Cyphostemma sp. — T 521, 556, 396
Climber at NGA north and MBO (2 spp.?)

194. RUTACEAE

Clausena anisata (Willd.) Benth. — T 263
Shrub in forest edge. Occasional at MBO, NGA.

Diphasiopsis fadenii Kokw. — Joana CM 9032, T 575
Tree to 10 m. Occasional at MBO, rare at NGA north. Endemic to Kenya (Taita-Taveta Distr.).

Fagaropsis angolensis (Engl.) Dale — F 72/209
Tree. Rare at NGA.

Teclea nobilis Del. — T 464
Tree to 8 m. Occasional at MBO, NGA.

Teclea simplicifolia (Engl.) Verdc. — T 526
Tree to 5 m. 1 seen at NGA.

Teclea trichocarpa (Engl.) Engl. — T *
Tree. Occasional at NGA north.

Toddalia asiatica (L.) Lam. — T 228, 492
Climber in forest edges. Common at NGA, occasional at CHA, MBO, RON, SAG.

Vepris sp. — T 480, 569
Shrub or tree. NGA, SAG.

195. SIMAROUBACEAE

Brucea antidysenterica JF Mill. — Joana CM 9013, T 163
Shrub to 3 m. Occasional at MBO, VUR. In 1938 found at Wundanyi.

197. MELIACEAE

Ekebergia capensis Sparrm. — F 72/207, T 881
Tree to 20 m. Rare to occasional at CHA, MBO, NGA.

Lepidotrichilia volkensii (Guerke) Leroy — DH 4324, T 399
Tree to 8 m. Rare to occasional at CHA, MBO, NGA, YAL, Wesu.

Turraea holstii Guerke — F 69/880, T 1111
Shrub or tree to 6 m. Occasional at CHA, MBO, NGA, YAL.

Turraea robusta Guerke — T 532
Tree to 12 m. Common at NGA north.

198. SAPINDACEAE

Allophylus abyssinicus Radlk. — F 71/262a, T 501
Tree to 15 m. Common at CHA, MBO, NGA.

Allophylus ferrugineus Taub. — T 573
Shrub, 1.2 m. Occasional at NGA north.

Allophylus "rubifolius group" of FTEA typescript — T 522
Large liana. 1 seen at NGA-north.

Blighia unijugata Bak. — F 71/59
Tree. Only in small sacred forest patch near MBO, alt. 1200 m.

Dodonaea viscosa Jacq. — T *
Shrub of secondary forest edges. Rare at MBO.

Filicium decipiens (Wight & Arn.) Thw. — T 802, 1182
Tree of riverine/swamp forest. Occasional at MWA, RON. Rare in Kenya.

Haplocoelum foliolosum (Hiern) Bullock — F 72/202, T 517
Tree to 12 m. Frquent at NGA north.

202. MELIANTHACEAE

Bersama abyssinica Fres. ssp. *abyssinica* var. *abyssinica/holstii* — T 555
One sapling seen at NGA north.

205. ANACARDIACEAE

Sorindeia madagascariensis DC. — F 71/1012, T 880
Tree to 15 m. Rare at CHA, MBO, NGA.

206. CONNARACEAE

Agelaea heterophylla Gilg — Bally 8783, T 1014
Shrub or climber. Occasional at CHA, MBO, MWA and in 1953 at Ngerenyi.

Jaundea pinnata (P. Beauv.) Schellenb. — DH 4337, 4375, T *
Climber. Rare at CHA (in 1953), MBO, NGA, SAG.

212. ARALIACEAE

Cussonia spicata Thunb. — T *
Tree of forest edges. Occasional at CHA, MBO, MWA, NGA, SAG, YAL.

Polyscias fulva (Hiern) Harms — DH 4378, T 264
Canopy tree. Frequent at MBO, NGA; occasional at CHA. Rare in Kenya.

Polyscias stuhlmannii Harms *var. stuhlmannii* — Gardner FD 2922, T 461
Tree to 25 m. Common at MBO, NGA. Endemic to Taitas, Usambaras and Ulugurus.

Schefflera myriantha (Bak.) Drake — Gardner FD 2931, T 140
Epiphyte or tree. Occasional at CHA, MBO, NGA, SAG, VUR, YAL. Rare in Kenya.

213. UMBELLIFERAE

Caucalis incognita Norman — T 477
Herb in forest edge. Occasional at NGA.

Heteromorpha trifoliolata (Wendl.) Eckl. & Zeyh. — T 394
Shrub to 2 m in forest edge. Rare at MBO.

Peucedanum linderi Norman — T 155
Herb to 3 m in secondary forest. Common at VUR.

Sanicula elata G. Don — F 71/246, T 99
Herb to 30 cm in secondary forest. Common at MBO, VUR.

215. ERICACEAE

Agauria salicifolia (Lam.) Oliv. — Joana CM 9091, T 1177
Tree to 9 m in disturbed forest. Occasional at MBO, MWA, RON, VUR, Wesu.

Philippia pallidiflora Engl. ssp. *usambarensis* (Alm. & Th. Fr. jr.) Ross — Joana CM 8874, T 107
Tree to 6 m in rocky forest edges. Uncommon at MWA, Wesu, YAL, common at NGA, locally dominant at VUR. Also in 1941 at Susu.

221. EBENACEAE

Diospyros abyssinica (Hiern) F. White — T 241
Tree to 8 m. 2 seen at NGA, 1 seen at CHA.

222. SAPOTACEAE

Aningeria adolfi-friedericii (Engl.) Robyns & Gilbert ssp. cf. *usambarensis* Hemsley — F 71/237, T 225
Canopy tree. Occasional at MBO, NGA, rare at SAG. Endemic to Taitas and Usambaras.

Bequaertiodendron natalense (Sond.) Heine & Hemsley — F 70/570, T 1005
Tree to 12 m. Occasional at MBO, NGA.

Chrysophyllum gorungosanum Engl. — DH 4364, T 287
Tree to 30 m. Frequent at MBO, NGA.

223. MYRSINACEAE

Maesa lanceolata Forssk. — Joana CM 8784, T 50
Tree to 12 m in light forest. Common at CHA, MBO, NGA, VUR, Wesu, YAL; in 1938 at Wundanyi; rare at SAG.

Rapanea melanophloeos (L.) Mez. — F 70/575, T 1172
Tree to 25 m. Occasional at CHA, MBO, MWA, NGA, RON, SAG.

228. LOGANIACEAE

Anthocleista grandiflora Gilg — F 70/521, T 1171
Tree to 12 m in swamp forest or forest edge. Common at MWA, RON; a few near the stream at MBO.

Buddleia pulchella NE Br. — DH 4327, T 465
Climber to 10 m in forest edge. Frequent at NGA. Only Kenyan locality.

Mostuea brunonis Didr. var. *brunonis* — Bally 8720
Shrub to 1 m. SAG, in 1953.

Nuxia congesta Fres. — Kabuye 82/81, T 104
Tree to 20 m in disturbed forest. Common at VUR, rare at Wesu, NGA, SAG.

Nuxia floribunda Benth. — Dale 3783, T 909
Tree to 10 m in forest edge. Rare at CHA, MBO, NGA, SAG, Wesu, YAL. Taitas and Ngulia are the only Kenyan localities.

Strychnos henningsii Gilg — F 71/974, T 785
Tree to 20 m. Frequent at MBO.

Strychnos cf. mitis S. Moore — F 70/723, T *
Tree to 12 m. Rare at MBO.

229. OLEACEAE

Chionanthus mildbraedii (Gilg & Schellenb.) Steam — T 382
Tree to 6 m. 1 seen at MBO. Rare in Kenya.

230. APOCYNACEAE

Acokanthera oppositifolia (Lam.) Codd — Joana CM 8902, T 305
Shrub to 2.5 m in forest edges. Occasional at NGA; in 1934 and 1953 at SAG.

cf. Baissea sp. — T 512
Large liana in forest edge. Locally common at NGA.

Landolphia buchananii (Hall. f.) Stapf — T 509, Beentje 2192
Large liana. Common at CHA, MBO, NGA; rare at SAG.

cf. Pleiocarpa sp. — F 69/881, T 217
Shrub to 6 m. Occasional at CHA, MBO, NGA.

Rauvolfia mannii Stapf — Joana CM 8793, T 354
Shrub to 2 m in disturbed forest. Occasional at CHA, MBO, NGA, RON, SAG. In 1939 at Wundanyi.

Tabernaemontana stapfiana Britten — DH 4368, T 325
Canopy tree. Common at CHA, MBO, NGA; occasional at SAG.

231. ASCLEPIADACEAE

Ceropegia sp. — Joana CM 8988, F 72/277
Twiner. Rare at MBO.

Pentarrhinum cf. insipidum E. Mey. — T 1048
Climber to 7 m. Rare at NGA.

Secamone punctulata Decne. — T 563, 1012
Woody twiner in forest margins. Rare at MBO, NGA.

Secamone sp. — T 552
Woody climber in forest margins. 1 seen at NGA.

Tacazzea galaetogoga Bullock — T 339
Woody twiner in forest edges, 1 seen at NGA.

cf. Tylophora sp. — T 594
Twiner. Occasional at NGA.

Unidentified — T 820
Woody climber. Occasional at NGA.

232. RUBIACEAE

Anthospermum herbaceum L.f. var. *herbaceum* — DH 4302, T 136
Herb to 2 m. Locally common at VUR.

Aulacocalyx diervillioides (K. Schum.) Petit — F 71/982, T 209
Tree to 12 m. Occasional at CHA, MBO, NGA.

Canthium oligocarpum Hiern ssp. *friesiorum* (Robyns) Bridson — T 253
Tree to 7 m. Occasional at MBO, NGA.

Chassalia discolor K. Schum. ssp. *teitensis* Verdc. — Joana CM 9086, T 363
Shrub to 2.5 m. Common at MBO, NGA; 1 seen at CHA; in 1937 found in Mwangoji forest (not traced) by Dale. Endemic to Taita Hills.

Chassalia parviflora K. Schum. — Gillett et al. 17146, F 71/107
Shrub to 2 m. Common at MBO, NGA; rare at CHA, SAG.

Coffea fadenii Bridson — F 70/559, T 342
Tree to 10 m. Locally common at MBO, rare at NGA. Endemic to Taita Hills.

Cremaspora triflora (Thonn.) K. Schum. ssp. *triflora* — T 803, 1173
Weak shrub to 2.5 m. 2 seen at RON, occasional at MWA; also found in Msau River valley. Taitas are the only Kenyan locality.

Galiniera coffaeoides Del. — T 150, 919
Shrub or tree to 5 m. Occasional at VUR, YAL.

Galium brenanii Ehrend. & Verdc. — Verdcourt & Polhill 2732, T 94
Scrambling herb. Frequent at VUR. Endemic to Taitas and Tanzanian Eastern Arc forests.

Galium spurium L. ssp. *africanum* Verdc. — T 10
Prostate herb at forest edge on rock. Wesu.

Keetia gueinzii (Sond.) Bridson — DH 4384, T 385
Shrub to 2.5 m (although T 385 is a tree to 15 m). Common at CHA, MBO, NGA, RON, SAG. In 1953 in relict forest below NGA.

Lasianthus kilimandscharicus K. Schum. ssp. *kilimandscharicus* — F 71/983, T 955
Shrub to 5.5 m. Occasional at NGA, rare at MBO.

Mitragyne rubrostipulata (K. Schum.) Havil. — F 71/241, T 770
Tree to 30 m near forest stream. 1 seen at MBO. Rare in Kenya.

Oxyanthus speciosus DC. ssp. *stenocarpus* (K. Schum.) Bridson — T 240, 893
Shrub or tree to 6 m. Rare at CHA, common at NGA.

Oxyanthus goetzei K. Schum. ssp. *keniensis* Bridson — T 551
2 saplings seen at NGA north. Rare in Kenya.

Pauridiantha paucinervis (Hiern) Brem. ssp. *holstii* (K. Schum.) Verdc. — Joana CM 9030, T 213
Shrub to 6 m. Abundant at MBO, NGA, SAG; occasional at MWA, RON.

Pavetta crebrifolia Hiern — T 887
Shrub to 3 m. Occasional at CHA.

Pavetta sp. — T 1122
Shrub. Rare at MBO.

Pentas hindsioides K. Schum. var. *hindsioides* — Dale FD 3813, T 1009
Woody herb to 1.5 m in forest edges. Occasional at MBO, NGA; locally common at YAL. Endemic to Taitas, Kasigau, Pare Mts. and Usambaras.

Pentas lanceolata (Forssk.) Deflers ssp. *quartiniana* (A. Rich.) Verdc. var. *nemorosa* (Chiov.) Verdc. — T 828, 1064
Herb to 80 cm. Locally common at CHA, SAG.

- ssp. *lanceolata* var. *lanceolata* — Beentje 2133
Shrub to 1 m in forest margin. Rare at NGA.

Pentas pubiflora S. Moore ssp. *pubiflora* — T 11, 549
Woody herb to 1.2 m in clearings in the drier forest parts. Common at NGA north, Wesu.

Pentas schimperana (A. Rich.) Vatke ssp. *schimperana* — T 911, 953
Herb to 75 cm. Rare at MBO, YAL.

Pentas zanzibarica (Klotzsch) Vatke var. *zanzibarica* — Bally 8707, T 114
Herb to 1 m. Common at VUR, occasional at SAG.

Psychotria alsophila K. Schum. — T 519, Beentje 2191
Shrub to 1.5 m. Rare at NGA north. Endemic to Taitas and Tanzanian mountain forests.

Psychotria crassipetala Petit — DH 4336, T 207
Shrub or tree to 12 m. Common at MBO, NGA; rare at CHA. Endemic to Taita Hills.

Psychotria lauracea (K. Schum.) Petit — Dale 3851, T 998
Shrub to 3 m. Occasional at CHA, NGA; 1 seen at Wesu; in 1937 at Susu.

Psychotria petitii Verdc. — Dale FD 3815, T 210
Tree to 10 m. Common at MBO, SAG, NGA, VUR. Endemic to Taita Hills.

Psychotria sp. aff. petitii — F 72/256, T 166
Shrub or small tree. Rare at VUR. Although Verdcourt believes this to be *P. petitii*, we think it might be a new species, because of the aberrant fruits.

Psychotria pseudoplatyphylla Petit — Dale 3816, T 207
Shrub or tree to 4 m. Common at MBO, NGA; also between Wundanyi and Magamenyi; rare at CHA. Endemic to Eastern Arc forests.

Psychotria riparia (K. Schum. & K. Krause) Petit var. *riparia* — T *
Tree; 1 seen at MWA.

Psychotria sp. B. of FTEA — F 72/211
Shrub to 1.2 m. NGA. Endemic to NGA; feared to be extinct.

Psychotria sp. — T 165
Shrub or tree. Occasional at VUR.

Psychotria sp. — T 1074
Shrub. Rare at SAG. Possibly =*P. petitii*..

Psydrax parviflora (Afz.) Bridson ssp. *rubricostata* (Robyns) Bridson — Gillett et al. 17115, T 888
Shrub or tree to 12 m. Occasional at CHA, MBO, NGA.

Rytigynia eickii (K. Schum. & K. Krause) Bullock — F 77/335, T 334
Tree to 13 m. Occasional at NGA (more common at NGA north).

Rytigynia uhligii (K. Schum. & K. Krause) Verdc. — Dale 1999, T 1118
Shrub or tree to 7 (13) m. Common at Wesu, occasional at CHA, MBO, NGA; rare at SAG, VUR, YAL, and relict forest at Wundanyi.

Spermacoce princeae (K. Schum.) Verdc. var. *princeae* — T 111, 434
Herb in forest edge. Rare at MBO, VUR.

Tricalysia ovalifolia Hiern var. *glabrata* (Oliv.) Brenan — T 523
Shrub or tree to 4 m. Common at CHA, NGA north.

Vangueria volkensii K. Schum. var. *volkensii* — DH 4376, T 577
Shrub or tree to 3 m in forest edges. Rare at CHA, NGA north.

Vangueria sp. — T 567
Sapling; 1 seen at NGA north.

Unidentified: shrub at NGA — T 900
shrub at YAL — T 922
Shrub at SAG (?*Psychotria*) — T 1074
Shrub at MBO (?*Coffea*) — T 1180

238. COMPOSITAE

Adenostemma mauritianum DC. — Napier 1117, T 954
Annual herb to 1.5 m in forest edges. Occasional at MBO, NGA; in 1937 on Susu, in 1931 at Wesu.

Anisopappus oliveranus Willd. — Kabuye 82/79, T 439
Scrambling herb to 1 m in forest edges. Rare at MBO, YAL, Wundanyi.

Bidens taitensis Scherff — Beentje 2136, T 14
Herb to 1.2 m in secondary forest. Common at MBO, NGA, VUR, Wesu.

Blumea brevipes Oliv. & Hiern — T 440
Woody herb of forest edges. Rare at MBO.

Crassocephalum mannii (Hook. f.) Milne-Redh. — Beentje 2140, T 20
Shrub or tree to 8 m in disturbed forest. Common at MBO, Wesu. Rare at CHA, NGA, YAL.

Microglossa cf. pyrifolia (Lam.) Kuntze — DH 4313, T 158
Herb to 1 m in secondary forest. Rare at VUR; in 1953 at YAL.

Senecio cf. mirabilis Muschler — F 70/712, 71/986a
Succulent epiphyte. Frequent at MBO. Endemic to Usambaras and Taitas.

Senecio syringifolius O. Hoffm. — T 134, 1110
Succulent climber in forest edges. Occasional at CHA, NGA, SAG, VUR.

Vernonia auriculifera Hiern — T 330
Shrub to 5 m in forest margins. Common at NGA, YAL.

Vernonia holstii O. Hoffm. — T 1101
Shrub to 2.5 m in forest edges. Common at SAG.

Vernonia jugalis Oliv. & Hoffm. — T 144
Shrub to 2 m in secondary forest. Occasional at VUR.

Vernonia usambarensis O. Hoffm. — T 490
Woody herb to 1.5 m in forest edges. Common at NGA north.

Vernonia sp. — T 329
Shrub to 3 m. NGA.

Vernonia sp. aff. urticifolia A. Rich. =Mori 18 — T 786
Scandent shrub to 3 m. Rare at MBO.

244. LOBELIACEAE

Lobelia gibberoa Hemsl. — Bally 8757, T 88
Monocarpic herb to 5 m in forest edges. Common at VUR, occasional at NGA.

249. BORAGINACEAE

Ehretia cymosa Thonn. var. *sylvatica* (Guerke) Brenan — T 564, 855
Tree to 20 m. Occasional at CHA, MBO, NGA.

Paracynoglossum geometricum (Baker & Wright) R. Mill. — DH 4315, T 118
Herb in forest edges. Occasional at NGA, VUR; in 1953 at YAL.

250. SOLANACEAE

Solanum aculeatissimum Jacq. — T 413
Woody herb in forest edges. Occasional at MBO.

Solanum giganteum Jacq. — T 376
Shrub to 2 m. 1 small group at MBO.

Solanum indicum L. ssp. *keniense* Turrill — T 45, 1108
Shrub to 2 m in forest edges. Rare at CHA, NGA, Wesu.

Solanum schumannianum Dammer — Joana CM 8757, T 128
Shrub to 3 m in secondary forest. Rare at CHA, NGA, VUR, in 1953 at YAL, in 1938 at Wundanyi.

Solanum terminale Forssk. — Napier 1132, T 857
Climbing shrub to 4 m. Rare at CHA, NGA.

251. CONVULVULACEAE

Ipomoea involucrata Beauv. — Gillett et al. 17096, T 120
Twiner in secondary forest. Rare at VUR. Rare in Kenya.

Ipomoea wightii (Wall.) Choisy var. *kilimandscharica* (Dammer) Verdc. — T 845
Climber in forest margin. Rare at CHA.

252. SCROPHULARIACEAE

Alectra sessiliflora (Vahl) Kuntze var. *monticola* (Engl.) Melch. — T 356, 1003
Herb to 50 cm in forest edges. Locally common at MBO; rare at YAL.

Veronica abyssinica Fres. — T 109
Creeping herb in secondeary forest. Locally common at VUR.

256. GESNERIACEAE

Saintpaulia teitensis BL Burtt — Joana CM 8982, T 766
Herb on rocks in deep forest, less often on treetrunks or terrestrial. Locally common at MBO; endemic to MBO.

Streptocarpus caulescens Vatke — DH 4295, T 4
Epiphytic herb. Occasional to locally common at CHA, CHO, MBO, NGA, SAG, VUR, in 1953 at YAL. Endemic to Kenya.

Streptocarpus glandulosissimus Engl. — Joana CM 8997, Bally 13513
Epiphytic or epilithic herb. Occasional at MBO.

Streptocarpus kirkii JD Hooker — Bally 13605, T 360
Epiphytic herb. Occasional at CHA, MBO, SAG. Taitas are the only Kenyan locality.

Streptocarpus montanus Oliv. — Joana CM 9044, Bally 13603
Epilithic or epiphytic herb. Occasional to locally common at MBO, NGA, SAG, VUR, YAL. Rare in Kenya.

259. ACANTHACEAE

Crossandra friesiorum Mildbr. — T 996
Creeping herb. Locally common in disturbed forest on Mraru E ridge (MBO)

Crossandra tridentata Lindau — Joana CM 9067, T 191
Woody herb to 1 m. Frequent at MBO, NGA.

Isoglossa gregorii (S. Moore) Lindau — DH 4311, T 112
Herb to 40 cm in secondary forest. Occasional at VUR, YAL.

Isoglossa lactea Lindau — Napier 1118, T 871
Herb to 1 m in forest edges. Common at CHA; in 1931 at Wesu.

Isoglossa laxa Oliv. — Bally 8771, T 349
Herb to 70 cm in forest stream. Locally common at NGA.

Isoglossa substrobilina CB Cl. — T 298
Herb to 30 cm in forest edges. Rare at NGA.

Justicia pseudorungia Lindau — F 71/260, T 530
Woody herb to 1.5 m. Rare at NGA north, SAG. Rare in Kenya.

Phaulopsis imbricata (Forssk.) Sweet — T 999
Prostate herb in forest edges. Locally common at MBO.

Thunbergia alata Sims — F 69/856, T 255
Twining herb of forest edges. Occasional at NGA.

263. VERBENACEAE

Clerodendrum capitatum (Schum.) Thonn. var. *cephalanthum* Oliv. — T 359
Shrub to 1.2 m near forest streams. Locally common at MBO.

Clerodendrum johnstonii Oliv. — Joana CM 8789, T 505
Shrub or climber in forest edges. Common at NGA; in 1938 at Wundanyi.

Clerodendrum sp. — F 71/218. 71/229
Rare at MBO.

Lippia ukambensis Lindau — T 223
Shrub to 2 m in forest edges. Occasional at NGA.

Vitex keniensis Turrill — T 466
Tree to 20 m. Occasional at NGA.

Vitex strickeri Vatke & Hildebrandt — T 515, 1106
Shrub to 4 m. Rare at CHA, NGA north.

264. LABIATAE

Aeollanthus densiflorus Ryding — DH 4389, T 300
Succulent, semi-prostate herb in rock crevices. Locally common at NGA.

Plectranthus laxiflorus Benth. — Napier 1133, T 20
Succulent herb to 1.5 m of forest edges. Common at CHA, NGA, VUR, YAL, Wesu.

Plectranthus longipes Bak. — T 367
Semi-prostate herb. Rare at MBO.

Plectranthus cf. sereti De Wild. — DH 4338, T 222
Herb to 30 cm. Common at MBO, NGA, especially along paths. If the identity is correct, this is a new record for Kenya.

Plectranthus sp. — T 12
Herb to 1.3 m of disturbed forest. Common at Wesu.

Solenostemon sylvaticus (Guerke) Agnew — DH 4312, T 135
Herb in secondary forest. Occasional at VUR, in 1953 at YAL.

Stachys aculeolata Hook. f. — DH 4325, T 137
Creeping herb in secondary forest. Occasional at VUR, in 1953 at YAL.
Unidentified, "*Coleus sp.*" — DH 4305

ANGIOSPERMAE: MONOCOTYLEDONES

280. COMMELINACEAE

Aneilema aequinoctiale (P. Beauv.) Loudon — F 69/839, T 245
Scrambling herb. Occasional at CHA, MBO, MWA, NGA, SAG, Wesu.
Aneilema leiocaule K. Schum. — F 70/485, T 904
Herb, usually near streams. Occasional at CHA, NGA, VUR, YAL.
Commelina benghalensis L. — T *
Scrambling herb of forest edges; abundant at Wesu.

287. MUSACEAE

Ensete ventricosum (Welw.) Cheesm. — T 456
Wild banana. Locally common at CHA, MBO, NGA, VUR; rare at SAG.

290. ZINGIBERACEAE

Aframomum angustifolium (Sonn.) K. Schum. — Bally 8799, F 71/1001
Herb of swampy places. Common at MWA, RON.

293. LILIACEAE

Asparagus asparagoides (L.) Wight — Joana CM 9024, T 103
Herbaceous climber to 6 m. Common at MBO, NGA, VUR; in 1953 at YAL.
Asparagus falcatus L. — T *
Scrambling herb. Occasional at MBO, NGA north.
*Asparagus setaceus (*Kunth) Jessop — T 211, 436
Twiner. Occasional at MBO, NGA.
Chlorophytum comosum (Thunb.) Jacq. — F 70/750
Herb. Rare at MBO.
Chlorophytum limurense Rendle — DH 4335, T 949
Herb. Frequent at MBO, NGA.
Chlorophytum sparsiflorum Bak. — T 198
Herb. Occasional at MBO, NGA.
Dracaena afromontana Mildbr. — T 1130
Tree to 3 m in forest edge. Rare at VUR.
Dracaena laxissima Engl. — Beentje 2149, T 1076
Shrub to 4 m. Occasional at MBO, NGA; abundant at SAG.
Dracaena steudneri Engl. var. *kilimandscharica* Engl. — T 199, 915
Shrub or tree to 5 m. Frequent at CHA, MBO, NGA; one clump at YAL.

297. SMILACACEAE

Smilax kraussiana Meisn. — Gardner 1207
Climber; collected in "forest" in 1941 (presumably Ngangao).

302. ARACEAE

Culcasia falcifolia Engl. — Joana CM 8774, T 260
Climbing herb. Common at CHA, MBO, NGA, Wundanyi.

303. LEMNACEAE

Wolffia arrhiza (L.) Horkel — T 1052
Tiny aquatic, covering 50 % of a pool at NGA. Rare in Kenya.

306. AMARYLLIDACEAE

Scadoxus multiflorus (Martyn) Raf. ssp. *multiflorus* — F 71/216, T 48
Scapose herb. Occasional to locally common at CHA, MBO, NGA, Wesu.

311. DIOSCOREACEAE

Dioscorea asteriscus Burkill — T 1098
Climber to 5 m. Rare at SAG.

314. PALMAE

Phoenix reclinata Jacq. DH 4369, F 71/242
Tree to 10 m in disturbed forest sites. Frequent at MBO, NGA, RON, SAG; in 1953 at CHA.

323. BURMANNIACEAE

Gymnosiphon usambaricus Engl. Bally 8747, T 484
Saprophytic herb in moist sites. Rare at MBO, NGA, SAG. Endemic to Taitas, Kasigau, and Tanzanian mountain forests.

326. ORCHIDACEAE

Angraecum cf. sacciferum Lindl. F 72/205, T 457
High epiphyte. 2 seen at NGA. Rare in Kenya.

Bulbophyllum intertextum Lindl. F 70/778, 72/263
Low epiphyte. Locally common at MBO.

Calanthe sylvatica (Thou.) Lindl. F 71/293, T 764
Terrestrial near streams. Locally common at MBO.

Cheirostylis lepida (Reichb. f.) Rolfe F 70/545
MBO.

Cynorkis sp. T 1196
Terrestrial at forest edge. Rare at MBO.

Disperis nemorosa Rendle Dale 3790, Beentje 2184
Small terrestrial at forest edge. Locally common at NGA; in 1937 at Mwangoji (locality unknown).

Eulophia streptopetalum Lindl. F 72/203, Beentje 2185
Terrestrial at forest edge. Rare at NGA.

Platylepis glandulosa (Lindl.) Reichb. f. F 70/522a, 72/258
MWA. First records for Kenya.

Polystachya albescens Ridl. F 72/254
Epiphyte. Rare at VUR. First record for Kenya.

Polystachya caespitifica Kraenzl ssp. *latilabris* (Summerh.) Cribb & Podzorsky F 70/776, 71/57a
Epiphyte. Rare at MBO.

Polystachya cultriformis (Thou.) Spreng. DH 4388, T 494
Epiphyte. Rare at MBO.

Polystachya lindblomii Schltr. F 70/777
Epiphyte. Rare at MBO, SAG. Rare in Kenya.

Polystachya spatella Kraenzl. T 195
Epiphyte. 1 seen at NGA.

Polystachya transvaalensis Schltr. F 70/774, T 947
Low or high epiphyte. Rare at MBO, frequent at VUR.

Polystachya sp. DH 4386
No data. CHA anno 1953.

Polystachya sp. T 1181
Epiphyte. Rare at MBO.

Stolzia repens (Rolfe) Summerh. F 71/57b, T 1020
Epiphyte. Locally common at CHA, MBO.

Tridactyle cruciformis Summerh. F 70/568, 71/46
Pendent epiphyte. Common at MBO. Endemic to Kenya and NE Tanzania.

Ypsilopus sp. F 70/567, 71/971
Probably a new species. Rare at MBO.

331. CYPERACEAE

Carex castanostachya K. Schum. F 70/736
Tufted perennial. Rare at MBO. Endemic to Taita Hills and N Tanzanian mountain forests.

Cyperus maranguensis K. Schum. T 431, 585
Tufted perennial to 1 m, in forest margins. Rare at MBO, NGA.

Cyperus pseudoleptocladus Kuk. var. *polycarpus* Kuk. T 429
Tufted perennial to 1.5 m in forest clearings. Locally common at MBO.

Mariscus sp. Kabuye 82/52, T 18
Tufted perennial to 1 m. Rare at Wesu.

332. GRAMINEAE

Digitaria pearsonii Stapf — T 19
Grass. Rare at Wesu.

Ehrharta erecta Lam. var. *abyssinica* (Hochst.) Pilg. — T 572
Pathside grass. Locally common at NGA north.

Hyparrhenia cymbaria (L.) Stapf — T 939
Partly decumbent grass to 3 m. Rare at YAL.

Isachne mauritiana Kunth — Beentje 2131, T 1105
Straggling grass. Rare at CHA, common at MBO, NGA.

Melinia minutiflora P. Beauv. — Bally 8581, T 1179
Decumbent perennial in forest margins. Locally common at MBO.

Oplismenus undulatifolius (Ard.) Roem. & Schult. — T 231
Decumbent perennial. Common at NGA, occasional at MBO, SAG. Rare in Kenya.

Panicum calvum Stapf — T 102
Grass of forest edges. Rare at VUR.

Panicum trichocladum K. Schum. — T 17, 441
Decumbent grass. Occasional at MBO, Wesu.

Pennisetum trachyphyllum Pilg. — T 890, 941
Perennial to 3 m of wet sites. Occasional at CHA, YAL.

Pseudechinolaena polystachya (Kunth) Stapf — T 351, 442
Decumbent matforming grass of disturbed sites. Locally common at MBO, NGA.

Pseudobromus sylvaticus (Kunth) Stapf — T 234, 558
Tufted perennial. Common at NGA.

Setaria plicatilis (Hochst.) Engl. — Beentje 2132, T 574
Tufted perennial of disturbed sites. Locally common at NGA.

Setaria poiretiana (Schult.) Kunth — Bally 13618
Tufted perennial to 2 m. Common at NGA.

Sporobolus natalensis (Steud.) Th. Dur. & Schinz — T 265
Tufted perennial of forest margins. Locally common at NGA.

INDEX TO GENERA OF THE CHECKLIST

Acalypha 51
Acokanthera 56
Acridocarpus 51
Adenostemma 58
Aeollanthus 60
Aframomum 61
Agauria 56
Agelaea 55
Albizia 52
Alectra 59
Allophylus 55
Amauropelta 45
Amphicarpa 52
Aneilema 61
Angraecum 62
Aningeria 56
Anisopappus 58
Anthocleista 56
Anthospermum 57
Antopetitia 52
Aphloia 49
Apodytes 54
Arachnoides 45
Argomuellera 51
Athropteris 45
Asparagus 61
Asplenium 46
Alaucocalyx 57

Baissea 56
Basella 49
Begonia 50
Bequaertiodendron 56
Bersama 55
Bidens 59
Blechnum 56
Blighia 45
Blotiella 44
Blumea 59
Brucea 55
Buddleia 56
Bulbophyllum 62

Calanthe 62
Canthium 57
Cardamine 48
Carex 62
Cassia 52
Caucalis 55
Celosia 49
Celtis 53
Ceropegia 57
Chassalia 57
Cheilanthes 44
Cheirostylis 62
Chionanthus 56
Chlorophytum 61
Christella 46
Chrysophyllum 56
Cissampelos 48
Cissus 54
Clausena 54
Clematis 48
Clerodendrum 60
Clutia 51
Coccinia 60
Coffea 57
Cola 61
Commelina 61
Craibia 52
Crassocephalum 59
Crassula 49
Cremaspora 57
Crossandra 60
Crotalaria 52
Croton 61
Ctenitis 45
Cryptocarya 48
Culcasia 61
Cussonia 55
Cyathea 45
Cyclosorus 46
Cynometra 52
Cynorkis 62
Cyperus 62
Cyphostemma 54

Dalbergia 52
Dasylepis 49
Desmodium 52
Dichapetalum 52
Dicranolepis 49
Dicranopteris 44
Didymochlaena 45
Digitaria 63
Dioscorea 61
Diospyros 56
Diphasiopsis 54
Diplazium 46
Disperis 62
Dodonaea 55
Dombeya 51
Dorstenia 53
Doryopteris 45
Dovyalis 50
Dracaena 61
Drymaria 49
Dryoathyrium 46
Dryopteris 45
Drypetes 51

Ehretia 59
Ehrharta 63
Ekebergia 55
Elaeodendron 53
Elaphoglossum 45
Elatostema 53
Englerina 54
Ensete 61
Erianthemum 54
Eriosema 52
Erythroxylon 51
Eulophia 62
Euphorbia 51

Fagaropsis 54
Filicium 55
Ficus 53

Galiniera 57
Galium 57
Garcinia 51
Geranium 49
Gerrardanthus 50
Gouania 54
Grammitis 47
Gymnosiphon 62

Haplocoelum 55
Heteromorpha 55
Hippocratea 53
Hymenophyllum 44
Hyparrhenia 63
Hypolepis 43

Ilex 53

Impatiens 49
Indigofera 52
Ipomoea 59
Isachne 63
Isoglossa 60

Jaundea 55
Justicia 60

Keetia 57
Kotschya 52

Landolphia 56
Lasianthus 57
Lepidotrichilia 55
Leptonychia 61
Lippia 51
Lobelia 59
Lomariopsis 45
Loxogramme 47
Lycopodium 43

Macaranga 51
Maesa 56
Maesopsis 54
Marattia 44
Margaritaria 51
Mariscus 62
Maytenus 53
Melinia 63
Memecylon 50
Microglossa 59
Millettia 52
Mitragyna 57
Mohria 44
Momordica 50
Mostuea 56
Myrica 53
Mystroxylon 54

Neoboutonia 51
Newtonia 52
Nuxia 56

Ochna 50
Ocotea 48
Ophioglossum 44
Opilia 54
Oplismenus 63
Oreosyce 50
Osmunda 44
Ouratea 50
Oxyanthus 57

Panicum 63
Paracynoglossum 59
Passiflora 50
Pauridiantha 57
Pavetta 57
Pavonia 51
Pellaea 45
Pennisetum 63
Pentarrhinum 57
Pentas 48
Peperomia 48
Peponium 50
Peucedanum 55
Phaulopsis 60
Philippia 56
Phoenix 62
Phytolacca 49
Pilea 53
Piper 48
Platylepis 62
Plectranthus 60
Pleiocarpa 56
Pleopeltis 47
Pneumatopteris 46
Podocarpus 48
Polyscias 56
Polystachya 62
Polystichum 45
Pouzolzia 53
Prunus 52
Pseudechinolaena 63
Pseudobromus 63
Pseudocyclosorus 46
Pseudophegopteris 46
Psychotria 58
Psydrax 58
Pteridium 44
Pteris 45

Rapanea 56
Rauvolfia 56
Rhipsalis 50
Rinorea 49
Ritchiea 48
Rubus 52
Rytigynia 58

Saintpaulia 60
Sanicula 56
Scadoxus 61
Schefflera 55
Secamone 57
Selaginella 53
Senecio 49
Setaria 63
Sida 51
Smilax 61
Solanum 59
Solenostemon 60
Sorindeia 55
Spermacoce 58
Sporobolus 63
Stachys 61
Stegnogramma 46
Stolzia 62
Streptocarpus 60
Strombosia 54
Strychnos 56
Syzygium 50

Tabernaemontana 57
Tacazzea 57
Teclea 54
Tectaria 45
Thalictrum 48
Thunbergia 60
Tiliacora 48
Toddalia 54
Trema 53
Tricalysia 58
Trichomanes 44
Tridactyle 62
Trimeria 50
Turraea 55
Tylophora 57

Urera 53
Uvaria 48

Vangueria 58
Vepris 54
Vernonia 59
Veronica 59
Vigna 53
Viola 49
Vitex 60
Vittaria 47

Wolffia 61
Xiphopteris 47
Xymalos 48
Ypsilopus 62
Zehneria 50
Zimmermannia 51

INDEX TO FAMILIES

Acanthaceae 60
Adianthaceae 44
Amaranthaceae 49
Amaryllidaceae 61
Anacardiaceae 55
Annonaceae 48
Apocynaceae 56
Aquifoliaceae 53
Araceae 61
Araliaceae 55
Asclepiadaceae 57
Aspidiaceae 45
Aspleniaceae 46
Athyriaceae 46

Basellaceae 49
Begoniaceae 50
Blechnaceae 46
Boraginaceae 59
Burmanniaceae 62

Cactaceae 50
Caesalpiniaceae 52
Capparaceae 48
Caryophyllaceae 49
Celastraceae 53
Commelinaceae 61
Compositae 58
Connaraceae 55
Convulvulaceae 59
Crassulaceae 49
Cruciferae 48
Cucurbitaceae 50
Cyatheaceae 45
Cyperaceae 62

Davalliaceae 45
Dennstaedtiaceae 44
Dichapetalaceae 52
Dioscoreaceae 61

Ebenaceae 56
Ericaceae 56
Erythroxylaceae 51
Euphorbiaceae 51

Flacourtiaceae 49

Geraniaceae 49
Gesneriaceae 60
Gleicheniaceae 44
Gramineae 63
Grammitidaceae 47
Guttiferae 51

Hymenophyllaceae 44

Icacinaceae 54

Labiatae 60
Lauraceae 48
Lemnaceae 61
Liliaceae 61
Lobeliaceae 59
Loganiaceae 56
Lomariopsidaceae 45
Loranthaceae 54
Lycopodiaceae 43

Malvaceae 51
Marattiaceae 44
Melastomataceae 50
Meliaceae 55
Melianthaceae 55
Menispermaceae 48
Mimosaceae 52
Monimiaceae 48
Moraceae 53
Musaceae 61
Myricaceae 53
Myrsinaceae 56
Myrtaceae 50

Ochnaceae 50
Olacaceae 54
Oleaceae 56
Ophioglossidaceae 44
Opiliaceae 54
Orchidaceae 62
Osmundaceae 44

Palmae 62
Papilionaceae 52
Passifloraceae 50
Phytolaccaceae 49
Piperaceae 48
Podocarpaceae 48
Polypodiaceae 47

Ranunculaceae 48
Rhamnaceae 54
Rosaceae 52
Rubiaceae 57
Rutaceae 54

Sapindaceae 55
Sapotaceae 56
Schizeaceae 44
Scrophulariaceae 59
Selaginellaceae 43
Simaroubaceae 55
Smilacaceae 61
Solanaceae 59
Sterculiaceae 51

Thelypteridaceae 45
Thymeleaceae 49

Ulmaceae 53
Umbelliferae 55
Urticaceae 53

Verbenaceae 60
Violaceae 49
Vitaceae 54
Vittariaceae 47

Zingiberaceae 61

NOTES FROM THE EAST AFRICAN HERBARIUM # 1

A 17 MYR FOSSIL *CANARIUM* ENDOCARP FROM LAKE TURKANA REGION, KENYA

C.H.S. KABUYE

Abstract

A record is made of a *Canarium* sp. (Burseraceae) from a silicified endocarp collected from the Lothidok Range, west of Lake Turkana.

Introduction

Dr. Frank Brown, a geologist from the University of Utah working in the Lothidok Range (03º 21'N 34º48' E) collected a number of plant fossils at a site northwest of the Lodwar-Lokwa Kangole road. Among these was a fossil which has been identified as an endocarp of a *Canarium* sp. (Burseraceae). It bears the accession number KNMP-LS 19159 and has been dated between 16.5 and 17.5 myr.

Fossil description

The endocarp is ovoid-lanceolate in outline, 4.3 cm long and 1.9 cm wide, has its widest point just below the middle, is trigonous in cross-section with a weaker longitudinal line between the thick obtuse angles; both ends are bluntly pointed, with a small, triangular hole at the apex. Part of the lid on one of the three sides is broken away in a way typical of Canarium endocarps. See **Fig. 1**.

Discussion

The genus *Canarium* comprises, according to Gillett (in prep.) 77 species in high rainfall areas in the old world tropics. It is commonest in Southeast Asia and New Guinea; two species, *C. schweinfurthii* and *C. madagascariense*, occur in continental Africa and Madagascar. *C. schweinfurthii*, the incense tree, is the commonest, extending from Senegal to southern Sudan and south to Angola and Zambia; its habitat is closed forest, especially along lakes, while in drier areas it occurs near rivers. *C. madagascariense* occurs in coastal Tanzania and Mozambique, as well as in Madagascar, in forest remnants and river valleys. Both species require an annual rainfall between 900 and 1400 mm.

The endocarp of *C. schweinfurthii* is 3-4 cm long and 1.3-1.6 cm across, with its greatest width at a third of its length from the base. It is 3-angled with quite sharp angles and has ridges between the angles almost as prominent as the angles. In *C. madagascariense* the endocarp is ca. 3.5 cm long and 1.8 cm wide, with its greatest width at a third of its length from the base; its angles are more or less flat or even sunken, each angle has branching from it, on each side a weak longitudinal ridge arising about 9 mm from the base. The median ridges between the angles are not prominent.

The fossil under discussion does not match either of the two African species. It will be necessary to study the extra-African species to see whether it belongs to one of these, or whether it is an extinct African species.

Since nearly all species of *Canarium* are deciduous trees found in river valleys, swamp forest or closed forest

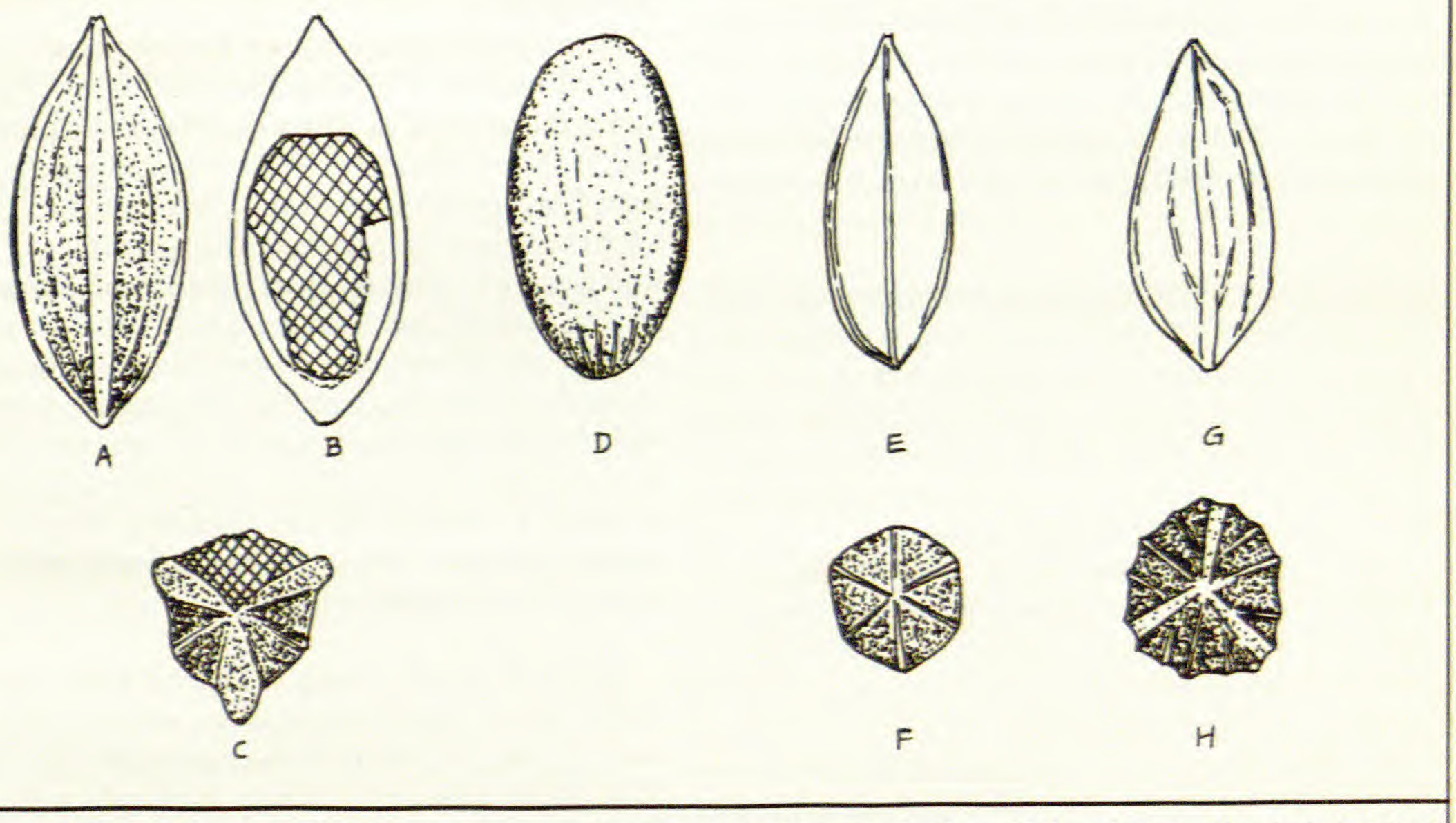


Figure 1. A-C KNMP-LS 19159. A: side view; B: side view, lid partly broken; C: basal view. Matrix is hatched.
D-F *Canarina schweinfurthii*. D: fruit; E: endocarp, side view; F: endocarp, basal view.
G-H *Canarina madagascariense*. G: endocarp, side view; H: endocarp, basal view.

(Leenhouts 1959, Gillett in prep.), it can be surmised that the area near Lake Turkana where the fossil was found was much moister 17 million years ago than it is today.

REFERENCES

Gillett, J.B. (in prep.) Burseraceae. Flora of Tropical East Africa.

Leenhouts, P.W. (1959). Revision of the Burseraceae of the Malaysia area in a wider sense X, a: *Canarium*. In *Blumea* 9: 275-475.

NEW RECORDS OF RARE KENYAN PLANTS 1

Q. LUKE

ANNONACEAE

Isolona cauliflora Verdc.

This species, previously known only from the Usambaras, was in fact found in the Shimba Hills, Mwele Mdogo Forest as early as 1953 (*Templer 1*) but not determined as such until recently. Usually a thin understorey tree to 8 m, its red/orange flowers appear on long whippy branches, normally from the base of the trunk, trailing along the forest floor and often buried in the leaf litter. Good fruit collections have now been obtained and its distribution area was found to extend north to Mangea Hill at 500 m.

KENYA. Kwale District: Shimba Hills, Makadara Forest, "evergreen forest" at 400 m, 16 Sept. 1982, *Polhill 4782* (EA, K) "petals bronzy red"; same locality (picnic site) "evergreen forest on deep red sand", 26 Dec. 1982, *J.B. Gillett & S.A. Robertson 23.997* (EA) "fruit ellipsoid, syncarpellous, many-seeded, dark blackish green, corrugated with prominent veins, ca. 5 x 3.5 cm; seeds irregularly arranged, fattened ovoid, 10 x 9 x 1.6 mm; some fruits on branches 2 m above ground level".

Kilifi District: Mangea Hill, "evergreen forest of *Julbernardia, Inhambanella, Cynometra*" at 500 m, 25 Feb. 1987, *Luke & Robertson 278* (EA, K) "tree 2.5 m, stem 7 cm dia. at base, fruiting branch from base with red/pink fruit 10 cm in dia".

Lettowianthus sp. of Verdcourt in F.T.E.A. Annonaceae (1971) p. 28.

This unnamed species known from the Usambaras and one collection in 1953 from Shimba Hills, Mwele Mdogo Forest (*Drummond & Hemsley 3974*) has recently been collected from Mkongoni North Forest, where three trees were found growing together. Verdcourt in FTEA hesitated to combine collections of this taxon from T3 and K7 with those of *L. stellatus* Diels from T6 and T8 since only fruiting material had been collected of the former. His descriptions of both taxa do not differ significantly for vegetative and fruiting material, other than the constriction of the fruit between seeds in the dried state, since shown to be unreliable (*Vollesen 3325*). It is most likely that *L. sp.* is indeed *L. stellatus* though flowering material is still needed to be sure. This tree is rare in Kenya and endemic to the Kenya/Tanzania region.

KENYA. Kwale District: Shimba Hills, Mkongani North, "forest- *Diospyros, Drypetes, Mimusops, Combretum*", 14 July 1987, *Luke & Robertson 532* (EA, K) "tree 13 m; dense light green foliage. Bark pale yellow/grey. Fruit ellipsoid, green speckled white, purple when ripe, ca 2 x 1.5 cm, glabrous, on stipes to 3 cm, in almost globose clusters of ca. 20 from a peduncle to 2 cm on old wood".

DILLENIACEAE

Tetracera littoralis Gilg

This attractive scandent shrub or climber, endemic to the Kenya/Tanzania region, was previously only known in K7 from the Arabuko-Sokoke forest. Hawthorne in 1981 apparently identified this species at Kaya Jibana, but this collection is not at EA. This species has now been found in a number of localities and is probably far more common in our coastal vegetation than first thought.

KENYA. Kilifi District: near Kaya Jibana, edge of cultivation at ca 200 m, 10 Feb. 1987, *Luke & Robertson 189* (EA, K, MO); near Cha Simba, road to N. Chonyi Chief's office, at ca 220 m, 11 Feb. 1987, *Luke & Robertson 191a*; Mangea Hill, edge of *Julbernardia, Inhambanella, Cynometra* forest, at 500 m, 19 July 1987, *Luke & Robertson 665*.

Kwale District: Shimba Hills, Mkongani North forest, *Diospyros, Drypetes, Mimusops, Combretum* at 280 m, 14 July 1987, *Luke & Robertson 529*.

FLACOURTIACEAE

Casaeria gladiiformis Mast.

This tree, fairly widely distributed in countries south of Kenya, has only been recently recorded from K7. The few collections from Kenya have been in K3 and K5.

KENYA. Kwale District: Shimba Hills, road entering Mwele Mdogo forest, in wooded grassland with *Antidesma, Hirtella, Apodytes* at 360 m, 18 Feb. 1987, *Luke & Robertson 240* (EA, K, MO), "tree 5 m, long slightly zig-zag drooping branches. Fruits bright orange from cushions"; Shimba Hills, Mkongani North forest, "with *Diospyros, Drypetes, Mimusops, Combretum*" at 280 m, 13 July 1987, *Luke & Robertson 511*.

TILIACEAE

Christiana africana DC.

The presence of this predominantly West African tree in Tanzania was reported by Verdcourt in Kew Bull. 17: 501 (1964). It has recently been found in two localities in Kenya. It is worth noting that the collection from the Shimba Hills matches typical *C. africana*, as does the T3 material; the two T6 specimens (*Semsei 3370, Luke 724*) however, have fruits which are larger, thicker walled, and are pectinate inside. Further investigation is needed.

KENYA. Kwale District: Kiruku Hill, "small degraded patch of forest on hillside" at 140 m, 14 July 1987, *Luke & Robertson 542*; Shimba Hills, Mwele Mdogo forest, "*Odyendea, Antiaris, Malacantha, Newtonia, Erythrophloeum, Diospyros, Tabernaemontana, Drypetes* forest" at 370 m, 6 Jan. 1988, *Luke 900*, "tree 10 m, local population at beginning of forest".

STERCULIACEAE

Cola uloloma Brenan, Kew Bull. 1: 150 (1956)

Though proving to be a fairly common constituent of coastal forest, this species was not represented in the EA herbarium until recently. A collection from Shimba Hills, Mwele Mdogo (*Drummond & Hemsley 3972*) was mentioned in K.T.S. (1961). An understorey tree to ca 7 m, with leaves with long drip-tips, and older leaves showing yellow. The petioles are uncharacteristic for *Cola*, being short (ca 3 mm) and lacking a pulvinus. Endemic to the T3/K7 region.

KENYA. Kwale District: Muhaka forest; "moist lowland evergreen forest with *Julbernardia, Craibia, Mkilua, Sloetiopsis, Uvariodendron*" at 30-45 m, 2 March 1977, *Faden 77/608* (sterile); Shimba Hills, Longomwagandi at ca 400 m, 29 March 1973, *G.W. Sangai EA 15790* (sterile).

Kilifi District: Kaya Kambe, "semideciduous forest on sandstone" at ca 150 m, 9 July 1987, *Robertson & Luke 4787*, "fruits orange to 2.5 mm"; Pangani, "near stream through limestone rocks" at 80 m, 10 July 1987, *Luke & Robertson 494* (EA, K), "tree 5 m, clean stem and rounded crown. Flowers white/yellow with stellate hairs. Perianth lobes 5, with an opaque fringe becoming very woolly"; Mangea Hill, "*Julbernardia, Inhambanella, Cynometra* forest" at 500 m, 8 April 1987, *Luke & Robertson 307* (EA, K).

Sterculia sp. aff. ***schliebenii*** Mildbr.

Twice collected in the Shimba Hills, this species was previously thought to be closely related to *S. tragacantha*, a West & Central African tree. A new collection from nearby, and further examination of Tanzanian material has led to two unnamed specimens from T8 being identified as *S. schliebenii* (*Gillman 1357* from the type locality, Lake Lutamba, and *Semsei 688*); the Kenyan specimens are very close. At present, however, the lack of sufficient material at the EA herbarium and the T8 distribution, prevent definite identification of the Kenyan material, though it is interesting to note that the distibution of *Gigasiphon macrosiphon* is T8 and K7.

KENYA. Kwale District: Shimba Hills, S of Pengo Hill to Kidongo Gate, at ca 380 m, 8 Nov. 1970, *Faden et al. 70/826*, "tree ca 5 m, several stems, calyx maroon, sessile anthers present below carpel. 1 tree seen"; same locality (presumably same tree), 19 Dec. 1970, *Mahasi EA 14892* (fruits banana-shaped, 8 x 2.5 cm, with blunt acuminate apex of 7 mm long); Mwele Mdogo forest, "with *Odyendea, Antiaris, Malacantha, Newtonia, Erythrophloeum, Diospyros, Drypetes, Tabernaemontana*" at 370 m, 6 Jan. 1988, *Luke 896* (EA, K), "single tree 12 m, at edge of forest. Bark grey flaking on brown, slash pink, watery. Leafless with reddish inflorescences 'tufted' at branch ends, giving a 'pink haze' effect. Calyx green-white inside. Follicles green, tinged purple".

EUPHORBIACEAE

Acalypha echinus Pax & K. Hoffm.

Collected once in riverine forest at Marafa in 1961 (Polhill & Paulo 797) this shrub has now been found in a similar habitat on the lower Tana River. The species is endemic to T3, 6 & K7.

KENYA. Tana R. district: Tana Primate Reserve, at ca 30 m, Nov. 1987, *K. Medley 249, 308*.

Cavacoa aurea (Cavaco) J. Leon.

First collected in East Africa at Kaya Ribe in ?1961 (?*Birch*), this tree has now been collected in two other localities. Only known before from Mozambique and South Africa; this seemingly discontinuous distribution deserves further investigation.

KENYA. Kilifi District: Kaya Jibana, on path leading to the Kaya at 250 m, 10 Feb. 1987, *Robertson & Luke 4500* (EA, K), "shrub, stipules deciduous"; Kaya Kambe, "in semi-deciduous forest on sandstone", at ca 150 m, 9 July 1987, *Robertson & Luke 4800* (EA, K, fruits).

Cleistanthus schlechteri (Pax) Hutch.

A rare tree in Kenya. The typical variety with glabrous fruits has been collected twice in Kwale District *(Faden & Faden 77/737, Graham in F.D. 1652)*. A single tree has now been found with pubescent fruit, and hence is identifiable as var. *pubescens* (Hutch.) J. Leon.

KENYA. Kilifi District: near Gotani, in disturbed dry bushland at 280 m, 12 Feb. 1987, *Luke & Robertson 202*.

MORACEAE

Ficus craterostoma Mildbr. & Burret

This easily recognisable fig with truncate leaf apices has not been recorded from Kenya before. It has now been collected from several localities. *Hawthorne* reports (in MS) collections from Kaya Kambe and Kaya Kivara, but no details are available.

KENYA. Kilifi District: Benyagundo Hill, forest remnant at 280 m, 12 Feb. 1987, *Luke & Robertson 199* (EA, BERG) "epiphyte, 2 m, sterile"; Mangea Hill, degraded forest at ca 500 m, 25 Feb. 1987, *Luke & Robertson 275* (BERG) "tree 10 m, figs in leaf axils, 8 mm, sessile".

Kwale District: Shimba Hills, near lodge at ca 350 m, *Robertson & Luke: sight record.*

CELASTRACEAE

Salacia lehmbachii Loes.

This shrub has been recorded for the first time in Kenya. Its square stems and pendant elongated fruit, almost triangular in cross-section, distinguish it from other members of the genus.

KENYA. Kilifi District: Kaya Jibana, path leading to Kaya at 250 m, *Robertson & Luke 4502* (EA, K)..

A NEW COMBINATION IN *OURATEA* (OCHNACEAE)

H.J. BEENTJE

In the past, *Ouratea* has been split into several genera such as *Campylospermum* Farron and *Cercanthemum* van Tieghem. For the new "Kenya trees, shrubs and lianas" I am reinstating the "old" *Ouratea* names as far as necessary; one species requires a new combination.

Ouratea sacleuxii (van Tieghem) Beentje **comb. nov.**

Cercanthemum sacleuxii van Tieghem, Ann. Sc. Nat. ser. 8 (Bot.), XVI: 308 (1902).

Ouratea sp. of T.T.C.L.: 386 (1949).

Campylospermum sacleuxii (van Tieghem) Farron, B.J.B.B. 35: 401 (1965).

UTAFITI Volume 1 Number 2

JULY 1988

CONTENTS

H.J. Beentje (Ed.) An ecological and floristical study of the forests of the Taita Hills, Kenya **23-66**

Abstract: a survey of the remaining forest patches of the Taita Hills, Taita Taveta District, Kenya was carried out in May-June 1985 by a team of scientists from the National Museums of Kenya. A description of the vegetation is given, as well as a brief treatment of the fauna of the hill forests; rare species and endemics are enumerated. Comparisons are made between the extent of the forest in 1985 and in 1961. A checklist of forest plants is provided, listing the 1985 collections as well as earlier ones.

1. **H.J. Beentje & Ndegwa Ndiang'ui.** Ecology of the forests 23-42
2. **Robert B. Faden, H.J. Beentje & D.O. Nyakundi.** Checklist of the forest plant-species 43-66

NOTES FROM THE EAST AFRICAN HERBARIUM # 1 **67-70**

C.H.S. Kabuye. A 17 myr fossil *Canarium* endocarp from Lake Turkana region, Kenya 67-68
Q. Luke. New records of rare Kenyan plants 1 68-70
H.J. Beentje. A new combination in *Ouratea* (Ochnaceae) 70

UTAFITI is published several times a year, and incorporates original research papers on work carried out at the National Museums of Kenya.
Every major paper is peer-reviewed by professionals from outside the Museums.

Editor Dr. H.J. Beentje

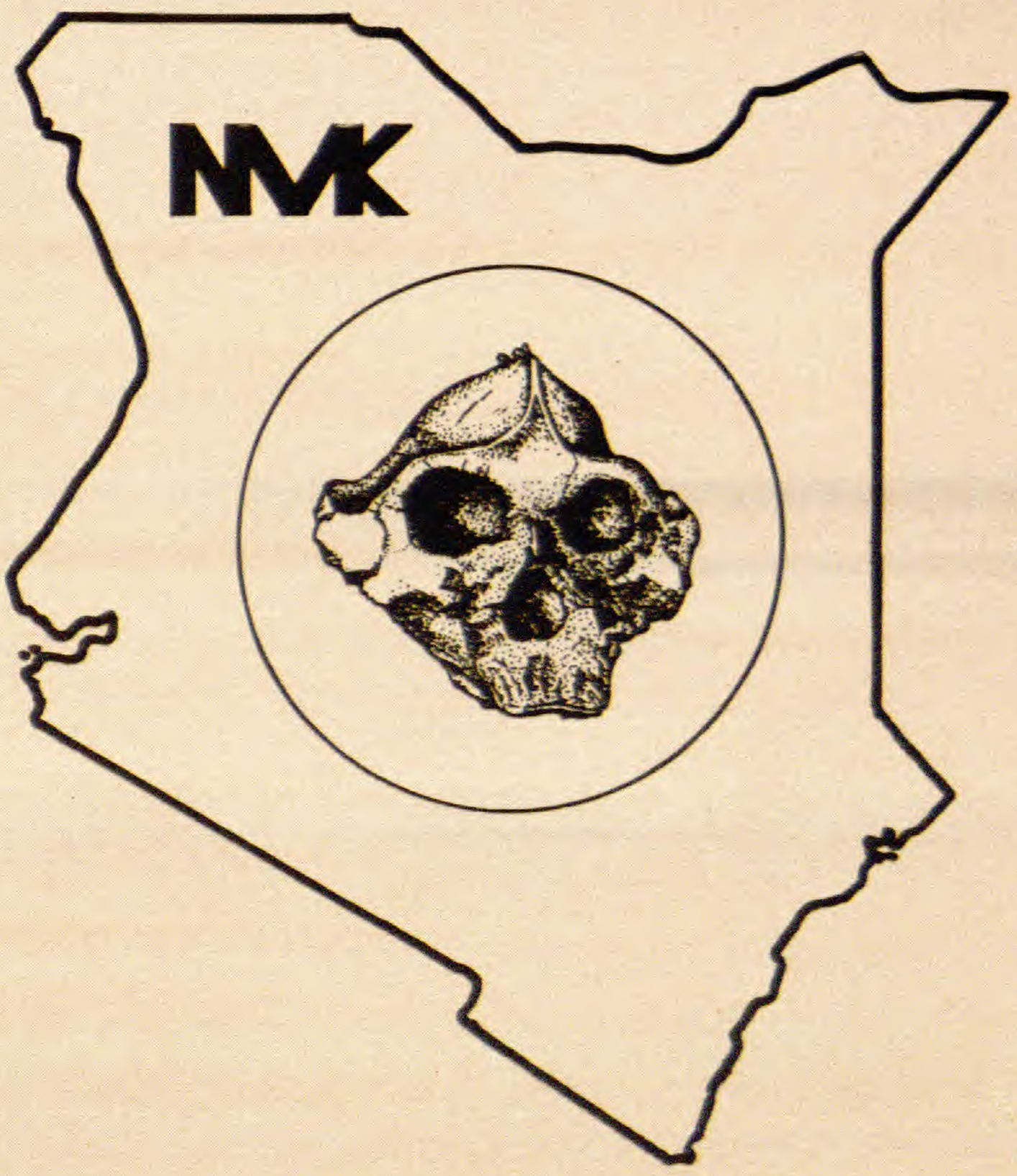
Editorial Committee
Dr. H. Adan
Dr. R. Bagine
Dr. M. Issahakia
Miss C.H.S. Kabuye
Dr. M. Leakey
Mr. A. MacKay
Dr. S. Wandibba

Typesetting and layout by the editor.
Printed by Kenya Litho Ltd., Changamwe Road, P.O. Box 40775, Nairobi.
Produced by the National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya

QK1
.U85

UTAFITI

OCCASIONAL PAPERS OF THE NATIONAL MUSEUMS OF KENYA



NATIONAL MUSEUMS OF KENYA

VOLUME 1 NUMBER 3 NOVEMBER 1988

Atlas of the Rare Trees of Kenya

H.J. Beentje

ECONOMICAL

FEB 22 1989

GARDEN LIBRARY

Abstract

Ninety-two species of globally rare, vulnerable and endangered trees are discussed. Each species is illustrated and accompanied by a distribution dot map.

One-third of all rare species occur in coastal forests. The forests of the Taita Hills and the dry forests of central Kenya are also habitats with large numbers of rare trees.

In an appendix 69 taxa of endemic shrubs and lianas are treated briefly.

Introduction

Why write about rare trees? I believe trees are part of our heritage, and that they should be saved from extinction so that future generations may also enjoy them - whether for pure enjoyment, or to use in various ways. "What is lost is lost, and gone forever"- and they will be gone forever, if nothing is done to save them, since most of them occur in areas where human influence is diminishing their natural habitat. To do something towards saving these trees from extinction, one has to know which trees are rare, where they occur, and in which way they are threatened. This publication is a first step towards such knowledge; other literature about this subject is scanty (Lucas & Synge 1978, Mungai et al. 1979, Beentje 1986).

The ninety-five trees treated here are all rare in a global sense. This means they are rare in Kenya, but also elsewhere. "Rare" means that they occur in small numbers, and in few places.

Tree species that are rare in Kenya, but are not uncommon in other parts of Africa, are not included.

Those trees have been included of which only small numbers, that is less than 20, are preserved at the major herbaria dealing with Kenya (EA and K). If small numbers of collections are from a common habitat (e.g. dry bushland) and the species occurs over a wide area, I have omitted that species, since it is probably undercollected instead of rare.

I have also omitted rare varieties of species, when other varieties of the same species are not rare.

So are these trees really rare? I think so, but I cannot be certain. Only fieldwork can ascertain this. There are areas in Kenya that are not well known botanically: Boni forest in Lamu district, Mandera district, and large parts of the Mau are examples of this. Some trees treated here might be more common in such areas than is known at this moment - and other, as yet unknown, rare trees might occur there.

On the other hand, some species that are represented in our herbaria by more than 20 collections might be rare, either because of the collections are mainly old and the species has become rare in recent years, or because of large numbers of collections made in only a few places. On the whole, I feel that as far as numbers of vulnerable and endangered species are concerned, I am probably not far off; and as far as rare species are concerned, that there are probably quite a few omissions. Field work will have to make this more clear. Coastal field work by Robertson & Luke (see, e.g. Robertson 1987) has been incorporated up to october 1987.

I hope this publication provides baseline knowledge for fieldwork, as well as an incentive to field botanists. Descriptions have been kept to a minimum; many of the species have been described in full in the Flora of Tropical East Africa (FTEA); all species will be treated in the forthcoming "Kenya trees, shrubs and lianas" (Beentje, in prep.).

Status Categories

I have used the categories proposed by IUCN to indicate the degree of threat to individual species in their wild habitats.

- **RARE** -species confined to a restricted geographical area or habitat, or thinly scattered over a more extensive range.
- **VULNERABLE** - species of which most or all populations are decreasing because of overexploitation, extensive destruction of habitat, or other environmental disturbance, and species that are still widespread but are under threat from serious adverse factors throughout their range.
- **ENDANGERED** - species in danger of extinction, whose survival is unlikely if the factors causing their decline continue to operate. Included are species whose numbers have been reduced to a critical level, or whose habitats are so reduced that they are in immediate danger of extinction.
- **EXTINCT** - species which are no longer known to exist after repeated searches of the known localities and other likely places.

Conclusions

Of the 92 tree species treated in this publication, the breakdown into the various categories is as follows:

• Rare	39 species
• Vulnerable	32 species
• Endangered	20 species
• Feared extinct	1 species

The distribution of these rare trees is as follows (numbers in brackets denote species with a category vulnerable or endangered); [numbers in square brackets denote strict endemics, i.e. not occurring anywhere else]

• Coastal forests	32	(25)	[12]
• Taita Hills forests	10	(6)	[7]
• Central Kenya, dry forests	9	(6)	[6]
• Northeast Kenya, dry bushland	10	(2)	[3]
of which on limestone	5	(1)	
• Central Kenya, riverine	5	(4)	[3]
• Central Kenya, moist forest	3	(2)	[3]
• North/central hills	7	(-)	[2]
• Coast, not restricted to forest	10	(1)	
• Coast, littoral thicket	2	(2)	

Of the habitat with the largest number of rare species, the coastal forests, there are several sites with high numbers of rare species:

• Shimba Hills	12	(6)
• Arabuko-Sokoke forest	8	(6)
• Pangani Rocks	7	(7)
• Witu forest	7	(3)
• Cha Simba rocks	6	(6)
• Tana River	5	(2)
• Mangea	3	(2)
• Mrima	3	(3)

I would like to point out that especially Pangani Rocks should be saved as soon as possible: this site is earmarked for quarrying by a (non-Kenyan) company. Six endangered species and one vulnerable species occur here. This small forest is the most endangered site in Kenya today.

I also wish to point out that this publication deals only with rare *trees;* but the occurrence of rare trees is very likely to indicate the occurrence of rare species of shrubs, lianas and herbs as well, and that sites or habitats with many rare trees are very likely to contain many other rare species as well.

Lannea malifolia (Chiov.) Sacleux

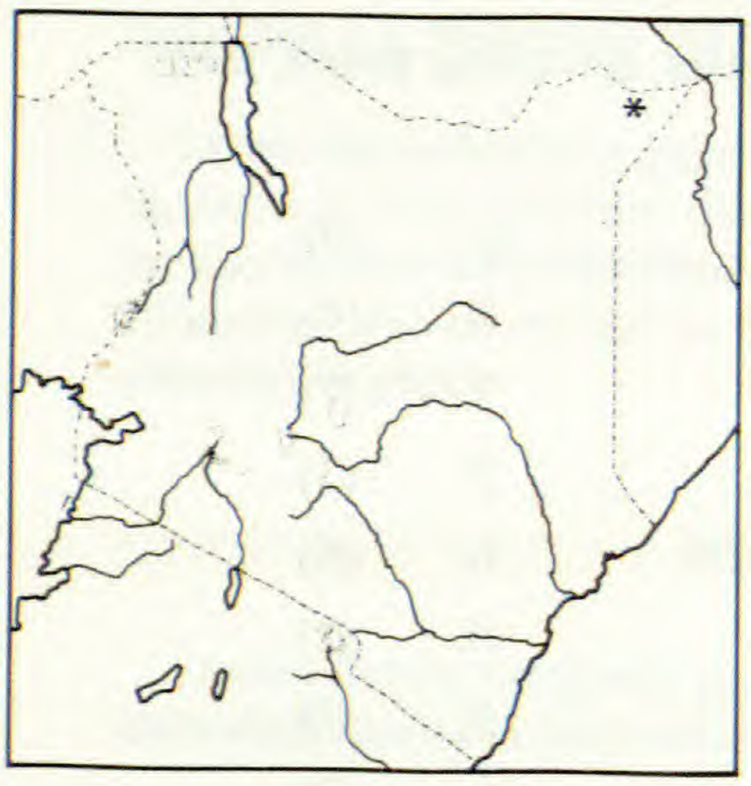
Anacardiaceae

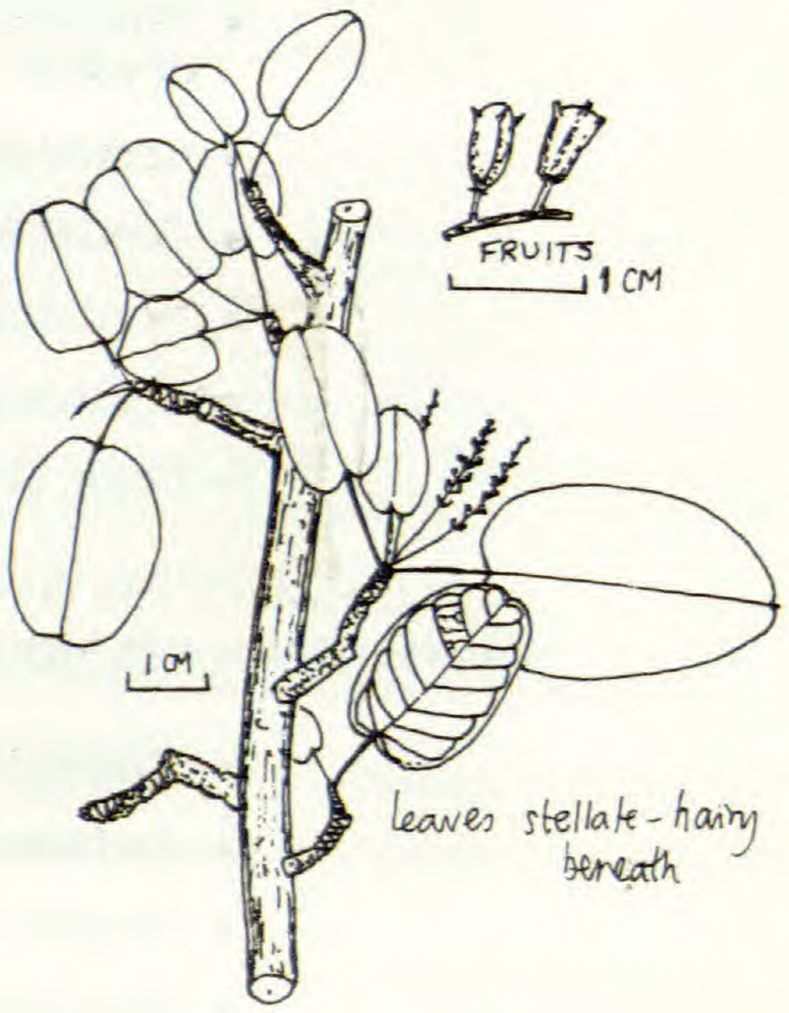
Local Names & Uses: Kobesh / Wa-anrih (Somali)

Distribution: northern Somalia and Ethiopia (Harar area); northeast Kenya(Melka Cumbisa near Rhamu); alt. ca. 240 m.

Habitat: unknown for Kenya; in Somalia on shallow alluvial soils overlaying limestone.

Description: tree, 6-9 m tall, with fissured bark. Leaves 1-7-foliolate. Flowers yellowgreen,to 2.5 mm long; fruits red.





Status:

Rare. No further data.

Sclerocarya gillettii Kokwaro

Anacardiaceae

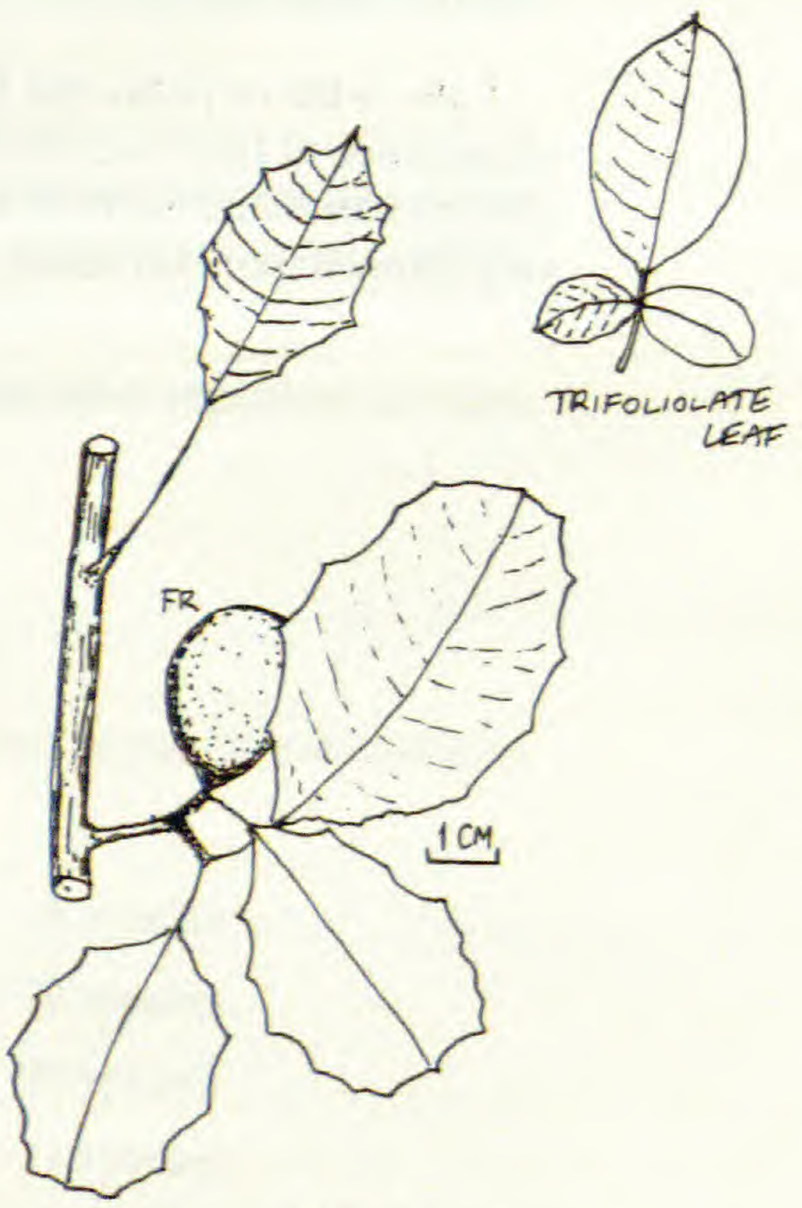
Local Names & Uses: Dananiu (Somali). The fruit is edible.

Distribution: endemic to Kenya.

Habitat: dry *Acacia-Commiphora* bushland with *Boswellia, Jatropha* and *Lannea.* Alt. 150-300 m.

Description: shrub or small tree 2-5 m tall; bark grey, smooth or flaky. Leaves 1-foliolate, occasionally 3-9-foliolate. Male flowers red or cream, to 2.5 mm long; female flowers unknown. Fruit green.





Status:

Rare. No further data.

Isolona cauliflora Verdc.

Annonaceae.

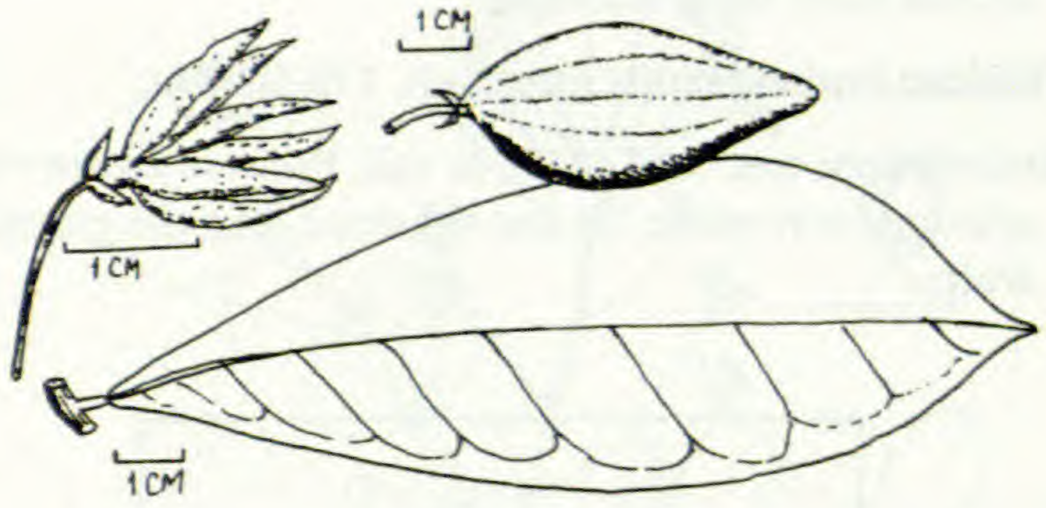
Local Names & Uses: none known.

Distribution: coastal Kenya (Makadara forest, Mangea forest) and coastal Tanzania (East Usambaras, last found in 1926)

Habitat: moist coastal forest; alt. 250-500 m.

Description: tree 3-8 m tall. Flowers and fruits on long, almost leafless stems snaking along the ground among the leaf litter. Flowers red, fruit reddish to black.





Status:

Rare, Vulnerable. This tree seems to occur in very small numbers; and though Makadara forest is part of the Shimba Hills National Reserve, the other population on Mangea is under threat. It is possible that the Tanzanian population is already gone, in which case the Kenyan populations might be considered **Endangered.**

Uvariodendron anisatum Verdc.

Annonaceae

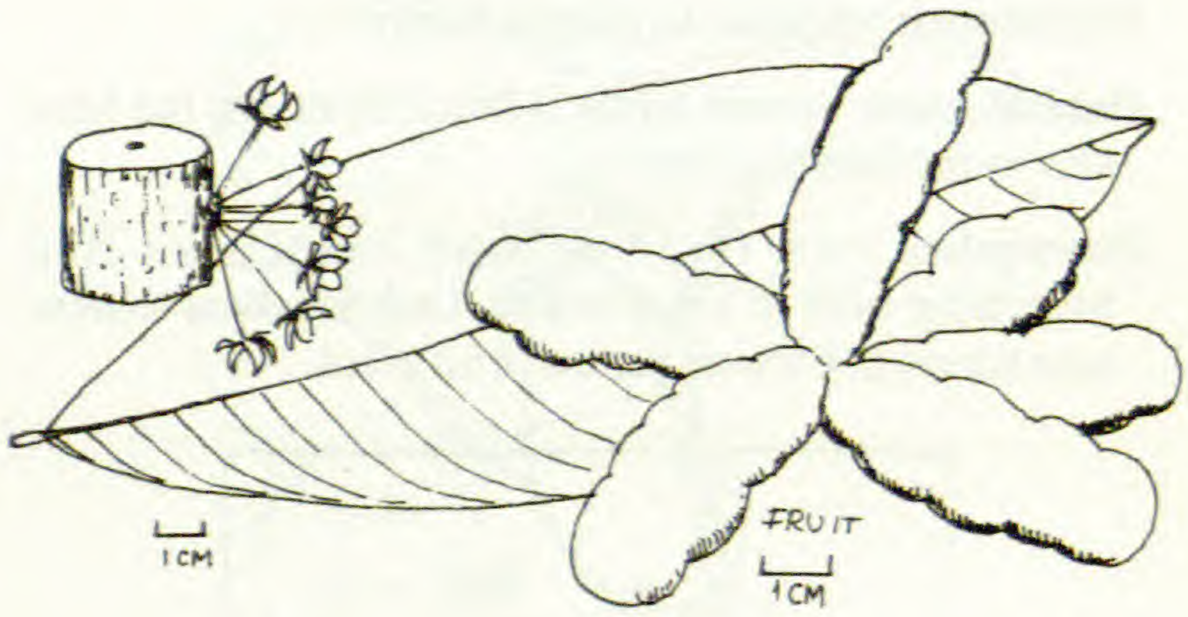
Local Names & Uses: Mutonga (Kikuyu); Mutongu (Meru).

Distribution: endemic to central Kenya (Karura forest, Thika area, Meru forest, Emali forest)

Habitat: dry upland forest; alt. 1190-1800 m.

Description: tree to 9 m tall, most parts smelling of aniseed. Flowers and fruits on old wood or on the trunk. Flowers cream, fruits blueblack.





Status:

Rare. Rather common in Karura, Emali and lower Imenti forests. Most dry upland forests however, including Emali and lower Imenti, are being encroached upon. In the near future this species will become - **Vulnerable.**

Uvariodendron gorgonis Verdc.

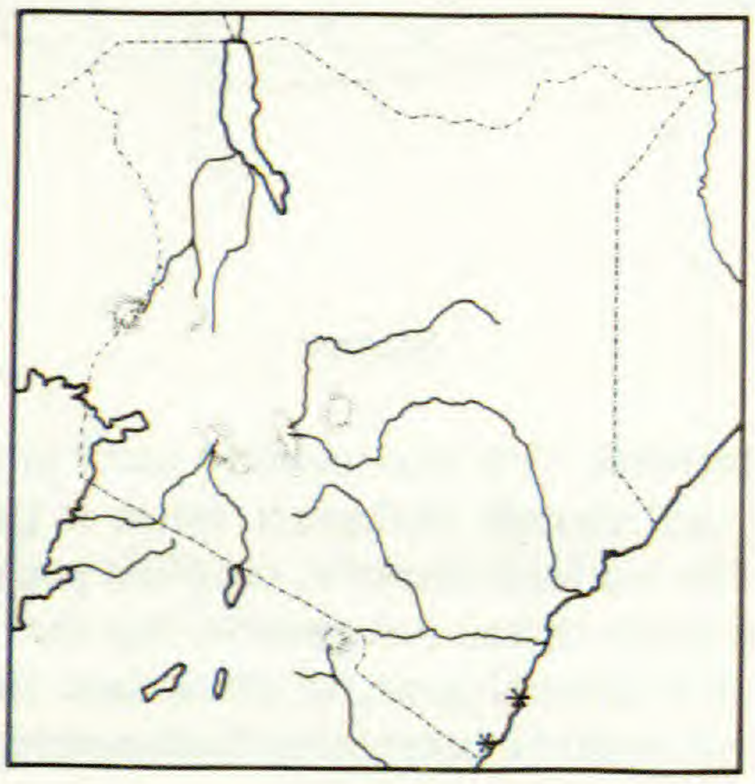
Annonaceae

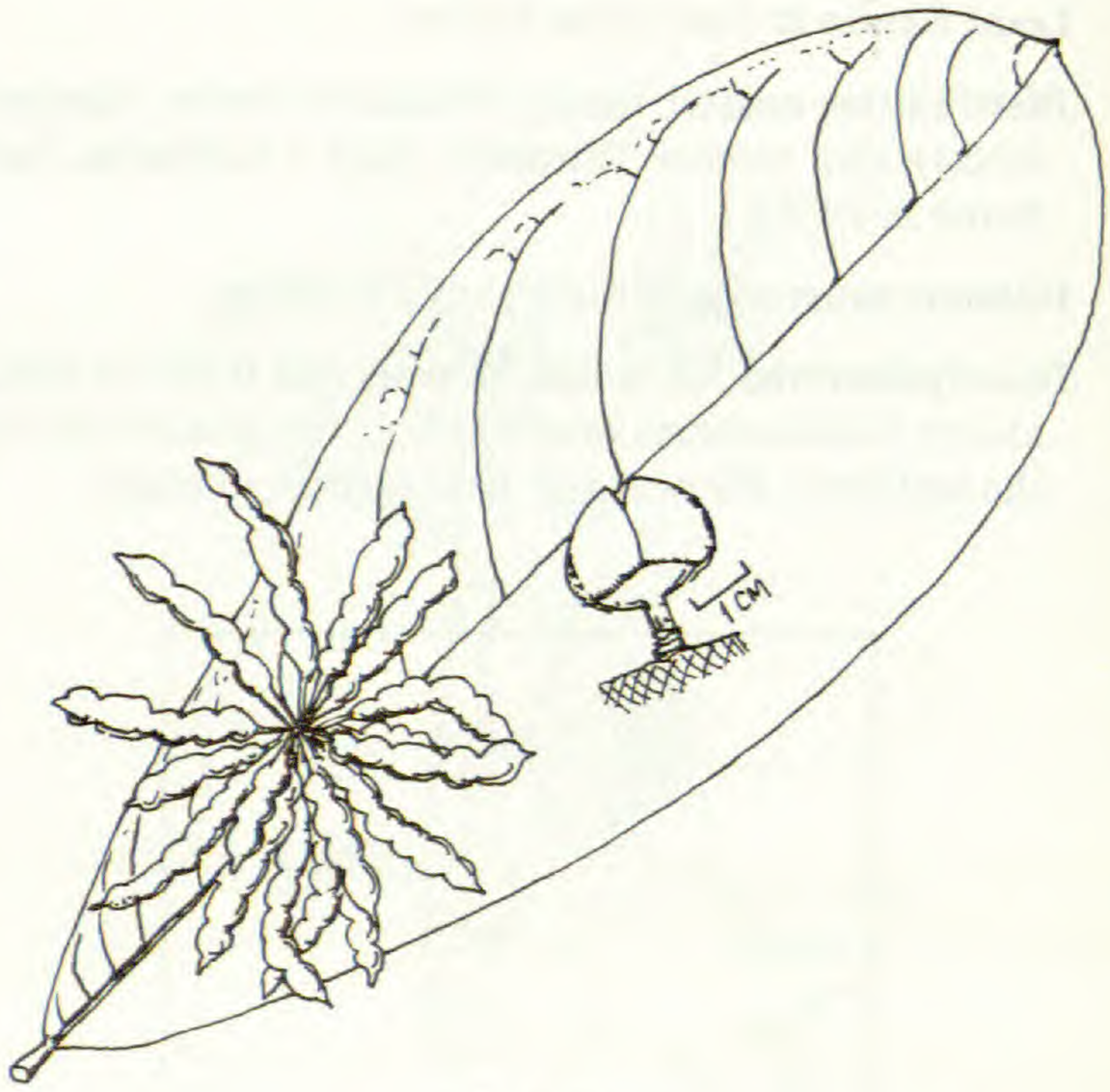
Local Names & Uses: none known.

Distribution: coastal Kenya (Mrima Hill and Pangani rocks) and Tanzania (Uluguru Mountains and one collection from the Usambaras)

Habitat: lowland moist forest; alt. 170-1000 m.

Description: tree 3-12 (27?) m tall. Flowers cream outside, maroon inside, on the old wood, like the greenish fruit.





Status:

Rare, Vulnerable, probably **Endangered**. At least the Kenyan populations of this tree are threatened by immediate destruction.

Polyscias kikuyensis Summerh.

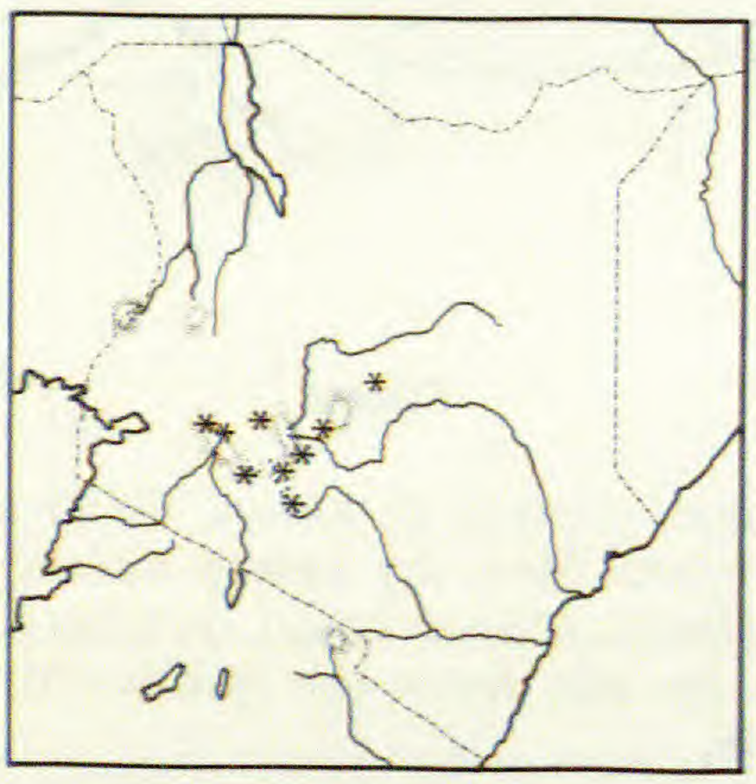
Araliaceae

Local Names & Uses: Mutati (Kikuyu). In the 1930s the timber was used to make butterboxes, as the wood is soft, white, and non-smelly.

Distribution: endemic to central Kenya

Habitat: moist upland forest; 1750-2750 m. On the Mau also in the bamboo zone.

Description: tree 15-24 m, with candelabra-like branching; bole to 1.4 m across. Leaves yellow-tomentose beneath. Flowers yellow, fruit black.





Status:

Rare, probably **Vulnerable**. This species does not seem to occur in any protected area.

Polyscias stuhlmannii Harms var. *stuhlmannii*

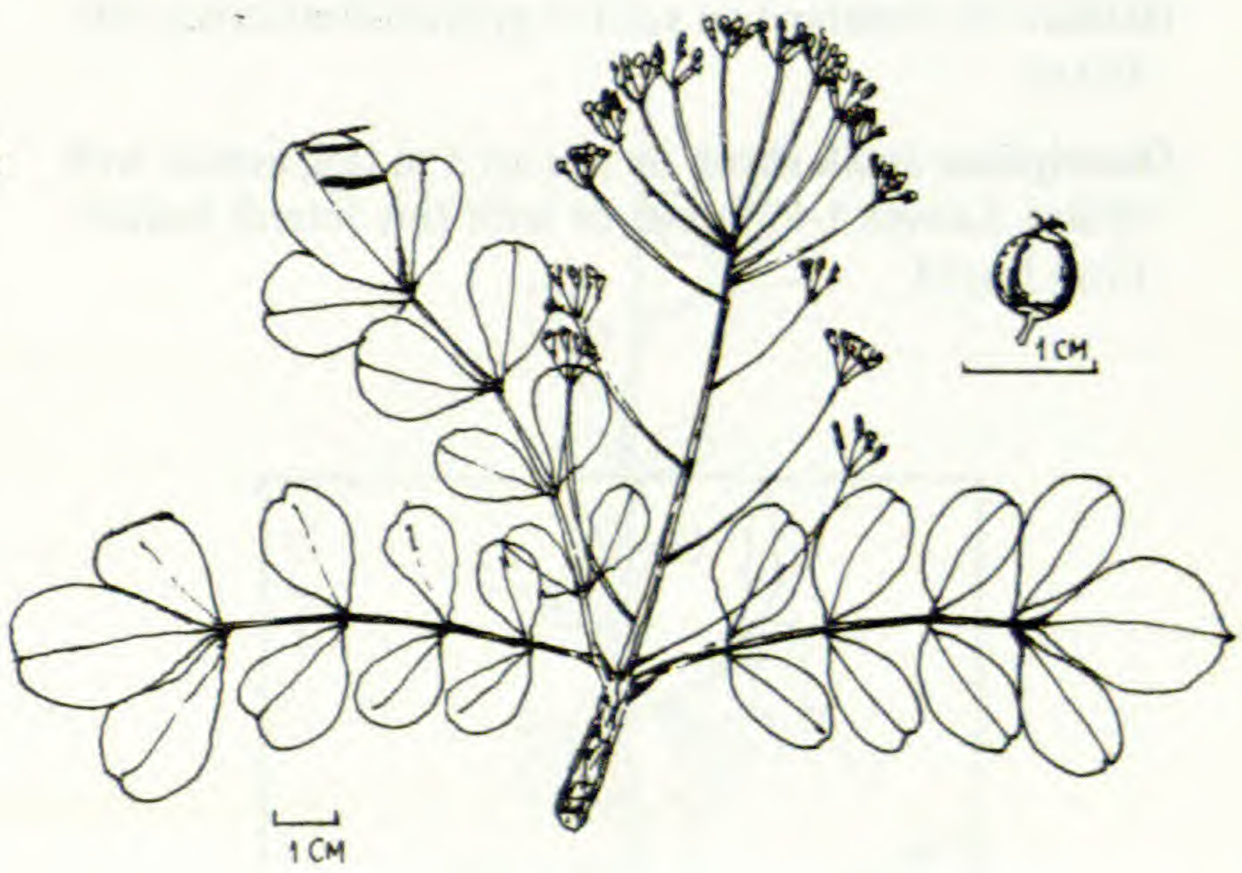
Araliaceae

Local Names & Uses: Kidongadi (Taita)

Distribution: Kenya (Taita Hills) and Tanzania (Usambara, Ukaguru and Uluguru mountains)

Habitat: moist upland forest; 1450-2300 m.

Description: tree 5-20 m tall, with candelabra-like branching. Flowers reddish brown.





Status:

Rare. Not uncommon in the Taita Hills forests, where it seems to prefer forest margins.

Balanites wilsoniana Dawe & Sprague

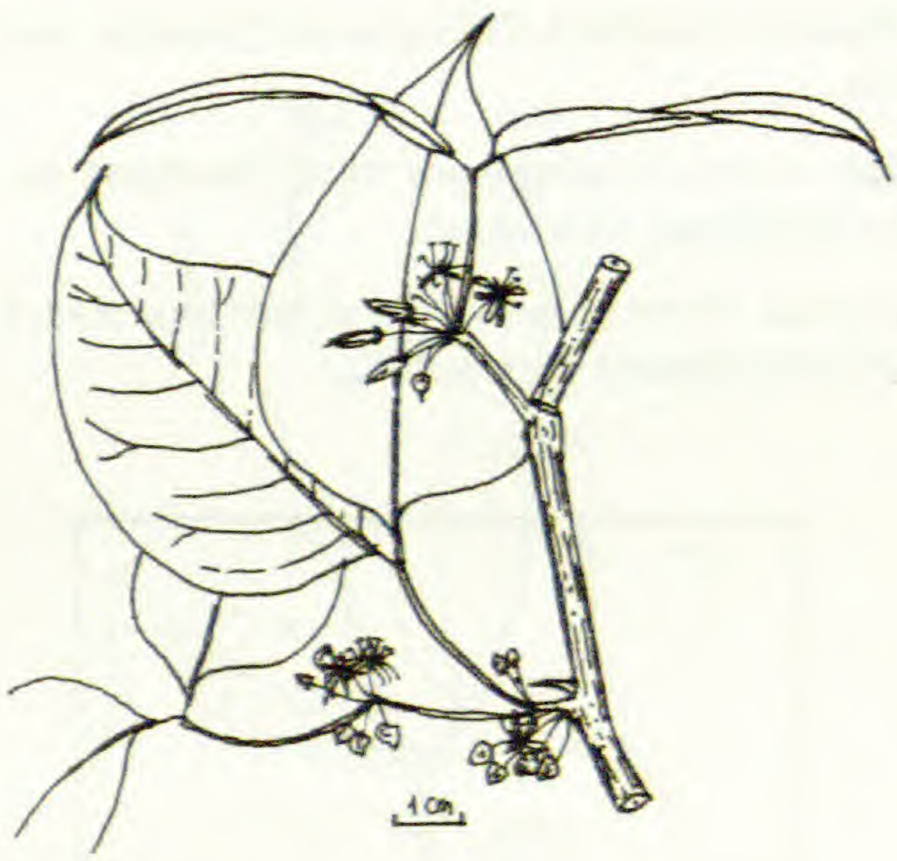
Balanitaceae

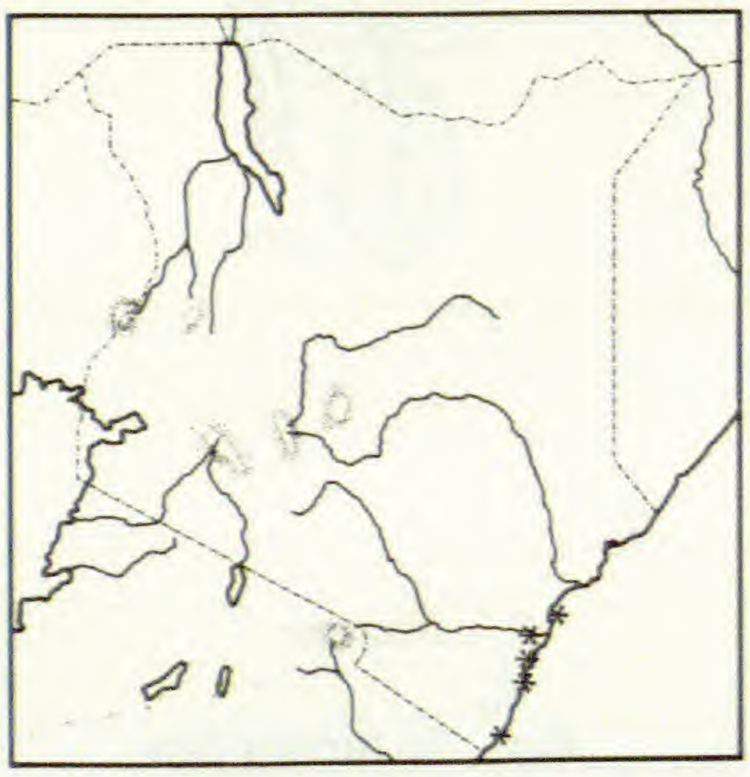
Local Names & Uses: Mkonga (Giriama)

Distribution: coastal Tanzania and Kenya.

Habitat: littoral closed-canopy thicket and littoral forest; near sealevel.

Description: tree 5-18 m tall, with fluted grey trunk. Leaves 2-foliolate. Flowers yellowgreen.





Status:

Rare, Vulnerable. This habitat is being destroyed everywhere, as it is right in this zone that all the tourist hotels are being built. Might be **Endangered**.

Commiphora chaetocarpa Gillett ined.

Burseraceae

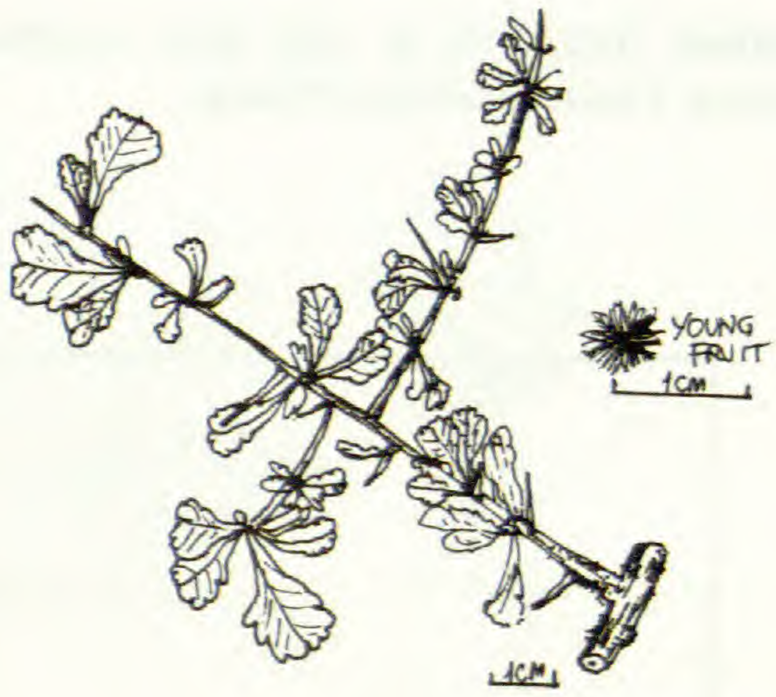
Local Names & Uses: none known.

Distribution: central Somalia and Kenya (near Garissa).

Habitat: dry bushland on sand or gypsum/limestone; 200-350 m.

Description: small shrub or tree to 3 m tall, armed with spines. Leaves 1-foliolate, or with tiny lateral leaflets. Fruit hispid.





Status:

Rare. No further data.

Commiphora ciliata Vollesen

Burseraceae

Local Names & Uses: Habla subba (Somali); ?Angule (Boran).

Distribution: Southern Ethiopia and Somalia, northeast Kenya.

Habitat: *Acacia-Commiphora* bush/woodland on (sand over) limestone; 650-800 m.

Description: shrub or tree 1.5-6 m tall; unarmed. Leaves 3-foliolate; flowers dark red.





Status:

Rare. No further data.

Commiphora swynnertonii B.D. Burtt

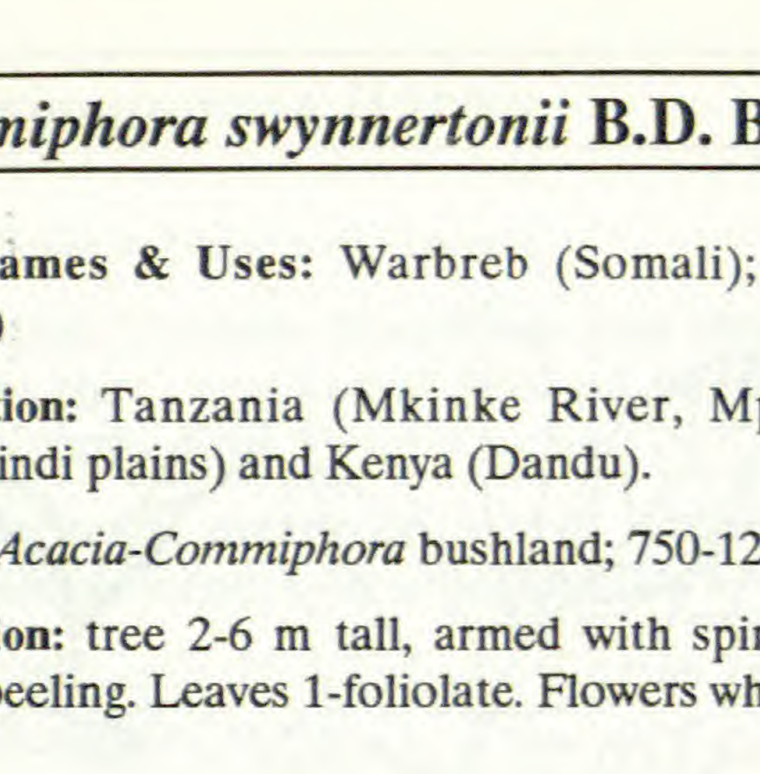
Burseraceae

Local Names & Uses: Warbreb (Somali); Dabaso (Boran)

Distribution: Tanzania (Mkinke River, Mpwapwa, Kilimalindi plains) and Kenya (Dandu).

Habitat: *Acacia-Commiphora* bushland; 750-1200 m.

Description: tree 2-6 m tall, armed with spines; bark white, peeling. Leaves 1-foliolate. Flowers white.





Status:

Rare. No further data.

Notobuxus obtusifolia Mildbr.

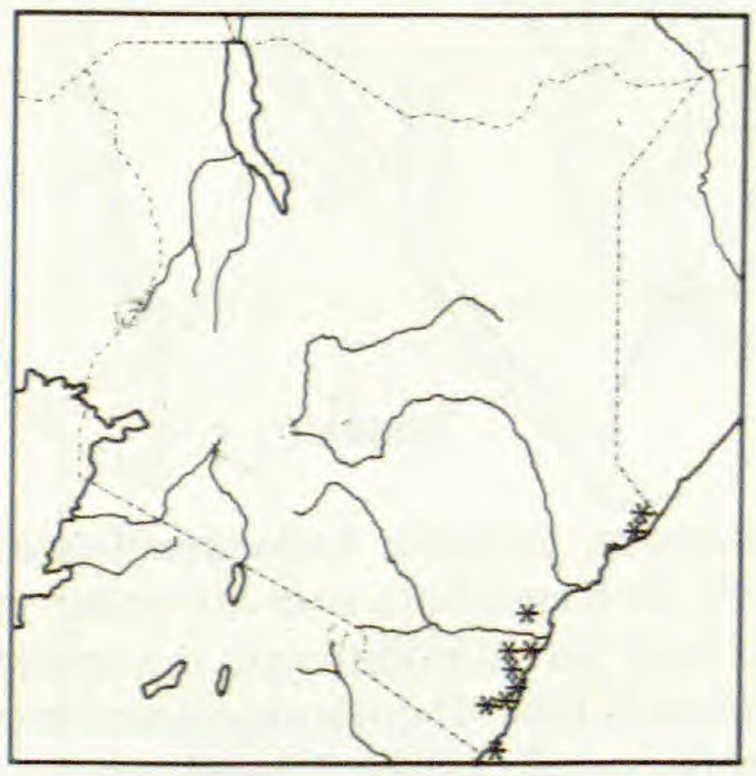
Buxaceae

Local Names & Uses: Mdhahabu (Swahili, Giriama); Masere/Sokokoe (Giriama), Babala (San).

Distribution: coastal Tanzania and Kenya (Boni, Arabuko, Hadu, Gazi, Kinondo).

Habitat: wood/bushland (Boni) or dry evergreen forest.

Description: shrub or small tree 1-6 m. Flowers green, fruit black.





Status:

Rare.

Caesalpinia insolita (Harms) Brenan & Gillett

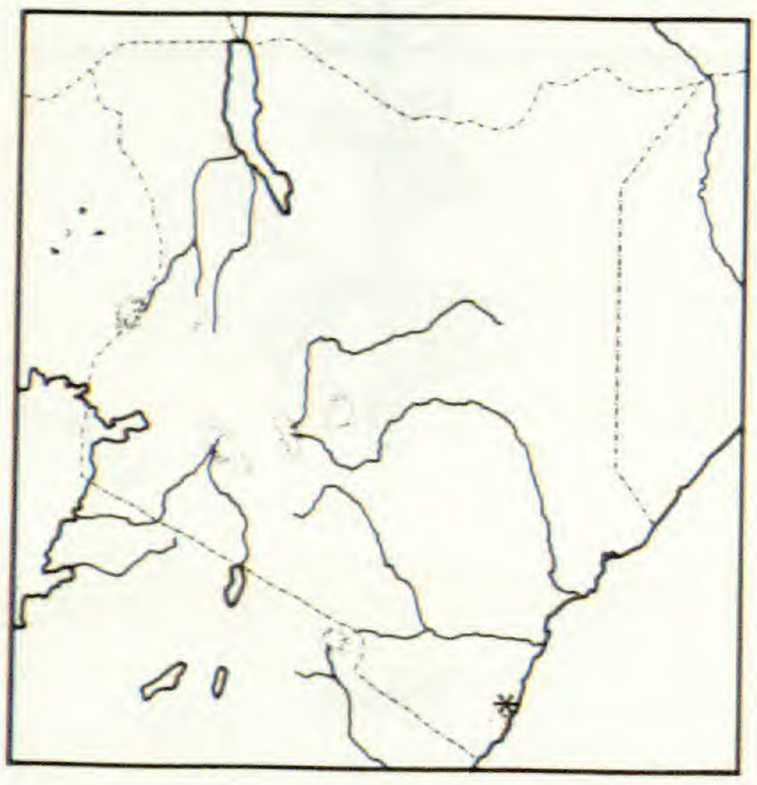
Caesalpiniaceae

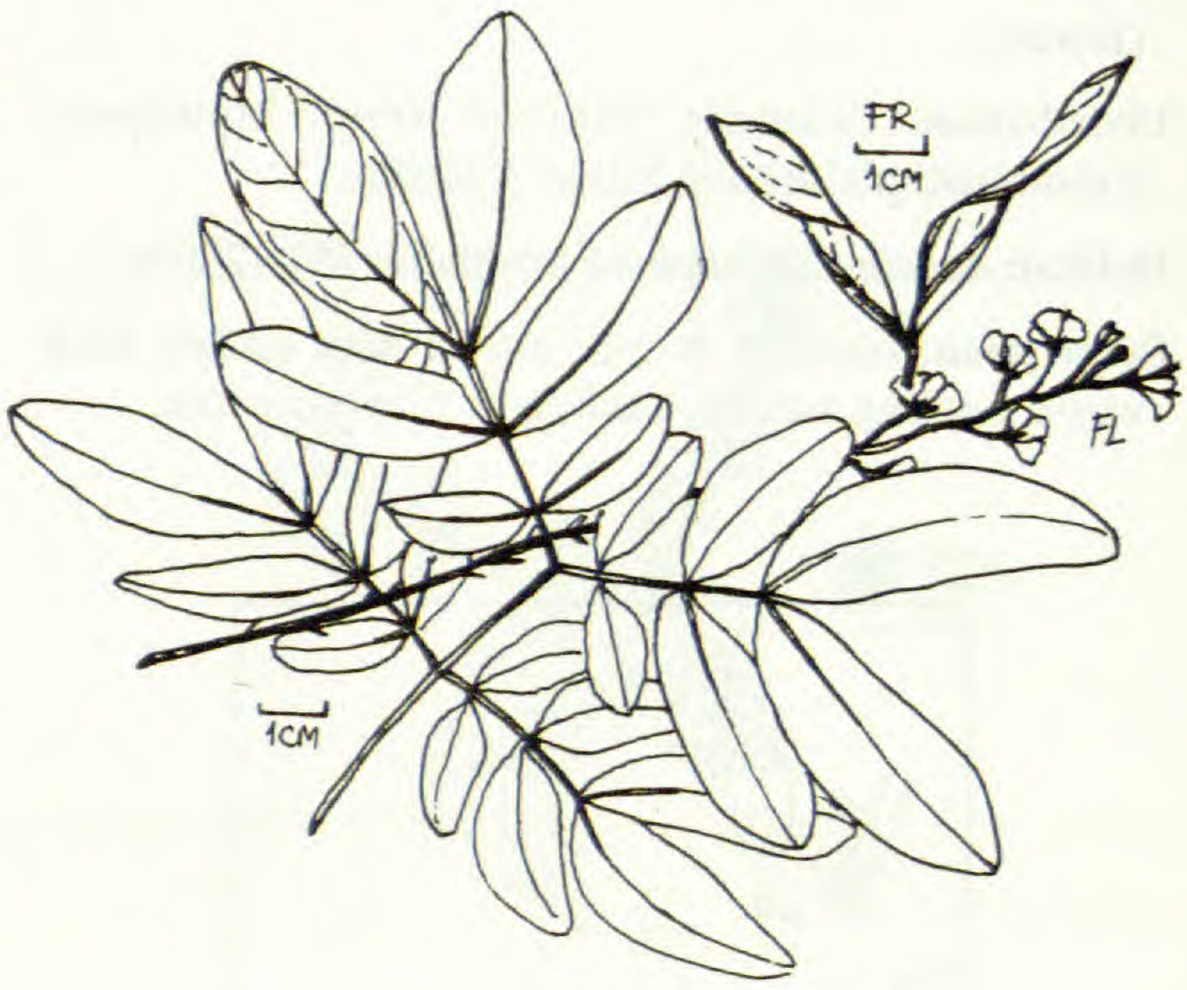
Local Names & Uses: none known.

Distribution: coastal Tanzania (Handeni, Lindi) and Kenya (Kaya Ribe, Kaya Mwaka, Mwachi) and northern Madagascar (see Capuron in Adansonia 2, 7: 199 (1967)).

Habitat: evergreen coastal forest; 90-520 m.

Description: tree 16-20 m tall, with buttresses; unarmed. Leaves paripinnate. Flowers yellow.





Status:

Rare, Vulnerable. This habitat is being rapidly destroyed, and the site at Mwachi is certainly destroyed

Cynometra lukei **sp. nov.: see page 125**

Caesalpiniaceae

Gigasiphon macrosiphon (Harms) Brenan

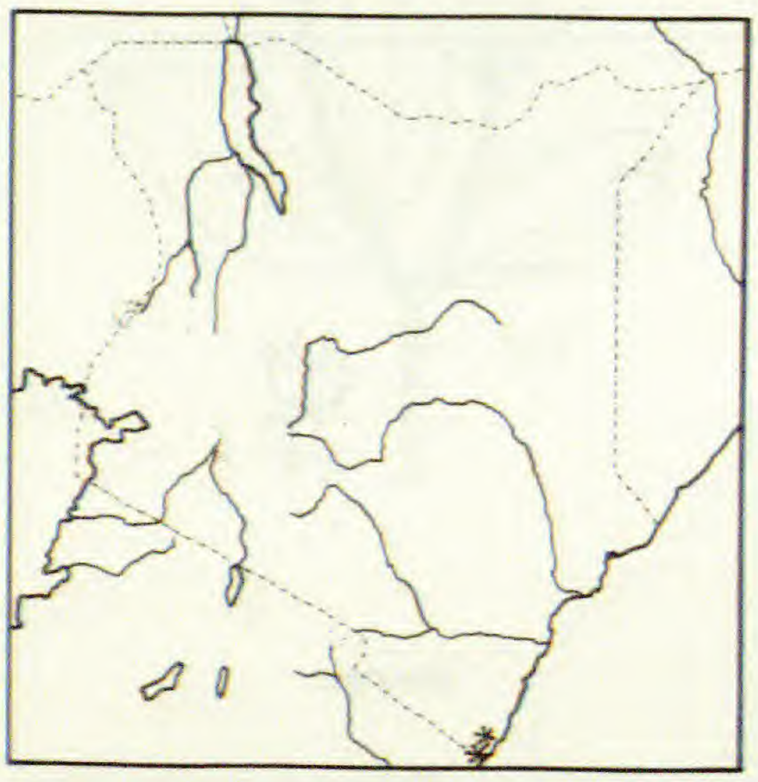
Caesalpiniaceae

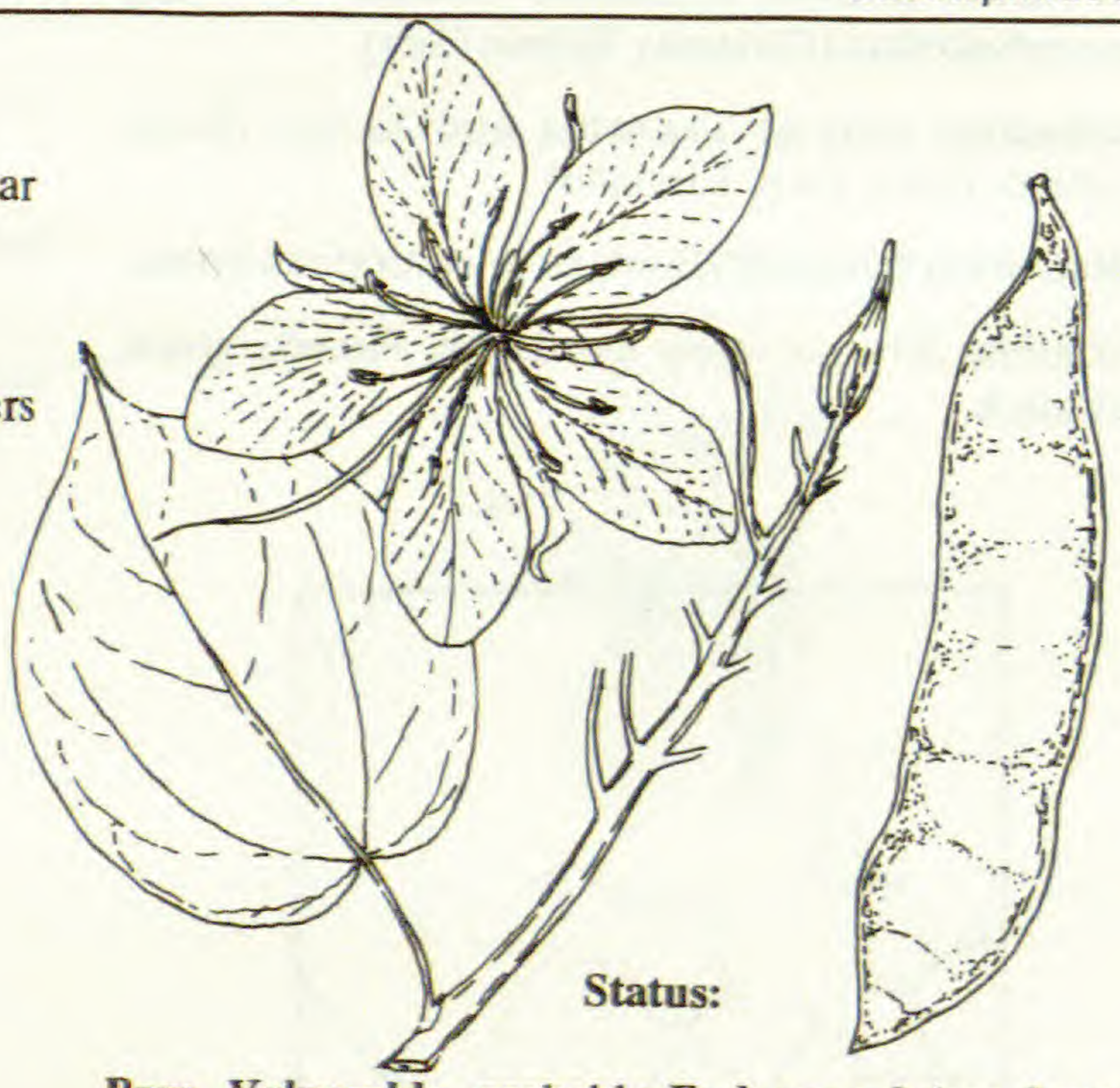
Local Names & Uses: none known.

Distribution: coastal Tanzania (Rondo plateau and near Tanga) and Kenya (Mrima and Marenje forests).

Habitat: moist lowland forest; alt. 100-810 m.

Description: tree 12-20 m tall. Leaves simple. Flowers large, white.





Status:

Rare, Vulnerable, probably **Endangered** (see Lucas & Synge 1978). In Kenya both sites are under threat, and Mrima has been partially destroyed; this species was last collected there in 1964. There is a specimen in cultivation at Waimea Botanical Garden, Hawaii.

Oxystigma msoo Harms

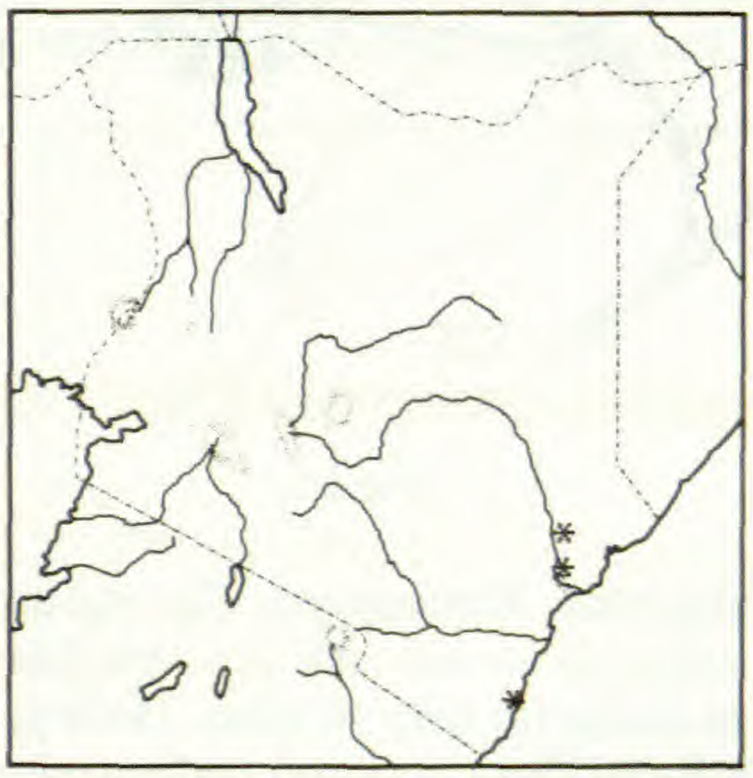
Caesalpiniaceae

Local Names & Uses: none known.

Distribution: Tanzania (Rau forest near Moshi and in Pangani distr.) and Kenya (Haiwani forest and near Garsen on the Tana, Pangani rocks).

Habitat: moist evergreen forest, riverine forest, groundwater forest; 1-60 m (in Tanzania to 1210 m).

Description: tree 25-50 m tall. Leaves compound. Flowers white.





Status:

Rare, Vulnerable, possibly **Endangered**. Only known from 5 sites, most of which are being encroached upon. (see RODGERS, B.J.N.B. 53: 161-164 (1983)).

Warburgia stuhlmannii Engl.

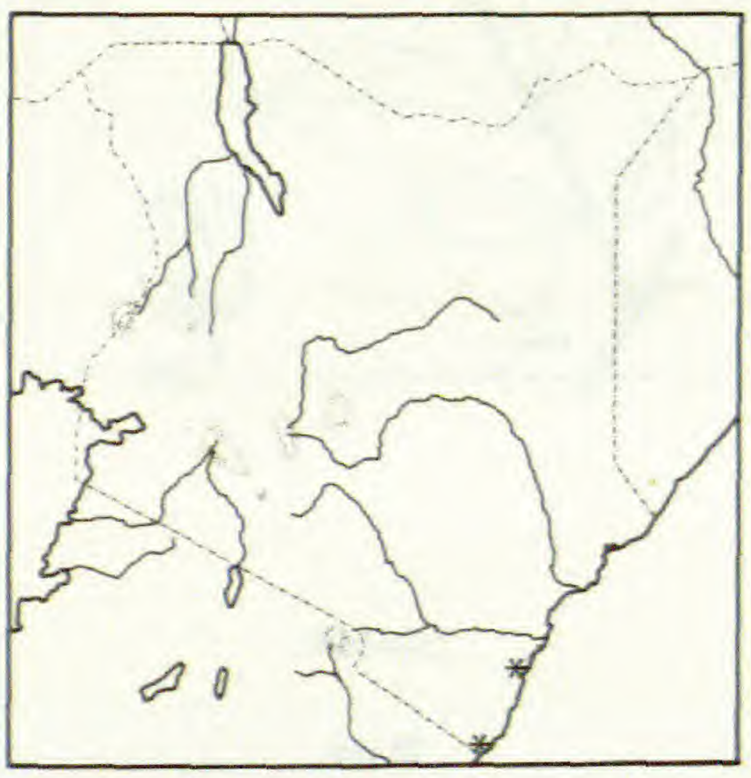
Canellaceae

Local Names & Uses: Mkaa (Swahili). The bark is used in a remedy against rheumatism and toothache.

Distribution: coastal Tanzania (Msubugwe Forest Reserve and near Tanga) and Kenya (Kaembeni-Dida, near Mbongo, near Kinango, and in 1929 near Vanga).

Habitat: coastal forest and wooded grassland; alt. 1-225 m.

Description: tree 12-24 m. Flowers yellowgreen, ca. 5 mm long. Fruit green with a waxy bloom.





Status:

Rare, Vulnerable. The status of Msubugwe is unknown to me, but in the other 3 localities habitat destruction has been, and is, going on.

Combretum tenuipetiolatum Wickens — Combretaceae

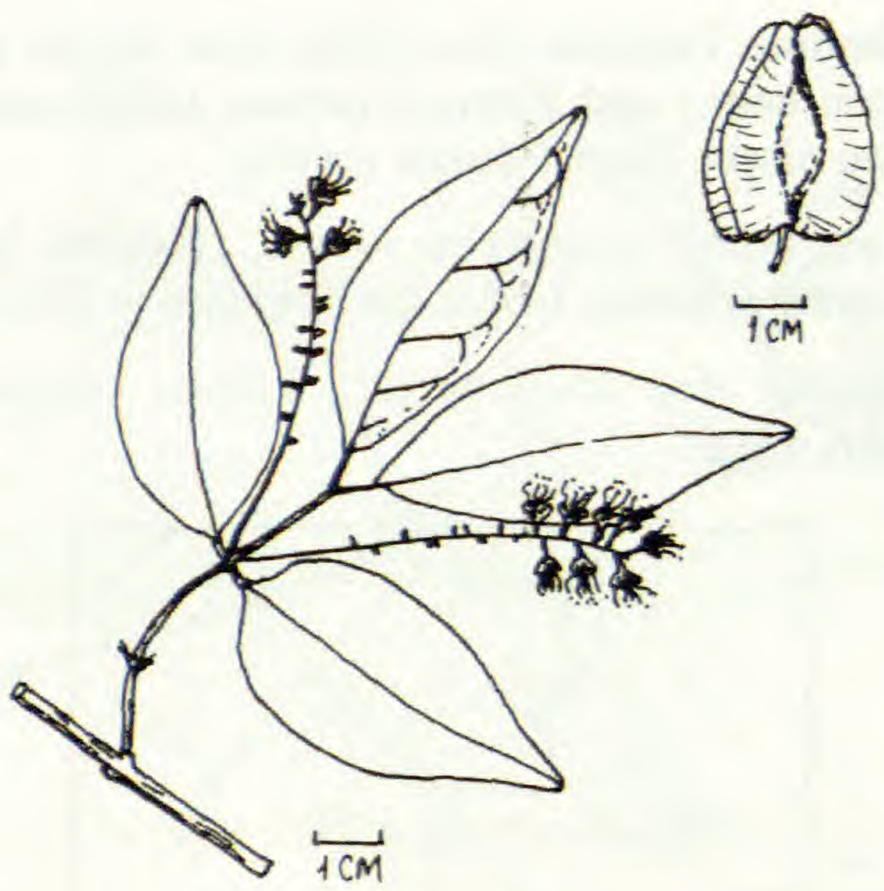
Local Names & Uses: none known.

Distribution: coastal Tanzania (Potwe forest in Korogwe) and Kenya (Rabai in 1931, Mombasa distr. in 1884)

Habitat: coastal evergreen forest at altitudes below 200 m.

Description: small tree (size unknown). Leaves opposite. Flowers yellow. Fruit redbrown, 4-winged.





Status:

Rare, Vulnerable, Endangered. The status of Potwe forest is unknown to me, and the tree has not been collected in Kenya for over 50 years. There is still some forest near Rabai, but it is sacred, and botanists have not visited this site for a long time.

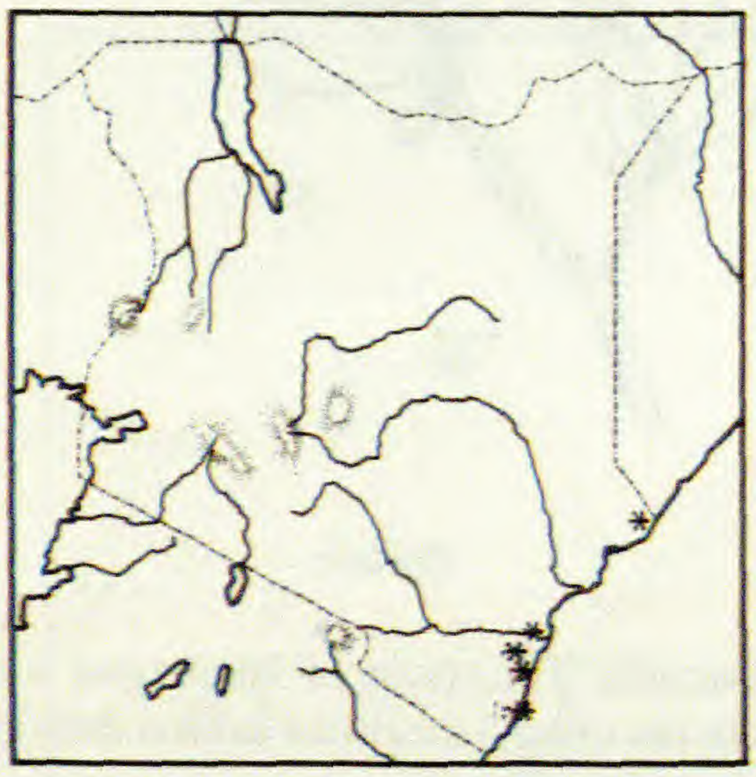
Pteleopsis tetraptera Wickens — Combretaceae

Local Names & Uses: Mlakwenzi/Mwofu (Swahili); Shola (Boni); Mutulama kwa lala (Giriama).

Distribution: coastal Tanzania (Kabaku forest in Lushoto) and Kenya (Boni, Marafa, Arabuko-Sokoke, Mowesa).

Habitat: coastal forest, woodland and bushland; 1-300 m.

Description: tree 4-12 m tall. Flowers white or cream. Fruit 4-8-winged.





Status:

Rare.

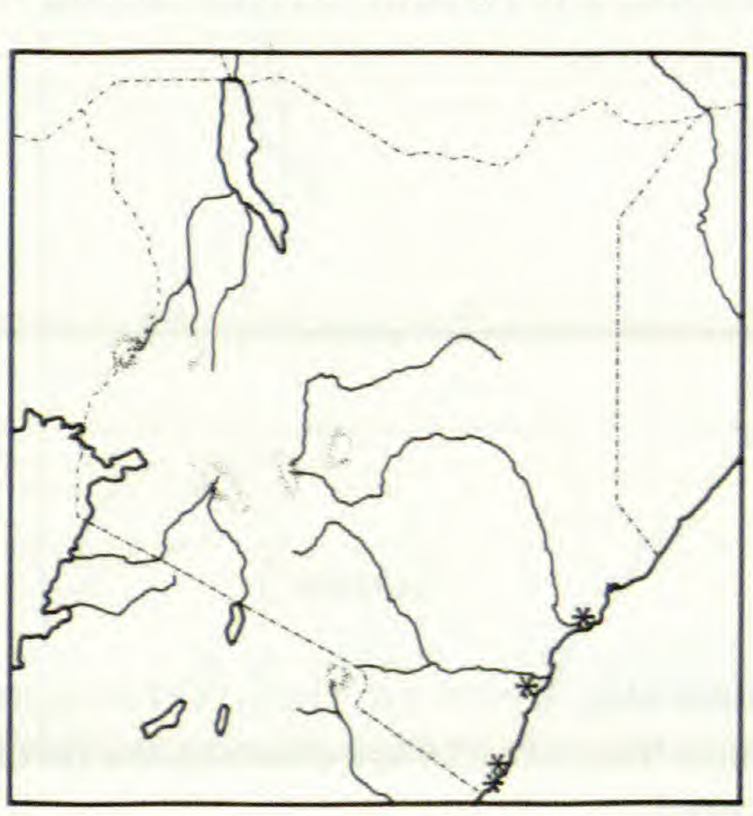
Ellipanthus hemandradenioides Brenan — *Connaraceae*

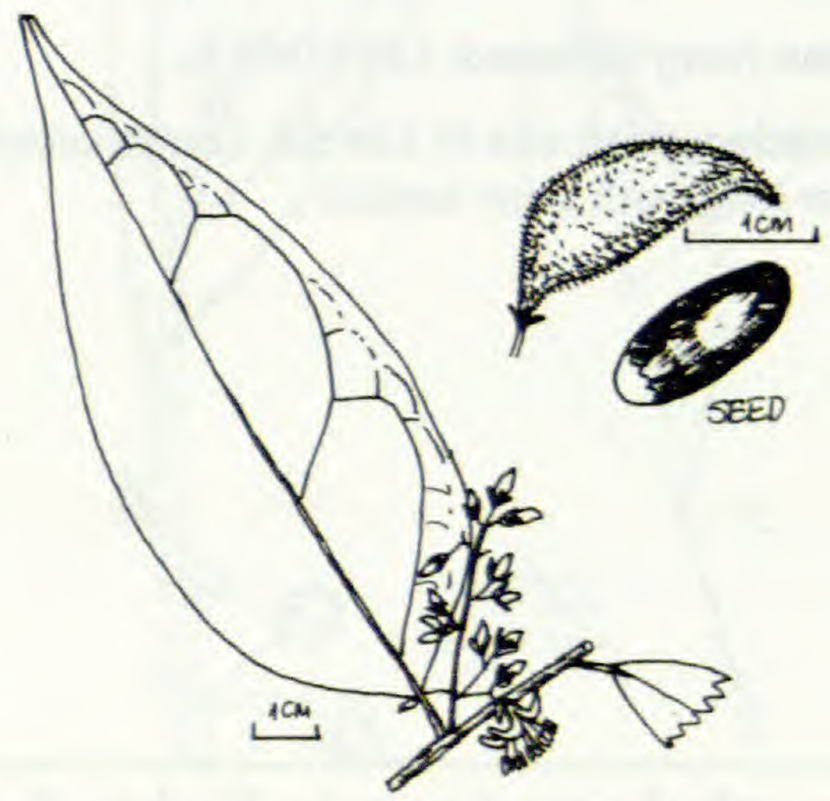
Local Names & Uses: Mwaanyiza (Swahili), Moganji/Mowari (Giriama). The wood is used for building.

Distribution: coastal Tanzania (Nyamaku in Tanga, Ngubulumi Forest Reserve in Utete) and Kenya (Mangea, Arabuko-Sokoke, Gedi, Witu, Buda, Shimba, Mida).

Habitat: moist evergreen coastal forest; alt. 1-400 m.

Description: tree 4-10 m tall. Flowers white, fruit red, velvety, with black seeds with a yellow aril.



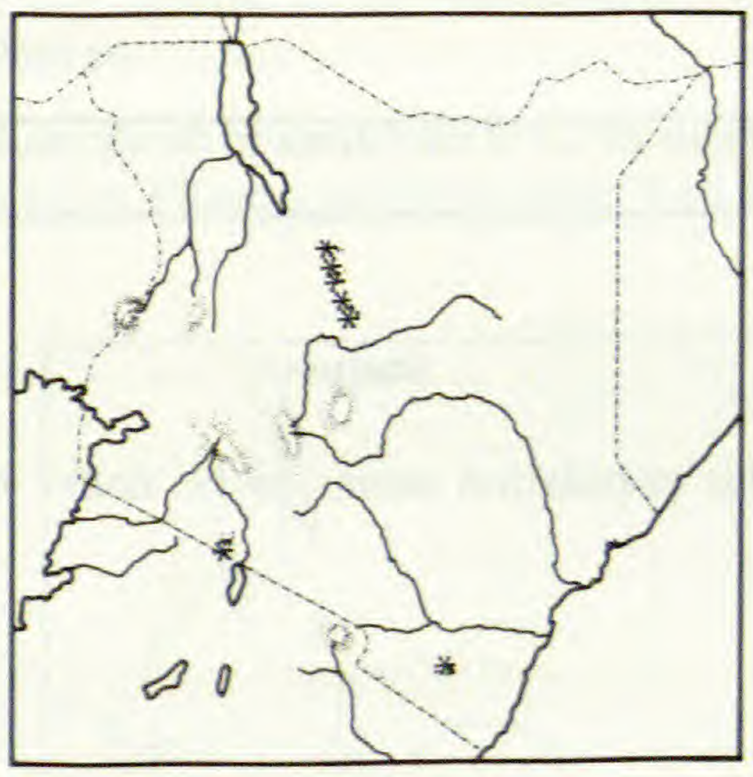


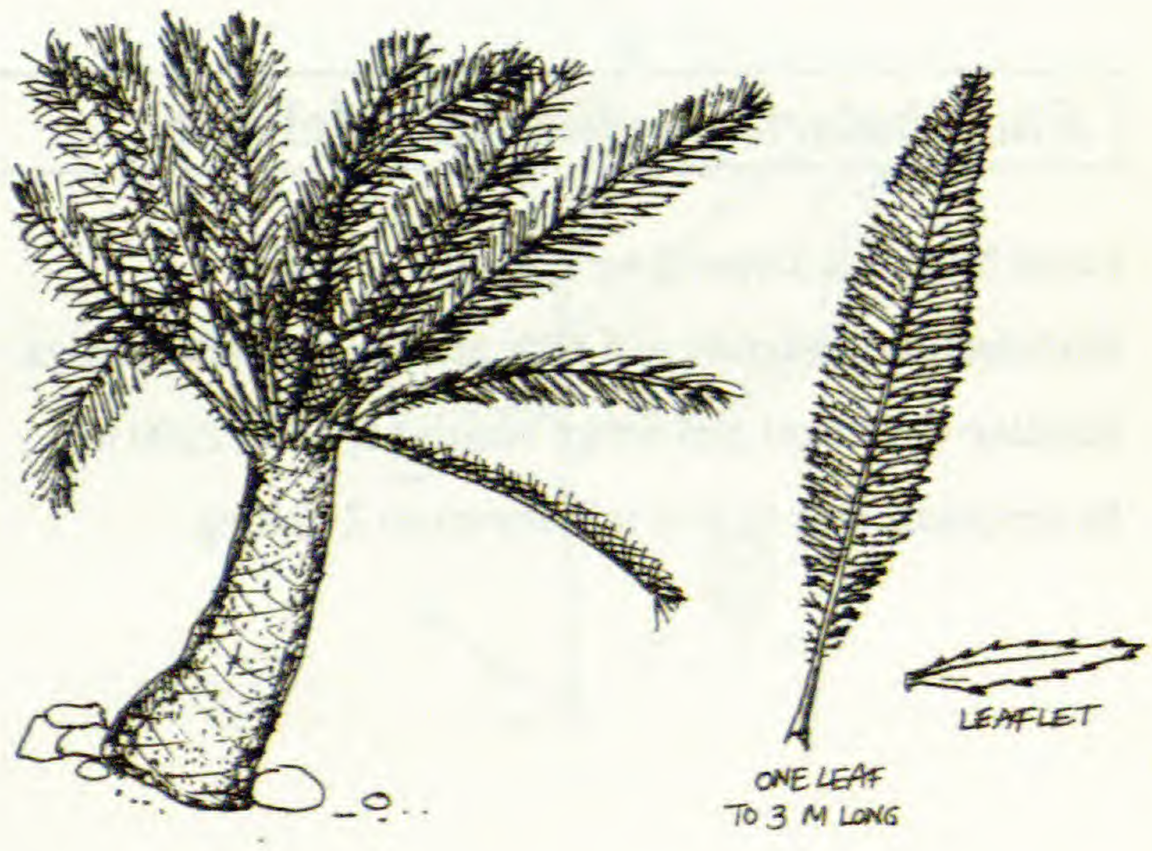
Status:

Rare. Gedi National Monument and the Shimba Hills National Reserve provide a partial protection.

ENCEPHALARTOS — *Cycadaceae*

A genus of palm-like trees. For security reasons no details can be given of localities, as horticulturalists and cycad collectors have been known to plunder sites.





Encephalartos bubalinus Melville

Local Names & Uses: none known.

Distribution: endemic to a small area on the Tanzania-Kenya border.

Habitat: rocky bushland; 1300-1800 m.

Description: small tree to 3 m tall. Leaves compound, to 1.5 m long, with spiny leaflets.

Status:

Rare, Vulnerable. There is no information on the current status of the population.

Encephalartos kisambo Faden & Beentje ined.

Local Names & Uses: Kisambo (Taita-Sagalla).

Distribution: endemic to a small area near Voi.

Habitat: evergreen forest and rocky bushland; alt.700-1000 m.

Description: small tree to 3 m tall. Leaves as in preceding species.

Status:

Rare, Vulnerable. There are reports that squatters have moved into this area and are clearing the forest. Possibly **Endangered.**

Encephalartos tegulaneus Melville

Local Names & Uses: none known.

Distribution: endemic to a hilly area in northern Kenya.

Habitat: dry forest and rocky bushland; 1800-2100 m.

Description: tree to 8 m tall. leaves to 2 m long.

Status:

Rare. This population seems to be under no present threat.

Aristogeitonia monophylla Airy Shaw — *Euphorbiaceae*

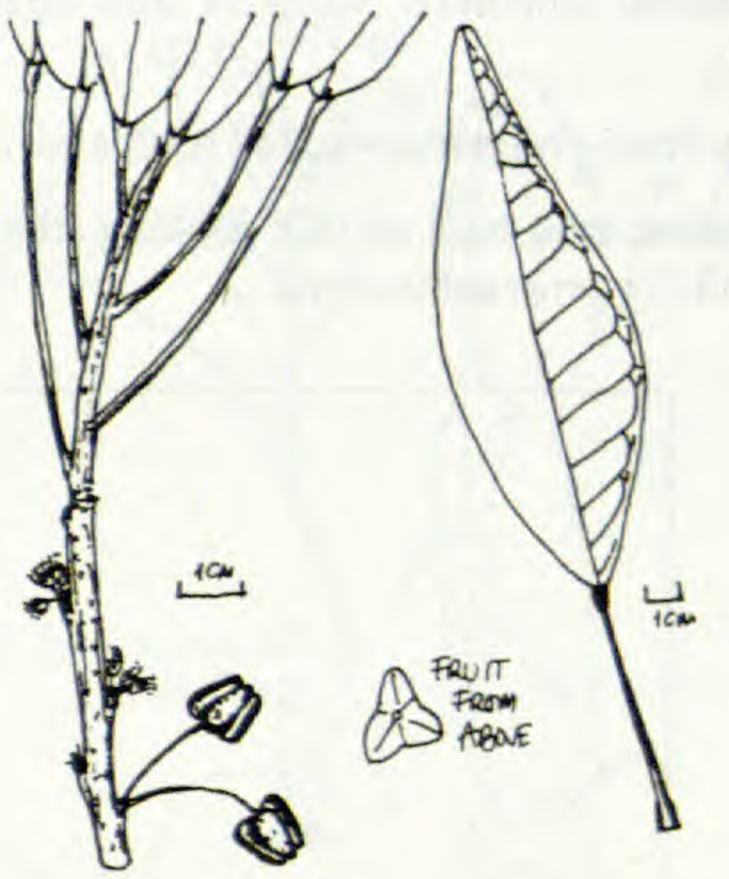
Local Names & Uses: none known.

Distribution: coastal Tanzania (Kumbamtoni near Pangani) and Kenya (Cha Simba, Mwarakaya, Pangani rocks, Mrarani, southern Arabuko-Sokoke).

Habitat: near the sea on coral, more inland on limestone outcrops; alt. 1-220 m.

Description: shrub or tree 2-9 m tall. Leaves to 30 cm long. Fruit bright red, on older wood or among the leaves.





Status:

Rare, Vulnerable. Most of the limestone outcrops are under threat by agriculture or quarrying; possibly Endangered.

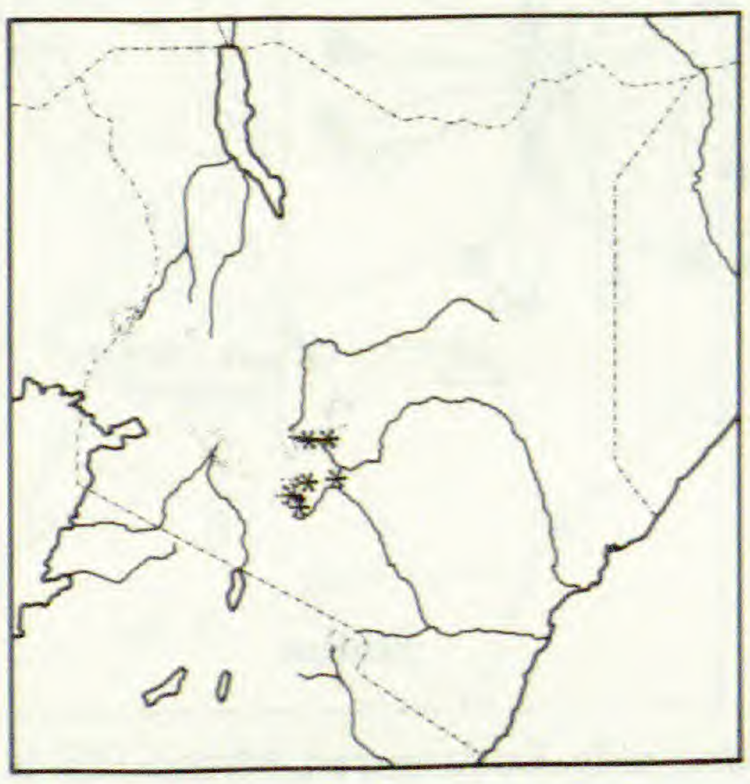
Croton alienus Pax — *Euphorbiaceae*

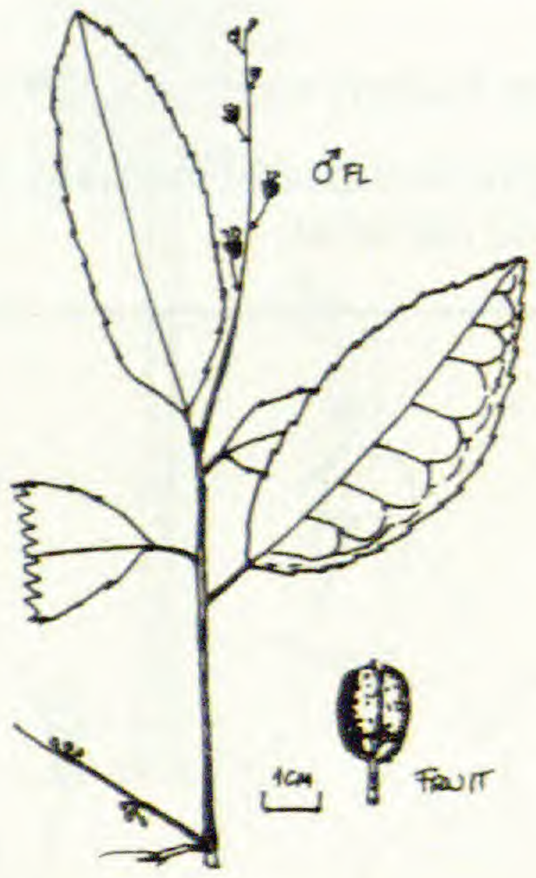
Local Names & Uses: Musenia (Kikuyu)

Distribution: endemic to central Kenya (Karura, Kiambu, Thika, W Mt. Kenya, Nyeri).

Habitat: dry upland forest *(Croton-Brachylaena);* alt. 1450-1950 m.

Description: shrub or small tree to 4.5 m; dioecious; with stellate hairs. Flowers greenish white, fruit dark red or black.





Status:

Rare, possibly **Vulnerable.** Restricted to a small area with high human population pressure.

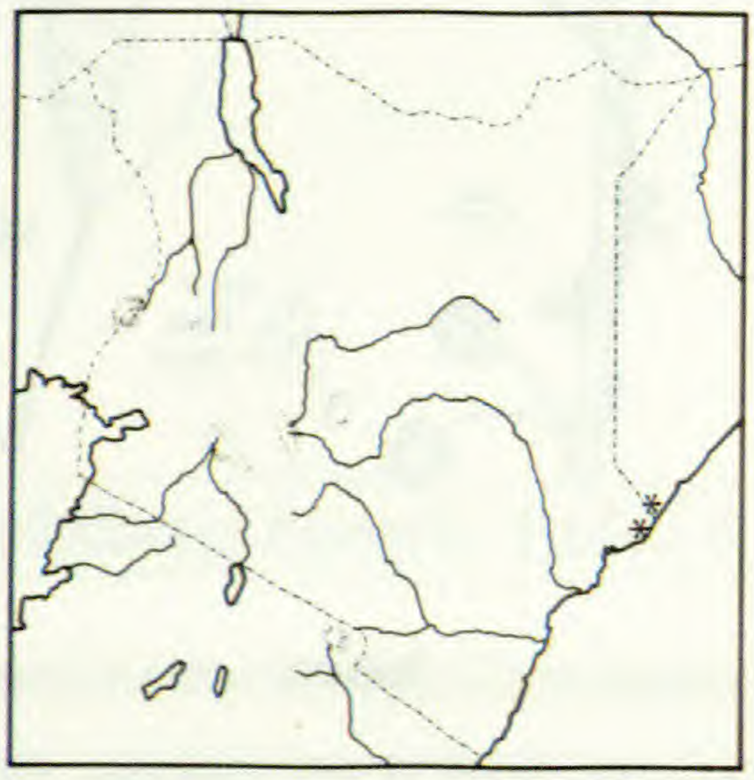
Croton megalocarpoides Friis & Gilbert — *Euphorbiaceae*

Local names & uses: none known.

Distribution: southern Somalia and coastal Kenya (Boni).

Habitat: semi-evergreen wooded bushland; alt. 1-350 m.

Description: tree to 8 m tall, looking like the central Kenyan *Croton megalocarpus*.





Status:

Rare.

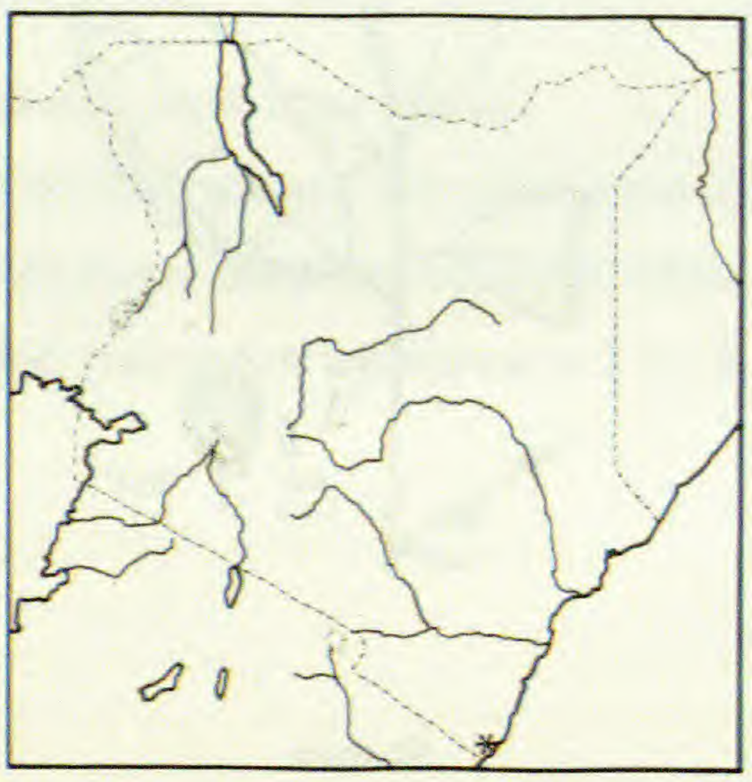
Drypetes usambarica Pax var. *mrimae* Radc. Sm. — *Euphorbiaceae*

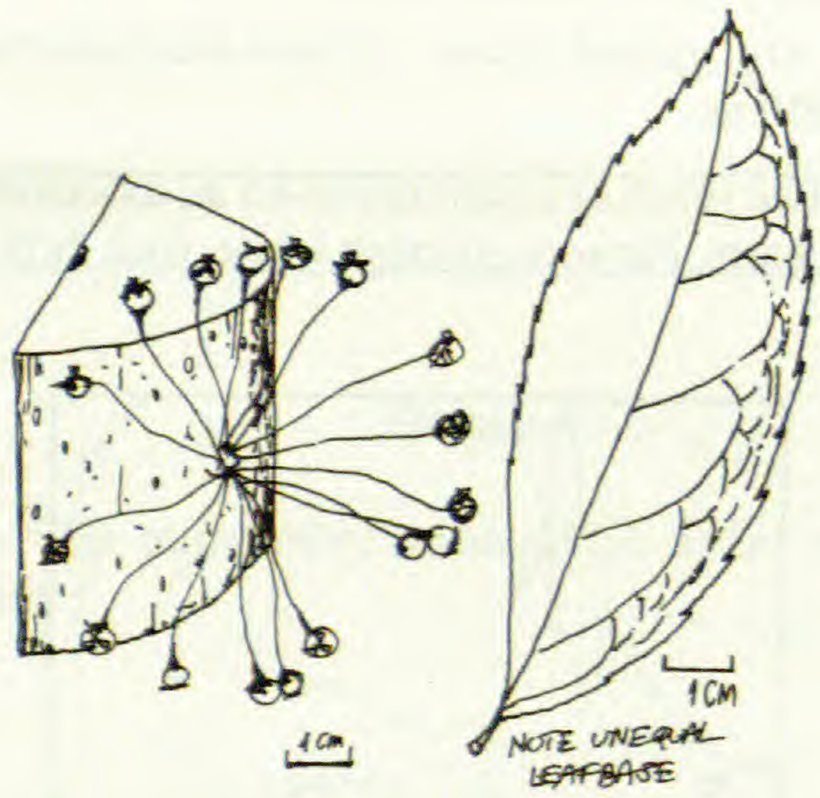
Local Names & Uses: none known

Distribution: endemic to Mrima Hill and Shimba Hills (one site)

Habitat: moist lowland forest; alt. ?100-380 m.

Description: tree to 9 m tall. Flowers ca. 3 mm long. Fruits in umbels, on old wood.





Status:

Rare, Vulnerable, Endangered. Mrima Hill is threatened periodically by mining companies.

Euphorbia cussonoides Bally

Euphorbiaceae

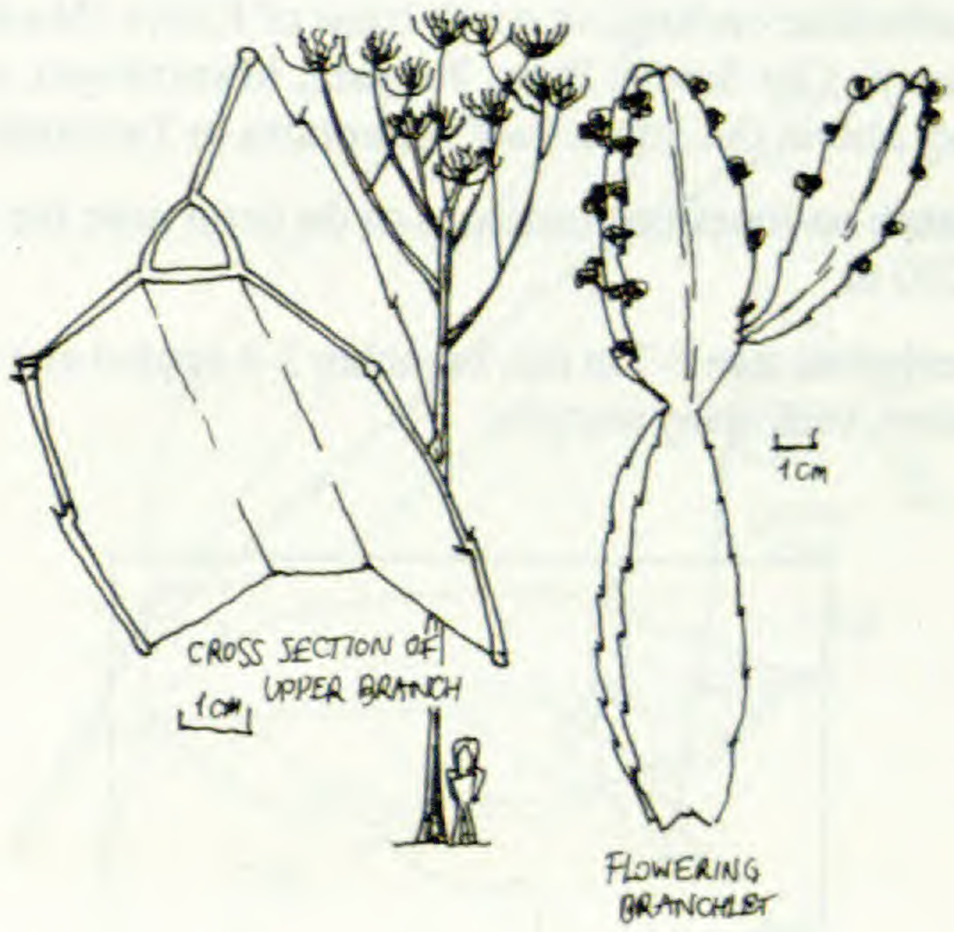
Local Names & Uses: Kithuri (Kikuyu); Mramba (Embu).

Distribution: endemic to central Kenya (Ngong, anno 1939; Thika; Ndaragu near Embu).

Habitat: dry upland forest and riverine forest; alt. 1450-1800 m.

Description: tree to 24 m tall with a long clean bole, resembling a *Cussonia;* branches succulent, 3-angled, with spiny margins.





Status:

Rare, Vulnerable, possibly **Endangered.** The only site where the tree has been seen in recent years is along the Chania River near Thika. There might be a single tree left on the Ngong hills (J.B. Gillett, pers. comm.)

Euphorbia tanaensis Bally

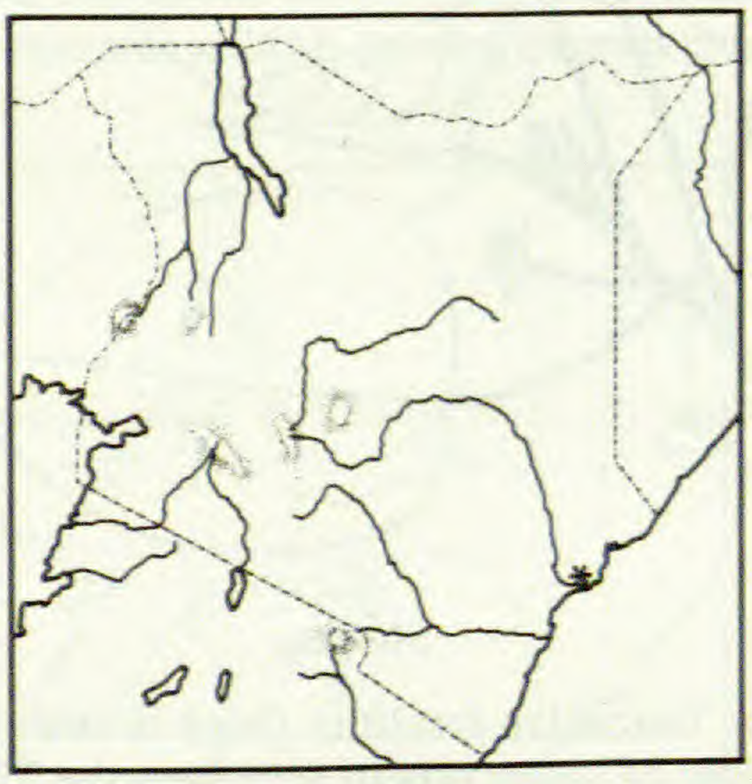
Euphorbiaceae

Local Names & Uses: none known.

Distribution: endemic to Witu forest.

Habitat: groundwater forest; near sealevel.

Description: tree to 18 m tall with long clean bole; branches succulent, (5-)6-angled, spiny on the margins; fruit crimson.





Status:

Rare, Vulnerable, Endangered. Mrs. S.A. Robertson visited the site in 1986 and found 3 mature trees. Forest rangers did not know of any other specimens. The forest is a Forest Reserve, and the 3 trees do not seem in any particular danger.

Euphorbia wakefieldii N.E. Brown — *Euphorbiaceae*

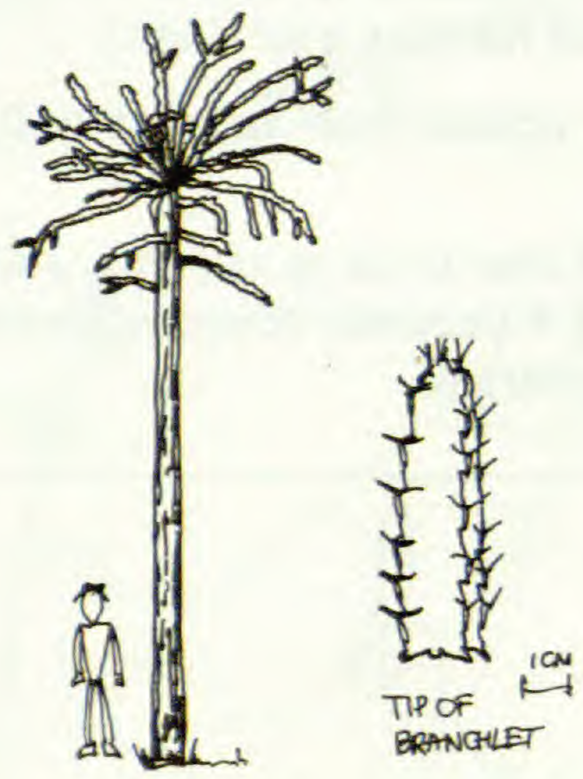
Local Names & Uses: none known.

Distribution: endemic to south coast of Kenya (Mwachi, Chonyi, Cha Simba, Ribe, Pangani, Mwarakaya); possibly also in the South Pare Mountains in Tanzania.

Habitat: on limestone outcrops or on coral near the sea; 5-270 m.

Description: tree 5-7 m tall; branches 3-4-angled and succulent, with spiny margins.





Status:

Rare, Vulnerable, Endangered (see Lucas & Synge 1978). These localities are all threatened by encroaching agriculture or quarrying.

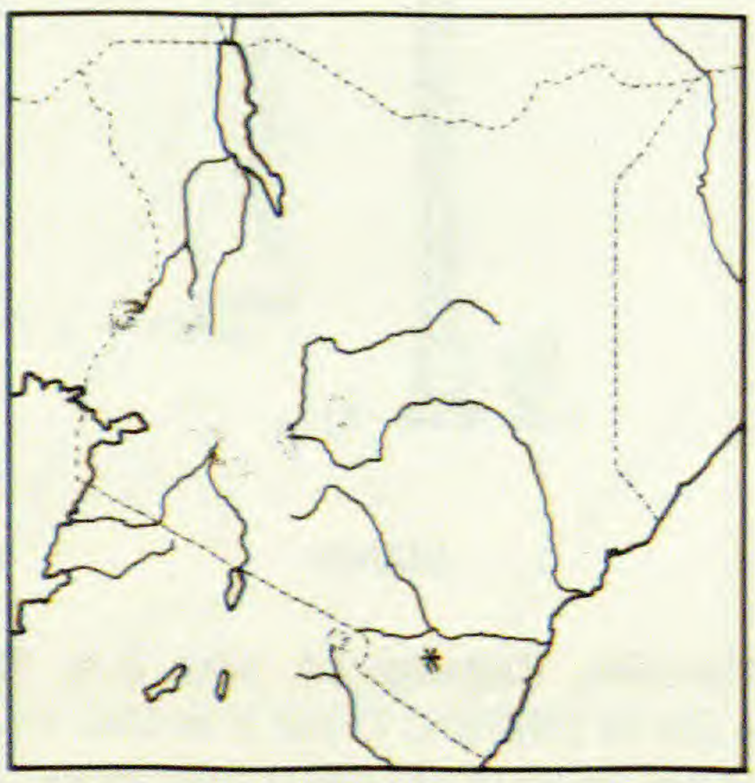
Macaranga conglomerata Brenan — *Euphorbiaceae*

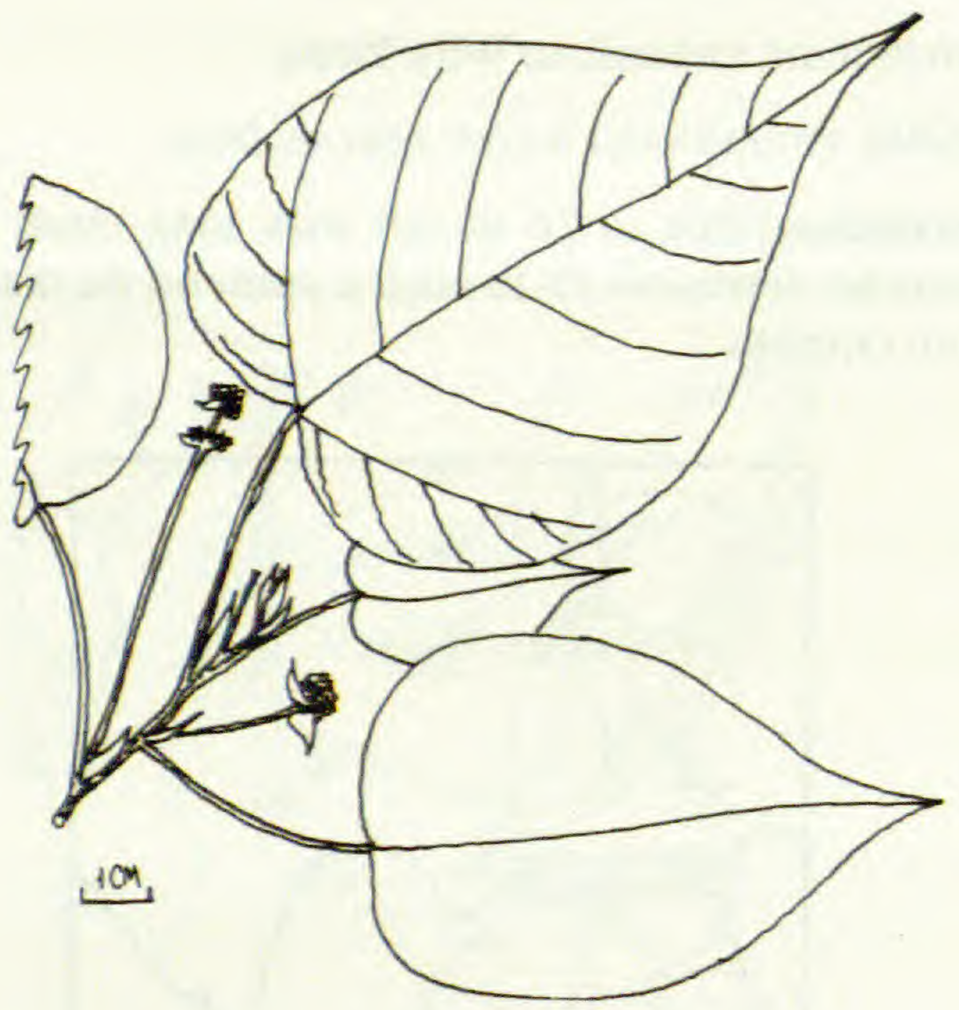
Local Names & Uses: none known.

Distribution: Tanzania (Magamba forest reserve, Sungwi forest reserve) and Kenya (Taita Hills).

Habitat: moist upland forest; 1400-1950 m.

Description: tree 9-30 m tall; inflorescence dense; long-pedunculate.





Status:

Rare. The Tanzanian localities (both in the west Usambaras) might be under threat; at present the Taita forests do not seem under threat, although they do not enjoy any official protection.

Micrococca scariosa Prain — *Euphorbiaceae*

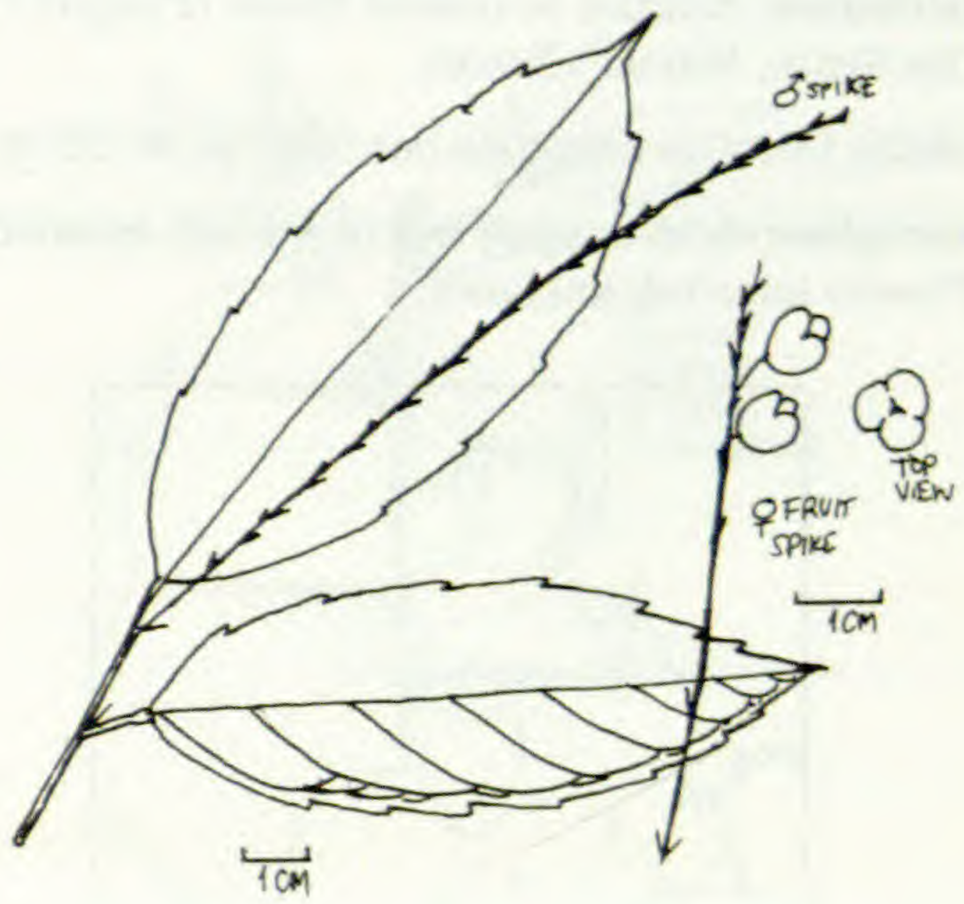
Local Names & Uses: none known.

Distribution: coastal Tanzania (Amboni caves near Tanga, Kimboza forest reserve, Mouyoni on Zanzibar) and Kenya (Pangani rocks).

Habitat: swamp forest or forest on limestone; 10-200 m.

Description: shrub or tree 2-7.5 m tall; monoecious or dioecious.





Status:

Rare, Vulnerable, possibly **Endangered.** Certainly the Kenyan site is being threatened by quarrying.

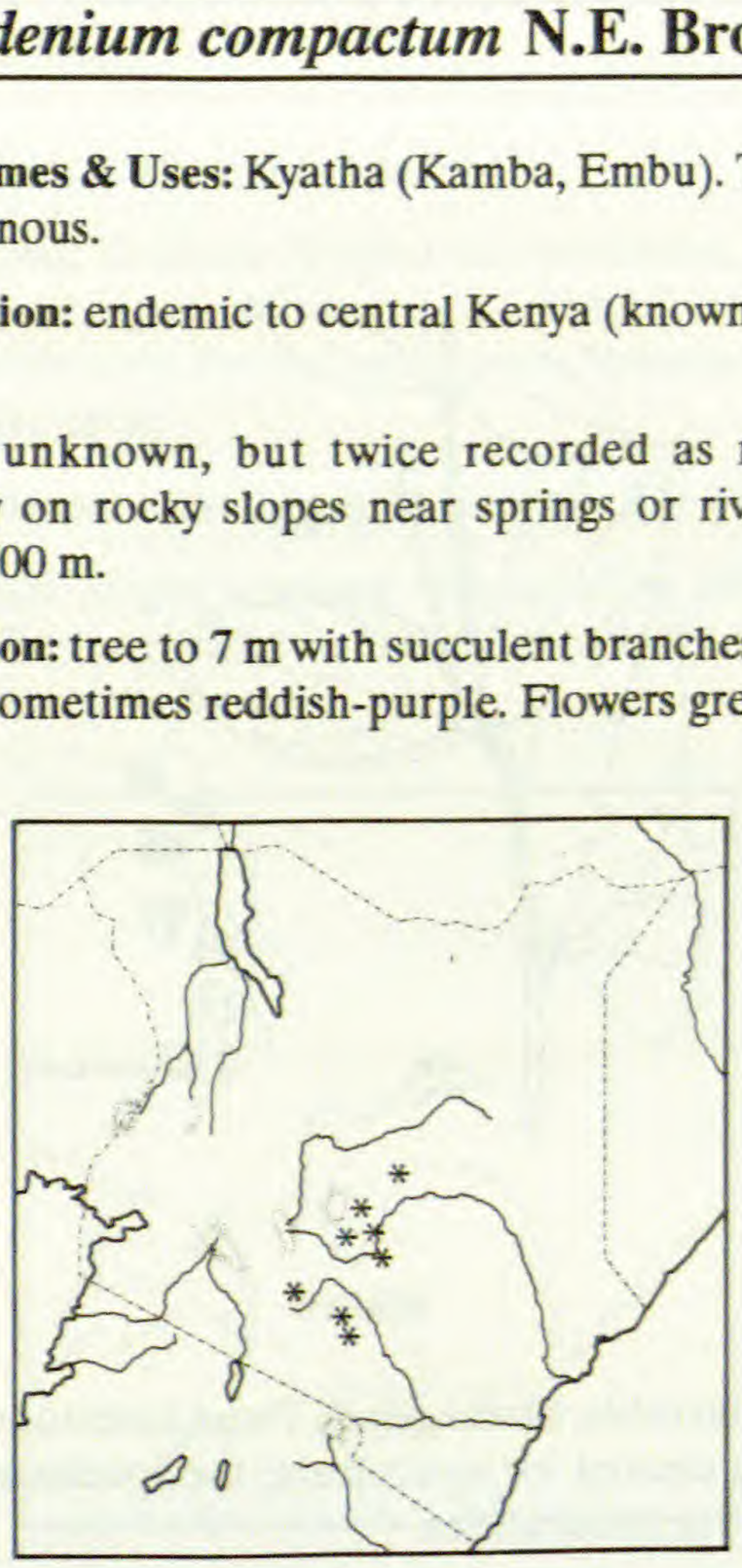
Synadenium compactum N.E. Brown — *Euphorbiaceae*

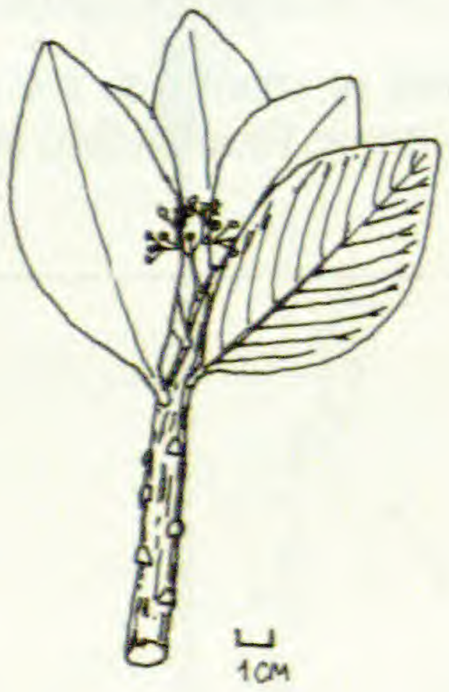
Local Names & Uses: Kyatha (Kamba, Embu). The latex is poisonous.

Distribution: endemic to central Kenya (known from 15 sites).

Habitat: unknown, but twice recorded as riverine; possibly on rocky slopes near springs or rivers. Alt. ?700-1700 m.

Description: tree to 7 m with succulent branches. Leaves fleshy, sometimes reddish-purple. Flowers greenish.





Status:

Rare. The population at Meru National Park enjoys protection.

Savia fadenii Radcl.-Sm.

Euphorbiaceae

Local Names & Uses: none known.

Distribution: endemic to coastal Kenya (Pangani rocks, Cha Simba, Marafa, Chonyi).

Habitat: forest on limestone outcrops; alt 90-220 m.

Description: shrub or small tree to 4 m tall; monoecious. Flowers tiny; fruit unknown.





Status:

Rare, Vulnerable, Endangered. All limestone outcrops are under threat by agricultural encroachment and quarrying. The species is also rare in its localities.

Thecacoris usambarensis Verdc.

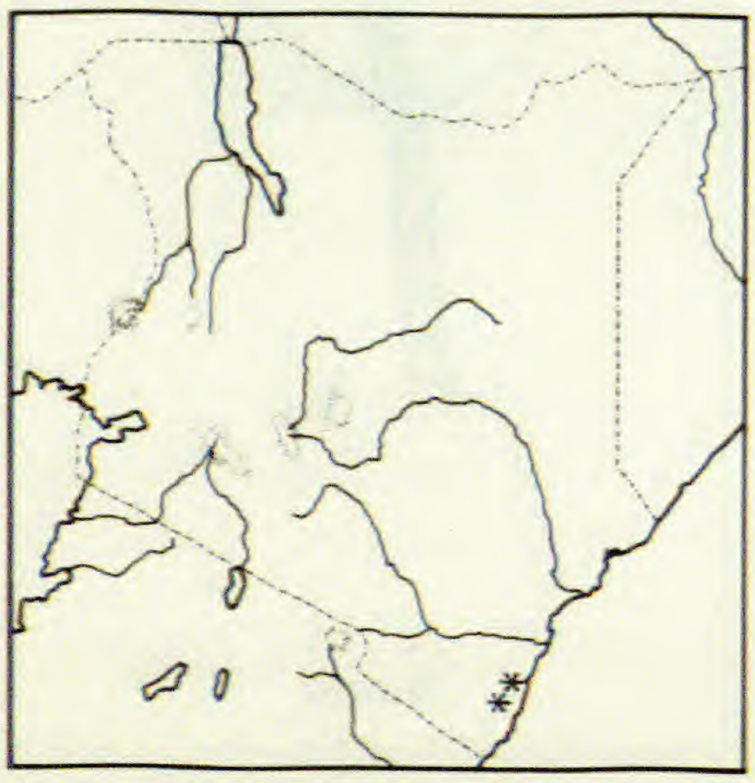
Euphorbiaceae

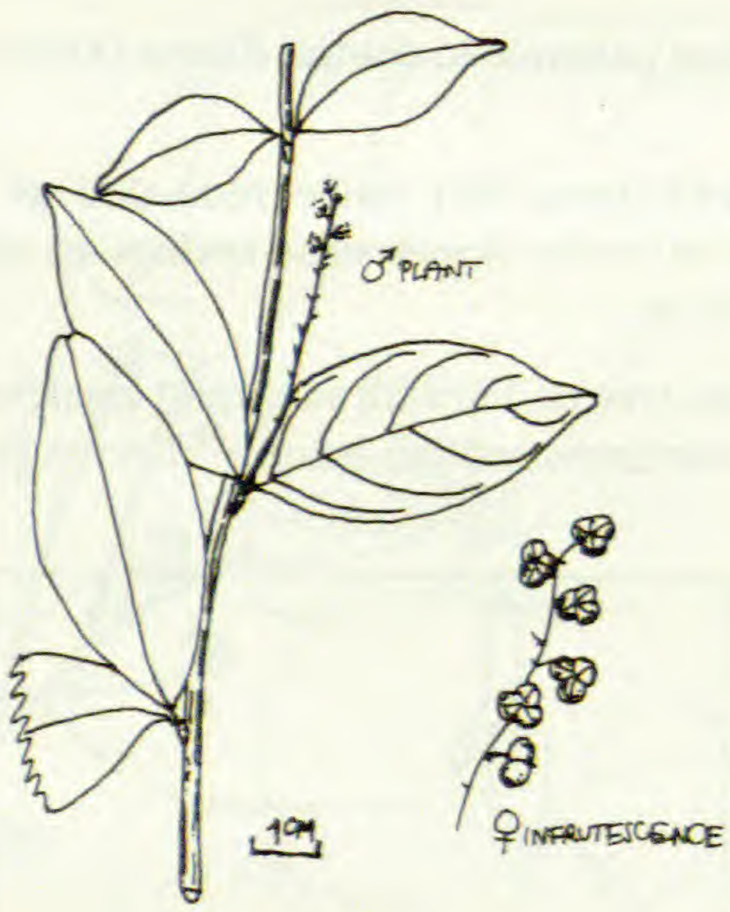
Local Names & Uses: none known.

Distribution: coastal Tanzania (Mgambo, eastern Usambaras) and Kenya (Chonyi, Cha Simba and Mitunguni).

Habitat: limestone outcrops; 70-240 m.

Description: shrub or small tree 1-4 m tall; dioecious. Leaves slightly fleshy. Flowers tiny, green.





Status:

Rare, Vulnerable, Endangered. These limestone outcrops are being cleared for agriculture; the species also seems to be rare in its localities.

Dovyalis sp. A of FTEA (a new, undescribed species)

Flacourtiaceae

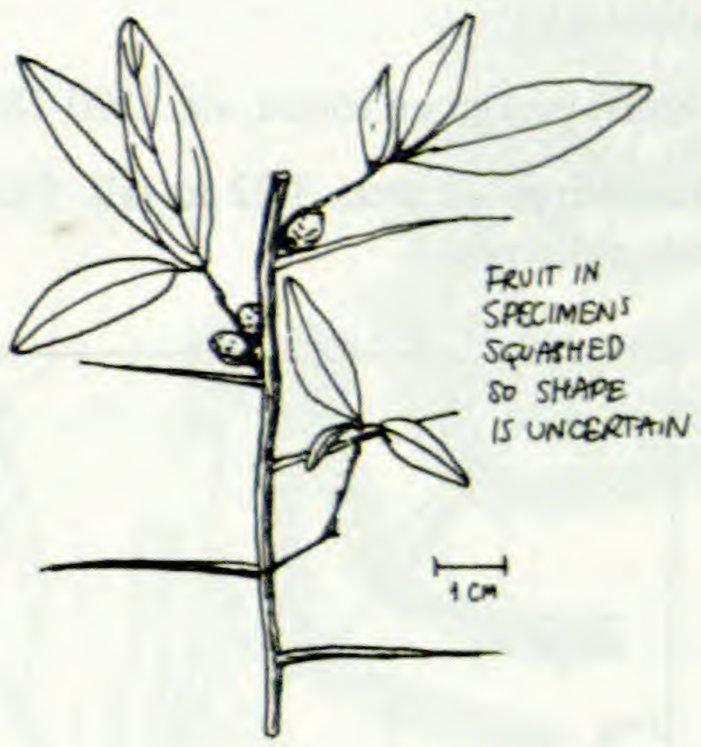
Local Names & Uses: Mdungu-tundu (Giriama), Mnao-mnao (Swahili). The fruit is edible.

Distribution: endemic to coastal Kenya (Mrima Hill, Arabuko-Sokoke, Gedi).

Habitat: moist lowland forest, alt. 15-300 m.

Description: small tree to 4 m tall, with spines to 4.5 cm long. Flowers unknown. Fruits orange, velvety.





Status:

Rare, Vulnerable. The locality at Gedi is a National Monument. If numbers at Gedi are low, the status might be **Endangered,** as both Mrima and Arabuko are severely disturbed.

Aloe ballyi Reynolds

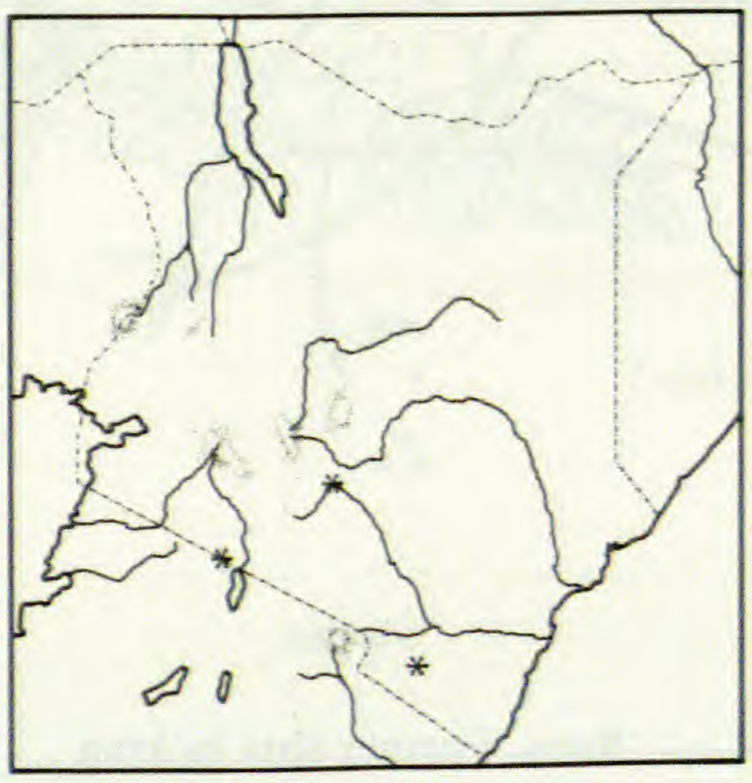
Liliaceae

Local Names & Uses: none known

Distribution: Tanzania (South Pare mountains, Manyara escarpment,Ngubora river, Lake Eyassi) and Kenya (Taita Hills area, Entasekera, Ewaso Nyiro near Narok and Thika area).

Habitat: dense, rather dry bushland; alt. 900-1900 m.

Description: single-stemmed tree to 10 m tall. Leaves fleshy. Flowers orange or red. Whole plant smelling of rats or mice when cut.





Status:

Rare. Further data lacking, but this type of bushland is exploited for charcoal burning, so the status might be Vulnerable.

Memecylon taitense Wickens — *Melastomataceae*

Local Names & Uses: none known.

Distribution: endemic to Taita Hills (Ngangao and Mbololo forests).

Habitat: moist evergreen forest, alt. 1500-1850 m.

Description: shrub or tree, 3-22 m tall. Flowers white, tiny. Fruit unknown.





Status:

Rare, Vulnerable. At this moment the Taita Hills forests do not seem threatened, but neither do they enjoy any protection status.

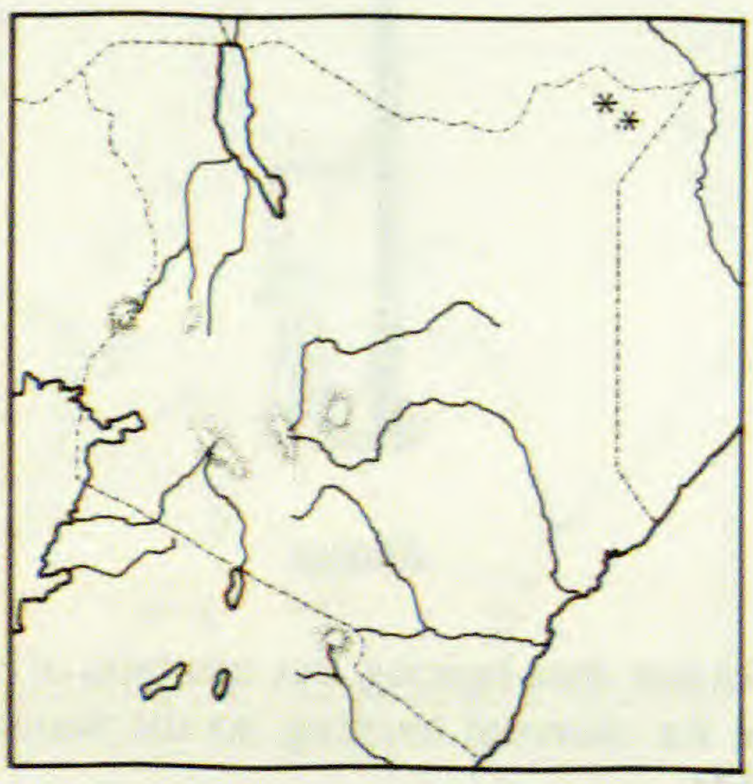
Acacia condyloclada Chiov. — *Mimosaceae*

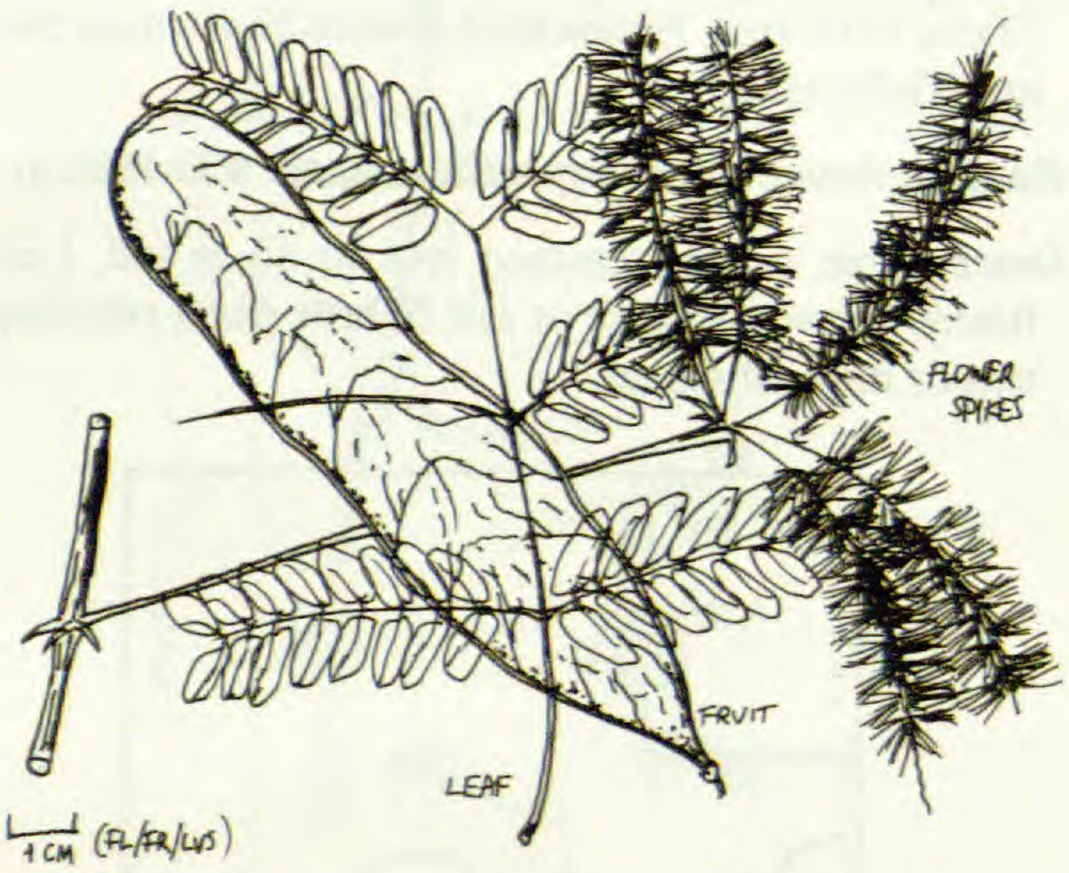
Local Names & Uses: Adad geri (Somali).

Distribution: local in the Ogade and northern Somalia; in Kenya only known from the Rhamu area.

Habitat: dry *Acacia-Commiphora* bushland on limestone; alt. 400-850 m.

Description: tree, 2-11 m tall, with white or yellow bark; spines 1-3 per node, almost straight, to 1 cm. Flowers in long spikes, colour unknown. Fruit (purplish) brown.





Status:

Rare. Further data lacking.

Acacia dolichocephala Harms

Mimosaceae

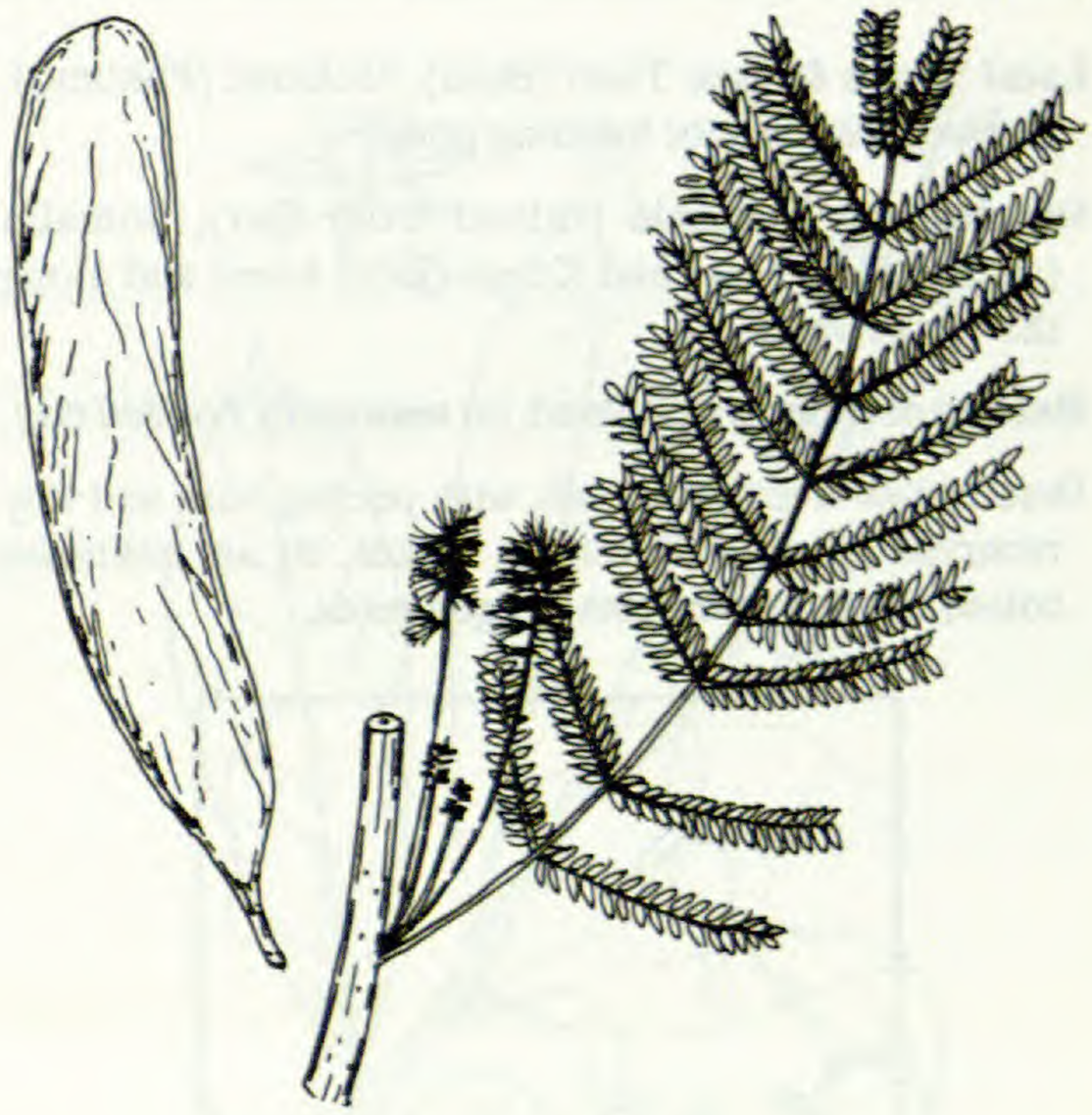
Local Names & Uses: none known

Distribution: Sudan, Ethiopia, Uganda, Tanzania, and Kenya (at the foot of the Kacheliba escarpment: 5 trees known from this site)

Habitat: along rivers in dry areas; alt. 1100-1950 m.

Description: tree 4-12 m tall, with spines in pairs, to 4 mm long, or absent. Flowers orange-yellow, in elliptical heads or short spikes. Fruit purplebrown.





Status:

Rare. Despite its rather wide distribution; only small numbers seem to occur. The most recent Kenyan collection is from 1962.

Albizia tanganyicensis Bak. f. ssp. *adamsoniorum* Brenan

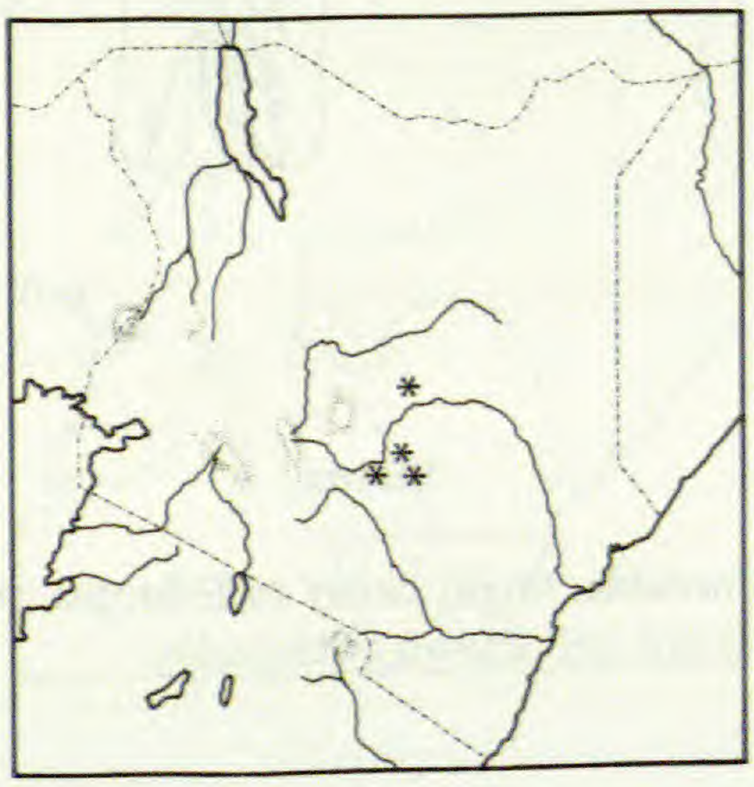
Mimosaceae

Local Names & Uses: Isavi/Kethekajuu (Kamba), Mushabe (Meru).

Distribution: endemic to central Kenya.

Habitat: on rocky inselbergs or in rocky sites in open woodland; occasionally this is the only tree on rocky outcrops. Alt. 450-950 m.

Description: tree 4-20 m tall, with smooth, peeling papery bark. Flowers white or pale yellow, in heads. Fruit reddish- or purplebrown.





Status:

Rare. The populations in Meru National Park are protected.

Newtonia erlangeri (Harms) Brenan

Mimosaceae

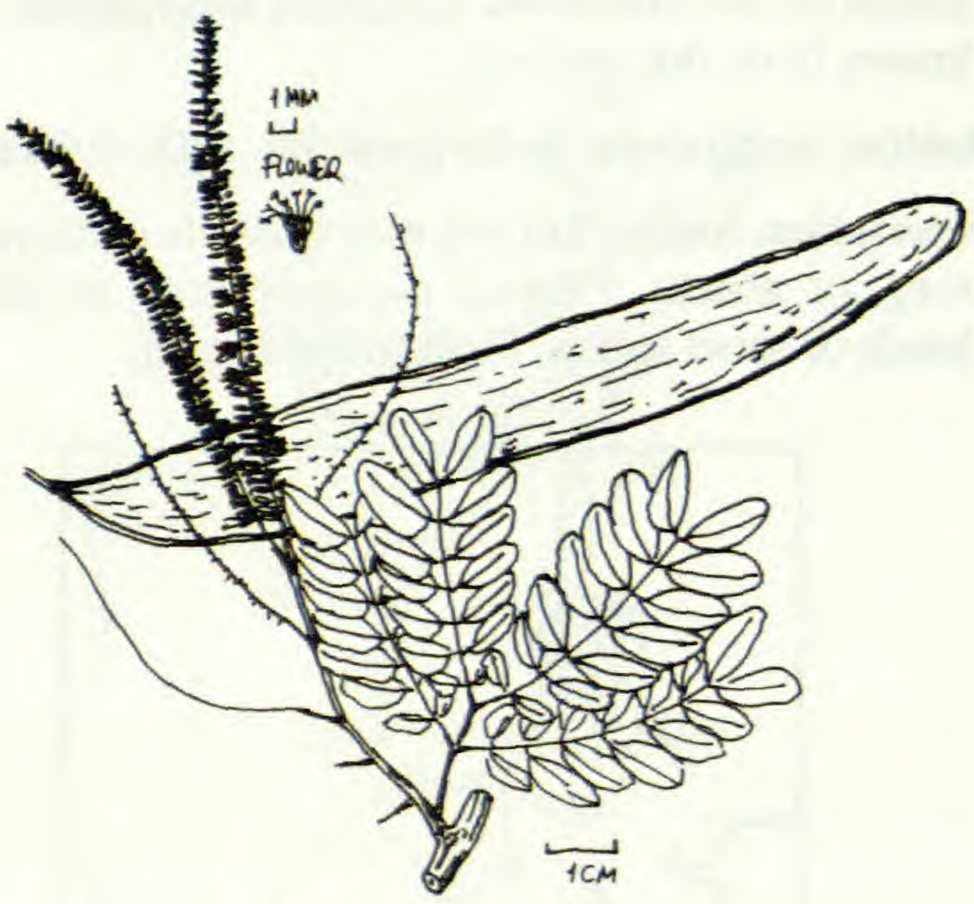
Local Names & Uses: Tuari (Boni), Mukame (Pokomo). The wood is used for building poles.

Distribution: Tanzania (inland from Dar), Somalia (central coast area) and Kenya (Boni forest and along the Tana river).

Habitat: deciduous woodland, on seasonally flooded clay.

Description: tree 4-18 m tall, with peeling bark and tiny recurved spines. Flowers in spikes, of an unknown colour. Fruit brown, with winged seeds.





Status:

Rare. Further data lacking; in Kenya this area is not very well known botanically.

Moringa arborea Verdc.

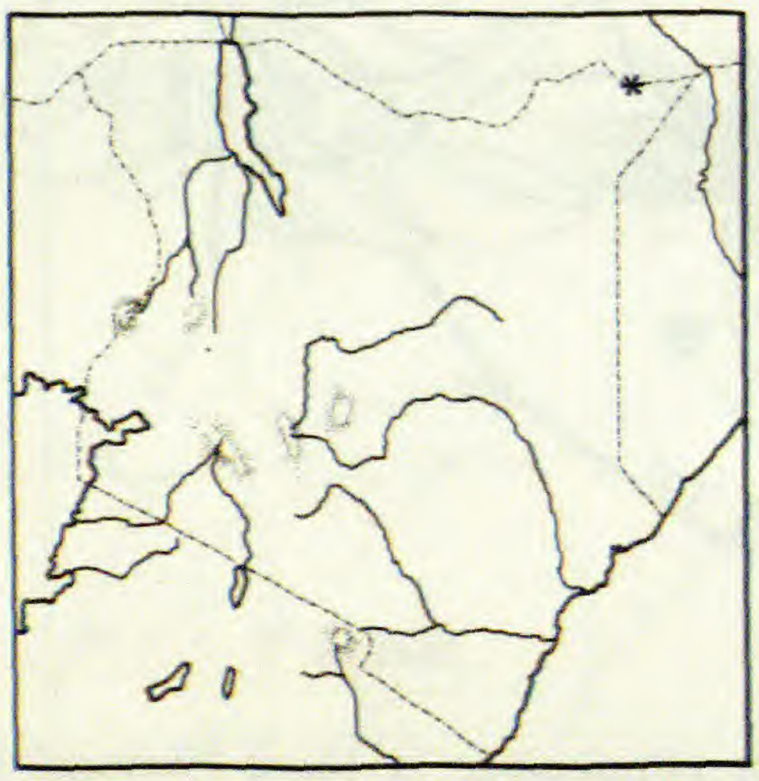
Moringaceae

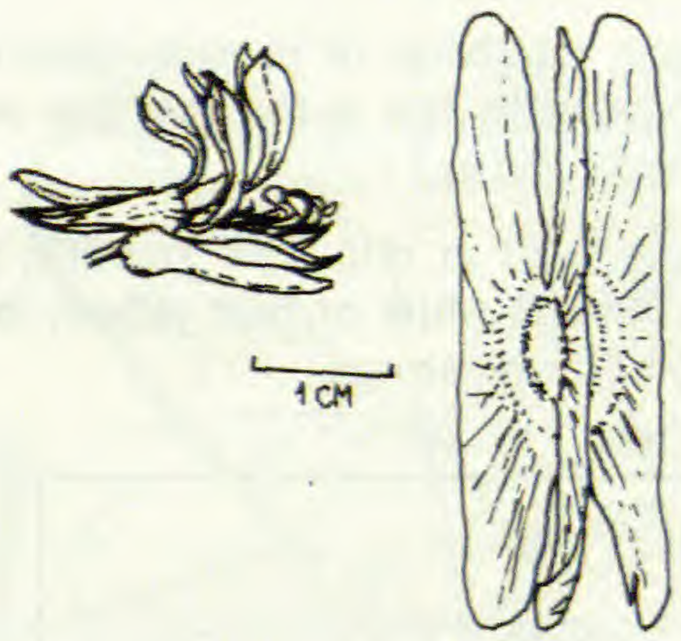
Local Names & Uses: none known.

Distribution: only known from the type collection, 35 km WNW of Ramu.

Habitat: dried-out lugga; alt. ca. 500m.

Description: tree 15 m tall, with smooth grey bark. Leaves unknown. Flowers cream, in long inflorescences. Fruit 53-57 cm long, 16-18 mm across.





Status:

Rare, Vulnerable. Might occur in Ethiopia as well, but this area is not well known botanically.

Ouratea sacleuxii (van Tiegh.) Beentje comb. nov. — *Ochnaceae*

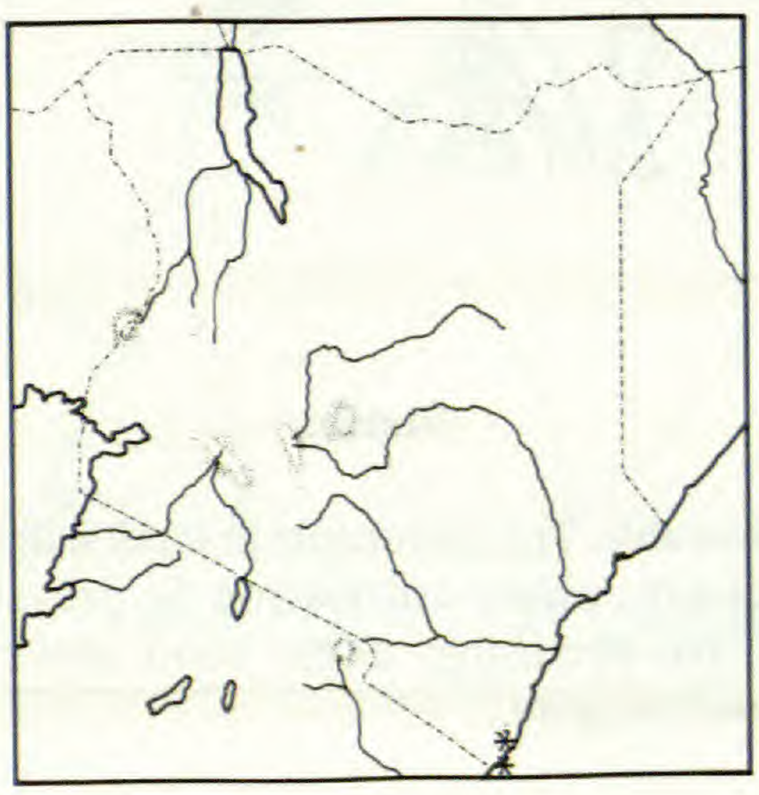
Local Names & Uses: none known.

Distribution: Tanzania (below Amani, Mtibwa, Sanje, Turiani, Lukoga) and Kenya (Shimba Hills and Gogoni forest).

Habitat: moist evergreen forest; alt. 300-750 m.

Description: shrub or tree 1-6 m tall. Leaves up to 34 by 9 cm. Flowers yellow. Fruit red or black, several together on the enlarged red calyx.

Note: Formerly known as Cercanthemum Sacleuxii van Tiegh.





Status:

Rare. Protected in the Shimba Hills National Reserve; the status of the other sites is unknown to me.

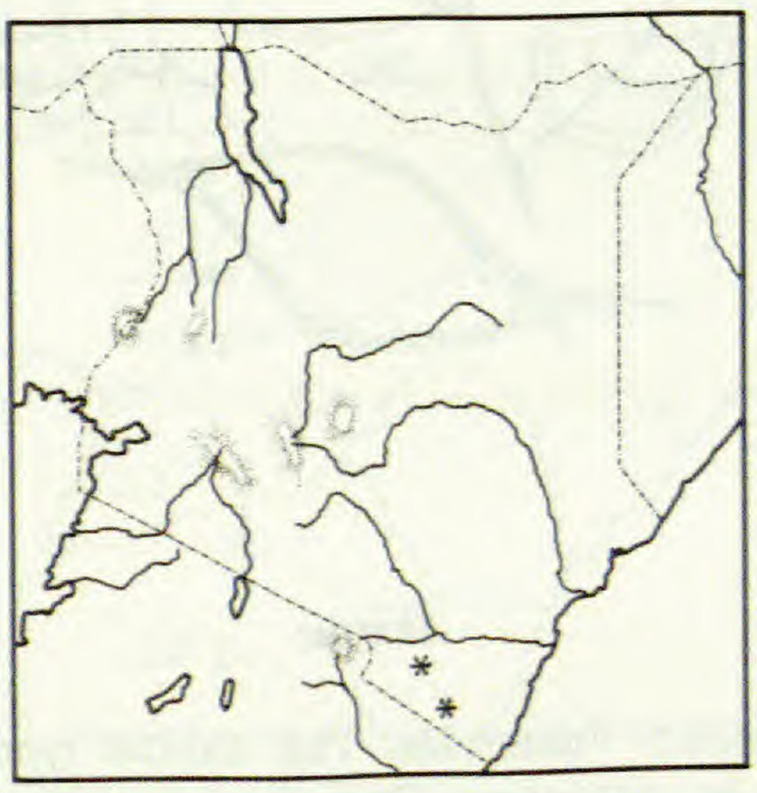
Ouratea schusteri Engl. — *Ochnaceae*

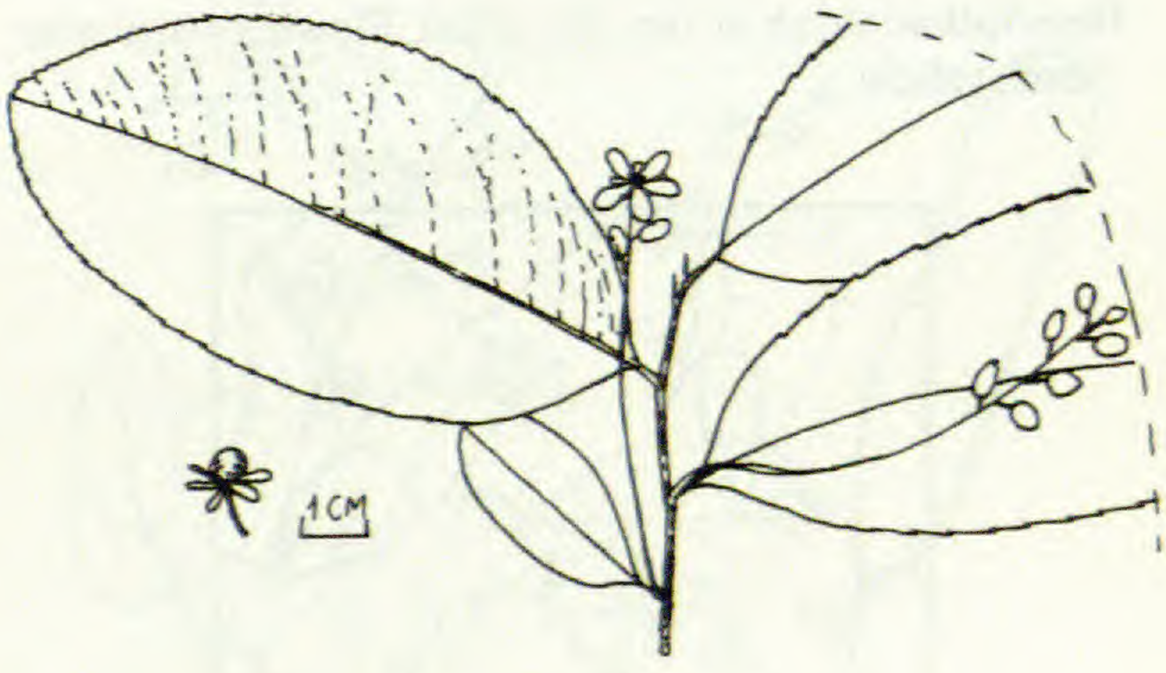
Local Names & Uses: none known.

Distribution: Tanzania (western Usambaras, Uluguru Mountains) and Kenya (Taita Hills and Kasigau).

Habitat: moist evergreen *(Ocotea)* forest; alt. 1500-2050 m.

Description: shrub or tree 2-15 m tall. Flowers yellow. Fruit as in *O. sacleuxii.*





Status:

Rare. The Kenyan populations are not officially protected, but not under threat; the numbers in Taita Hills are rather low, so probably **Vulnerable.**

Pandanus murira Beentje ined.

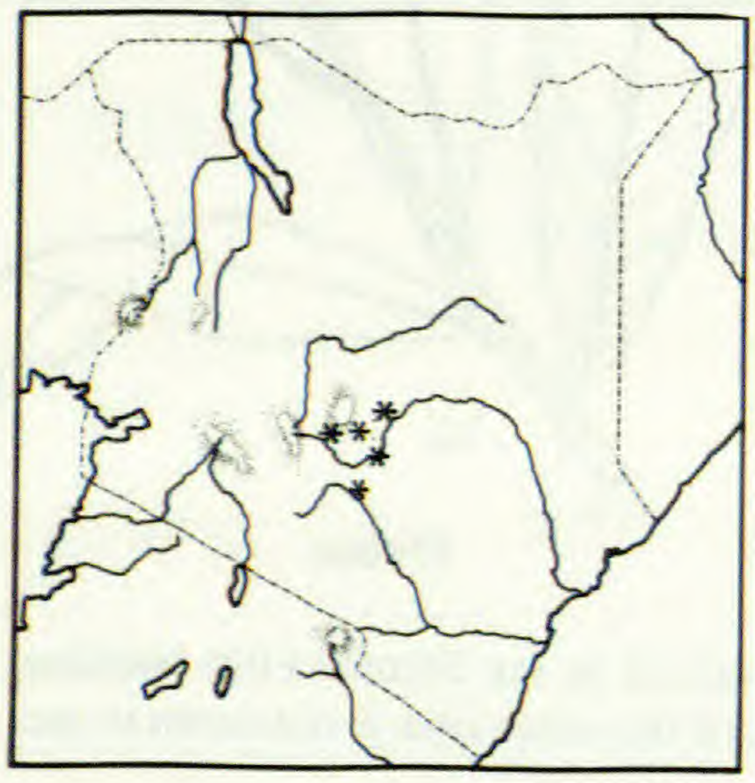
Pandanaceae

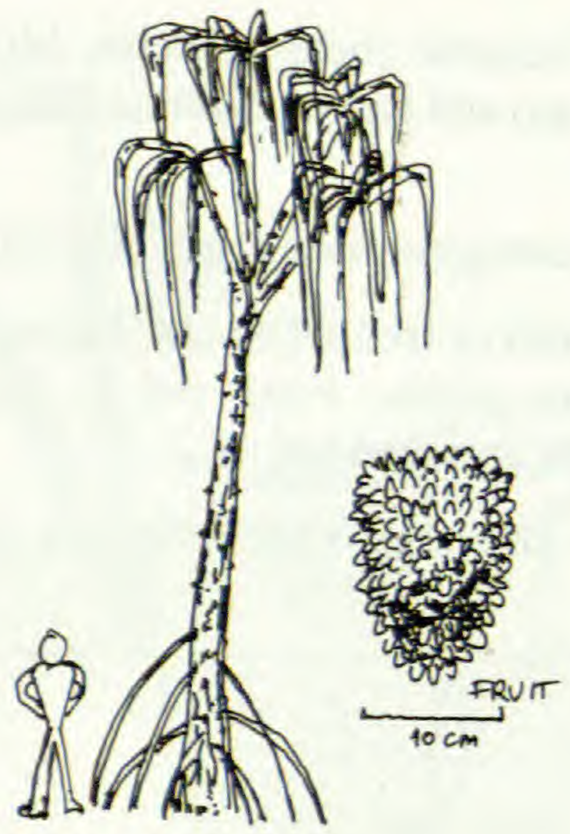
Local Names & Uses: Murira (Embu). The wood is used as building poles.

Distribution: endemic to central Kenya.

Habitat: on riverbanks close to the water; alt. 800-1200 m.

Description: tree to 15 m tall with stilt roots to 2 m high; trunk somewhat spiny. Leaves long and narrow, with spiny margins and midrib. Flowers in large inflorescences. Fruits large, with conical bosses.





Status:

Rare, Vulnerable. The tree occurs in small numbers along several rivers, where cultivation is prevalent. The numbers are declining; might soon move into the **Endangered** category.

Baphia keniensis Brummitt

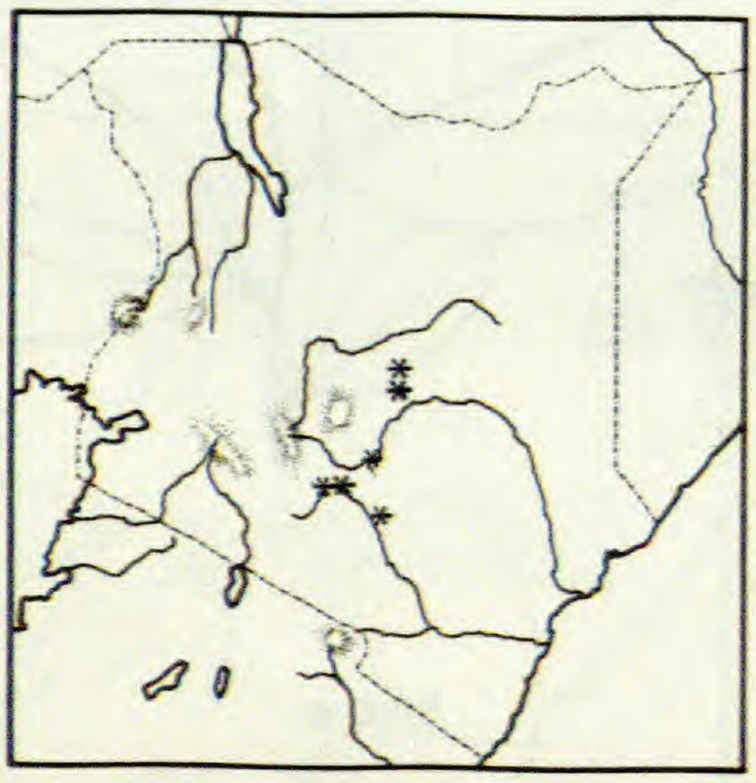
Papilionaceae

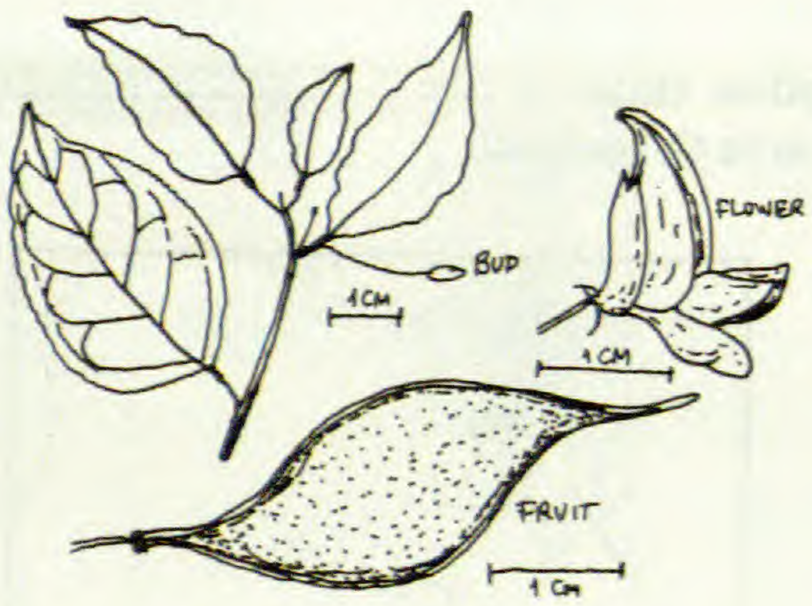
Local Names & Uses: none known.

Distribution: endemic to central Kenya.

Habitat: on riverbanks; alt. 750-1500 m.

Description: shrub or tree 2-9 m tall. Flowers white with some yellow.





Status:

Rare, possibly **Vulnerable.** This habitat type is under pressure by cultivators. Only the population in Meru National Park enjoys protection.

Dicraeopetalum stipulare Harms

Papilionaceae

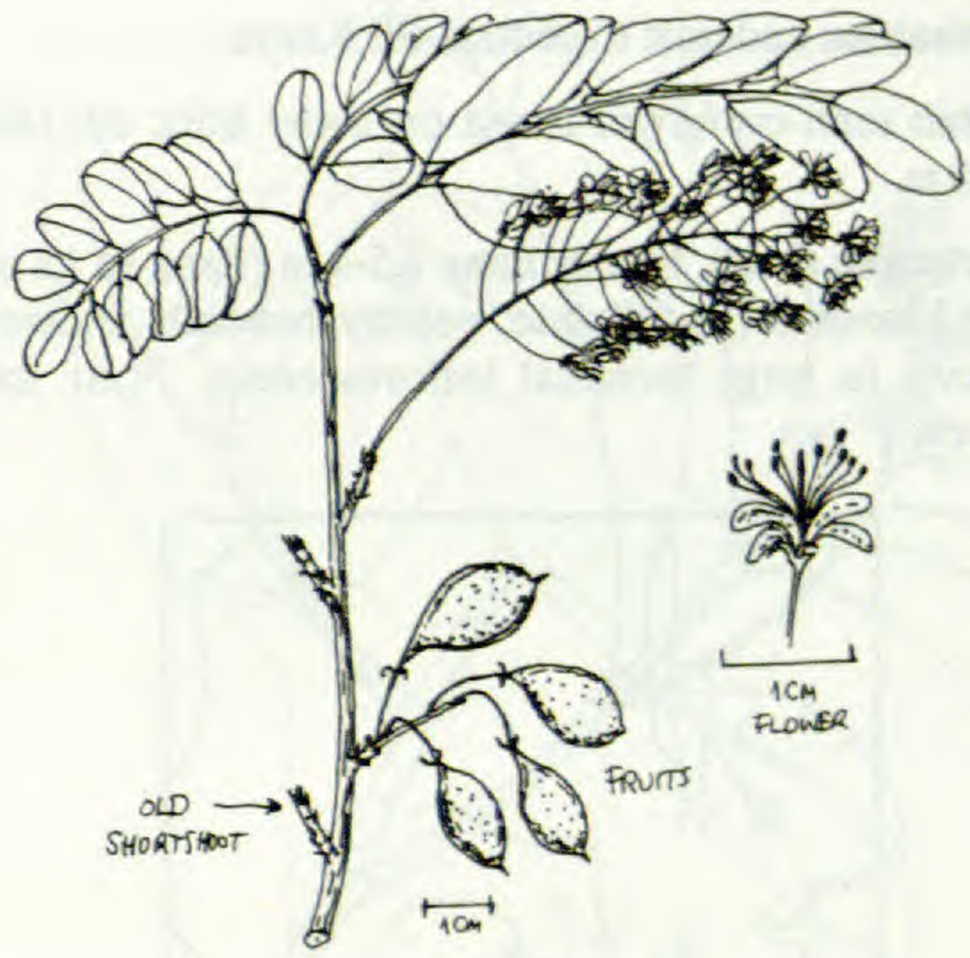
Local Names & Uses: Sabi-sayde/Salma selmi (Somali).

Distribution: Ethiopia (anno 1900, Adjabo plateau), Somalia (Bay region) and Kenya (anno 1952, el Wak area).

Habitat: *Acacia-Commiphora* bushland on sand or limestone; alt. 300-600 m.

Description: shrub or tree 4-12 m tall. Leaves imparipinnate. Flowers white, in racemes. Fruit papery, flat.





Status:

Rare and possibly **Vulnerable.** Only small numbers seem to occur. The vegetation type is common, so there might very well be undiscovered populations.

Lonchocarpus kanurii Brenan & Gillett

Papilionaceae

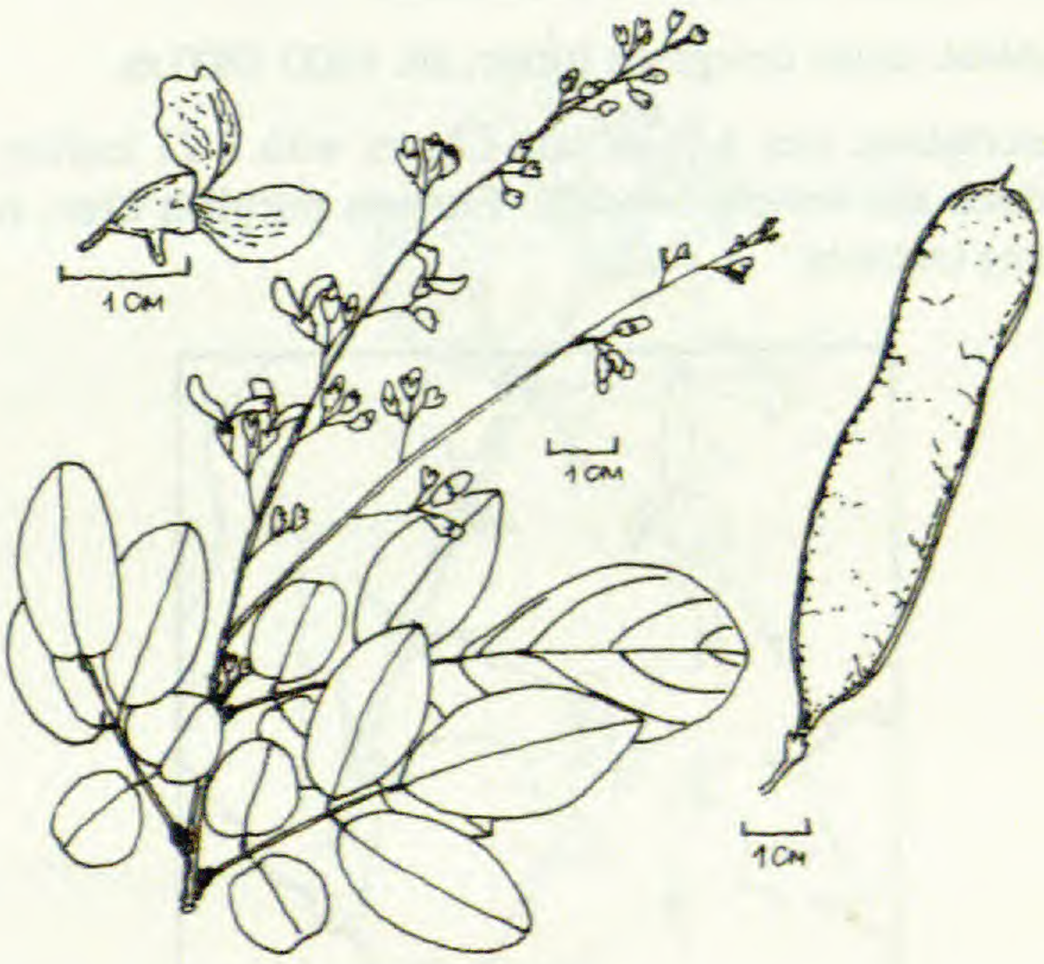
Local Names & Uses: none known.

Distribution: Somalia (inland from Mogadishu) and Kenya (between Garissa and Wajir).

Habitat: open *Acacia* bushland on red sand; alt. 150-300 m.

Description: tree 3-7 m tall. Leaves 3-5 (-7)-foliolate. Flowers purple, in racemes. Fruit oblong, flat.





Status:

Rare. Fairly common within its small distribution area.

Millettia leucantha Vatke

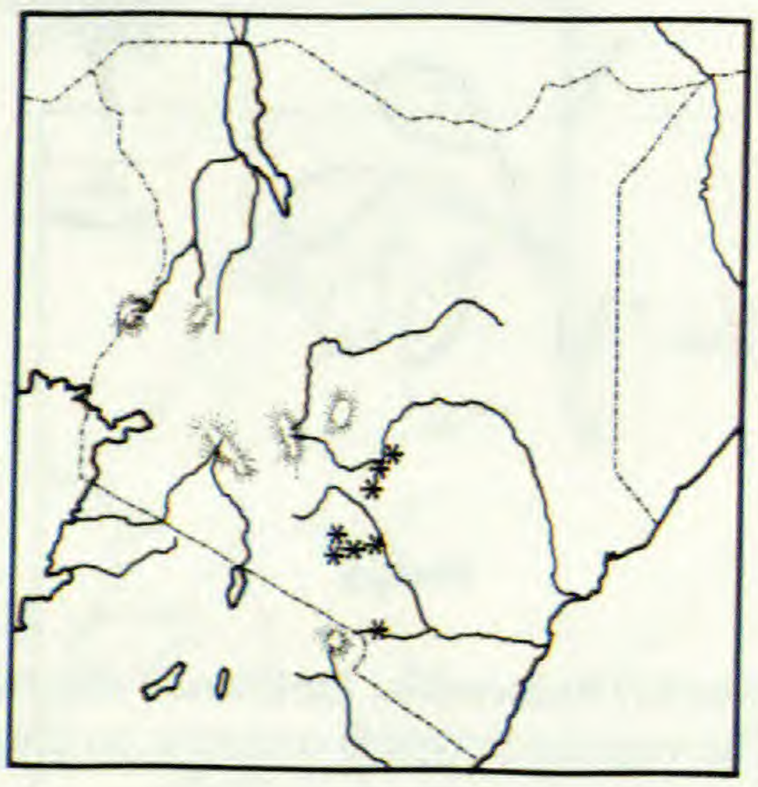
Papilionaceae

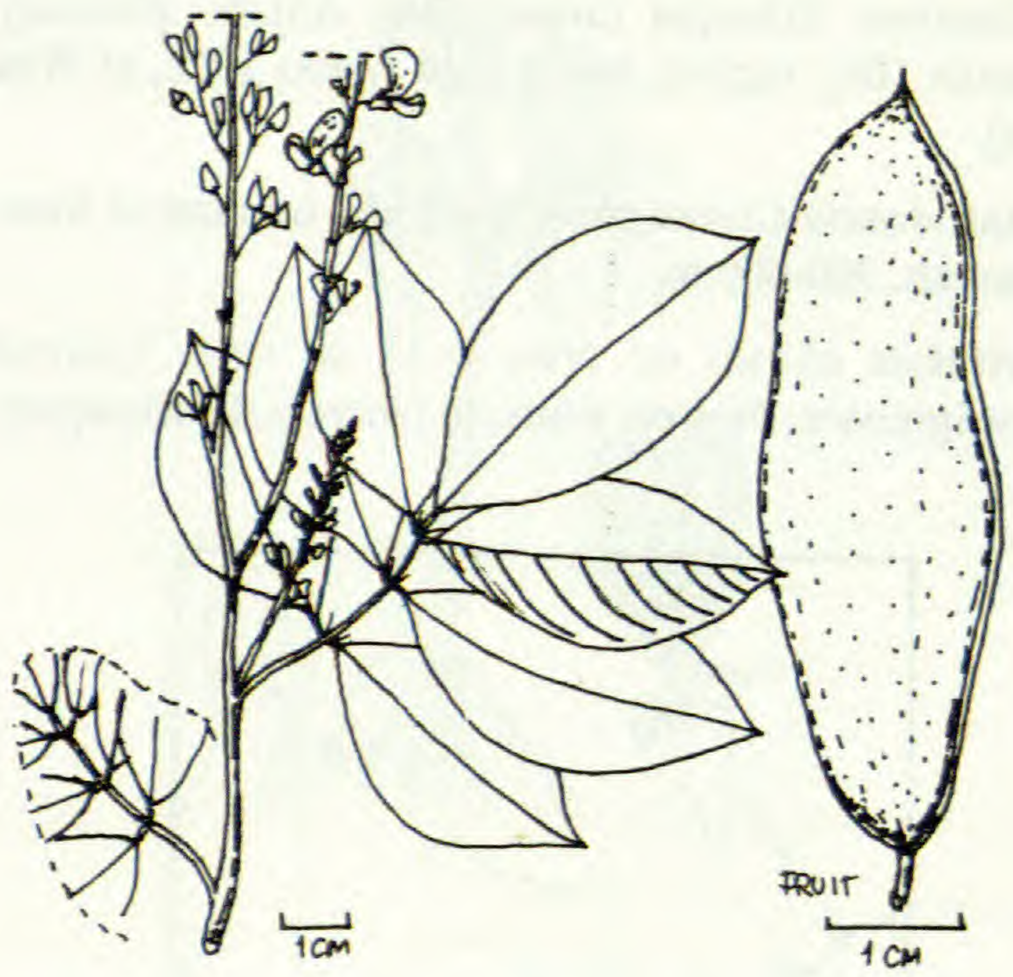
Local Names & Uses: none known.

Distribution: endemic to central-SE Kenya.

Habitat: semi-evergreen forest on rocky hills; alt. 600-1700 m.

Description: shrub, tree or liana 1.5-4 m (liana to 12 m) tall. Leaves 5-(7)-foliolate, velvety beneath. Flowers mauve, in large terminal inflorescences. Fruit flat, velvety.





Status:

Rare, Vulnerable. The forests on these isolated hilltops are rapidly disappearing. Only on Ngulia, in Tsavo National Park, is this species protected. Might soon move into the **Endangered** category.

Millettia oblata Dunn ssp. *teitensis* Gillett

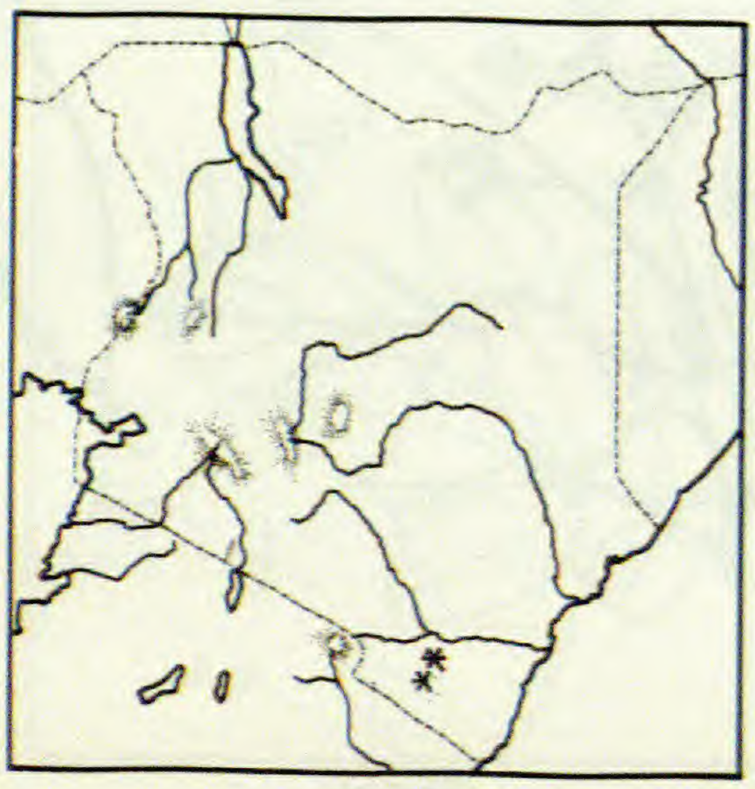
Papilionaceae

Local Names & Uses: Mwava (Taita)

Distribution: endemic to Taita Hills.

Habitat: moist evergreen forest; alt. 1400-1800 m.

Description: tree 4-21 m tall. Leaves with 9-21 leaflets, which are velvety beneath. Flowers purplish blue, in long racemes.





Status:

Rare, Vulnerable. Its area is very small, and not officially protected. However, at the moment these forests do not seem under threat.

Lasiodiscus mildbraedii Engl. ssp.*ferrugineus* (Verdc.) Faden

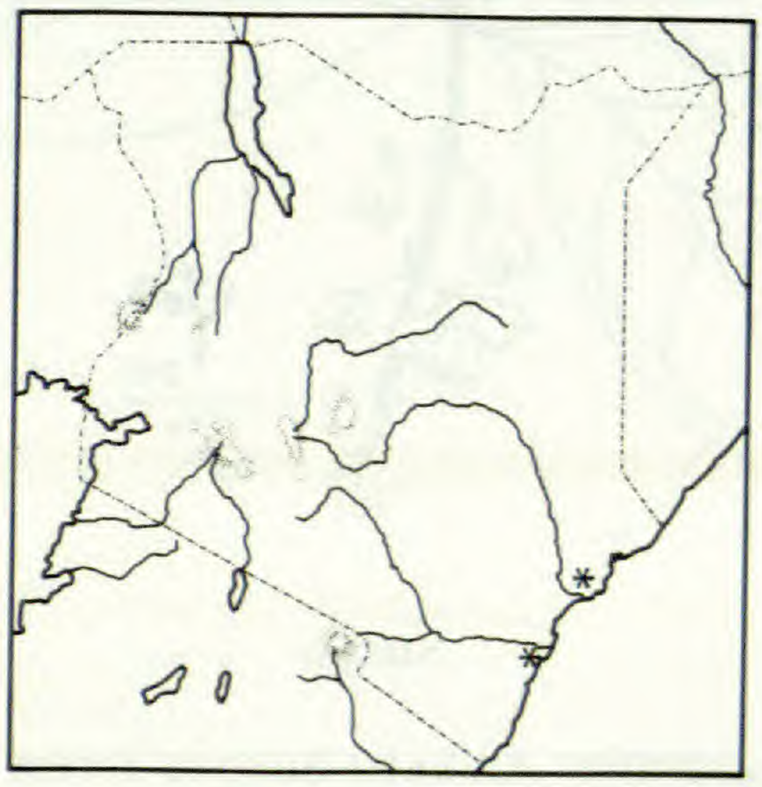
Rhamnaceae

Local Names & Uses: Mbage wa mbage/Muholoholo (Swahili).

Distribution: endemic to coastal Kenya (Witu and Arabuko-Sokoke)

Habitat: dry evergreen forest; alt. 1-150 m.

Description: shrub or tree 1.5-6 m tall. Flowers white, in long-stalked groups. Fruit round, to 1 cm across.





Status:

Rare, Vulnerable. The populations seem to be small, and all coastal forests are under some threat, even when they fall under the Forest Department.

Canthium glaucum Hiern ssp. glaucum

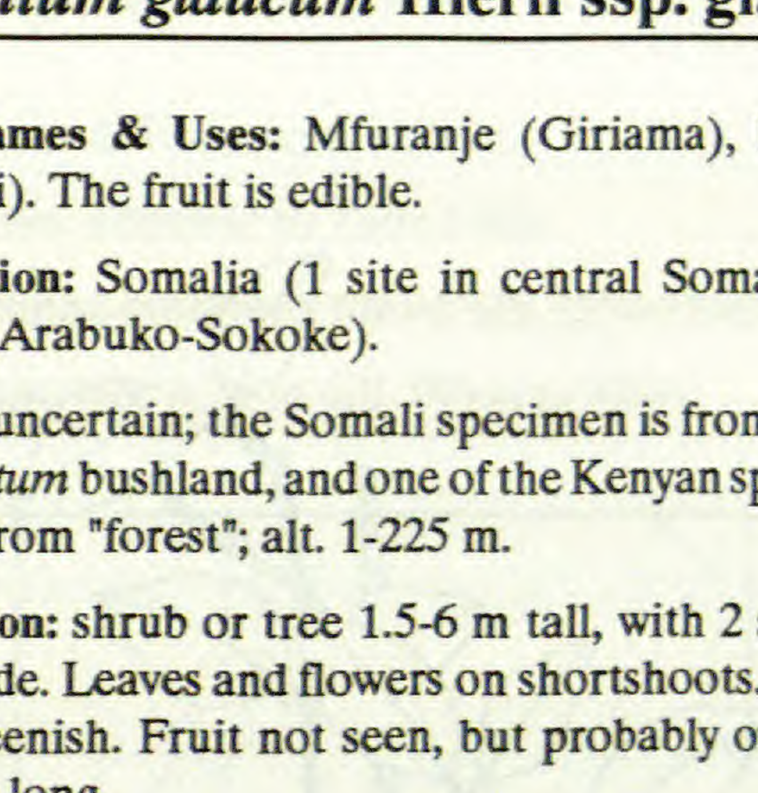
Rubiaceae

Local Names & Uses: Mfuranje (Giriama), Mtengeji (Swahili). The fruit is edible.

Distribution: Somalia (1 site in central Somalia) and Kenya (Arabuko-Sokoke).

Habitat: uncertain; the Somali specimen is from *Acacia-Combretum* bushland, and one of the Kenyan specimens comes from "forest"; alt. 1-225 m.

Description: shrub or tree 1.5-6 m tall, with 2 spines at each node. Leaves and flowers on shortshoots. Flowers tiny, greenish. Fruit not seen, but probably ovoid and ca. 1 cm long.





Status:

Rare, Vulnerable. Numbers seem to be very low. Last collected in Kenya in 1965. Might be **Endangered.**

Canthium kilifiensis Bridson

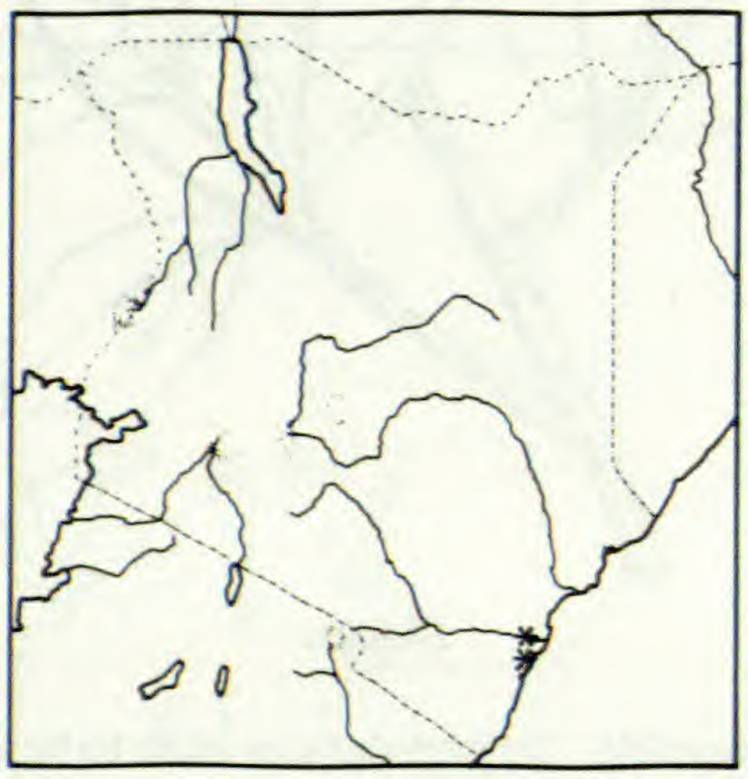
Rubiaceae

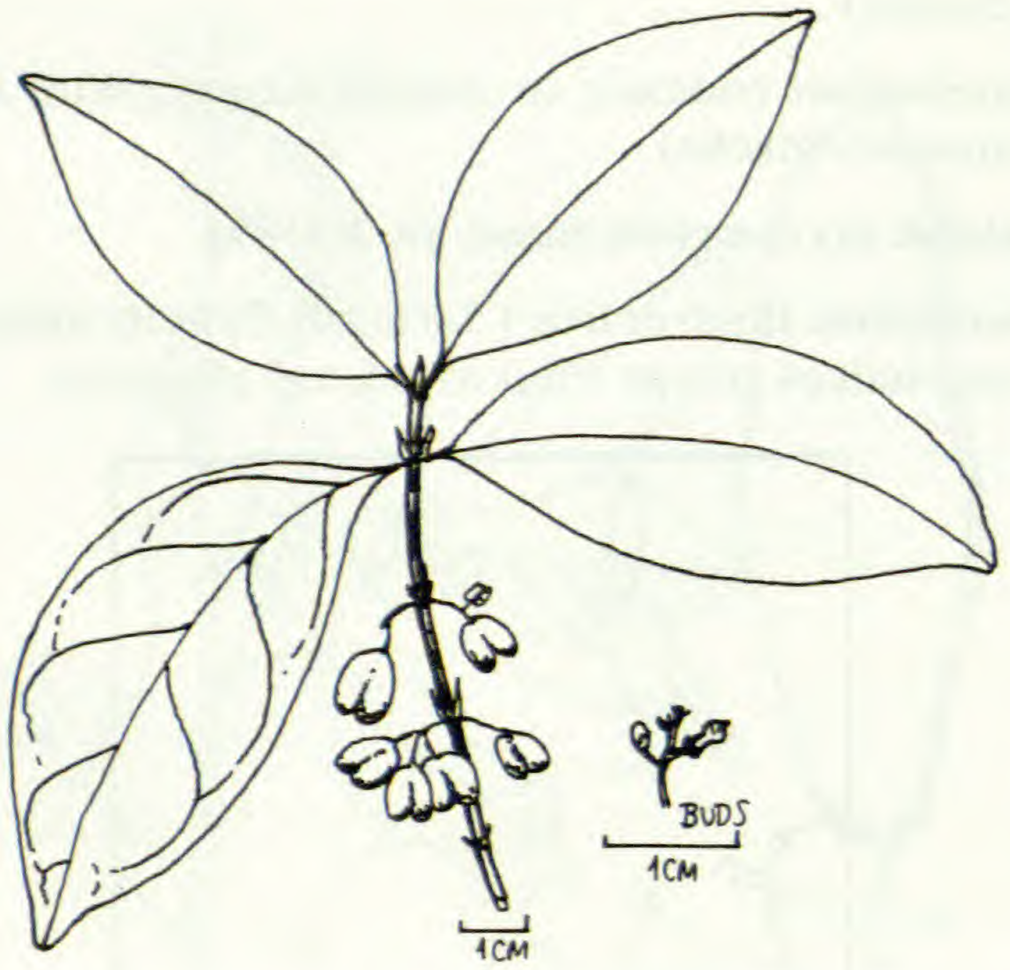
Local Names & Uses: Mfupapu (Swahili).

Distribution: endemic to coastal Kenya (Arabuko-Sokoke and ? Marafa).

Habitat: *Brachystegia* woodland and *Cynometra* forest; alt. 30-130 m.

Description: shrub or tree to 6 m tall. Flowers small, greenish. Fruit sometimes 2-3-lobed.





Status:

Rare, Vulnerable. Arabuko-Sokoke forest is partly protected, but the disturbance of even these parts is continuing.

Canthium robynsianum Bullock

Rubiaceae

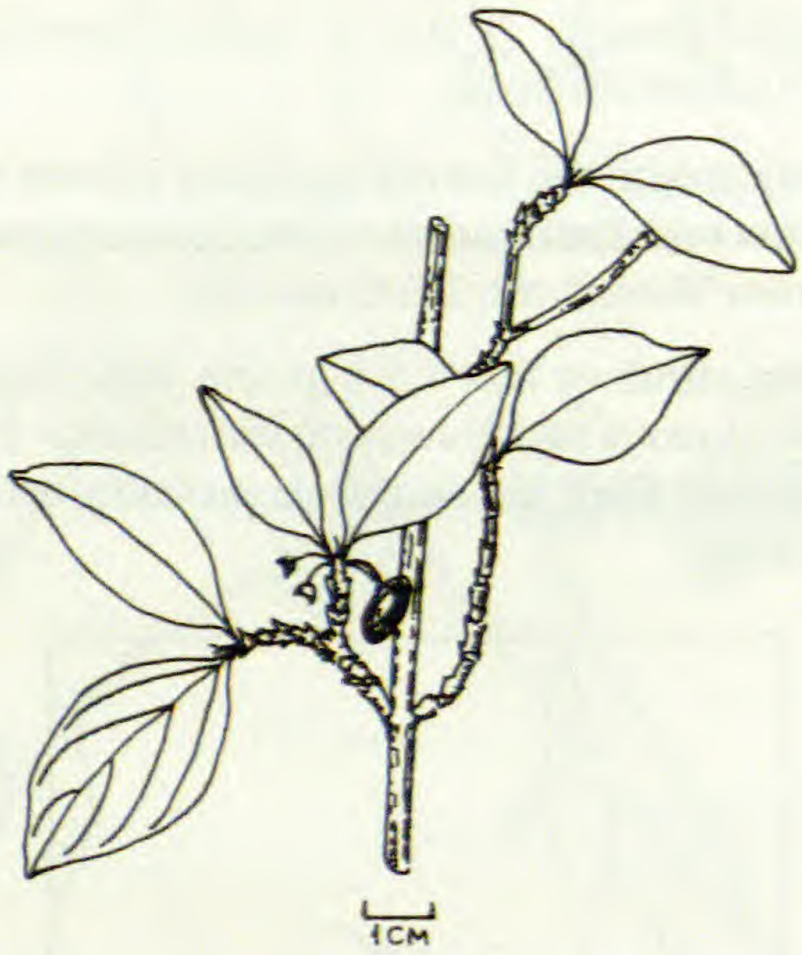
Local Names & Uses: Mkumba Ngombe (Swahili).

Distribution: Tanzania (Handeni and Tanga districts, E Usambaras, Ulugurus) and coastal Kenya (Boni, Arabuko-Sokoke, and in 1902 in the Shimba Hills).

Habitat: dense bushland or *Brachystegia* woodland; alt. 1-960 m.

Description: shrub or tree 1-4.5 m, with pale grey bark. Leaves and flowers on short shoots. Flowers white, small.





Status:

Rare and possibly **Vulnerable.** Arabuko-Sokoke forest is disturbed, and the status of Boni is uncertain.

Coffea arabica L.

Rubiaceae

Although the inclusion of this commercial species might seem rather strange, the wild populations of this tree occur in moist evergreen forest in southwest Ethiopia and on Marsabit. The Marsabit population represents an extremely valuable resource as a source of wild genes, and great care should be taken that these plants are not destroyed or interfered with.





Coffea fadenii Bridson

Rubiaceae

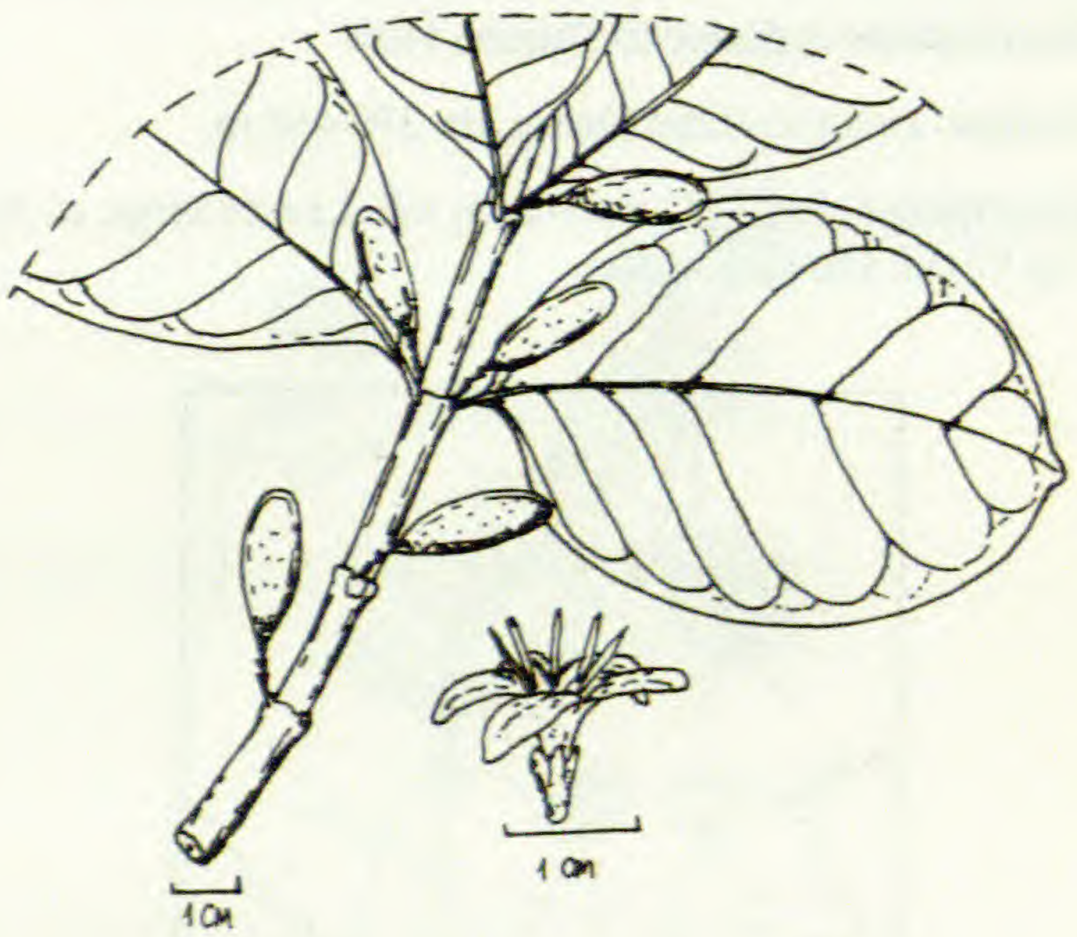
Local Names & Uses: none known.

Distribution: endemic to Taita Hills.

Habitat: moist evergreen forest; alt. 1550-1850 m.

Description: tree 5-15 m tall. Flowers white.





Status:

Rare, Vulnerable. Occurs in Ngangao and Mbololo forests, which are not officially protected. The numbers are quite low. Again, this might represent a valuable source of wild genes for coffee improvement purposes.

Ixora scheffleri K. Schum. & K. Krause ssp. *keniensis* Bridson — *Rubiaceae*

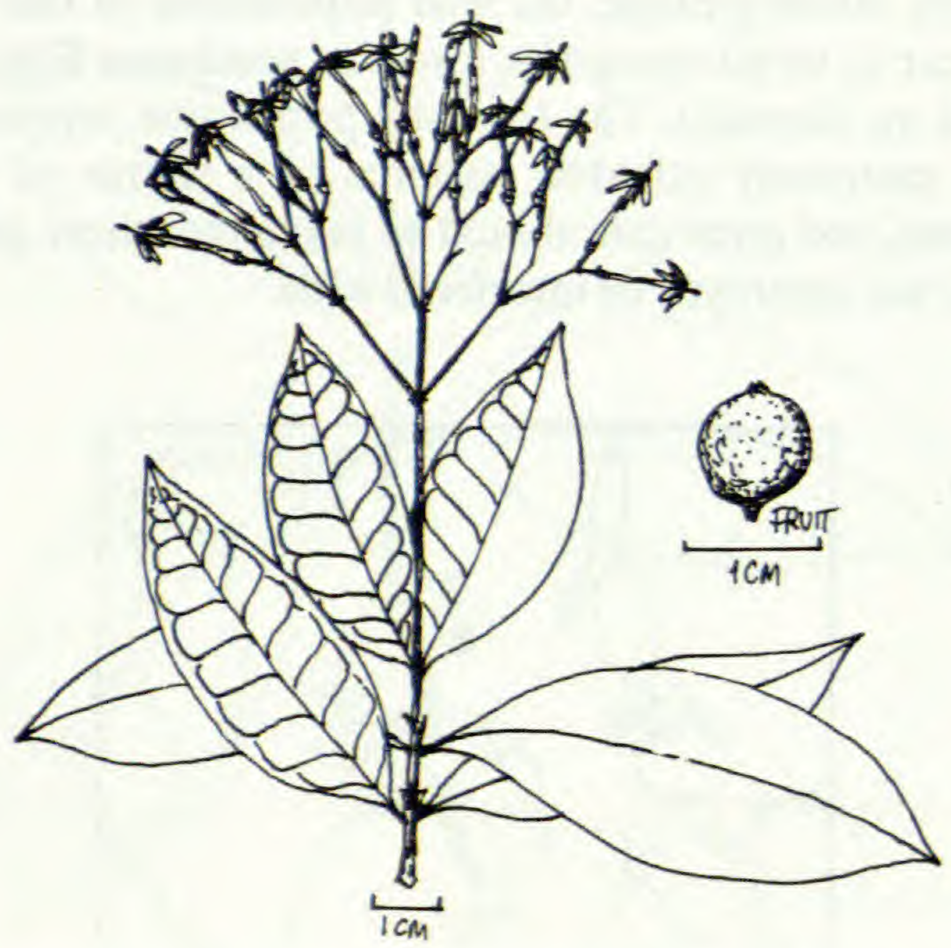
Local Names & Uses: Mutichuma/Kiruru (Kikuyu), Muthioya (Embu).

Distribution: endemic to the S and SW slopes of Mount Kenya.

Habitat: moist evergreen *Ocotea* forest; alt. 1900-2250 m.

Description: tree to 7.5 m. Flowers white, buds pink, in long-stalked inflorescences.





Status:

Rare, Vulnerable, Endangered. The camphor forests have been seriously depleted by logging. The most recent collection is from 1967; possibly **Extinct**, but more searches are needed.

Oxyanthus pyriformis (Hochst.) Skeels ssp. *longitubus* Bridson — *Rubiaceae*

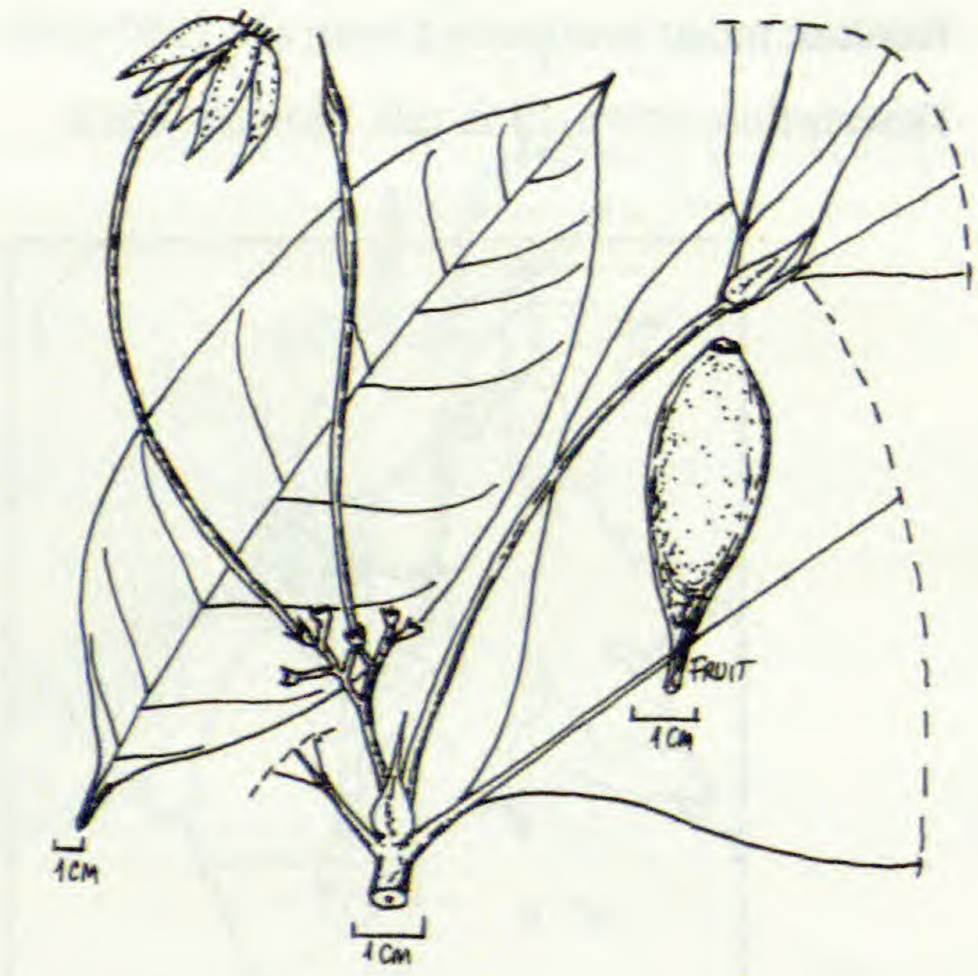
Local Names & Uses: none known

Distribution: endemic to Shimba Hills

Habitat: moist lowland forest; alt. 370-450 m.

Description: shrub or tree 3-10 m tall. Leaves large, to 30 by 17 cm. Flowers white.





Status:

Rare. Shimba Hills is a National Reserve, although agriculture seems to be encroaching.

Oxyanthus pyriformis (Hochst.) Skeels ssp. *brevitubus* Bridson

Rubiaceae

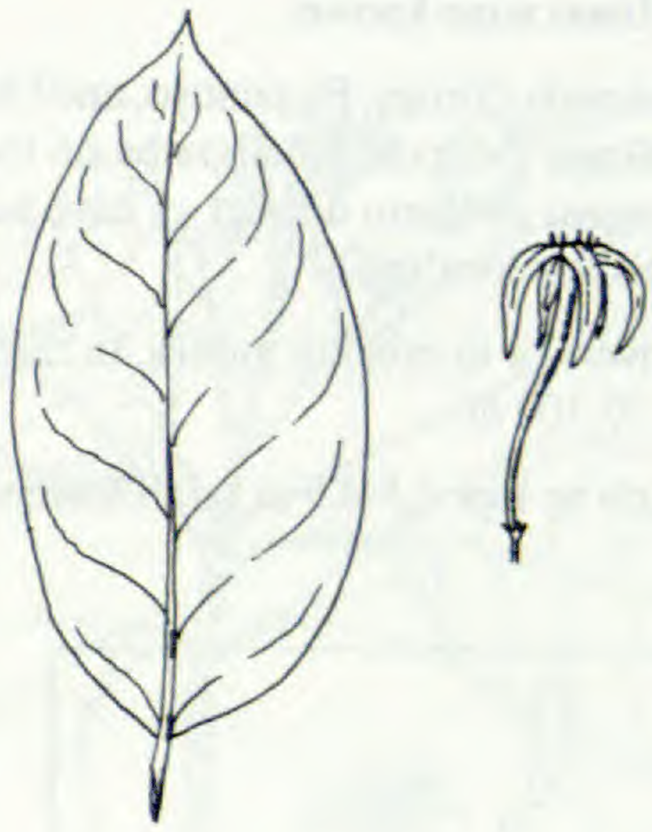
Local Names & Uses: Muzuki (Kamba).

Distribution: Tanzania (Mount Meru) and Kenya (Mutito Hill anno 1937, Emali Hill anno 1940).

Habitat: dry evergreen forest; alt. 1200-1700 m.

Description: differs from ssp. *longitubus* in the rounded leafbase and the much shorter corolla tube.





Status:

Rare, Vulnerable. Only 4 specimens are known, which indicates a low population. The Tanzanian population is probably safe in Ngurdoto National Park; in Kenya neither of the sites is protected in any way. The forest on Mutito Hill, near Kitui, has probably disappeared; the forest on Emali Hill is still there, but this species has not been collected on any of our recent visits.

Pachystigma gillettii (Tennant) Verdc. ined.

Rubiaceae

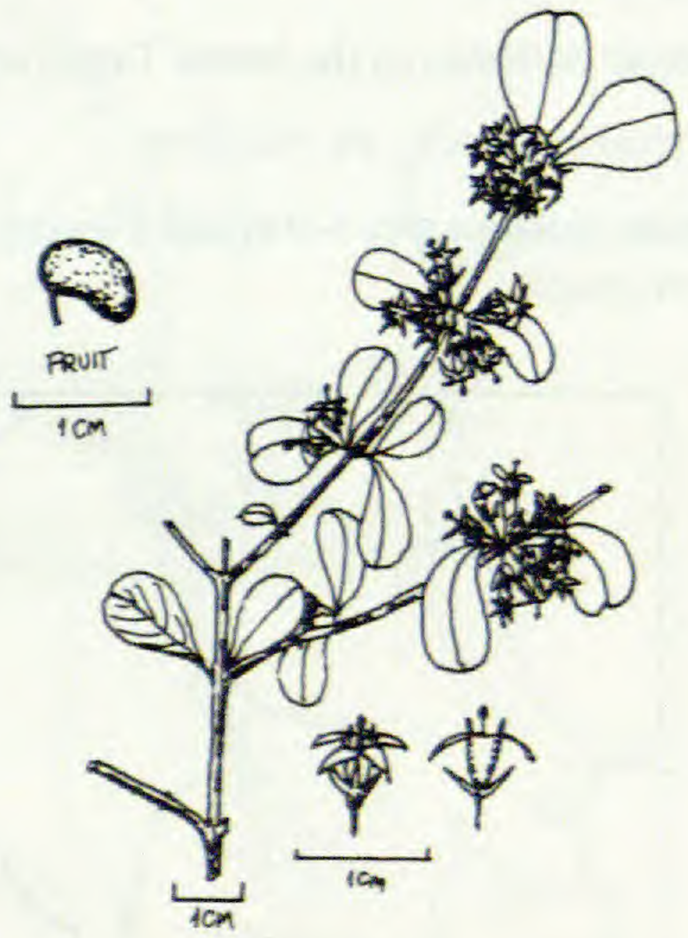
Local Names & Uses: used by the Rendille as a remedy against malaria.

Distribution: endemic to northeast Kenya (Meru N.P., Ngurunit, War Gedud, Dandu)

Habitat: rocky *Acacia-Commiphora* bushland; alt. 450-900 m.

Description: shrub or tree 2-3 m tall. Flowers white or yellow.





Status:

Rare. This habitat is common in the area, so there is a definite possibility that the species occurs in more sites. The population in Meru National Park is protected.

Pavetta linearifolia Brem.

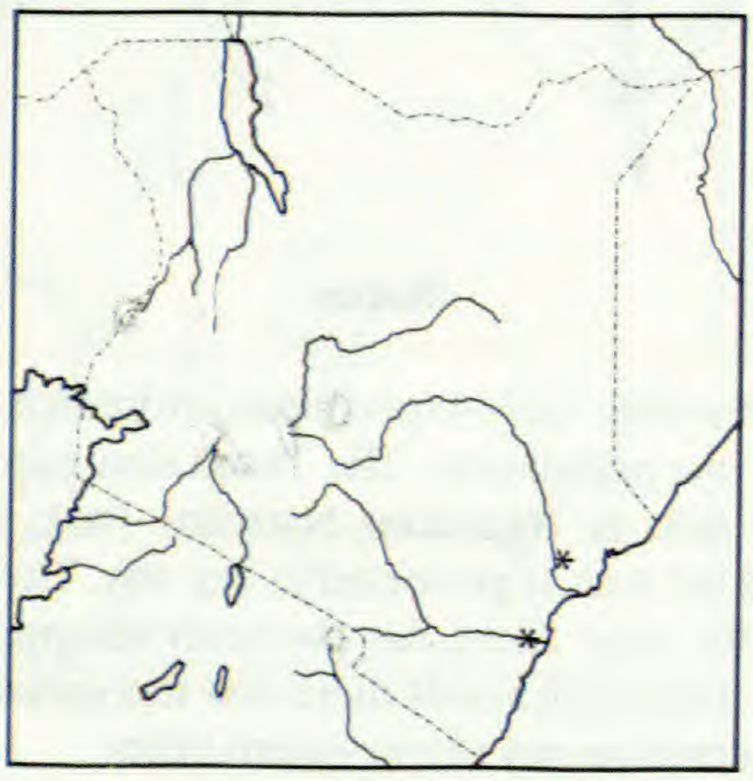
Rubiaceae

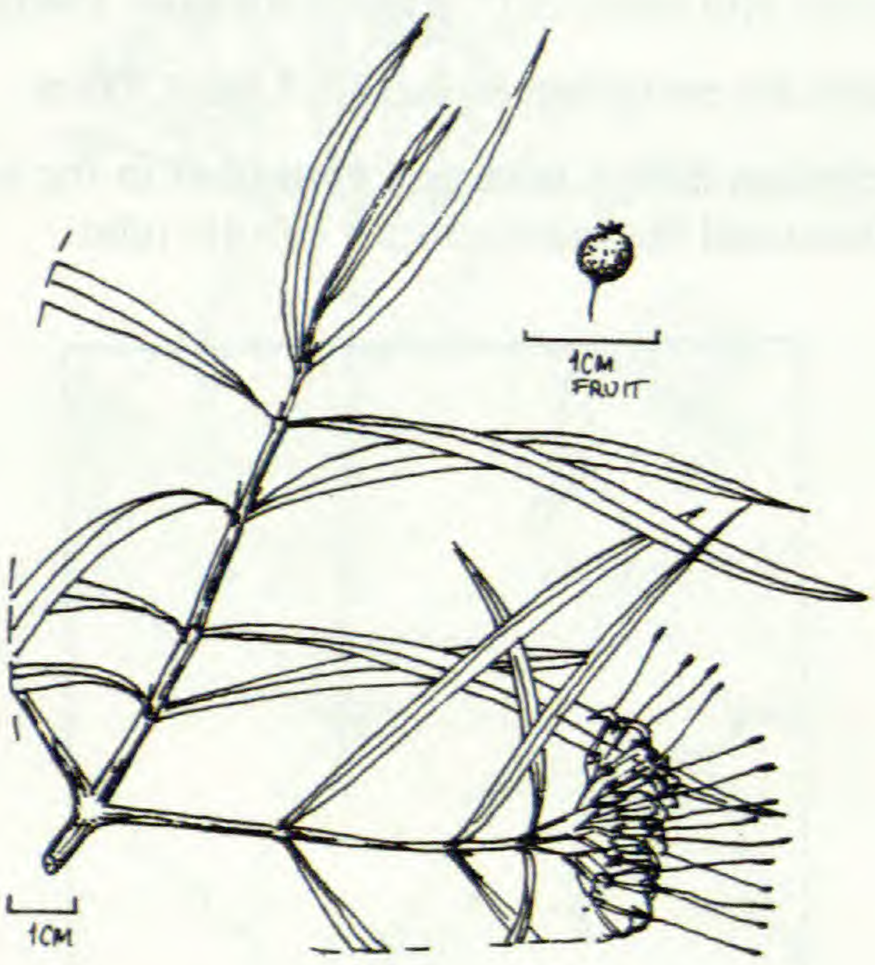
Local Names & Uses: none known.

Distribution: Tanzania (Tanga, Bagamoyo, and Usaramo districts) and Kenya (Marafa, Kinakomba on the Tana river, and Kitangani in Lamu district - I have been unable to trace this last locality).

Habitat: along rivers or in erosion gullies, in thickets or woodland; alt. 50-100 m.

Description: shrub or tree 1.5-4.5 m tall. Flowers white. Fruit black.





Status:

Rare. No further data.

Pavetta sphaerobotrys K. Schum. ssp. *tanaica* (Brem.) Bridson

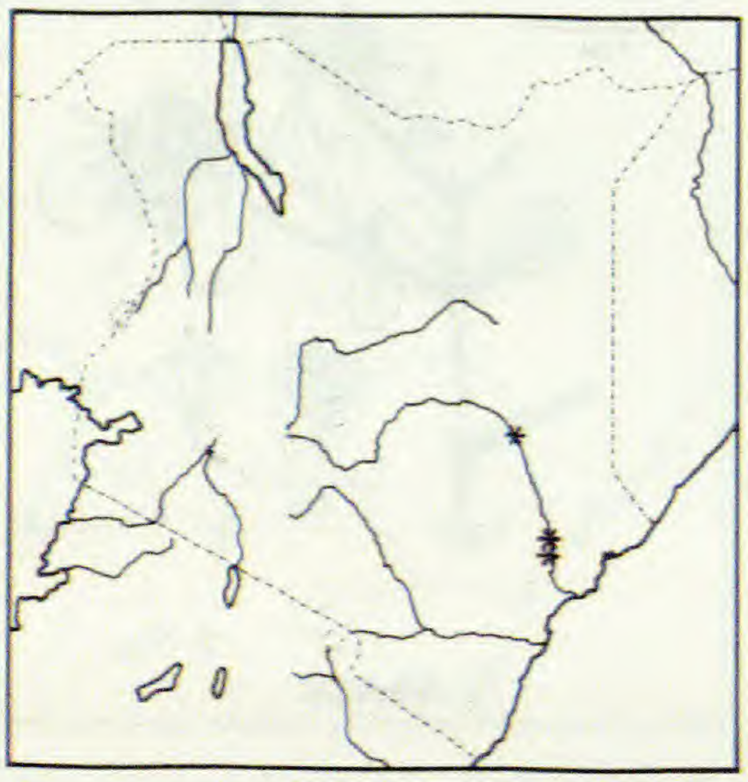
Rubiaceae

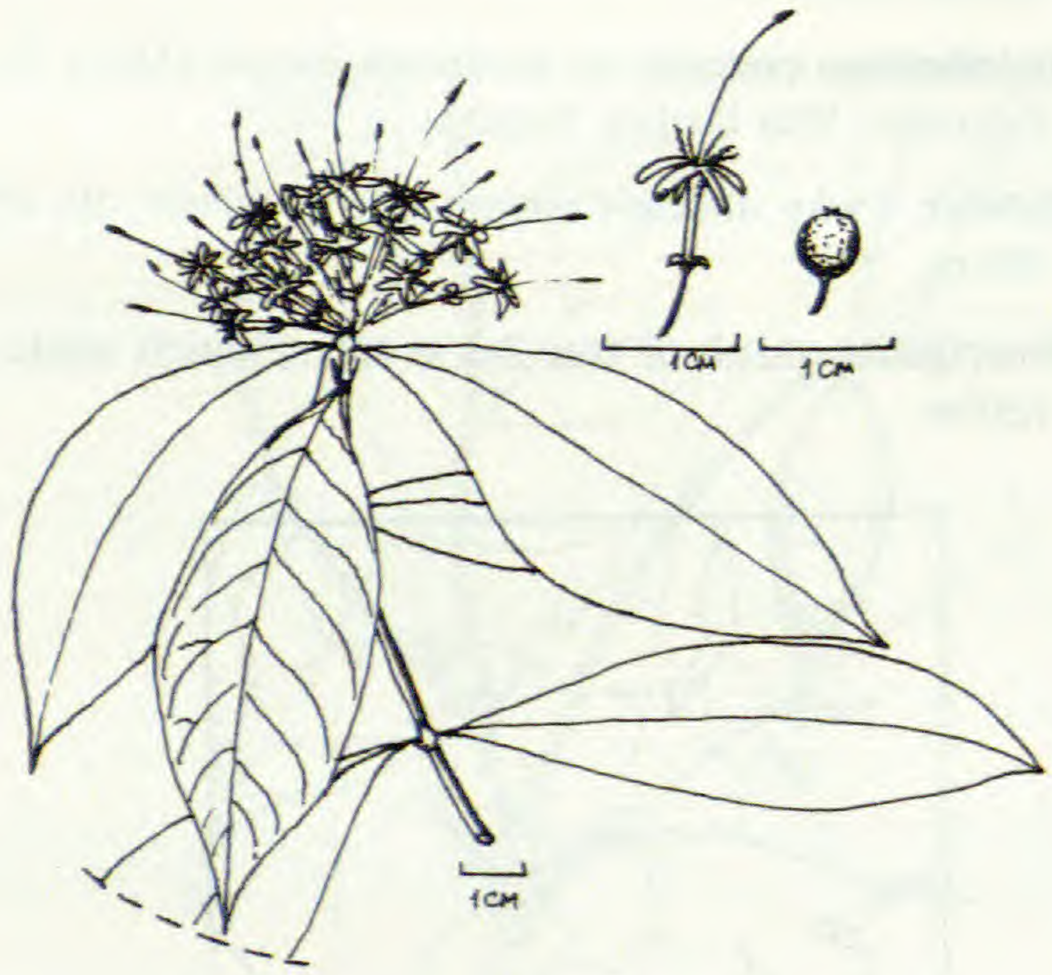
Local Names & Uses: Muchumi/Mungombe (Pokomo). The fruit is edible.

Distribution: endemic to the lower Tana river.

Habitat: riverine forest; alt. 30-60 m.

Description: shrub or tree 3-9 m tall. Flowers white. Fruit yellow or purple.





Status:

Rare, Vulnerable. Although protected in the Tana River Primate Reserve, the changed flood regime caused by dams upstream might affect the populations.

Psychotria crassipetala Petit

Rubiaceae

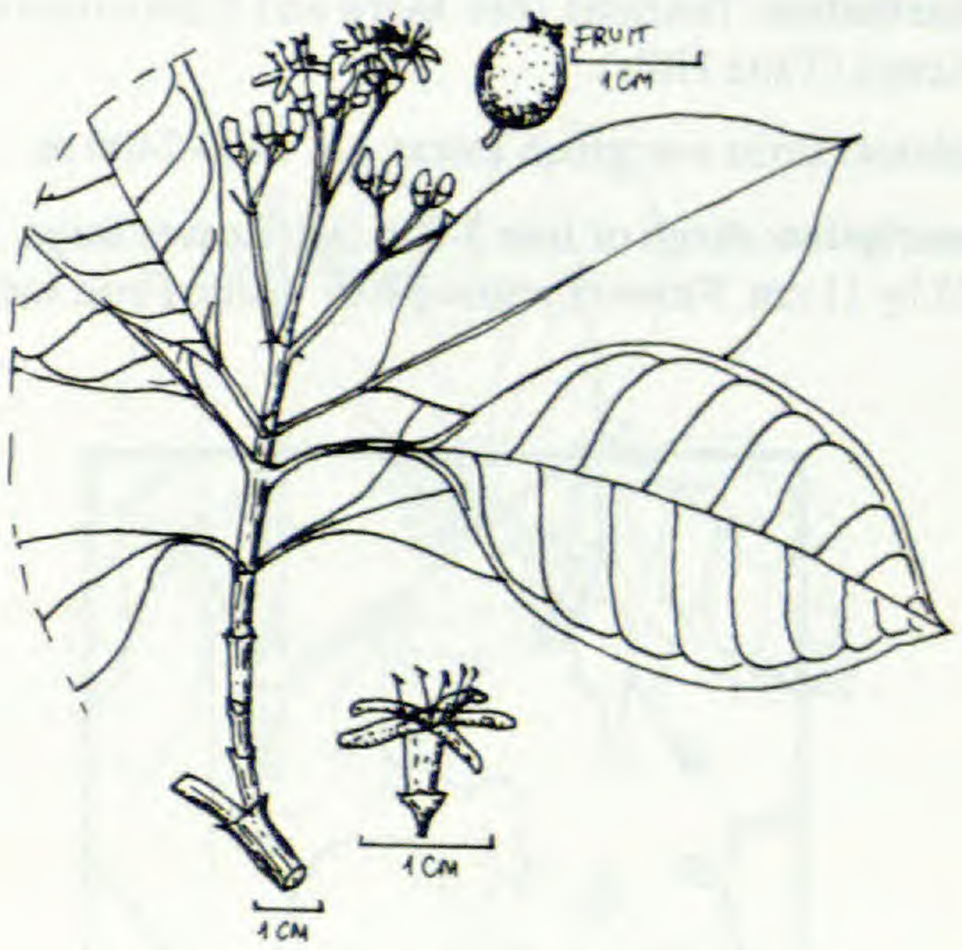
Local Names & Uses: none known.

Distribution: endemic to Taita Hills.

Habitat: moist evergreen forest; alt. 1500-1900 m.

Description: shrub or tree 3-12 m tall. Flowers white. Fruit blue.





Status:

Rare, Vulnerable. Although at present not under threat; still the population is restricted to two forests of less than 3 square kilometers.

Psychotria petitii Verdc.

Rubiaceae

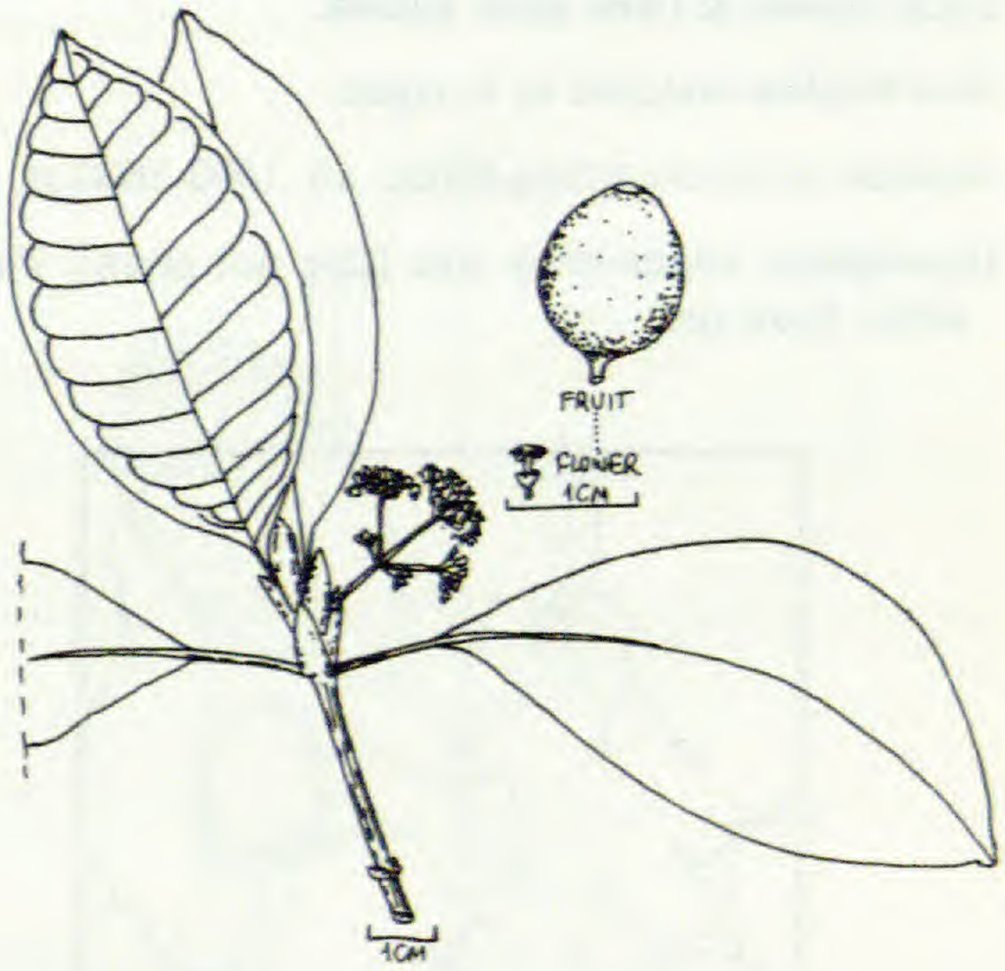
Local Names & Uses: none known.

Distribution: endemic to Taita Hills.

Habitat: moist evergreen forest; alt. 1550-1950 m.

Description: shrub or tree 3-10 m tall. Flowers white. Fruit red.





Status:

Rare, Vulnerable (see status notes on last species).

Note. A population on Vuria (also in the Taita Hills, at an altitude of 2200 m) might represent a new variety or subspecies. This population is **Endangered,** as the destruction of the forest remnant on Vuria is continuing.

Psychotria pseudoplatyphylla Petit

Rubiaceae

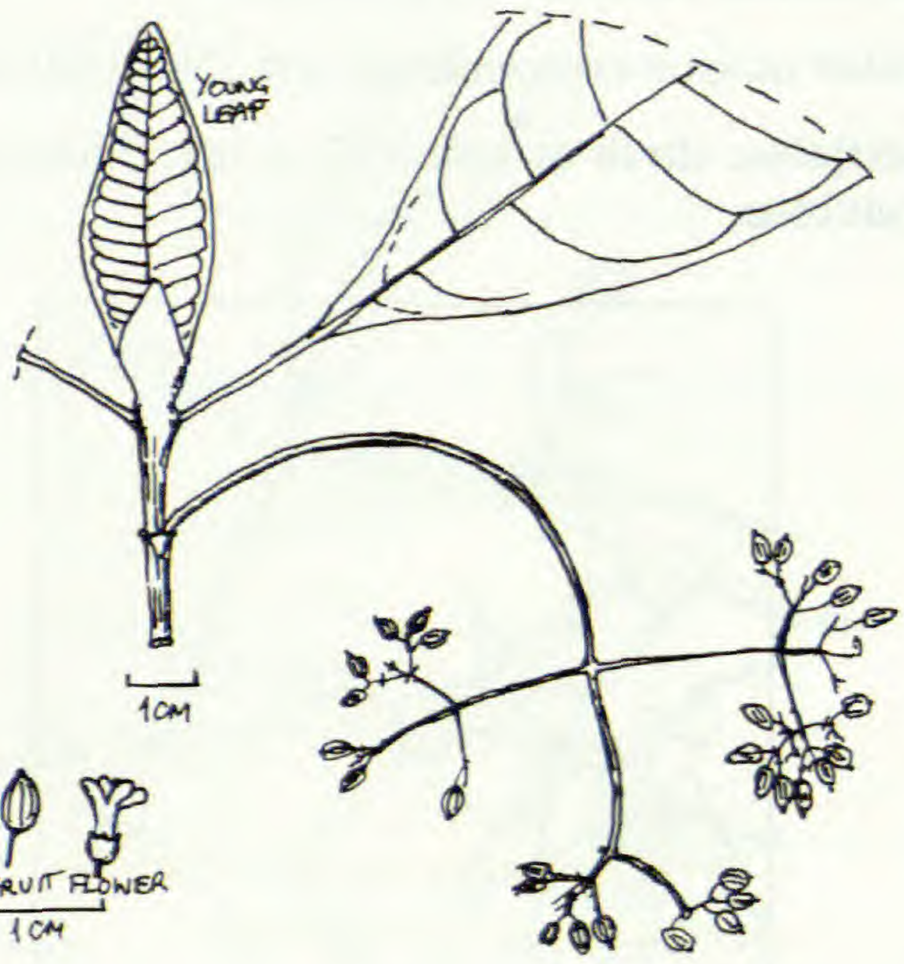
Local Names & Uses: none known.

Distribution: Tanzania (Mt. Meru and Kilimanjaro) and Kenya (Taita Hills).

Habitat: moist evergreen forest; alt. 1450-2400 m.

Description: shrub or tree 3-5 m tall. Leaves large, up to 22 by 11 cm. Flowers yellowish or white. Fruit red.





Status:

Rare. Protected in Tanzania (both sites are National Parks).

Psychotria taitensis Verdc.

Rubiaceae

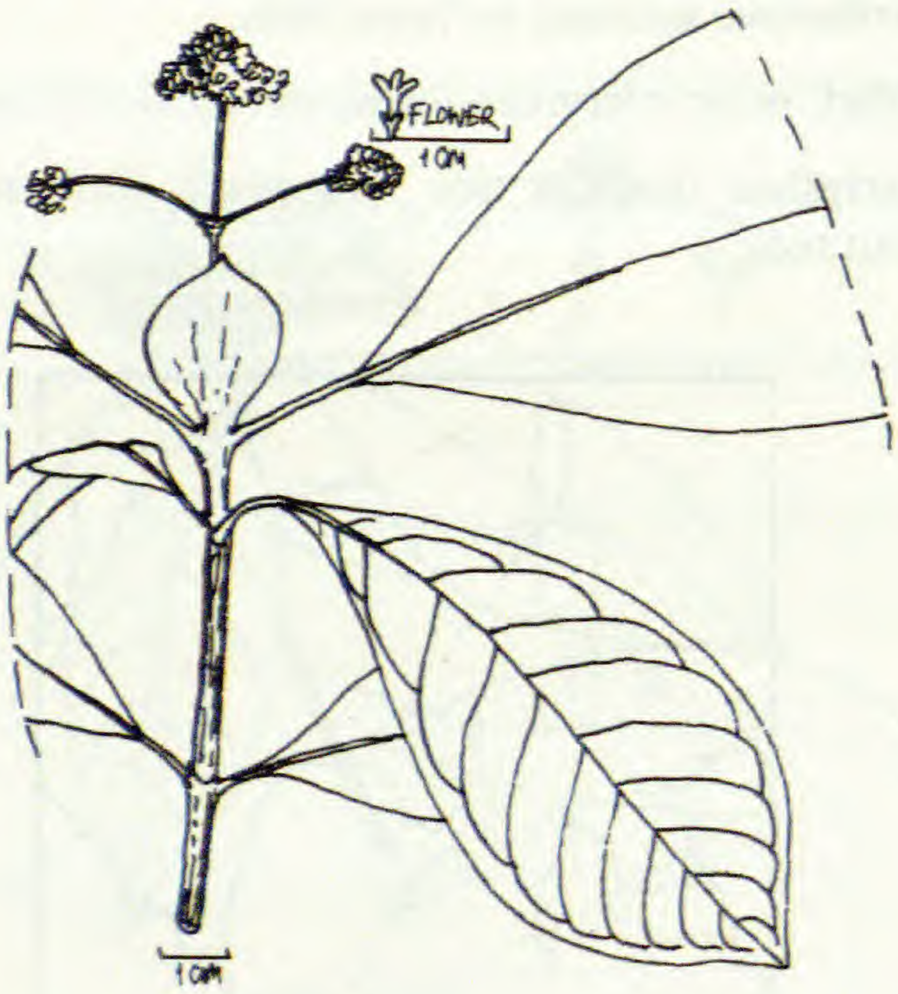
Local Names & Uses: none known.

Distribution: endemic to Kasigau.

Habitat: moist evergreen forest; alt. 1400-1600 m.

Description: understorey tree (size not given). Flowers white. Fruit red.





Status:

Rare, Vulnerable. The forest is not officially protected, but there seems to be no immediate threat.

Rytigynia induta (Bullock) Verdc. & Bridson

Rubiaceae

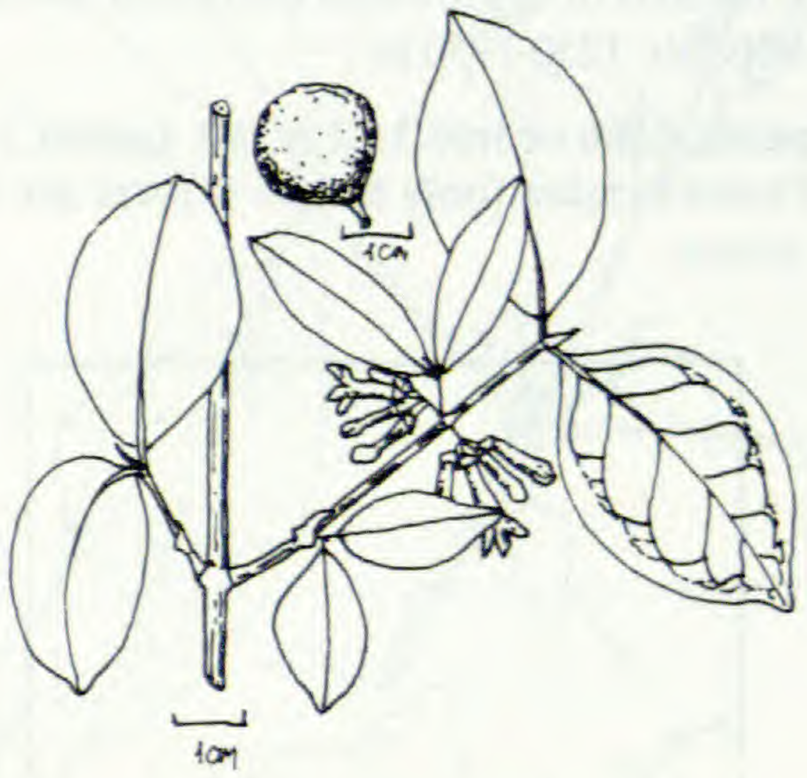
Local Names & Uses: Kimolwet (Kipsigis), Engum (Maasai). The fruit is edible.

Distribution: Tanzania (Loliondo, Kondo, Mt. Ufiomi) and Kenya (Nzaui, Emali Hill, Loita Hills).

Habitat: Podocarpus forest (-margins); alt. 1770-2250 m.

Description: shrub or tree 3-11 m tall. Flowers greenish outside, cream inside. Fruit black.





Status:

Rare, Vulnerable. This type of semi-evergreen forest on isolated hills is being encroached upon everywhere.

Diphasia sp. A of FTEA

Rutaceae

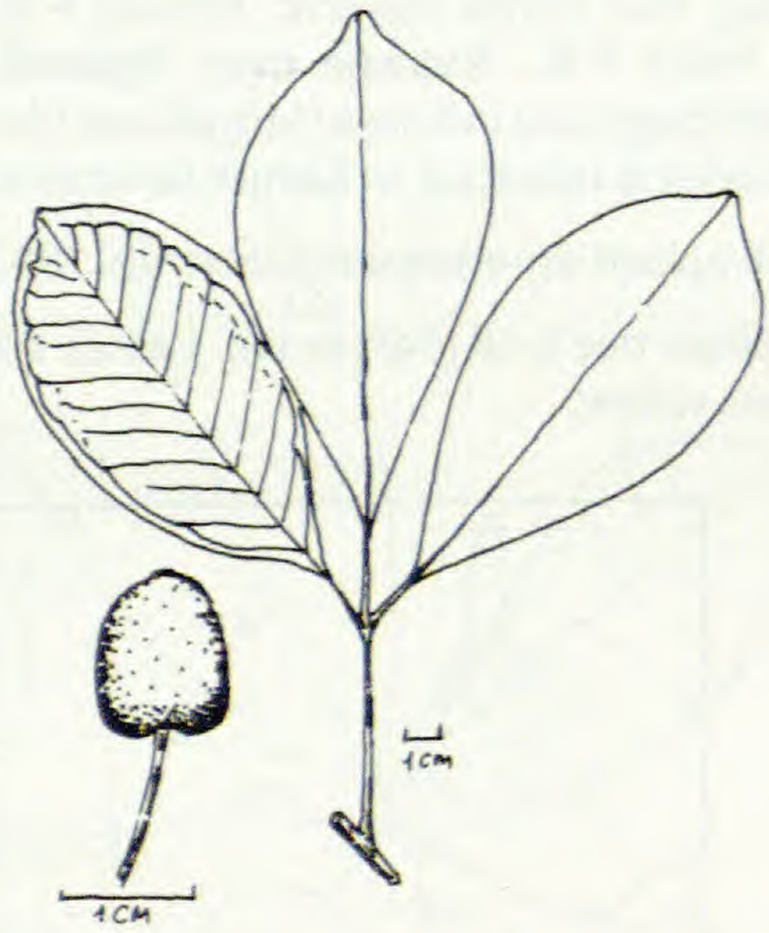
Local Names & Uses: none known.

Distribution: endemic to Kinindo forest on the south coast.

Habitat: evergreen forest on coral rag; alt. ca. 5 m.

Description: tree ca. 25 m tall with smooth grey bark. Leaves trifoliolate. Flowers unknown.





Status:

Rare, Vulnerable, Endangered. Kinondo forest is unprotected.

Diphasiopsis fadenii Kokwaro

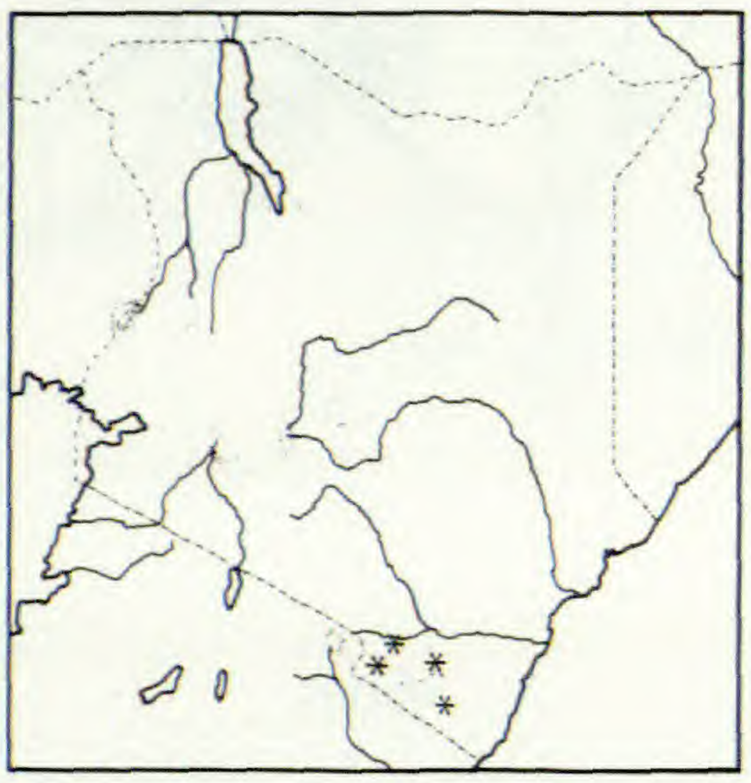
Rutaceae

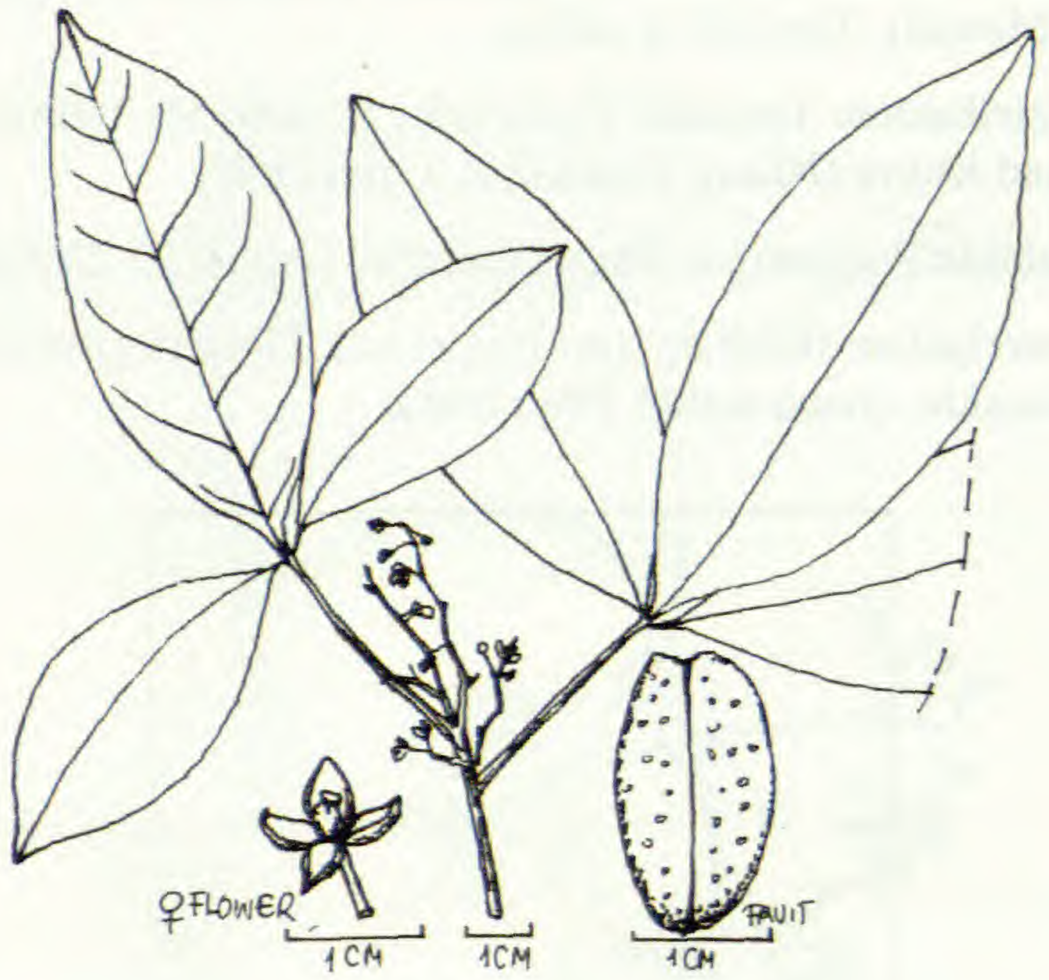
Local Names & Uses: Kimuu (Kamba)

Distribution: endemic to SE Kenya.

Habitat: thickets or dry to moist evergreen forest on isolated hills; alt. 1250-1950 m.

Description: shrub or tree 3-22 m tall. Leaves 2-3-foliolate. Flowers cream (only female flowers are known). Fruit yellow.





Status:

Rare. The populations within Tsavo National Park are protected; those within the Taita Hills do not seem under any immediate threat.

Teclea hanangensis Kokwaro

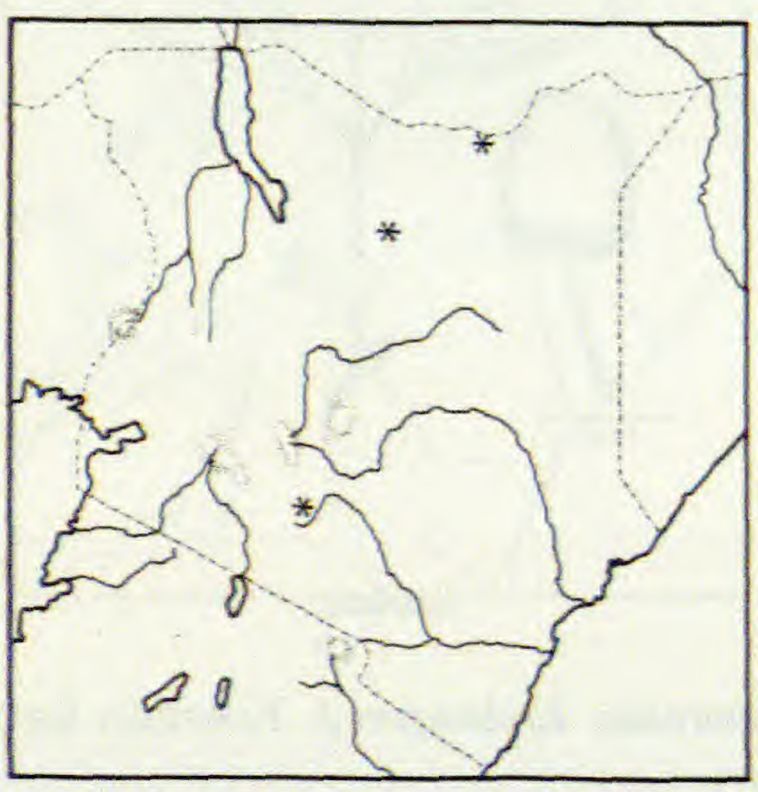
Rutaceae

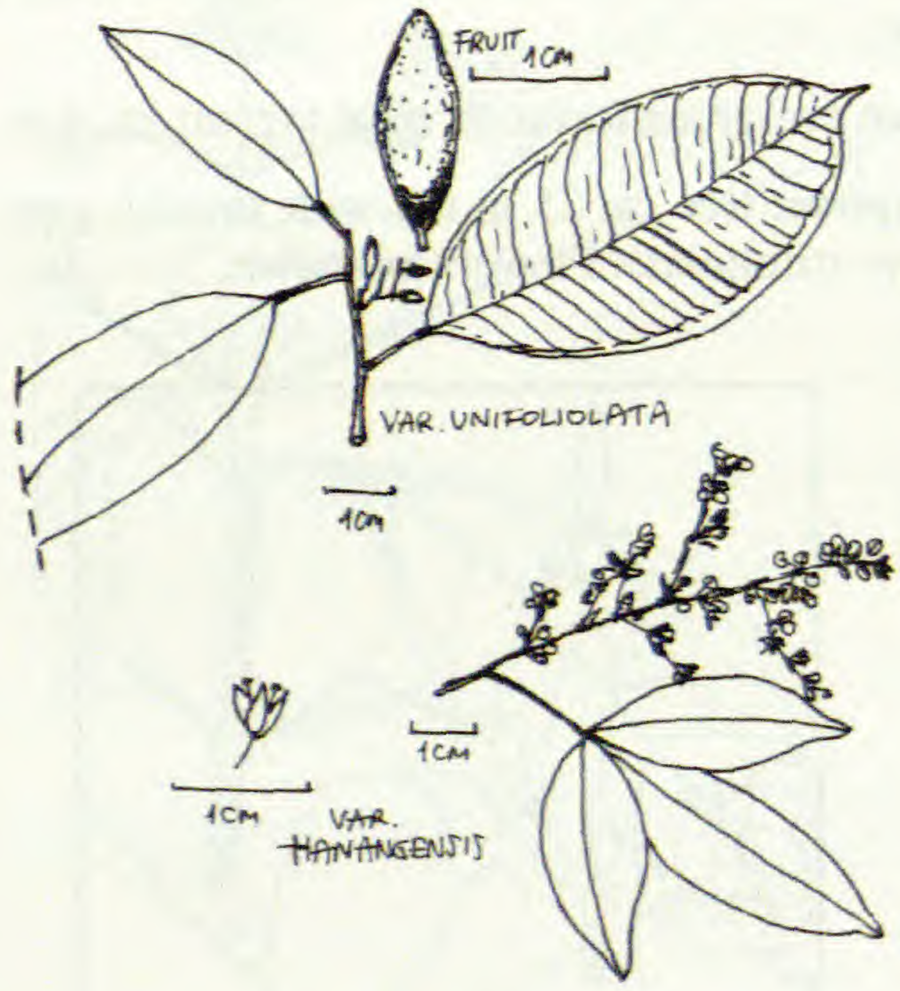
Local Names & Uses: Mike (Boran)

Distribution: var. *hanangensis* occurs in Tanzania (Mt. Hanang, Nou Forest Reserve, Marang F.R., Shagayu F.R., Imaye F.R., Ruhudje river, Nyalawa river and around Iringa) and in Kenya (Moyale and Marsabit) var. *unifoliolata* is restricted to Karura forest near Nairobi.

Habitat: upland dry evergreen forest; alt. 700-2500 m.

Description: tree 8-18 (?45) m tall. Leaves 1-3-foliolate. Flowers yellow.





Status:

Rare.

Vepris glandulosa (Hoyle & Leakey) Kokwaro

Rutaceae

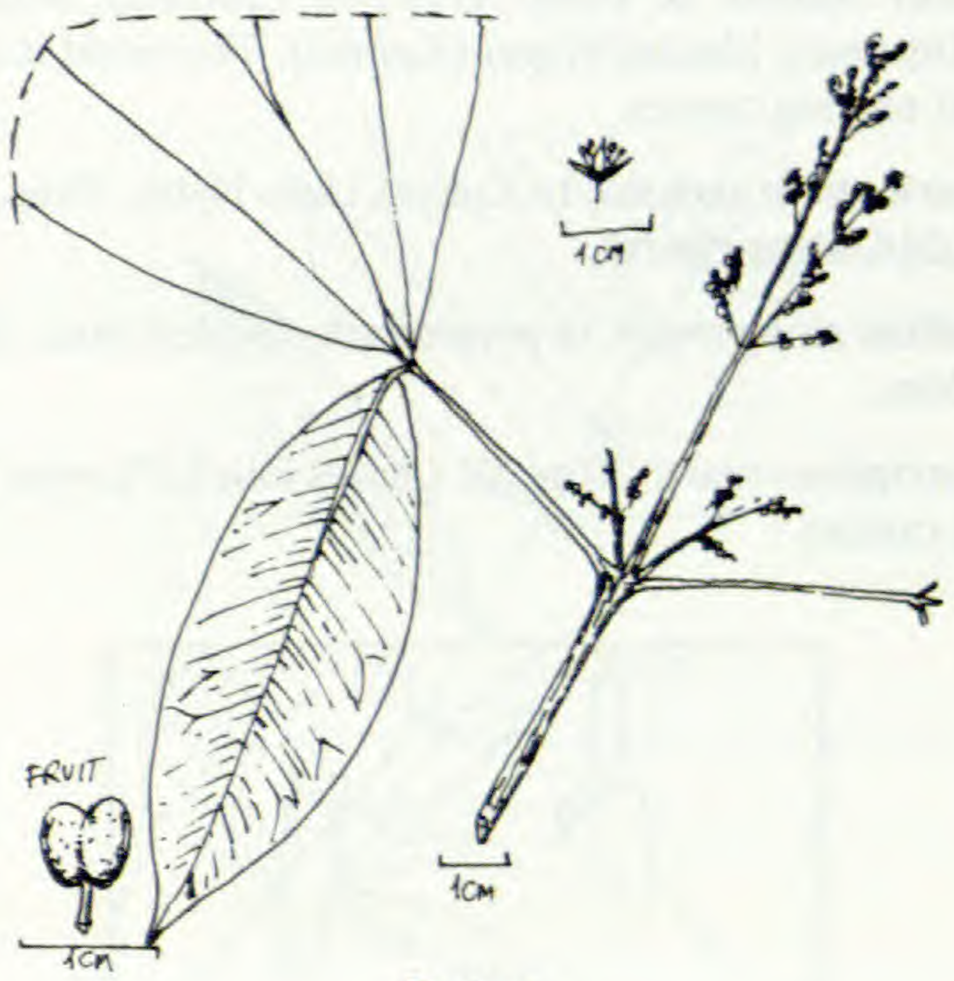
Local Names & Uses: Munderendu waikurari/Munderendu waitu (Kikuyu).

Distribution: endemic to Muguga Forest (also used to occur in a forest to the south of this, but this forest has been cut down).

Habitat: dry evergreen forest; alt. ca. 2100 m.

Description: tree 3-7 m tall, with smooth grey bark. Leaves 3-foliolate. Flowers greenish. Fruit crimson, 2-lobed.





Status:

Rare, Vulnerable, Endangered (see Lucas & Synge 1978). The forest is protected, but some treepoaching is going on. This species is highly susceptible to sunburn and will die when the forest canopy is damaged. Some seedlings have been raised (N. Gachati, pers. comm.).

Vepris samburuensis Kokwaro

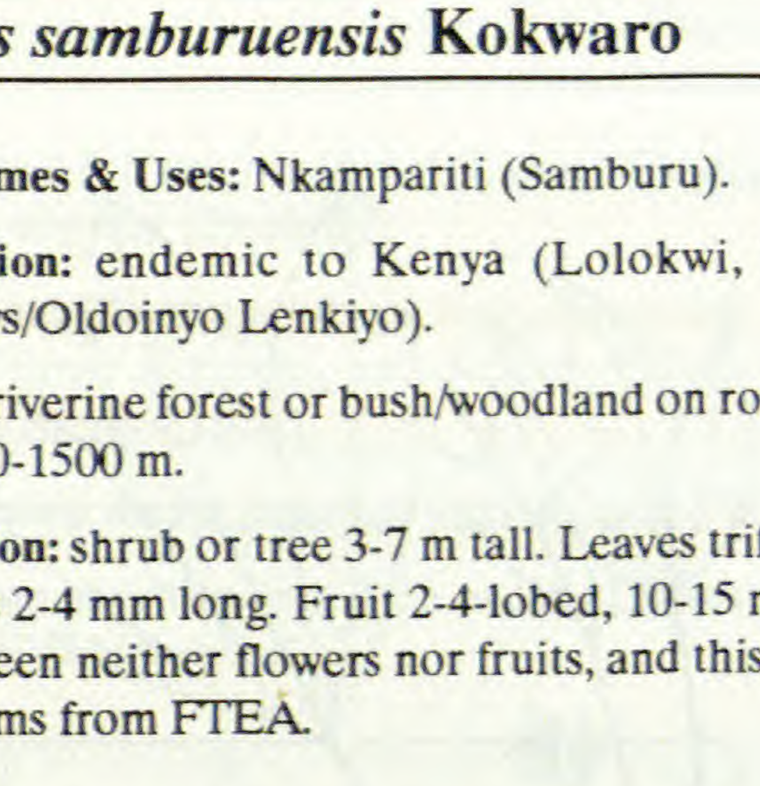
Rutaceae

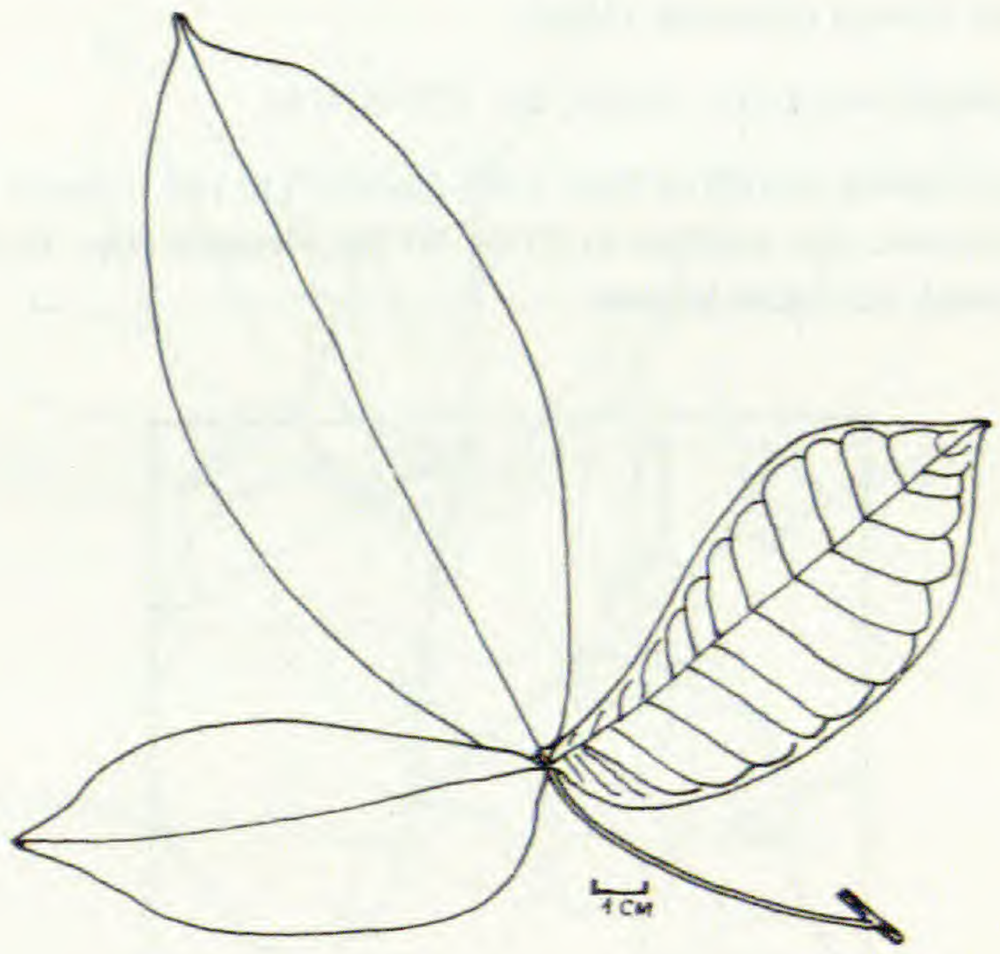
Local Names & Uses: Nkampariti (Samburu).

Distribution: endemic to Kenya (Lolokwi, Ndotos, Mathews/Oldoinyo Lenkiyo).

Habitat: riverine forest or bush/woodland on rocky hills; alt. 1000-1500 m.

Description: shrub or tree 3-7 m tall. Leaves trifoliolate. Flowers 2-4 mm long. Fruit 2-4-lobed, 10-15 mm long. I have seen neither flowers nor fruits, and this description stems from FTEA.





Status:

Rare. No further data.

Populus ilicifolia (Engl.) Rouleau

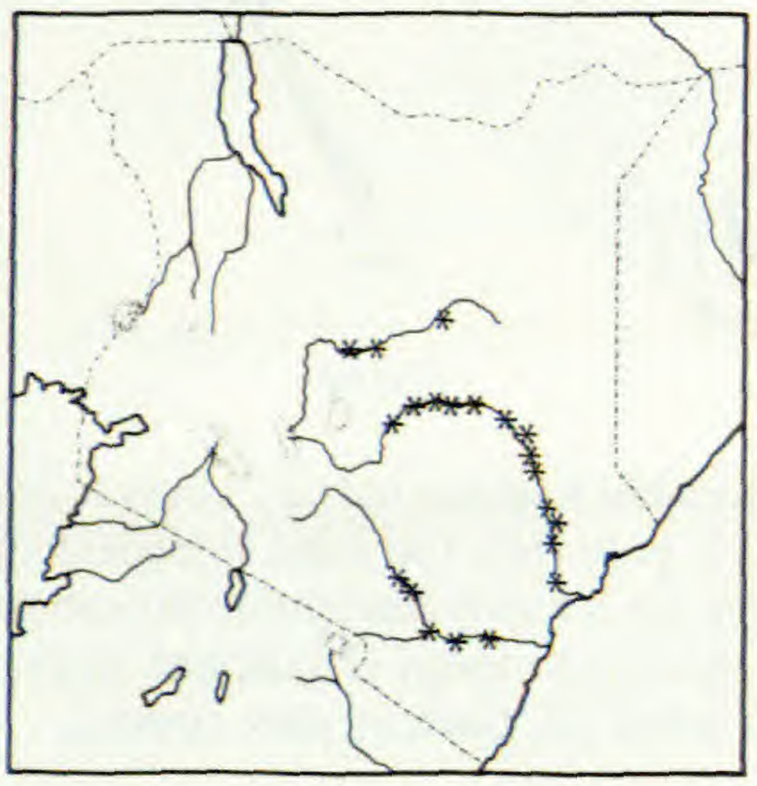
Salicaceae

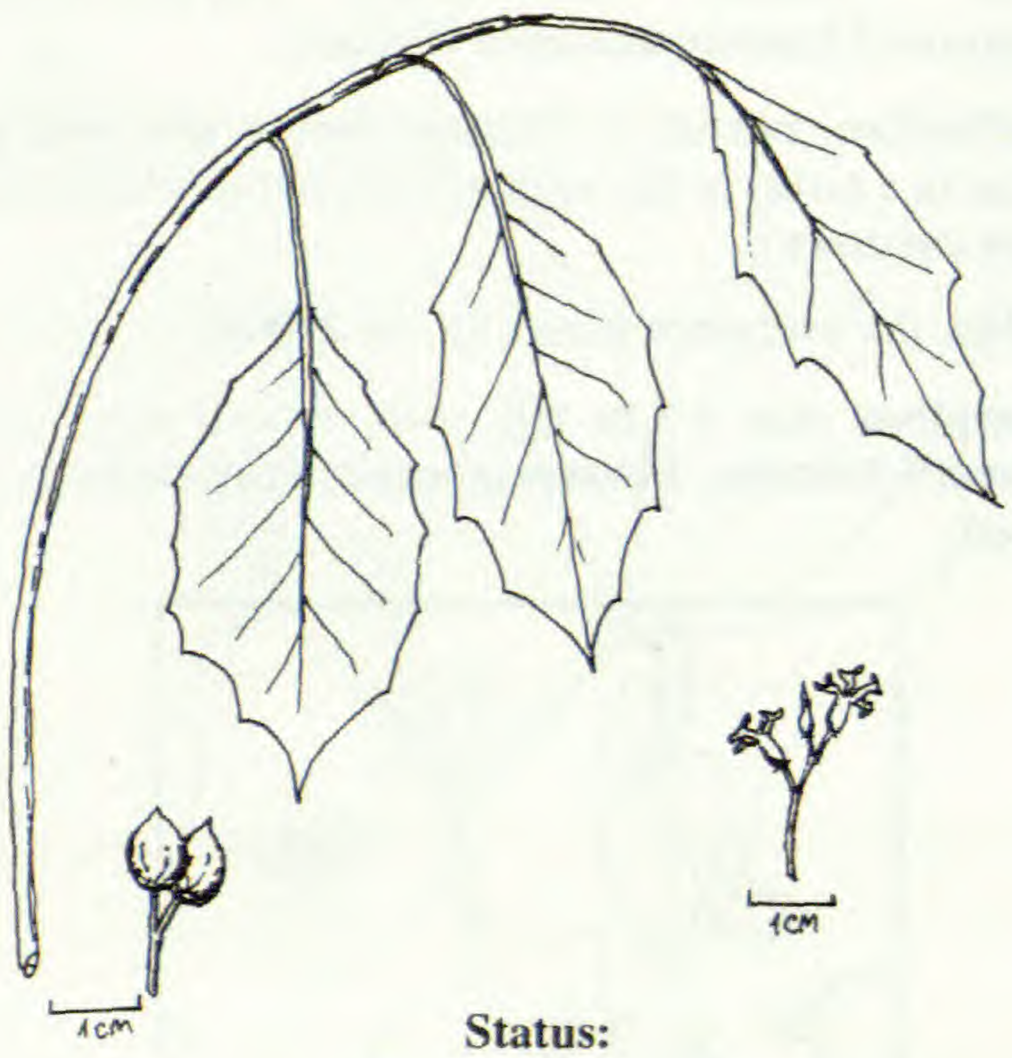
Local Names & Uses: Guduba (Boran), Mlalali (Duruma), Makini/Mugai (Kamba). The wood is used for making canoes.

Distribution: endemic to Kenya (Uaso Nyiro, Tana, and Athi/Galana rivers).

Habitat: along rivers, in periodically flooded sites; alt. 1-850m.

Description: tree to 30 m tall. Leaves lobed. Flowers tiny, in catkins.





Status:

Rare. Due to its limited distribution. Populations along the Tana river will probably be affected due to the changed flood regime caused by dams upstream. The seeds of this species stay viable for very limited periods only (less than one hour?)

Allophylus zimmermannianus F.G. Davies ined.

Sapindaceae

Local Names & Uses: none known.

Distribution: Tanzania (Sigi river, Kisiwani, near Lindi) and Kenya (Shimba Hills).

Habitat: evergreen forest; alt. 350-810 m.

Description: shrub or tree 3-4.5 (more?) m tall. Leaves 3-foliolate, the leaflets to 22 by 10 cm.Flowers tiny. Fruit round, to 5 mm across.





Status:

Rare, Vulnerable. All Tanzanian collections are from before 1952; the single Kenyan collection is from 1968. Possibly **Endangered** because of the low population density and habitat destruction.

Chytranthus obliquinervis Radlk.

Sapindaceae

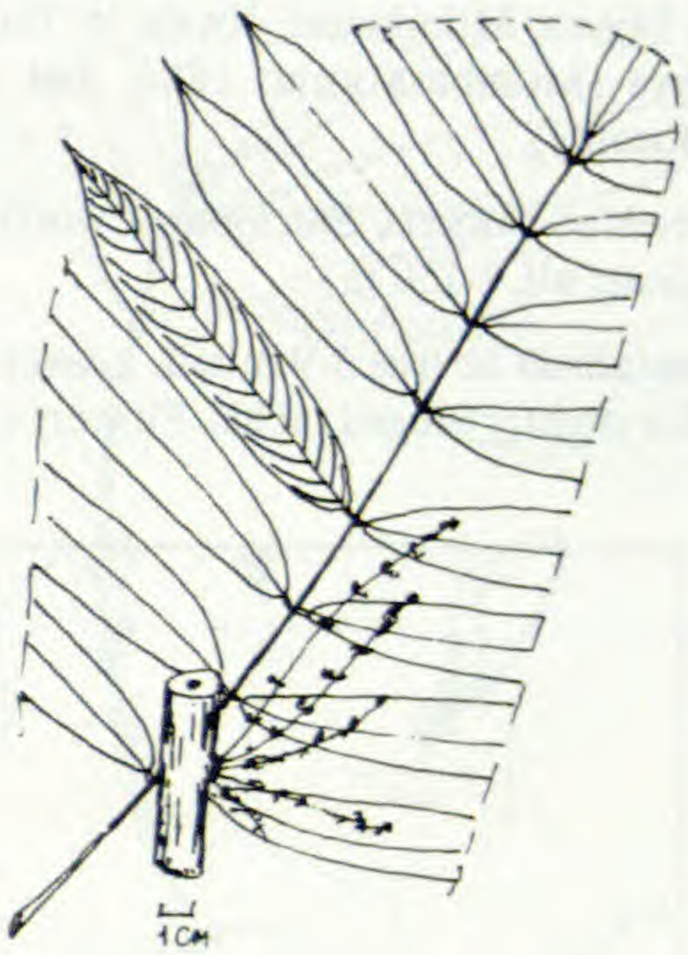
Local Names & Uses: Mpwakapwaka (Digo), Mwakamwaka (Swahili).

Distribution: coastal Tanzania (east Usambaras) and Kenya (Shimba Hills, Gogoni, Muhaka, Buda, Mwandeo, Tana river, Witu).

Habitat: moist evergreen forest; alt. 1-900 m.

Description: shrub or tree 2-15 m tall, single-stemmed and with a large tuft of leaves at the top. Leaves pinnate, the leaflets to 45 cm long. Flowers cream, in short racemes on the trunk.





Status:

Rare.

Haplocoelopsis africana F.G. Davies

Sapindaceae

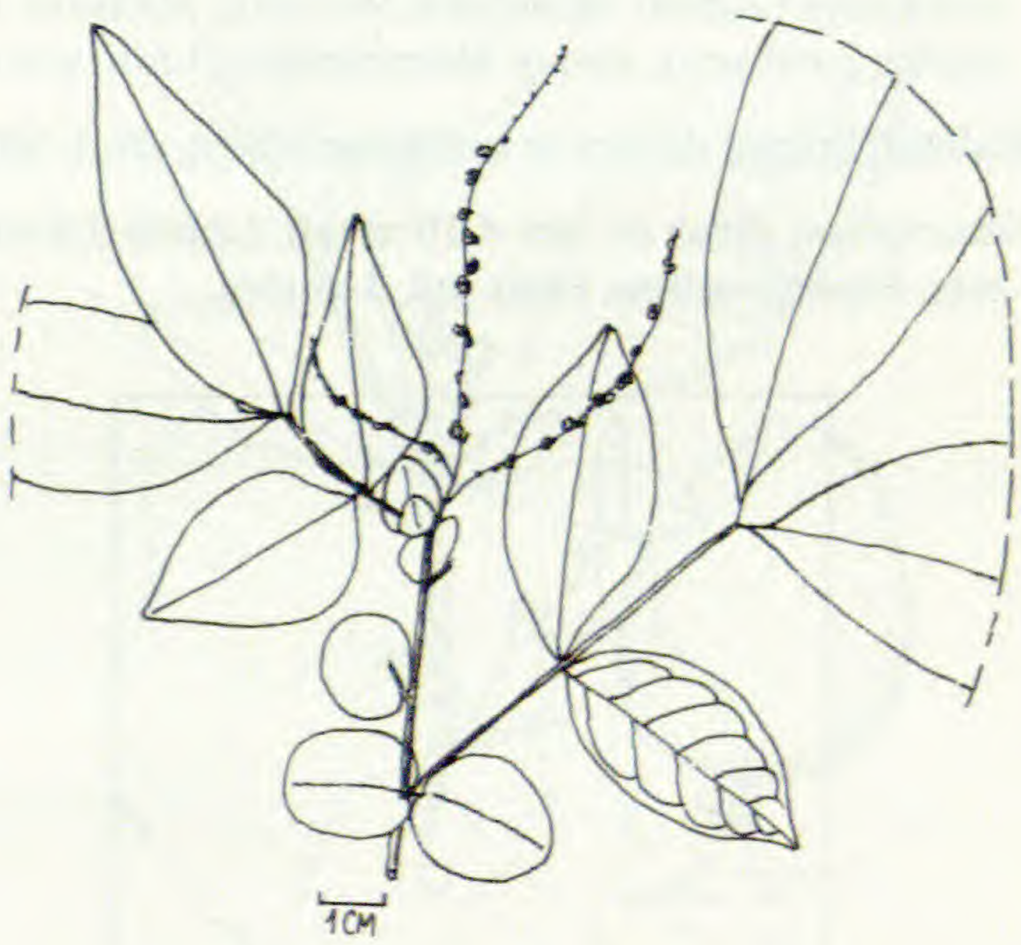
Local Names & Uses: Muanyiza (Lamu), Gogiza (Boni), Mtumba mweusi (Swahili).

Distribution: Tanzania (Pugu Hills, Makonde thicket, Banda Forest Reserve) and Kenya (Witu, Mangea, Marenje, Shimba Hills).

Habitat: moist or dry forest or thicket; alt. 1-700 m.

Description: shrub or tree 2-15 m tall. Leaves with 4-8 leaflets. Flowers cream.





Status:

Rare.

Haplocoelum mombasense Bullock

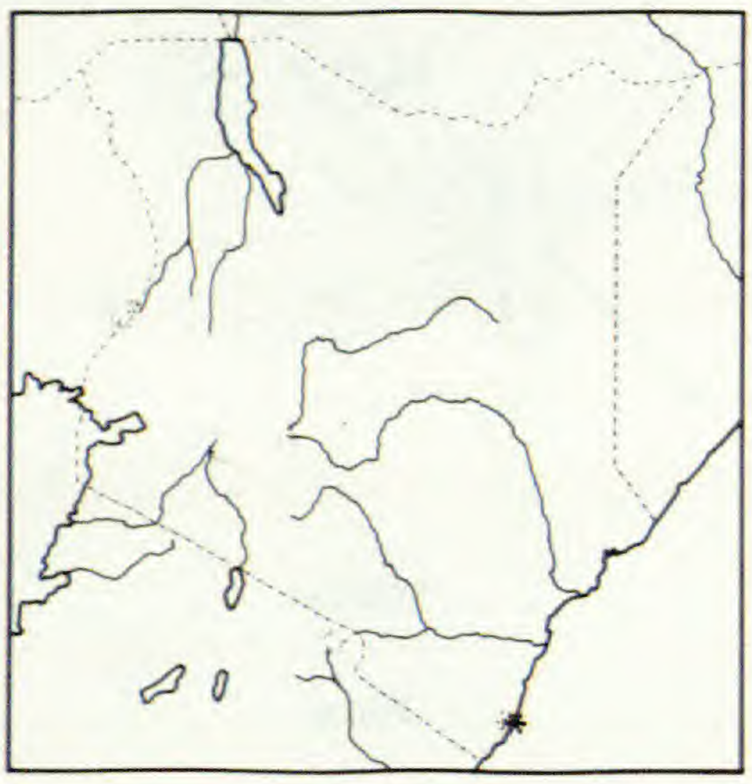
Sapindaceae

Local Names & Uses: none known.

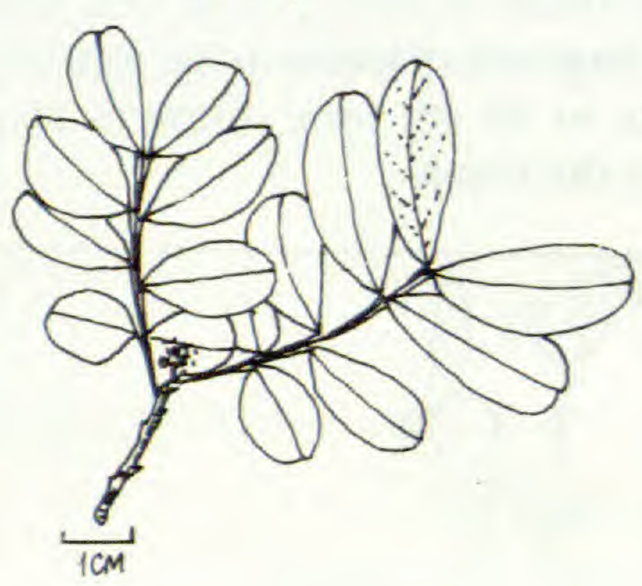
Distribution: Tanzania (Pugu hills, Selous Game Reserve, Mgera, Mtimbwani, Kwale in Tanga, Ngole) and Kenya (Mombasa anno 1884, and anno 1925 without locality).

Habitat: riverine thickets, *Brachystegia* woodland, along the sea shore; alt. 1-150 m.

Description: shrub or tree 3-9 m tall. Leaves 4-18-foliolate, with a slightly winged rachis. Flowers cream. Fruit yellow.







Status:

Rare. Presumably extinct in Kenya.

Haplocoelum trigonocarpum Radlk.

Sapindaceae

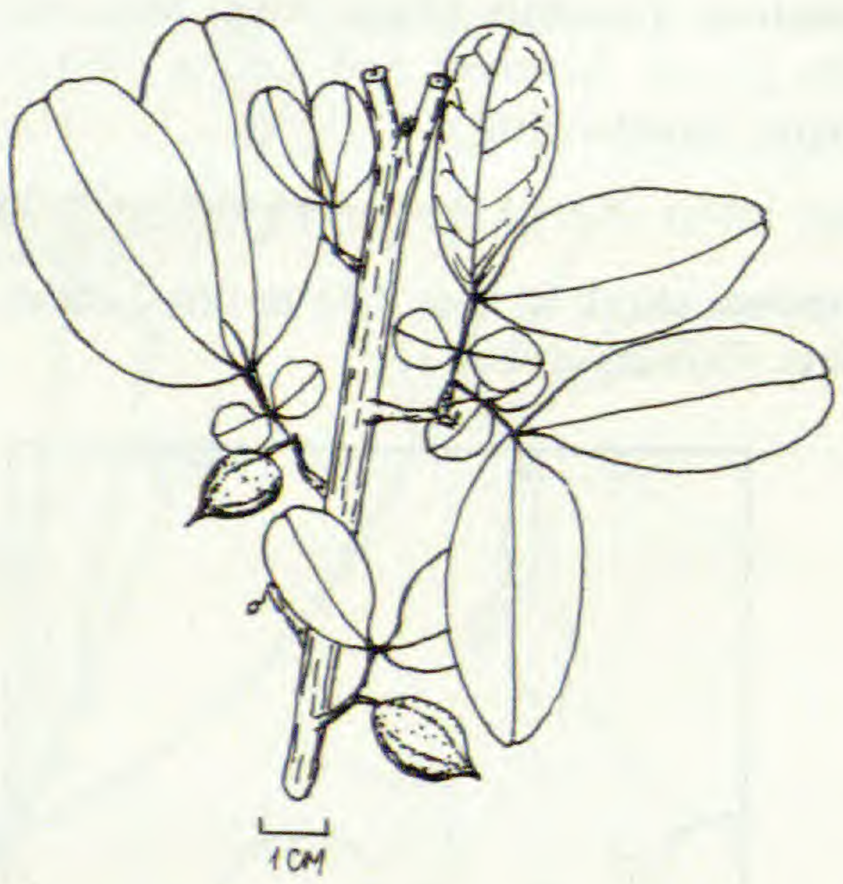
Local Names & Uses: none known.

Distribution: Tanzania (Sawa, Kawe, Msubugwe, Pemba) and Kenya (Jombo, Mombasa, Watamu, Manyani, Cha Simba, Samburu); also in Mozambique (Lurio river).

Habitat: littoral thicket or evergreen forest; alt. 1-300 m.

Description: shrub or tree 4-10 m tall. Leaves 2-8-foliolate. Flowers yellow. Fruit red, 3-angled.





Status:

Rare. The littoral thicket is being rapidly destroyed, at least along the Kenyan coast. Might be **Vulnerable.**

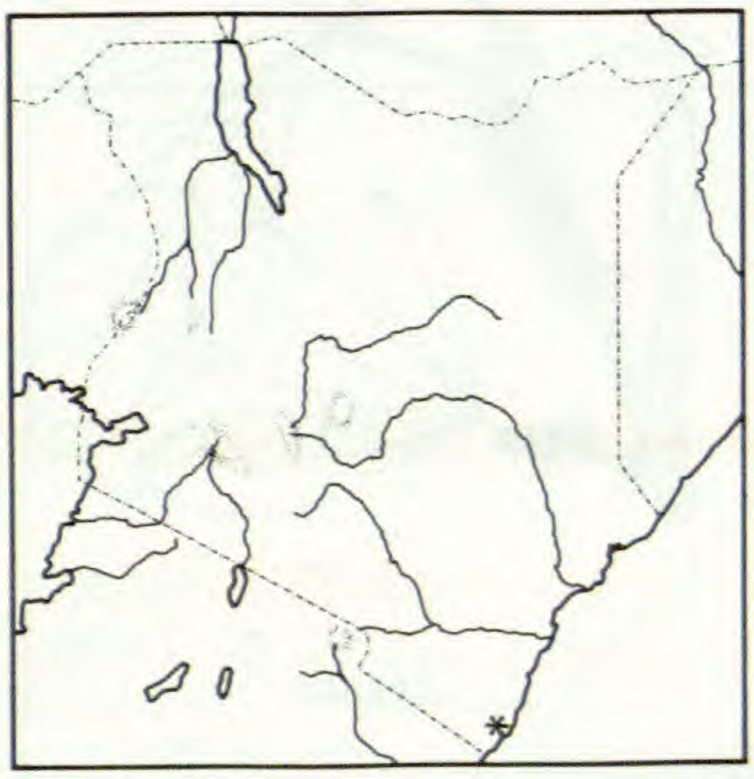
Afrosersalisia kaessneri (Engl.) J.H. Hemsl. — *Sapotaceae*

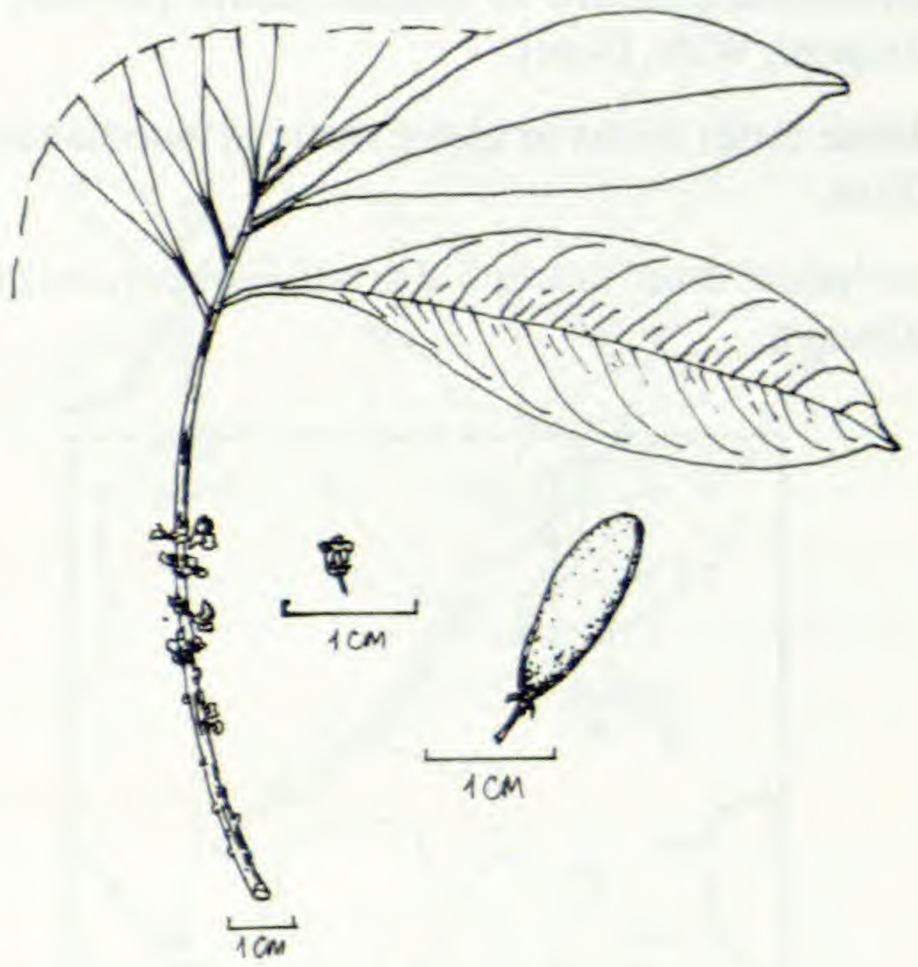
Local Names & Uses: Mungwene (Digo)

Distribution: endemic to Shimba Hills and Makoni (type), though possibly in Mtapila plateau in Tanzania.

Habitat: moist evergreen forest; alt. 300-400 m.

Description: shrub or tree 1.5-12 m tall. Flowers white, on branches below the leaves. Fruit orange.





Status:

Rare, Vulnerable. Due to the restricted distribution.

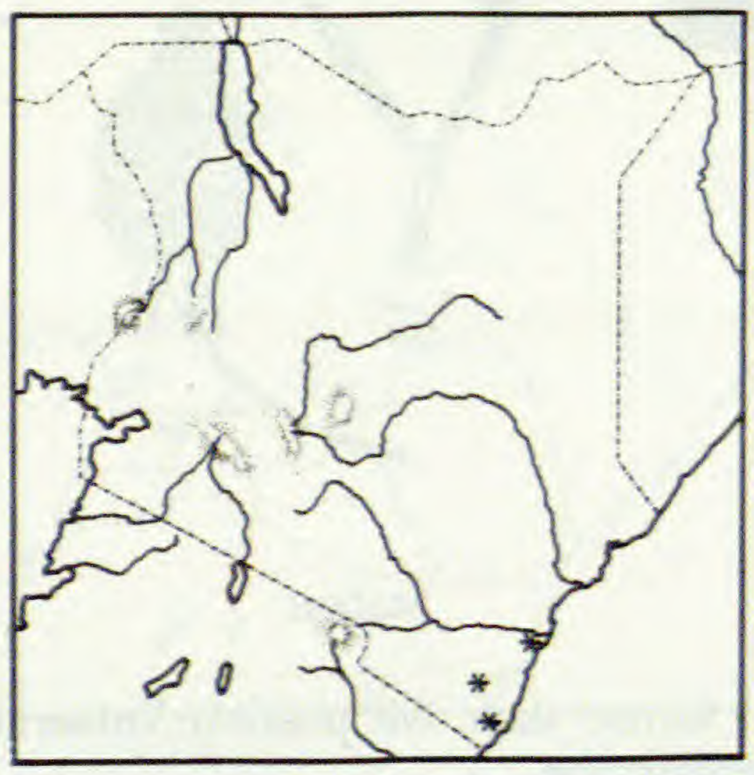
Mimusops somalensis Chiov. — *Sapotaceae*

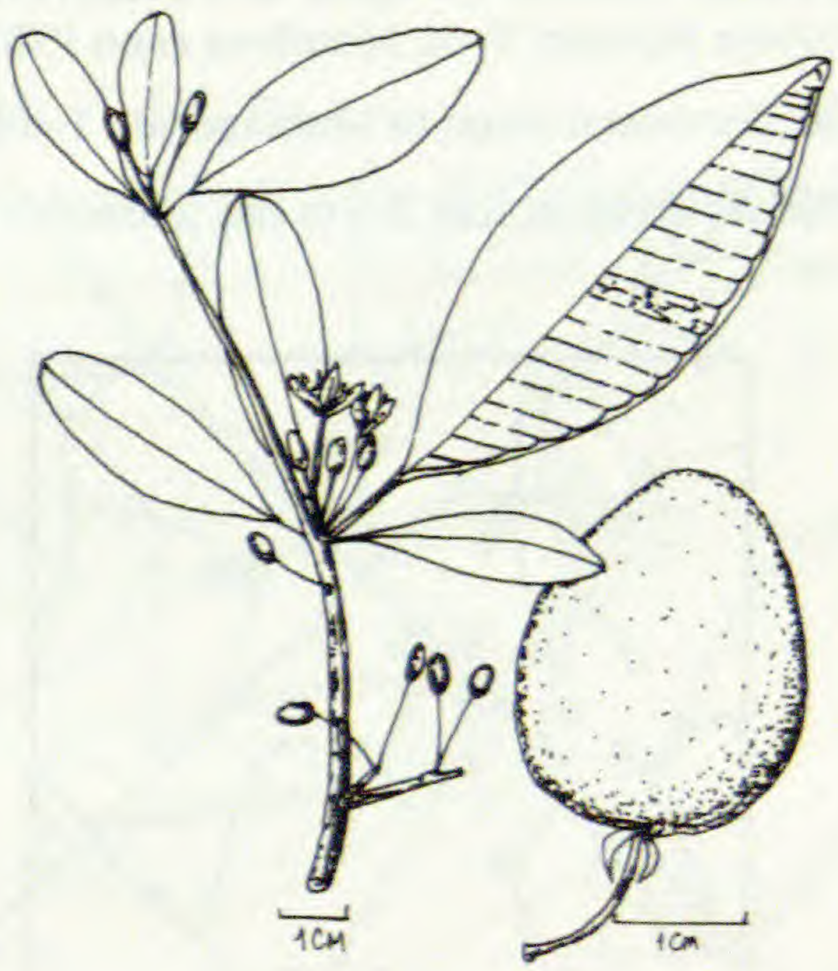
Local Names & Uses: none known

Distribution: Tanzania (Pongwe, Kilwa, Kingupira, Selous, Moa) and Kenya (Samburu in Kwale distr., Kinango, near Mariakani, Jilore).

Habitat: woodland and evergreen bushland; alt. 120-500 m.

Description: tree 18-25 m tall. Flower colour unknown. Fruit brownish-violet.





Status:

Rare. In Kenya this type of vegetation is being exploited for charcoal.

Pachystela subverticillata E.A. Bruce

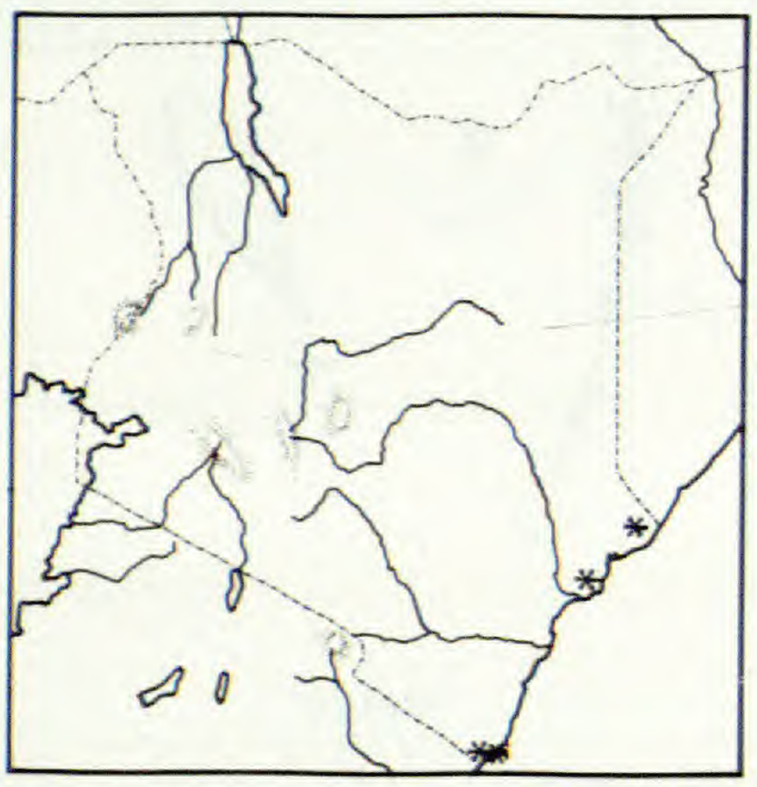
Sapotaceae

Local Names & Uses: Msamvia wa mwitu (Swahili), Mcharibi/Mkundukuwaka (Lamu).

Distribution: endemic to coastal Kenya (Mrima, Buda, Gongoni, Witu, Boni).

Habitat: moist forest or along rivers in woodland; alt. 1-300 m.

Description: shrub or tree 3-8 m tall. Flowers cream. Fruit unknown.





Status:

Rare, Vulnerable. Only the population at Witu enjoys any protection.

Vitellariopsis kirkii (Baker) Dubard

Sapotaceae

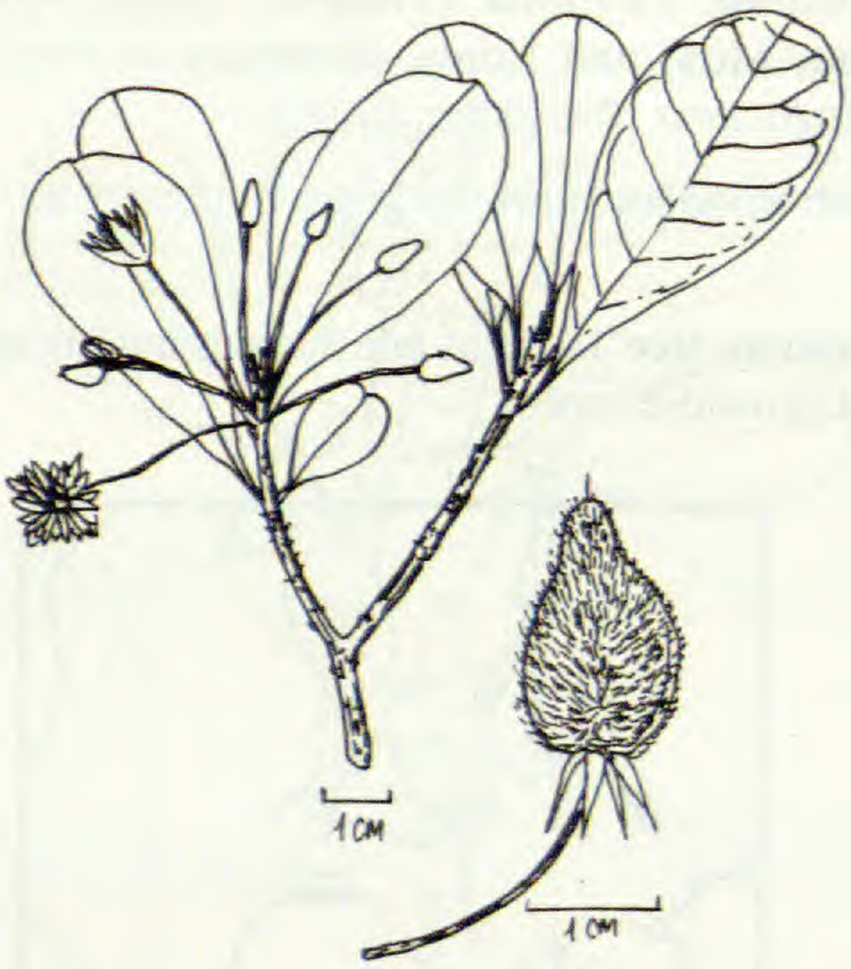
Local Names & Uses: Mlishangwe (Swahili).

Distribution: Tanzania (Pangani distr., Kisarawe distr.) and Kenya (Kaume, Taru, Mombasa anno 1920).

Habitat: dry coastal forest or bushland; alt. 1-400 m.

Description: shrub or tree 3-6 m tall. Flowers cream or yellow.





Status:

Rare. No further data, but possibly **Vulnerable** due to habitat destruction.

Brucea tenuifolia Engl. ssp. *keniensis* ined.

Simaroubaceae

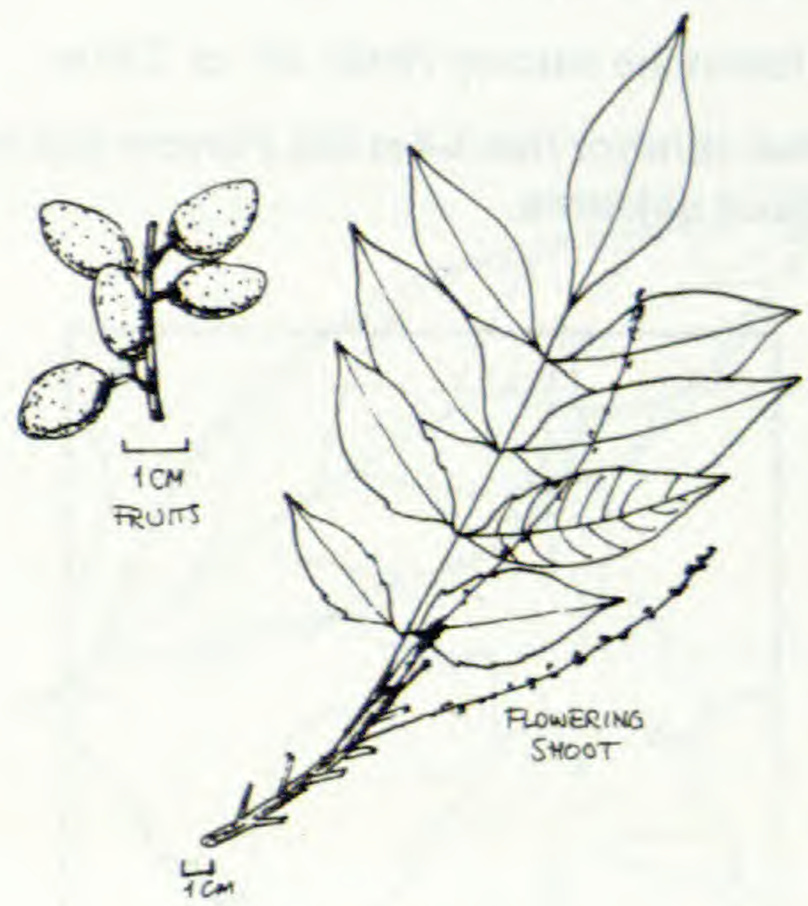
Local Names & Uses: none known.

Distribution: endemic to central Kenya (Kamiti, Thika, Meru National Park, Kiambu).

Habitat: riverine or groundwater forest; alt. 750-1800 m.

Description: shrub or tree 1-4.5 m tall. Leaves pinnate, with 7-11 leaflets, which are up to 16 cm long. Flowers tiny, in long spikes. Fruit red.





Status:

Rare, Vulnerable. The populations seem to be quite small, but those at Thika and Meru N.P. seem, at least at present, safe.

Odyendea zimmermannii Engl.

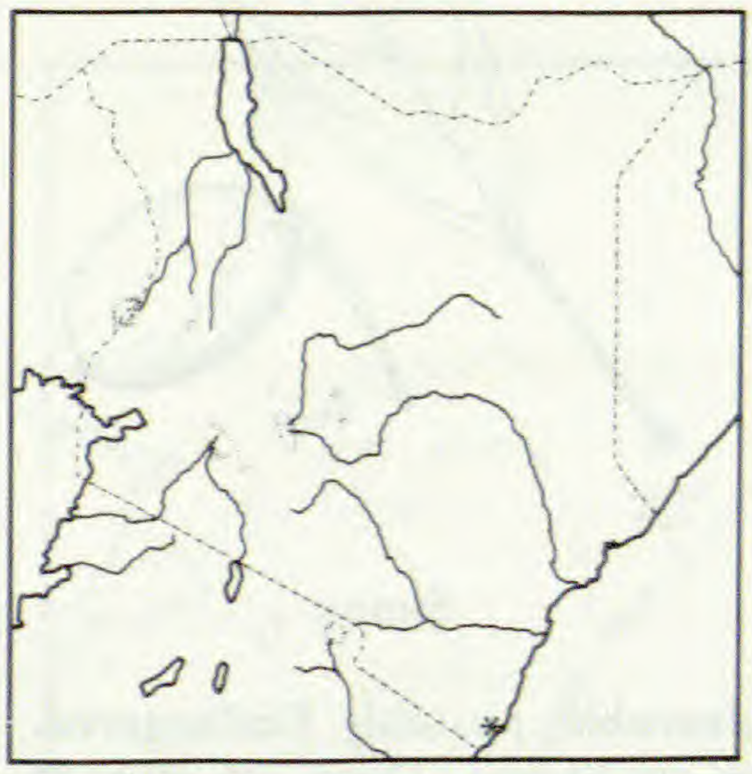
Simaroubaceae

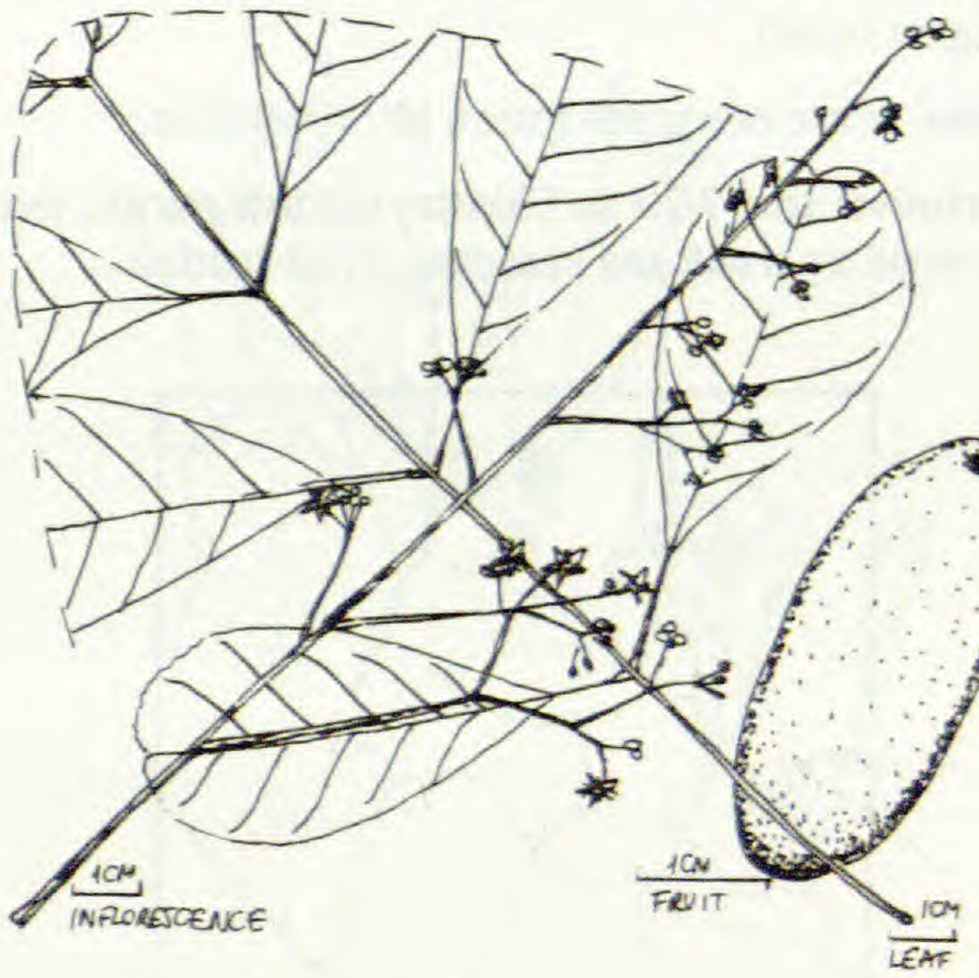
Local Names & Uses: none known.

Distribution: Tanzania (Pemba, Nguru Mountains, east Usambaras) and Kenya (Shimba Hills).

Habitat: moist evergreen forest; alt. 1-1500 m.

Description: tree 8-30 m tall with long smooth bole. Leaves pinnate with 6-14 leaflets. Flowers small, green. Fruit blueblack.





Status:

Rare.

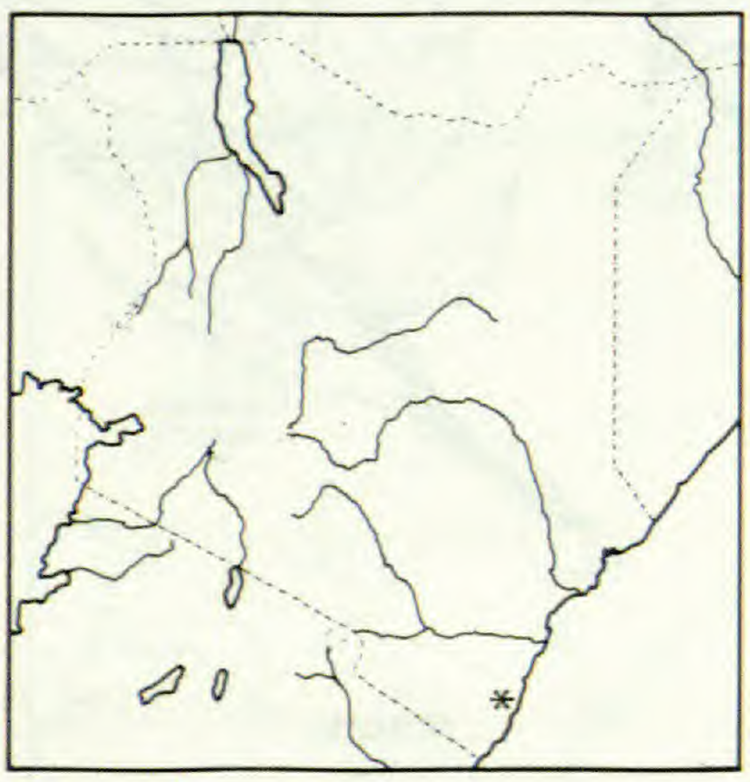
Cola octoloboides Brenan — *Sterculiaceae*

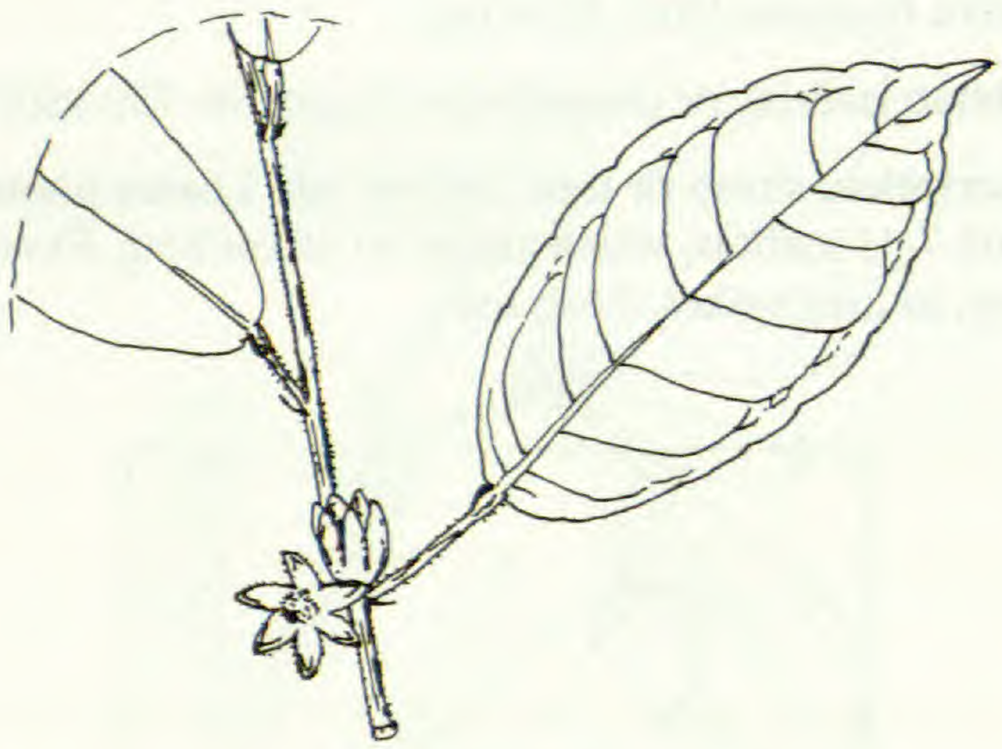
Local Names & Uses: none known.

Distribution: endemic to Cha Simba.

Habitat: limestone outcrop clefts; alt. ca. 220 m.

Description: shrub or tree 3-4 m tall. Flowers dull orange, fleshy. Fruit unknown.





Status:

Rare, Vulnerable, Endangered. The site is threatened by agricultural encroachment. Discussions are going on to safeguard the outcrop, but have not been completed or implemented.

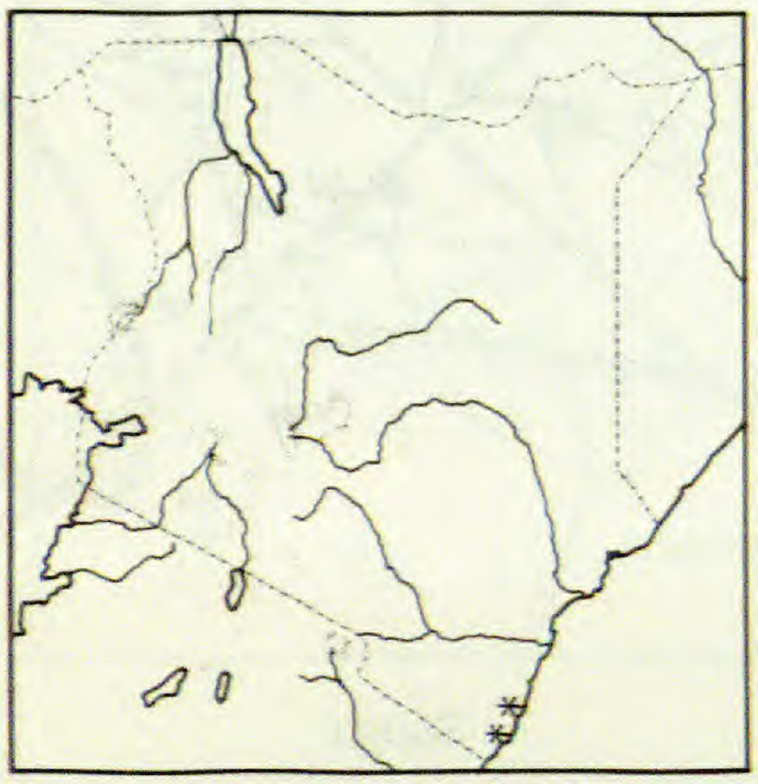
Cola porphyrantha Brenan — *Sterculiaceae*

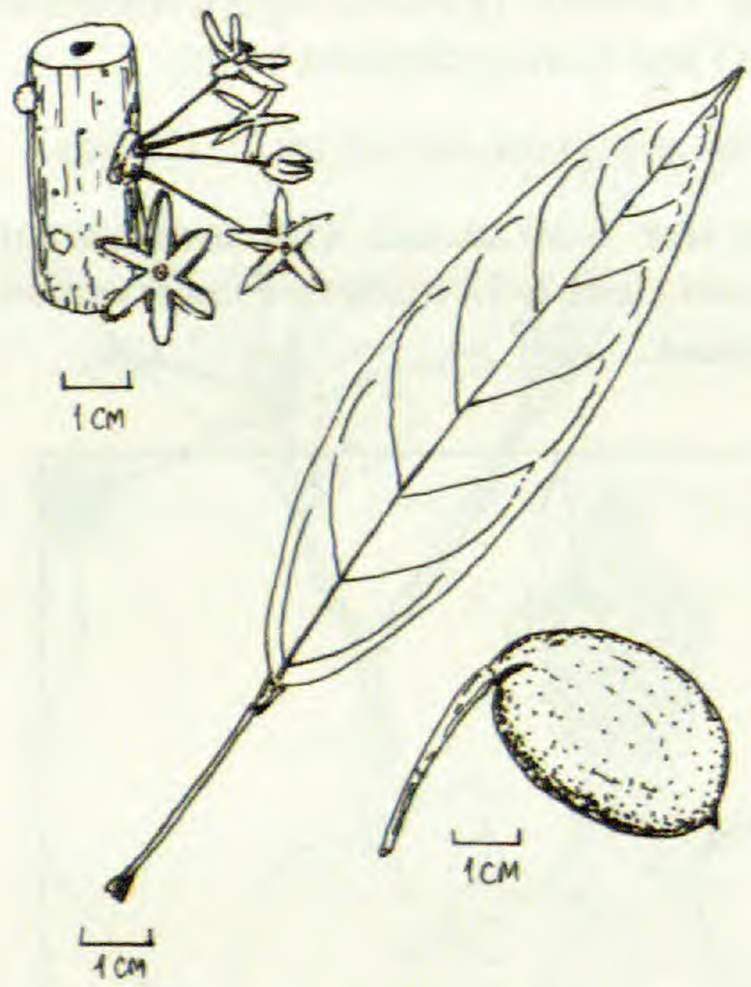
Local Names & Uses: Mutsamvia (Digo). The fruit is edible.

Distribution: Endemic to coastal Kenya (Shimba Hills, Pangani rocks).

Habitat: dense evergreen forest; alt. 170-420 m.

Description: tree 7-20 m. Flowers reddish purple, from old wood on trunk and branches. Fruit reddish.





Status:

Rare, Vulnerable, possibly **Endangered.** Only 3 collections are known. There are plans to quarry at Pangani.

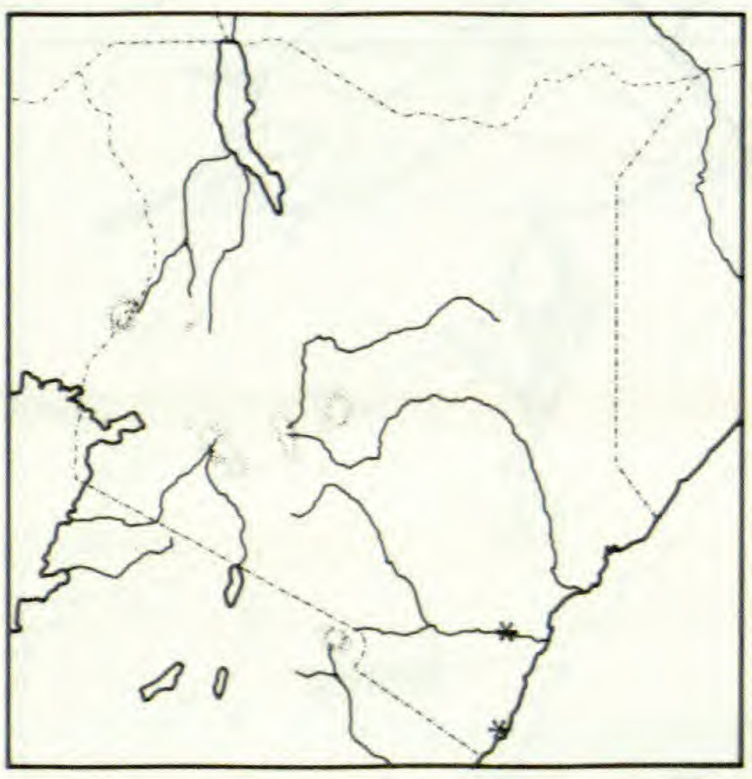
Cola uloloma Brenan — *Sterculiaceae*

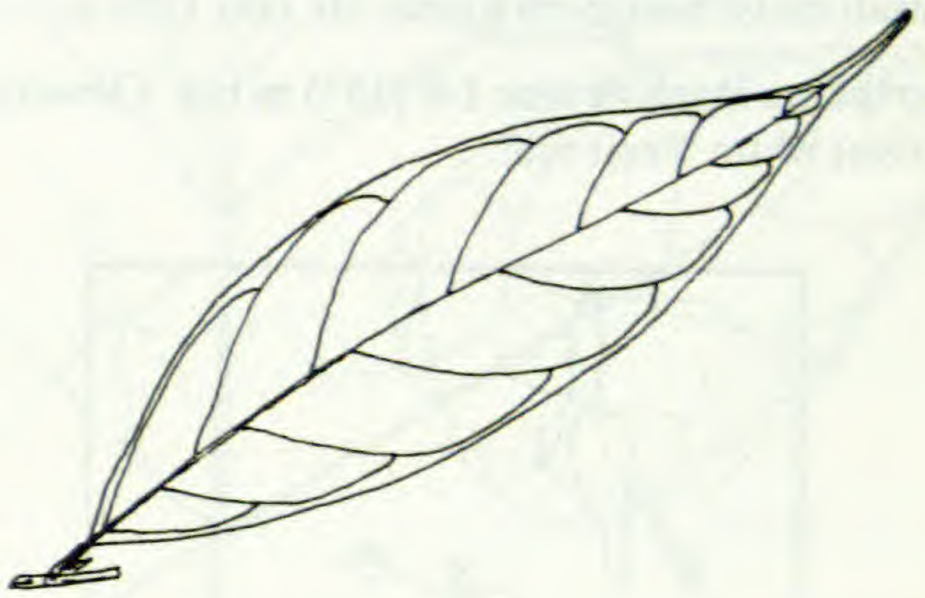
Local Names & Uses: none known.

Distribution: coastal Tanzania (Pangani district) and Kenya (Muhaka forest and Mangea).

Habitat: moist evergreen forest; alt. 30-500 m.

Description: Dioecious tree to 4 m tall. Male flowers pinkish brown, 5-6 mm long, in axillary fascicles. Female flowers and fruit unknown.





Status:

Rare, Vulnerable, possibly **Endangered.** Numbers seem to be very low, and all three sites are unprotected as well as under threat.

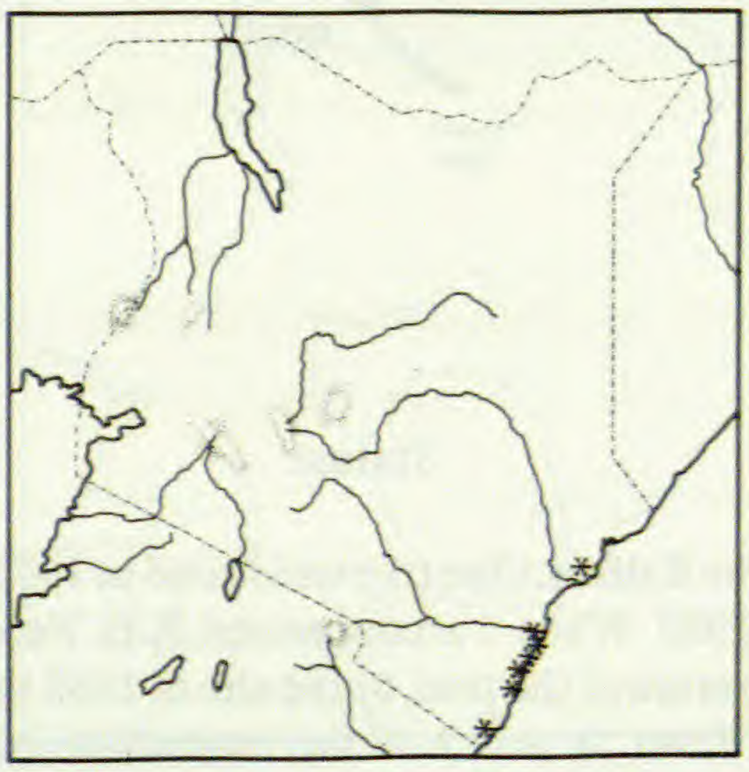
Nesogordonia holtzii (Engl.) Capuron — *Sterculiaceae*

Local Names & Uses: Muhero (Lamu), Mranza (Giriama).

Distribution: coastal Tanzania (Maramba, Ngomeni, Pugu, Pande) and Kenya (Witu, Boni, Arabuko, Mwarakaya, Mwasangombe).

Habitat: evergreen forest or dense woodland, also on limestone; alt. 1-230 m.

Description: shrub or tree 2-25 m tall. Flowers yellow.





Status:

Rare. In Kenya only protected at Witu.

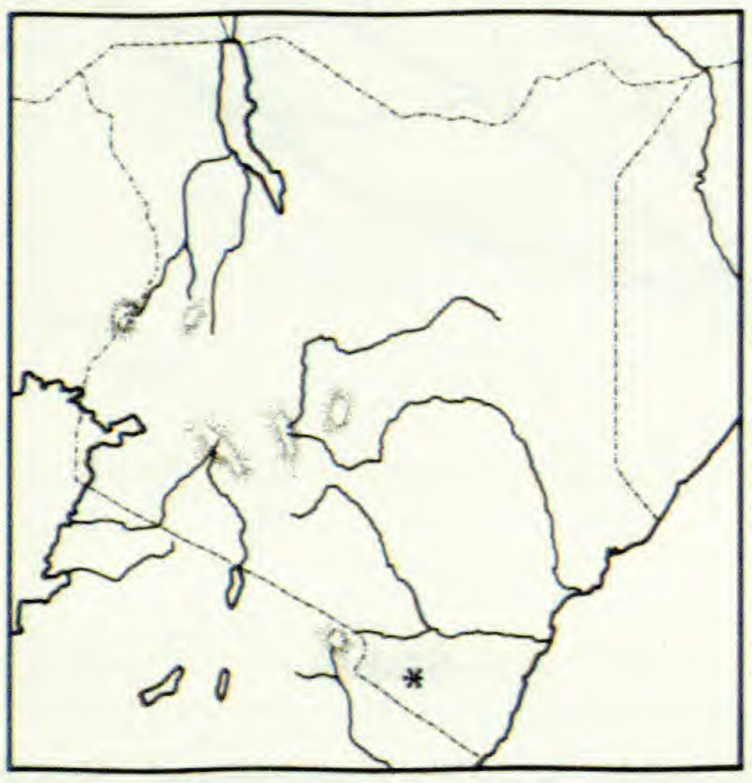
Dicranolepis usambarica Gilg — *Thymeleaceae*

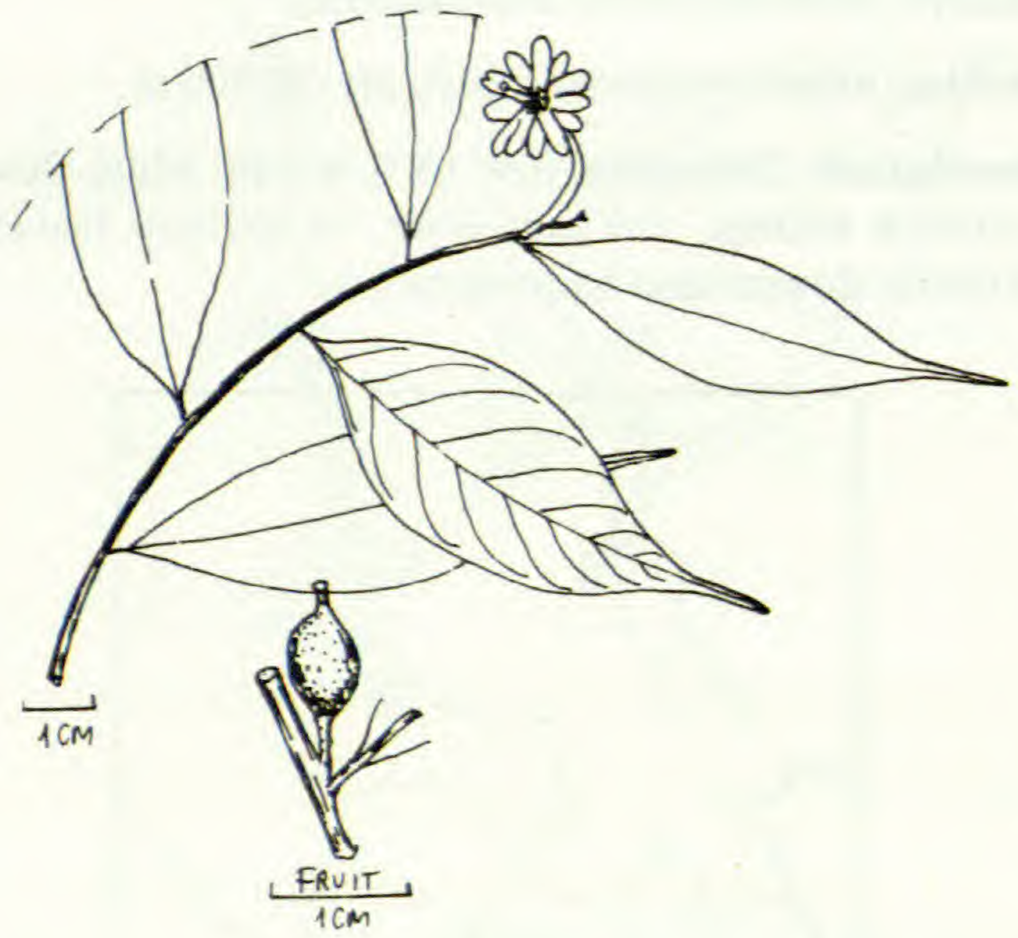
Local Names & Uses: none known.

Distribution: Tanzania (West Usambara, Uluguru, Nguru Mountains) and Kenya (Taita Hills).

Habitat: moist evergreen forest; alt. 600-1850 m.

Description: shrub or tree 1-6 (15?) m tall. Flowers (yellowish) white. Fruit red.





Status:

Rare. The Taita Hills population is not officially protected, but does not seem under any immediate threat.

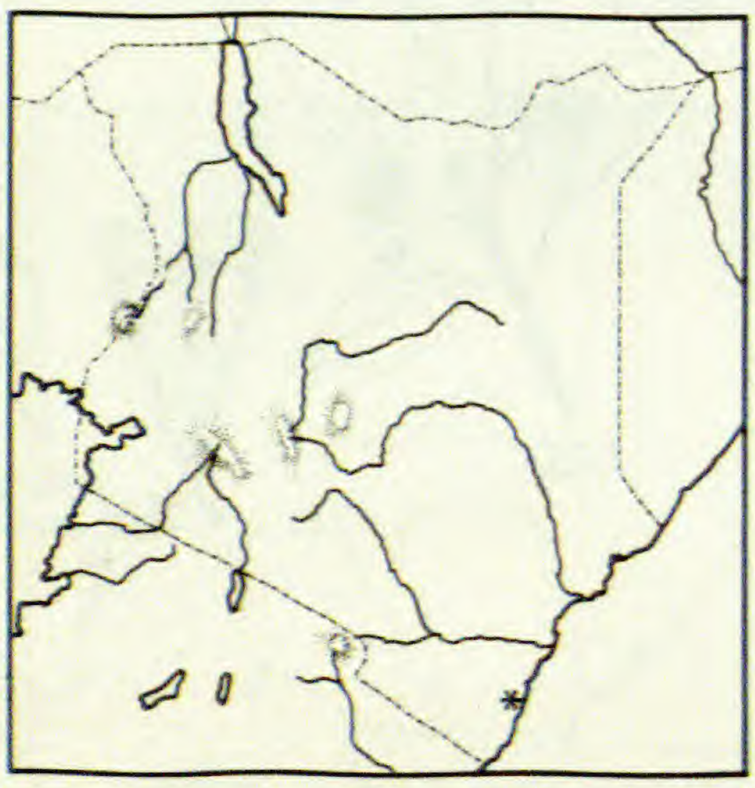
Holmskioldia sp. nov. (A new, undescribed species) — *Verbenaceae*

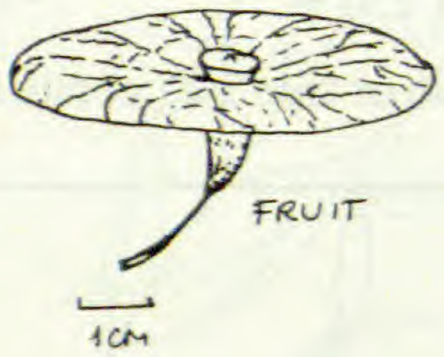
Local Names & Uses: Mukolo (Giriama).

Distribution: only known from Mwarakaya sacred forest.

Habitat: forest on limestone; alt. ca. 200 m.

Description: tree 12 m tall, with peeling bark. Leaves and flowers unknown.





Status:

feared to be **Extinct.** One tree was found in 1977, and seen again in 1980. When I accompanied R.B. Faden, one of the discoverers of the tree, to the site in 1985 the tree had been cut down. A search of the immediate area did not produce any other sightings.

Premna maxima T.C.E. Fries

Verbenaceae

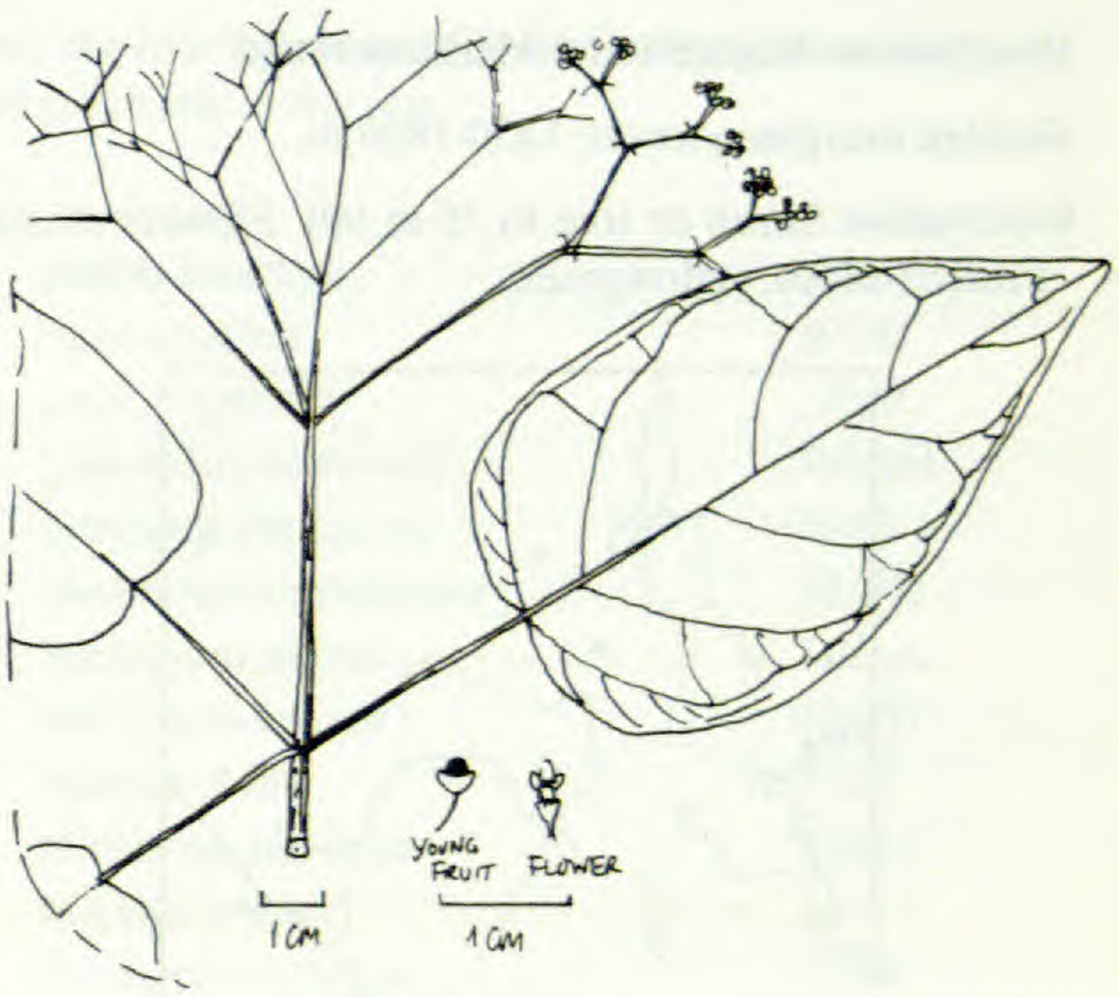
Local Names & Uses: Muchichiu (Meru). The wood is used to make furniture.

Distribution: endemic to Kenya (Marsabit, Northeast Mt. Kenya).

Habitat: moist evergreen forest; alt. 1190-1500 m.

Description: tree 12-30 m tall, with buttresses. Leaves opposite or in threes. Flowers cream. Fruit purple when young.





Status:

Rare. Protected at Marsabit National Reserve, but might be **Vulnerable** because both these forests are being encroached upon.

Vitex zanzibarensis Vatke

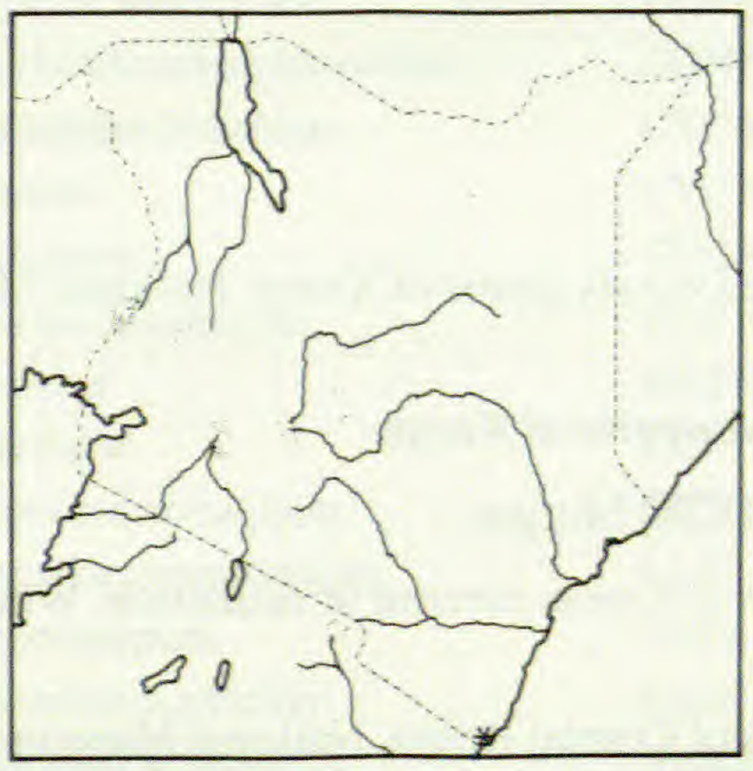
Verbenaceae

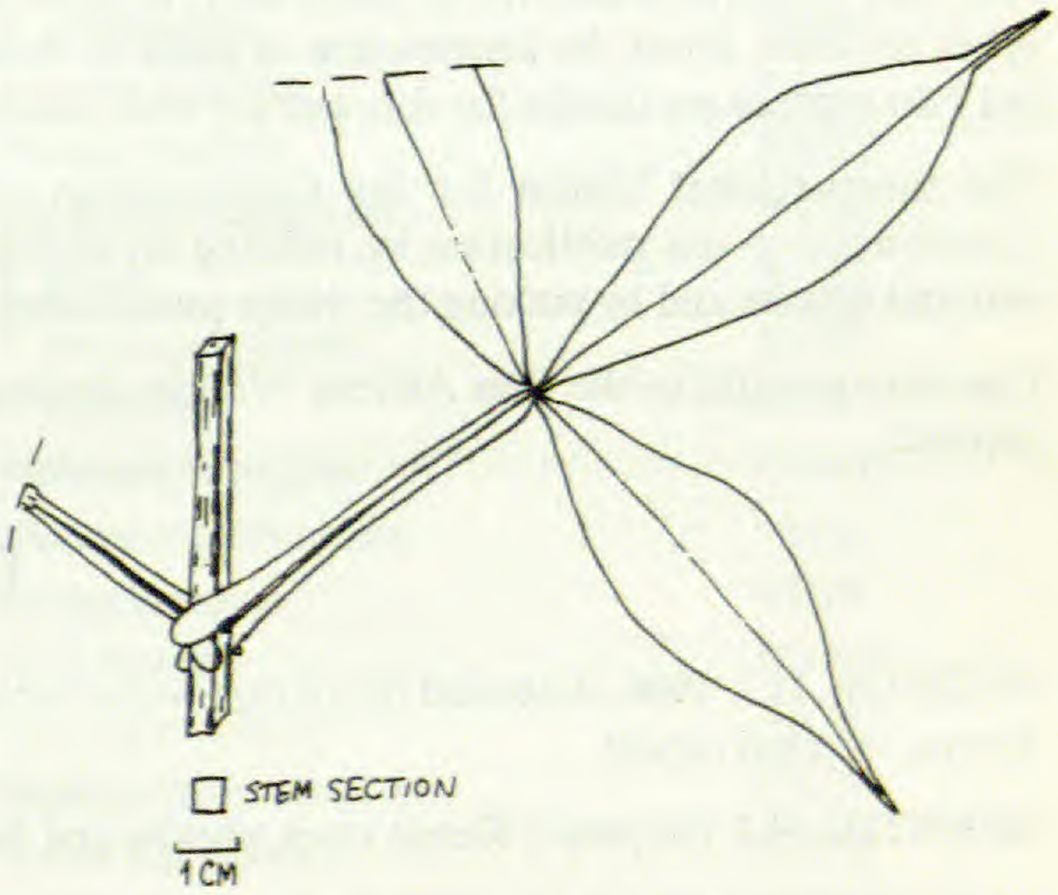
Local Names & Uses: none known.

Distribution: Tanzania (Pugu, Banda, Kola, Malemba and Bagamoyo) and Kenya (Gogoni forest).

Habitat: moist evergreen forest; alt. 1-400 m.

Description: Large forest tree with hard, reddish wood. Leaves opposite, with a winged petiole and 3 leaflets. I have not seen the flowers and fruits of the material present at Kew.





Status:

Rare. The Kenyan collection was made in 1942.

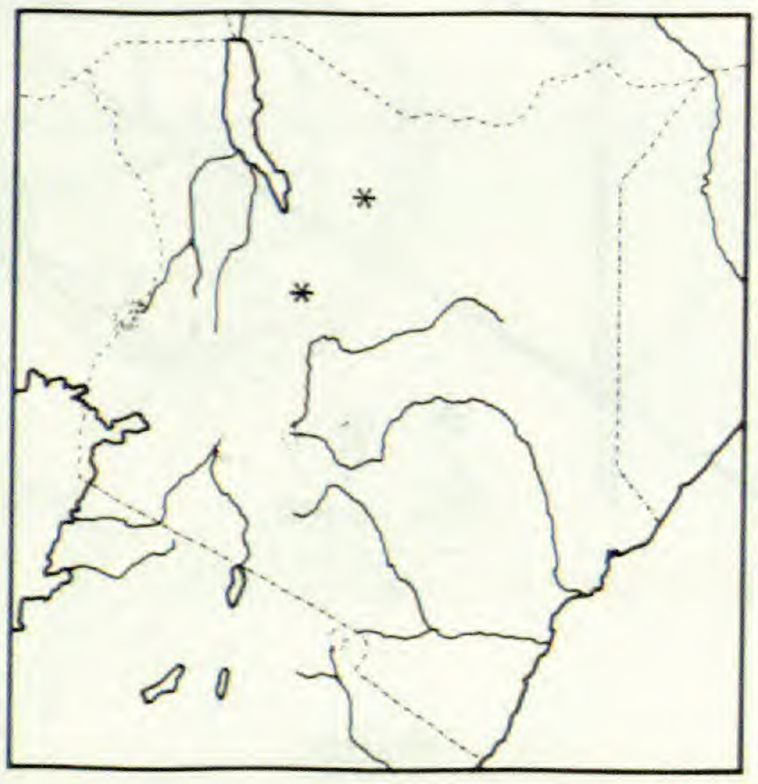
Rinorea convallarioides (Bak. f.) Eyles ssp. *marsabitensis* Grey-Wilson *Violaceae*

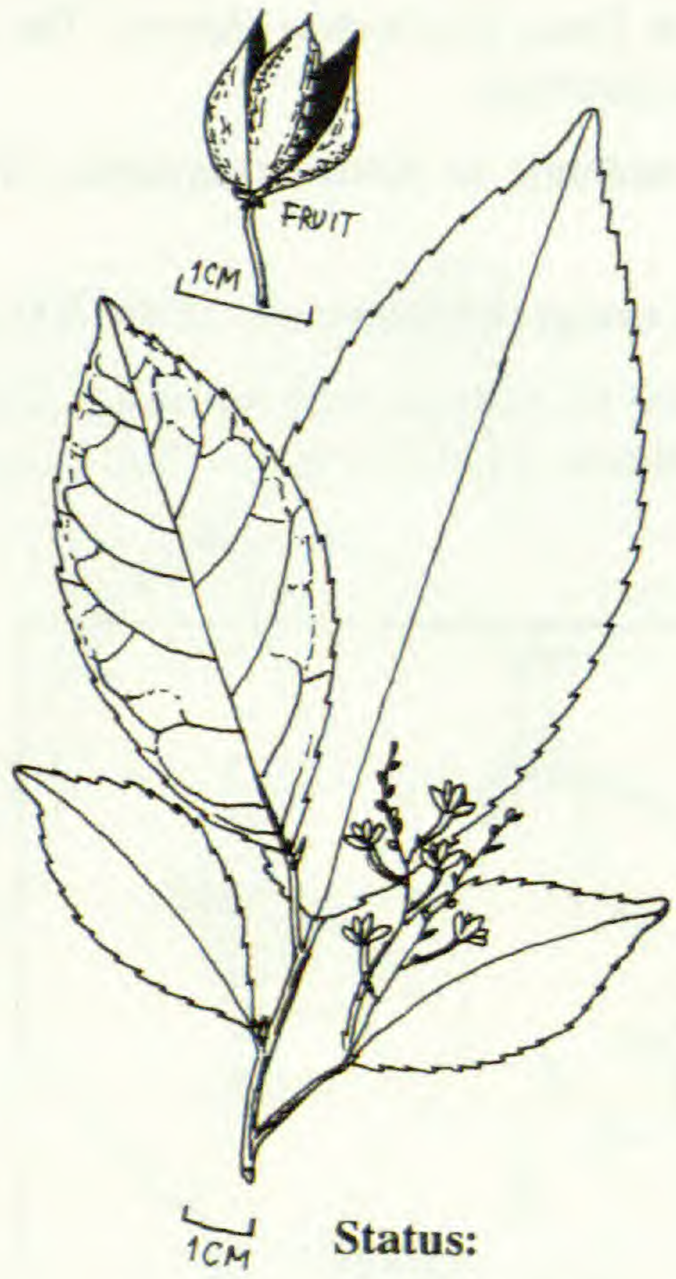
Local Names & Uses: none known.

Distribution: Marsabit and Mathews range.

Habitat: evergreen forest; 1450-1800 m.

Description: Shrub or tree to 15 m tall. Flowers cream. Fruits 3-lobed, yellowgreen.





Status:

Rare. I have not enough information about the status of these forests, but there seems to be no specific threat.

Acknowledgments

I wish to thank Mr. G.R. Cunningham-van Someren and Mr. J.B. Gillett for their critical reading of an earlier draft of this paper.

Mrs. S.A. Robertson and Mr. Q. Luke have, in their investigations on the coastal flora of this country, time and again upset my ideas about the distribution of some of these rare species. It is not just me who should be grateful for this, but I do express my thanks for this and for their interest and criticism on my notes on habitat and descriptions.

The International Union for the Conservation of Nature (IUCN), Communications Unit has made a great contribution to this publication by, redoing my distribution maps in a more acceptible way, by doing the layout of the text and figures and by making the whole publication camera-ready for printing.

I am very grateful to the East African Wildlife Society for the funds which made it possible for this publication to be printed.

Literature

BEENTJE, H.J. 1986. A second list of rare, vulnerable and endangered woody plants of Kenya. National Museums of Kenya, internal report.

BEENTJE, H.J. (in prep.) Kenya trees, shrubs and lianas. National Museums of Kenya.

LUCAS, G. & SYNGE, H. 1978. The IUCN Plant Red Data book. IUCN, Morges.

MUNGAI, G.M., GILLETT, J.B. & EAGLE, G.F. 1979. Plant species in Kenya, survival or extinction. Wildlife Clubs of Kenya Conservation Bulletin.

ROBERTSON, S.A. 1987. Preliminary floristic survey of Kaya forests of Coastal Kenya. National Museums of Kenya (restricted circulation).

Index

The species are arranged alphabetically. After the species name, the first four letters of the family indicate where in the text the species can be found: the families are arranged alphabetically in the text.

Acacia condylada	MIMO	Isolona cauliflora	ANNO
A. dolichocephala	MIMO	Ixora scheffleri	RUBI
Afrosersalisia kaesneri	SAPO	Lannea malifolia	ANAC
Albizia tanganyicensis	MIMO	Lasiodiscus mildbraedii	RHAM
Allophylus zimmermannianus	SAPI	Lonchocarpus kanurii	PAPI
Aloe ballyi	LILI	Macaranga conglomerata	EUPH
Aristogeitonia monophylla	EUPH	Memecylon teitense	MELA
Balanites wilsoniana	BALA	Micrococca scariosa	EUPH
Baphia keniensis	PAPI	Millettia oblata	PAPI
Brucea tenuifolia	SIMA	Mimusops somalensis	SAPO
Caesalpinia insolita	CAES	Moringa arborea	MORI
Canthium glaucum	RUBI	Nesogordonia holtzii	STER
C. kilifiensis	RUBI	Newtonia erlangeri	MIMO
C. robynsianum	RUBI	Notobuxus obtusifolia	BUXA
Chytranthus obliquinervis	SAPI	Odyendea zimmermannii	SIMA
Coffea arabica	RUBI	Ouratea sacleuxii	OCHN
C. fadenii	RUBI	O. schusteri	OCHN
Cola octoloboides	STER	Oxystigma msoo	CAES
C. porphyrantha	STER	Oxyanthus pyriformis	RUBI
C. ululoma	STER	Pachystela subverticillata	SAPO
Combretum tenuipetiolatum	COMB	Pachystigma gillettii	RUBI
Commiphora chaetocarpa	BURS	Pandanus murira	PAND
C. ciliata	BURS	Pavetta linearifolia	RUBI
C. swynnertonii	BURS	P. sphaerobotrys	RUBI
Croton alienus	EUPH	Polyscias kikuyensis	ARAL
C. megalocarpoides	EUPH	P. stuhlmannii	ARAL
Dicraeopetalum stipulare	PAPI	Populus ilicifolius	SALI
Dicranolepis usambarica	THYM	Premna maxima	VERB
Diphasia sp.	RUTA	Psychotria crassipetala	RUBI
Diphasiopsis fadenii	RUTA	P. petitii	RUBI
Dovyalis sp. A	FLAC	P. pseudoplatyphylla	RUBI
Drypetes H usambarica	EUPH	P. taitensis	RUBI
Ellipanthus hemandradenioides	CONN	Pteleopsis tetraptera	COMB
Encephalartos bubalinus	CYCA	Rinorea convallarioides	VIOL
E. kisambo	CYCA	Rytigynia induta	RUBI
E. tegulaneus	CYCA	Savia fadenii	EUPH
Euphorbia cussonoides	EUPH	Sclerocarya gillettii	ANAC
E. tanaensis	EUPH	Synadenium compactum	EUPH
E. wakefieldii	EUPH	Teclea hanangensis	RUTA
Gigasiphon macrosiphon	CAES	Thecacoris usambarensis	EUPH
Haplocoelum mombasense	SAPI	Uvariodendron anisatum	ANNO
H. trigonocarpum	SAPI	U. gorgonis	ANNO
Haplocoelopsis africana	SAPI	Vepris glandulosa	RUTA
Holmskioldia sp. nov.	VERB	Vitellariopsis kirkii	SAPO
Warburgia stuhlmannii	CANE	Vitex zanzibarica	VERB

Appendix

List of shrubs and lianas which are rare within Kenya and do not occur outside the country, plus some trees which might be rare, and whose taxonomic status is uncertain (at least to me) or for which I have seen no material. Status (RARE, VULNERABLE etc.) has only been assigned where there is enough information for this; omission of status does not infer anything.

ACANTHACEAE

Rhinacanthus pulcher Milne-Redh.
Woody herb; in dry bushland in middle Tana & lower Uaso Nyiro reaches. Rare.

ANCISTROCLADACEAE

Ancistrocladus robertsoniorum J. Leonard
Liana; only known from Buda forest (Kwale District). Vulnerable.

BORAGINACEAE

Cordia crenata/keniense
Shrub or tree; in dry bushland in northern areas.

CAESALPINIACEAE

Caesalphinia dauensis Thulin
Shrub; in dry bushland on limestone in the Daua River Valley (NE Kenya). Vulnerable.

Cynometra sp.1 of KTSL
Tree; in moist forest in Taita Hills; never yet collected in flower or fruit. If a new species, then Rare.

CAPPARACEAE

Boscia keniensis Beentje
Shrub; along luggas and alluvium in the middle/lower Tana R. reaaches, to Marsabit district. Rare.

Cadaba parvula Polhill
Shrub; known from a single collection from dry bushland near Isiolo.

CELASTRACEAE

Maytenus keniensis Robson ined.
Shrub collected twice in moist forest on SW Mount Kenya. Rare.

COMBRETACEAE

Combretum tanaense J.J. Clark
Liana; in riverine forest along upper Tana and Athi Rivers. Vulnerable.

COMPOSITAE

Senecio johnstonii Oliv. ssp. battiscombei (R.E & T.C.E. Fries) Mabberley var. *battiscombei*
Giant groundsel; in moorland on Mt Kenya and Nyandarua (Aberdares). Rare.

- var.*cheranganiensis* (Cotton & Blakelock) C. Jeffrey
in moorland on Cherangani Mts. Vulnerable.

Senecio johnstonii Oliv. ssp. *elgonensis* (T.C.E. Fries) Mabberley var. *elgonensis*
Giant groundsel; in moorland on Mt. Elgon. Rare.

- var.*ligulatus* (Cotton & Blakelock) C. Jeffrey
in moorland on Mt. Elgon. Rare.

Senecio keniensis Bak. *ssp. keniensis*
Giant groundsel; in moorland on Mt. Kenya. Rare.

- ssp.*brassiciformis* (R.E. & T.C.E. Fries) C. Jeffrey
in moorland on Nyandarua (Aberdares). Rare.

Senecio keniodendron R.E. & T.C.E. Fries
Giant groundsel; in moorland on Mt. Kenya and Nyandarua (Aberdares). Rare.

Vernonia fischeri O. Hoffm.
(Scrambling) shrub; in bushland on rock at Mwingi and Makueni. Rare.

CONNARACEAE

Connarus sp. nov.?
Liana; in moist forest at Shimba Hills. Rare.

CONVULVULACEAE

Ipomoea lapidosa Vatke
Liana; on rock in wood/bushland in SE Kenya and Samburu.

DICHAPETALACEAE

Dichapetalum fadenii Breteler
Climber; in forest on limestone at Cha Simba. Endangered.

EBENACEAE

Diospyros greenwayi F. White ined.
Shrub or tree; in dry moist forest in Shimba Hills, Buda forest and Witu Forest. Rare.

Diospyros kabuyeana F. White ined.
Tree; in forest at Mrima Hills, Pangani and Mnazini. Rare.

Diospyros shimbaensis F. White ined.
Shrub or tree; in moist forest at Shimba Hills. Rare.

Diospyros wajirensis F. White ined.
Shrub; in dry bushland near Wajir. Rare.

ERICACEAE

Erica trimera (Engl.) Beentje ined. ssp *Keniensis* (S. Moore) Beentje ined.
Shrub; in moorland on Mt. Elgon. Rare.

EUPHORBIACEAE

Bridelia taitensis Vatke & Pax
Shrub; in woodland or bushed grassland on rocky hills.

Erythrococca pubescens A.R. Smith.
Shrub; in coastal bushland (4 site only). Rare.

Euphorbia fluminis S. Carter
Succulent shrub, semi-scandent; in woodland on alluvium, lower Tana River. Vulnerable.

Euphorbia friesiorum (Hassler) S. Carter
Shrub or small tree; on rocky slopes and in woodland in central Kenya. Rare.

Phyllanthus sacleuxii A.R. Smith
Shrub; forest on Shimba Hills and lower Taita/Sagalla Hills. Rare.

Savia fadenii A.R. Smith
Shrub; in forest on limestone at Cha Shimba and Gandi. Endangered.

Zimmermannia ovata E.A. Bruce
Shrub; in dry forest at North Ngangao Forest (Taita Hills). Vulnerable.

LAURACEAE

Ocotea argylei Robyns & Wilczek
Tree; collected twice in moist forest in the SW Mau (Posta Hill) but probably = *O. kenyensis*

LILACEAE

Aloe cheranganiensis S. Carter & P. Brandham
Shrub; in dry bushland on N. Cherangani Hills. Rare/Vulnerable.

Aloe nyeriensis Christian
Shrub; rocky bushland in upper Uaso Nyiro reaches. Vulnerable.

LOBELIACEAE

Lobelia bambuseti R.E. & T.C.E. Fries
Shrub; in bamboo or podo forest margins and-clearings on Mt. Kenya and Nyandarua (Aberdares.) Rare.

MALPHIGIACEAE

Acridocarpus wattimae Beentje ined.
Climber; in dry forest at north Ngangao Forest, Taita Hills. Vulnerable.

MELASTOMATACEAE

Memecylon buxoides Wickens
Shrub; only collection in 1942, Mutha forest (Kitui district). Endangered, if not extinct.

Memecylon fragrans A. & R. Fernandes
Shrub; in dry and moist coastal forest at Arabuko-Sokoke and Buda. Vulnerable.

MELIACEAE

Turraea cornucopia White & Styles ined.
Shrub; in bush/woodland ecotone, in rocky sites (near Lolokwe and S of Ngong). Rare.

MYRSINACEAE

Embelia keniensis R.E. Fries
Liana; in moist forest on Mt. Kenya (anno 1922) and Tigoni (1988). In cult. Hort. Luke. Vulnerable.

OCHNACEAE

Ochna sp. A of KSTL
Shrub; in dune thickets in the Kiunga area. Rare. This taxon might be a subspecies of *O. ovata*

PAPILIONACEAE

Dalbergia eremicola Polhill
Shrub; in dry bushland near Wajir. Rare.

Millettia tanaensis Gillett.
Shrub; in dry bushland on the upper Tana River reaches. Rare/Vulnerable.

PASSIFLORACEAE

Adenia metriosiphon de Wilde
Climber; in dry forest or riverine bushland in the Nairobi area. Rare.

ROSACEAE

Rubus keniensis Standl.
Scrambler; in moist forest margins on Mt. Kenya and Nyandarua (Aberdares). Rare.

RUBIACEAE

Canthium fadenii Bridson ined.
Shrub; in dry riverine forest and adjacent bushland at Thika Falls and Nganeni. Vulnerable.

Canthium keniense Bullock
Shrub or small tree; in dry forests in the Nairobi/Machakos area. Rare

Chassalia discolor K. Schum. ssp. *taitensis* Verdc.
Shrub; collected in moist forest on Taita Hills. Rare.

Coffea paolia Bridson
Shrub; twice, in dry bushland near Galole. Rare/Vulnerable.

Pavetta hymenophylla Brem.
Shrub; in moist forest on Mount Kenya; last collected in 1964. Rare.

Pavetta tarennoides S. Moore
Shrub or tree; in forest on Shimba Hills. Rare.

Pavetta teitana K. Schum.
Shrub or small tree in rock crevices in SE Kenya. Rare.

Psychotria sp. B. of FTEA
Shrub; collected twice in Northern Ngangao forest (Taita Hills). Searched for, feared Extinct.

Psychotria sp. C of FTEA
Shrub; collected once in forest on the Mau

Psydrax sp. B of KB 40:716
Shrub; in thicket/forest at Kilifi, collected twice. Rare.

Rytigynia mrimaensis Verdc.
Shrub; in moist forest at Mrima Hill and possibly Gedi. Vulnerable.

Rytigynia parvifolia Verdc.
Shrub; in *Brachystegia* woodland or dense bushland on the Coast. Rare.

Tarenna kibuwae Bridson
Shrub; in dry bushland near Garissa. Rare.

Tricalysia bridsoniana Hiern var. *bridsoniana*
Shrub; in forest at Arabuko-Sokoke. Rare.

SIMAROUBACEAE

Brucea microcarpa Stannard
Shrub; in riverine or swamp-forest at Thika Falls, Kiambu, Kamiti, Rojwero (Meru Park). Rare.

SOLANACEAE

Solanum sp. J of UKWF
Woody herb or shrub; in moist forest at Limuru and NW Mt. Kenya. Vulnerable.

TURNERACEAE

Loewia thomasii (Urb.) J. Lewis
Shrublet; in dry bushland, between Mado Gashi and Garissa and at Witu. Rare.

VITACEAE

Cyphostemma jiguu Verdc.
Shrub; in riverine bushland, Embu district. Rare.

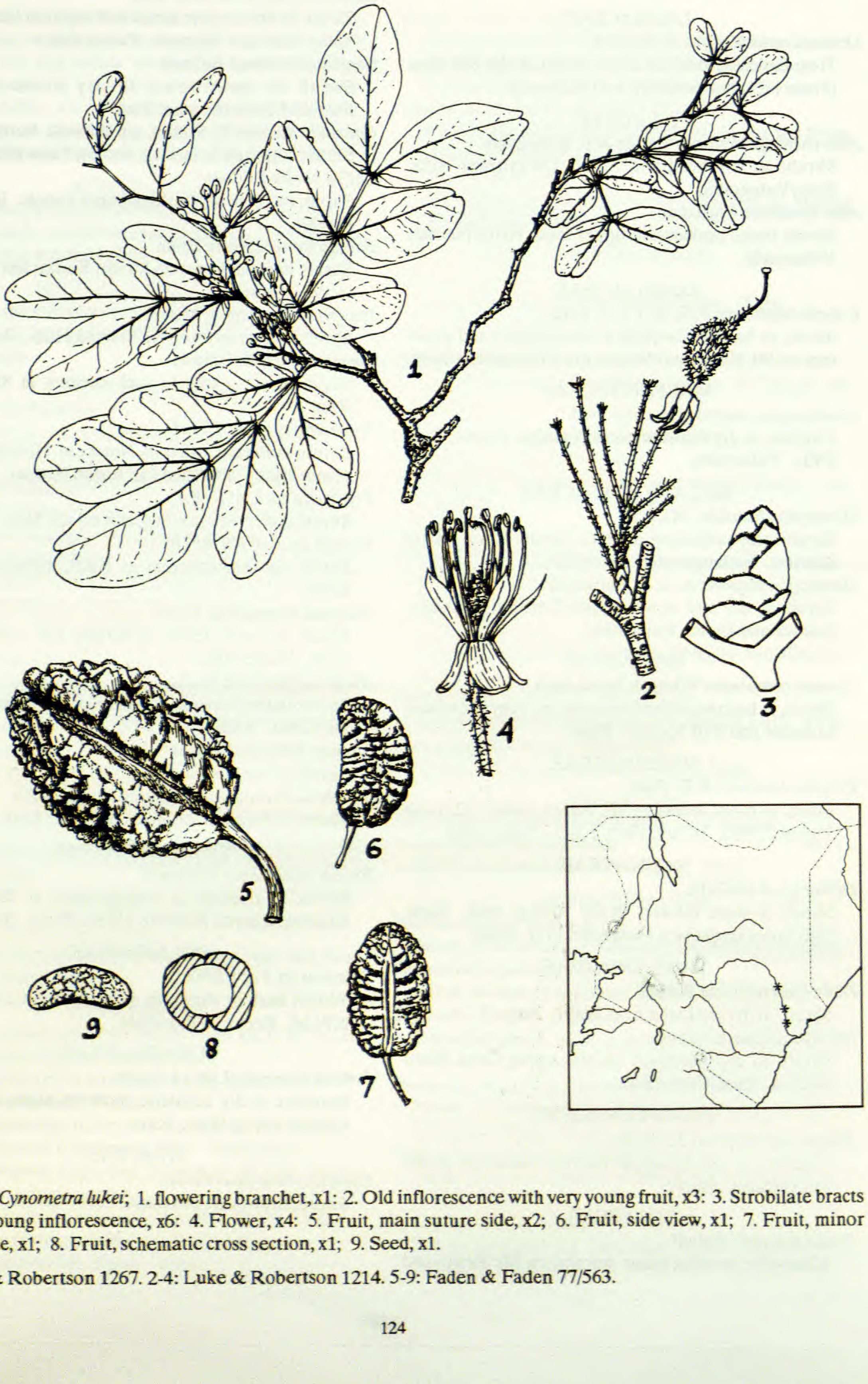


Figure 1. *Cynometra lukei*; 1. flowering branchet, x1: 2. Old inflorescence with very young fruit, x3: 3. Strobilate bracts on very young inflorescence, x6: 4. Flower, x4: 5. Fruit, main suture side, x2; 6. Fruit, side view, x1; 7. Fruit, minor suture side, x1; 8. Fruit, schematic cross section, x1; 9. Seed, x1.

1: Luke & Robertson 1267. 2-4: Luke & Robertson 1214. 5-9: Faden & Faden 77/563.

A New Species of Cynometra (Caesalpiniaceae) from Kenya

H.J. Beentje

Abstract *Cynometra lukei* is described from the Tana River forests, Kenya. Its nearest relatives are central African species. An illustration and map are provided.

The first collections of this taxon were identified as *Cynometra webberi*, since vegetatively these two resemble each other. The first fruits were collected by Faden in 1977, and it was clear that this taxon was new, since all other Kenyan *Cynometra* species have flattened fruits. It was not until 1988 that flowering material was collected, and so now a proper description can be made.

Cynometra lukei *Beentje* sp. nov. fructibus indehiscentis racemisque axillaribus C. *schlechteri* Harms affinis, a qua foliolorum apicibus obtusis, floribus minoris, staminibus paucioribus fructibusque sulcatis distincta. Typus: Kenya, Lango ya Simba forest, *Luke & Robertson 1267* (Holotypus EA; isotypi K, MO, US, WAG)

Tree 10-15m high, with spreading crown and more or less fluted trunk, sometimes branching near the base; bark smooth, greyish. Young branches puberulous, soon glabrescent, lenticellate, zigzag. Leaves 2-3 jugate; new flush reddish-yellow; stipules quickly caducous, linear-subulate, 4-6mm long, 0.1-0.2mm wide; petiole 2-5mm long, thickened, densely puberulous; leaflets opposite, sessile, obliquely elliptic , elliptic-lanceolate or elliptic-obovate, 0.6-5.5cm long, 0.5-3.4 cm wide, apex obtuse and emarginate, base cuneate on one side, cuneate or obtuse on the other, glabrous except for the emarginate apex where a few minute hairs are usually present. Inflorescence an axillary short dense raceme, with a puberulous axis 3-8mm long, in the young stage covered by overlapping bracts ca. 1.5-3 by 1.7-2.5mm, ciliate; bracteoles 1-1.2 by 0.3-0.6 mm, pubescent on the midrib, very caducous. Sepals 4, reflexed, unequal, elliptic, 2.5-4mm long, 1-2.8 mm wide, hooded at the apex, white with a red base; petals 5 (but often with 1-2 caducous), narrowly obovate, 3.8-4.5 by 0.8-1.2 mm, apex acute; stamens 9 (rarely 10?), the filaments slightly connate at the very base, unequal, 4-9 mm long; anthers 0.5-0.7 mm long, dorsifixed; ovary asymmetric, flattened, 2-2.6 by 1.6-2 by 0.6-1mm, tomentose, with a 0.5-1 mm long stipe; style inserted on one side of the ovary, 3-4mm long; stigma very small. Pods ellipsoid-obovoid, 22-27 by 14-17 mm, deeply grooved on one suture, slightly grooved on the opposite suture, tuberculate, densely and minutely puberulous, 1-seeded. Seed 24mm long, 8mm across.

Kenya, Tana River District: near Wenje, in floodplain woodland, alt. 30m, locally common, ster. 8 June 1973, *Marsh 5.* Guru North forest, in riverine forest on heavy soils, flooded, locally common, sometimes in dominant stands, fl. & yfr. 5 Sept. 1988, *Medley 409;* same loc., on soils with impeded drainage in seasonally flooded back levee, with *Acalypha echinus, Lawsonia inermis, Maytenus heterophylla, Lecaniodiscus, Garcinia livingstonei, Hyphaene compressa,* fl. 24 July 1988, *Luke & Robertson 1214.* 3 km N of Wema, frequent on deep grey alluvial clay/silt, not close to the river, with *Lannea, Garcinia, Strychnos, Diospyros, Phoenix, Haplocoelum foliolosum* and many Rubiaceous shrubs, ster. 17 July 1972, *Gillett & Kibuwa 1924.* 1 km E of Wema in dry forest, ster. 29 July 1988, *Luke & Robertson 1253.* Lango ya Simba forest, in forest patch with *Mimusops, Garcinia livingstonei,* fr. 20 Feb. 1977, *Faden 77/563;* same loc., fl. & yfr. 8 Aug. 1988, *Luke & Robertson 1267* (type).

Gachathi has also recorded this species at Bura.

Habitat: rather dry riverine forest on seasonally flooded soils; alt. 20-50m.

Local Name: Mpakata (Pokomo, fide Medley)

The first Kenyan *Cynometra* with indehiscent, ellipsoid, tuberculate pods. This species clearly belongs in groups 1 of Leonard (1951), together with Zairean and Western Central African species; they have in common the scarious bracts, the non-articulated pedicels, the absence of a disk and the partly connate filaments, as well as the fruit characters. The closest resemblance is to *C. schlechteri* Harms from Western Zaire and Gabon, but *C. lukei* differs in the leaflet apex (non-acuminate), the smaller size of bracts, bracteoles and flower parts in general, the lower number of stamens (9, as opposed to 10-12), the grooved fruit and the obtuse fruit apex.

I have named this species after Mr. Quentin Luke, one of the collectors of the type, one of the foremost Kenyan field botanists, and someone with an infallible eye for rare species.

Since this species only occurs in a restricted habitat, which is threatened by altered flood regimes caused by dams upstream, by clearing of forests for irrigation schemes, and by increased use of the forests by a rapidly expanding population, this species can be considered as Vulnerable. The fruits are presumably dispersed by the river, and rot in the mud, thereby releasing the seed.

References:

LEONARD J. 1951. Les Cynometra et les genres voisins en Afrique tropicale. *Bull. Jard. Bot. Etat* 21:373-446.

UTAFITI Volume 1 Number 3

NOVEMBER 1988

CONTENTS

Atlas of the rare trees of Kenya - *H.J. Beentje* 71-123
Appendix: rare endemic shrubs and lianas 122-123

A new species of *Cynometra* (Caesalpiniaceae) from Kenya
H.J. Beentje 124-125

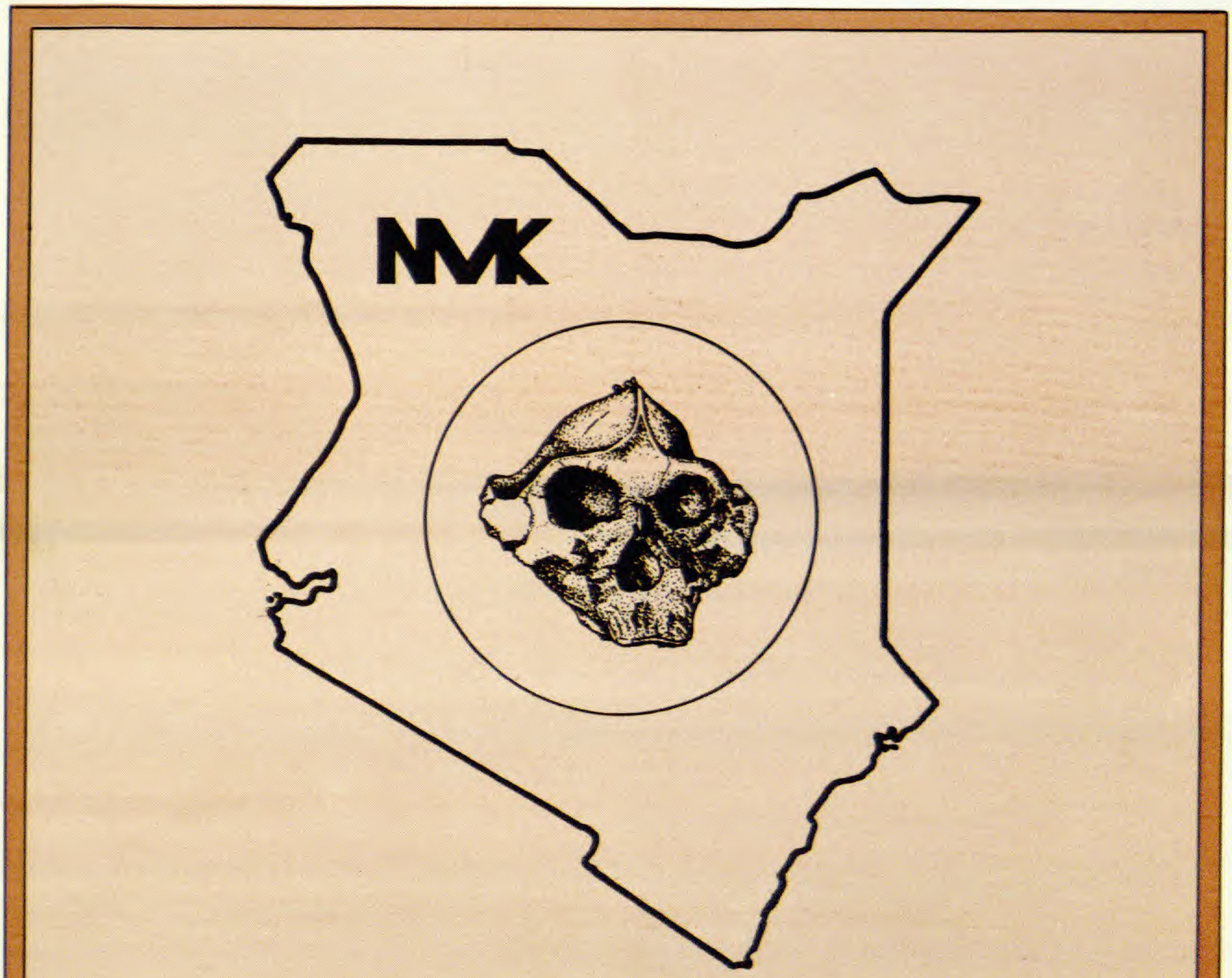
UTAFITI is published several times a year, and incorporates original research papers on work carried out at the National Museums of Kenya.
Every major paper is peer-reviewed by professionals from outside the Museums.

Editor Dr. H.J. Beentje
Editorial Committee Dr. H. Adan
Dr. R. Bagine
Dr. M. Issahakia
Miss C.H.S. Kabuye
Dr. M. Leakey
Mr. A. MacKay
Dr. S. Wandibba

Typesetting and layout by Liz Jarvis, IUCN Regional Office, Nairobi.
Printed by Kenya Litho Ltd., Changamwe Road, P.O. Box 40775, Nairobi.
Produced by the National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya

UTAFITI

OCCASIONAL PAPERS OF THE NATIONAL MUSEUMS OF KENYA



NATIONAL MUSEUMS OF KENYA

VOLUME 2 NUMBER 1 MARCH 1989

A SURVEY OF THE RIVERINE FORESTS IN THE WEMA/HEWANI VICINITY, WITH REFERENCE TO DEVELOPMENT AND THE PRESERVATION OF ENDEMIC PRIMATES AND HUMAN RESOURCES

Kimberly E. Medley[1,2], Margaret F. Kinnaird [2,3] & Barbara S. Decker [2,4]

Abstract: Current development of the Tana Delta Rice Irrigation Scheme is disrupting the forest habitat within the southern range of two endemic and endangered primates, the Tana River red colobus and the crested mangabey. Vegetation sampling and primate censuses show that, in comparison to the forests protected in the Tana River Primate Reserve, these forests have a different floristic composition, primate populations with low group sizes in very small forests, and a diverse forest resource for the local human population. Stewardship considerations are presented which should establish compatibility between the large-scale development project and forest resource preservation.

INTRODUCTION

The forests of the Wema/Hewani vicinity, although south of the Tana River National Primate Reserve (TRNPR) maintain populations of the endangered Tana River red colobus monkey (*Colobus badius rufomitratus*) and the crested mangabey (*Cercocebus galeritus galeritus*), Kenya's only two endemic primates (IUCN 1976). The region comprises the southernmost range of these endemic primates and also the most southern extent of floodplain forest development along the Tana River (Marsh 1976; Hughes 1984). The TRNPR was established in 1976 to preserve the best remaining populations of these primates and their forest habitat within one contiguous unit (1750 ha. of forest area). One concern, however, was that the stability of the riverine forest ecosystem, and the primate populations within, would be dependent on proper stewardship of the remaining forest patches outside the Reserve. The development of the Bura Irrigation Project and small-scale irrigation projects (e.g. at Hola) have seriously impacted most forest areas north of the Reserve (Hughes 1987; Ledec 1987). The forests within the Wema/Hewani area are consequently the best remaining habitat outside the Reserve.

Current activities in this region, associated with the development of the 16.000 ha Tana Delta Rice Irrigation Scheme, are having a serious impact on the forests. Forest clearing and burning have occurred at several localities and are related to the construction of a north-south dike near the river, and as a consequence of grassland maintenance by pastoral people.

The objectives of this report are to summarize the ecological significance of these forests, to outline the project plans and activities for the rice scheme, and to propose some stewardship considerations which might ensure forest and primate preservation within the development framework (see reference maps, Figure 1 and 2).

SUMMARY OF ECOLOGICAL SIGNIFICANCE

The forests

Lowland riverine forest, in an otherwise semi-arid environment, is a rare forest type within Kenya and throughout Africa. Although low in floristic diversity when compared to tropical rainforest, the combination of species from coastal Africa, central Africa and local semi-arid areas results in a unique community composition. The the forests upstream vary in composition as a consequence of lowered precipitation and distance from the coastal floristic element. On this basis, the most floristically rich forests would be just above the lower delta (Hughes 1984); these include the forests in the Wema/Hewani region.

Furthermore, research within the riverine forests of the Tana River (Andrews et al. 1975; Marsh 1976, Hughes 1984) has shown that different forest types are closely associated with certain landform types. These landform types include sandy levees, backwater clay deposits, oxbows and pointbars. Many of the forests in the Wema/Hewani area occur within an old river course. There are representatives of all landform types, but at some distance from the current river bed. The maintenance and regeneration within these forests is still poorly understood. Two of the smaller forests, Hewani East 2 and 3 (respectively #60 and #61; together less than 10 hectare) contain red colobus, suggesting that very small forests may be an adequate habitat for this primate. For these reasons, an understanding of the ecology of these forests is critical to a comprehensive knowledge of the Tana River floodplain forests.

In response to a concern over the current development activities in the area, we conducted a botanical survey within two small forest patches near Hewani village. Eight plots werte systematically located within Hewani East 3 (#61) and nested plots at random orientation were established for the study of seedlings, trees greater than 1 m in height, and canopy trees greater than 10 cm in diameter. Additionally, within Hewani East 2 (#60), the

1- Department of Botany and Plant Pathology, 166 Plant Biology, Michigan State University, East Lansing, Michigan 48824, U.S.A.
2- Tana River Primate Project, National Museums of Kenya, P.O. Box 88, Garsen, Kenya
3- School of Forest Resources and Conservation, 118 Newins-Ziegler Hall, University of Florida, Gainesville, Florida 32611, U.S.A.
4- Graduate Institute of the Liberal Arts, Emory University, Atlanta, Georgia, U.S.A.

MISSOURI BOTANICAL
AUG 22 1989

diameters of trees greater than 10 cm were recorded along one belt transect (ca. 540 square meter), and the basal area coverage of one major canopy tree species, *Mimusops fruticosa*, was measured in one large plot (ca. 700 sq. m). This survey enabled us to compare a representative forest from this region to those currently under study within the TRNPR, and to ascertain their comparative value. Several ecological attributes obtained from this study are presented in Table 1.

Although this study was conducted in only one area, several significant discoveries were made. First, the floristic composition and structure may be defined as "riverine forest". This is in contrast to the classification of the Hewani forests and all forest patches within this region as "wooded bushland" in the report by the Japan International Cooperation Agency (JICA 1984). We believe the forests have been incorrectly classified and their value as a forest resource inadequately assessed. Second, the dominant tree in all layers is *Barringtonia racemosa*. This tree has not been recorded within the TRNPR to date, and certainly does not form a major forest component within the reserve. Therefore, the Wema/Hewani forest community, defined by dominant tree species, differs from any forest within the TRNPR. Third, although there is no information on the use of *Barringtonia racemosa* by the endangered primates, the other important canopy trees present in the Hewani forests (*Pachystela msolo, Sorindeia madagascariensis, Ficus sycomorus*) have been ranked as very important primate food resources (Marsh 1978; Homewood 1976). Two of these species, *Pachystela msolo* and *Ficus sycomorus*, show a high density as young trees. The forest is in an apparently young stage of development. Finally, in one section of Hewani East 2 (#60), *Mimusops fruticosa* has the highest basal area (i.e. the highest number of very large trees) of this species recorded within the floodplain forests. One of the larger East African trees, *Oxystigma msoo*, also occurs in these forests (first Kenya record collected at a nearby locality: Gillett 19933).

In summary, this survey suggests that these forests differ substantially from the riverine forests within the TRNPR. Their preservation is critical to the maintenance of the biological diversity of the floodplain forest ecosystem. Furthermore, the diversity of these forests is equally important as a resource to the local people (see Table 1). The size of some canopy tree species (e.g. *Mimusops fruticosa*), the height of many *Phoenix reclinata* palms (above 6 m), the absence of coppicing (basal branching after cutting) and the large stem diameters of some understory species (e.g. *Polysphaeria multiflora*) indicate that the forest has been less disturbed than many areas within the TRNPR. The forest conservation practices of the Pokomo in fuelwood and polewood acquisition are such that they appear to disturb the structure of the forest (e.g. lowered height of palms and coppicing of understory trees) but this, with some management, should not seriously alter the regenerative capacity and floristic composition. As poles and firewood are only two of the many forest uses, the removal and subsequent replacement by monodominant, one-purpose stands would seriously reduce the available natural resources of this region. It would also eliminate the local availability of seeds and saplings of indigenous forest species important to people and primates. Recently there has been a sharp increase in forest utilization, including canoe construction, removal of large *Phoenix reclinata* stems and pole removal (primarily for survey stakes). We believe this activity is related to the current construction, and the expectation that the forest will be destroyed.

The primates

Annual primate censuses have been conducted in the Wema/Hewani vicinity from 1985 to present (Table 2). These censuses were preceded by a detailed survey conducted by C. Marsh (1976) during the establishment of the Reserve. The methods of census remained similar throughout the years (see Marsh 1986) and included on average seven forest areas (Marsh 1986; Decker & Kinnaird, in press). Construction of the dike was initiated between the surveys of 1986 and 1987; we therefore focus in this discussion on the results of the census we completed in October 1987.

Red colobus appear to have increased by 1-2 groups since the 1986 count; however, it should be pointed out that group sizes were small. Of the 6 groups sighted, only one comprised as many as 6 individuals. This is in contrast to a mean group size of 12 calculated friom 13 forests within the Reserve (Decker and Kinnaird, submitted). It is possible that these smaller group sizes reflect a reduction in colobus density in the Wema/Hewani forests not demonstrated by the group counts. Small group sizes may also be the result of larger groups fissioning due to reduced habitat and/or food supply. Few areas of high, continuous canopy now remain in these forests. Those that do remain are small, often composed exclusively of closely spaced *Mimusops fruticosa*. All colobus sighted during the census were in large *Ficus sycomorus* or in *Mimusops fruticosa* where 2-3 trees formed a closed canopy. Throughout their geographical range, the number of red colobus has declined over the last fifteen years by 80 % to only 200-300 individuals; they may now be the most endangered primate in Africa (Mittelmeier, pers. comm.)

The number of mangabey groups may have declined by as much as 2. Mangabeys were not seen and their presence was only noted by male long-calls. Long-calls were infrequent, heard only twice within the three-day survey. One long-call was recorded from a small 2-3 ha plot of flowering *Mimusops fruticosa* trees. This forest fragment had recently been isolated from the Wema East 1 (#56) forest by road and dike construction. Throughout their geographical range, the number of crested mangabeys has declined by 25 % over the last fifteen years to only 800-1100 individuals (Decker & Kinnaird, submitted; Marsh 1986).

It is important to note that these forests have maintained groups of the endangered red colobus and crested mangabey for at least one decade (Andrews et al. 1975). Without some management, it is not known whether the Wema and Hewani forests will be able to sustain groups of mangabeys or red colobus over either a short- or long-term. It is possible that red colobus can subsist at reduced numbers, but there is a danger of small, isolated groups

becoming genetically nonviable. If mangabeys are able to traverse expanses of open wooded grassland or cross roads to exploit food resources in widely dispersed forest patches, these patches may form an adequate habitat. If the forests become more fragmented and isolated due to construction or controlled flooding, the chances of survival are less. None of the habitat north of Wema/Hewani towards Sailoni is suitable for mangabey or red colobus.

Kinnaird (in press) stresses the importance of mangabey groups living in these and other forests outside the Reserve in increasing the overall effective population size to one considered sufficient for long-term viability. Marsh (1986) also notes that 10-15 % of the total remaining red colobus population occurs outside the Reserve in the forests of this region. Without the cessation of current forest destruction in this area, a significant portion of the southern range for these species will be destroyed. The endangered status of these two primates emphasizes the importance of the survival of the groups inhabiting the Wema/Hewani forests.

THE LOWER TANA DELTA RICE IRRIGATION SCHEME

Plans and current construction

This scheme is administered by the Tana-Athi River Development Authority (TARDA) and contracted through Lima Ltd. (dike construction). Although the details of the scheme may be obtained from these authorities, it is important to outline these activities which directly impact the riverine forests of the Wema/Hewani vicinity.

The overall scheme will eventually encompass 16.000 hectare divided into three sections: one section north of the Garsen-Lamu road (Wema/Hewani vicinity), and two large sections south of the road. The area to be utilized for rice production is approximately 10.000-14.000 hectare. The two southern sections are not near the river course and will probably not affect the riverine forests. They will be separated by narrow pastoral corridors to allow seasonal movement of cattle.

The project began with the construction of an earthen dike that surrounds the northern section in the Wema/Hewani area (Figure 1). Flooding of the scheme is likely to begin in 1990. The area to be flooded includes only the eastern portion of the land enclosed by the dike. Only one forest, Home East (#63) is within that area. The western portion, including the villages of Wema and Hewani and the other forests will be left intac. Subsistence agriculture will be maintained in this area.

The entire project area will become Government land, administered by TARDA, and will grow rice exclusively for export. Labourers will be hired locally to the extent possible, with no tenant farmers translocated from other areas of Kenya; relatively few people will be employed, as the scheme will be operated as a mechanized estate.

All of the forests, with the exception of Home East (#63), are located within the protected area of the scheme, or outside of the dikes. The primary disturbances to the forests within the enclosed area are those associated with the construction of the dike and the consequent changes in the flooding and water table regime. Current disturbances include forest fragmentation (Wema East 1, #56), burning, or tree felling along forest edges (Wema East 2, # 59; Hewani East 2, #60; Home East, #63), and increased forest utilization (Hewani East 2, #60).

Planned and probable effects of rice scheme implementation

The Home East forest (#63) may or may not be cleared and become a part of the flooded and planted sector of the rice scheme. All baboons in the area will be removed to prevent crop raiding. Other probable consequences include:

1. Increased forest utilization for firewood and other human needs as the population density increases.

2. A rise in mean river level resulting from the managed provision of water to the rice scheme, and greater flood levels within the unprotected areas on the west and east banks.

3. A change in the hydrologic conditions of forests protected by the dike.

4. The provision of a dry season habitat for stock in the vicinity, potentially resulting in increased grazing and browsing pressure on the forests. Fish and bird populations are also likely to be affected by alterations in hydrology and the use of pesticides, but these subjects are beyond the scope of this paper.

STEWARDSHIP CONSIDERATIONS

It is evident that the riverine forests in the Wema/Hewani vicinity will be destroyed if protection of these areas is not actively incorporated into the development plan for the rice scheme. With some protective management, and restoration of areas currently disturbed, it may be possible to maintain the forests and primates along with the establishment of a large rice scheme. The objective of such a management plan would be an ecologically-based development project that works to maintain the biological diversity of Kenya's remaining riverine forests.

Specific stewardship considerations would include:

1. Expand the protective dike to include the Home East Forest.

2. Stop all bush burning along the forest edges .

3. Consider forest enrichment planting along the forest edges to increase the area of forest patches, and potentially to connect patches.

4. Consider managed plantings of indigenous forest species within the scheme to provide a more diverse forest resource for the local population and to reduce impact on the existing forests.

5. Restrict the removal of large trees from the forests, including those for the construction of canoes.

6. Closely monitor the number of groups and group composition of red colobus and crested mangabeys, to determine their ability to exist in a highly fragmented habitat.

It is our belief that none of these considerations directly impedes the construction of the large-scale irrigation project, aimed at the increased production of rice. On the contrary, they attempt to link the objective of economic gain to the proper care of nearby resources. Stewardship

considerations provide a means by which we can address a combined challenge in effective project implementation and natural resource preservation.

ACKNOWLEDGEMENTS

This study was funded by the New York Zoological Society, World Wildlife Fund-US grant #3728, and National Science Foundation grant #BNS-8610531, in affiliation with the National Museums of Kenya (NMK) and the NMK Institute of Primate Research.

Permission to conduct research in Kenya was granted by the Office of the President (permits OP.13/001/17 C 24/9, OP 13/001/16 C 282/12 and OP 13/001/12 C 42/41).

Our work is part of a multi-disciplinary study, the Tana River Primate Project of the National Museums of Kenya, with core support provided by the Yerkes Regional Primate Center, Emory University and Anheuser-Busch.

We especially thank Dr. James G. Else, Head of the NMK Biological Resources Program,Dr. Thomas T. Struhsaker, New York Zoological Society, Wildlife Conservation International and Dr. John Beaman, Professor of Botany, Michigan State University for their critical review of the manuscript, our home institutions for the academic support provided through our degree programs, the East African Herbarium for their assistance on plant identifications, the Wema Catholic Mission for accomodation while we were working in the Wema/Hewani area, F. Decker and our field assistants, B. Mohammed and J. Galana for their help in the acquisition of the field data incorporated in this report.

REFERENCES

Andrews P., Groves C.P., and Horne J.F.M. 1975. Ecology of the lower Tana River floodplain (Kenya). J. E.A. Nat. Hist. Soc. & Nat. Mus. 151: 1-31.

Decker B.S. & Kinnaird M.F. (submitted). Tana River Primates: results of recent censuses. *Primates.*

Homewood K. 1976. The ecology and behaviour of the Tana Mangabey *(Cercocebus galeritus galeritus)*. PhD thesis, Univ. of London.

Hughes F.M. 1984. The Tana River floodplain forest, Kenya: Ecology and impact of development. PhD thesis, Univ. of Cambridge.

Hughes F.M. 1987. Conflicting uses for forest resources in the lower Tana River basin of Kenya. Pp 211-228, in: Conservation in action; D. Anderson & R. Grove (eds.). Cambridge Univ. Press, Cambridge.

IUCN. 1976. Red Data Book, vol. I: Mammalia. IUCN, Morges.

Japan International Cooperation Agency. 1984. Land use mapping (Topographic mapping project) in East Kenya. Final Report.

Kinnaird M.F. (in press) Estimates of effective population size for a forest primate: the Tana River crested mangabey (*Cercocebus galeritus galeritus*). Primate Conservation.

Ledec G. 1987. Effects of Kenya's Bura Settlement Project on biological diversity and other conservation concerns. Conservation Biology 3, 1: 247-258.

Marsh C.W. 1976. A management plan for the Tana River Game Reserve. Report to the Department of Wildlife Conservation and Management, Nairobi.

Marsh C.W. 1978. Ecology and social organization of the Tana River red colobus, *Colobus badius rufomitratus.* PhD thesis, Univ. of Bristol.

Marsh C.W. 1985. A resurvey of Tana River Primates and their forest habitat. Paper prepared for the Insitute of Primate Research, NMK, and the Wildlife Conservation and Management Department.

Marsh C.W. 1986. A resurvey of the Tana River primates and their forest habitat. Primate Conservation 7: 72-81.

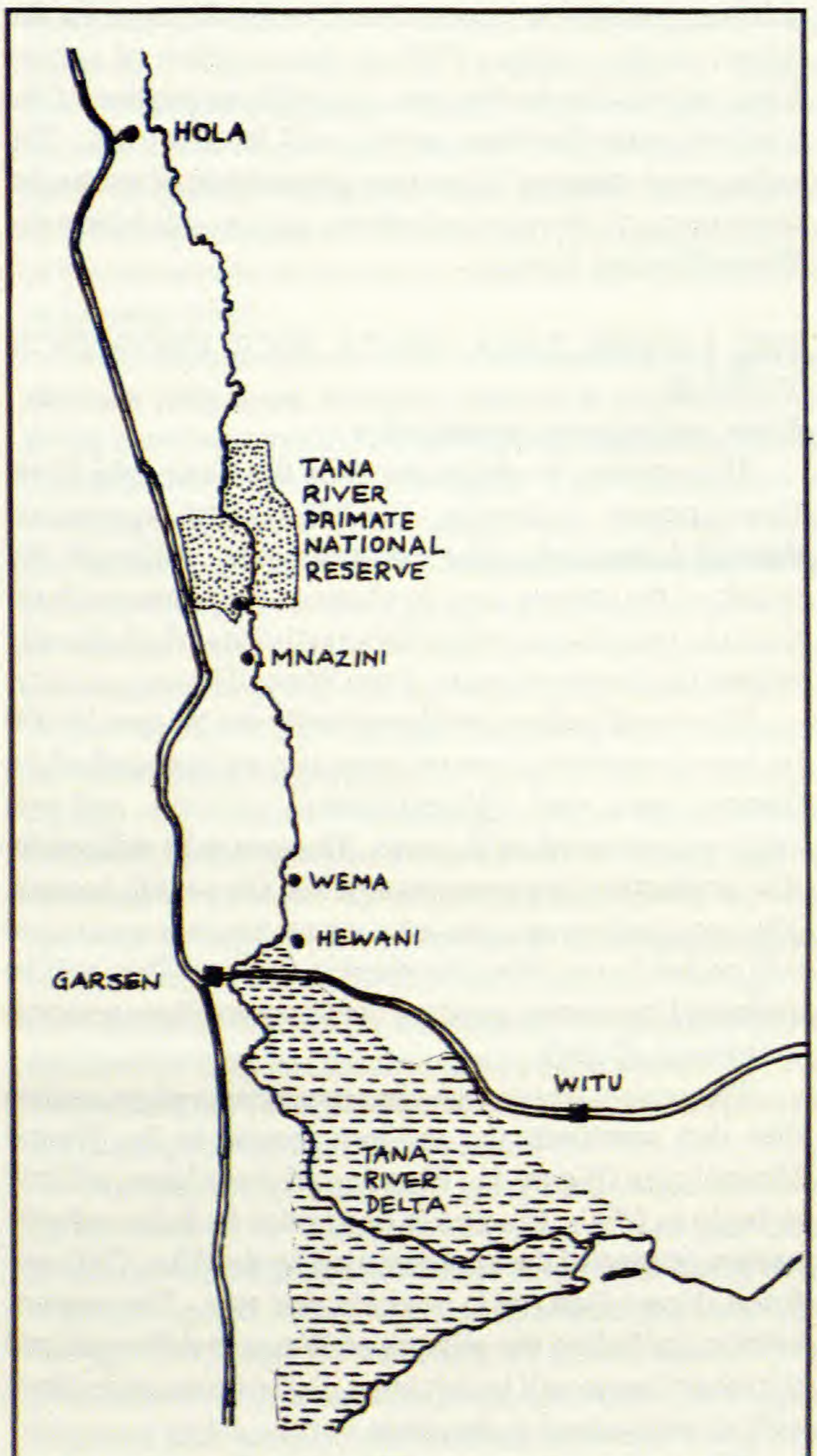


Figure 1. **The lower Tana River area**

TABLE 1. Results summary from a plant ecological study in Hewani East 3 (#61) and Hewani East 2 (#60)

A. Hewani East 3 (#61). Important tree species at the canopy, sapling and seedling layers. Importance of a species is based on its density, frequency and coverage (basal area) relative to all species sampled.

Canopy tree species (>10 cm DBH)	Density (nrs/ha)	Importance	Pokomo uses
Barringtonia racemosa	368	1.582	firewood, short poles
Pachystela msolo	112	.656	canoes, paddles, spoons
Sorindeia madagascariensis	115	.347	medicinal, firewood, fruits eaten
Ficus sycomorus	34	.214	firewood, canoes, beehives, drums
Antidesma venosum	34	.201	firewood, tool handles, fruits eaten
Phoenix reclinata	2656		poles, mats, baskets, twine, furniture
Saplings and understory trees (> 1 m high, <10 cm DBH)			
Barringtonia racemosa	3073	1.186	
Chytranthus obliquinervis	1354	.499	not used (soft wood)
Pachystela msolo	356		
Polysphaeria multiflora ssp. *multiflora*	313	.256	poles
Rinorea elliptica	260	.165	firewood, tool handles (very hard wood)
Seedlings (> 3 cm high, < 1 m high)			
Phoenix reclinata	13437	.734	
Barringtonia racemosa	5625	.333	
Polysphaeria multiflora ssp. *multiflora*	2500	.194	
Sorindeia madagascariensis	1527	.144	
Pachystela msolo	25	.138	

B. Hewani East 2 (#60). Density and coverage estimates for the primary tree species (> 10 cm DBH) within one belt transect, and a measure of *Mimusops fruticosa* within one large plot.

Belt transect study (ca. 540 sq. m.)	Density (nrs/ha)	Coverage (sq. m /ha)
Phoenix reclinata	204	20.94 (43% burned)
Barringtonia racemosa	241	12.59 (16.4 % cut)
Mimusops fruticosa	19	4.826
Polysphaeria multiflora ssp. *multiflora*	37	1.14 (48 % cut)
Pachystela msolo		.36 (100 % dead)
Plot study (ca 700 sq. m.)		
Mimusops fruticosa	214	38.174 (mean tree diameter 58 cm DBH)

TABLE 2. Results of censuses completed for the Tana River red colobus, *Colobus badius rufomitratus* (COL) and the crested mangabey, *Cercocebus galeritus galeritus* (MAN). Data from Decker & Kinnaird, submitted; Marsh 1986, Marsh 1976. Numbers indicate social groups; so = solitary

Forest	1987		1986		1985		1975	
	COL	MAN	COL	MAN	COL	MAN	COL	MAN
Wema E 1 (#56)	0	1	1	1-2	0	1	0	1-2
Hewani W 1 (#62)	1	0	0	0	0	1	1-2	1-2
Hewani E 1 (#59)	so	0	1	0	0	0	0	0
Hewani E 2 (#60)	2	0	1	0	1	0	1	0
Hewani E 3 (#61)	1	0	0	0	1	0	1	0
Home forest (#64)	2+so	1	1-2	1-2	0	2	3	2
Home East (#63)	0	0	0	0	no census		0	0
Group totals	6	2	4-5	2-4	2	3	6-7	4-6
Solitary individuals	2							

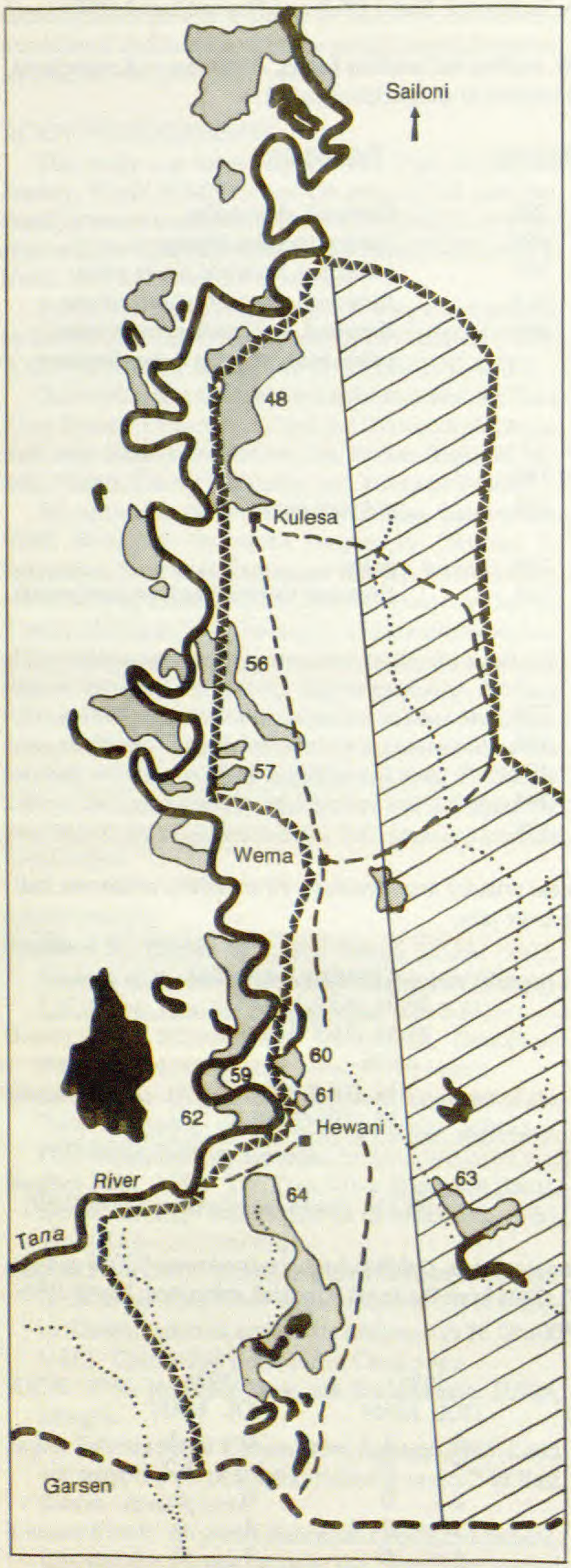


Figure 2. Wema/Hewani vicinity:
riverine forests and development plans for the Tana Delta Rice Irrigation scheme.

ENCEPHALARTOS KISAMBO, A NEW CYCAD FROM KENYA, WITH A NOTE ON *E. TEGULANEUS*

Robert B. Faden[1] & H.J. Beentje[2]

Abstract: a new species of *Encephalartos* (Cycadaceae) is described from Taita/Taveta District, Kenya. The note on *E. tegulaneus* contains additional data derived from collections discovered or made since the original desription was drawn up.

Encephalartos kisambo Faden & Beentje **sp. nov.**

E. hildebrandtii affinis a qua imprimis differt folioliis falcatis marginibus pauciore-spiniferis strobilorumque marium bullis minus deflexis superficiebus medianis carentibus, strobilorum feminorum bullis minus profundis superficiebus medianis superficiebusque lateralibus aequantibus.

Typus: Kenya, Maungu Hills, Faden, Faden, Smeenk & Kichoi 71/965 (holotypus K; isotypus BR, EA, MO, PRE, UPS, US, WAG).

Encephalartos sp. 'B' of Heenan, Bot. J. Linn. Soc. 74: 285, Fig. 1c (1977)

Dioecious tree; trunk 0.9-2.2 m tall, 45-52 cm in diameter, erect or leaning, rarely with several (up to 12) trunks. Leaf scars rhomboidal, 12.5-15 cm wide, 5-7.5 cm high. Scale leaves linear to linear-lanceolate, 8-14 cm long, to 1.5 cm wide, glabrescent adaxially, densely dark brown tomentose abaxially. Leaves clustered at the summit of the trunk, 239-360 cm long, 51-76 cm wide, with 89-96 pairs of leaflets; petiole with a swollen base which is sometimes pubescent with matted brown hairs, sometimes glabrous; lamina lanceolate, glabrous when mature, with the leaflets gradually reduced towards the base in leaves of mature trees (abruptly reduced in young plants); median leaflets more or less crowded and overlapping, attached 2.5-3 cm apart (measured between centers of attachment along the rachis), lanceolate-oblong, falcate, 24-37.5 cm long, 2.9-3.7 cm wide, coriaceous, with the apex pungent, the margins revolute, anterior margin with 3-4 (-5) spines (to 10 mm long) all within 7 cm of the base of the leaflet, posterior margin unarmed (except on young plants) or with a single spine below the middle of the leaflet; lower leaflets passing downwards from spinose-palmate to bifurcate to simple spines at the base of the lamina. Male cones cylindrical, 49-64 cm long, 10-12.5 cm wide, creamy yellow at maturity, sometimes curved; peduncles 15-32 cm long, 3.5-4.5 cm wide when fresh, densely covered by a dark brown tomentum; median scales borne at more or less right angles or ascending, obovate, 3-4 cm long, bulla triangular to rhomboidal, deflexed, truncate, glabrous, 2.0-2.7 cm wide, 1.1-1.4 cm deep; abaxial face with two broad, trapezoidal facets (one lateral, one medial) and one very narrow, triangular to oblong lateral facet, latero-sagittal ridge between the large facets nearly medial, distinct, the other latero-sagittal ridge distinct or indistinct, lateral margins acute, arched; terminal facet rhomboidal, 1/3-1/2 as wide and deep as the bulla; abaxial face receding, facets and latero-sagittal ridges similar to those of the adaxial, but ridges usually less distinct. Female cones borne in groups, cylindrical, 42-45 cm long, 16-16.5 cm wide, pale yellow or orange at maturity; peduncles 11-15 cm long, 5-5.5 cm wide when fresh, with pubescence as in the male cones; median scales with bulla 3.5-4.8 cm wide, 1.5-2.2 cm deep, rhomboidal, its facets trapezoidal, smooth (or sometimes the abaxial ones slightly verrucose), becoming strongly verrucose towards the margins; adaxial face with two broad facets (one medial, one lateral) and one narrow lateral facet, latero-sagittal ridges distinct, lateral ridges acute, straight or slightly arched; terminal facet compressed-hexagonal to rhomboidal, 1.4-1.8 cm wide; abaxial face partly exposed, the facets and latero-sagittal ridges similar to those of the adaxial face but the ridges only moderately distinct, seminal ridge ill-defined; lateral lobes triangular to irregular, rugose-verrucose to nearly smooth, with acute angles; median lobes not developed. Seeds with orange-yellow testa, ellipsoid, 3-3.9 cm long, 1.7-2.5 cm wide.

KENYA. Taita-Taveta District, Maungu (Nyangala) Hills, alt. ca. 900 m, 28 March 1970, P.G. Archer 606 (EA); same locality, alt. 975 m, 1 May 1970, Archer 614 (EA); same locality, alt. 1025 m, in dry evergreen mist forest with many epiphytes, few understory herbs, with *Craibia sp., Drypetes gerrardii, Eugenia sp., Erythroxylum emarginatum, Manilkara discolor, Cussonia holstii*, 26 Dec. 1971, R.B. & A.J. Faden, C. & N. Smeenk & D. Kichoi 71/965 (BR, EA, K, MO, PRE, UPS, US, WAG); same locality (also known as Ngasha Range), especially on South-east slopes, alt. ca. 800 m, in dry forest, less common in dry bushland on W slopes, 15 Sept. 1985, T.D. Willing & I.J. Robertson 85/1 (EA, K).

HABITAT: Low-canopy dry evergreen mist forest (summit, south-eastern and eastern slopes); occasionally on exposed steep slopes in dry bushland; alt. 800-1050 m.

DISTRIBUTION: Known with certainty only from a very small area in the Maungu Hills. Archer (on the label of Archer 614) records the species as occupying an area of

1. Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington D.C. 20560, U.S.A.
2. East African Herbarium, National Museums of Kenya

about 160 hectare. The report by Heenan (1977) of this species from Kasigau and Sagala needs confirmation.

The specific name is the local name in the Taita language.

The only reference to this species in the literature is Heenan (1977) which refers to it as *Encephalartos sp.* 'B (Voi)'. Because Heenan has not cited any specimens, we have omitted his measurements where they exceed ours.

The species is perhaps most closely related to *E. hildebrandtii* A. Br. & Bouché, which has a more coastal distribution and occurs at lower elevations in Kenya. The new species further differs in its leaflets which are falcate and which have fewer teeth on their margins; in the male cones which are generally larger, with less sharply deflexed bullae of the cone scales; in the shallower bullae of the female cones, of which the medial facet is trapezoidal and not rectangular, and of equal size to one lateral facet (instead of smaller); and in the orange-yellow (instead of red) seeds.

Encephalartos tegulaneus Melville differs from *E. kisambo* by its smaller, more widely spaced leaflets which may have two teeth on the posterior margin (see below); male cones with the medial scales longer, the bulla much less deflexed and its adaxial face with a quadrangular facet; and the female cones with the bulla of the medial cone scales subtriangular, wider and deeper, with the facets various but not as in *E. kisambo*. *Encephalartos bubalinus* Melville differs from the new species in its smaller leaves and leaflets; the much smaller male cones with median scales much smaller and proportionally broader; and the bulla of the female cone scales wider and deeper, with the median adaxial facet rectangular.

The two undescribed species from the Western Usambara Mountains referred to in Flora of Tropical East Africa: Gymnospermae (Melville, 1958) also differ significantly from *E. kisambo*. Drummond & Hemsley 1372 (K) (*Encephalartos* sp. A of FTEA) has smaller leaves with widely spaced, smaller leaflets that lack spines or have one to two spines on the lower margin. The sterile plant Drummond & Hemsley 3150 (K) differs from *E. kisambo* in its shorter, proportionally broader leaves with several teeth on each margin.

The only other collection which we have seen that might belong in *E. kisambo* is Pócs 6137/B from the Kanga Mountains in Tanzania. The specimen (at EA) consists of a portion of a rachis and two pairs of leaflets, the largest being 27 cm long and 3 cm wide. The forward margin has five spinose teeth within 3 cm of the leaf base; the rear margin lacks teeth. The specimen differs from *E. kisambo* in three characters: adjacent leaflets are more widely spaced (they do not overlap); the leaflets are oblong (not lanceolate-oblong); and they are not at all falcate. We suspect that it is not conspecific with *E. kisambo*, but in the absence of fertile material we cannot be certain.

Three species of vascular epiphytes have been observed on *E. kisambo*: *Impatiens walleriana* Hook. f. (Balsaminaceae), *Streptocarpus caulescens* Vatke (Gesneriaceae) and the fern *Davallia chaerophylloides* (Poir.) Steud. (Davalliaceae).

The very local distribution of *E. kisambo* leaves it extremely vulnerable to habitat destruction and to the ravages of unscrupulous collectors. We have reason to believe that it has already been collected in considerable numbers by non-Kenyans, for sale to cycad enthusiasts. One of us has already given it the status **Vulnerable,** possibly **Endangered** (Beentje, 1988). We feel that it should be given complete protection as soon as possible.

The small patch of forest in which *E. kisambo* occurs is also the only Kenyan locality for two orchid species, *Oberonia disticha* (Lam.) Schltr., and *Polystachya polychaete* Kraenzl., and is the type locality (and one of only two sites) for the Kenyan endemic orchid *Polystachya teitensis* Cribb.

A NOTE ON *ENCEPHALARTOS TEGULANEUS*

E. tegulaneus is generally believed to have been collected for the first time by Joy Adamson in 1954. Indeed, it is upon this collection alone that the original description was based (Melville, 1957), and this is the only collection cited in FTEA Gymnospermae (Melville, 1958). Research for this paper has led one of us (R.B.F.) to discover a much earlier specimen, and presumably truly the first collection of this species. It is an unnumbered collection made by Edmund Heller on 1 September 1911 in the Mathews Range. The specimen, which is in the U.S. National Herbarium (US sheet no. 634263) and was collected on the 1911-1912 Paul J. Rainey Expedition to East Africa sponsored by the Smithsonian Institution, consists of the apex of a leaf. It has the following data on a hand-written label: Mt. Garguez (=Warges), North Creek, 4000-5000 ft alt., abundant on lower edge of forest and in forest on west slope to 6000 ft; tree 8-12 ft; flower stalk preserved; photographed; Sept. 1--11, EH. It was originally determined as *Encephalartos hildebrandtii*. No photographs or reproductive material have been found.

A recent collection of this species from the Mathews Range (A. Faden 87/12, at EA and US) shows a somewhat different arrangement of spines on the leaf margins from that reported in the type description (Melville, 1957). The longest median leaflets are 28.5 cm long and 2.2 cm wide (-2.5 cm wide in Bronner s.n., June 1987, from Warges). The anterior edge has one or two teeth towards the base, as reported, but the posterior edge may have up to two teeth, the lower one being near the middle or distal to it, and the upper (when two are present) being near the apex.

While the original description as well as FTEA report this species as being only known from Mt. Lolokwe (said to be part of the Mathews, but actually distinct), it has since been found in the Ndoto Mountains (J. Beentje in Beentje 3985). As mentioned above, it also occurs in the Mathews Range proper (additional collections seen: Kerfoot 2494, J.G. Williams & J. Smart 3, Beentje 4045). In both these localities it can be one of the dominant lower story species in the dry forests of higher altitudes, which on the Mathews (at 1600-2150 m) are dominated by *Podocarpus latifolius*

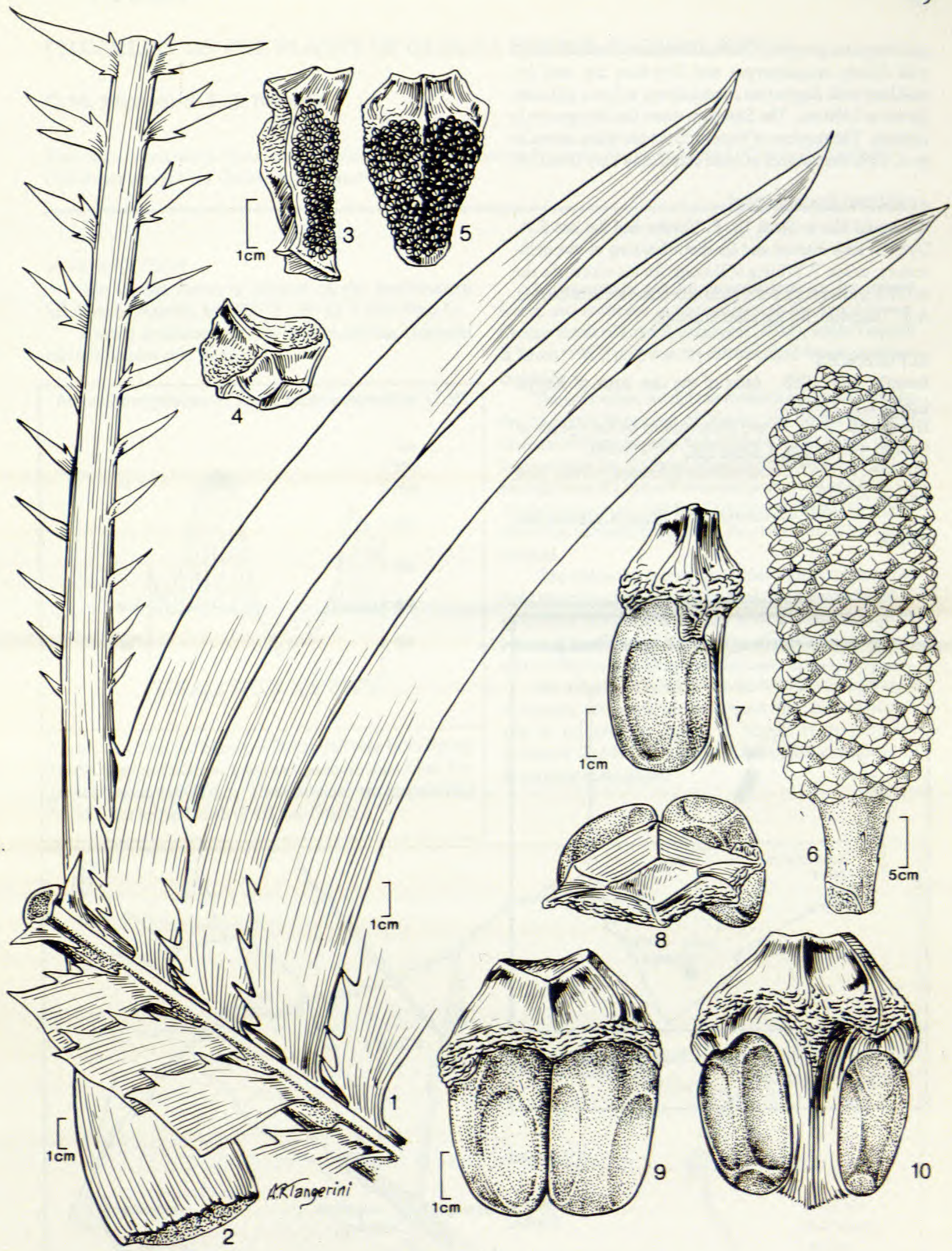


FIGURE 1. ***Encephalartos kisambo*** -- 1: median leaflets of leaf of mature plant. 2: leaf base. 3-5: median cone scale of male cone, 3-lateral view, 4-end view, 5-abaxial view. 6: female cone. 7-10: median cone scale of female cone, 7-lateral view, 8-end view, 9-adaxial view, 10-abaxial view. [1-10 from Faden et al. 71/965]. Drawn by Alice R. Tangerini.

and *Juniperus procera*.. It is less common in moister forest with *Croton megalocarpus* and *Strychnos spp.* and dry bushland with *Euphorbia candelabrum* at lower altitudes (down to 1400 m). The Samburu name for this species is Lpision. The number of female cones per plant seems to be 4, while the number of male cones may vary from 3-6.

ACKNOWLEDGEMENTS

We would like to thank Dr. P. Vorster and the late R.A. Dyer for their interest and for their checking of recent literature; to Mr. T. Willing of Broome for his visit to the site in 1985, and for his careful field notes; and to the artist, Ms. A.R. Tangerini, for the clear drawing.

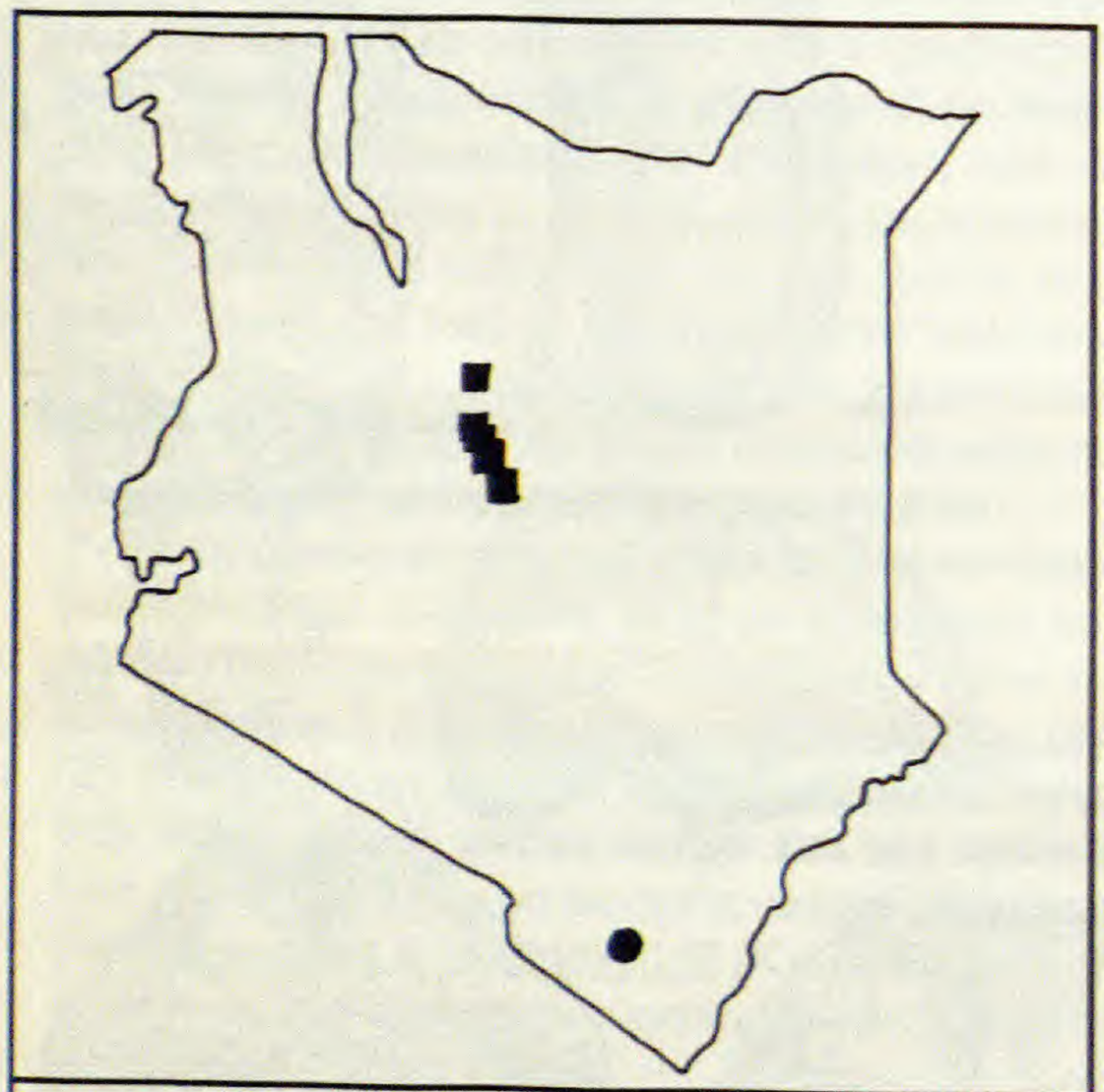
REFERENCES

Beentje, H.J. 1988. Atlas of the rare trees of Kenya. Utafiti 1, 3: 71-123.

Heenan, D. 1977. Some observations on the cycads of Central Africa. Bot. J. Linn. Soc. 74: 279-288.

Melville, R. 1957. *Encephalartos* in Central Africa. Kew Bull. 2: 237-257.

---------- 1958. Gymnospermae. Flora of tropical East Africa.



Distribution of *Encephalartos kisambo* (circle) and *E. tegulaneus* (squares)

CHECKLIST OF THE PLANTS OF OLOLUA FOREST, NAIROBI, KENYA

G.M. Mungai & H.J. Beentje

Abstract: an annotated checklist is presented of the plants occurring in the dry upland forest (*Croton-Brachylaena-Calodendrum* type) of Ololua, near Nairobi.

INTRODUCTION

The Ololua Forest is situated on the southwestern outskirts of Nairobi, at 01º22' S, 36º 42' E (see **Map 1**). It lies at an altitude of 1750-1850 m, and has a bimodal rainfall pattern (see Figure 1)

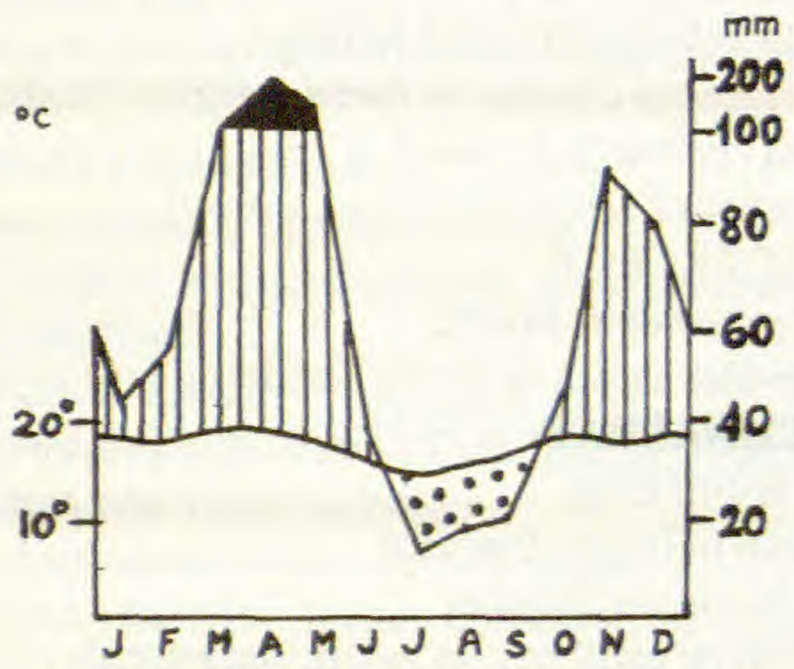


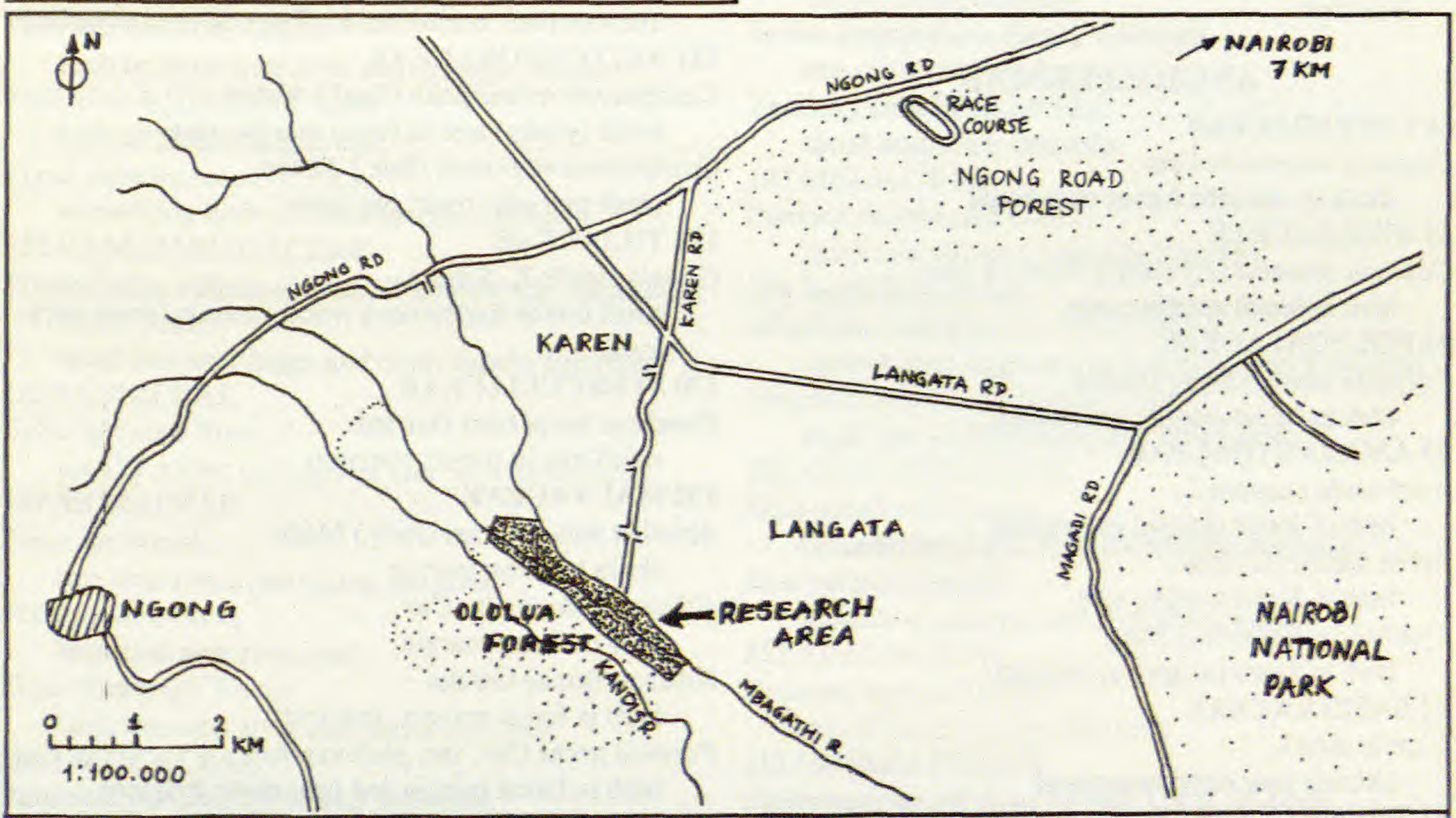
Figure 1. Climate diagram, with rainfall data from Ngong Forest Station (1890 m.) and temperature data from Dagoretti Corner (1800 m.). These stations are respectively 6 and 8 km to the North of Ololua Forest.

Its vegetation can be characterized as dry upland forest, and is similar in composition to the *Brachylaena-Croton* forest of Lind & Morrison (1974), while Trapnell & Brunt (1987) map it as dry intermediate forest (undifferentiated).

The area where we did our research is administered by the National Museums of Kenya and forms the most undisturbed part of the Ololua Forest. The extent of the forest within the National Museums fence is ca. 125 ha.; the total area of Ololua Forest has been given as 325 ha for 1976 (Doute et al. 1976). Only forest plants have been taken into account; plants from the cleared areas have been omitted.

The following records are either sight records and/or field identifications (by both authors) or are vouchered by specimens deposited at the East African Herbarium (EA), National Museums of Kenya. The sequence of families is that of Hutchinson, as used at the East African herbarium.

We would like to acknowledge Mr. Charles Dewhurst of Nairobi, who made his collections from the forest available to us; and Dr. Robert E. Magill of the Missouri Botanical Garden, St. Louis, U.S.A., who identified our Bryophyte collections.



Map 1. The location of Ololua forest and its environs

REFERENCES

Doute R., Ochanda N. & Epp H. 1981. Forest cover mapping in Kenya using remote sensing techniques. KREMU Technical Report.

Lind E.M. & Morrison M.E.S. 1974. East African Vegetation. Longman, London.

Trapnell C.G. & Brunt M.A. 1987. Vegetation and Climate maps of south-western Kenya. LRDC/ ODA, Surbiton.

ANNOTATED CHECKLIST

PTERIDOPHYTA

ADIANTACEAE

Adiantum capillis-veneris L.
rare on rocks in river

Doryopteris concolor (Langsd. & Fisch.) Kuhn
occasional in forest

Pellaea adiantoides (Willd.) J. Sm.
common in forest margins and clearings

ASPLENIACEAE

Asplenium aethiopicum (Burm. f.) Becherer
occasional in forest

DAVALLIACEAE

Nephrolepis biserrata (Swartz) Schott
occasional near river

POLYPODIACEAE

Pleopeltis macrocarpa (Willd.) Kaulf.
epiphyte in forest and on rocks near river; rare

GYMNOSPERMAE

PODOCARPACEAE

Podocarpus falcatus Mirb.
tree to 20 m in riverine forest + one seedling seen near river

ANGIOSPERMAE

36 CAPPARACEAE

Capparis tomentosa Lam.
shrub in riverine forest; occasional

41 RESEDACEAE

Caylusia abyssinica (Fresen.) Fisch. & Mey.
herb in forest margins; rare

42 POLYGALACEAE

Polygala sadebeckiana Guerke
herb in forest margin; uncommon

63 AMARANTHACEAE

Achyranthes aspera L.
herb of forest margin; occasional

Aerva lanata (L.) Juss.
herb in forest margin; rare

Cyathula schimperana Moq.
herb in forest margin; occasional

64 BASELLACEAE

Basella alba L.
climber near river; occasional

81 THYMELEACEAE

Gnidia subcordata Meisn.
small tree of forest margins; occasional

93 FLACOURTIACEAE

Dovyalis macrocalyx (Oliv.) Warb.
shrub or small tree in forest; occasional

Rawsonia lucida Harv. & Sond.
shrub of forest margin; rare;

Scolopia zeyheri (Nees) Harv.
shrub;

Trimeria grandifolia (Hochst.) Warb. ssp. *tropica* (Burkill) Sleumer
shrub near river; occasional

95 CANELLACEAE

Warburgia ugandensis Sprague
tree in forest; occasional, more common towards the river

101 PASSIFLORACEAE

Passiflora sp.
climber in forest margin; occasional

103 CUCURBITACEAE

Coccinia trilobata (Cogn.) Jeffrey
herbaceous climber in forest margin; occasional.

Zehneria scabra (L.f.) Sond.
climber of forest margins; common

107 CACTACEAE

Cereus peruvianus Foerst.
tree-like cactus in forest; exotic

114 OCHNACEAE

Ochna holstii Engl.
shrub in forest; frequent

Ochna insculpta Sleumer
shrub or small tree in forest; occasional

Ochna ovata F. Hoffm.
shrub or small tree in forest; occasional

118 MYRTACEAE

Syzygium cordatum Krauss
tree on riverbank; rare

Syzygium guineense (Willd.) DC.
tree near river, occasional to 18 m, common as sapling

121 RHIZOPHORACEAE

Cassipourea rotundifolia (Engl.) Alston
small (young) tree in forest margin; rare

Cassipourea malosana (Bak.) Alston
small tree near river; one seen

128 TILIACEAE

Grewia similis K. Schum.
small tree or sometimes a woody liana in forest; occasional.

130 STERCULIACEAE

Dombeya burgessiae Gerrard
small tree in forest; common

132 MALVACEAE

Abutilon mauritianum (Jacq.) Medic
shrub in forest margin

Hibiscus calophyllus Cav.
herb of forest margin

Hibiscus fuscus Garcke
herb in forest margin; frequent

Pavonia urens Cav. var. *glabrescens*
herb in forest margin and near river; frequent

Pavonia patens (Andr.) Chiov.
herb, occasional

Sida tenuicarpa Vollesen
herb, occasional in banks of lugga

136 EUPHORBIACEAE

Acalypha racemosa Baill.
herbaceous scrambler in forest; occasional
Croton megalocarpus Hutch.
tree, dominant in forest canopy layer
Drypetes gerrardii Hutch.
tree of forest understory; common
Erythrococca bongensis Pax
shrub of forest (margin); occasional
Erythrococca fischeri Pax
spiny shrub to 2.5 m; rare in forest
Meineckia phyllanthoides (Baill.) Webster
herb or small shrub of forest floor; locally dominant
Synadenium glaucescens Pax
shrub in forest; two seen
Tragia brevipes Pax
stinging herb or scrambler of forest floor; locally common

146. CAESALPINIACEAE

Pterolobium stellatum (Forssk.) Brenan
spiny liana in forest; occasional, more common towards the river

147 MIMOSACEAE

Albizia gummifera (J.F. Gmel.) C.A. Sm.
large tree near river; common
Newtonia buchananii (Bak.) Gilb. & Bout.
large tree near river; locally common

148 PAPILIONACEAE

Crotalaria axillaris Ait.
woody herb of forest margin or bushland; occasional
Crotalaria goodiiformis Vatke
shrub of forest (margin); occasional
Indigofera swaziensis Bolus var. *swaziensis*
shrub of forest margin; frequent
Sesbania keniensis Gillett
herb or shrub near river and in lugga; frequent
Tephrosia hildebrandtii Vatke
herb of forest margin; rare
Vigna membranacea A. Rich.
scrambling herb of forest margin; common

151 HAMAMELIDACEAE

Trichocladus ellipticus Eckl. & Zeyher ssp. *malosanus* (Bak.) Verdc.
small tree near lugga and river; locally common

165 ULMACEAE

Celtis africana Burm. f.
usually a tree; one sapling seen in riverine forest

167 MORACEAE

Ficus sur Forssk.
tree near river; one young one seen
Ficus sycomorus L.
large tree near river, rare
Ficus thonningii Blume
large tree near river and lugga; two seen

169 URTICACEAE

Pouzolzia parasitica(Forssk.) Schweinf.
large herb near river; occasional

173 CELASTRACEAE

Elaeodendron buchananii (Loes.) Loes.
shrub or medium tree of forest; frequent
Hippocratea africana (Wild.) Loes.
liana to 8 m in riverine forest; occasional to frequent
Maytenus heterophylla (Eckl. & Zeyh.) Robson
small tree of forest margin; frequent
Maytenus senegalensis (Lam.) Exell
shrub of forest margin; one seen
Maytenus undata (Thunb.) Blakelock
shrub on bank of lugga; rare
Mystroxylon aethiopicum (Thunb.) Loes.
small tree or shrub in forest; occasional

185 LORANTHACEAE

Englerina woodfordioides (Schweinf.) ined.
parasite of forest margin; occasional
Viscum tuberculatum A. Rich.
parasite; frequent

186 SANTALACEAE

Osyris abyssinica A. Rich.
locally common in riverine forest

190 RHAMNACEAE

Helinus mystacinus (Ait.) Steud.
scrambler in forest margin; occasional
Scutia myrtina (Burm. f.) Kurz
shrub or large liana in forest; occasional

193 VITACEAE

Cyphostemma nierense (Th. Fr. jr.) Desc.
climber in forest margins; common

194 RUTACEAE

Calodendrum capense (L.f.) Thunb.
canopy tree in forest; co-dominant
Clausena anisata (Willd.) Benth.
shrub of forest; abundant
Teclea trichocarpa (Engl.) Engl.
tree of forest; common
Teclea simplicifolia (Engl.) Verdoorn
tree of forest; frequent
Zanthoxylum chalybeum Engl.
shrub near river; one seen

197 MELIACEAE

Turraea mombasana C.DC.
small tree of forest (margin); frequent

198 SAPINDACEAE

Allophylus rubifolius (A. Rich.) Engl.
climber near lugga and in forest margin; occasional
Allophylus kilimandscharicus Taub.
small tree in forest (margin); occasional

205 ANACARDIACEAE

Rhus natalensis Krauss
shrub or small tree of forest margin; common
Rhus vulgaris Meikle
shrub or small tree near river; occasional

212 ARALIACEAE

Cussonia spicata Thunb.
tree of forest margin; one seen

213 UMBELLIFERAE

Heteromorpha trifoliata (Wendl.) Eckl. & Zeyh.
small tree in forest margin; occasional
Torilis arvensis (Huds.) Link
herb on pathsides; occasional

221 EBENACEAE
Diospyros abyssinica (Hiern) F. White
tree with reticulate bark in forest; occasional
Euclea divinorum Hiern
small tree in forest; occasional
222 SAPOTACEAE
Manilkara discolor (Sond.) J.H. Hemsl.
tree near river; one seen
228 LOGANIACEAE
Strychnos henningsii Gilg
tree in forest; frequent
229 OLEACEAE
Jasminum fluminense Vell.
climber in forest; occasional
Olea europaea L.ssp. *africana* (Mill.) P.G. Green
tree in forest; common
Schrebera alata (Hochst.) Welw.
tree in open forest or forest margins; common
230 APOCYNACEAE
Acokanthera oppositifolia (Lam.) Codd
small tree in forest margins; occasional; especially common near lugga
Acokanthera schimperi (A.DC.) Schweinf.
small tree in forest margin; occasional
Carissa edulis (Forssk.) Vahl
shrub in forest margin; locally common
231 ASCLEPIADACEAE
Ceropegia sp.
herbaceous twiner; one seen in forest margin; sterile, but should be either *C. meyeri-johannis* or *C. albisepta* var. *bruceana*
Dregea schimperi (Dcne.) Bullock
climber in riverine forest; occasional
Sarcostemma viminale (L.) R. Br.
succulent twiner in forest margin; rare
Secamone punctulata Dcne.
twiner near river; rare
232 RUBIACEAE
Canthium keniense Bullock
small tree in forest; occasional
Keetia gueinzii (Sond.) Bridson
shrub near river; one seen
Oldenlandia johnstonii (Oliv.) Engl.
Trailing herb, locally common in forest margins
Pentas bussei K. Krause
herb in forest margin; locally common
Pentas lanceolata (Forssk.) Deflers
herb in forest margin; occasional
Psychotria kirkii Hiernvar. *nairobiensis* (Brem.) Verdc.
shrub in forest margin; occasional
Psydrax schimperianum (A. Rich.) Bridson ssp. *schimperiana*
small tree in forest; frequent
Tarenna graveolens (S. Moore) Brem.
small tree in forest; occasional
Vangueria infausta Burch. ssp. *rotundata* (Robyns) Verdc.
shrub or small tree in forest; frequent
Vangueria madagascariensis Gmel.
shrub or small tree in forest (margin); occasional.

238 COMPOSITAE
Aspilia mossambicensis (Oliv.) Wild
Shrub or climber; common in disturbed sites
Brachylaena huillensis O. Hoffm.
large tree in forest; frequent
Helichrysum schimperi (Sch. Bip.) Moeser
herb in forest margin; occasional
Mikania cordata (Burm. f.) B.L. Robinson
herbaceous climber; locally common near river
Psiadia punctulata (DC.) Vatke
shrub in forest margin; abundant
Schkuria pinnata (Lam.) O. Ktze.
herb on roadside; occasional
Senecio discifolius Oliv.
herb in forest margin; one seen
Senecio lyratipartitus A. Rich.
herbaceous climber of forest margin; occasional
Senecio petitianus A. Rich.
herbaceous climber; occasional
Senecio stuhlmannii Klatt
herb in forest margin; occasional
Solanecio angulatus (Vahl) C. Jeffrey
slightly succulent liana of forest margin; occasional
Sphaeranthus bullatus Mattf.
herb; occasional in lugga
Vernonia brachycalyx O. Hoffm.
large shrub in forest margins; frequent
Vernonia holstii O. Hoffm.
herb; occasional in forest margin
Vernonia jugalis Oliv. & Hiern
woody herb; occasional near river
Vernonia lasiopus O. Hoffm.
herb; occasional near river
249 BORAGINACEAE
Ehretia cymosa Thonn.
large shrub near river
250 SOLANACEAE
Solanum incanum L.
shrub in forest margin; locally common
Solanum indicum L.
shrub in forest; occasional
259 ACANTHACEAE
Barleria ventricosa Nees
herb of forest floor; occasional
Hypoestes verticillaris (L.f.) Roem. & Schult.
herb of forest margins; common
Isoglossa lactea Lindau
herb in forest; occasional
Justicia diclipteroides Lindau
herb of pathsides; common
Phaulopsis imbricata (Forssk.) Sweet
small herb of forest floor; locally dominant
Ruellia patula Jacq.
semi-erect herb of more open forest; occasional
Thunbergia alata Sims
herb of disturbed forest margin; occasional
263 VERBENACEAE
Lippia javanica (Burm. f.) Spreng
shrub of forest margins and disturbed areas; locally common

Lippia ukambensis Vatke
shrub of forest margins and disturbed areas; locally common

264 LABIATAE

Leonotis nepetifolia R. Br.
herb of disturbed areas

Leonotis mollissima Guerke
woody herb; occasional

Ocimum suave Willd.
herb of forest margins; frequent to common

Plectranthus zatarhendi (Forssk.) E.A. Bruce
herb of rocky lugga banks and forest floor;occasional

Tinnaea aethiopica Hook. f.
shrub in forest margins; frequent

280 COMMELINACEAE

Aneilema aequinoctiale (P. Beauv.) Kunth
trailing herb in forest; occasional

Commelina benghalensis (L.)
herb in forest margin near lugga; occasional

Commelina foliacea Chiov.
herb in forest margin; occasional

Commelina imberbis Hassk.
herb in forest margin; common

293 LILIACEAE

Asparagus asparagoides (L.) Wight
scrambling herb in forest margin; occasional

Asparagus falcatus L.
scrambling herb in forest margin; occasional

Asparagus racemosus Willd.
scrambling herb in forest margin; occasional

Asparagus setaceus (Kunth) Jessop
scrambling herb in forest margin; occasional

Chlorophytum bakeri Poelln.
herb in forest; occasional

Dracaena laxissima Engl.
trailing shrub near river

Sansevieria parva N.E. Br.
succulent herb; forming dense stands on rocks in riverine forest

297 SMILACACEAE

Smilax aspera L.
climbing, prickly shrub near river; locally common

306 AMARYLLIDACEAE

Scadoxus multiflorus (Martyn) Raf.
herb; rare in forest

326 ORCHIDACEAE

Angraecopsis breviloba Summerh.
epiphyte; 1 seen

Angraecum erectum Summerh.
epiphyte in lugga margin tree; 1 seen

Microcoelia guyoniana (Reichb. f.) Summerh.
small epiphyte; rare

Polystachya vaginata Summerh.
epiphyte; rare

Rangaeris amaniensis (Kraenzl.) Summerh.
epiphyte; frequent

Stolzia repens (Rolfe) Summerh.
epiphyte in moister forest; rare

331 CYPERACEAE

Cyperus maranguensis K. Schum.
sedge of pathsides and forest margins

332 GRAMINEAE

Oplismenus hirtellus (L.) P. Beauv.
grass in forest; frequent

Setaria plicatilis (Hochst.) Engl.
grass of forest near lugga; frequent

APPENDIX: **BRYOPHYTA**

Mosses have been collected in a less systematic way than the higher plants of the main checklist. To stimulate interest, this incomplete list is given. Determinations have been made by Dr. R. E. Magill of the Missouri Botanical Garden, to whom we are very grateful. The numbers are collection numbers of Beentje.

3523. *Brachythecium sp.*
3527. *Fissidens palmifolius* (P. Beauv.) Broth.
3522. *Fissidens rufescens* Hornsch.
3519. *Forrstroemia producta* (Hornsch.) Par.
3518. *Haplohymenium pseudo-triste* (C. Muell.) Broth.
3524. *Leptodon smithii* (Hedw.) Web.
3520. *Papillaria africana* (C. Muell.) Jaeg.
3526. *Philonotis dregeana* (C. Muell.) Jaeg.
3521. *Pseudoleskea* cf. *leskoides* (Par.) C. Muell.
3517, 3525. *Racopilum* cf. *tomentosum* (Hedw.) Brid

THE REINSTATEMENT OF *CLEMATIS SIGENSIS* ENGL. (RANUNCULACEAE)

H.J. Beentje

Abstract: *C. sigensis* Engl., formerly included under the synonymy of *S. simensis* Fres., is reinstated; this species occurs in the coastal areas of Tanzania and Kenya.

In the Flora of Tropical East Africa: Ranunculaceae (1952) *C. sigensis* Engl. is included in the synonymy of *C. simensis* Fres. While the type of *C. sigensis*, Warnecke 452, is from the Sigi Valley at 500 m altitude, the altitude range given for *C. simensis* is 1000-3360 m.

A specimen collected in the Shimba Hills, Kenya (Robert Schmidt 1232) drew my attention to this discrepancy. No Kenyan *Clematis* had been collected at such low altitudes before, I thought; but a search in the East African Herbarium turned up another Kenyan specimen (Gillett 18715), also from the Shimba Hills, laid in under *C. viridiflora* Benth. Under the Tanzanian material of *C. simensis* I found four specimens from the East Usambaras, Luguza and Gereza.

While I was writing this article, another specimen has been found on Dzombo Mountain, south of the Shimba Hills in Kenya, by the National Museums Expedition to Mrima and Dzombo (Robertson & Luke, in prep.)

All these specimens have leaflets with entire margins - although Gillett 18715 has the leaflets of the lower leaves lobed. The achenes are also longer than those of *C. simensis*: 5-7 cm as opposed to 2.5-4 cm long. The stipules of *C. sigensis* are 4-6 mm long, as opposed to those of *C. simensis* which are so short to be almost invisible.

Therefore I am reinstating *C. sigensis* as separate from *C. simensis*, as well as from all other African *Clematis* spp. The following description is based on the material seen at the East African Herbarium, and agrees with the original description of Engler (1910), as well as with the figure in the protologue.

Clematis sigensis *Engl.* in E.J. 45: 271, fig. 2: A-B (1910). Typus: Tanzania, Lushoto District, Sigi Valley, Warnecke 452 (holotypus B).

Liana 2- 25 m long; younger stems hairy but becoming glabrous with age, longitudinally ribbed and furrowed. Leaves pinnate, with 5 leaflets; leaflets ovate, acuminate or blunt with a mucro, cuneate to rounded at the base, entire and unlobed, or rarely lobed on the lowermost leaves, glabrous or nearly so. Inflorescence many-flowered; pedicels 9-26 mm long; flower buds ellipsoid. Sepals 12-15 mm long, cream or white. Achenes hairy, 5-7 cm long including the plumose style.

DISTRIBUTION: K7, T3.
HABITAT: Moist forest; 180-600 m.
KENYA. Kwale District: Shimba Hills, Longo Magandi, Sept. 1968, Gillett 18715! & same loc., Nov. 1988, R. Schmidt 1232! Dzombo Mt., NMK 1989 Mrima/Dzombo Expedition 306!
TANZANIA. Muheza District: Longuza, Oct. 1969, Ruffo 236! Korogwe District: Gereza East, Mnyussi, Sept. 1954, Semsei 1793! Lushoto District, Sigi Valley, Sept. 1916, Zimmermann 6395! Locality not traced: Sibn 1 (?), Aug. 1917, Zimmermann 6394!

REFERENCES

Engler A. 1910. Ranunculaceae africanae. Engl. Bot. Jahrbuch 45: 266-275.
Milne-Redhead E. & Turrill W.B. 1952. Ranunculaceae. Flora of tropical East Africa. Crown Agent for the Colonies, London.
Robertson S.A. & Luke Q. (in prep.) Checklist of the plants occurring in Mrima and Dzombo Fores Reserves, Kenya.

UTAFITI Volume 2 Number 1

15 MARCH 1989

CONTENTS

A survey of the riverine forests in the Wema/Hewani vicinity, with reference to development and the preservation of endemic primates and human resources
Kimberly E. Medley, Margaret F. Kinnaird & Barbara S. Decker 1-6

Encephalartos kisambo*, a new cycad from Kenya, with a note on *E. tegulaneus
Robert B. Faden & H.J. Beentje 7-10

Checklist of the plants of Ololua forest, Nairobi, Kenya
G.M. Mungai & H.J. Beentje 11-15

The reinstatement of *Clematis sigensis* Engl. (Ranunculaceae)
H.J. Beentje 16

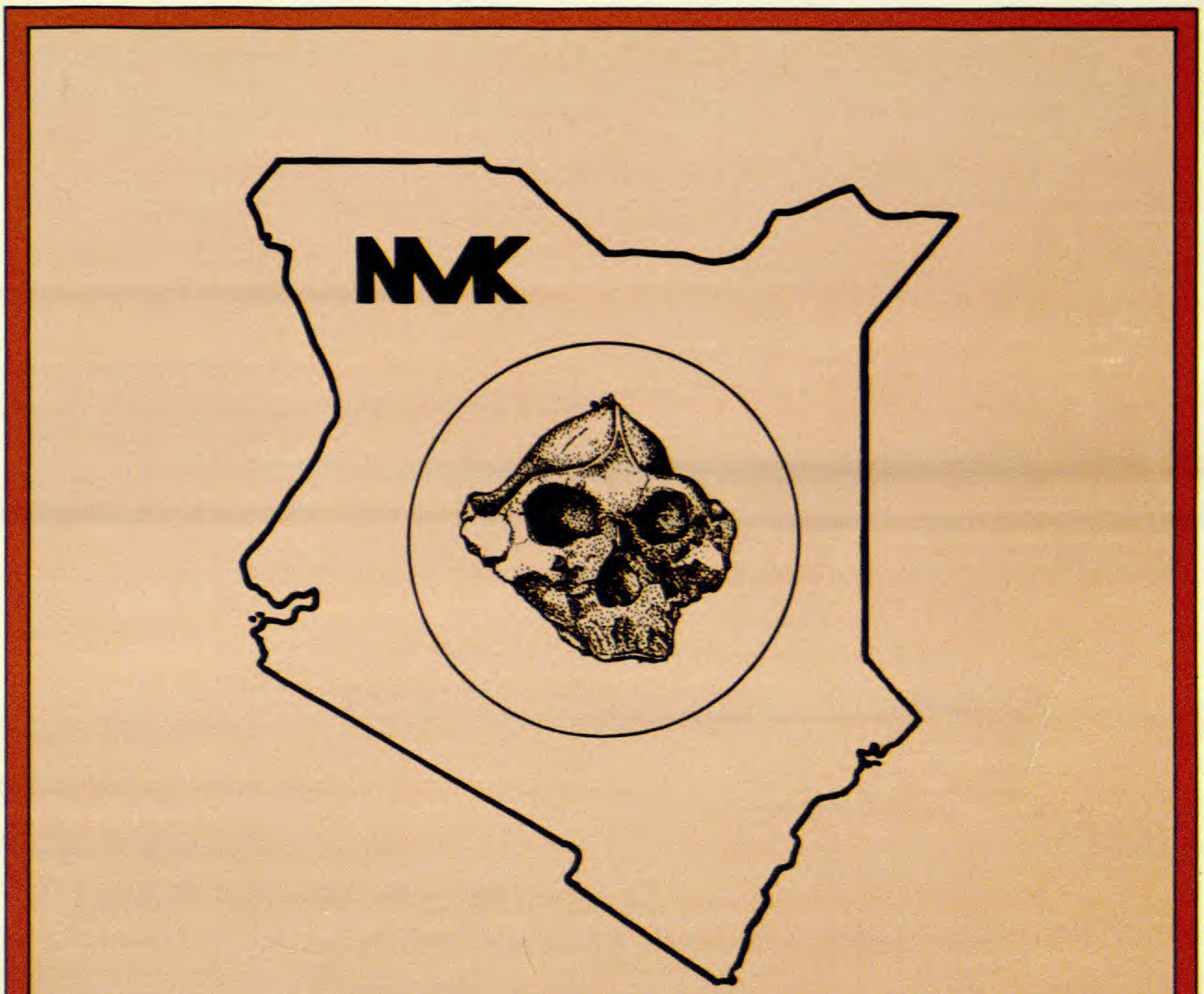
UTAFITI is published quarterly; extra numbers may be published as the need arises. UTAFITI incorporates original research papers on work carried out at the National Museums of Kenya. Every major paper is peer-reviewed by professionals from outside the Museums.

Editor Dr. H.J. Beentje
Editorial Committee
Dr. H. Adan
Dr. R. Bagine
Dr. M. Issahakia
Miss C.H.S. Kabuye
Dr. M. Leakey
Mr. A. MacKay
Dr. S. Wandibba

Typesetting and layout by the editor
Printed by Kenya Litho, P.O. Box 40775, Nairobi
Produced by the National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya
ISSN 9966-9847-4-7

UTAFITI

OCCASIONAL PAPERS OF THE NATIONAL MUSEUMS OF KENYA



NATIONAL MUSEUMS OF KENYA

VOLUME 2 NUMBER 2 APRIL 1989



PROCEEDINGS OF THE WORKSHOP ON PLANT GENETIC RESOURCES

6-7 JULY 1987

ORGANIZED BY
C.H.S. KABUYE & A.R.D. TAYLOR

HOSTED BY THE NATIONAL MUSEUMS OF KENYA

AND SPONSORED BY
THE INTERNATIONAL BOARD FOR PLANT GENETIC RESOURCES



Edited by H.J. Beentje & B. Khayota
National Museums of Kenya
Nairobi
1989

MISSOURI BOTANICAL

AUG 22 1989

GARDEN LIBRARY

The workshop on Plant Genetic Resources was held on 6-7 July 1987 at the National Museums of Kenya. The organization was in the hands of Miss C.H.S. Kabuye and Dr. A.R.D. Taylor.
The International Board for Plant Genetic Resources sponsored both the workshop and the Proceedings of the workshop.

CONTENTS

INTRODUCTION

R. E. Leakey (NMK). Welcoming address 19
Dr. Hamdallah Zedan (UNEP). Introduction: Genetic Resources in the wide perspective 20

CONSTRAINTS IN GENETIC RESOURCES CONSERVATION

Dr. R. Malpas (IUCN). Diversity: its importance to wild species 24
Dr. A.F. Attere (IBPGR). Diversity: its importance for crops 25
Dr. Abou-Zeid (National Gene Bank). Maintenance of diversity in ex-situ conservation 27
Dr. A.R.D. Taylor (University of Nairobi). Documentation 27

PRESENT ACTIVITIES IN RESEARCH AND BREEDING STATIONS

E. Murugi Kariuki: KEFRI 29
Dr. M.W. Oggema: National Plant Breeding Station, Njoro 30
P. Kusewa: Dryland Farming Research Station, Katumani 30
M.O. Osoro: National Sugar Research Centre, Kibos 31
D.K. Muthoka: National Agriculture Research Station, Kitale 33
J.B.O. Owuor: Coffee Research Foundation 34
H. D'Souza: Agricultural Development Corporation 35
O. Njue: Coastal Agricultural Research Station 35
M. Ndambuki: Kenya Seed Company 36
C.K. Njuguna: Tea Research Foundation of Kenya 36
O.E. Baraza: National Irrigation Board 37
J.K. Rutto & C. Mburu: Western Agricultural Research Station, Kakamega 38
Prof. D.M. Mukunya: University of Nairobi 39
Prof. F. Owino: Moi University 39
E. Murugi & J.R. Wawiye: Forest Department 40
P.G. von Carlowitz: ICRAF 40
L. Kangethe, G. Arum & A. Aworry: KENGO 42

WILD POPULATIONS

Ndegwa Ndian'gui (EA Herbarium).- Status of wild populations 44
F. Msafiri (KREMU).- The role of KREMU 45

PRIORITIES FOR ACTION: EX-SITU CONSERVATION

E.N. Seme (National Genebank).- Operation of the Genebank 47
C.H.S. Kabuye (EA Herbarium).- Establishment of Botanical Gardens and propagation units for endemic species 48

PRIORITIES FOR ACTION: IN-SITU CONSERVATION

Dr. H.J. Beentje (EA Herbarium).- Baseline knowledge of wild plants and priorities for action 49
D.M. Mbuvi (WCMD).- Management for protected areas 52

SETTING UP A NATIONAL PLANT GENETIC RESOURCES COMMITTEE

C. Gitau.- Introduction 54
Recommendations of the "in-situ" working group (Chairman D.M. Mbuvi) 55
Recommendations by Prof. Owino 56
Recommendations of the "ex-situ" working group (Chairman H. Kamau) 56
Dr. R.E. Leakey - Recommendations to the NCST 57
Dr. J.A. Odera - Summary of recommendations 57

CONSERVATION POLICY

Prof. D.M. Mukunya & Prof. S.K. Imbamba - Manpower development issues 58

DISCUSSION 58

INTERNATIONAL NETWORK ASSISTANCE STATEMENTS

Dr. R. Benstead-Smith - IUCN 61
P. von Carlowitz - ICRAF 62
Dr. A.F. Attere - IBPGR 63
Dr. Abou-Zeid - GTZ 63
Dr. J.J. Gaudet - USAID 64
J.R.F. Hansell - ODA 64

CLOSING SPEECH

Dr. R.E. Leakey, National Museums of Kenya 65

LIST OF PARTICIPANTS 68
INDEX TO ABBREVIATIONS 69

WELCOMING ADDRESS

R.E. Leakey

I would like to start by offering a very warm welcome to all of you, and to say how very grateful I am to the International Board of Plant Genetic Resources for sponsoring this workshop.

An earlier meeting to discuss these topics was held in August 1986, sponsored jointly by the Ministry of Agriculture and ICIPE. I believe the time has come that a second meeting would be useful to keep up the impetus and review progress.

The National Museum has large collections that go beyond the botanical resources of Kenya and East Africa generally. Our biological collections incorporate reference material in entomology, ichtyology, herpetology, mammology, ornithology and our paleo-sections. These collections are of importance not just for East Africa, but for the continent as a whole. We at the Museum are increasingly aware of the need to be more useful to the community than simply be a rather closed taxonomic centre. It was with this in mind that the Board of the Museums met recently to discuss the importance of expanding our activities in the botanical field.

We felt that work in the botanical field should go beyond the collecting of plants and their identification and we are instituting a programme now that will be dealing with more applied areas, such as chemotaxonomy and phytochemistry.

It is against this background that we are getting more involved with other programmes and other institutions, and that is why I welcomed the initiative taken by my staff to hold this workshop.

The National Museums makes no pretensions about being involved in the agricultural field; we are primarily concerned with the area of endemics and the indigenous bio-resources in this part of the world.

In 1984 the Museum hosted a Strategy Conference on plant communities, and we have continued to be active in developing inventories of endangered Kenyan habitats, such as the Taita Hills and the Coastal forests.

The African Ministers meeting in Cairo, held in December 1985, recommended the setting up of technical cooperation networks. A conference in Nairobi in October 1986, under the auspices of UNEP, established guidelines involving Regional and National Networks on different aspects of the environment. As a result of this, in February 1987 the Ministry of Environment and Natural Resources identified various focal points for National networks and the National Museums was selected as the focal point for Genetic Resources.

This workshop provides an excellent opportunity to give us clear guidelines on what we should be doing. There is a great opportunity here for exchange of scientific information, particularly with a view to developing a concensus as to what should happen in the genetic resources area.

There is a lot of competition in this field and a lot of unnecessary duplication of efforts, a lot of waste of time and of public funds. I hope that as a result of discussions here, we will at least know what we should *not* do, because someone else is doing it already.

I also hope that as a result of this workshop a Committee can be set up to meet regularly and discuss guidelines and implementations on matters concerning genetic resources.

GENETIC RESOURCES IN THE WIDE PERSPECTIVE

Dr. Hamdallah Zedan

Biological diversity and ecosystem conservation is rapidly becoming one of the most important issues of the year 2000. Species and their genetic materials promise to play an expanding role in sustainable development. Their contributions to agriculture, forestry, medicine, industry and environment amount to billions of dollars per year.

Species that are important to human welfare are not just wild relatives of agricultural crops and domesticated animals. Many species are far more important in terms of the role they play in a healthy and productive ecosystem. The natural vegetation cycles nutrients, helps to stabilize the climate, provides a sink for carbon, moderates down-hill flow of water, aids in flood control and prevention of silting of costly water reservoirs, filters pollutants, controls soil erosion and desertification, etc. Yet living natural resources such as plants, animals and microorganisms and the ecosystems of which they are a part and on which they depend, are severely threatened and vast stocks of biological diversity are in danger of disappearing, just as science is learning how to exploit their genetic variability.

A very small fraction of the estimated 10 million species of animals, plants and microbes in existence today already supports our welfare through their contribution to modern agriculture, industry, medicine, energy, biotechnology and the environment and many more benefits could come from wild and underexploited species. Countless plants and animals - the numbers have been estimated at more than 3 million - as well as microorganisms are still undescribed. Most of these occur in the tropics, and many may be of significant value as sources of foods, fibres, drugs, chemicals and other raw materials. To date, scientists have conducted cursory screening of only one in ten, more detailed screening of one in fifty, and intensive screening of only one in a hundred. As for animals, the number screened amounts to only a tiny fraction of the 5-10 million of the earth's species. Thus, an analysis of all plant and animal species would reveal many new materials of benefit to mankind. Moreover, the emergence of techniques such as genetic engineering and tissue culture reinforces the need for maintaining the richest possible pool of wild genes. The projected loss in species diversity could cripple the genetic base for the continued improvement and maintenance of currently utilized species and deprive us of many potentially useful ones.

Irrespective of this fact, the loss of genetic diversity is continuing; we could lose one million out of the earth's 5-10 million species by the end of this century. It is estimated that by the middle of the next century we could lose at least one third of the earth's total species and the genetic material they contain. The ultimate causes are the irreversible alteration or destruction of habitats through the unprecedented expansion of human population in the last few decades and the ever-growing demands on living resources through illegal trade, indiscriminate hunting, etc. These factors have led to extensive transformation of ecosystems , either through urban development or the spread of new technologies , sometimes carelessly misapplied in agriculture, industry and transportation. It may be argued that ecosystem destruction and species extinction occur naturally even without human intervention. This is true, but human activities increased the rate of extinction hundreds of times.

Not only species and their ecosystems, but also varieties and races within plant and animal species are being lost, thus reducing the diversity of genetic material. In domesticated plant and animal species thousands of traditional cultivars, breeds, varieties and races with great genetic diversity (variability) and dramatically increased adaptibility for long-term survival have accumulated. The broad genetic base of these domesticated races enabled a significant proportion of their populations to survive under various environmental stresses, such as drought, high temperature, pests and disease, salinity, etc. and it is imperative to preserve their wild relatives as the base for continuing genetic selection and improvement.

In the past few decades, however, man has developed, through scientific breeding, high yielding crop and plant varieties, animal breeds and microbial strains, characterized by greater genetic uniformity and a narrower genetic base. At present, man relies on an increasingly limited number of species and varieties for his food, fibre, timber, medicines and other natural products, and this trend is not likely to be reversed in the near future. At the same time traditional varieties were abandoned (causing their permanent loss) in favour of new ones and the chances of obtaining their wild relatives as potential breeding material is increasingly limited by the loss and degradation of their habitat.

The concentration of genetic strains has continued to such an extent that now almost every coffee plant in Brazil descends from a single plant, the entire U.S. soybean industry is derived from 6 plants, all from one site in Asia, and all rubber trees growing outside America descend from a single collection of seeds.

Although the new plant breeds increased productivity dramatically and brought great gains, they also created a number of problems. Recent experiences show that because of their narrow genetic base they are:

- ill-fitted for the needs of small producers with low management inputs;
- vulnerable to adverse conditions and to pests and disease;
- liable to change genetically, losing the specific qualities maximized by breeding;
- too narrowly based genetically for further breeding.

If the valuable gene pools by which this dangerous situation could be corrected continue to disappear, the loss could be irreparable.

The disappearance of traditional animal breeds is advancing at an alarming rate as well, mainly because of the indiscriminate crossing of local breeds with exotics with

a high productivity, and the technical ease with which artificial insemination can be applied.

Microorganisms present a special case. Their presence and activity is essential to the health and the functioning of ecosystems and the whole environment through, among other factors, mineralization and cycling of important elements, photosynthesis, fertility of soil, pest and vector control and detoxification of pollutants. They also play a significant role in bioproductivity, either directly through the synthesis of food, feed, medicines and chemicals, or indirectly through making nutrients available for other primary producers. Although specific microbial strains are not likely to become extinct except under extremely harsh conditions, retrieval of such strains from natural ecosystems is technically almost impossible; the only way to make valuable strains available for exploitation is by their conservation in culture collections, which is relatively simple and inexpensive.

The case for conservation of biological diversity on scientific as well as economic grounds has now been well-established. It is reinforced by growing awareness of the scientific, ethical, cultural, psychological and recreational values attached to the conservation of species, races and varieties within species, as well as ecosystems as a whole, in all parts of the world. The emerging awareness of the need for urgent positive action to conserve and develop the world's biological diversity in terms of genetic resources as man's chief insurance against their destruction has resulted in a number of efforts. But the magnitude of the problem is still far from being fully appreciated by decision-makers and supported by public opinion; all too often only lip service is paid to conservation requirements in development projects, and many of the nations possessing a rich biological diversity have insufficient capacity to manage these living resources.

National efforts for conservation are still ill-organized, and few countries have undertaken the preparation of a national conservation strategy or guidelines to meet conservation requirements; conservation programmes including planning, training, education, research and cooperation on national and international levels are lacking. Assistance and guidance available to developing countries are absent, or have been modest. Most developing countries do not have enough knowledge, and ecosystem conservation in national development policies and programs appear to be neither practiced nor adopted. Policy makers and the general public for whom policy is made must realize the size and urgency of the threat as well as the link between conservation and sustainable development. This may require reforms of tax and tenure systems and changes in trade patterns.

A North-South and South-South collective harmonized action for the conservation and sound management of earth's biological diversity is needed. Everybody bears some responsibility for over-exploitation and degradation of biological diversity. Although two-thirds of all species occur in the tropics (i.e. the developing world) it is the developed nations that possess the technological expertise to exploit the genetic resources of species; a situation which raises several important issues important to North-South relations, and which highlights the interdependancy of these relations. For example, possession of individual species may be limited to one nation, while significant benefits from the use of this species may accrue to all nations. Also, mismanagement of important ecosystems belonging to one country may cause severe damage to other nations. Deforestation in Nepal, for example, has caused great damage in India and Bangladesh.

Thus, nations possessing biological diversity have a duty to safeguard their species on behalf of the international community; the community at large has a duty to enable these nations by providing whatever assistance is required in terms of funds, skills, etc. This justifies the need to develop agreements that satisfy the "rights of possession" of those who have the resources and the "rights of access" to needy ones.

There is however a cost element in conservation of natural resources and their natural ecosystems, and of course a benefit depending on the utility of the genetic resources. Within the available financial resources and to match costs and benefits, indiscriminate conservation of all genotypes would be prohibitively expensive, technically impossible and not fully utilizable. The main issues requiring attention in the national and international efforts in this area are therefore:

1. Conservation of *samples* of selected ecosystems as a whole as reservoirs of species diversity - many of which remain to be discovered - and development of appropriate management plans and detailed inventories;
2. Establishment of mechanisms of generating information on less known and under-exploited genetic resources, and development of criteria for selection of those to be conserved. Information is needed on their geographical distribution, modes of reproduction, breeding potential and diversity, as well as conservation methodology;
3. Continuous updating and review of criteria for conservation priorities. Genetic diversity is a dynamic state, and a species with no known potential may move to one with a broad potential;
4. Gearing genetic resources conservation with rational utilization, as the ultimate objective of conservation is the deployment of the preserved genetic material for sustainable development;
5. Assisting developing countries to improve their own traditional varieties into more productive varieties that can perform better under the prevailing conditions; thus the value of a given genetic resource - be it plant, animal or microorganism - would not be estimated only by its role in intensive production systems but also in sustainable production systems;
6. Improving accessibility to conserved genetic resources.

A number of national and international efforts are already being tried but their combined activities are tiny in the face of the large needs. Less than 4 % of the total land area of the Earth is managed for conservation, and these areas are unevenly distributed and often poorly pro-

tected. This area is quite insufficient, particularly as regards the tropical forest ecosystems, to ensure adequate maintenance of biological diversity. In addition, local people are rarely associated with the planning and management of protected areas, and under mounting short-term economic and social pressures, may use these areas for incompatible purposes such as poaching, unmanaged grazing or woodcutting. The need for integration of conservation and rural development and for local understanding of that need calls for new conservation methods and for the establishment of non-conventional protected areas which are of direct benefit to the local people.

There is an urgent need for increased support to developing countries by providing them with specialized expertise and training for conservation and increasing the awareness of decision-makers and the general public. Governments also need assistance to enable them to become parties to conservation conventions and to fulfill their obligations under such conventions.

As a positive response to the World Conservation Strategy, which reaffirmed living resource conservation and its direct linkage to sustainable development, countries have to embark on the formulation, adoption and implementation of comprehensive National Conservation Strategies and thus to integrate conservation with their socio-economic development plans and programs to ensure that development is sustainable. The National Conservation Strategy process involves the strategic planning of resource use in a wide variety of sectors. World assessment of renewable natural resources should continue on a systematic basis with a phased approach to resource monitoring and data management.

Many international organizations, including UNEP, IBPGR, FAO, UNESCO and IUCN have a history of co-operation in the area of natural resources conservation. They were instrumental in implementing the proposals recommended by the World Conservation Strategy and by a number of relevant expert group consultations and meetings.

One major regional event in this area took place in 1985 at the initiative of UNEP. Recognizing the fact that conservation of genetic resources is an integrated part of sustained management, the African Ministers' Conference on the Environment - which held its first meeting in Cairo in 1985 - decided to establish or strengthen an African Network for Genetic Resources Conservation and Management as one of the eight technical networks that will be established in the region. Another decision which bears relevance to genetic resources is the implementation of 150 village pilot projects and 30 pilot semi-arid stock raising zones aimed at self-sufficiency in food and energy, using local expertise and local genetic resources.

The Network's objective is:

1. To promote the scientific and technical capabilities of the African region by forging links between national scientific research and technological development institutions;
2. To promote inter-country co-operation for conservation and management of genetic resources;
3. To assist countries to integrate conservation with optimum resource utilization for improving agriculture, industry, health and environment in a sustainable way.

The establishment and development of the network would provide answers to at least the basic needs of every country, such as the availability of genetic resources, source locations, source potential, etc. However, it should be emphasized that development and/or strengthening of National Conservation Programmes should precede - or proceed concurrently with - the development of the regional network which should build upon presently existing activities and responsibilities of various national and international agencies in relevant areas to make for a greater degree of co-operation and complementary aid to avoid unnecessary duplication and overlapping.

Initiation of the implementation of a network would entail the following:

1. Identification of national experts and institutions active in genetic resource conservation, management and utilization;
2. Identification of NGO's, networks, associations, panels, committee's, etc. that can help in the implementation of the network;
3. Survey of existing national/regional programmes and activities of genetic resources;
4. Visits to selected promising institutions reported to be most appropriate to linkage via networking and meeting with national experts, professionals, policy and decision makers to make an assessment, taking into account the available natural, financial and manpower resources; equipment, adequacy of communications, willingness to collaborate; problems to be alleviated; legal, economic, political and social issues which may result in non-technical obstacles; etc.
5. Identification of institutes and organizations located in developed countries that are able and willing to co-operate with the network;
6. Identification of UN-organizations and relevant existing or planned networks and expert panels, and examining ways and means of possible cooperation with the network;
7. Setting up of a policy/scientific advisory council (to develop strategies for the network establishment and operation) and operating committees (for the implementation of the council decisions) with one co-ordinating unit in each country;
8. Discussion of the council plans and strategies with scientists, professionals and decision-makers from African countries and internationally prominent experts and representatives of UN organizations, NGO's and potential donors to adopt strategies and priorities and to ensure effective co-ordination;
9. Preparation of packages of activities to implement the adopted strategies and priorities;
10. Approaching potential donors (including UN agencies) for financial support of the network. This would be in addition to the technical and scientific expertise and in cash/kind contribution of member states;
11. Adjusting new technologies to the range of prevalent

farming conditions within various ecosystems.

A national member of this network would ideally be a central institution with access to one or more of the nature reserves, biosphere reserves, germplasm banks, or biological reference collections. This may not be easy at the initial stage because nature reserves may belong to different government departments ranging from forestry to tourism; germplasm banks often belong to ministries of agriculture; reference collections may belong to various natural history museums, etc.

A preparatory phase may need to precede the full establishment of this network. In this phase, countries would be encouraged to establish national commissions, or central government bodies, for the conservation of genetic resources. Such commissions or bodies would be ideal members of this network.

CONSTRAINTS IN GENETIC RESOURCES CONSERVATION

DIVERSITY: ITS IMPORTANCE TO WILD SPECIES

R. Malpas

Worldwide some 25.000 plant species and more than 1000 animal species are presently thought to be threatened with extinction. These figures, however, are underestimates since they do not take into account the extinction of small animal species, e.g. insects, which are lost when their habitats are destroyed. If we do try to take these losses into account, estimates are that 500.000-1.000.000 species will be lost by the end of the century.

The most serious threat to the survival of species and therefore to genetic diversity is the destruction and degradation of natural habitat by man, e.g. the clearance of vast tracts of tropical rain forest is resulting in present day mass extinction of species. Other human interference such as wetland drainage, expansion of human settlements and expanding agriculture are all contributing to this destruction of genetic diversity. Exploitation of wild species, for example for food or commercial trade, is also posing a serious threat to diversity. Modern technological advances, if anything, have increased our dependance on wild species, e.g. wild species represent a source of new crop varieties which are capable of producing high yields, or withstanding harsh conditions and disease. They also represent a source of new medicines for the treatment of human diseases. There is every reason to believe that our dependance on wild species will in fact *increase* in the years to come, and it is therefore a matter of clear common sense that we should make every effort to preserve as large a bank of genetic diversity as possible, not only to support current scientific advances but also as a security for the future.

Even species which seem of little or no value to mankind today, may be of critical use in the future, and the important point here is that once such species are lost, there is no hope of ever retrieving them. They have taken more than a million years to evolve from even their closest relatives.

But the problem is more complex than this. Species are a crucial element in natural ecosystems, and loss or disturbances of these ecosystems as well as loss of these elements, have far-reaching consequences. So loss of species is therefore of importance to a human community for many other reasons, such as for the management of water catchments and the prevention of soil erosion.

One final point is that the loss of genetic diversity may have important consequences on the species themselves. Genetic differences within a species allow the species to adapt to climatic changes, disease outbreaks and many other environmental factors. Any reduction in that diversity, for example in the endangered mountain gorillas in Ruanda (of which the population has been reduced to 120-200 animals) obviously has very serious consequences to that species; this species is very susceptible to certain diseases or other factors which could lead to extinction.

The World Conservation Strategy which was published by IUCN, UNEP and WWF in 1980 phases the preservation of genetic diversity along with the maintenance of essential ecological processes and sustainable utilization of species as one of the three main goals of conservation. A large part of IUCN's worldwide conservation efforts is focused on this aspect and I would like to mention the work of the species survival commission and its many specialist groups which are working to prevent species extinction by developing an understanding of the requirements of the individual species, and by developing specific field conservation activities. On the assumption that actions to prevent extinction of species can only be based on up to date and accurate information, IUCN established a conservation monitoring centre in 1983, with the responsibility for establishing a comprehensive computer database on the status of plant and animal species around the world, and for making this information available in a clear and simple form to decision makers.

At the regional level, the IUCN Eastern Africa Regional Office focuses on practical field activities, and on conserving particular habitats and their constituent species, e.g. our work in the Eastern Usambara mountains in Tanzania, an area with unique species diversity and endemism. In this area we just completed a study which aims to draw up a conservation plan for the forests. The main focus of this study has been to understand the species composition of the forest in terms of its trees, other plants and animals and to establish the individual requirements of the various species. From this understanding, the forest management plan is being compiled which hopefully will ensure the long-term survival of the full diversity of forest fauna and flora. As a follow-up to this management plan, we are now launching a project in the villages surrounding the forest, which will focus on improvement of agricultural practices and the establishment of village woodlots, both activities aimed at relieving pressure on the natural forests.

Our projects in the East Usambaras perhaps illustrate best what we consider as the two main ways of approaching the conservation of natural diversity at the national level.

First, we believe that a research and inventory effort is needed which will identify key genetic resources and provide a proper understanding of the natural areas to which they belong.

Second, we feel there is a need to implement practical projects in the field which will ensure that the representative natural areas and their constituent species are preserved. And in keeping with the latest conservation thinking, we believe that this project should not aim at the strict protection of habitats by excluding all human use, but that it should provide use of resources by the local

communities. These two approaches should perhaps ideally be launched under a National Genetic Resources Conservation Strategy, which in turn would form one element of the broader National Conservation Strategy.

To conclude, I would like to say that IUCN fully supports the goals of this workshop. We very much hope that the structure for launching a national genetic resources strategy will emerge in the next two days, with companion plans for carrying out the national inventory of genetic resources and the representative habitats through establishing a database, and launching field activities to conserve these resources. I would like to say that IUCN stands ready to assist in all of these efforts in every way we can.

DIVERSITY, ITS IMPORTANCE TO CROPS

A.F. Attere

An understanding of the nature and extent of crop plant diversity is fundamental to plant genetic resources. Without this we would be unable to collect, conserve or utilize satisfactorily the vast array of diversity which is found in the majority of crop plants and their wild relatives (Ford Lloyd & Jackson 1986).

Crop plants have evolved from wild species under the influence of humans. Diversity is a result of crop plant evolution under domestication since the origin of agriculture to modern times.

Domestication of plants was a major event in man's cultural evolution. It is an evolutionary process operating under the influence of human activities. This process of domestication has resulted in a number of phenotypic changes, as well as in reproductive biology. Plants lost the ability to survive as wild plants through mutations which enable man to harvest plants more easily, such as the non-brittle rachis mutation in cereals and the loss of dehiscence in the pulses. Crops often show gigantism, especially in parts of plants selected by man such as seeds and fruits.

Crop plants are subjected to the rigours of both natural and artificial selection pressures. Wild plants must be adapted to the environment in which they grow, and plants which diverge significantly may be selected against. In many ways cultivated plants have been released from these selection pressures, and great diversity, particularly morphological diversity, has accumulated in many crops.

During domestication crop plants were brought into contact with many different wild plants, with which they hybridized and exchanged genes, thus increasing the physiological adaptation of the plants. Other features are the suppression of defensive mechanisms, the reduction of sexual fertility in vegetatively propagated crops, and change from the perennial to the annual habit. A change in reproductive biology from outbreeding to inbreeding has enabled crops to exploit fully their new man-made habitats. Several morphological features are associated with this change. Reproductive changes in finger millet have been documented (Ganeshaiah & Uma Shaanker 1982) including synchronity of flowering and increase in gynoecium volume.

The pattern of genetic diversity seen in crop plants results from the interaction of gene mutation and migration, recombination, selection and genetic drift (Ford Lloyd & Jackson 1986). Migration can increase variation in populations by adding allied genetic material. During their wandering humans have taken their crops with them to new sites and geographical variation has been increased through adaptation to different environmental conditions. Hybridization with allied species not found in the original region of domestication has often occurred with stabilization of hybrids through polyploidization.

Harlan (1966) considered that the evolution of crop plants progresses primarily on a differentation-hybrydization cyclic system.

Vasilov was the first to focus attention on the diversity to be found in crop plants and to the fact that it was concentrated in "areas of diversity", centres of origin for many crops. He investigated the distribution of the major crop plants and determined areas were there were concentrations of botanical varieties, using detailed studies of their morphology, cytology, genetics and their resistance to pests and diseases and adaptations to different climatic conditions. Eight of these centres of diversity were identified, and these centres have been the reservoirs from which plant breeders have collected valuable materials for their work. Recognizing some gaps in this classification Harlan (1971) developed the notion of centres and non-centres, suggesting that agriculture began independently in three areas, each one associated with a large and diffuse non-centre. Recently Hawkes (1983) proposed an alternative scheme in which he distinguishes nuclear centres of agricultural origins from the regions of diversity which developed later, when farming had spread out from the nuclear centres in which it had originated.

Primitive cultivation which persisted until very recently in these parts of the world permitted contact among already variable races of crops, and geneflow between these and their related wild species. These were also modified by the local environment in which they were grown, and by the cultural methods adopted by farmers. Thus emerged distinctive local races which we call land races or primitive cultivars, adapted to numerous agroecological situations.

A situation now exists in the world which requires plant breeders and other agricultural scientists to identify efforts towards a solution of the threatening population explosion and the need to alleviate hunger and malnutrition. This requires new genetic inputs to solve the problems associated with expanded production and to improve quality under harsh environmental conditions.

Diverse genepools are the foundation of an effective crop improvement programme. Not only do genetic resources provide the necessary building blocks for further varietal improvement, but genetic diversity is essential if high levels of productivity are to be sustained. They are a source of inherited diversity and in the past breeders and agronomists found valuable characters which have increased yields, conferred resistance to pests and diseases, and have provided nutritional, aesthetic and technical qualities. They have also made it possible to extend the adaptation of crops to adverse agro-edaphic conditions.

As modern agriculture progressed, more productive varieties and new crops were introduced into production, similar varieties tend to occupy vast areas and uniformity has the hazard of potential vulnerability to diseases. The best known example of genetic vulnerability due to varietal uniformity was the maize disaster in 1970 in the U.S.A., due to an epidemic of southern corn leaf blight on maize hybrids with identical cytoplasm for male sterility, designated Texas (T). In recent decades it was recognized that the areas which had seemed to be inexhaustible sources of breeding material were rapidly being changed under a wave of new varieties with high yield potentials and under conditions of modern agriculture. These genetic reservoirs were thus doomed to extinction.

A world wide concern over the loss of valuable genetic diversity has been widely recognized in the past 25 years. Several international institutions, such as the International Board for Plant Genetic Resources (IBPGR), as well as regional and national institutions are now specialized in collecting and conserving this diversity, which is the basis for sustained and continuous breeding programmes vital for the survival of mankind.

REFERENCES

Ford-Lloyd B.V. & Jackson M. 1986. Plant genetic resources: an introduction to their conservation and use. Edward Arnold, London.

Ganeshaiah K.N. & Uma Shaanker R. 1982. Evolution of reproductive behaviour in the genus *Eleusine*. Euphytica 31: 397-404.

Harlan J.R. 1966. Plant introduction and biosystematics. In: Frey K.J. (Ed.) - Plant breeding. Iowa State University Press, Ames.

Harlan J.R. 1971. Agricultural origins, centers and non centers. Sciences 174: 468-474.

Hawkes J.G. 1983. The diversity of crop plants. Harvard University Press, Cambridge.

MAINTENANCE OF DIVERSITY IN EX-SITU CONSERVATION

Dr. A. Abou-Zeid

Concern over the loss of valuable sources of plant germplasm has been widely recognized. Many institutions around the world hold collections of crop germplasm and germplasm of wild crop relatives.

During the last twenty years many collection missions have been made in Kenya. Most of this collected germplasm was lost because of the absence of proper conservation facilities and/or poor data documentation. Fortunately, some of these collections were duplicated to other genebanks abroad and can be brought back to Kenya.

In most cases seeds are the right crop planting material because they are easy and cheap to conserve. In respect of the physiology of seed conservation, two seed groups can be classified. "Orthodox" seeds can be dried and conserved for long periods at low storage temperatures and "recalcitrant" seeds which will be damaged if dried or exposed to low temperatures.

There are three types of seed storage:

1. Short term storage indicates a period up to 2 years in controlled or uncontrolled storage conditions.
2. Medium term indicates a period from 2 to 10 years at a temperature of 0-5 degrees centigrade
3. Long term indicates a period of more than 10 years at temperatures between -10 and -20 degrees centigrade.

It is necessary to dry seeds to a moisture content of 10-4 % and to pack them in sealed containers before storage, particularly for medium and long-term conservation. Vegetatively propagated crops as well as species with recalcitrant seeds are normally preserved in tissue culture or in field collections.

In Kenya about 52.000 germplasm collections are being conserved in cold stores at various breeding and research stations:
Cereals 25.000; pulses 5.000; cash crops 6.900; root and timber 1.000; pasture species 11.000; other crops 3.100 accessions.

Thirteen cold stores for the maintenance of working collections exist at different stations in Kenya, with a total storage capacity of 773 square meters.

The National Crop Plant Genetic Resources Centre in Kenya (National Genebank, Muguga) has developed a standard documentation system for use in Genebank activities, and will soon accommodate facilities for data computerization and for long-term seed conservation with a storage capacity of 150 square meters at a temperature of -18° C.

All efforts should be made to identify previously collected germplasm, and to eliminate duplicates. Special attention should be given to make the optimum use of available documentation facilities and know-how. An information flow between Research Stations and the Genebank should be guaranteed. Systematic germplasm collections must be carried out in order to save endangered crop plant genetic resources and their wild relatives.

DOCUMENTATION AND THE AIMS OF CONSERVATION

Dr. A.R.D. Taylor

Our aim is always to maximize genetic diversity. This explains all the activities we are discussing: running gene banks, establishing or maintaining Reserves or Parks, talking about in-situ or ex-situ conservation. Broadly speaking, crops are best conserved through ex-situ methods, while wild species must be conserved in-situ through necessity. Forest species bridge these categories and both these techniques are used. Documentation is defined as the collection of information about species - their location and diversity, whether talking about wild populations or the population in a gene bank. Ultimately the whole purpose behind documentation is to guide conservation action; the science (some would say the art) of documentation is far better developed for crops than it is for wild species.

My task is to outline some common problems and suggested solutions for documentation applied to conservation.

Taking a holistic view, every plant species should be conserved and thoroughly documented, and in principle in-situ and ex-situ methods apply equally to all plants. We of course compromise in this because some plants are more important to us than others - we eat some and burn others, while attempting to eradicate those classed as 'weeds'. We, however, cannot afford this attitude if we are honest about conservation.

Reflecting our differences in interest in plants we can eat and those we can only look at, there have arisen two rather independent systems of global documentation, one co-ordinated by the International Union for the Conservation of Nature and the other by the International Board for Plant Genetic Resources. Neither are United Nations bodies, but collaborate closely with the UN Environment Programme and the UN Food and Agriculture Organization respectively. In fact the IUCN and the IBPGR collaborate on their common interests - wild plants which are crop relatives. Their documentation systems are very different in operation. The IUCN operates four database units: threatened plants, species conservation, protected areas and wildlife trade monitoring units. The IBPGR, however, has a decentralized system of databases specializing in each major crop at each of the co-operating International Agricultural Research Centres (IARC's) around the world, as well as the participating national gene banks. The main difference between their approaches is a result of IUCN's interest in in-situ conservation and IBPGR's emphasis on ex-situ conservation.

How does one make sense of all this at a national level? In the national interest, plant resources should be conserved for utilization and the information systems in use should serve conservation efficiently whether being used for crops, trees or medicinal plants. Every gene bank in the world seems to have a different system of recording data about its accessions; a process of documentation evolution is still apparent, similarly, in that every national park or reserve has species inventories taken in dif-

ferent ways. How then can a decision be taken about whether ex-situ conservation should be used to support a deteriorating in-situ strategy? One approach which should be tried is to identify key species in each conserved community and use these as 'marker' or 'indicator' species for the state of genetic diversity in each area. Agreed phenotypic markers must be developed for the assessment of diversity (see Simpson & Withers 1986) and used in documentation of wild communities as well as for the contents of the gene banks. Another approach which has been used quite widely already has been to computerise herbarium records for a region and to use this to map species distribution over time. There is no reason, however, why morphotypic characters in duplicates of herbarium specimens should not help in diversity assessment.

The reverse situation is of course the assessment of whether ex-situ conservation collections held in seed banks possess sufficient genetic diversity compared to the parent growing population from which the collection was abstracted. This can be done again using a combination of biochemical and morphotype descriptors and it would be desirable to standardise both the descriptors and the method of documenting these. The situation for crops is quite advanced: the IBPGR publishes recommendations for most stored crops, and these are regularly updated. For wild species, including crop relatives and trees, much remains to be done.

Within Kenya, there are already several documentation systems in use for the various seed stores, some barely adequate to record accessions, others of an incredible complexity. The prime consideration should be to ensure that all accessions of germplasm are documented to a standard enabling sound genetic diversity assessment; with this in mind it is recommended that IBPGR's collection forms be used for field collections - if properly completed they enable decisions to be taken on whether the sample collected was sufficiently diverse. The IBPGR's standards for storage documentation should also be used, for similar reasons. This recommendation applies to *all* plant categories. Genetic diversity indexing should also be applied to gene bank accessions, preferably through isozyme analysis, but also using conventional morphotypic descriptors. As a guide, there are four categories of descriptor recommended by the IBPGR for gene banks: Passport information, Characterisation data, Preliminary evaluation data and Full evaluation data (see Ford-Lloyd & Jackson 1986).

For many crops stored in Kenya's seed storage facilities, the above data is available for internationally recognized breeders lines. The priority should be to evaluate locally bred lines and landraces to the same standard and implement suitable documentation.

Finally, at this stage in Kenya's development, it would be wise to consider a unified system of computer documentation so that records maintained at the various gene banks and seed stores around the country are held to the same high standard, and to enable effective information exchange with the international community.

REFERENCES

Ford-Lloyd, B. & Jackson, M. 1986. Chapter 5: the management of genetic resource data, in: Plant genetic resources: an introduction to their conservation and use. Arnold, U.K.

Simpson, M.J.A & Withers, L.A. 1986. Characterisation of plant genetic resources using electrophoresis: a guide to the literature. IBPGR, Rome.

Question (Dr. Oggema): Why do you feel that Kenya is the country where the IBPGR system could be adopted? You are aware that we have inherited a lot of systems from our donors, some of which are quite good.

Answer: The emphasis is on unification of the system as we start computerization.

PRESENT ACTIVITIES IN BREEDING STATIONS AND RESEARCH INSTITUTES

KENYA FORESTRY RESEARCH INSTITUTE AND KENYA FORESTRY SEED CENTRE

E. Murugi Kariuki

The Kenya Forestry Research Institute (KEFRI) is responsible for improvement and conservation of forest in Kenya, in collaboration with the Forest Department. With the assistance of the Federal Republic of Germany a Forestry Seed Centre was established. This became operational in November 1986. The Seed Centre collects, processes, stores and distributes seeds. It has five collection centres representing the different regions of the country. Its cold storage facilities are divided in three rooms, two at +3 degrees centigrade and one at -18 degrees.

The research being conducted in the Seed Centre has an emphasis on storage trials, especially of indigenous species, so as to determine the optimum method for storing these seeds.Orthodox seeds are those that can be stored for medium (2-10 years) or long (>10 years) periods at low moisture contents in sealed containers at 3-5 degrees or -18 degrees (Willan 1985). Recalcitrant seeds are those that cannot withstand appreciable drying without injury (Willan 1985). Conservation of species with recalcitrant seeds in-situ is therefore of great importance.

In our collection centres we have a specific form which collectors are supposed to fill in, with details on each species, where it has been collected, and which species it is associated with. In future, all this information will be compiled and documented.

For indigenous species there is a distinct lack of information on their storage requirements and best provenance areas. KEFRI is really starting from scratch to find out these requirements and to collect seeds; collectors are now required to collect voucher herbarium specimens at the same time when they collect the seed, to ascertain the name of the species. We are trying to improve on seed quality, as well as on the number of species collected in Kenya.

There is 2.150.000 ha of indigenous forest, 50.000 ha of nature resources, 22.000 ha of indigenous hard and soft wood plantations and 150.000 ha of exotic species plantations- e.g. pine, cypress, eucalypts, acacia. There are several stands of clonal material and provenances, especially of Central American pines (Odera 1984). In the indigenous forests there is restricted selective felling, geared to promote diversity and quality of the residual crop.

At KEFRI, the different divisions collaborate with one another. The Seed Centre works especially closely with the Tree Breeding Division, on breeding and selection of both exotic and indigenous species.

The genetic resources in Kenya could be better managed and utilized by:

1. Integration of plant germplasm conservation in the National Land use agenda.
2. Introducing a legal requirement for producing Environmental Impact Assessment Statements.
3. Placing a mandatory ban on further alienation of forest land for agriculture, by increasing agricultural productivity in existing areas by adoption of modern farming methods and the green revolution packages.
4. Striking a realistic balance between the conservation and production functions of our forests.
5. Training of more tree breeding staff.

REFERENCES

Odera, J.A. 1984. The seed supply in Kenya. In: Proceedings of a workshop to discuss the establishment of a regional forest seed centre, Harare, 11-13.01.1984. Pp 35-48. IDRC-MR IIIe.

Willan, R.L. 1985. A guide to forest seed handling with special reference to the tropics. FAO, Rome.

NATIONAL PLANT BREEDING STATION, NJORO

Dr. M.W. Oggema

The National Plant Breeding Station is one of the oldest research stations in Kenya, started in 1908. In 1926 the Station became the only breeding station in Kenya, and it was handling all crops : coffee, horticultural crops, cereal crops, pasture crops, oil seed crops and all others. This has now changed, and at the moment we are dealing with wheat, barley, all oil seed crops and some triticums. Because of inadequate storage facilities, NPB station can only store germplasm on a short term basis, that is about two years. So after every two years we rejuvenate our material.

We also keep fungal spores in vials in liquid nitrogen or in refrigerators on both long and short term basis. These are classified according to susceptible or resistant reaction on known plant host genes. The collections we have are mainly for rust species and sclerosis.

The Station receives much germplasm from IBPGR groups: CIMMYT, CIAT and ICRISAT. It also receives genetic material through personal contacts and exchange from institutions in foreign countries. The process of importation and exportation is a continuous one. The station introduces, breeds and selects germplasm to improve productivity; we also collect land varieties of species such as castor and sesame from different agro-ecological zones.

The station is very well known all over the world for its breeding of wheat, barley and sunflower; in crops such as rapeseed, triticum, oats and linseed we concentrate on selection from introductions, and then introduce them to the farmers.

We rarely use wild species in our hybridization programs, but our aim is to use them in the future particularly for species such as barley and castor which both have wild relatives in this country.

I would like to suggest that our staff is given more training, as most of them are quite young and lack both experience and training.

I also wish to state that there should be a central gene bank for non-commercial crop species, that is undomesticated crops.

Question (Miss Murugi): How is seed storage effected?
Answer: We store for 2 years, and then grow the same seed lot for seed production to try and keep the gene pool the same.
Question (Dr. Lamprey): Where does the wild barley grow? Is the habitat secure, in case you need to collect more?
Answer: Wild barley occurs on high ground in the Mau area.
Comment (Dr. Lamprey): Security of wild populations through habitat conservation is vital.
Question (Prof. Owino): Are wheat and barley germplasm kept elsewhere as well?
Answer: Yes, in Maryland (USA) and the Netherlands.

DRYLAND FARMING RESEARCH STATION, KATUMANI

P. Kusewa

Katumani is one of the newest research stations in Kenya, started in 1956. But for various activities it is one of the most important in the country. About two years ago, through the assistance of IBPGR and GTZ, we were provided with cold storage facilities, and since then we have been able to initiate and programme our germplasm collection. As a dryland farming research station, we are mainly concerned with food crops, pasture and pasture legume crops, and recently we are getting involved with agroforestry for dryland areas.

Major areas for plant genetic resources at Katumani are collection, maintenance, conservation, characterisation, evaluation, documentation and utilization of the germplasm. The food/pasture species involved are cereals, legumes, root crops and oil crops found in the semi-arid areas of Kenya. In addition to these local materials we receive a lot of germplasm from other countries and organizations such as ICRISAT, CIAT and CIMMYT.

Among our cereal collections there are maize, sorghum, millet, finger-millet, proso millet and foxtail millet. Interesting legumes are cowpeas, pigeon peas, common beans, mung beans, chickpea, black gram, lablab bean, soybean, ground nuts and velvet bean. Among our oil crops there is some jojoba, safflower and castor. As root crops we have sweet potatoes and cassava. As pasture species we have collections of rose grass, napier, gene, magarigari, star grass and sea grass.

As legume fodder crops we have bugina, stylosanthes and a few acacias.

Collection

The objectives of our collection programme is to increase variability, which is a key factor in genetic improvement. We have organized collection missions together with other international research centres such as ICRISAT. We collect in various parts of Kenya, to collect seed and vegetative parts, according to the way species are propagated.

At present our collections number about 10.000, including a good number of exotic material: like pigeon pea from ICRISAT and cowpea from Nigeria.

We recently wrote up a program which is now being discussed by NCST, to collect and utilize wild relatives of our crops, such as cow peas and pigeon peas.

Maintenance

Germplasm is maintained both in-situ and ex-situ. The ex-situ material is stored in the cold room, while in-situ material is in a living collection in the field. We have irrigation facilities at Katumani to maintain vegetatively propagated material like cassava, sweet potato and grasses. Cold storage is at 4° C, after seed has been sun-dried to a moisture content of 4-11 %.

Characterization

After collecting and maintaining, we have to characterize our material so that we know what we have. The various records are based on IBPGR descriptors of respective crops. At present 1.200 accessions of finger millet, about 900 accessions of pearl millet , 150 accessions of foxtail millet and 2 accessions of barnyard millet are being characterized. This is carried out by growing accessions along checked cultivars of matching maturity, and recording characteristics. In collaboration with ICRISAT a set of 500 accessions of pigeon pea is being characterized at two locations, at Katumani (Maruba farm) and Kiboko. This has resulted in identification of a number of genotypes with desirable traits, which will be utilized in the pigeon pea improvement programme.

Documentation

Relevant data are taken from the different accessions we have collected. The data which is generated during evaluation is compiled and distributed to the interested scientists, and breeders, with copies being kept at the centre. Eventually we hope to have these data on computer for more easy access.

Since 1985 we have a Research Officer working on germplasm at Katumani, but we feel we need more than one person, both in the scientific and technical sector, to assist the Research Officer in all the different activities we are carrying out.

We feel that the establishment of a National Gene Bank in Kenya would play an important role in coordinating all the different activities in germplasm collection and conservation in Kenya.

Question (Mr. Ndegwa): How do you go about collecting and handling indigenous plants in addition to others?
Answer: By mapping the areas and timing the phenological stage to collect seed.

NATIONAL SUGAR RESEARCH CENTRE, KIBOS: STATUS OF SUGARCANE GERMPLASM CONSERVATION AND USE IN KENYA

M.O. Osoro

Introduction

Sugarcane production in Kenya developed out of the jaggery business initiated by the Asian community at the beginning of the century. Hence, before the establishment of a plantation white sugar factory in 1924, all sugarcane was for the production of jaggery. The germplasm for the initiation of the sugar industry was imported from India by the Indian settlers who had experience in the manufacture of jaggery.

From this small beginning sugarcane growing has grown to a major industry. The sugarcane crop now covers an area of over 95.000 ha (Muturi 1986). There are now seven major sugar factories. To cater for sugarcane improvement the government has set up research, supporting the sugarcane development programme.

Responsibilities of the National sugar research centre

The National Sugar research centre comes under the Kenya Agricultural Research Institute. The centre is responsible for the development of an overall programme of research in the sugarcane crop. Its broad objectives are:

1. To develop new high-yielding, disease- and pest-resistant and high quality varieties of sugarcane through a programme of selection and field testing , and to bulk and distribute selected material for planting.
2. To determine factors which limit sugarcane yields in various ecological zones.
3. To study pests and diseases of the sugarcane plant with a view of devising control measures against these.
4. To disseminate the information obtained from field trials to farmers and all others interested in the development of sugar in Kenya.

Production of superior-yielding hybrid canes has been achieved mainly by introducing varieties from other countries. Good commercial varieties are imported through the Plant Quarantine Station at Muguga. After vigorous closed and open quarantine at Muguga the canes are released to the National Sugar Research Centre for open quarantine observations and multiplication before they are subjected to agronomic, pathological and selection trials.

After the collapse of the East African Sugarcane breeding programme in 1977 no more material was received from Kibaha, Tanzania, so in 1982 the government established its own breeding program for Kenya. The breeding programme is based at the Coast Agricultural Research Centre, Mtwapa, where environmental conditions for flowering and seed setting are excellent Jagathasan 1985). The progenies of the crosses are selected both in Coast Province and Western Kenya. Disease and pest screening is conducted at the National Sugar Research Centre at Kibos.

Sugar germplasm conservation

The Plant Quarantine Station at Muguga maintains a sugarcane clonal collection with 519 varieties (Sankaranaranayanan et al. 1968). The majority of these varieties are introductions with only a few varieties which resulted from the former East African Community Sugar Breeding Programme. Of the 200 man-made cugarcane hybrids which are maintained at the world sugarcane collection at Can Point, USA and Coimbolore, India (Sankaranaranayanan et al. 1968), 87 hybrids are maintained at Muguga. These hybrids are freely distributed to all who request them.

The National Sugar Research Centre at Kibos maintains a collection of 300 varieties. All the introduced varieties are duplicates of those at Muguga. Some collections are also maintained by the major sugar factories; and there is also a collection of genetic stocks at Mtwapa and Ramisi. These collections contain all elite genotypes used by breeders all over the world as parents in the breeding of new varieties.

Clonal maintenance of two to several years remain the basis at present but potential for maintenance as seed or tissue culture should be considered. The clones are replanted as the ratoons get old.

The germplasm exchange program

The Kenya programme of sugarcane exchange is coordinated by the Plant Quarantine Section, Muguga. In the past Kenya has imported vegetative material from India, USA, Taiwan, Australia, Mauritius, Brazil, the West Indies and Mexico. Kenya has exported vegetative material to Ethiopia, Somalia, Tanzania, Australia and Zimbabwe. Loss of viability of the vegetative material while in transit is often experienced.

Wild crop relatives in East Africa

The Kenya sugarcane breeding program is still in its infant stages. Hence, no efforts have been made to collect, maintain and evaluate wild species or wild relatives of sugarcane. However, of the sugarcane and related grasses *Saccharum edule* Hassk., *S. officinarum* L., *S. sinense* Roxb., *S. spontaneum* L. , *Miscanthidium violaceum* (Schw.) Robyns, *M. erectum* (Steud.) Hubbard, *Miscanthus floridulus* (Labill.) Warb., *Narenga porphyrocoma* (Hense) Bor and *Sclerostya fusca* (Roxb.) A. Camus occurring wild in East Africa only *Miscanthidium violaceum* (from Uganda) and *Saccharum spontaneum* (from Kenya) have been collected (Price 1968).

Proposed management and organization of plant genetic resources

The nature of collecting, conserving and utilization of plant genetic resources requires national and international coordination. Management of national plant genetic resources in Kenya should be effected by setting up a Plant Genetic Resources Centre, as recommended earlier (Proceedings National Seminar on germplasm & Seed technology 1986). The centre would coordinate the network of national and regional research centres, institutions of higher learning and other agencies to collect, introduce, maintain and catalogue and distribute all types of germplasm. Most of the research centres in Kenya are organized around crop commodities for which the Director of KARI is responsible. The research centres have specialist committees. For the proper management of plant genetic resources, it is suggested that commodity specialist centres are strengthened. These committees should comprise plant breeders, plant pathologists, entomologists, crop physiologists , etc. The responsibilities of the specialist committees in conjunction with the Plant Genetic Resource Centre should include:

1. to prepare reports indicating national progress in collecting, conserving and utilization for each crop of significance to Kenyan Agriculture.
2. to identify strengths and weaknesses, and to recommend actions to be taken.

KARI should provide leadership and funding of plant germplasm conservation and utilization. The Minister of Agriculture or the Ministry of Research, Science and Technology should be responsible for policy formulation.

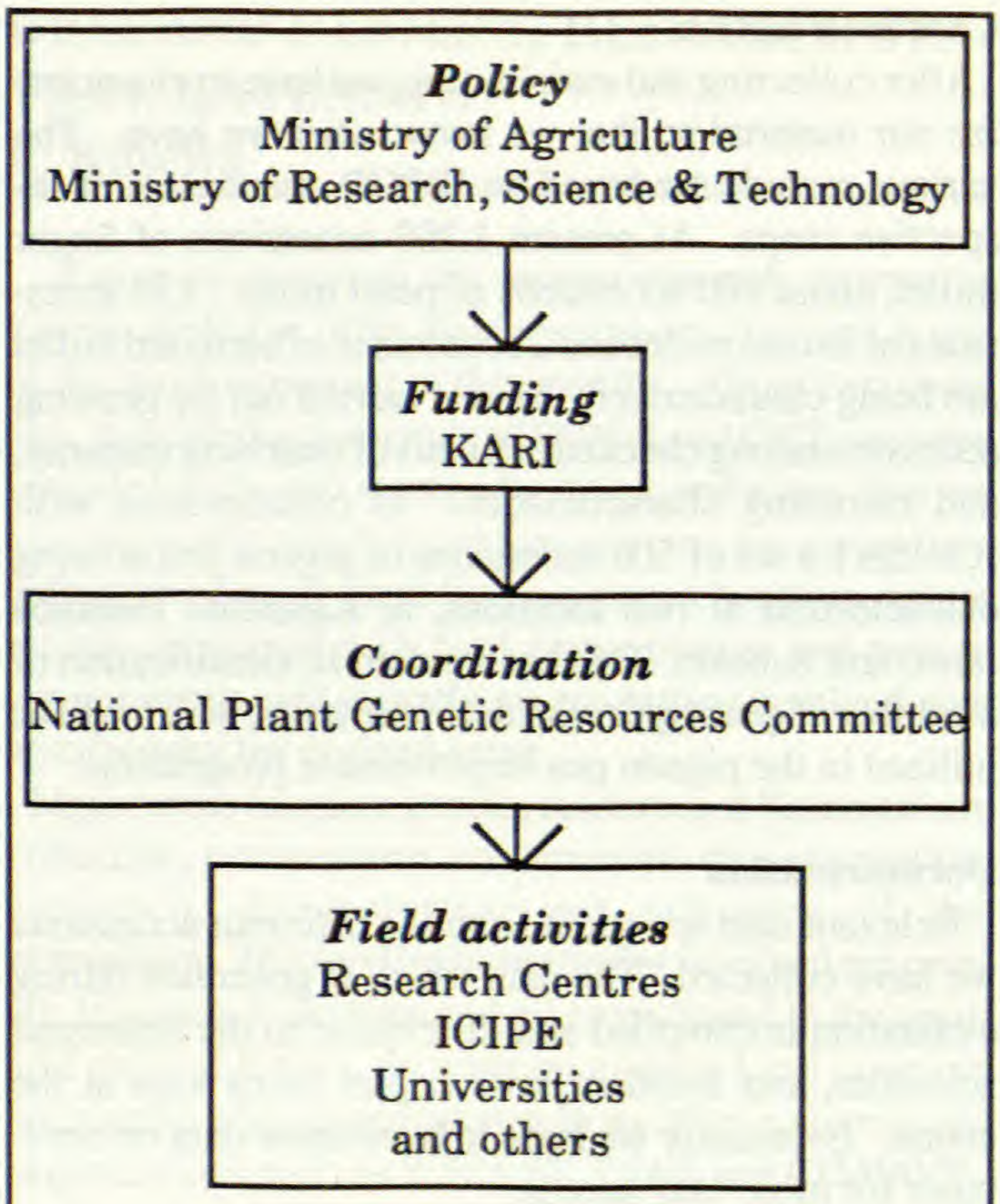


Figure 1

Personnel requirements

Qualified scientists are needed to strengthen the plant breeding programmes, and these should be leaders in plant genetic conservation, evaluation and use. The sugarcane germplasm collection is hampered by the non-availability of qualified staff. A training programme for local staff on germplasm handling should be mounted.

REFERENCES

Jagathasan D. 1985. *Sugar Gene Journal* 6: 12-14.
Muturi S.N. 1986. Kenya Sugar Authority Statistical

Series 1986.
Price S. 1968. Chromosome numbers in miscellaneous clones of Saccharum and allied genera. *Proceedings of 13th congress of the International Society of Sugarcane technologists,Taiwan*: 921-926.
Proceedings of the National Seminar on germplasm and seed technology. Nairobi, Kenya, 1986.
Sankaranaranayanan P., Krishnamurty T.N. & Satish Rao C. 1968. Germplasm evaluation in sugarcane foreign hybrid varieties (Barbados, Queensland Australia and USA). *Proceedings of 13th congress of International Society of Sugarcane technologists, Taiwan*: 892-900.

NATIONAL AGRICULTURE RESEARCH STATION, KITALE

D.K. Muthoka

The Station is responsible for keeping maize, forages and pasture, fodder shrubs, sorghum and rice germplasm. Germplasm is kept both in cold storage and in the field; the latter is true for fodder and pasture plant species; cold storage is used for maize (3.216 accessions), pasture, forages and fodder shrubs (10.325 accessions), sorghum (5.241 accessions) and rice (200 lines).

Maize

Maize was introduced in Kenya in 1494. Caribbean flint types of maize, still predominant in the East African Coastal strip, were introduced by Portuguese and Arab explorers and traders.

The big and sudden rise in the importance of maize followed the introduction after 1900 of a different type from South Africa. The most successful introductions to Kenya were Hickory King, (Natal) White horsetooth, Ladysmith white, Salisbury white, Champion (Potchefstroom) white pearl and Iowa silver mine. Hickory king had been introduced to Natal from the USA shortly before the Boer war. South Africa had also imported, or derived, the other stocks from the Southern USA, and they can mostly be classified as white southern dents. These have originally come from Mexico, and show particular affinities with the cylindrical dent race Tuxpeno.

The last distinct type of maize to arrive in Kenya prior to modern introductions was the high altitude race Cuzco from Peru.

The local yellow maize, still found in East Africa but now declining in use, is probably derived mainly from early introductions of Caribbean flint, and partly from later introductions via South Africa of yellow dents.

The many different types of famine-relief maize that have often been shipped in , seem to have left little contribution, perhaps because most of them were not suited to Kenyan climate and altitude.

We now have over 3.216 new maize introductions in cold storage. Some of these are being used by breeders in breeding varieties/hybrids with resistance to leaf blight (*Helminthosporum turcicum*), leaf rust (*Puccinia sorghi*) and *Puccinia polysora* and maize streak disease.

Pasture and fodder

Eastern Africa is recognized as the centre of origin of 8-10 of the most economically important tropical and sub-tropical pasture species, contributing 20-25 % of total sown pasture species. It is also a fact that East Africa's indigenous grasses are the most outstanding in yield and quality in the tropical and sub-tropical regions. Since 1951 rapid progress has been made in the forage collection and introduction of pasture grasses and legumes. The richness of grass species (594 species) in Kenya offered an excellent chance of selecting better varieties. Bogdan collected 4.661 entries during 1950-1973. The local collection of ecotypes comprises 1.369 grasses, 908 legumes and 40 shrubs. New introductions

include 974 grasses, 1.227 legumes and 143 shrubs.

Further collection and introduction was carried out by the FAO Trust Fund Forage Collection and Evaluation Project (TF KEN 29 NOR) which was based at Kitale during 1974-1982. The local collection comprises 2.067 grasses, 951 legumes and 254 shrubs. The introductions include 648 grasses, 1.115 legumes and 629 shrubs. The term fodder shrubs and herbs is used in a broad sense, including shrubs and broad-leaved herbs, including the less important legumes.

Further improvements were made by mass collections of further grass ecotypes, which can be partly attributed to the success achieved in the selection programmes of Rhodes grass and Nandi setaria.

Laborious efforts were made by Ibrahim and Muthoka to document the enormous amount of information collected by Bogdan. By relocating his collection on soil, vegetation, ecological and rainfall maps, very valuable and interesting information was extracted.

Imports and exports

Imports of germplasm come from international agricultural research centres such as CIMMYT, IBPGR, ICRISAT, CIAT and ILCA.

Germplasm is exported to many African and overseas countries.

Other functions

Plant breeding and selection is carried out at the station, especially on maize, forage plants, fodder legumes, fodder shrubs and pastures.

Constraints

The station is hampered in its task by:

1. lack of trained personnel
2. lack of training facilities
3. lack of storage
4. lack of facilities such as computers, seed driers, packaging machines, etc.

Proposed future action by National Gene Bank

1. collection and exploration coordination
2. documentation of germplasm
3. manpower development and training
4. providing facilities

COFFEE RESEARCH FOUNDATION, RUIRU

J.B. Owuor

Coffee forms one of the leading commodities of international trade, and for Kenya it forms one of the major sources of foreign exchange.

Africa has potentially the largest area suitable for coffee production; unfortunately, the continent only accounts for 25 % of the world production of coffee. This could be improved vastly, if we would utilize our vast genetic resources to combat production problems: mainly diseases and pests, and the deterioration of soil fertility.

Contrary to what one would expect, the Coffee Research Foundation does not have a clear mandate to specify that it should take charge of the conservation of coffee genetic resources. This fact is not given the kind of importance which it deserves.

The current inventory of germplasm at our research station is basically arabica coffee. Of the many species of coffee that exist, only two are important: *Coffea arabica* and *Coffea canephora* , which is robusta coffee. Of our ca. 1.000 accessions, over 970 are of *Coffea arabica* and of these most are already exploited. So there is little room in which a plant breeder, faced with future problems, can move to find material to utilize.

It is not often realized that along with Ethiopia and Sudan, Kenya ought to be considered as a centre of origin of *Coffea arabica*. French workers have recently provided evidence that arabica coffee originated in parts of Nandi and Marsabit. Taking this into account, it seems rather a sorry state that we have not made any collection missions in these parts of the country, and that we do not have any material in our collections collected by Kenyans. The missions which have been here to collect were French, such as ORSTOM and FAO missions, and the material from Kenya we have is duplicate material from these missions.

So one of our proposals is that national collecting missions, where CRF collaborates with a national centre, should be undertaken immediately - because agricultural activity, including the growing of introduced coffee, is fast encroaching in these areas.

We also have proposals on how a National Plant Genetic Resource Centre should be set up, and what kind of functions would have to take our centre into account: increasing the genetic pool, ensuring the conservation of bank material, evaluation of bank material, to create an implementation and analysis unit, and to dispatch material and information to the centres as well as training.

AGRICULTURAL DEVELOPMENT CORPORATION

H. D'Souza

The Agricultural Development Corporation is one of the National Statutory Organizations. It is charged with the responsibility of managing state farms in the National interest. Over 30 ADC farms exist; they are located mainly at the coast, in the high altitude areas of Molo (over 2400 m) and at the medium altitudes (1800-2000 m) of Trans Nzoia.

The management of state farms also involves maintenance of perennial crop varieties which were inherited from the previous colonial owners of the farms; this is especially true for citrus. As part of our development strategies, large orchards have been established and fruits of temperate origin such as apples, apricots, pears, peaches and plums have been imported. Some varieties of these trees have not adapted very well but they have been preserved in small numbers, while the productive varieties are planted on a commercial scale.

It may be of interest to note that ADC is also actively involved in the multiplication of all potato varieties and cereal crops for commercial use. This is simply the maintenance of quality seed in the national interest.

Whereas many public or private institutions have the freedom to keep their plant collections, it is suggested that the National Research Centres should take the responsibility for collecting, identifying and maintaining the plant genetic materials that are best adapted to their climatic conditions. This should be done under the guidance of a central committee.

COASTAL AGRICULTURAL RESEARCH STATION

O.C. Njue

While the main station is situated at Mtwapa, there are sub-stations at Matuga, Msabaha, and Mpeketoni in Lamu. We deal with crop plants such as coconut, cashewnut, citrus, mango, sugarcane, pineapple and banana; minor crops are soya, simsim, guava and chiku. Cassava is an important crop on which much research is done. We also have some fodder crops, grasses and pasture legumes, on which we are cooperating closely with Kitale. As Dr. Osoro has mentioned, we do most of the flowering of sugarcane. We also undertake some breeding work and there are about 104 cultivars of sugarcane. Maize breeding is another of our activities, and quite good work is going on.

We also have cold storage facilities, in which we conserve plant germplasm of some legumes, such as cow-pea, pigeon pea, greengram and groundnut. These have to be put in the field at intervals, as we only have short- and medium-term term cold storage.

We also cooperate closely with the National Horticultural Research Station at Thika on citrus, mango, banana, pawpaw and grape.

KENYA SEED COMPANY, KITALE

M. Ndambuki

While our headquarters are at Kitale, we have a number of branches handling various crops: maize is basically at Kitale, wheat and barley are at Nakuru, vegetable seed is handled at Nairobi and we have our processing plant there as well.

Our company started in 1956, mainly for sunflower seed production for bird feed in Europe. In 1958 the company took up pasture seed production for grasses developed by the then Grassland Research Station for dairy farmers. In 1963 we started on hybrid maize seed production, now our main activity, and later on wheat and barley. We now grow a lot of wheat and barley on contract for the breweries; recently the Ministry has approached us to bulk-grow soya beans. We already grow sorghum, soya, and vegetables for seeds.

I must say that the custodians for this basic material are the research stations, as they are the source of the elite lines which they pass over to the company for multiplication. At our Elgon Downs Farm at Endebess we do some maintenance in growing basic material, communicating with the breeders to keep the variety true to type. In this we work closely with the National Research Stations; in our control plots we ensure that the material we pass on to the farmers is the same as it was originally developed by the breeders. We also run some research mainly to solve seed production problems, and we also try to develop our own material, working from material from foreign seed companies.

We do have problems, such as the isolation we have to apply to keep lines of crops pure. This does give land problems; a lot of our seed, in maize especially, is grown on ADC farms.

We work closely with the inspection service, the National Seed Quality Control Services. We also fall under the International Seed Trade Association, as we also export some of our seed, so we have to meet their standards as well.

We are working more on the utilization of genetic resources than on conservation, but we do conserve our elite lines. We have a cold store, but not a very reliable one; our plans are to build another one for breeding material and one for storing basic material, as we intend to have at least 25 % carry-over stock, to meet adverse weather conditions.

TEA RESEARCH FOUNDATION OF KENYA

C.K. Njuguna

The foundations' main object is to promote research into, and to investigate all problems relating to tea and such other crops and systems of husbandry as are associated with tea throughout Kenya. One of our responsibilities is the improvement of the tea crop, both in yield and in quality.

Tea germplasm and maintenance

The foundation introduced tea planting material, both seeds and clones, from all parts of Kenya and from Uganda, Tanzania, Malawi, Zaire and Reunion. This tea is maintained at the Foundation's Timbilil Estate, Kericho.

Tea is an open-pollinated crop and in a field of seedling tea every plant in that field is different genetically from any other plant. This means that at the Foundation there are as many genetically different tea plants as there are seedlings, which at Timbilil Estate means tens of thousands. Tea plants are known to live for up to 100 or more years. The oldest plants on Timbilil Estate are about 30 years. As tea seed viability is short the tea germplasm has to be maintained in-situ.

In the late 1960s it was decided that any tea clone which was found to have low yield would be uprooted, and its area used for other experimental material. It was later realised that even low-yielding clones may be useful later in characters other than yield. It was therefore decided that all clones planted in the field would in future be maintained unless a clone failed to survive. Now over 2600 clones are maintained.

A museum of the major Kenyan tea clones has recently been established at the Foundation. To date 62 major and 12 minor clones have been included in the Museum; more will be added as they become available. Also the major tea seedling stocks, commonly known as jats, found in Kenya will be added to the Museum. To date 5 jats have been planted in the museum. Land will be available in the near future for further expansion.

Though there has not been a problem of land availability at the Foundation's Timbilil Estate to date, the Foundation would like to have a substation somewhere East of the Rift Valley where some of the major tea types can be duplicated for preservation. This would also give an opportunity to test planting material more widely.

Import and export of tea germplasm

Before the break-up of the East African Community there was no problem of getting tea planting material from either Uganda or Tanzania. Now it may be difficult to get planting material from these countries. However, Kenya has most of the tea types found in these countries.

If the need arises, the Foundation can import materiai from other African countries through the Plant Quarantine Station at Muguga. This Station is not well-geared to grow tea plants but with cooperation from the Foundation it can be done. No live tea material is allowed to be imported from outside Africa.

The Foundation usually does not export tea germplasm apart from small amounts of tea seeds or cuttings for research purposes to other cooperating institutions. The export of tea planting material is generally done by the commercial firms, including the Kenya Tea Development Authority. These firms, however, have to get permission to export tea material from the Ministry of Agriculture.

Tea improvement

Tea breeding and selection is the major research work done at the Foundation. The Foundation also cooperates with the technical departments of two tea companies which are working on the breeding and selection of better tea planting material.

There are no wild relatives of tea indigenous to East Africa.

Manpower availability

The Foundation has found it difficult to recruit qualified scientists such as plant physiologists and cytogeneticists. These are either not there or the remuneration offered by the Foundation is not good enough to attract the right calibre of scientists. At the moment the Foundation is not in a position to sponsor scientists for further studies at the institutions of higher learning.

Management of tea genetic resources

The tea genetic resources are well-managed and utilised in Kenya. There is one tea company uprooting old tea in Kericho and replanting. Before uprooting a few plants in every field are being selected and propagated vegetatively to produce clones for trials. This will preserve the germplasm. The company has allowed the Foundation to join in this programme of selecting better tea material from the fields due for uprooting and replanting.

Woodfuel species

Due to the prevailing world energy crisis, the Foundation has embarked on testing a number of woodfuel species to identify which ones are the best for use in tea factories and for domestic use by smallholders. Currently the genera being tested are *Eucalyptus, Acacia, Casuarina* and *Leucaena.*

NATIONAL IRRIGATION BOARD

O.E. Baraza

The National Irrigation Board was established in 1966 with the responsibility of managing the large scale irrigation settlement schemes in Kenya. To date it has six such schemes distributed countrywide. These are Tana, Mwea, Ahero, West Kano, Bunyala and Perkerra Irrigation Schemes. In Tana Irrigation Scheme maize and groundnuts are the main crops; Mwea, Ahero, West Kano and Bunyala are rice schemes while Perkerra grows citrus, bananas, onions and chillies.

Since its inception NIB has been involved in research aimed at improving its operation and increasing the yield of crops. To this end two research stations have been established at Ahero and Hola.

Rice

As this is a non-indigenous crop most of the varieties grown in large scale schemes have come from outside. Small-scale producers in the coastal region however have varieties which they have maintained for a long time, with very desirable characters, but low in yield.

Characters considered during selection include yield, resistance to prevalent diseases and pests, stem rot etc., milling qualities, cooking and taste qualities, and adaptability to the growing environment. No single variety combines the optima of all these characters, hence the need to do breeding work. It is necessary to preserve seed of varieties with desirable characters for use in the future.

Cotton

This is also a non-indigenous crop. Current commercial stock-breeding is done elsewhere in East Africa but resection has been done locally. Variety selection material has come from cotton-growing areas from all over the world. Characters for consideration during selection include quality of fibre, ginning out-turn, resistance to diseases and adaptability to the growing environment. The need to preserve material with desirable characters applies here as well.

Conclusion

Changes in policy on quality characteristics and/or pricing of the material for commercial production also requires that tested material of desirable characters be preserved.

We propose that for short-term storage of genetic material the National Commodity Research Stations could coordinate, but for the long term we think there is a need for a National Gene Bank to undertake this work.

WESTERN AGRICULTURAL RESEARCH STATION, KAKAMEGA

J.K. Rutto & C. Mburu

The centre deals with crops, pastures and fodder, not to mention animals. Mostly these commodities are dealt with in collaboration with other stations. Specifically, the centre deals with sorghum, maize, finger millet, beans, local and exotic vegetables, groundnuts, soyabeans, fruits, cassava, sweet potatoes, pasture and fodder. However, the centre's responsibility as far as plant genetic resources is concerned is partial and includes *Sorghum bicolor, Eleusine spp., Arachis hypogaea, Glycine max, Manihot spp., Ipomoea spp.*, local vegetables and fodders. These are both conserved in the cold store and in working collections in the field.

Other germplasm conserved in the field include:

1. Banana, with 23 lines, both local and exotic. Replicates in other locations are necessary.
2. Cassava, with 34 lines, both local and exotic. Promising lines are also maintained in other Government institutions around the centre, where they are in danger of being lost due to poor care and casual stealing. More replicates in different localities are necessary, as well as tissue culture.
3. Sweet potato, 40 lines, both local and exotic. Virus diseases threaten the crop, and more sites are necessary for maintenance.
4. Fodders: 10 lines in the field and some in seed form. Not many problems.
5. Fruits: citrus, 7 lines; mango, 9 lines; avocado, 6 lines.

These are all maintained in a small museum, and some are used in propagation work. The problem facing the museum is that of management, due to limited funds. This brings about a shortage of labour for maintenance, purchase of fertilizer, herbicides, insecticides, etc. With mangoes and to a lesser extent the citrus, the material does not seem adapted to prevailing conditions. Therefore replicates in other localities are necessary.

Cold storage is effected at a temperature of 2-10 º C for 2-10 years. Germplasm is conserved for *Sorghum bicolor* (431 lines), *Eleusine coriacea* (97 lines), local vegetables (6 types of local varieties), *Arachis hypogaea* (15 lines, mostly from Muguga), and Glycine *max* (40 lines, mostly from Muguga).

Breeding and selection

Due to a lack of breeders not much work is done concerning the above species. Considerable breeding in Sorghum is being done at the Centre's substation, Alupe. Selection work has been carried out at Serere and currently at Kakamega (W.A.R.C.) on *Eleusine coriacea, Arachis hypogaea, Glycine max* and local vegetables, and to a lesser extent on *Manihot esculenta* and *Ipomoea spp.*

Import and export

The Centre exchanges with other local institutes, but international exchange is only effected as far as *Sorghum bicolor* and *Eleusine coriacea* are concerned; imports are done from ICRISAT, India, CIMMYT, Uganda, Ethiopia, Sudan and other countries.

Constraints

Germplasm is usually imported or exported through the Plant Quarantine Station at Muguga for phytosanitary certification and it takes rather too long for the germplasm in question to reach its destination. Lack of knowledge of the available germplasm and where it can be found limits importation of material of particular importance. There is a need, therefore, for a National Gene Bank to document the world as well as the local germplasm and to give the documentation as wide a circulation as possible.

Crop relatives: wild species

As hardly any breeding work is being done, no wild relatives have been put to use for breeding work. However, it should be mentioned that the region (East Africa) is very rich in wild relatives of Sorghum and local vegetables. There is a need for a collection mission throughout Kenya for some of the species and their wild relatives, as soon as possible to avoid the loss of germplasm by deterioration of wild plant habitats.

Manpower and/or training constraints

Manpower is lacking at the Centre as far as plant genetic resources are concerned. The personnel concerned with crops are agronomists and not very conversant with germplasm management other than selection and production. Strictly speaking, no one has been adequately trained on the plant genetic resources management. Therefore collection, documentation, maintenance, conservation and usage is carried out independently by various scientists. Personnel should be trained to deal with genetic resources effectively to avoid loss of the existing germplasm.

Management and uitilization of plant genetic resources

Of late, several Agricultural Research Stations have acquired cold rooms from the National Gene Bank, which is a step forward to better management of germplasm. More efforts should be put towards maintenance of these stores. As mentioned earlier the collection of germplasm together with their wild relatives should be a priority, especially for species which are believed to have originated in East Africa. More attention should be given to the already existing germplasm in a bid to conserve, regenerate and document the available material. The documentation should be fed to the National Gene Bank, which in turn can feed all the stations with the national information on germplasm; this would reduce unnecessary duplication of some work by the stations.

Due to lack of trained staff the potential of most of the germplasm has not been exploited. The training of staff is therefore crucial. As plant genetic resources form the basis of all other fields such as agronomy, breeding, pathology etc. it should be given as much attention as these other fields.

UNIVERSITY OF NAIROBI
Prof. D.M. Mukunya

We have looked at the Research Stations as the main research conservators of germplasm. The Nairobi University Faculty of Agriculture has a department of crop science, concerned with crop development, research and education, and a number of staff members are involved in research and conservation of germplasm. This is in collaboration with national institutes such as the Horticultural Research Station; for example, Dr. Njue is now doing research into characterization of local vegetables. With Kusewa we have a collaboration programme on pigeon pea, and currently there are ca. 800 accessions of pigeon pea collected from Kenya and Uganda. We have also been working on beans, and the Horticultural Research Station at Thika should have over 1.500 duplicates of the University collection of beans. At the department of botany there are quite a number of accessions of wild rice.

There are also small accession numbers of maize and cowpeas; but the most interesting germplasm is that of *Rhizobium*, a collection of the various bacteria used as inoculants for grain legumes, forage and crop varieties. These are maintained in the departments of soil science and botany, and I believe that should be part of our National Germplasm resource.

MOI UNIVERSITY
Prof. F. Owino

Most of the efforts at the University towards the conservation of forest genetic resources has been directed towards in-situ conservation: trying to get a part of some forest to be a nature reserve. Those areas have been left pretty well intact, although at the moment there are some problems of destruction and disturbance, just as in many other forests. Within these reserves we still have a very broad base of biological diversity, and probably maximum genetic variability with respect to individual tree species.

One point which I would like to raise is whether this strategy of nature reserves is a realistic one for the future. This strategy requires a fairly specific legal framework. I am not convinced that the nature reserves as we have them now are sufficiently protected. Examples such as the very valuable small blocks of forest at the coast, the kayas, are probably better protected under the National Museum. But I will leave this issue for discussion later.

We do have much woody vegetation in the arid and semi-arid zone and this is threatened. From the foresters point of view this area is less known than the closed forest and this is the one area that calls for a close working together between ecologists, foresters and wildlife people. This belt is very important, it covers large tracts of this country, and it is neglected from the point of view of foresters; the ecologists working there are usually not tree people.

The mangrove forests of the coast are also facing destructive pressure at the moment; this is a very valuable forest type which must be maintained and which will require special conservation strategies.

The bamboo forests have also been in the news recently, and there is pressure on the Forest Department to restore these to their former state.

The only other development which I would like to highlight is that there is now increasing interest in indigenous trees, and special emphasis is given to multipurpose trees. A start has been made at the University to survey and collect from individual species.

We have started a small germplasm collection at the University, and I hope that together with KEFRI this will improve.

As one of the basic issues I regard the manpower shortage. We have to create germplasm for future needs, and this is true for both forestry and crops people.

There has also been a suggestion about a national germplasm documentation centre. Should we pool all documentation, for both trees and crops, or should we keep these separate? I hope that we can have an institution large enough to care for both, taking into account the shortage of manpower we have noted.

FOREST DEPARTMENT
J.R. Wawiye

Forestry is currently under pressure from the agricultural people. Everybody wants land that the forest is occupying, and we are trying our best to conserve, and indeed increase, what we have. As you know, there is a lot of work going on in agroforestry. KEFRI is a very important institution and needs a lot of support to do what it can do. We cover ex-situ and in-situ germplasm: in-situ we have about 2.15 million hectares of indigenous forest reserve, and about 50.000 hectares of nature reserve, plus 32.000 ha of indigenous hard and soft wood plantations. We also have 150.000 ha of exotic species, these being mainly used for industrial purposes.

In the indigenous forest we have restricted selection geared to promote diversity and quality of the crop. Implementation is sometimes difficult because sometimes people come in and cut trees without a licence. At the seed centre we are working on selection of indigenous species, starting with high-priority ones; the aim is to have a minimum of 50 trees selected so that we can keep a broad baseline.

We also have clonal banks of pines and cypress; for species such as *Pinus caribbea var. hondurensis* and *Pinus oocarpa* selection has been done.

In the centre we also have cold storage facilities: the short term one (+3 º) is mainly for incoming and outgoing seed; the long term storage is at - 18 º. Since there is not enough information on indigenous species we have started storage trials to see at which temperature species should be stored.

We import and export seeds for research or for afforestation programs and for breeding and selection. We work together with the breeding section on this.

As regards manpower, we need more staff. In the seed centre we do not have enough staff, and for the whole institute the position is the same.

I would like to suggest that plant germplasm conservation is integrated in the National land use agenda; that a legal requirement is introduced for environmental impact assessments; that there comes into being a mandatory ban on further alienation of forest lands, and that agriculture productivity in existing agricultural areas is increased, by the adaptation of modern farming methods under the green revolution packages; and that a realistic balance is struck between conservation and the production functions of our forests.

OPPORTUNITIES AND LIMITATIONS OF MULTIPURPOSE TREE AND SHRUB GERMPLASM SUPPLIES
P.G. von Carlowitz

Introduction

During an international workshop on multipurpose tree germplasm held in 1983 in Washington DC the general concern that internationally the availability of germplasm for lesser-known multipurpose tree and shrub species is insufficient and may therefore retard development of agroforestry and other forms of integrated landuse was voiced. Consequently, one of the recommendations of the workshop was to carry out a survey of suppliers of such germplasm and to publish a specialized seed directory which would facilitate communication and trade between those who require germplasm of multipurpose tree and shrub species for research and development activities and those who can supply it.

From late 1985 to early 1986, such a worldwide survey of seed suppliers was carried out. Questionnaires were sent to more than 400 government-based seed banks, seed banks operated by research institutes, international organizations, development agencies and commercial seed suppliers. About 100 of them responded and their particulars were published in the first edition of the "multipurpose tree and shrub seed directory".

Critical analysis of the survey results

It came as a surprise, and to some extent made nonsense of the general concern over insufficient germplasm availability, that the 100 suppliers listed stated their ability to supply for close to 700 of those species which by ICRAF's definition qualify as multipurpose tree and shrub species. This surprisingly large number of species may be even bigger considering that a sizeable number of species contained in some of the suppliers' seed lists could not be clearly identified as multipurpose species due to the use of insufficient or unclear taxonomic nomenclature.

Another surprising aspect evident from the data regards the range of prices for seeds of various species. Differences in price of over a thousand per cent per kilogram of seed of a particular species are quite common. This even applies to more commonly known and commonly used species such as *Acacia albida*. The prices quoted by the 19 seed suppliers who can provide this germplasm range from US$ 4 to US$ 106 per kilogram. *Azadirachta indica* with 18 suppliers and a price range of 5000 per cent is another example. Even in the case of the widely spread and well known *Leucaena leucocephala*, the prices differ from the cheapest of the 38 suppliers to the most expensive one by 1300 per cent. A lot of other examples could be cited.

A closer look at the location of the different suppliers, the species they trade in and the prices they charge suggest that prices are not necessarily low where the seeds can be collected nearby, or that they are high when the natural seed source was obviously far from the suppliers' location. Equally, the abundance of flowering and fruiting that are characteristic for certain species do not seem to influence the prices distinctly.

Although some allowances have to be made with regard to high prices occasionally and justifiably charged for research quantities from expensive collections abroad, the wide-ranging price scales indicate an obviously rather disorganized and uncoordinated market, particularly for lesser known species.

It is also obvious that high prices are not necessarily related to high quality of seeds or vice versa. This impression was not confirmed but was supported by random purchases of seeds from some suppliers.

Although the survey may have been useful in facilitating communication between seed requesters and seed suppliers, in identifying the large number of species for which seeds are available, and in exposing a price structure which leaves much to desire, it also has its limitations. Within the limits of the number of questions one can ask with a reasonable likelihood of receiving answers, care had been taken to assess the competence of the seed suppliers. However, information received on their institutional status, sources of germplasm, ability to provide proper seed documentation, and methods of and facilities for seed storage methods and facilities may give some indication as to their professionalism but cannot provide conclusive evidence of the level of reliability.

It provided equally difficult - in fact, almost impossible - to assess the quality of the germplasm which is offered by the various suppliers. Even in cases where suppliers stated that seeds are collected by their own staff and from their own seed stands or orchards, there were no reasonable means and ways to find out whether the basic rules for seed collection were being observed.

The selection of healthy, vigorous parent trees which are not overmature and the avoidance of isolated trees of naturally cross-pollinating species is one consideration. The definition of utilization-oriented ideotypes to provide guidelines for the selection of parent trees of the appropriate phenotype is quite another. While it can and should be expected that the basic rules mentioned above are normally observed, it cannot be expected that ideotype-oriented selections of parent trees of multipurpose tree species are being conducted. Researchers concerned with the use of woody perennials in agroforestry systems or other forms of integrated land use have so far failed to provide definitions of utilization-oriented ideotypes although this is an increasingly important aspect of germplasm improvement of multipurpose trees and shrubs. Therefore seed collectors and suppliers cannot be held responsible for the omission of such considerations.

Some reports received from seed suppliers indicated that they keep stocks of, or are able to provide, more than one provenance of seeds for individual species. This is particularly true for better-known species such as *Gliricidia sepium, Leucaena leucocephala* and some *Acacia* species. However, it was difficult to accommodate all this detailed information in a seed directory without enlarging it to a bulky publication which would then be difficult to handle as a reference tool on seed sources. Nevertheless, the second edition will take account of such important additional details and will mention, in the remarks column for individual suppliers, the availability of several provenances wherever applicable.

Conclusions and further needs

There can be no doubt that renewed efforts are necessary to inventorize more seed suppliers in order to gauge the full range of multipurpose tree and shrub species covered in terms of seed supply. This would not only provide a better and wider range of facilities for the development of agroforestry and many other forms of mixed land use, but may also contribute to the ex-situ conservation of germplasm. The previous survey carried out by ICRAF, involving only a fraction of all companies, institutes and organizations engaged in collecting, trading and distributing germplasm covered close to 700 species. This indicates that for more species than these germplasm is collected, stored and available for use. No attempt has been made so far to analyze the list of species covered in order to identify those species among them which are rare and probably endangered. However, it is not unlikely that the existing large number of seed collectors and suppliers can make and already are making a positive contribution to the ex-situ conservation of germplasm.

KENGO: KENYA ENERGY NON-GOVERNMENTAL ORGANIZATIONS

L.Kangethe, G. Arum & A. Aworry

Introduction

When we are talking of in-situ conservation, let us not just talk about the habitat, but also on the ecology of that habitat. As scientists, it is very easy to talk of inventories, gene banks and data banks - but is that enough? Are we keeping inventories of things which do not exist anymore? How do we link this process of data collection and documentation to the survival and multiplication of what is already there? We must enact strategies that respects both this scientific process and the social aspect of public awareness, public education and policy action. Without due regard to these issues we will be working on a hollow perspective.

The conservation of genetic resources can only be achieved by local participation at the grassroots level. It is therefore of paramount importance that indigenous knowledge on habitat management be taken into consideration in the development of a national strategy on genetic resources; such as traditional resource utilization and indigenous land use patterns and systems. The dissemination of information on the value of genetic resources must be given priority if such management and observation is to be achieved.

Rural grassroots communities should be involved in the planning, development, management and utilization of nature reserves. This will ensure that the target community hosting the nature reserves benefits directly from the exploitation of these resources. A greater sense of responsibility and the need to conserve natural resources will naturally be instilled in the public if such an approach is used.

KENGO's efforts in creating awareness on the need to conserve and manage genetic resources focus on indigenous trees. Since 1983 KENGO is undertaking research and is disseminating information on indigenous trees; this dissemination takes the shape of forums, seminars and workshops; of public exhibitions with slide shows, displays of plant specimens, seed and tree profiles; and of publication of articles in local dailies on indigenous trees and seed, as well as weekly radio programmes. Educational material on trees and seeds are also produced.

Research on indigenous trees

The principal purpose of KENGO's research is to collect information on the uses and value of local tree species as perceived by the local communities. It is by no means intended as a botanical survey; however, researchers can benefit from the wealth of useful data it has made available.

Data collection field trips generate dried plant specimens with full botanical descriptions; photographs of trees, showing both the whole tree and close-ups of flowers, seeds, leaves and bark; tree seeds for germination trials; and data collection via comprehensive questionnaires, either botanical (data on localities, natural habitat, and phenotypic characteristics) or socio-economic (data on fruiting and seeding time, seed dispersal, seed treatment; propagation methods; local uses; agroforestry potential; limitations of the tree, such as susceptibility to pests and diseases, known toxicity; and socio-cultural aspects such as taboos). Questionnaires also try to ascertain which tree communities have dissappeared from the area and why. This information is sought from older members of the community.

Data compilation is finalized by literature review and consultation of resource persons in relevant organizations such as the Forest Department, the University of Nairobi and the East African Herbarium.

Results

So far 28 articles have appeared in local dailies; the "KENGO news" also publishes articles; 12 district workshops on agroforestry and tree planting have been held; a major workshop has been held during the UN decade for women conference in 1985; a journalist workshop has been held on environment and development; and a workshop has been held for media policy makers on environment and development.

All these promotional activities have contributed to the change in national policy on the planting of indigenous trees for conservation at the grassroot level.

The project has so far been concentrating on the trees of the arid and semi-arid areas of Kenya, and a book on 109 trees is in the process of being published. The next area to be surveyed will be the coastal zones, and finally the high potential areas.

A special survey of the indigenous fruit trees of Kenya will be embarked on in August 1987.

In the pipeline is a project on the indigenous vegetables of Kenya, to be started in August 1987.

Research on seed

As public awareness on the value of indigenous trees has been raised, the problem arises that there is little or no documentation on seed germination, viability, procurement and handling. Systematic knowledge on presowing techniques and on the mass production of seedlings in tree nurseries is scarce or lacking. To fill this gap, KENGO initiated the tree seed project.

The methodology is to carry out, in collaboration with J.K.C.A.T., ground seed germination trials, to do growth performance tests on dryland indigenous trees, to carry out in-situ conservation of selected dryland trees and to do extension work to educate and create awareness in college students and the local community.

In this project KENGO collaborates closely with KEFRI, the University of Nairobi and JKCAT.

Seed stands for 40 dryland indigenous tree species have so far been established, and more will follow. Data on propagation trials for these 40 species are being collected, and will be published.

About 4000 seedlings have been distributed to the local community.

40 extension workers have been trained on the various aspects of seed collection.

Two publications have been produced: "How to collect, handle and store seeds" and "Pocket directory on trees and

seeds of Kenya".

Slide shows prepared at KENGO include: "seeds for tree planting"/"Mbegu kwa upandishaji wa miti", a how-to on seed technology, in english and swahili; "the value of indigenous trees" (in english).

Several workshops for media personnel (journalists workshop at Homa Bay, media policy makers workshop at Kabarnet, and a workshop on the value of indigenous vegetation in Nairobi) recommended the research on, and writing of a report on the state of seed and genetic resources in Kenya. This report has now been published by KENGO.

WILD POPULATIONS

THE STATUS OF WILD POPULATIONS

Ndegwa Ndiang'ui

Life support systems are centered on primary productivity as the single most common denominator. And while plants form the resource base in ecosystems, they have not received the attention they deserve as regards their conservation. Wildlife conservation has over the years tended to concentrate activities on the fauna with little emphasis on the flora. And in general the case for plant resource conservation has not been articulate enough to bring them to the forefront along with other competitors for land and financial resource allocation, as well as for public appreciation.

There is a very large and yet unrealised potential value of the indigenous flora in tropical Africa. But with the rise in human population and the rate at which stocks of wild populations of plants are disappearing due to other land uses, it is probable that some species will disappear even before we know that they existed. Thus the potentially beneficial germplasm is largely untapped, whether for its value in agriculture, horticulture, medicine, industry or other purposes. Some of this germplasm is faced with extinction.

The various wild populations of plants in Kenya today range from afroalpine vegetation to rock desert to mangrove forests, displaying an enormous wealth of diversity in genetic resources within the various habitats. Some of these habitats have been botanically explored, while others are little known floristically. The purpose of conducting floristic or vegetation inventories in these habitats is to establish the components comprising these communities. On these basic data conservation strategies of the resource in question are founded.

Vegetation inventories and the mapping of plant communities form essential tools in plant resource conservation. But conducting vegetation inventories for a country with such varied habitats as Kenya is an enormous task which requires qualified personnel and a great deal of funding. Even with these prerequisites (which are lacking anyway) the importance of such an institution as the East African Herbarium cannot be overemphasized. The Herbarium is an active institute which has assumed a positive role in the conservation of plant resources. With a reference collection of about half a million plant specimens from East Africa the herbarium is well-equipped with the primary data necessary to start such inventories.

Among its present activities, the Herbarium is involved in compiling checklists of plants of various habitats in the country and in conducting vegetation inventories, especially of endangered habitats. Already checklists have been completed for no less than 20 habitats. In other areas plant collecting has been done without the compilation of such checklists. From checklists various data can be generated, such as the species composition, the levels of endemism and information about endangered species.

The Herbarium has compiled a list of about 50 habitats in the country that are considered to be critically in need of a vegetation inventory. The objective is to try and acquire the basic data in order to have a foresight in problems of ecological stability and species interactions within such ecosystems.

Habitats that have been considered endangered contain species that are themselves threatened. In some cases the threat is due to overexploitation of timber, for example *Podocarpus* and *Ocotea* in the Taita Hills, or *Dalbergia melanoxylon*, the African Blackwood, which has been exploited heavily by the woodcarving industry.

Other species may be threatened due to the reduction in size of their original habitat, e.g. the Taita African Violet, *Saintpaulia teitensis*, which is endemic to the Taita forests; the same is true for a wild coffee species, *Coffea fadenii*. Mrima Hill in Kwale District is another example of a habitat with endemics which has been drastically reduced by intensive agriculture and open cast mining.

Species of plants from the semi-arid environment are faced with threat from the imminent increase in wildlife and livestock populations which exceed the land's carrying capacity. Overgrazing and denudation lead to soil erosion and land degradation, and that includes a genetic erosion of plant resources. Some constituents of this semi-arid environment are wild relatives of crops such as *Eleusine*, *Sorghum* and *Gossypium*.

From a plant resource conservation standpoint the setting aside of a plant sanctuary such as Mutomo Hill Plant Sanctuary serves to conserve and protect plants in their natural habitats, especially in the semi-arid areas.

Wild populations of plants today are rather discontinuous in community structure and form rather isolated sites. Most of these sites exist today in a sea of culturally modified environment; some of these are the only gene pools left for species, and species richness decreases with the decreasing amount of space under vegetation cover. There is an imminent danger of depleting the natural stocks of desirable species, while uncontrolled harvesting ecologically destabilises the ecosystems. The cutting down of the largest and most mature trees constitutes a genetic erosion, especially where there is a lack of documentation to indicate how much wood is in stock for exploitation.

The cause for species extinction in wild populations is generally the reduction of geographic range of the species or the decrease of density of the species within a given habitat. These processes are currently taking place all over Kenya, and they threaten species richness as well as the viability and stability of gene pools of wild populations of plants. We are faced with an ecologically complex problem of determining how small an indigenous patch of forest can be made to maintain a viable population; and this pays little attention to the possible genotypic effects on the populations.

In conclusion I would like to say it is not too late to initiate documentation of species through botanical surveys and vegetation inventories. Research should be initiated to establish growth rates, seed availability, germinability, location of selected genotypes in the field, etc. Research should endeavour to achieve genetic improvement once good genotypes have been identified. Biologi-

cal limitation, especially in the area of genetic improvement, constitutes an obstacle to development, which, if overcome, would enable the world to feed and clothe itself on a sustainable basis, where development would not be destructive to the environment but in consonance with the maintenance and improvement of productive habitats.

THE ROLE OF KREMU

F. Msafiri

Introduction

Conservation of genetic resources can only proceed when we know what to conserve, how much of it, where it is and how it is threatened. KREMU is responsible for monitoring of range resources and high potential plant resources, as well as sources of forage for animals and woodfuel in order to detect condition and trend. In 1977 KREMU started establishing ground stations for collecting baseline data on plant species, their density and biomass. These stations were meant to act as permanent monitoring sites, and therefore they are supposed to be representative for large areas.

Inventories

To be able to assess what there is in terms of plant genetic resources, inventories are the most important activities since they tell us how much of these resources we have.

KREMU adopted two sampling methodologies for doing this - viz. Point Centre Quarter for measuring woody species and Quadrate for estimating biomass and species composition. These two methodologies give us density and species frequencies. They also enable us to detect plants which are indicators of different range conditions as well as endangered species. Some of the indicator species include:

- For overutilized rangeland: *Microchloa kunthii, Oropetium capense, Astripomoea sp.*
- Salinity: *Salvadora persica, Sporobolus spicatus*
- High water table: *Acacia xanthophloea*
- Black cotton soil: *Acacia drepanolobium, Pennisetum mezianum*

From the survey carried out by KREMU in Taita-Taveta and Kwale, some plant species were discovered to be under threat locally and these include *Dalbergia melanoxylon* and *Terminalia spinosa.* Both these species are in high demand for charcoal burning. The felling of *Terminalia spinosa* leads to destruction of other species such as *Acacia* spp. and to a lesser extent *Combretum* spp. As a result of this severe soil erosion has been caused between Samburu and Mariakani.

Some threatened habitats

From some of KREMU's field stations, there are clear indications about some habitats being under threat. Loita plains and the woodlands around Lake Elmentaita are good examples. In 1977, when KREMU station no. 6 was established near Ngore-Ngore in Narok District, wheat farming had not extended south of the Narok - Ngore-Ngore road. Within a span of less than 5 years, the whole of our 10 x 10 km station was taken up by a wheat field (Fig. 1). This is a serious threat to the Loita plains as a buffer zone for wildlife in Masai Mara, apart from the diverse and unique vegetation of the Loita plains themselves.

In the same year, Gilgil Station was established around Lake Elmentaita. Today, the whole station is taken up by settlement. The problem with Gilgil station is the threat to

the *Acacia xanthophloea* woodland around the lake. Although there are probably no people settled within the woodland, there is a likelihood of treepoaching for domestic use, which might cause environmental problems with the lake itself.

Another threatened area is the miombo woodland of Kilifi and Kinango in Coast province. The *Brachystegia* woodland south of Kinango is already being cleared for cultivation and this goes together with charcoal burning of this same species around Mangea Hill in Kilifi district.

Plant species documentation

KREMU is collaborating with the National Museums to document all plant species in all Kenyan herbaria. Presently, there is no comprehensive information system allowing potential users to have easy access to data. This exercise, once completed, will enable individual users to retrieve information on species distribution. This will be made possible by the Geographical Information System computer KREMU is installing. The system will also enable users to identify those species which were collected a long time ago and never since. This enables researchers to check whether the species is extinct, or whether it had been by-passed by collectors due to its rarity. Should the species be identified in the field, arrangements can be made to get the plants conserved, either in-situ or ex-situ.

Conclusion

With KREMU's expertise in Landsat imagery interpretation and vegetation inventories, it is my hope that KREMU will contribute greatly in the inventory of plant genetic resources and in the identifying of areas needed for in-situ conservation.

PRIORITIES FOR ACTION: EX-SITU CONSERVATION

OPERATIONS OF THE NATIONAL GENE BANK

E.N. Seme

There is an awareness now that there is a need for the conservation of our natural heritage. It was the Ministry of Agriculture that initiated the establishment of our National Gene Bank, when it was realized that we are losing germplasm of our natural heritage not only in the field, but also from the research stations. To confirm this, in 1978 some surveys were conducted by GTZ experts, and they revealed that there was a considerable amount of germplasm being lost in the research stations due to the fact that germplasm is kept under adverse storage conditions. GTZ came up with a proposal that a National Gene Bank be established by the Ministry of Agriculture to take care of germplasm. In 1982 this proposal was implemented with technical and financial assistance from the Federal Republic of Germany, and Dr. Abou-Zeid was posted to Kenya to help establish the National Gene Bank.

Since that time quite a lot of work has been done. The establishment of the National Gene Bank is taking place in two phases: phase 1 was to rehabilitate all cold storage facilities in the country, especially in the major research stations. To that effect, 5 cold storage facilities were given to Katumani, Kitale, Njoro, Kakamega and Mtwapa. Also, two workshops were conducted dealing with the documentation of germplasm, as there was no standard of documentation common to all stations. Collection record sheets and data sheets are now standardized, agreeing with IBPGR documentation procedures. We also have a storage file for vegetatively propagated germplasm. Packing materials and sealing machines have also been provided to the stations.

Phase 2 was the actual construction of the central genebank building with its cold storage facilities. We managed to overcome problems of bureaucracy, and at the end of this month the contractors will hand over the central gene bank building to us. We will now start equipping the building, the laboratories and installing cold storage facilities, and we hope that at the end of the year the gene bank will be functioning.

Another aspect is the field gene bank. We have sites for the conservation of some species which we cannot keep in cold storage, e.g. bananas. These field sites are situated at Matuga (for the coastal area) and Matuamba (for high altitude crops); Matuga, being prone to drought, is now provided with irrigation facilities, and bananas, avocados, cashew, some citrus and coconuts are already installed. Another of these field stations is planned in Kakamega.

The purpose of the National Gene Bank as we see it is

1. To organise germplasm and collection missions at a National level
2. To introduce new genetic resources in consultation with other research stations and the National Plant Quarantine Station
3. To deal with the international exchange of germplasm and relevant information,
4. To conserve germplasm temporarily in tissue culture
5. To multiply germplasm and to evaluate on a preliminary basis for specific gene bank purposes
6. To coordinate all crop plant genetic resource activities, seed processing and packaging for long-term storage and long-term deep-freeze seed storage
7. To manage documentation work in Kenya for data collection from research stations
8. To organize technical meetings and workshops dealing with gene bank affairs.

We have now identified a gene bank committee; the members are drawn from various institutions that deal with plant genetic resources. We have been delaying the meeting because of the previous uncertainties over the construction of the central genebank.

ESTABLISHMENT OF BOTANIC GARDENS AND PROPAGATION UNITS FOR ENDANGERED SPECIES

Christine H.S. Kabuye

Plant resources in the wild are regarded as a free source for our requirements, be it for food, medicine, timber, industrial purposes, fuel or forage. But there has been a tendency to over-utilize these sources and often destroying them for other development. As a result a number of species are becoming rare or are near to extinction, warranting conservation measures.

Although conservation of species in their natural habitats is the best way of ensuring their continued genetic diversity, this is not always possible, as the habitats themselves may be threatened. Alternatives must then be found to save at least the ones known to be of potential value. Establishing botanic gardens, preferably with conditions similar to the threatened habitats would help to establish them elsewhere. Propagation units would handle research on the best methods of propagating the various species.

The Workshop on the status and options for the management of plant communities in Kenya, held here at the Museum in March 1984, recommended establishing two major gardens: one in Nairobi and one in Mombasa, as well as smaller ones in each province. This was endorsed by the Strategy conference for the management and protection of Kenya's plant communities, held in August 1984.

Although little has been done to implement this, a few regional Museums have land to develop a botanical garden. In Nairobi there are plans to develop a part of Ololua forest for this purpose. At the coast a small site next to Gedi National Monument can be developed for species adapted to coral.

Elsewhere there are facilities, public or private, which could be improved or developed, such as the botanic gardens at Mazeras (Coast); in Nairobi the Arboretum and City Park could serve as an ex-situ refuge for dry upland species. Suggestions have been made on the possibility of developing botanic gardens at main entrances to National Parks and Reserves, and I would like to learn of any comments on this possibility. With this idea in mind a botanical garden for coastal hinterland species could be sited in the Shimba Hills, while one for the dry interior could be sited at Tsavo National Park. Such gardens will not only be for conservation purposes but will also act as public awareness centres, focusing attention on our plant genetic resources.

In all this, species within threatened habitats will have to be identified, information about their possible use will have to be obtained, and their distribution elsewhere will have to be worked out. This information will determine whether conservation of a particular species in a botanical garden is a priority. Once this need has been established, it will become necessary to obtain propagation material. The propagation units will be advised to collect, grow and multiply material for the appropriate gardens.

Plans are underway to establish a propagation unit under the Museum, specifically to deal with threatened species of economic importance, with medicinal or horticultural potential; an example of the last kind is *Gigasiphon macrosiphon*, a threatened species only known from Mrima Hill. As KEFRI is looking for forest tree seed for future improvement of stocks, so KEMRI should be encouraged to grow plants for medicinal purposes, and KARI is encouraged to consider plants of agricultural importance such as crop relatives or potential new crops.

As planning and managing botanic gardens is a relatively new development, a lot of input will be needed. We will require horticulturalists, nurserymen, landscape planners and technicians, both to man the garden and the propagation units, as well as funds to run the facilities.

The first priority is to organize the Nairobi and Mombasa Gardens while negotiations are started to acquire land for other gardens.

To work through the threatened habitats and to identify the species under threat we need a good number of ecologists and taxonomists, together with transport. The information records at the Herbarium, which are our database on endangered species, need to be put on computer to make retrieval easier and faster.

Baseline knowledge of wild plants and priorities for action

H.J. Beentje

The main priority for action is definitely the protection of example vegetation types. In this, we can define three phases:

1. Inventory of selected sites
2. Formulation of priority sites to be protected, and proposing these
3. Political implementation of scientific proposals

Inventories

I should first of all emphasize that, although not many good inventories have been made, it is already quite clear which sites are priority sites to be protected, as they are examples of vegetation types, and contain rare species as well. These sites can, and should be, protected **now**, and information about these sites can be obtained from articles in "Endangered Resources For Development" (Anonymous, 1984).

There are not many organizations in Kenya that are able to carry out good, integrated inventories. I use the word integrated as not only consisting of a list of plants, but also providing information about the vegetation type(s), about local names and uses of the plants, about the occurrence of rare species, and about the status of, and threats to, the site. KREMU and the East African Herbarium are probably the only two organizations able to carry out such inventories, and of these two the Herbarium is hampered by a lack of transport facilities.

Good fieldguides are another prerequisite for good inventories: at the moment I am working on a new edition of "Kenya trees and shrubs", to encompass all woody plants of Kenya over 1.5 m high; Dr. Agnew is working on a second edition of his "Upland Kenya wild flowers". What is lacking, therefore, is a guide to the herbs of the Coast, and a guide to the herbs of Northern Kenya.

Figure 1 shows inventories undertaken so far. It is clear that some areas, richest in species, suffer from a lack of botanical knowledge; examples are the forest belt of Mount Kenya and the coastal forests. Due to threats on the vegetation, priority in inventories should be given to forests, the limestone areas of the northeast, and woodlands.

Figure 2 was prepared from over a thousand distribution maps of woody species. It shows which areas have been under-collected. Each dot represents at least two plant collections: whether this means just 2 collections or many more was impossible to indicate.

Priority sites

The formulation of priority sites to be protected should be based on a cross-section of representative vegetation types, influenced by species-richness and the occurrence of rare species. The knowledge of vegetation types at this moment enables us to draw up a list of representative vegetation types. Species-richness and the occurrence of rare species often go together in Kenya, and this rarity of species can be inferred from distribution maps, the frequency with which a species occurs, and the distribution of its habitat; status of, and threats to, this habitat also play a role.

For Kenya, not much has been published about rare species, but I am preparing an Atlas of the rare trees of Kenya (Beentje 1988), and there is a preliminary list of rare and endangered woody species (Beentje, 1986). Out of a total number of 1800 woody plants of Kenya, 270 are rare (i.e. 16%); extrapolating to the total number of Kenyan higher plant species, estimated at 7000, over 1100 species are rare, and rare in a world sense, not just for Kenya.

Concentration areas of rare species are, according to these two publications:

1. coastal Kenya, with 50% of all rare species, of which most occur in moist forests.
2. central Kenya: 15%
3. Taita Hills forests: 15%
4. northeast Kenya: 10%

Kakamega forest, although without rare species in a world sense, is extremely rich in species and should be conserved for that reason alone; it is a gene pool of exceptional richness, now sadly being depleted at a furious rate.

Political implementation of scientific proposals

Let me repeat: the necessary knowledge for proposing priority sites to be protected in-situ is already there. Although the data are scanty, enough is known to say which sites are richest in species, where most of the rare species occur, and which areas need quick protection to save them from encroachment and destruction: see **Table 1**. It only needs a concensus, a concerted proposal from the scientific community in Kenya to give the necessary weight to a scientific proposal to the politicians at both national and local level. If such a concerted proposal can be made quickly, and if the local communities are also involved in such a proposal, then scientists, I think, have done their duty.

TABLE 1
Priority sites to be protected

COAST:
Mangea Hill forest (< 5 square kilometer)
Tana River forests (selected blocks, ca. 10 sq. km.)
Pangani Rocks (< 1 sq. km.)

TAITA-TAVETA:
Taita Hills forests (<3 sq. km.)

KITUI:
Mutha and Endau forest (ca. 5 sq. km.)

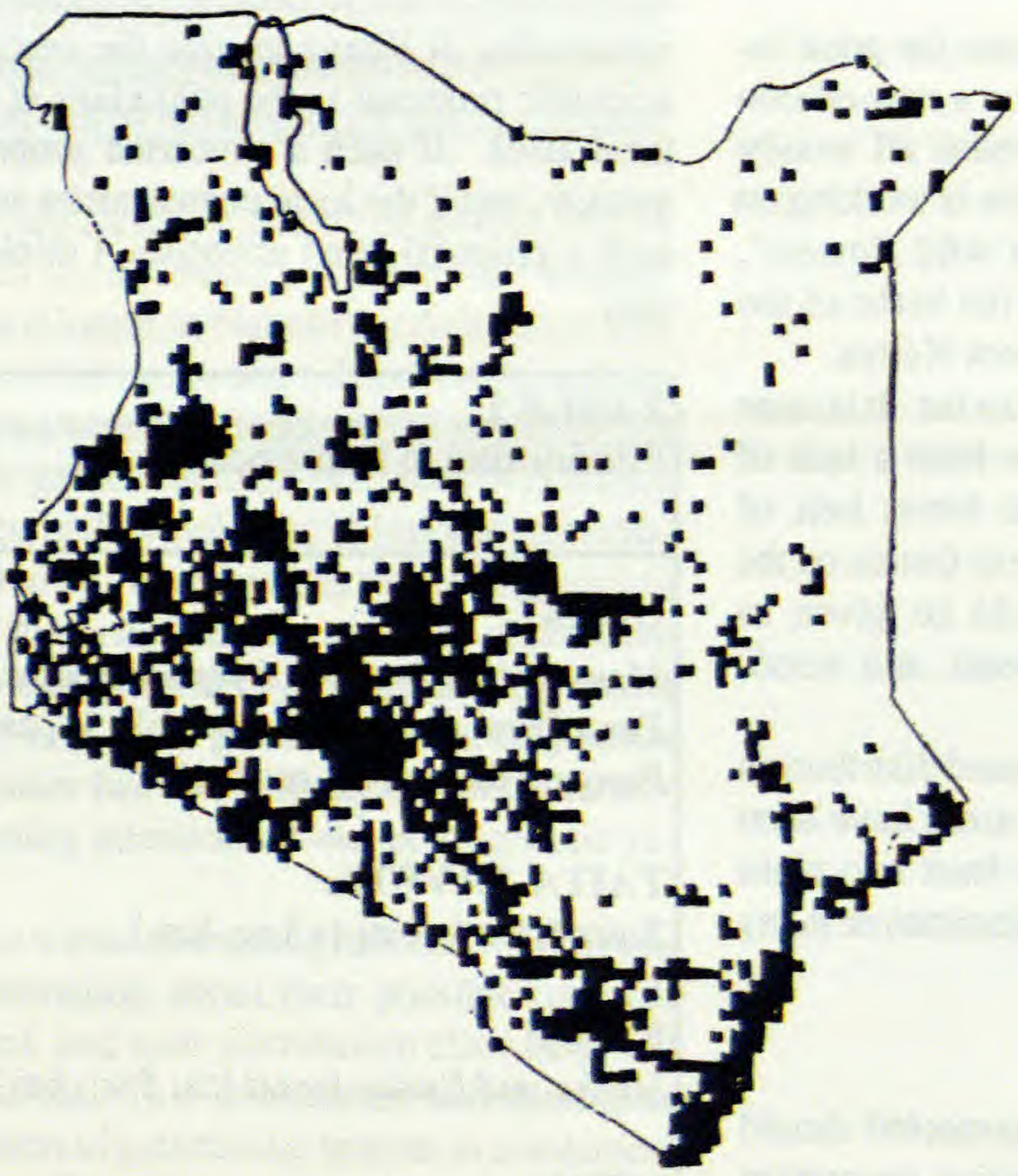
MERU:
parts of *Imenti forest* (selected blocks to ca. 10 sq. km.)

NANDI:
part of N and S *Nandi forest* (selected blocks to ca. 25 sq. km.)



Figure 1. Status of inventarization of areas

See reference list for literature



Black squares denote areas of 32 x 32 km where 2 or more plant species have been collected.
Sample prepared from 1060 distribution maps of woody plants of Kenya.

Figure 2. Collected and under-collected areas

REFERENCES

Agnew A.D.Q. 1974. Upland Kenya Wild Flowers. Oxford University Press.

Anonymous. 1984. Endangered Resources for Development. NES/ETMA, Nairobi.

Beentje H.J. 1986. A second list of rare and endangered plants of Kenya. National Museums of Kenya, internal report.

Beentje H.J. 1988. Atlas of the rare trees of Kenya. *Utafiti* 1, 3: 71-121.

REFERENCES FOR FIGURE 1

NOTE: when several inventories exist for the same area usually the most recent one, or the best one, is the only one to be taken into account. Vegetation maps have not been mentioned except where they are accompanied by a checklist; a list of vegetation maps of Kenya has been compiled by Mr. F. Bulski for UNEP.

Ament J.G. & Gillett J.B. 1975. The vascular plants of Meru National Park. *J. E.A. Nat. Hist. Soc. & Nat. Mus.* 154: 1-34.

Andrews P. 1973. Vegetation of Rusinga Island. *J. E. A. Nat. Hist. Soc.* 142: 1-8.

Andrews P., Groves C.P. & Horne J.F.M. 1975. Ecology of the lower Tana River floodplain. *J. E.A. Nat. Hist. Soc. & Nat. Mus.* 151: 1-31.

Anonymous. 1984. Conservation of vulnerable tropical ecosystems: the case study of Kakamega Forest. Wildlife trustees, Nairobi.

Barkham J.P. & Rainey M.E. 1976. Vegetation of Samburu-Isiolo Game Reserve. *E.A. Wildl. J.* 14,4: 297-329.

Beentje H.J. 1986. Annotated checklist of the plants of Mt. Kenya above 3500 m. *Bull. Mountain Club Kenya* 83: 46-50.

Beentje H.J. (ed.) 1988. An ecological and floristic study of the Taita Hills forests. *Utafiti* 1, 2: 23-66.

Beentje H.J. 1988. Preliminary checklist of the plants of Saiwa Swamp National Park. Report to the Ministry of Tourism & Wildlife, National Parks service.

Beentje H.J. & Luke Q. (in prep.) Annotated list of forest plants occurring on the eastern slopes of Mount Kenya.

Faden R.B. (undated). Checklist of Turkana (=Sibiloi) National Park. (typescript).

Fayad V.C. & Fayad C.C. 1980. An ecological survey of the Nguruman Range (privately published).

Fenner M. 1981. Annotated checklist of Masalani/Bushwhackers (typescript).

Gillett J.B. (undated). Checklist of Baringo North, Nginyang and Weiwei (typescript).

Glover P.E. 1973. List of plants numbered in the Shimba Hills Reserve. (Kenya National Parks).

Glover P.E. & Trump E.C. 1970. An ecological survey of the Narok District of Kenya Masailand. (Kenya National Parks).

Greenway P.J. (undated). Checklist of the plants of Nasampolai Valley, Narok District (typescript).

Greenway P.J. 1969. Checklist of plants recorded in Tsavo National Park east. *J. E.A. Nat. Hist. Soc.* 118: 169-209.

Hamilton A.C. & Perrott R.A. 1980. The vegetation of Mount Elgon, East Africa. (Research report to Kenya Govt.).

Hepper F.N. & Jaeger P.M.L. 1981. Annotated checklist of the plants of Mount Kulal. IPAL technical report D3. UNEP/MAB, Nairobi.

Herlocker D. 1979. Vegetation of Southwest Marsabit District. IPAL technical report D1. UNEP/MAB, Nairobi.

Hughes F.M.R. 1984(?) The Tana River floodplain forest, Kenya. PhD thesis, Cambridge.

Isaac W.E. 1967-1971. Marine botany of the Kenya coast. *J. E.A. Nat. Hist. Soc.* 114: 75-83, 116: 1-47, 122: 1-23.

Jensen C. 1982. Checklist of Amboseli National Park. (typescript).

Kabuye C.H.S., Mungai G.M. & Mutangah J.G. 1986. Flora of Kora. In: Coe M. & Collins N.M.: Kora, an ecological inventory. RGS, London.

Kerfoot O. 1964. Vegetation of the SW Mau Forest. *E.A. Agr. & For. J.* 29: 295-318.

Kokwaro J.O. 1985. The distribution and economic importance of the mangrove forests of Kenya. *J. E.A. Nat. Hist. Soc. & Nat. Mus.* 188: 1-10.

Kuchar P. & Costich D.E. 1980. Annotated checklist of the vascular plants of Maasai Mara Game Reserve. KREMU technical report 110.

Lucas G.L. 1968. Woody species of the coastal forests/ woody species of Kakamega forest/plants of Mutomo Hill. In: Hedberg O. (ed.), Conservation of vegetation in Africa south of the Sahara. Acta Phyt. Suec. 54.

Mabberley D.J. 1975. Notes on the vegetation of the Cherangani Hills. *J. E.A. Nat. Hist. Soc.* 150: 1-11.

Marsh C. 1976. A management plan for the Tana River Primate Reserve (Report to the NY Zool. Soc.).

Moomaw J.C. 1960. A study of the plant ecology of the coast region of Kenya. Government Printer, Nairobi.

Msafiri F. 1984. A vegetation map of Lolgorien area, Narok District. KREMU technical report 119.

Mungai G.M. 1985. Partial checklist of Kitale Museum nature trail and compound. (typescript).

Mungai G.M. & Beentje H.J. (in prep.). An annotated checklist of the vascular plants of Ololua Forest, Nairobi.

Mungai G.M. & BeentjeH.J. (in prep.). An annotated checklist of the plants of Kieni Forest, Kiambu District.

Ndegwa Ndiangui 1984. Plant communities of the Kiboko area. In Endangered resources for development: 247-254.

Ndegwa Ndiangui (MS). An ecological checklist of Kiboko National Range Research Station.

Qvortrup S.A. & Blankenstrip L.H. 1975. Checklist for Kekopey Ranch, Gilgil. *E.A. Agr. & For. J.* 40: 439-452.

Robertson S.A. 1987. Preliminary floristic survey of Kaya forests of coastal Kenya. National Museums of Kenya internal report.

Steiner M. & Gerhardt K. 1986. An inventory of a coastal forest in Kenya at Gedi National Monument. Uppsala Univ. report 36.

Taiti S. 1973. A vegetation survey of the Maasai Mara Game Reserve (PhD thesis, Univ. of Nairobi).

Tweedie E.M. 1976. Habitats and checklist of plants on the Kenyan side of Mount Elgon. *Kew Bull.* 1976: 227-257.

Van Leeuwen M. 1982. Vegetation and land use of the Kilifi area. TPIP nr. 3, Agr. Univ. Wageningen.
Verdcourt B. (undated). Preliminary checklist of the Nyambeni Hills forests. (typescript).

THE ROLE OF NATIONAL PARKS AND RESERVES IN CONSERVING GENETIC RESOURCES

D.M. Mbuvi

Introduction

Genetic resources conservation is a relatively new concept. However, from the historical point of view the collection and utilization of useful plants and animals is as old as the history of man. It must have originated when man moved from a hunting/gathering society into a more agricultural society.

We must record with appreciation the foresight of early pioneers in the establishing of the network of Parks and Reserves, started during the colonial era. Today Kenya can claim to be in the forefront of the countries of the world with fairly representative samples of all the biotic communities, including the marine ones, protected in 20 National Parks and 27 National Reserves, preserved, at least in theory, in perpetuity.

Ecological basis for conservation

Kenya is a country with an extreme richness of habitats. Due to the richness of species in terms of diversity and abundance, as well as the scenic attractions of our landscapes, we can consider ourselves as a wildlife tourist paradise.. Kenya enjoys an enormous numbers of climates, from the tropical, via the temperate to the alpine zone:

1. Afro-alpine zone (moorlands)
2. Equatorial zone (forest, derived grassland or bushland)
3. Sub-humid zone (moist woodlands or *Combretum* savanna)
4. Semi-arid zone (*Acacia-Themeda*)
5. Arid zone (*Acacia-Commiphora*)
6. Very arid or desert zone (Dwarf shrub or bushed grassland)

The biotic communities and natural regions of Kenya

These were formulated by the Wildlife Conservation and Management department (Wildlife planning unit) as a precursor for the evaluation of the National Parks and Reserves system. The main objectives were:

1. to ensure that the Parks and Reserve system represents the Kenyan natural resources in a comprehensive manner.
2. to provide a rational basis for assessing and evaluating the existing system of Parks and Reserves.
3. to provide a rational basis for the identification and establishment of new Parks and Reserves.
4. to provide an analysis of local and natural factors that will influence the future management and development of the Parks/Reserves system.

In this regard, a guide was produced which will be of considerable interest and value to planners and managers of natural resources. It depicts 19 biotic communities which were defined and mapped, incorporating all major plant and animal species found in Kenya. Also recognized were 13 Natural Regions, some of which have been divided in sub-regions. They represent virtually every landform type ranging from the glaciated mountains and

permanent snow of Mount Kenya to recent volcanic areas and desert landscapes.

Current Parks and Reserves

It is gratifying to note that overlays for the major biotic communities against the existing Parks and Reserves reflect a fair representation except for one or two areas. This is also true of the Natural Regions versus Parks and Reserves.

The Wildlife Act defines National Parks and National Reserves in the same way: in practice National Reserves are managed by local authorities, which are inevitably influenced by social-economical or political factors.

The long-term survival of National Parks is threatened by two factors:

1. peripheral influences from human activities: settlement, cultivation, grazing etc.
2. tourism activities within the Parks/Reserves, which sometimes becomes a destructive activity, especially in relation to the plant cover in Amboseli, the Mara and Samburu.

It has been said that tourism activity can be more destructive than any other human activity, including grazing under the patrol system.

Management plans are now being drawn up to steer activities for the long-term survival of Parks and Reserves.

Question (Mr. Ndambuki): Do you in any way regulate the relative numbers of animal species in wildlife conservation?

Answer:No, not in any way; in fact we have noted what looks like a new species, e.g. the waterbuck now present at Lake Nakuru is different from the past one, presumably due to competition as a result of increased numbers.

Question (Dr. Odera): What is being done to control destruction of forest by game animals?

Answer: Large mammals are not being manipulated as far as destruction of forest is concerned. A joint programme is needed to be drawn up by the two parties.

SETTING UP A NATIONAL PLANT GENETIC RESOURCES COMMITTEE

INTRODUCTION
C. Gitau

I would like to begin by giving some background information. At the 11th session of the UNEP governing council, the governments of Africa were invited to convene an African environmental conference to discuss national environmental priorities and to identify common problems worthy of a regional programme of action to deal with serious environmental problems. Two years later, in its decision 13/6 of the 13th session of the UNEP governing council, the council approved the executive directors proposal to convene the African Environmental Conference, and an expert group meeting proceeding in December 1985; as a result of this the first African Ministerial Conference on the Environment was held in Cairo.

Kenya sent a strong delegation, headed by the Hon. Jeremiah Nyagah, Minister of Environment and Natural Resources, who was elected as one of the vice-presidents of the conference. One of the resolutions adopted during the conference was to establish or strengthen 8 specialized regional networks, one being in the field of genetic resources.

The purpose of this network is

1. to promote co-operation between the technical and research institutions of African states,
2. to promote information exchange,
3. to conduct basic studies and
4. to develop links between national departments in specific areas.

Accordingly the National Environmental Secretariat, one of the departments of the Ministry of Environment and Natural Resources, identified the National Museums of Kenya as the focal point for matters related to genetic resources.

This workshop has therefore been organized to work out a strategy to co-ordinate the activities specifically connected with plant genetic resources. For this to be done it is necessary to set up a committee which should meet at regular intervals, to review progress of recommendations which will come out of this workshop, and to guide future activities.

May I propose that this committee be composed of the following:

National Museums of Kenya: 2 representatives
K.A.R.I.: 3 (1 from Plant Quarantine, 1 from the Gene Bank, 1 from the crop section)
KEFRI: 1
N.C.S.T.: 1
Nairobi University: 2 (1 from Chiromo, 1 from Kabete)
Kenyatta University: 1
Moi University: 1
Egerton University: 1
KREMU: 1
N.E.S.: 1
KEMRI: 1.

Question (Mr. Osoro): What are going to be the roles of the two National Committees - one which was first formed at the Serena Hotel in 1986 and the one formed now?
Answer: The committee formed at the Serena Hotel was composed of Permanent Secretaries; the committee just formed is a scientific one.
Question (?): Would it be a good idea to have a decentralized system with subcommittees, e.g. KEFRI, Gene Bank, crops (KARI), KEMRI, etc. This committee (NPGR comm.) should then be the overall coordinator which should report to the policy committee.
Answer: Yes. this is accepted as a useful proposal.
Question (Miss Murugi): are the in-situ and ex-situ working groups formed here part of the steering committee?
Answer: No - they are just part of this workshop.
Question (Mr. Ndegwa): Relating to the media coverage of the NPGR committee, would it be practicable to co-opt the Director of Broadcasting or his representative?
Answer: These were invited to this workshop, but did not turn up.
Question (Mr. Ndambuki): Since there already exists a National Plant Genetic Resource committee, established in 1986, and also a Gene Bank committee, how does this present PGR committee fit in? There seems to be a conflict of interests.
Answer: The Gene Bank Committee could be answerable to, or fit under the umbrella of, the NPGR committee, which advises the committee of Permanent Secretaries.

RECOMMENDATIONS OF THE "IN-SITU" WORKING GROUP

Chairman: D.M. Mbuvi

Reference was made to the 1984 Strategy conference for the Management of Kenya's plant communities. It was agreed that the broad recommendations adopted at that workshop be used as terms of reference in drawing out the working groups recommendations, as follows:

1. Evaluation of the 1984 and 1986 workshops' recommendations to assess their current implementation, and to find out the bottlenecks in those that were not implemented.
2. Among the priority species to be conserved are the wild relatives of crop species, and endangered/threatened plants.
3. A major priority is the conducting of vegetation inventories in areas where this has not yet been done.

   3b. Funds should be sought to enable the concerned institutions to conduct these surveys as a matter of urgency; these institutions are the National Museums, WCMD, KREMU and KEFRI.
4. Access to germplasm resources in Kenya should be regulated. especially to foreigners, and this should be monitored by the National Plant Genetic Resources Committee.
5. Manpower development and training: career prospects for plant geneticists and people working in related fields should be made more attractive in order to attract and retain professionals.

   5b. Donor agencies and institutions such as the Tea and Coffee Boards should support training in these areas; especially short-term professional courses should be developed.
6. Funding: the new Ministry of Research, Science and Technology should be involved in seeking for funds to support the field of in-situ conservation.
7. Public education. DDC's should be informed of the importance of Environmental Impact Assessments. The National Plant Resource Committee should publicise, and seek for support in such institutions to include development authorities (TDA, LBA , development authorities etc.)
8. Those areas identified for in-situ conservation should be continuously monitored by the NES department of environmental impact assessment.
9. On small sites of conservation value: a new category was proposed to include coastal Kayas, their western equivalents, and the small Taita Hills forests. This category should comprise Sites of Special Scientific and Cultural Interest, possibly to be conserved under National Monuments.
10. Conservation objectives: - *short term:* endangered species should be identified along with their habitats. Identification of endangered species to be done by the National Museums. - *long term*: conservation measures should be instituted within these habitats, even within already protected areas, to control destructive human activities.
11. Collection missions should be organized and coordinated by the national Gene Bank, to include food crop and cash crop relatives, horticultural, medicinal, pasture/forage and forest species.
12. In addition to the National Committee on Plant Genetic Resources this in-situ working group recommends to hold regular meetings to address itself to in-situ conservation measures.

Question (Dr. Gaudet): Who will carry out the evaluation of the 1984 and 1986 workshop recommendations?
Answer: The organizers of these workshops should be approached about such an evaluation.
Question: (Dr. Gaudet): Some bilateral agencies have a requirement to carry out environmental impact assessments on overseas projects. In Kenya NES is resposible for E.I.A. for projects. Should they expand their mandate?
Answer: NES should be approached about expanding their mandate to require E.I.A. for agriculture projects, and require collection and conservation of genetic material.

RECOMMENDATIONS

by Professor F. Owino

That the National Herbarium be the focal institution for plant germplasm collection and -documentation. The National Herbarium should have a mandate to obtain funds internally and externally in support of vegetation inventories, germplasm collection and the documentation of wild species.

That the National Herbarium should work closely with the National Gene Bank and relevant institutions such as KARI, KEFRI and the Universities to ensure that both domesticated and wild plant genetic resources are sufficiently surveyed, collected and documented.

RECOMMENDATIONS OF THE "EX-SITU" WORKING GROUP

Chairman: H. Kamau

1. Priorities should be
- exploration
- survey and inventory
- collection
- characterization
- evaluation and germplasm exchange

in that order.

2. Documentation will be carried out by the National Plant Genetic Resources Centre and will be a continuous process.

3. Storage of germplasm will involve maintenance, multiplication and regeneration.

4. Priority crops for collection are listed below:

Cereals: maize, wheat, rice, sorghum and endangered species.

Legumes: beans, cowpea, pigeon pea, green grams, mung bean, chickpea, endangered species.

Horticultural crops: vegetables, fruits, root crops, ornamentals, spices, endangered species.

Oil crops: sunflowers, castor oil, soya bean, coconut, groundnuts, rape seed, endangered species.

Cash crops: coffee, tea, pyrethrum, cotton, sisal, sugar, others.

Tree species: industrial, fuelwood, agroforestry, soil trees & environmental conservation, food/browse/fodder, shade/social/medicinal, endangered species.

Tubers/roots

Pasture species

Forage species

5. Responsibilities:

5.1 the National Crop Plants Genetics Resources Centre will carry out the following activities:

5.1.1 long term conservation
5.1.2 central documentation
5.1.3 exchange of germplasm, internal and external
5.1.4 training
5.1.5 ensure germplasm security
5.1.6 collection of un-mandated crops
5.1.7 dissemination of information to research institutes

5.2 Research institutions will carry out the following activities:

5.2.1 collection
5.2.2 characterization
5.2.3 evaluation
5.2.4 utilization
5.2.5 short/medium term storage
5.2.6 documentaion
5.2.7 feed-back to the National Crop Plant Genetic Re sources Centre of material and information

5.3 the Universities will be responsible for the follow ing activities:

5.3.1 training
5.3.2 manpower development
5.3.3 further evaluation
5.3.4 basic research and development of wild species
5.3.5 collection

5.3.6 characterization
5.3.7 evaluation
5.3.8 utilization
5.3.9 feed-back to the Gene Bank for central documentation and long-term storage

6. There will be common activities applicable to all institutions such as in-vitro conservation.

Question (Prof. Mukunya): Do we need to duplicate the base genetic material at the Central Gene Bank and Research Centres within the country?
Answer: The Central Gene Bank should conserve all materials, both active and inactive. The National Research Stations should keep active collections.

RECOMMENDATION TO THE NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY by Dr. R.E. Leakey

It has been noted that in spite of the important progress in achieving research co-ordination by the National Council for Science and Technology, there remains a problem with respect to export of biological material from Kenya, especially by foreign scientists.
It is therefore recommended that the National Council for Science and Technology be requested to consider ways of strengthening the national reference collections by requiring all foreign visiting workers to deposit any unique material and duplicates of all other material with an appropriate Kenyan institution.

SUMMARY OF RECOMMENDATIONS by Dr. J.A. Odera

The whole aspect of the consrevation of plant germplasm requires a national approach because we have crops and trees both in the wild and domesticated. The resposibility of conserving this resource cannot be left with any one agency. We are therefore recommending that a holistic approach is taken, i.e. we look at this from a national point of view, and we are proposing that there should be a National Plant Genetic Resources Committee, constituted of an ex-situ group (with the National Gene Bank with its network of outstations, KEFRI and the Herbarium) and an in-situ group (Wildlife Conservation and Management Department, Forest Department, National Encvironmental Secretariat, KREMU).
Then we have the National Council for Science and Technology, a Government institution with the task of overseeing all aspects of research and development in Kenya.
I do not know how the new Ministry is going to fit in here, that is outside my mandate for this presentation.
The National Museums of Kenya will have the function of holding the Committee meetings and be the central point for bringing all these people together.
Foreign collectors, as in the past, are to apply to the Office of the President for a Research Permit. The applications go to the National Council for Science and Technology for evaluation and recommendation. The applications then go back to the Office of the President for issue or denial of a permit. It is recommended that the Herbarium be involved in the evaluation of the research projects. It is recommended that the Herbarium be the main depository of any plant collections. All collectors should affiliate with the Herbarium.
We see the ex-situ and in-situ groups coming together under the umbrella of the National Committee, and then deciding on policies.

Question (Mr. von Carlowitz): Has the National PGR Council an official advisory function?
Answer: Yes, to the Government bodies concerned on priorities and conservation policy, and other topics.

CONSERVATION POLICY

MANPOWER DEVELOPMENT ISSUES
Prof. D.M. Mukunya & Prof. S.K. Imbamba

The kind of training we need among the people who are going to steer this important national effort should supply a good background in the basic sciences e.g. biology, mathematics, chemistry, logic, computer sciences, statistcs.

The people heading the institutions that will be conserving germplasm should have university degrees, e.g. BSc..

Then we need specialists i.e. plant physiologists, plant ecologists, taxonomists, environmentalists, etcetera.

Do the Universities (Moi, Egerton, Nairobi, Kenyatta and Baraton) have the capability to produce such people? Do we have enough lecturers around that we can give basic BSc. degrees and also go further and train plant breeders and physiologists to higher levels?

The answer must be yes, and no. We have had to ask money from undergraduates in order to train them to postgraduate level, as there were not enough funds. If there are international organizations which can come to our aid in this area, we shall be very pleased. We also lack facilities; there is a certain amount of research in our institutions but not as much as we should like, we need people with MSc. and PhD degrees conducting research in these areas.

In the last 10 years we have trained about 20 plant breeders; these are in great demand, both locally and internationally, and they cannot be retained in any post for a long time; high salaries elsewhere lure them away. This has contributed significantly to the stagnation of our own development.

DISCUSSION

Dr. Taylor: The National Gene Bank would essentially become self-sufficient in the next 2 or 3 years through German involvement. In the meantime the Universities should offer some higher training, if necessary an informal diploma course, to fill the gap; we have specialists working with the gene banks now, but their time is taken up with their responsibilities. A training strategy should be developed for gene banks making use of the expertise that is already there.

Dr. Abou-Zeid:We do have in mind to train more people according to our needs, and we have scientists receiving training abroad. We are losing some scientists because they are attracted elsewhere; we would like to recommend that we are given facilities to enable our scientists to remain in one place.

Prof. Owino: I wanted to raise two issues with respect to manpower development. There may be a case here for some crash programme to train in the Herbarium and in the University. This could be done at two levels, a specific course for those that are already on the job, to make them more suitable, and a masters level training in one of the Universities.

Dr. Odera: There is something wrong somewhere in the training in specialized areas e.g. breeders, physiologists, taxonomists; we need to come up with a strong recommendation to institute a crash training programme. Has the problem been that young scientists were discouraged from taking breeding studies?

Prof. Mukunya: Around 1979/80 there was great concern because we were getting very few postgraduate students applying for breeding, and a committee set up to investigate this discovered that there was a feeling among students that breeders did not have enough avenues of possiblities. Right now we are getting more applications in this field than in any other, since people have discovered that there are more openings and green pastures.

We also now have about six plant breeding lecturers and 20 other academic staff in the department of crop science. I do not know about the forestry area.

Prof. Owino: We have not really started a tree breeding programme at MSc. level and this is something that could be discussed. There are certain aspects of germplasm collection that link directly with the botanists in the Herbarium and this is one area which has received relatively little professional prominence.

(Unknown): Would it be possible to have the postgraduate programmes continuous instead of taking breeders this year, and pathologists next year? And would it be possible to shorten the civil stint of two years, which a BSc now has to do before he can do further training, to 6 months?

Prof. Mukunya: The postgraduate programmes have a capacity to take a minimum of 10 students, but we prefer to have 20 students, and so we have alternate year courses. We are also overhauling the postgraduate programmes, and there is to be no more extension beyond two years for postgraduate years.

Prof. Owino: For the purposes of gene bank and germplasm exploration, we need to make recommenda-

tions here at this workshop. We recommend that a crash training programme be proposed in the department of Botany, since the collection and documentation of germplasm seems to have to come out of the department of Science.

Dr. Odera: A number of organizations, such as the Herbarium, KEFRI, WCMD are faced with a shortage of trained manpower in these areas. We will be doing a service to germplasm conservation if we can come out with a specific recommendation that refers to crash training of resource persons on germplasm management, to cover ecology, taxonomy, physiology and breeding.

Dr. Oggema:We have always sponsored students to the University of Nairobi, but when they are given a thesis, they are given something irrelevant to the Gene Bank. This has accounted for loss of staff in our stations. Can't we have a forum where we discuss the thesis projects of these students?

Prof. Imbamba: We try as much as possible to let students carry out research in areas of their own interest. Occasionally the lack of facilities makes this impossible. The other issue is the question of taking students for the same course every year, because the supervisor has to finish with one lot before registering another.

Dr. Abou-Zeid: How much would be the training costs for one student for one year?

Prof. Mukunya: Right now the cost of training a postgraduate student is about 45.000/- to 48.000/-. As long as someone is taking care of the bills, it is possible to have short-term training courses at the University of Nairobi, which can be arranged between the concerned institution and the staff of the University.

NCST representative: We have been receiving quite a number of applications for funding projects for MSc students from other departments, and the feeling is that the 9.000/- which was mentioned for research work is not enough.

Prof. Mukunya: The 9.000/- is actually a laboratory field fee. If a student has a good research proposal we sometimes ask the dean committee to fund this, and also NCST, DAAD, IDRC etc., in order to accelerate the completion of the thesis.

Prof. Imbamba: The figures given are the amounts needed to pay the university to do a masters, but the student also has to eat and live, there is money necessary to do research, and that brings the total to 45.000/-

Dr. Odera: The problem at the university now is the lack of funds for training at the postgraduate level, and also a lack of teaching or supervisory staff. Why can't we come up with a figure and go to a donor so as to train students under relevant environment, and get value for the money? This workshop recognises the urgency of undertaking supportive studies on the management of plant genetic resources, gene banks and allied activities, seeing the existing paucity of trained manpower, and recommends that the National Germplasm Committee should prepare a crash programme focusing on postgraduate training, with possible donor support.

Prof. Mukunya: Within the last 3 years the University of Nairobi came up with a document for accelerated postgraduate training and updating of facilities in the University, particularly in preparation for the work that is going to be done by national institutes such as KARI, KEFRI etc. and so far USAID has a package for training people in research, which will have to be given to local institutions that will be training the research workers. There was a feeling that the University of Nairobi postgraduate programmes in the Department of Science could take up the bulk of training of MSc programmes, and it was found out that in terms of expenditure, training someone in Kenya is much less than sending them out.

P. von Carlowitz (ICRAF): There is also a shortage of training and teaching staff. In the initial case of such a programme which may be funded from outside, wouldn't there be too big a workload and gaps e.g. in taxonomy. Eventually such a program may generate an own institution capability, but initially it would be very difficult to put an extra load on your regular programmes, given the fact that you are still very few to act as trainers in such a programme.

Prof. Mukunya: It was considered that whichever donor would accept to fund this would also think about the local capability in terms of staffing. For example the University of Nairobi has established over 48 linkages with universities all over the world, so we can have exchanges of staff as well as student exchange. In areas where we have no lecturers we can get them from our sister universities.

Dr. Attere: We have to capitalize on these linkages. There are universities in U.K. which have been involved in training people for plant genetic resources activities; we could try and link with that university so that they start training for the first 2-3 years, while lecturers start a genetic resources course here.

Dr. Abou-Zeid: According to our rule we should train people locally.

Prof. Owino: I support the proposal from Dr. Odera that a crash programme be recommended to be undertaken by a local institution, but this should not be left to the National Germplasm Committee. A proposal for such training should come from a training institution. All the workshop can do is give the go -ahead to such an institution to come up with a proposal, and then the Committee can bless it. Could we be more specific and have a local University come up with a proposal for support of funding.

The Faculty of Science here in Nairobi has a reasonable strength in botany and could be strengthened to move into genetics, and I would recommend that this be the proposing institution.

Dr. Taylor: I come from the botany department here at Chiromo. I think it is the duty of this workshop to outline in general terms how many people need to be trained, and over what period, so we can relate funds to be asked for to those factors. This is needed by the faculty to make decisions about funding and staff.

Mr. Mbuvi: Is the issue of numbers that has been raised based on the capability of the university, or demand?

Prof. Mukunya: On demand, in the germplasm sector.

Dr. Odera: Interested institutions will demand and work out the number that they would require and then a number can emerge. But I am not sure how this would work out. Prof. Owino says that we should mandate one university to prepare a package but I do not know how this will work out

effectively.
Miss Kabuye:We see in this workshop that there is a lot to be done but we have very few people to do it. We were talking about surveying, collecting, monitoring, and working out which habitats are endangered, which species are endangered in the wild. All this needs people to go out and find out what is happening in the field, and it must be done now. We do not need a programme for the next ten years - we need one now. What we need to work out is how many people we need to have for this crash training programme, how much funding is needed, and then ask a University to take care of such a crash training programme.
Dr. Taylor: I agree the manpower desire should be specified very closely, and that this should be done on a national basis. The financial implications should be worked out very soon. The National Germplasm Committee should bmandated to ask donors, specifically for this crash training programme.
Dr. Odera: So the National Germplasm Committee should prepare a crash program proposal and then call donors.
Mr. von Carlowitz: This Committee couldn't act in starting discussions with the donors directly. This would have to go through government institutions. The way I see it is that the National Germplasm Committee would prepare the whole thing and pass it on to a respective Ministry suitable to call on the donors.
Dr. Attere: If the Universities and the National Museums come up with a programme proposal for a crash course, IBPGR will be able to cost most of that course, I can say that right now.
Prof. Mukunya: The Germplasm Committee is preceded by a powerful committee of 5 Permanent Secretaries, who were mandated at the Serena Hotel workshop.
Prof. Imbamba: I will provide the necessary information together with Prof. Mukunya. We have the figures, we know how much it costs, and we can tell how long the training wil take. We can provide this information to Miss Kabuye.
Prof Mukunya: We have already identified the Herbarium as the clearing house of whatever activities we have. We will have to give them the opportunity to define the proposal.
Dr. Odera: No! Not the Herbarium, but the National Germplasm Committee.
Prof. Imbamba: We will have to move fast; in October this year the new course is starting, if we are assured of enough students coming in we can get prepared.
Prof. Owino: If this is going to be a training proposal we better leave these to a training institution. If we can make a recommendation which is specific to a training institution, the whole thing will move faster.
Dr. Taylor: This crash course should not necessarily be an MSc course, but an interdisciplinary course; it takes 2 years to get every MSc course on the books, and we have no chance to meet this years MSc deadline, so this course should be an ad hoc course. The university is mandated to set up ad hoc courses, and then we are free to move outside deadlines.
Mr. Awori: It would be useful at this stage to name 3 people to act on behalf of this Committee to develop such a proposal; this can then be presented as a draft to the Committee to review.
Prof. Mukunya: I propose as the in-situ group KEFRI, the Herbarium, the dept. of Botany and WCMD, and I propose Dr. Odera to be the chairman.
Mr. Mugo: I propose representatives from the Herbarium, as well as Seme (ex-situ), Odera (in-situ) to be the chairman, Mbuvi, Mukunya and Kokwaro from the botany department.
Mr. Ndegwa: We should have a time limit for this subcommittee to convene.
Miss Kabuye: I suggest we have the National Committee meet as soon as possible, in the 2nd week of August.
Mr. Mugo: As a result of this discussion, we have now come up with a proposal for a crash training course programme. We have agreed that the Germplasm Committee should write up a programme, through a small working group composed of Dr. Odera (chairman), the Herbarium, Mr. Seme, Mr. Mbuvi, Prof. Mukunya and Prof. Kokwaro. This group will start sitting this friday, so they can come up with a proposal for the main National Germplasm Committee, not later than the second week of August.

INTERNATIONAL NETWORK ASSISTANCE STATEMENTS

INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE

Dr. R. Benstead-Smith

The International Union for the conservation of nature recognises the importance of conserving natural resources, both ex-situ and in-situ, and this is in fact one of its main goals.

We are better able to help in-situ conservation. We would certainly like an opportunity to work with the national institutions in helping them to set up practical projects, to help set up funding for these, and then work with these institutions in implementing these projects. Two particular areas of what has been talked about these last two days seem most appropriate for us: one is the inventory of plant genetic resources, i.e. studies of particular areas which have not yet received special study; and more generally, to set up a national data base.

IUCN headquarters in Switzerland stores data on a global level, and the Conservation Monitoring Centre is very interested in helping set up national databases of biological resources in a number of countries.

The combined forces of the regional office here and the Conservation Monitoring Centre in U.K. would be able to help set up some sort of national database here, if that is what is wanted. I am thinking particularly of things like Dr. Beentje's presentation where he gave maps of the distribution of species; for all that sort of information IUCN has some sort of storage system with a possibility of putting it in a more accessible, and more expandable, basis so that it won't become cumbersome as more and more information is gathered.

In connection with that, I would like to comment that a lot has been talked about identifying endangered species to be conserved; I think it is important that species are not seen in isolation, particularly in complex ecosystems like tropical forests.

There has to be a pilot programme of research into the life history of these species. Globally very little is known about the dynamics of tropical forest, and how particular species survive. There is no reason to suppose that just because you identify the species, you know how to conserve it. You have to do research on how that species is surviving within the natural ecosystem, and make sure that you keep those conditions there to enable it to survive. Without that sort of research, the kind of questions that were raised yesterday about minimum area, minimum viable populations etc. do not mean anything until you understand how the species is reproducing.

At the same time, I feel there is plenty of room for action already. There is already quite a lot of information available which has led to certain areas to be identified as being very important for the conservation of genetic resources, e.g. the Taita Hills, Coastal forests etc. These are small areas rich in biological resources, and they do need some kind of protection.

Another way in which IUCN would like to help is in setting up projects to protect those specific areas. A few points arise: one is which would be the appropriate institution to work with in that case. Yesterday there was some talk of designating some of these smaller areas as National Monuments or something like that. But until you identify who is responsible for a particular area, then nobody can set up anything to help protect the area. I think it is maybe worthwhile for the Committee to review the question of what the legal status of such areas is going to be.

Another point is that in protecting those areas we also want to look at the interests of the local communities. In what way do they depend on those areas or would they like to use them. How can these areas be protected without detriment to the local communities. The kind of public awareness work that the KENGO representative was talking about is important, especially where genetic resources are concerned, because when you are protecting say important catchment areas or forests important to timber production, you can demonstrate some immediate rewards in that locality.

When one is talking about the benefits of genetic resources, very often these are not local benefits but national benefits, and often they are not immediate benefits, but long-term ones. It is not an easy idea to sell to local communities; maybe it is easiest to pick on an area which is known to have species of particular value e.g. rare coffee species or indigenous tree species; these are demonstratable values.

INTERNATIONAL CENTRE FOR RESEARCH IN AGROFORESTRY (ICRAF)

P. von Carlowitz

The International Centre for Research in Agroforestry is an International Research Council, not an institute, with a worldwide mandate of Agroforestry research in the tropics and sub-tropics. It is made up of quite a unique combination of representatives and scientists of practically all disciplines which in one way or another are relevant to agroforestry. At present and compared to other big institutes it is still rather a small organization, but more recently it has been growing quite fast and we hope that by the end of next year, we will have reached the strength and staff level we require considering the enormous practical research task and our wide spread geographical mandate area, our limited financial and professional staff resources do not commit the implementation of the many required research projects by ourselves. Furthermore, such an attempt would ignore one of the more important mandate areas of the institution i.e. institution to promote the capability and capacity of national research institutes and research organizations which are related to this rather new scientific discipline as agroforestry happens to be. Contrary to agriculture and forestry which can look back on a history of about 200 and 300 thousand years, we are looking back on no history whatsoever unless you call 15 years history.

By status, mandate and structure as well as funding ICRAF is naturally set to work and operate through networks and collaboration with other institutions of various kinds e.g. donor institutions, research institutions and Universities in the tropics and sub-tropics as our actual mandate. We are not dealing with the temperate zone. Our conceptual approaches and research designs require operational research networks and various technologies which have been developed. This kind of network approach has also been acknowledged by our 14 or so donors who directly or indirectly support these activities. Several networks in a number of years have been set up or initiated. I should mention that collaboration with other institutions is very pronounced in ICRAF. It takes various forms. Either formal approaches like here in Kenya, e.g. with Dr. Odera and his institute, and more informal although quite intensive collaboration with Moi University; and many other in the 3 continents i.e. Latin America, Africa and Asia.

Examples of active networks we have are in the field of information, active field research and experimentation, in particular in Africa under the broad heading of what we call Agroforestry Research Network Africa within our collaboration programme. There is also a network which is just in the beginning of multipurpose tree related data bases. In every field we cannot do the whole thing ourselves, and interaction with other institutions and those people who do similar work is necessary to avoid unnecessary and expensive overlapping, to establish common grounds, to identify research steps etc.

There is also a network through which we establish an agroforestry systems network or inventory which we thought necessary to base further improvement on. In all of these activities, one which we should not forget is the regional germplasm development centres with particular emphasis on woody perennials within this group, with emphasis on multipurpose trees for integrated land use i.e. agroforestry.

Preliminary discussions have been held on this. We believe that there are certain activities in germplasm development which could be done efficiently and economically in a regional approach rather than a national approach, not ignoring the necessity of national germplasm banks and gene banks. But when it comes to training for example, or with regard to active germplasm banks which include dissemination of germplasm, e.g. for rare species or lesser used species, a regional approach may be more economical.

What is very often difficult is to get staff, in particular computer programmers. The last thing to mention which has something to do with collaboration and networking is our education and training facilities. We have an ever-increasing and rather strong training and education programme geared towards the promotion of agroforestry research; where they operate on various levels we have short courses, in Latin America, Africa and Asia. They are set up to serve researchers and semi-level government decision makers of the concerned ministries. Another programme is internship training where for 3 months to 6 months someone is working on a small but self contained research project. Then we have the senior fellowship research programme where a scientists from tropical and sub tropical countries are with us for a year and tackle the complete research programme.

This has been so successful that we have increased this opportunities considerably. The idea from our point of view behind that is to set up a promotion network. In agroforestry we still need promotion. We have to sell the idea and to define what we mean with that. The best way of doing this is to draw more people in and let them go back satisfied with what we do and what we think, and if they are convinced of the whole approach, the wider the idea of which we are convinced will spread.

INTERNATIONAL BOARD FOR PLANT GENETIC RESOURCES (IBPGR)
Dr. A.F. Attere

First of all I should thank the National Museum for associating IBPGR with the organisation of this workshop; once again, it has given us the opportunity to be associated with scientists working on the field of genetic resources in Kenya.

The IBPGR is one of the 13 centres of CGIAR in FAO, Rome. We are charged with the mandate of promoting plant genetic resources conservation globally. This means mainly to ensure that the natural crops are properly collected, conserved, evaluated, documented and freely available to all scientists all over the world. In Kenya, since 1978, we have been associated in various types of activities. We have given some equipment, scientific material, funds etc to various institutions in Kenya towards the conservation of plant genetic resources. We are pleased to be associated with this workshop which has recognised the need for a multidisciplinary approach when it comes to genetic conservation in Kenya; there is a need to develop and encourage manpower and we agreed that we will recommend that a multidisciplinary course for plant genetic resources be initiated at the University level, and serve the needs of Kenya as well as the needs of the region.

I would like to say again that one of the things I B P G R will look forward to is try and fund this course if it happens to be here in Kenya for Kenya and the region.

Right now we have trained a number of Kenya research staff in terms of Plant Genetic Resources activities and while we wait for the proposal to be submitted we are still ready to train more people in the university of Birmingham where we have the only course on plant genetic conservation right now operating in the world.

Right now we have already made money available to the National Gene Bank to start some of these activities as far as collecting is concerned and we are waiting for a proposal for characterization and multiplication of some of the resources existing in Kenya, right now. We look forward to repatriate any material which is of Kenya origin but which is now being duplicated or conserved in other gene banks in the networks, back to the national gene bank to Kenya.

We also look forward to seeing the national committee for genetic resources solve the problem of publicity or support i.e. if this committee can be a presidential committee for plant genetic resources in Kenya, I think we will have the right backing, publicity and support that is needed.

We look forward to seeing this committee operational during the second workshop on plant Genetic resources for Africa which I B P G R and U N E P hopefully will be organising in Kenya next year.

GTZ
Dr. Abou-Zeid

G T Z started in 1972 to establish national and International Gene banks in several countries. We started with Ethiopia, Costa Rica and now Kenya. We give support to other gene banks directly or indirectly through other organizations by giving technical support.

The National Gene Bank Programme in Kenya was started in 1983. We started all activities with G T Z institutions in the country. We came up with a number of a new cold stores for medium and short term cold storage. We have now 773 cubic m storage capacity for medium and short term cold storage in different institutions in Kenya. All the institutions were provided with proper packing material, and technical guidelines for management of germplasm. Generally we trained a number of scientists in different aspects.

Our National Gene Bank here will accommodate all facilities for seed processing, seed testing and for long term conservation. We will have 2 cold stores with total storage capacity of 150 cubic m and will be running at -18º c. We will have also facilities for seed drying.

We hope to have everything in action by January 1988.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT (U S A I D)
J.J. Gaudet

Over the years, U S A I D has funded a lot of activities related directly to the conservation of the natural material or in some cases conservation as relating to germ material etc, e.g. U S A I D has funded agricultural research programmes. U S A I D has also to a certain degree funded organisations like I C R A F, N E S and more recently in 1986, a certain amount of money from U S A I D was used for preparation of the materials for the proceedings of 1986 conference on the Strategy of Conservation of Plant Genetic materials.

Most of these activities, projects etc. were initiated in Washington. Recently at this workshop I have been in contact with some people here relating to some potential for funding activities in germplasm and biological diversity.

There is a new project that is beginning shortly, entitled Natural Resource Management in Africa which can be used towards this end.

BRITISH DEVELOPMENT DIVISION IN EAST AFRICA (O D A)
J.R.F. Hansell

We are the regional office of the ODA's development administration in London and our remit is the whole of East Africa, Somalia and Sudan. We are responsible for identifying projects there, to monitor them, ensure that the finances are available and evaluating the projects.

Unfortunately there are only 2 of us in the natural resources sector covering all five countries. So as a result of this we wait for people like you to come to us with projects. Unfortunately we don't have the manpower to go forward to look for projects for funding. In this respect therefore, I am pleased to say that in Kenya you have been active in putting forward programmes of this nature to us. The effective conservation and use of Kenya's Natural Resources is a high priority both for the government of Kenya and the donor. As a donor, we are delighted that the government of Kenya has designated the National Museums of Kenya as the coordinator of the national plant germplasm resource activities.

We have received in O D A a request to assist in the establishment of a plant conservation and propagation unit with a focus on developing propagation methods for wild plant species, including the crop relatives and indigenous species. As we have heard in this meeting much emphasis in agriculture is placed on use of exotic crops. Similarly forests of exotic trees cover much of the landscape. As a result, indigenous species for local land races have been overlooked as a resource. The museum has set up sites in which in-situ conservation is currently being practised e.g. Gedi and Ololua.

Ex-situ conservation of germplasm in the field of agricultural crops is being carried out by the ministry of agriculture with assistance from G T Z . For forestry species this is complimented by the tree seed bank at Muguga, KEFRI. We in O D A recognise the importance of the genetic resource species and the interest it arouses in both the scientific and layman circles around the world. We in U K have for many years had traditional links with the East African countries, through the Herbarium at Kew and the University of Edinburgh etc. We are hoping to develop and continue these links and I would like to say that we are very close to signing an agreement with Moi University for assistance through the forestry department in terms of manpower training and research in forestry.

I am delighted to say that we have been discussing at ODA the area that you are discussing and look forward to be able to cooperate and assist in this.

CLOSING SPEECH

R.E. Leakey

I have not had the advantage of listening to the last sessions, but I think I have picked up enough to make a modest attempt at summarising and bringing out some points which I believe are important. Before I do so, I would like to put the discussion into the context of the past perspective, the archaeological context, and I would like to state that many people forget that the use of plants in the domesticated sense, by man on this planet is at the most 10,000 years. The ability of man to exploit his environment as a hunter-gatherer goes back at least 2 million years and the domestication of most of the crops we now utilise, has taken place in the last 5000 years. One of the most interesting points that has arisen recently, is the understanding that hunter-gatherers communities living in the semi-arid and parts of the planet earth today, utilise plant resources that make up 75-80% of plant resources that are growing below ground, tubers and rhizomes; a very small part of the plant world being exploited above ground, yet much of our discussion in the last two days has related to the conservation of species that are above ground rather than the resources that are at present, totally unexploited, by man in the broad sense. This is an important point to remember.

The other point that I would like to bring out is also one of perspective; we are not here purely as academics discussing academic issues, we are here considering matters that concern the future of our country, our region and our planet; the future in terms of survival of our species. We are naturally selfish, and our preoccupation is the welfare of humanity within the confines of the discussion, and it is worth pointing out that many of our leaders around the world have a very short term perspective.

Over the last 10 years we have read and worried a great deal about the increasing drought conditions that are prevailing in many parts of Africa; the Sahara zone is of particular significance. Lake Turkana in northern Kenya receives 98% of its water from the Ethiopians highlands and the level of Lake Turkana is a very good measure of the rainfall received by Ethiopia. During the last 15 years, the water level on Turkana has dropped 41 feet. This was measured in front of my camp. And that drop of 41 feet has I think, been reflected in the drought and the famine that we have read about and been concerned about. Carbon dating and Potassium Argon - isotope work done in the last 2 years has established that as recently as 3000 years ago, Lake Turkana was 60 meters lower than it is today. This given you some indication of the possibilities of further drastic climatic change affecting this region and much of this discussion about the conservation of species /genetic resources should be seen in the context of a changing world and a world, that historically, has changed very little but pre-historically has changed very dramatically. I think this should be remembered in terms of the background to some of our deliberations.

Let me now turn to some more specific issues and say straight away that I think this workshop has demonstrated that in Kenya, there are Kenyans trained and ready and positioned to help Kenya, and what these Kenyans need is help from their friends. This country has reached the stage in its development where we should be able to hold the initiative, and use that initiative to get help and I think the time has passed when we looked for external initiatives; and I think that the onus is on us as Kenyans heading and working in Kenyan institutions to use that initiative, and the goodwill that is so abundant from our friends, to solve some of our national problems.

Another point I should like to make that has come through very clearly, is that this workshop was designed to discuss the strenthening of national institutions and not the building of new national institutions. A great many conferences, workshops and symposiums over the last decade, have been called with a view to creating new empires, new structures, new edifices; this particular Workshop has identified areas of weakness in existing structures and the need to strengthen those through coordination and communication rather than to try to push them aside and say well lets start again with a new white elephant; that an important point for us to remember in the course of this discussion.

Of course we are a young , developing country; particularly at the current moment, we in Kenya face quite severe financial constraints and all of us, who work for Kenyan institutions are aware of the directives that have been received from the Treasury in the last few weeks, about cutting the budget; and many of us have to face very very severe financial cutbacks in our programmes and these cutbacks will affect training, our ability to produce better documentation programmes - it will affect our ability to exploit the institutional potential and the collection of new material in all sorts of different ways and I think we must be realistic and recognise that we are proposing new advances at possibly one of the worst times Nevertheless, I would like to bring out the fact that at least in Kenya, and this is true of some of our neighbours as well, we are very fortunate to have very strong political support for the concept of the conservation of the genetic resources, particularly in the botanical field and I don't think one could ask for greater political awareness than is given by President Moi in his support for forest conservation, soil conservation and the whole genetic resources area.

I think that we have identified that our main weakness is an institutional weakness in terms of the lack of ability to communicate and co-ordinate rather than a weakness from the area of political support; and much more could be done as has been suggested to capitalise on that potential and political support that has been given and is given constantly by the President.

The other thing that has become very clear, as a result of our discussions in the last 2 days, is that there is a lot of professional goodwill in Kenya - there are a number of Kenyan experts in different instiitutions and different fields who, when they actually get together are prepared to work together and talk together . It is important to remark on the fact that a large number of international agencies have indicated, not just today, but previously, their willingness to help and I dare say as the director of this institution, that there is a lot of money looking for good

projects in Kenya. We are not short of money in Kenya from international agencies, we are short of good projects and that comes down to our ability as Kenyans in Kenyan institutions to formulate workable programmes to attract the funding, in the national interest. I can not over-emphasise my complete conviction that money is there if we ask for it. The initiative must be ours - if we are going to move forwards.

I would like to touch on two or three brief points that I think are worth mentioning. Kenya does need a more cohesive programme, both in ex-situ and in-situ programmes of conservation. There is a need to recognise that the Forest Department, the Dept. of Wildlife, the National Museums with its ability to legislate under the Momument Act, can do far more than has been done - and this is an area that we have identified and where perhaps in the next six months we will see some progress - this certainly will be my hope. In terms of the ex situ conservation' again a lot has been identified in terms of need and areas where much can be be done. The National Gene bank and the effort that is going on in that area is very important. Both in terms of ex-situ and in-situ programmes, there is a potential to attract support because of the regional implication for what is being done in Kenya. We have to remember there is, as Kissinger put it, a domino effect to progress in a single country, and I think there is much to be said for the support of programmes in Kenya in terms of what they will do for our region because of this ripple effect.

The question of training is one which we as Kenyans are constantly facing - its an area that is difficult and its compounded by many issues. I do not think it is necessary to go into, and our training institutions are stressed to say the least; they have many problems and we should be realistic in terms of what can be done over night. Nevertheless the idea of a crash training programme in the area of genetic resources conservation is tremendously important, and I am very enthusiastic about the possibility that something can be done in the near future to improve the level of manpower that is available to deal with some of the issues discussed over the last two days. Although we have high level political support for the concept, there is much more that could be done in terms of public support - public at two levels; public in terms of civil service level. There is a great deal of apathy on the part of administration in the government system (and this is surely coming from ignorance) and there is a great deal of apathy from the public at large, considering often that the problem is not theirs, but somebody else's. I think that public awareness is something that could be dealt with in part though this crash training programme that is being discussed.

An area that is very dear to my heart and one where I believe a great deal of progress could be made quickly if we get our act together nationally, is in the data retrieval area. It is quite clear we could jump a decade if we started the right way and that is to get our information into a system where it would be at national level. It is pertinent to this disussion that in the developing countries we are still talking about the technological revolution and appropriate technology for development, whereas in the developed countries they are now in the communication revolution, they are dealing with computers at a level that we often have not thought of. I think the database/data retrieval/computerisation is an area where enormous quantum leap could be anticipated, relatively easily if we discuss it in the right terms. I was particularly pleased to hear the representative of IUCN indicate a willingness to assist - there are a number of areas in which we could get help, but it should be a national endeavour rather that a source of little bits that don't communicate with each other and perpetuation of a problem which we are sadly too familiar with.

The final point I should like to make is that around the room we have already had sincere offers of help from external agencies; I would like to pay tribute to the IBPGR's help in getting this meeting off the ground in the first place and in the hope that it is giving in so many different areas, and I think that it is a very important part of the endeavor for the future. I would like to pay tribute to that assistance which has been given and will be given in the future.

I recognise that IBPGR gets help from UNEP itself and having UNEP so close gives me an opportunity to pay tribute to UNEP's role in this; but when you have a giant so close, you often think that the giant will do the work for you and I do not think we should forget in fact that we are a slight disadvantage in having UNEP here because it makes us lazy. We think UNEP will deal with our problem for us and I think you must remember that UNEP is there for the the world, not just for Kenya. Many of us Kenyans think that Gigiri is there just for us but it deals with everyone's problem. The offer from UNEP to continue with some of the initiatives taken as a result of this meeting is very much appreciated.

I would also like to say that the offer from USAID is significant; as a result of the rather peculiar way that the United States works, the Congress has unwillingly thrown something towards us that if we are clear, we can take; and that is a lot of help in this genetic diversity programme - as Kenyans we should be able to take advantage of and some initiatives have been and will be taken.

The representative from Great Britain speaking for the ODA, spoke very clearly and I am slightly embarrassed because he mentioned mostly things that he's hoping to do for the National Museums, but I would stress that what he is doing for the National Museum is in the area of botanic/ genetic resources/ conservation /propagation, and is very much in line with the recommendation that I believe has come from the workshop.

It would be wrong to conclude without recognising ICRAF and its networking which will prove very useful particularly respect to germplasm banking; similarly the GTZ input in the national gene bank and the support that you are giving in this whole area is recognised. There is much that you are doing and from what I have heard much you could still do; and now wewould ask you as a representative of the GTZ to keep in close touch with some of the initiatives that will follow this.

It is very exciting to have that sort of support so easily offered. Finally I would like to say that all of this will come to nothing if we forget that the meeting was called to try

and establish a way in which we could communicate better as Kenyans and Kenyan institutions. The workshop was designed to try and establish a forum in which follow-up action and initiatives can be taken for the benefit of our country. The idea of national genetic resources committee is important, I take it as a great honour that so many of you have so willingly agreed to support the initiatives that has been taken, but we shouldn't underestimate or minimize the initiatives that have been taken before upon which this initiative has been built; I believe that in the National Museums through the National Herbarium, a great deal can be achieved and will be achieved and I would like to place the total support of the National Museums of Kenya towards this initiative. Thank you all.

UTAFITI Volume 2 Number 2

5 APRIL 1989

CONTENTS

Proceedings of the workshop of Plant Genetic Resources 1987 17-69
Edited by H.J. Beentje & B.N. Khayota

UTAFITI is published quarterly; extra numbers may be published as the need arises. UTAFITI incorporates original research papers on work carried out at the National Museums of Kenya. Every major paper is peer-reviewed by professionals from outside the Museums.

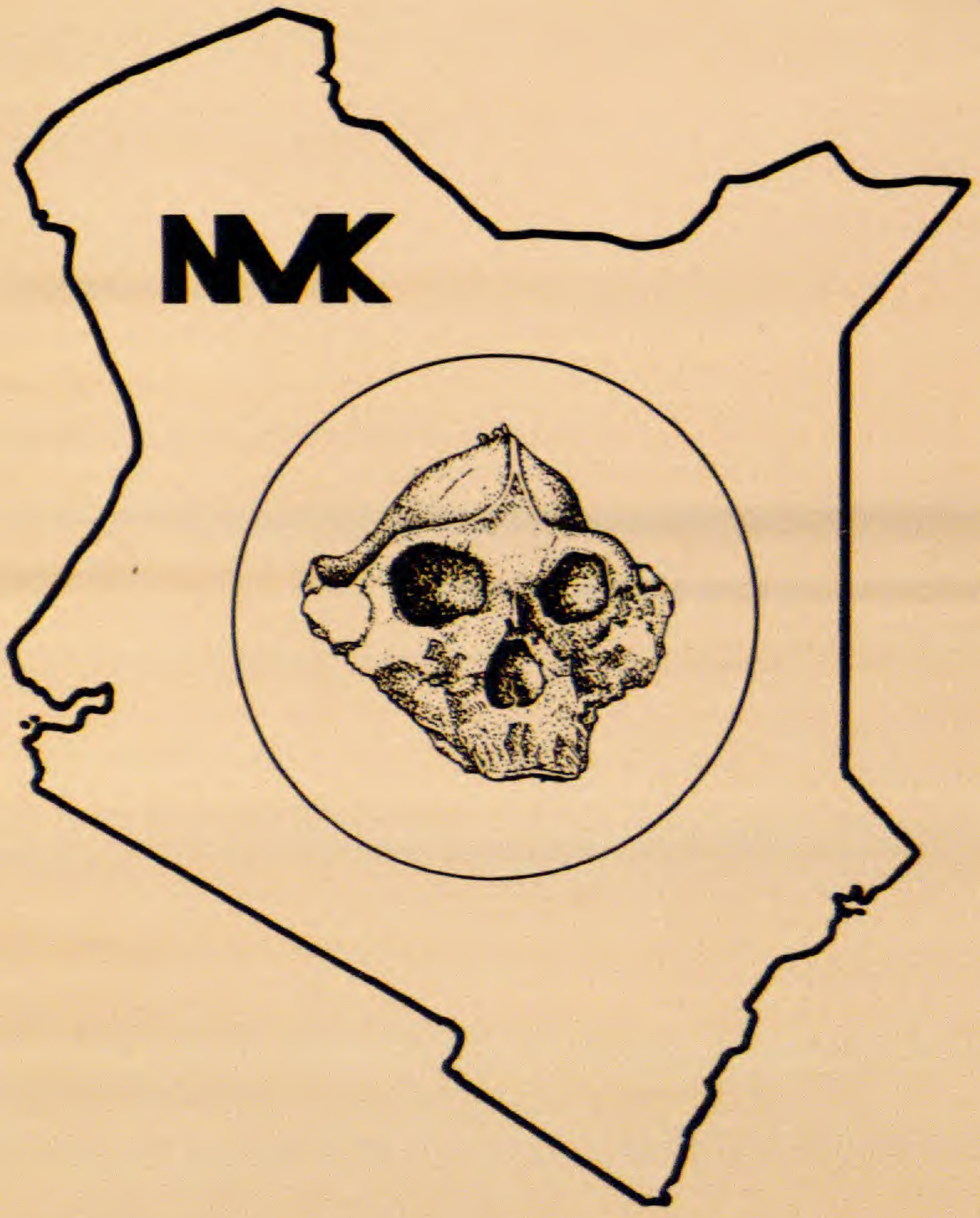
Editor
Dr. H.J. Beentje

Editorial Committee
Dr. H. Adan
Dr. R. Bagine
Dr. M. Issahakia
Miss C.H.S. Kabuye
Dr. M. Leakey
Mr. A. MacKay
Dr. S. Wandibba

Typesetting and layout by the editor
Printed by Man Graphics, P.O. Box 12714, Nairobi
Produced by the National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya
ISSN 9966-9847-4-7

UTAFITI

OCCASIONAL PAPERS OF THE NATIONAL MUSEUMS OF KENYA



NATIONAL MUSEUMS OF KENYA

VOLUME 3 NUMBER 1 JUNE 1990

THE TANA RIVER RED COLOBUS
(*Colobus badius rufomitratus*)

Ochiago W. Odhiambo[1]

Abstact: The population of the red colobus,*Colobus badius rufomitratus*, was censused between September 1988 and June 1989, in the gallery forest on either side of the TanaRiver, to assess its current status. This study has shown that the species, with a population of 264 ± 77 individuals, is still endangered. Among the environmental variables considered, the size of the forest was the only one that correlated significantly with the colobus population size in the forest. Therefore, the structure and function of the forest should be conserved to ensure the survival of the species.

INTRODUCTION

The Tana river red colobus, *Colobus badius rufomitratus*, is the colobine species belonging to the family Cercopithecidae (Struhsaker, 1975). The species is endemic to the gallery forest of the flood plain of the Tana River (Marsh, 1976, 1978, 1985), shown in Figure 1. A survey carried out by Marsh (1985) revealed that the colobus population had declined by over 80% within a decade. In 1975, there were 1500 ± 300 extant individuals but by 1985 only 250 ± 50 colobus were censused. The species has since then been considered endangered and is listed in the I.U.C.N. Red Data Book (Lee *et al.*, 1988). Studies carried out by Marsh (1976,1978,1985) also showed that due to various human activities like shifting culativation, the size of forested areas has declined. In this study, the population of the species was censused within a period of 9 months (September, 1988 to June, 1989) to assess its current status. This was compared with the past population estimates to determine its trends. The size of each forest patch, the tree density and species diversity per forest patch and the number of tree species found in each forest were also determined and correlated with the colobus numbers per forest.

METHODS

The Tana river red colobus, *Colobus badius rufomitratus*, is a shy arborial species. Thus, the actual census was carried out over a two months period (May and June, 1989), the time when annual census is normally carried out in the Tana River Primate Reserve. The proceeding months were spent habituating the groups, determining which forests they inhabited and recording the status of the environment variables, mentioned above, for each forest.

Census involved a systematic search of the entire forest on foot. This involved walking in a north-south or east-west direction with the aid of a compass and maps. Search 'paths' were about 100 metres apart. Some of the clues used in the search included listening for any vocalization, and shaking tree branches. Questioning local people also helped occasionally. Since, at times, the colobus associated with other sympatric primate species such as baboons, mangabeys and Syke's monkeys, when any of these species was sighted or heard vocalizing, the area was thoroughly searched. The number of individuals was determined by counting the monkeys as they jumped from one tree branch to another over an open gap in the canopy. Such counts were done by two people (the author and an assistant) independently and were repeated many times, especially when the figures differed.

The area of each forest was determined by counting the number of squares (each representing one hectare) each forest covered in the map. Tree species diversity and density for each forest were estimated using the P.C.Q(Point-Centre Quadrat) method (Mouller-Dombois and Ellenberg, 1974). This was done only for forests outside the Tana River Primate Reserve because data for forests within the reserve were available form earlier studies. Plant species diversity indices were worked out on the basis of the Shannon-Weaver method (Zar, 1984). The trees considered in this study were only those that were at least 10 metres tall because the colobus tended to spend most of their foraging and resting time at or above that height.

RESULTS

Within the 52 sq.km. geographical range of the colobus (Lee *et al.*, 1988), there are 22 extant colobus groups living in the 17 different forests. Most (76.5%) of the inhabited forests are on the western bank of the Tana River. Only four (21.5%) of the 17 forests are inhabited by more than one group while seven (41%) of these forests are located outside the reserve (Table 1).

Based on a sample of 16 groups that were intensively studied, the colobus live in distinct groups with no overlap of their home ranges. Group size ranged between 2 and 22 individuals with a mean group sizes of 12. The current colobus population, therefore, is 204

1- Dept. of Conservation/ Ecology , Institute of Primate Research, National Museums of Kenya

MISSOURI BOTANICAL

JAN 28 1991



FIGURE 1. The Study Sites with the Tana River Primate Reserve shown in the inset

± 77 (at 95 % C.L).
The forest patches were of variable sizes (Table 2), ranging from 4.5 to 220 hectares. The number of species of trees (at least 10 metres tall) in each forest also varied a lot, ranging between 8 and 31 species, and so did the tree density and species diversity per forest. Despite all this, the only environmental variable that correlated significantly with the number of colobus per forest was forest size (Correlation test, two-tailed, r=0.824*, d.f.= 11).

TABLE 1. Colobus census at the study sites in the Tana River Primate Reserve (1989)

Study Site(forest)	Existing groups	Individuals / Group (as of May, 1989)
*Kipende	1	9
*Maroni	1	5
*Makere	1	16
Guru N.	1	5
Guru S.	1	22
Mchechelo W.	1	12
Congolani C.	1	22
#Sifa E.	1	-
Baomo N.	1	2
Baomo S.	3	19,8 and 15
Kitere	1	10
Mnazini N.	2	9 and 18
Mnazini S.	1	17
#*Mnazini E.	2	-
*Bubesa A.	1	3
#*Hewani E.	1	-
#*Wema	2	-
Total	17	22 192

- Counting not accurate
* Forests outside the reserve
# Forests on the west bank of Tana River.

DISCUSSION

The current colobus population of 264± 77 (at 95% C.L.) indicates that it has not changed much since 1985 when the population was estimated to be 250 ± 50 (Marsh, 1985). The species is, therefore, still endangered and needs protection, especially in the face of the increasing demand for agricultural land. The population of the local Pokomo people has been increasing at the rate of about 3% per annum since 1962 (Andrews *et al.*,1975). These people stay both within and outside the reserve which means that, due to their demand on environmental resources, thecolobus population may not remain stable for long and may soon begin to decline again unless active and appropriate conservation and management strategies are adopted now. A mere creation of a reserve, apparently, does not suffice. Removal of the people from the reserve may be a necessary step towards ensuring that the structure and functions of the forests within the reserve are not disrupted.

The local people interfere with the structure and functions of the forests both directly and indirectly by engaging in practices such as shifting cultivation and selective felling of certain tree species and young plants that could replace dead or old trees. The shifting cultivation involves clearing of a large tract of forested land which in turn leads to a reduction of the existing, or potential, size of a group's home range. For example, the home ranges of colobus groups living in Baomo S., Kipende, Makere and Mnazini N. forests have been thus affected. Selective felling of certain tree species is normally done to get construction materials for canoes, houses, bee hives and firewood. Unfortunately, some of these tree species are the ones preferred as food sources by the endangeredcolobus. For example, *Ficus sycomorus*, which is used for ca-

* Significant at P< 0.05

TABLE 2. Study site variables in the Tana River Primate Reserve (1989)

Study Site	Size (ha.)	Trees		Diversity Indices		Colobus no. /forest
		species no.	Density /ha.	S**	E***	
Baomo N.	21.5	17	37.1	1.02	0.83	2
Boabesa	4.5	8	14.7	0.59	0.66	3
Maroni	27.0	9	18.0	0.48	0.51	5
Guru N.	6.5	16	21.3	1.12	0.92	5
Kipende	21.0	13	107.6	0.47	0.42	9
Kitere	12.5	12	66.3	0.56	0.52	10
Mchelelo	14.0	26	42.5	1.11	0.78	12
Makere	48.0	8	138.5	0.28	0.31	16
Mnazini S.	36.5	23	69.6	1.03	0.75	17
Guru S.	32.0	31	38.2	1.33	1.28	22
Congolani C.	45.0	25	34.5	2.11	1.51	22
MnaziniN*.	38.0	13	58.7	0.69	0.62	27
Baomo S*.	220	25	64.2	1.04	0.75	42
n=13						
Total	526.5	-	-	-	-	192
Mean	40.5	17.1	54.7	0.91	0.76	14.8
SD	55.7	8.38	35.9	0.48	0.33	11.4
Range(Min)	4.5	8	14.7	0.47	0.31	2
(Min)	220	31	107.6	2.11	1.51	42

* Forest with more than one colobus group
** Shannon's Diversity Index
*** Evennes (J') Diversity Index

noes is one of the major food sources for the Tana colobus.

After the removal of the people from the reserve it would be advisable to translocate the colobus groups living outside the reserve into the reserve. This will not only protect the colobus from any retribution by the local people, but will also reduce the current inter-group distances and thus enhance inter-group migrations which are currently inhibited, to some extent, by the presence of villages and farms between most adjacent forests. The above suggested possible solution is complicated by the fact that there are comparatively more colobus on the west bank of the Tana River, where there are more people, than on the east, even though the forests in the later are rarely disturbed. This may lead one to think that the colobus prefer staying close to people. For example, the colobus groups in Mnazini, Maroni, Kipende and Bubesa forests stay very close to villages/farms. This, however, is still an open question because there may be other possible explanations such as the 1984 drought, or a lethal contagious disease, having wiped out more groups in the east than in the west bank forests (Marsh, 1985). The physiognomic structure and floristic composition of comparatively less disturbed forests are similar on either side of the river.

Apparently, the forest size is the only environmental variable among those considered that correlates significantly with the number of colobus per forest. This may be because larger forests like Baomo S. are more resilient to disturbances. The red colobus, compared to other sympatric primate species, including man, has a very narrow niche breadth which means that in case exploitation and/or interference competition intensifies within the Tana primate community guild, the colubus is the most likely species to be subjected to competitive exclusion. This is exactly what reduction of forest size and selective felling of certain tree species might lead to.

Tree species diversity, density and the number of trees per species per forest (those at least 10 metres tall) do not seem to correlate significantly with the number of colobus per forest. This may be due to various factors. For example, a forest may have a large number, or density, of trees but only a small number of these species provide colobus with food. An example of this is Kipende Forest. It is, however, difficult to determine a valid correlation between the colobus per forest and the density of the favoured plant species. This is because the colobus tend to feed on different plant species in different seasons depending on the species that have young leaves and/or fruits at a given time period. Some plant species like *Ficus sycamorous* , for example, provide colobus with food throughout the

year due to the asynchronous way it produces fruits. Others like *Sorindeia obtusifurliolata*, for example, produce fruits in a synchronous way while the rest fall between these two extremes. Different plant species dominate in different forests. Therefore, another factor that could determine the number of colobus per forest is the reliability of each forest patch as far as the provision of food throughout the year is concerned. Forests with reliable food supply like Baomo S. can support a large number of colobus. The aspect of food reliability still requires farther investigation.

ACKNOWLEDGEMENTS

I wish to thank the following organizations for sponsoring this red colobus project in one way or another, Wildlife Conservation International, New York Zoological Society, East African Wildlife Society, National Museums of Kenya, African Wildlife Foundation, the University of Nairobi and the Department of Wildlife Conservation and Management (Hola District Warden's Office).

LITERATURE CITED

Andrews,P.,Grove,p. and Hame,M. 1975.Ecology of the lower Tana River flood plain (Kenya). The Journal of East African Natural History Society and National Museums.No.1, pp 29.

Lee,C., Dhomback,J.and Bennett,E. 1988. Threatened primates of Africa.The I.U.C.N. Red Data Book. I.U.C.N. Gland, Zwitzerland and Cambridge, U.K. pp 155.

Marsh,C. 1976. A management plan for the Tana River Game Reserve, Kenya. New York Zoological Society. University of Bristol, pp 81.

Marsh,C. 1978. Ecology and social organization of the Tana River red colobus, *colobus badius rufomitratus*. PhD thesis, Bristol, pp 325.

Marsh, C. 1985. A resurvey of Tana River primates and their forest habitat. A report to theInstitute of Primate Research, National Museums of Kenya and the Department of WildlifeConservation and Management, pp 29.

Mouller-Dombois, D. and Ellenberg, H. 1974. Aims and Methods of vegetation ecology. Wiley International Edition. John Wiley and Sons. New York, Chichester, Brisbane, Toronto, pp 311.

Struhsaker, T. 1975. The red colobus monkey. Schaller, G. (Ed). University of Chicago.

Zar, J. 1984. Biostatistical analysis. Bette, K. (Ed). Prentice-Hall, Inc., Englewood Cliffs, New Jersey, pp 718.

AN EVALUATION OF BIOLOGICAL CONTROL OF SNAIL INTERMEDIATE HOSTS OF SCHISTOSOMIASIS BY THE MOLLUSCIVOROUS FISH *ASTATOREOCHROMIS ALLUAUDI*

Pieter Kat[1] and Musombi Kibberenge[1]

Abstract: Thirty years ago, molluscivorous fish (*Astatoreochromis alluaudi*) were introduced into small dams in western Kenya to test the efficacy of this species in population control of snail intermediate hosts of schistosomiasis. While the initial results were encouraging, this follow-up study revealed that the fish are no longer effective at controlling snail populations. This failure could be attributed to two main reasons: the presence of refuges from which snails could be regularly recruited ; and the lack of specificity in the diet of the fish.

INTRODUCTION

Specialized molluscivorous fish as well as those that exhibit strong tendencies to prey on molluscs have long been advocated as potential biocontrol agents of the snail vectors of schistotomiasis (e.g. Michelson, 1957; WHO, 1967, 1973, 1982; Wright, 1969; Ferguson & Ruiz-Tiben, 1971; Ferguson, 1972; Hairston *et al.*, 1975; Graber *et al*, 1981; McCullough, 1981a). For example, *Haplochromis mellandi* was effective in reducing populations of *Bulinus* and *Biomphalaria* spp. in a variety of aquatic habitats in Zaire (de Bont & de Bont-Hers, 1952; de Bont, 1956). Control of *Lymnea* and *Biomphalaria* spp. was achieved by introducing *A. alluaudi* into ponds in Cameroon (Bard & Mvongo, 1963; Mvongo and Bard, 1964). The same species significantly reduced *Biomphalaria* spp. in dams in western Kenya (McMahon *et al*, 1977), and is now being considered for use in fish ponds in Rwanda (E. Malek, pers. comm.). Other haplochromine cichlids were used against snails in Zambia (FAO-UN, 1957). In South America, *Tilapia melanopleura*, although not molluscivorous, was demonstrated to control *Biomphalaria* spp in aquaria and a limited field trial (Azevedo, 1960; Andrade & Antunes, 1969). Other field trials are in progress, and McCullough (1981b) presents several anecdotal examples of snail control by a variety of fish predators in Brazil.

In spite of the apparent promise of these results, considerable pessimism about vertebrate predators as biocontrol agents has been expressed. Berg (1973:319) stated that "vertebrate... diets are reputed to be so varied that they do not threaten any prey species unless they are confined with it"; fishes in general satisfy rather few of DeBach's (1974) criteria for effective natural enemies of undesirable organisms (in that they cannot respond well to rapid changes in prey density, and that their generation times are too long in relation to their prey); and both Ferguson & Ruiz-Tiben (1971) and McCullough (1981a) expressed doubt that fish could be useful in all but a few habitat situations. Also, *A. alluaudi*, considered the most efficient molluscivore in a review by Mvongo & Bard (1964) can develop non-specialized dentition and feeding habits (Greenwood, 1965), and Webbe (1961) found *Biomphalaria* spp. in ponds in the presence of this fish.

To be considered effective, a biological control agent should not only be capable of having an immediate effect on prey populations when it is introduced, but should also be capable of exercising long term control. This combination is especially important in the control of snail vectors, which are capable of self-fertilization, prolific reproduction, and rapid colonization from nearby and even distant sources (e.g. Dazo *et al.*, 1966; Demian and Kamel, 1972; Brown, 1980). However, as McCullough (1981b) has pointed out, such capabilities would rule out use of obligatory molluscivores in favour of fish that have a strong predilection for consuming snails, and which would be opportunistic in terms of diet selection when snail populations are low. Jordan *et al.*, (1980) considered this necessary combination of periodic specificity and opportunism a major constraint in the identification of any effective predator.

Previous experiments that have documented declines in snail population densities after introduction of predatory fishes have not been concerned with subsequent long term trends in fish and snail populations, and have not documented changes, if any, in fish dietary preferences over time. An opportunity to examine long term trends in fish and prey snail populations has been afforded by the study of McMahon *et al.*, (1977: experiments performed 1953 to 1967) in which *A. alluaudi* was introduced (in 1954 and 1959) into a series of eleven small dams in western Kenya. The authors concluded that the fish particularly reduced populations of *Biomphalaria pfeifferi*, and was also

1- Malacology Section, National Museums of Kenya

effective , on a lesser scale , against *Bulinus* spp. A follow-up survey, in this case roughly 30 years after the introduction of the molluscivores, was undertaken with the following objectives:-

- to investigate whether *A. alluaudi* had survived in the ponds;
- if so, what the long-term effect of these fish has been in terms of snail control; and
- to determine whether the fish have remained molluscivorous, or whether there is evidence from stomach contents and dentition type to indicate that they have become generalized feeders.

MATERIALS AND METHODS

a)The Dams

Considerable difficulty was encountered in locating the eleven experimental sites of McMahon *et al.*, (1977), as these were identified by name only, and several names had been changed slightly , or completely, in the interim. For example, Chueri had become Chwele, Kavujay is now Kabuchai, etc. Five of the original sites (Lutonya, Kibabi, Bukura, Chwele, and Kabuchai) were identified with certainty, and other dams such as Khalaba and Makhonge, which contained *A. alluaudi* (and which were ,therefore , considered part of the original experiment, as the fish was apparently not stocked except by McMahon *et al.*,(1977) and could not have colonized these dams naturally) but which could not be matched with the list of McMahon et al., (1977), were sampled. Two dams, Lutonya and Futuro, were apparently drained. In all, five dams with populations of *A. alluaudi* were located, and three dams without this fish (Kibabii was stocked by McMahon *et al.*, (1977) but the fish is now not present) were used as controls. The locations of all the dams are listed in the Appendix.

According to McMahon *et al.* (1977), the dams were constructed during the years 1946-1950, with earth forming the dam walls. In most cases, small seasonal streams provide the water during the wet seasons. Papyrus and other grasses frequently form dense stands along the pond and stream margins, and aquatic weeds are generally common within the ponds. The dams form a major source of water for the nearby villagers, and their livestock, and vary in surface area from about 0.4 to 4 ha. In all cases,water levels fluctuate on the order of about 1m during the year.

b) Sampling

Two sampling trips to the area were conducted from February 18 to 21, 1986, and from January 19 to 23, 1987. Fish were sampled by means of a 10m seine net, which proved effective in all but a few dams in which the banks were either too steep (Bukura) or completely surrounded by dense stands of papyrus (Khalaba). In those areas, fish were caught with a large scoop net. No attempt was made at quantitative sampling of fish populations, but several seine hauls were made at each location to ascertain species compositions of the fauna and relative abundance of *A. alluaudi*. . When present, 30 - 40 individuals of *A. alluaudi* were collected by seine, fixed in 10% formalin solution, and preserved in 70% alcohol for analyses of stomach contents and dentition. The lower pharyngeal jaw was dissected from several individuals from each site, cleaned in a dilute solution of hydrogen peroxide, and examined at low magnification with a scanning electron microscope.

Snails were sampled by means of 15cm diameter sieves. Samples were collected from the pond margins, within fringing stands of vegetation, and from habitats outside the ponds such as pond outflows, and pools in the beds of inflowing streams . Each sample consisted of snails collected by five scoops taken relatively close to each other. At least five replicate sets were taken from each habitat. Small non-vector gastropod and bivalve species such as *Segmentorbis angustus, Gyraulus constulatus, Ceratophallus natalensis, Spaerium* sp., and *Pisidium* sp. were collected but not included in the analysis.

RESULTS

The fish species present in each of the dams and their relative abundances are listed in Table 1. In general, all dams contained large fish populations, numerically dominated by either *Tilapia zilli* or *T. leucosticta*, and in one case (Chwele Dam) by *A. alluaudi*.. Apart from *A. alluaudi* and, to a lesser extent, *Clarias* sp., the fish species represented are not molluscivorous. *Tilapia* spp., however, have been noted to reduce snail populations in reservoirs (e.g. McCullough, 1981a) by cropping or eliminating vegetation on which snails feed or lay their eggs, and possibly by eating egg capsules and juvenile snails.

Pairwise comparisons of snail population densities in control and test sites are presented in Tables 2 and 3. It is important to point out that vector snail populations occurred at all sites (except Kabuchai) and that some sites contained populations of *Biomphalaria pfeifferi* as well as *Bulinus* spp. (including *B. natalensis* (Kibabii, Chwele), *B. forskalii* (Kibabii), and *B. africanus* (Makhonge, Khalaba)). Parenthetically, none of the snail species or populations shed cercariae of human schistosomes, although bovine cercariae were recovered from both *B. forskalii* and *B. africanus*. In comparisons between test and control sites, population densities of *B. pfeifferi* (Table 2) were either non-significantly different (8 of 12 comparisons) or slightly significantly higher ($p<.05$) at control sites (4 of 12 comparisons). Population densities of *Bulinus* spp (Table 2: *B. africanus* or *B. natalensis*) showed either non-significant differences (1 of 6 comparisons) between control and test sites, slightly significantly higher ($p<.05$) densities at control sites (3 of 6 comparisons), or slightly to very slightly significantly higher ($.1<p<.05$) densities at test sites (2 of 6 comparisons). Population densities of *Lymnea natalensis* (Table 3) were either non-significantly different (8 of 12 comparisons) between control and test sites, or slightly to highly significantly higher ($.05<p<.001$) at test sites (4 of 12 comparisons).

In addition to the control and test sites, several habitats peripheral to the study ponds were sampled. Pairwise comparisons of snail population densities within ponds and in peripheral habitats are presented in Table 4.

Table 1. Fish species present , and their relative abundance*, in the dams surveyed in western Kenya (1986-87)

	Species**					
Sites	Aa	Tz	Tl	Cl	Al	Ha
Kabuchai	2	-	1	-	3	-
Bukura	3	1	-	-	-	2
Khalaba	3	1	-	4	2	-
Chwele	1	2	-	4	3	-
Makhonge	2	1	-	3	-	-
Namasanda	-	1	-	-	-	-
Kibabii	-	1	-	3	2	-
Nabumu.	-	1	-	2	-	-

* Fish abundance is given on a scale of 1 to 4 with 1 standing for most abundant and 4 for least abundant

**The species of fish are :- Aa: *Astatoreochromis alluaudi;* Tz: *Tilapia zillii*; Tl: *Tilapia leucocosticta*; Cl: *Clarias* sp.; Al: *Alestes* sp.; Ha: *Haplochromis* sp.

Table 2. Pairwise comparisons of mean population densities (t-test) of *Biomphalaria pfeifferi* and *Bulinus* spp. at test and control sites in western Kenya (1986-87)

		Biomphalaria Pfeifferi						
	Sites	Bukura[1]	Khalaba	Chwele	Makhonge	Namasand	Kibabii	Nabumu.
Bulinus spp	Bukura	X	p<.05 (Bukura)[2]	ns	ns	ns	ns	ns
	Khalaba	-	X	p<.01 (Khalaba)	ns	ns	ns	ns
	Chwele	-	p<.1 (Chwele)	X	ns	p<.05 (Namasanda)	p<.05 (Kibabii)	p.<05 (Nabumu.)
	Makhonge	-	p<.001 (Makhonge)	ns	X	ns	p<.05 (Kibabii)	ns
	Namasan.	-	-	-	-	X	ns	ns
	Kibabii	-	p<.05[3] (Kibabii)	p<.1 (Chwele)	ns	-	X	ns
	Nabumu.	-	p<.05 (Nabumu.)	p<.05 (Chwele)	p<.05 (Nabumu.)	-	ns	X

*comparisons are based on pooled data from two visits (see sampling part in the methodology section of text)

[1] - underlined sites contain *A. alluaudi*

[2] - bracketed sites below significance levels denote sites with significantly higher snail densities

[3] - underlined levels of significance designate comparisons between test and control sites

\- denotes absence of the species at one or both sites

ns- not significant

For *Bulinus* spp. (*B. africanus*, *B. nataklensis* and *B. forskalii*) and *Biomphalaria* , such comparisons either revealed no signifficant differences (3 of 8 cases) or were slightly to highly significantly higher (.05<p<.001) than snail densities outside the ponds (5 of 8 cases). In general, the peripheral habitats such as small pools in the beds of feeder streams, dam outflows, and very shallow water with dense stands of vegetation around the pond margins represent environments inaccessible to fish.

Thirty to forty *A. alluaudi* from Kabuchai, Makhonge, and Chwele dams, and fewer specimens from dams that could not be seined (see above) were collected for analysis of dentition type and stomach contents. Scanning electron microscopy reveals that jaws contain a mixture of large, rounded molariform teeth confined to the two median rows, as well as slender papilliform teeth clustered around the edges and in the corners of the jaw. The number of molariform teeth increases with age of the fish but even the largest fish caught retained considerable numbers of papilliform teeth, and molariform teeth are usually cuspidate. Surfaces of molariform teeth were only rarely worn, indicating little hard food in the diet. The jaws correspond, in both development and dentition type, to aquarium-raised *Astatoreochromis* specimens and individuals from natural populations in which snails constitute a minor part of the diet (see Greenwood, 1959, 1965).

Stomach contents of the fish analysed are presented in Table 5. Only in one fish were any snail shell fragments found in the stomach and intestinal tract (*A. alluaudi* swallows crushed shells; see Greenwood, 1965). Insect remains, vegetative matter (plant tissues and small seeds), and detritus predominated in the stomach contents. This diet is analogous to that reported by Greenwood (1965) for *A. alluaudi* from several lakes in Uganda in which snails are rare.

DISCUSSION

The data gathered in this study do not support results of previous authors (e.g. Bard & Mvongo, 1963; Mvongo & Bard, 1964; McMahon *et al.*, 1977) concerning the ability of *A. alluaudi* to effectively control populations of snails that are intermadiate hosts of schistosomiasis. Snail population densities were only in a few cases significantly lower in comparisons between control and test sites and, contrary to expectations, they were occasionally higher at test sites.

Stomach contents and dentition analysis reveal that the supposedly specialized molluscivore has become a generalized feeder since its introduction to the dams, and that the efficacy of *A. alluaudi* in the long-term control of these snail populations is, therefore, minimal. Since snail vector population density thresholds permitting disease transmission are unknown, and since *A. alluaudi* is incapable of eradicating snails, biological control by this predator should only be considered as part of an overall control programme in which other methods are also employed.

The reasons for the inability of *A. alluaudi* in particular, and perhaps other molluscivorous cichlid fish species in general, to control snail populations can be divided into two main causes:-

- the presence of refuges both within the ponds (marginal habitats) and around the ponds (peripheral habitats) from which snails can be recruited regularly; and

- the ability of the fish to become a generalized feeder with snails forming a minimal part of its diet.

The ability of prey to find a refuge from predators has always been a major problem in attempts at biological control.. In the case of the ponds containing *A. alluaudi*, such refuges occur in the form of dense stands of vegetation in shallow water around the pond margins as well as small pools or streams peripheral to the ponds. Since only very small fish, at best, can gain access to marginal refuges, survival of snails there is virtually guaranteed. It is difficult to evaluate the role of *A. alluaudi* in the overall pattern of higher densities of snails in peripheral habitats when compared to the ponds as such differences were also seen in comparisons with ponds that do not contain *A. alluaudi*. This might suggest that other fish species also contribute to snail mortality, or, more likely, that such peripheral habitats are more conducive to higher snail densities. This could result directly from the higher density of vegetation which provides a greater food supply as well as more egg-laying sites, for example. Also, such higher densities in small pools around the edges of the ponds could result from concentration of snails by a progressive decrease in the size of these pools as they dry up. Pond outflows, where present, also contained higher snail densities than the ponds themselves, which might again be attributed to an increased supply of food. However, regardless of the causes of the increased densities of snails in peripheral habitats, these represent a refuge inaccessible to any fish, from which recruitment into the ponds is possible during periods of high water levels.

Non-specificity of biological control agents has often been cited as a reason for their failure (e.g. Berg, 1973; McCullough, 1981a), and in this study can be seen as a major contributing factor to the low efficiency of *A. alluaudi* in snail control. The ability of *A. alluaudi* to switch to a generalized diet might be characteristic of all cichlid fishes and, therefore, merits further study as such fish are usually proposed as control agents.

The development of a specialized mulluscivorous diet in *A. alluaudi* appears to result from a combination of genetic and environmental factors. Greenwood (1959) mentions that post-larval fish of this species already exhibit a tendency towards pharyngeal hypertrophy in that these fish possess coarse lower pharyngeal teeth. Such hypertrophy seems genetically determined. Continued development along these lines during ontogeny, resulting in an adult fish characterized by considerable hypertrophy of the jaw bones as well as possession of enlarged molariform teeth that cover most of the lower jaw, seems to depend on the presence of molluscs in the diet. Such fish are found in Lake Victoria, for example, where the thick-shelled snail *Melanoides tuberculata* forms a major dietary component. On the other hand, fish that lack thedevelopmental stimu-

Table 3. Pairwise comparison of mean population densities (t-test) of *Lymnea natalensis* at test and control sites* in western Kenya (1986-87)

		Lymnea spp					
	Sites	Bukura	Khalaba	Chwele	Makhonge	Namas.	Kibadii	Nabumu.
B	Bukura[1]	-	p<.1	p<.05	p<.01	ns	ns	ns
u			(Bukura)[2]	(Chwele)	(Makhonge)			
l	Khalaba		-	ns	p<001	ns	ns	ns
i				(Makhonge)				
n	Chwele		-	p<.01	ns	p<.05	ns
u				(Makhonge)		(Chwele)	
s	Makhonge			-	p<.001[3]	p<.001	p<.05
s	Namasanda				-	ns	ns
p							
p	Kibabii					-	ns
	Nabumu						-

* Comparisons are based on pooled data from two visits (see sampling part in the methodology section)
[1]-underlined sites contain *A. alluaudi*
[2]-bracketed sites indicate those sites with significantly higher densities
[3]-underlined levels of significance designate comparisons between test and control sites

Table 4 . Pairwise comparison of mean population densities (t-test) of *Biomphalaria* and *Bulinus* spp within ponds and within peripheral habitats of the study site in western Kenya (1986-87)

	Snail Species	
Sites	*Bulinus spp*	*Biomphalaria spp*
Kibabii	(p<.05)[1]	ns
Namasanda	*	(p<.001)
Bukura[2]	*	(p<.001)
Khalaba	(p<.01)	ns
Makhonge	ns	(p<.05)

[1]-bracketed significance levels indicate significantly higher snail density levels in the peripheral habitats
[2]-underlined sites contain *A. alluaudi*
*-gastropod species not present

Table 5. Stomach contents of *Astatoreochromis alluaudi*, in order of importance* at each study site in western Kenya (1986-87)

Sites	Stomach contents				
	Detritus	Insects	Fish	Vegetative	Snails
Bukura (4)**	3	1	-	2	-
Chwele (40)	1	2	4	3	-
Kabuchai (30)	3	1	4	2	5
Khalaba (3)	4	1	3	2	-
Makhonge (30)	1	2	4	3	-

* the order of importance is on a scale of 1 to 5 with 1 standing for the most important and 5 for the least important

** numbers in brackets represent sample sizes

lus of a snail diet, or those that take snails as an occasional prey item, do not develop the degree of hypertrophy characteristic of specialized molluscivores. This is suggested by specimens derived from Lake Victoria parent stock and fed on aquarium food (Greenwood, 1965), as well as specimens from lakes such as Nabugabo (Uganda) where snail population densities are naturally very low (Greenwood, 1959).

A similar lack of hypertrophy is seen in specimens of *A. alluaudi* collected in this study. Their diet, as judged by stomach contents, consists almost entirely of food material other than snails. These fish, although derived from Lake Victoria parent stock (McMahon *et al.*, 1977), have, therefore, developed without the environmental stimulus necessary for hypertrophy. As Greenwood (1959, 1965) points out, *A. alluaudi* possesses the potential to develop into a molluscivore, but can successfully adapt to a more varied diet. Once development along these alternative lines has occurred, however, the ability of *A. alluaudi* to consume snails might be reduced: Greenwood (1965) mentions unsuccessful attempts to feed snails to fish raised on aquarium food. If specialized molluscivory is an adaptation rather than a genetically-programmed course of development in *A. alluaudi*, then the efficacy of similar "molluscivores" in a biological control situation will depend on both the degree of development that is under genetic control as well as diets of other fish species present in the habitat. In Lake Victoria, for example, *A. alluaudi* is part of a complex assemblage of specialized piscivores, insectivores, molluscivores, and zooplanktivores, each with a rather defined depth distribution and/or substrate preference (Witte, 1984). In this situation, possession of an initial competitive edge in terms of post-larval jaw hypertrophy is important in that strong competition from other fish species would tend to limit the availability of food types. An experimental observation by Liem and Kaufman (1984) has relevance here: a molariform morph of *Cichlasoma minckley* only feeds selectively on hard-shelled snails (for which its specialized morphology is adapted) during periods of low food abundance, while it switches opportunistically to a variety of energy-rich food types during periods of high food abundance. Ideally, a fish species used in biological control would possess a more directed and genetically controlled course of development towards molluscivory, especially in environments lacking competitors for other food types. Whether such species exist remains to be determined, but the potential of a molluscivore should be examined from this perspective. Certainly, the degree of specialization that a molluscivore maintains after introduction should be monitored over several generations.

The presence of snail refuges also compromised efficiency of snail control in this study. Future field trials of these fish should consider the possibility of some habitat modification to aid in snail control. As this is likely to be time-consuming and labour intensive in most situations, perhaps the use of fish alone should be discontinued in complex habitats in favour of an integrated control programme in which fish are only one of several snail predators introduced (other predators could include invertebrates capable of penetrating snail refuges), and in which predators are combined with other means of snail and schistosomiasis control.

ACKNOWLEDGEMENTS

We would like to thank the staff of the Bungoma District Fisheries Office, headed by Rachel Ajando, for their help in identifying sites and collecting fish; Blaire Van Valkenburgh for taking the SEM pictures of pharyngeal jaws; and the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, for financial support.

REFERENCES

Andrade R.M. & Antunes C.M.F. (1969) Combate biologico: *Tilapia melanopleura* Dumeril versus *Biomphalaria glabrata* (Say) en condicoes de laboratorio. Rev.Bras. Malar, e Doencas Trop. 21,49.

Azevedo P. (1960) Poixos como auxiliares de combate cquistossomosc. Dcpto. Prod.Animal., SUDEPE e Soc., Brasil Zootecnica.

Bard J. & Mvongo L. (1963) Note de'information sur l'*Astatoreochromis alluaudi* poisson molluscophage utilizablc dans la prophylaxie de la bilharziose. Bull. Soc. Path. Exot. 56,119.

Berg C.O. (1973) Biological control of snail-borne diseases: a review. Exp. Parasitol. 33,318.

Brown D.S. (1980) Freshwater snails of Africa and their medical importance.Taylor & Francis, London.

Dazo B.C., Hairston N.G. & Dawood I.K. (1966). The ecology of *Bulinus truncatus* and *Biomphalari alexandrina* and its implications for the control of bilharziasis in the Egypt-49 area. Bull. WHO 35,339.

De Bach P. (1974) Biological control by natural enemies. Cambridge University Press, Cambridge.

De Bont A.F. (1956) Biological control of freshwater molluscs and of the diseases transmitted by them. Ann. Soc. Belg. Med. Trop. 36,667.

De Bont A.F. & De Bont Hers M.J. (1952) Mollusc control and fish farming in central Africa. Nature, Lond. 170,323.

Demain E.S. & Kamel E.G. (1972) Growth and population dynamics of *Bulinus truncatus* under semi-field conditions in Egypt. Proc. Egypt. Acad. Sci. 25,37.

FAO-UN (1957) La Tilapia y su cultivo - segunda resena y bibliographia. Bol. Pesca FAO 10.

Ferguson F.F. (1972) Biological control of schistosomiasis snails. In Proceedings of a symposium on the future of schistosomiasis control (ed. by M.J. Miller)Tulane University, New Orleans, Louisiana, p.85.

Ferguson, F.F. & Ruiz-Tiben E. (1971) Review of biological control methods for schistosome-bearing snails. Ethiop. Med. J. 9,95.

Graber M., Euzeby A. & Grevey J.P.(1981) Biological control of the snail vectors of bilharzia. Predatory action of *Tilapia rendalli* Boulenger and Saratherodon *mossambica* towards *Biomphalaria glabrata* Say. Hydrobiologica 78,253.

Greenwood P.H. (1959). The monotypic genera of cichlid fishes in Lake Victoria, Part II. Bull. British Mus. (Nat. Hist.) 5,165.

Greenwood P.H. (1965) Environmental effects on the pharyngeal mill of chichlid, *Astatoreochromis alluaudi*, and their taxonomic implications. Proc. Linn. Soc. Lond. 176,1.

Hairston N.G., Wurzinger K.H. & Burch, J.B. (1975) Non-chemical methods of snail control. WHO/TDR/BCV/75.573.

Jordan P., Christie J.D. & Unrau G.O. (1980). Schistosomiasis transmission with particular reference to possible ecolgical and biological methods of control.. A review. Acta Tropica, 37,95.

Liem K.F. & Kaufman L.S. (1984). Intraspecific macroevolution: Functional biology of the polymorphic cichlid species *Cichlasoma minckleyi.* In Evolution of fish species flocks (ed. by A.A. Echelle and I. Kornfield) University of Maine at Orono Press, p. 203.

McCullough F.S. (1981a) Biological control of the snail intermediate hosts of *Schistosoma* spp. A review of its present status and future prospects. Acta Tropica, 38,5.

McCullough F.S. (1981b). Appraisal of the potential of the use of fish for control of disease vectors other than malaria. WHO/TDR/BCV/I.C.81.2/WP.22.

McMahon J.P., Highton, J.B. & Marshall T.F. de C. (1977). Studies on biological control of intermediate hosts of schistosomiasis in Western Kenya. Env. Cons. 4,285.

Michelson E.H. (1957). Studies on biological control of schistosome-bearing snails, predators and parasites of Mollusca: A review of the literature. Parasitology, 47,413.

Mvongo L. & Bard J. (1964). Seconde note d'information sur I'*Astatoreochromis alluaudi* poisson molluscophage utilizable dans la prophylaxie de la bilharziose. Bull. soc. Path. Exot. 57,21.

Webbe G. (1961). Laboratory and field trials of a new molluscicide, Bayer 73, in Tanganyika. Bull. WHO 25,525.

WHO (1967). Epidemiology and control of schistosomiasis. WHO Technical Report Series, No. 372, WHO, Geneva.

WHO (1973). Schistosomiasis control. WHO Technical Report Series, No. 515, WHO, Geneva.

WHO (1982). Report of the sixth meeting of the Scientific Working Group on Biological Control of Vectors. WHO/TDR/VEC - SWG(6)/82.3.

Witte F. (1984). Ecological differentiation in Lake Victoria haplochromines; Comparison of cichlid species flocks in African great lakes. In Evolution of cichlid species flocks (ed. by A.A. Echelle and I. kornifield) University of Marine at Orono Press, p. 55.

Wright C.A. (1969). Some biological views on the control of schistosomiasis. Transactions of the Royal Society of Tropical Medicine and Hygeine, 63,77.

APPENDIX

Location of sample sites:

Site	Latitude	Logitude
Bukura	0' 14"N	34' 38"E
Chwele	0' 44"N	34' 34"E
Kabsuchai	0' 39"N	34' 34"E
Khalaba	0' 40"N	34' 33"E
Kibabii	0' 37"N	34' 32"E
Makhonge	0' 44"N	34' 35"E
Nabumukhoya	0' 43"N	34' 32"E
Namasanda	0' 31"N	34' 33"E

NAME CHANGES IN EAST AFRICAN *ERICACEAE*

H.J. Beentje[1]

Abstract: since *Philippia* (Ericaceae) is now generally considered to be synonymous with *Erica*, new combinations are made for the Kenyan taxa formerly included in *Philippia*.

The differences between the genera *Philippia* Klotzsch and *Erica* L. have been a source of confusion. Oliver (1987, 1988) has placed *Philippia* in synonymy under *Erica*, and I support this move. For the forthcoming "Kenya trees, shrubs and lianas" (Beentje, in preparation) the following combinations need to be made.

1. Erica excelsa (Alm & Fries) Beentje **comb. nov.**
Philippia excelsa Alm & Fries in K. Svenska Vetensk. Akad. Handl. ser. 3, 4 (4): 41 (1927). K.T.S.: 180(1961).

2. Erica trimera (Engl.) Beentje **comb. nov.**
Philippia trimera Engl., Pflanzenw. Ost-Afr. C: 302 (1895). Ross in Bull. Jard. Bot. Etat 27, 4: 745 (1957).
Philippia longifolia Engl., Bot. Jahrb. 43: 345 (1909).
Philippia lebrunii Staner, Rev. Zool. Bot. Afr. 22: 243 (1932).
Philippia humbertii Staner, Ann. Soc. Sci. Bruxelles 53: 160 (1933), non Perrier de la Bathie.
Philippia neo-humbertii Staner, Rev. Zool. Bot. Afr. 23: 232 (1933).

- ssp. keniensis (S. Moore) Beentje **comb. nov.**
Philippia keniensis S. Moore, J. Bot. 39: 259 (1901).
Philippia trimera Engl. ssp. *keniensis* (S. Moore) Hedb., Symb. Bot. Upsal. 15, 1: 145 (1957). Ross in Bull. Jard. Bot. Etat 27, 4: 747 (1957). K.T.S.: 180 (1961).
Philippia trimera Engl. ssp. *kilimanjarica* Hedb., Symb. Bot. Upsal. 15, 1: 146 (1957).
Philippia jaegeri Engl., Bot. Jahrb. 43: 368 (1909).
Philippia trimera Engl. ssp. *jaegeri* (Engl.) Hedb., Symb. Bot. Upsal. 15, 1: 145 (1957), p.p.
Philippia hexagona TCE Fries, Notizbl. Bot. Gart. Berlin 8: 690 (1924).

- ssp. elgonensis (Mildbr.) Beentje **comb. nov.**
Philippia elgonensis Mildbr., Notizbl. Bot. Gart. Berlin 8: 232 (1922).
Erica elgonensis (Mildbr.) Alm & Fries, K. Svenska Vetensk. Akad. Handl. ser. 3, 4 (4): 42 (1927).
Philippia keniensis S. Moore ssp. *elgonensis* (Mildbr.) Ross, Bull. Jard. Bot. Etat 27, 4: 748 (1957). K.T.S.: 180 (1961).
Philippia trimera Engl. ssp. *elgonensis* (Mildbr.) Hedb., Symb. Bot. Upsal. 15, 1: 146 (1957).

3. Erica mannii (Hook. f.) Beentje **comb. nov.**
Ericinella mannii Hook. f., J. Proc. Linn. Soc. London Bot. 6: 16 (1862). Oliver in F.T.A. 3: 484 (1877).
Philippia mannii (Hook. f.) Alm & Fries in K. Svenska Vetensk. Akad. Handl. ser. 3, 4 (4): 37 (1927). Ross in Hepper, F.W.T.A. ed. 2, 2: 2 (1963); in Bol. Soc. Brot. ser. 2, 53: 142 (1981); in Fl. Zambesiaca 7, 1: 178 (1983).

- ssp. usambarensis (Alm & Fries) Beentje **comb. nov.**
Philippia usambarensis Alm & Fries in K. Svenska Vetensk. Akad. Handl. ser. 3, 4 (4): 35 (1927). Brenan in T.T.C.L.: 194 (1949).
Philippia pallidiflora Engl. ssp. *usambarensis* (Alm & Fries) Ross, Bull. Jard. Bot. Etat 27 (11): 752 (1957). K.T.S.: 180 (1961)
Philippia benguelensis sensu K.T.S.: 179 (1961) non (Engl.) Welw. ex Britten.
Philippia mannii (Hook. f.) Alm & Fries ssp. *usambarensis* (Alm & Fries) Ross, Bol. Soc. Brot. ser. 2, 53: 144 (1981); in Fl. Zambesiaca 7, 1: 179 (1983).

REFERENCES

Oliver EGH. 1987. Studies in Ericoideae (Ericaceae) VII The placing of the genus *Philippia* into synonymy under *Erica*; the southern African species. S. Afr. J. Bot. 53 (6): 455-458.

Oliver EGH. 1988. Studies in Ericoideae (Ericaceae) VI. The generic relationship between *Erica* and *Philippia* in southern Africa. Bothalia 18, 1: 1-10.

1- Formerly with the East African Herbarium, National Muesums of Kenya

UTAFITI Volume 3 Number 1
15 JUNE 1990

CONTENTS

The Tana River Colobus (*Colobus badius rufomitratus*)
Ochiago W. Odhiambo 1-5

An Evaluation of Biological Control of Snail Intermediate Hosts of Schistosomiasis by the Molluscivorous Fish *Astatoreochromis alluaudi*
Pieter W. Kat and Musombi Kibberenge 6-12

Name changes in East African *Ericaceae*
H.J Beentje 13

UTAFITI is published quarterly; extra numbers may be published as the need arises. UTAFITI incorporates original research papers on work carried out at the National Museums of Kenya. Every major paper is peer-reviewed by professionals from outside the Museums.

Editor Dr. W. Migongo-Bake

Editorial Committee
Prof. S. Njuguna
Dr. C. Bambra
Dr. M. Leakey
Dr. R. Aman
Mr. Q. Luke

Typesetting and layout by the editor
Printed by Man Graphics Ltd, P.O Box 12714, Nairobi
Produced by the National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya
ISSN 9966-9847-4-7

QL
.U8

UTAFITI

OCCASIONAL PAPERS OF THE NATIONAL MUSEUMS OF KENYA



VOLUME 4 NUMBER 1 JANUARY 1992

EDITED BY L. A. BENNUN

EDITORIAL BOARD

R. A. AMAN R. K. BAGINE C. S. BAMBRA

M. G. LEAKEY Q. LUKE S. G. NJUGUNA

PUBLISHED BY THE NATIONAL MUSEUMS OF KENYA P.O. BOX 40658 NAIROBI KENYA
ISSN 9966 - 9847 - 4 - 7

Utafiti 4(1): 1-33

REPRODUCTIVE BIOLOGY OF THE VERVET MONKEY (*CERCOPITHECUS AETHIOPS*): A REVIEW

R . M. Eley
Institute of Primate Research, National Museums of Kenya,
Box 24481, Karen, Nairobi, Kenya

CONTENTS

Abstract 1

Introduction 1

Overview
- Habitat 1
- Distribution 1
- Food 2
- Behaviour 2

Anatomy of the Reproductive Tract
- Females 2
- Males 3

Puberty
- Females 6
- Males 8

Menopause 8

Sexual Behaviour 9

Menstrual Cycle
- Detection of cyclic activity 11
- Detection of menstruation 11
- Intermenstrual bleeding 12
- Staging of the menstrual cycle 12
- Menses length 13
- Menstrual cycle length 13
- Hormonal profile 14

Pregnancy
- Diagnosis 15
- Implantation 15
- Gestation length 15
- Parturition 16
- Hormonal profile 16

Hormonal Profile of Males 17

Effect of Capture 17

Breeding Success 18

Foetal and Infant Wastage 19

Postpartum Menses and Lactational Amenorrhea 22

Interbirth Interval 23

Seasonality 25

Conclusions 27

References 28

MISSOURI BOTANI
JUL 21 19
GARDEN LIBRA

ABSTRACT

This review discusses many aspects of the reproductive physiology of the vervet or African green monkey (*Cercopithecus aethiops*). Included are data on anatomy, endocrinology and histology: the effects of environmental factors on reproduction are also described. Particular emphasis is placed on a comparison between the data available from studies in the wild and those from captive situations.

INTRODUCTION

For a number of years vervets or African green monkeys (*Cercopithecus aethiops*)[1] have been studied both in the wild and in captivity. In addition to behavioural research these monkeys are utilised in biomedical research where they are used as an animal model for human health-related problems. In order to satisfy the laboratory demand, animals born and raised in captivity are supplemented with those trapped from the wild, in particular from Barbados and East Africa.

Considerable information exists for many aspects of reproductive biology in these animals, especially in the field of reproductive behaviour (see for example literature by Cheney et al. 1981, 1988; Fairbanks 1990a; Fairbanks & McGuire 1984; Harcourt 1987; Keddy 1986; Lee 1984a & b, 1987; Raleigh & McGuire 1990 and Struhsaker 1967). In contrast, data on reproductive anatomy, physiology and endocrinology are few. This review summarizes much of the existing information in these latter fields to provide a summary of the published works and a concise source of reference. Only data pertaining to the vervet are reported and comparisons with other species are not presented. An excellent source of reference for comparative aspects among primates is the volume edited by Dukelow & Erwin (1986).

[1] For the purpose of this review several "forms" are considered to be *C. aethiops*. These include those species referred to as the African green monkey, the tantalus monkey, the grivet, the vervet, the black-faced vervet monkey and the savannah monkey, and to species identified as *C. aethiops, C. pygerythrus, C. tantalus* and *C. sabaeus*. In this review they are all referred to as the vervet or *C. aethiops*.

OVERVIEW
(from Eley 1990)

Morphology

The vervet is a grey-brown monkey with a greenish hue to the pelage on its back, a white-fringed black face, long whitish cheek whiskers, white surrounds to the eyes, black feet and a black tip to the tail. The male has a blue scrotum, red penis and red anus; in the female the perineal region is red and the nipples have a blue hue. Adult males weigh between 4 and 7 kg, head and body length is 40 – 60 cm and the tail is about 15 cm longer than the body. The female is lighter and smaller with measurements about 60 to 80% of those of the male.

Subspecies differences are not very pronounced, being dependent upon slight differences in tail-end and coat colour and the quantity of white whiskers. To the casual observer the best indication of the subspecies in question is geographical distribution.

Infants have a darker pelage than adults but lighter skin colouration; for example in their pink faces which change colour to the black of the adult during the first year of life.

Habitat

Vervets are found in savannah, in woodland, and in riverine, gallery, lake shore and coastal forests. They are not commonly found in heavily forested areas or open grasslands and have been displaced or exterminated from many agricultural areas.

Distribution

Vervets are the most widely distributed of all the African monkeys and perhaps are the most abundant non-human primates in the world. With the exception of the forests of the Congo basin and the deserts of southwestern Africa vervets are found throughout the continent south of the Sahara. Their range extends from Somalia in the east to Mauritania and Senegal in the west and from the Cape in the south to a latitude of 18 degrees in the north. During the 17th century vervets were caught by sailors and transported across the Atlantic where they may

be found in the West Indies (Grenada and St. Kitts) and the Cape Verde Islands (St. Jago). These New World vervets, particularly those from St. Kitts have been studied for a number of years.

Food

Vervets are truly omnivorous, eating fruit, buds, seeds, roots, bark, flowers, gum, insects, small vertebrates and eggs. Products of *Acacia* trees provide a major source of food, and water found in the depressions of branches may, in some circumstances, provide the only source of water. Like baboons (*Papio* spp.), vervets are opportunistic feeders allowing them to survive in a wide variety of conditions and to eat a wide variety of food types. They are accomplished crop raiders and at many lodges tid-bits provide a substantial part of their diet. Vervets once habituated to man are quite persistent and rejection can result in a nasty bite.

Behaviour

Unlike other guenons, vervets and the closely related patas monkey (*Erythrocebus patas*) have shifted from an almost entirely arboreal existence to one where terrestrial activity is considerable. They appear equally at home in the trees or on the ground and this flexibility is reflected in their wide distribution.

A vervet troop can vary between 6 and 60 individuals but consists most often of between 20 and 30 individuals. Vervets differ from the other guenons in that they are usually found in multi-male, multi-female groups, with a linear dominance hierarchy among the males and a matriarchal kinship relationship among the females. Most other guenons have single-male, multi-female groupings. In St. Kitts, McGuire (1974) reported that all groups of more than nine animals contained at least two adult males. Typically one male is fully integrated into the group and the other males are peripheral (Fairbanks, pers. comm.). The males are generally tolerant of each other with no particular agonistic or antagonistic activity. Sexual consortships are not formed and after birth there is no paternal care of the offspring.

As a gesture of aggression vervet males exhibit the famous "red, white and blue" display referring to the exhibition of the red penis and perianus, blue scrotum and white rump hairs. Head bobbing is a threatening gesture which is frequently displayed.

It has been suggested that complex communication exists within all primate species and this has been well documented for vervets (see Seyfarth et al. 1980). Calls are acoustically different for many situations and elicit different responses. For example, an alarm call for an aerial predator causes other troop members to look skyward, whereas a snake call elicits glances to the ground.

Infant vervets spend considerable time clinging to the ventral surface of their mothers, where both of the long pink pendulous nipples are sucked simultaneously. The breasts often have a bluish tinge to them; the female equivalent of the male's blue scrotum.

Birth peaks are observed in the wild but tend to disappear in captivity. Nutrition is probably the major factor determining seasonality, for around game park lodges or in captivity where food is more plentiful breeding will occur all year round.

ANATOMY OF THE REPRODUCTIVE TRACT

Females

Several reports indicate the size of the uterus in the vervet monkey. Some data have been gathered from dissection of dead individuals but more typically are collected through intra-rectal palpation. The non-gravid uterus has been reported to be firm, 0.5 cm wide and 1.75 – 2.0 cm long, with a bulge at the top of the fundus (Johnson et al. 1973). Previous reproductive history of these animals was not given. In the same study, at 25 – 30 days of pregnancy, the dimensions had increased to 0.75 – 1.5 cm wide and 2.5 – 3.5 cm long; this expansion allowed for easy detection of pregnancy by intra-rectal palpation.

Seier (1986) recorded a wide variation in the width and length of the non-gravid uterus (width: mean 1.5 cm, range 0.5 – 2.5 cm; length: 2.8 cm, range 1.0 – 5.5 cm) and reported a club shape, ventral midline cleft and a bilateral

bulge in the fundus. He also used intra-rectal palpation for pregnancy diagnosis and stated that if an individual animal's non-gravid dimensions, shape and tone were known diagnosis was possible as early as 15 days post conception.

Measurements (n=59) at the Institute of Primate Research (IPR), Nairobi, of the uteri of cycling animals yielded values (mean ± s.d.) for width, length and thickness (dorsal-ventral dimensions) of 1.87 ± 0.26 cm (range 1.33 – 2.94 cm), 2.79 ± 0.39 cm (1.78 – 4.0 cm) and 1.54 ± 0.25 cm (0.81 – 2.56 cm), respectively.

Undoubtedly some variation in reported sizes is due to the reproductive history of the animals. All the IPR animals had at least one prior pregnancy, and uterine sizes would therefore be expected to be larger than in nulliparous individuals. The important fact from all the studies is that, with prior information about an individual, small changes in size are easily detected for pregnancy diagnosis.

Ovarian sizes of the same 59 IPR animals were 0.93 ± 0.15 cm and 0.89 ± 0.19 cm for length of the left and right ovaries, respectively, (range 0.55 – 1.34 cm), and 0.55 ± 0.08 cm and 0.57 ± 0.18 cm (range 0.32 – 0.80 cm) for widths. Cross sections of these ovaries during the follicular phase, revealed a large corpus luteum with many follicles around the periphery. Ovulation induction with gonadotropins such as FSH and hCG has not been entirely successful, resulting in "over-stimulated" follicles and subsequent refractiveness to repeated doses (Roussel et al. 1968).

Kimani (1987) undertook a histological study of the vaginal wall of the vervet and identified three layers: a) mucous membrane comprised of squamous surface epithelium and underlying lamina propria, b) a muscular layer of both longitudinal and circular muscle, and c) adventitial connective tissue. The author noted the existence of many elastic fibres in the lamina propria and the muscle layers, and suggested that these had an important role during copulation and parturition.

Njuguna et al. (1984) undertook a study to evaluate the potential of the vervet to act as a model for the study of menstrual blood loss in humans. They found however, that unlike the human and the baboon, the external urethral meatus in the vervet is located several millimetres inside the vaginal introitis. As a consequence blood was washed off, and not retained by, the tampon. It is possible that this anatomy could add to the covert menstruation (see below) in the vervet as blood could be diluted by the urine.

Eley et al. (1989) reviewed the histology of the vervet uterus during the menstrual cycle. The follicular phase was characterized by mild pseudostratification of the columnar epithelium and absence of glandular secretions; in contrast the uterine histology during the luteal phase was dominated by marked pseudostratification of tall columnar epithelium with glandular secretions in the lumen. Of particular interest during the follicular phase was the presence of structures which were more usually to be found during the luteal phase (Kudolo et al. 1986; Eley et al. 1989). These were tortuous uterine glands with secretions in the lumen. The authors suggested that the absence of complete epithelium sloughing during the previous cycle could account for this situation and could be related to the fact that menstruation is often scant in this species.

Bramblett et al. (1975) observed that the external genitalia in male and female infant vervets were virtually indistinguisable and examination for the vaginal opening was necessary for reliable sexing.

Male

External genitalia in the male vervet consists of a small rosy pink to scarlet penis with an acorn- or helmet-shaped light orange to scarlet prepuce. The scrotum may be quite pallid in younger animals but the adult male vervet is well characterised by the powder-blue to greenish-blue colouration. Some regional variation is seen in colour. Struhsaker (1967) described in detail the behaviour associated with the "red, white and blue" display of the male genitalia.

Colouration of the scrotum has attracted quite a number of studies. Testicular size and colour intensity are reported to be an indication of sexual maturity (Harcourt et al. 1981) with the colour darkening from pale to intense blue as

the animal matures. Melanocytes are postulated to be the cause of the blue colouration, which is quite common among the cercopithecidae (Dixson & Herbert 1974). The latter authors studied the talopoin monkey (*C. talapoin*), which has a similar scrotal colouration, and found dense layers of a melanin-like pigment in the dermis. This pigmentation was independent of androgens.

Price et al. (1976) noted that the intensity of colour was affected by the rank of the animal; colour intensity was lost as the animal fell in social rank. They undertook a detailed study of the vervet scrotum and found that while the epidermis and upper dermis were free of pigment, the mid and lower dermis contained dense deposits of melanin situated in melanocytes. The location of the melanin thus varied from that reported by Machinda & Giacomotti (1967) who placed the location of the melanotic melanocytes in the epidermis.

Price et al. (1976) also reported that the labium major in the female vervet was similar to the male scrotum in the distribution of melanin. The authors studied whether the control of this colouration was due to pigment distribution or vascular changes. They concluded that the degree of colouration was not due to the pigment as turnover was too slow. It was then demonstrated that pallor was induced by injecting fluid and colour restored by removing fluid. The authors hypothesised that colour was modulated by dermal hydration but they did not speculate as to how this was regulated.

In a preliminary study at IPR there were no changes in testis size or penis length of male vervets measured repeatedly between the ages of one month and 22 months of age (Table 1).

Zaidi et al. (1982) reported testis weight in seven male vervets of between 2.0 and 3.0 kg body weight (which would make them two to three years of age and just prior to the rapid increase in testicular size seen by Hiyaoka et al. (1990)). Testis weight for six of the animals ranged from 1.74 to 5.45 g. The remaining animal's testis weight was 12.38 g which is more characteristic of an adult (see below).

Table 1. Testis and penis measurements (cm) in immature vervets (n = 23)

Variable		Mean	s.d.	Min	Max
Right testis	– length	1.41	0.39	1.04	2.56
	– width	0.54	0.06	0.50	0.58
Left testis	– length	1.32	0.20	0.82	1.60
	– width	0.80	0.12	0.56	1.12
Penis length		3.08	0.48	1.94	3.92
Os penis length		0.89	0.12	0.70	1.09

Adult animals over five years of age at IPR had the measurements shown in Table 2.

Dixson (1987a) measured the os penis (baculum) in five vervets and reported a length of 16.5 mm with a range of 14.6 – 18.2 mm. These measurements when related to body weight were consistent with other Old World monkeys, and characteristic of those species in which intromission is brief and ends immediately after ejaculation, as opposed to those in which copulation involves long

Table 2. Testis and penis measurements (cm) in adult vervets (n = 11)

Variable		Mean	s.d.	Min	Max
Right testis	– length	4.51	0.49	4.01	5.79
	– width	2.80	0.20	2.44	3.08
Left testis	– length	4.70	0.41	3.87	5.30
	– width	2.95	0.30	2.52	3.42
Penis length		8.72	1.51	5.88	11.72
Os penis length		2.00	0.16	1.80	2.26

intromission and/or maintenance of intromission during the post-ejaculatory interval.

In a further comprehensive article Dixson (1987b) compared many aspects of penile morphology of 130 primate species including the vervet which, in terms of complexity of morphology, was similar to other species which demonstrate multimale mating systems.

From measurements on six individuals, testis weight of 13.0 g, or 0.26% of adult body weight, has been reported (Harcourt et al. 1981). Testicular volume of between 10 and 14 cc was recorded by Eley et al. (1986) from 12 monthly measurements on nine adult animals. The volume was unrelated to the body weight of the individual. Testicular volume has also been reported to be unrelated to dominance rank (Raleigh & McGuire 1990).

Harrison & Lewis (1986) reported that in *Cercopithecus* monkeys the epididymes are triangular in section with a common ejaculatory duct, a single unbranched convoluted seminal vesicle, a pyramidal shaped prostate and well developed bulbourethral glands. However, after dissection of four male vervets Miller (pers. comm.) noted that the seminal vesicles were in fact bilobed in this species. Seminiferous tubule diameter in adult males was given as 143 μm by Eley et al. (1986).

The ultrastructure of vervet Leydig cells was studied by Camatini et al. (1981). They noted the similarity to those described in other mammals but emphasised that the endoplasmic reticulum is more extensive and polymorphic than in man. In a later report (cited by Gould 1982) the same authors indicated that the Leydig cells undergo extensive development between two and three years of age. They further suggested that the pattern of development and testosterone secretion did not parallel that in man, and as a consequence of this the vervet monkey could not be used as a temporal model for the human.

Spermatogonial stem cells were investigated in detail by Clermont (1969). He identified 12 stages of the cycle of the seminiferous epithelium and two types of spermatogonia. One of these he referred to as "reserve stem cell" as it did not appear to be involved in the production of spermatocytes. The spermatogenic cycle was reported by Barr (1973) to be identical to that for a number of other primate species lasting 9 – 12 days. The total duration of spermatogenesis was 36 – 48 days (Barr 1973).

The binding capacity and affinity of Leydig cell LH receptors were reported by Zaidi et al. (1982) who undertook a comparative study of the vervet with the rhesus (*Macaca mulatta*) and human.

Table 3. Characteristics of ejaculate in vervet monkeys (from Seier et al. 1989)

	Non-breeding males		Breeding males	
	Mean	s.d. (n)	Mean	s.d. (n)
Number of animals	37		10	
Number of samples	78		13	
Volume (ml)	0.45	0.50 (57)	0.86	0.69 (13)
pH	7.80	0.95 (25)	9.00	0.23 (10)
Conc (million/ml)	186.00	165.5 (46)	117.15	211.00 (10)
Progression	2.95	0.90 (42)	3.00	1.00 (9)
Motile sperm (%)	55.40	18.40 (58)	43.60	19.10 (11)
Live sperm (%)	68.00	14.90 (36)	53.30	18.90 (10)
Abnormal sperm (%)	3.50	4.60 (27)	6.00	4.4 (10)

Johnson et al. (1973) reported difficulty in semen collection in vervets as compared to macaques (*Macaca* spp.). However, according to other authors, electroejaculation of the vervet can be performed successfully as long as the correct size probe is used (e.g. 1.3 cm diameter; Kraemer & Kuehl 1984). Using this method Valerio & Dalgard (1975) reported an ejaculated volume of 1.24 ml, no coagulation and 145 million sperm. Motility was 58%, abnormality 24% and 13% were dead.

A recent report by Seier et al. (1989) gives results from 91 semen samples obtained by electroejaculation from 47 males. Of these 78 samples were from 37 individually caged males of unknown fertility and the remaining 13 samples were from 10 breeding males of known fertility. The authors noted that the overall figures were lower than those obtained for macaques. A summary of the results from this recent study are given in Table 3.

The small number of breeding males did not allow true comparisons to be made between the two groups. Moreover the sexual behaviour of the individuals, in terms of number of matings for the breeding animals and frequency of masturbation in the individually caged animals, also could have affected the results. However, despite the recognised potential for errors it is obvious that a very wide range does exist for all the parameters. A concentration of as low as 4 million sperm per ml was noted in a fertile and highly successful male. The most common type of abnormality was that of detached tails. The authors also observed that although the majority of samples did coagulate, this trait was inconsistent.

Hiyaoka & Cho (1990) recently reported a method of collecting semen by manipulation of the penis with the fingers. Semen was successfully collected weekly under anaesthesia for three or four consecutive weeks from five adult animals (six or seven years of age) with ejaculation occurring within five to fifteen seconds after the initiation of stimulation. The volume of semen collected, the number of spermatozoa and the motility averaged 1.5 ml, 3.1 x 10^8/ml and 46%, respectively. Five animals which were five years of age did not respond to the stimulation.

The fructose, lactic acid and citric acid content of vervet sperm were given by Ackerman & Roussel (1968). Mean figures were reported for concentration, motility and abnormal sperm for a set of four and a set of two samples. Concentration was 288 ± 295 and 57 ± 7 x 10^6 sperm/ml and figures for motility and abnormal sperm were given as 34 ± 7% and 38 ± 32%, and 40 ± 6 and 26 ± 12, respectively.

The same laboratory undertook a number of comparative studies of primate sperm with the aim of long term storage and preservation. They noted that spermatophagy and phagocytosis of sperm cells occurred in the testes and epididymides (Roussel et al. 1967). The same authors later reported on improved methods for electroejaculation (Roussel & Austin 1968).

Freezing of sperm was evaluated for up to 72 hours post collection (Roussel & Austin 1967a). Trypsin liquification of the coagulum was found not to have any detrimental effect on subsequent motility (Roussel & Austin 1967b) and an egg yolk-glutamate-glycerol extender was used prior to immersion in liquid nitrogen. After thawing, motility in the eight samples obtained from three vervets fell from 53% (range 40 – 55%) to 28% (20 – 31%), constituting a 51% survival. In a later study seven semen samples which had been frozen for seven months were evaluated (Ackerman & Roussel 1971). Post-thaw motility was very low, below 1%, and as such long term storage was not viable. These data on semen storage are quite dated and more up-to-date work using more recent technology obviously needs to be done in this area in the vervet monkey.

PUBERTY

Females

Asanov (1972) reported that sexual maturity in the female vervet in captivity was attained by 30 months, while Henzi & Lucas (1980) reported the same event to occur at between 2.5 and 3 years of age. Neither author defined the event. Hiyaoka et al. (1989) monitored menarche in five females and determined that it was strongly correlated to maturing rate and growth. Age at menarche ranged from 26 to 40 months (mean 32 mo.) at a mean body weight of 2.33 kg (range 2.13 – 2.73 kg) which was 88% of mature body weight (mean 2.63, range 2.28 – 3.18 kg).

Asanov (1972) also noted that there was no relationship between season and the age of maturity. Furthermore, although the interval from sexual maturity to first pregnancy (ten months) was not related to the age at which maturity was achieved, pregnancies were more likely to result in a pathological outcome (i.e. foetal wastage) in animals which reached sexual maturity at an early age.

Rowell & Richards (1979) reported that the earliest age at first birth in captivity in Kenya was 40 months, with a median of 47 months and a large range of 40 – 108 months (n = 8). Earliest conception would therefore have been 35 months which agrees with the data given above for age at sexual maturity. From the other studies noted above, menarche or at least sexual maturity, occurred within a relatively small range of ages. The existence of animals which conceived (or at least delivered their first live offspring) much later could suggest that the period immediately after menarche, at least in some individuals, was one of relatively lower fertility.

Other birth data come from colony-born animals in the USA. Fairbanks & McGuire (1984) reported age at first birth in 17 colony-born females to average 4.1 years with a range of 3 to 5 years although the precise ages of the animals in question were not given. In a later study Fairbanks (1990) stated that of 27 animals which had been allomothers during the first and second years of their life, 16 gave birth after 3 years and 11 at age four or older. The data would suggest that allomothering reduced the age to first conception perhaps by some type of social facilitation. Age of first birth has also been reported by Fairbanks (pers. comm.) to decline with successive generations in captivity.

Bramblett et al. (1975) noted menarche at 26, 30 and 34 months, with age of first delivery in these three females of 39, none and 73 months, respectively. This too would suggest a number of infertile "cycles" prior to conception. Other animals for which the age of menarche was not known gave birth at 39, 42 and 43 months.

At IPR, where no timing of puberty is available, 24 colony-born animals gave birth between 34 and 96 months of age, with a mean age of 53 months. Only one female gave birth at less than 40 months of age (36 months of age) indicating that conceptions infrequently occur at less than 3 years of age. All these animals were maintained in group cages with their mothers, between two and five other adult females and their offspring, and one male. There was no relationship between age at conception and survival of the offspring. Furthermore pregnancy outcome in these colony-born, primiparous animals did not differ from that of multiparous animals.

Horrocks (1986) estimated age at first pregnancy at 34 months for wild-caught animals. Age was based on nipple size and length of the canines. It was recognised by the author that these parameters could be indicative of sexual maturation and not maturity *per se*. It has been reported for baboons by Kahumbu & Eley (1991) that tooth eruption and emergence in wild animals is delayed considerably compared to captive-bred animals. There is little reason to doubt that this would also be the case with other primate species; as age estimates for vervets are based on the teeth of captive animals, it is therefore probable that the wild-caught animals were in fact older than the estimates given in the paper.

Consequently, the available data would suggest that in captivity first delivery is usually between three and a half and four and a half years of age. In wild vervets at Samburu, Turner et al. (1987) diagnosed pregnancy by serum amino-peptidase (see below) in two animals of "approximately" 36 and 42 months of age. In another long term Kenyan study in which animals had been observed on a continual basis for six years, Cheney et al. (1988) reported that although most females in Amboseli first gave birth at five years of age, there were three four-year-old animals which had given birth to live offspring. Without specifying the exact age of the animals or the number of births the authors gave figures of 4.4 ± 0.6, 5.1 ± 0.6 and 5.7 ± 1.1 years (mean ± s.d.) for the first birth in the three study groups, which had access to nutrition which the authors described as "good", "intermediate" and "poor", respectively. Although these ages were not significantly different there was a trend which demonstrated the importance of nutrition. The authors did not demonstrate any effect of dominance on age at first delivery.

As in captivity, there is a wide range of ages at first birth for wild animals. However in general

it would appear that in the wild first birth occurs between four-and-a-half and five-and-a-half years of age. This suggests that in captivity, under conditions which are conducive to accelerated growth and development, age of first delivery is brought forward by as much as one year compared to the wild.

Males

Hiyaoka et al. (1990) monitored sexual maturity in five laboratory-bred males by evaluation of growth rate, serum testosterone and testicular size. They indicated that onset of sexual maturity occurred at the critical point in the body weight curve and testicular size began increasing at this time (approx 2.5 years). A rise in testosterone concentration which occurred at approximately 46 months (range 42 – 53 mo.) of age coincided with the time of sexual maturation as defined by face and scrotal skin colour, and testicular size. The latter increased from a capacity index of 3 (major axial length x minor axial length x width) prior to one year of age, to 5 by 18 months, 10 at 3 years of age and 20 + at 4 years of age. Sexual maturity occurred at a mean body weight of 3.67 kg (range 3.35 – 4.13 kg), which was 75% of mature body weight (mean 4.96 kg, range 4.62 – 5.66 kg).

Reproductive development of the male vervet was also studied by Brady et al. (1985). They compared a number of parameters in animals of 26, 32, 38 and 44 months of age as well as in adults. There was no significant difference among the ages in luteinising hormone (LH) response to gonadotrophin releasing hormone (GnRH) challenge. However, some individuals at less than 38 months of age failed to respond to the challenge, which would suggest that developmental changes do occur in the responsiveness of the pituitary. Basal testosterone and testosterone response to gonadotrophin releasing hormone was greater in adults than in ages 38 months and younger and, although non-significant, there was a trend for basal testosterone response to be greater at 44 months.

Sperm were demonstrable in some individuals of 38 and 44 mo. Those with sperm had higher body weight (5.0 ± 1.33 kg) than those without (4.18 ± 1.26 kg). Testicular volume was also higher in those with sperm (approx 14 cc versus 4 cc) as was basal testosterone (4 ng/ml versus ng/ml). From these data the authors inferred that sexual maturity occurred after 40 months of age.

All the data would suggest that in laboratory-bred animals puberty is achieved between three and four years of age in males. These data are therefore consistent with the data from females under similar conditions.

Reference to sexual maturity in wild males is, as in females, dependent in most studies on the assessment of age through parameters which may be under-estimates of the true chronological age. Horrocks (1986) used full descent of the scrotum and length of the canine teeth as the indicators of sexual maturity, and gave a figure of 60 months. No male under 4.4 kg was mature and the average weight was 5.3 kg (n = 61). Cheney et al. (1988) reported that copulation with ejaculation began at about 5 years of age in Amboseli animals. No reports exist as to the age of first successful insemination in males.

Consequently it would appear that puberty in males, like age of first delivery in females, occurs some 12 months or so later in the wild than in captivity.

One final note on sexual "maturity" comes from Struhsaker (1967) who observed that one male of 51 days of age exhibited behaviour resembling masturbation. Masturbation was however most frequent in older males and the author noted 19 such acts in 12 animals during 1200 h of observation. Although the sample size was small Struhsaker concluded that the frequency of masturbation was highest during the birth season and lowest during the breeding season with sexual competence present in the males at all times of the year.

MENOPAUSE

No specific data are available for menopause. However, fifteen females all greater than 10 years of age were reported to be still reproductively competent in Amboseli (Cheney et al. 1988). The authors suggested that loss in fecundity was only evident after 13 years of age. Fairbanks & McGuire (1986) reported that in the Sepulveda colony in California two of six wild caught females were still alive at 12 and 13 years of age by which time

they had experienced 10 pregnancies. The authors noted that the primary cause of death in these old animals in the protected environment of the colony was due to complications in pregnancy and delivery. In captivity at IPR one female gave birth every year from the age of seven to 16 (her access to males was denied until she was six hence the lateness of her first pregnancy).

The only available data for males is that from Seier (pers. comm.) who reports one male in excess of 23 years of age who has been in captivity for 20 years and is still breeding successfully.

SEXUAL BEHAVIOUR

Some questions must be raised as to exactly what authors mean by "copulation". This was clearly illustrated by Struhsaker (1967) who in over 2200 hours of observation in Amboseli noted 176 heterosexual mountings which he classified as either full or incomplete. He further noted that only 65 ended in either a pause (presumed to indicate ejaculation) or ejaculation (semen observed). Therefore where reference to copulation is not qualified it cannot be assumed that intromission and ejaculation actually occurred.

Rowell (1970) reported 574 acts of copulation in five adult females (housed with one male) in a two-year study of captive vervet monkeys in Uganda. Thirty-two complete menstrual cycles were followed and during these 205 copulations were recorded. A further 198 occurred during 11 pregnancies with the number of acts per pregnancy ranging from one to 44. As mating was not frequently seen, the fact that ejaculation had occurred was based on the presence of sperm in vaginal fluids collected by thrice-weekly lavage. The lavage was carried out throughout pregnancy except for the last few weeks and began again five weeks postpartum. Copulation occurred throughout the entire cycle and pregnancy. The frequency caused the author to refer to the vervet as being in a state of "continual oestrus" except for the immediate postpartum period. Although one animal whose infant died at birth did begin copulating at 23 days postpartum the normal interval was between five and 14 weeks post partum.

Other data exist for early postpartum copulations in captivity. For example Bramblett et al. (1975) detected the large numbers of sperm in the vaginal vault of an individual one month after parturition, and Booth (1962) noted a copulation at five days postpartum. The fate of the infant in these two cases is not reported. Fairbanks & McGuire (1984) reported that in several instances mothers who had delivered a live infant and were suckling copulated within the first few days after delivery.

In a later paper Rowell (1971) stated that copulations occurred throughout the menstrual cycle, pregnancy and lactation with no difference in male/female agonistic behaviour, although there were significantly more total interactions during the menstrual cycle than in the two other reproductive states. One of five females copulated more frequently during the peri-ovulatory period than in the follicular and luteal phases and another copulated less in the latter half of the cycle. The other three showed no change in interaction frequency throughout the cycle. Rowell (1971) also reported that the incidence of copulations was not related to the stage of the sexual cycle of the female. A similar observation was made by Booth (1962).

The results of Rowell (1971) regarding the frequency of copulation are however quite different from those of several other workers. Schapiro (1984) for example, after studying captive vervets in harem groups (cages comprising on average of three mature females) at IPR for one year, reported only one sexual act occurred for every five hours of observation. The reason for this is unclear but it should be restated that Rowell used results from vaginal lavage as a indication of copulation. Although Rowell (1971) reported no effect on behaviour due to the lavage procedure, Bramblett et al. (1975) noted that the incidence of copulations was dramatically reduced once swabbing was stopped, implying that the procedure promoted attention by the males. These authors noted that after cessation of swabbing sexual acts were very rarely observed. In fact copulation was only observed with "estrus females" five times in 31 months. There were a further eight births for which copulation was not observed and the authors suggested that copulations only took place in the early morning.

Booth (1972), observing captive vervets in Kenya, noted that copulation occurred in the observation period from 0745 and 1200 hours and again between 1700 and 1800 hours but not between 1200 and 1700 hours when the animals were usually resting. The author further reported that the animals were very shy and elusive and the act itself was seldom observed.

Andelman (1984) reported that in the wild copulations occurred outside of the peri-ovulatory period. She followed four females over a two-year period in Amboseli National Park in Kenya and monitored urinary progesterone metabolites to correlate behavioural observations with reproductive status. One female was seen to copulate seven times (at intervals of 11.8 ± 6.9 days) in the first three months of pregnancy one year, 11 times during lactational amenorrhea but never during the subsequent pregnancy. Another female copulated on three occasions prior to the initiation of ovarian activity one year and also during pregnancy the following year. The author noted that the patterns of copulations were extremely variable both among individual females and within an individual from year to year.

During his Amboseli study Struhsaker (1967) listed 176 copulatory acts, 65 with ejaculation and/or pause . These acts all occurred between 0600 and 1900 hours with a reduction between noon and 1400 hours. No copulations were observed in the hour prior to 0600 hours nor after 1900 hours. The incidence was less than one mount per adult female per 10 h of observation. Copulations or mounts with ejaculation were absent during the birth season at which time the incidence of masturbation increased.

Most of the other data from the wild also suggest a low incidence of copulation. Indeed Haddow (1952) described the vervet as a "sexless" monkey and, because he saw no copulations during the day, suggested that copulations only occurred at night. In Samburu Whitten (1982) observed 20 females in three different troops and presented figures ranging from zero to 27 copulations per 100 h of observation. Neither the actual numbers of copulations nor the definition of a copulation were given. On St. Kitts only 10 copulations and five acts of masturbation were seen in 42 months of study (McGuire 1974). However, there were frequent acts of heterosexual behaviour such as inspection, presentation and grooming. Cheney et al. (1988) reported that less than 70 copulations were observed in seven years of study in Amboseli, and in West Africa, Kavanagh (1983) noted 12 copulations in 415 hours of study in one group and 10 in 475 hours in another. Although the animals were not observed during the months in which the conception peak occurred, the results would suggest that in the wild the incidence of copulation is not high.

Struhsaker (1967), Klein (1978) and Lee (1984a) all identified a distinct copulatory season in Amboseli. This indicates that fewer copulations occur during pregnancy and lactation, or that there was a reduction in sexual activity during a period of acyclicity as reported by Andelman (1984). As noted by this latter author copulations do occur during lactation and pregnancy. As a further example, Struhsaker (1967) observed copulation by 20 days postpartum in one female although copulation with ejaculation was not noted until 104 days. Furthermore copulations occurred up to 82 days prepartum; these data indicate sexual activity in all reproductive states of cyclicity, pregnancy and lactation.

Kavanagh (1983) also stated that copulation frequency in vervet monkeys was low and indicated that the females were the ones who initiated the activity. This is in agreement with Schapiro (1984), who in his study of captive animals, noted that only 15 – 20 % of male initiations were accepted. In Rowell's report (1971) the act of courtship was very brief with the females occasionally soliciting copulation by pulling on the male's penis.

Andelman (1984) noted that successful copulations took less than 30 seconds. Total mounts in her study were low with 0.06/h versus 1/h for baboons. She presented data to suggest that the females exert a strong choice on male attention and that up to 50% of all male advances were rejected. Females were more attractive, but not more receptive, to males during the peri-ovulatory period but were more receptive during pregnancy than during the peri-ovulatory period. For further discussion on partner selection see Keddy (1986).

Whitten (1982) concluded that colouration of the sex skin was a prerequisite to mating. Only

three of 16 females started mating prior to the colour change from white to pink. However, as results indicate that conception occurred outside the period of observed mating the precise requirement for colour is unclear.

Struhsaker (1967) noted that one animal was in prolonged "oestrus" (i.e. sexually receptive) for 66 days with frequent mountings being observed. The existence of a nymphomania due perhaps to cystic follicles cannot be discounted here.

MENSTRUAL CYCLE

Detection of cyclic activity

Whitten (1982) noted that the onset of mating activity in the wild vervets of Samburu was accompanied by changes in the colour of the perineum. Colouration was a prerequisite for mating and fertility. The perineum changed from white to pale pink in 95% of the females near the beginning of the mating season and to deep pink in 77% during peak mating months. Those females whose perineums deepened in colour were more likely to conceive than those in which no change occurred. Six of seven animals who gave birth had showed a deep pink perineum and six of ten which did not show this colour failed to conceive.

Andelman (1984) and Cheney et al. (1988) both looked for the same phenomenon in the Amboseli vervets but failed to find any external morphological changes which were associated with ovulation. Perhaps there are differences in behaviour and morphology in different locations; Amboseli male vervets for example, give the "red, white and blue" display (Struhsaker 1967) while Samburu vervets do not (Whitten 1982).

Wickler (1967) also reported colour changes in captive animals but these were not noted by Rowell (1970). Butler (1966) noted that both the skin of the perineum and the root of the tail were red in some animals but the colouration was sporadic and bore no constant relationship to the cycle. Two hundred and forty-nine menstrual cycles were monitored at IPR (Eley et al. 1989). Variation in colour existed among different individuals, but changes during the cycle within the same animal were slight and not predictable. Even the intra-muscular administration of a long-acting oestrogen at a dose which caused definitive changes in baboon peri-anal skin had no effect in the vervet (Eley unpubl. obs.).

Consequently, although seasonal changes may occur due to the onset of ovarian activity, monitoring of the stages of the cycle by perineal skin colouration is not reliable.

Detection of menstruation

Both Zuckerman (1932) and Butler (1966) reported overt menstruation in vervets. The former author indicated subspecies differences in the external manifestations of menses, but as this was based on observations on one individual the validity of this statement is questionable. Butler (1966) stated that menstruation was easy to see by blood on the perineum and Cho et al. (1987) reported that after the first pregnancy visual detection of menstrual bleeding was easy as the volume of blood was increased.

These views on overt bleeding are not shared by the majority of workers. For example, Rowell (1970) detected menstruation by vaginal lavage but concluded that menstruation was "rarely visible externally". Bramblett et al. (1975) reported that only one in ten animals gave a clear and consistent external indication of menstruation. That particular female was the only one which had not conceived. Johnson et al. (1973) also noted that only a few animals show blood on the swab during menses, the rest required a test for occult blood. Hess et al. (1979) concurred that the majority of menses were detectable only by vaginal swabbing.

The reason for the covert menstruation is unclear, but preliminary evidence suggests that it may be associated with incomplete sloughing of the endometrium. This is based on the observation that luteal type structures are seen during the follicular phase in histological sections (Eley et al. 1989).

As a consequence of these observations, swabbing or testing for occult blood became recommended for captive animals (Zuckerman 1953; Rowell 1971; Johnson et al. 1973; Hess et al. 1979). However, Bramblett et al. (1975) suggested that although in most cases red blood cells were present, large numbers of

leucocytes, basal cells and mucus made detection difficult in about 10% of animals even after the preparation of slides.

Intermenstrual bleeding

Hess et al. (1979) reported intermenstrual bleeding as detected by vaginal lavage for one or two days in 23 cycles from 11 animals, out of a total of 183 cycles from 21 females. This activity has also been detected by other workers (e.g. Bramblett et al. 1975). Rowell (1970) took three vaginal lavage samples per week and noted bleeding in 26 of 32 cycles. The median was on day 16 with 18 occurring between days 11 and 19. Using radioimmunoassay, Else et al. (1986) reported a high incidence of "short" cycles of less than 20 days. Consequently it is possible that the next menstruation could in some cases be confused with intermenstrual bleeding. For example Butler (1966) reported one case of intermenstrual bleeding on the 21st to 23rd day of a cycle, which could simply have been a short cycle. However he refers to seven cycles having lengths of 2 – 14 days and these are possibly due to intermenstrual bleeding bouts rather than true menstruation.

Butler (1966) also noted that some animals showed redness and swelling on the skin of the perineum and the root of the tail for a few days between successive menses. However, this was sporadic in its appearance and bore no constant relationship to the stage of the menstrual cycle.

Staging of the menstrual cycle

Rowell (1970) noted that there was no externally visible indication of the progression of the menstrual cycle. As a consequence, vaginal lavage has been used in an attempt to identify the stages of the cycle by a variety of workers. Early work by Butler (1966) suggested that there were no obvious cycle effects on cytology but this observation was based on only one animal. Rowell (1970) reported that leucocyte count peaked at menstruation. She also observed a mid-cycle leucocyte peak at a median of 16 days (64% between 11 and 19 days) before the next menstruation in 25 of 32 cycles. Mean sediment reading of cornified vaginal cells in 14 cycles from five animals did not however demonstrate any cyclicity.

Rowell (1970) found less vaginal cornification in the vervet than that reported for either rhesus monkeys or baboons. In view of the copulation frequency which this author observed, she suggested that there might be little need for vaginal protection, and hence vaginal cornification, in an animal that mated "little and often" (i.e. frequently but for short duration).

Bramblett et al. (1975) also noted that there was a leucocyte peak during ovulation in some animals. However, the appearance of these cells during other parts of the cycle was too common for them to be used as a reliable indicator. These authors showed that the proliferative phase was distinguishable by the rise in superficial and cornified cells but, apart from more intermediate cells in the secretory phase, this was indistinguishable from the peri-ovulatory period.

The workers at IPR (Eley et al. 1989) reported both quantitative and qualitative changes in cells throughout the cycle but concluded that vaginal cytology was an unreliable way of accurately monitoring cycle stages. Although fluctuations in numbers of leucocytes, superficial and parabasal cells did occur during the cycle the pattern was too broad to be precise as to the time of ovulation.

A recent paper by Seier et al. (1991) addressed vaginal cytology specifically. They used hormonal measurements to correlate the changes in cells found in vaginal smears taken from the lateral vaginal wall three times weekly post menses and four times weekly around ovulation in 15 female vervets. The karyopyknotic index (KPI; ratio of mature superficial to intermediate squamous cells) was reported to parallel the oestrogen concentration. A mid-cycle maturation produced many anucleate squamous cells, which then exfoliated and formed a diagnostic vaginal discharge. The authors concluded that the methodology was useful for establishing the existence of cycles but, in agreement with other authors, doubted that ovulation could be accurately determined.

Seier (pers. comm.) stresses that smears must be made from the lateral vaginal wall and with direct vision. Any other method (e.g. lavage) will not yield reliable reproducable results as the sample could contain superficial squamous cells from the vulva. These epithelial cells are

not dependant upon hormonal influence for maturation.

The period of sexual receptivity itself may sometimes be detectable by behaviour. Struhsaker (1967) for example, stated that females presented themselves to males if the former were in "oestrus". In contrast, an aggressive response was made to the male's advances if the female was in "anoestrus".

Menses length

Menses lengths of 2.0, 4.4, 4.4 ± 2.1 (n = 243, range 1 – 12), 3.6 ± 0.5 (n = 35, range 2 – 7), 3.7 ± 2.3 (n = 583) and 5.0 (n = 20, range 3 – 9) days have been reported by Zuckerman (1932), Asanov (1972), Hess et al. (1979), Butler (1966), Johnson et al. (1973) and Seier et al. (1991), respectively. These are in agreement with our own published figures of 4.87 (Eley et al. 1989). The last authors report the range of menstruation to vary between 1 and 16 days which compares favourably with the 1 to 15 day range given by Johnson et al. (1973).

Menstrual cycle length

As with menses length most of the reported figures are in agreement (Table 4).

The figures by Hess et al. (1979) and Eley et al. (1989) were derived from radioimmunoassay of progesterone, LH and oestradiol. The authors reported ovulation to occur on days 13 – 14 or 13, respectively, following an LH peak the day before. The follicular and luteal phases would therefore be 12 – 13 and 17 – 19 days. Asanov (1972) reported a follicular phase length of 11–14 days.

Apart from variation due to individual animals, differences in reported figures are affected by the range of cycle lengths used in calculation and also the method of calculation itself. For example the figure of Eley et al. (1989) in Table 4 is a mean of 20 within-animal means; each one of those being determined from between 4 and 37 cycles. However the vervet in captivity experiences many cycles outside of the "normal" 20 – 50 day range which was used for those calculations (Eley & Tarara 1984). Use of all cycles in calculations yields results such as those of Butler (1966) given above. It should be noted that Butler did suggest that some of the figures he obtained were from adolescents or in one case a menopausal animal. If Butler's figures are broken down further, it is seen that one animal cycled 11 times with values between 12 and 103 days. If those cycles longer than 50 days (n = 4) are deleted the mean cycle length for the 7 remaining cycles is 31.4 days.

Table 4. Menstrual cycle length in vervet monkeys

Length (days)		Range (days)	Number of cycles	Number of animals	Reference
Mean	s.d.				
31.0				1	Zuckerman 1953
72.3	36.2	24–149	29	7	Butler 1966
33.0		25–46	32	5	Rowell 1970
31.4	5.3				Asanov 1972
30.9	9.6	16–50	392	29	Johnson et al. 1973
31.4	5.3	18–49	183	21	Hess et al. 1979
32.6		20–50	700	20	Eley et al. 1989
30.6		25–40	20	11	Seier et al. 1991

Prolonged periods between menstruations are often referred to as amenorrheic periods but perhaps should be more correctly referred to as prolonged intermenstrual periods. Johnson et al. (1973) noted 95 such periods (range 51 – 240 days, mean 84.2 ± 37.4 days) out of a total of 487 cycles, Hess et al. (1979) reported 15 (range 51 – 80 days, mean 62.0 ± 9.2 days) out

of 198 cycles and Else et al. (1986) noted that 26% of the 600 cycles they monitored by vaginal swabs were prolonged.

Rowell (1970) reported that 64% of cycles (21 of 32) were within 5 days of the median cycle length of 33 days. At IPR 29 females were monitored for a total of 692 cycles. Of these 19.4% were in excess of 50 days (mean = 88.5 days) and they contributed to 39.6% of the total time (Else et al. 1986). Although long cycles occured year round, there was a tendency for their incidence to be least during the months which coincided with the peak period of conception in colony and wild animals in Kenya (see below).

In conclusion it would appear that menstrual cycle length is on average about 32 days but is highly variable. This variability is found both within and among individuals and may be affected by some type of residual seasonal effect. Published figures are highly dependent upon the figures which are used in the calculations and in the calculations themselves. It is recommended that in the absence of uniformity exact details of methodology are given in any publications.

Hormonal profile

Serum hormones throughout the menstrual cycle have been monitored by Hess et al. (1979) and more recently by researchers at IPR (Eley et al. 1989). Total oestrogens, oestradiol, progesterone and luteinizing hormone demonstrate profiles characteristic of old world primates in general. Serum oestradiol 17, which is the principal plasma oestrogen in the vervet (Makawiti 1984), rises from a baseline of about 100 pmol/l during the follicular phase to peak at over 500 pmol/l on the day before the LH surge. During the luteal phase concentration is again in the 100 – 150 pmol/l range. Seier (pers. comm.) reports the existence of a smaller secondary oestradiol peak during the luteal phase in some cycles. This phenomenon has not been reported by other authors.

Hess et al. (1979) reported in their study of 21 animals that the pre-ovulatory peak of oestradiol occurs between days 6 and 14 with the majority in the 11 to 14 day range. In the later study by Eley et al. (1989), in which 12 animals were monitored during two cycles each, the range was slightly less; based on this, peak ovulation was predicted to occur on day 11 of the cycle. It must be recognised of course that as with cycle length itself a considerable amount of variability is to be expected.

Using an antiserum to ovine luteinising hormone Hess et al. (1979) assayed "LH-like" activity during mid-cycle in vervets. They found that peak activity was associated with the initial rise in progesterone, which rose above 1 nmol/l the day after the LH peak to be maintained at above 4 nmol/l for the duration of the luteal phase. The duration of the luteal phase was less variable than the follicular phase with a length of 17.9 ± 1.4 days. According to Eley et al. (1989) the luteal phase length was 21.3 days.

Urinary steroids have recently been analysed and data have become available. Both Setchel et al. (1980) and Makawiti (1984) noted that the progesterone metabolite pregnanediol-3-glucuronide was abundant in urine. Setchel et al. (1980), who analyzed the urine from a single female for 40 days, also reported the presence of pregnenediol and 16-hydroxy-pregnenalone. Other steroid metabolites identified by the authors were oestrone- and oestradiol-3-glucuronides (the former being predominant), and the C19 steroids androsterone, aetiocholanolone and their 11-hydroxylated derivatives. Daily fluctuations in these C19 steroids were noted, but a relationship with cyclicity was not established, suggesting that they were not major metabolites of progesterone. Two phenolic compounds of non-steroidal nature and designated C180/410 and C180/442 were detected during the cycle. They exhibited quantitative changes which preceded the rise in pregnanediol by one day.

Bronstein et al. (1973) also reported on the concentration of the sex steroids in the urine of vervets. Unfortunately this paper has not been obtained by the author.

Some data on steroid receptors have been published. As noted above Kudolo et al. (1984, 1986) described the dynamics of progesterone and oestrogen receptors during the normal and prolonged cycle, and similar work has been published by Klein et al. (1985) and Potgieter et al. (1985, 1986). These studies quantify the receptors and their changing occupancies

during the phases of the cycle.

The only other data to relate to pituitary function are by Girod and associates. They reported that the majority (85%) of anterior pituitary cells react with antisera to LH and FSH or their subunits (Girod et al. 1981). Prolactin cells were identified in the same organ with antisera raised to ovine prolactin (Girod & Dubois 1976).

PREGNANCY

Pregnancy diagnosis

Pregnancy is diagnosed by a variety of methods. The one most commonly used is that of rectal palpation. Hess et al. (1979) accurately detected pregnancy by this method at 25 – 30 days of the 165 day pregnancy. Seier (1986) was confident of detection by 15 – 21 days post conception. As variations in individuals at the same stage of gestation do occur, the earlier diagnosis required prior knowledge of each female's non gravid uterine size, shape and tone (see "Anatomy of the Reproductive Tract" as described above). After 70 days softening of the uterus made precise staging of the pregnancy difficult. Seier (1986) tabulated the various widths, lengths, shapes and consistencies from conception to day 70 of pregnancy to aid in this procedure.

Johnson et al. (1973) also used this method for pregnancy determination. They noted a 50 – 300% increase in width and a 50 – 100% increase in length of the 25 – 30 day gravid uterus as compared to the non-gravid one, and also reported a noticeable change in tone.

Other methods include the detection of pregnancy-specific blood components. For example Dracopoli & Brett (1982) and Turner et al. (1987) used a serum aminopeptidase variant to determine pregnancy after the second month. Chorionic gonadotropin (CG) was isolated from pregnant vervets by Mwenda et al. (1990) but the methodology is not yet refined enough to use for routine pregnancy diagnosis. Moreover the profile of CG secretion may restrict use to a very limited time period in early pregnancy.

Implantation bleeding was reported by Hess et al. (1979). In 10 of 42 pregnancies (23%) blood appeared for a period of between one and five days (with a usual length of one or two days) some 13 – 29 days post-mating. Johnson et al. (1973) noted the same phenomenon in 33% of pregnancies, lasting one day between days 15 – 21 of pregnancy. Similar events were noted by Rowell (1970) between 12 – 24 days (n = 10/12) for a duration longer, but lighter than, menstruation; by Valerio & Dalgard (1975) between days 13 – 29 and by Bramblett et al. (1975), who described a "greatly reduced menstrual flow", 7 – 11 days post conception. Use of this method for detection is therefore an additional, but unreliable, tool.

Rowell (1970) also noted a leucocyte peak in the vaginal lavage in 11 of 12 conception cycles between 12 – 24 days after the last menstruation which would be associated with ovulation. This was followed 10 – 24 days later by more red blood cells which was presumed to be implantation bleeding. Leucocyte counts also increased greatly during the fifth and tenth week of pregnancy.

Implantation

The morphology of implantation from 30 days to near term was addressed by Owiti et al. (1986, 1989). Fetal membranes were obtained from one animal after timed mating and from 32 wild caught animals. The placenta shows many features in common with those of the rhesus monkey and humans. Implantation is superficial and bidiscoid with a placenta classified as villous and haemomonochorial.

Developmental staging was accomplished by Hendrickx & Sawyer (1978). They concluded that vervets experience a delay in the embryonic period when compared to the baboon and human. The primitive streak is established at 26 days in comparison to day 16 – 17 in the latter animals. Hendrickx & Sawyer (1978) also reported the embryotoxic effect of thalidomide on vervets; it caused limb reduction and craniofacial, internal and external ear defects.

Gestation length

The first reports of gestation length were probably inaccurate, but were recognised as such by the authors; 213 days (Zuckerman

1953) and 180 – 213 days (Napier & Napier 1967). More recent reports put gestation length at around 160 days (Table 5).

Parturition

Booth (1962) reported that she had not seen any births in the natural environment, but that in captivity in Kenya births had been observed both during the day time and at night in *Cercopithecus* monkeys. The author did not clarify whether these were vervets or mitis monkeys (*Cercopithecus mitis*). Johnson et al. (1973) did not observe any of the 38 births in their colony and concluded that they all took place at night. Birth occurred at night in 75 of 77 occasions in one captive colony (Fairbanks & McGuire 1984). In the two instances where birth occurred during the day the mother died.

At IPR no daytime birth has ever been recorded in over 300 births and Seier (1986) noted that only 3 of 92 births occurred during the daytime. In the latter study parturition was signalled by dilation of the cervix and swelling of the vulva. Once labour began the process only took about 15 – 20 minutes with the mother assisting in pulling the fetus out with her hands.

Hormonal profile

Hess et al. (1979) reported total oestrogen to rise to a maximum of 5 ng/ml during pregnancy with a nadir between days 30 – 50. This is in agreement with the 7 ng/ml noted by Hodges (pers. comm.). Progesterone during pregnancy remains at the same concentration as during the cycle in the range of 5 – 10 ng/ml apart from a brief rise to 20 ng/ml concommitant with the oestradiol nadir (Hess et al. 1979). This 30 – 50 day period is probably an indication of a change over from luteal to placental steroidogenesis. The latter authors noted that the progesterone elevation at parturition was not as dramatic as in some other species and both oestrogen and progesterone concentrations fell rapidly within three days after parturition.

Table 5. Gestation length (days) in vervet monkeys

Gestation length mean	s.d.		Range	Number	Source
157	3.6[1]			5	Hess et al. 1979
164	6.6	(males)		24	Johnson et al. 1973
161.6	5.5	(females		14	Johnson et al. 1973
163.2	6.3	(combined)		38	Johnson et al. 1973
163	6.0				Valerio & Delgard 1975
165			142 – 170		Rowell & Richards 1979
163	2.0				Bramblett et al. 1975
162 [2]		(males)			Eley 1988
165 [2]		(females)			Eley 1988
164.1[2]		(combined)	158 - 171	12	Eley 1988

[1]first day of multiple (6 day) mating or day of single mating designated day 0.
[2] mating on days 11–13 of cycle; day 12 designated day 0 of pregnancy.

Setchell et al. (1980) monitored urinary pregnanediol in a single vervet throughout pregnancy and reported a peak between the 30th and 70th day with daily excretion rising to 200 μg/day. The amount then fell to 20 μg/day and rose gradually throughout the remainder of pregnancy to reach 50 μg/day at term. The phenolic non-steroidal compounds (see above) which were seen during the cycle also rose in early pregnancy but fell to undetectable levels by term. It was unclear whether these compounds were of ovarian or adrenal origin. More data on pregnancy endocrine profiles are reported by Koritnik et al. (1984) who studied progesterone and oestradiol in relation to lipids and lipoproteins in ten females throughout pregnancy. Progesterone concentrations rose during the first 60 days of pregnancy to a concentration of between 12 and 16 ng/ml. Concentration then fell to, and remained at, around 8 ng/ml throughout the remainder of pregnancy. Oestradiol rose from

below 200 pg/ml to around 500 pg/ml at term. These data were in agreement with those of Hess et al. (1979) with oestradiol following the profile of total oestogens in the earlier study.

Andelman et al. (1985) used urinary steroids as a "practical method of monitoring ovarian and placental function" in the field. They followed wild vervets in Amboseli National Park and were successful in diagnosing pregnancy by analyzing for pregnanediol glucuronide. Concentrations rose from $< 2\mu g$/mg creatinine during anoestrus to $10\mu g$/mg during pregnancy. From analysis of these data the animals in Amboseli conceived in the first or second cycle after resumption of cyclicity following lactation. The same technique has been used for both pregnanediol and oestrone glucuronides in captive animals at the IPR (Kahumbu & Eley, unpubl. obs.) and this non-invasive method could have many future applications.

HORMONAL PROFILE OF MALES

Testosterone concentrations in males have been reported by Asanov (1972), Steklis et al. (1985) and Eley et al. (1986). The first author reported concentration to be in the range of 23 – 43 nmol/l in adult males. A similar concentration of 25 nmol/l from 12 monthly samples from nine animals was reported by the last authors where, despite a 15% fluctuation in the testes volume throughout the year, testosterone showed no circannual rhythm.

Steklis et al. (1985) while reporting a similar concentration in the range of 7 – 10 ng/ml (equivalent to 22 – 30 nmol/l) stated that up to a ten-fold difference was seen within an animal on any two consecutive samples. Mean testosterone concentration for dominant males was 9.9 ± 1.2 ng/ml (range 7.0 – 19.7 ng/ml) as compared to 7.0 ± 0.7 ng/ml (range 3.1 – 18.6 ng/ml) for non dominant males. Although there was a trend for the dominant animals' concentrations to be higher this difference was not significant ($p < 0.01$). They concluded that serum testosterone was more closely related to the frequency of aggression than to the stable dominance rank.

Cortisol too was unrelated to rank (McGuire et al. 1986, Raleigh 1987) in stable groups. However in times of intermale competition cortisol was higher in the males who became dominant. These results were discussed in more detail by Raleigh & McGuire (1990).

Zaidi et al. (1982) found a correlation between testicular weight and testicular testosterone concentration in immature animals. In six animals serum testosterone was 1.09, 1.16, 2.82, 3.64, 4.62 and 5.24 ng/ml and the matching testicular testosterone was 11.2, 10.8, 18.5, 38.4, 104.1 and 60.4 ng/g tissue. Eley et al. (1986) found no significant correlation between serum testosterone and testicular volume in adult animals. Neither was there any relationship between testosterone concentration and whether or not the animal was used for breeding.

A diurnal rhythm was reported for serum androgens (testosterone and dihydro-testosterone were the major reactants to the antisera) by Beattie & Bullock (1978) from 10 adult males housed in pairs. Androgens ranged from 4 – 8 ng/ml between 0900 and 1800 hours and then rose to 10 – 13 ng/ml between 2100 and 0600 hours. Oestradiol, although highly variable, also demonstrated periodicity which essentially paralleled but lagged behind the androgens. A peak of 16 pg/ml was recorded at 2400 hours declining to 12 ng/ml and then 8 pg/ml at 0300 and 0600 hours, respectively. Between 0900 and 2100 hours the concentrations ranged from 3 – 8 pg/ml. Testosterone is a precursor to oestradiol; however, the authors did not speculate as to whether conversion was occurring at the gonads, adrenals or another peripheral site. The physiological role of the oestrogen was suggested to be as a control of serum testosterone, either by pituitary inhibition or by elevation in testosterone-binding globulin.

EFFECT OF CAPTURE

It is generally accepted that vervets, like other primates, stop cycling at capture and there are data to substantiate this. Johnson et al. (1975) reported that it took between 6 and 12 months before females resumed regular and established menstrual cycles and Asanov (1971) reported a 14 month period after capture to provide viable offspring. In Kenya, Else (1985) noted that there was an interval in excess of one year before females resumed cyclicity. Kushner et al. (1982) noted that of 26

harem groups that were established 25 groups produced their first live infant on average 232 ± 58 days (range 157 – 416) after group establishment. The interval between capture and group establishment was not given.

Our own experience from commercially trapped animals is that very few newly acquired animals give birth in captivity. This would suggest that abortions occur after trapping and before delivery to the institute (pers. obs.). Certainly on a number of occasions abortions have been observed in quarantine, supporting this assumption.

Turner et al. (1987) trapped and held vervets for 72 hours in Samburu. Only 4 of the 8 animals diagnosed as pregnant had a subsequent live birth. However as a similar pregnancy to live birth ratio occurred in non-trapped animals the cause of the loss in infants could not be attributed to the trapping procedure.

BREEDING SUCCESS

Rowell (1970) stated that captive vervets bred successfully and this feeling is echoed by a number of authors. The definition of success is however quite subjective and, as seen below, depends on the type of management system (e.g. group-caged versus individually-caged; natural versus forced weaning).

Johnson et al. (1975) time-mated females from day 10 of the cycle for 6 days and reported matings per conception of between 4.8 and 11.4 and a conception rate for the mating series of between 8.7 and 20.8%. Over a four-year period, when the number of females ranged from 21 to 34 animals, and infants were removed and hand reared, the percentage that conceived was 43, 59, 75 and 70%. In Japan, Cho et al. (1987) reported 160 pregnancies in 7 years from 36 females. First conceptions were achieved by pairing a male with a female "every other day" for up to 14 weeks. Subsequent conceptions were by the "timed mating" method. Bramblett et al. (1975) documented 38 births from 10 adults over a seven year period. The exact details of their mating regime were not given.

Hess et al. (1979) noted that mating for a six-day period improved conception to 45.8% from the 21.8% for single day exposure to the male. In the single mating series the highest conceptions were achieved when mating occurred during the 11 – 15 day period. Our own results from individually caged animals were not as high as this when measured by the success of embryo recovery; 13 embryos were recovered from 56 five-day mating periods (Tarara & Eley, unpubl. obs.).

Kushner et al. (1982) in the USA reported that of 109 females in harem groupings 92% (100) had become pregnant at least once and 89% (97) had given birth at least once. A total of 221 pregnancies was reported, yielding 186 live births (84%). Infants were weaned at six months.

At IPR, in the first report of that colony's success, Else (1985) refers to a 90% pregnancy rate over 3 years in 25 females maintained in harem groups of 3 to 5 females per group. Live births were 85% resulting in an annual productivity rate of 75%. The colony has now been maintained for over 10 years and the yearly pregnancy rate is over 80%. This value is however slightly inflated due to the removal of some females for medical reasons. At IPR, data suggest that stable social groupings in a harem structure can lead to higher productivity than timed mating of individually caged females.

Fairbanks & McGuire (1984) suggested that vervets had higher birth rates in captivity than did other cercopithecines and noted that high-ranking females were the most successful. They reported over an eight-year period an average of one birth per female per year and an inter-birth interval of 10.7 months.

Seier (1986) in South Africa recorded 95 offspring from 115 pregnancies in 5 years from 26 females. In that colony the breeding system is that of breeding pairs. Harem groupings were found not to be effective due to incompatibility and rank order problems. It was recognised however that the relatively small space available in the harem cages exacerbated these problems. By 1990 total pregnancies had reached 247 resulting in 191 live births (Seier, pers. comm.). The discrepancy between live births and total pregnancies was in part due to experimentally terminated pregnancies and does not therefore reflect a true picture of embryonic loss.

Productivity of captive-born animals does not appear to differ from that of wild-caught animals. Seier (1991) reported 32 conceptions and 26 live births among colony-bred females and 11 successful inseminations from colony-bred males. Although numbers are small the foetal wastage in colony-born animals was only 7.1% as compared to 17.3% in wild-born breeders. At IPR 24 colony-born females have given birth with no apparent differences between them and the wild-caught animals.

It would appear from all these reports that one offspring each year is easily attained. However the overall productivity is not as good as one would deduce from the pregnancy rate, due to the high fetal wastage and infant loss. In this regard many of the studies do not show such encouraging results. For example in the California colony reported on by Fairbanks & McGuire (1984), of the 77 pregnancies that were recorded, 22% ended in abortion or stillbirth and a further 13% resulted in young that died within the first month of life. This aspect of productivity is covered in more detail in a subsequent section entitled "Foetal and infant wastage".

In the wild Turner et al. (1987) noted a wide yearly variation in reproductive success and conception rates of 76% and 58% were given for the two years of study. Whitten (1982) suggested that this was due to contributing factors of nutrition, social rank and maternal investment. Many individuals only give birth every two years. Whitten (1982) calculated that birth rates ranged from 8% to 66% in three troops over a three-year period in Samburu. In Senegal, Galat & Galat-Luong (1977) noted that mortality was variable year to year and reported that in one year competition with rats for food resulted in a very low reproductive productivity. The effect of nutrition was also shown by Brennan et al. (1985) who noted that provisioned animals in Amboseli had a higher birth rate.

Turner et al. (1987) diagnosed 30 of 43 adult females to be pregnant (seven by blood analysis, the remainder by observation) and yet only 22 gave birth. The rate of foetal loss among these trapped and released animals was not different from non-trapped animals. Abortion rate was variable among troops, and old and young animals were the most affected. The authors indicated that higher-ranking females are less likely to abort and Fairbanks & McGuire (1984) reported the same phenomenon in captive animals.

It would appear therefore that data on pregnancy and live births are often misleading when viewed alone without regard to the survival of the offspring.

FOETAL AND INFANT WASTAGE

Johnson et al. (1973) reported 28% (19/75) of pregnancies to result in abortion or stillbirths compared to figures of 22% (17/77) given by Fairbanks & McGuire (1984), 16.7% by Seier (1986) and 16% (35/221) by Kushner et al. (1982). Updated figures by Seier (pers. comm.) on over 200 pregnancies (almost double those of the previous report; Seier 1986) give foetal wastage as 17% with 25 abortions and 14 stillbirths.

The major reasons for such losses were given by Johnson et al. (1973) as "over-excitement" (abortion) and breech presentation (stillbirth). The definition of over-excitement was not given. The figures from these studies are far higher than the 9.5% given by Hess et al. (1979). This last figure was however recognised to be an underestimate as two-thirds of pregnancies were surgically terminated and not allowed to go through their natural course. In our own experience at IPR early abortions can go undetected, especially in outdoor caging and if the mother eats the aborted tissue. Tissue or blood are more likely to be seen in individual suspended cages.

Kushner et al. (1982) reported that the incidence of foetal death was not affected by the number of previous births that an animal had in captivity. Infant death was however affected, with first-time mothers' infants more likely to die and at an earlier age.

Fairbanks (pers. comm.) indicated a trend for age at first birth to be reduced in successive colony born generations. As a consequence of this some of the more recent animals have been experiencing problems with distocia. Deaths of some mothers have occurred during delivery and efforts are under way to prevent pregnancy in animals less than three years of age.

Providing that primiparous animals have achieved a certain physical size, parity *per se* may not have an effect on survival of the offspring. A relationship of foetal survival and age of the mother was not seen by Seier (1986) who specifically questioned its occurrence. Figures for foetal wastage from the first to the fifth pregnancy ranged from 6.2% to 23.5% but did not relate to parity. Similar observations on parity were made by Fairbanks & McGuire (1984). However this is not in agreement with Asanov (1972) who noted that first pregnancies were more likely to have a pathological outcome. Furthermore fertility increased with each subsequent generation mainly through a reduction in the number of abortions and stillbirths.

Losses are not however confined to those during pregnancy and delivery and infant loss in captivity is quite high in vervet monkey colonies. For example, Kushner et al. (1982) reported that for their colony, where mothers are isolated prior to birth, and mother and infant are not returned to the harem groups for one to two weeks after birth, 23 infants from 221 pregnancies (10%) and 186 live births (12%) died at less than five months of age with a greater incidence among male offspring (17 males, 6 females). Mean age of death was 33 days but 10 died within the first 10 days. No infants died between 5 and 15 months. Total loss throughout pregnancy to 15 months was 58 or 26%. This management practice of removal of mothers could potentially be dangerous as it can lead to shifts in rank resulting in aggression among the females left in the cage and/or to the mother and infant on return.

Fairbanks & McGuire (1984) noted that 13% (10/77) of infants died in the first month of life; however, after that time the infant had a 95% chance of surviving to adulthood as only a further five died between 30 days and 13 months. In their colony 32 of 77 (41%) of infants therefore died *in utero* or before 13 months of age. Losses before one month of age of the 27 infants who were live-born (out of 77 pregnancies) were attributed to congenital problems, failure of nursing and heat dehydration. The authors also reported that the age but not rank of mothers at their first pregnancy was positively correlated to the number of infants surviving through their first year. Abortions and stillbirths were the prime source of foetal wastage in older animals whereas in young animals more losses occurred after birth than for multiparous animals, suggesting that poor mothering (either behavioural or physiological) was the cause. Mortality of live-born infants was 45% (10/22) in mothers three to five years of age in contrast to 10% (2/20) in mothers who were six to eight years of age.

Table 6. Results of the IPR Breeding Programme, 1979-1988

	Total	% Term pregnancies	% Live births
Pregnancies	258		
Abortions	6		
Term pregnancies	252		
Still births	6	6.3	
Live births	236		
Alive two years	127	50.3	53.8
Infant deaths	110	43.6	46.6
< 1 mo	36	14.3	15.2
> 1 mo < 6 mo	10	3.9	4.2
> 6 mo < 1 yr	31	12.3	13.1
> 1 yr < 2 yr	33	13.0	3.9

In the study of Seier (1986) only two neonatal deaths and two infant deaths were reported from 95 live births. The management system of isolating pregnant females until weaning at five or six months postpartum was used in this colony. By 1991 with almost 200 live births recorded neonatal mortality still accounted for only eight losses (Seier pers. comm.).

The incidence of deaths within the vervet colony at IPR is presented in Table 6.

At IPR most of the losses in the first month occur in the first three days and are due to starvation attributable to maternal neglect, theft by another adult female, inability of the infant to suckle or inability of the mother to produce milk. Establishment of nursery facilities (and subsequent rearing in peer groups) could reduce these losses but the cost and practical difficulty of this has prevented such action.

Fairbanks (1990b) looked at allomothers and found that live-born infants of females who had experience in allomothering were more likely to survive than those whose mothers were without the experience. Prior maternal experience had no affect upon abortions. Furthermore *in utero* and neonatal deaths were reduced, and infant survival improved, in young mothers if their own mother was present, suggesting that stable generational matrilines reduce reproductive stress (Fairbanks & McGuire 1986).

Overall infant wastage at IPR is such that over 45% of all infants do not reach two years of age. This is the same figure as during the first years of life in the wild (see below) and similar to the 41% for the California colony up to 13 months (Fairbanks & McGuire 1984). However the distribution of deaths is somewhat different at IPR to that in California. IPR has fewer abortions (6.3% versus 22%), although it is possible that at IPR some of the early abortions are missed if the mother or cage-mates eat the evidence. From one to six months losses are extremely low in both colonies but at IPR they again increase from 3.9% to 12.3% between six months and one year of age which is coincident with the time after weaning. In California, where losses were 6% over this one month to one year period the infants are given "ample weaning food" which could account for this difference.

From the data of Seier (1986) it would appear that the key to infant survival may lie in the management practices. Females are isolated throughout pregnancy, parturition and lactation, and are fed supplemental food during these periods. After weaning at six months the infants are housed in pairs for two to three weeks and then group-caged with about six peers per cage. Whenever possible, a single pregnant or lactating female is added to this peer group to ensure development of maternal behaviour in juvenile and adolescent females.

The colony of vervets at IPR has been found to have a 40% incidence of simian immuno-deficiency virus (SIV; a retrovirus similar to HIV) and currently the relationship (if any) between this and survival rate of infants is being evaluated.

Reported survival of infants in the wild is also low although the reasons for losses are probably somewhat different than those in captivity. Changes in the ecosystem and predation, which are not usually encountered in the captive situation, are responsible for many of the losses. In Amboseli for example, 57% of infants died in the first year and only 27% of females survived to breeding age (Cheney et al. 1988). In this report, which covered a number of years, peaks of mortality occurred at four months of age and again between eight and nine months, corresponding respectively to a reduction in the carrying of the infant by the mother and weaning during the dry season. No effect was seen due to dominance rank or parity of the mother and predation was a more important factor than illness; the former accounted for 69% of mortality.

Turner et al. (1987) recorded, in the wild, a 70% conception rate (30 of 43 diagnosed pregnant by a serum aminopeptidase phenotype) and from these conceptions 22 of 30 (73%) had a live birth. Abortion or still birth accounted for a 26% loss. Most abortions occurred in the very young and the very old animals. Rank was also very important; three of four females which did give birth were high ranking and three out of four that did not give birth were low or middle ranking. Whether age or rank effects were related to the stress of capture for blood sampling is not known. Infant survival figures were not given but these were the same animals that were studied by Whitten (1982), who

reported that 70% of infants survived through to end of parental care at approximately one year of age. No data were available for abortions. There was 5% loss in the first month, 15% loss between one and six months of age and a further 10% loss up to ten months of age. Mortality peaks were similar to those given by Cheney et al. (1988) with peak losses at less than one month, at four to six months, coincident with the end of infant carriage, and at eight to ten months at the time of weaning. In conclusion, infant mortality in captivity and the wild are both high. Productivity is higher in captivity only due to the much lower interbirth interval. The major difference in mortality is that predation and untreated illnesses do not occur in captivity. However the vervet is known to be prone to stress which could account for the high mortality in captivity.

POSTPARTUM MENSES AND LACTATIONAL AMENORRHEA

According to Fairbanks & McGuire (1984) lactation lasted six months, while Asanov (1972) reported lactation to continue for six to seven months. In the former study 20 of 47 conceptions occurred when infants were less than 5.5 months of age and still suckling. In the latter study only 2.3% of the animals were cycling by three months postpartum, increasing to 70% by eight months.

In Asanov's study, if pregnancy was terminated the animals resumed cyclicity after three to four months. The actual period was dependent upon the gestational age at termination. After a live birth, weaning or infant death was the prerequisite for resumption of the cycle; the more protracted the lactation, the later the resumption. Asanov (1972) reported that skilful timing of weaning at the time when resumption of menstrual activity occurs "naturally", enables production of two offspring in a 14-month period. Kushner et al. (1982) weaned infants at six months of age. In six cases mothers conceived within 14 days, and 54% (39 of 72) conceived prior to weaning. From these data it would appear that lactational amenorrhea lasts for a minimum of three months and more probably up to six months.

Johnson et al. (1973) and Hess et al. (1979) reported the interval from parturition to the resumption of cyclicity (as marked by menstruation) to be 56.9 ± 18.9 days (range 24 – 108 days, n = 37) and 84.0 ± 34 days (range 30 – 143 days, n = 11), respectively. In both of these colonies the infants are weaned from their mothers shortly after birth and hand-reared. This interval is therefore analogous to the situation of neonatal death where resumption of cyclicity is not affected by lactation.

Similarly in two instances at IPR when the infants of individually caged females died in the first few hours after birth, menstruation was detected after 77 and 88 days. However in five animals whose infants lived, the interval was extended to 183 days (range 153 – 208 days). In three of these animals the infant was removed at 160 days of age and menstruation began 14, 31 and 52 days later. In the other two females menses occurred at 153 and 204 days postpartum while the infant was still with the mother. From these few data therefore, there is no evidence that removal of the infant at this late stage had any effect.

Consequently in captivity where nutritional effects should not be a factor, cyclic resumption would be expected at about six months after parturition if suckling is allowed continuously. Pregnancy would then interrupt lactation and one infant per year would be expected.

Rowell (1970) indicated that the lactational interval in vervets was short when measured in terms of copulatory behaviour. All animals were copulating by 14 weeks post partum and some as early as five weeks. In females whose infants are suckling it is unlikely that menstrual cycles had resumed at this time. Consequently unless these data were collected from non-suckling animals they suggest that copulation is disassociated from cyclicity. Booth (1962) reported copulations soon after parturition if infants were removed and hand-reared.

In an early report Struhsaker (1967) indicated that weaning in Amboseli begins after four months. Lee (1984a) reported that under conditions of yearly births in Amboseli, weaning was completed by ten months; however most animals only gave birth every second year. The same author (Lee 1987) reviewed parental investment and possible explanations for the time of weaning. She

considered the duration of lactation to be affected by (a) the ability of the mother to sustain lactation nutritionally, and (b) the factors which affect the ability of the infant to sustain itself, viz. growth rate and adequate diet. Without doubt these factors will determine the ability of the mother to continue lactation and the dependence of the infant on this source of nutrition. However perhaps an equally important factor is the ability of lactation to suppress resumption of cyclicity. For once pregnancy results, the duration of lactation will be curtailed either by the hormonal milieu of the pregnancy acting directly on the mammary gland and associated axis, or indirectly by influence on behaviour "forcing" weaning. Indeed conflict between mothers and their infants does increase as pregnancy advances (Lee 1987).

Undoubtedly lactation does suppress ovulation although a great deal of individual variation exists. Lee (1987) found that suckling bouts were decreased from 3.4 to 1.5 bouts/h prior to conception. In animals that did not conceive, bouts were constant at 2.3/h. These results confirm that in general lactation suppresses cyclicity. However the fact that those animals which conceived had higher numbers of bouts to begin with could imply that they were in a different condition to the others, and that the number of bouts was a reflection of the ability of an animal to conceive once reduction in suckling began.

In the wild troops at Samburu, Whitten (1982) recorded length of lactation to vary between nine and 18.5 months and Lee (1984a) reports weaning to occur at ten months of age in Amboseli for those animals which gave birth every year. In Samburu there were differences according to the provisional status of the animals. Average length was nine months for the food-provisioned Lodge Troop in contrast to the 10.9 and 13.6 months for the two non-provisioned troops of animals. In this study the time of the year at which the birth occurred also affected the duration of lactation.

INTERBIRTH INTERVAL

Interbirth interval (IBI) is affected by a variety of factors. In the wild, nutrition is obviously extremely important. In captivity, where nutrition levels are usually higher than that in the wild situation, intervals are most affected by the survival of the offspring and are substantially reduced after stillbirth or abortion. Figures for IBI in the literature are given as both median values and as means and direct comparison is therefore not always possible.

Fairbanks & McGuire (1984) reported a 10.7 month median IBI (n = 46) in captivity with only one female exceeding 19 months. One female had an IBI of 5.9 months and three others six months. In all four cases the infant from the previous birth was alive. In a later paper with data from 81 intervals Fairbanks (1990a) presented a figure of 12.3 months for IBI if the infant survived. The longer period in the later data set was attributed to the inclusion of five females who missed a birth for one year and two who missed a birth for two years. These values of median IBI compare to the mean figures of 357 days (range 201 – 700 days) given by Kushner et al. (1982) for 85 intervals, 337.9 days (n = 29) by Bramblett et al. (1975), 10.5 months (Valerio & Dalgard 1975) and 344 days (Bramblett & Bramblett 1982).

Although the animals studied by Kushner et al. (1982) were artificially weaned at six months of age the majority of females (39 of 72) had reconceived before this time. Quite remarkably six of the females were reported to have conceived within 14 days post-partum.

As would be expected IBI is affected by the fate of the infant. Kushner et al. (1982) for example, reported an IBI of 320 days in 12 females whose newborns died; this constituted a reduction of over one month as compared to the IBI of those mothers whose infants survived. Horrocks (1986) noted IBI to be 11.6 months if the infant survived (n=22) and 8.4 months if it died. The mean suckling time for the former group was 8.6 months indicating conception during the suckling period. Rowell & Richards (1979) also noted a reduction in IBI in five of seven mothers whose infants were stillborn in contrast to the median of 12 months if the infants survived. The same authors reported that the IBI was greatest in those females who had not achieved their full adult weight.

In a more recent report Fairbanks (1990b) noted that there was a significant reduction in IBI following a failed pregnancy (abortion, stillbirth and/or neonatal death). For 119

intervals (excluding those following abortions), the median for all periods was 11.8 months. When broken down further this value included the figures of 12.3 months, given above, for the 81 intervals when the offspring survived and 10.3 months for those whose infants died at less than six months.

Asanov (1972) noted resumption of cyclic activity by two months in 30% of animals following abortion and in 100% by four months. The interval was correlated with the stage of pregnancy at which termination occurred. This relationship is also seen in an experimental situation at IPR. Vervets who had embryectomies in the first month of pregnancy resumed cyclicity within 20 days while two animals who underwent embryectomies at 50 days of pregnancy took 33 and 47 days to begin cycling (Eley unpubl. obs.).

Figures for nine years of breeding from IPR were given by Eley (1988). IBI was reduced from 346 days (n =128) for mothers whose infants lived greater than one month, to 288 days (n = 30) for those whose infants died at between birth and one month of age and reduced even further to 245 days (n =12) for those whose infants were aborted or stillborn. These figures therefore indicate a two-month period to conception following abortion, a five-month period if the neonate died and seven months if the infant survived.

The exception to this rule appears in the paper of Bramblett & Bramblett (1982) who recorded no difference in the IBI for females who had a surviving infant from the previous year and those who lost their infant prior to the onset of the next pregnancy.

Factors other than infant survival affect IBI. Rowell & Richards (1979) noted that IBI was longer with younger animals but this was not demonstrated by Fairbanks & McGuire (1984). Nor did they find that IBI was affected by advancing age, but it was affected by dominance, being reduced from 13.3 months (n=24) to 12.2 months (n=28) to 11.7 months (n=29) for low, middle and high dominance groups, respectively. This was postulated to be due, at least in part, to the more frequent allomothering with higher ranking mothers. As a consequence high ranking mothers had a higher rate of fecundity with 1.1 births/female-year as compared to 0.82 births per female-year for the low ranking mothers. In another study of captive animals (Bramblett & Bramblett 1982) animals in the highest ranking lineage also had the shortest IBI.

Fairbanks (1990a) in a later study, looked specifically at allomothering and reported that mothers who permitted allomothering had shortened IBI. Rank was also positively correlated with allomothering and with shortened IBI. It was postulated that allomothering either gave the mother more time to forage for food or that an increased interval between suckling bouts was the contributory factor.

Fairbanks & McGuire (1987) also reported that IBI was shorter by two months (11.7 versus 13.6) in groups where new males had been introduced, mainly due to the lower incidence of "skipping a birth season". The authors reported that in these groups there was an initial period soon after male introduction when the mothers spent more time with their infants, but overall the sexual stimulus of the new males caused earlier maternal rejection, earlier weaning and an earlier return to oestrus.

As noted above IBI is shortened if the infant does not survive. However the IBI between the two successsive deliveries may be lengthened if the previous pregnancy resulted in infant loss. Fairbanks (1988) compared nine vervets who had lost their infant from the previous pregnancy within the first two months of its life, with 14 mothers whose infants had survived and 11 primiparous animals. She reported that there was an increased maternal protectiveness towards the next infant if the previous infant had died. This was manifested by more ventral contact and more restriction of the infant's movements, and resulted in all nine mothers having IBI of greater than 11.5 months. In contrast six out of 14 of the "successful" mothers had intervals shorter than 11.5 months. Ten of the primiparous animals also had intervals longer than 11.5 months contrary to the previous statement that younger animals did not have extended IBI (Fairbanks & McGuire 1984).

Fairbanks & McGuire (1984) concluded that the survival of a suckling infant was not affected by the duration of the interbirth interval to the next parturition, nor did the presence of a suckling infant affect the outcome of the

subsequent pregnancy. The incidence of live births versus abortions or stillbirths for the next pregnancy were no different if the interbirth interval (IBI) was less than or greater than 11 months.

In the wild the IBI is invariably longer than in captivity (unless nutrition is "good" - see below) with 12 out of 20 animals in Lee's study in Amboseli only giving birth every second year (Lee 1984a). Whitten (1982) reported 1.7 offspring per three years in Samburu. Lee (1987) cites references for the effect of low nutritional intake increasing the IBI, reducing the rate of conception and causing menarche to occur at a later age. Rate of conception was measured by the birth rate and is therefore confounded by the number of abortions.

In Amboseli animals which had access to "good", "intermediate" and "poor" nutrition were studied. Those on the poorer nutrition had IBI approaching two years (21.3 ± 5.0 months) while those having good and intermediate nutrition had IBI of 16.3 ± 5.6 months and 13.8 ± 3.5 months, respectively (Cheney et al. 1988). Animals which had access to the garbage pits around the lodges had the "best" nutrition and the shortest intervals (Lee 1987). Similarly in Samburu where Klein (1978) had recorded an IBI of 1.2 – 1.4 years, Whitten (1982) recorded 11.7 months in provisioned wild animals and 22.2 months in non-provisioned animals. However these results are based on 20 females in three non-provisioned troops and only three females in the provisioned troop. If the infant dies the mother is less likely to skip a year between births and deliver again in synchrony with the remaining females in the troop (Cheney et al. 1988).

Another factor reported to affect IBI in the wild, as it does in captivity, is that of dominance. In Samburu high ranking females mated earlier in the season, had a shorter IBI and weaned their infants earlier (Whitten 1982, 1983). However Cheney et al. (1988) found no evidence for this in Amboseli. Nor did they find any relation between IBI and sex of the offspring.

Table 7. Reported incidence of seasonality[1]

Location	Period	Reference
Free living		
Amboseli, Kenya	Oct – Mar	Struhsaker 1967
Kenya	Apr – Sep	Gartlan 1969
Zambia	Oct – Jan	Lancaster 1971
S. Africa	Sep – Dec	Henzi & Lucas 1980
Senegal	Jan – Mar	Dunbar 1974
St. Kitts	May – Jun	McGuire et al. 1974
Amboseli, Kenya	Sep – Jan	Lee 1984b
Captive		
San Diego	Aug – Mar	Chase et al. 1966
Yerkes	Jan – Jul	Hadidan & Bernstein 1979
Kampala	Jan – Jul	Rowell 1970
Tigoni, Kenya	Jan – Aug	Rowell & Richards 1979
Tigoni, Kenya	Nov – Jan	Else 1985
Texas	Jan – Jul	Bramblett et al. 1975

[1]*see Butynski 1988 for further information*

SEASONALITY

Butynski (1988) reviewed the birth season in wild guenons. He analyzed the data from 13 sites distributed across Africa. In 10 of the 13 sites a birth peak occurred between November

and March. In the other three the births were centred on the June to August period. The author noted that in locations where a bimodal rainfall was recorded, the birth season was up to 5 months in length in contrast to only 2.6 months in locations where there was only one annual wet period. He concluded that food was a direct and major determinant of birth peaks, and rainfall, as the main restriction to plant growth, was an indirect but major determinant.

Other authors, while not denying the importance of nutrition, put more weight on synchrony being due to social facilitation. For example, Kavanagh (1983) suggested that the seasonality of the vervet monkey *per se* was not the determining factor, but rather that the synchrony in birth was a result of social facilitation. This was based on his observations that seasonality in the animals was not obviously related to food availability or rainfall.

A somewhat different interpretation to food *per se* was made by Whitten & Naftolin (1987) who identified phenolic acids and flavanoids in the more common food of the vervets at Samburu. Ferulic acid and kaemferol were the most common phenolic constituents isolated. Both these compounds affect biochemical processes necessary for reproduction. The former has been shown to have an effect on cycles and spermatogenesis in voles and mice. Kaemferol inhibits the biosynthesis of oestrogen and the binding of the hormone to its receptor *in vitro*. It is inferred that these compounds would inhibit reproduction. One of the authors (Whitten 1982) had previously demonstrated that one particular food was eaten at a time coincidental with the onset of breeding. The particular food in question were the blossoms of the *Acacia elatior* tree found along the river banks. A stimulatory effect of one or more compounds was suggested; either in the form of nutrients *per se*, as essential nutrients, or by some other stimulatory compound like oestrogens.

Struhsaker (1967) noted that in Amboseli all females in a troop were sexually receptive at the same time leading to a birth season although males would copulate all year round. Rejection of male advances often resulted in masturbation by the males. Further existence of synchrony was seen in Amboseli by Lee (1984b) who observed only 28.5 days (range 16 – 47 days) between the first and last infants born in any one group. However, seasonality was absent in provisioned vervets in Amboseli (Lee et al. 1986) and as a consequence the IBI was far shorter than that of the non-provisioned animals, many of whom would skip a season (Cheney et al. 1981). IBI of between 13.8 and 21.3 months were given by the latter authors with 85% of births in any one year occurring in a three-month period. This would imply a rigid seasonality in the wild.

It is interesting to note that authors tend to discuss birth occurrence relative to the appearance of food: food for the offspring (who will take solids by two months of age (Klein 1978)) and for the mother's lactational needs. However perhaps from a physiological standpoint it would be more correct to consider births relative to the conception allowed by the previous year's food supply. In environments where food availability is restricted to certain periods of the year further conception will occur only if the mother is nutritionally satisfied and the demands of lactation are below a certain threshold. This threshold cannot be reached for several months postpartum because of ovarian inhibition due to lactation. Subsequently resumption of cyclicity will depend on the ongoing requirements of that offspring weighed against her own intake.

In captivity births have been reported as seasonal, fixed peak, non-fixed peak and year-round (Zuckerman 1953; Booth 1962; Napier & Napier 1967; Conaway & Sade 1969; Hadidian & Bernstein 1970; Hess et al. 1979; Bramblett & Bramblett 1982; Kushner et al. 1982; Fairbanks & McGuire 1984).

Rowell (1970) reported no seasonality in leucocyte counts, sediment levels or copulations, and a random distribution of births was seen in this Tigoni (Kenya) colony (Rowell & Richards 1979). However, statistical analysis revealed that conceptions occurred mainly in dry months. Fairbanks & McGuire (1984) remarked that vervets were interesting animals in which to study reproduction, as they were capable, if placed in favourable circumstances, of breaking out of seasonal breeding patterns. In the California colony births occur every month of the year but are not random with the majority between May and September (Fairbanks pers. comm.).

Seasonality in captive vervets has been studied in some detail at IPR. Females brought into captivity had birth peaks in the five-month November to February period which fell from 80% of births in the first year to 40% after four years. Some synchrony of births does occur within the cages at the IPR where Schapiro (1984) noted that female cage mates were all likely to give birth within six weeks of each other, rather than over the three- month period of the birth peak which occurred in the entire colony at that time. Rowell & Richards (1979) also noted that vervet births in captivity were clumped and provided evidence for some degree of social facilitation.

A study was undertaken at IPR in order to test the likelihood of conception outside of the normal period. Females were given access to males only during this non-breeding period. They gave birth and males had active spermatogenesis at all times of the year. The "off season" breeders continue to give birth off season with an identical IBI to the other animals. Infant death or abortion had the same effect as usual; i.e. a shortened IBI.

True seasonal breeding males (e.g. rhesus monkeys) show testicular atrophy during the off season while females are acyclic. This does not happen in captive vervets. Singly caged female vervets had a greater incidence of long cycles during the off period but conceptions were possible at all times of the year.

Furthermore Eley et al. (1986) monitored testis size and testosterone concentration in nine adult male vervets over a one-year period. They found a rise and fall in volume throughout the period which amounted to about 15% of the maximum volume. Testosterone concentration did not follow this pattern and the authors concluded that any rhythm was unlikely to have an effect on fertility. Histological appraisal of the testis revealed spermatogenesis to be ongoing at all times. This is in agreement with Conaway & Sade (1969) who examined testicular tissue from 19 animals on St. Kitts. They concluded that despite small seasonal changes in testis volume, spermatogenesis and seminiferous tubule diameter the animals were probably fertile all year round.

Struhsaker (1967) noted that males masturbated with ejaculation all year round and he also saw off-season copulations with females who had failed to give birth. The author concluded that male vervets are not seasonal. However he did note seasonality in the red, white and blue display which was confined to the breeding peak.

Breeding and birth peaks which are referred to as seasonality are undoubtably overcome by nutrition as they disappear in captive animals and provisioned wild animals. This was recognised by Booth (1962) who noted that the peaks in the wild were associated with food and varied widely among locations even in the same country. Once animals were provisioned they bred all year round. In marginal situations seasonality exists keyed by environmental conditions such as nutrition and phyto-oestrogens, by physiological events such as pregnancy and lactation and behavioural phenomena such as social facilitation.

When all the data are combined it would appear that a) there is some inherent seasonality in vervet monkeys but this is relatively minor when compared to true seasonal breeders; b) nutrition and/or hormonal analogues in natural products are the key to cyclicity; and c) the one-year period resulting from a 5.5 month gestation plus a "reasonable period of lactational amenorrhea" has contributed to the belief that thee is a seasonality in the vervet.

CONCLUSIONS

Data from both field and captive situations have contributed to the knowledge of reproduction in the vervet monkey. In the past data acquired in the field, apart from behavioural observations, tended to be limited to *ad hoc* sampling. As a consequence most physiological knowledge was derived from captive animals, and it could be questioned whether these data were representative of the wild situation. With improved technologies in assay techniques, anaesthetics, biopsy etc. it is now possible to collect physiological data from the field on a longitudinal basis. What is evident from comparison of these different types of data collections is that the main differences between wild and captive animals are related to the age and frequency of occurrence of reproductive events. For example, the normal high nutritional status of captivity accelerates events such as puberty and

eliminates seasonality.

Survivorship of infant vervets in the wild is low owing to the harsh environmental conditions and high incidence of predation. In captivity, unless very intense management practices are maintained, survivorship is also lower than desirable. The reasons for this are unclear, but the vervet as a generalisation can be said to be far more prone to stress than many other primate species.

There is a large discrepancy in the existing knowledge of reproductive biology between the vervet and other more commonly used primate species such as the rhesus and the baboon. Semen preservation, ovulation induction, embryogenesis and foetal development are just some obvious examples of this. It is hoped that in the coming years these gaps will be filled.

ACKNOWLEDGEMENTS

The author would like to thank Leon Bennun, Barbara Decker, Lynn Fairbanks, Jurgen Seier and Mbaruk Suleman for their helpful comments during preparation of this paper.

REFERENCES

Ackerman, D.R. & Roussel, J.D. 1968. Fructose, lactic acid and citric acid content of the semen of eleven subhuman primate species and of man. *J. Reprod. Fert.* 17: 563–566.

Ackerman, D.R. & Roussel, J.D. 1971. Citric acid, lactic acid and oxygen metabolism of frozen thawed semen from four subhuman primate species. *J. Reprod. Fert.* 27: 441– 443.

Andelman, S.J. 1984. *Ecology and Reproductive Strategies of Vervet Monkeys (*Cercopithecus aethiops*) in Amboseli National Park, Kenya.* Ph.D. thesis, Univ. Washington.

Andelman, S.J., Else, J.G., Hearn, J.P. & Hodges, J.K. 1985. The non-invasive monitoring of reproductive events in wild vervet monkeys using pregnanediol-3-glucoronide and its correlation with behaviourial observations. *J. Zool.* (London). 205: 467– 477.

Asanov, S.S. 1972. Comparative features of the reproductive biology of Hamadryas baboons (*Papio hamadryas*), grivet monkeys (*Cercopithecus aethiops*) and rhesus monkeys (*Macaca mulatta*). Pp. 458 – 472 in: *The use of non-human primates in research on human reproduction* (Diczfalusy, E. & Standley, D.D. eds.). Stockholm, Sweden; WHO Research and Training Centre on Human Reproduction, Karolinska Institute,

Barr, A.B. 1973. Timing of spermatogenesis in four nonhuman primate species. *Fertil. Steril.* 24: 381 – 389.

Beattie, C.W. & Bullock, B.C., 1978. Diurnal variation of serum androgen and oestradiol-17B in the adult male green monkey (*Cercopithecus* sp). *Biol. Reprod.* 19: 36 – 39.

Booth, C. 1962. Some observations on behaviour of *Cercopithecus* monkeys. *Ann. N. Y. Acad. Sci.* 102: 477 – 487.

Brady, A.G., Koritnik, D.R. & Stevens, S.W. 1985. Hormonal responses to gonadotropin-releasing hormone during testicular development in male African green monkeys. *J. Med. Primatol.* 14: 293 – 304.

Bramblett, C.A. & Bramblett, S.S.1982. Seasonality of births in captive vervet monkeys. *Amer. J. Phys. Anthropol.* 57: 171 – 172.

Bramblett, C.A., Pejaver, L.D. & Drickman, D.J. **1975.** Reproduction in captive vervet and Sykes monkeys. *J. Mammal.* 56: 940 – 946.

Brennan, E.J., Else, J.G. & Altmann, J. 1985. Ecology and behaviour of a pest primate in a tourist lodge habitat. *Afr. J. Ecol.* 23: 35 – 44.

Bronstein, M.E., Zairatjane, V.B., Zelenetskaya, U.S., Fanchenko, N.D. & Chernyshev, U.I. 1973. On certain peculiarities of the ovarian structure and the level of urine excretion of sex steroids in the green monkey (*Cercopithecus aethiops pygerythrus*). *Arkh. Anat. Gistol. Embriol.* 64: 88 – 93.

Butler, H. 1966. Observations on the menstrual cycle of the grivet monkey (*Cercopithecus aethiops*) in Sudan. *Folia Primatol.* 4: 194 – 205.

Butynski, T.M. 1988. Guenon birth seasons and correlates with rainfall and food. Pp. 284 – 322 in: *A primate radiation: evolutionary biology of the African guenons* (Gautier-Hion, A., Bouliere, F., Gautier, J-P. & Kingdon J. eds.). Cambridge: Cambridge University Press.

Camatini, M., Franchi, P. & Decurtis, I. 1981. Ultrastructure of Leydig cells in the African green monkey. *J. Ultrastruct. Res.* 76: 224 – 234.

Chase, J.E. & Long, J.O. 1966. A successful breeding colony of African green monkeys, *Cercopithecus aethiops*. In: *Experimental breeding of subhuman primates.* Fifth Annual Report, Appendix IV, NIH Cancer Institute, Contract PH 43-63-56, San Diego: Institute of Comparative Biology, Zoological Society of San Diego.

Cheney, D.L., Lee, P.C. & Seyfarth, R.M. 1981. Behavioural correlates of non-random mortality among free-ranging female vervet monkeys. *Behav. Ecol. Sociobiol.* 9: 153 – 161.

Cheney, D.L., Seyfarth, R.M., Andelman, S.J., Lee, P.C. 1988. Reproductive success in vervet monkeys. Pp. 384 – 402 in: *Reproductive success: studies of individual variation in contrasting breeding systems* (Clutton-Brock, T.H. ed.). Chicago: Univ. of Chicago Press.

Cho, D., Hiyaoka, A., Suzuki, M. & Honjo, S. 1987. Breeding performance and characteristics of menstrual bleeding in the African green monkeys (*Cercopithecus aethiops*) under individual housing condition. *Int. J. Primatol.* 8: 481.

Conaway, C.H. & Sade, D.S. 1969. Annual testis cycle of the green monkey (*Cercopithecus aethiops*) on St. Kitts, West Indies. *J. Mammal.* 150: 833 – 833.

Clermont, Y. 1969. Two classes of spermatogonial stem cells in the vervet monkey (*Cercopithecus aethiops*). *Amer. J. Anat.* 126: 57 – 72.

Dixson, A.F. 1987a. Baculum length and copulatory behaviour in primates. *Amer. J. Primatol.* 13: 51 – 60.

Dixson, A.F. 1987b. Observation on the evolution of the generation and copulatory behaviour in male primates. *J. Zool.* 213: 423 – 443.

Dixson, A.F. & Herbert, J. 1974. The effect of testosterone on the sexual skin and genitalia of the male talapoin monkey. *J. Reprod. Fert.* 38: 217 – 219.

Dracopoli, N.C. & Brett, F.L. 1982. Serum aminopeptidases in pregnant vervet monkeys (*Cercopithecus aethiops*). *Biochem Genet.* 20: 825 – 831

Dukelow, W.R. & Erwin, J. (eds.) 1986. *Comparative primate biology, Vol 3: Reproduction and development.* New York: Alan R. Liss.

Dunbar, R.I.M. 1974. Observations on the ecology and social organisation of the green monkey (*Cercopithecus sabaeus*) in Senegal. *Primates* 15: 341–350 .

Eley, R.M. 1988. Nonhuman primate models for biomedical research: Breeding and captive management of old world monkeys in their country of origin. Pp. 27 –39 in: *Non human primates : Developmental biology and toxicology,* (Neubert, D., Merker, H-J. & Hendrickx, A.J. eds.). Berlin: Ueberreuter Wissenschaft.

Eley, R.M. 1990. *Know your monkeys – A guide to the primates of Kenya.* Nairobi: Institute of Primate Research/National Museums of Kenya.

Eley, R.M., Else, J.G., Gulamhussein, N. & Lequin, R. M. 1986. Reproduction in the vervet monkey (*Cercopithecus aethiops*): 1. Testicular volume and testosterone. *Amer. J.Primatol.* 10: 229 – 235.

Eley, R.M. & Tarara, R. 1984. The prolonged intermenstrual interval in the vervet monkey (*Cercopithecus aethiops*).*Int. J. Primatol.*5: 335.

Eley, R.M., Tarara, R., Worthman, C. & Else, J.G. 1989. Reproduction in the vervet monkey (*Cercopithecus aethiops*), III. The menstrual cycle. *Amer. J. Primatol.* 17: 1 – 10.

Else, J.G. 1985. Captive propagation of vervet monkeys (*Cercopithecus aethiops*) in harems. *Lab. Anim. Sci.* 35: 373 – 375.

Else, J.G., Eley, R.M., Wangula, C., Worthman, C.M. & Lequin, R.M. 1986. Reproduction in the vervet monkey (*Cercopithecus aethiops*), II: Annual pattern and preliminary hormonal

data. *Amer. J. Primatol.* 11: 333 – 342.

Fanchenko, N.D., Alekseeva, M.L., Shchdrini, R.N. & Novikov. E.A. 1986. Functional characteristics of the reproductive system of the female green monkey. *Akush Ginekol.* (Mosk) March, 1986.

Fairbanks, L.A. 1988. Mother-infant behavior in vervet monkeys. Response to failure of last pregnancy. *Behav. Ecol. Sociobiol.* 23:157– 165.

Fairbanks, L.A. 1990a. Reciprocal benefits of allomothering for female vervet monkeys. *Anim. Behav.* 40: 553 – 562.

Fairbanks, L.A. 1990b. Dominance rank, fecundity and the use of allomothers by female vervet monkeys. *Amer. J. Primatol.* 20: 190.

Fairbanks, L.A. & McGuire, M.T. 1984. Determinants of fecundity and reproductive success in captive vervet monkeys. *Amer. J. Primatol.* 7: 27 – 38.

Fairbanks, L.A. & McGuire, M.T. 1986. Age, reproductive value, and dominance-related behavior in vervet monkey females: cross-generational influences on social relationships and reproduction. *Anim. Behav.* 34: 1710 – 1721.

Fairbanks, L.A. & McGuire, M.T. 1987. Mother-infant relationships in vervet mother responses to new adult males. *Int. J. Primatol.* 8: 351 – 366.

Galat, G. & Galat-Luong, A. 1977. Demographie et regime alimentaire d'une troupe de *Cercopithecus aethiops sabaeus* en habitat marginal au nord Senegal. *La Terre et la Vie* 31: 557 – 577.

Gartlan, S.J. 1969. Sexual and maternal behaviour of the vervet monkey, (*Cercopithecus aethiops*). *J. Reprod. Fertil.* Suppl. 6: 137 – 150.

Girod, C. & Dubois, M.P. 1976. Demonstration by immuno-fluorescence of somatotropic cells and prolactin cells in monkeys, *Erythrocebus patas*, *Cercopithecus aethiops* and *Papio hamadryas*. *Compt. Rend. Seanc. Soc. Biol. Filiales* (Paris) 170: 1214 – 1218.

Girod, C., Dubois, M.P. & Trouillas, J. 1981. Immuno-histochemical localization of FSH and LH in the pars distalis of the vervet (*Cercopithecus aethiops*) and baboon (*Papio hamadryas*) pituitaries. *Cell Tissue Res.* 217: 245 – 257.

Gould, K.G. 1982. Report on symposium entitled: "Comparative biology of primate semen" Pp. 217 – 220 in: *Advanced views in primate biology* (Chiarelli, A.B. & Corruccini, R.S. eds.). Berlin: Springer-Verlag.

Haddow, A.J. 1952. Field and laboratory studies on an African monkey (*Cercopithecus ascanius schmidti*). *Proc. Zool. Soc. London.* 122: 297 – 394.

Hadidian, J. & Bernstein, I.S. 1979. Female reproductive cycles and birth data from an old world monkey colony. *Primates* 20: 429 – 442.

Harcourt, A.H. 1987. Dominance and fertility in female primates. *J. Zool.* 213: 471 – 487.

Harcourt, A.H., Harvey, P.H., Lawson, S.G. & Short, R.V. 1981. Testis weight, body weight and breeding systems in primates. *Nature* 293: 55 – 57.

Harrison, R.M. & Lewis, R.W. 1986. The male reproductive tract and its fluids. Pp. 101 – 148 in: *Comparative primate biology, Vol. 3: Reproduction and development* (Dukelow, W.R. & Erwin, J. eds.). New York: Alan R. Liss.

Hendrickx, A.G. & Sawyer, R.H. 1978. Development staging and thalidomide teratogenicity in the green monkey (*Cercopithecus aethiops*). *Teratology*. 18: 393 – 403.

Henzi, S.P. & Lucas, J.W. 1980. Observations on the inter-troop movement of adult vervet monkeys (*Cercopithecus aethiops*). *Folia Primatol.* 33: 220 – 235.

Hess, D.L., Hendrickx, A.G. & Stabenfeldt, G.H. 1979. Reproductive and hormonal patterns in the African green monkey (*Cercopithecus aethiops*). *J. Med. Primatol.* 8: 237 – 281.

Hiyaoka, A. & Cho, F. 1990. A method for collecting semen by fingers in the African green monkey (*Cercopithecus aethiops*) and properties of the semen collected. *Exp. Anim.* 39: 121– 124.

Hiyaoka, A., Yoshida, T., Cho, F. & Goto, N. 1989. Growth curves of body weight changes in laboratory bred female African green monkeys (*C. aethiops*). *Exp. Anim.* 38: 239 – 244.

Hiyaoka, A., Yoshida, T., Cho, F. & Goto, N. 1990. Growth curves of body weight and their relationship to sexual maturity in laboratory bred male African green monkeys (*C. aethiops*). *Exp . Anim.* 39: 345 – 352.

Horrocks, J.A. 1986. Life history characteristics of a wild population of vervets (*Cercopithecus aethiops sabaeus*) in Barbados, West Indies. *Int. J. Primatol.* 7: 31 – 47.

Johnson, P.T., Valerio, D.A. & Thompson, G.E. 1973. Breeding the African green monkey, *Cercopithecus aethiops*, in a laboratory environment. *J. Anim. Sci.* 23: 355 – 359.

Kahumbu, P. & Eley, R.M. 1991. Teeth emergence in wild olive baboons in Kenya and formulation of a dental schedule for aging wild baboon populations. *Amer. J. Primato*l.23: 1– 9.

Kavanagh, M. 1983. Birth seasonality in *Cercopithecus aethiops*: A social advantage from synchrony. Pp. 89 – 98 in: *Perspectives in primate biology* (Seth, P.K. ed.). New Delhi: Today and Tomorrow's.

Keddy, A.C. 1986. Female mate choice in vervet monkeys (*Cercopithecus aethiops sabaeus*). *Amer. J. Primatol.* 10: 125 – 134

Kimani, J.K. 1987. Histological organization of the vagina in the vervet monkey with reference to the histomorphology of the elastic fibre system. *Int. J. Primatol.* 8: 478.

Klein, D.J. 1978. *The diet and reproductive cycles of a population of vervet monkeys,* Cercopithecus aethiops. Ph.D. thesis, New York University, New York.

Klein, T., Potgeiter, H.C., Spies, J.H. & Van der Watt Savage, N. 1985. The reversibility of the stabilization effect of sodium molybdate on uterine estrogen and progesterone receptors of the vervet monkey. *J. Recept. Res.* 5: 12 – 23

Koritnik, D.R., Wood, L.L., Shandilya, L.N. & Rudel, L.L. 1984. Lipids, lipoproteins and endocrine profiles during pregnancy in the African green monkey (*Cercopithecus aethiops*). *Metabolism* 33: 840 – 844.

Kraemer, D.C. & Kuel, T.J. 1984. Semen collection and evaluation of breeding soundness in non human primates. Pp. 1134 – 1137 in: *Current therapy in theriogenology* (Morrow D. ed.). Philadelphia: Saunders.

Kudolo, G.B., Mbai, F.N. & Eley, R.M. 1986. Reproduction in the vervet monkey: Endometrial oestrogen and progestin receptor dynamics during the normal and prolonged menstrual cycles. *J.Endocrinol.* 110: 429 – 439.

Kudolo, G.B., Thiongo, M., Eley, R.M. & Else, J.G. 1984. Estradiol and progesterone receptor dynamics in East African Primates. *Int. J. Primatol.* 5: 354.

Kushner, H., Kraft-Shreyer, N., Angelakos, E.T. & Wudarski, E.M. 1982. Analysis of reproductive data in a breeding colony of African green monkeys. *J. Med. Primatol.* 11: 77 – 84.

Lancaster, J.B. 1971. Play-mothering: The relation between juvenile female and young infants among free-ranging vervet monkeys (*C. aethiops*). *Folia Primatol.* 15: 161 – 182.

Lee, P.C. 1984a. Ecological constraints to the social development of vervet monkeys. *Behaviour* 94: 245 – 262

Lee, P.C. 1984b. Early infant development and maternal care in free-ranging vervet monkeys. *Primates* 25: 36 – 47.

Lee, P.C. 1987. Nutrition, fertility and maternal investment in primates. *J. Zool.* 213: 409 – 422.

Lee, P.C., Brennan, E.J., Else, J.G. & Altmann, J. 1986. The ecology and behaviour of vervet monkeys in a tourist lodge habitat. Pp. 229 – 236 in: *Primate ecology and conservation* (Else, J.G. & Lee, P.C. eds.). Cambridge: Cambridge University Press.

Makawiti, D. 1984. *The development of immunochemical tests to monitor reproductive cycles in non-human primates.* PhD thesis, University of London

Machinda, H. & Giacomotti, L. 1967. The anatomical and histochemical properties on the skin of the external genitalia of the primates. *Folia Primatol.* 6: 48 – 49.

McGuire, M. (ed.) 1974. *The St. Kitts Vervet: Contributions to primatology* . Basel: S. Karger.

McGuire, M.T., Brammer, G.L. & Raleigh, M.J. 1986. Resting cortisol levels and the emergence of dominant male status in vervet monkeys. *Horm. Behav.* 20: 106 – 117

Mwenda, J.M., Bambra, C.S. & Tarara R. 1990. Studies with human, baboon and vervet monkey chorionic gonadotrophins. *J. Med. Primatol.* 19: 715 – 724.

Napier, J.R. & Napier, P.H. 1967. *A handbook of living primates.* Academic Press, New York.

Njuguna, J., Wall, H. & Else, J.G. 1984. The baboon and vervet monkey as possible animal models for menstrual blood loss studies. *J. Obstet. Gynaecol. E. C. Africa.* 2: 27 – 29.

Owiti, G.E.O., Cukierski, M., Tarara, P.R., Enders A. & Hendrickx, A.G. 1986. Early placentation in the African green monkey (*C. aethiops*). *Acta Anatomica* 127: 184 – 194.

Owiti, G.E.O., Tarara, R.P. & Hendrickx, A.G. 1989. Fetal membranes and placenta of the African green monkey (*Cercopithecus aethiops*). *Anat. Embryol.* 179: 591 – 604

Potgieter, H.C., Klein, T., Magagare, F., Savage, N. & Wittlyf, J.L. 1986. Molybdate and the molecular properties of the vervet monkey estrogen receptor. *J. Steroid Biochem.* 25: 951 – 956

Potgieter, H.C., Spies, J.H., Klein, T., Thiery, M. & Vander-Watt, J.J. 1985. Estrogen and progesterone receptors in the uterus of the vervet monkey. *J. Recept. Res.* 5: 193 – 218.

Price, J.S. Brunton, J.L., Shuster, S. & Wolff, K. 1976. Control of scrotal colour in the vervet monkey. *J. Med. Primatol.* 5: 296 – 304.

Raleigh, M.J. 1987. The influence of social rank and behaviour styles on endocrine profile in vervet monkeys (*Cercopithecus aethiops sabaeus*). *Int. J. Primatol.* 8: 456.

Raleigh, M.J. & McGuire, M.T. 1990. Social influences on endocrine function in male vervet monkeys. Pp. 95 –111 in: *Socioendocrinology of primate reproduction* New York: Wiley-Liss Inc.

Roussel, J.D. & Austin, C.R. 1967a. Preservation of primate spermatozoa by freezing. *J. Reprod. Fertil.* 13: 333 – 335.

Roussel, J.D. & Austin, C.R. 1967b. Enzymatic liquefaction of primate semen. *Int. J. Fertil.* 12: 228 .

Roussel, J.D. & Austin, C.R. 1968. Improved electro-ejaculation of primates. *J. Inst. Anim. Tech.* 19: 22 – 32.

Roussel, J.D. Cleve, T.H. & Austin, C.R. 1968. Use of human post menopausal gonadotrophin (Pergonal) for promoting ovarian follicular and oocyte development in monkeys. Pp. 162 – 171 in: *Use of non human primates in drug evaluation* (Vagtborg, H. ed.). Austin: University of Texas Press.

Roussel, J.D., Stallcup, O.Y. & Austin, C.R. 1967. Selective phagocytosis of spermatozoa in the epididymis of bulls, rabbits and monkeys. *Fertil. Steril.* 18: 509 – 516.

Rowell, T.E. 1970. Reproductive cycles of two *Cercopithecus* monkeys. *J. Reprod. Fertil.* 22: 321 – 338.

Rowell, T.E. 1971. Organization of caged groups of *Cercopithecus* monkeys. *Anim. Behav.* 19: 625 – 645.

Rowell, T.E. & Richards, S.M. 1979. Reproductive strategies of some African monkeys. *J. Mammal.* 60: 58 – 69.

Schapiro, S.J. 1984. Reproductive synchronization in *Cercopithecus aethiops* vs *C. mitis*. *Amer. J. Primatol.* 6: 421 – 422.

Seier, J.V. 1986. Breeding Vervet monkeys in a closed environment. *J. Medical Primatol.* 15: 339 – 349.

Seier, J.V., Fincham, J.E., Menkveld, R. & Venter, F.S. 1989. Semen characteristics of vervet monkeys. *Lab. Anim.* 23: 43 – 47.

Seier, J.V., Venter, F.S., Fincham J.E. & Taljaard J.J.F. 1991. Hormonal vaginal cytology of vervet monkeys. *J.Med. Primatol.* 20: 1 – 5.

Seier, J.V. 1991. The rearing environment and breeding performance of captive bred vervet monkeys: some preliminary results. *Lab. Anim.*

News 3: 1 – 2.

Setchell, K.D.R., Bull, E. & Adlercreutz, H. 1980. Steroid excretion during the reproductive cycle and in pregnancy of the vervet monkey (*Cercopithecus aethiops pygerythrus*). *J. Steroid Biochem.* 12: 375 – 384.

Seyfarth, R.M., Cheney, D.L. & Marler, P. 1980. Vervet monkey alarm calls. *Anim. Behav*. 28: 1070 – 1094.

Steklis, H.D., Brammer G.I., Raleigh, M.Y. & McGuire, M.T. 1985. Serum testosterone, male dominance and aggression in captive groups of vervet monkey (*Cercopithecus aethiops sabaeus*). *Horm. Behav.* 19: 154 – 163.

Struhsaker, T.T. 1967. Behavior of vervet monkeys (*Cercopithecus aethiops*). *Univ. Calif. Publ. Zool.* 82: 1 – 74.

Turner, T.R., Whitten, P.L., Jolly, C.J. & Else, J.G. 1987. Pregnancy outcome in free ranging vervet monkeys, (*Cercopithecus aethiops*). *Amer. J. Primatol.* 12: 197 – 20.

Valerio, D.A. & Dalgard, D.W. 1971. Experiences in the laboratory breeding of non-human primates. Pp. 49 – 62 in: *Breeding simians for developmental biology* (Perkins, F.T. & Donahue, D. eds.). Lab. Anim. Handbook 6. London: Laboratory Animals Ltd.

Whitten, P.L. 1982. *Female reproductive strategies among vervet monkeys.* Ph.D. thesis, Harvard University, Cambridge.

Whitten, P.L. 1983. Diet and dominance among female vervet monkeys (*Cercopithecus aethiops*). *Amer. J. Primatol.* 5: 139 – 159.

Whitten, P.L. & Naftolin, F. 1987. Hormonally active plant chemicals in vervet monkey diets. *Amer. J. Primatol.* 12: 376.

Wickler, W. 1967. Socio-sexual signals and their intra-specific imitation in primates. Pp. 69 – 167 in: *Primate ethology* (Morris, D. ed.). London: Weidenfield and Nicolson.

Zaidi, P., Wickings, E.J., Arslan, M. & Nieschlag. R. 1982. Characterization and comparison of testicular LH/hCG receptors of rhesus monkeys (*Macaca mulatta*) and green monkeys (*Cercopithecus aethiops*). *Amer. J. Primatol.* 2: 285 – 290.

Zuckerman, S. 1932. *The social life of monkeys and apes.* London: Kegan Paul.

Zuckerman, S. 1953. The breeding seasons of mammals in captivity. *Proc. Zool. Soc.* (Lond.). 122 : 827 – 950.

TYPESETTING AND LAYOUT BY R. ELEY.
PRINTED BY REGAL PRESS, NAIROBI.