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THE TAXONOMY AND ECOLOGY OF THE TREES OF THE BOBIRI FOREST RESERVE, GHANA, WEST AFRICA

BY

SAMUEL V. A. KISSEADOO

VOLUME 1

A dissertation submitted to the Graduate Faculty in Biology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

1993

This manuscript has been read and accepted for the Graduate Faculty in Biology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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ABSTRACT

THE TAXONOMY AND ECOLOGY OF THE TREES OF THE BOBIRI FOREST RESERVE, GHANA, WEST AFRICA

by

Samuel V. A. Kisseadoo

Advisor : Dr. Scott A. Mori.

The point-centered quarter method was used to sample 1000 trees in a portion of the Bobiri forest reserve in Ghana, West Africa that had not been disturbed for 60 years. Standard measures of tree diameter and height, bole, and bark characteristics were recorded for each of the 104 species of the sample. Supplementary data was gathered from additional species falling outside of the sample. Voucher specimens were gathered for all of the sampled trees and the leaves from these specimens were used to reconstruct computerized average leaf images of all of the species and families. The primary goal of the study was to describe this African forest using ecological techniques heretofore not applied to the forests of the continent. The secondary goal of the study was to furnish complete descriptions

of the vegetative features of each of the species studied in order to facilitate their field identification.

Calculation of Importance Values indicates that *Celtis zenkeri* , *Funtumia africana* , and *Sterculia rhinopetala* are the most important species in this forest. Therefore it is suggested that what was named the Celtis-Triplochiton Association by Taylor (1960), based on casual observation of dominant species, should be renamed the Celtis-Funtumia-Sterculia Association. The most important families of this forest, based on a calculation of Family Importance Value (FIV) are the Sterculiaceae and Ulmaceae.

An analysis of tree height suggested possible stratification in this forest, with three probable tiers of the tree canopies. Correlations between height and diameter indicated that diameter is a good predictor of tree height. Bark features, ranging from the presence or absence of latex to the degree of fissuring, provide useful features for the identification of trees of the Bobiri forest.
Correlations of tree diameter with bark thickness indicate that bark generally becomes thicker as the trees increase in diameter. The

majority of the trees are buttressed (77%), and the degree of buttressing is higher than those recorded for Neotropical forests. Most of the trees possess straight boles, and smooth barks that are not very thick.

Leaf analysis has demonstrated that detailed leaf features, especially venation patterns, previously not fully utilized for the identification of Ghanaian (and other African) trees, have great utility in identification at all taxonomic levels. Majority of the leaves have hairs that are simple, and only few species have foliar glands. An average leaf of a tree in the Bobiri forest is simple, mesophyllic, elliptic or narrowly elliptic in form, possesses an entire margin, has an acute or acuminate apex and an acute or sometimes cuneate to obtuse base, and usualy possesses Brochidodromous venation.

In comparison with Neotropical forests, diversity (104 species in the 1000 tree sample) of the Bobiri forest is low. However, density (735 trees/hectare) is high, and the trees often have very tall stature---for example, a tree of *Triplochiton scleroxylon* measured 70.9 meters.

Because of increasing demands on the forests of Ghana, those forests best representing natural stands must be identified and protected before there are none left to protect. The least disturbed sections of the Bobiri forest, including the area where this study was made, should be allowed to continue as intact biological reserves without economic exploitation.

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TABLE OF CONTENTS

TITLE PAGE

APPROVAL PAGE ii

ABSTRACT iii

ACKNOWLEDGMENTS vii

LIST OF TABLES xiv

LIST OF FIGURES xviii

LIST OF PLATES xxiv

CHAPTER 1

INTRODUCTION TO TROPICAL FORESTS 1

- Species Richness 2
- Tropical Forest Destruction 6

CHAPTER 2

AFRICA 10

- African Vegetation Types 11
- West African Geography 14
- West African Forest Types 18
- West African Forest Composition And Structure 20

The Dahomey Gap 24

CHAPTER 3

GHANA 26

Geography And Economy 26

The Vegetation And Forests Of Ghana 35

Conservation In Ghana 41

CHAPTER 4

THE BOBIRI FOREST RESERVE 47

CHAPTER 5

MATERIALS AND METHODS 53

CHAPTER 6

SPECIES IMPORTANCE VALUES 58

CHAPTER 7

FAMILY IMPORTANCE VALUES 67

CHAPTER 8

BUTTRESSES 78

CHAPTER 9

TREE SIZE AND STRATIFICATION 113

CHAPTER 10

BARK 131

CHAPTER 11

MORPHOLOGICAL CHARACTERS OF THE 104 SPECIES

IN THE 1000-TREE SAMPLE (including plates) 138

CONCLUSIONS 749

TABLES 754

FIGURES 827

PLATES (1-18) 1011

LITERATURE CITED 1047

LIST OF TABLES

Table	Title	Page
I	Comparison of the number of species of plants in some tropical localities.	754
II	Comparison of diversity in the Bobiri forest with diversity in other tropical forests.	756
III	List of importance values of the 104 species in the 1000 tree sample of the Bobiri forest reserve.	758
IV	Comparison of species diversity and tree density of the Bobiri forest with four other Neotropical forests.	765
V	Comparison of the most important species of the Bobiri reserve with those of three Neotropical forests.	766
VI	Dominant plant families for the Bobiri forest and some tropical forests.	767
VII	Family importance values (FIV) for the 25 families in the 1000 tree sample of the Bobiri forest reserve.	772

VIII	Comparison of family importance values for the five most important families of the Bobiri forest with FIV's of six Neotropical localities.	774
IX	Comparison of the importance of some families in the Bobiri reserve with families in six Neotropical forests.	778
X	Family/species-buttress relationship in the Bobiri forest reserve.	781
XI	Nature of trunk bases for some tree species in the Bobiri forest.	783
XII	Tree size (DBH) at which buttresses begin to develop in some Ghanaian forest trees.	784
XIII	Species with the widest, tallest, and thickest buttresses for the 1000 tree sample in the Bobiri forest.	785
XIV	Species with the greatest numbers of buttresses (total counted in individual trees) in the Bobiri forest reserve.	787

XV	Comparison of buttressing for some tropical localities.	789
XVI	The 20 tallest trees in the Bobiri forest reserve.	790
XVII	The 30 trees with the largest DBH in the Bobiri forest reserve (DBH > 40 cm).	792
XVIII	DBH and height classes for the 1000 tree sample in the Bobiri forest reserve.	795
XIX	Sizes of the largest trees in the 25 families sampled in the Bobiri forest reserve.	797
XX	Average tree size for the largest trees in each of the 25 families in the 1000 tree sample of the Bobiri forest reserve.	809
XXI	Some of the tallest trees reported in the world, compared with the largest tree of the Bobiri forest.	812
XXII	Additional terms for leaf morphology.	814
XXIII	The numbers and percentages of species and trees possessing the major vegetative characters enumerated for the 1000 tree sample in the Bobiri	

forest reserve. 816

XXIV The form, apex, base, and margin of average digitized leaf images of the 25 families in the Bobiri forest sample. 824

LIST OF FIGURES

Figure	Title	Page
1	Map showing forest and other vegetation of Africa.	827
2	The vegetation zones of West Africa.	828
3	Forest types in Ghana.	829
4 a & b	Forest and wildlife reserves in Ghana.	830
5	Map of Ghana showing the research area (the Bobiri forest reserve).	831
6	Map of the research site in the Bobiri forest, showing the four kilometer transect line.	832
7	Profile diagram of the Bobiri forest reserve.	833
8	Species curve for the 1000 tree sample of the Bobiri forest.	834
9	Relation between the frequency and the importance value of the species in the Bobiri forest reserve.	835
10	Relation between the number of trees in	

	a species and the importance value of the species in the Bobiri forest.	835
11	The relation between trunk basal area and the importance value of a species in the Bobiri forest reserve.	836
12	Relation between the density and the frequency in the 104 species in the 1000 tree sample of the Bobiri forest reserve.	837
13	Relation between FIV and number of species in a family.	838
14	Variation of family importance values with respect to numbers of trees in each of the 25 families in the 1000 tree sample.	839
15	The influence of total trunk basal area on family importance values for the 25 families in the 1000 tree sample of the Bobiri forest.	839
16	Comparison of family importance values of the five most important families of the Bobiri	

	forest with the five most important families of six Neotropical forests.	840
17	Comparison of the total basal areas of the five most important families of the Bobiri forest, with values of five Neotropical forests.	841
18	Terminology for buttresses.	842
19	The number of buttresses per tree in each of the 25 families of the 1000 tree sample of the Bobiri forest reserve.	843
20	The number of trees with buttresses in the 16 buttressed families in the 1000 tree sample of the Bobiri forest.	843
21-55	Buttreess development in buttrressed species of the Bobiri forest.	844
56	Comparison of buttressed and unbuttressed trees in the Bobiri forest, with buttressing in two Neotropical forests.	862
57	Relation between buttress height and width	

	of trees in the Bobiri forest.	863
58	Relation between buttress height and height of trees in the Bobiri forest.	864
59	Relation between buttress width and DBH of trees in the Bobiri forest.	865
60	Classification of buttresses of the forest trees of Ghana.	866
61 a & b	Height variation for the 20 tallest species, and variation in diameter size for the 30 largest species, in the Bobiri forest reserve.	868
62	Comparison of the largest trees in the 25 families of the 1000 tree sample in the Bobiri forest.	869
63	DBH and height class relation in the Bobiri forest.	870
64-78	DBH-Height relation for families with 10 or more individuals in the 1000 tree sample of the Bobiri forest reserve.	871
79	Diameter-Height relation for the 1000 trees sampled to demonstrate stratification.	883

80	Bar chart for the tallest, mature (reproductive) individual species in the 25 families of the 1000 tree sample of the Bobiri forest, to confirm possible stratification.	884
81	Bark and wood descriptions.	885
82-95	Variation of bark thickness in trees of the Bobiri forest reserve.	886
96 & 97	Additional terms for leaf morphology.	899
98	Types of hairs on the leaves of trees of the Bobiri forest.	901
99-102	Illustration of major leaf features, especially venation patterns, and average digitized reconstructed leaf images for individual species in the 1000 tree sample of the Bobiri forest.	902
203-206	Average digitized reconstructed leaf images for the 25 families in the 1000 tree sample of the Bobiri forest reserve.	1006

207 Average digitized reconstructed leaf image for the Bobiri forest (for all the 104 species in the 1000 tree sample). 1010

LIST OF PLATES

Plate	Title	Page
1	Forest transition to savanna (the Accra plains, part of the Dahomey gap) near Aburi, Ghana.	1012
2A	Deforestation on the Akwapim ranges.	1014
2B	Deforestation of the moist semi-deciduous forest of Ghana through cocoa farming.	1014
3A	Destruction of forest through slash-burn.	1016
3B	Afforestation with Teak in Ghana.	1016
5 & 6	Characteristic lianas in the Bobiri forest.	1018
7A & B	The influence of the amount of light reaching the forest floor, on the growth of vines and herbs in the Bobiri forest.	1020
8A, B, & C	Characteristic herbs in the Bobiri forest reserve.	1026
9-13	Major sources of disturbances in the Bobiri forest reserve.	1028
14A & B	Research centers in the Bobiri forest.	1038
15A & B	The state of the Bobiri river of the Bobiri forest,	

	in the wet and the dry (harmattan) seasons.	1040
16	Climbing spikes and clipper used for plant collection.	1042
17A & B	The fluting of the trunk of *Khaya senegalensis* through constant debarking.	1044
18	Profile of the Bobiri forest, suggesting some form of stratification.	1046
19-129	Characteristic morphological features of the species in the 1000 tree sample.	151-744

CHAPTER 1

INTRODUCTION TO TROPICAL FORESTS

This study is a report on the systematics and ecology of the Bobiri forest located in the west African country of Ghana. However, before presenting the result of my study, I will provide an overview of tropical forests of the world with emphasis on Africa.

Tropical forests (TF) are estimated to cover 9-10 million km^2 (Myers, 1980). These forests include a wide variety of forest types --- ranging from those with marked dry seasons to true rainforests with abundant rainfall in all months of the year.

Caufield (1982) estimates tropical forest cover to be 900 million hectares, and Grainger (1983) gives the approximate area as 1 $x10^9$ ha which is more than one-third of all closed forests in the world. Latin America contains 58% of the world's TF, Africa 19%, and South-East Asia and Oceania 23%. Whitmore (1990) states that Africa has the smallest block of TF (1.8 x 106 km^2), followed by Malesia (2.5 x 106 km^2), and the Neotropics (4 x 106 km^2).

A total of 70 countries contain TF. Over four-fifths of this biome occurs in only nine countries : Bolivia, Brazil, Colombia, Peru, and

Venezuela in Latin America; Indonesia, and Malaysia in South East Asia; Gabon, and Zaire in Africa (Myers, 1980). Caufield (1982) calculates that Brazil alone possesses 33% of the world's total. Zaire and Indonesia each possess 10% and Colombia, Peru, Venezuela, Gabon, Burma, and Papua New Guinea together have over 200,000 km^2 of tropical forests.

Species Richness

The biologically rich tropical forests are found in some of the least known portions of the earth. A tiny country in the tropics, such as Panama, has as many plant species as the whole continent of Europe. Oldeman (1983) suggests that tropical forests are so complex that they probably will never be completely understood by man. Janzen (1975) adds that, with the exception of a few horticulturally important ferns, the ecology of tropical primitive plants is essentially unknown. He emphasizes that it is nearly impossible to make generalizations about tropical plant biology that will be true over large areas yet are precise enough to be of use in a specific area. Gentry (1986) states that although tropical forests are widely thought to be much more species

rich than most temperate ecosystems, there are few comparative data available.

Whitmore (1990) reports that of the total of about 250,000 species of flowering plants in the world, about two-thirds occur in the tropics. Caufield (1986) calculates that between 40 and 50% of all types of living things (according to her as many as 5 million species) live in tropical forests. Without question, these forests are the richest regions on earth in terms of biological diversity.

Whitmore (1990) states that the number of tree species per hectare in tropical forests usually ranges from 20-200 (considerably higher values have been recorded). The total number of vascular plant species in a hectare is about three times as high as the number of tree species and no two hectares have exactly the same composition. Lawson (1986) states that in the Ivory Coast in West Africa, 60-70 different species of trees occur in a single hectare.

Debate on the location of the world's richest tropical forests continues. Most studies indicate that this honor lies with forests of either Asia or the Neotropics. Africa, according to most authors, has the least diverse forests.

Richards (1973) explains why African forests are "poor" when compared to those of Amazonia and Malesia, and suggests that this difference is not due to insufficient knowledge. He stated that in the forests of tropical Africa, a very large proportion of the species have wide, though sometimes discontinuous, ranges. Endemic species are relatively few in Africa, in contrast to the situation in the Neotropics and Asia where endemic species are very numerous. Richards (1973) also points out that Africa is poor in certain plant groups that are speciose in other tropical areas of the world. The most conspicuous examples are the palms and the orchids, but other families such as the Lauraceae, Myrtaceae, and Myristicaceae are less diverse in Africa. For example, the Flora of West Tropical Africa (Hutchinson & Dalziel, 1954-72) has only 13 genera and about 24 species of Palms. In contrast, Allen (1956) reports that at Golfo Dulce, a small area on the Pacific coast of Costa Rica, there are more genera of palms than in the whole of West Africa. Corner (1966) mentions that in the whole of Africa, there are only 15 genera and about 50 species of Palms, compared with 92 genera and 1,140 species in the Americas, and 107 genera and 1,150 species in tropical Asia and

Australasia.

Jacobs (1988) claims that Malesian forests are the richest in the world. The total number of Malesian species is between 25,000 and 30,000; about two-thirds of which are found only in lowland forests (van Steenis, 1948). Moore (1973) reports that the Malesian palm flora is the richest in the world with 1,385 species in 97 genera (including 560 species of rattans). Poore (1968), in his study of a 23 ha area of lowland forest in Jengka (Malaysia), found a total of 377 upper canopy species; out of this number, 307 (81%) were represented by only one to 10 mature individuals each. No fewer than 143 species (38%) were represented by only a single mature individual each. Richards (1952) tabulated 109 species of trees with girths of 30 cm on two plots of one ha each in the lowlands of Malaya.

In the Neotropics, Gentry (1986) recorded 300 species of trees of 10 cm DBH among the 600 individuals enumerated --- every second tree encountered was a different species! Until recently this plot was thought to be the richest in the world. However, a recent study in the extra-Amazonian forests of eastern Brazil using trees 5 cm DBH has found 450 different species (Thomas, 1993).

Nevertheless, not all tropical forests are rich in tree species (Whitmore, 1975; Connel, 1978). For example, Langdale-Brown et al. (1964) found that in Uganda (East Africa) habitats diminish in diversity of woody plant species in the order: 1) medium altitude moist evergreen forest, 2) moist semi-deciduous forest at medium altitude, and 3) moist evergreen forest at higher altitudes. In Ghana, Hall and Swaine (1981) reported that of the seven major forest types, the Wet Evergreen forest type is the richest in species.

Table I summarizes and compares the number of species for some tropical localities around the world and Table II shows the number of species for specific tree sizes in plots in various tropical forests.

Tropical Forest Destruction

The alarming rate at which tropical forests are being deforested and misused is an urgent matter of global concern. Myers (1986) reported that at least 76,000 and possibly as much as 92,000 km^2 of forest are being completely and permanently cleared each year, and another 100,000 km^2 or so is being severely disrupted. This means

that about 1% of the biome is being destroyed each year, and more than 1% impoverished. As a result, tropical forests now occupy only about 40% of their original extent (Lanley, 1981). Fuelwood gathering, cattle ranching, commercial logging, and the activities of small-scale cultivators are largely responsible for the destruction of the biologically richest habitats in the world.

Jacobs (1988) calculates that tropical Africa had lost one million km^2 of moist forest to shifting cultivators even before the arrival of modern technology in the last quarter century. Of Africa's present tropical forests, as much as 400,000 km^2 is being influenced by shifting cultivation, with an estimated loss of 40,000 km^2 per year of forest cover. Kio (1983) claims that indiscriminate exploitation and the ravages of shifting cultivation are the main causes of forest destruction in Africa and Taylor (1962) emphasized the direct and indirect activities of man in farming, forest burning, and timber exploitation as major causes of forest destruction in Africa (Plates 2 & 3). Already in 1966, Lawson pointed out that very little undisturbed forest was left in West Africa!

As mentioned earlier, tropical forests contain about one half the

world's plant and animal species. Therefore, rampant tropical forest destruction has had and will continue to have a major impact on species extinction. The "Global 2,000" report estimates that one million tropical forest species could be extinct by the end of this century.

The impact of tropical forest destruction is long-lasting. Once species are driven to extinction they are gone forever. Moreover, if forest destruction is too severe it may take hundreds of years for the forests to regenerate. Caufield (1986) has pointed out that if an area of tropical forest is repeatedly cleared and burned for farming, or if the clearing is too expansive, primary forest species will not be able to recolonize the area. For example, large areas of forest around Anglar Wat in Cambodia, cleared 600 hundred years ago and left undisturbed ever since, are still distinguishable from the surrounding primary forest.

Taylor (1962) stated that "The forest is a legacy bequeathed by past generations to the present generation and to be handed over intact, if not improved, to the following generations." Jacobs (1988) remarked that botanical science has always played a role in

conservation, but until recently this role was small in the humid tropics. I hope that the information provided in this study will provide the botanical information needed to promote conservation of the Bobiri forest. It is the responsibility of biologists to provide the information needed to : 1) to maintain essential ecological processes and life-support systems, 2) to preserve genetic diversity, and 3) to ensure the sustainable utilization of species and ecosystems as is suggested in the World Conservation Strategy (IUCN, 1980).

CHAPTER 2

AFRICA

Africa is the second largest continent, comprising 20% of the earth's surface. The total area of Africa is 30,244,049 km^2, as compared to North America with 24,247,038 km^2, South America with 17,821,028 km^2, Europe with 10,354,636 km^2, Asia with 44,391,162 km2, Australasia with 8,547,000 km^2, and Antarctica with 13, 338,500 km^2 (Benneh, 1987).

Africa is largely tropical but extends into temperate zones to 37^o N and 35^o S latitudes (McNaughton & Georgiadis, 1986). African tropical forest is centered on the basin of the Congo River from where it extends westwards to the coast of West Africa (Hopkins, 1965). Forest covers at the most 9% of tropical Africa (Bourliere, 1973) (Fig. 1). Tropical Africa is reputed to contain some 1,500,000-1,675,000 km^2 of tropical forest (Myers, 1980). Of this amount 70,000-88,000 km^2 is in West Africa, 20,000-23,000 km^2 in East Africa, 15,000 km^2 in Madagascar, and 1,450,000-1,350,000 km^2 in Central Africa (of which approximately 900,000-1,000,000 km^2 is in Zaire alone).

African Vegetation Types

Aubreville (1949) divided the forests of Africa into four distinct vegetation units which are still recognized by most authors though sometimes under different names. These are the 1) Guinea Forest, 2) Nigeria Forest, 3) Cameroon-Gabon Forest, and 4) Congo Forest.

Until the 1950's, classifications of vegetation zones in Africa were made by botanists and geographers based only on the knowledge of one specific area or country (Martin, 1991). This resulted in a confusing multitude of terms for comparable types of vegetation as well as a number of identical terms for very different types. Matters were even further complicated by the fact that these terms existed in several different languages. To resolve this problem, the Scientific Council of Africa South of the Sahara, called for a meeting of specialists in plant geography in 1956, at Yangambi, Zaire, to agree on a uniform system of nomenclature (CCTA/CSA, 1956). The "Yangambi classification" led to the first acceptable vegetation map of Africa published in 1959 and edited by the Association pour l'Etude Taxonomique de la Flore d'Afrique Tropicale (AETFAT). The most recent

UNESCO/AETFAT/UNSO Vegetation Map of Africa (1 : 5 000 000) is based on the original AETFAT map and contains very detailed descriptions by White (1983). This map is based on the morphology of vegetation types, and on floristic composition rather than on climatic zones which some previous workers have used. The map's classification of rainforest includes both moist evergreen forests and semi-deciduous forests including dry semi-deciduous forests.

White (1976, 1979) defines a Guineo-Congolian phytogeographical region in Africa which is forested with adjacent Sudanian and Zambezian regions which consist of savanna. A phytogeographic region as defined by White (1979) is a geographical unit with more than 50% endemism and more than 1000 endemic species. Within the Guineo-Congolian Region, White (1979) recognizes three subcenters of endemism which are the Upper Guinea subcenter (corresponding to Aubreville's (1962) "Domaine Libero-Ivoreen"), the lower Guinea subcenter (corresponding to Aubreville's "Domaine Camerouno-Gabonais"), and a Congolian subcenter (corresponding to Aubreville's "Domaine Congolais"). Each of these subcenters possesses a considerable number of endemics, though the proportion is in each

case less than 50% of the total flora. The subcenters are separated by "intervals" with relatively few endemics. For example, the vegetation of the "Sangha River Interval", consisting of considerable swamp forest, separates the Lower Guinea and Congolian subcenters. Langdale-Brown et al. (1964) classified the moist forest of Uganda into moist evergreen forest, and moist semi-deciduous forest. They explained that there is no sharp distinction between evergreen and semi-deciduous forest. However, in this continuum there is an increasing duration and severity of the dry season, matched by a gradual increase in the number of species which shed all their leaves and an increase in duration of the period when they are leafless.

The largest proportion of dry forest ecosystems is in Africa and the world's tropical islands, where they account for 70-80% of the forested area (McNaughton & Georgiadis, 1986). In South America, they represent 22%, and in Central America almost 50% of the forest area. White (1983), however, mentioned that nearly all the forests in Africa are evergreen or semi-evergreen, though deciduous forests occur locally.

Endemism is high in some places in Africa. For example, of

more than 10,000 flowering plant species known in Madagascar, over 80% are endemic (Turner, 1977). The isolated remnants of montane tracts of forest in the northern part of Tanzania harbor many endemic species, together with a degree of sub-specific differentiation without parallel elsewhere in Africa (Turner,1977). The Gabon-Cameroon border and the Liberia-Ivory Coast border forests also have high endemism. The number of seed-plant families believed to be indigenous to Africa and satellite islands is 234; that for South America with satellite islands, including the Antilles, is 228 (Thorne, 1973). Of the 276 different families represented on the two continents and adjacent islands, 186 are found on both continents.

West African Geography

West Africa, with about 1.5 million square miles, is bounded by 15^{0} N latitude and the equator to the south (along the Gulf of Guinea). The entire area is therefore in the tropics. Figure 2 shows the 16 countries that make up West Africa. Arranged according to size, beginning with the largest country, these are: Mali, Niger, Nigeria, Cameroon, the Ivory Coast, Burkina Faso, Ghana, Guinea, Senegal, Benin,

Liberia, Sierra Leone, Togo, Guinea Bissau, and Gambia. ECOWAS is the Economic Community of West African States (except Cameroon), which began in May 1975 when a treaty was signed in Lagos by 15 states. The Cape Verde Islands joined in 1977. ECOWAS aims at forging cooperation and development in economic and cultural activities. The organization has eliminated trade barriers to a large extent among member states. There is the agreement that enables West Africans to travel to member states without obtaining visas, and road links have been constructed between neighboring states. The most highly populated area is in eastern Nigeria where the average population density is over 250 per square mile (Hopkins, 1965).

Most of West Africa lies between 183 and 336 meters altitude. The altitude gradually increases from the coast inland. The tallest mountain is Mt. Cameroon with a height of 4,070 m, and the longest river is the Niger with a length of 4,160 km, followed by the Black Volta of Ghana (2,080 km), and the Senegal River (1,624 km) (Benneh, 1987).

As in most of Africa, the surface rocks are mainly of the Precambrian Era (500-3000 million years old). Although the soil is

deep, nutrients are stored only in the thin topsoil layer. In some places, outcrops of granite protrude from beneath the surface creating peculiar rock formations at times reaching far above the surrounding forest canopy. In the wettest areas along the coast, weathering of the basement rock has produced ferralitic soils of a yellowish hue. They are quite acidic and leach out especially in areas of maximum precipitation. Few minerals remain consisting primarily of kaolinitic minerals with iron and aluminium oxides. The soil is extremely poor in nutrients. Rainforest soils of this kind, also known as oxisols, are particularly unsuitable for agriculture. Further inland where precipitation measures about 1500-1750 mm annually, ferralitic soils are of a reddish color and less acidic or even neutral. These are the forest ochrosols. They are richer in nutrients especially in less washed out places, in depressions and at the bottom of valleys. In transitional forest areas bordering on savanna regions, ochrosols are reddish brown in color.

Most soils in West Africa are latosols, reddish or yellowish-brown in color, with stable aggregates that ensure free drainage. The clay is mainly composed of kaolin with iron and

aluminum oxides. These are remarkably constant chemically, and as their clay fraction has a low exchange capacity, their cations are related to their acidity and amount of organic matter. Two major types of latosols (with intermediates) occur : oxysols which occur where high rainfall causes excessive leaching and the development of a generally deep, acid soil, and ochrosols which occur where the leaching is less intense. For the ochrosols, the upper soil is neutral or slightly acidic, and there is an increase in acidity down the profile. Ochrosols, therefore tend to hold more cations in their surface horizons and have a more stable microbiological population after burning than oxysols. The ochrosols thus tend to be more fertile (Lawson, 1966; FAO/UNEP, 1981; Hall & Swaine, 1981).

Mean daily temperatures range from 21^{o} C to 33^{o} C. Mean monthly maximum temperatures range from 33^{o} C near the south to about 44^{o} C in the north. However, mean monthly minimum temperatures decrease inland from about 21^{o} C to about 10^{o} C. Martin (1991) reports that West Africa's mean annual temperature is 26^{o}-27^{o} C whereas the monthly average ranges from 24^{o}-28^{o} C. The seasonal fluctuation of the mean temperature is therefore considerably less

than the day to day fluctuations. Martin (1991) remarks that in addition to closed forests in West Africa showing steady daily and annual temperatures, their temperature characteristics also show little difference when compared with rainforests at similar altitudes on other continents.

Africa's highest levels of rainfall have been recorded at the foot of Mount Cameroon in West Africa, where some places show impressive levels of 10,000 mm or more annual rainfall.

West African Forest Types

The French botanist Chevalier (1938) was the first to describe vegetation zones in West Africa. Figure 2 shows the different vegetation zones which botanists accept today, after years of modifications.

Forest occupies most of the southern coast of West Africa and stretches for about 200 miles inland (Lawson, 1966). The nine West African countries named by FAO/UNEP (1981) as possessing closed broad-leafed forests, in descending order of estimated 1985 forest

sizes, are : Nigeria, Ivory Coast, Guinea, Liberia, Ghana, Sierra Leone, Guinea Bissau, Togo, and Benin.

Gledhill (1972), in his account of West African trees, classified the forests as Swamp Forest, Evergreen Forest, Semi-deciduous Forest, Riverine Forest, and Secondary Forest. Steentoft (1988) also classified the forests as Swamp Forest, Lowland Forest (subdivided into High Forest and Secondary Forest), Riverine Forest (usually on well-drained riverbanks), Forest of Inselbergs (where surrounding forest may continue up the flanks of large areas of exposed rock), Forest-Savanna mosaic (mixture of forest or woodland with secondary grassland), Forest Outliers (strips of lowland forest confined to river valleys), and Fringing Forest (confined to stream valleys, also known as Gallery forest).

The Lowland Forest occurs as an uninterrupted belt of vegetation that is nearly parallel to the coastline. The eastern section of the Lowland forest merges into the dense, rich, Congo forest of the basin of the Congo River, and therefore has many species in common, although it is less rich in species, with the Congo forest. The western section of the Lowland forest covers western Ghana where it begins,

and stretches westwards to the eastern border of Sierra Leone.

West African Forest Composition and Structure

The West African forest is one of the great tropical forests of the world. However, very little of it has remained free from disturbance by man. The distribution of closed broad-leafed forest in West Africa was estimated by FAO/UNEP (1981) to be 179,270 km^2, which was estimated to have been reduced to 143,260 km^2 by 1985.

Edaphic conditions are far from uniform throughout the area. The vegetation is therefore a complex mosaic, partly determined by recovery after disturbance by man and partly determined by soil conditions such as aeration and nutrient supply.

Throughout West Africa, there are usually distinctive wet (rainy) and dry (harmattan) seasons. The forest zone receives at least 1,200 mm of rainfall a year. Martin (1991) reports that most African rainforests receive an annual precipitation of between 1600 and 2000 mm. Areas that receive less than 1600 mm annual rainfall are typical for transition to guinea savanna vegetation. The rainfall, however, is highly seasonal in distribution so that near the coast the growing

season lasts at least nine months (with two rainfall peaks), while further inland it may approach only seven months. In areas where there is a single-peak rainy season but very high rainfall (e.g., western Liberia), the forests may have long growing seasons similar to those in two-peak rainfall areas.

Rainfall variation is often reflected in the terminologies employed by natives of West Africa to recognize the appearance of certain crops or animals (e.g., yam season, plantain season, corn season, kapok season, snail season, fish season, etc.).

Most of the high forest of West Africa is best considered secondary forest. Some of it is of sufficient age to be similar to primary forest but there is little pristine forest left anywhere in West Africa. Most of the large trees have been logged. Martin (1991) reports that out of the nine West African countries having rainforest, only four now produce significant quantities of timber; in order of increasing importance for export, these are : Nigeria, Liberia, Ghana, and the Ivory Coast.

The very tallest trees are termed emergents- -- these do not form a continuous layer or story (Steentoft, 1988). Leaf shedding is

most obvious among emergent and upper story species. The emergent trees are at least 35 m high; under these are upper canopy trees of 20-25 m and the understory trees of 5-20 m. The shrub layer occupies a zone from 2-5 m high, beneath which there is a herb layer of about 2 m high (Steentoft, 1988; Hall & Swaine, 1981; Lawson, 1966). The shrub layer has numerous species of Rubiaceae, and the herb layer has several species of grasses, especially *Olyra latifolia* (Plate 8A) and *Leptaspis cochleata.*

Lind and Morrison (1974) state that in general appearance and structure, the forests of East Africa are similar to some of the forests of Zaire and of West Africa. Many of the genera found in the forests of East Africa also occur in West Africa, although the East African forests lack many genera that are widely distributed in Zaire and West Africa. Richards (1952) added that many genera widely distributed in Zaire are not found in West Africa.

Certain parts of the forests of Cameroon, particularly those bordering Gabon, have some of the richest floras found in Africa (Richards, 1963; Letottzey, 1976). This area has been postulated as a center of diversity and part of a presumed Pleistocene refuge

(Hamilton, 1976). The forest at the border has an exceptional number of endemic plant species and a major concentration of endemic mammal species, particularly primates (Richards, 1973; Kingdon, 1971). The border between Liberia and the Ivory Coast, coinciding with the Upper Guinea Pleistocene Refuge, is a forest area that is also exceptionally rich in endemic species of both plants and animals, notably mammals (Kingdon, 1971). In the Tai forest area of western Ivory Coast, for example, Guillaumet (1967) reports that 54% of the 1300 plant species identified are endemic. Martin (1991) reports that most of the approximate 8000 plant species which occur in West and Central African rainforests show traits of endemism. Martin (1991) further emphasizes that for conservation purposes, these centers of endemism are of very special importance.

Hall and Swaine (1981) report that eight species of forest trees are thought to be endemic to Ghana. In all, 18 forest species are endemic to Ghana (including shrubs and herbs); of these, seven are known from Wet Evergreen Forest (the forest type richest in species in Ghana) where Ghana's only endemic tree genus, *Monocylanthus* (Annonaceae) occurs (Hall & Swaine, 1981).

The Dahomey Gap

The Dahomey Gap or Dahomey Interval, is a corridor of grassland that separates the Upper Guinea and Lower Guinea regional subcenters. It is therefore one of the separating "intervals" for the regional subcenters, and possesses few endemics itself. Martin (1991) describes it as a dry region, with less than 1200 mm of annual rainfall, situated between the two wettest areas (east and west of the Gap) along the West African coast. The climate conforms to that of similar grassland communities in West Africa. The city of Takoradi in Ghana (with 1194 mm of annual rainfall), marks the beginning of the Dahomey gap on the coastline of West Africa. The gap reaches the coast in Dahomey (now Benin, Fig. 2) from the northern savannas of West Africa, and stretches for 300 km from Cotonou in Benin to Accra in Ghana.

Jacobs (1988) describes the Gap as a zone of a drastically changed vegetation of apparently recent origin, though recent surveys have demonstrated that the number of species restricted to the area west of the gap is greater than was supposed. Hall and Swaine (1981) are therefore of the opinion that the gap is older than most previous authors have indicated. Richards (1973) pointed out that the Dahomey

Gap is an important boundary for plants as well as animals and that a good many species are known which do not cross it. However as knowledge of the African flora increases, a considerable number of species previously thought to occur only west or east of the gap have proved to have a wider distribution. A large proportion of African trees, lianas, and small forest plants extend all the way from Guinea and Sierra Leone through Nigeria and the Cameroons to the Congo, and some even further. Nevertheless, Lawson (1966) emphasizes that the Dahomey Gap is important in determining the distributional patterns of plant and animal life in West Africa because it forms a distinct barrier to the passage of forest species from west to east and vice versa

CHAPTER 3

GHANA

Geography And Economy

Ghana (called the Gold Coast before its independence in 1957), has an area of 238,538 km2 and a population of about 15 million. The country lies between longitudes 3° 07'W and 1° 14' E and latitudes 4° 45' and 11° 11'N (FAO & UNEP, 1981). The country is situated immediately above the equator and spans 675 km from south to north and 540 km from east to west (Fig. 2). The coastline, which forms the southern border, stretches for 565 km.

The countries adjacent to Ghana are Togo on the east, the Ivory Coast on the west, and Burkino Faso (formerly Upper Volta) in the north (Figs. 2 & 5). Although Ghana has considerable areas of flatlands, especially in the north, the topography of the country is generally undulating. The Mampong, Akwapim, Gambaga, Ejura, and Kwahu scarps are the most prominent elevations, although they seldom exceed 600 meters. The highest elevation is Mount Afadzato at 880 meters. This mountain is located in the Volta Region and is part of a series of hills which run in a northeast-southwest direction, and

continue northeastward into Togo.

The largest and most important river is the Volta, which enters the sea at Ada; other rivers such as the Tano, Pra, and Ankobra run southerly to the sea and are navigable for about 80 km. In the heart of the Ashanti Region lies Ghana's only natural lake, the Bosumtwi, which is fed by surrounding streams. With the exception of this lake, all of Ghana's major rivers empty into the Atlantic Ocean. The Densu river supplies Accra (the capital) with its drinking water. The drainage of the Volta is dominated by the tributaries of the main river, which include one of the world's largest artificial lakes (Volta Lake) of over 770,000 ha (about 8,482 km2) and a length of 480 km. This lake contains 147,600 million cubic meters of water (Benneh, 1987; FAO & UNEP, 1981; Remy, 1977). The Volta Lake, which is navigable throughout its length, was created by the Akosombo Hydro-electric Dam, one of the largest in Africa, which now supplies power to neighboring Togo, Benin, and Burkino Faso. As in other parts of West Africa, the soils of Ghana are variable (FAO & UNEP, 1981). They are generally moderately fertile and consequently capable of supporting good growth, unless the vegetation is removed and the land remains

bare for some years. Remy (1977) calculates that two-thirds of the land of Ghana is fertile and suitable for growing crops. In the north, where there is only one rainy season, cereals, which require only two or three months to ripen, are most commonly cultivated along with yams.

There are two rainy seasons in the southern part of the country, April-July and September-November. The southwest has the highest amounts of rainfall, ranging from 1,250 to 2,150 mm per year. The southeast also has two rainy seasons but a considerably lower annual rainfall of 750 mm. In the northern areas of the country, rainfall ranges between 1,100 and 1,250 mm, and occurs in a single season from April to September, followed by a long dry season. The highest annual rainfall recorded in Ghana is 2032 mm (about 550 mm monthly) in Axim in the extreme southwest close to the border with the Ivory Coast. The rainfall of Kumasi (second largest city), in the vicinity of the Bobiri forest reserve where the present study was conducted, is 58 inches annually (about 240 mm monthly).

The peak of the monsoon warm moist winds across the country is mainly from May to August in the northern two-thirds of the

country, while in the southern one-third of the country they blow all year (Benneh, 1987).

The mean annual temperatures in Ghana average between 26 and 29^{o} C.

The climate of Ghana is greatly influenced by the "Harmattan" season. This is a period when the Inter-tropical Convergence Zone (a front which controls the prevailing wind masses that blow across West Africa and cause them to be diverted in a northeastern or southwesterly direction) moves southward, and as a result very dry northeast trade winds blow south from the Sahara desert between December and February. This causes extreme dryness and a significant drop in humidity which has a major impact on crops and the vegetation. Martin (1991) reports that the harmattan causes the relative humidity within the forest to drop from its normal level of 90% to about 70%. At the northern edge of the rainforest, humidity can even sink to desert-like levels. The wind carries desert sand with it that often creates a foggy atmosphere even in bright daylight.

The drop in humidity results in massive leaf-fall, dehydration of plants, drying up of water resources, and discomfort to man and

animals.

The 1975-80 statistics for Ghana showed an annual population growth of 2.96% (FAO & UNEP, 1981). At present only Accra (the capital) has a population over 500,000. Three other cities which are among the 10 regional capitals, have populations of 100,000-500,000 (Benneh, 1987). The FAO Production Yearbook of 1978 (vol. 32) indicates that about one half of the economically active population works in the agricultural sector, living in rural settlements with less than 5,000 inhabitants.

The cultivation of cocoa (*Theobroma cacao* L.), which is the chief agricultural export and most important cash crop of Ghana, is restricted to the moist forest zones of the country. Cocoa grows well in fairly rich, well-drained soils, where rainfall is more than 1,250 mm per year. However, the rain must be well distributed throughout the year (Benneh, 1987). If the dry season is too long, the cocoa pods will not develop and, if the wet season is too long, harmful diseases (such as fungal infection by *Phytophtora palmivora*) spreads rapidly through the crop.

Before the introduction of some Brazilian cocoa plants (from

the island of Fernando Po) into Ghana in 1879 by a Ghanaian named Tetteh Quarshie, the Oil Palm represented the major export.

The first cocoa plants were successfully cultivated on the Akwapim Ridges (Plate 2A). The colonial government quickly realized the value of the crop, and set up a nursery at the Botanical Garden at Aburi on the Akwapim Ridges (about 10 km from Accra) in 1890 to supply low-cost seedlings to growers. The government's promotion of cocoa as a cash crop accelerated the replacement of forest zone by cocoa plantations. Cocoa soon became the major source of revenue --- accounting for two-thirds of total exports.

Other commercial crops of Ghana are: oil palm (*Elaeis guineensis* Jacq.), Shea butter (from the nut of the shea tree, *Butyrospermum paradoxum* (Gaertn. f.) Hepper ssp. *parkii* (G. Don) Hepper), copra (*Cocos nucifera* L.), citrus (*Citrus* spp.), cola (*Cola nitida* (Vent.) Schott & Endl.), coffee (*Coffea arabica* L.), and staple foods such as maize (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), plantain (*Musa sapientum* L. ssp. *paradisiaca* L.), cocoyam (*Xanthosoma caracu* K. Koch & Bouche, and *X. sagittifolium* (L) Schott), banana (*Musa sapientum* L.), rice (*Oryza sativa* L.), millet and guinea corn (*Sorghum*

spp), and yams (*Dioscorea* spp.). Vegetables such as onions (*Allium cepa* L.), pepper (*Capsicum annuum* L.), tomatoes, (*Lycopersicon esculentum* Mill.) , and eggplant (*Solanum melongena* L. and *S. incarnum* L.) are widely grown but are especially important in the wet forest region and in fertile soils around Lake Volta (Benneh, 1987). Cotton (*Gossypium* spp.) is also cultivated to supplement imported supplies.

The cultivation of staple foods is carried out largely by individual farmers, usually at subsistence level, but in recent years the government and some commercial farmers have embarked upon large scale production of several of these crops and other introduced crops such as pineapple (*Ananas comosus* Merr.) and sugar cane (*Saccharum officinale* L.).

Some of these introduced crops do so well that Ghana and other West African countries have become major producers of them. For example, Ghana and the Ivory Coast (west of Ghana) are among the four leading cocoa producing countries in the world. In contrast to an earlier introduction of cocoa to Ghana, cocoa was not brought to the Ivory Coast until 1912 (Martin, 1991). Nigeria is the world's leading producer of yam, whose origin is the Far East (Martin, 1984), followed

by the Ivory Coast, Indonesia, Ghana, and Togo.

Similarly some native West African crops have naturalized in other parts of the world. Among the cucurbitaceous fruits and vegetables grown in Ghana, the fluted cucumber (*Telfaria occidentalis* Hook.) and the watermelon *(Citrullus lanatus* (Thumb.) Manst.) have West Africa as their origin (Martin, 1984). The oil palm (*Elaeis guineensis*) is endemic to West and Central Africa (Martin, 1984).

The forests of Ghana contain timber of high market value and timber (mainly hardwoods) is next to cocoa in exports. The export of timber began in 1891 (Remy, 1977). Over the years, 300 species of trees have been utilized in the timber trade, but up to World War II, mahogany (*Khaya* spp.) was almost the only wood exported. At the time of Ghana's independence, lumber sales amounted to between seven and eight million pounds sterling per year (Remy, 1977). In addition to valuable wood from the trees of Ghana and neighboring countries, tremendous use was made of exudates as well. For example, from 1870, gum copal from trees of the genus *Daniella*, found in closed rainforests, was exported for the manufacture of varnish. The European demand for rubber tapped from *Funtumia* trees also rose steadily after

1883 (Martin, 1991). Today, however, artificial resin has replaced gum copal in the production of varnish, and the rubber grown in West Africa today is actually caoutchouc from Brazilian *Hevea* rubber trees grown on large plantations, causing the same deforestation problems as cocoa and oil palm cultivation (Martin, 1991).There are virtually no farms in any region of Ghana where sheep and goats are not raised. The non-Moslem farmers also raise pigs. Cattle are mainly raised on the coastal plains and in the northern savannas. Nevertheless, Ghana has a meat shortage and is obliged to import up to 60% its consumption (Remy, 1977).

Gold, diamond, bauxite, manganese and iron are the mineral exports of Ghana. The original name of the country, Gold Coast, given by Portuguese, English, French, Danish, and Dutch explorers, was coined because of the abundance of gold found in the southern sector of the country. Martin (1991) reports that gold, ivory, and cola nuts were shipped from the coast of western Ghana in 1700, and that British, Dutch, and Danish trading posts vied for the best ports. Because the rainforests in Latin America and Southeast Asia were further away from Europe, West Africa's proximity to Europe has influenced its trade

relations for centuries and left its mark on the rainforest (Martin, 1991). It was not until around 1877 that a Frenchman, Pierre Bonnat, discovered a gold mine in Tarkwa that had been worked by Africans for 50 years. By 1882, six European mining companies were busy mining gold in the region, and by 1914, the sole mining product was gold, until diamonds were discovered in 1919, followed by other minerals. The gold mines of Ghana are still reputed to be second in richness only to those of South Africa.

The Vegetation and Forests of Ghana

The natural vegetation of Ghana is tropical high forest in the southwest, savanna woodland in the drier climate to the north of the forest zone, and savanna grasslands in the northern third and eastern parts of the country (Figs. 2-3, 5).

Remy (1977) points out that the forest of Ghana coincides with the Precambrian plateau of the country.

The savanna grasslands are divided into the Guinea savanna, which is immediately above the savanna woodland, and the Sudan savanna. The latter is much drier and ranges northward into Burkino

Faso. Even further to the north, the near-desert, often drought-stricken Sahel zone is found. Near the coast of Ghana, there are areas of scrub and grassland (Plate 1) as well as mangrove vegetation around the estuaries.

Because my study is of the Bobiri forest, the remaining discussion treats only the vegetation of the forest zone of Ghana. Taylor (1952) classified the forests of Ghana into: 1) Rainforest, 2) Cynometra-Lophira-Tarrietia association, 3) Moist semi-deciduous forest, 4) Lophira-Triplochiton Association, 5) Celtis-Triplochiton association, and 6) Antiaris-Chlorophora association. Mooney (1959) followed with his classification of Ghanaian forests into: 1) Rainforest, 2) Moist semi-deciduous forest, 3) Celtis-Triplochiton association (i. Wet Facies, ii. Dry Facies, iii. Bia association), and 4) Antiaris-Chlorophora association. The Mooney classification does not differ markedly from that of Taylor.

These classifications are more or less arbitrary, based mainly on an estimation of the dominant trees as determined by casual observation. Therefore, these schemes have been much criticized. For example, Hall and Swaine (1981) emphasize that in the mixed tropical

forest of Ghana, the canopy is usually formed by a fluctuating mixture of species --- none of which is dominant! The latest and most accepted classification of Ghanaian forests, based on quantitative data (using a computer data analysis technique called "ordination") by Hall and Swaine (1981), after observing 1,248 vascular plants, groups the forests of Ghana into the following seven types (with subtypes in some instances; see Fig. 3): 1) Wet Evergreen Forest, 2) Moist Evergreen forest, 3) Upland Evergreen Forest, 4) Moist Semi-Deciduous Forest, 5) Dry Semi-Deciduous Forest, 6) Southern Marginal Forest, and 7) South-East Outlier Forest. Types 1-5 are all well known in West African countries outside Ghana but types six and seven are not yet recognized outside the country (Hall and Swaine, 1981). Martin (1991) thinks that the best analysis of West African rainforest types so far is that conducted by Hall and Swaine (1981).

The closed high forest (which can be broadly divided into rainforest and moist semi-deciduous forest) lies within the "two-peak" rainfall belt (May-June and September -October). Many authors suggest that these closed, broad-leaved forests are stratified (Steentoft, 1988; FAO & UNEP, 1981; Taylor,1960; Hall & Swaine, 1981). The

following three strata are usually recognized: 1) closed lower canopy made up of trees with well developed crowns and low branches (up to 18 m high), 2) closed upper canopy (about 40 m high) of trees with tall, straight boles, most of which have small crowns, and 3) emergents which are very tall trees up to 60 m or more in height, and which do not form a closed canopy. Lianas are common in such forests, some of which grow up into the crowns of the topmost canopies (Plates 4-6).

Rainforest is situated in the most southwestern part of Ghana where rainfall is highest (between 1,800 and 3,000 mm annually) and relative humidity is very high and close to the saturation point. The harmattan has no real effect here, and there is no month without significant rain. This rainforest is characterized by trees such as *Cynometra ananta* Hutch. & Dalz., *Lophira procera* Banks ex Gaertn., and *Heritiera utilis* (Sprague) Sprague , all of which are evergreen. Common in the lower canopy are trees such as *Diospyros* spp., *Cola chlamydantha* K. Schum., *Pentadesma butyraceae* Sabine, *Protomegabaria stapfiana* (Pax) Hutch., and *Strombosia pustulata* Oliv. *Celtis* spp. and *Triplochiton scleroxylon* K. Schum., common in other Ghanaian forests, are absent from the rainforest. Typical shrubs are

Randia hispida K. Schum., and *Bertiera racemosa* (G. Don) K. Schum. (FAO & UNEP, 1981).

The moist, semi-deciduous forest generally covers regions with elevations higher than 150 m above sea level. The Ejura, Mampong, and Kwahu scarps, and the hills of Western Ashanti are prominent topographic features within this forest region. The annual rainfall varies between 1,250 and 1,750 mm, although the upper limit may be exceeded at some of the higher altitudes.

Many of the species in the upper and emergent canopies are deciduous for variable periods between October and April. The characteristic species of the lower canopy are evergreen. There is considerable humidity under this canopy, although drier conditions prevail along the northern limits of this forest type during the short harmattan season.

Moist, semi-deciduous forest contains more useful timber species than rainforest. Some of the characteristic species are *Triplochiton scleroxylon* K. Schum., *Celtis* spp., *Cynometra ananta* Hutch. & Dalz., *Lophira procera* Banks ex Gaertn., *Entandrophragma* spp., *Khaya ivorensis* A. Chev., *Guarea cedrata* (A. Chev.) J. Pellegr., *Lovoa*

klaineana Harms, *Piptadeniastrum africanum* (Hook. f.) Brenan, *Daniellia similis* Craib ex Holl., *Distemonanthus benthamianus* Baill., *Parkia bicolor* A. Chev., *Cylicodiscus gabunensis* Harms, *Cola cordifolia* (Cav.) R. Br., *Pterygota macrocarpa* K. Schum, *Antiaris toxicaria* var *africana* (Engl.) C. C. Berg., *Chlorophora excelsa* (Welw.) Benth., *Morus mesozygia* Stapf, *Nesogordonia papaverifera* (A. Chev.) R. Capuron, *Mansonia altissima* (A. Chev.) A. Chev., *Aningeria spp., Chrysophyllum spp., and Sterculia spp.*

Understory trees characteristic of this forest are : *Diospyros* spp., *Cola chlamydantha* K. Schum, *Pentadesma butyraceae* Sabine, *Protomegabaria stapfiana* (Beille) Hutch. , *Strombosia pustulata* Oliv., *Corynanthe pachyceras* K. Schum., *Lecaniodiscus cupanioides* Planch. ex Benth., *Monodora myristica* (Gaertn.) Dunal, *Chidlowia sanguinea* Hoyle, *Talbotiella gentii* Hutch. & Greenway, and *Myrianthus* spp.

Large areas of the moist semi-deciduous forests have been farmed for cocoa and food crops (Plate 2B).

Riverine forest is found in the southern part of Ghana. The upper canopy of riverine forest includes *Afzelia africana* Sm., *Albizia gummifera* (J. F. Gmel.) C. A. Sm., *Antiaris toxicaria* Engl., *Bombax*

buonopozense P. Beauv., *Ceiba pentandra* (Linn.) Gaertn. *Terminalia superba* Engl. & Diels, *Erythrophleum guineense* (Guill. & Perr.) Brenan, *Cola cordifolia* (Cav.) R. Br., *Chlorophora excelsa* (Welw.) Benth., and *Triplochiton scleroxylon* K. Schum.

The lower canopy is characterized by : *Trichilia prieuriana* A. Juss., *Napoleonaea parviflora* Hook. & Planch., *Teclea grandifolia* Excel & Mendonca, *Monodora myristica* (Gaertn.) Dunal, *Caloncoba dusenii* Gilg., and *Celtis scotellioides* A. Chev.

There are more than 2,000 species of vascular plants in the Ghanaian forest, with about 700 of them trees (Hall & Swaine, 1981). Lawson (1966) reports 600 or more species of trees in the neighboring Ivory Coast.

Conservation in Ghana

Myers (1980) reported that the remaining moist forests of Ghana are almost entirely confined to forest reserves which, according to the Conservator of Forests in Accra, totaled 19,864 $km2^2$ in 1980. The FAO/UNEP (1981) figure for the total area of reserved forest in

Ghana was 16,788km^2, representing 20.5% of total closed forest area. Whitmore (1990) similarly reported that the only remaining tropical forests in Ghana survive as forest reserves created by the former colonial government, and "set today in a sea of agricultural settlement."

An FAO and UNEP report in 1980 stated that deforestation had decreased from 45,000 ha/year before 1976 (Forestry Dept. of Ghana, 1976) to an estimated 22,000 ha/ from 1981-85. However, this decrease was caused, to a large extent, by the reduction of forest available for deforestation. The amount of forest outside of reserves is today only a minute fraction of the total arable land area.

The main factor for the disappearance of Ghana's moist forests during the past several decades has been shifting cultivation. The total "forest area" occupied by shifting cultivation at the end of 1980 was estimated at 9,180,000 ha, about 6,500,000 in the high forest zone and the remaining 2,680,000 ha in derived woodland and savanna (Forestry Dept. of Ghana, 1978).

The FAO (1980) report states that no virgin forest remained at the time of their study. Even forest reserves have been modified

through the extraction of timber and slash and burn farming (Plate 3A). However, D. K. Abbiw and A. A. Enti, Ghanaian specialists on the forests and plants of the country, suggest that relatively undisturbed forests may be found in the western part of the country. During my study of the Bobiri forest, I did not encounter forest that had not been disturbed in one way or the other by man (Plates 9-13).

Hall and Swaine (1981) enumerated the primary causes of deforestation in Ghana as: 1) land clearing for farming (cocoa and domestic food products), 2) commercial timber cutting, and 3) firewood gathering. Other causes of forest perturbation are hunting, removal of trees for local construction, homesteading within the reserves, forest fires, erosion (accelerated by the activities of man such as mining), grazing of domestic animals within the reserves, and destructive extraction of forest products such as palm wine. The use of fire and axe for honey-gathering also contributes to forest destruction.

Hall and Swaine (1981) reported that Ghanaian forests with economically important timbers, such as the Bia-Tano Reserve have scarcely any canopy left. In doing their ecological studies, Hall and

Swaine often encountered difficulty in establishing plots in undisturbed forest. In my study of the Bobiri forest, a selective and flexible sampling method had to be utilized in order to avoid areas excessively disturbed by man. In those Ghanaian forests where the canopy has been severely disrupted by timber extraction, lianas are extremely abundant, presumably because of the greater availability of light. In the Bobiri forest, lianas often form a nearly impenetrable stratum that is difficult to pass when climbing trees (Plates 4-6).

A major problem in the conservation of Ghana's forest is that many of the reserves are inhabited by people who carry out farming and timber extraction with little constraint (Plates 12 & 13). Residents within the reserves often maintain the right to cultivate permanent crops such as cocoa and coffee. As a result some of "reserves" bear closer resemblance to farms than forest!

Another problem in forest conservation in Ghana is periodic forest fire, especially during unusually long and severe harmattan seasons. These fires could be accidental, or emanate from slash burning, a farming practice which is very common in Ghana (Plate 3A). The warm, dry winds of the harmattan dry out grasslands and forests

and make them especially prone to fire. A Forestry Department report of 1988 stated that the climate of Ghana had become progressively drier. From 1969 to 1983, rainfall decreased in quantity, started late, stopped earlier than usual, and was more unpredictable (Forestry Dept. Report, 1988). As a result, some of the worst droughts in history occurred. In 1983, I witnessed a drought which resulted in unprecedented fires. During that year, the harmattan was unusually long and its dry winds caused such severe desiccation that the smallest fire often sparked an unparalleled conflagration that quickly spread for miles. No vegetation throughout the nation escaped fire. Entire villages, crops, livestock, homes, and forests were burned. Rivers and wells dried up (Plate 15), slopes became denuded of soil, agricultural lands lost their fertility, and the climate became increasingly inhospitable.

During this period, the country's vegetation suffered severe damage. In several areas of the savanna zone, but especially in the northeast, desertification progressed. Many areas of forest were invaded by grasses and less drought resistent species were damaged or eliminated. Fire may be the reason that so few mosses and ferns are

found in the understory of the Bobiri forest.

CHAPTER 4

THE BOBIRI FOREST RESERVE

The Bobiri Forest (6^{o} 38'N, 1^{o} 17'W) is 54.6 km^2 in area (21.1 square miles). It is located in the Ashanti Region of Ghana (Fig. 5), about 25 km east of Kumasi. Following Hall and Swaine (1981), the forest type is Moist Semi-Deciduous South-East subtype which was previously called the Celtis-Triplochiton Association of the moist semi-deciduous forest by Taylor (1960).

The annual rainfall in the area is moderate (1,200-1800 mm/year) with an average of 1,500 mm/year.

The soils have high base saturation with a pH of 5-6. Information from A. A. Enti indicates that the topsoil has a deep layer of humus up to about 20 cm deep. The hill tops of the forest have well-drained, yellow-brown, loamy soil, and the hillsides or slopes are composed of laterite that is somewhat leached. The valley bottoms have deep, alluvial soils that become sandy loam near streams.

The forest type at Bobiri is the most extensive of the forest types in Ghana, and also occurs widely in West Africa (Hall & Swaine, 1981). Trees in this forest are taller than in any other forest type in

Ghana, reaching heights often exceeding 50-60 m. The upper canopy consists of a mixture of deciduous and evergreen species in varying populations (Plate 18), but overall, the two kinds of trees occur in about equal proportions, hence the term "semi-deciduous." The understory trees are sometimes abundant, e.g., the population density of *Cleidion gabonicum* Baill. in the Bobiri forest reaches 280 trees (> 10 cm GBH)/hectare. In contrast, the upper canopy is generally composed of a few species from a possible list of about 60 (Hall & Swaine, 1981). There is little light penetration to the forest floor in the dense areas of the forest due to the close canopy of tall trees and presence of many vines whose leaves reach the canopy (Plate 5). Growth of herbs is consequently very limited in the older parts of the forest. The main grass that has been able to adapt to the low light intensity is *Olyra latifolia* (Plate 8A). Where sigificant disturbance has occurred within the forest, a few herbs like *Costus* spp., and species of the family Marantaceae spring up in abundance (Plate 8B & C).

Barbour et al. (1987) stated that the upper canopy trees of tropical semi-deciduous forest are mostly drought-deciduous.

Moreover, many of the understory trees are evergreen and sclerophyllous, and most of the leaves are without pronounced drip tips.

The characteristic species are *Khaya ivorensis* A. Chev., *Terminalia ivorensis* A. Chev., *Daniella ogea* (Harms) Rolfe ex Holl., *Turraeanthus africanus* (Welw. ex C. DC.), *Chytranthus macrobotrys* (Gilg) Exell & Mendonca, *Illigera pentaphylla* Welw., *Pteris togoensis* Hieron., and *Cola nitida* (Vent.) Schott & Endl.

Density values provided by the Forestry Department suggest that *Khaya ivorensis* and *Terminalia ivorensis* achieve their greatest density in forest reserves within this forest subtype.

The semi-deciduous forest type found at Bobiri is known to be the best suited for growing cocoa (*Theobroma cacao*). The edible cola (*Cola nitida*) is native to the Bobiri Reserve.

The Bobiri Reserve was first established in 1939. Foggie (1947) reported that it had been the site of many silvicultural and ecological observations.

In 1988 and 1989, I carried out field work in the Bobiri. The objectives of my study were to: 1) describe the composition and

structure of the forest based on a selective and flexible sample of 1000 trees, 2) describe the leaves of the forest by using reconstructed digitized leaf images, and 3) determine the utility of bole, bark, and leaf features in the identification of the trees of the forest. My long-term goal is to use this methodology to describe the floristic composition and structure of other Ghanaian forests. My overall hypothesis is that African forests can be described by utilizing species composition and structural features such as tree height and diameter, bole and bark appearance, and leaf structure, form, and size.

An important product of this study is the detailed description of the 104 species of tree found in my 1000-tree sample. These descriptions will facilitate species identification based on sterile material. Correct identification of plants is the first step in the wise utilization and conservation of plants. It is particularly important that vegetative features of trees can be used in identification because the flowers and fruits traditionally used by botanists for identification are often not present.

The results of this study will: 1) add to the taxonomic knowledge of a subset of the trees of West Africa, and 2) provide an

ecological description of a moist forest in central Ghana. Special emphasis has been placed on leaf shape and size. This is the first time computerized leaf images have been used to describe the trees of an African forest. Using this methodology, an advanced Raunkiaer (1934) type of classification of vegetation types based on leaves is possible.

Lawson (1986) remarked that at a time when West African plant life is undergoing rapid and destructive changes, it is of great importance to record as much information on the vegetation as possible, particularly that of the forests. It is especially critical that Africans themselves learn to study the vegetation that surrounds them. In the past, most of the studies of the systematics and ecology of African plants have been carried out by foreign botanists. It is only through the training of African botanists and, subsequently, the stimulation of local interest in plants that there is any hope for the conservation of African ecosystems.

I chose the Bobiri forest for my study for several reasons. In the first place, considerable information is available so that my study would have at least the basic taxonomic information needed for tree identification. I was already familiar with the vegetation of the Bobiri

forest because of my undergraduate training in ecology at the nearby University of Kumasi and therefore already had a notion of the species found in this forest.

For the most part, the basis for research at Bobiri had already been established through studies of the Botany Department of Oxford University in England. There have been extensive collections and ample material is available for study and comparison in local and foreign herbaria. In addition, silvicultural as well as some ecological data were available from the Forestry Department of Ghana. Finally, and most importantly, Mr. A. A. Enti, an authority on the Bobiri forest was available to aid in field identification of difficult taxa.

Although the Bobiri forest is not pristine, the forest possesses some patches that have not had major disturbance for at least 50 years. These areas have been set aside for research.

CHAPTER 5

MATERIALS AND METHODS

A goal of my study of the Bobiri forest was to characterize the forest based on the closest approximation possible of the orginal vegetation. Because of the high degree of disturbance in the Bobiri forest (Plates 9-13), it was not possible to locate transects in an entirely random method. Random plot selection would have resulted in the sampling of an excessive amount of secondary growth. Therefore, a haphazardly placed line transect employing the point-centered quarter method of Cottam and Curtis (1956) was employed.

All ecological studies have some initial bias in that the vegetation to be sampled is subjectively selected in the first place. For example, it would be a waste of time to randomly sample the entire earth, including the oceans, if rainforest were the object of the study. The area to be sampled is first stratified based on a subjective definition of rainforest. This problem has been pointed out by Tracey (1985) who admited that the sampling methods she used to gather data for her floristic studies of Australian rain forest were based on subjective site selection.

To select the study site, I interviewed forest rangers to determine an area within the Bobiri Reserve which had not experienced major disturbance by man. This was necessary in order to gather information from forest with a floristic composition as close as possible to the original moist, semi-deciduous forest native to the area. An area that had not been logged since 1937 was selected.

Once the area to be sampled was determined, a map of the trail system of the reserve was employed to determine where to start the transect. The azimuth of the transect was selected before entering the area, and the actual starting point of the transect was predetermined by taking a randomly selected number of steps from a trail juncture.

Because I was trying to sample non-flooded forest, only points growing on well-drained soils were sampled. In addition, any sample points falling in an area of major disturbance (defined as large tree falls including more than two sample points) were excluded. Consequently, when flooded forest or large-scale disturbances entered the sample, the point was excluded by taking a right angle turn to the azimuth of the transect. Several large trees did not grow in flooded

areas of the forests in Ghana, and flooding also encouraged the growth of some grasses, herbs, and palms at the expense of the growth of other trees.

The right angle turns during sampling, were alternated, first right and then left. As a result, the transect zigzags throughout the least disturbed, non-flooded forest of this area (Fig. 6). No logging sites, farms, or extensive secondary vegetation were met during the process. However, like in most African forests, parts of this area have been disturbed in the past by hunters and local farmers, and may have experienced some burning during the exceptionally dry year of 1983 when fires entered the Bobiri forest.

A total of 1000 trees were sampled. Four trees, >10 cm DBH, were selected at each point, using the point-center quarter method as described by Mori and Boom (1987). Each point was placed 20 meters from the previous point. The sample, therefore, included four tagged trees at each of 250 points and covered five kilometers. Because the nearest tree in each of the four quarters at a point is sampled, there is no bias in the actual selection of the trees.

One must be cautious when comparing diversity values

obtained with this transect method with those obtained with quadrat methods. Mori and Boom (1987) have pointed out that the greatest diversity, if similar forests and tree numbers are sampled, will be obtained from the point-centered quarter method, less diversity from linear quadrats, and still less diversity from square quadrats. The reason for the greater diversity in the point-centered quarter method is because the transect samples greater topographic variation as well a greater number of aggregated species.

Using special tree climbing spikes with safety belt and a clipper pole (Plate 16), access was gained to the leaves of the tall trees of the Bobiri forest. Voucher specimens were prepared and taken to the University of Ghana for comparison in the herbarium after preliminary identification by the Bobiri forest ranger, Francis Banin. The determinations were also reviewed by A. A. Enti of the University of Ghana. Mr. D. K. Abbiw, taxonomist and head curator of the Ghana Herbarium in Legon University, helped with identification and current changes in nomenclature. The few, more difficult species, were identified with the assistance of Dr. F. N. Hepper at Kew Gardens.

The following information was gathered from each tree: 1)

height---tree heights were measured (in meters) with a clinometer; 2) diameter---the diameter at breast height (DBH) was measured (in centimeters) with a diameter tape; 3) buttress---the presence or absence of buttressing, and number of buttresses, were recorded; the height, length, and thickness of each buttress was also measured; 4) bole features---observations were made on how straight, crooked, or twisted each bole was; 5) bark---smoothness, roughness, absence or precence of spines, hoop marks, and eyemarks, texture, and lenticel arrangement were recorded, and 6) slash---color changes, presence or absence of exudates, amounts and stickiness of exudates, slash thickness, and characteristics of the outer and inner barks were recorded.

Back in the lab, leaf features were examined directly from the specimens up to 40x. Each leaf was illustrated to especially show the venation pattern. For the leaf boundary study (Kincaid & Schneider, 1983), leaf outlines were traced with a digitizer on a magnetic tablet connected to a computer, and the images were stored as separate files. Average leaf images were then drawn by merging the files and reconstructing the images using their Fourier Coefficients.

CHAPTER 6

SPECIES IMPORTANCE VALUES

Importance Values (IV) for each species were calculated by adding relative frequency, relative density, and relative dominance (Curtis and Cottam, 1962). The sum of these values is an indication of the overall importance of a given species in the Bobiri forest.

Using data from the point-centered quarter method, the relative frequency is the number of occurrences of species A divided by the total number of occurrences of all species, the relative density is the number of individuals of species A divided by the total number of individuals sampled (1000 in my sample), and the relative dominance is the total basal area of species A divided by the total basal area of all trees sampled.

Because the point-centered quarter method is a non-bounded sampling method, my definition of relative frequency needs further explanation. In my study, points were grouped into larger units because, for most species, if the points alone are used, frequency and density are nearly

equal. Therefore five consecutive points were combined to make a single sampling unit, i.e. points 1-5 constituted sampling unit one, points 6-10 formed sampling unit two, and so forth. In this way the 250 points yielded 50 sampling units. The presence of each species was recorded each time it appeared in a sampling unit.

To calculate absolute density per hectare, all of the individual distances from the sampling point to each tree were summed and divided by four times the number of points used (250). This gave an average distance which is equal to the square root of the mean area of the plants under consideration disregarding species (Mori & Boom, 1987). The distance squared was divided into 10,000 m^2 to obtain the total number of individuals per hectare.

To calculate absolute dominance per hectare, the sum of all the basal areas was divided by 1000 (trees) to obtain the average basal area per tree in square centimeters. The average basal area per tree was then multiplied by the number of trees per hectare to obtain the total basal area per hectare.

Absolute frequency of each species was calculated by dividing the

number of sampling units in which a species occurred by the total number of sample units (= 50). Absolute density and dominance of each species were calculated by multiplying their relative density and dominance by the total number of trees and total dominance per hectare, respectively.

Mori & Boom, (1987) pointed out that importance values give an indication of : 1) the distribution of a particular species throughout the forest (the relative frequency), 2) the abundance of a species (the relative density), and 3) how large the individual trees are (relative dominance), in comparison with all of the other species found in the sample. The importance values for the Bobiri forest are listed in Table III.

The variables frequency (number of occurrences), numbers of trees (density), and basal areas (dominance) were regressed against importance values for the 104 species (Figures 9, 10, and 11). The frequency/IV curve had r^2 of .949, density/IV curve had r^2 of .952, and basal area/IV curve had r^2 of .890. The resulting coefficients of determination (r^2 values) clearly indicate a very strong positive correlation for all three relationships. The resulting regressional equations are of high predictive

values. Comparing the correlations, we can deduce that all three variables have about the same influence on the importance values. However, tree density (r^2 = .952) has a slightly higher influence on the importance values of the species in the Bobiri forest than the frequency (r^2 = .949). The basal area of the species (dominance) has slightly less influence on the importance values of individual species in the Bobiri forest (r^2 = .890). It implies that frequency and density are the best predictors of IV in the Bobiri forest, and that dominance has the least predictive value.

The r^2 value of .988 for the density/frequency relation (Fig. 12) indicates a very strong positive correlation between the number of trees in a species, and how frequently the species occurs throughout the forest. In the Bobiri forest, therefore, individuals of a species are scattered along the transect line, i. e. there is little suggestion of aggregation of individuals within a species. However, more sophisticated tests will have to be carried out to test this suggestion.

The most important trees in the Bobiri forest are *Celtis zenkeri* Engl. (Ulmaceae) and *Funtumia africana* (Benth) Stapf (Apocynaceae), with

importance values of 41.40 and 25.87, respectively. *Celtis zenkeri* is an emergent species that can reach 60 m height and 180 cm DBH (the tree with the largest diameter in the 1000 tree sample). *Funtumia africana* is lower in the canopy, reaching a height of 40 m and a DBH of 50 cm. *Celtis zenkeri* accounts for 13% of the 1000 trees, and has an absolute density of 96 trees per hectare. *Funtumia africana* accounts for 11.4% of the trees, and has an absolute density of 84 trees per hectare.

There were 736 trees per hectare greater than 10 cm. DBH. The total basal area was 44.30 m^2 for the 1000 trees, and the average basal area per tree was 0.44 m^2. The total basal area was 32.59 m^2 per hectare.

Out of the 1000 trees sampled, 104 species were present. This gives an average of 9.6 individuals for every species. This is a fair representation of the forest when compared with the list provided 33 years ago by Taylor (1960) for 95 acres. He came up with 98 species, 70% of which were in my sample. Thirty seven species in my transect were not included in his list. At that time, he was not able to separate the species of some genera. For example, I identified four species of *Celtis* which he listed as *Celtis spp.* A number of species in his list

which were absent from mine simply did not fall along my transect. The March 1993 ODA (UK) tree inventory of Ghana's forests reports that there is a total of 112 species of trees in the Bobiri forest reserve (Hawthorne, 1993). Out of this number, I encountered 104, which is a very good representation of the Bobiri forest trees. Hawthorne (1993), however did not record two new tree species of the Olacaceae (*Strombosia grandifolia* and *Strombosia zenkeri*) that I came across in my sample. This then brings the total number of trees in the Bobiri forest to 114. This underscores the fact that the point-centered quarter method is an excellent sample procedure for tree diversity. All the canopy and understory trees represented in the profile diagram of Hall and Swaine (1981) occur in my sample (Fig. 7).

Using the method described by Mori & Boom (1987), a species-area curve was constructed using subsample units of 40 trees (Fig. 8). This curve demonstrates that a considerable number of new species were encountered as sampling proceeded along the transect. The number of new species in each 40-tree unit as well as the cumulative number of species was calculated for each of the 25 units in the 1000 tree sample

(Fig. 8).

The species area curve (Figure 8) clearly indicates that more sampling would have unveiled more species, because until the penultimate batch of trees sampled (960 trees out of 1000), new species were still being found. Tracey (1985) has pointed out the difficulty in obtaining a complete list of species in a complex rainforest.

Taylor (1952) classified the forest type at Bobiri as the Celtis-Triplochiton Association. Hall and Swaine (1981), who have recently classified it as Moist Semi-Deciduous Forest, criticized Taylor's method as arbitrary, because it was based only on visual inspection of dominant trees. Based on the present study, the Bobiri forest is more appropriately named the Celtis-Funtumia-Sterculia Association, because of the high importance values of *Celtis zenkeri, Funtumia africana,* and *Sterculia rhinopetala.* Since this is the first time that importance values have been calculated for forest trees in Ghana, it is not possible to compare the Bobiri forest with other forests in Ghana. Future measurements in other forest types will enable comparisons to be made, and allow the various forest types to be classified based on the

importance values of their species.

A comparison was made with four Neotropical forests, which were also sampled with the point-centered quarter method. The number of species in the first 800 trees was calculated. The Bahia study, however, sampled only 600 trees among which were 179 species. For comparison, the number of species was extrapolated to 239 for an 800 tree sample, using simple proportion and assuming linear increase. The results in Table IV indicate that diversity in the Bobiri forest is low compared to the Neotropical forests. In all cases, the number of species encountered in the Neotropical forests is more than twice the number of species encountered in the Bobiri forest. This underscores the common notion of the poverty of the African flora as compared to the Neotropics. The tree density of 735 trees per hectare, however, ranks second among the values for the five areas, and is 1.35 times higher than the value of 546 trees per hectare found for the same number of 1000 trees sampled at Camaipi, Brazil.

Table V compares the IV of the most important species in the Bobiri reserve with those of three other Neotropical forests. The results in

Table V demonstrates that the importance value of 41.4 for the most important species in the Bobiri forest reserve, *Celtis zenkeri,* is quite high. The value of 41.4 is second only to the value of 51.1 for *Geissospermum argentum* Woods, (Apocynaceae) at Camaipi, and is twice as high as the importance value of 17.9 for *Tetragastris altissima* (Engl.) O. Kuntze (Busseraceae) at Saul, French Guiana.

CHAPTER 7

FAMILY IMPORTANCE VALUES

Dominant Plant Families

In the tropical forests of Africa as well as in the Neotropics, some plant families are considered to be more dominant than others. These dominant families are the families of plants that the majority of species in these forests belong to. Some ecologists classify dominant families based on data from quantitative studies. Other botanists base their conclusions on observations from collected specimens by taxonomists, and ascertain which families were most represented for a particular locality. The various forests and their dominant families (in descending order of dominance) are listed in table VI.

From Table VI, one can see very close similarities in the dominant families for various neotropical forests, and similar close affinities for African forest localities. In West Africa, 50% of the families of the emergent and upper canopy trees of the moist forest are in common with families of the dry forest.

Family Importance Values

Based on the sum of Relative Diversity, Relative Density, and Relative Dominance of the families in the 1000 tree sample, Family Importance Values (FIV, Mori & Boom, 1983) were calculated for the Bobiri forest.

The value for each family was calculated as follows :

1) Relative diversity = Number of species in family/Total number of species = X; 2) Relative density = Number of trees in family/Total number of trees = Y; and 3) Relative dominance = Basal area of family/Total basal area = Z. Then, (X+Y+Z) x 100 = FIV for a particular family.

Table VII gives the FIV values for the 25 families in the sample, the number of species in each family, the number of trees per family, the number of trees in each species of a family, and the total basal area occupied by all trees of each family.

The FIV index was calculated in order to answer the questions : Is

there a relationship between the numbers of trees in a family and the importance of that family in the Bobiri forest ? Does the number of species in a family, or the total basal area of the tree trunks influence the family importance value? What are the most important families of trees in the Bobiri forest ?

The most important family in the Bobiri forest reserve is the Sterculiaceae (FIV 59.8). The next four families in order of importance are the Ulmaceae (FIV 42.6), the Meliaceae (FIV 28.4), the Apocynaceae (FIV 27.9), and the Moraceae (FIV 20.3). The total basal area for the 1000 individuals, of the total of 104 species, was 443,011.8 cm^2. The total number of trees per species for the whole sample was 207.9. This means that for equal distribution of individuals, my sample should have yielded about 208 trees (exactly twice the number of species). The 1000 individuals for the 104 species results from the exceptionally high numbers (density) of individuals for some species that cause a skewing of the total numbers of trees sampled for a locality (e.g., *Funtumia africana* alone had 114 individuals). These five most important families have basal areas of at least 20,000 cm^2, and at least 55 individuals per

family out of the 1000 tree sample (i.e. they contain 25% of the total number of trees sampled). The calculations showed that there are about four species per family, and about 40 trees for every family sampled.

The number of trees per species of a family was calculated to give an idea of the average number of trees one could expect for each species in a family that is sampled. Looking at Table VII, the numbers of trees per species in a family is generally high for families with high FIV's, but are more variable than either the numbers of species in a family, or the numbers of individual trees for a family. The reason for the number of trees per species being the least consistent is that it is determined by both the number of species and the number of trees in a family. The FIV is determined only by the number of trees in a family but not how many species are in the family.

Factors That Influence FIV Values

The calculations allow for a comparison of the factors that cause families to attain high importance values. Looking at the way in which families attain their importance, it is clear that the Papilionaceae, for

example, is more important than the Combretaceae because of its higher diversity (although density and sizes are smaller). The Combretaceae, on the other hand, although having lower diversity than the Annonaceae, is more important because of the large size of its individuals.

The family importance values were regressed on the variables for relative diversity (number of species in a family), relative density (number of trees in a family), and relative dominance (total basal area in a family). This was done to find out which of the three variables has the greatest influence on the family importance values. It would enable any botanist to have an idea which measurement would be the most reliable to obtain first, in order to determine the importance of a family.

Figure 13 shows a relatively weak positive correlation between the number of species in a family, and the importance value of that family.

Figure 14 indicates a very strong positive correlation between the numbers of trees in the families and their importance values. The R^2 value of .94 is of high predictive value.

Figure 15 shows a very strong correlation for the basal area-FIV relation, with R^2 of .97 which is of a high predictive value.

The results clearly indicate that the density and the dominance measurements of a family in the Bobiri forest, have the highest influence on the family importance values. The total basal area (dominance), however, seems to influence the family importance value slightly more than the numbers of trees (density) in a family. Figure 15 clearly shows that as total basal areas become smaller, the families become less important or vice versa. This is opposite to the case for the importance values of individual species where tree numbers are slightly more influential than basal areas in determining species importance. The numbers of species in the families of the Bobiri forest have very little influence on their family importance values.

A large basal area implies that either the family has trees with large trunk diameters, or has a large number of individuals. Larger trunk sizes in a species has strong influence in raising the family importance value. Therefore if a family has a large number of small trees, its FIV could be lower than another family with fewer number of trees that possess large trunks. An example of how one very large tree can skew the FIV is found in the Sapotaceae. Although the Sapotaceae has only

eight individuals in the sample, six of these are *Aningeria robusta* with large individuals. One particular individual of *Aningeria robusta* had a DBH of 110 cm, and thus raised the basal area of the Sapotaceae to 14,497 cm^2 and caused it to be the eleventh most important family. The Papilionaceae, on the other hand, has 13 individuals in the sample, and the Combretaceae has 20 individuals, and these families are twelfth and thirteenth in importance respectively. The Papilionaceae and the Combretaceae, although they have more trees in the sample, are less important than the Sapotaceae because of smaller trunk diameters than the trees of the Sapotaceae.

Comparison Of The FIV Values Of The Bobiri Forest With Values Of Families In Neotropical Forests

Table VIII compares the five most important families of the Bobiri reserve with those of six Neotropical forest localities. One can see that in all localities higher basal areas and larger numbers of individuals per

family are the two most important factors that determine high FIV's.

Figure 16 shows that, in comparison with the 6 Neotropical localities, Bobiri has the highest FIV value (about 60) for its most important family (the Sterculiaceae), followed by Camaipi, Amapa, Brazil with FIV value of 57.8 for its most important family, the Apocynaceae, and thirdly the Lecythidaceae of Manaus-Itacoatiara of Amazonia with FIV of 54.5.

A single classification Analysis of Variance to test the significance of any differences among the compared variables (with the program Statview) yielded the following results :

Variable	Anova	
	F	P
FIV	1.965	.0828
Number of trees/Family	1.304	.2673
Basal area (m^2)	3.227*	.0121

* = $0.01 < p < 0.05$

These results indicate that there are only very slight differences among the FIV's for the various localities, and the F statistic was not

significant (although the 92% probability was close to the 95% level of significance). There were, however, quite significant differences (99%) among sizes of the tree trunks for the various forests, as opposed to the numbers of trees found in the various families which did not show any significant differences. We can infer, then, that the trunk basal areas of the trees in a family are the primary determining factors for the variations in Family Importance Values for these forests. Comparing the total basal areas for the five most important families (Fig. 17) with the corresponding FIV values in Figure 16, indicates that many of the families with high FIV values in both Africa and the Neotropics, also possess high basal areas. Camaipi, Amapa, Brazil possesses the highest trunk basal area (21.36 m^2), and has the widest gap between the basal area of the most important family and values for the rest of the families. The Bobiri forest in Ghana has the second highest trunk basal area (12.54 m^2) for the most important family. The Bobiri forest, however, has the widest gap between the highest trunk basal areas for the two most important families (Sterculiaceae with 12.54 m^2 and Ulmaceae with 10.29 m^2), and the basal areas for the rest of the 23 families in the 1000

tree sample. The basal area closest to the value for these two families in the Bobiri forest is 3.86 m^2 for the Meliaceae.

The influence of basal area on FIV values in other forests, further confirms the deductions previously inferred from the results for the Bobiri forest, as to the basal area being the most influential factor in determining family importance.

Figure 17 indicates, however, that except for the two most important families (Sterculiaceae and Ulmaceae), total basal areas for the important families of the Bobiri forest are quite lower in comparison with most of the five neotropical regions. Extreme disturbance of the West African forests may have contributed significantly to smaller tree trunk sizes, as compared to the less disturbed forests of the Neotropical regions. Other factors like slower growth rates might also be contributing factors to smaller trunk sizes.

Considering the five most important families for all the seven localities, only the Apocynaceae and the Moraceae in the Bobiri forest also dominate in some of the six Neotropical areas. The Sterculiaceae, Ulmaceae, and the Meliaceae, which are the top three important families

for the Bobiri reserve, are not among the top five, in five out of the six Neotropical forests. Only the Meliaceae is important in the forest of Amazonian Ecuador. The Caesalpiniaceae and the Sapotaceae stand out as the most important families for all seven localities (absent from the top five in only one locality), followed by the Mimosaceae. A family may not be important in a locality, but could be important in another forest in the same or a different region. The Moraceae, for example, is not very important in French Guiana, but is an important family in the forests of Brazil, Ecuador, and Ghana. Table IX compares the importance of some of the families common to most of the seven localities, to accentuate the varying positions of importance for families in different forests.

I conclude that in the Bobiri forest reserve, plant families generally achieve their importance, primarily based on the total number of trees per family, and the total trunk basal area occupied by trees in that family. Increase in species diversity also causes families to assume higher importance in the forest but only to small degrees.

CHAPTER 8

BUTTRESSES

Introduction

Buttresses are a characteristic feature of tropical forests (Jacobs,1981), and often a conspicuous trunk feature of Ghanaian trees.

The extent of buttressing ranges from small, incipient buttresses to significantly long or tall plank-buttresses associated with such trees as *Celtis zenkeri* Engl., *Ceiba pentandra* (Linn.) Gaertn., *Strombosia glaucescens* Engl., *Piptadeniastrum africanum* (Hook. f.) Brenan, *Terminalia superba* Engl. & Diels, and *Aningeria robusta* (Chev.) Aubrev. & Pellegr. On the other hand, some very large trees like *Berlinia tomentella* Keay, *Blighia sapida* Konig, and *Daniella ogea* (Harms) Rolfe ex Holl., as well as some medium sized trees like *Funtumia africana* (Benth.) Stapf, and *Hannoa klaineana* Pierre & Engl., never exhibit any buttressing.

Tree Identification

Although Taylor (1960), and Whitmore (1990) stated that buttress formation is not usually apparent until the tree gets older, buttresses provide useful diagnostic features for separating some taxa. In some species, for example *Piptadeniastrum africanum* (Hook. f.) Brenan, buttresses appear early. Nevertheless, the use of buttresses for separating species should be used mostly for the comparison of adult trees.

Some families, genera, and species, typically produce buttresses while others do not. The presence and structure of buttresses, combined with other bole characteristics, offer many characters for use in the identification of Ghanaian trees. Some trees in West Africa can be easily distinguished by their characteristic buttresses. After careful observations of Ghanaian forest trees, I concluded that buttresses are useful vegetative features that can be

used to characterize certain families and genera, and even to separate species. For example, *Celtis zenkeri* Engl. has significantly wide and tall but slender buttresses that sometimes anastomose, after a long time, to form small cavities that collect water. *Sterculia rhinopetala* K. Schum. has short but thick buttresses, *Cylicodiscus gabunensis* Harms has extensive buttresses that can be crooked and "wandering", *Terminalia superba* has characteristic triangular buttresses, while species of *Myrianthus* and *Lecaniodiscus* typically have many small flying buttresses. Using the four species of *Celtis* present in the Bobiri forest as an example, the one with short buttresses quite close to the trunk is most likely to be *Celtis mildbraedii Engl.* or *Celtis brownii* Planch. Of the remaining two species, the one with the highest number of buttresses (seven or more) is *Celtis adolfi-friderici* Engl. The species with the smallest buttresses among the four which may also exhibit weird branching or anastomoses, is *Celtis brownii.*

Davis and Richards (1934), for example, found tremendous use of buttresses in separating closely related species of trees in Guyana.

Hutchinson and Dalziel (1954-72) made a marginal but specific use of such taxonomic characteristics in their compilation of the Flora of West Tropical Africa. Other workers have made some use of buttresses, especially in their preliminary characterization of African trees. Hall and Swaine (1981) found buttress features useful in preparing their list of the forest trees of Ghana. Hawthorne (1989), who has compiled the latest vegetative field key to help identify the forest trees of Ghana, also found buttresses quite useful.

Ecological Utility

Buttresses are also useful for characterizing vegetation types within tropical forest formations. For example Hall and Swaine (1981) made use of some buttress characteristics to describe vegetation types

when classifying the forests of Ghana. Davis and Richards (1934) used buttress features in addition to other features, to describe the five forest types in Guyana : 1) forest with huge plank buttresses usually reaching heights over 6 m and spreading out from the base for about an equal distance, 2) forest with strongly plank-buttressed trees, but buttresses seldom reaching more than 2-3 m above ground, 3) forest with trees that seldom possess large buttresses, and also have few entirely unbuttressed trees, 4) forest with trees that are very little or not at all buttressed, and 5) forest with almost complete absence of buttressing. They also showed that buttresses were more common in wetter forest types.

At least some genera of trees seem to maintain their mode of buttressing across other forest formations in Africa. For example, in East Africa, Lind and Morrison (1974) reported that trees belonging to the genus *Aningeria* are heavily buttressed. In the Bobiri forest,

Aningeria robusta (Sapotaceae) was heavily buttressed, and is reported in the literature to possess similar buttress features in other West African forests (Lind & Morrison, 1974). Lind and Morrison (1974) also stated that buttressed trees are common in the Medium Altitude Moist Evergreen Forest of East Africa, and fluting as well as buttressing are more prominent in semi-deciduous than evergreen forests. They observed that some species, like *Alstonia boonei* De Wild., were all practically buttressed " with no stem at all at the base ". These observations are also valid for the moist semi-deciduous forest of Ghana.

Why Do Trees Have Buttresses ?

Buttresses As Support

Botanists have long been interested in the adaptive advantages of buttresses to trees. Francis (1924) and Navez (1930) showed a strong

correlation between slopes and the appearance of buttresses on the upward sides of trees. They suggested that buttresses supported the tree thereby preventing it from falling down slopes. Regarding this hypothesis of buttresses fostering tree stability and anchorage, Davis and Richards (1934) reached a slightly different conclusion based on their observations of the forest trees of Guyana. They suggested that the formation of buttresses depends on the absence of a tap root which is due to shallowness of soil produced by water-logging on low-lying ground, or to stoniness on slopes.

Davis and Richards (1934) emphasized that buttressing is to a large extent a hereditarily fixed factor. Francis (1924), Navez (1930), and Richards (1952) all agreed with the hypothesis that there is a general lack of tap roots in buttressed trees and a reliance on relatively shallow surface roots. Richards (1952) reviewed all the classical explanations, and suggested that " the usefulness of buttresses

is perhaps incidental rather than a primary cause for their existence." He gave a great deal of attention to it and discussed four theoretical explanations whose overall gamut portrays buttresses as the extension of a rooting system that is originally superficial.

Henwood (1973), using engineering analysis, confirmed that buttresses are structures that afford the tree better anchorage. He explained that buttressed roots are effective as structural members, supporting large trees on substrates that offer poor anchorage. They develop on the windward side of trees and act as tension members to reduce the stresses on those roots on which they occur, thus making these trees less susceptible to falling or breakage. Francis (1924) observed, however, that some young trees developed buttresses before exposure to wind stress, and there were numerous examples of dominant trees without buttresses. Henwood (1973) explained this as a species specific trait for the development of buttresses while still young in

order to have a head start for the spurt of growth necessary when openings develop in the canopy.

Petch (1930), from his studies on trees of Ceylon, indicated that buttresses do not seem associated with the strains produced by winds, and rather appear to be randomly distributed around the bole. He concluded that buttressing is correlated with the lack of tap roots.

Baker (1973) slightly corrected the very high correlation found by Senn (1923), Navez (1930) and others regarding buttressing and wind-induced stresses. From data obtained during his 1956-57 studies on *Ceiba pentandra* trees on the old campus of the University of Ghana at Achimota in Accra, he found that when the trees are older and larger, the preponderance of buttresses on windward sides is much more clearly marked and is highly significant statistically. To this extent Senn (1973), Navez (1930), and others are justified in maintaining that buttresses are developed mainly on the side facing a prevailing wind.

The findings of Baker (1973) were : more buttresses on the windward side of trees, greater height on the side with fewer buttresses even if it is the leeward side, and leaning trees or those growing on slopes having buttress height greater on the side away from the lean or on the upslope side. Supporting evidence was obtained by observing small numbers of trees of *Bombax buonopozense* P. Beauv. (Bombacaceae) and *Hildegardia barteri* (Mast.) Kosterm. (Sterculiaceae).

Observations, so far, suggest to me that more credence should be given to the anchorage-stability theory as a probable reason for buttressing in most trees.

Buttresses And Tree Characteristics

One of the familiar tree characteristics for any observer is the disproportionate crown distribution around the perimeter of a tree trunk. For some trees it can even be used as a diagnostic feature. In the Bobiri

forest reserve, I came across several instances where buttresses developed more at the side of the trunk opposite to that with the highest crown concentration, apparently helping the tree to be more balanced. Petch (1930) however concluded from his studies on trees of Ceylon that the few cases where buttresses appeared to be correlated with strains produced by the crown were fortuitous. Henwood (1973) emphasized that buttresses could develop in response to the stresses associated with an unbalanced crown, and have been said to offer a structural advantage in such cases as well. Henwood
(1973) further explained that the development of buttresses in young trees could be attributed to uneven canopies on small trees.

Along the same lines, Lowe (1963), in correlating the height of buttresses to the diameter of the stem, found no correlation between the crown radius or stem length and the buttress-height-stem-diameter relationship, thereby implying that buttresses are not a response to

mechanical strains at the base of the tree. McMahon (1972) put forward the hypothesis that the need for buttresses could be related to other characteristics of the species such as mechanical properties of the wood, depth and extent of the root system, crown diameter, and to such environmental factors as wind force and direction, and soil depth. Noel and Harris (1971) did some work on trees that lent credibility to early hypotheses of definite correlation between mechanical stress and the production of a structurally sound trunk.

Smith (1972) provided a descriptive model for buttressed tree bases, and proposed new hypotheses concerning buttress function and evolution. He proposed 19 alternative theories based upon field observations, a descriptive model, and theoretical considerations. The model predicted higher surface/volume ratios for buttressed bases but roughly equivalent or lower total wood volume. Improved support (according to Smith) might thus be achieved without increased energy

expenditure on wood. Increased risk of fire and of winter-drought stress may also result in decreased buttressing with increasing latitude (which explains why temperate trees lack buttresses).

Buttresses As Reducers Of Competition

Black and Harper (1979) put forward the proposal that one seemingly apparent advantage to buttressing is the obvious increase in individual space occupied at ground level by buttressed over non buttressed trees. For example, using the data available in Francis (1924) and Navez (1930), they estimated that the surface area occupied by the plank buttresses of *Ceiba pentandra* tree is nearly four times that covered by the central trunk. Such space is unavailable for rooting by other plants. Buttressing may thus be viewed as a competitive mechanism. They also mentioned that buttresses may also provide some

defence against soil-rooted woody vines by inhibiting their free and quick ascent of the tree trunk.

Boom and Mori (1982) did not find support for the Black and Harper (1979) hypothesis in which the presence of buttresses was suggested as a possible mechanism for reducing liana loads. They found no significant difference between the liana loads of buttressed and unbuttressed trees.

Buttresses As Means Of Increasing Transportation Of Assimilates

Halle et al (1978) discovered that there is a balance between the cambium activity of trees and the amount of assimilates produced, which has to be transported by the tree. This changes both with the age of the tree and with climatic factors. In transpiration-prone climates, an enlargement of the cambium surface is advantageous for the purpose of transporting more sap through an increased amount of wood. It should

be borne in mind that buttress formation causes an increase in the ratio of sapwood to wood in a tree. This argument suggests that buttresses enhance the transportation of food, water, and other nutrients.

The foregone arguments and propositions clearly suggest that buttress formation may be the result of an interaction between genetic and environmental factors, which enhance the anchorage and stability of tropical trees, make them better competitors, enable them to make optimum use of environmental resources, and generally contribute to their overall survival in the forest cummunity.

TERMINOLOGY

The variables of height, width, and thickness of a buttress were utilized in my taxonomic and ecological descriptions. These and other terminologies encountered in the text are defined as : 1) buttress height or tallness, which is the vertical distance from the origin of the

buttress at ground level to its termination up the trunk, 2) buttress width (wide, extended, long, also applied), which is the horizontal extension of a buttress away from the trunk, 3) buttress thickness, which is the extent of widening of a buttress at its edge measured perpendicularly to the height, 4) trunk fluted at base, which is trunk enlarged only at base without buttresses, 5) fluted trunk, which is a trunk dissected to form ridges from base of trunk to considerable distance upwards, and 5) incipient buttresses, which are small buttresses only beginning to form. These terms are illustrated in Figure 18.

Occurrence Of Buttresses In The Bobiri Forest Reserve

FAMILIES, AND PERCENTAGE OF TREES, WITH BUTTRESSES

Out of the 1000 tree sample, 522 (52.2%) had significant buttressing (width > 15 cm), 248 (24.8%) had incipient buttresses (very small

buttresses < 15 cm in width), and 230 (23%) had no buttresses at all. Out of the 230 unbuttressed trees, 161 (16.1%) were noticeably fluted at the base.

Tall or extended buttresses were found in species of Caesalpiniaceae, Combretaceae, Euphorbiaceae, Meliaceae, Mimosaceae, Moraceae, Sapindaceae, Sapotaceae, Sterculiaceae, and Ulmaceae.

Absence of buttressing was found in species of Apocynaceae, Caesalpiniaceae, Sapindaceae, and Olacaceae (e.g., *Strombosia glaucescens* shows no sign of buttresses even at DBH of 50 cm).

Table X gives an idea of which families have buttresses in the Bobiri forest, how many species within a family are buttressed, and the average number of buttresses per tree in a family (Fig. 19). The results indicate that about 64% (16 out of 25 families) of the families sampled possess buttresses (Fig. 20).

The family with the highest number of buttressed species was

the Moraceae followed by the Sterculiaceae and the Meliaceae. As to the total number of buttressed trees in a family, the Ulmaceae ranked first followed by the Sterculiaceae and the Moraceae. The Sapindaceae had the highest mean number of buttresses per tree followed by the Olacaceae and Moraceae.

Percentage Of Species With Buttresses

Of the total of 104 tree species in the sample, 50 species (48.1%) exhibited measureable buttressing, while 18 species (17.3%) had only incipient buttresses, leaving 36 species (34.6%) without any form of buttresses. In a moist Tropical forest such as Bobiri, with frequent strong winds and rainstorms, a high percentage of species with buttresses is not unexpected, because buttresses do contribute towards the stabilization of trees in the face of numerous threats of tree-fall.

The percentage of buttressed species or numbers of trees with buttresses may be higher than I found, because some trees develop buttresses only after attaining a specific DBH. The forest may also not be old enough to allow some trees to reach the size at which buttresses develop. For some species, buttressing cannot be easily predicted.

Table XI portrays the unpredictable sizes at which buttresses occur in some species. For such species, both small and large trees could develop buttresses or be simply fluted at the base.

Table XII shows the tree sizes at which some Ghanaian forest trees begin to develop buttresses. Some species begin to develop buttresses only when the tree has grown to a considerably large size, e.g., *Ongokea gore* (Hua) Pierre. For some other species, e.g., *Alstonia boonei*, buttress development begins at a young age. Knowing the conditions under which each tree grows, we may postulate that in situations where buttressing is not easily predictable for a particular

tree size within a species, buttress formation may probably be more under environmental than genetic control, although there is an interplay between both factors for this particular phenomenon.

Figures 21-55 show the species by species representation of buttress development for all buttressed species among the 104 tree species in the 1000 tree sample. The Height-Diameter plots show the various tree sizes encountered in each species sample, and when buttresses begin to develop. The tick on each circle (representing a particular tree) stands for one buttress. Thus, a circle with five ticks had five developed (measurable) buttresses at time of sampling.

Some species like *Albizia zigia* (DC.) J. F. Macbr., *Dalbergiella welwitschii* (Bak.) Bak. f., and *Musanga cecropioides* F. Br. had all the members of the sample buttressed (both old and young trees). Some species, e.g., *Celtis zenkeri*, had a majority (at least 70%) of the trees buttressed. Others like *Guarea cedrata* (A. Chev.) Pellegr. had few

members (about 10%) buttressed. A few like *Triplochiton scleroxylon* K. Schum., had many members (about 50%) buttressed. Generally, older trees stood greater chance of developing buttresses. Where buttresses were present for all size classes, older members usually developed more buttresses per tree than younger trees. Some species deviated from this general trend by having the same higher buttress numbers for both old and young trees, e.g., *Terminalia superba, Myrianthus libericus* Rendle, and *Myrianthus arboreus* P. Beauv.

On the whole, there was more buttressing for emergent and canopy trees, and less buttressing in understorey trees, although at all levels some buttressing could be found.

If we accept support as the primary role of buttresses as suggested by Smith (1972), Henwood (1973), and Mori & Boom (1987), then a more dissected topography (which creates more instability), different species composition, or bigger tree sizes for a particular locality, could account

for more buttresses than another location which is less dissected, has fewer species composition, or has smaller trees.

These factors may be true for West African forests too. For some families like Olacaceae and Lecythidaceae, members usually grew large before putting out buttresses. Mori et al (1987) found out that, for the Lecythidaceae of French Guiana, only species reaching mature heights of 30m (canopy and emergent species) or more produced significant buttresses. Davis and Richards (1933) also observed that buttressing was more common among canopy and emergent species but absent in understorey trees in Guyana.

Buttresses Of The Highest Dimensions

Table XIII lists the species with the widest, tallest, and thickest buttresses in the Bobiri forest reserve. The figures indicate that *Terminalia superba* stands out as the species with the most pronounced

buttresses in the sample. This is an important timber tree with characteristic triangular plank buttresses. The considerable buttress height and its light brown trunk color, both enhance its visibility in the forest. It is one of the tallest trees in the forest (up to 60 m) and is among the largest in diameter (up to 70 cm DBH). This species, in addition to those listed with it (Table XIV), tend to support the hypothesis that buttresses are an adaptive feature for support as the trees grow bigger and taller.

Table XIV shows the 19 species of the Bobiri reserve with seven or more buttresses per tree. The Sapindaceae rank highest in the proliferation of buttresses, followed by the Euphorbiaceae, the Moraceae, and Sterculiaceae, all with ten or more buttresses per tree.

Comparison With Other Forests

When the total number of buttressed trees in the Bobiri forest is

compared with buttressing in the Neotropical forests of Bahia, Brazil, and Saul, French Guiana (Fig. 56), the results demonstrate that the number of buttressed trees in the Bobiri forest are more than twice those found in the Neotropical forests. Table XV compares some of the tallest and widest buttresses, as well as the percentage of buttressed trees in Ghana with those in some Neotropical forests.

The paucity of detailed information on buttresses for most tropical localities allows only a limited quantitative comparison to be made here. Although the data suggest that buttressing is more common in Africa than other tropical areas, more data are needed to confirm this. Should this postulate be affirmed, it would not be unexpected because Africa possesses some of the tallest and largest forest trees.

Correlations Among Buttress Dimensions

Figure 57 shows the correlation between buttress height and width

of individual trees with the highest DBH in the Bobiri forest reserve. There is a strong positive correlation, with a high r^2 value of 0.914. This implies that for large trees in the Bobiri reserve, buttresses grow taller as the trees increase in diameter.

Figure 58 shows the positive correlation that exists between the height of a buttress and the height of the corresponding tree, for the tallest buttresses of the Bobiri forest reserve (regardless of species). The correlation is weak ($r^2 = 0.134$), implying that although buttress heights increase as trees grow taller, such increases in buttress heights are very slow and relatively small, compared to the huge increases in tree heights.

Figure 59 shows a very weak negative correlation ($r^2 = 0.007$) between the width of a buttress and the corresponding tree diameter immediately above the buttress. This probably means that as trees grow bigger in the Bobiri forest, cambial activity results in increased

buttress height rather than increased buttress width. Smaller trees have wider buttresses compared to trunk diameter than bigger trees (Fig. 59) Figures 57 and 58 demonstrate that increases in the heights of buttresses are more dependent on the enlargement of the tree trunks rather than the heights of the trees.

Kinds Of Buttresses, Variations, And Frequency

Hawthorne (1989), after examining buttresses in the forest reserves of Ghana, classified buttresses into nine categories for field use in tree identification. After detailed examination of trees in the Bobiri forest and trees in other areas of Ghana, I recognize 20 different types (Figure 60).

These variations, I believe, are the results of a combination of genetic and environmental factors that a particular tree species is exposed to,

therefore there may be some variations outside of Ghana.

On the whole, buttresses appear to be more frequent in fluted trees. My observations suggest to me a close association between buttressing and fluting, because incipient buttresses almost always develop from the bases of stems already fluted at the base. I observed, for example, that in *Gmelina arborea* (L.) (a popular shade tree in Ghana), only a few trees developed small buttresses after considerable growth. I observed at least 100 debarked or mechanically disturbed tree trunks both in the savanna in Accra as well as in the forest areas between Accra and Kumasi, and found that these trees developed several bumps on the tree trunk, developed flutes, and had buttresses they would otherwise not develop. A similar situation was found in *Khaya senegalensis* A. Chev., which is planted as a shade tree and is extensively debarked for medicinal purposes. Heavily debarked tree trunks grow big, crooked bumps, become extremely fluted, and

develop bigger buttresses than trees that are not debarked. I always traced the line of fluting and found it to directly correspond with the position of a buttress.

Key To Buttress Classification

1. **Standard Regular Triangular Buttress (Fig. 60-1) :**

Triangular-shaped buttresses all of similar medium height and width, uniformly subtending an acute angle to ground level about 45^{o}. When the number is four, they are arranged at right angles (e.g., *Carapa procera*).

2. **Extended Regular Triangular Buttress (Fig. 60-2) :**

Triangular-shaped buttresses all short but relatively wide, entering the soil at a very acute angle. All have similar dimensions. When four in number, each pair is at a right angle to the other pair (e.g., *Terminalia superba*).

3. **Lanceolate Regular Triangular Buttress (Fig.60-3) :**

Triangular-shaped buttresses all short but equally of small width, entering the soil at a very acute angle. All have similar dimensions. When four in number, each pair is at right angle to the other pair (e.g., *Terminalia superba, Bussea occidentalis*).

4. **Elevated Regular Triangular Buttresses (Fig. 60-4) :** Tall triangular-shaped buttresses of small width, uniform dimensions. When four in number, one pair is usually at right angle to the other pair. They often enter the soil at an angle greater than 45^0 (e.g., *Alstonia boonei, Celtis zenkeri*).

5. **Irregular Triangular Buttresses (Fig. 60-5) :** Triangular buttresses of varied dimensions on the same trunk (some tall, others short, some of longer width than others). Two pairs are common, in which case one pair is often at right angle to the other pair (e.g., *Pterygota macrocarpa*).

6. **Regular Concave Buttresses (Fig. 60-6) :** Concave-shaped

buttresses of similar dimensions (could be short or tall, extended or of small width). When two pairs are present, they are at a right angle to each other (e.g., *Ceiba pentandra*).

7. **Irregular Concave Buttresses (Fig. 60-7) :** Concave-shaped buttresses of varied dimensions on the same trunk. When two pairs are present, they are at a right angles to each other (e.g., *Blighia sapida*).

8. **Clubbed-Fluting Buttresses (Fig. 60-8) :** Concave-shaped buttresses with swollen ends at points of entry into the soil (giving club-shaped appearance). They are often tall when present on large trunks. Usually more than four buttresses of similar dimensions are present (e.g., *Spathodea campanulata*).

9. **Concave-Fluting Steep Buttresses (Fig. 60-9) :** Very tall lightly concave-shaped buttresses, near triangular-shaped, with very small width. The tops run along the length of the trunk as ridges (e. g.,

Treculia africana, Ricinodendron heudelotii).

10. **Regular Arched Buttresses (Fig. 60-10) :** Relatively short arch-shaped buttresses of small width, usually few in number. The dimensions are similar. When four in number they are at a right angle to each other (e.g., *Letaulus daphnoides*).

11. **Clubbed Fan Buttresses (Fig. 60-11) :** Short club-shaped buttresses with arrangement that gives base of trunk a fan-like appearance from a distance. Numbers are often more than four (e.g., *Sterculia rhinopetala*).

12. **Flying buttresses (Fig. 60-12) :** Mixture of arched and straight buttresses of much varied dimensions, all emerging from the trunk at separate points like branches, with gaps between them, and entering the soil independently. They closely resemble stilt or prop roots. Can be numerous, as high as 60 (e.g., *Myrianthus arboreus, Musanga cecropioides*).

13. **Wandering Branched Buttresses (Fig. 60-13) :** Very short branching buttresses usually very wide, and which can extend to seven meters or more. Most of them originate near ground level and grow in all directions randomly and creep for long distances before entering the soil (e.g., *Piptadeniastrum africanum*).

14. **Flexuous-Fluting Branched Buttresses (Fig. 60-14) :** Twisted tall buttresses with arched bases resulting sometimes in the creation of little enclosures between the buttresses at trunk base. The basal portion of the bole appears very fluted with deep vertical depressions (e.g., *Alstonia boonei, Rauwolfia vomitoria*).

15. **Knobbed Buttresses (Fig. 60-15) :** Short buttresses usually quite extended, with numerous characteristic swollen knobs (blunt sizeable vertical projections). All buttresses have crooked patterns (e.g., *Cylicodiscus gabonensis*).

16. **Spiral Fluting Steep Buttresses (Fig. 60-16) :** Very short

buttresses originating spirally on the bole at separate heights and entering the soil close to base of trunk. Their top portions have diagonal arrangement on the bole (e.g., *Duboscia viridiflora*).

17. **Irregular Arched Buttresses (Fig. 60-17) :** Mixture of tall and short arched buttresses of varying dimensions on the same bole. Some of the short ones appear triangular. The buttresses are often not wide (e.g., *Pterygota macrocarpa*).

18. **Clubbed Convex Buttresses (Fig. 60-18) :** Short convex-shaped buttresses, often few in number, entering the soil close to base of trunk. The swollen shapes give them club-like appearance. Does not spread out like in 60-11 (e.g., *Albizia zygia*).

19. **Sinewy-Branched Random Buttresses (Fig. 60-19) :** Crooked tall buttresses with profuse branching, often with many swollen points, appearing sinewy. Typically found in species of *Ficus.* Often the buttresses cover a considerable portion of the bole, sometimes up to 60%

or more (e.g., *Ficus capensis*).

20. **Concave Branched Buttresses (Fig. 60-20) :** Concave-shaped buttresses with much branching. Most often they are quite short and not very wide, but occasionally they may be tall and considerably extended (e.g., *Aningeria robusta*).

Subdivisions

I also recognize subdivisions in these 20 categories, with respect to buttress size and thickness. Plank buttresses, for example, which are buttresses with characteristic narrow edges, are commonly found in groups 1, 2, 4, 5, 6, and 17. It was not included as a category in this classification because I consider it a very broad term that covers several classes of buttresses. It falls in the same broad category as thick, tall/high, wide, small, large, branched, narrow etc. buttresses which botanists commonly use in their descriptions. I recommend

subdivisions for the various classes. For example, Regular Concave Buttress (60-6) could be subdivided into : a) regular plank concave buttress, b) regular thick concave buttress, c) regular tall concave buttress, d) regular narrow concave buttress, e) regular wide concave buttress, f) regular small concave buttress, and g) regular large concave buttress.

CHAPTER 9

TREE SIZE AND STRATIFICATION

Tree Size

Tree size is an important taxonomic feature that can be used to distinguish one species from another. Some families are characterized by small or large trees. The basal area of a tree trunk tells an investigator how large a tree is. Raunkier (1934) classified tree species according to their maximum attainable heights. Megaphanerophytes can exceed a height of 30 m, at which size they have an average breast-height diameter of 40 cm (Rollet, 1974). Heights for other classes are : mesophanerophytes (8-30 m), microphanerophytes (2-8 m), and nanophanerophytes (0.25-2 m).

Out of the 1000-tree sample in the Bobiri forest reserve, 77 represented megaphanerophytes (7.7%), 880 were mesophanerophytes (88%), and 43 trees (4.3%) could be classified as microphanerophytes. There were no nanophanerophytes, indicating that no tree in the Bobiri reserve with more than 10 cm DBH had a height less than 2 meters.

Among the megaphanerophytes, a few could be regarded as emergents that towered above the general canopy. The 20 tallest trees are listed in Table XVI. Figure 61a shows the height variation in the 20 tallest tree species in the Bobiri forest. Figure 61a indicates a relatively steady decline in tree heights from the emergent species to the upper and lower canopy tree species.

Table XVII shows the species with the largest DBH in the Bobiri forest. Figure 61b shows the variation in the diameter sizes for the 30 largest species of trees in the Bobiri forest. As is the case for the tree heights (Fig. 60), there is a steady decline in large species diameters. These results are in conformity with the tree size relations that exists in most tropical forests.

Some species of trees can be characterized by size in the Bobiri forest. We can say, for example, that *Triplochiton scleroxylon* is a "tall species", and *Celtis zenkeri* is a "large diameter species". I would like to caution that the conclusions here are for the largest trees of the forest, most of which are mature, and had flowered or fruited in my collections.

The sizes I used for regression also agree with the mature heights measured by other workers like Taylor (1960), and Hall and Swaine (1981). Conclusions based on a whole forest sample (1000 trees in this instance) with many juvenile trees that are still growing, would be erroneous.

The tree with the largest diameter at breast height (180 cm) was *Celtis zenkeri* in the family Ulmaceae, followed by *Aningeria robusta* with DBH of 110 cm. in the Sapotaceae, and *Cylicodiscus gabonensis* with DBH of 110 cm. in the Mimosaceae. Figure 62 shows the overall distribution of tree sizes in the Bobiri forest reserve. Figure 62 shows considerable disparity between the largest trees and the the rest of trees of the Bobiri forest. The wide differences in tree heights very clearly mark out the emergent and other tall trees.

Figure 62 shows the general pattern of distribution of tree sizes in the Bobiri forest reserve. Figure 62 indicates a very close relationship between the heights and diameters of the largest trees in the Bobiri forest. The tallest trees often possess the biggest trunk diameters as

well. Although 85% of the tallest individual trees listed in Table XVI are found in the large diameter list in Table XVII, the tallest trees are not necessarily always the largest in trunk diameter. For example, *Khaya ivorensis* is the sixth tallest tree in the 1000 tree sample, but is not among the first 30 trees with the largest diameters in the 1000-tree sample.

The tallest tree was found in the Sterculiaceae (*Triplochiton scleroxylon* with height of 70.79 m), followed by *Aningeria robusta* of the Sapotaceae (57.6 m). The mean height for these 20 tallest trees was 50.71, which implies that when measuring heights of the tallest trees in the Bobiri forest reserve, one should expect heights of about 50 m or more.

Hall and Swaine (1981) observed that trees of the Bobiri type of forest (Moist Semi-deciduous) become taller than in any other forest type in Ghana. They reported that heights often exceeded 50 m, and sometimes 60 m. In consonance with this finding, at least 12 trees in my sample exceeded 50 m in height, and at least one measured 70.9 m. This is taller

than most maximum heights recorded by botanists for the forests of Ghana (e.g., 60 m by Taylor, 1960).

The curves for size-class distribution of tree diameters and heights (Fig. 63) show the reverse J-shape or negative exponential distribution characteristic of most forests. The height class, however, shows an initial lower numbers of small trees which very soon grow in height and reach their peak heights, still having relatively small diameters. After that the number of tall trees with large diameter drop sharply, and the distribution curve assumes a reverse J-shape (like the DBH curve), with few members that are taller than 30 m. The DBH and height classes are found in Table XVIII. Schulz (1960) pointed out that a knowledge of the size class distribution of the species, reflects the history of the reproduction of the species concerned. The Bobiri forest size class data indicates the proportion of species that have survived the transition from the sapling stage into the initial 10-19 cm. DBH or 0-10 m. height class. We can also estimate how many juvenile trees grow through the subsequent size classes to become large or adult trees in the

moist semi-deciduous forest of the Bobiri reserve. Majority of the trees (615) are in the 10-19 cm. DBH class, and the number is thrice the number of trees (216) in the next 20-29 cm. DBH class which comes second in abundance. Very few trees reached or exceeded 70 cm. DBH. The 10-19 m. height class has the highest number of trees (580) in the Bobiri forest, followed by the 20-29 m. and 30-39 m. height classes. Future investigation in other moist semi-deciduous forest localities in Ghana might show a similar distribution pattern for this forest type in the country. One should note, however, that the forest is not at equilibrium, and the history of disturbance in the Bobiri forest may have skewed the present results.

Figures 64-78 show the DBH-Height scattergrams for 30 species in eleven families, with ten or more individuals, out of the 104 species of the 1000 tree sample in the Bobiri forest. The regression lines indicate that in all cases there was positive correlation, though many had several outliers. The r^2 values were low for many of them. The best DBH-Height correlations were found in *Ricinodendron heudelotii* in the

Euphorbiaceae(r^2 = .757), *Sterculia oblonga* in the Sterculiaceae (r^2 = .753), *Triplochiton scleroxylon* in the Sterculiaceae (r^2 = .752), *Guarea cedrata* in the Meliaceae, and *Carapa procera* in the Meliaceae (r^2 = .709). The two most important species in the Bobiri forest, *Celtis zenkeri* and *Funtumia africana*, both had very weak positive correlations (r^2 of .159 and .288 respectively) for their DBH-Height relations. This was partly due to the very wide differences in sizes between the largest individuals and the smaller trees which constituted the highest number in the samples for the two species. Figures 64-78 support the fact that most species have increase in DBH with corresponding increases in height or vice versa. They also show the deviations from this general trend in some species where height increases did not always mean diameter increases, e.g., *Turraenthus africanus, Celtis mildbraedii,* and *Cola gigantea.* For such species, there were a lot of outliers from the regression line.

Table XIX provides a list of the largest trees for the species in each of the 25 families in the 1000 tree sample. The results support the

notion already expressed for species, that some families in the Bobiri reserve can be generally classified as large tree families, e.g., the Sterculiaceae, Mimosaceae, and Ulmaceae. These families, and other families with large trees, commonly form the emergent and upper canopy trees, and with their straight, tall boles also provide useful timber in the forest. They generally give the forest its chracteristic physiognomy from a distance (especially from the air). Others like the Rubiaceae, the Anacardiaceae, and the Papilionaceae can be generally classified as small tree families. The Moraceae, for example, can be generally classified as medium-sized tree family. Table XIX enables any scientist to have an idea of the maximum sizes of trees he would expect in a family, when a sample of trees is taken in the Bobiri forest reserve.

Table XX shows the mean values for the largest trees in each family for the 25 families in the 1000 tree sample of the Bobiri reserve. Eight families in the list are represented by only one individual in the sample. Excluding the families represented by only one individual, the Ulmaceae has the highest average DBH (81.3 cm.), and the Anacardiaceae

has the lowest average DBH (13.3 cm.). The Mimosaceae possesses the highest average tree height (42.1 m.), while the Bignoniaceae ranks lowest in average tree height (11.5) for the largest trees.

Discussing the average tree diameters and average tree heights for tree families would be an important part of the ecological description of the Bobiri forest. It also has taxonomic value when one is using field measurements to assign tree taxa to families.

The results in Table XX indicate that the Ulmaceae has the highest standard deviation (71.1) for the mean diameter value, and therefore has the highest variation in the mean diameter, the Sapotaceae, with standard deviation of 45.4, has second highest variation in mean diameter size for its largest trees, and the Mimosaceae, with a standard deviation of 36.8, ranks third in mean DBH variation for the largest tree diameters. The Bignoniaceae (standard deviation of 1.8) and the Anacardiaceae (standard deviation of 3.1), which have the smallest trees, possess the least variation in mean diameter size.

Table XX again shows that the Sapotaceae, with a standard

deviation of 21.4, has the highest variation for the mean height, the Sterculiaceae, with standard deviation of 19.9, ranks second in mean height variation, and the Mimosaceae, with a standard deviation of 17.9, ranks third in mean height variation. The Bignoniaceae and the Anacardiaceae have the lowest mean height variation (with standard deviations of 0.3 and 1.8 respectively). The results in Table XX suggest, therefore, that in the Bobiri forest, small tree families have the most stable mean tree sizes, whiles mean tree sizes vary more for large tree families. It must be noted, however, that this is dependent, to appreciable degrees, on sample size, forest history, and physiology of the species sampled.

Comparison Of Tree Sizes With Other Forests

Table XXI compares the tallest tree in the 1000 tree sample in the Bobiri forest with the tallest trees recorded around the world. Although Whitmore (1990), in his most recent account on the

world's tallest trees did not include any trees in Africa, *Triplochiton scleroxylon* (Sterculiaceae), with height of 70.8 m. in my Bobiri forest sample, will be the ninth tallest tree in the world on Whitmore's (1990) list. *Triplochiton scleroxylon* is taller than Whitmore's (1990) world's ninth tallest tree *Agathis dammara* (Coniferae) in Indonesia with a height of 70 m. The tallest tree in the Bobiri reserve was a *Ceiba pentandra* (Bombacaceae) which was outside of my sample and measured 80 m tall. Across Ghana, *Ceiba pentandra* is usually the tallest and largest tree spotted from a far distance in most towns and villages. In most of the deforested areas, the most common large tree I saw was *Ceiba pentandra*. It is usually left untouched because the wood makes poor charcoal, firewood, or timber; it is the kapok from the fruits that is very useful to the natives for pillows and mattresses.

A Ghana Forestry Department report states that one individual tree of the species *Tieghemella heckelii* (Sapotaceae) in the moist forest of the Essen-Apam forest reserve (300 meters from the motor road linking Akim Oda and Agona Swedru in the Eastern Region of Ghana) is the

largest tree in West Africa. This big tree measures 66.15m in height, and has a girth of 10.36m. These measurements were taken in the early 1960's by Dr. Kadambi, an Indian forester who invented the "Versatile Clinometer" for the measurement of tree heights. The age of this tree is estimated between 300 and 400 years. Taylor (1960) had mentioned that the emergents in the High Forest of Ghana are up to 61 m or more and he included *Triplochiton scleroxylon* among *Terminalia superba, Entandrophragma spp, Khaya spp., Ceiba pentandra, Antiaris africana, Cylicodiscus gabonensis,* and *Piptadeniastrum africanum* as the tallest emergents in the forests of Ghana. This also confirms the discussion by Hall and Swaine (1981) that the Moist Semi-Deciduous Forest of Ghana possesses tall trees.

Stratification

Some botanical investigators of tropical rain forests have described and distinguished layers or strata as one of their major physiognomic features (Cain, 1934 & 1936; Daubenmire, 1936 & 1968; Braun, 1950; Richards, 1952; Jones, 1955; Kostler, 1956; Oosting, 1956; Webb, 1959; Sukachev & Dylis, 1964; Lawson, 1966; Reiners 1967; Myers, 1980; Hall and Swaine, 1981; Mori et al., 1987; Steentoft, 1988).

Halle et al., (1978) extensively explored Richards original (1952) theory which states that trees of tropical forests grow into at least three strate, and disagreed because Richards' version of strata means these layers are continuously subject to processes of renovation and senescence. Richards, however, recently stated (Richards, 1983) that "in the mixed types of rain forest, strata are not evident, though when numbers of trees are plotted against height classes there are sometimes rather indistinct peaks at certain height classes." He further states that he now recognizes that in most types of mixed rain forest the boundaries between the strata are more or less arbitrary and cannot be objectively

defined.

Other workers have been unable to discern such layers clearly (Cain and Castro, 1959; Schulz, 1960; Grubb, et al., 1963; Paijmas, 1970). Rollet (1974) denied the existence of stratification. Stratification is therefore quite debatable among scientists, and appears convincing to some investigators in certain forests, but unacceptable or obscure to some workers in other forests. Whitmore (1990), although he does not disagree with the concept of stratification, stated that the idea is a simplification and an abstraction. Jacobs (1988) mentioned that the question of stratification has been disputed since 1920.

Smith (1973), put forward nine hypotheses to suggest an explanation for both the existence of stratification, and the apparent increase in the numbers of strata with decreasing latitude. Some of the highlights in the hypotheses of Smith (1973) are that stratification may result from : 1) periodic flushes of tree reproduction, 2) aggregation of suppressed saplings in the understorey, 3) vertical stratification of canopy foliage which may optimize utilization of light, and 4) random

aggregation of tree crowns in the vertical plane. Smith (1973) further explained that the high diversity of tree species in tropical forests might permit the aggregation of trees into three or four strata, each diverse enough to impede predation. Smith (1973) also stated that a stratification need not be uniform throughout a given forest region in order to be of selective value; i.e. strata need not occur at exactly the same heights or in the same numbers. Smith (1973) emphasized that a pattern of stratification need not be obvious to a human observer in order to be ecologically significant, and he concluded on the usefulness of stratification as : 1) helping to optimize light utilization, 2) increasing carbon dioxide concentrations within the forest canopy, 3) increasing pollination and dispersal rates within the forest, 4) reducing predation on flowers, fruits, and leaves, and 5) increasing structural integrity of the forest.

Swaine and Hall (1986) explained that stratification could only be found if trees were to increase in height quickly between strata, pausing, as it were, within each stratum. They further mentioned that strata may

be useful abstractions, but it seems unlikely that they are discontinuous. Lawson (1966) emphasized that the concept of strata is not an easy one for people other than experienced ecologists to appreciate, because the general impression of the tropical forest is of a mass of trees whose heights are apparently random.

Tansley and Chipp (1926) said that in the African rain forest "the canopy consists of three strata or tiers, whilst a fourth and lowest stratum includes the smallest trees and biggest shrubs." In almost all instances, three or more tiers are designated, primarily resulting from the diversity of tree heights and diameters. Lind and Morrison (1974) stated that the forest in East Africa is stratified, partly due to the large numbers of different species with different sizes. This idea agrees with the comment of Whitmore (1990), that stratification is not prominent in species-poor forest. Taylor (1960) mentioned that the High Forest of Ghana is stratified into three layers. Lawson (1966) described, for West African forests, three strata : 1) emergent trees which are 40-60 m tall, 2) a more continuous upper canopy of trees that are 20-40 m tall, and 3)

a dense lower canopy of trees that are about 5-20 m tall, and whose crowns vary considerably in shape. This was affirmed by Steentoft (1988) who recognized similar strata, and was further confirmed by FAO and UNEP (1981) who also described three strata of similar dimensions to those of Lawson.

With this background information, I first made careful visual inspection of the trees in the Bobiri forest for any indications of stratification. Plate 18 shows a profile of mature trees of a 55-year old intact portion of the forest, with some of its charactreristic species, suggesting degree of stratification. Using one of the methods suggested for the investigation of stratification (Lawson, 1966; Schulz, 1960; Whitmore, 1990), I plotted the diameters of all the 1000 trees against the corresponding heights (Figure 79), in order to find out if the resulting lines fell into groups that would correspond to the various strata in the forest. The results (Figure 79) suggest some form of three groups : a lower group within heights 0-20 m, a second group within 20-40 m height group, and a third (possibly emergent group) measuring 40 m or

more in height.

To further investigate this hypothesis, I plotted the heights of mature (reproductive) individuals to observe any possible groupings into strata. Most workers have used mature trees of species for such investigation, since all members of a sample would be at different stages of growth, and will consequently grow into the next stratum with time. The results in Figure 80 further support the idea of three probable strata in the Bobiri forest.

Plate 18 portrays mature trees in a section of the Bobiri forest preserved for research. This area, which has been relatively undisturbed since the reserve was demarcated 60 years ago, contains representatives of characteristic species of the forest which have reached maturity. A critical look at Plate 18 strongly suggests that the canopies fall into at least three strata, and a possible fourth stratum if a shrub layer is distinguished from smaller trees in the initial 0-20 m layer.

CHAPTER 10

BARK

Biggs et al., (1984) defined the bark as all tissues external to vascular cambium. They further explained that there are three sublayers of the bark, collectively called the periderm, which are : 1) the phellogen (cork cambium), 2) the phellem (cork), the suberized protective tissue formed outwardly by the phellogen, and 3) the phelloderm, a living parenchyma formed inwardly by the phellogen. In most woody plants, a periderm replaces the epidermis as the protective layer within the first year of growth.

Mature bark usually can be divided into an outer and an inner bark. The inner bark includes the functional phloem, i.e. the region between the most recent periderm and the vascular cambium, while the outer bark includes the dead tissue from the innermost periderm outward and may be made up of any or all of the following : cortex, phloem, and periderm. The term rhytidome is equivalent of the outer bark. In Fig. 81, I illustrate the terms used to describe bark. The outer surface of the bark, the color, and structure of the inner and outer barks, and the relative thickness of the inner and outer barks are useful features in tree identification.

In my study of the trees of the Bobiri forest, I found bark and slash characters to provide some of the most reliable characters for identification. It is true that trees may pass through changes in slash color and structure at various stages of growth. Nevertheless, many of the trees of West Africa have consistent slash characters that help in the recognition of genera and species. As Whitmore (1990) pointed out, the bark surface may be smooth, scaly, fissured, scrolled, or dippled. Such features have immense taxonomic value. Smooth barks have long, persistent surfaces, and these often house lichens which may be taxon specific, e.g., *Diospyros spp.* commonly have a dark green microlichen (Whitmore, 1990).

Some species have characteristic bark which give their boles a unique appearance. Species of *Erythrina* and *Ceiba* have spines, *Lannea welwitschii* has characteristic round patches, *Cylicodiscus gabonensis* has a very rough flaky bark, and *Ficus exasperata* possesses very smooth, shiny bark. An experienced forester can spot these trees with relative ease.

Slash

Some species have a characteristic slash which aids in their recognition. For example, members of the genus *Celtis* have unique rings and spots in their slash, *Ongokea gore* has a very brittle slash, and *Entandrophragma angolense* has soft, meaty slash (resembling corned beef). The slash may contain latex, resin, or colored sap (Whitmore 1990). Sticky, copious latex is common in the slash of members of the Apocynaceae. *Amphimas pterocarpoides* has colored, copious sap resembling blood, *Gieubourtia ehie* and *Daniella ogea* have a characteristic resin of commercial value, *Petersianthus macrocarpa* has a very fibrous, feotid-smelling slash, and species of *Erythrina* have a slash smell closely resembling the odor of green beans.

Slash characters can also be used to help recognize difficult species or genera. For example, the slash of *Cola gigantea* is thicker than that of *Cola nitida*. Both slashes turn brownish after three minutes, but *Cola gigantea* shows a much deeper brown color in the inner bark, a purplish taint in the outer bark, and is more fibrous.

Bark/Slash Thickness

A fresh slash of a tree reveals the true thickness of the bark. Dried bark specimens shrink to some extent, and therefore, do not give accurate measurements of the bark thickness. Bark thickness generally increases with increasing latitude (Smith, 1972). Bark also tends to thicken with increasing altitude (Smith, 1972). These observations point out that caution should be exercised when comparing bark thickness for different trees of the same species at different locations. The same species at different elevations or different latitudes may exhibit differences in bark thickness as a result of ecological differences rather than genetic differences. In other words, an individual of a species growing at a higher latitude and altitude may have a thicker bark than an individual of the same species growing at a lower latitude and altitude. Therefore, in making comparisons for identification, not only the age of the tree, but also the ecological conditions under which the tree grows must be taken into consideration.

As part of the collection of useful trunk features during the sampling of the Bobiri forest, the thickness of the bark was measured

for each of the 1000 trees. The thickness was measured from the sapwood outward and therefore included both the inner and outer barks.

The thickest slash was found in the Sterculiaceae and Meliaceae (14 mm in *Cola gigantea* and *Turraenthus africanus* respectively). Other thick barks were those of *Petersianthus macrocarpum* (10 mm) and *Triplochiton scleroxylon* (9 mm). The thinnest slash was found in the Ebenaceae (0.2 mm in *Diospyros monbuttensis*).

Figures 82-96 show the relation between bark thickness and tree diameter for the 29 species in the 1000 tree sample that contained ten or more individuals. The results indicate that 23 species have positive correlation, i.e., as the trees increase in diameter, there is a general corresponding increase in bark thickness. Eighteen of these had r^2 values greater than 0.5, and therefore exhibited considerable correlation. The most prominent of these are : *Carapa procera* .83, *Ficus exasperata* .78, *Entandrophragma angolense* .85, *Blighia welwitschii* .87, *Triplochiton scleroxylon* .83, *Turraenthus africanus* .69, *Rauvolfia vomitoria* .74, and *Piptadeniastrum africanum* .83. Five species had low R^2 values : *Celtis zenkeri* .39 , *Celtis adolfi friderici* .08, *Sterculia oblonga* .004, *Pterygota macrocarpa* .37, and *Myrianthus libericus* .24, implying a very

weak DBH/bark thickness correlation. This suggests that increase in trunk diameter does not have a corresponding predictable bark increase in thickness in these species with low R^2 values.

Alstonia boonei, Petersianthus macrocarpa, Ricinodendron heudelotii Sterculia rhinopetala, and *Sterculia tragacantha* showed a negative correlation. The results, on the whole, suggest that as trees grow bigger in the Bobiri forest there is a general increase in bark thickness.

External bark appearance may change as trees of the same species increase in diameter. Whitmore (1962) suggests that the barks of Dipterocarpaceae do not stop changing in appearance until trees of this family reach 30 to 40 cm in diameter. Since most of the trees in the Bobiri forest have not yet reached this size, caution must be exercised in tree identification---i.e., a small tree of a species may have deeply fissured bark. However, this kind of change only occurs in species with persistent, multiple periderms. Species with single periderms may maintain a smooth bark regardless of the size of their diameter.

Nevertheless, external bark appearance and features revealed in the slash provide excellent characters for tree identification in the Bobiri forest. These features, however, must be considered in the context of the

ecological conditions under which the tree is growing and of the size of the tree. Bark features of the 104 species I sampled in the Bobiri forest, are provided in chapter 11 (Morphological Characteristics).

CHAPTER 11

MORPHOLOGICAL CHARACTERISTICS OF THE TREES OF THE BOBIRI FOREST RESERVE

Morphological studies were done for leaves of all 104 species because of the potential use of external morphological characters in field and herbarium identification of unknown species. Primary emphasis was on leaf and slash characters which were supplemented with additional features of the bark, bole, buttress, and crown. In some instances a few ecological details were included. It must be emphasized that many morphological features of plants are subject to environmental modification and must therefore be used with caution. For example, variations may appear in individuals of species in environments more extreme than to which they are normally adapted.

These characters are particularly important because they form the future basis for the construction of a comprehensive key to the species of forest trees of Ghana based on vegetative features. With regard to the use of leaf morphology at higher taxonomic levels, Hickey (1979) pointed out "leaf morphology has remained a virtually unexploited tool

for systematic studies of the dicotyledons. This has resulted, in part, from the lack of a comprehensive and unambiguous classification of leaf morphological features and from a belief that such features respond in a relatively plastic manner to environmental forces." I found leaf features of trees of the Bobiri forest very consistent and taxonomically reliable. I see the need, therefore, to use detailed leaf morphological features to characterize trees in my sample, and thereby contribute towards the extensive use of vegetative characters to identify trees in Ghana.

I have found it necessary to add a few characters to Hickey's (1979) classification in order to be able to give a more complete description of some leaf features of African trees. These additional terms are defined in Table XXII and illustrated in Figures 97 and 98.

Enumeration of the morphological characters

A method similar to that of Roth (1984) was used to enumerate the taxonomic and ecological features of the 104 tree species sampled in the Bobiri Reserve. Roth (1984) elaborated on the stratification of trees as seen in leaf structure for a selected number of forest trees. She gave

summary of the major external and anatomical features of the leaves of each species studied.

(i) Leaves

Characters I chose were those which are: 1) easily observed in the field or lab; 2) relatively consistent among the leaves of a species; and 3) useful in the separation of taxa.

Some characters are sometimes difficult to classify. Hickey (1979) pointed out that "in some cases it is not possible to avoid being somewhat arbitrary." One of the examples he cited was the difficulty in distinguishing acute leaf apices from acuminate ones because of the transition of one to the other. I observed in the trees of the Bobiri forest that some leaf apices appeared midway between acuminate and attenuate, whilst other leaf bases were intermediate between obtuse and rounded. In addition, it is often difficult to be sure if a particular leaf base is acute or cuneate.

Howard (1979) pointed out that it is sometimes difficult to distinguish between a pinnately compound leaf and a pinnately lobed leaf.

I, for example, found the leaflets of *Ceiba pentandra* to possess very short petiolules that are slightly winged, whilst Hutchinson and Dalziel (1954-72) found them to be sessile. Hickey (1979), however, emphasized that such difficulties in character descriptions are inevitable in imposing a classification on natural features and in no way detract from the utility of doing so.

Some very useful features are absent from most leaves, but are extremely useful for distinguishing those species that possess them. A typical feature of this nature is the presence of glands. *Funtumia africana* (Apocynaceae) and *Ricinodendron heudelotii* (Euphorbiaceae) are common trees in Bobiri forest with foliar glands. Only a few trees of the Bobiri forest have glands on the leaves.

My leaf descriptions have been compared with those for the Flora of West Tropical Africa prepared by Hutchinson and Dalziel (1954-1972), Taylor (1960), Hall and Swaine (1981), and Hawthorne (1989). The latter, in particular, provides extensive information of many vegetative features that can be used to identify Ghanaian trees in the field. In some cases I have modified previuos descriptions. For example, Hutchinson and Dalziel

(1954-72) in their Flora of West Tropical Africa, mention that *Ceiba pentandra* is 8-15-foliolate, but I found many specimens with five leaflets. Moreover, they describe the maximum width of a leaflet as 4 cm, but I have encountered many specimens that are 6 cm broad. I found swollen structures that I believe are glands, about 0.5 mm in diameter, on both upper and lower surfaces of the blade of *Ceiba pentandra*, a feature which surprisingly has not been reported. Similar cases of leaf dimension differences were found for some species (e.g., 6 cm was reported as the upper limit for the width of leaves of *Kigelia africana* , but I studied specimens up to 10 cm broad). Detailed observation of leaf indumentation also revealed unreported features. For example, Hutchinson and Dalziel (1954-72) reported that *Amphimas pterocarpoides* is glabrous, but I found numerous hairs on the veins on the abaxial side as well as the petiolule that were apparent even at 10x magnification. Only the adaxial surface is glabrous. I also found hairs on the leaves of *Hymenostegia afzelii* and *Cleidion gabonicum* contrary to the glabrous descriptions of Hutchinson and Dalziel (1954-72). Hawthorne (1989) said that *Berlinia tomentella* has glabrous leaflets, but I found hairs on the

abaxial surface, petiolule, and rachis, at 12x magnification, which were not present on the adaxial side. The few stellate hairs on the abaxial surface of *Anthonota macrophylla* are easily overlooked.

Figure 99 illustrates the different kinds of hairs seen on the leaves of the trees of Bobiri forest. The three basic types are short, long, and stellate hairs with variations for different species. Examples of species with the different foliar hairs are listed at the bottom of Figure 98.

Morphometrics, by way of computer imagery, was also used to examine and compare patterns in leaf morphology. Raunkiaer (1934) described life forms of plants according to leaf size classes, and this has proved useful over the years. However, modern methods of computer imagery now allow improvements on the Raunkiaer (1934) system.

Dry leaves of the various species were selected for tracing, and the images stored on a disk using the Fourier transform based **Leaf Boundary Method** of Kincaid and Schneider (1983). For species represented by only one or two individuals, 25 leaves of variable sizes were randomly selected for tracing. For species with more individuals, a

random selection of 25 leaves was made from as many different collections as possible.

Using a Strobe model 100 plotter, the leaf images were reconstructed to scale from their Fourier coefficients. The program also gave useful leaf variables such as **area**, and **dissection index** (a ratio of the leaf perimeter to the area).

Because the program provides an average leaf image, I investigated the possibility that: 1) the average leaf images could be used to describe species, genera, and even families, and 2) that the average leaf image of all species could be used to characterize the Bobiri forest.

Average reconstructed computer leaf diagrams are shown alongside my illustrations of a typical leaf of each species at the end of the species descriptions (Figs. 99-202). Figures 203-206 shows the avearge digitized leaf image for each of the 25 families in the 1000 tree sample, and Table XXIV shows the numbers of families that possess the specific characters of leaf form, apex, base, and margin as depicted by the average family leaf image. Fig. 207 shows the average leaf image

for the whole forest. The Blow-up Factor (BF) is the scale for reconstruction.

(ii) Bark and slash

General bark texture, color, and thickness as well as specific textures and colors of outer and inner barks were carefully examined. The configuration of the outside of the bark was described in detail, including lenticel arrangement, nature of spines, roughness or smoothness, eyemarks, hoop marks, and color (See Fig 77). The cork (phellem) is the outermost suberized layer of dead cells that is next the outer bark. Between the cork and the outer bark there is, quite often, a very thin, pigmented layer of a different color from the outer bark which I refer to in the descriptions as " cover of outer bark ". The inner bark is the next inner layer after the outer bark, and comes just before the meristematic cambium (which is a one-cell thick layer of cells immediately before the sapwood).

Although the reliability and consistency of slash characters has been questioned, I found them useful taxonomically as have field workers in

Ghana. As Hawthorne (1989) remarked, the smell of a slash as well as the color is useful for field identification. The slash including its smell can be so characteristic for a particular species that with experience it is relatively easy to identify it by its slash. In Ghana, the wood of *Baphia nitida*, is used as pestle and chewing stick and the leaves are used to stop bleeding etc. These uses which exposed me to the characteristic smell of the species from my childhood, enables me to quickly identify it anywhere, or distinguish other plants with a "Baphia smell" (e.g., *Berlinia tomentella,* and *Crudia gabonensis*).

In my study a slash was made by using a sharp matchete to cut into the bark at an angle that exposed the layers for easier observation. Care was taken to turn away one's eyes during impact to avoid splashing of sap into the eyes because of the irritant or toxic nature of some saps. Constant observations were made from the first few seconds to 10 minutes and then at short intervals of several minutes up to an hour after the slash to ascertain all possible changes in color. Such observations were done on sampled trees as well as on trees outside of the sample in order to check on slash variation. Exudates were examined for their

abundance, stickiness, color consistency, smell and taste.

(iii) Tree size, trunk, and buttress

The general appearance in cross section of the bole of each tree was described (e. g., round, fluted etc.). The height of each tree was described and measured. The growth pattern also caused a bole to be characterized as either straight or crooked. In several instances the crown was also described (round, spreading etc.). The presence or absence of buttressing was also noted. The general sizes of the buttresses were usually described : Height or Tallness = upward or vertical orientation; Width = horizontal extension from trunk; Thickness = side to side dimension of a buttress, observing from the elevated top portion. See illustration in Fig. 18.

(IV) Species descriptions

The species have been grouped into the 25 families encountered in

the sample (arranged alphabetically) with family vegetative characters enumerated at the beginning. The family descriptions are for species found in Ghana and West Africa only.

The features are numbered **1-21**, with subdivisions. Numbers **1-14** deal with features of the leaf; **15-20** deal with characters of the trunk; **21** gives additional general features or characteristics.

For the height category, **H** refers to a height of 30 m or more; **h** for 10 to 29 m; **hh** for 10 m or less. For most species, the maximum attainable height (published) has been given.

Terminology used for the trunk, stem branches, and slash conform to the Flora of West Tropical Africa (Hutchinson and Dalziel, 1954-72). A few are in accordance with the descriptions of Hall and Swaine (1981) and Hawthorne (1989).

The general color for a particular slash as it appears to an observer from a close distance is given first, followed by a more detailed layer by layer analysis of the outer and inner barks. "Wood" in the text refers to the sapwood exposed by a cutlass after slashing the trunk.

Because of the fluctuating sizes and ages at which some species produce buttresses, the presence or absence of buttressing was based in part on published buttress records of mature trees especially for species represented in my sample by immature trees.

Leaf dimensions do not include the petiole, and the length of blade from base to apex is given first, followed by the width at the widest point. Terminology used for leaf characters, mainly conforms to that of Hickey (1979). Unless otherwise stated, observations of hairs and other leaf indumentation were made at 10x magnification in the field, and re-examined at 40x in the herbarium.

Table XXIII gives a summary of the numbers and percentages of species and individual trees possessing the characters of the trunk, buttresses, and leaf. Table XXIV gives a summary of the characters for the average digitized leaf images of the 25 families in the 1000 tree sample. The scientific as well as the vernacular names (in the Akan language of Ghana) are given for the tree species.

ANACARDIACEAE

Trees or shrubs. Bark usually exudes resin. Leaves usually alternate, very rarely opposite, usually pinnately compound and clustered, less frequently simple. Stipules very rarely present.

A family of 15 genera and 58 species in West Africa. There are two genera and two species in the Bobiri forest reserve.

PLATE 19

Antrocaryon micraster (Anacardiaceae)

A---Bole.

B & C----Bark and slash.


A
B
C

Family	Species	Vernacular name
Anacardiaceae	*Antrocaryon micraster*	aprokuma

1. Organization

a. Leaf Type----Compound, even pinnate.

b. Phyllotaxy----Alternate. The leaflets are opposite.

2. Shape

a. Form----Elliptic **b. Apex**----Attenuate to acuminate.

c. Base----Half obtuse, other half decurrent; apical leaves sometimes cuneate.

3. Margin----Entire; sometimes slightly crenate.

4. Glands----Absent. **5. Leaflet Size**---10-15 x 4-8 cm.

6. Petiolule----Normal; very short.

7. Hairs

a. Abaxial surface

i. Type, color and location----Erect, white, 0.2-0.5 mm long; on blade, petiolule, and rachis. Majority have curved

tips.

ii. Density---Copious and carpeting, especially on veins. Much more densely pubescent when young.

b. Adaxial surface

i. Type, color, and location----Similar to abaxial but a little shorter; those along primary and sec. veins mostly curved or a little twisted, making them look like fur.

ii. Density---Blade carpeted , especially along primary vein, giving it white color against dark green background.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Generally markedly curved; unbranched.

10. Secondary veins

a. Angle of divergence---Acute wide, nearly uniform, but those near base and apex a little more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Generally acute, but obtuse

near apex. Enclosed by tertiary arches.

d. Inter-sec. vein----Simple.

e. Number----20-25.

11. Tertiary vein

Pattern----Random reticulate

12. Higher order venation----Quaternary veins random; rest obscure.

13. Marginal ultimate venation------Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Majority quadrangular and pentagonal.

15. Bark

a. Texture, & features----Fibrous and soft; vertically fissured; outside rough. Lenticels in vertical rows, mostly along wide but shallow vertical markings. "Swollen eyemarks".

b. Color----Brown.

16. Slash

a. **Gen. Color**----Red; sometimes orange especially when young.

b. **Characteristics**----Cover of outer bark deep orange; outer bark a little brittle; inner bark red with creamy streaks, sometimes with a few orange specks, and very spongy. Slash has slight pleasant smell; resinous.

c. **Exudate**----Clear to slightly opaque, scanty, non-sticky; feels smooth when rubbed between fingers.

d. **Thickness**----About 2 mm.

17. **Wood**----Soft, cream, with thin brown streaks.

18. **Height category**----h to H. Up to 46 m.

19. **Buttressing**---- Usually not well developed or absent.

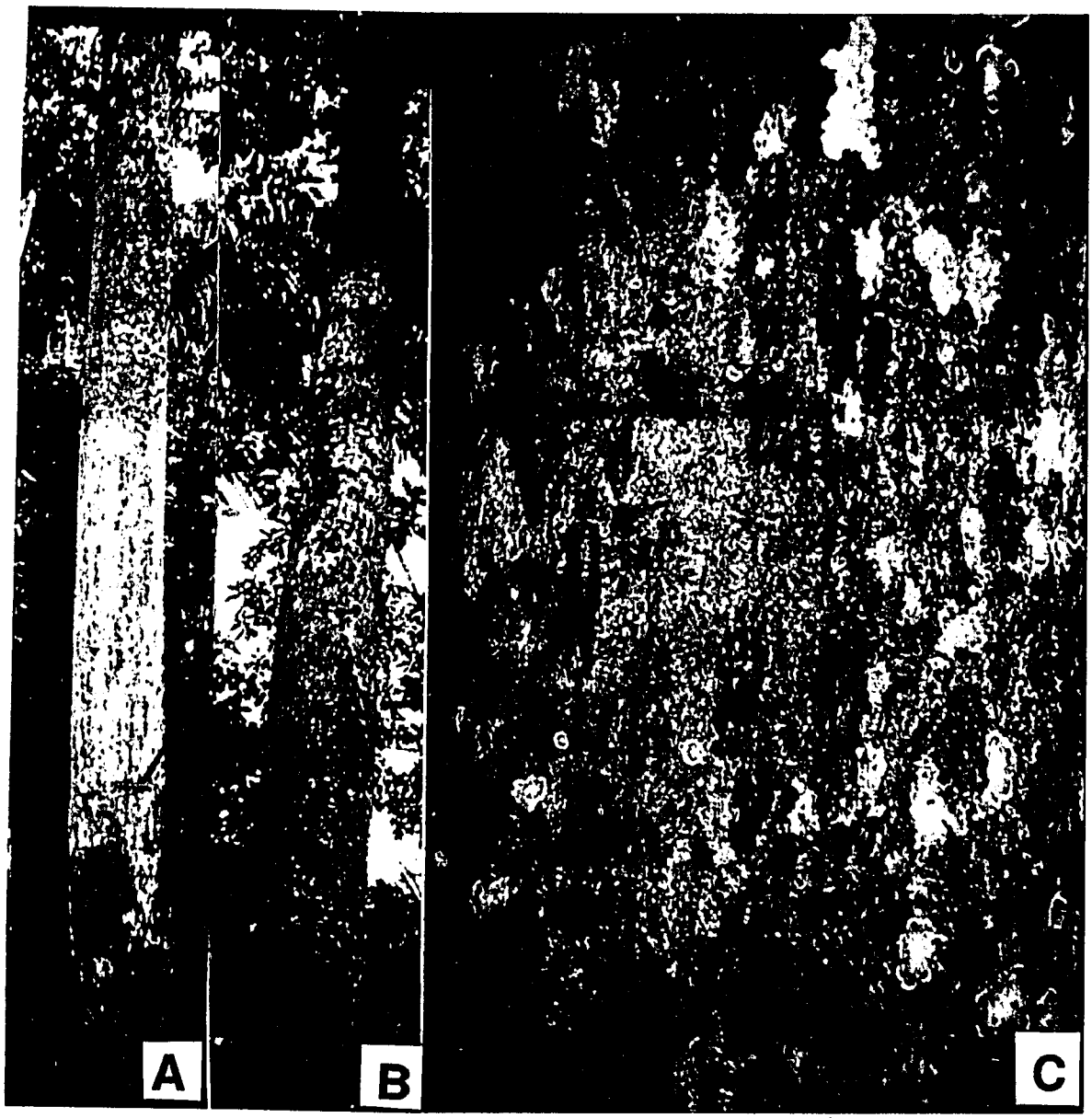
20. **Bole**----Round, crooked trunk with large bumps.

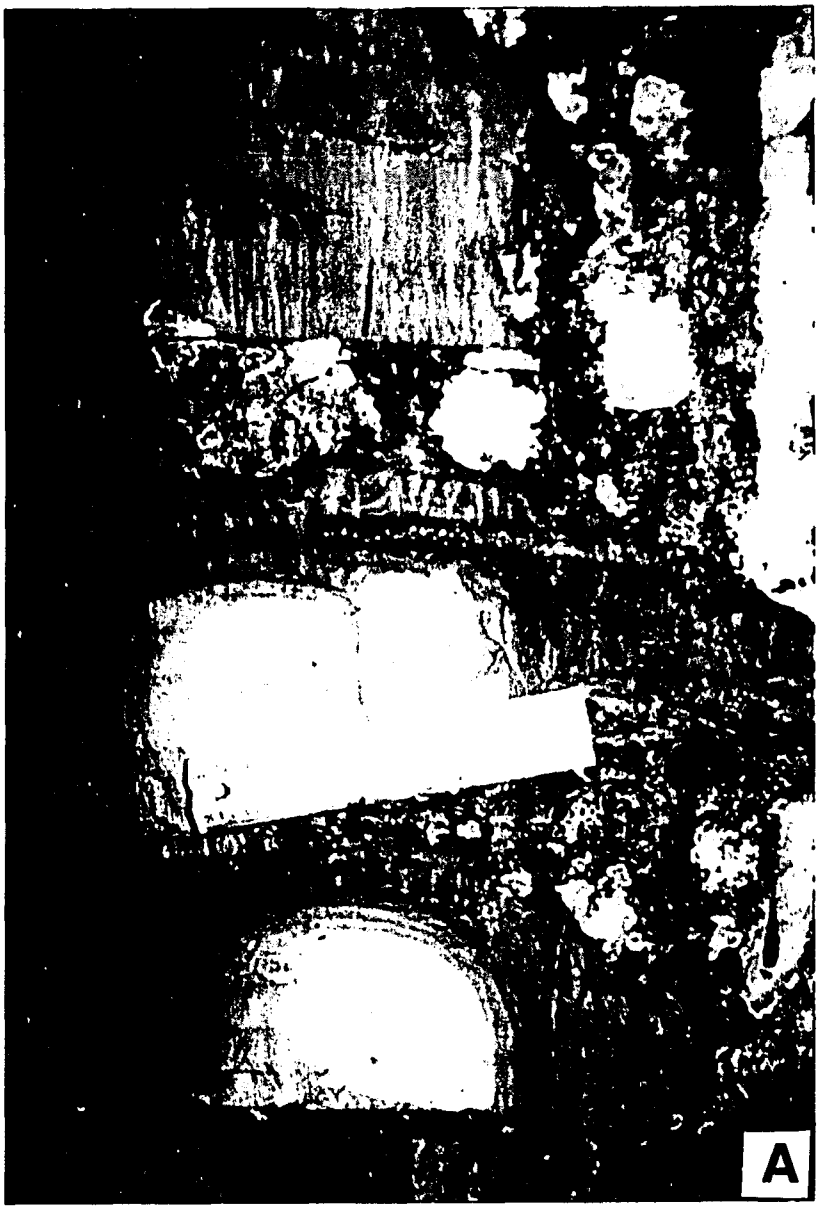
21. **Additional remarks**----Bole appearance resembles that of *Manihot*, and could easily be confused with wild *Manihot* from a distance. Deciduous leaves crowded at end of branches. Leaflets somewhat papery.

PLATES 20 & 21

Lannea welwitschii (Anacardiaceae)

20A & B----Bole. 20C----Bark. 21A----Slash.


A
B
C


A

Family	Species	Vernacular name
Anacardiaceae	*Lannea welwitschii*	kumanini

1. Organization

a. Type-----Compound, regular odd pinnate.

b. Phyllotaxy-----Alternate. The leaflets are opposite.

2. Shape

a. Form----Narrow elliptic. **b. Apex**---Acuminate.

c. Base----Cuneate.

3. Margin----Entire to slightly crenate.

4. Glands----Absent.

5. Leaflet Size----10-20 x 6-12 cm.

6. Petiole----Normal, small, slightly club-shaped. Has wrinkles with vertical striations.

7. Hairs

a. Abaxial surface

i. Type, color, and location----Erect hairs, quite short, about 0.1 mm long, found only on primary vein and scanty

on sec veins near the base; additional few brown stellate hairs on young leaves and twigs; all other veins and rest of blade glabrous.

ii. Density----Scanty, concentrated only around the base.

b. Adaxial surface----Glabrous. Cuticle of dry leaf easily peels off.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved; unbranched.

10. Secondary veins

a. Angle of divergence---Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute to right angle, enclosed by sec, tertiary and quaternary arches.

d. Inter-sec vein----Generally simple.

e. Number----5-10.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins random; rest

obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Mainly pentagonal.

15. Bark

a. Texture, & features----Very fibrous, resembles corned beef. Outside rough, with characteristic rough hollow patches (pitted) that are ellipsoid-shaped down the trunk, resulting from selective flaking of the bark. Bark sticks to wood. Very thin dark brown cork. A few hoop marks.

b. Color----Gray to whitish gray.

16. Slash

a. Gen color----Red or deep crimson-pink with whitish wavy streaks.

b. Characteristics----Outer bark reddish purple; inner bark light yellow, thinner, and browns after one minute.

Thicker outer bark browns a little after two minutes.

Relatively strong quite agreeable smell.

c. Exudate----Clear and sticky.

d. Thickness----Relatively thick; about 3-4 mm.

17. Wood----Very hard, light to deep yellow withfew brownish streaks after exposure.

18. Height category----h to H. Up to 30 m.

19. Buttressing----Usually absent, and not even fluted at base; a few individuals have small buttresses.

20. Bole----Cylindrical but sometimes twisted a little; up to 1.2 m DBH. Sometimes straight but often crooked.

21. Additional remarks----Dry leaflets are dark brown on adaxial side and paler brown on abaxial side. Veins are generally impressed or sunken. Leaves of immature tree often become constricted close to petiolules and stem when dried.

ANNONACEAE

Trees, shrubs or climbers. Usually sweetly aromatic. Bark is fibrous or spongy. The yellow to orange slash almost always darkens, has characteristic fruity scent and a peppery taste. Leaves are simple, alternate, entire, and extipulate. Small to medium sized trees, commonly found in the lower storeys of the forest.

A family of 24 genera and 113 species in West Africa. There are six species and four genera in the Bobiri forest.

Family	Species	Vernacular name
Annonaceae	*Enantia polycarpa*	duasika

1. Organization

a. Type----Simple.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Narrow elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire; sometimes slightly crenate.

4. Glands----Absent. **5. Leaf size**----10-15 x 3.5-5 cm.

6. Petiole----Normal.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Stellate mixed with simple appressed hairs, 0.1-1.0 mm long, on blade and petiole. White to light brown hairs protrude above apex for up to .8 mm. Longest hairs found on primary vein.

ii. Density----Copious on veins, especially primary vein.

b. Adaxial surface

i. Type, color, and location----Cluster of similar hairs on abaxial side, along primary vein channel alone. Rest of blade glabrous.

ii. Density----Quite dense along middle of leaf.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate apically and basally; acute wide midway; lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute. Enclosed by tertiary arches.

d. Inter-sec vein----Absent.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Predominantly quadrangular.

15. Bark

a. Texture----Smooth, generally with wide patches. Quite pliable and easily peeled off wood.

b. Color----Dark gray to blackish.

16. Slash

a. General color----Bright golden yellow.

b. General characteristics----Contoured. Presence of granular areas and wide pores, especially in the outer bark. Color remained almost the same for four years in New York after being brought from Ghana.

c. Exudate----None **d. Thickness**----3-4 mm.

17. Wood----Yellow; has strong smell that is quite agreeable.

18. Height category----h. Up to 20 m.

19. Buttressing----Absent.

20. Bole----Cylindrical; generally crooked. Sometimes flattened

1-3 m from base, after which there are protruding points.

21. Additional remarks----Venation very obscure on adaxial side.

Crown has horizontal boughs.

Family	Species	Vernacular name
Annonaceae	*Greenwayodendron oliveri*	duabiri

---

1. Organization

a. Type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to narrow elliptic.

b. Apex----Acumunate. **c. Base**----Cuneate.

3. Margin----Entire. **4. Glands**----Very minute on abaxial side.

5. Leaf size----4.5-7.5 x 10-20 cm.

6. Petiole----Normal, slender, v. short (usually less than 2 mm

long).

7. Hairs

a. Abaxial surface

i. Type, color, & location----Tiny, appressed, 0.1-0.3 mm long. On blade and petiole.

ii. Density----Scanty.

b. Adaxial surface

i. Type, color, and location----Same as abaxial side.

ii. Density----Very few; almost glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Usually straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform; lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse in older leaves but acute in younger leaves. Enclosed by sec and tertiary arches.

d. Inter-sec vein--- Generally simple.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Quite obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

Development----Incomplete.

15. Bark

a. Texture & features----Smooth. Fibrous and spongy.

Hoop marks and some eyemarks. Diamond-shaped holes.

b. Color----Dark grey to black.

16. Slash

a.General color----Yellowish to brownish orange.

b. General characteristics----Color turns dark brown after one minute. Presence of many large pores, especially in the outer bark. Strong spicy scent resembling smell of fruits of *Xylopia aethiopica* .

c. Exudate----None.

d. Thickness----1.2-1.8 mm.

17. Wood----Relatively soft.

18. Height category----hh. Better described as treelet.

19. Buttressing----Absent; fluted slightly at base.

20. Bole----Round, straight, very low branching.

21. Additional remarks---- Fresh leaves are darker green below (than upper surface). Crown is dense and dark green. The leaves are noticeably assymmetrical. Dry blade has tiny bumps, especially on primary vein (not very noticeable on adaxial side except on primary vein). Petiole has prominent bumps arranged in horizontal rows. Very young twigs and expanding leaves have dense appressed hairs.

Family	Species	Vernacular name
Annonaceae	*Mischogyne elliotiana*	

---

1. Organization

a. Type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to narrow elliptic.

b. Apex----Acuminate.

c. Base----Obtuse to slightly acute.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----8-20 x 2.5-6 cm.

6. Petiole----Normal, but a little club-shaped and hairy, with round bumps under microscope.

7. Hairs

a. Abaxial surface----Young leaves hairy; older leaves usually glabrous.

i. Type, color, & location----Appressed; up to 1.1 mm long.

ii. **Density**----Copious if present, covering whole blade.

b. **Adaxial surface**----Young leaves almost glabrous except sparse straight hairs on primary vein channel and along some secondaries nearer to junction with midvein. Older leaves glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Generally straight; sometimes markedly curved; unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute wide, nearly uniform, but sometimes lowest pair a little more acute while middle pairs approach right angle.

b. **Course**----Curved abruptly, unbranched

c. **Loop-forming branches**----Right angle to obtuse. Enclosed by secondary and tertiary arches.

d. **Inter-sec vein**----Absent.

11. **Tertiary vein**

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins orthogonal. Rest obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular or triangular.

15. Bark

a. Texture, & features----Smooth, with thin cushion-like cork. Very flexible. Has shallow, whitish, vertical streaks up to about 3.0 m from base. Flakes when old.

b. Color----Generally gray with brown taint; closer to base of trunk is dark gray when old.

16. Slash

a. General color----Cream.

b. Characteristics----Inner bark more pliable. Cream color turns dark brown after five minutes (begins after one minute).

c. Exudate----None.

d. Thickness----About 1.5 mm.

17. Wood----A little soft.

18. Height category----h. Up to 7.0 m.

19. Buttressing----Absent.

20. Bole----Looks like a dead tree 1/4 way up when old. Usually fluted to 1/10 bole height. Most often has many slender shoots from ground level to 1.0 m up.

21. Additional remarks----There is abundant hair on buds and young twigs near apex of plant. Very prominent venation on adaxial side. Leaves more or less coriaceous. Often in riverine forest.

Family	Species	Vernacular name
Annonaceae	*Xylopia quintasii*	obaa

---

1. Organization

a. Type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to slightly narrow elliptic.

b. Apex----Acuminate; sometimes slightly acute.

c. Base----Cuneate.

3. Margin----Entire; sometimes slightly crenate.

4. Glands----Absent. **5. Leaf size**----8-13 x 3-6 cm.

6. Petiole----Normal; grooved on adaxial side.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Short, appressed, 0.1-0.4 mm. Mainly on midvein and blade margin; so obscure that careful observation beyond 10x reveals them. Same hairs on petiole.

ii. Density----Sparse on blade; more abundant on buds and ring of tissue at base of petiole.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, generally uniform but lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute; enclosed by secondary and tertiary arches. Secondaries curve a little away from the margin.

d. Inter-sec vein----Absent.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture----Smooth. Easily stripped from wood. Very fibrous.

b. Color----Gray-brown.

16. Slash

a. General color----Light brown to yellow.

b. Characteristics----Darkens to brown after four minutes. Initial light brownish -yellow color is the same as the back of the wood. Strong pleasant smell.

c. Exudate----None.

d. Thickness----About 2 mm.

17. Wood----Creamy; becomes light brownish-yellow after exposure.

18. Height category----h. Up to 30 m.

19. Buttressing----Absent; sometimes fluted at the base.

20. Bole----Round, grey-brown, straight and clean.

21. Additional remarks----Leaves feel leathery; shiny under microscope, especially adaxially. Twigs have conspicuous lenticels. Slender tree.

APOCYNACEAE

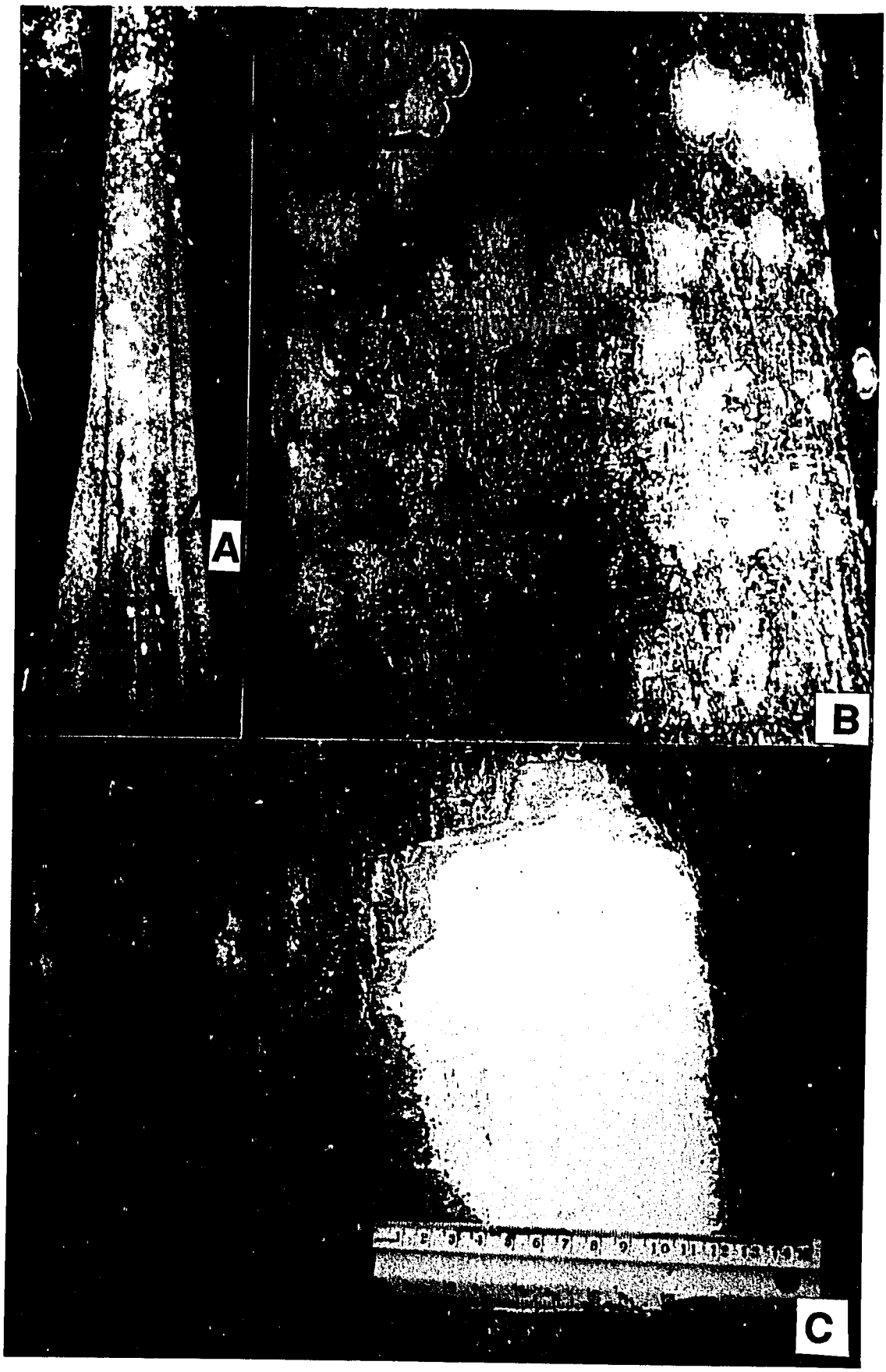
Trees, shrubs, or climbers. Leaves arranged opposite or whorl, rarely alternate, simple, entire; do not usually possess stipules. Latex is characteristic of the family.

A family of 39 genera and 140 species in West Africa. There are four genera and five species in the Bobiri forest reserve.

PLATE 22

Alstonia boonei (Apocynaceae)

A----Bole and buttresses. B----Bark. C----Slash.


A
B
C

Family	Species	Vernacular name
Apocynaceae	*Alstonia boonei*	sinuro

---

1. Organization

a. Type----Simple. **b. Phyllotaxy**----Whorl.

2. Shape

a. Form----Narrow elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate. **3. Margin**----Entire.

4. Glands----A few scattered swellings on blade, 0.3-0.4 mm in diameter, looking like glands.

5. Leaf size----7-25 x 3-11 cm.

6. Petiole----Normal but quite flattened.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Right angle, nearly uniform, but upper ones more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse.

d. Inter-sec vein----Absent. **e. Number**----30-55 pairs.

11. Tertiary vein

Pattern----Ramified; admedial.

12. Higher order venation----Quarternary veins random; rest obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Lacking.

15. Bark

a. Texture, & features----A little rough outside; Geometrical markings of cork in zig-zag pattern. Very gritty. Eyemarks on old bark. Bark of young branches has very prominent hoop marks. Very prominent big lenticels quite spaced, but some look vertcally arranged while others are distributed haphazardly.

b. Color----Brown or grey brown.

16. Slash

a. **General color**----Brownish-orange or yellow brown.

b. **Characteristics**----Outer bark brownish-orange with outside light yellow. Inner bark cream-colored. Light brown ring developed near the wood after long exposure. Smell a little repulsive.

c. **Exudate**----White copious latex, quite sticky.

d. **Thickness**-----About 0.5 mm.

17. **Wood**----Slightly hard.

18. **Height category**----h to H. Up to 40 m.

19. **Buttressing**----Present; typically tall (and arched for older trees) but with short width.

20. **Bole**----Relatively straight. Sometimes flattened near base but generally round.

21. **Additional remarks**----Tree common in disturbed forest. Branches usually three or more per node. Abaxial side of leaf paler green; adaxial side dark green. Secondary veins generally horizontal and parallel. Slash develops wide callus and heals quite well in six months.

PLATE 23

Funtumia africana (Apocynaceae)

A----Bole.

B----Leaves (showing the typical Brochidodromous venation pattern of leaves in the Bobiri forest) and mature fruit.

C----Seeds with buoyant pappus ready for air dispersal.

D----Slash.


A
B
Ozúnon
C
D

Family	Species	Vernacular name
Apocynaceae	*Funtumia africana*	okae

---

1. Organization.

a. Type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Narrow elliptic. **b. Apex**----Acuminate.

c. Base-----Cuneate to decurrent.

3. Margin----Broadly crenate.

4. Glands----Present (a classic example) as pits; 0.3-1.0 mm at primary-sec apical junctions of veins. Glands have oblong slits, and are surrounded by dark exudate.

5. Leaf size----12-28 x 3.5-12 cm.

6. Petiole----Normal but very slightly winged.

7. Hairs----Both sides of leaf glabrous except tuft of hairs (domatia) in the axils of primary-sec junction of abaxial side.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to slightly markedly curved.

10. Secondary veins

a. Angle of divergence----Acute moderate; upper more acute than lower.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute; enclosed by tertiary arches.

d. Inter-sec vein----Absent.

e. Number----6-12 pairs.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Simple and mostly convex; few retroflexed or recurved.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly opposite.

12. Higher order venation----Very obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Lacking.

15. Bark

a. Texture, & features----Brittle; outside smooth. Has few hoop marks interrupted by several prominent large eyemarks. Very many scattered lenticels, some arranged in vertical rows.

b. Color----Silvery grey to dark.

16. Slash

a. General color----Brownish to orange.

b. Characteristics----Both outer and inner bark brittle. After dark very thin cork, back of outer bark is very dark brown.

c. Exudate----White copious latex, sticking to fingers when rubbed.

d. Thickness----5-6 mm.

17. Wood----Relatively soft.

18. Height category----Usually h, but can be H. Up to 45 m.

19. Buttressing----Absent; often fluted at base.

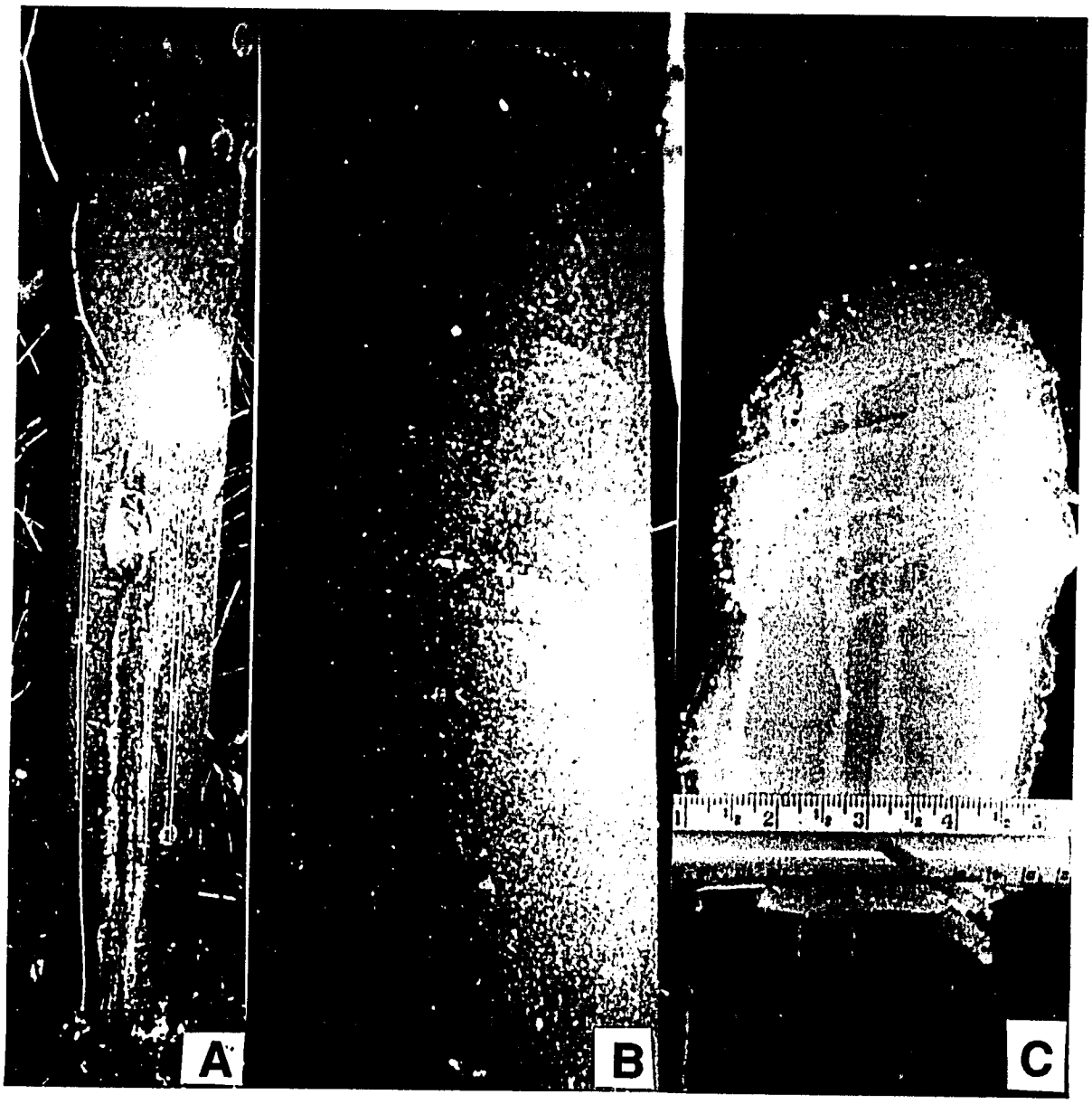
20. Bole----Round trunk, often crooked.

21. Additional remarks----All axillary buds are glabrous. Primary vein is markedly bigger than sec veins. Leaf is very brittle when dry. Slash heals poorly, with very little callus formation.

PLATE 24

Funtumia elastica (Apocynaceae)

A----Bole. B----Bole and bark. C----Slash.


A
B
C

Family	Species	Vernacular name
Apocynaceae	*Funtumia elastica*	fruntum

---

1. Organization

a. Type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Narrow elliptic. **b. Apex**----Acuminate.

c. Base----Decurrent.

3. Margin----Slightly crenate. **4. Glands**----Absent.

5. Leaf size----12-28 x 3.5-12 cm.

6. Petiole----Normal, but with slight extensions of blade on each side.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Short erect hairs (0.2-0.4 mm) in pit domatia at primary-sec junctions on apical side; a few scattered along base of primary vein. Another kind of very short erect hairs, about 0.1 mm (seen only at > 20x) on primary and secondary veins.

ii. **Density**----Sparse, and only localised around main veins.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight or markedly curved; unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute. Enclosed by tertiary arches.

d. **Inter-sec vein**----Absent.

e. **Number**----30-55 pairs.

11. **Tertiary vein**

Pattern----Percurrent.

i. **Course**----Mostly simple, some forked, generally convex.

ii. **Relation to midvein**----Oblique.

iii. **Arrangement**----Predominantly opposite.

12. **Higher order venation**----Obscure.

13. **Marginal ultimate venation**----Looped.

14. Areoles----Lacking.

15. Bark

a. Texture, & features----Smooth outside; brittle. Large eyemarks and a few hoop marks.

b. Color----Dark grey.

16. Slash

a. General color----Creamy-orange or pale brown.

b. Characteristics----Faint smell; outside of outer bark very dark brown. Inner bark appears a little creamy.

c. Exudate----White copious latex that quickly rolls into balls when rubbed between fingers.

d. Thickness----About 5 mm.

17. Wood----Creamy to very light yellow; relatively soft.

18. Height category----h. Up to 20 m.

19. Buttressing----Absent; usually slightly fluted at the base.

20. Bole----Generally round; straight near the base but often crooked near branches.

21. Additional remarks----Primary vein appears as shallow channel

on adaxial side of leaf. Branches lower than *F. africana*. Common in all forest types in Ghana.

Family	Species	Vernacular name
Apocynaceae	*Pleiocarpa mutica*	onwenma

---

1. Organization

a. Type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Elliptic to narrow elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire to slightly crenate. **4. Glands**----Absent.

5. Leaf size----8-20 x 2.5-8 cm. **6. Petiole**----Normal.

7. Hairs----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. **Angle of divergence**----Acute wide to right angle, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by tertiary arches.

d. **Inter-sec vein**----Absent.

e. **Number**----8-23 pairs.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Areoles----Imperfect.

14. Bark

a. **Texture, & features**----Brittle; slightly rough. Scattered small lenticels. A few hoop marks.

b. **Color**----Grey-brown.

15. Slash

a. **General color**----Light brown to orange.

b. **Characteristics**----Outer bark gritty and orange-brown; inner

bark more cream-colored.

c. Exudate----White latex, quite sticky.

d. Thickness----1-2 mm.

17. Wood----Quite hard, light brown.

18. Height category----hh. Up to 8 m.

19. Buttressing----Small buttresses sometimes present.

20. Bole----Crooked.

21. Additional remarks----Small tree, usually in understorey or swamp. Crown spreads out. Can be as short as one meter. Venation very conspicuous.

PLATES 25 & 26

Rauvolfia vomitoria (Apocynaceae)

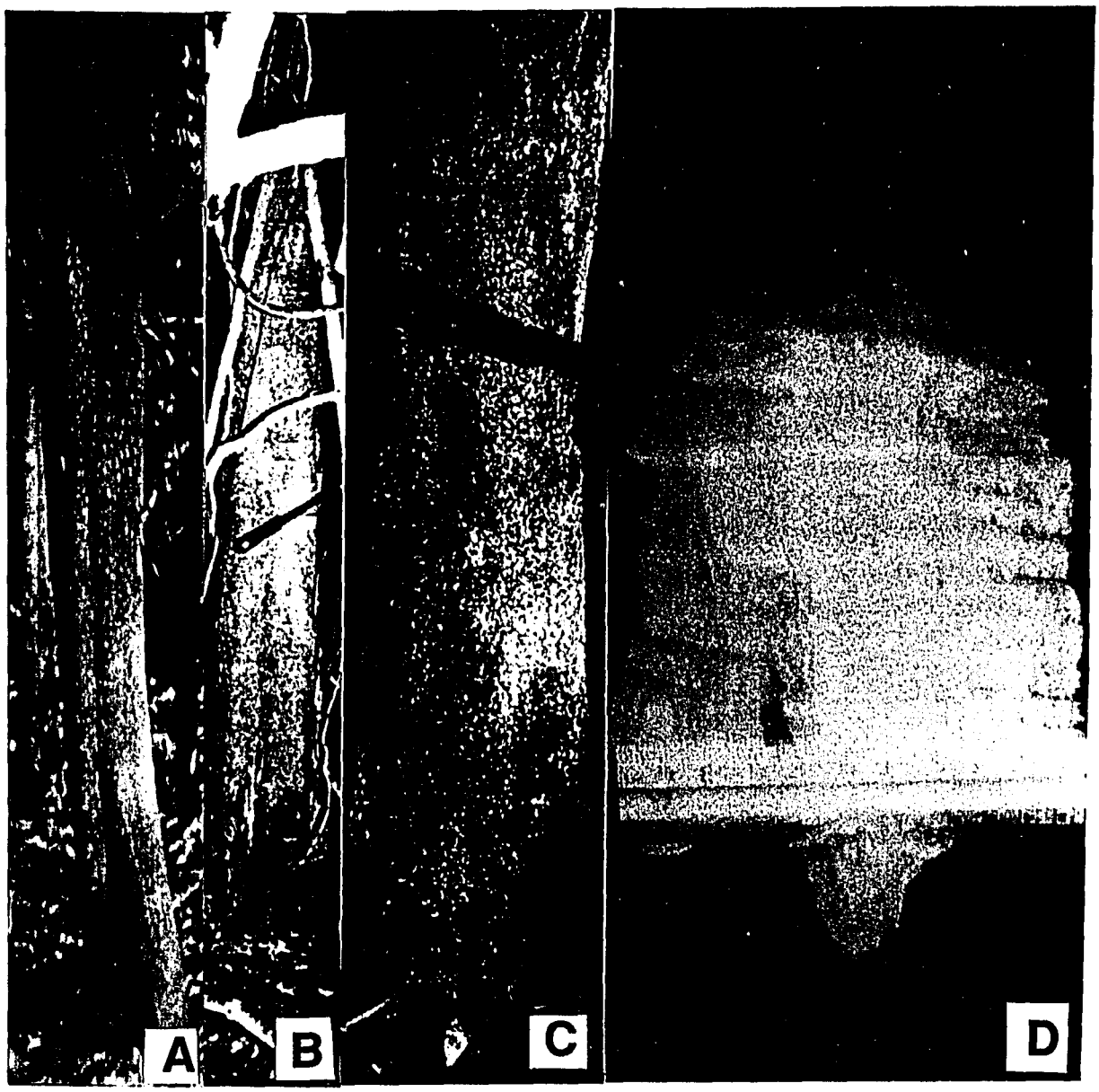
25A----Leaves and fruit.

25B----Bark.

26A, B & C----Bole.

26D----Slash.


A
B


A
B
C
D

Family	Species	Vernacular name
Apocynaceae	*Rauvolfia vomitoria*	kakapenpen

---

1. Organization

a. Type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Narrow elliptic. **b. Apex**----Attenuate.

c. Base----Decurrent to cuneate.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----8-24 x 3-10 cm.

6. Petiole----Normal, but blade extends narrowly to short distance.

7. Hairs----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Right angle. Nearly uniform; lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches---Right angle; enclosed by secondary and tertiary arches.

d. Inter-sec vein----Simple.

e. Number----8-16 pairs.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect; seen to some extent only in very young leaves; lacking in older leaves.

15. Bark

a. Texture, & features----Outside slightly rough due to lenticels. Brittle. Bark splits where bumps appear on bole. Presence of very prominent lenticels, scattered generally, but many in vertical or spiral rows. Presence of hoopmarks.

b. Color----Grey-brown.

16. Slash

a. General color----Light brownish-orange.

b. Characteristics----Color turns more brownish after four minutes. Outer bark yellowish-brown and brittle; inner bark cream-colored and pliable. Faint, pleasant smell.

c. Exudate----None.

d. Thickness----About 1.5 mm.

17. Wood----Creamy-yellow hardwood.

18. Height category----hh to h. Up to 16 m.

19. Buttressing----Generally absent, but trunk fluted.

20. Bole----Usually triangular near base, but rest of trunk round. Deeply fluted to at least 2 m up the trunk. Bole has rough bumps. Swollen points of wood near crown and on branches.

21. Additional remarks----Sun-loving tree of disturbed forest. Leaves thin and papery. Primary vein far larger than secondary veins which appear rather buried in lamina. Adaxial side darker green than the light green abaxial side. Primary vein seen as shallow channel on adaxial side. Vasculature more apparent in new leaves.

BIGNONIACEAE

Family of trees, shrubs and sometimes climbers. Leaves opposite (rarely alternate), mostly compound (digitate or pinnate), with a terminal odd leaflet that is sometimes tendril-like in the climbers. Stipules absent, but some genera have pseudostipules. Some species possess leaflets with basal glands. Rachis usually smooth. Have characteristic showy flowers and often grown for ornamental purposes.

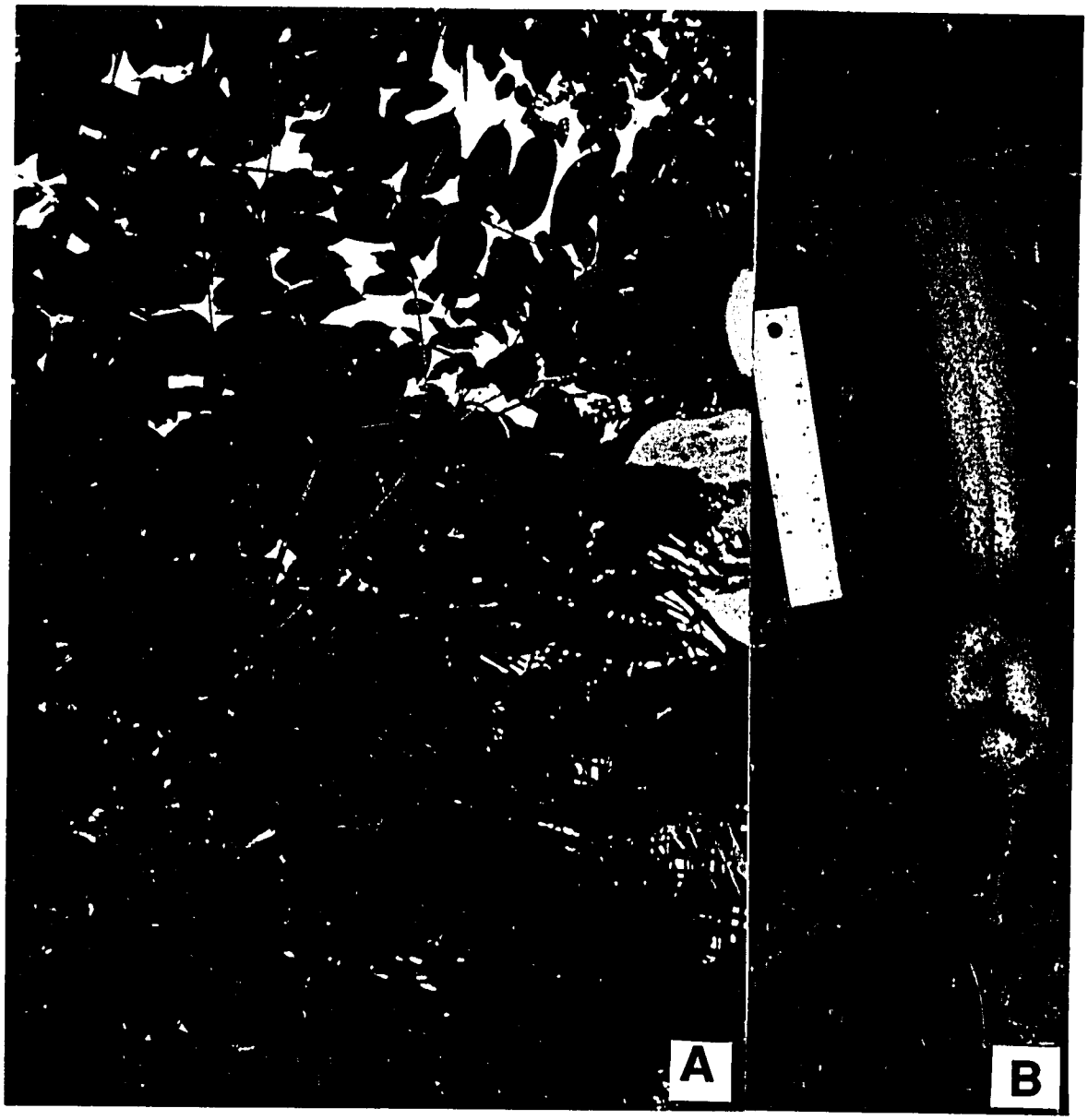
A family of six genera and eight species distributed in West Africa. In Ghana, the family is represented by well-known flowering trees, 12 of which are introduced, some native to Africa, e.g. *Spathodea campanulata.* In the Bobiri forest there are two genera and two species.

PLATE 27

Kigelia africana (Bignoniaceae)

A----Branches, leaves, and young fruit.

B----Mature fruit.


A
B

Family	Species	Vernacular name
Bignoniaceae	*Kigelia africana*	nufuten

---

1. Organization

a. Type----Compound leaf; odd pinnate.

b. Phyllotaxy----Opposite.

2. Shape

a. Form----Elliptic to slightly narrow ovate.

b. Apex----Acuminate. **c. Base**----Cuneate.

3. Margin----Entire to slightly crenate or serrate near apex.

4. Glands----Tiny numerous glands on both sides of blade, primary vein and petiolules; glands also on rachis but bigger (visible), up to 2 mm long and 1.5 mm wide towards base of rachis (resembling scar tissue).

5. Leaf size----Whole leaf up to 50 cm long; leaflets up to 20 cm long and 10 cm broad.

6. Petiole----Normal. **7. Hairs**----Both surfaces glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform, lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Generally right angle; slightly obtuse near apex.

d. Inter-sec vein----Absent. **e. Number**----7-12 pairs.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Mostly simple; few forked; majority convex, some concave, few recurved.

ii. **Relation to midvein**----Oblique.

iii. **Arrangement**----Predominantly opposite.

12. **Higher order venation**----Quarternary veins orthogonal; rest obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**

a. **Development**----Well developed.

b. **Shape**----Quadrangular or pentagonal.

15. **Bark**

a. **Texture, & features**----Smooth; quite pliable and fibrous. Quite shiny.

b. **Color**----Grey, sometimes with greenish taint.

16. **Slash**

a. **General color**----Creamy-light orange to grey-green sometimes.

b. **Characteristics**----Outer bark orange to greenish-grey; inner bark creamy. Slight smell. Usually darkens through different shades of green.

c. Exudate----None.

d. Thickness----About 3 mm.

17. Wood----Relatively soft.

18. Height category----h to hh. Up to 15 m.

19 Buttressing----Generally absent.

20. Bole----Generally round, crooked.

21. Additional remarks----Small to medium sized tree with low branching. The "Sausage Tree", so called because pendulous fruits up to 35 cm long, look like large sausages. Grows commonly in wet places of the forest.

PLATES 28 & 29

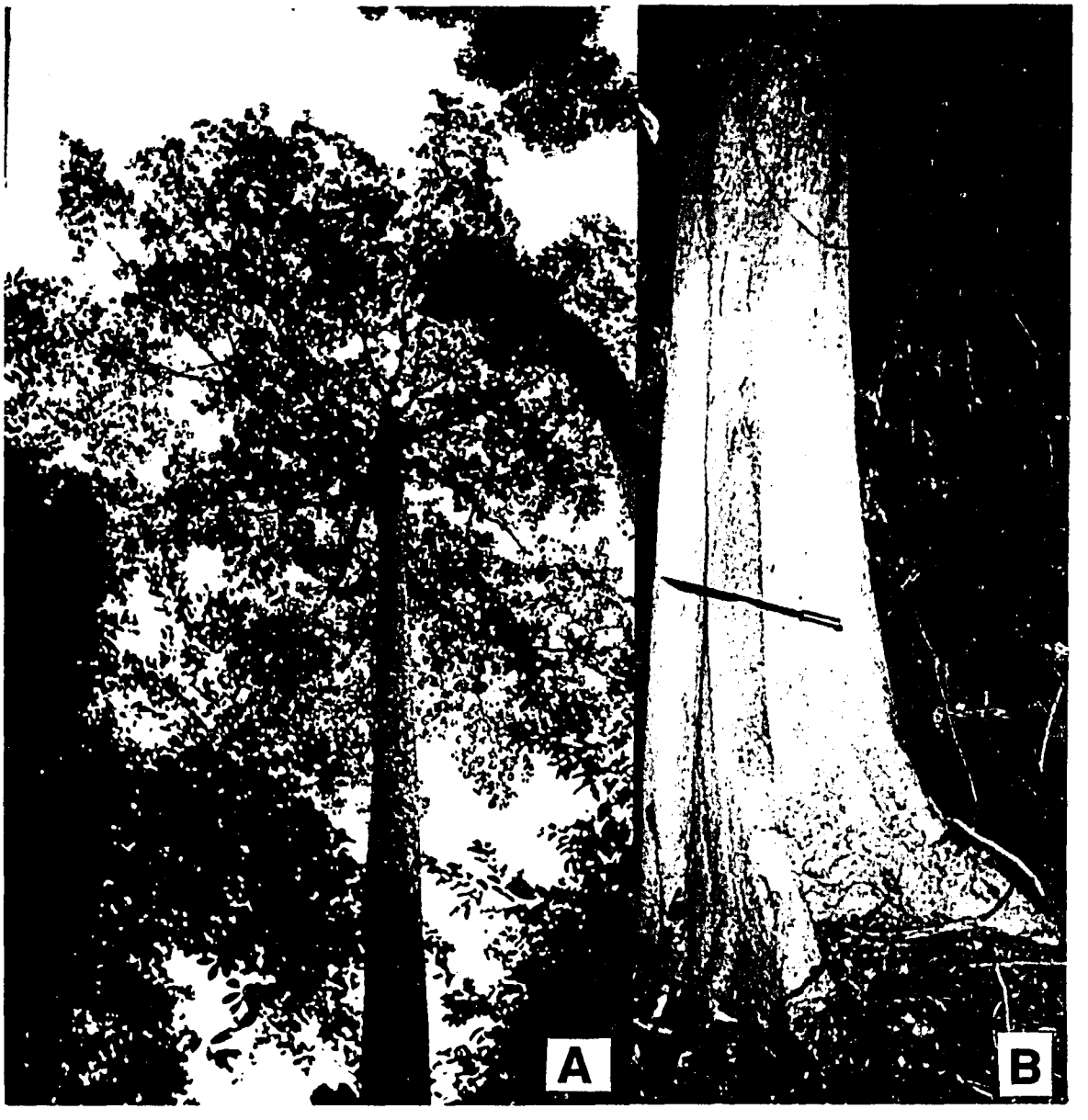
Spathodea campanulata (Bignoniaceae)

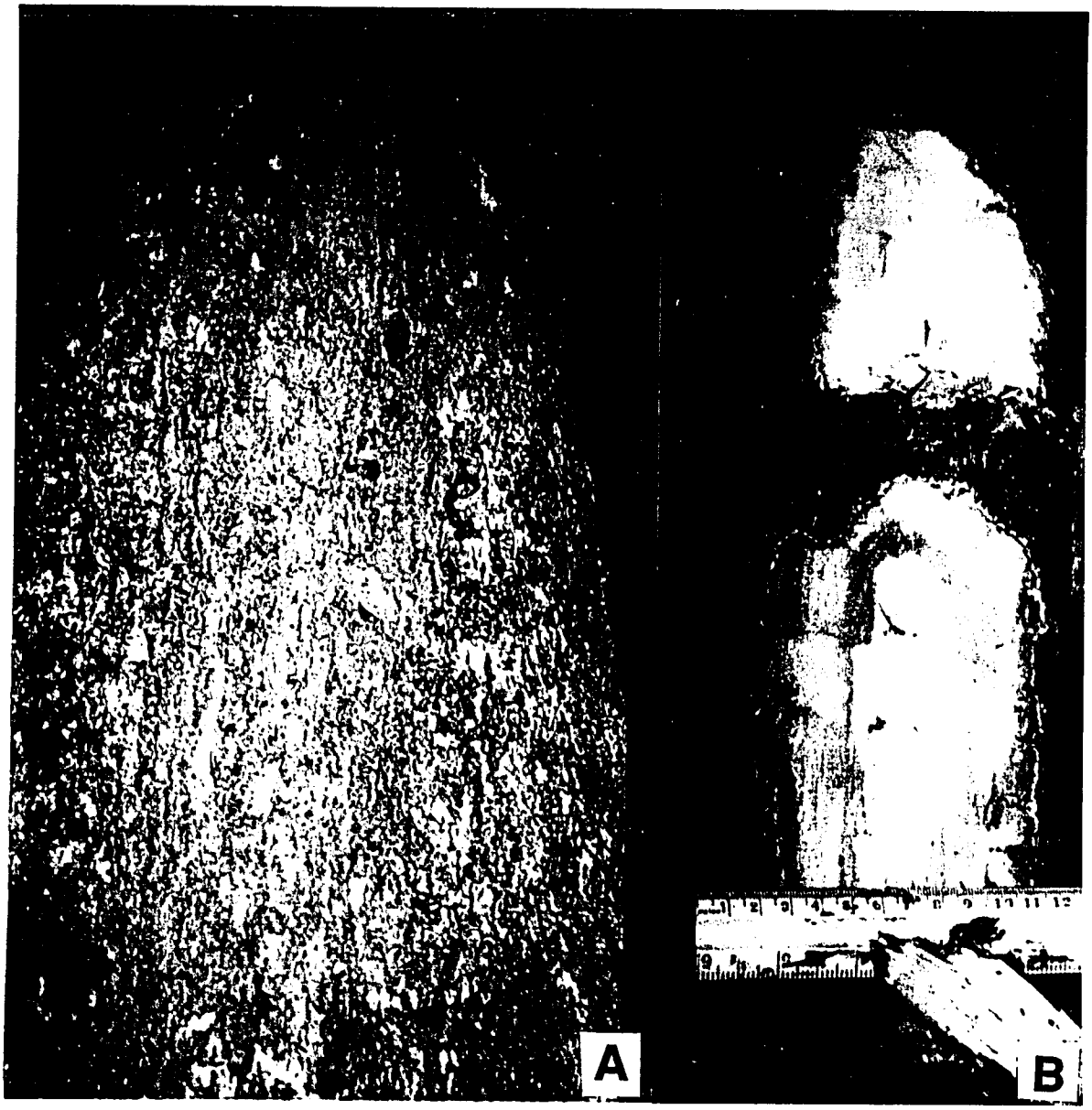
28A----Bole and crown.

28B----Bole and buttresses.

29A----Bark.

29B----Slash (above--after 10 seconds; below--after one minute).


A
B


A
B

Family	Species	Vernacular name
Bignoniaceae	*Spathodea campanulata*	akuakuo-ninsuo

---

1. Organization

a. Type----Compound. Regular odd pinnate.

b. Phyllotaxy----Leaflets opposite, 4-8 pairs.

2. Shape

a. Form----Narrow elliptic. **b. Apex**----Acuminate.

b. Base----Decurrent to cuneate.

3. Margin----Entire; slight signs of crenations.

4. Glands----Present as visible elliptic protrusions, seen as white spots on dry material around base of rachis (a few along it's length). Large gland at base of leaflet.

5. Leaf size----Compoud leaf up to 45 cm long; leaflets up to 7 cm broad and 17 cm long.

6. Petiole----Normal, short. Lamina extends slightly as a "lip" on two sides.

7. Hairs

a. Abaxial surface

i. Type, color, and location----Short appressed hairs about 0.1-0.2 mm long on primary and secondary veins (and some intercostal areas) at 10x magnification. Another type of hairs, very short (seen only as tiny dots at 10x), a little more visible at 20x (0.05-0.1 mm).

ii. Density----Slightly longer hairs scanty; shorter hairs more abundant.

b. Adaxial surface

i. Type, color, & location----Appressed hairs 0.1-0.2 mm on all veins. Shorter hairs along grooves of primary and sec veins and base of tertiaries. Tiny dot-like hairs around rachis.

ii. Density----Longer hairs very few; shorter hairs quite dense.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute wide. Relatively uniform;

lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----About right angle from base to 3/4 way up; obtuse near apex. Enclosed by tertiary and quarternary arches.

d. Inter-sec vein----Absent.

e. Number----6-12 pairs.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Majority simple; some forked; many convex.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly opposite.

12. Higher order venation----Quarternary vein random; rest obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Pentagonal or polygonal.

15. Bark

a. **Texture, & features**----Fairly smooth when young, but becomes rough and scaly with age. Fissured and fibrous. Has deep vertical slits when old (characteristic striations of flaking bark and vertically arranged lenticels). About 0.5-1.0 mm cork that can be felt like cushion.

b. **Color**----Light brown or brownish-grey.

16. **Slash**

a. **General color**----Cream.

b. **Characteristics**----Becomes slightly grey with light green taint after one minute, and changes to grey in 15 minutes. Back of creamy wood also becomes light grey, and gets more grey after long exposure. Outer and inner barks both cream-colored; inner bark near wood becomes darker grey after long exposure. Cover of outer bark behind cork cream with green streaks. Smell quite strong and agreeable.

c. **Exudate**----None.

d. **Thickness**----2-3 mm.

17. **Wood**----Creamy, soft.

18. Height category----hh to h. Up to 22 m.

19. Buttressing----Present; higher up the stem than wider.

20. Bole----Very much fluted, sometimes up to 4 m up. Quite often straight near base , but crooked nearer branches.

21. Additional remarks----Opposite leaves are sometimes unequal in each pair. Bears conspicuous flaming inflorescence (named the African Tulip Tree). In flower, can be easily confused with *Delonix regia* (Caesalpiniaceae) from a distance. Often planted, but also occurs naturally in fringing forest. Base of light green rachis darkens when dry, with slight constriction.

BOMBACACEAE

Small family of trees. Leaves simple or digitate, alternate, often lepidote. Stipules deciduous. Branches arise in whorls on the stem. Trees are sometimes very large, and can be huge emergents, which can be seen from a distance towering above the canopy of the forest. The three known genera of Ghanaian forests are all deciduous.

A family of three genera and six species in West Africa. Two genera and four species are found in the Bobiri forest.

PLATES 30 & 31

Ceiba pentandra (Bombacaceae)

30A----Whole tree. 30B----Bole (with spines) and buttresses.

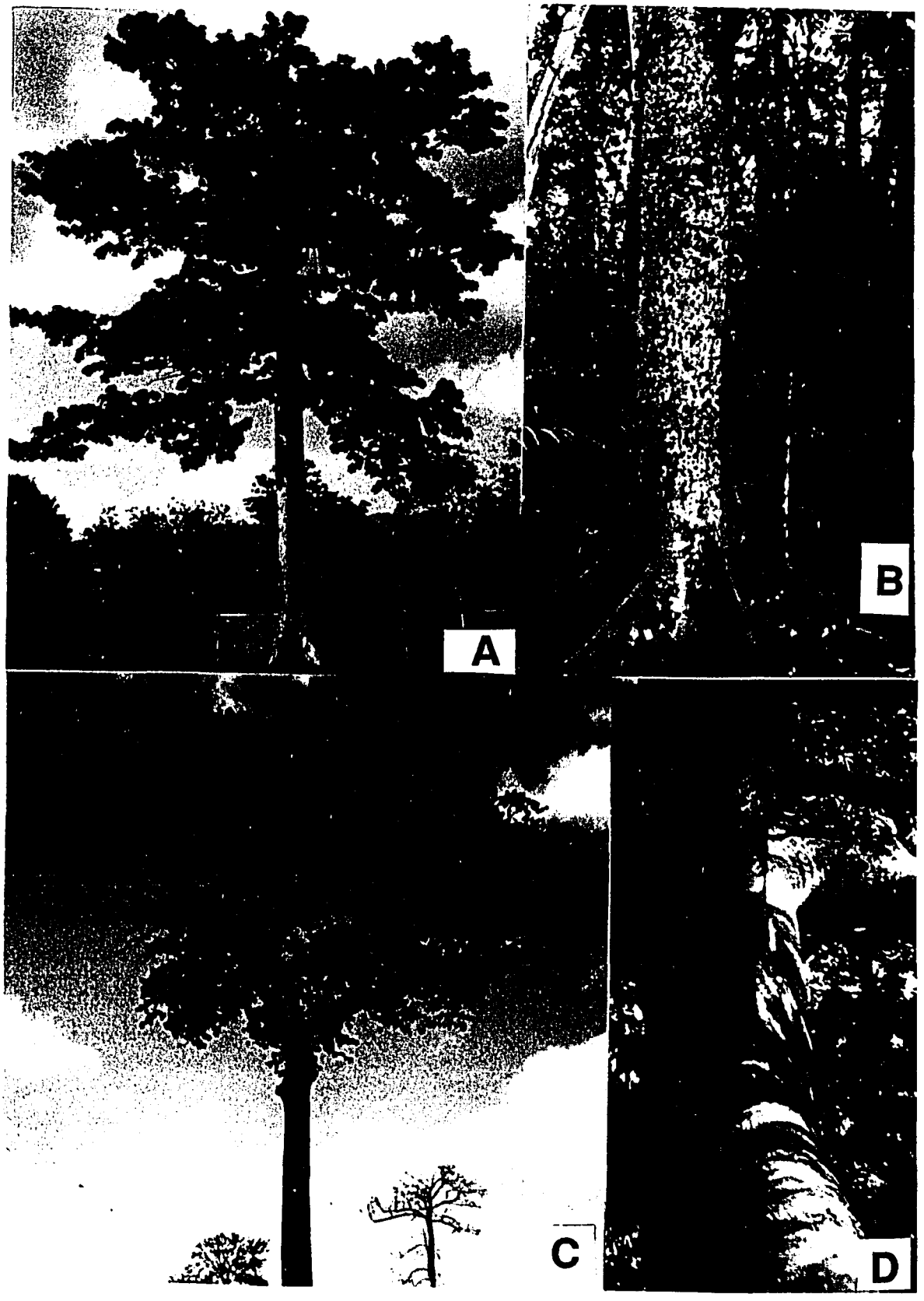
30C----Crown showing deciduousness (older leaves still on branches on the left and new leaves growing after old leaves fell from branches on the right).

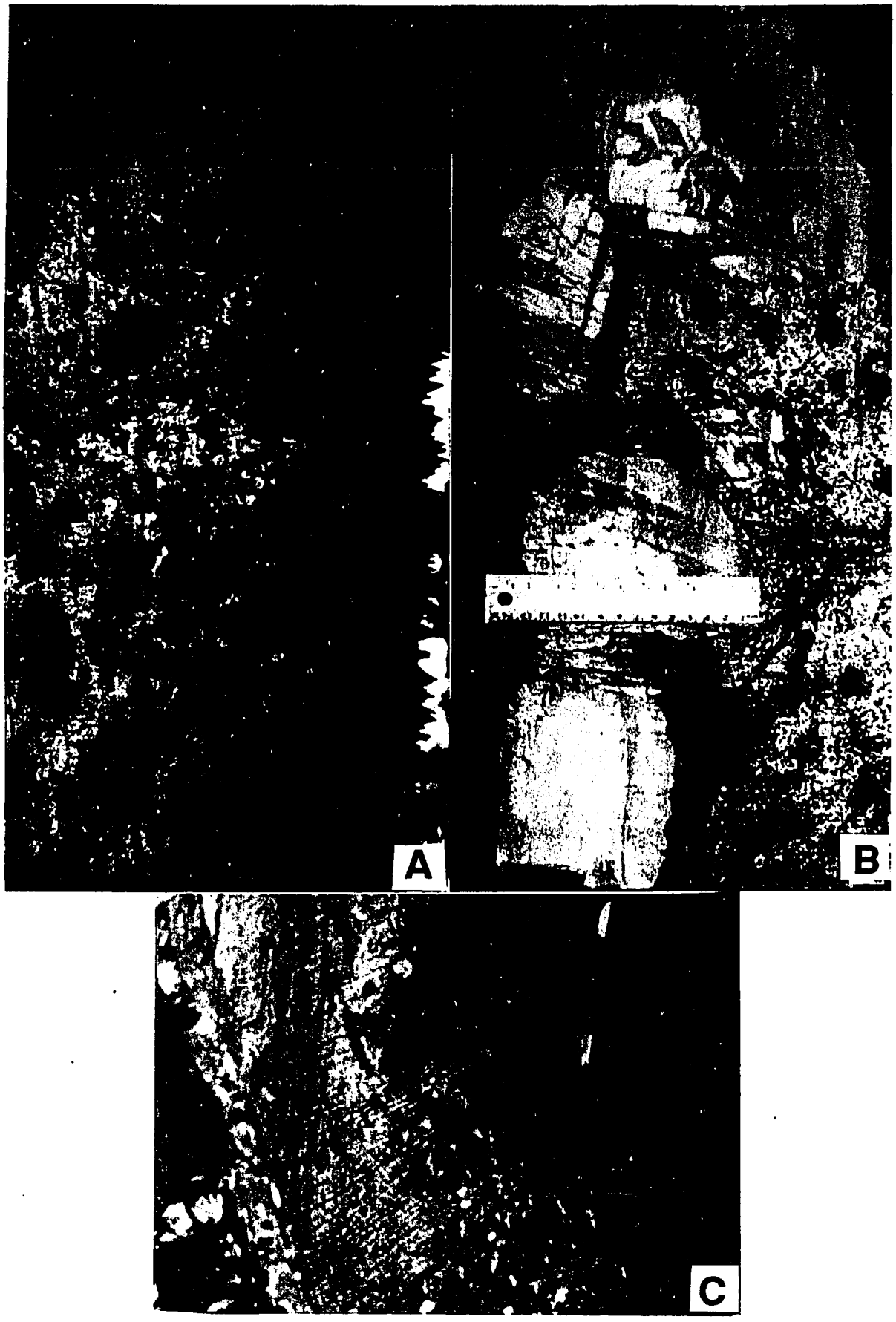
30D----Bole and bigger branches without spines near the crown.

31A----Bark and spines.

31B----Slash (below--after five seconds; above--after 30 seconds).

31C----Buttress showing hoop marks and spines.


A
B
C
D


A
B
C

Family	Species	Vernacular name
Bombacaceae	*Ceiba pentandra*	onyina

---

1. Organization

a. Type----Digitately compound (Palmate); 5-14 leaflets.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Narrow elliptic. **b. Apex**----Acuminate.

c. Base----Decurrent to cuneate.

3. Margin----Entire.

4. Glands----Present on blade, scattered on both sides, about 0.5 mm in diameter.

5. Leaf size----10-20 cm x 3-6 cm.

6. Petiole----The very short petiolule is slightly winged, with the blade extending narrowly to the base and joining on the adaxial side. Some workers (e.g., Hutchinson and Dalziel, 1954-72) describe the leaflets as sessile.

7. Hairs----Both sides of leaf and rachis glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate to wide; Lower pairs more obtuse.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by tertiary and quarternary arches.

d. Inter-sec vein----Composite.

11. Tertiary vein

Pattern----Percurrent.

i. Course----All forked, majority sinuous, a few convex.

ii. Relation to midvein----Mostly oblique; some right angle.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quarternary veins random; rest obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular or polygonal.

15. Bark

a. Texture, & features----Very fibrous and hard. Except for sharp prominent spikes, rest of bark is smooth. Spines more common on younger bark. Spines could be distributed along the whole length of the stem and even on projected top of buttresses (flattened sides of buttresses have no spines; sometimes buttresses and bark of some old trees have no spines at all). Near the base spines are very sharp and bigger than after 1/3 way up all the way to the bramches when they become smaller (some 1/3 the size of those below). Most spines have their sharp points curving upwards; a few are forked. Part of the soft cork tissue surrounds base of spine as if it broke through the bark. Smooth areas have shallow vertical markings (slits up to 0.5 cm wide).

b. Color----Gray, with an often greenish tint, especially on young twigs. Very young barks look more greenish.

16. Slash

a. General color----Cream with wide pinkish streaks.

b. Characteristics----Initially, there is a brittle outermost layer which is pinkish-brown, followed by a creamish layer, then an inner very fibrous bark that is purplish-cream. Behind the thin cork, the back of the outer bark is purple with green streaks. After 5 secs browning begins, and is completed after 3 minutes; then the outer bark becomes brown with yellow-brown streaks, while the inner bark becomes completely brown. The slippery back of the wood also becomes brown. Has agreeable, moderate smell.

c. Exudate----None.

d. Thickness----About 10 mm.

17. Wood----A little soft, white. Also browns after 3 minutes.

18. Height category----H. Up to 61 m.

19. Buttressing----Possesses convex buttresses that can be as tall as 15 m (Hall and Swaine, 1981).

20. Bole----Sometimes flattened slightly near the base; usually

cylindrical and straight, but sometimes older trees have slightly twisted trunks, and a little bent near the crown 3/4 way up.

21. Additional remarks----A species with classic examples of inter-secondary veins (present in almost every intercostal area). Tree planted in towns and villages in West Africa. sometimes cultivated. Dry fruit produces characteristic white Kapok which is eight times as light as cotton; fiber is remarkably water-repellent; each comprises a single air-filled cell wich helps disperse the seeds by the wind. Leaflets radiate from long stalk. Very common in secondary forest.

CAESALPINIACEAE

Trees or shrubs. Very rarely herbs or scramblers. Leaves pinnate or bipinnate, rarely simple. Flowers mostly showy.

Family of 58 genera and 181 species in West Africa. There are nine genera and 12 species in the Bobiri forest reserve.

PLATES 32 & 33

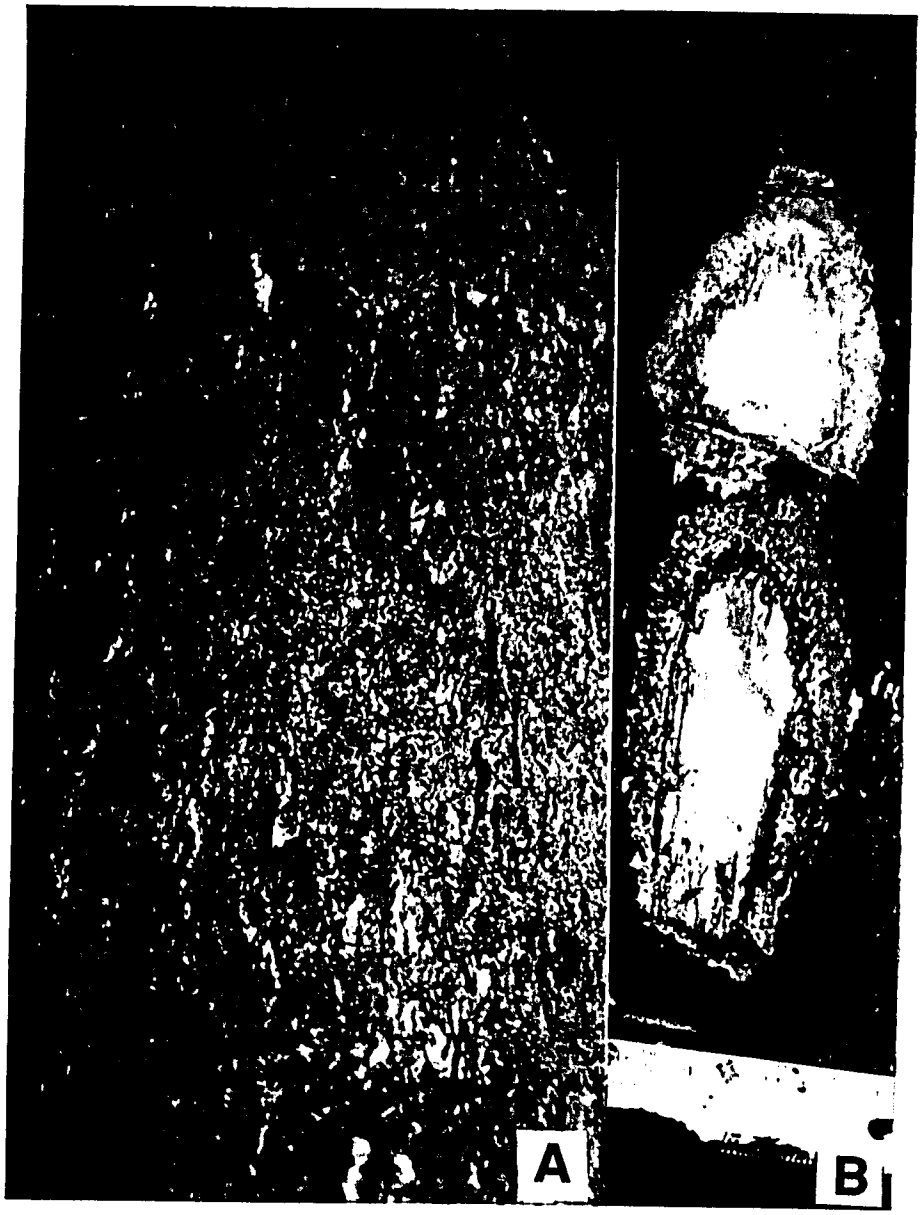
Amphimas pterocarpoides (Caesalpiniaceae)

32A----Bole and buttresses. 32B----Bole and crown.

33A----Bark.

33B----Slash (above--after five seconds; below--after 30 seconds).


A
B


A
B

Family	Species	Vernacular name
Caesalpiniaceae	*Amphimas pterocarpoides*	yaya

---

1. Organization

a. Leaf type----Compound, regular odd pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite or subopposite.

5-6 pairs.

2. Shape

a. Form----Narrow ovate to lanceolate. **b. Apex**----Attenuate.

c. Base----Cordate. **3. Margin**----Entire.

4. Glands----Absent. **5. Blade size**----6-16 cm x 2-7 cm.

6. a. Petiolule----Normal; quite short with dense hairs.

b. Rachis----Very hairy.

7. Hairs

a. Abaxial surface

i. Type, color & location----Erect, soft, easily bent,

reddish-brown; usually on primary and sec veins.

ii. Density----Fewer on blade; dense on petiolule and bigger

veins.

b. Adaxial surface----Generally shiny and glabrous except for a few hairs in the primary vein channel near the base.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform, but lowest pair more obtuse (nearly at right angles).

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Variable; acute below, right angle midway, obtuse near apex. Enclosed by sec and tertiary arches, forming intramarginal vein.

d. Inter-sec vein----Composite.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Forked, sinuous.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quarternary veins orthogonal; rest obscure.

13. Marginal ultimate venation----Looped, with a **fimbrial vein.**

14. Areoles

a. Development----Well developed.

b. Shape----Majority quadrangular and pentagonal.

15. Bark

a. Texture, & features----Fibrous to brittle, thick, soft, and quite gritty. Outside rough. Scattered lenticels. Presence of rectangular fissures.

b. Color----Gray-brown, often with light green taint.

16. Slash

a. General color----Orange to brownish or yellow-brown.

b. Characteristics----Cover of outer bark creamy-yellow ; yellow ring between inner and outer barks; inner bark creamy-orange with black dots, then cream-colored layer with reddish dots near wood. Relatively strong smell.

c. Exudate----Blood-red; non-sticky, flows after a few secs,

only from dark red spots of inner bark near wood .

After 5 mins plant looks like it is bleeding slowly, this continues for several hours; after 24 hours the trunk has blood-like stains.

d. Thickness----2 mm.

17. Wood----Moderately hard; creamy-light yellow.

18. Height category----H. Up to 46 m.

19. Buttressing----Present. Thick and short in appearance.

20. Bole----Usually straight; sometimes crooked near crown. Round, fluted at the base when young, without buttress.

21. Additional remarks----The only species of the genus so far reported from West Africa. Clusters of hair on leaf resembles animal hairs with pointed tips. Young stout twigs have copious brown hairs and pronounced stipules that leave hemispheric scars at nodes. Stipels filiform, about 7 mm long. Several bees collect exudate from trunk a day after slashing. Crown quite flattened and spreading.

Family	Species	Vernacular name
Caesalpiniaceae	*Anthonotha macrophylla*	totoro

---

1. Organization

a. Leaf type----Compound, even pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite. Usually 3-4 pairs.

2. Shape

a. Form----Elliptic. Apical pair narrowly elliptic and much elongated.

b. Apex----Acuminate. **c. Base**----Cuneate to acute.

3. Margin----Entire; sometimes with slight crenations.

4. Glands----Absent. **5. Blade size**----Up to 30 x 12 cm.

6. a. Petiolule----Normal, but slightly enlarged and wrinkled, with a few vertical ridges and bumps.

b. Rachis----Has thin lines of vertical ridges. Brown base is wrinkled, swollen, and has same configuration and hairs as petiolule; rest of rachis quite smooth, glabrous (up to 40x) and

whitish with brown patches similar to those found on stems. Careful examination of rachis reveals brown patches as areas with very short tiny erect hairs, seen only after 40x magnification.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Stellate, up to 8 arms and 0.3 mm diameter mixed with erect hairs. Mostly near base of blade, on primary vein, petiole, and some intercostal areas.

ii. Density----Both types few. Stellate hairs so few that they may be overlooked. Erect hairs seen only after 20x. Greater part of blade glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Generally straight; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute; a little obtuse near apex. Enclosed by tertiary arches.

d. Inter-sec vein----Simple.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Gritty and fibrous. Has scattered lenticels. Outside smooth.

b. Color----Gray with white taint.

16. Slash

a. General color----Creamy-light brown, orange-brown or red.

b. Characteristics----Sometimes has brown contours. Turns dark brown after 4 mins. Strong pleasant smell.

c. Exudate----Light brown.

d. Thickness----About 2 mm.

17. Wood----Creamy-light yellow to light orange hardwood.

18. Height category----hh to h.

19. Buttressing----Usually absent; fluted at base.

20. Bole----Round, crooked, smooth. Has scattered lenticels. Often with many adventitious shoots.

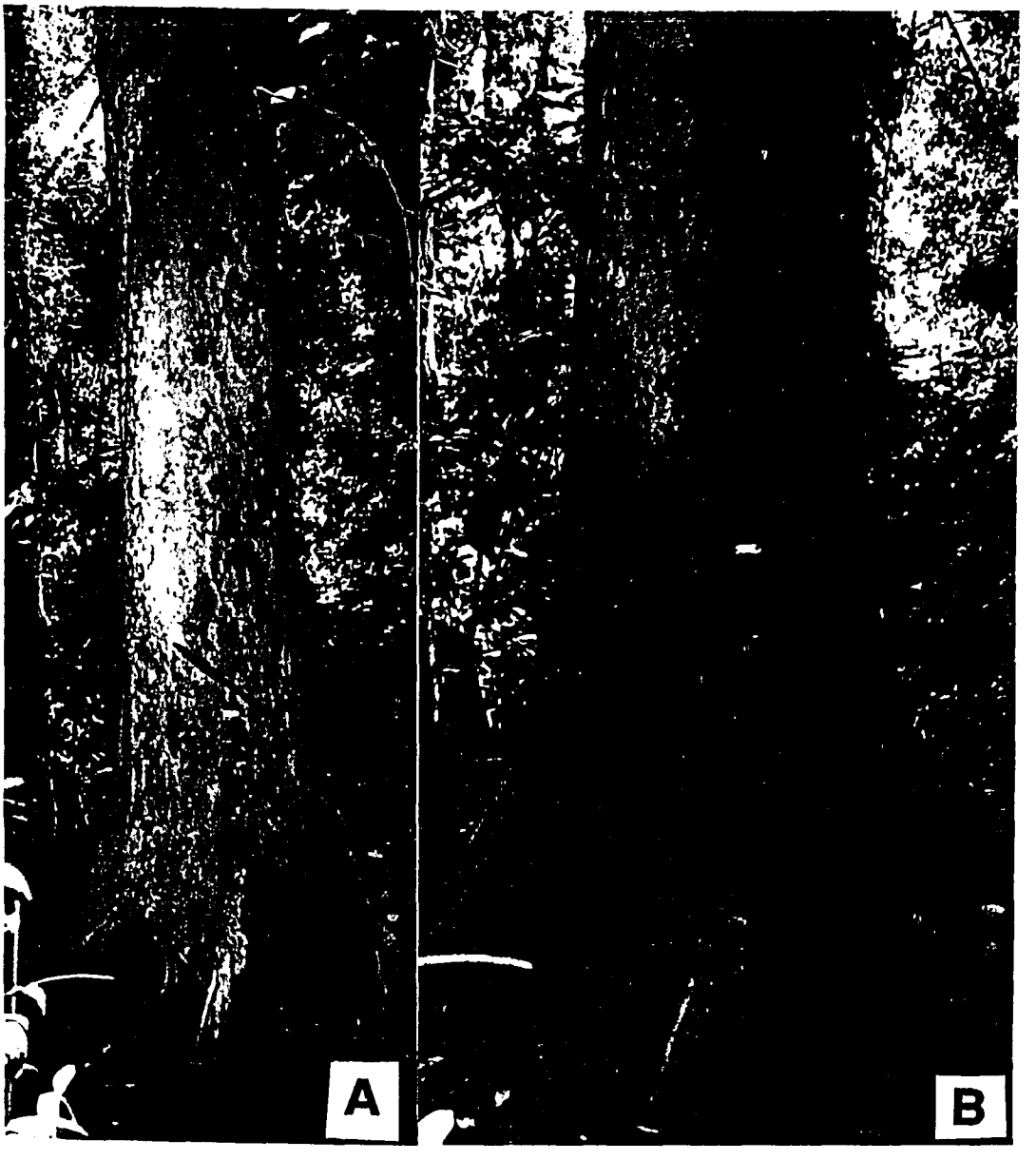
21. Additional remarks----Widespread, common understorey tree. Low branching (about 1/4 way up from base). Gray branchlets. Underside of leaflets silvery.

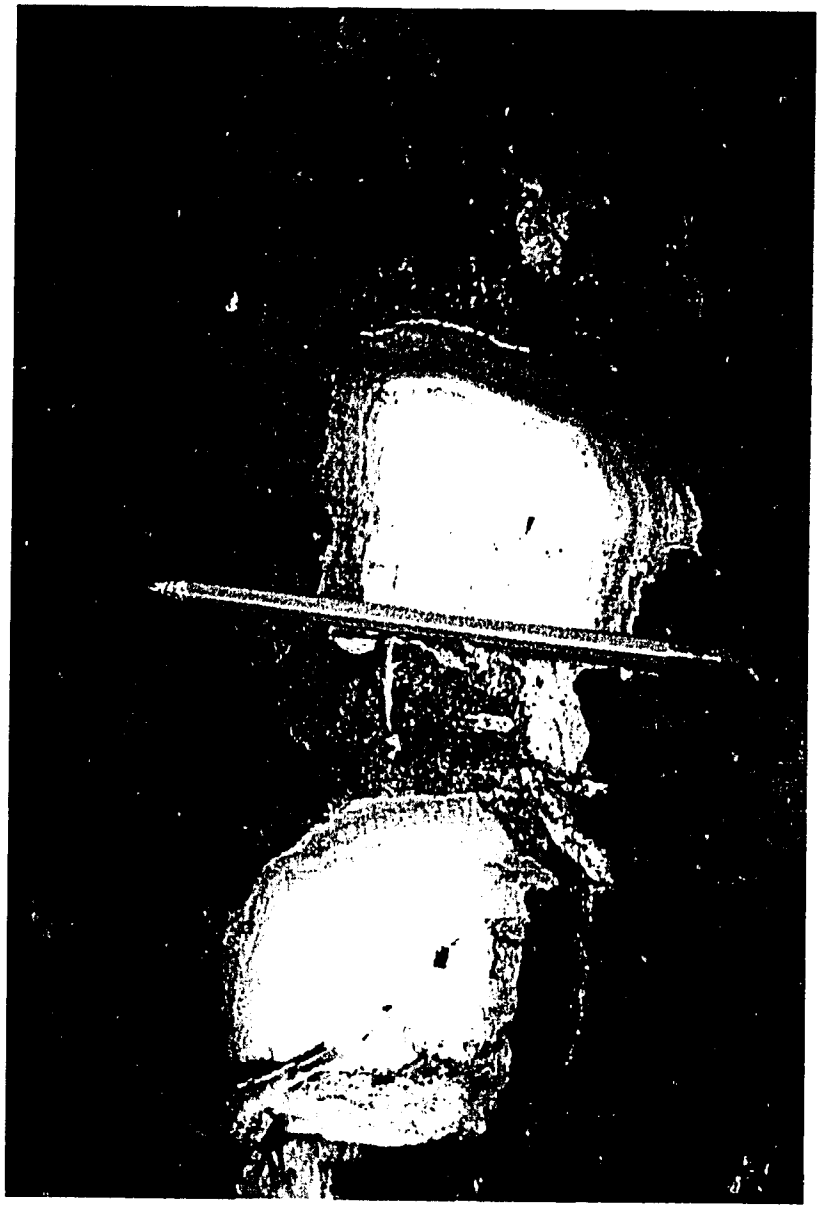
PLATES 34 & 35

Berlinia confusa (Caesalpiniaceae)

34A & B----Bole and buttresses.

35----Slash (below--after 30 seconds; above--after two minutes).


A
B



Family	Species	Vernacular name
Caesalpiniaceae	*Berlinia confusa*	kwatafompaboanini

---

1. Organization

a. Leaf type----Compound leaf, even pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite. 3-5 pairs.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Acute to cuneate.

3. Margin----Entire, sometimes with slight crenations.

4. Glands----Absent. **5. Blade size**----5.5-17 x 3-9 cm.

6. a. Petiolule----Normal. Very dark brown when dry; with pronounced spiral or wavy wrinkles. Fluted, with vertical twisted ridges.

b. Rachis----Base slightly swollen, with wrinkles similar to petiolule. Usually < 5 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, brown, simple hairs

seen only as dots at 10x (.05-15 mm long) on primary and sec veins; more clearly seen at 15x. Most visible on petiolule and rachis. Apex has tiny depression and projection of primary vein, all surrounded by same type of hairs but longer (up to 0.3 mm at x10).

ii. **Density**----Scattered on sec vein but carpets primary vein. Densely carpets petiolule, rachis and tip of apex.

b. **Adaxial surface**----Glabrous and shiny.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, quite uniform; lowest pair a little more acute.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by secondary and tertiary arches.

d. **Inter-sec vein**----Simple.

11. **Tertiary vein**

Pattern----Othorgonal reticulate.

12. Higher order venation----Quarternary veins orthogonal; rest of higher order vens obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Usually hard and fibrous; quite pliable when young. Outside very rough and flaking, especially when old, with thick cork (4-5 mm). Flaky with large scales when old. Eyemarks present.

b. Color----Brown.

16. Slash

a. General color----Light brown to creamy-light yellow.

b. Characteristics----Back of outer bark below cork light brown. First layer of outer bark very brittle; rest of outer bark and inner bark very fibrous. Different shades of brown for whole slash, giving 4-5 rings. Lining of inner bark near wood creamy brown, becomes deeper brown after 2 mins, after which rings

become more visible. Quite strong, agreeable, distinctive, smell somewhat spicy.

c. **Exudate**----Scanty, creamy, slightly sticky, becoming brown after 10 mins. After several hours exudate looks like ointment on slash; oil-like when rubbed between fingers, but later rolls into a ball.

d. **Thickness**----4-5 mm.

17. **Wood**----Creamy-light yellow hardwood with vertical markings.

18. **Height category**----h to H. Up to 37 m.

19. **Buttressing**----Big buttresses.

20. **Bole**----Usually twisted and irregular. Straight or slanted.

21. **Additional remarks**----Young leaves bright red. Dense brown hairs on young twigs. Adaxial side of dry leaf darker green compared with paler green abaxial side. Tiny numerous brown dots seen on blade of dry leaf, appearing as dark spots on adaxial side.

Family	Species	Vernacular name
Caesalpiniaceae	*Berlinia occidentalis*	kwatafompaboakokoo

---

1. Organization

a. Leaf Type----Compound.

b. Phyllotaxy----Alternate. Leaflets opposite. 3-6 pairs.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

Cordate-shaped.

c. Base----Cuneate to acute.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----8-16 x 3-7 cm.

6. Petiolule----Normal, but slightly swollen and wrinkled, with horizontal markings. Usually rectangular shaped in cross section. Short.

7. Hairs

a. Abaxial surface

i. **Type, color, & location**----Erect, fine, mainly around primary vein.

ii. **Density**----Few; seen only after > 20x. Rest of blade glabrous.

b. **Adaxial side**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved; unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute narrow, nearly uniform but lowest pair a little more acute.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by secondary and tertiary arches.

d. **Inter-sec vein**----Simple.

11. **Tertiary vein**

Pattern----Percurrent.

i. **Course**----Forked, some sinuous or convex.

ii. **Relation to midvein**----Generally oblique; some angular.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quarternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Fibrous; outside smooth. Eyemarks present.

b. Color----Brown.

16. Slash

a. General color----Creamy-light yellow to orange brown.

b. Characteristics----Darkens to brown after 5 mins. Inner bark paler in color. Strong pleasant smell like slash of *Baphia nitida* or vegetables.

c. Exudate----Slightly sticky. Collects after an hour into a creamy-brown gum resembling milky pudding.

d. Thickness----About 1.5-2 mm.

17. Wood----Creamy-orange hardwood.

18. Height category----h. Up to 22 m.

19. Buttressing----Present.

20. Bole----Round; quite straight; a little crooked near crown.

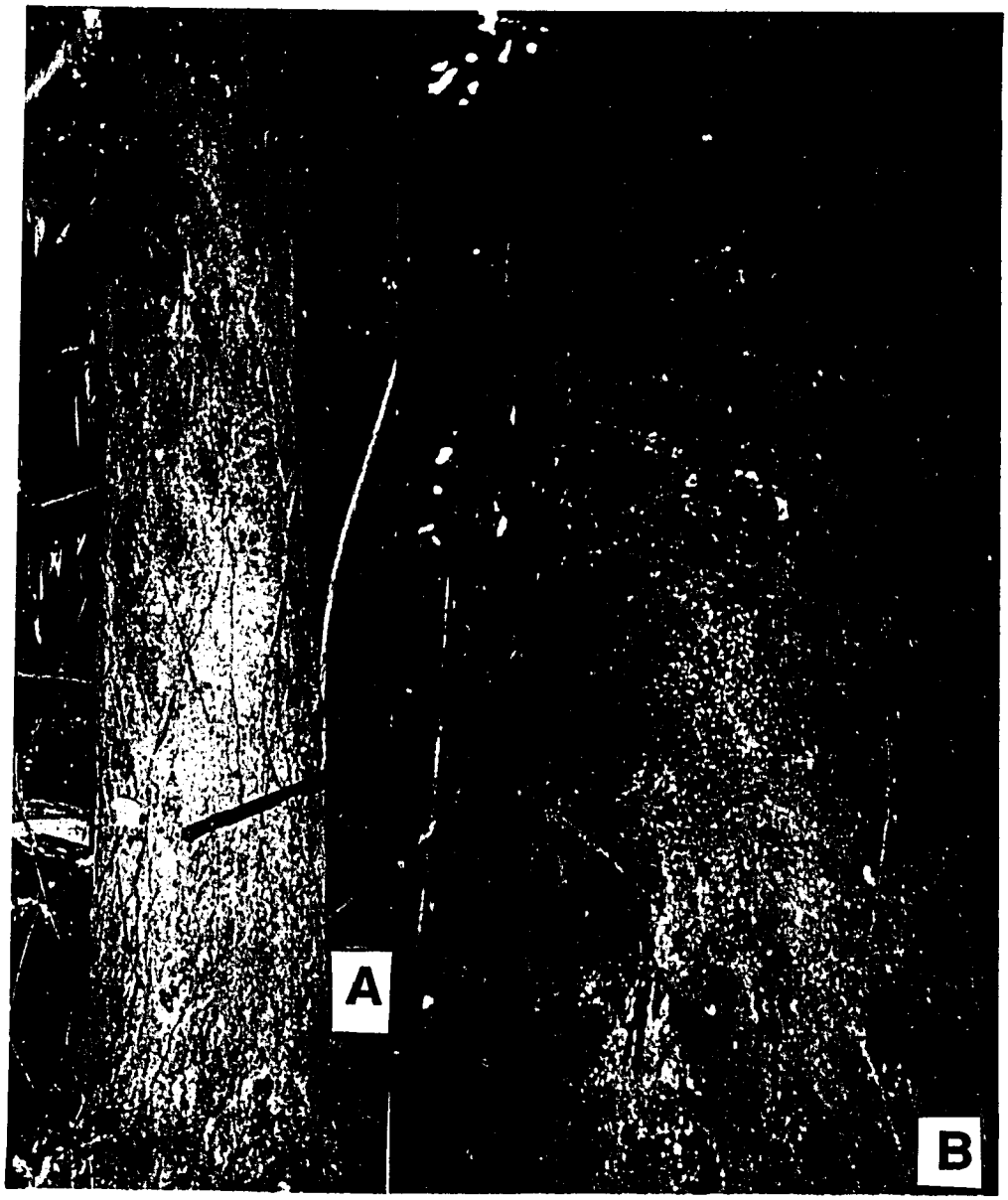
21. Additional remarks----Usually present at forest margins. Often with dome-shaped dense crown.

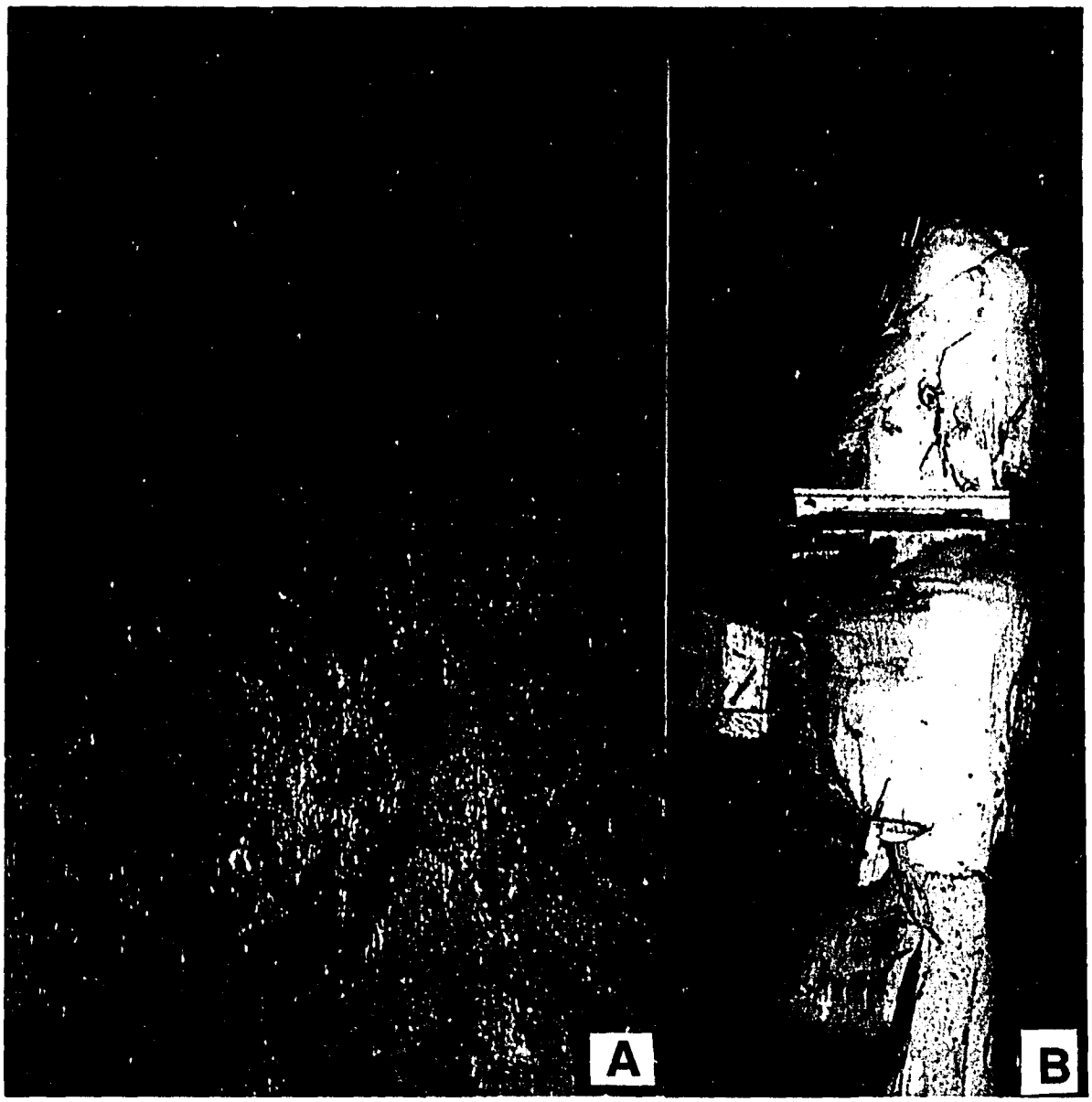
PLATES 36 & 37

Berlinia tomentella (Caesalpiniaceae)

36A----Bole. 36B----Bole and bark. 37A----Bark.

37B----Slash (above--after 30 seconds; below--after two minutes.


A
B


A
B

Family	Species	Vernacular name
Caesalpiniaceae	*Berlinia tomentella*	kwatafompaboabere

---

1. Organization

a. Leaf type----Compound; even pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite.

2. Shape

a. Form----Elliptic to narrowly elliptic.

b. Apex----Acuminate.

c. Base----Acute to sometimes slightly obtuse.

3. Margin----Entire.

4. Glands----Absent.

5. Blade size----7-25 x 3-10 cm.

6. a. Petiolule----Normal. Very wrinkled with wavy horizontal ridges.

b. Rachis----Base club-shaped.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, brown hairs,

0.1-0.3 mm long. Very obscure and elusive, blending into

brownish light-green color of blade. Blade looks glabrous at first but hairs visible at 12x. Similar hairs on petiolule but mixed with white hairs. Same type of hairs on rachis.

ii. Density----Scattered and scanty on blade, as well as along lengths of petiolule and rachis. Quite abundant at base of petiolule and rachis. Copious on buds.

b. Adaxial surface----Glabrous, except for a few appressed hairs at base of blade near apex of petiolule.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched. Infrequently forks into two and rejoins.

c. Loop-forming branches----Acute. Obtuse near apex. Enclosed by tertiary arches.

d. Inter-secondary vein----Simple.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Mostly forked, a few straight or recurved, majority sinuous.

ii. Relation to midvein----Majority oblique to midvein; few angular, some random.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quarternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Majority quadrangular and pentagonal.

15. Bark

a. Texture, & features----Spongy. Outside slightly rough. Wide patches with very shallow numerous characteristic vertical net-like markings. Thin cork that easily separates.

b. Color----Light gray.

16. Slash

a. **General color**----Creamy brown.

b. **Characteristics**----Cover of outer bark light brown with creamy-brown "blisters". Outer bark brown and brittle. Inner bark cream-colored, very spongy. Darkens to deep brown after 2 mins. (begins after 15 secs). Strong perfume-like odour (resembling burnt fruit of plantain), scent perceptible from one meter away. Bark easily separates from wood. Sapwood very slippery, also becomes brown after exposure.

c. **Exudate**----Clear, non-sticky, scanty.

d. **Thickness**----About 7 mm.

17. **Wood**----Creamy yellow-brown, very hard.

18. **Height category**----h. Up to 16 m.

19. **Buttressing**----Usually absent. Fluted at base.

20. **Bole**----Relatively round and straight.

21. **Additional remarks**----Forest tree with spreading crown, usually in wet places. Leaflets paler green on abaxial side. Shade leaflets have long drip tips. Slash heals well after 6 months. Long strips of bark peelable due to highly spongy inner bark.

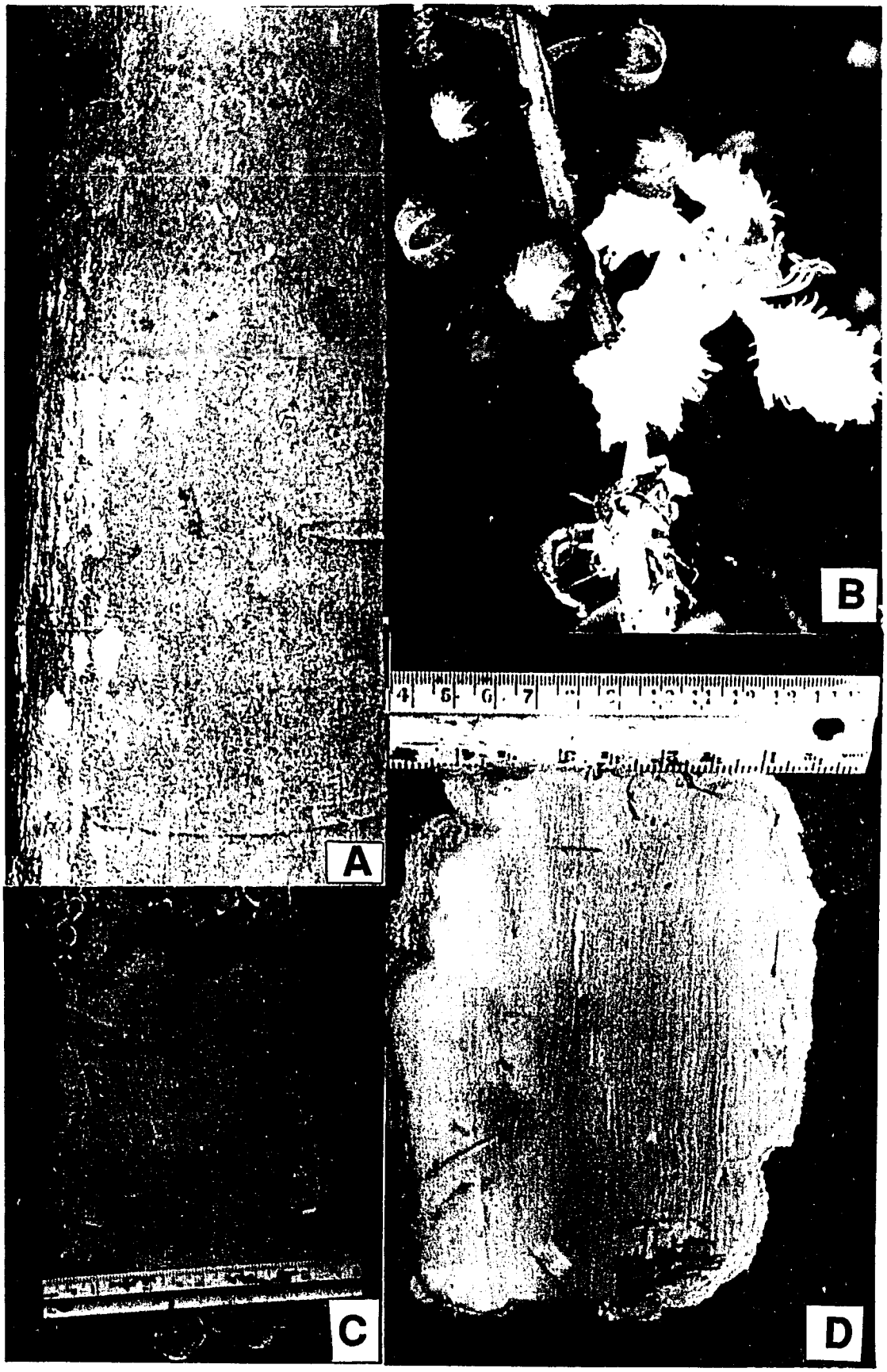
PLATE 38

Bussea occidentalis (Caesalpiniaceae)

A----Bole and eyemarks.

B----Flowers.

C & D----Slash.


A
B
C
D

Family	Species	Vernacular name
Caesalpiniaceae	*Bussea occidentalis*	kotoprepre

---

1. Organization

a. Leaf type----Bipinnately compound, odd pinnate.

b. Phyllotaxy----Spiral. Pinnae paired opposite, 2-6 pairs.

2. Shape

a. Form----Narrowly elliptic.

b. Apex----Attenuate to slightly acuminate.

c. Base----Acute to cuneate, assymetrical.

3. Margin----Entire; sometimes with slight crenations.

4. Glands----Absent. **5. Blade size**----6-10 x 2.5-4 cm.

6. a. Petiolule----Normal. Horizontal W-shaped wrinkles (when magnified).

b. Rachis----Rusty brown when young. Base enlarged and wrinkled.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed brown hairs (up to

0.25 mm long) among very short erect brown hairs seen initially as dots but more clearly after 20x. Hairs most visible (like brown powder) at base of primary vein, petiolule, rachis, and twigs.

ii. **Density**----Dense at all areas present. Areas without hairs on rachis and twigs appear as light-green streaks.

b. **Adaxial surface**----Shiny (especially under microscope) and glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform, but lowest pair a little more acute.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by secondary and tertiary arches.

d. **Inter-secondary vein**----Simple.

11. **Tertiary vein**

Pattern----Orthogonal reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, features----Very brittle, hard, and quite fibrous. Very gritty. Outside quite smooth. Vivid, prominent, and elongated eyemarks. Some hoop marks. Very many scattered prominent lenticels, some having horizontal or vertical arrangement.

b. Color----Gray-brown to whitish-gray.

16. Slash

a. General color----Brown or orange.

b. Characteristics----Becomes darker brown with light gray taint after 15 mins. Back of outer bark brown, sometimes with green streaks. Outer bark very brittle, with 2 or 3 yellowish rings with brownish-cream layers between, then a creamy-brown layer followed by a brown layer. Inner bark

thinner, more fibrous and slightly pliable. Layer near wood creamy-orange. After 24 hours slash usually covered by white fungi-like powder. Strong agreeable and savoury smell like ginger. Sapwood very slippery.

c. Exudate----Clear, watery, non-sticky exudate, sometimes a little reddish.

d. Thickness----About 2-2.5 mm.

17. **Wood**----Light yellow to light brown or brownish-orange hardwood, with white vertical lines.

18. **Height category**----h to H. Up to 31 m.

19. **Buttressing**----Usually fluted and unbuttressed. Sometimes with small buttresses on larger trees.

20. **Bole**----Often crooked; sometimes straight but crooked near crown. Relatively round but with slight bumps.

21. **Additional remarks**----Large tree. Leaflets relatively large. The only species of the genus so far recorded for West Africa.

Family	Species	Vernacular name
Caesalpiniaceae	*Copaifera salikounda*	entedua

---

1. Organization

a. Leaf type----Compound, even pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite or subopposite.

10-16 pairs.

2. Shape

a. Form----Elliptic. **b. Apex**----Retuse.

c. Base----Assymetric, one side straight and other side convex.

Generally acute.

3. Margin----Entire; sometimes with slight crenations.

4. Glands----Absent. **5. Blade size**----1.8-5.8 x 1.1-2.6 cm.

6. a.Petiolule----Very short, normal, a little enlarged at base,

sometimes twisted. Bumps and wrinkles at higher magnification.

b. Rachis----Has vertical lines; 6-13 cm. long.

7. Hairs

a. Abaxial surface

i. **Type, color, & location**----Appressed, 0.1-0.3 mm long, sickle-shaped, lax, yellowish hairs on primary and fimbrial veins only. A few hairs sometimes scattered around blade margin but seen only at 20x.

ii. **Density**----Abundantly carpets rachis, petiolule, primary and fimbrial veins, making rachis appear furred. Scanty around edge of blade; all other areas and rest of blade glabrous and shiny.

b. **Adaxial surface**----Glabrous and shiny, except very few of similar abaxial hairs sometimes scattered along blade margin and near base.

8. **Venation**----Simple Craspedodromous.

9. **Primary vein**----Straight, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Majority recurved; a few straight.

c. **Loop-forming branches**----Absent.

d. **Inter-secondary vein**----Simple.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation ----With a fimbrial vein.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Very hard, fibrous, and pliable. Outside rough, but smooth when young. Prominent eyemarks and a number of thin hoop marks.

b. Color----Gray.

16. Slash

a. General color----Light red, or pinkish-brown to orange.

b. Characteristics----Outer bark a little brittle; inner bark very fibrous. No change after 10 mins. Strong spicy smell.

c. Exudate----Very scanty, slightly sticky to touch, quickly dries to make fingers smooth.

d. Thickness----1.0-1.5 mm.

17. Wood----Quite hard; white.

18. Height category----h to H.

19. Buttressing----Generally fluted at base; root spurs at base when old.

20. Bole---- Usually straight half way from base and crooked upwards. Quite cylindrical.

21. Additional remarks----Leaf margin thickened. Large forest tree, often gregarious.

Family	Species	Vernacular name
Caesalpiniaceae	*Crudia gabonensis*	samantaanini

---

1. Organization

a. Leaf type----Compound, bipinnate.

b. Phyllotaxy----Alternate. Leaflets alternate, 5-9 pairs.

2. Shape

a. Form----Elliptic. **b. Apex**----Attenuate to acuminate.

b. Base----Obtuse to cuneate.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----6-15 x 2.5-5.5 cm.

6. a. Petiolule----Normal, very small, with horizontal wrinkles.

b. Rachis----Enlarged base.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Tiny appressed brown hairs, about 0.1-1.5 mm long, especially on primary vein and petiolule. Similar hairs on rachis but mixed with erect ones.

ii. Density----Scattered on blade, more abundant on rachis.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute; enclosed by secondary

and tertiary arches.

d. Inter-secondary vein----Simple.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Brittle, fibrous, and hard. Outside usually quite smooth; becomes rough with age. Prominent, wide eyemarks up to 10 cm long and 2 cm wide. A few hoop marks. Scattered lenticels.

b. Color----Gray-brown.

16. Slash

a. General color----Brownish-orange to light yellow, with light brown streaks.

b. Characteristics----Becomes darker brown after 3 mins. Outer bark light yellow to orange; inner bark light brown. Creamy-orange ring near wood. Sapwood very light yellow and changing to gray after 5 mins. Inner bark becomes dark brown after 15 mins. Pleasant strong peppery smell. Bark easily separates from wood. A lot of Dipteran insects and black ants usually gather around slash.

c. Exudate----Scanty, clear, non-sticky exudate.

d. Thickness----1-1.5 mm.

17. Wood----Very hard; light yellowish-orange to light brown.

18. Height category----h. Up to 25 m.

19. Buttressing----Present. Usually fluted at base or with small buttresses when young.

20. Bole----Straight and round; sometimes crooked near crown.

21. Additional remarks----Forest tree with compact crown and paired, caducous stipules, especially on very young twigs.

PLATES 39 & 40

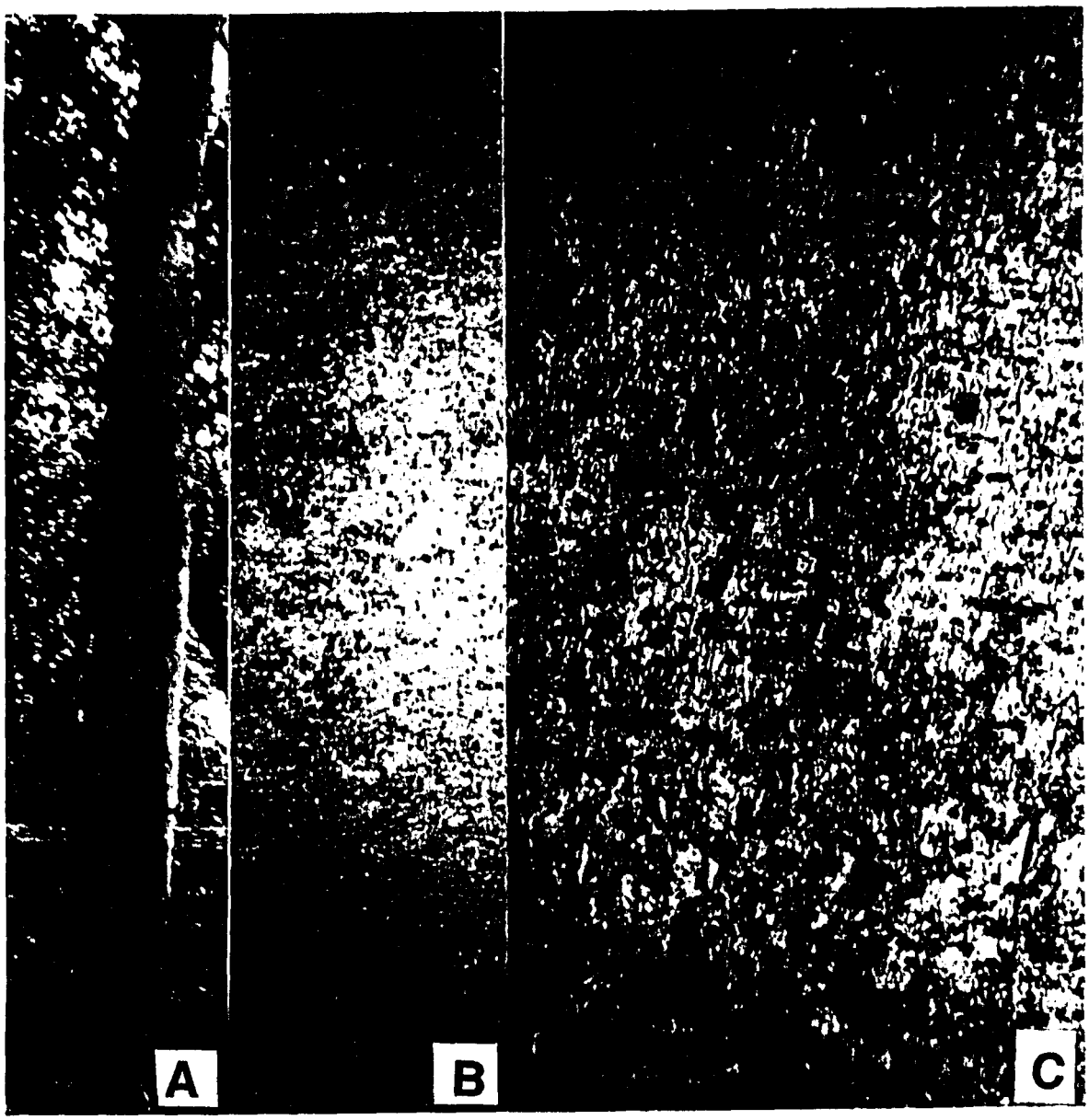
Daniellia ogea (Caesalpiniaceae)

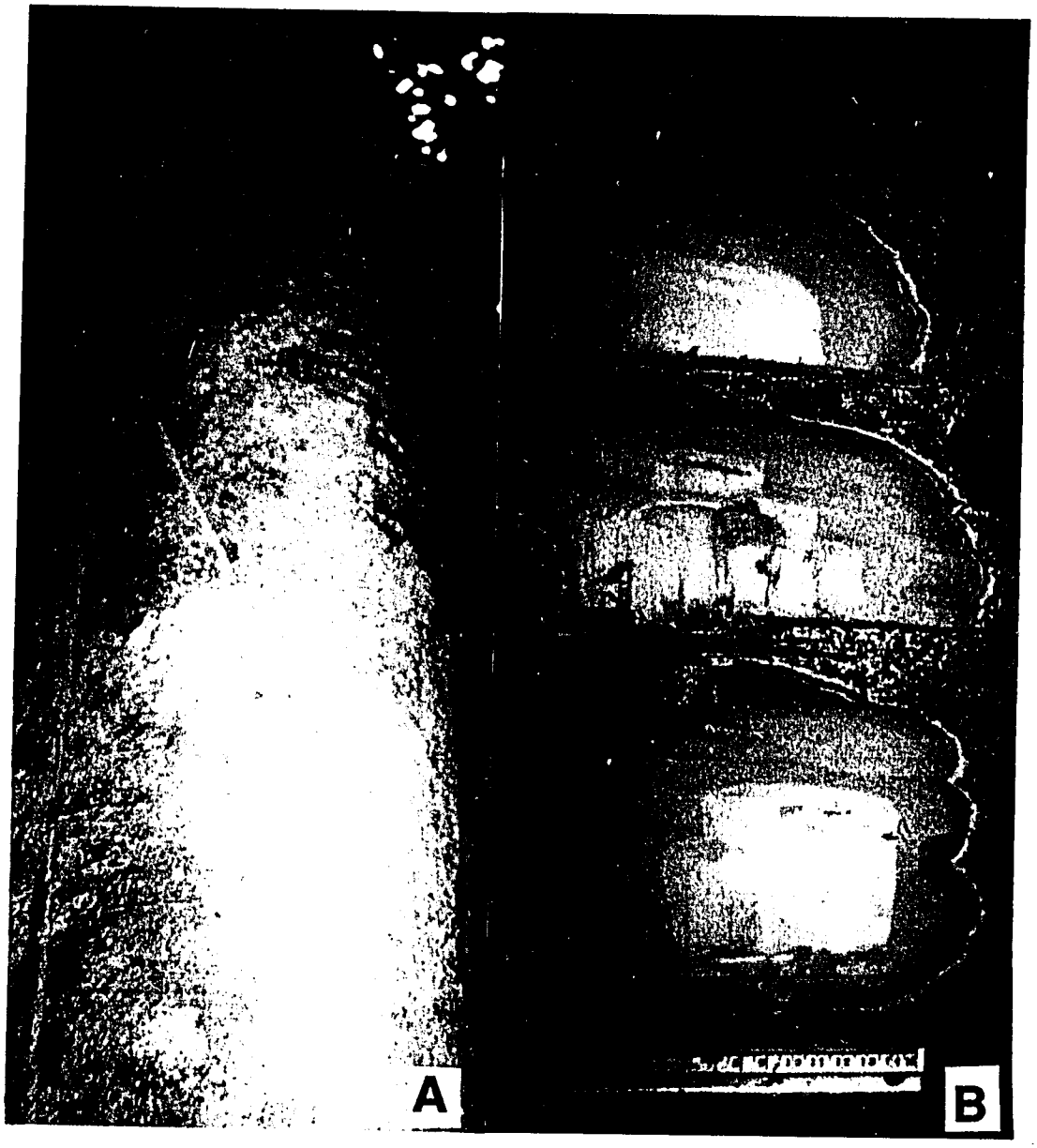
39A----Bole and buttresses.

39B & C----Bark.

40A----Bole and hoop marks.

40B----Slash.


A
B
C


A
B

Family	Species	Vernacular name
Caesalpiniaceae	*Daniellia ogea*	ehyedua

---

1. Organization

a. Leaf type----Compound, odd pinnate.

b. Phyllotaxy----Alternate. Leaflets sub-opposite; 6-9 pairs.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Obtuse to decurrent; asymmetric.

3. Margin----Entire, sometimes with wide crenations.

4. Glands----Absent. **5. Blade size**----6-11 x 2.5-3.5 cm.

6. a. Petiolule----Normal, small, short, wrinkled.

b. Rachis----Shiny under microscope; with vertical narrow ridges; base slightly enlarged; wrinkled.

7. Hairs

a. Abaxial surface

i. Type, color, and location----Very tiny short hairs, seen as small dots only after 20x, on primary and some sec veins.

Short white appressed hairs on petiole (about 0.1-0.15 mm long).

ii. **Density**----Very scanty on primary and some sec veins. Very few on petiole.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform; a little more acute near apex.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by tertiary and quarternary arches.

d. **Inter-secondary vein**----Simple.

11. **Tertiary vein**

Pattern----Random reticulate.

12. **Higher order venation**----Quarternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect; some hexagonal and pentagonal.

15. Bark

a. Texture, & features----Fibrous and quite spongy. Outside very slightly rough. Scattered lenticels, a few in vertical or spiral rows. Prominent eyemarks and some hoop marks.

b. Color----Gray-brown, sometimes with light-green tint.

16. Slash

a. General color----Creamy-brown or reddish-brown.

b. Characteristics----Outer bark brownish and brittle; inner bark cream-colored and spongy. Sapwood light brown to light yellow. Pleasant, quite sweet, relatively strong smell.

c. Exudate----Very scanty and slightly sticky.

d. Thickness----About 2 mm.

17. Wood----Creamy; very hard.

18. Height category----H. Up to 55 m.

19. Buttressing----Usually absent, usually not even fluted at base. Occasionally with very short, rounded buttresses.

20. Bole----Very cylindrical.

21. Additional remarks----Sapling leaves considerably larger than adult leaves. Surface of leaf appears bumpy under microscope.

Family	Species	Vernacular name
Caesalpiniaceae	*Distemonanthus benthamianus*	bonsamdua

---

1. Organization

a. Leaf Type----Compound; odd pinnate.

b. Phyllotaxy----Alternate. Leaflets alternate, 9-11 pairs.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Rounded to obtuse.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----5-12.8 x 2-5.8 cm.

6. a. Petiolule----Normal; very short; slightly longer for apical leaflet. Wrinkled and fluted under microscope.

b. Rachis----Hairy.

7. Hairs

a. Abaxial surface

i. Type, color and location----Appressed, brown, up to 1.0 mm long, most conspicuous on primary vein. Brown hairs on petiolule and rachis but more erect with curved apices.

ii. Density----Quite dense on blade but less dense elsewhere.

b. Adaxial surface----Appears to be glabrous up to 20x when tiny short blunt hairs are seen scattered on veins and intercostal areas.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Relatively straight to slightly curved; unbranched.

10. Secondary veins

a. Angle of divergence----Acute, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Generally right angle, enclosed

by tertiary and quarternary arches.

d. Inter-secondary vein----Simple.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Quarternary veins orthogonal; rest obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Majority quadrangular.

15. Bark

a. Texture, & features----Fibrous to brittle. Flaking.

b. Color----Light green to yellowish or red. Younger bark looks reddish-brown or orange. Characteristic hexagonal and polygonal patterns on it.

16. Slash

a. General color----Light-yellowish or orange to brownish-pink.

b. Characteristics----Mixture of fibrous and brittle layers of

outer and inner bark. Strong, pleasant scent.

c. Exudate----Scanty and sticky.

d. Thickness----About 2 mm.

17. Wood----Yellowish to creamy hardwood, with conspicuous ripple marks.

18. Height category----H. Up to 37 m.

19. Buttressing----Present; narrow and tall.

20. Bole----Round and straight, sometimes crooked near crown.

21. Additional remarks----Primary vein protrudes beyond leaf apex for up to 0.3 mm. Adaxial leaflet surface darker green than abaxial surface. Secondary veins very conspicuous. Large tree of moist forest.

PLATES 41 & 42

Hymenostegia afzelii (Caesalpiniaceae)

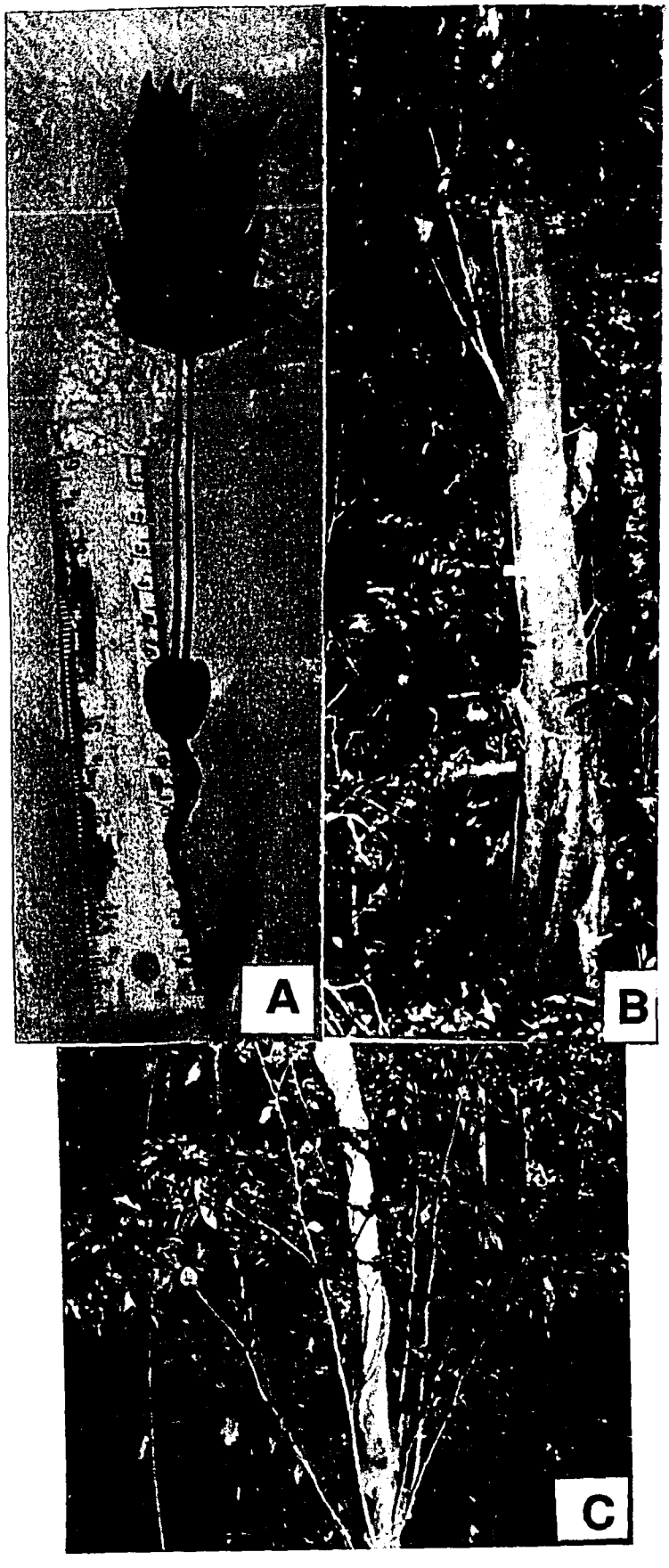
41A----Seedling.

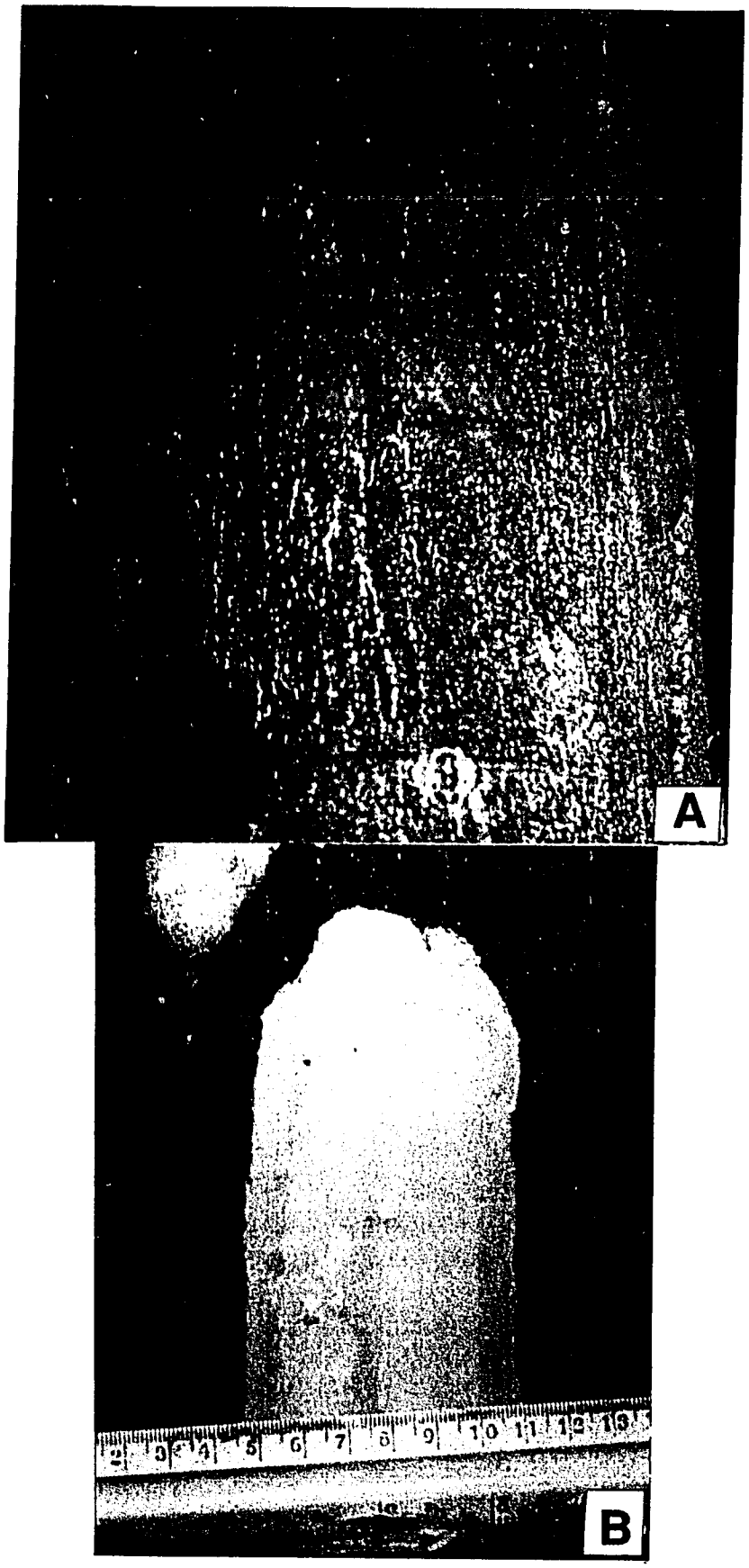
41B----Bole and buttresses.

41C----Bole and branches.

42A----Bark and hoop marks.

42B----Slash.


A
B
C


A
B

Family	Species	Vernacular name
Caesalpiniaceae	*Hymenostegia afzelii*	takorowa

---

1. Organization

a. Leaf type----Compound.

b. Phyllotaxy----Alternate. Leaflets opposite. 1-4 pairs of leaflets.

2. Shape

a. Form----Elliptic to oblong. **b. Apex**----Acuminate; bent.

c. Base----Obtuse.

3. Margin----Entire.

4. Glands----Small (0.1-0.2 mm diameter), round, scattered on both surfaces of blade, brown, seen as very tiny dots to the unaided eye.

5. Blade size----7-11 x 2-5.5 cm. Lowest pair of leaflets (if present) smaller, about 3 cm long.

6. a. Petiolule----Normal; about 0.7 cm long.

b. Rachis----Winged.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Scandent or curled, on blade and midvein, at laminar-petiolar junction, branches, and axillary buds. Length 0.1-1.0 mm.

ii. Density----Scattered on blade; more abundant on midvein and base of blade; very dense on young twigs and buds.

b. Adaxial surface----Similar to abaxial side but fewer hairs.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to slightly markedly curved near apex; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse; enclosed by tertiary and quarternary arches.

d. Inter-secondary vein----Composite.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped; with a **fimbrial vein.**

14. Areoles

a. Development----Well developed; oriented.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Brittle and gritty. Outside smooth. Eyemarks, some almost becoming hoop marks. Faint creamy-yellow thin markings. Very tiny scattered lenticels.

b. Color----Gray.

16. Slash

a. General color----Yellow.

b. Characteristics----Cover of outer bark orange, the remainder

yellowish; inner bark darker yellow as well as sapwood after two mins; very pungent smell even from a meter's distance, especially immediately after slashing. Sweet taste.

c. Exudate----None.

d. Thickness----1-3 mm.

17. Wood----Very hard yellowish-orange wood, same color as slash.

18. Height category----h to hh. Up to 22 m.

19. Buttressing----Slightly buttressed; often very fluted at base.

20. Bole----Often has characteristic profuse offshoots. Sinewy and crooked.

21. Additional remarks----Primary vein has tiny swollen points, especially towards base. Adaxial leaf surface is darker green than abaxial. Dead portions of blade with epidermis removed reveals beautiful areolation of tertiary and quarternary veins. Branchlets closer to leaves are very slender (1.5-2 mm diam.). Widespread forest tree most common in wet forest but also widespread in dry forest.

COMBRETACEAE

Trees or shrubs. Often scandent. Leaves opposite or alternate, simple, extipulate. Rarely verticillate.

A family of nine genera and 80 species in West Africa.

There is one genus and one species in the Bobiri forest reserve.

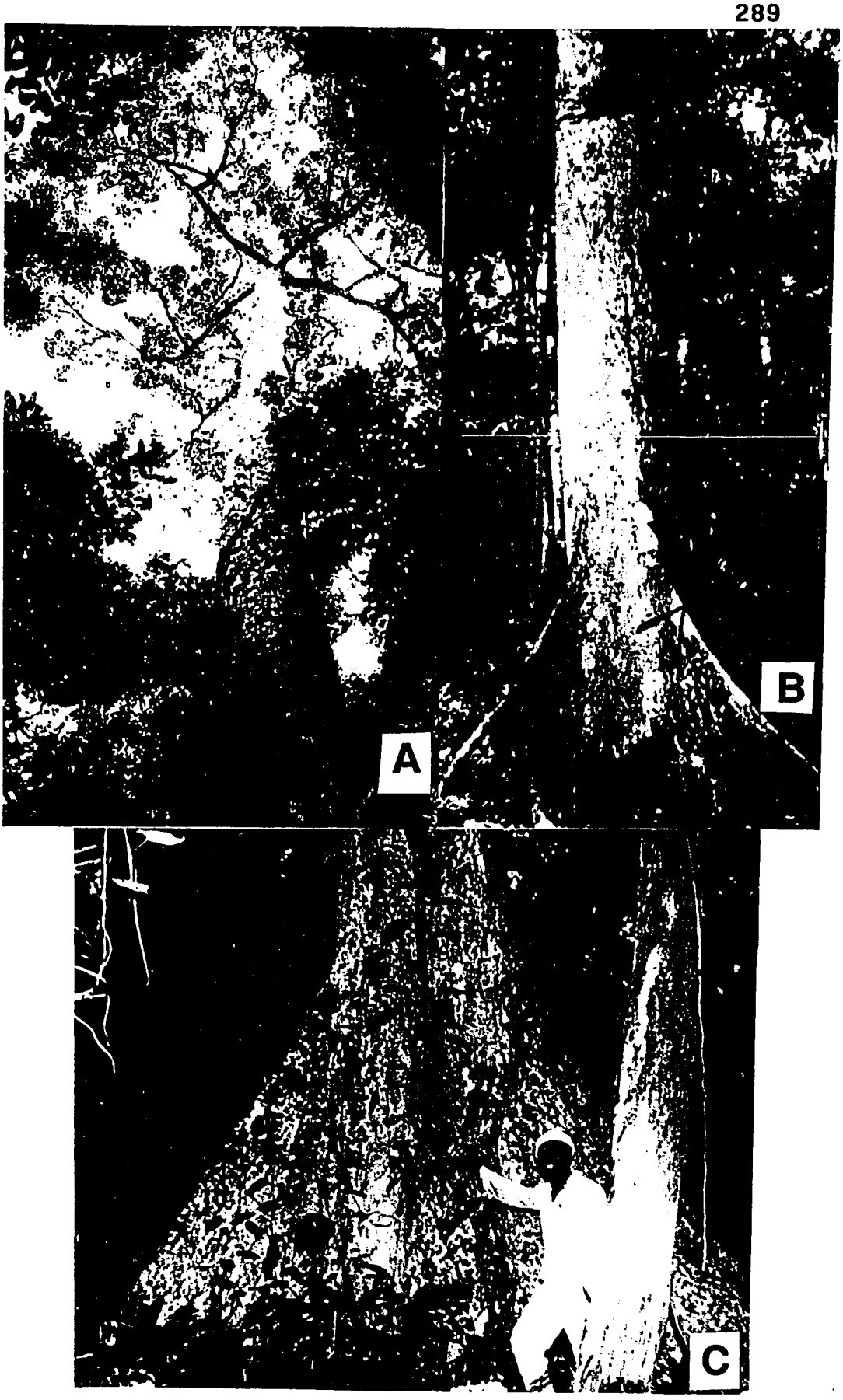
PLATES 43 & 44

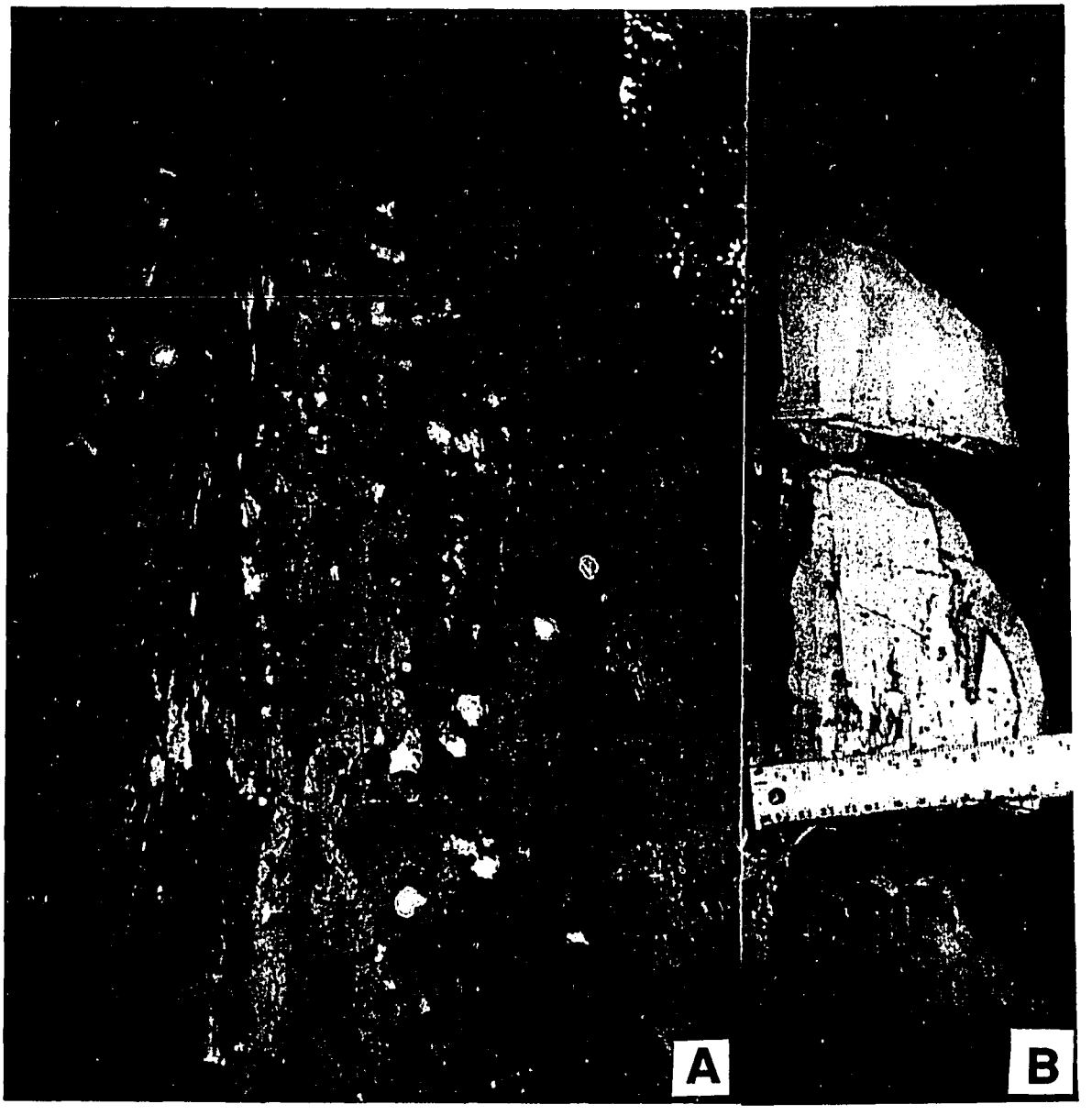
Terminalia superba (Combretaceae)

43A----Bole and crown. 43B & C----Bole and buttresses.

44A----Bark.

44B----Slash (above--after 30 seconds; below--after two minutes).


A
B
C


A
B

Family	Species	Vernacular name
Combretaceae	*Terminalia superba*	ofram

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire.

4. Glands----A pair of subopposite glands on side of patiole.

5. Blade size----10-17 x 6-10 cm.

6. Petiole----Normal. Long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Mixture of scandent, appressed, and flexuous brown hairs on primary, sec, tertiary, and fimbrial veins. Similar hairs on petiole and buds. Rest of blade glabrous.

ii. Density----Hairs carpet petiole and buds. Quite abundant on

primary and sec veins. Scanty on tertiary veins. Hairs carpet acuminate tip.

b. Adaxial surface

i. Type, color, & location----Mixture of appressed and scandent hairs on primary vein, and some secs and tertiaries. Similar hairs at apex and tip of petiole. Rest of blade glabrous.

ii. Density----Few hairs on all veins. Hairs carpet petiole and base of primary vein.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Slightly markedly curved; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform. Lowest pair acute wide.

b. Course----Curved abruptly, unbranched. **Stalked.**

c. Loop-forming branches----Acute. Enclosed by tertiary and quaternary arches.

d. Inter-sec vein----Simple.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Forked, sinuous.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a fimbrial vein.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture & features----Fibrous and fissured. Outside generally smooth but a little rough when old; slightly flaky. Scattered brown lenticels. Vertical slits 1-4 mm deep. Sometimes has rough, wide patches. Old bark has gray cork.

b. Color----Light brown. Younger bark brownish-gray.

16. Slash

a. General color----Light brown, or orange to light yellow.

b. Characteristics----Becomes deeper brown after one min. Brownish-yellow after 5 mins. Cover of outer bark brown with cream streaks; the remainder brown. Very pliable. Deep yellow ring near wood. Moderate agreeable smell.

c. Exudate----None.

d. Thickness----

17. Wood----Very hard. Yellowish or cream with light gray tint.

18. Height category----H. Generally up to 46 m. Can be up to 61 m. high.

19. Buttressing----Huge, tall, plank buttresses.

20. Bole----Triangular for a short distance up the buttresses, but greater part round. Clean, straight bole.

21. Additional remarks----Leaves crowded at ends of twigs. Crown usually flat. Tall tree of the forest.

EBENACEAE

Trees or shrubs. Heartwood sometimes black (Ebony of commerce). Leaves nearly always alternate, extipulate, entire.

A family of one genus and 39 species in West Africa. There are one genus and three species in the Bobiri forest reserve. Many are of local economic importance; a few are of considerable commercial importance.

Family	Species	Vernacular name
Ebenaceae	*Diospyros monbuttensis*	atwere-nantin

---

1. Organization

Leaf type----Simple.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire, with slight crenations.

4. Glands----Absent.

5. Blade size----Up to 20 cm long and 7.5 cm broad.

6. Petiole----Normal, thin, short.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Mixture of white curled and appressed hairs, in pit domatia at primary-sec apical junctions, appearing wooly. Similar hairs on primary, sec, and tertiary veins, and at leaf margin. Mixture of appressed and erect hairs (up to 0.2 mm long) on petiole. Rest of blade glabrous.

ii. Density----Abundant in domatia; few on veins, margin, and petiole.

b. Adaxial surface

i. Type, color, & location----Similar abaxial hairs on primary vein, sec veins, and petiole. Rest of blade glabrous.

ii. Density----Quite abundant on petiole; few on veins.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform; lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute to right angle; obtuse near apex.

d. Inter-sec vein----Simple.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Straight and forked in about equal proportions. Few concave.

ii. Relation to midvein----Mostly oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Fibrous, papery. Older trees have blunt sharp spines; areas without spines relatively smooth. Very flaky, sometimes flakes roll into scrolls.

b. Color----Dark brown to reddish, or purple brown. Sometimes green or yellow-brown.

16. Slash

a. General color----Yellowish to yellow-brown.

b. Characteristics----Darkens after 3 mins. Outer bark brownish; inner bark cream-colored. Sapwood yellowish. Quite pleasant smell.

c. Exudate----Slightly sticky exudate that darkens.

d. Thickness----About 2 mm.

17. Wood----Creamy-light yellow hard wood.

18. Height category----h. Up to 12 m.

19. Buttressing----Usually fluted at base. **20. Bole**----Crooked.

21. Additional remarks----Small tree. Leaves dry brown, with venation on adaxial side appearing as white lines.

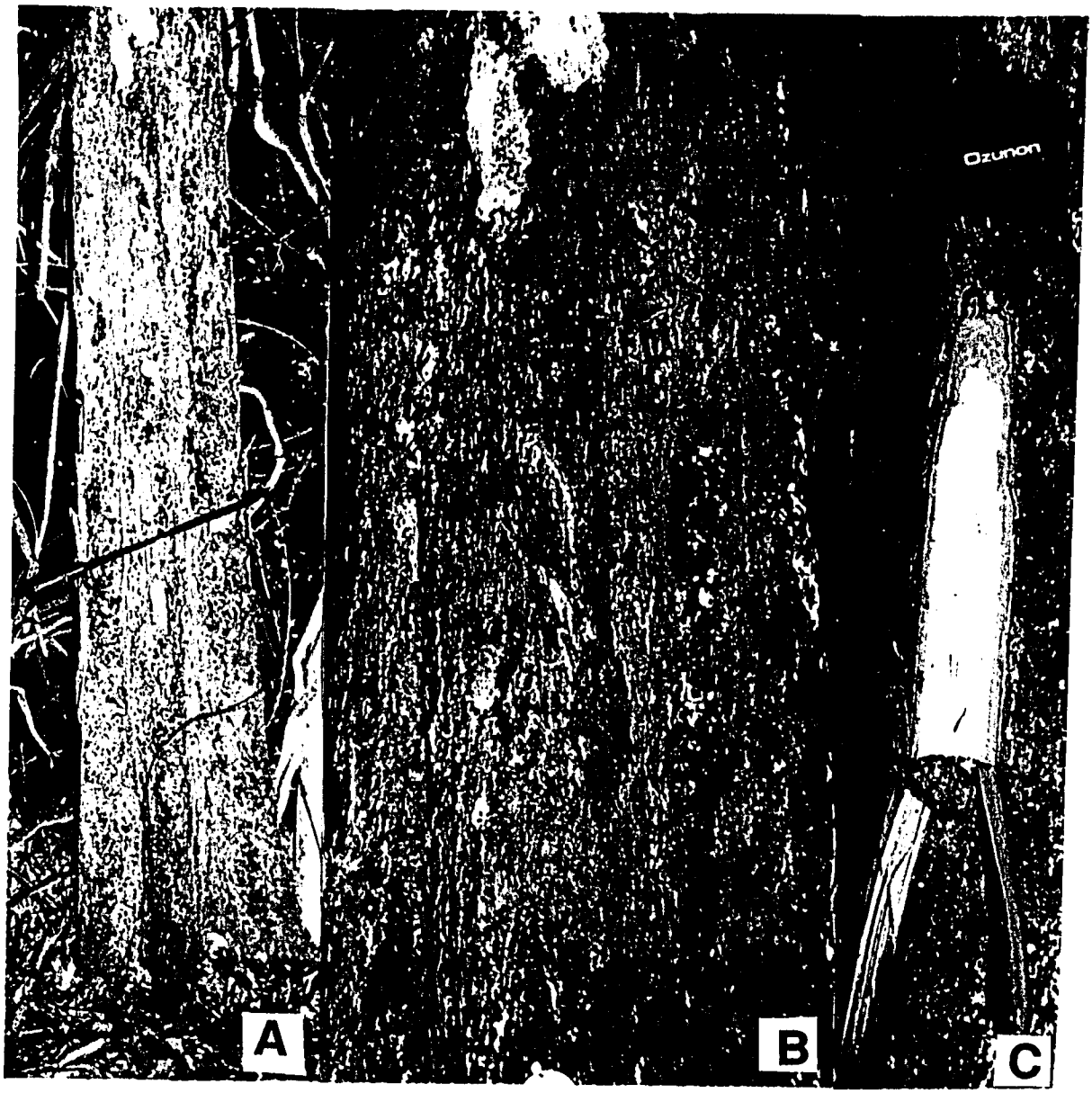
PLATE 45

Diospyros soubreana (Ebenaceae)

A----Bole and buttresses.

B----Bole and bark.

C----Slash.


Ozunon
A
B
C

Family	Species	Vernacular name
Ebenaceae	*Diospyros soubreana*	otweto

---

1. Organization

Leaf type----Simple.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----Up to 14 cm long and 6 cm broad.

6. Petiole----Normal; with very thin extension of blade. Has vertical ridges.

7. Hairs

a. Abaxial surface

i. Type, color & location----Appressed, light brown hairs (0.1-0.6 mm long) on all veins, intercostal areas, and petiole.

ii. Density----Very copious on whole leaf.

b. Adaxial surface----Blade glabrous except very scanty short

hairs at base of primary vein.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Slightly straight to markedly curved; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly; unbranched.

c. Loop-forming branches----Acute. Enclosed by sec. and tertiary arches.

d. Inter-sec vein----Absent.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Fibrous. Outside rough. Flakes slightly, especially close to the base of trunk. Has many scattered lenticels, a few in spiral or vertical rows.

b. Color----Gray, gray-brown, or black.

16. Slash

a. General color----Reddish-purple, or orange-brown with dark tint.

b. Characteristics----Same after 24 hours. Has faint white streaks. Outer bark purplish to dark; inner bark orange-brown.

c. Exudate----None.

d. Thickness----About 3 mm.

17. Wood----Cream. A little soft.

18. Height category----hh. Up to 6 m.

19. Buttressing----Fluted at base.

20. Bole----Round. Often straight nearer base but crooked near crown.

21. Additional remarks----Forest treelet or shrub. Leaves dry dark brown or black.

PLATE 46

Diospyros viridicans (Ebenaceae)

A & B----Bole and buttresses.


A
B

Family	Species	Vernacular name
Ebenaceae	*Diospyros viridicans*	atwea

---

1. Organization

Leaf type----Simple.

2. Shape

a. Form----Elliptic to obovate **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Slightly crenate. **4. Glands**----Absent.

5. Leaf size----Up to 17 cm long and 11 cm broad.

6. Petiole----Normal.

7. Hairs

a. Abaxial surface----Relatively glabrous except a few scattered short hairs.

b. Adaxial surface----Glabrous and glossy.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved; unbranched.

10. Secondary vein

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by tertiary arches.

d. **Inter-sec vein**----Simple.

11. **Tertiary vein**

Pattern----Percurrent.

i. **Course**----Simple, straight.

ii. **Relation to midvein**----Oblique.

iii. **Arrangement**----Predominantly opposite.

12. **Higher order venation**----Quaternary veins orthogonal; rest obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**

a. **Development**----Well developed.

b. **Shape**----Quadrangular and pentagonal.

15. **Bark**

a. **Texture, & features**----Fibrous. Many lenticels, some in

vertical rows. Outside smooth when young; becomes scaly with age.

b. Color----Dark gray or black.

16. Slash

a. General color----Yellowish.

b. Characteristics----Outer bark creamy-light yellow; sometimes a little soft and brittle. Inner bark yellowish and fibrous.

c. Exudate----None.

d. Thickness----About 2 mm.

17. Wood----Cream; slightly soft.

18. Height category----h. Up to 20 m.

19. Buttressing----Fluted at base.

20 Bole----Straight, round.

21. Additional remarks----Small or medium-sized forest tree. Common in most Ghanaian forests. Leaves dry reddish.

EUPHORBIACEAE

Trees, shrubs, or herbs. Occasionally have milky latex. Leaves simple or palmately compound, sometimes reduced, alternate, rarely opposite, usually stipulate. Most species are small trees. Red slashes are common. Many large trees have stilt roots.

A large and heterogeneous family of 65 genera and 280 species in West Africa, including nine introduced species. There are six genera and twelve species in the Bobiri forest reserve.

PLATE 47

Cleidion gabonicum (Euphorbiaceae)

A----Bole.

B----Bole, branch, and leaves.

C & D----Bark and slash.


A
B
C
D

Family	Species	Vernacular name
Euphorbiaceae	*Cleidion gabonicum*	mpawu

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Acute.

3. Margin----Usually entire but sometimes slightly crenate to faintly serrate.

4. Glands----Present on lamina near base of midvein.

5. Leaf size----10-17 x 4-7.5 cm.

6. Petiole----Normal; apex and base rugose and fluted.

7. Hairs

a. Abaxial surface

i. Type, color & location----Short appressed brown hairs up to 0.5 mm on veins and intercostal areas. Curled yellowish hairs on petiole. End of thickened secondary veins often

have fringe of hairs.

ii. Density----Scattered on veins; few in intercostal areas.

b. Adaxial surface----Glabrous except for a few hairs at base of primary vein.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved to slightly straight; unbranched.

10. Secondary vein

a. Angle of divergence----Acute wide, nearly uniform; lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute; right angle near apex. Enclosed by secondary and tertiary arches.

d. Inter-secondary vein----Simple.

11. Tertiary vein

Pattern----Percurrent

i. Course----Mostly forked and sinuous. Many recurved.

ii. Relation to midvein----Right angle and oblique in about equal proportions.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete to lacking.

15. Bark

a. Texture, & features----Brittle. Outside smooth to rough. Shallow vertical slits especially near base. Scattered small lenticels, some vertically arranged.

b. Color----Brown to gray or deep gray, sometimes with greenish-white taint resembling bark of *Ficus asperifolia.*

16. Slash

a. General color----Light orange or light yellow with white streaks.

b. Characteristics----Outer bark brittle, orange to light brown with cream-colored dots and streaks. Inner bark cream-colored, thin, and flexible. White ring near wood. Sapwood very slippery. Bark easily separates from wood.

c. Exudate----None. **d. Thickness**----About 1-3 mm.

17. Wood----Light orange, moderately hard.

18. Height category----hh to h. Up to 15 m.

19. Buttressing----Present, can be flying.

20. Bole----Crooked except near base. Round.

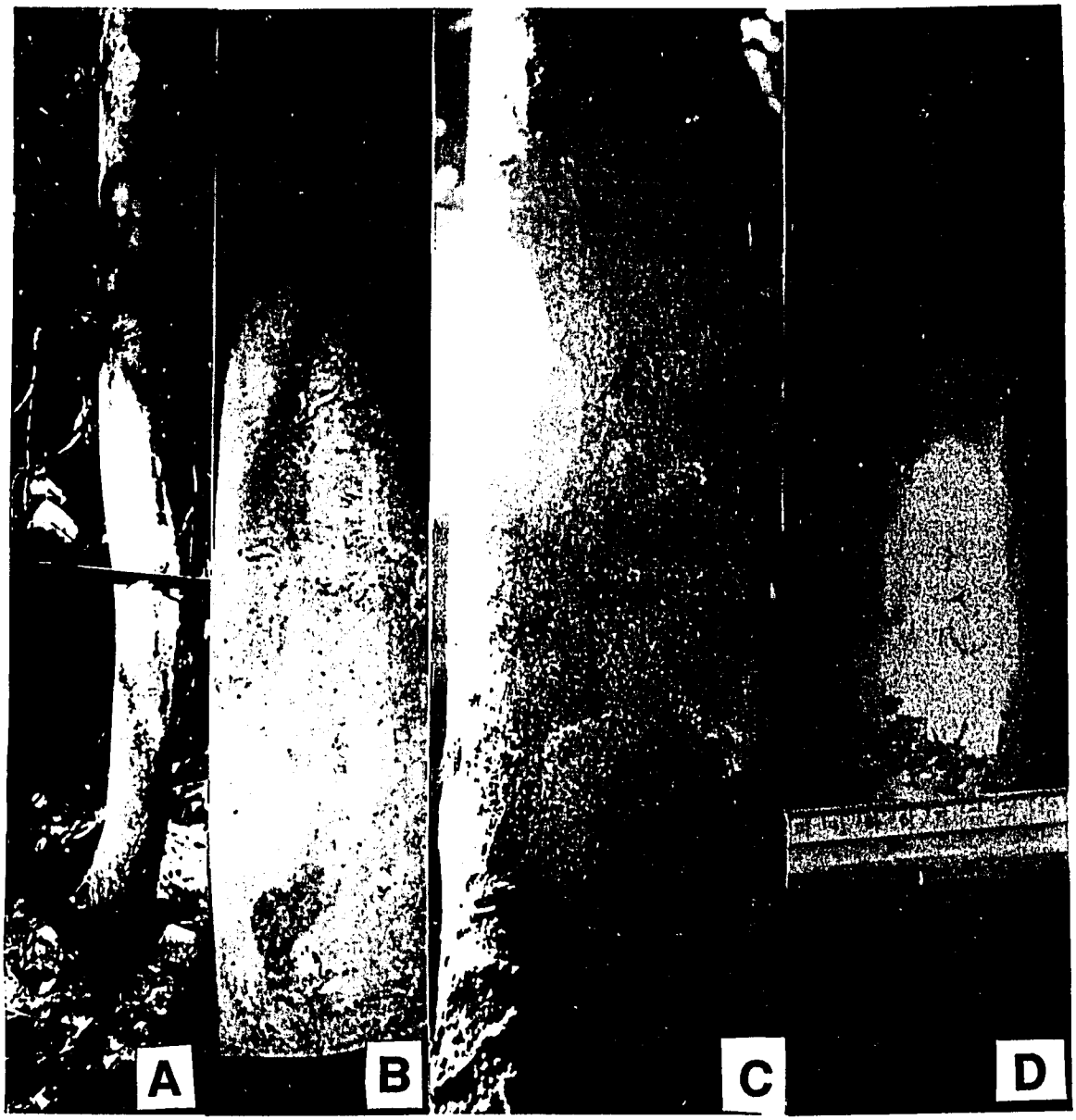
21. Additional remarks----Small tree with low branching.

Branchlets slightly pubescent. Leaves yellowish abaxially.

PLATE 48

Discoglypremna caloneura (Euphorbiaceae)

A----Bole. B & C----Bark. D----Slash.


A
B
C
D

Family	Species	Vernacular name
Euphorbiaceae	*Discoglypremna caloneura*	fetefre

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Widely elliptic to ovate.

b. Apex----Acuminate.

c. Base----Obtuse.

3. Margin----Serrate. Irregular spacing, rounded sinuses, simple series. Each sinus is fed by a branch of secondary vein.

4. Glands----Present as swellings, often in two pairs, close to petiole near base of lamina. Swellings in the sinuses of the serrations (usually at the termination of sec veins) resembling glands as well.

5. Leaf size----5-7.5 x 5-10 cm.

6. Petiole----Normal, very long, up to 14 cm long. Usually **apiconstrict** as well as **basiconstrict.**

7. Hairs

a. Abaxial surface

i. Type, color, & location----Erect hairs in pit domatia up to 0.5 mm long. Domatia at megacentral-primary branch or primary-sec junctions apically. Second type of tiny appressed hairs on all veins and petiole.

ii. Density----Hairs of domatia quite dense; tiny hairs dense on primary and sec veins, and carpets petiole like thin layer of cushion.

b. Adaxial surface----Most parts glabrous except for tiny hairs on primary and some sec veins.

8. Venation----Actinodromous (Perfect, marginal, basal).

9. Primary vein----Markedly curved including megacentral vein. Branched.

10. Secondary veins

a. Angle of divergence----Mixed. Secondaries join two primaries mostly at near 90^{o} except outer secondaries that are usually acute.

b. Course----Some curved abruptly, others uniformly; usually branched near margins, some sinuous.

c. Loop-forming branches----Obtuse (i.e. for secondaries nearer margin joining primaries).

d. Inter-sec vein----Absent.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Quarternary veins randomly oriented. Rest obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Brittle and gritty. Outside quite smooth. Prominent eyemarks. Hoop marks and tiny, numerous bumps.

b. Color----Brownish.

16. Slash

a. General color----Light yellow to orange-brown or a little

pink, usually with white spots.

b. Characteristics----Outer bark light brownish-yellow or greenish and brittle. Inner bark thinner, lightyellow and quite spongy. Strong fruity smell slightly pungent. Bark easily separates from wood. Slash remains the same color overnight.

c. Exudate----None. **d. Thickness**----About 2 mm.

17. Wood----Creamy to light yellow soft wood.

18. Height category----h to H. Up to 30 m.

19. Buttressing----Present.

20. Bole----Usually crooked. Sometimes triangular near base and flattened slightly, then round near crown, but usually cylindrical.

21. Additional remarks----Small forest tree common in disturbed forest. Conspicuously tri-nerved at base (three primaries). Prominent veins.

Family	Species	Vernacular name
Euphorbiaceae	*Drypetes aframensis*	opaha-tene

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to narrowly elliptic.

b. Apex----Acuminate. **c. Base**----Cuneate.

3. Margin----Generally entire with slight crenations or serrations 1/3 way down from apex. Serrations with angle acute, slightly convex basally and straight apically, irregular spacings, simple series, rounded sinuses.

4. Glands----Scattered, tiny, round dots on blade resembling glands.

5. Leaf size----5-19 x 2.5-9 cm.

6. Petiole----Normal, distinct, 4-6 mm long.

7. Hairs----Glabrous on both surfaces. Only buds have a few appressed white hairs. Young twigs sparingly pubescent or glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary vein

a. Angle of divergence----Acute narrow; lowest pair a little more acute.

b. Course----Curved abruptly, a short distance from margin, unbranched.

c. Loop-forming branches----Acute to right angle. Enclosed by tertiary arches.

d. Inter-secondary vein----Absent.

e. Number----7 or more.

11. Tertiary vein

Pattern----Orthogonal reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete to lacking.

15. Bark

a. Texture----Brittle and gritty.

b. Color----Gray-brown.

16. Slash

a. General color----Orange to light brown.

b. Characteristics----Outside of outer bark deeper brown; slash turns reddish-brown to dark brown after long exposure. Faint scent.

c. Exudate----None. **d. Thickness**----1-3 mm.

17. Wood----Yellowish hardwood.

18. Height category----h to hh. Up to 13 m.

19. Buttressing----Absent. Fluted at base.

20. Bole----Round, usually straight, sometimes slightly bent or crook near crown.

21. Additional remarks---- Twigs have prominent ellipsoid-shaped lenticels. Dry leaves yellowish. Leaves resemble those of *Celtis* spp. Veins not prominent on adaxial side. Primary vein relatively large compared with secondary. Abaxial side of blade has slightly silvery tint, and is shiny under microscope.

Family	Species	Vernacular name
Euphorbiaceae	*Drypetes gilgiana*	katrika

---

1. Organization

Leaf type----Simple.

2. Shape

a. Form----Elliptic to widely elliptic.

b. Apex----Acuminate. **c. Base**----Cuneate.

3. Margin----Entire to slightly crenate.

4. Glands----Absent. **5. Leaf size**----4-12 x 1.5-6 cm.

6. Petiole----Normal; dark when dry.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed hairs 0.1-0.2 mm long on primary and sec veins, sometimes on a few tertiaries; rest of blade glabrous. Hairs on petiole and buds.

ii. Density----Scattered on veins. Few on petiole. Dense on

buds.

b. Adaxial surface----Glabrous except for scanty, very short hairs along primary vein, especially near base.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, sometimes straight; unbranched.

10. Secondary vein

a. Angle of divergence----Acute moderate, nearly uniform, lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute; enclosed by tertiary arches.

d. Inter-secondary vein----Absent.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Quite well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Brittle. Outside rough. Shallow vertical markings.

b. Color----Gray-brown.

16. Slash

a. General color----Light brownish-orange.

b. Characteristics----Turns darker brown after exposure, with sapwood becoming very dark. Cover of outer bark dark. Two or three rings of brown in outer bark.

c. Exudate----None. **d. Thickness**----2-3 mm.

17. Wood----Cream-colored, hard.

18. Height category----hh. Up to 10.5 m.

19 Buttressing----Absent; fluted at the base. Sometimes with sharp root processes near base of trunk.

20. Bole----Round, straight, sometimes crooked near crown.

21. Additional remarks----Small forest tree, sometimes spreading. Secondary veins **stalked**.

PLATE 49

Drypetes principum (Euphorbiaceae)

A----Bole.

B----Bole, bark, and slash.


A
B

Family	Species	Vernacular name
Euphorbiaceae	*Drypetes principum*	opaha

---

1. Organization

Leaf type----Simple.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Serrate. Simple series, angular sinuses, irregular spacings, apical angle acute.

4. Glands----Absent. **5. Leaf size**----9-23 x 2-10 cm.

6. Petiole----Normal; has vertical wrinkles.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed hairs, 0.1-0.5 mm long, especially on primary vein. Similar hairs on petiole but thicker.

ii. Density----Sparse.

b. Adaxial surface----Most parts glabrous except for very few appressed hairs on primary vein and near base.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Generally markedly curved to slightly straight; unbranched.

10. Secondary veins

a. Angle of divergence----Acute mederate, generally uniform but lowest pair a little more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute; enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Absent.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped; with a fimbrial vein.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Brittle; Outside smooth. Shallow vertical markings. Most lenticels in vertical rows, some scattered.

b. Color----Gray or gray-green.

16. Slash

a. General color----Cream to orange.

b. Characteristics----Outer bark creamy; inner bark orange to brown. Slash becomes light brown after 15 mins, then gray-brown after one min, and darker gray after five mins. Sapwood slippery and also becomes brown after two mins. Quite strong pleasant smell.

c. Exudate----Light brown, non-sticky exudate only from inner bark and wood.

17. Wood----Creamy to light yellow, a little soft.

18. Height category----hh to h. Up to 10.5 m.

19. Buttressing----Fluted very much at base with signs of slight buttressing. Slender, few stilt roots up to about 0.3 m up the trunk for most mature trees.

20. Bole----Round, and crooked.

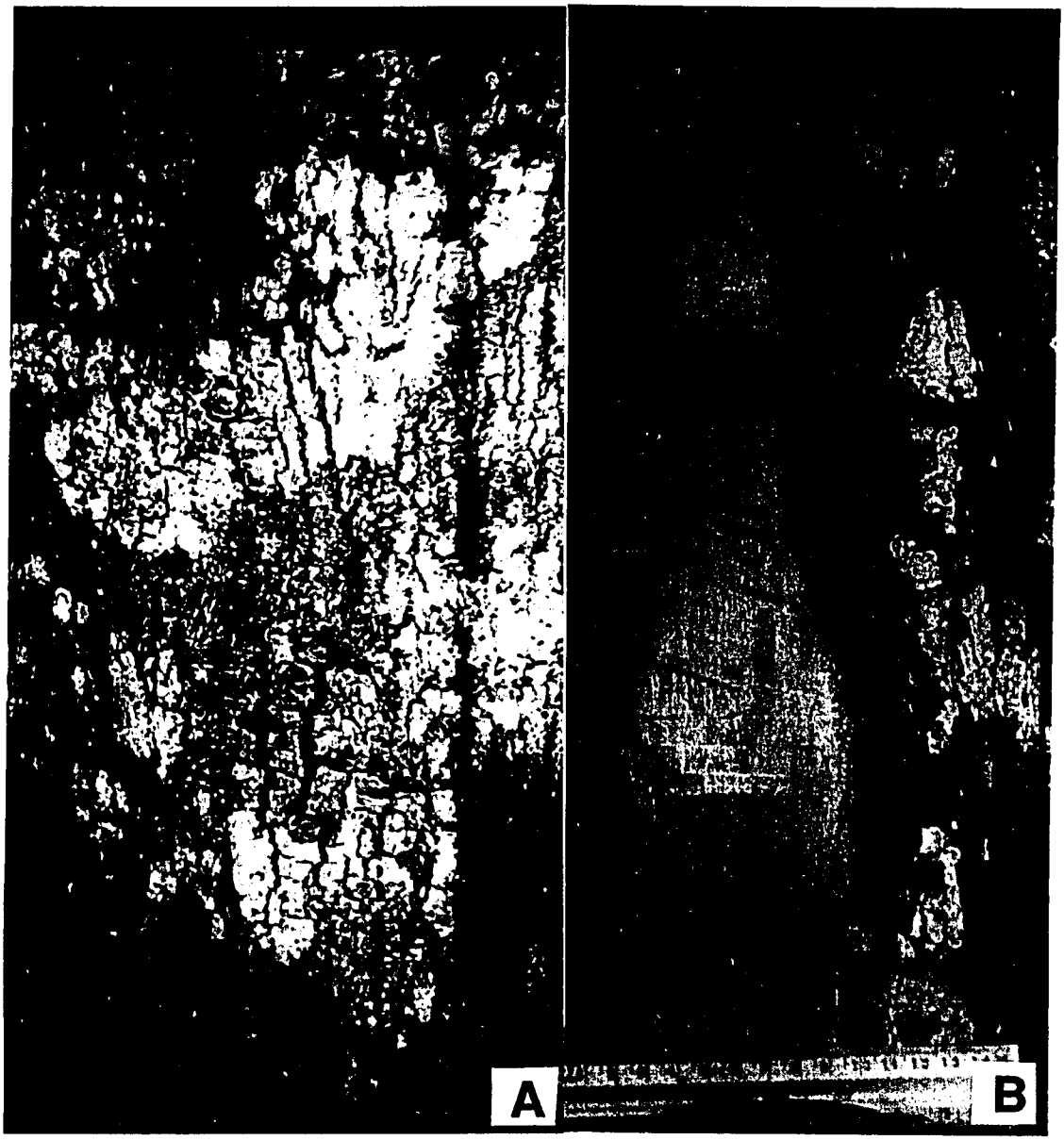
21. Additional remarks----Small forest tree with low branching (begins about halfway from base). Both surfaces of leaf shiny under microscope. Branches of tertiary veins along margins join sinuses and protrude to form the apex of teeth along margin.

PLATE 50

Macaranga heudelotii (Euphorbiaceae)

A----Bark.

B----Slash.


A
B

Family	Species	Vernacular name
Euphorbiaceae	*Macaranga heudelotii*	awora opam

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Acute to slightly obtuse.

3. Margin----Entire.

4. Glands----Present at base of leaf, sometimes situated on two small lobes.

5. Leaf size----4.5-12.5 x 2-5.5 cm.

6. Petiole----Normal, short (usually less than 3 cm long).

7. Hairs

a. Abaxial surface

i. Type, color, & location----Brownish-orange erect hairs visible on petiole and primary vein. Appressed flexuous hairs on all veins and intercostal areas, up to 7 mm long.

Hairs on young twigs.

ii. Density----Hairs densely cover entire blade and twigs.

b. Adaxial surface----Most parts of blade glabrous;

sparsely distributed appressed hairs on veins.

8. Venation----Simple Craspedodromous.

9. Primary vein----Straight to markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute narrow, nearly uniform.

b. Course----Curved uniformly, unbranched.

c. Loop-forming branches----Absent.

d. Inter-secondary vein----Absent.

e. Number----10-13 pairs.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Mostly simple and straight, few forked or

recurved.

ii. Relation to midvein----Oblique.

iii. **Arrangement**----Predominantly opposite.

12. **Higher order venation**----Quaternary veins orthogonal, rest obscure.

13. **Marginal ultimate venation**----With a fimbrial vein that extends as two vertical ridges at base of blade and join petiole.

14. **Areoles**

a. **Development**----Well developed.

b. **Shape**----Triangular and quadrangular.

15. **Bark**

a. **Texture, & features**----Brittle to fibrous (when old). Outside rough. Very prominent sharp spine scattered all over including bark of buttresses; older trees have spine confined to twigs with bark of bole having very few, and depressions showing positions of former spines. Round spines longer than those of *Ceiba pentandra*. Numerous shallow vertical markings and a few eyemarks.

b. **Color**----Brownish-gray with white tint, brown, or dark brown with gray tint.

16. Slash

a. General color----Light reddish-brown or brownish-purple.

b. Characteristics----Becomes brownish after 15 mins. Inner bark near wood slightly creamy. Sapwood light yellow, becomong light brown after 15 mins. Strong, repulsive smell, that emanates more from wood than bark.

c. Exudate----None. **d. Thickness**----1.0-2.5 mm.

17. Wood----Light yellowish-orange, yellow-brown, or creamy, hard. About one centimeter of first layer of sapwood deep yellow.

18. Height category----hh. Up to 9 m.

19. Buttressing----Flying buttresses and stilt roots, some very small in diameter.

20. Bole----Round, generally crooked, with little bumps.

21. Additional remarks----Shrub or small tree usually in swamp forest and riversides, with low branching. The most common understorey tree in the Bobiri forest reserve.

Family	Species	Vernacular name
Euphorbiaceae	*Maniophyton fulvum*	

---

1. Organization

Leaf type----Simple.

2. Shape

a. Form----Suborbiculate. **b. Apex**----Acuminate.

c. Base----Lobate.

3. Margin----Slightly crenate. **4. Glands**----Absent.

5. Leaf size----Up to 25 cm long and broad.

6. Petiole----Normal, long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Mixture of erect and appressed brown hairs 0.2-2.0 mm long on all veins and intercostal areas. The longest hairs (especially on primary vein) have distinguishing cluster of short hairs (0.5-0.1 mm) at their bases, with some of the short hairs distributed along the

primary veins. Some of the long hairs are on buds (as long as 3.2 mm), petiole, and nodes of young twigs. Branchlets have short stellate hairs.

ii. **Density**----All types copious on all organs when present.

b. Adaxial surface

i. **Type**----Same types of hairs on abaxial side.

ii. **Density**----Less abundant than on abaxial side.

8. **Venation**----Actinodromous (Perfect, marginal, basal).

9. **Primary vein**----Straight, branched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate for outer secondaries; right angle for other secondaries. Lowest pair of outer secondaries more acute.

b. **Course**----Curved abruptly, unbranched; provided with outer sec veins.

c. **Loop-forming branches**----Acute to right angle, enclosed by tertiary arches.

d. **Inter-secondary vein**----Absent.

11. Tertiary veins

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal; rest obscure.

13. Marginal ultimate venation----Looped, with a fimbrial vein.

14. Areoles

a. Development----Well developed.

b. Shape----Polygonal and quadrangular.

15. Bark

a. Texture and features----Fibrous. Outside smooth. Grouped hoop marks, sometimes up to 10 in a group. Scattered lenticels. Wide ellipsoid eyemarks that usually turn into hoop marks for the remaining length.

b. Color----Brownish-gray.

16. Slash

a. General color----Purple.

b. Characteristics----Cover of outer bark greenish. Outer bark light purple; inner bark deeper purple; inside lining of inner

bark creamy with light purple tint. Whole slash browns in 10 secs, and it as well as the wood becomes deeper brown after one minute. Slight but quite agreeable smell. Mode of color change very similar to that of *Ficus asperifolia.*

c. Exudate----Copious, sticky, white latex with brown taint that turns darker brown after two mins.

d. Thickness----about 5 mm.

17. Wood----Soft, creamy, with horizontal rings.

18. Height category----hh.

19. Buttressing----Smooth plank buttresses closely resembling those of *Ficus asperifolia.* Buttresses often well above breast height and branched close to trunk.

20. Bole----Smooth, round, crooked.

21. Additional remarks----Shrub or climber that sometimes becomes a treelet. Leaves often polymorphous, 5-nerved at base. Adaxial side very dark green; abaxial side lighter green.

Family	Species	Vernacular name
Euphorbiaceae	*Mareya micrantha*	dubrafo

---

1. Organization

Leaf type----Simple.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

b. Base----Cuneate.

3. Margin----Shallowly serrate but entire near base; serrations with apical angle acute , apical straight, basal convex, sinus angular, irregular spacing, simple series.

4. Glands----Absent. **5. Leaf size**----8-24 x 3-9 cm.

6. Petiole----Normal; apex and base rugose with horizontal striations.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed reddish-brown hairs 0.2-0.4 mm long, mixed with hairs 0.5-1.0 mm long on all veins; quite visible without magnification under bright light.

Some other tiny hairs seen as little tufts on primary vein. Tiny appressed hairs on petiole. Buds and young twigs hairy.

ii. **Density**----Abundant.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute wide, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Right angle to obtuse near apex, enclosed by secondary and tertiary arches.

d. **Inter-secondary vein**----Simple.

11. **Tertiary vein**

Pattern----Percurrent.

i. **Course**----majority recurved, a few sinuous, mainly forked, a few simple.

ii. **Relation to midvein**----Majority right angle to midvein, some oblique.

iii. **Arrangement**----Predominantly alternate.

12. **Higher order venation**----Quaternary veins random; rest of higher order veins obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**----Incomplete to lacking.

15. **Bark**

a. **Texture, & features**----Brittle-fibrous. Outside smooth. Scattered lenticels, some in vertical arrangement.

b. **Color**----Gray.

16. **Slash**

a. **General color**----Light brown to orange brown.

b. **Characteristics**----Outer bark brownish, inner bark creamy brown. Slash becomes deeper brown after three minutes of exposure. Quite pleasant strong smell. Bitter taste.

c. **Exudate**----Watery, non-sticky.

d. **Thickness**----1.0-1.5 mm.

17. **Wood**----Light brown to light yellow; quite hard.

18. **Height category**----hh. Up to 13 m.

19. Buttressing----Present; small.

20. Bole----Quite straight.

21. Additional remarks----Shrub or tree. Adaxial side of dry leaf with geometrical patterns under microscope, and shiny under light. Bumps (2-3) at leaf base-petiole junction.

PLATES 51 & 52

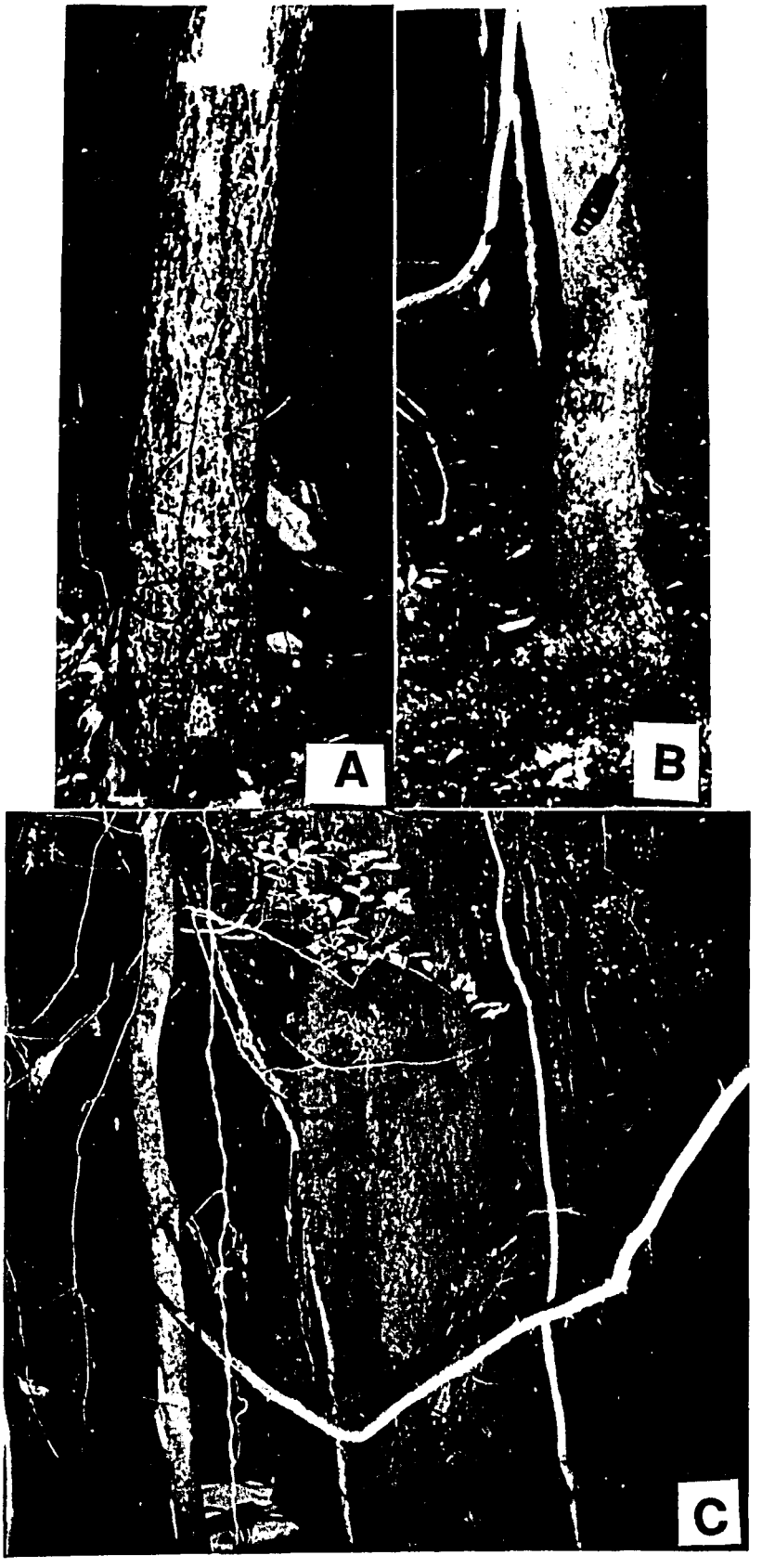
Ricinodendron heudelotii (Euphorbiaceae)

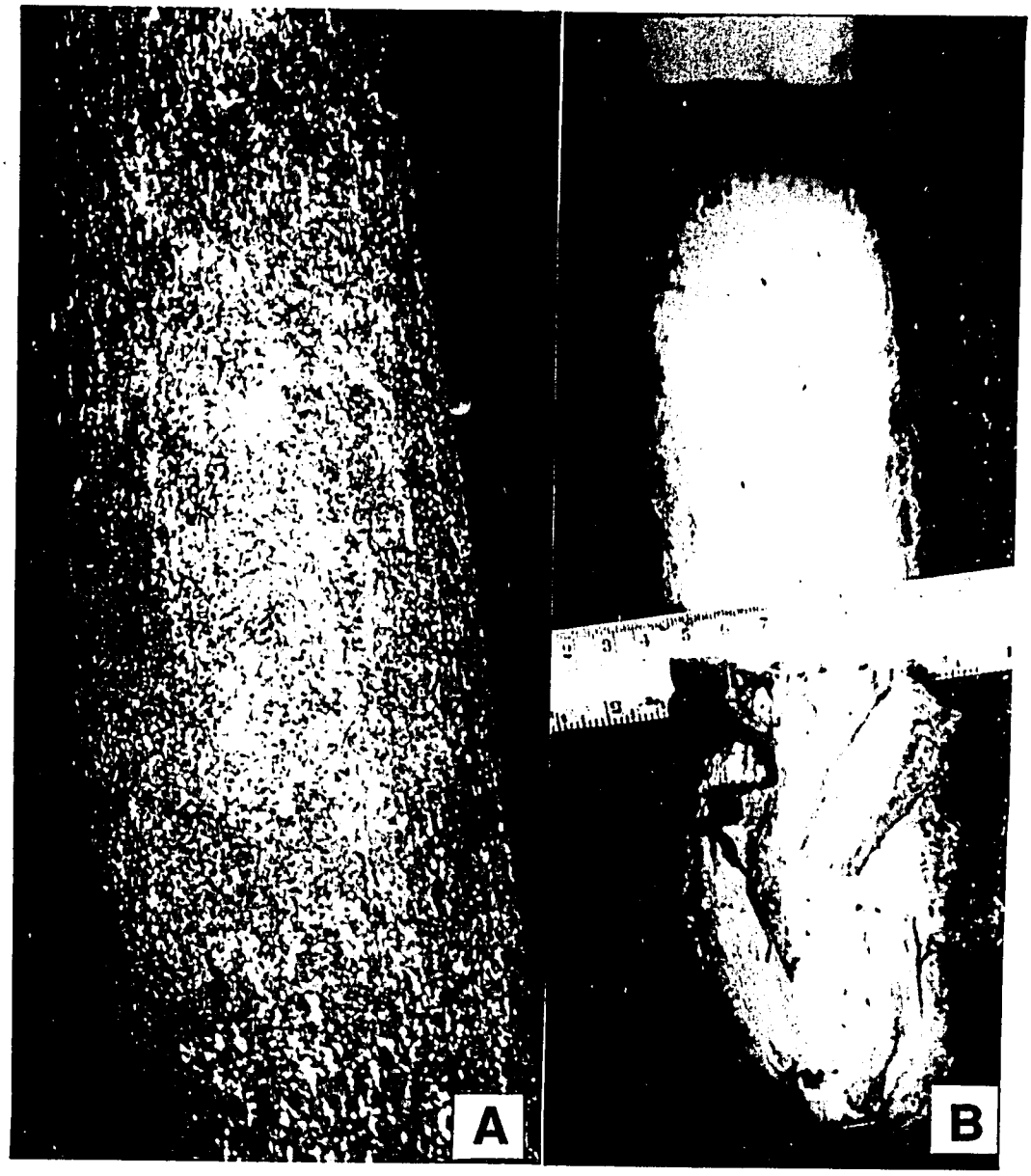
51A &B----Bole of young tree with incipient buttresses.

51C----Bole and buttresses of old tree.

52A----Bole and bark.

52B----Slash.


A
B
C


A
B

Family	Species	Vernacular name
Euphorbiaceae	*Ricinodendron heudelotii*	wama

---

1. Organization

Leaf type----Compound, palmate, 3-5 foliate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire, with small glandular teeth.

4. Glands----Small glands (0.5-0.8 mm diam.) at leaf margin connected to secondary veins. Little glandular dots (0.1 mm diam.) densely scattered in intercostal areas, the tips usually pointed but some have truncated apices which then become round patches. Brownish glandular "mounds"with holes on top (0.8-1.2 mm diam.) along rachis and petiolules (larger around base of rachis as visible bumps, 2.5-3.0 mm diam.). Paired glands at base or top of rachis. Glands up to 0.7 mm diam. on primary and sec veins too.

5. Leaf size----6-23 x 2.5-15 cm.

6. a. **Petiolule**----Normal, very short. Hutchinson and Dalziel (1954-72) describe the leaflets as sessile.

b. **Rachis**----Long, up to 21 cm. Shiny, reddish-brown resin usually around base and in scars where it was attached to branch.

7. **Hairs**

a. **Abaxial surface**----Stellate hairs on all areas of blade when young. Older leaves glabrous.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute.

d. **Inter-secondary vein**----Absent.

e. **Number**----10-16 pairs.

11. **Tertiary vein**

Pattern----Percurrent.

i. **Course**----Simple, convex, some recurved (10-30 % per intercostal area).

ii. **Relation to midvein**----Mostly oblique, becoming more right angled near apex.

iii. **Arrangement**----Predominantly opposite, distant.

12. **Higher order venation**----Quaternary veins orthogonal, rest of higher order veins obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**----Imperfect.

15. **Bark**

a. **Texture, & features**----Fibrous and fissured. Outside rough, flakes when old. Outside layer a little brittle when old; very pliable and peelable. Shallow vertical slits.

b. **Color**----Gray to brownish.

16. **Slash**

a. **General color**----Purple to reddish-purple or orange to pink.

b. **Characteristics**----Becomes reddish-brown with slightly purple tint after 20 mins. Cover of outer bark brownish with

slightly reddish-purple taint. Outer bark reddish-purple or pink; inner bark creamy to orange. Strong savoury smell. Sometimes becomes dark brown after several hours of exposure. Sapwood orange.

c. Exudate----Reddish and watery, resembling blood. Smooth and lubricating, not sticky.

d. Thickness----1.0-5.0 mm.

17. Wood----Light yellow or creamy, relatively soft when young but slightly hard when old.

18. Height category----H. Up to 46 m.

19. Buttressing----Presence of thick buttresses.

20. Bole----Quite round, straight, sometimes quite crooked or flattened. Bulging points. Sometimes fluted to about 5 m from base.

21. Additional remarks----A large deciduous tree usually in drier parts of the forest, especially in secondary regrowth, but also found in some wet forests. Stipules are large, foliaceous, persistent, suborbicular, up to 2.5 cm long, and deeply toothed.

From a distance, the leaves appear like those of *Manihot*. Cuticle commonly peels off dry leaves. Damaged portions of leaf exude dark brown waxy sap. Dry leaf is dark green. Venation pattern is very conspicuous. Slash heals well after 6 months.

GUTTIFERAE

Trees or shrubs. Characterized by yellow resinous sap, simple, opposite, and entire leaves that lack stipules.

A family of five genera and 22 species in West Africa. There is one genus and one species in the Bobiri forest reserve.

PLATES 53 & 54

Mammea africana (Guttiferae)

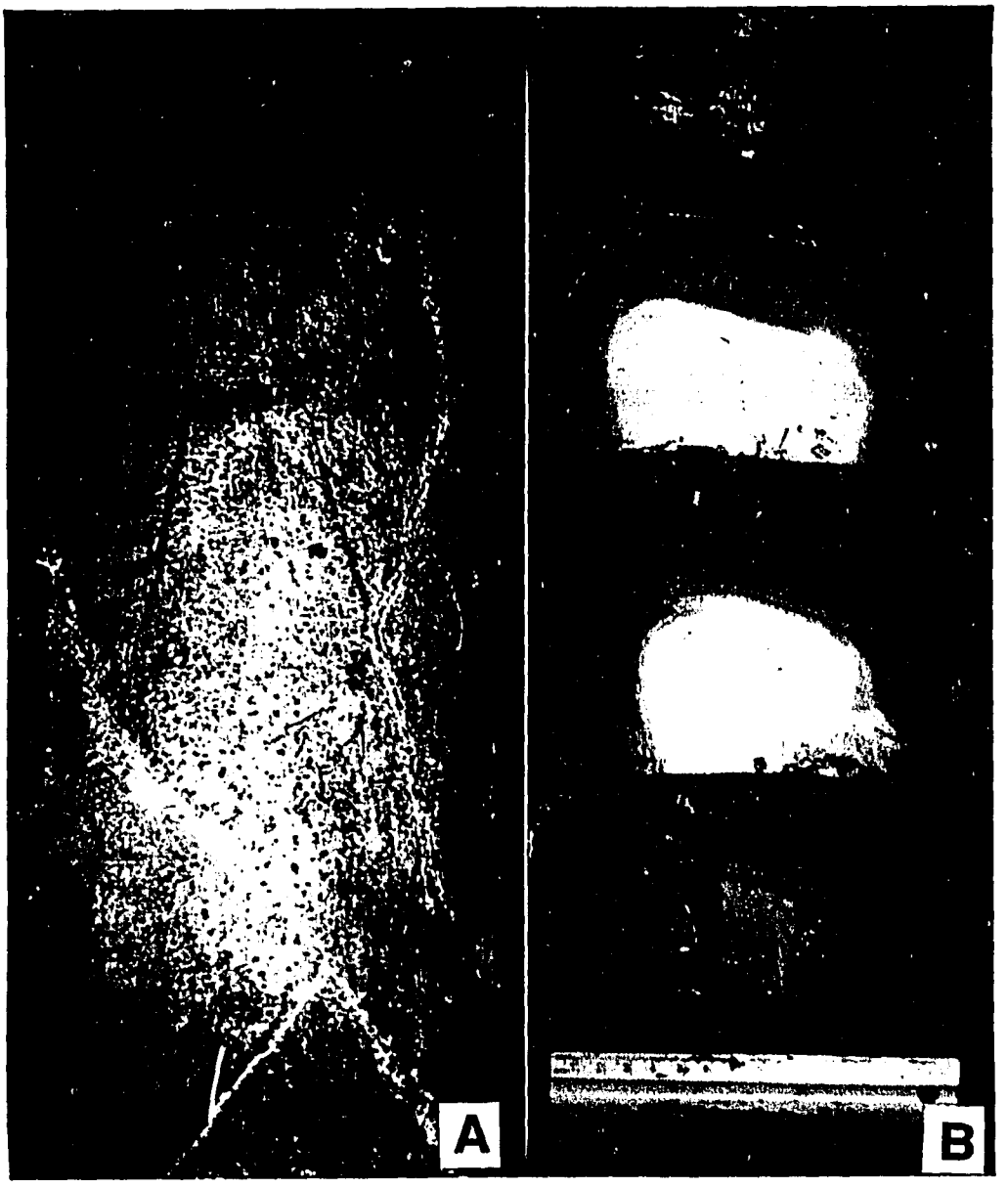
53A----Bole.

53B----Bark.

54A----Bark and hoop marks.

54B----Slash.


A
B


A
B

Family	Species	Vernacular name
Guttifereae	*Mammea africana*	bompagya

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Narrowly elliptic.

b. Apex----Acuminate to very slightly attenuate.

c. Base----Cuneate to very slightly decurrent.

3. Margin----Entire, with slight signs of crenations.

4. Glands----Tiny scattered dots especially on abaxial side resembling glands.

5. Leaf size----15-25 x 6-9 cm.

6. Petiole----Normal; usually flattened dorsoventrally and wrinkled. About 2 cm long.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute wide, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by secondary and tertiary arches.

d. Inter-secondary vein----Simple.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins random; rest obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Brittle-fibrous. Outside slightly rough to smooth. Several dark brown prominent scattered lenticels with few in vertical rows. Sometimes with pale scales.

b. Color----Brown or brownish-gray with creamy tint.

16. Slash

a. General color----Reddish-brown or deep reddish-purple.

b. Characteristics----First layer of reddish outer bark with one or two brownish-cream colored rings; rest is thick and reddish-purple. Inner bark cream-colored and flexible. Slash becomes brown after 5 secs, becomes brownish-purple after 3 mins, deeper brown after 5 mins, and dark brown after 10 mins. Wood also turns brown after 3 mins. Moderate pleasant smell.

c. Exudate----Creamy-yellow or deep yellow very sticky exudate, remains the same color overnight. Exudes in drops from points in inner bark.

d. Thickness----About 2 mm.

17. Wood----Quite hard, light-brown.

18. Height category----h to H. Up to 15-31 m.

19. Buttressing----Present in some mature trees; small.

20. Bole----Straight to slightly crooked. Round with many bumps.

21. Additional remarks----Large forest tree with large leaves. Adaxial surface of leaf shiny, the blade is thick and leathery. Thick prominent primary vein 10 times bigger than secondaries. Dry leaves are brownish-orange or slightly yellowish. Young branches have characteristic line above each node.

ICACINACEAE

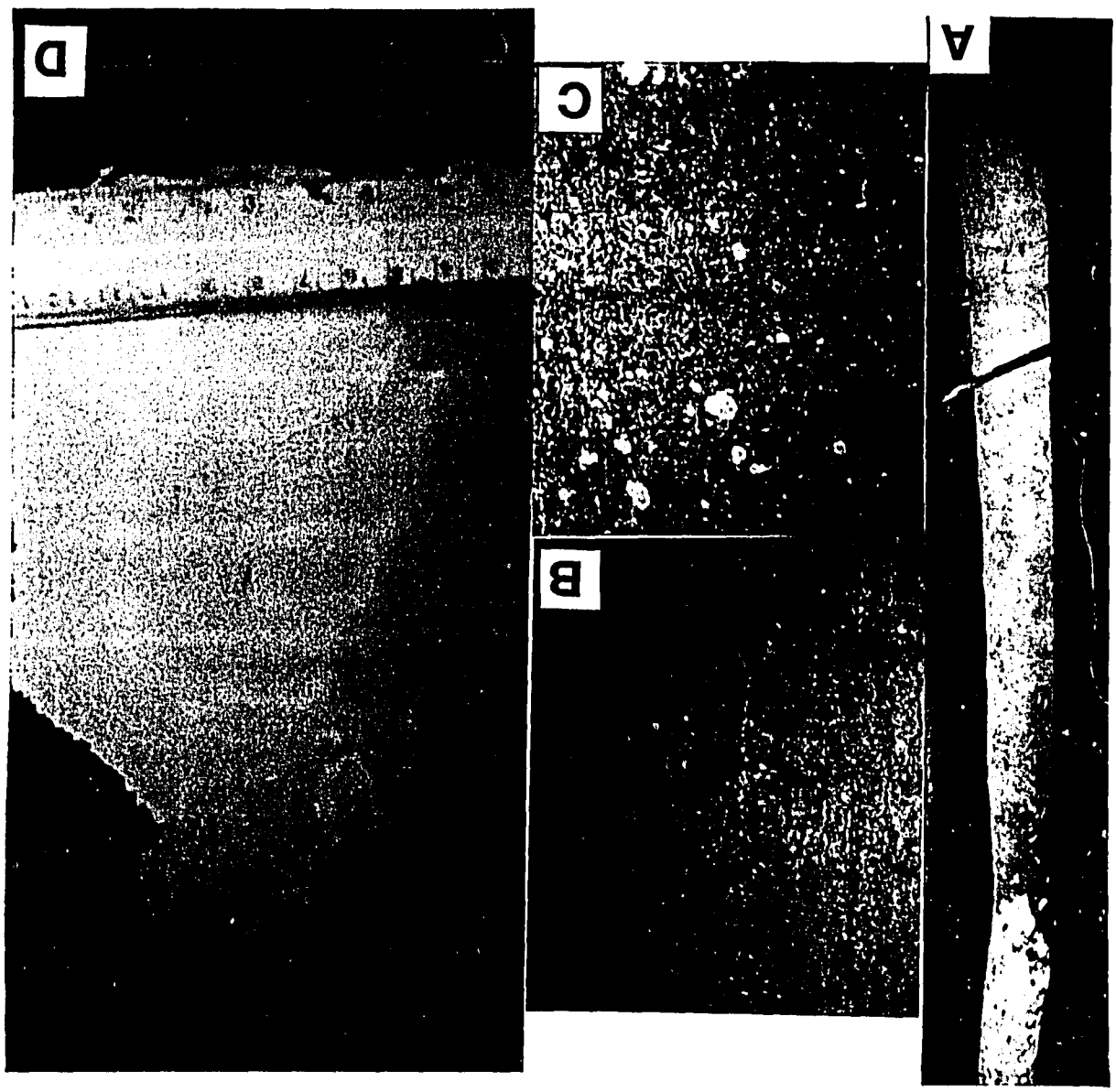
Trees or shrubs, rarely climbers. Leaves alternate, rarely opposite, simple. Stipules absent.

A small family of 12 genera and 40 species in West Africa. There is one genus and one species in the Bobiri forest reserve.

PLATE 55

Leptaulus daphnoides (Icacinaceae)

A----Bole. B & C----Bark. D----Slash.


D
C
B
A

Family	Species	Vernacular name
Icacinaceae	*Leptaulus daphnoides*	afena-akoa

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1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Acute to cuneate.

3. Margin----Entire with slight crenations.

4. Glands----Absent. **5. Leaf size**----3-16 x 1.5-8 cm.

6. Petiole----Normal, thin, often with slight extension of blade. Has shallow vertical ridges that extend to primary vein.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Generally straight; sometimes curved at apex. Unbranched.

10. Secondary veins

a. Angle of divergence----Acute wide, upper more acute, and almost all at right angle near base.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Right angle to acute, enclosed by tertiary arches.

d. Inter-secondary vein----Simple.

e. Number----5-7 pairs.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Brittle, easily separates from wood. Outside smooth to rough. Scattered lenticels sometimes arranged in helical and vertical rows. Few eyemarks and a few hoop marks.

b. Color----Gray or brown.

16 Slash

a. General color----Orange to light yellow, cream, or light brown.

b. Characteristics----Outer bark orange-brown and very brittle. Cream-colored inner bark thinner and brittle to slightly fibrous. Quite pungent relatively disagrreable smell like *Allium cepa* . Sapwood very slippery. Slash remains same color after 3 hours.

c. Exudate----Clear, scanty, non-sticky exudate.

d. Thickness----1.5-2.0 mm.

17. Wood----Cream to light yellow, very hard.

18. Height category----h. Up to 20 m.

19. Buttressing----Generally absent; fluted at base.

20. Bole----Round, straight to slightly crooked.

21. Additional remarks----Forest tree or shrub. Dry leaves appear yellowish-green on abaxial side. Leaf quite leathery. Primary vein extends one mm beyond apex of blade. Primary vein

markedly bigger than secs or tertiaries.

LECYTHIDACEAE

Trees or shrubs. Leaves usually very clustered, leaves simple, alternate, not gland-dotted, sometimes with large glands on margin. Stipules absent.

A family of three genera and 14 species in West Africa. There are two genera and two species in the Bobiri forest reserve.

PLATE 56

Petersianthus macrocarpaus (Lecythidaceae)

Branches, leaves, and flowers.



Family	Species	Vernacular name
Lecythidaceae	*Petersianthus macrocarpus*	esia

---

1. Organization

Leaf type----Simple.

2. Shape

a. Form----Elliptic. **b. Apex**----Acute to acuminate.

c. Base----Cuneate to decurrent.

3. Margin----Crenate.

4. Glands----Typical laminar glands in angle of divergence of sec veins 0.3-1.0 mm diam. (at 10x); also found widely spaced along some sec veins and scattered in some intercostal areas. Seen as round domes on adaxial side of leaf, but round structures with apical hole (like a crater) on abaxial side. Little brown glands surrounded by transparent tissue in the sinuses of crenations at leaf margin, connected to tertiary and quarternary veins, sometimes with a brittle hairlike projection pointing apically.

5. Leaf size----10-16 x 5-7.5 cm.

6. Petiole----Slightly winged, decurrent on both sides to midpoint.

Short.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Tiny erect hairs around the leaf base, on petiole, (0.1-0.2 mm long). Another type of longer erect hairs (0.4 mm long 20x) at fringes of the lamina at base. Transparent hairs (0.6-1.0 mm long) in pit domatia around open glands at primary-sec apical junctions.

ii. Density----All types of hairs sparsely distributed except those in pit domatia which are quite dense.

b. Adaxial surface

i. Type, color, & location----Erect hairs (0.4 mm long at 20x) distributed on primary vein (absent from the same location on abaxial side). Transparent hairs (0.6-1.0 mm long) sometimes on the summit of the isolated glands.

ii. Density----Abundant around base of primary vein but

scattered along the length of it; sparse on glands.

Irvine (1960) describes leaf as entirely glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, sometimes a little sinuous, unbranched.

10. Secondary veins

a. Angle of divergence----Generally wide but sometimes acute moderate. A few suddenly deviate to give narrow angle of divergence, especially near apex; lower sec veins generally more obtuse than upper sec veins.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute.

d. Inter-secondary veins----A few veins come close to becoming composite inter-secondaries, enclosed by tertiary and quarternary arches.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Forked generally; some convex, concave, recurved,

or sinuous.

ii. Relation to midvein----Some at right angle, majority oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quarternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Very spongy, thick, and fibrous. Outside rough. vertically oriented anastomosing slits. Old bark has up to one mm thick pale brown cork.

b. Color----Brown or grea.

16. Slash

a. General color----Creamy-brown with purple tint, light orange with purple tint, or pink.

b. Characteristics----Turns a little grayish with purple tint after 6 mins, with grayish-brown ring near wood.

Unpleasant strong smell. Old sap remains for up to 8 months (or more) on slash even after callus has grown and turns very dark brown. Bitter taste. Outer bark very deeply fissured.

c. Exudate----Slightly transluscent, non-sticky exudate that oozes slowly.

d. Thickness----3-10 mm.

17. Wood----Creamy-yellow, hard.

18. Height category----H. Up to 40 m.

19. Buttressing----Usually unbuttressed, sometimes slightly fluted at base; small buttresses sometimes develop in old trees beyond DBH 50cm.

20. Bole----Usually straight, sometimes slightly crooked, few swollen points.

21. Additional remarks----Rain forest tree. Slash heals well after six months. Old leaves appear reddish.

MELIACEAE

Trees or shrubs. Wood is usually hard and scented. Leaves alternate, mostly pinnate, infrequently simple, bipinnate, or tripinnate, for most species commonly clustered towards ends of twigs. Usually readily recognized by the pinnate englandular leaves. Stipules absent.

A mainly tropical family of 13 genera and 37 species in West Africa. There are seven genera and 12 species in the Bobiri forest reserve.

PLATES 57 & 58

Carapa procera (Meliaceae)

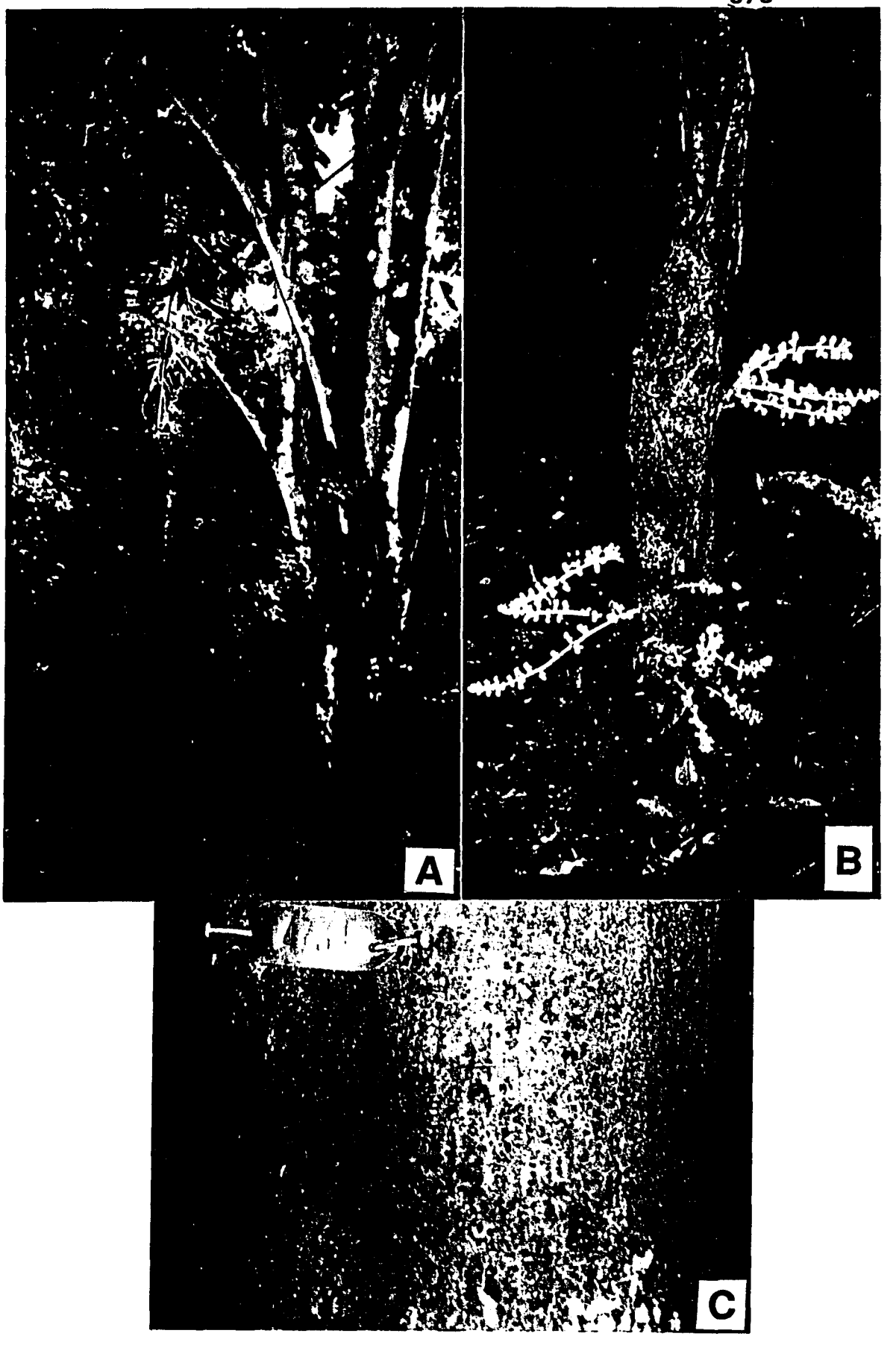
57A----Bole and branches.

57B----Bole and inflorescence showing characteristic cauliflory.

57C----Bark.

58A----Bole, bark and healed slash.

58B----Slash (above--after 30 seconds; below--after one minute).


A
B
C


A
B

Family	Species	Vernacular name
Meliaceae	*Carapa procera*	kwakuo-bese

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1. Organization

a. Leaf type----Compound, regular odd pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite or alternate. 6-21 pairs.

2. Shape----Very variable.

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire, sometimes with slight crenations.

4. Glands----Absent.

5. Blade size----Very variable. Usually up to 50 cm long and 15 cm broad but can be up to 2 m long.

6. Petiolule----Normal, with folds on abaxial side.

7. Hairs

a. Abaxial side

i. Type, color, & location----Very short erect hairs visible

only after 12x, mainly on primary vein. Also with inconspicuous white flexuous hairs up to 0.5 mm long; on petiolule as well.

ii. **Density**----All hairs scanty and scattered.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to slightly markedly curved, unbranched.

10. **Secondary vein**

a. **Angle of divergence**----Acute moderate, nearly uniform. Lowest pair slightly more acute.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by tertiary and quaternary arches.

d. **Inter-secondary vein**----Simple.

11. **Tertiary vein**

Pattern----Percurrent.

i. **Course**----Forked, mainly sinuous, a few convex and recurved.

ii. **Relation to midvein**----Generally oblique; some angular.

iii. **Arrangement**----Predominantly alternate.

12. **Higher order venation**----Quaternary veins orthogonal; rest obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**----Imperfect.

15. **Bark**

a. **Texture, & features**----Fibrous. Outside smooth to slightly rough. Typical vertical splits of the bark and very prominent lenticels in vertical rows along slits, giving the bole a zebra-like appearance.

b. **Color**----Gray with dark green tint.

16. **Slash**

a. **General color**----Reddish or brownish-purple.

b. **Characteristics**----Cover of outer bark deeper brown with creamy-green stripes, followed by a thin orange layer; rest of outer bark reddish or brownish like inner bark. After 3 mins outer bark becomes deeper brown with slightly grayish-purple tint; inner bark develops a yellowish-orange layer followed by a

cream-colored layer and an inner ring of orange near wood. Slash brown after 15 mins, with brown streaks in wood. Moderate agreeable smell.

c. Exudate----None. **d. Thickness**----About 3 mm.

17. Wood----Moderately hard, creamy.

18. Height category----h. Up to 16 m.

19. Buttressing----Presence of small buttresses.

20. Bole----Round, usually straight.

21. Additional remarks----Habit varies from a sprawling tree with arching branches in swamp forest to a tall tree with clear bole in lowland rain forest. The long leaves are usually seen clustered at end of twigs. Seed very bitter; villagers report that several animals feed on them (e.g. brush-tailed porcupine and rat).

PLATES 59 & 60

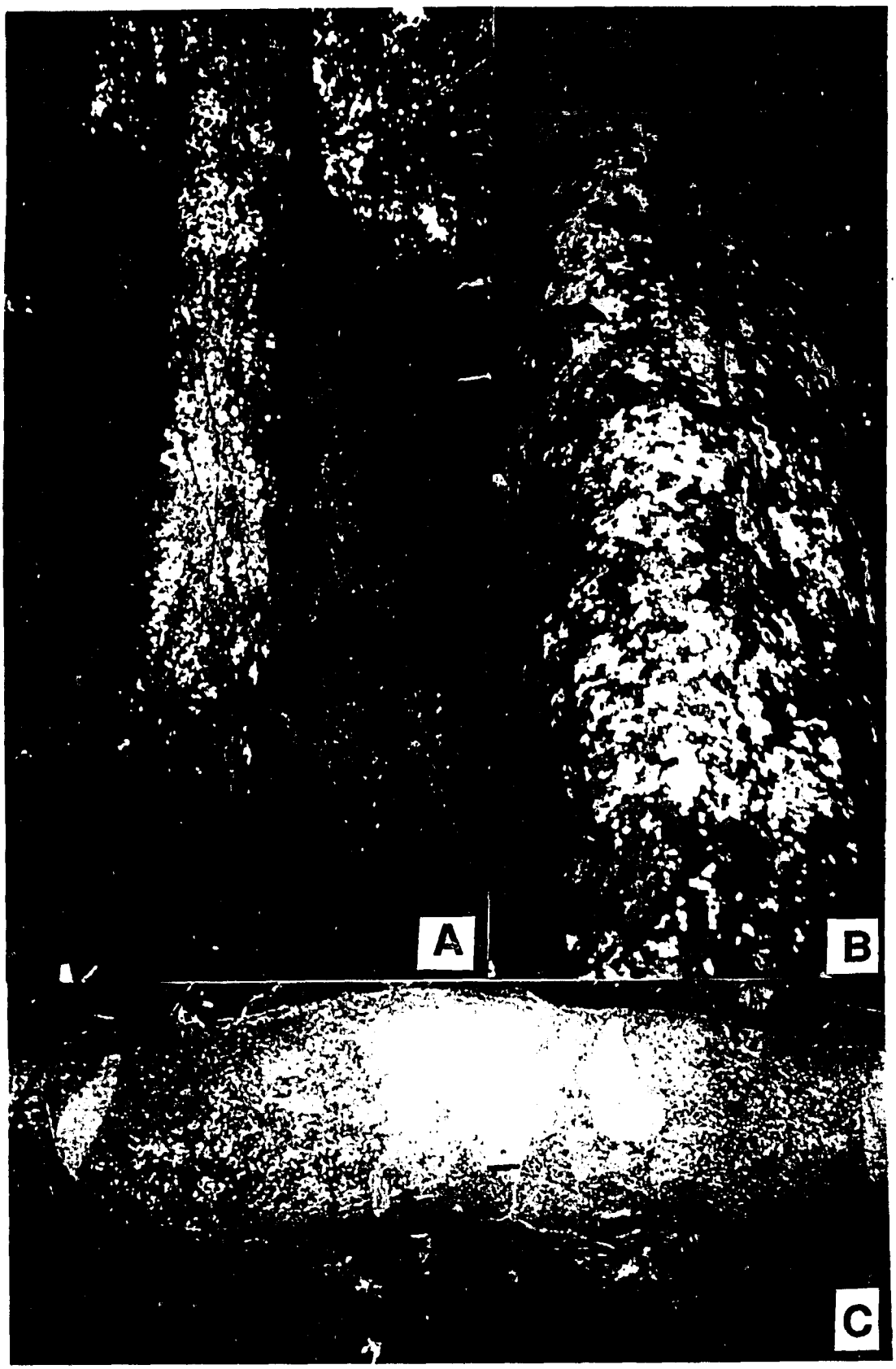
Entandrophragma angolense (Meliaceae)

59A----Bole and buttresses. 59B----Bole and bark.

59C----Wandering buttress.

60A----Young bole with characteristic eyemarks and hoop marks.

60B----Slash (above--after 10 seconds; below--after one minute).


A
B
C


A
B

Family	Species	Vernacular name
Meliaceae	*Entandrophragma angolense*	edinam

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1. Organization

a. Leaf type----Compound, pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite or subopposite; 7-10 pairs.

2. Shape

a. Form----Narrowly obovate or narrow oblong.

b. Apex----Acuminate. **c. Base**----Acute.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----7-28 x 3-10.5 cm.

6. a. Petiolule----Flattened and fluted at base. Rough and rugose with vertical ridges. Usually 12-16 cm long.

b. Rachis----Usually 25-45 cm long. Glabrous. Smooth and round. Has tiny dots that could be glands.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Erect to lax whitish hairs, 0.2-0.5 mm long on primary and sec veins. Rest of blade glabrous. Similar hairs on petiolule.

ii. Density----Quite abundant on primary vein; scanty elsewhere.

b. Adaxial surface----Glabrous except scanty erect tiny hairs at base of primary vein and petiolule.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved; unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, sometimes acute narrow close to apex.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute. Enclosed by tertiary arches.

d. Inter-secondary veins----Simple.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Forked, mostly sinuous, a few convex.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Brittle, thick, and fleshy. Outside smooth to slightly rough. Sometimes flakes, especially old bark. Presence of bumps. Scattered lenticels with many in vertical rows. Very shallow deep brown vertical striations. Many eyemarks. Easily separates from wood.

b. Color----Brown, brownish-gray, or orange-brown.

16. Slash

a. General color----Dark red with pink tint, or pink with yellow tint.

b. Characteristics----Cover of outer bark yellowish with purple streaks. Outer bark pink, or reddish with cream-colored radial streaks, becomes deeper purple with brownish-yellow

streaks after 2 mins, and purple with deep purple to brownish streaks after 5 mins. Inner bark develops ring of yellow after 5 mins. Sapwood becomes brown after 2 mins. Quite strong, slightly disagreeable smell.

c. Exudate----None.

d. Thickness----3-5 mm.

17. Wood----Cream-colored, hard.

18. Height category----H. Up to 50 m.

19. Buttressing----Broad, short, buttresses.

20. Bole----Round, straight.

21. Additional remarks----Large tree with open crown. Leaves clustered at end of branches.

Family	Species	Vernacular name
Meliaceae	*Entandrophragma candollei*	penkwa-akoa

1. Organization

a. Leaf type----Compound, pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite, 5-9 pairs.

2. Shape

a. Form----Oblong to slightly elliptic. **b. Apex**----Obtuse.

c. Base----Rounded to obtuse.

3. Margin----Slightly crenate. **4. Glands**----Absent.

5. Blade size----3.5-22.5 cm x 2.0-11.5 cm.

6. a. Petiolule----Fluted at base with vertcal ridges, 6.5-15 cm long, sometimes laterally winged.

b. Rachis----5-30 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Domatia of hairs 0.1-0.6 mm long at apical junctions of primary-sec veins. Scattered, erect, hairs, 0.5-0.2 mm long, on petiolule and rachis, primary and sec veins, sometimes in intercostal areas, and observed on tertiary veins at 20x.

ii. Density----Abundant in domatia, on petiolule, rachis, primary vein, and sec vein. Few elsewhere.

b. Adaxial surface----Glabrous, except few erect hairs in channel of primary vein. Shiny.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Usually straight. Sometimes markedly curved. Unbranched.

10. Secondary veins

a. Angle of divergence----Upper 2/3 acute moderate. Lower 1/3 acute wide to right angle.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute to right angle, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Simple.

e. Number----14-22 pairs.

11. Tertiary vein

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal. Rest of

higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Brittle to slightly spongy, outside slightly rough. Scales that fall off leaving small pits. Very prominent scattered lenticels, some in vertical rows. Few eyemarks.

b. Color----Gray-brown.

16. Slash

a. General color----Dark brown or pinkish-orange.

b. Characteristics----Outer bark deeper brown and brittle; inner bark lighter brown and spongy. Presence of few white streaks. Sapwood turns yellow-brown after 5 mins. Bitter.

c. Exudate----None. **d. Thickness**----About 3 mm.

17. Wood----Creamy-orange, hard.

18. Height category----H. Up to 45 m

19. Buttressing----Absent. Sometimes fluted at base.

20. Bole----Round, straight, sometimes crooked near crown.

21. Additional remarks----Leaves of saplings are larger than those of mature trees. Dark crown that is wide-spreading. Young twigs have velvety, dark brown hairs.

PLATES 61 & 62

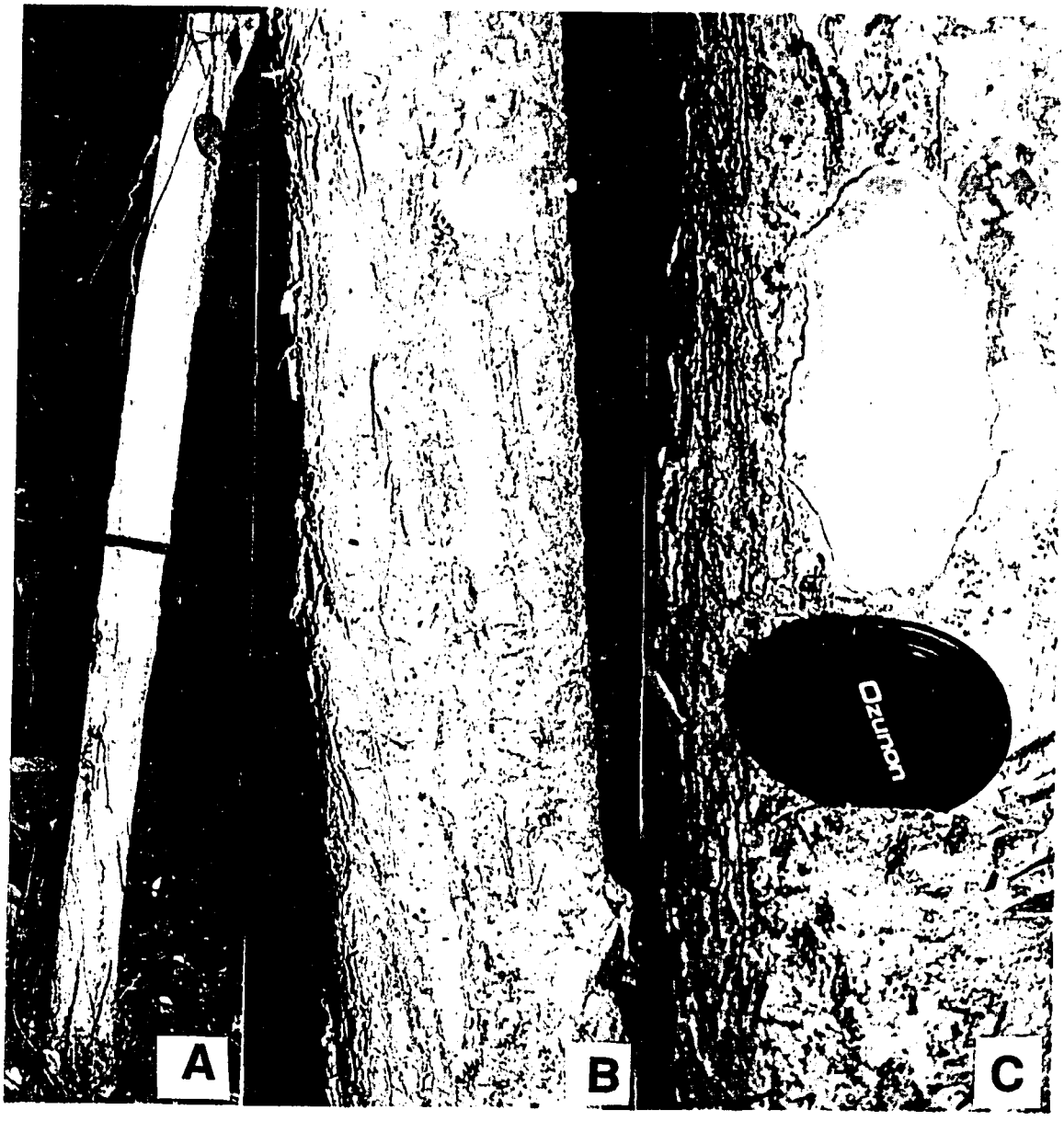
Entandrophragma cylindricum (Meliaceae)

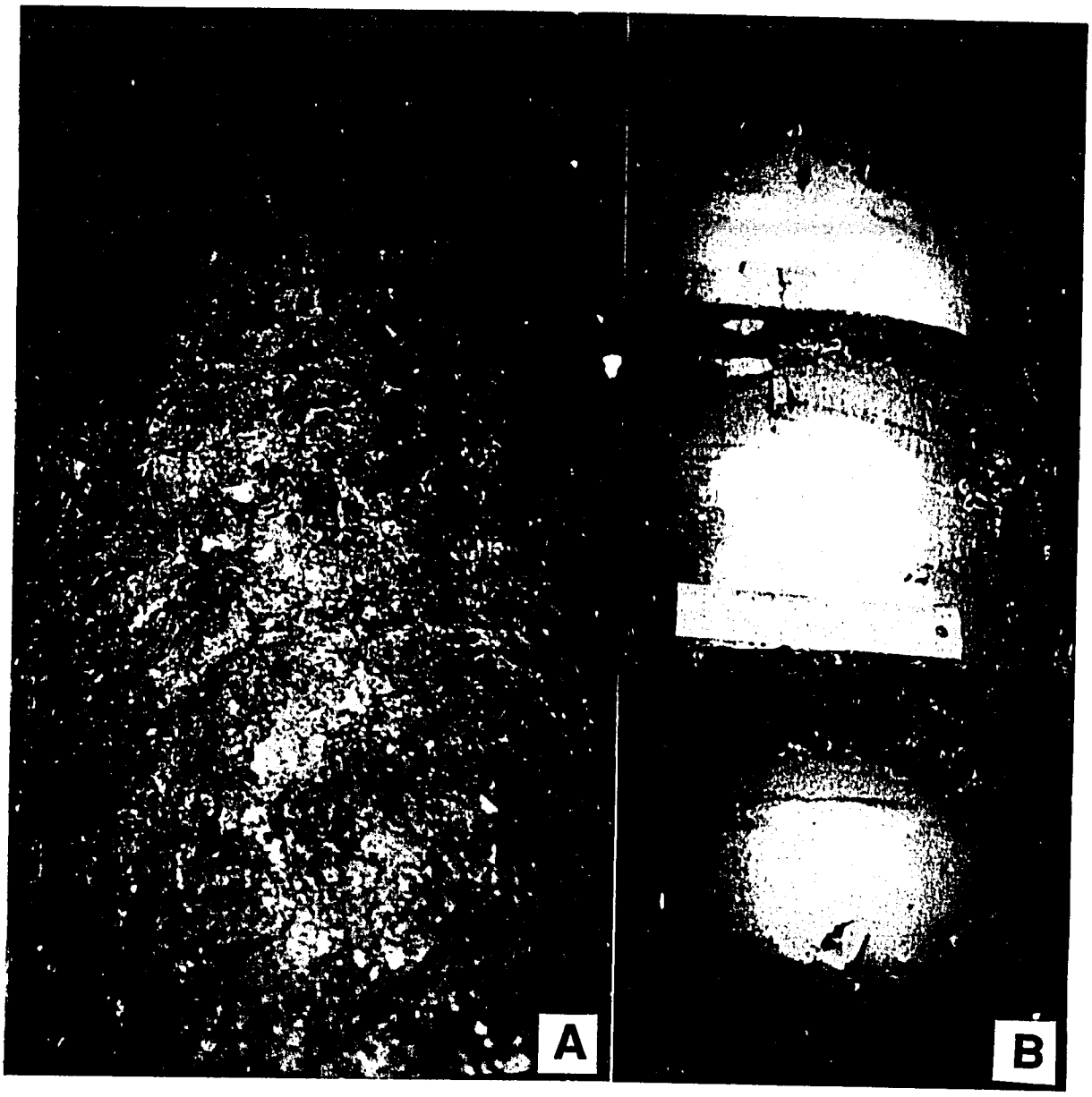
61A & B----Young bole.

61C----Young bark and slash.

62A----Old bark.

62B----Slash.


A
B
C
Ozumon


A
B

Species	Family	Vernacular name
Meliaceae	*Entandrophragma cylindricum*	penkwa

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1. Organization

a. Leaf type----Compound, regular pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite or subopposite, 5-9 pairs

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate, usually asymmetrical.

3. Margin----Entire to very slightly crenate.

4. Glands----Absent. **5. Blade size**----8-16 x 2.5-5.5 cm.

6. a. Petiolule----Sometimes slightly winged, long, flattened, slightly enlarged at base, 5-10 cm long. Shiny, brown, faint vertical ridges and wrinkles.

b. Rachis----Long, 15-55 cm in length.

7. Hairs

a. Abaxial surface

i. **Type, color, & location**----Erect hairs up to 0.4 mm long in domatia at primary-sec vein, and some sec-tertiary vein junctions. Other very short erect hairs on primary and sec veins at 20x, and on petiolule. Very short brown hairs on Rachis.

ii. **Density**----Domatia quite abundant especially at sec-tertiary junctions. Other hairs on veins, petiolule, and upper parts of rachis scattered. Dense at lower parts of rachis.

b. **Adaxial surface**----Shiny and generally glabrous except sparse very short hairs at 20x on primary vein especially at base. Sometimes few hairs in domatia at primary-sec junctions.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Simple.

e. Number----6-12 pairs.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Majority pentagonal and polygonal.

15. Bark

a. Texture, & features----Fibrous to very brittle. Outside smooth but flakes when old and then becomes very rough. Rough little spots. Lenticels arranged in vertical rows in singles or in small clusters, or scattered. A few wide, rough patches. Short, vertical slits, sometimes wide.

b. Color----Light gray-brown or grayish white.

16. **Slash**

a. **General color**----Brown, brownish-pink, or reddish brown, with cream-colored streaks.

b. **Characteristics**----Becomes dark brown after five secs (need to be fast to get a photo of original color). Cover of outer bark brown on top of thin white layer; outer bark thick and brownish, becoming brownish-pink after 15 mins.; inner bark slightly thick and whitish. Brown streaks from outer bark merge into inner bark. Sapwood light yellowish-brown, or creamy-light yellow, becoming light purple after 15 mins. Quite strong sweet scent.

c. **Exudate**----None. d. **Thickness**----2-4 mm.

17. **Wood**----White with light yellow tint, hard.

18. **Height category**----H. Up to 62 m.

19. **Buttressing**----Broad, low buttresses. Sometimes fluted at base.

20. **Bole**----Erect, very cylindrical. Sometimes has round little bumps.

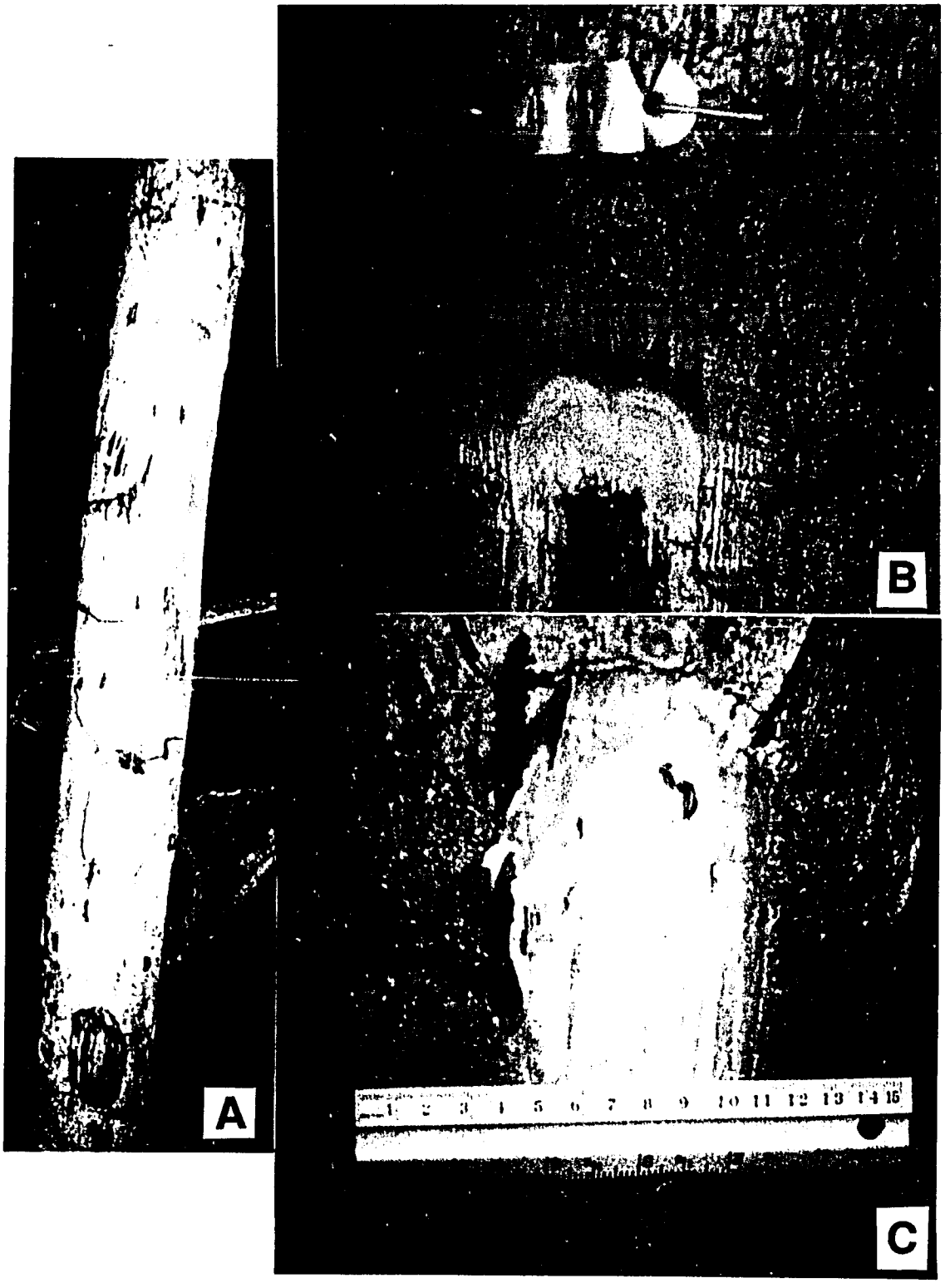
21. **Additional remarks**----Large tree. Young twigs carpeted by short brown hairs.

PLATE 63

Guarea cedrata (Meliaceae)

A----Bole.

B & C----Bark and slash.


A
B
C

Family	Species	Vernacular name
Meliaceae	*Guarea cedrata*	kwabohoro

---

1. Organization

a. Leaf type----Compound, odd and even pinnate on same branch.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Narrowly elliptic.

b. Apex----Attenuate to acuminate.

c. Base----Cuneate to decurrent.

3. Margin----Entire, with slight crenations.

4. Glands----Absent.

5. Blade size----8-32 x 2.5-10.5 cm.

6. a. Petiolule----Slightly enlarged at base; 2-4.5 cm long. Often with inrolled wings 3-6 mm wide.

b. Rachis----2-18 cm long.

7. Hairs

a. Abaxial surface

i. **Type, color, & location**----Short white appressed hairs 0.1-0.3 mm long on primary vein, sec veins, and petiolule. Another kind of shorter yellowish hairs carpet tiny bumps on petiolule. Longer transparent hairs up to 1.0 cm long scattered among short hairs on primary vein and petiolule.

i. **Density**----Short white hairs abundant on primary vein, sparse at other locations. Short yellowish hairs copious on petiolule. Long hairs scanty.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved , unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Simple.

e. Number----16-22.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Forked, convex, few recurved, some retroflexed.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins random. Rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Irregular, random.

15. Bark

a. Texture, & features----Fibrous. Outside relatively smooth. A few rough, sea-shell shaped patches from flaking, especially nearer base. Prominent wide eyemarks up to 35 cm long and 4 cm wide.

b. Color----Gray-brown or gray-white.

16. Slash

a. **General color**----Pinkish, light purple, light brown to reddish, or cream-colored.

b. **Characteristics**----Turns rusty brown after 3 mins. Outer bark more brownish, sometimes with pink layer. Inner bark cream-colored. Light yellow sapwood turns light brown after 30 mins. Strong sweet scent.

c. **Exudate**----None.

d. **Thickness**----3-5 mm.

17. **Wood**----Light yellow, moderately hard.

18. **Height category**----H. Up to 50 m.

19. **Buttressing**----Thick buttresses.

20. **Bole**----Long, straight, round.

21. **Additional remarks**----Large tree with dense crown. New leaves appear reddish. Leaflets are papery. Vasculature very clear.

PLATES 64 & 65

Khaya ivorensis (Meliaceae)

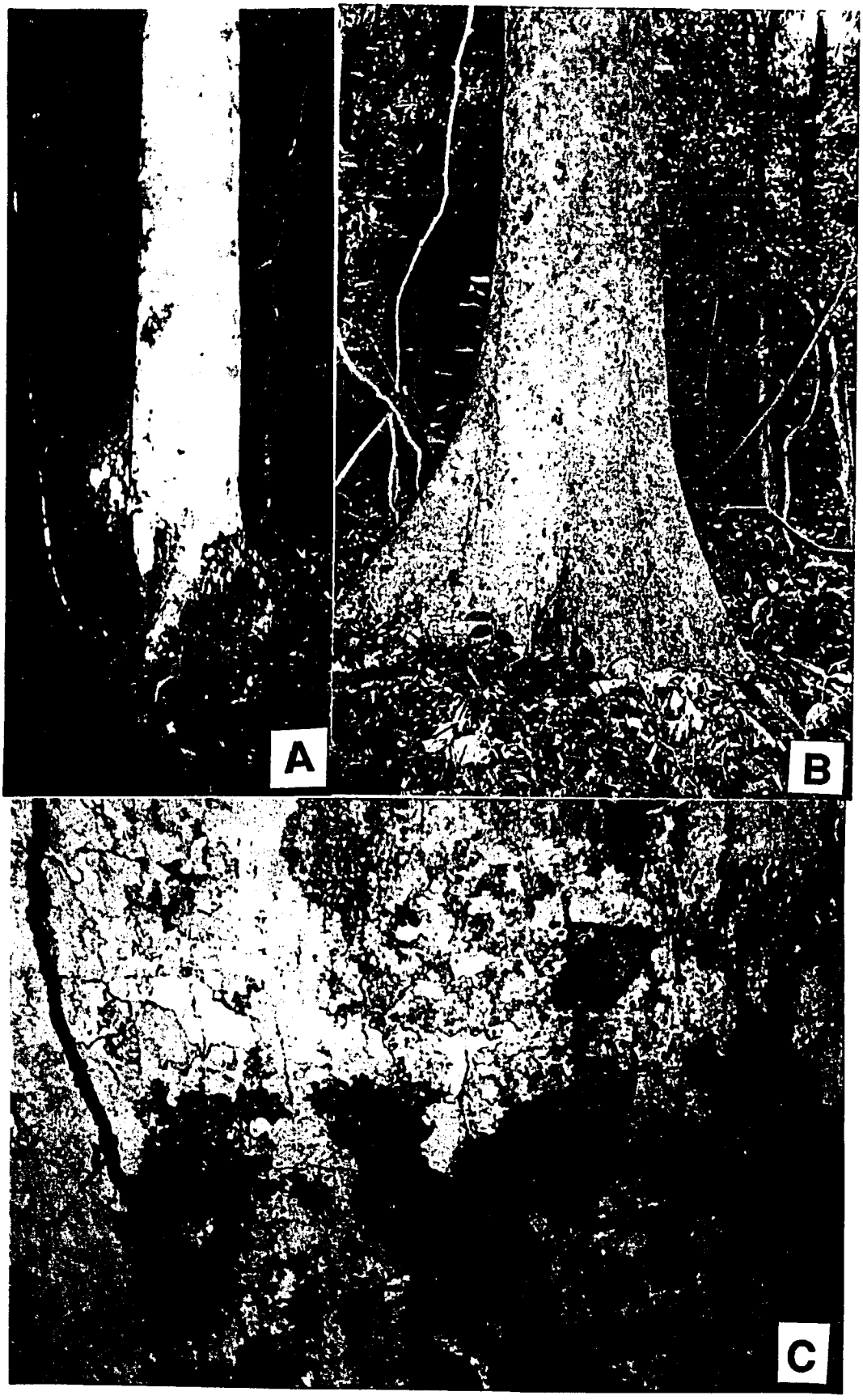
64A & B----Bole and buttresses.

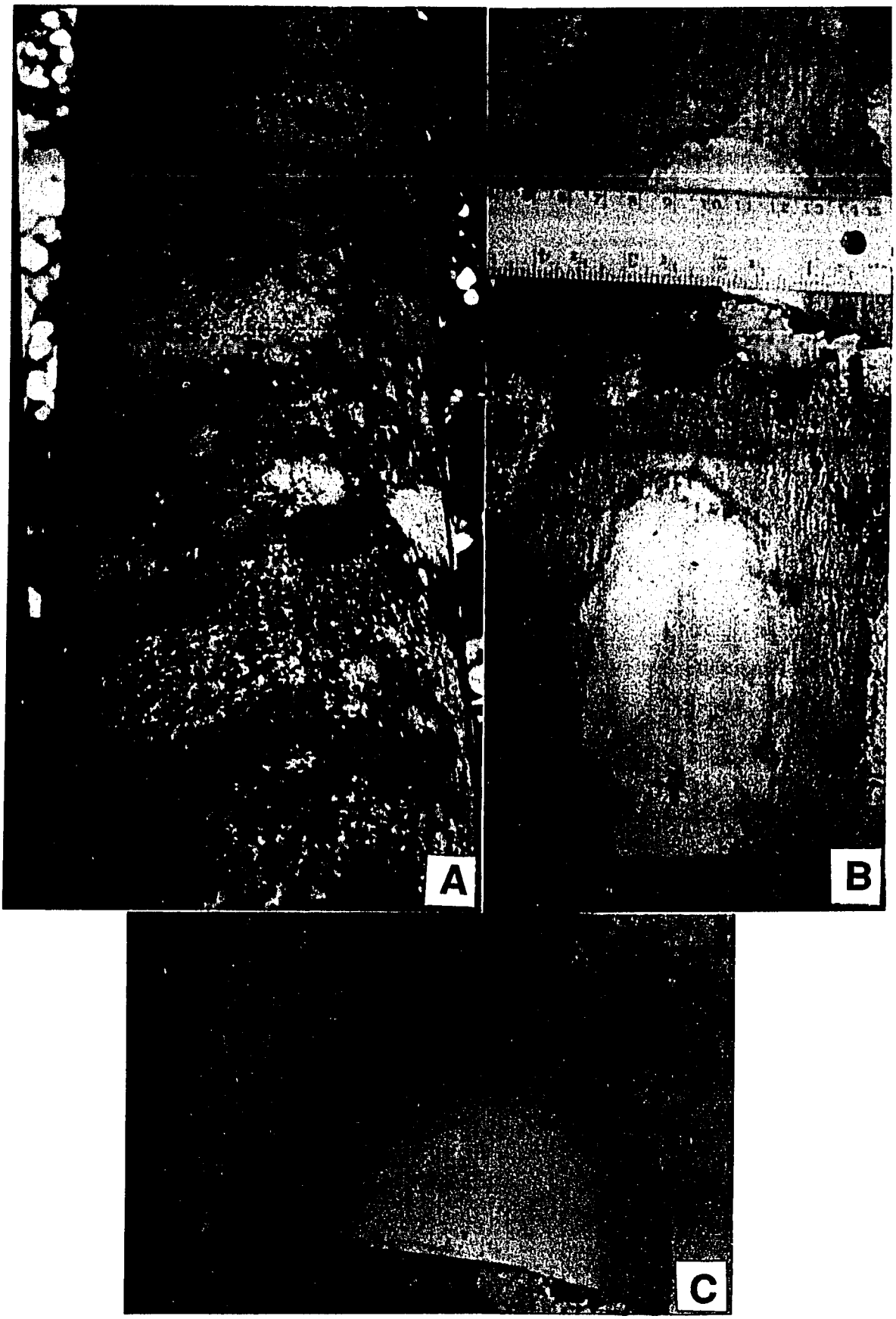
64C----Old bark.

65A----Bole and bark.

65B----Slash after one minute.

65C----Slash after ten seconds.


A
B
C


A
B
C

Family	Species	Vernacular name
Meliaceae	*Khaya iverensis*	dubini

---

1. Organization

a. Leaf type----Compound, even pinnate.

b. Phyllotaxy----Alternate. Leaflets alternate, 4-7 pairs in adult, 5-7 pairs in sapling.

2. Shape

a. Form----Narrowly elliptic.

b. Apex----Acuminate, pronounced drip tip, bent sideways.

c. Base----Acute to decurrent. Unequal.

3. Margin----Entire.

4. Glands----Absent.

5. Leaf size----5-19 x 2-6.2 cm.

6. a. Petiolule----Flattened and fluted.

b. Rachis----Long, very woody resembling a branch, basiconstrict and rugose at base.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Majority acute wide, a few right angle, generally **mixed.**

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse to slightly 90^{o}.

d. Inter-secondary vein----Simple.

e. Number----5-9 pairs.

11. Tertiary vein

Pattern----Random reticulate. Most branches end blindly in intercostal area without joining other branches.

12. Higher order venation----Quaternary veins random. Rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Lacking.

15. Bark

a. Texture, & features----Fibrous, thick, and spongy. Old bark scaly, flakes, leaving deep pits and patches. Outside quite smooth. Many lenticels arranged in short vertical rows.

b. Color----Brown, gray, whitish, or gray-brown.

16. Slash

a. General color----Reddish-brown, reddish-purple, or deep red.

b. Characteristics----Cover of outer bark very deep red. Outer bark brittle and reddish. Inner bark reddish-brown with cream-colored inner layer. Often yellow-purple streaks develop after 3 mins, and whole slash becomes brownish after 5 mins. Sometimes slash remains unchanged up to one hour. In young trees, first layer of sapwood yellow, followed by ring of white wood, then purple or reddish purple wood. Generally sapwood becomes yellow after two mins. Strong, pleasant smell. Very bitter bark

c. Exudate----None.

d. Thickness----2-4 mm.

17. Wood----Cream-colored, or reddish-purple. Hard.

18. Height category----H. Up to 55 m.

19. Buttressing----Strongly buttressed. Big buttresses.

20. Bole----Round, straight, up to 30 m.

21. Additional remarks----Large tree with leaves crowded at end of branches. Primary vein merges into petiolule as shallow depression. Mostly found in moist forest. Slash heals completely after 6 months.

Family	Species	Vernacular name
Meliaceae	*Lovoa trichiloides*	dubinibiri

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1. Organization

a. Leaf type----Compound, even pinnate.

b. Phyllotaxy----Alternate. Leaflets subopposite, up to 6 pairs.

2. Shape

a. Form----Elliptic to narrowly elliptic.

b. Apex----Acuminate to acute. **c. Base**----Cuneate.

3. Margin----Entire to slightly crenate. **4. Glands**----Absent.

5. Blade size----Up to 20 x 9 cm.

6. a. Petiolule----Normal, **fluted.**

b. Rachis----Abaxial side rounded, adaxial side flattened. Slightly winged.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute wide, nearly uniform, lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, sometimes obtuse near apex. Enclosed by sec and tertiary arches.

d. Inter-secondary vein----Simple.

e. Number----16 or more.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Fibrous. Outside smooth. Many scattered lenticels, a few in spiral, or vertical rows, giving a slightly rough bark in older trees. Large, irregular, flaking pieces.

b. Color----Dark or gray-brown.

16. Slash

a. General color----Crimson to pink, reddish-purple.

b. Characteristics----Presence of faint white streaks. Strong sweet smell. No change after 24 hours.

c. Exudate----None.

d. Thickness----About 3 mm.

17. Wood----Cream-colored. Slightly soft.

18. Height category----H. Up to 46 m.

19. Buttressing----Short, thick buttresses. Sometimes absent.

20. Bole----Cylindrical, straight.

21. Additional remarks----Large forest tree with dark, heavy, evergreen crown. Usually in moist forest. Edge of dry leaf slightly folds over abaxially.

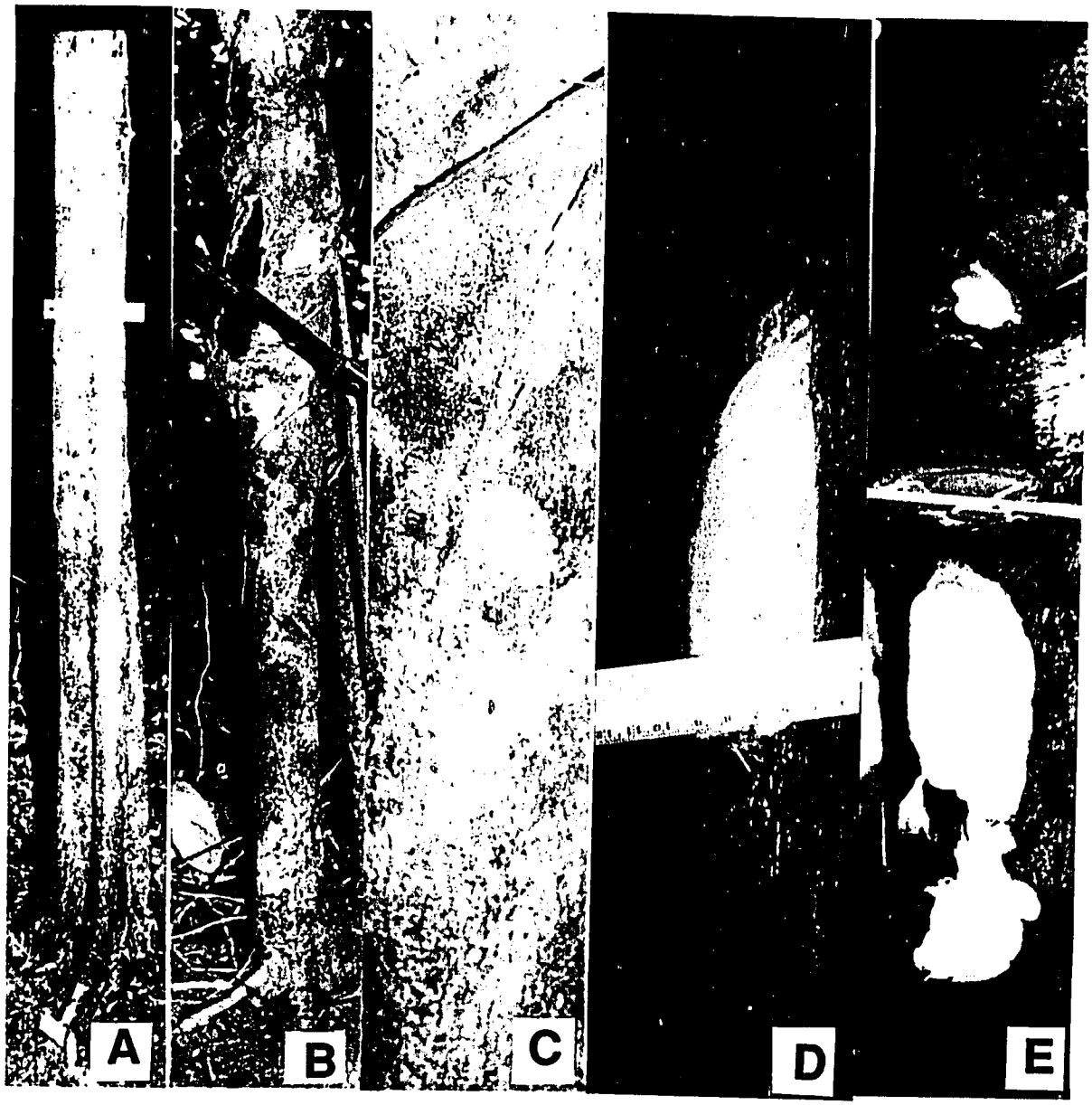
PLATE 66

Trichilia prieuriana (Meliaceae)

A & B----Bole and buttresses.

B----Bark.

D & E----Slash.


A
B
C
D
E

Family	Species	Vernacular name
Meliaceae	*Trichilia prieuriana*	kakadikuro

---

1. Organization

a. Leaf type----Compound, pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite, 2-4 pairs, odd terminal leaflet largest, lowest pair smallest.

2. Shape

a. Form----Narrowly elliptic, lamina asymmetrical.

b. Apex----Attenuate to acuminate.

c. Base----Cuneate to decurrent.

3. Margin----Entire.

4. Glands----Absent.

5. Blade size----4-20 x 2.2-7.5 cm.

6. a. Petiolule----Slightly winged, 5-12 cm long.

b. Rachis----Slightly **fluted,** and flattened at base. 7-16 cm long.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute to right angle, enclosed by tertiary arches.

d. Inter-secondary vein----Composite. **e. Number**----6-12.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Lacking.

15. Bark

a. Texture, & features----Fibrous, and stringy. Outside rough, and slightly flaky. Presence of whitish patches on old trees.

b. Color----Gray, or gray-brown.

16. Slash

a. **General color**----Light orange with purple tint, or brownish-pink.

b. **Characteristics**----Cream-colored streaks. Presence of rings of fiber. Cover of outer bark reddish-brown. Outer bark pale gray-brown, or cream-colored with slight purple tint. Inner bark light brown. Slash becomes slightly brownish after 2 mins. Light yellow sapwood, becomes deeper yellow after 5 min, and gray after 30 mins. Slight pleasant smell.

c. **Exudate**----Yellowish, scanty, non-sticky sap on sapwood after 5 mins.

d. **Thickness**----4-5 mm.

17. **Wood**----Light yellow, light brown after 10 mins. Very hard.

18. **Height category**----h to hh. Usually 4 to 15 m, can be up to 22 m.

19. **Buttressing**----Small buttresses, some branched, or base fluted.

20. **Bole**----Crooked, irregular (especially near base) but sometimes round near crown. Sometimes flattened. Very sinewy.

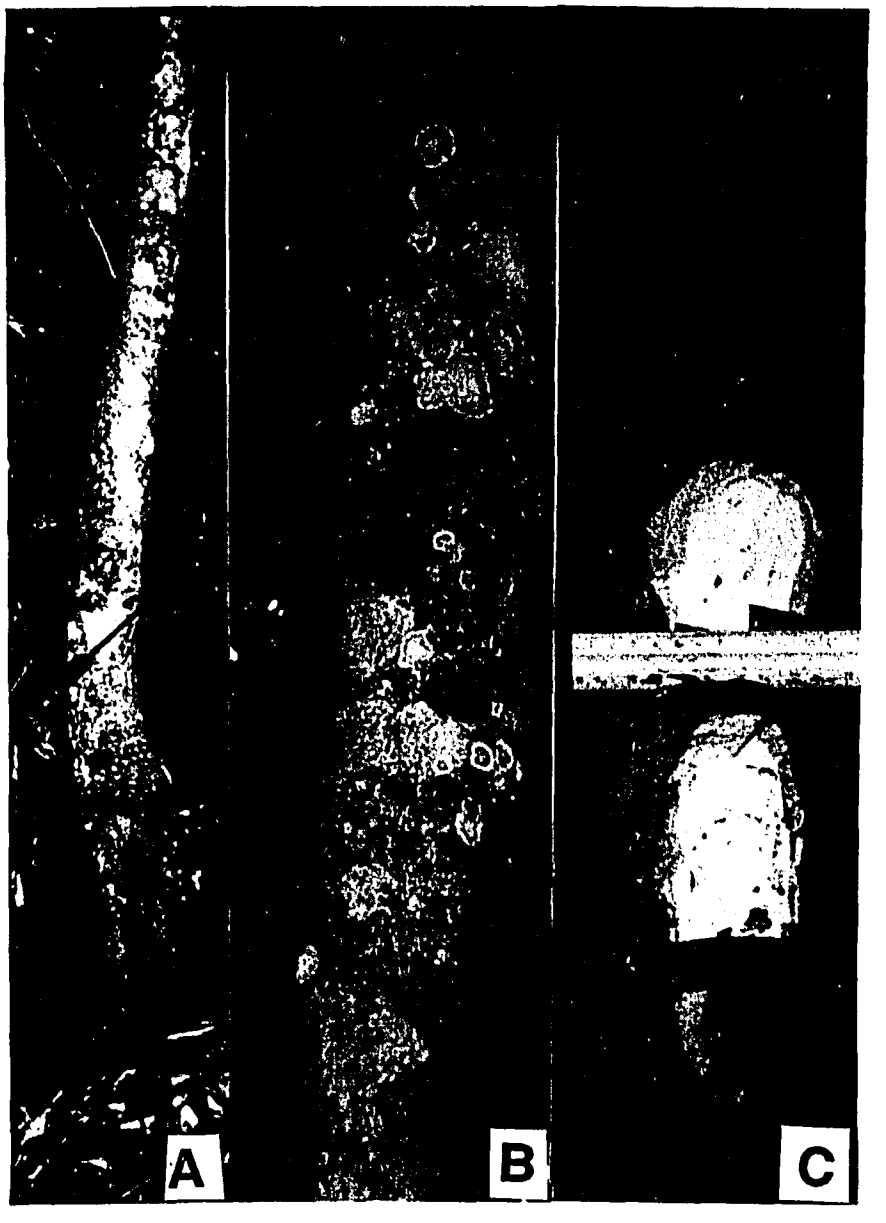
21. **Additional remarks**----Understorey tree with low branching, mostly found in dry forests. Slash heals moderately after 6 months.

PLATE 67

Trichilia tessmannii (Meliaceae)

A & B----Bole.

C----Slash (above--after ten seconds; below--after one minute).


A
B
C

Family	Species	Vernacular name
Meliaceae	*Trichilia tessmannii*	tanuronini

---

1. Organization

a. Leaf type----Compound, odd pinnate.

b. Phyllotaxy----Alternate. Leaflets subopposite, 5-7 pairs.

2. Shape

a. Form----Elliptic. **b. Apex**----Acumunate.

c. Base----Acute.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----6-8 x 1.5-7 cm.

6. a. Petiolule----Normal. Has shallow vertical ridges. 7.5-23 cm long.

b. Rachis----7.5-38 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Soft, orange, erect, long hairs, creating velvety surface coarse to the touch, on whole blade.

Similar hairs on petiolule and young twig.

ii. Density----Very dense, even obscuring veins especially of higher order.

b. Adaxial surface

i. Type, color, & location----Soft, orange, erect, long hairs mainly on primary and sec veins. Most parts of intercostal areas glabrous and shiny.

ii. Density----Moderately abundant.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Right angle to acute, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Absent.

e. Number----15-25.

11. Tertiary vein

Pattern----Orthogonal reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Fibrous and very pliable. Outside smooth. Tiny elongated lenticels aligned horizontally. Easily separates from wood

b. Color----Gray.

16. Slash

a. General color----Light yellow, or pinkish white.

b. Characteristics----Becomes brown after 3 mins. Few light brown rings. Cover of outer bark light orange-brown with greenish tint, turning dark brown after one min. Outer bark cream-colored with pink taint. Inner bark cream-colored. Sapwood very slippery.

c. Exudate----Cream-colored to yellowish drops of latex.

d. Thickness----About 2 mm.

17. Wood----Cream-light yellow, hard, becomes slightly brown on exposure.

18. Height category----H. Up to 32 m or more.

19. Buttressing----Small buttresses.

20. Bole----Cylindrical, straight.

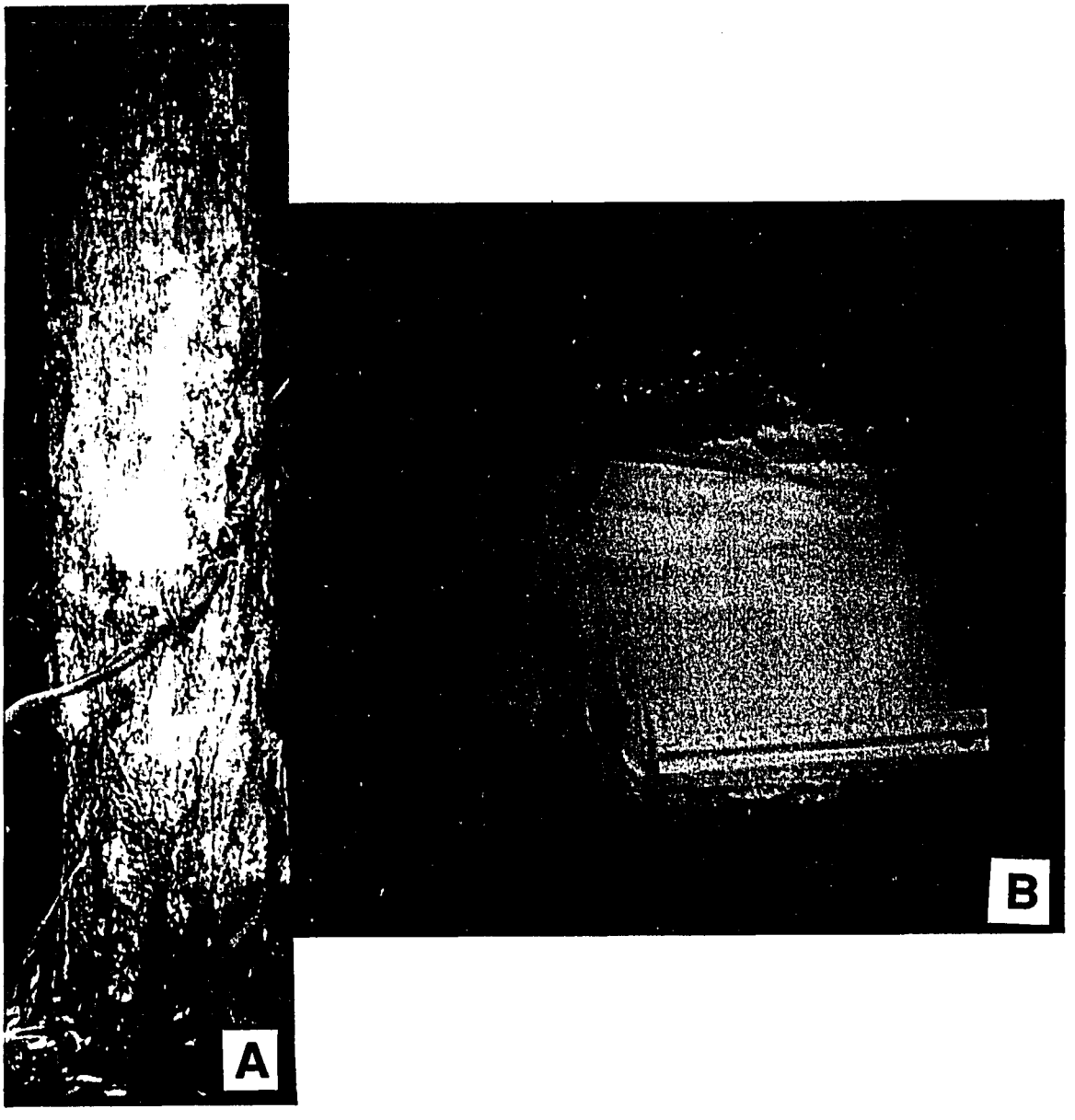
21. Additional remarks----Large tree with dark crown.

PLATE 68

Turraenthus africanus (Meliaceae)

A----Bole.

B----Bark and slash.


A
B

Family	Species	Vernacular name
Meliaceae	*Turraenthus africanus*	apapaye

---

1. Organization

a. Leaf type----Compound, pinnate.

b. Phyllotaxy----Alternate. Leaflets alternate or subopposite.

5-15 pairs.

2. Shape

a. Form----Lanceolate to lorate.

b. Apex----Acuminate, folded or drip tipped.

c. Base----Cuneate to decurrent.

3. Margin----entire.

4. Glands----Numerous little dots in depressions all over blade (glands and resin canals ?). Dots resemble glands on orange epicarp.

5. Blade size----6-25 x 2.5-8 cm long.

6. a. Petiolule----Brown in appearance from brownish lenticels.

Fluted, 0.5-1.5 cm long. Grooved. Dark, shiny deposits of resin on outside.

b. Rachis----Slightly winged. **Fluted.** 4-60 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Short, brown hairs, 0.2-0.5 mm long at lamina-petiolule junction, midrib, and base of petiolule. Short, erect, brown hairs, about 0.2 mm long, along edge of blade, on some sec veins, some intercostal areas, and rachis. Tufts of brown hairs appear as dots along edges of channel and at base of rachis.

ii. Density----Hairs of all types abundant at all locations.

b. Adaxial surface----Shiny and relatively glabrous except a few hairs sometimes on primary, and sec veins.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, unbranched, silvery-green in color.

10. Secondary veins

a. Angle of divergence----Acute wide, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by tertiary and

quaternary arches.

d. Inter-secondary veins----Simple.

e. Number----15-30.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Thick, fibrous, fissured. Outside smooth. Several eyemarks. Sometimes slightly flaky with some rough patches. Few hoopmarks. Very shallow vertical lines.

b. Color----Brown (with gray tint when young), grayish-white, silvery-brown, or yellowish.

16. Slash

a. General color----Cream-colored, or pale yellow with orange

speckles.

b. Characteristics----Outer bark cream-colored with slight pink tint; inner bark light yellow. Outer bark becomes slightly deeper purple after 2 mins. Pleasant moderate smell.

c. Exudate----Scanty, slightly sticky sap.

d. Thickness----6-14 mm.

17. Wood----Creamy-yellow, moderately hard.

18. Height category----hh to H. 13-34 m.

19. Buttressing----Present, or fluted at base.

20. Bole----Straight, round, sometimes flattened, low branching, sometimes has little shoots.

21. Additional remarks----Tree with heavy, dark green crown, and thick, low boughs. Young stems have aggregations of brown hairs along shallow longitudinal channels, alongside round lenticels. Tufts of brown hairs on branches. Leaf margin has thin line, and rolls out when dry. Often gregarious especially in moist forest.

MIMOSACEAE

Trees or shrubs, very rarely herbs, often in dry regions, frequently spiny.

Leaves mostly bipinnate, rarely simply pinnate, often with large glands on the rachis.

There are 24 genera and 82 species (3 introduced) in West Africa. There are 4 genera and 10 species in the Bobiri forest reserve.

PLATES 69 & 70

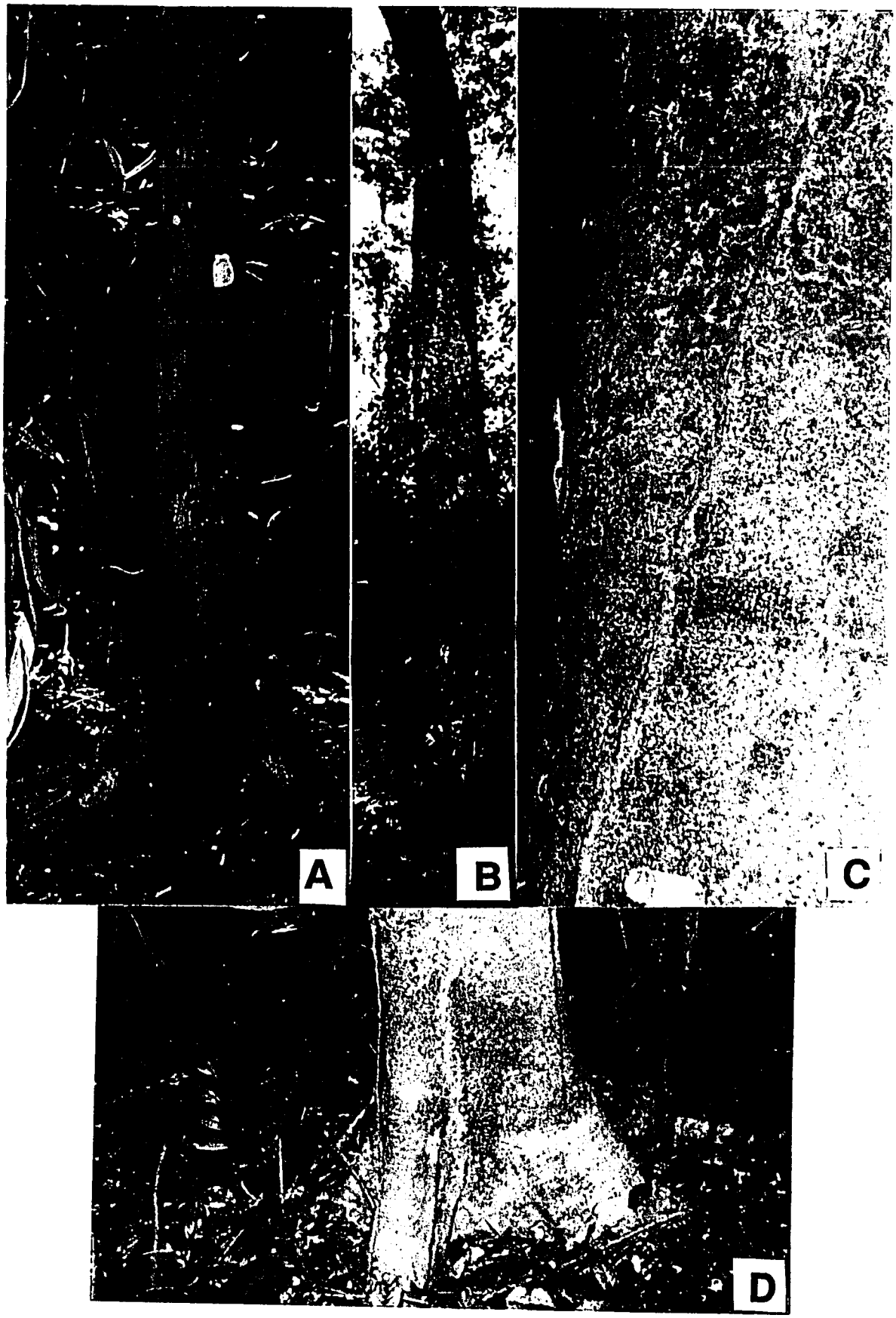
Albizia adianthifolia (Mimosaceae)

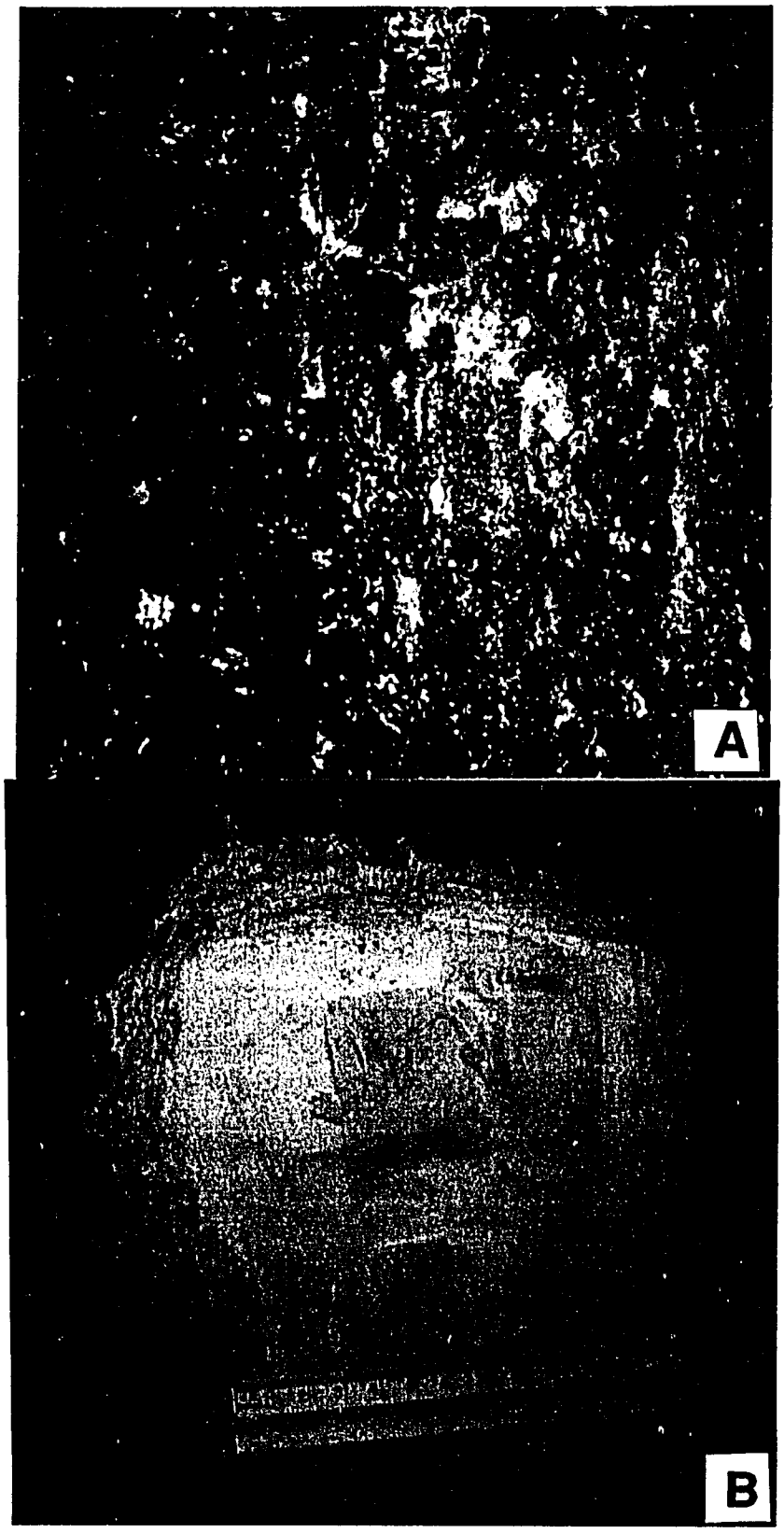
69A, B & D----Bole and buttresses.

69C----Bark.

70A----Old bark.

70B----Slash.


A
B
C
D


A
B

Family	Species	Vernacular name
Mimosaceae	*Albizia adianthifolia*	pampena

---

1. Organization

a. Leaf type----Compound, bipinnate, even pinnate.

b. Phyllotaxy----Alternate. Pinnae and leaflets paired opposite.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

b. Base----Acute to obtuse. **3. Margin**----Entire.

4. Glands----Present on petiolule and rachis as round spots with apical holes.

5. Blade size----7-17 x 3.5-9 mm.

6. Petiolule----Normal, short, thin, dark-colored when dry.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, yellowish hairs, 0.05-0.1 mm on primary and sec veins at 20x. Similar hairs on petiolule and rachis.

ii. Density----Scanty on leaf; more abundant on petiolule and rachis.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched. Extends up to 0.3 mm beyond blade.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform. Lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Right angle, enclosed by tertiary and quaternary arches.

d. Inter-sec vein----Composite.

11. Tertiary veins

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal. Rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Brittle to spongy. Outside smooth when young, rough and flaking when old. Thin eyemarks.

b. Color----Light gray to gray-brown.

16. Slash

a. General color----Orange to yellow, or cream-colored..

b. Characteristics----Cream-colored to orange, brittle, outer bark; inner bark yellowish and spongy. Brown ring in inner bark; one or two prominent, brown, broken rings in outer bark. Slash develops few light red streaks after an hour. Moderate pleasant smell.

c. Exudate----Colorless to light orange, slightly sticky to gummy sap.

d. Thickness----1.0-2.5 mm.

17. Wood----Light yellow sapwood, dark brown heartwood, with

pleasant odor. Extremely hard; has sometimes bent axe blades of the villagers.

18. Height category----H. Up to 38 m.

19. Buttressing----Not easy to predict, usually absent, but small buttresses present in some young and old trees. Sometimes fluted at base.

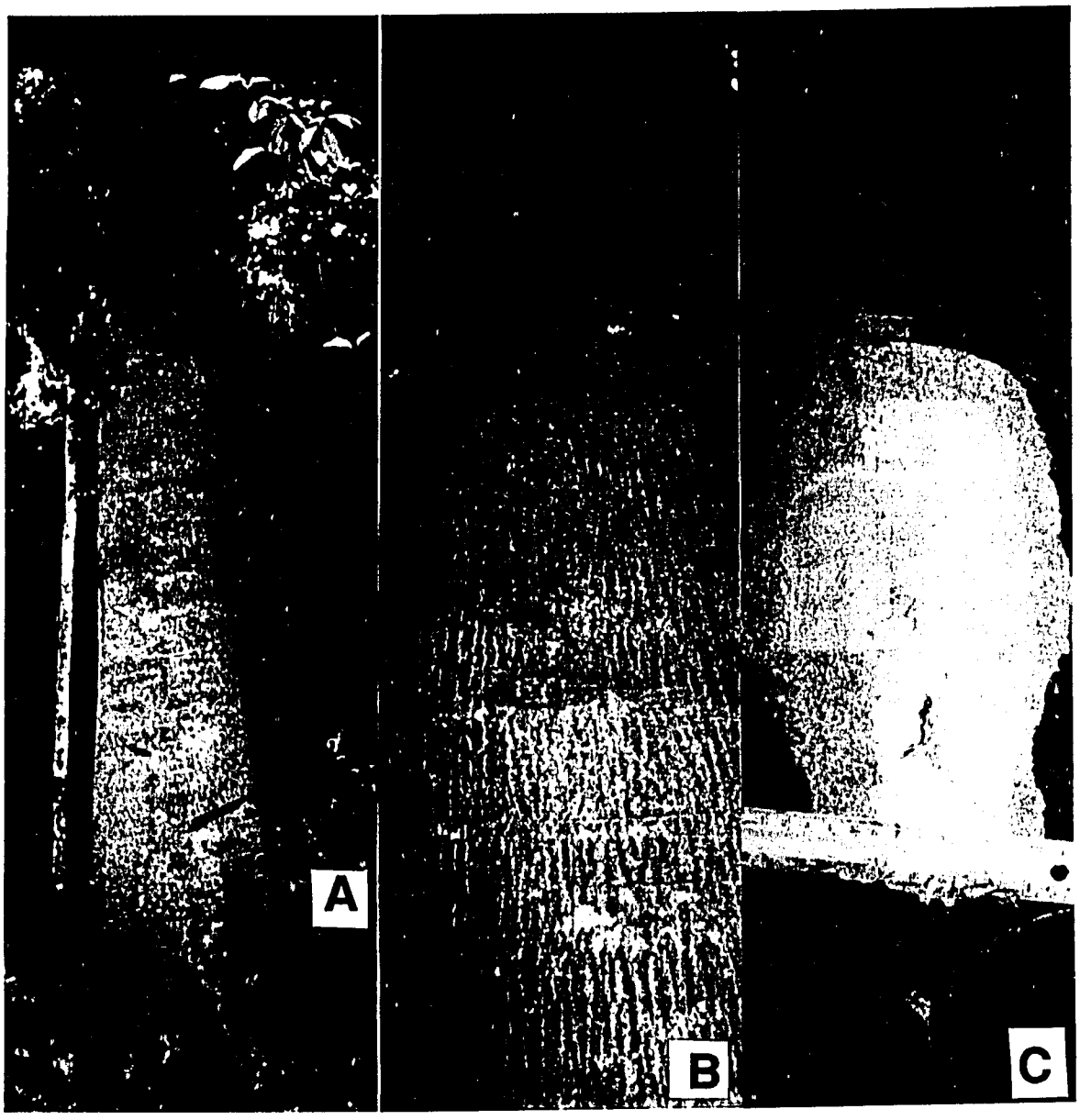
20. Bole----Straight, cylindrical.

21. Additional remarks----Common in disturbed forest. Top of crown flattened. Leaflets papery. Stipules ovate.

PLATE 71

Albizia zygia (Mimosaceae)

A----Bole and buttresses. B----Bark. C----Slash.


A
B
C

Family	Species	Vernacular name
Mimosaceae	*Albizia zygia*	okuro

---

1. Organization

a.Type--------Compound, even bipinnate.

b. Phyllotaxy----Alternate. Leaflets opposite, 3-5 (rarely 6) pairs, terminal pair largest. Pinnae 1-3 (rarely 4) pairs, broadening upwards.

2. Shape

a. Form------Narrow elliptic. **b. Apex**---Acute to acuminate.

c. Base------Cuneate to decurrent.

3. Margin-------Entire. **4. Glands**----Absent.

5. Blade size----1.5-8.5 x 1.0-5.0 cm.

6. Petiolule-----Normal; brown, very short, conical-shaped, thin.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed hairs 0.1-0.3 mm

long, mixed with straight and curled hairs, mainly on primary and sec veins.

ii. Density----Few.

b. Adaxial surface

i. Type, color, & location----Curled hairs on veins, especially primary; rest of blade shiny and glabrous except at margin and base.

ii. Density---Slightly abundant.

8. Venation-----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence-----Acute moderate, nearly uniform. Lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches---Narrowly acute, enclosed by tertiary and quaternary arches.

d. Inter-sec vein-----Composite.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins random; rest of higher order veins obscure.

13. Marginal ultimate venation-----Looped.

14. Areoles

a. Development-----Well developed.

b. Shape---Quadrangular.

15. Bark

a. Texture, & features---Very brittle. Outside smooth; slightly rough when old, with dented spots from flaking. Numerous shallow vertical markings, and some eyemarks.

b. Color----Brown to grey, sometimes with whitish tint especially when young.

16. Slash

a. Gen.Color----Orange-brown, yellowish-orange, or reddish-brown.

b. Characteristics----Cover of outer bark orange. Outer bark brittle, with cream-colored spots; inner bark light

creamy-brown, sticks to sapwood. Inner bark near wood soapy when rubbed for 2 mins or more.

c. Exudate----Scanty, clear exudate, a little sticky. Develops brownish gum after an hour.

d. Thickness---- 0.5-3.0 mm.

17. Wood----Very hard. Creamy brown.

18. Height category---- h. Up to 25 m.

19. Buttressing----Always buttressed, usually 3-7 per tree.

20. Bole----Round, often straight near base but sometimes crooked near crown. Infrequently crooked.

21. Additional remarks------Branching is low in forest regrowth but branches high in mature forest. Buttress sizes small in comparison with large sizes of the trees. Slash heals well with wide callus. Abaxial side of leaf pale green; adaxial side dark green and shiny. One of very few cases where venation is more prominent on adaxial side of the leaf. Characteristic apical leaflets resembling wings of butterfly.

Family	Species	Vernacular name
Mimosaceae	*Calpocalyx brevibracteatus*	atrotre

---

1. Organization

a. Leaf type----Compound, bipinnate.

b. Phyllotaxy----Alternate. Leaflets opposite. 4-7 pairs.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Attenuate.

c. Base----Cuneate.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----6-15 x 2-6 cm.

6. **a. Petiolule**----Very short and thin, 3-7 mm long, with horizontal wrinkles, brownish when old. Petioles **fluted**, 1.5-4.5 cm long.

b. Rachis----Base brown, **fluted**, with horizontal wrinkles.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed hairs, 0.1-0.2 mm long on blade. Tiny, erect, brown hairs, 0.5-0.1 mm long on

petiole, and up to 0.2 mm long on rachis.

ii. **Density**----Sparse on blade; dense on rachis, giving it brownish appearance.

b. **Adaxial surface**----Glabrous and shiny under microscope.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform. Lowest pair more acute.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute, enclosed by sec and tertiary arches.

d. **Inter-secondary vein**----Absent.

11. **Tertiary veins**

Pattern----Random reticulate.

12. **Higher order venation**----Obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**----Imperfect.

15. Bark

a. Texture, & features----Very brittle to fibrous, hard. Peels off easily. Scattered, oval-shaped lenticels. Few prominent eyemarks near base of trunk, more eyemarks on bark up trunk. Outside smooth.

b. Color----Gray.

16. Slash

a. General color----Light creamy-brown, brown, orange-brown, or red.

b. Characteristics----Presence of white streaks. Cover of outer bark brown. Sapwood light yellow, gray after 5 mins.

c. Exudate----None. **d. Thickness**----About 1 mm.

17. Wood----Orange, very hard.

18. Height category----h. Up to 25 m.

19. Buttressing----Fluted at base; sometimes with small buttresses.

20. Bole----Crooked, round.

21. Additional remarks----Tree with small crown. Young twigs and buds carpeted with brown hairs.

PLATES 72 & 73

Cylicodiscus gabunensis (Mimosaceae)

72A----Bole and incipient buttresses.

72B----Young bole and bark with spines.

73A----Old bole.

73B----Very rough, flaky old bark without spines.


A
B


A
B

Family	Species	Vernacular name
Mimosaceae	*Cylicodiscus gabunensis*	denyao

---

1. Organization

a. Leaf type----Compound, bipinnate.

b. Phyllotaxy----Alternate. Pinnae opposite, one pair. Leaflets alternate to sub-opposite.

2. Shape

a. Form----Narrowly elliptic.

b. Apex----Attenuate to acuminate.

c. Base----Decurrent.

3. Margin----Entire. **4. Glands**----Present at apex of petiole.

5. Blade size----5-15.8 x 3-5.5 cm.

6. a. Petiolule----Normal.

b. Rachis----Abaxial side round, adaxial side flattened. Primary rachis 2-2.5 cm long, with swollen points where leaflets are attached; sec rachis up to 12 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed hairs, 0.1-0.2 mm long on primary and sec veins, and intercostal areas at 15x. Similar hairs on petiolule.

ii. Density----Sparse and scattered.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved to straight.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Composite.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Forked, a few straight.

ii. Relation to midvein----Oblique.

iii. **Arrangement**----Predominantly alternate.

12. **Higher order venation**----Obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**----Incomplete.

15. **Bark**

a. **Texture, & features**----Very fibrous, hard, very pliable. Young bark has brown, prominent, blunt spines; absence of spines on old bark which has large flakes. Deep, vertical slits on old bark. Outside very rough.

b. **Color**---- Moderate to very dark brown.

16. **Slash**

a. **General color**----Brownish-yellow, yellow, orange, orange with purple tint (when young) or reddish-orange.

b. **Characteristics**----Cover of outer bark very dark brown or orange. Slash becomes yellowish-orange after 2 mins. Inner bark near sapwood becomes brownish-gray after 10 mins. Very strong, repulsive, stinking smell, even one meter away from slash. Smell more rotten-like for older barks.

Poisonous !

c. Exudate----Slightly copious, sticky, slippery, yellow or light brown sap resembling honey. Not sticky when dry.

d. Thickness----2.5-6.0 mm.

17. Wood----Yellow-brown, very hard. Makes very good charcoal.

18. Height category----H. Up to 62 m.

19. Buttressing----Short, thick buttresses that could be very much extended, and wandering. Old buttresses have rounded outgrowths. Young trees have low branching (a tree with 11 cm DBH had branches 1.8 m from base).

20. Bole----Cylindrical, straight, up to 25 m clean bole and 12 m girth.

21. Additional remarks----Large emergent tree with spreading crown. Sapling armed with spines. Slash almost totally heals after 6 months.

PLATES 74 & 75

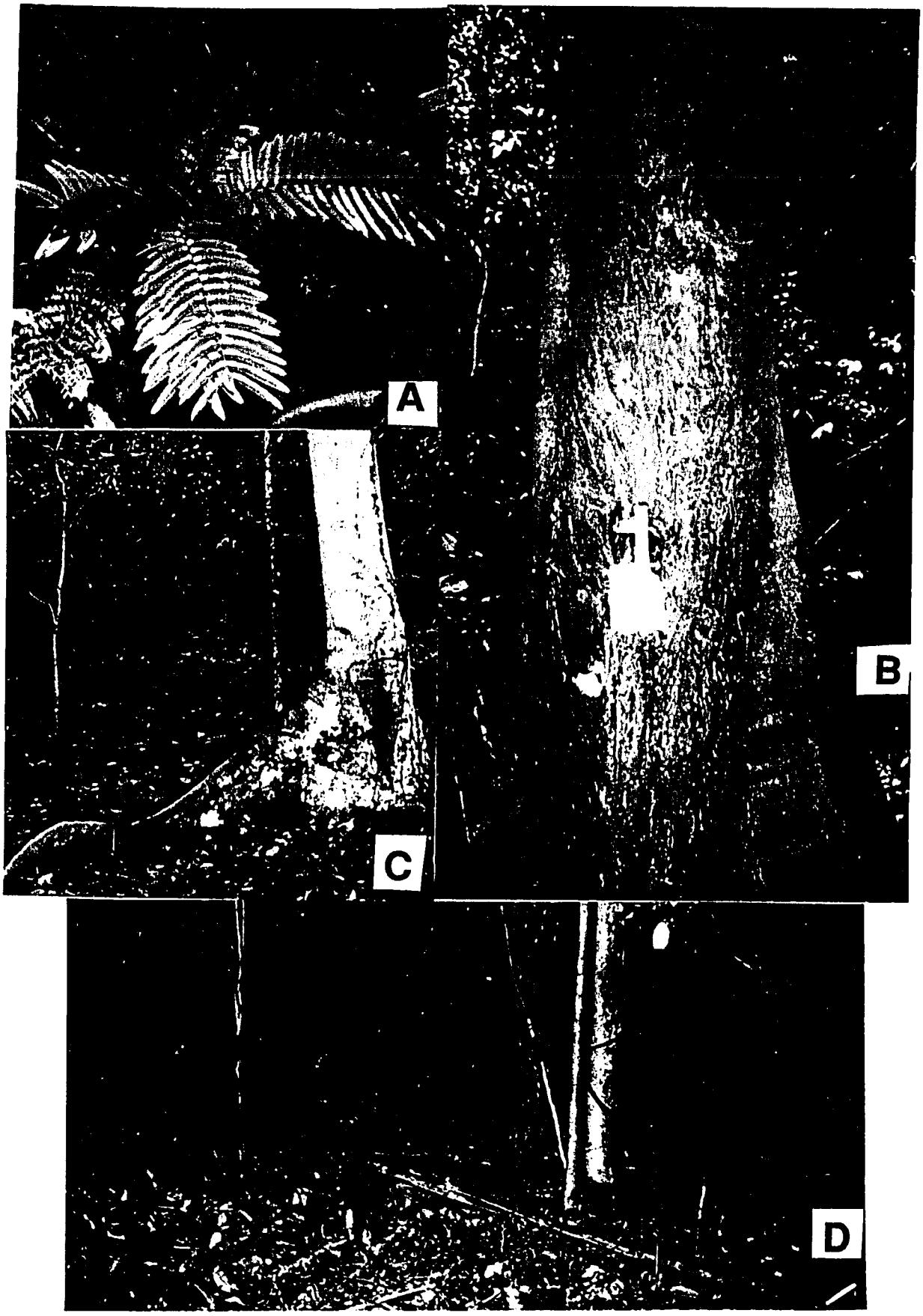
Piptadeniastrum africanum (Mimosaceae)

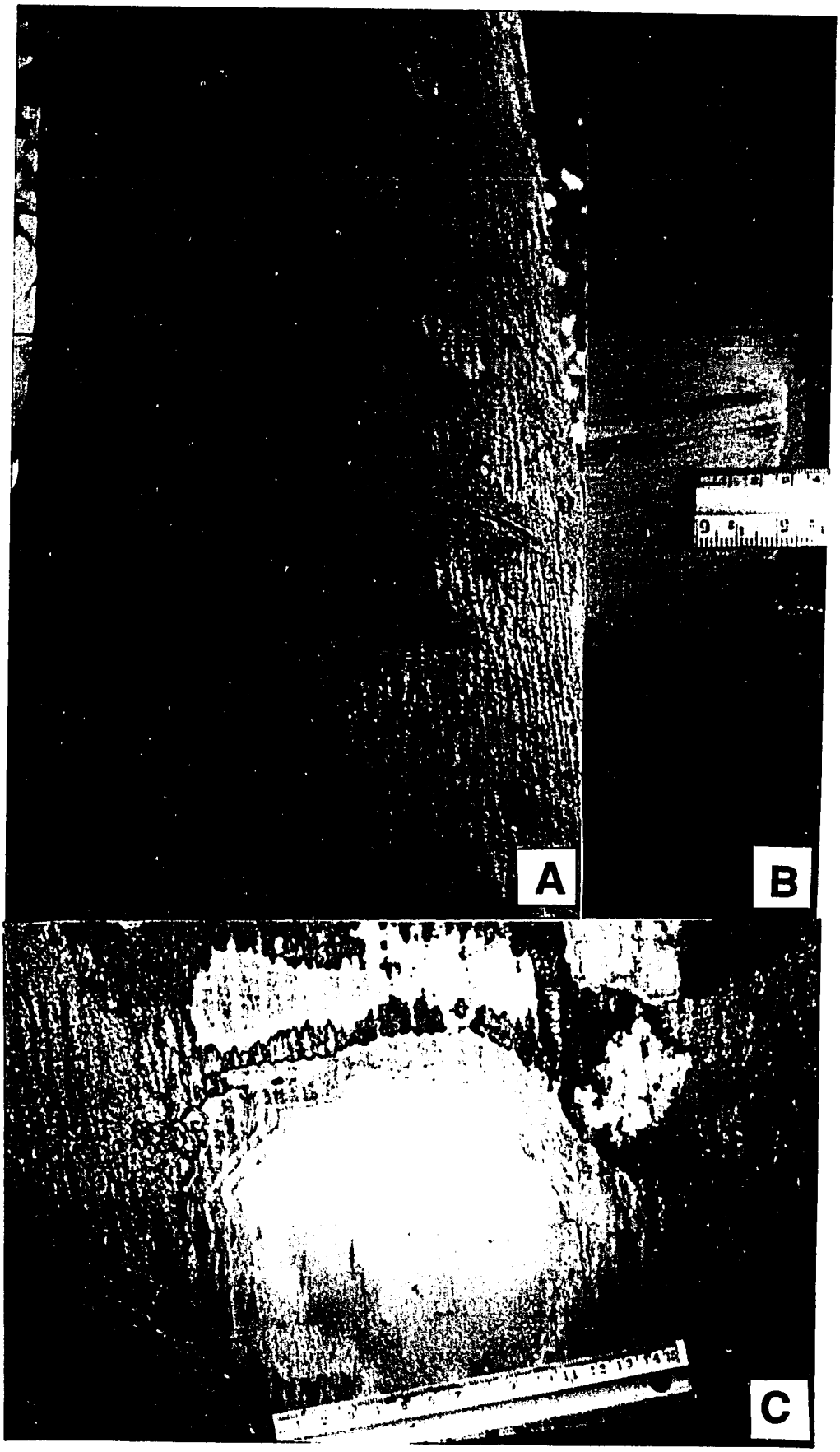
74A----Seedling and leaves.

74B, C, & D----Bole and buttresses.

75A----Bark, eyemarks, and hoop marks.

75C----Slash.


A
B
C
D


A
B
C

Family	Species	Vernacular name
Mimosaceae	*Piptadeniastrum africanum*	dahoma

---

1. Organization

a. Leaf type----Compound, bipinnate.

b. Phyllotaxy----Alternate. Leaflets opposite, pinnae 10-19 pairs.

2. Shape

a. Form----Oblong. **b. Apex**----Acute to slightly obtuse.

c. Base----Truncate.

3. Margin----Entire.

4. Glands----Elevated glands on rachis and petioles, especially on young leaves.

5. Blade size----3-8.5 x 0.8-1.25 cm.

6. a. Petiolule----Sessile. Petiole 1-2 cm long, with dark brown deposits (resin ?).

b. Rachis----Fluted, with triangular ridges at base similar to those on young twigs. Dark brown deposits along rachis, with higher

concentrations in form of aggregations at swollen base.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Erect, white hairs, 1.0 mm long at blade margin and base. Other type of appressed hairs, 1.0 mm long at blade margin. Erect hairs, up to 2 mm long on petiole and rachis. Flexuous-straggling hairs on rachis, mixed with erect hairs. Long, thin, white hairs, up to one cm long at some rachis-stem nodes.

ii. Density----All types of hair abundant. Hairs carpet petiole and especially rachis like cushion. Hairs denser at leaf base than on blade.

b. Adaxial surface----Hairs similar to abaxial surface.

8. Venation----Simple Craspedodromous.

9. Primary vein----Markedly curved, unbranched. Divides blade into 2 unequal parts (about 1 : 4).

10. Secondary veins

a. Angle of divergence----Acute narrow, nearly uniform.

b. Course----Curved uniformly, unbranched.

c. Loop-forming branches----Absent.

d. Inter-secondary vein----Absent.

11. Tertiary veins----Very obscure ! Could not be determined.

12. Higher order venation----Not visible.

13. Marginal ultimate venation----Fimbrial vein that is intramarginal.

14. Areoles----Lacking.

15. Bark

a. Texture, & features----Fibrous to slightly brittle, outside smooth. Faint, shallow, orange-brown, vertical markings along which tiny, brownish-orange lenticels are arranged. Hoop marks near base of stem, and on buttresses. Prominent eyemarks. Bark easily separates from wood.

b. Color----Gray-brown to orange.

16. Slash

a. General color----Pale yellow, creamy-orange, or light brown.

b. Characteristics----Cover of outer bark green. Outer bark

very brittle; inner bark fibrous. Brown dots in outer bark. Deep brown line in outer bark; brown line in inner bark. Slash becomes more brownish after 2 mins. Sapwood light yellow. Strong, pleasant smell like that of coconut fruit, or slash of *Baphia nitida.*

c. Exudate----Usually absent. Sometimes clear, scanty, slightly sticky sap.

d. Thickness----1-5 mm.

17. Wood----Cream-colored, hard.

18. Height category----H. Up to 46 m.

19. Buttressing----Extensive, large, plank buttresses that wander for up to 7 meters or more, sometimes branching.

20. Bole----Usually straight, round, sometimes crooked near crown.

21. Additional remarks----Emergent tree, common in wet forests, with spreading branches and fine fern-like foliage. Crown resembles an umbrella. Branching can be low.

MORACEAE

Trees or shrubs, often with milky latex. Leaves alternate, rarely opposite, simple. Stipules paired, often caducuous, leaving a scar.

A family of 14 genera and 117 species (several introduced) in West Africa. There are six genera and ten species in the Bobiri forest reserve.

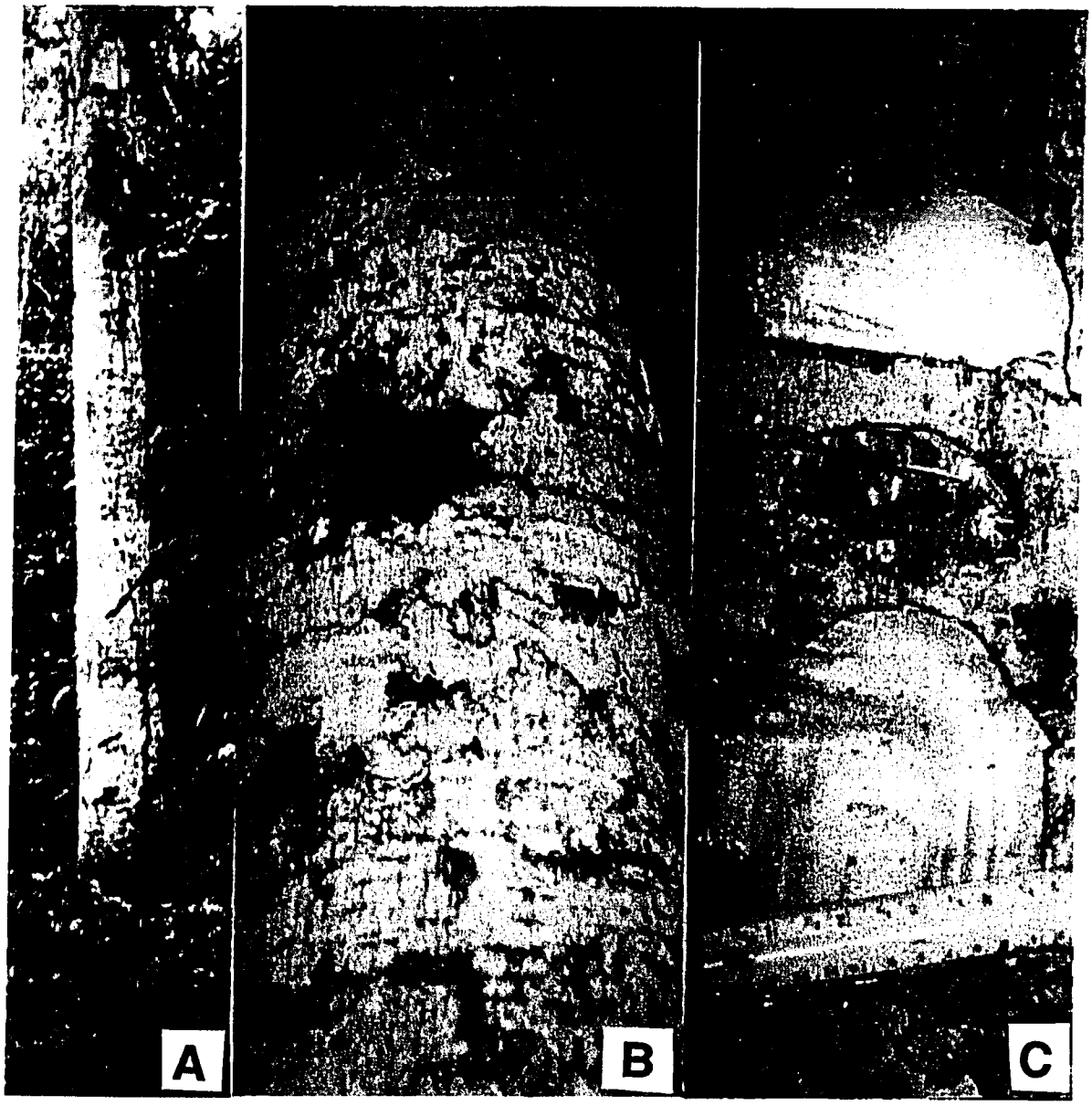
PLATE 76

Antiaris toxicaria (Moraceae)

A----Bole and incipient buttress.

B----Bark.

C----Bark and slash.


A
B
C

Family	Species	Vernacular name
Moraceae	*Antiaris toxicaria*	kyen-kyen

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Rounded to cordate.

3. Margin----Serrate. Apical angle acute, apical concave, basal convex, regular spacing, rounded sinuses, simple series.

4. Glands----Absent. **5. Leaf size**----5.5-16 x 3.5-11 cm.

6. Petiole----Normal, sometimes slightly flattened, very hairy.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Prickly, visible, erect hairs, up to 0.5 mm long on blade, and up to 1.5 mm long on primary vein. They appear white on veins and blade but brown on primary vein, petiole, buds, young twigs, and

expanding leaves. Buds have other type of appressed hairs that are sickle-shaped. All hairs have swollen base. Blade scabrid.

ii. **Density**----Very dense.

b. Adaxial surface

i. **Type, color, & location**----Same type of hairs found on abaxial surface on blade. Tuft of hairs at projections of serrations where some tertiary veins terminate.

ii. **Density**----Less abundant than abaxial surface except primary vein.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform. Lowest pair more obtuse.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute to right angle, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Simple.

11. Tertiary vein

Pattern-----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a fimbrial vein that is hairy. **Circumpubescent.**

14. Areoles

a. Development----Well developed.

b. Shape----Pentagonal and quadrangular.

15. Bark

a. Texture, & features----Very fibrous. Outside smooth. Shallow vertical markings. Big scattered lenticels, up to 3 mm in diameter (widest lenticels among the 103 species in sample). Prominent eyemarks.

b. Color----Gray; sometimes with light green tint.

16. Slash

a. General color----Light yellowish-orange to brown, or

cream-colored.

b. Characteristics----Presence of orange striations. Outer bark quite brittle; inner bark very spongy. Slash becomes brown after 5 mins, with dark ring near sapwood after 10 mins.

c. Exudate----Copious, quite sticky, watery, whitish to light brown latex. Becomes brownish (resembling milky tea) after 2 mins.

d. Thickness----2-3 mm.

17. Wood----Cream-colored, soft.

18. Height category----H. Up to 40 m.

19. Buttressing----Small to medium-sized buttresses.

20. Bole----Cylindrical, straight.

21. Additional remarks----Large deciduous tree common in dry forest. Branchlets rusty-tomentose. Crown quite round.

Family	Species	Vernacular name
Moraceae	*Ficus barteri*	domini

---

1. Organization

a. Leaf type----Compound.

b. Phyllotaxy----Alternate. Leaflets spirally arranged.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----10-40 x 1.6-5.0 cm.

6. Petiolule----Normal, 1.2-5.5 cm long.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform, lowest pair more acute, uppermost abtuse or right angle.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Composite.

11. Tertiary veins

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed. **b. Shape**----Quadrangular.

15. Bark

a. Texture, & features----Brittle. Outside smooth, hoop marks and some eyemarks. Scattered lenticels.

b. Color----Brown.

16. Slash

a. General color----Creamy-purple.

b. Characteristics----Cover of outer bark green. Slash begins to darken after 30 secs, sapwood and slash become brown after 2 mins, and dark brown after 5 mins. Faint smell.

c. Exudate----Copious, cream-colored, sticky latex, becoming yellowish-brown after 3 mins.

d. Thickness----7 mm.

17. Wood----Moderately hard.

18. Height category----hh. Up to 25 m.

19. Buttressing----Small buttresses. **20. Bole**----Round, crooked.

21. Additional remarks----Shrub, or small to medium-sized tree with solitary figs on stalks in leaf axils. Branchlets glabrous, purple, with prominent lenticels that appear as white dots. Presence of stipules that are not persistent. Primary vein very large compared to sec veins. Venation very conspicuous on abaxial side but quite obscure on adaxial side. Sec veins meet in sub-marginal veins. Abaxial side of dry leaf pale green; adaxial side dark green.

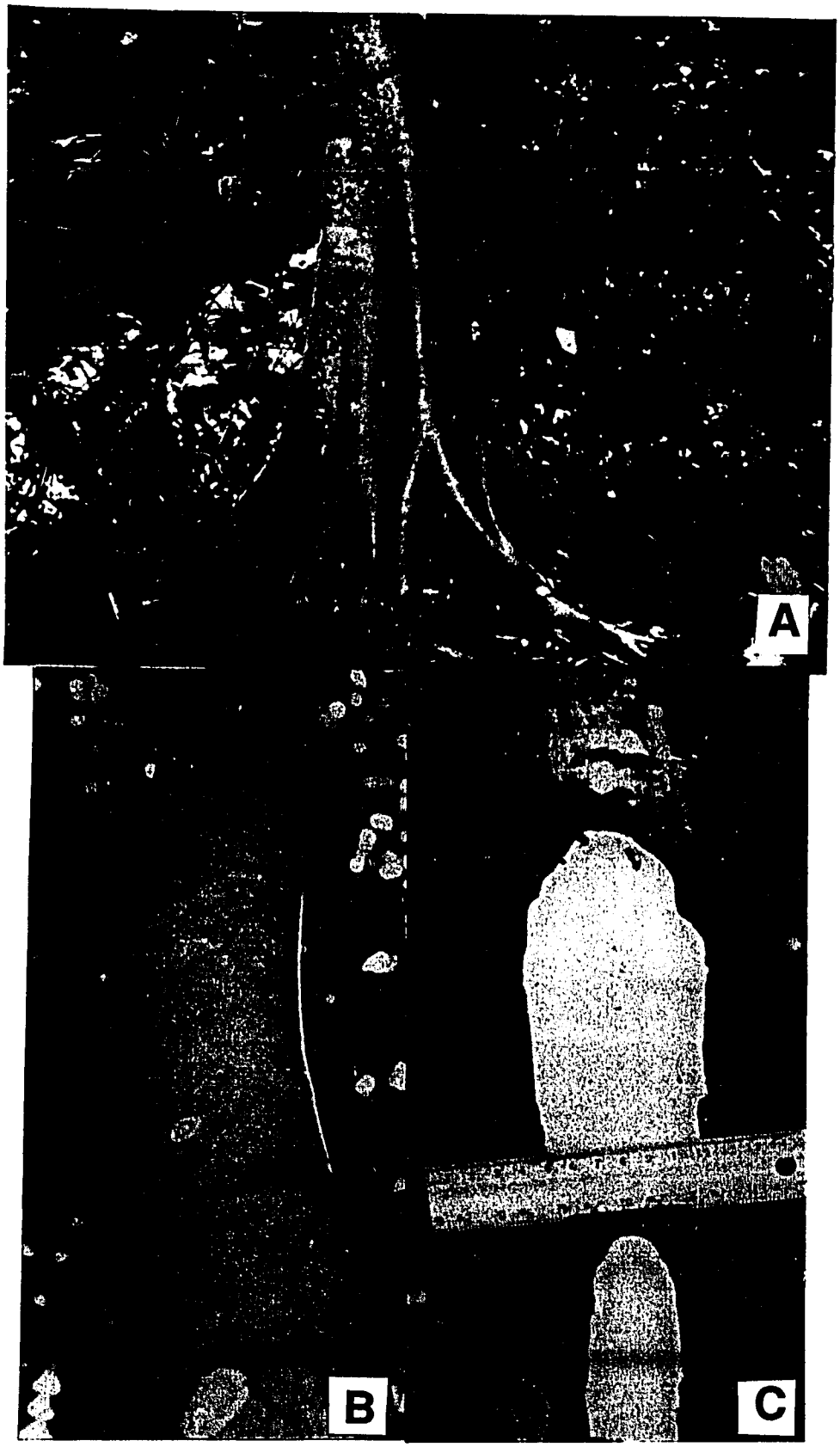
PLATE 77

Ficus exasperata (Moraceae)

A----Bole and buttresses.

B----Bole and bark.

C----Slash.


A
B
C

Family	Species	Vernacular name
Moraceae	*Ficus exasperata*	nyankyeren

---

1. Organization

a. Leaf type----Simple. Leaves of sapling and coppice usually deeply 3-lobed.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acute to acuminate.

c. Base----Rounded to obtuse.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----3.5-17 x 2.5-11 cm.

6. Petiole----Normal; slightly flattened dorsoventrally.

7. Hairs

a. Abaxial surface

i. Type, color, & location----All veins with 0.1-0.4 mm long mixture of erect, short, thick, and sharply-pointed spines, and long, thin hairs possessing curved apices. Some

hairs in intercostal areas too. Mixture of short, thick spines with rounded bases, and thin, smaller, very sharp spines at base of blade and on petiole. Majority of spines ascending, pointed towards leaf apex, causing extreme roughness when leaf is stroked with the finger basipetally.

ii. Density----Hairs and spines very abundant on veins and petiole; less abundant in intercostal areas.

b. Adaxial surface

i. Type, color, & location----Spines on whole leaf, few branching dichotomously, usually emanating from veins. No presence of hairs. Only spines with broader base found on petiole and base of primary vein. Most spines with apical alignment as on abaxial side.

ii. Density----Abundant.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform;

lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Absent.

e. Number----3-6 pairs.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Mixture of forked and simple, few straight, majority convex.

ii. Relation to midvein----Majority at right angle, some oblique.

iii. Arrangement----Alternate and opposite in about equal proportions.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Fibrous and pliable; outside very smooth. Several prominent, thin, wide eyemarks.

b. Color----Gray (sometimes with whitish tint), or grayish-green with white tint.

16. Slash

a. General color----Creamy-orange.

b. Characteristics----Cream-colored outer bark, light orange inner bark. Strong repulsive smell.

c. Exudate----Very copious, viscid, cream-colored, sticky exudate, rapidly becoming brown (but not as fast as in *Ficus exasperata*) after 30 secs.

17. Wood----Light orange, soft.

18. Height category----h. Up to 22 m.

19. Buttressing----Small buttresses, sometimes flying.

20. Bole----Round, straight, sometimes crooked near crown.

21. Additional remarks----Deciduous tree with low branching, usually in dry forest. Epidermis of primary and sec veins of lower half of leaf grow at junction of two to form about 1.5 mm long, glabrous "membrane" enclosing primary-sec angles on abaxial side (resembling webbed feet of toad). Venation pattern of leaf resembles railroad. Slash heals poorly.

PLATES 78 & 79

Ficus sur (Moraceae)

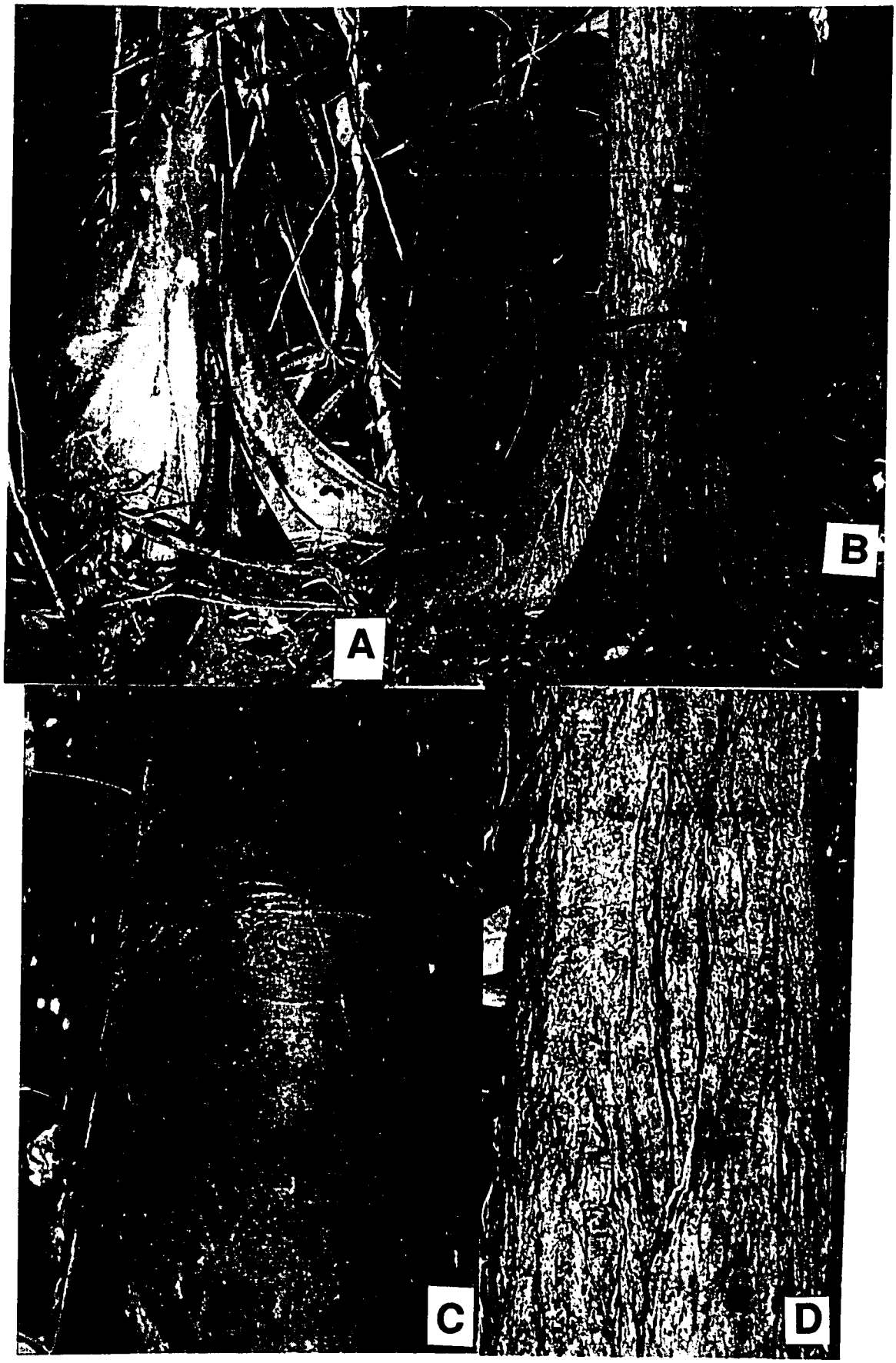
78A & B----Bole and buttresses.

78C & D----Bark and hoop marks.

79A----Slash (below--after 30 seconds; above--after one minute).

79B----Slash (above--after 15 seconds; below--after 30 seconds).

79C----Slash (after two minutes).


A
B
C
D


A
B
C

Family	Species	Vernacular name
Moraceae	*Ficus sur*	domoni

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Spiral.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Obtuse to rounded.

3. Margin----Serrate; irregular spacing, rounded sinuses, compound series, apical angle acute to slightly obtuse, apical side of angle concave to straight. Serrations joined by tiny branches of sec veins.

4. Glands----Absent.

5. Leaf size----Up to 25 cm long and 12 cm broad.

6. Petiole----Normal. Has thin vertical ridges.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Mostly erect hairs, mixed

with appressed hairs , 0.3-0.8 mm long, on all veins and intercostal areas. Appressed hairs mainly on primary and sec veins, also on buds and petiole.

ii. **Density**----Abundant on blade, few on petiole.

b. **Adaxial surface**----Few erect hairs scattered on adaxial side, mostly on primary vein; rest of blade glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform. Lowest pair more acute.

b. **Course**----Curved abruptly, branched.

c. **Loop-forming branches**----Acute, enclosed by sec and tertiary arches. Presence of **basal tertiary loops.**

d. **Inter-sec vein**----Absent.

11. **Tertiary veins**

Pattern----Percurrent.

i. **Course**----Majority simple and straight; some forked and

recurved.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly opposite, few alternate.

12. Higher order venation----Quaternary veins orthogonal. Rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Brittle. Outside smooth. Scattered lenticels, sometimes branched, some in vertical rows.

b. Color----Gray.

16. Slash

a. General color----Brown.

b. Characteristics----Cover of outer bark green. Outer bark very brittle. First layer of outer bark light brown, inner layer of outer bark deep brown. Inner bark light brown and brittle.

Faint, agreeable smell.

c. Exudate----Very copious, sticky, white latex, becoming brownish after 2 mins, with light gray tint after 5 mins. Rubbing between fingers quickens chaging of color to brown.

d. Thickness----About 7 mm.

17. Wood----Creamy-Light brown sapwood, dark brown heartwood, moderately hard.

18. Height category----hh to h. Up to 20 m.

19. Buttressing----Well buttressed.

20. Bole----Round, straight or crooked.

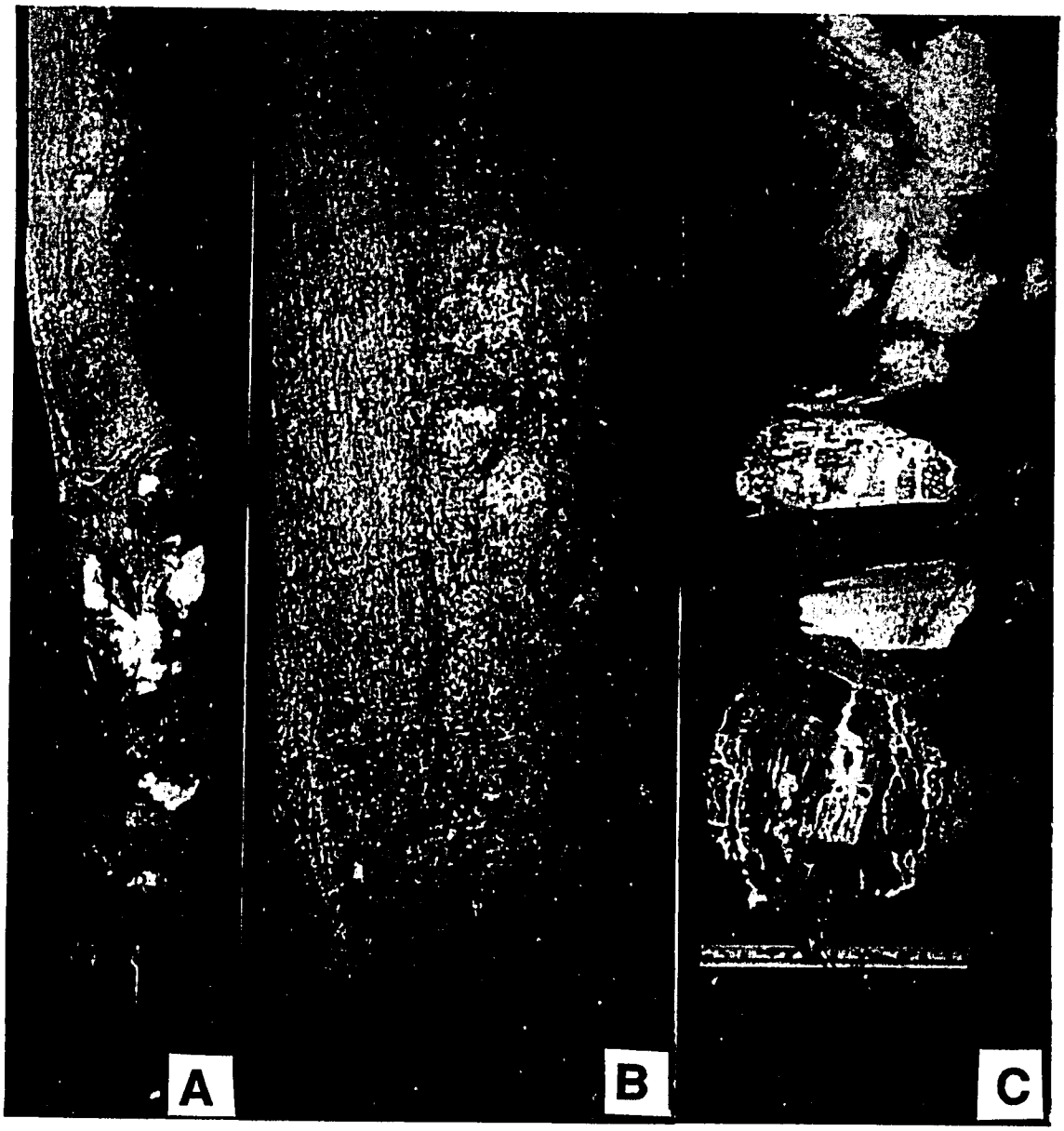
21. Additional remarks----Small to medium-sized tree, cauliflorous with figs borne in abundant clusters on trunk. Nodes have rings of hairs. A species that is quite variable (Hutchinson & Dalziel, 1954-72) within which several infraspecific taxa can probably be recognized. Common in more open country and sec forest. New leaves possess white spots on blade. Higher order venation more pronounced on adaxial side and gives chequered design to blade. Adaxial side shiny, quite contrary to dull abaxial surface.

PLATE 80

Ficus variifolia (Moraceae)

A----Bole. B----Bark and hoop marks.

C----Slash (above--after five seconds; below--after 15 seconds).


A
B
C

Family	Species	Vernacular name
Moraceae	*Ficus variifolia*	nyankyeren-nini

---

1. Organization

a. Leaf type----Simple but often lobed (pinnately 3-5 lobed), variable.

b. Phyllotaxy----Spiral.

2. Shape

a. Form----Orbiculate. **b. Apex**----Acuminate.

c. Base----Lobate to saggitate.

3. Margin----Slightly crenate. **4. Glands**----Absent.

5. Leaf size----5-17 x 2-11.5 cm.

6. Petiole----Long, up to 10 cm or more. Normal, with vertial ridges.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Long, light brown, mixture of appressed and erect, stiff hairs, 0.2-2.3 mm long on whole blade, especially primary and sec veins. Very short, erect

hairs, on petiole, primary vein, and sec vein, 0.1-0.2 mm long.

ii. Density----Long hairs copious, making leaf scabrid. Short hairs scattered.

b. Adaxial surface----Similar hairs and distribution as abaxial surface.

Density----Abundant but less dense tha abaxial surface. Hairs crowded at petiole-lamina junction. Surface scabrid.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched, with outer sec veins.

c. Loop-forming branches----Acute, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Absent.

e. Number----6-8 pairs.

11. Tertiary veins

a. Pattern----Percurrent.

i. Course----Straight, some reflexed or convex.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a **fimbrial vein.**

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Fibrous to brittle. Outside very smooth and slippery. Round, prominent eyemarks and few hoop marks. Scattered, ellipsoid lenticels, some aligned horizontally, a few vertically arranged.

b. Color----Grayish-silver, or gray with green tint.

16. Slash

a. **General color**----Purplish-red.

b. **Characteristics**----Slash begins to turn brown after one second, and becomes dark brown after one min (fastest-changing slash encountered in sample). Cover of outer bark green, followed by thin, orange layer, then brittle, light purple layer. Inner bark fibrous and light purple, sometimes with reddish tint. Strong, repulsive smell.

c. **Exudate**----Copious, watery, very sticky, creamy-yellow exudate, sometimes with brownish tint, becoming deeper brown after 5 mins.

d. **Thickness**----About 2 mm.

17. **Wood**----Light yellow, soft when young, moderately hard when old.

18. **Height category**----hh. Up to 10 m.

19. **Buttressing**----Small buttresses.

20. **Bole**----Round, slightly crooked.

21. **Additional remarks**----Shrub or small tree, often scrambling, with brownish-purple branchlets, ring scars at nodes, usually grows by rivers.

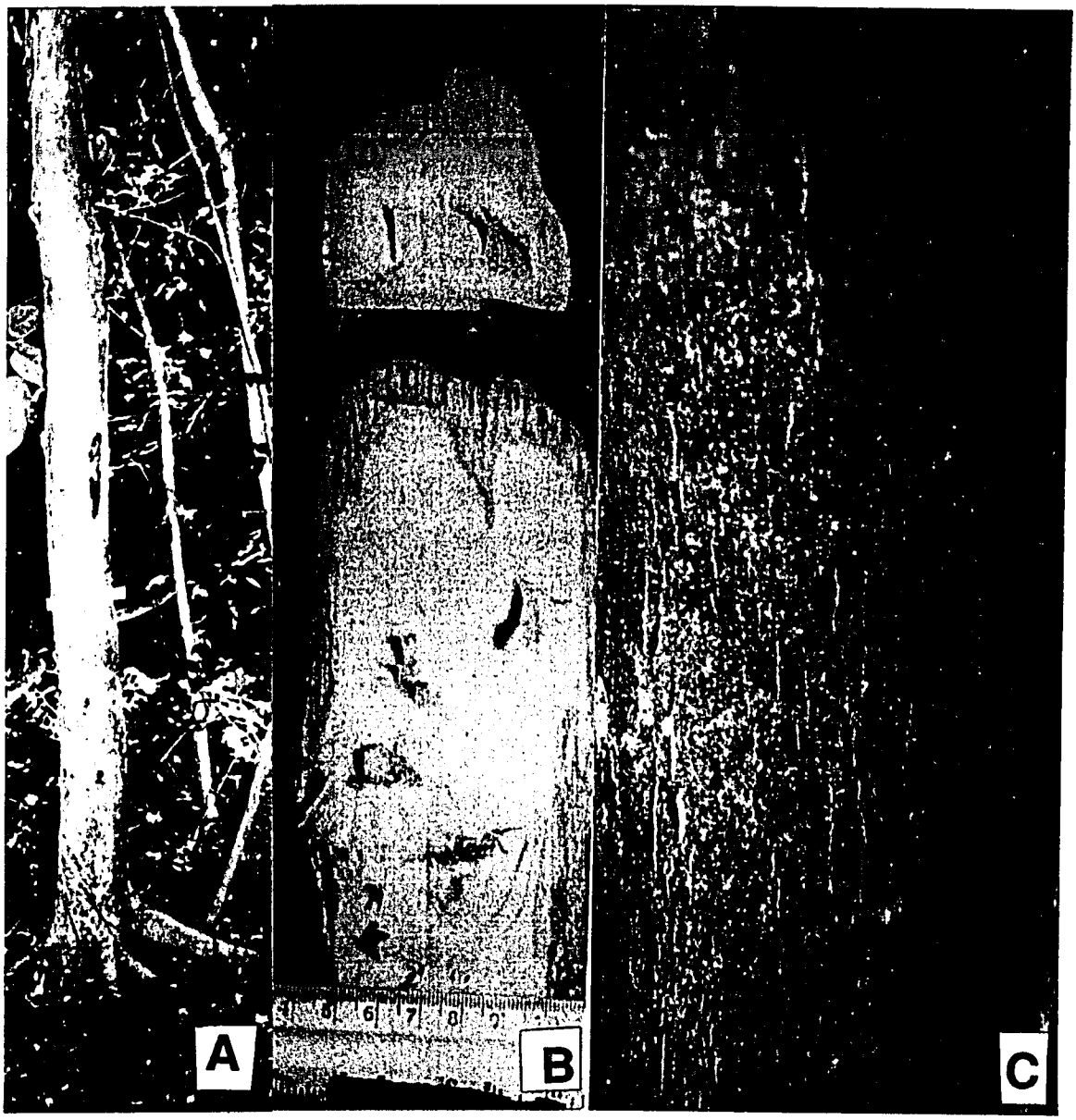
PLATE 81

Morus mesozygia (Moraceae)

A----Bole and incipient buttresses.

B----Slash.

C----Bark.


A
B
C

Family	Species	Vernacular name
Moraceae	*Morus mesozygia*	wonton

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate to attenuate.

c. Base----Rounded to cuneate.

3. Margin----Serrate to crenate. Simple series, irregular spacing, rounded to angular sinuses, basal side concave; apical side concave, convex, or straight.

4. Glands----Present, close to base of petioles, and on young twigs.

5. Leaf size----7-17.5 x 5-9.5 cm.

6. Petiole----Normal, 1.5-2 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed hairs, 0.2-1.0 mm long on all veins, longest on primary vein and petiole.

Erect hairs in intercostal areas and on higher order veins.

ii. Density----Abundant at all locations.

b. Adaxial surface----Some hairs on primary vein, few on sec veins; rest of blade glabrous.

8. Venation----Actinodromous (Basal, Perfect, Marginal).

9. Primary vein----Straight to markedly curved. Branched.

10. Secondary veins

a. Angle of divergence----Narrow to moderately acute, nearly uniform.

b. Course----Curved abruptly, branched, with outer sec veins.

c. Loop-forming branches----Acute, enclosed by sec and tertiary arches.

d. Inter-sec vein----Absent.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Simple, few forked, mostly convex, few concave, some recurved.

ii. Relation to midvein----Mostly right angle, few oblique.

iii. Arrangement----Predominantly opposite.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Brittle to fibrous, easily separates from wood. Outside smooth to rough, with few narrow eyemarks. Very shallow vertical markings along which small lenticels are arranged in vertical rows. Old bark flakes, leaving round patches up to 1/3 up the trunk.

b. Color----Gray, or gray-brown.

16. Slash

a. General color----Creamy-orange, creamy-yellow, or light orange, with broken, brown streaks.

b. Characteristics----Slash turns brownish, with grayish

purple tint after one min, deeper brown after 5 mins, and gray after 15 mins. Faint pleasant smell. Sapwood goes through similar changes. Many red ants visit slash and exudate.

c. Exudate----Copious, gummy exudate.

d. Thickness----About 3 mm.

17. Wood----Creamy to light yellow, slightly soft.

18. Height category----h to H. Up to 30 m.

19. Buttressing----Usually buttressed.

20. Bole----Cylindrical, straight near base but usually crooked near crown. Presence of bumps.

21. Additional remarks----Small to large tree, with reddish-brown, glabrous branches, dense crown, common in dry forest. Leaves are papery, always tri-nerved at base. Blade never joins petiole, but always terminates on two veins on opposite sides of **megaprimary vein** which always extends for about one mm beyond leaf apex, with hairs.

PLATES 82 & 83

Musanga cecropioides (Moraceae)

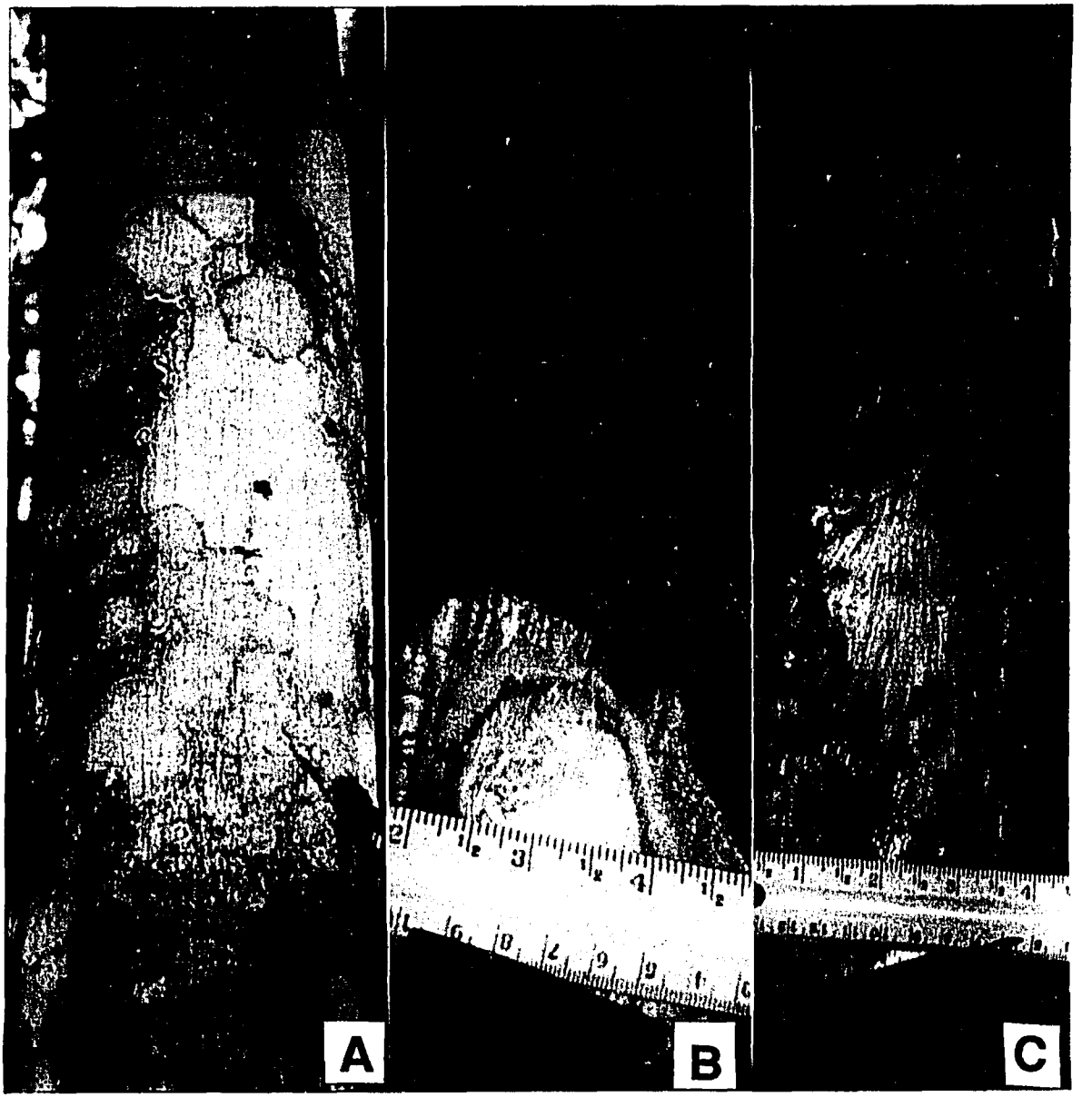
82A----Crown and leaves.

82B----Flying buttresses.

83A----Bole, bark, and hoop marks.

83B & C----Slash.


A
B


A
B
C

Family	Species	Vernacular name
Moraceae	*Musanga cecropioides*	odwuma

---

1. Organization

a. Leaf type----Compound, palmate, radially arranged. 12-15 leaflets.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Oblanceolate. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----Up to 45 cm long and 10 cm broad.

6. a. Petiolule----Sessile.

b. Rachis----Round. Shallow, vertical canals along the length; upper tip flattened; dome-shaped structure at apex on adaxial side, with leaflets arising from sides of dome radially. Up to 55 cm long in my sample; could be longer.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, white hairs, 0.2-0.3 mm long covering whole surface, and on rachis. At 20x, cluster of short hairs 0.1mm long at junction of rachis and blade (seen as a notch). Swollen upper tip of rachis has characteristic erect, ensiform, long hairs resembling legs of insect.

ii. Density----Very dense, carpeting whole leaf; quite abundant at base and tip of rachis but sparse along its length.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Right angle, enclosed by tertiary and quaternary arches. Intramarginal vein present.

d. Inter-secondary vein----Composite.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Majority forked but many simple. Few straight, many convex, few recurved.

ii. Relation to midvein----Oblique.

iii. Arrangement----Alternate and opposite in about equal proportions.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a fimbrial vein.

14. Areoles

a. Development----Well developed, oriented.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Fibrous and fissured. Outside smooth. Few hoop marks.

b. Color----Grayish-white to light brown.

16. Slash

a. General color----Reddish-purple with white streaks.

b. Characteristics----Slash turns grayish-purple after 15 secs. Moderate, pleasant odor.

c. Exudate----Scanty, non-sticky sap.

d. Thickness----2-3 mm.

17. Wood----Creamy-orange, soft to moderately hard.

18. Height category----h to H. Up to 50 m.

19. Buttressing----Always possessing many flying buttresses.

20. Bole----Round to irregular, straight.

21. Additional remarks----A quick-growing tree with umbrella-like crown, very common in secondary forest. Twigs are very stout and have pronounced pith. Stipules large, connate, 15-20 cm long, reddish, thick and papery. Venation very conspicuous on abaxial side of leaf but obscure on adaxial side.

PLATES 84 & 85

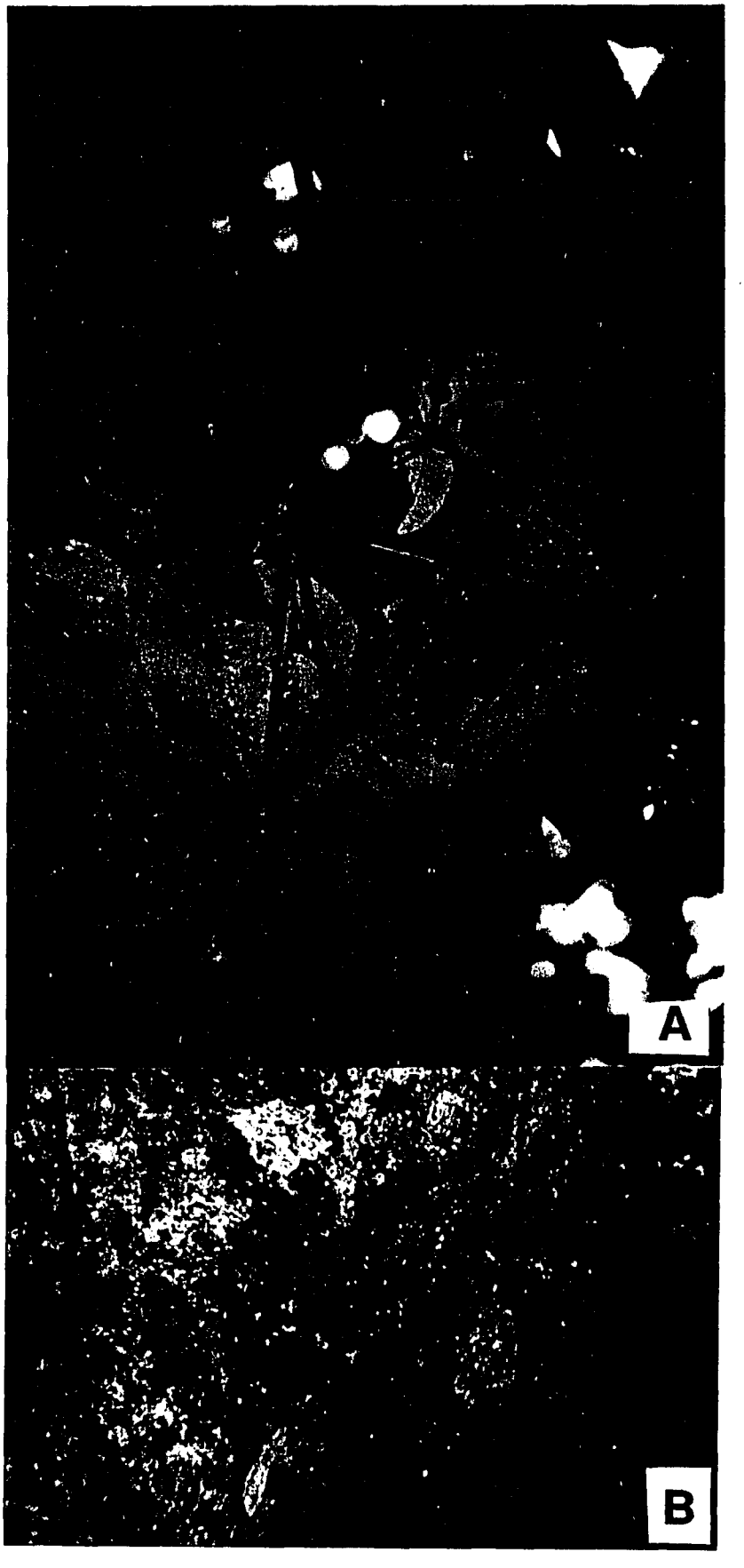
Myrianthus arboreus (Moraceae)

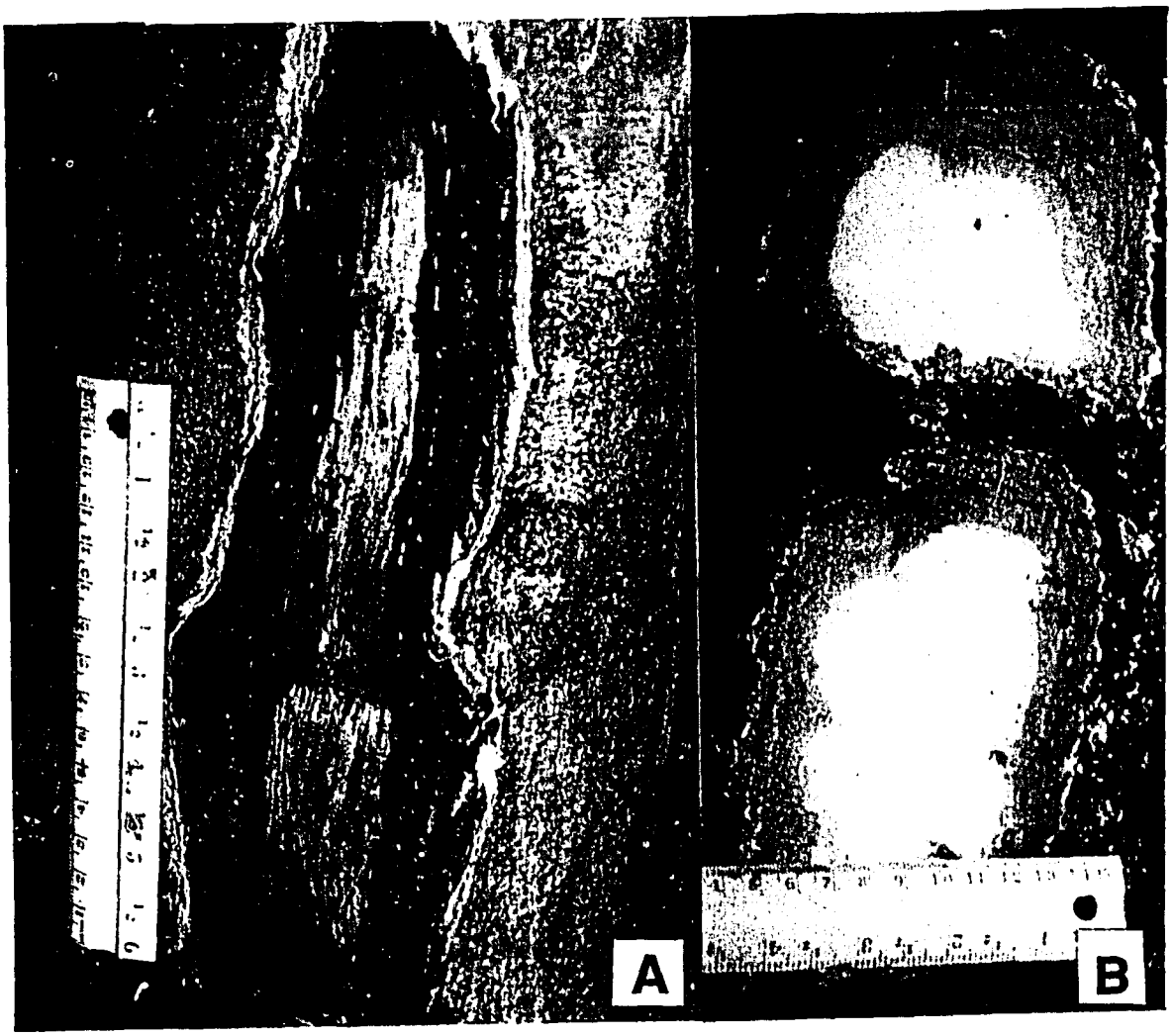
84A----Leaves and fruit.

84B----Bark.

85A----Bark and healed slash.

85B----Slash after one minute.


A
B


A
B

Family	Species	Vernacular name
Moraceae	*Myrianthus arboreus*	nyankuma-bere

---

1. Organization

a. Leaf type----Compound, palmate, 5-7 leaflets.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acute to acuminate.

c. Base----Decurrent.

3. Margin----Serrate; compound series, rounded sinuses, irregular spacing, apical side concave, basal side convex.

4. Glands----Absent. **5. Blade size**----Up to 50 x 22 cm.

6. a. Petiolule----Normal, very short,flattened sideways, has slight extension of blade. Sometimes sessile.

b. Rachis----Very long, up to 50 cm long, stout and woody, **fluted** apically and basally, very rugose apex, pronounced vertcal ridges along its length.

7. Hairs

a. Abaxial surface

i Type, color, & location----Appressed hairs, 0.05-0.2 mm long on primary and sec veins. Another type of very short, white hairs, < 0.1 mm long at 20x, appearing as wooly aggregations, on tertiary and higher order veins, as well as intercostal areas.

ii. Density----Both types of hair abundant at all locations.

b. Adaxial surface----Glabrous, except occasional scattered, appressed hairs near base of blade. Shiny, with tiny bumps, under microscope.

8. Venation----Simple Craspedodromous.

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform; sometimes lowest pair more acute.

b. Course----Straight, branched.

c. Loop-forming branches----Absent.

d. Inter-secondary vein----Absent.

e. Number----25-34 pairs.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Forked; few simple. Majority convex or retroflexed.

ii. Relation to midvein----Oblique.

iii. Arrangement----Equal nos of alternate and opposite.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed. **b. Shape**----Quadrangular.

15. Bark

a. Texture, & features----Brittle. Eyemarks and few hoop marks. Majority of lenticels arranged vertically. Easily separates from wood.

b. Color----Dark gray.

16. Slash

a. General color----Light creamy-orange with light brown tint, or brown.

b. Characteristics----Slash becomes deeper brown with gray tint after one min, and dark brown after 3 mins. Cover of outer bark greenish, or brown with green streaks.

c. Exudate----Clear, scanty, non-sticky exudate.

d. Thickness----0.5-2 mm.

17. Wood----Light yellow, soft to moderately hard.

18. Height category----h. Up 21 m.

19. Buttressing----Many flying buttresses.

20. Bole----Straight to crooked, short, round.

21. Additional remarks----Small tree with very low, spreading branches from a short stem, common in sec forest and wet places in forest. Leaflets thick, and leathery. Abaxial side subcoriaceous, with very pronounced venation; adaxial side smooth, with obscure venation. Brown spots usually at 10x, on primary and sec veins, cause them to appear brownish; higher order veins have few spots and appear whitish.

PLATES 86 & 87

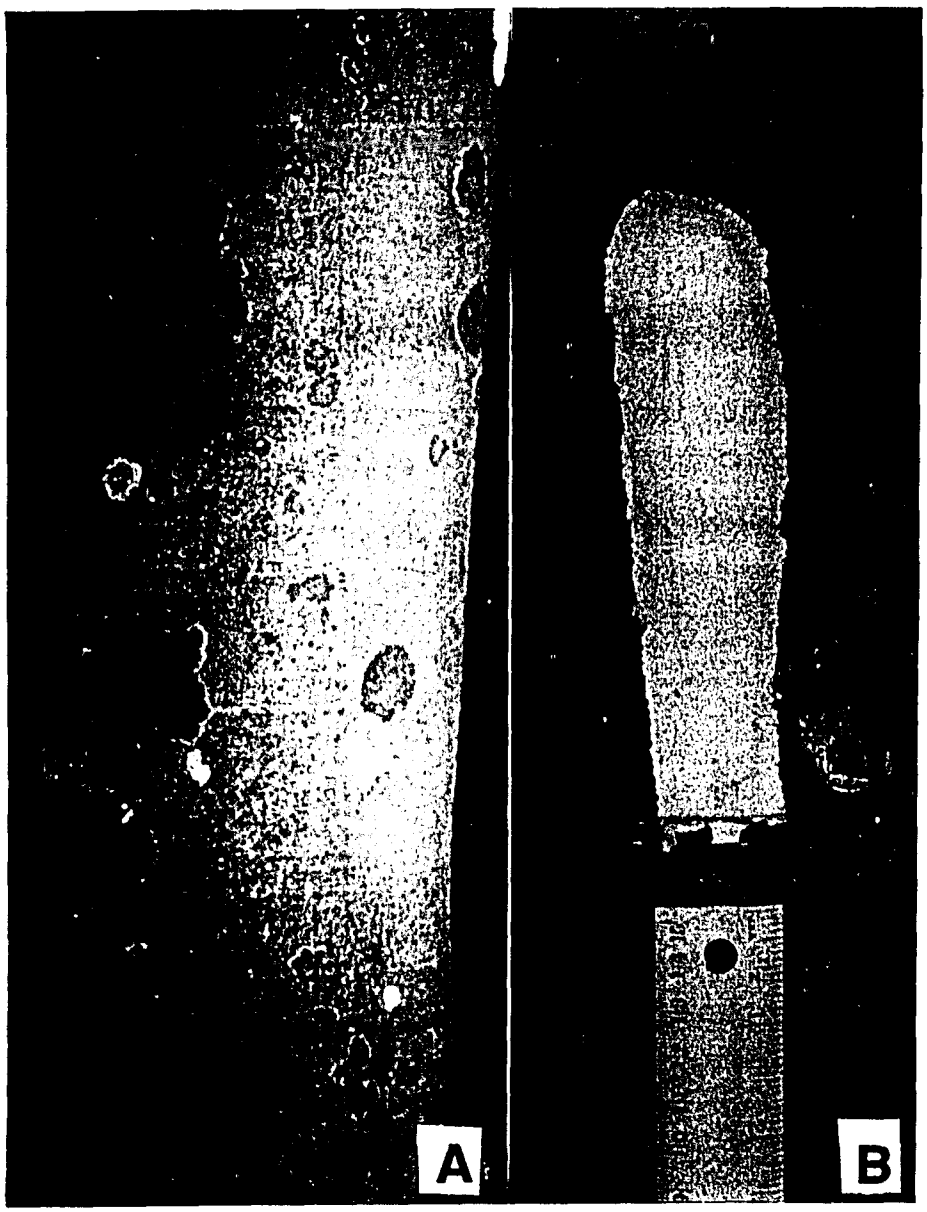
Myrianthus libericus (Moraceae)

86A & B----Bole and slash.

87A----Bark.

87B----Slash.


A
B


A
B

Family	Species	Vernacular name
Moraceae	*Myrianthus libericus*	nyankuma-nini

---

1. Organization

a. Leaf type----Simple. Often 2-3 lobed.

b. Phyllotaxy----Spiral.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Acute.

3. Margin----Serrated; compound series, irregular spacing, rounded sinuses, apical angle acute, apical side concave, basal side straight to convex.

4. Glands----Absent.

5. Leaf size----Unlobed leaves 8-35 x 4-14 cm; lobed leaves up to 37 cm long and 34 cm broad.

6. Petiole----Slighted **fluted** and flattened apically; 1-21 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, white hairs, 0.1-0.3 mm long on whole blade and veins. Longer, appressed, white hairs on primary vein, 0.3-0.6 mm long. Few erect hairs in intercostal areas. Hairs on petiole. Buds very hairy.

ii. Density----Shorter hairs very densely carpets blade like wool; longer hairs abundant but less dense. Few hairs on petiole. Buds very hairy, like fur on animal.

b. Adaxial surface----Glabrous and a little shiny, except few scattered hairs on primary vein, and close to base of some secondaries.

8. Venation----Semicraspedodromous.

9. Primary vein----Markedly curved.

10. Secondary veins

a. Angle of divergence----Narrowly acute, nearly uniform; basal pair slightly more acute.

b. Course----Curved abruptly, branched.

c. Loop-forming branches----Acute, enclosed by sec and

tertiary arches, with outer sec veins.

d. Inter-secondary vein----Composite.

e. Number----10-20.

11. Tertiary vein

Pattern----Percurrent.

i. Course----Forked, majority convex, many recurved.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Spongy to brittle, outside smooth. Peels off easily. Rings of leaf scars and eyemarks Prominent lenticels, some aligned horizontally, some

vertically, others scattered.

b. Color----Gray to dark.

16. Slash

a. General color----Creamy-orange, orange-brown, light yellow, or cream-colored.

b. Characteristics----Slash becomes brownish-orange after 3 mins, with brown ring in inner bark. Cover of outer bark brownish. Outer bark brownish, inner bark light brown to orange. Two reddish-purple rings, one in outer bark, and one in inner bark near sapwood. No other changes after several days.

c. Exudate----Clear, watery, non-sticky exudate.

d. Thickness----1-1.5 mm.

17. Wood----Light yellow, soft to moderately hard.

18. Height category----hh to h. Up to 18 m.

19. Buttressing----Usually with many flying buttresses; few cases fluted at base.

20. Bole----Crooked, sometimes straight. Presence of protruding

points.

21. Additional remarks----Tree common in sec forest, with variable leaf shapes and sizes. Each leaf margin tooth fed by branch of tertiary, or sec vein. Primary vein extends up to 0.4 mm beyond blade apex; vein branches of marginal teeth extend beyond blade as well. Primary vein significantly bigger than secondaries up to 3/5 way from base. Terminal portions of young twigs hairy.

PLATE 88

Trilepisium madagascariense (Moraceae)

A----Bole and buttresses.

B----Slash (above--after 10 seconds; below--after 30 seconds).


A
B

Family	Species	Vernacular name
Moraceae	*Trilepisium madagascariense*	okure

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate to acute; unequal.

3. Margin----Entire.

4. Glands----Little glands on slender apical twigs.

5. Leaf size----5-16 x 2.5-7.5 cm.

6. Petiole----Normal, flattened dorsoventrally, slightly **fluted**, groove on adaxial side, 1-2 cm long. Base of blade extends slightly and folds over on adaxial side as a "lip".

7. Hairs

a. Abaxial surface

i. Type, color, & location----Tiny, appressed hairs, about 0.05 mm long, appearing as dots till 40x, on veins and few

intercostal areas. (Hutchinson and Dalziel, 1954-72, observed leaf to be glabrous). Hawthorne (1989) found leaf glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved to straight. Unbranched.

10. Secondary veins

a. Angle of divergence----Moderately acute, nearly uniform. Lowest pair more acute ($< 45^{o}$).

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse to right angle, enclosed by tertiary and quaternary arches.

d. Inter-sec vein----Simple. **e. Number**----About 7 pairs.

11. Tertiary veins

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Brittle. Outside smooth, with scattered lenticels. Easily torn into long strips.

b. Color----Brownish with light gray tint.

16. Slash

a. General color----Cream-colored with pink taint, or yellowish.

b. Characteristics----Slash turns brown with gray tint after 2 mins. Very strong repulsive smell.

c. Exudate----White, copious, sticky latex that rapidly changes to orange and finally red after 4 mins, becoming very dark brown to black when dry.

d. Thickness----About 3 mm.

17. Wood----Moderately hard, cream-colored.

18. Height category----H. Up to 31 m.

19. Buttressing----Narrow buttresses, or fluted base.

20. Bole----Straight, round.

21. Additional remarks----Branchlets have characteristic circular leaf scars. Dense, dark crown. Leaves have very small, folds

resembling lobes at base, above which basal veins arise. Adaxial side of leaf shiny and paler than abaxial side, but greener when dry. Leaves often trinerved, or with a pair of ascending secondaries on two sides of primary vein.

MYRISTICACEAE

Trees, often large, frequently aromatic, with red exudate in bark, and whorled branches. Leaves alternate, entire, often with pellucid dots. Stipules absent. Often called the "nutmeg" family because fruits resemble nutmegs.

There are 4 genera and 8 species in West Africa. There is one genus and one species in the Bobiri forest reserve.

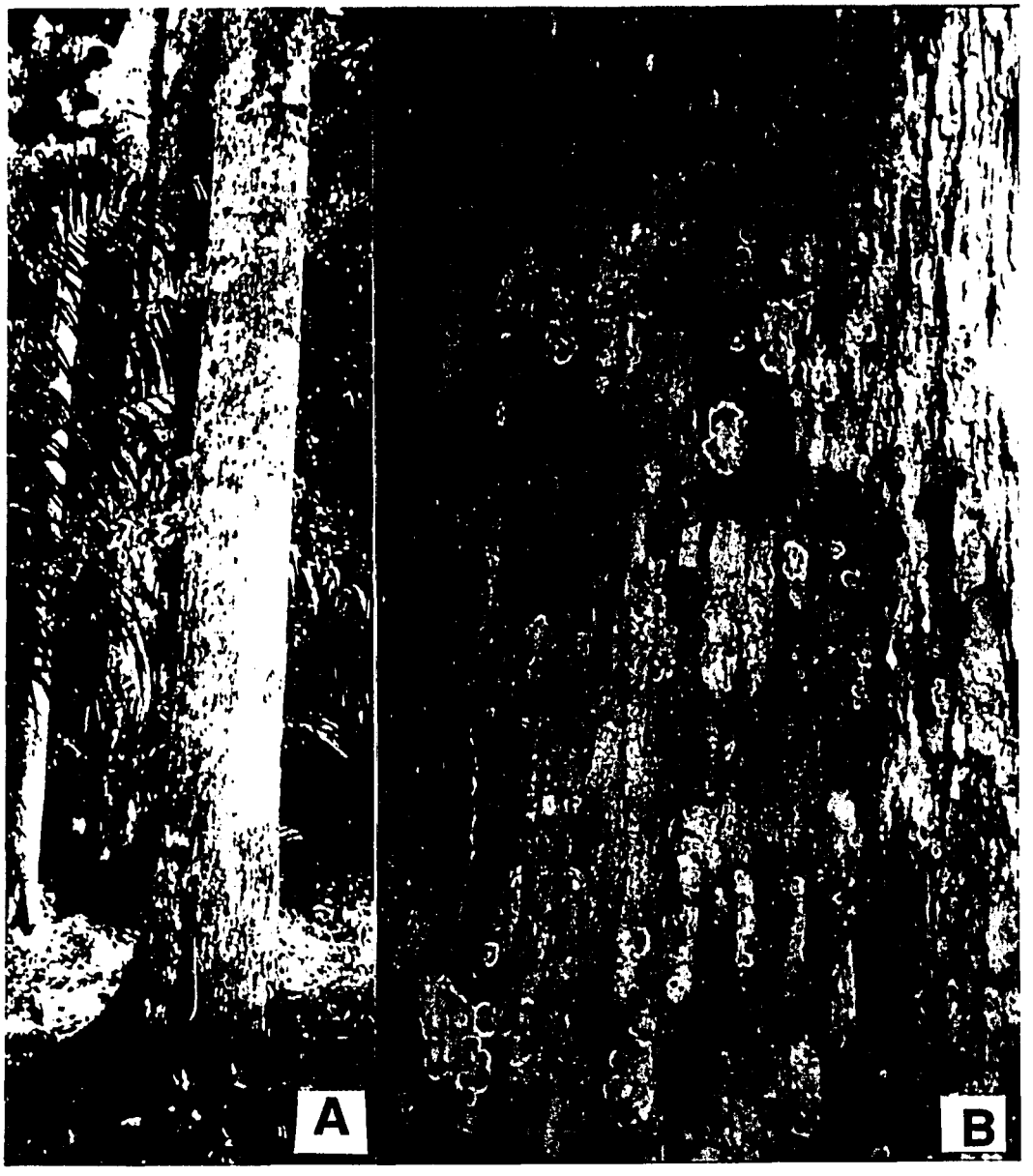
PLATES 89 & 90

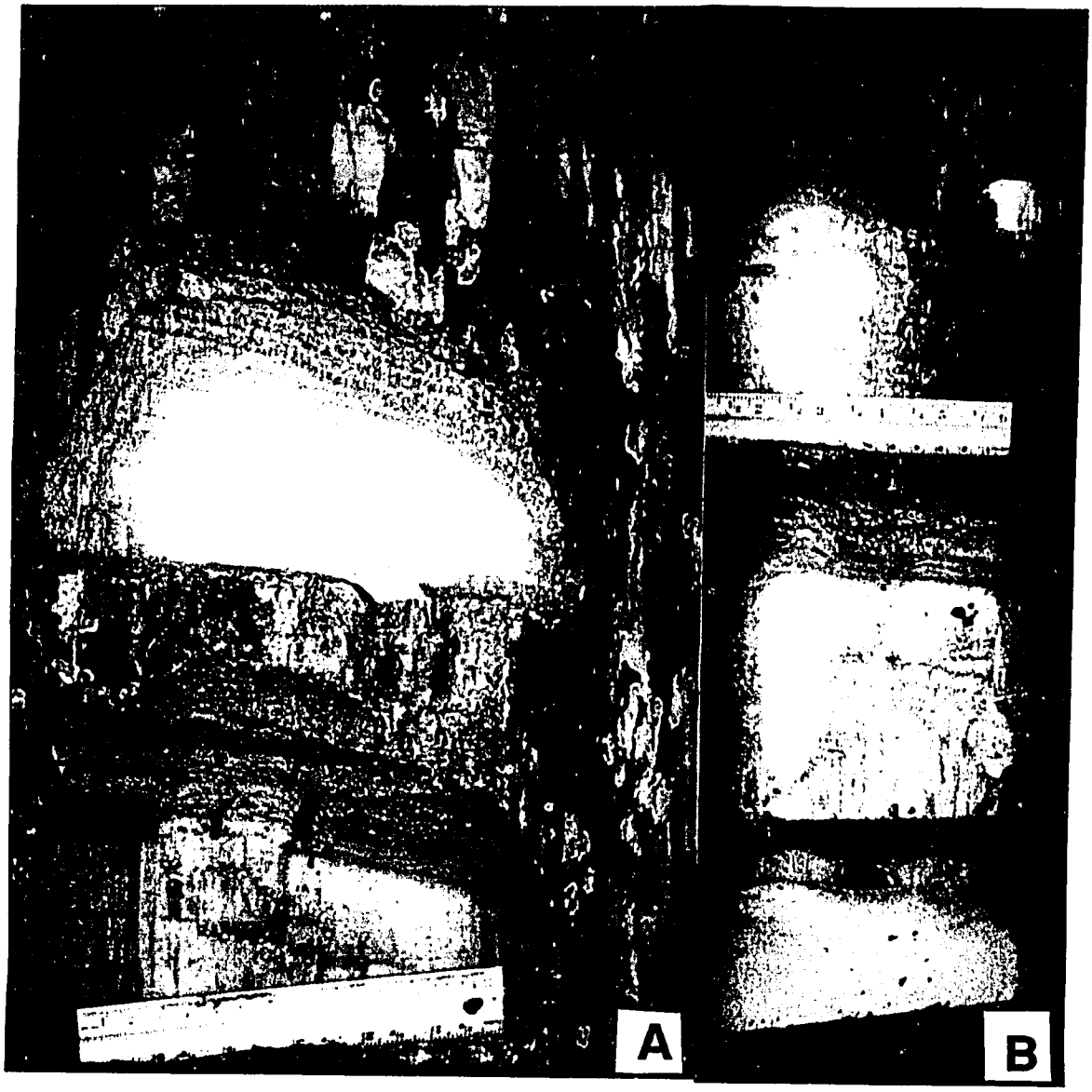
Picnanthus angolensis (Myristicaceae)

89A----Bole and buttresses. 89B----Bark.

90A----Slash (above--after 15 seconds; below--after one minute).

90B----Slash (below--after 10 seconds; above--after 30 seconds).


A
B


A
B

Family	Species	Vernacular name
Myristicaceae	*Pycnanthus angolensis*	otie

---

1. Organization

a. Leaf type----Compound, once pinnate, odd pinnate.

b. Phyllotaxy----Alternate. Leaflets alternate.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate to attenuate.

c. Base----Lobate. Always unequally divided.

3. Margin----entire. **4. Glands**----Absent.

5. Blade size----Up to 25 cm long and 6 cm broad.

6. a. Petiolule----Normal.

b. Rachis----Has few hairs; hoop marks near base.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Tufts of stellate, brown hairs especially on veins, petiolule, and rachis.

Characteristic long, black, erect hairs with rounded apices, 0.3-0.1 mm long at base of primary vein, on petiolule, rachis, and intercostal areas near base of blade.

ii. Density----Stellate hairs copious; other hairs sparse.

b. Adaxial surface----Most parts glabrous, except very few scattered hairs in intercostal area around midvein, and significant amout of erect hairs in primary vein channel.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute wide, nearly uniform, lowest pair obtuse.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Simple.

e. Number----20-35 pairs.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Forked.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Fibrous. Outside rough; has rectangular flakes when old. Several shallow vertical slits.

b. Color----Brown or brownish-gray.

16. Slash

a. General color----Light brown, pink-brown, creamy-red, or red, with few light yellow streaks.

b. Characteristics----Slash becomes brown after 30 secs,

rows of brown spots appear after one min, and whole slash turns deeper brown after 2 mins. Outer bark light brown with brownish spots; inner bark cream-colored or reddish. Faint, pleasant smell.

c. Exudate----Deep red, copious, watery exudate resembling blood. Sometimes yellowish. Sometimes sticky, but usually oily when rubbed between the fingers. It oozes so fast that one has to be quick in noting color of slash or would be masked by red exudate.

d. Thickness----3-5 mm.

17. Wood----Creamy or whitish; develops yellowish color and fine brownish streaks after exposure. Moderate to very hard.

18. Height category----H. Up to 38 m.

19. Buttressing----Small buttresses or fluted at base.

20. Bole----Straight; sometimes crooked. Long, cylindrical. Up to 4.5 m in girth.

21. Additional remarks----Tree with crown of horizontal, whorled branches. Common in disturbed forest. Typical, tiny wrinkles on

adaxial surface, masking higher order venation. Very dark brown, shiny, waxy material (resin ?) on petiole and primary vein. Venation very conspicuous on abaxial side. Leaves appear rusty due to color of indumentation; most leaves usually have several insect bites.

A

THE TAXONOMY AND ECOLOGY OF THE TREES OF THE BOBIRI FOREST RESERVE, GHANA, WEST AFRICA

BY

SAMUEL V. A. KISSEADOO

VOLUME 2

A dissertation submitted to the Graduate Faculty in Biology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

1993

OLACACEAE

Trees, shrubs, or climbers. Leaves alternate, and simple. Stipules absent.

A family of 10 genera and 20 species in West Africa.

There are three genera and six species in the Bobiri forest reserve.

Family	Species	Vernacular name
Olacaceae	*Aptandra zenkeri*	ayentudua

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1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Attenuate to acuminate.

c. Base----Acute to cuneate.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----6-10 x 3-5 cm.

6. Petiole----Normal, tiny, wrinkled under microscope.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Right angle; obtuse near apex.

d. Inter-secondary vein----Absent.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Brittle. Lenticels make outside feel slightly rough when old; bark of twigs smooth. Most lenticels arranged in vertical rows.

b. Color----Brown with light gray tint.

16. Slash

a. General color----Light yellow to orange.

b. Chracteristics----Outer bark orange; inner bark light yellow. Sapwood light yellow. Moderate, pleasant smell.

c. Exudate----Clear, scanty exudate on sapwood.

d. Thickness----1.5-2 mm.

17. Wood----Light yellow. Moderately hard.

18. Height category----h. Up to 13 m.

19. Buttressing----Usually fluted at base.

20. Bole----Crooked, sometimes flattened.

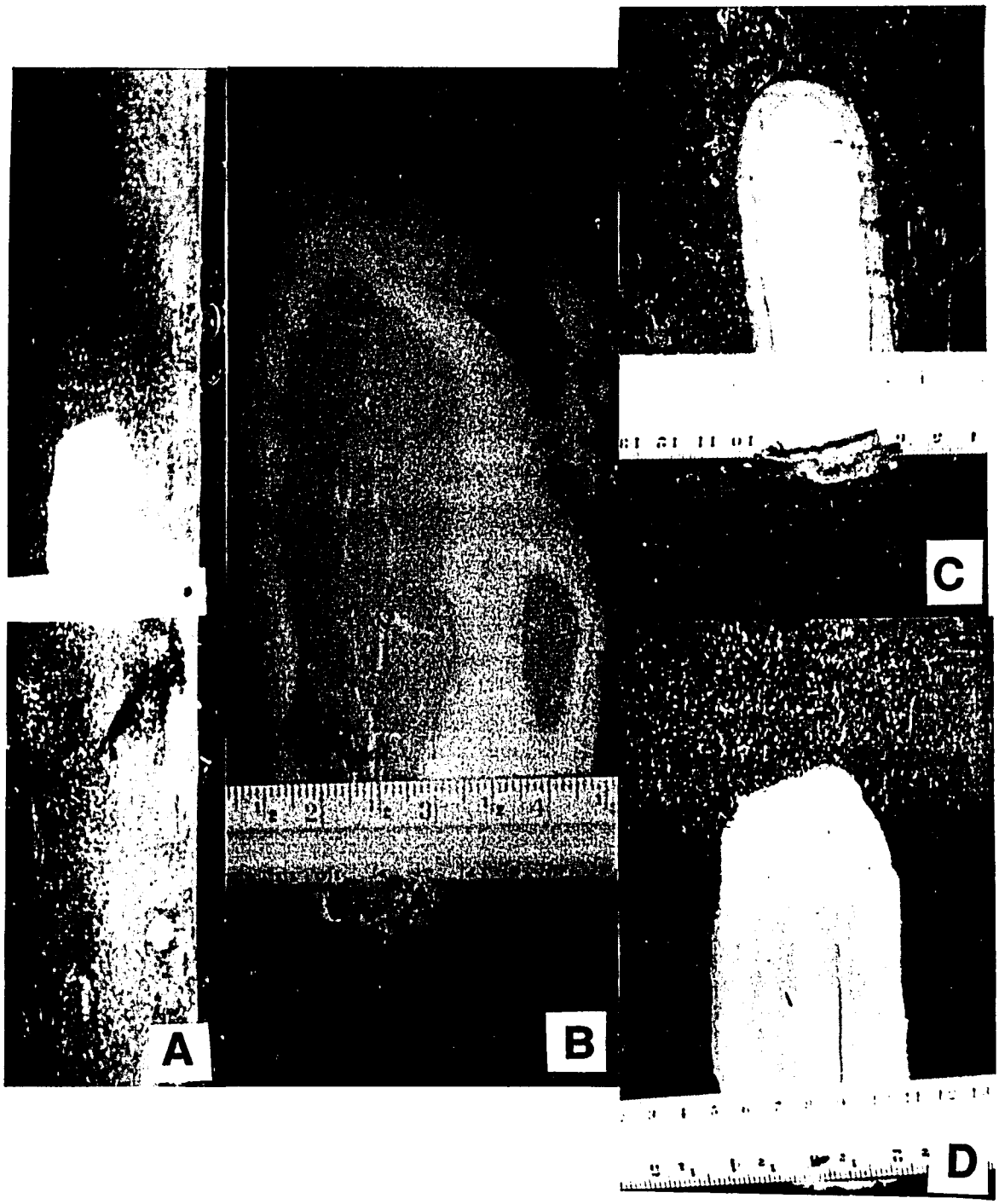
21. Additional remarks----Deciduous shrub or small tree with low branching and green, glabrous twigs. Leaves fleshy and quite leathery.

PLATE 91

Strombosia glaucescens (Olacaceae)

A----Bole.

B, C, & D----Bark and slash.


A
B
C
D

Family	Species	Vernacular name
Olacaceae	*Strombosia glaucescens*	afena

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Obtuse.

3. Margin----Entire.

4. Glands---Tiny, raised, spots on blade resembling glands. Larger, round glands, 0.2-0.4 mm wide scattered along margin, connected to tertiary or quaternary veins.

5. Leaf size----5-17 x 2.5-8 cm.

6. Petiole----Very slightly winged (blade extension about 0.1-0.2 mm thick), 0.7-2 cm long. Characteristic curved channel on adaxial side as continuation of midrib channel.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched. Fluted, with vertical ridges.

10. Secondary veins

a. Angle of divergence----Acute moderate; varies irregularly.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by sec, tertiary, and quaternary arches.

d.Inter-secondary vein----Composite.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Forked, convex, many recurved.

ii. Relation to midvein----Majority right angle, some oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins random; rest of

higher order veins obscure.

13. Marginal ultimate venation---Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Brittle, very hard. Outside smooth and slippery. Thin hoop marks. Scattered lenticels, some aligned horizontally. Old bark gives circular flakes, leaving round patches.

b. Color----Gray-brown, light brown, dark gray.

16. Slash

a. General color----Cream to light yellow, orange, or brown.

b. Characteristics----Cover of outer bark green. Slash interrupted by light brown rings. Outer bark cream-colored; inner bark cream-colored, light orange, or brown, with white streaks.

c. Exudate----None.

d. Thickness----1-5 mm.

17. Wood----Light yellow, or yellowish-brown, deepening in color in

heartwood. Hard.

18. Height category----h. Up to 25 m.

19. Buttressing----Often fluted at base; sometimes with small buttresses.

20. Bole----Round, straight, sometimes flattened near base.

21. Additional remarks----Very common medium-sized tree, with twigs slightly ridged. Leaves often with tiny, raised spots (pustulate), shiny when dry.

PLATE 92

Strombosia grandifolia (Olacaceae)

Bole.



Family	Species	Vernacular name
Olacaceae	*Strombosia grandifolia*	

---

1. Organization

a. Leaf type----Compound, odd pinnate.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate to attenuate.

b. Base----Cuneate to acute.

3. Margin----Entire. **4. Glands**----Absent.

5. Blade size----7-30 x 3-16 cm.

6. a. Petiolule----Normal, with vertical ridges.

b. Rachis----Presence of tiny, scattered, dark brown bumps.

Sometimes has few spine-like projections.

7. Hairs

a. Abaxial surface----Glabrous. Occasional, few, spine-like projections at base of blade. Shiny under microscope.

b. Adaxial surface----Glabrous. Shiny under microscope.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by tertiary arches.

d. Inter-secondary vein----Simple.

e. Number----4-8 pairs.

11. Tertiary veins

Pattern----Randon reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Brittle. Outside smooth. Eyemarks and few hoop marks.

b. Color----Dark gray.

16. Slash

a. General color----Creamy-yellow with red center.

b. Characteristics----Outer bark light yellow with one or two faint, brown rings; inner bark cream-colored. Sapwood red.

c. Exudate----None.

d. Thickness----About 2 mm.

17. Wood----Yellowish to red. Moderately hard.

18. Height category----h. Up to 13 m.

19. Buttressing----Absent.

20. Bole----Short, round, straight, sometimes crooked near crown.

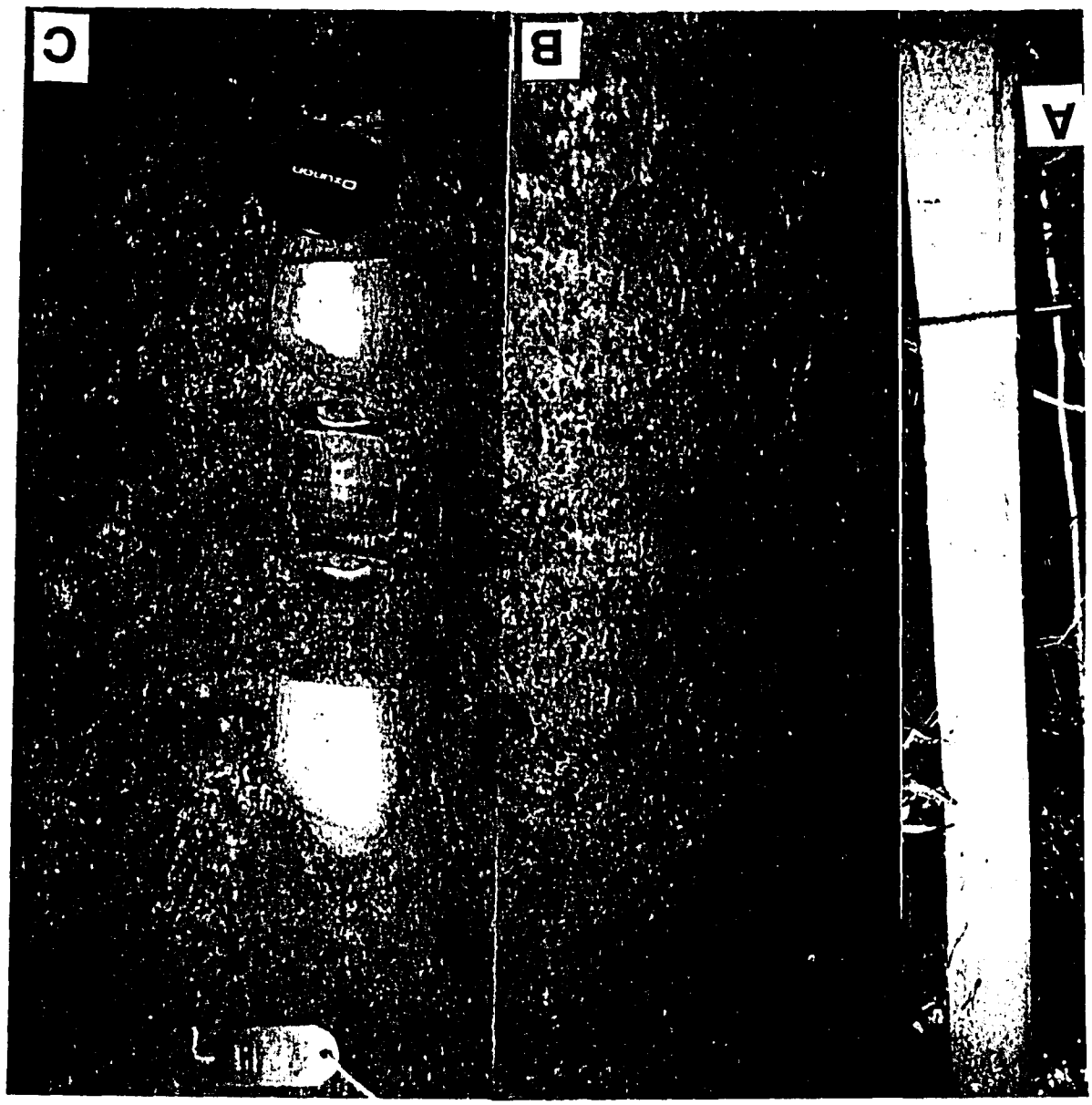
21. Additional remarks----Understorey tree with wide, spreading crown of dense, shining foliage. Previously unreported in Ghana.

PLATE 93

Strombosia zenkeri (Olacaceae)

A----Bole and buttresses. B----Bark.

C----Slash (above--after 15 seconds; below--after one minute).


C
B
A

Family	Species	Vernacular name
Olacaceae	*Stronbosia zenkeri*	

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate to decurrent.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----5-15 x 1.5-5.5 cm.

6. Petiole----Normal, up to 1.3 cm long. Flakes when dry.

7. Hairs

a. Abaxial surface----Glabrous. Shiny under microscope.

b. Adaxial surface----Glabrous. Shiny under microscope.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform,

lowest 2 pairs more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Majority right angled, few obtuse or acute.

d. Inter-secondary vein----Simple.

e. Number----5-7 pairs.

11. Tertiary veins

Pattern----Random to orthogonal reticulate.

12. Higher order venation-----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Brittle. Scattered lenticels, some in vertical rows. Some hoop marks and a few eyemarks. Smooth.

b. Color----Brown.

16. Slash

a. General color----Light brown.

b. Characteristics----Slash turns dark brown after 30 mins.

Odor that is nauseating.

c. Exudate----None. **d. Thickness**----1.5-2.5 mm.

17. Wood----Light yellow, moderately hard.

18. Height category----h. Up to 13 m.

19. Buttressing----Usually slightly fluted at base.

20. Bole----Straight, round, sometimes polygonal in shape up to 1/3 distance from base.

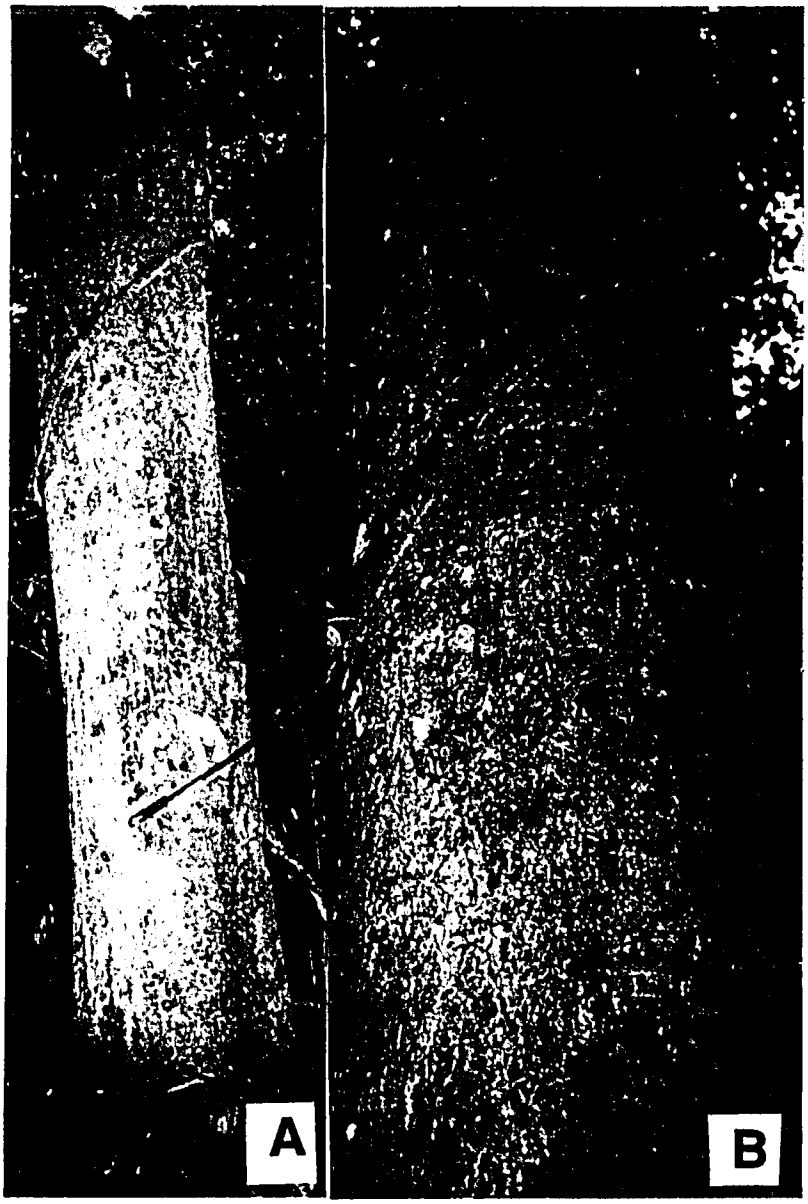
21. Additional remarks----Twigs subterete and slightly ridged.

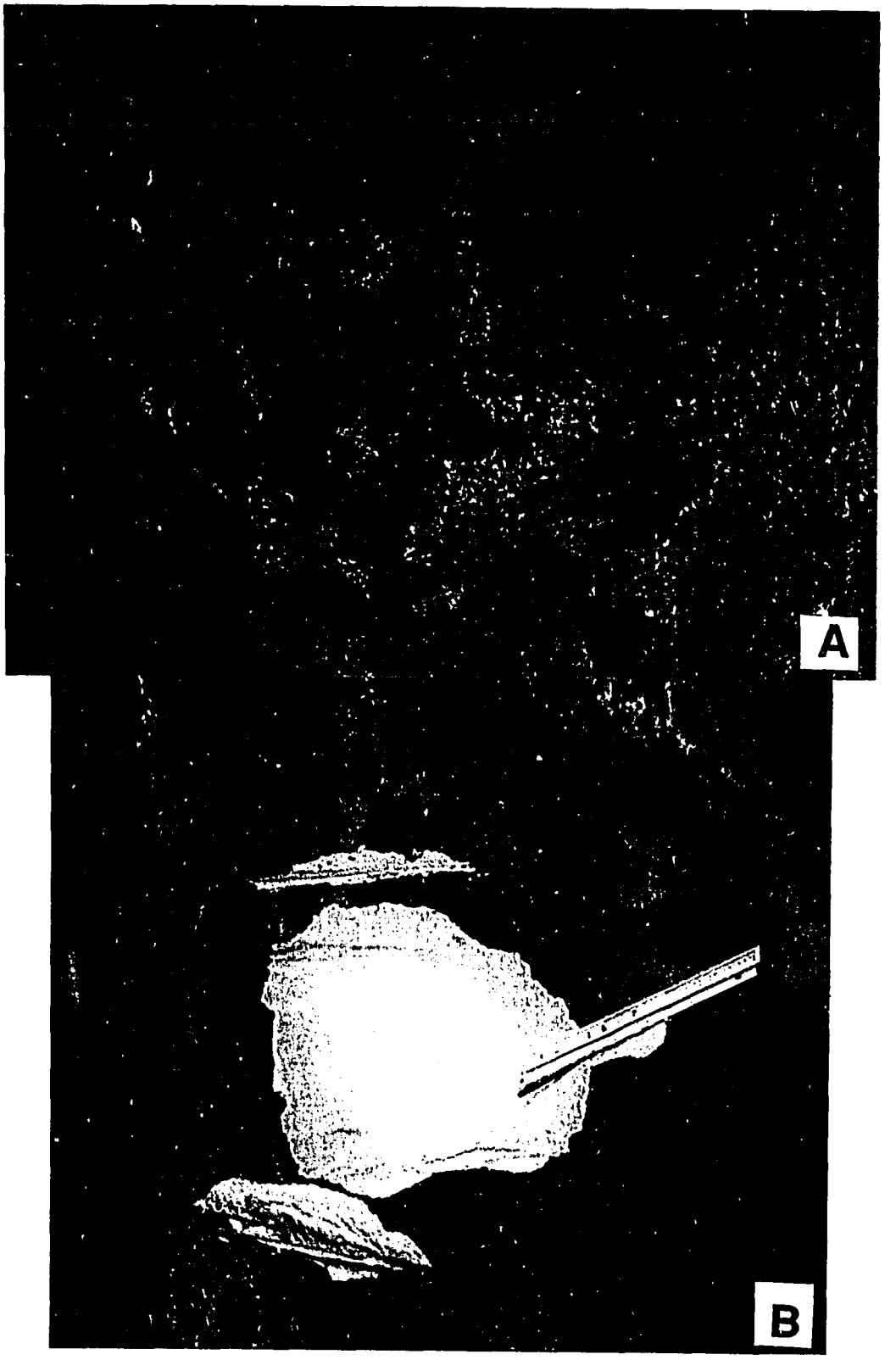
Venation obscure.

PLATES 94 & 95

Ongokea gore (Olacaceae)

94A & B----Bole. 95A----Bark. 95B----Slash.


A
B


A
B

Family	Species	Vernacular name
Olacaceae	*Ongokea gore*	bodwe

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Widely elliptic. **b. Apex**----Acuminate.

c. Base----Acute.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----4-11 x 2.5-4 cm .

6. Petiole----Normal, tiny, rugose under microscope.

7. Hairs

a. Abaxial surface----Glabrous. With tiny bumps under microscope.

b. Adaxial surface----Glabrous. With tiny bumps under microscope.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Lacking.

15. Bark

a. Texture, & features----Brittle and thick. Easily separates from wood. Outside slightly rough. Hoop marks and some eyemarks. Prominent, round, scattered lenticels, some in vertical rows. Characteristic, several, vertical and horizontal splits that give tiny segments, resembling holes on face of victim of chicken pox. Some areas flake when old. Feels

meaty or corky.

b. Color----Gray-brown, or gray.

16. Slash

a. General color----Brownish-yellow, yellowish-orange, or orange.

b. Characteristics----Cover of outer bark sometimes dark. Very thick yellowish to brown outer bark; inner bark creamy-orange and thinner. Slash has no color change after 2 days. Strong, pleasant smell.

c. Exudate----Scanty exudate, usually on sapwood, slightly sticky when rubbed, feeling oily after 10 secs.

d. Thickness----2-4 mm.

17. Wood----Light yellow, or orange; very hard.

18. Height category----H. Up to 40 m.

19. Buttressing----Usually without buttresses, but sometimes with small, thick buttresses. Often fluted at base, resembling foot of elephant.

20. Bole----Straight, very cylindrical. Sometimes slightly crooked.

21. Additional remarks----Glabrous forest tree with young twigs flattened. Adaxial side of leaf usually very dark brown to black when dry. Veins look dark in dry leaf. New leaves are dark when dry. Primary vein usually extends beyond apex of blade, for up to 0.2 mm. Callus heals very poorly; sometimes no callus at all after 6 months.

PAPILIONACEAE

Trees, shrubs, climbers, or herbs. Leaves simple, or compound, often imparipinnate or 3-foliate, usually stipulate; leaflets sometimes stipellate.

A large, homogenous, easily recognized family of 80 genera and 495 species in West Africa. There are three genera and seven species in the Bobiri forest reserve.

Family	Species	Vernacular name
Papilionaceae	*Baphia nitida*	odwen

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to narrowly elliptic.

b. Apex----Acuminate.

c. Base----Obtuse.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----8-12 x 3.5-5 cm.

6. Petiole----Normal. Characteristic apical, and basal horizontal wrinkles that make the two ends dark colored, leaving a narrower, smoother, light greenish-brown, middle portion. 13-25 mm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Lax, brown hairs, especially on primary vein; also on wrinkled ends of petiole and buds.

ii. **Density**----Sparse on leaf; abundant on buds.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by tertiary arches.

d. **Inter-secondary vein**----Absent.

11. **Tertiary veins**

Pattern----Random reticulate.

12. **Higher order venation**----Obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**----Incomplete.

15. **Bark**

a. **Texture, & features**----Fibrous, pliable. Outside smooth. Conspicuous, scattered lenticels, often in vertical rows.

Shallow, vertical markings.

b. Color----Gray, gray-brown, or gray with whitish tint.

16. Slash

a. General color----Creamy-yellow, brownish-orange, orange, or cream-colored.

b. Characteristics----Cover of outer bark green, followed by deep yellow thin layer. Outer bark slightly brittle; inner bark spongy and pliable. Very strong, pleasant odor. Slash shiny.

c. Exudate----None. **d. Thickness**----1-2 mm.

17. Wood----Brownish-orange to light yellow, very hard.

18. Height category----hh. Up to 10 m.

19. Buttressing----Absent. **20. Bole**----Crooked, round.

21. Additional remarks----Small tree, or shrub, often planted as a dye-wood ("camwood"). Widely used in West Africa for several domestic utilities (pestles, laddles, toys, fencing, chewing stick, fodder crop, medicine etc.). Few, erect, brown hairs on young, slender twigs. Abaxial side of leaf lighter green in color. Venation appears whitish on dark green background.

PLATE 96

Baphia pubescens (Papilionaceae)

A----Bole. B----Bark. C----Slash.


A
B
C

Family	Species	Vernacular name
Papilionaceae	*Baphia pubescens*	odwinkobere

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to narrowly elliptic.

b. Apex----Acuminate. **c. Base**----Acute to obtuse.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----4-12 x 2-5 cm.

6. Petiole----Normal, small, rugose under microscope, slightly fluted towards apex.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Light brown hairs, mostly curled, some appressed or flexuous, on all veins, intercostal areas, petiole, and buds.

ii. Density----Sparse; a little dense on primary and sec

veins. Copious on new apical leaves.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute wide, nearly uniform, lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by tertiary arches.

d. Inter-secondary vein----Simple.

e. Number----8-9 pairs.

11. Tertiary veins

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Fibrous. Outside smooth. Prominent eyemarks, and grouped hoop marks.

b. Color----Gray.

16. Slash

a. General color----Cream-colored to light yellow, pale brown, or orange-red.

b. Characteristics----Slash has dark lines. Cover of outer bark light purple or orange-brown. Outer bark brittle, yellow-brown. Inner bark fibrous and pliable, yellow-brown or orange-red with pinkish tint. Moderate to faint, pleasant smell. Sapwood slippery.

c. Exudate----Very scanty, non-sticky exudate.

d. Thickness----2.5-5 mm.

17. Wood----Creamy-light yellow, hard.

18. Height category----hh. Up to 7 m.

19. Buttressing----Slightly fluted at base.

20. Bole----Crooked, cylindrical.

21. Additional remarks----A shrub, or small tree, with brown-tomentose twigs. Stipular bracts, 3-5 mm long, early caducuous. Slash heals poorly.

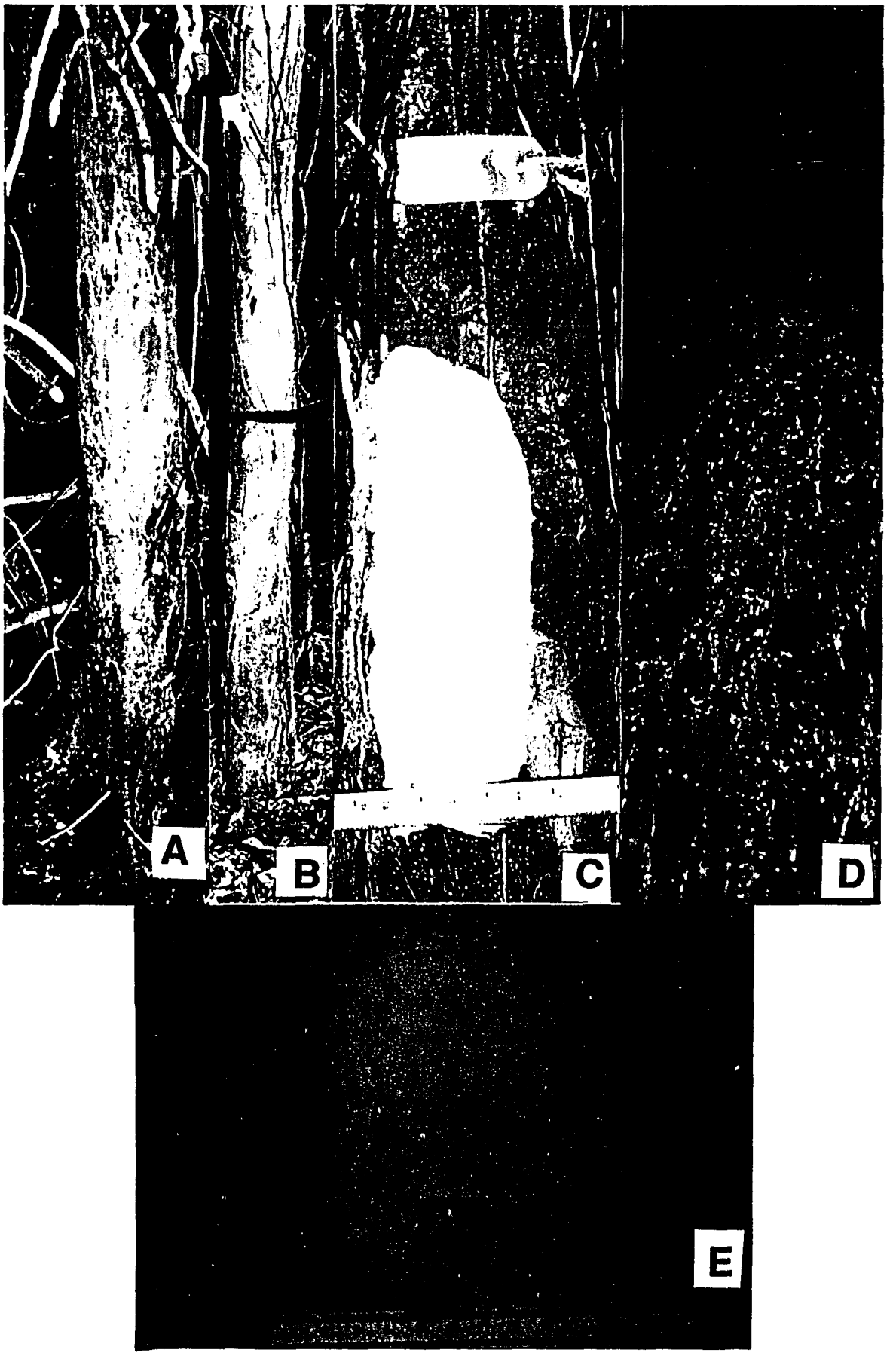
PLATE 97

Dalbergiella welwitschii (Papilionaceae)

A & B----Bole and incipient buttresses.

C & E----Slash.

D----Bark.


A
B
C
D
E

Family	Species	Vernacular name
Papilionaceae	*Dalbergiella welwitscihi*	

---

1. Organization

a. Leaf type----Compound, odd pinnate, 8-13 pairs

b. Phyllotaxy----Alternate. Leaflets opposite or subopposite.

2. Shape

a. Form----Narrowly oblong **b. Apex**----Obtuse to acute.

c. Base----Rounded. Apical leaflet cuneate.

3. Margin----Entire, sometimes slightly crenate.

4. Glands----Absent. **5. Blade size**----3-7 x 1.5-3.0 cm.

6. a. Petiolule----Normal, very short and tiny.

b. Rachis----Thin, long, up to 35 cm long. Base slightly fluted.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed and erect mixture of brown and white hairs, 0.1-0.2 mm long, on veins and intercostal areas; most pronounced on primary

vein and buds. Longer, brown hairs, up to 0.4 mm long, at base of primary vein, and petiolule; similar hairs on rachis but shorter.

ii. Density----Quite abundant generally; copious on petiolule.

b. Adaxial surface----Few scattered hairs on veins. Intramarginal vein with carpet of hairs. **Circumpubescent.**

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abriptly, unbranched.

c. Loop-forming branches----Acute to right angle, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal; rest of

higher order veins obscure.

13. Marginal ultimate venation----Looped, with a fimbrial vein.

14. Areoles

a. Development----Well developed.

b. Shape----Pentagonal and polygonal.

15. Bark

a. Texture, & features----Brittle, hard. Outside smooth; slightly rough near base of trunk. Eyemarks and few hoop marks, or vice versa. Many, tiny lenticels appearing as white dots on gray background, in vertical rows; few scattered. Slightly shiny.

b. Color----Gray, or gray-brown.

16. Slash

a. General color----Orange purple, or cream-colored.

b. Characteristics----Slightly deeper purple tint develops after 30 secs. Cover of outer bark green. First layer of outer bark orange-yellow, followed by creamy-orange layer, both brittle. Inner bark pliable, cream-colored, or light yellow,

with brownish-purple rings and streaks. Pleasant, moderate smell. Sapwood slippery.

c. Exudate----Scanty, clear, non-sticky exudate on sapwood.

d. Thickness----0.5-3 mm.

17. Wood----Yellowish or cream-colored, very hard.

18. Height category----h. Up to 25 m.

19. Buttressing----Very small buttresses.

20. Bole----Round, crooked.

21. Additional remarks----A climbing shrub, or small tree, often in riverine forest. Young twigs with short, erect, scattered hairs. Slash heals poorly.

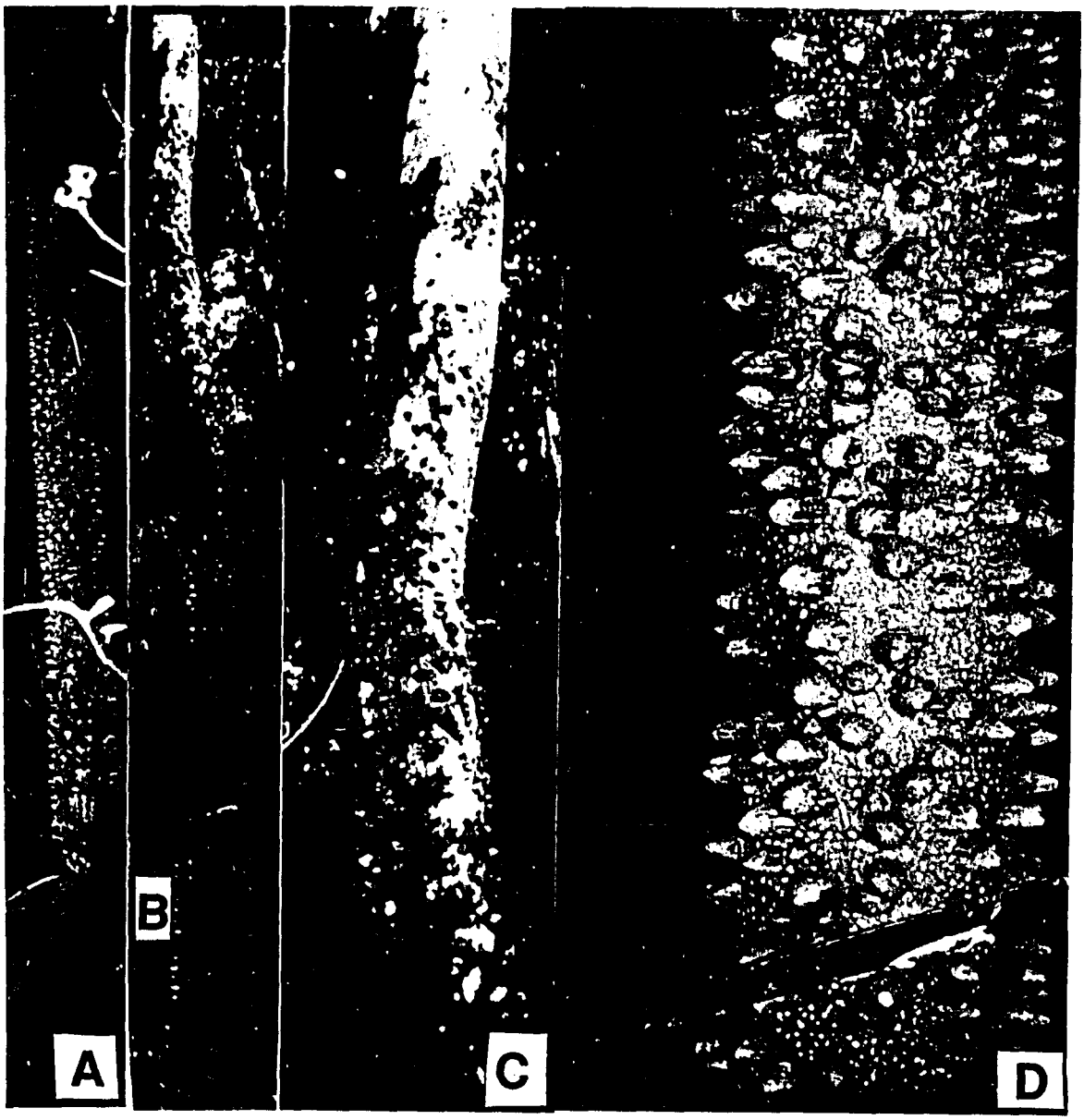
PLATES 98 & 99

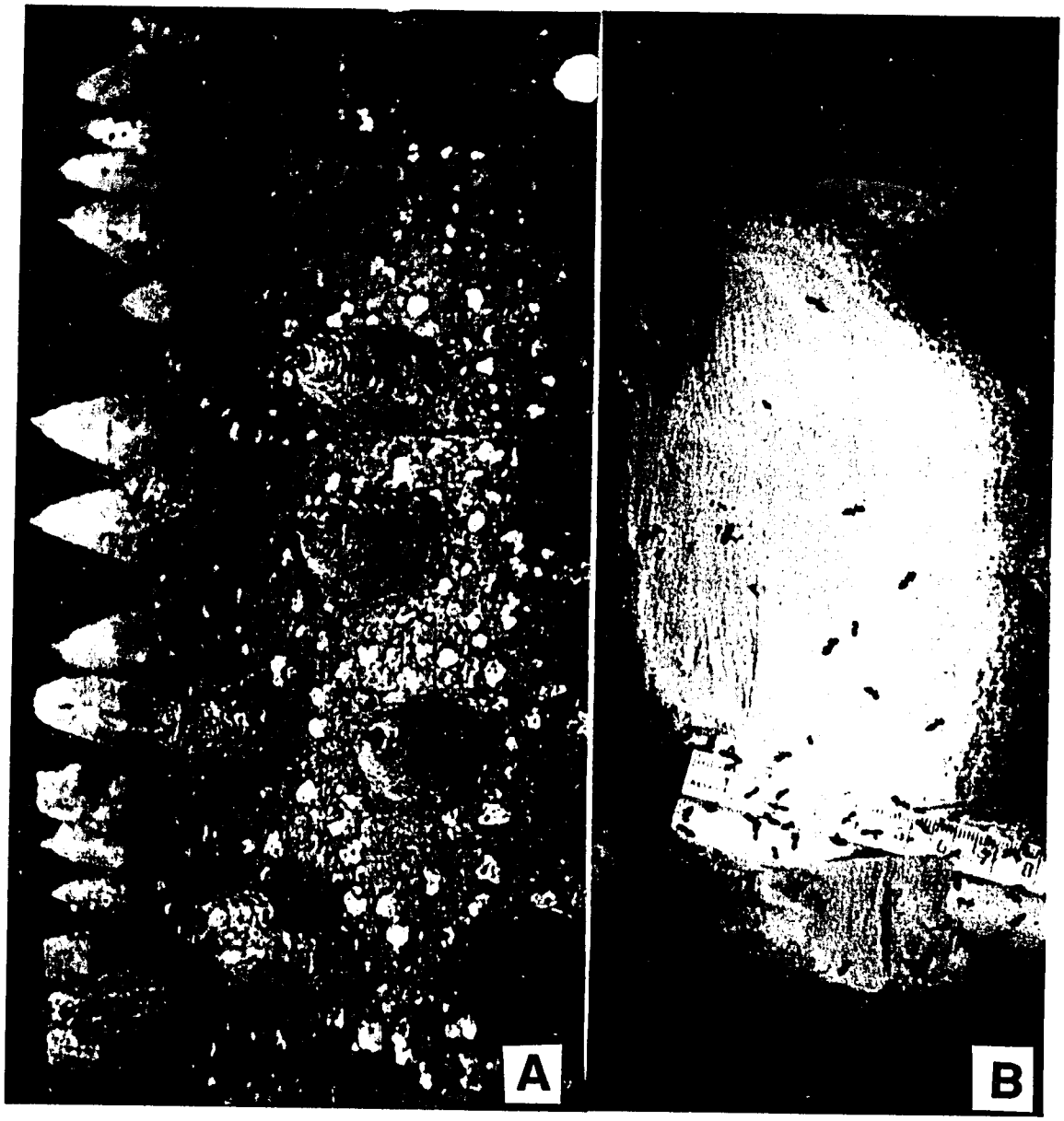
Erythrina senegalensis (Papilionaceae)

98A-D---Bole.

99A----Bark and spines.

99B----Slash.


A
B
C
D


A
B

Family	Species	Vernacular name
Papilionaceae	*Erythrina senegalensis*	osorowa

---

1. Organization

a. Leaf type----Compound, odd pinnate.

b. Phyllotaxy----Sub-opposite to alternate.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----One side obtuse, other side decurrent.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaflet size----7-25 x 4-10 cm.

6. a. Petiole----Normal, short, rugose with vertical ridges, slightly **fluted.** About 2 mm in diameter, thorny.

b. Rachis----Long, very smooth but has small, scattered, very sharp prickles with dark tips.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Very tiny, erect hairs on

primary vein at 15x (seen as dots at 10x). Very sharp spines, 1-4 in number, on lower portion of primary vein and petiole. Rest of blade glabrous.

ii. **Density**----Sparse.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to slightly markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute, enclosed by tertiary arches.

d. **Inter-secondary vein**----Simple.

11. **Tertiary veins**

Pattern----Random reticulate

12. **Higher order venation**----Obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**----Incomplete.

15. Bark

a. Texture, & features----Brittle to spongy. Sharp, woody, conical, scattered spines, 3-4 x 2-5 cm, very few nearer crown where length is reduced to 1 cm. Large, round, scattered lenticels.

b. Color----Brownish-gray.

16. Slash

a. General color----Brownish to creamy-brown.

b. Characteristics----Cover of outer bark brown with greenish tint. Outer bark brittle, brown, thicker; inner bark cream-colored, spongy, with very large pores. No color change, same color overnight. Strong, pleasant, distinguishing smell resembling odor of green beans.

c. Exudate----None.

d. Thickness----About 2 mm.

17. Wood----Yellowish, hard

18. Height category----hh to h. Usually up to 5 m, but can de up to 16 m.

19. **Buttressing----**Small buttresses.

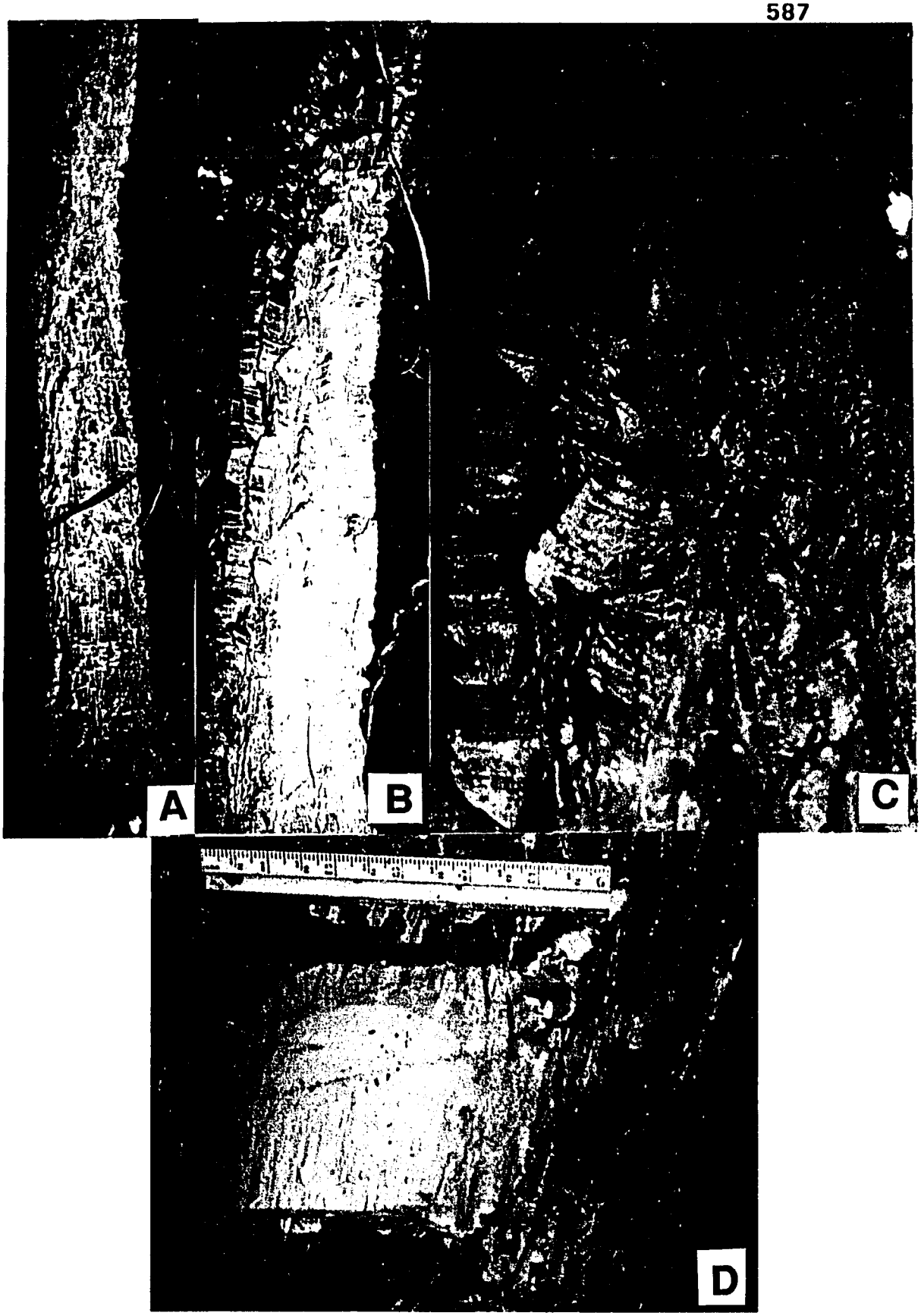
20. **Bole----**Cylindrical, straight.

21. **Additional remarks----**Usually small tree; can be medium-sized, armed with stout prickles slightly recurved from a woody base. Young twigs have sharp, scattered spines. More common in savannah. Slash heals poorly, with very small callus formation.

PLATE 100

Erythrina vogelii (Papilionaceae)

A & B----Bole. C----Bark and spines. D----Slash.


A
B
C
D

Family	Species	Vernacular name
Papilionaceae	*Erythrina vogelii*	osore

---

1. Organization

a. Leaf type----Compound, pinnately trifoliate.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Narrowly ovate; terminal leaflet elliptic.

b. Apex----Acuminate.

c. Base----One side rounded or obtuse, other side cuneate.

Terminal leaflet decurrent.

3. Margin----Entire.

4. Glands----Absent.

5. Leaflet size----9-17 x 5-9.5.

6.a. Petiole----Normal; has several vertical ridges, sometimes not

rounded but rectangular shaped, often thorny.

b. Rachis----Long, grooved, glabrous but sometimes thorny.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform, lowest pair acute narrow.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Lower veins acute; right angle from middle to leaf apex. Enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Simple.

11. Tertiary veins

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a fimbrial vein.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Fibrous. Has very sharp, woody, conical spines, jammed into ridges in vertical rows resembling tail of crocodile. Old spines of bark closer to base of trunk quite blunt, and more separated. Shallow, wide, vertical striations. Scattered lenticels, some in vertical rows. Spaces between spines smooth.

b. Color----Brown with gray tint.

16. Slash

a. General color----Orange to yellowish.

b. Characteristics----Cover of outer bark orange-yellow with green and brown streaks. Outer layer of spines purplish-brown; inner layer of spines orange yellow. Vertical, brown streaks in outer bark. Bark firmly attached to wood. Very strong, pungent, disagreeable odor.

c. Exudate----Scanty, clear, non-sticky exudate.

d. Thickness----1.5-2 mm.

17. Wood----Creamy-yellow or orange-creamy, hard (slightly soft when young).

18. Height category----hh to h. 7-16 m.

19. Buttressing----Small buttresses. Sometimes only fluted at base, or absence of both features.

20. Bole----Round, usually crooked, sometimes straight.

21. Additional remarks----Small tree of mature or secondary forest. Abaxial side of dry leaflet paler green; adaxial side darker green and shiny. Blade thin and papery. Quaternary veins look dark under microscope, compared to light brown primary, sec, and tertiary veins.

RUBIACEAE

Trees or shrubs, rarely herbs; herbaceous representatives largely in temperate regions. Slash varies from fibrous to gritty. Leaves opposite, rarely verticillate, entire, simple; stipules inter- or intra-petiolar, often connate, rarely leafy, not distinguishable from leaves. Commonly known as the 'coffee family'. Most species are small understorey trees with structure resembling coffee plants.

A family of 91 genera and 583 species in West Africa. There are four genera and six species in the Bobiri forest reserve.

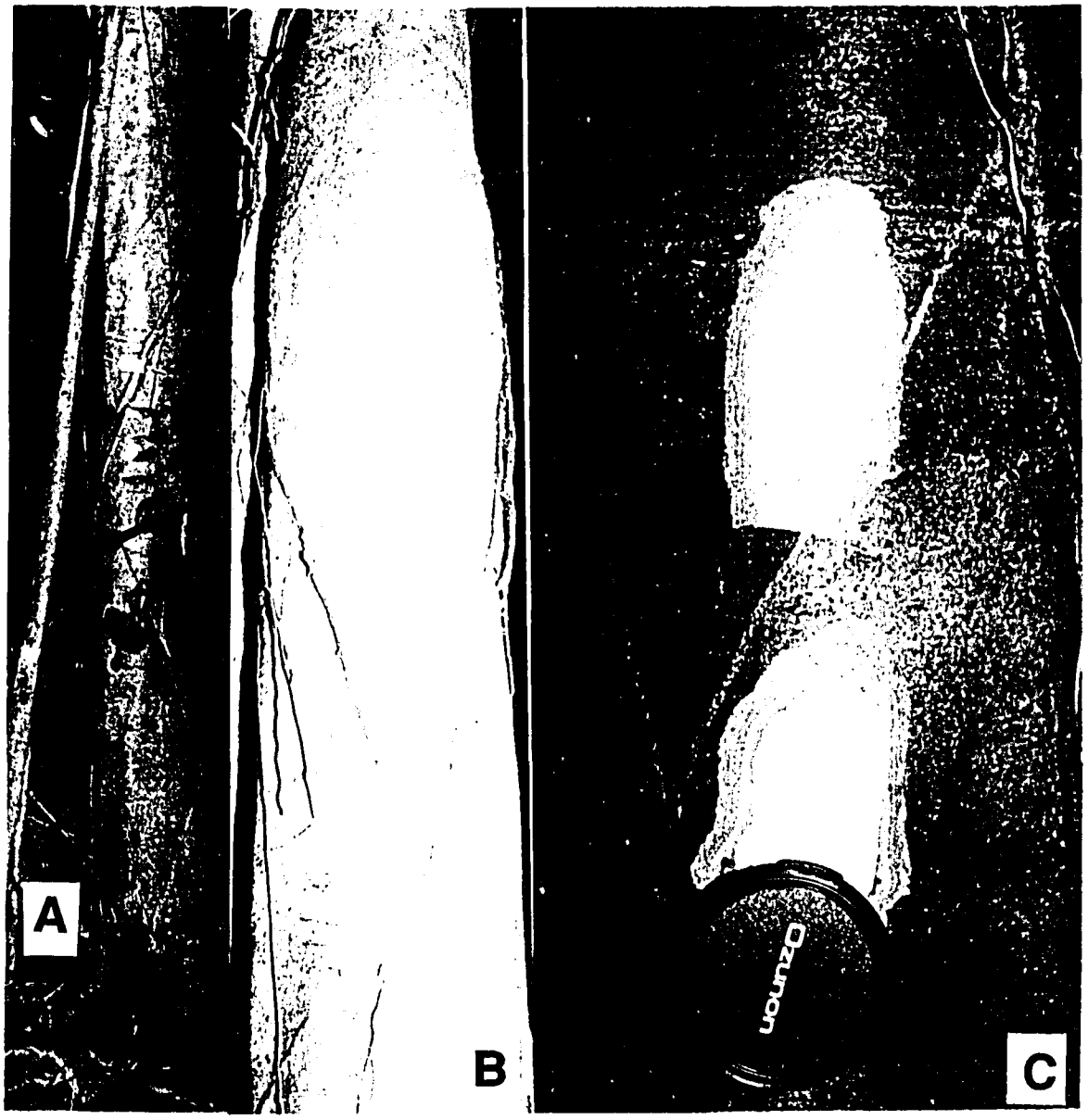
PLATE 101

Aulacocalyx jasminiflora (Rubiaceae)

A----Bole and incipient buttresses.

B----Bole and bark.

C----Bark and slash.


A
B
C
OZUNOA

Family	Species	Vernacular name
Rubiaceae	*Aulacocalyx jasminiflora*	ntweson

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire to slightly crenate.

4. Glands----Absent. **5. Leaf size**----6.5-16 x 2.2-9 cm.

6. Petiole----Normal, thin, has vertical ridges, rugose under microscope, blade extends on it very slightly.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, white hairs, 0.2-0.3 mm long, especially on primary vein; on petiole too.

ii. Density----Sparse on leaf; very scanty on petiole; more on juvenile than adult leaves.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform, lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute.

d. Inter-secondary vein----Composite.

e. Number----2-6 pairs.

11. Tertiary veins

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Brittle. Outside smooth.

b. Color----Gray-brown.

16. Slash

a. General color----Creamy-orange.

b. Characteristics----Presence of yellow streaks. Outer bark orange; inner bark creamy-yellow or orange-cream. Slash tastes bitter. Strong, pleasant odor.

c. Exudate----None.

d. Thickness----2-3 mm.

17. Wood----Creamy-orange, hard.

18. Height category----h. Up to 15 m.

19. Buttressing----Small buttresses, or fluted at base.

20. Bole----Crooked, fluted.

21. Additional remarks----Understorey tree. Young stems have copious brownish-orange hairs. Apical twigs slender. Leaves often arranged in groups of threes at some nodes. Stipules free. Juvenile leaves often dark when dry.

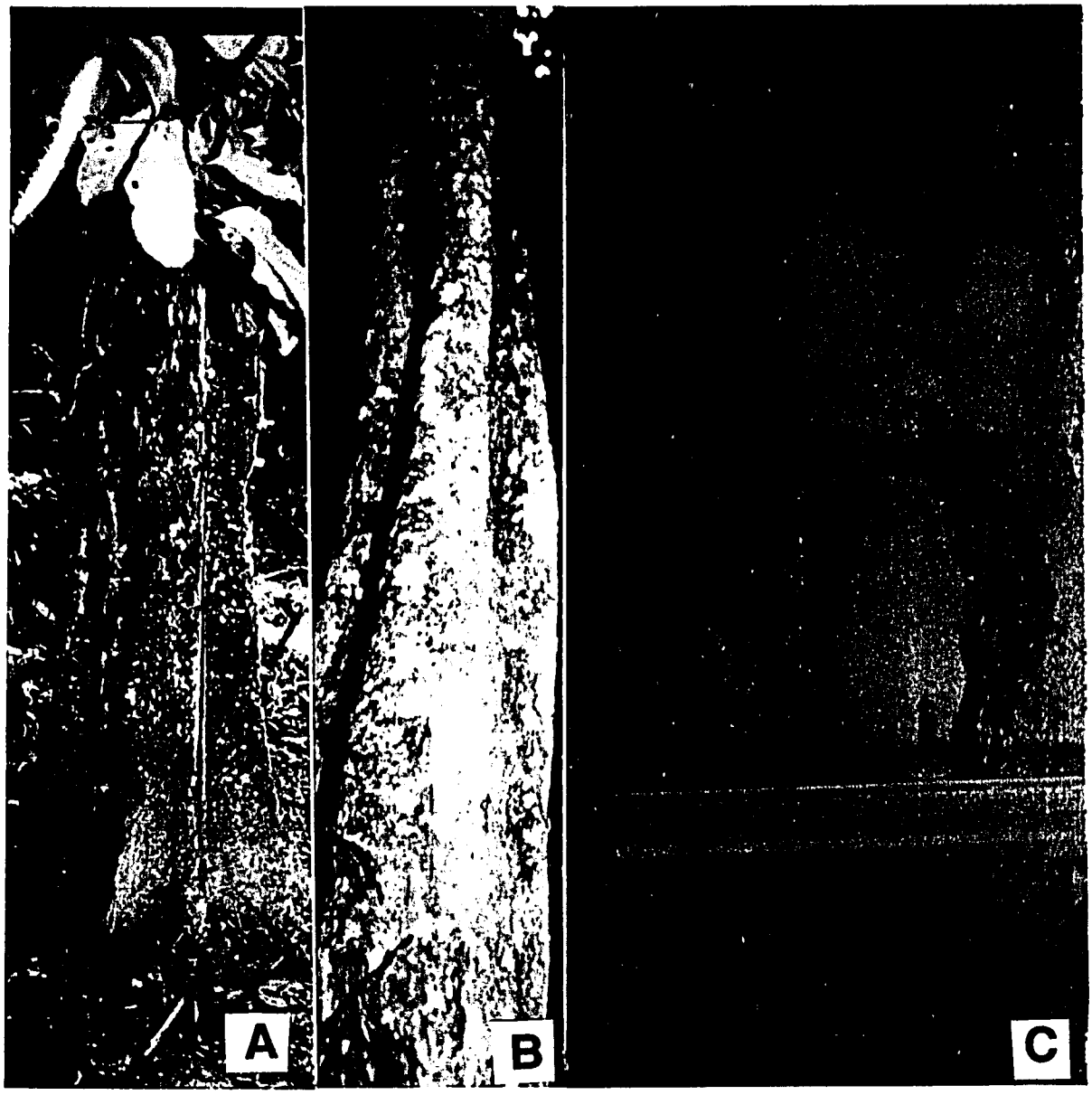
PLATE 102

Corynanthe pachyceras (Rubiaceae)

A---Bole and buttresses.

B----Bole.

C----Bark and slash.


A
B
C

Family	Species	Vernacular name
Rubiaceae	*Corynanthe pachyceras*	pamprama

---

1. Organization

a. Leaf type----Simple **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Decurrent.

3. Margin----Entire to slightly crenate. **4. Glands**----Absent.

5. Leaf size----14-26.5 x 4-10 cm.

6. Petiole----Normal, with slight extension of blade along channel on adaxial side. Has shallow, vertical ridges. Up to 5 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Very tiny, erect hairs at 20x, about 0.5 mm long, observed only as dots at 10x. Mainly on primary vein and some secondaries. Another type of appressed hairs, 0.15 mm long on primary vein. Rest of

blade glabrous.

ii. Density----Scattered.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform, lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by tertiary arches.

d. Inter-secondary vein----Simple.

e. Number----6-12 pairs.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Majority forked. Few retroflexed, straight, sinuous, or recurved.

ii. Relation to midvein----Oblique.

iii. **Arrangement**---Predominantly alternate.

12. **Higher order venation**----Obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**----Incomplete.

15. **Bark**

a. **Texture, & features**----Spongy and very pliable. Sometimes slightly brittle. Many, shallow, vertical lines.

b. **Color**----Dark gray.

16. **Slash**

a. **General color**----Yellowish-orange or brown.

b. **Characteristics**----Presence of cream-colored rings.Slash quickly darkens to brown after 30 secs, and deeper brown after 3 mins. Sapwood becomes grayish-brown after 2 mins. Moderate agreeable smell. Slash very bitter.

c. **Exudate**----None.

d. **Thickness**----1.2-4 mm.

17. **Wood**----Yellowish-orange, moderately hard.

18. **Height category**----h. Up to 22 m.

19. Buttressing----Usually fluted at base.

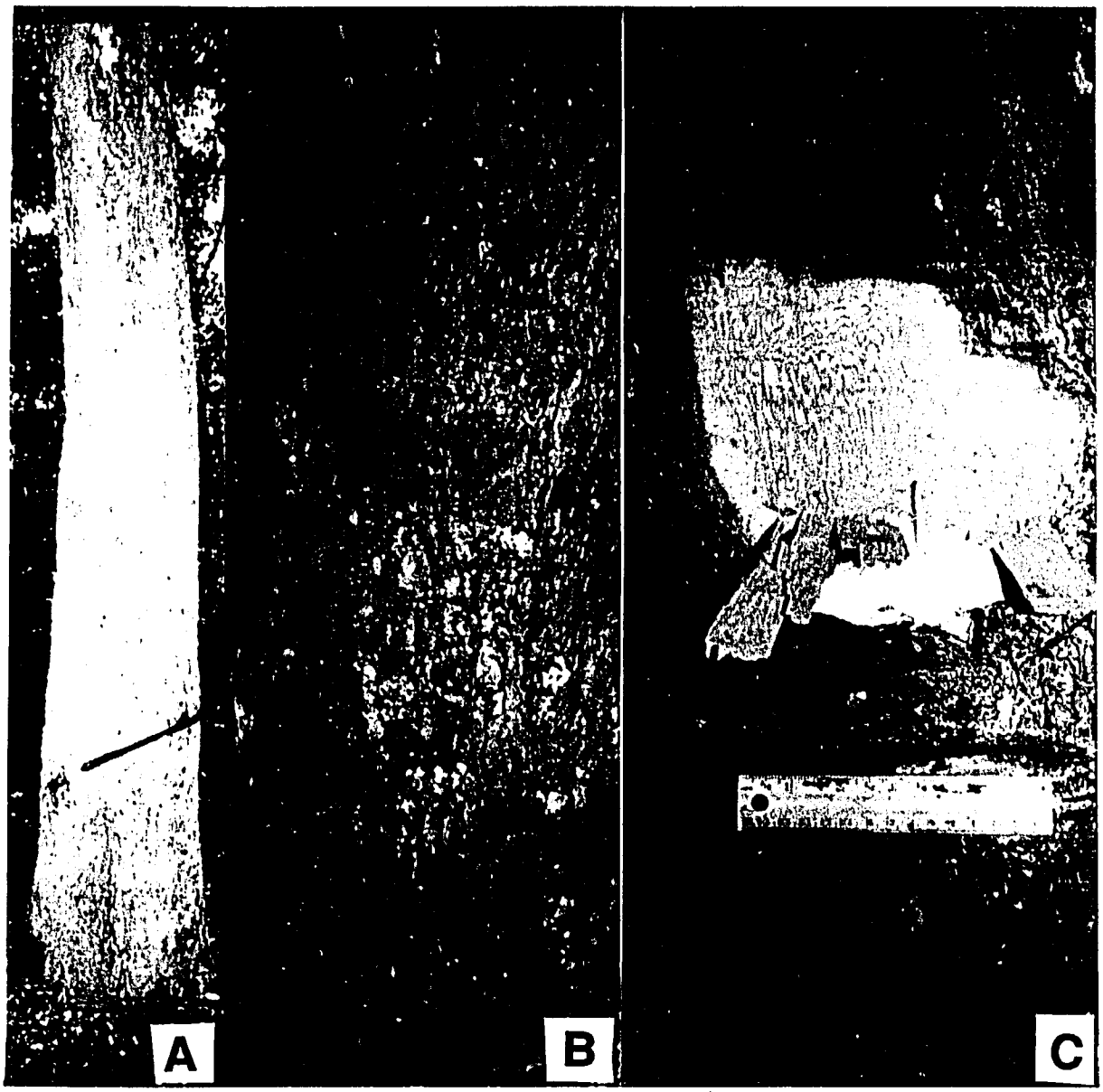
20. Bole----Bent, twisted, deeply fluted. Sometimes flattened near crown.

21. Additional remarks----Understorey tree, up to 2m girth. Twigs usually round and glabrous, with short internodes. Stipules early deciduous, leaving a short ring around nodes. New leaves red.

PLATE 103

Nauclea diderrichii (Rubiaceae)

A----Bole. B----Bark. C----Slash.


A
B
C

Family	Species	Vernacular name
Rubiaceae	*Nauclea diderichii*	kusia

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Elliptic. Some older leaves broadly elliptic.

b. Apex----Acuminate

c. Base----Decurrent to cuneate.

3. Margin----Entire to slightly crenate.

4. Glands----Absent.

5. Leaf size----8-40 x 4-18 cm.

6. Petiole----Normal, slightly flattened dorsoventrally, dark when dry.

7. Hairs

a. Abaxial surface

i. Type, color, & location----White hairs, 0.4-0.6 mm long in domatia at apical side of primary-sec and sec-tertiary

junctions; absent from junctions nearer base. Another type of straight, white, very short hairs, 0.3-0.5 mm long, on primary and sec veins. Short hairs on petiole.

ii. **Density**----Relatively few.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute, enclosed by sec and tertiary arches.

d. **Inter-secondary vein**----Simple.

e. **Number**----5-11.

11. **Tertiary veins**

Pattern----Percurrent.

i. **Course**----Majority forked, many sinuous, some retroflexed, few recurved.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation---Quaternary veins random; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete to lacking.

15. Bark

a. Texture, & features----Brittle to fibrous. Outside very rough; flakes when old. Quite deep, vertical striations.

b. Color----Brown, for both old and young trees.

16. Slash

a. General color----Brownish-yellow, pale orange-yellow, or cream colored.

b. Characteristics----Cover of outer bark yellowish with brown streaks, followed by thin brown layer, then thicker, very brittle outer bark with light brown streaks. Inner bark light creamy-brown, quite pliable. Sapwood very slippery. Strong, repulsive odor, smelled one meter away.

c. Exudate----Brownish-yellow, abundant, watery, non-sticky sap.

d. Thickness----2-2.5 mm.

17. Wood----Deep yellow, very hard.

18. Height category----h to H. 10-40 m.

19. Buttressing----Low buttresses. Sometimes fluted at base.

20. Bole----Round, straight to crooked, clear.

21. Additional remarks----Low branching common. Usually tall. Stipules broadest above the base, elliptic or obovate, often keeled, rounded or obtuse at apex, up to 50 mm long. Used for motars and fencing.

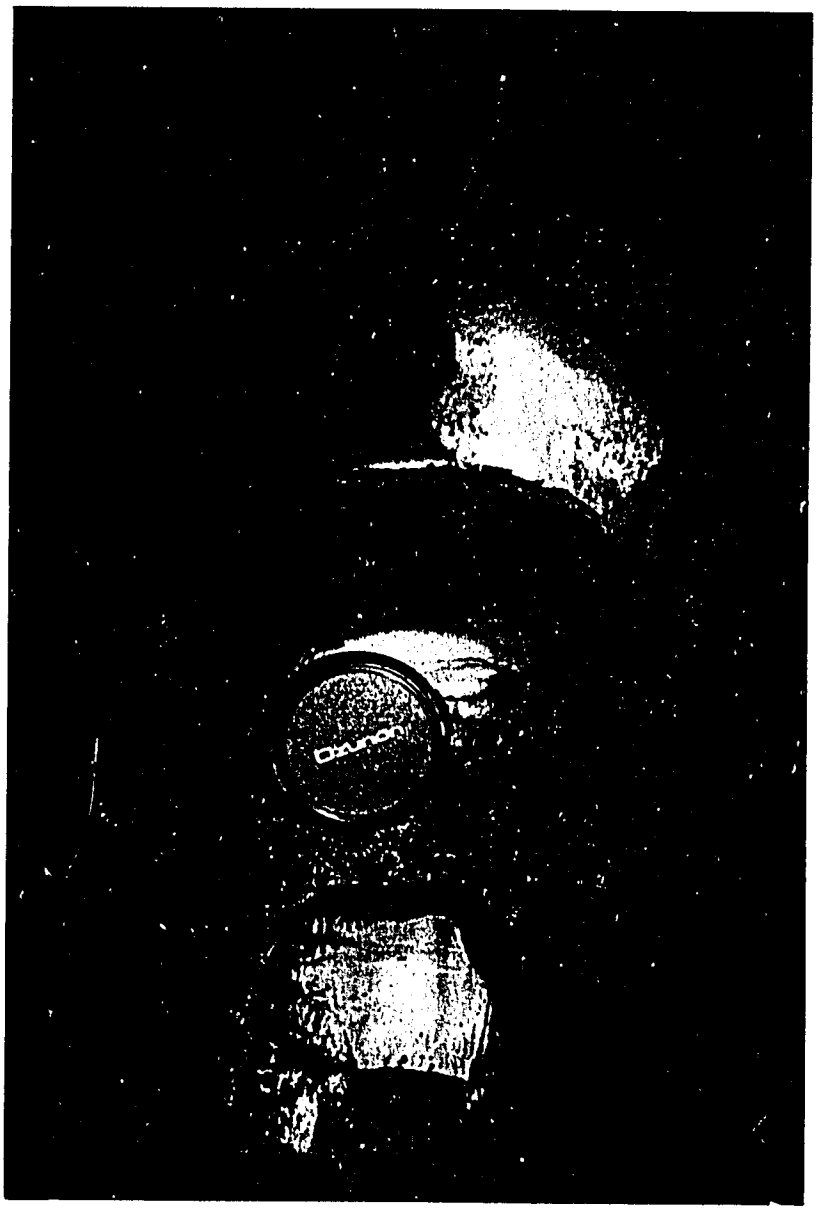
PLATES 104 & 105

Psydrax paviflora (Rubiaceae)

104A & B----Bole .

105----Bark and slash.


A
B


OLYMPUS

Family	Species	Vernacular name
Rubiaceae	*Psydrax parviflora*	ogyapam-nini

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1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Opposite.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cordate to lobate.

3. Margin----Entire. Sometimes slightly crenate.

4. Glands----Absent. **5. Leaf size**----11-16 x 5-8 cm.

6. Petiole----Normal, very straight.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, stiff, light brown hairs mixed with few erect ones and some with curved apices, 0.1-1.3 mm long on whole blade, petiole, and buds.

ii Density----Very dense; so abundant on primary and sec veins, petiole and buds that they are seen carpeting leaf

with unaided eye. Density makes blade rough when finger is moved across breadth of blade.

b. Adaxial surface

i. Type, color, & location----Similar hairs found on abaxial surface, on all veins and intercostal areas.

ii. Density----Abundant but less numerous than abaxial side; most abundant on primary and sec veins.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform. Lowest pair right angle.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Percurrent.

i. **Course**----Mostly forked, some simple, majority convex.

ii. **Relation to midvein**----Oblique.

iii. **Arrangement**----Opposite and alternate in about equal proportions.

12. **Higher order venation**----Quaternary veins orthogonal; rest of higher order veins obscure.

13. **Marginal ultimate venation**----Looped, with a fimbrial vein.

14. **Areoles**----Imperfect.

15. **Bark**

a. **Texture, & features**----Brittle. Outside slightly rough.

b. **Color**----Gray-brown or brown.

16. **Slash**

a. **General color**----Light brown.

b. **Characteristics**----Presence of gray spots. Outer bark very brittle and slightly more brownish than inner bark, with few cream-colored streaks. Inner bark has a lot of cream-colored streaks. Slash becomes dark brown after 15 secs, with very dark, dirty brown ring near surface of outer bark. Often dark

ring between outer and inner bark, with one or two dark streaks. Gray spots turn grrenish. Strong, pleasant, aromatic smell.

c. Exudate----Scanty, oily sap.

d. Thickness----2-2.5 mm.

17. Wood----Light brown to yellowish, very hard.

18. Height category----hh to h; sometimes H. 7-31 m.

19. Buttressing----Usually fluted at base.

20. Bole----Usually crooked except close to base; round. Bumps near base.

21. Additional remarks----Usually a tree but sometimes a shrub, common beside rivers. Stipules caducuous. Abaxial side of leaf deep green; adaxial side dark with greenish tint, shiny.

RUTACEAE

Shrubs or trees, rarely herbs. Leaves simple or compound (usually compound), mostly gland-dotted, stipules absent.

There are nine genera and 33 species in West Africa. There are two genera and three species in the Bobiri forest reserve.

Family	Species	Vernacular name
Rutaceae	*Zanthoxylum gilletii*	okuo

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1. Organization

a. Leaf type----Compound, odd pinnate.

b. Phyllotaxy----Alternate to spiral. Leaflets alternate.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Acute to obtuse, asymmetrical but usually with the two sides of lamina joining at about same level.

3. Margin----Entire to crenate.

4. Glands----Numerous scattered glands on blade and primary vein, seen as bumps on abaxial side, and as brown or white, little depressions on adaxial side usually at blade margin.

5. Blade size----12-25 x 3.5-9 cm.

6.a.Petiolule----Normal, brownish when dry, with shiny wrinkles, slightly **fluted**, glabrous, flattened dorsoventrally, up to 5 mm long.

b. Rachis----Long; 20-100 cm in length.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved, unbranched. Has spines on abaxial side.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b.Course----Curved abruptly, unbranched.

c. Loop-forming branches----Generally acute, few right angle to obtuse. Enclosed by tertiary arches.

d. Inter-secondary vein----Simple.

11. Tertiary veins

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Incomplete.

15. Bark

a. Texture, & features----Brittle to fibrous. Presence of large, woody-based spines similar to those of *Erythrina spp.* Spaces without spines smooth to rough. Scattered lenticels.

b. Color----Gray-brown.

16. Slash

a. General color----Creamy-brown, or orange-brown.

b. Characteristics----Outer bark brownish or orange; inner bark cream colored. Taste is like fruit that is slightly acidic, rapidly becoming hot in the mouth, leaving a refreshing,

pleasant, peppermint aftertaste. Strong, pleasant smell. Slash darkens after 10 mins.

c. Exudate----None. **d. Thickness**----About 3 mm.

17. Wood----Creamy-orange, hard.

18. Height category----h. Usually up to 13 m. Can be up to 35 m.

19. Buttressing----Small buttresses.

20. Bole----Round, crooked.

21. Additional remarks----Evergreen tree common in secondary forest, with very large leaves clustered at ends of branches. Crown resembles that of *Entandrophragma spp.*. Young, slender twigs brownish with white streaks and spines up to 3 mm long. Hutchinson and Dalziel (1954-72) mention that there seem to be several infraspecific variants; intensive and extensive field research needed to sort them out.

SAPINDACEAE

Trees, shrubs, or climbers. Leaves alternate or rarely opposite, simple,

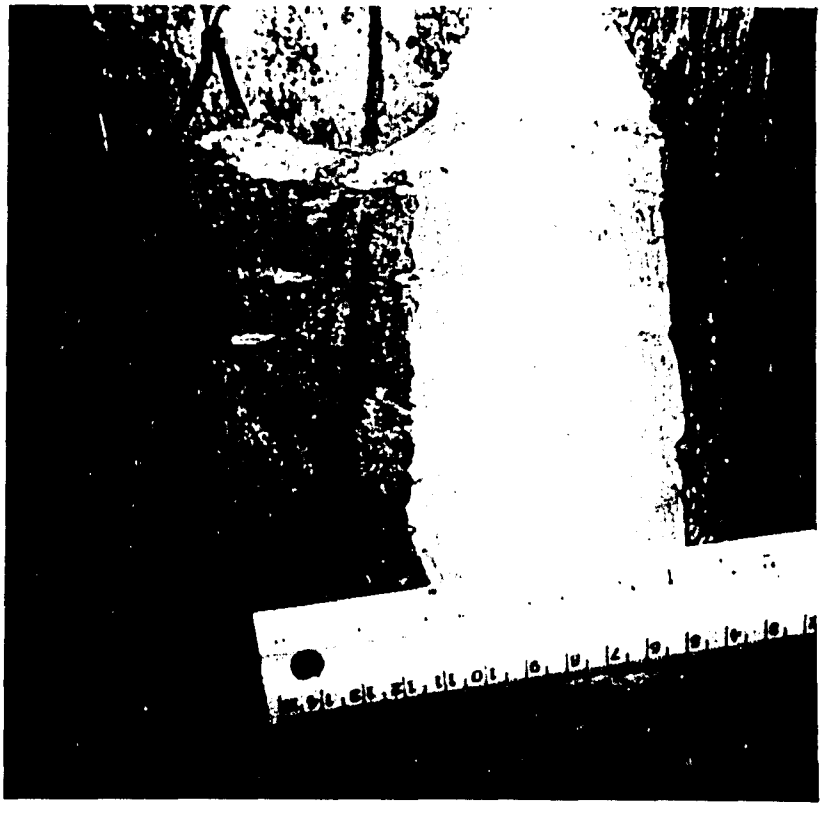
or 1- or 3-foliate, often pinnate, or bipinnate. Stipules rarely present.

A family of 23 genera and 86 species in West Africa. There are two genera and four species in the Bobiri forest reserve.

PLATE 106

Blighia sapida (Sapindaceae)

Bark and slash.



Family	Species	Vernacular name
Sapindaceae	*Blighia sapida*	akye

---

1. Organization

a. Leaf type----Compound, even pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite to subopposite, 2-5 pairs.

2. Shape

a. Form----Elliptic. **b. Apex**----Obtuse to mucronate.

c. Base----Cuneate to acute.

3. Margin----Entire to crenate. **4. Glands**----Absent.

5. Blade size----3-18 x 2-8.5 cm.

6.a. Petiole----Normal; slightly flattened dorsoventrally. Slight swelligs making it look bumpy.

b. Rachis----Flattened on adaxial side. 1.5-16 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Mixture of erect brown hairs

with bent tips and appressed, brown hairs, both types 0.2-1.5 mm long, on blade, petiole, rachis, and buds. Sometimes two hairs originate from common stalk.

ii. **Density**----Copious, carpeting blade, petiole, rachis, and buds.

b. **Adaxial surface**----Glabrous, except few scattered, short hairs near base of midvein and at edges of blade near base.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute wide, nearly uniform. Lowest pair more acute.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Right angle; enclosed by sec and tertiary arches.

d. **Inter-secondary vein**----Composite.

11. **Tertiary veins**

Pattern----Orthogonal reticulate

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Brittle to fibrous. Outside smooth. Thin hoop-marks. Prominent eyemarks. Sometimes flaking leaves rough patches. Bark easily separates from wood.

b. Color----Light brown to gray.

16. Slash

a. General color----Cream-colored, or light yellow to brown.

b. Characteristics----Presence of orange streaks. Cover of outer bark greenish. Outer bark thick and brittle; inner bark thin and slightly fibrous. Strong, pleasant smell.

c. Exudate----None.

d. Thickness----1-4 mm.

17. Wood----Light yellow, very hard.

18. Height category----hh to h. 7-25 m.

19. Buttressing----Usually fluted at base.

20. Bole----Cylindrical, straight, sometimes crooked near crown.

21. Additional remarks----Tree with spreading crown and ribbed branchlets, found in moist or dry forest. Common in the savanna regions and dry forests of eastern West Africa. Usually planted near dwellings. Cultivated in Tropical America and India. Slash heals well after 6 months.

Family	Species	Vernacular name
Sapindaceae	*Blighia unijugata*	akye-bere

---

1. Organization

a. Leaf type----Compound, pinnate.

b. Phyllotaxy----Alternate. Leaflets pposite. Basal leaflets

sub-opposite. 1-4 pairs, upper ones largest, rarely 1-foliate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire to crenate. **4. Glands**----Absent.

5. Leaf size----3.5-25 x 1.5-10 cm.

6.a. Petiole----Usually broadly winged; sometimes normal. Short. Channel on adaxial side. 0-7 cm long.

b. Rachis----0-5 cm long.

7. Hairs

a. Abaxial surface----Glabrous. Sometimes with tufts of hairs in domatia.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute to right angle.

d. Inter-secondary vein----Simple.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Forked and simple in about equal proportions. Many sinuous, some recurved, few retroflexed.

ii. Relation to midvein----Mostly oblique.

iii. Arrangement----Mostly opposite, some alternate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a fimbrial vein.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Brittle. Outside slightly rough.

b. Color----Gray.

16. Slash

a. General color----Creamy-brown.

b. Characteristics----Outer bark thin, brown, with few, tiny,

bown dots; inner bark light brownish-cream with thin streaks and larger, many brown dots that become dark brown after 5 mins, on whitish background. Characteristic strong smell resembling ripened fruit.

c. Exudate----None. **d. Thickness**----1-1.5 mm.

17. Wood----Brown, very hard, same color overnight after exposure.

18. Height category----hh to h. 4-20 m.

19. Buttressing----Small buttresses.

20. Bole----Crooked; sometimes flattened near base.

21. Additional remarks----Tree widespread in tropical Africa, in lower storeys of moist forest or canopy species in dry forest. New flushes of leaves white in color. Blade shiny, especially under microscope. Tiny dots scattered in intercostal areas of blade.

PLATE 107

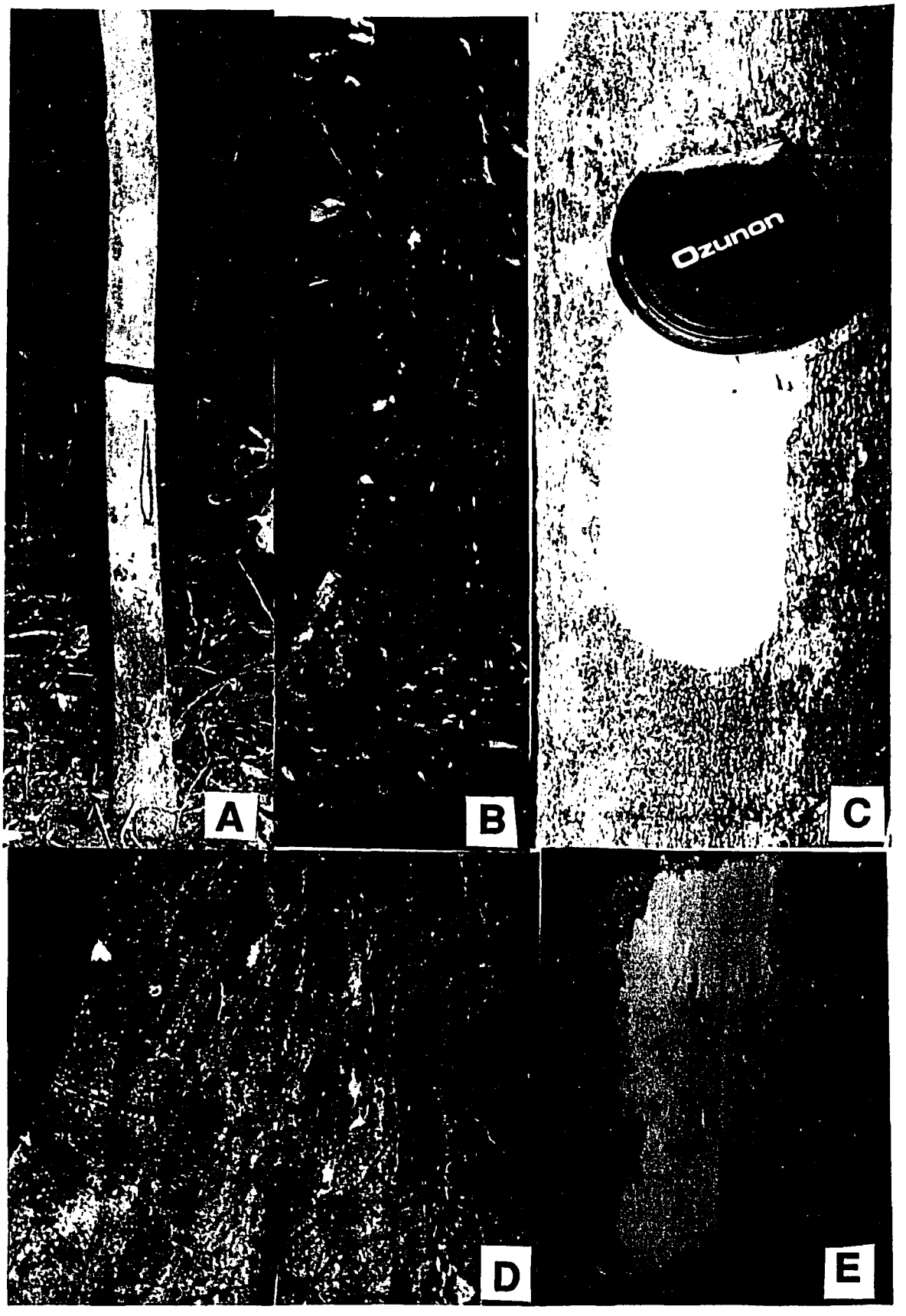
Blighia welwitschii (Sapindaceae)

A----Young bole.

B----Old bole and buttresses.

C & E----Bark and slash.

D----Buttress and hoop marks.


Ozunon
A
B
C
D
E

Family	Species	Vernacular name
Sapindaceae	*Blighia welwitschii*	akyekobiri

---

1. Organization

a. Leaf type----Compound, even pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite. 2-4 pairs, upper ones largest.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Crenate. Many long waves. **4. Glands**----Absent.

5. Blade size----5-20 x 2-8 cm long.

6.a. Petiole----Usually normal; sometimes slightly winged, or **fluted** and constricted at base; rugose; vertical ridges present; flattened. 1.5-10 cm long.

b. Rachis----Slightly **fluted** at base; rugose. 0.5-10 cm long.

7. Hairs

a. Abaxial surface

i. **Type, color, & location**----Mixture of erect and appressed hairs, 0.05-0.3 mm long on primary vein, sec veins, and buds. Similar brown hairs, on petiole, and rachis, at 20x. Domatia of hairs at primary-sec apical vein junctions. Another kind of very short, erect hairs at 40x on primary and sec veins.

ii. **Density**----Domatia and hairs on buds quite dense; rest of hairs relatively scanty.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform. Lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute or obtuse to right angle, enclosed by tertiary and quaternary arches.

d. Inter-secondary veins----Simple, short.

11. Tertiary veins

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a **fimbrial vein.**

14. Areoles

a. Development----Well developed.

b. Shape----Majority quadrangular and pentagonal.

15. Bark

a. Texture, & features----Very brittle. Outside smooth but with rough patches resembling bark of *Lannea welwitschii.* Very many hoop marks from butress to branches, and eyemarks. Thin, shallow, vertical lines along which lenticels are arranged in close rows.

b. Color----Gray to gray-brown.

16. Slash

a. General color----Orange to light brown.

b. Characteristics----Cover of outer bark light brown; darkens

to deep brown ring after 5 mins. Outer bark cream-colored; becomes dark brown with cream-colored streaks after 5 mins. Inner bark orange to light brown.

c. Exudate----None.

d. Thickness----1-8 mm.

17. Wood----Yellowish to orange, very hard.

18. Height category----H. Up to 46 m.

19. Buttressing----Small to medium-sized buttresses.

20. Bole----Straight, sometimes crooked near crown. Usually cylindrical but sometimes irregular in shape. Bumps on trunk.

21. Additional remarks----Tree usually restricted to moist forest, with pale brown flushes of new leaves. Characteristic branching pattern with branches originating from base of main trunk, sometimes attaining10 cm DBH or more.

Family	Species	Vernacular name
Sapindaceae	*Lecaniodiscus cupanioides*	dwindwera

---

1. Organization

a. Leaf type----Compound, pinnate.

b. Phyllotaxy----Alternate. Leaflets opposite or sub-opposite. Apex of mature compound leaf often with one of the apical leaflets fallen.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Decurrent to cuneate.

3. Margin----Crenate. **4. Glands**----Absent.

5. Blade size----6-13 x 4-9 cm.

6. a.Petiole----Short; base **fluted**; slightly flattened dorsoventrally.

b. Rachis----Base **fluted.**

7. Hairs

a. Abaxial surface

i. Type, color, & location----Mixture of erect and

appressed hairs, 0.05-0.15 mm long on blade, petiole, and rachis. Presence of stellate hairs interspersed among the other hairs.

ii. **Density**----Scattered on blade; dense on petiole and rachis.

b. **Adaxial surface**----Few simple and stellate hairs along primary vein channel, and on some sec veins. Rest of blade glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform, lowest pair more acute.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute, enclosed by tertiary and quaternary arches.

d. **Inter-secondary vein**----Absent.

11. **Tertiary veins**

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Weel developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Hard and brittle. Outside smooth.

b. Color----Gray.

16. Slash

a. General color----Light brownish-red or orange-brown.

b. Characteristics----Presence of coutours. Slash bemes deeper brownish-red after 10 mins. Moderate, agreeable smell.

c. Exudate----None.

d. Thickness----2-4 mm.

17. Wood----Light yellowish-cream, very hard.

18. Height category----hh to h. 2-12 m.

19. Buttressing----Small buttresses.

20. Bole----Straight, round.

21. Additional remarks----Small tree or shrub with spreading crown, common in secondary forest. Young stems have very dense, soft, curly, orange hairs.

SAPOTACEAE

Trees, shrubs, or rarely climbers, often with milky juice. Leaves alternate, entire, leathery. Stipules usually absent or caducuous. Some are of considerable economic importance.

There are two genera and four species in the Bobiri forest reserve.

PLATES 108 & 109

Aningeria robusta (Sapotaceae)

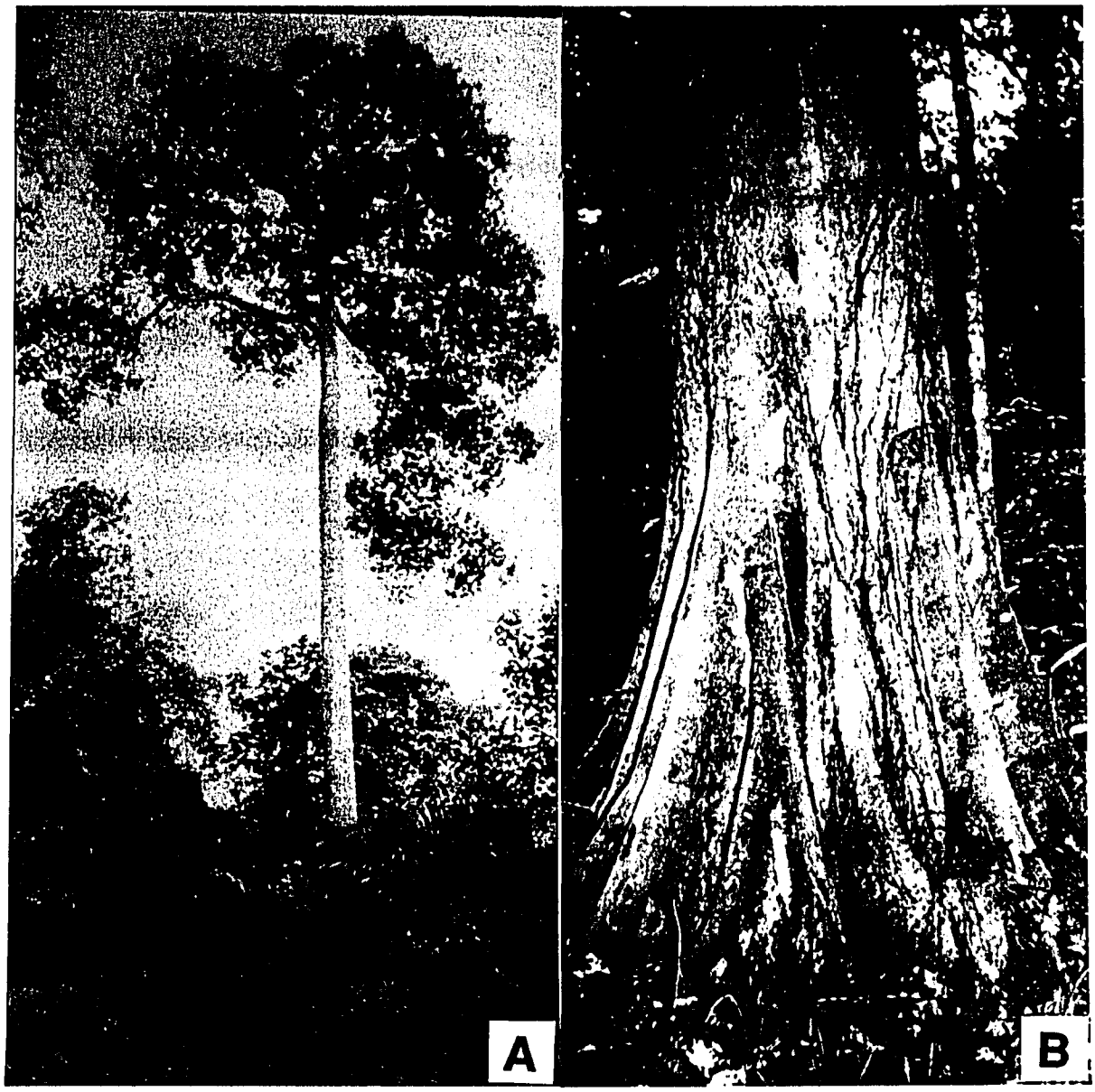
108A----Bole and crown.

108B----Bole and buttresses.

109A----Bole and buttresses.

109B----Bark.

109C----Slash.


A
B


A
B
C

Family	Species	Vernacular name
Sapotaceae	*Aningeria robusta*	asamfena-nini

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Narrow obovate. **b. Apex**----Retuse.

c. Base----Cuneate.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----8-17 x 4-7.5 cm.

6. Petiole----Normal.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Short, white, appressed hairs, 0.2-0.4 mm long, on primary vein, blade, buds, and young twig.

ii. Density----Abundant on buds and leaf axils; scattered elsewhere. Young leaves and shoots densely pubescent.

b. Adaxial surface----Similar to abaxial surface.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Generally markedly curved, unbranched.

Dark brown with reddish tint when dry.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute to right angle, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Simple.

e. Number----15-20.

11. Tertiary veins

Pattern----Random reticulate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Fibrous to brittle. Outside smooth to

rough; fissured, with vertical slits. Scattered lenticels, mostly in vertical rows.

b. Color----Brown with gray tint.

16. Slash

a. General color----Reddish purple, or light yellow to pink.

b. Characteristics----Presence of dark bands. Slash becomes brownish after 10 mins. Outer bark brittle; inner bark slightly fibrous. Sapwood yellowish.

c. Exudate----Cream-colored, copious, slightly sticky exudate, oily after rubbing and drying between fingers.

d. Thickness----3-6 mm.

17. Wood----Whitish; becomes yellowish-brown after 10 mins; very hard.

18. Height category----H. Up to 46 m.

19. Buttressing----Medium-sized to large (often triangular) buttresses.

20. Bole----Straight, clear, round.

21. Additional remarks----Common tree in the forests of Ghana.

Appressed, white hairs on young twigs. Dry exudate cover trunk as white powder for many weeks.

Family	Species	Vernacular name
Sapotaceae	*Chrysophyllum beguei*	duatadwe-nini

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1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to narrowly elliptic.

b. Apex----Acuminate.

c. Base----Asymmetrical; one side cuneate, other rounded.

3. Margin----Crenate. **4. Glands**----Absent.

5. Leaf size----Up to 18 cm long and 7 cm broad.

6. Petiole----Normal.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Contorted, scandent, reddish-brown, visible hairs on whole blade, petiole, and buds.

ii. Density----Copious; carpet primary and sec veins of mature leaves, whole blade of young leaves, buds, and young twigs.

b. Adaxial surface----Old leaves glabrous except few similar hairs at base of primary vein. Juvenile leaves carpeted by hairs, but as leaf grows older, hairs gradually diminish in to patchy aggregations till adaxial side becomes glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight to markedly curved.

10. Secondary veins

a. Angle of divergence----Lower angles acute wide, upper ones acute moderate. Lowest pair right angle.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse to right angle, enclosed

by tertiary arches.

d. Inter-secondary vein----Simple. Presence of Intramarginal vein.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Simple and forked in about equal proportions, some retroflexed, many recurved.

ii. Relation to midvein----Oblique and right angle in about equal proportions.

iii. Arrangement----Opposite and alternate in about equal proportions.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a fimbrial vein. Has **Circumpubescent** vein.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Spongy. Outside rough. Prominent vertical slits.

b. Color----Very dark gray.

16. Slash

a. General color----Light yellow.

b. Characteristics----Presence of orange lines. Moderate agreeable smell. Both outer and inner barks pale yellow and fibrous.

c. Exudate----White, copious, sticky exudate.

d. Thickness----2.5-3 mm.

17. Wood----Creamy-light yellow, moderately hard.

18. Height category----h. Up to 20 m.

19. Buttressing----Small buttresses or fluted at base.

20. Bole----Usually straight, sometimes crooked or slightly flattened.

21. Additional remarks----Medium tree or shrub with rusty-tomentose branches.

Family	Species	Vernacular name
Sapotaceae	*Chrysophyllum subnudum*	adasema

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Spiral.

2. Shape

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Acute.

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----8-16 x 2.5-5.5 cm.

6. Petiole----Normal. **Fluted.** 1-2 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, soft, brown hairs, 0.3-0.6 mm long on whole blade, especially primary and sec veins, buds, and petiole. Hairs on buds longer, up to 0.9 mm long. On veins, majority point apically, some basally.

ii. **Density**----Copious at all locations.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to markedly curved, unbranched. Carpet of brown hairs gives it the appearance of dead log. Extends beyond apex for up to 0.3 mm.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Variable. Acute near base, right angle midway, obtuse near apex. Enclosed by sec and tertiary arches.

d. **Inter-sec vein**----Absent. e. **Number**----10-15.

11. **Tertiary vein**

Pattern----Percurrent.

i. **Course**----Forked. Some convex.

ii. **Relation to midvein**----Majority oblique; some right angle.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins random. Rest of higher order veins obscure.

13. Marginal ultimate venation----Looped, with a **fimbrial vein.**

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Fibrous. Many, tiny lenticels, mostly scattered, but some vertically or diagonally aligned. Eyemarks present. Outside smooth to rough.

b. Color----Brown or gray-brown.

16. Slash

a. General color----Light brown, or reddish to yellow.

b. Characteristics----Becomes darker brown after 3 mins. Sapwood light brown, becoming darker brown after 3 mins. Strong, sweet smell.

c. Exudate----White latex, slightly sticky. Feels oily when

rubbed between fingers, then begins to be sticky. Stickiness lost when dry.

d. Thickness----About 3.5 mm.

17. Wood----Creamy-brown, very hard.

18. Height category----h to H. 11-32 m.

19. Buttressing----Small buttresses.

20. Bole----Round, straight.

21. Additional remarks----Small to large tree, absent from dry forest. Adaxial side of leaf shiny and dark green. Abaxial side green with glittering rainbow colors in bright light under microscope. One of few instances where venation is more prominent on adaxial than abaxial side under microscope. Primary vein on adaxial side of leaf joins petiole as characteristic deep channel curving near base of petiole.

SIMAROUBACEAE

Trees or shrubs, sometimes with bitter bark, slash pale and fibrous, rarely spiny. Leaflets alternate, rarely opposite, imparipinnate, rarely simple, often emarginate or apiculate, eglandular or rarely gland-dotted. Stipules absent.

There is one genus and one species in the Bobiri forest reserve.

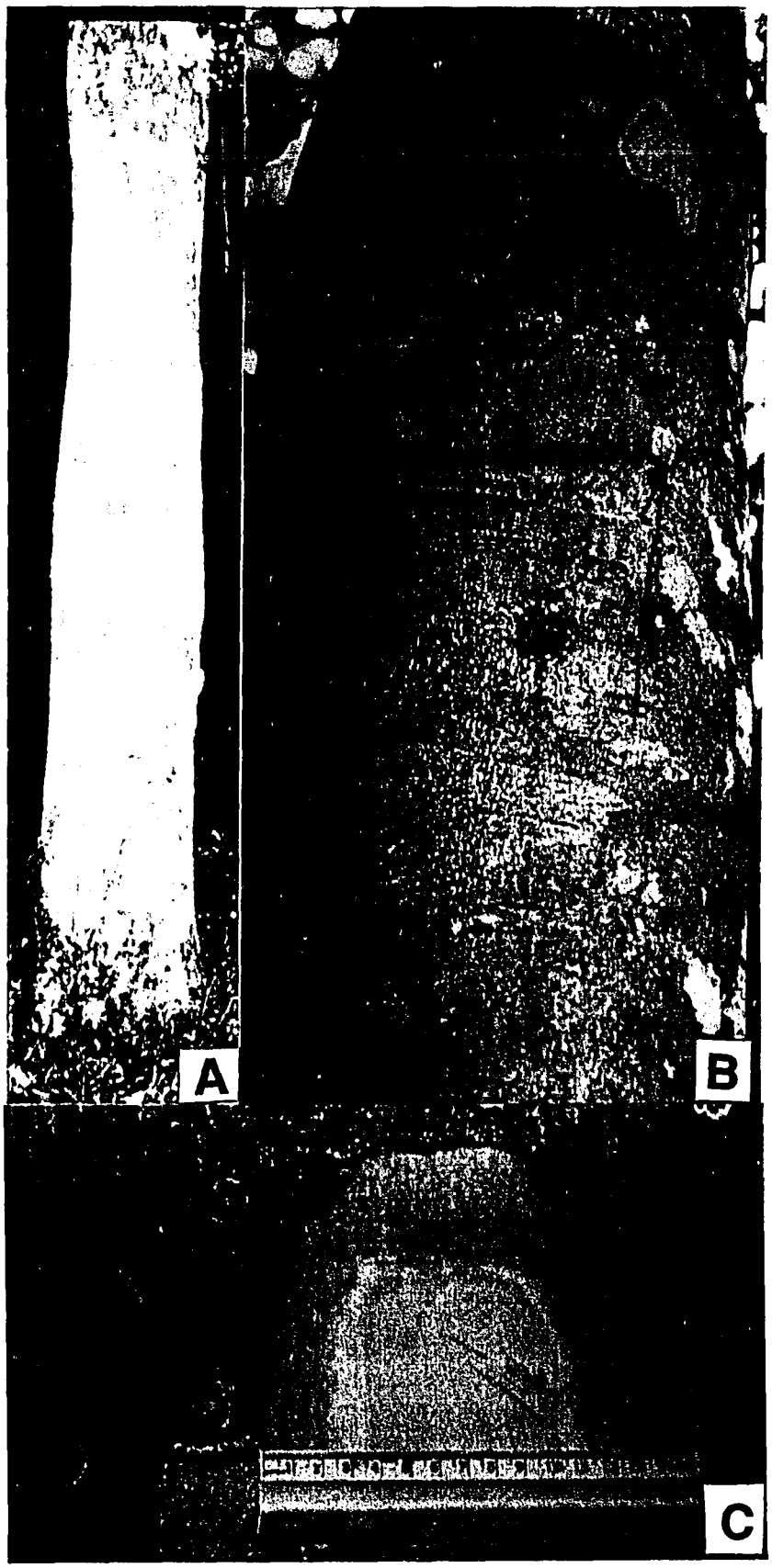
PLATE 110

Hannoa klaineana (Simaroubaceae)

A----Bole.

B----Bark, eyemarks, and hoop marks.

C----Slash.


A
B
C

Family	Species	Vernacular name
Simaroubaceae	*Hannoa klaineana*	fotie

---

1. Organization

a. Leaf type----Compound, regular odd pinnate.

b. Phyllotaxy----Alternate to sub-opposite. 2-8 pairs, plus terminal leaflet.

2. Shape

a. Form----Elliptic.

b. Apex----Emarginate to mucronate.

c. Base----Acute to decurrent.

3. Margin----Entire.

4. Glands----Absent.

5. Blade size----3.5-19 x 2-7.5 cm.

6. Petiole----Normal; sometimes slightly winged near apex. Up to 1.5 cm long.

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform, lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Right angle, enclosed by tertiary arches.

d. Inter-secondary vein----simple.

11. Tertiary veins

Pattern----Random reticulate. Quite obscure.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Lacking.

15. Bark

a. Texture, & features----Spongy. Outside smooth to rough. Flakes when old leaving rough patches. Shallow, vertical lines at protruding points of trunk. Many, little bumps. Prominent eyemarks and some hoop marks.

b. Color----Brownish to gray.

16. Slash

a. General color----Light yellowish-brown, orange, or whitish.

b. Characteristics----Cover of outer bark orange with green streaks. Outer bark brittle, inner bark very spongy. Light reddish-brown ring in outer part of outer bark. Strong, agreeable smell. Same color after 48 hours.

c. Exudate----None. **d. Thickness**----2-3 mm.

17. Wood----White or creamy-yellow. Soft sapwood; moderately hard heartwood.

18. Height category----h to H. Up to 35 m.

19. Buttressing----Absent. Sometimes fluted at base.

20. Bole----Round, tall, straight.

21. Additional remarks----Large, sun-loving tree with shining foliage, usually in rain forest.

STERCULIACEAE

Trees or shrubs, rarely herbs, often with soft wood, mostly with stellate hairs. Leaves alternate, simple or digitately compound. Stipules usually present.

There are 6 genera and 10 species in the Bobiri forest reserve.

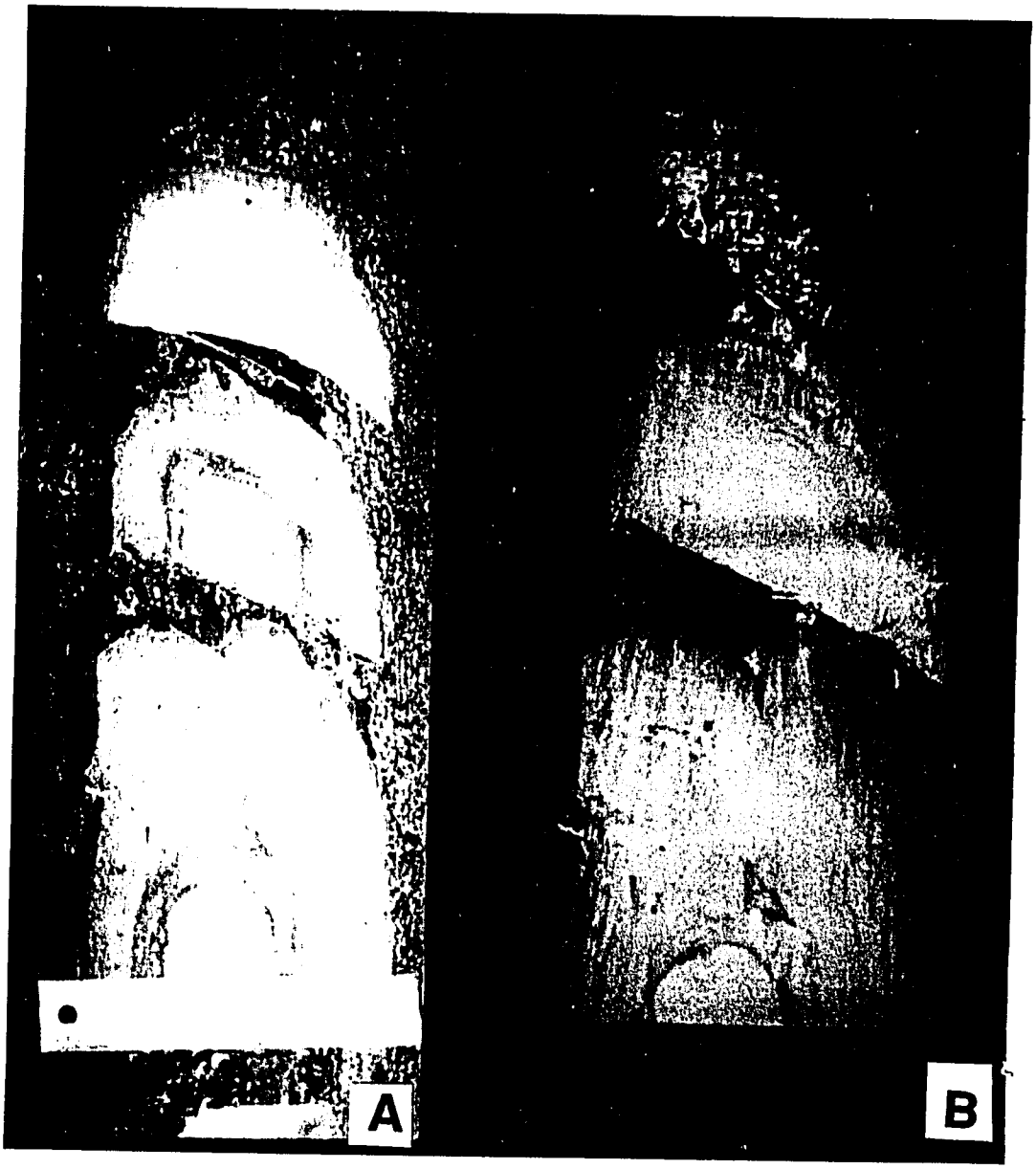
PLATES 111 & 112

Cola gigantea (Sterculiaceae)

111A----Bole and buttresses. 111B----Bark.

112A & B----Slash (above--after 15 seconds; below--after one minute.


A
B


A
B

Family	Species	Vernacular name
Sterculiaceae	*Cola gigantea*	watapuo

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Widely ovate. **b. Apex**----Acute.

c. Base----Lobate.

3. Margin----Entire to crenate.

4. Glands----Little, black dots on primary vein suggestive of glands.

5. Leaf size----13-37 x 10.5-30 cm.

6. Petiole----Normal. Round but flattened at base.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Very short, erect hairs, about 0.1 mm long at 20x, on primary and sec veins. Also stellate hairs resembling spiders at 20x, 5-10 branches (rarely 2-4) from a central point, each arm about 0.2 mm

long, on all veins, especially on old leaves. Buds have very short hairs, about 0.1 mm long, interspersed with 0.3 mm long, few, white hairs.

ii. **Density**----Abundant at all locations. Very copious on buds.

b. **Adaxial surface**----Same type and distribution as abaxial surface, with lesser density except on primary and sec veins.

8. **Venation**----Actinodromous (Perfect, Marginal, Basal).

9. **Primary vein**----Markedly curved, branched.

10. **Secondary veins**

a. **Angle of divergence**----Acute narrow, nearly uniform.

b. **Course**----Curved abruptly, unbranched, with outer sec veins.

c. **Loop-forming branches**----Acute to right angle, few obtuse, enclosed by tertiary and quaternary arches.

d. **Inter-secondary vein**----Absent.

11. **Tertiary veins**

Pattern----Percurrent.

i. Course----Forked.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Polygonal.

15. Bark

a. Texture, & features----Very spongy, pliable, thick, and fissured. More fibrous than in *Cola nitida* . Shallow, brown, vertical lines, and very prominent lenticels in vertical rows. Outside slightly rough. Old bark near base of trunk flakes. Prominent, large eyemarks.

b. Color----Gray or brown, sometimes with white patches.

16. Slash

a. General color----Creamy-brown with purple tint, purple with cream-colored streaks, or cream-colored.

b. Characteristics----Slash darkens to brownish purple after 3 mins, with darker brown ring near sapwood. Cover of outer bark light orange. Inner bark becomes deep brown after 30 mins. Sapwood becomes brown on exposure. Faint, agrreable smell, less stronger than for *Cola nitida.*

c. Exudate----Slippery, slightly sticky exudate, turning into whitish to transparent gum after 24 hours.

d. Thickness----10-14 mm.

17. Wood----Whitish, mederately soft.

18. Height category----h to H. Up to 31m.

19. Buttressing----Small to tall buttresses.

20. Bole----Often crooked; sometimes straight but crooked near crown. Usually round; infrequently flattened.

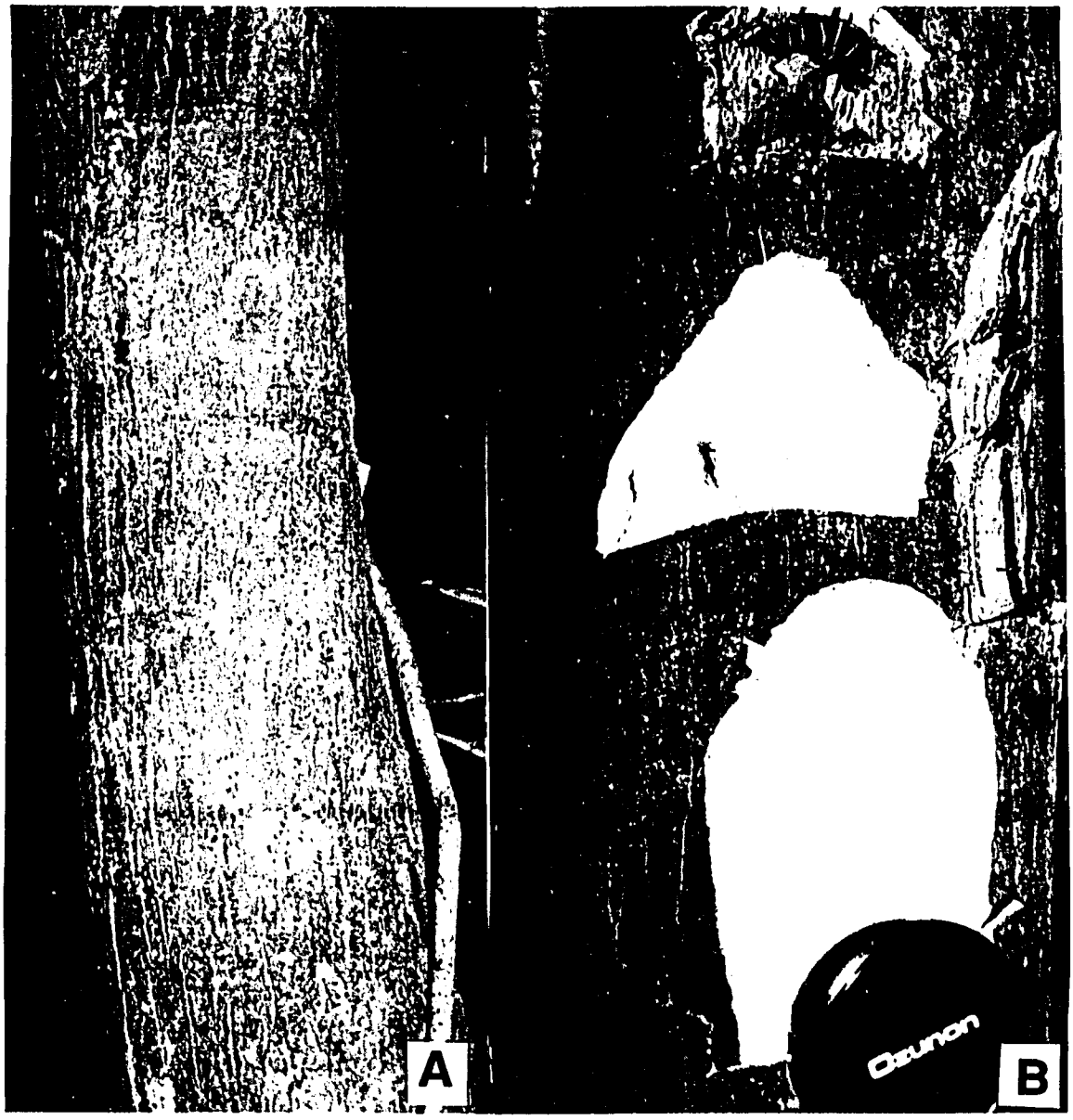
21. Additional remarks----Tree common in forest margins. Young twigs brown-tomentose. Slash heals very well after 6 months with wide callus.

PLATE 113

Cola millenii (Sterculiaceae)

A----Bole, bark, and eyemarks.

B----Bark and slash.


A
Daunon
B

Family	Species	Vernacular name
Sterculiaceae	*Cola millenii*	ananse-dodowa

---

1. Organization

a. Leaf type----Compound, Palmately trifoliate, usually 5-lobed, sometimes 3- or 7-lobed.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Leaflet narrowly elliptic, whole leaf palmately trifoliate.

b. Apex----Acumunate. **c. Base**----Rounded.

3. Margin----Entire to crenate.

4. Glands-----Tiny swellings at 15x on tertiary and quaternary veins resembling glands.

5. Blade size----Up to 30 x 35 cm. Usually smaller.

6. Petiole-----Normal, very long, **fluted**, enlarged ends flattened dorsoventrally and rugose.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Stellate hairs with 2-8 arms, 0.2-1.0 mm long, mostly on primary and sec veins, and petiole. Mixed up with appressed, simple hairs. Tertiary and higher order veins, and intercostal areas glabrous.

ii. Density----Moderately abundant.

b. Adaxial surface----Similar type and disribution as abaxial surface but denser on primary veins, and less dense on secs. Rest of blade shiny, and glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, branched.

10. Secondary veins

a. Angle of divergence----Acute moderate; more acute on one side than the other for the two outer leaflets.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by sec, tertiary, and quaternary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Simple, sinuous.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly opposite.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Spongy and thick. Outside smooth. Patches of rough bark sometimes surround big, clustered lenticels. Promonent eyemarks. Very shallow, brown, vertical lines, and few hoop marks.

b. Color----Gray or grayish-green.

16. Slash

a. General color----Cream-colored or creamy-yellow.

b. Characteristics----Horizontally aligned, brown or white streaks, usually in groups, in inner bark. Sapwood cream-colored to light yellowish-brown. Strong, pleasant smell that stimulates the appetite. Slash same color after 48 hours.

c. Exudate----Scanty, clear, slippery, non-sticky exudate on sapwood.

d. Thickness----3-4 mm.

17. Wood----Creamy-light yellow or light brown, moderately hard to soft.

18. Height category----hh to h. 4-20 m.

19. Buttressing----Usually fluted at base.

20. Bole----Crooked, round.

21. Additional remarks----Tree usually in secondary forest, often in dry localities. Leaves conspicuously lobed.

PLATES 114 & 115

Cola nitida (Sterculiaceae)

114A----Leaves, and flowers.

114B----Slash (below--after 15 seconds; above--after one minute).

114C----Bark and healed slash.

115A----Bark.

115B----Bole and incipient buttresses.


A
B
C


A
B

Family	Species	Vernacular name
Sterculiaceae	*Cola nitida*	bese

---

1. Organization

a. Leaf type----Simple.

b. Phyllotaxy----Alternate.

2. Shape

a. Form----Narrowly elliptic.

b. Apex----Acuminate.

c. Base----Cuneate.

3. Margin----Entire.

4. Glands----Absent.

5. Leaf size----Up to 33 x 13 cm. Usually smaller.

6. Petiole----Normal, **fluted**, swollen ends with deep brown wrinkles.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Tiny, erect hairs, 0.1 mm long at 20x on petiole. Stellate hairs on all veins and petioles, with arms 5 or more (up to 11), same type as in *Cola gigantea* but easier to make out.

ii. Density----All types of hairs scattered and relatively few.

b. Adaxial surface----Similar type of hairs as on abaxial surface but very sparse.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform. Lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute; right angle or obtuse near apex.

d. Inter-secondary vein----Composite.

11. Tertiary vein

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins random; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Pentagonal.

15. Bark

a. Texture, & features----Spongy. Outside smooth but slightly rough when old. Rough patches on old bark. Longitudinal lines and bean-shaped lenticels in vertical rows along shallow, wide markings (slits up to 1 mm wide). Flakes when old. Thick.

b. Color----Gray to brown, or dark.

16. Slash

a. General color----Purplish-cream or pale pink.

b. Characteristics----Presence of orange streaks. Begins to darken after 30 secs; outer bark becomes lighter brown and inner bark deeper brown after 3 mins. Thin, leathery cork easily peels off to reveal reddish-brown cover of outer bark with streaks of whitish-green marks. Creamy-yellow sapwood also becomes brownish after 2 mins, and deep brown after 4 mins. Moderate, pleasant smell. Back of sapwood

slippery. Taste slightly soapy.

c. Exudate---Brownish, slightly sticky exudate.

d. Thickness---5-7 mm.

17. Wood----Light brownish-orange, soft to moderately hard.

18. Height category----h. Up to 25 m.

19. Buttressing----Base fluted; sometimes with small buttresses.

20. Bole----Round, crooked, sometimes straight.

21. Additional remarks----Tree often cultivated, but native in West Africa as far east as Ghana; introduced elsewhere in the region. Slash heals very well after 6 months.

Family	Species	Vernacular name
Sterculiaceae	*Leptonychia pubescens*	foto-nua

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Narrowly elliptic.

b. Apex----Acuminate.

c. Base----Acute.

3. Margin----Entire to crenate.

4. Glands----Absent.

5. Leaf size----9-19 x 3.5-7 cm.

6. Petiole----Normal. Quite fusiform.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Orange, appressed hairs, 0.5-4.0 mm long, mixed with stellate hairs (3-10 arms), on all veins. Erect hairs in domatia at primary-sec and sec-tertiary apical junctions. Orange, stellate hairs on petiole, buds and young twigs.

ii. Density----Very dense on petiole, buds and young twigs. Quite abundant at other locations.

b. Adaxial surface----Glabrous.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Markedly curved, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, lowest pair more acute, uppermost right angle.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse, enclosed by sec and tertiary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Simple and forked in about equal proportions. Some straight, recurved or convex; few sinuous.

ii. Relation to midvein----Oblique.

iii. Arrangement----Alternate and opposite in about equal proportions.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Brittle. Outside rough. Prominent eyemarks.

b. Color----Gray.

16. Slash

a. General color----Cream to brown.

b. Characteristics----Cover of outer bark very dark brown. Portions of slash become pink after 5 mins, and more brownish after 10 mins. Strong, agreeable smell.

c. Exudate----None.

d. Thickness----2-3 mm.

17. Wood----Moderately soft.

18. Height category----hh. Up to 10 m.

19. Buttressing----Fluted at base.

20. Bole----Crooked, usually irregular with bumps, sometimes flattened near base.

21. Additional remarks----Small, understorey tree or shrub.

Silvery tint on abaxial side of old, dry leaves; adaxial side darker green than abaxial side. Veins on abaxial side of dry leaf appear as brown lines on dark green background. Trinerved.

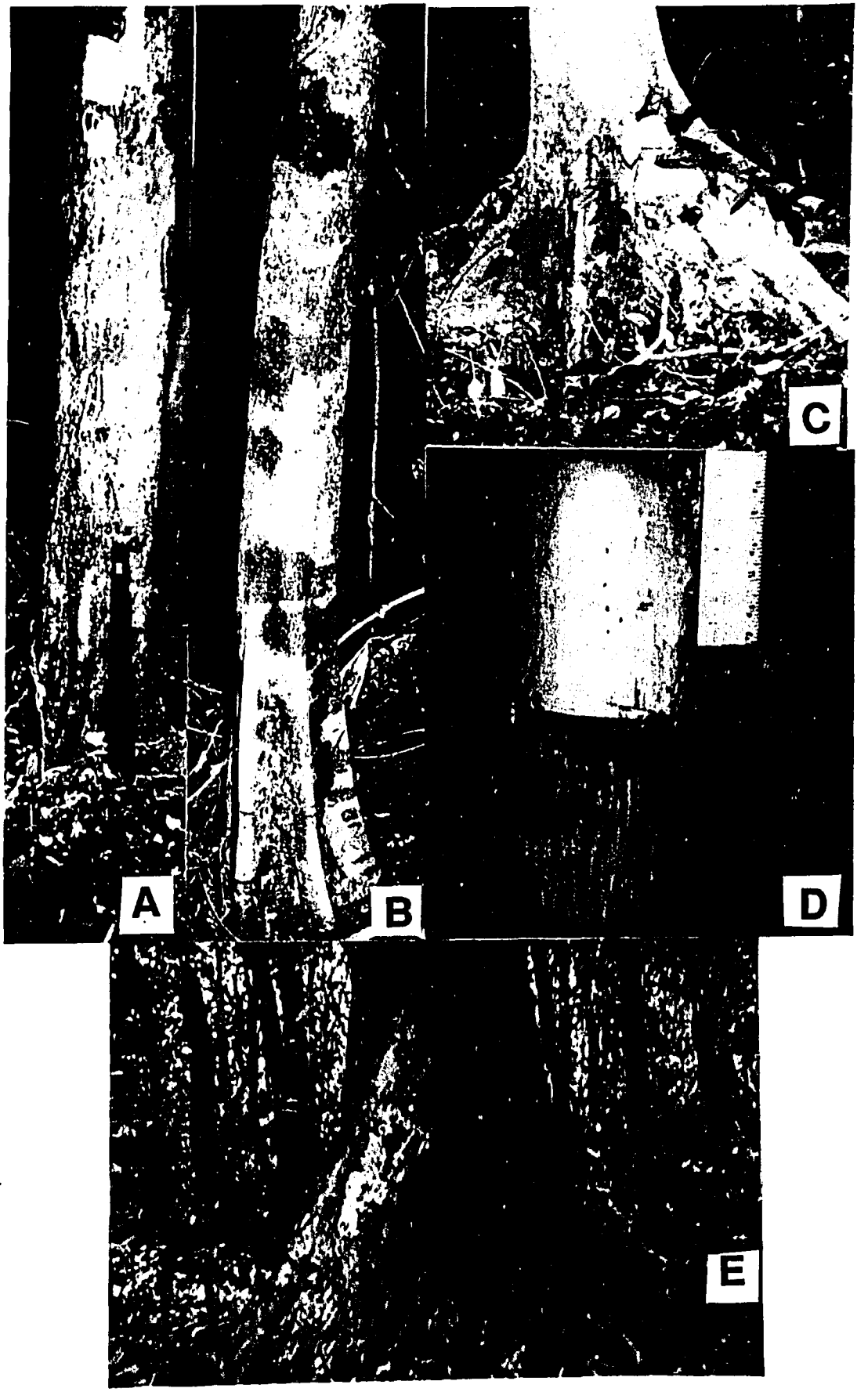
PLATE 116

Nesogordonia papaverifera (Sterculiaceae)

A & B----Young bole and incipient buttresses.

C & E----Old buttresses.

D----Slash.


A
B
C
D
E

Family	Species	Vernacular name
Sterculiaceae	*Nesogordonia papaverifera*	danta

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Obtuse to acute.

3. Margin----Entire. **4. Glands**----absent.

5. Leaf size----Up to 11.5 x 6.5 cm.

6. Petiole----Normal, slender, 1.5-4 cm long; **fluted** at apex and base.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Stellate hairs, 2-8 arms, each arm 0.1 mm long, on all veins and some intercostal areas. Longer, scandent hairs, 0.5 mm long, mainly at primary-sec apical junctions, and also at some

primary-tertiary and sec-tertiary junctions; also on petiole, buds and young twigs.

ii. Density----Scattered on blade; dense at other locations.

b. Adaxial surface----Glabrous and shiny, except few, very short, simple hairs at base of primary vein.

8. Venation----Camptodromous (Brochidodromous).

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform; lowest pair more acute.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Acute, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Hard and fibrous. Outside smooth when young; rough when old. Gray colored flakes sometimes peel off old bark, exposing brown patches, 1/4 up from base of trunk. Vertical, shallow slits.

b. Color----Gray-brown, or brownish with gray tint.

16. Slash

a. General color----Pink when bark is young; older bark brownish, purple, or reddish-purple.

b. Characteristics----White streaks. Slash darkens to brown after 3 mins. Cover of outer bark brown; outer bark brown or purple with cream-colored streaks, slightly brittle. Inner bark cream-colored, fibrous. Moderate, agreeable odor.

c. Exudate----None.

d. Thickness----1.5-4 mm.

17. Wood----White with purple tint, very hard.

18. Height category----h to H. Up to 31 m.

19. Buttressing----Medium-sized buttresses.

20. Bole----Clean, round, straight; sometimes crooked, irregular or flattened.

21. Additional remarks---Tall tree. Stipules linear, pointed, deciduous, clustered at apices of young twigs. Commonly used for mortar and drums in West Africa.

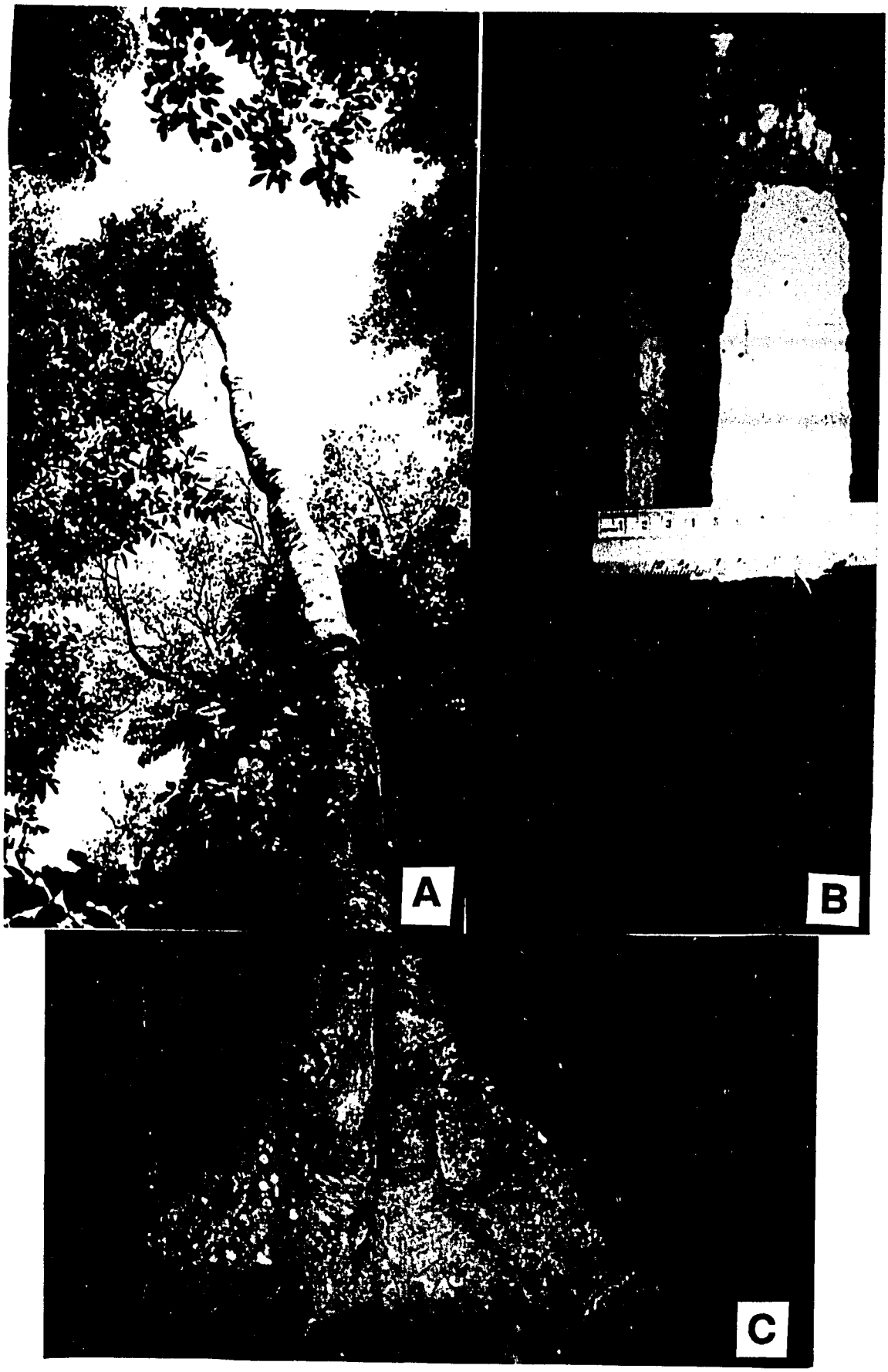
PLATE 117

Pterygota macrocarpa (Sterculiaceae)

A----Bole and crown whose growth has been hidered by lianas.

B----Bark and slash.

C----Buttresses.


A
B
C

Family	Species	Vernacular name
Sterculiaceae	*Pterygota macrocarpa*	kyereye

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Very widely ovate. **b. Apex**----Obtuse to acute.

c. Base----Saggitate (young leaves lobate).

3. Margin----Entire. **4. Glands**----Absent.

5. Leaf size----10-38 cm long and broad.

6. Petiole----Normal.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Short, appressed hairs, mixed with stellate hairs on young leaves and stems; older leaves usually glabrous.

ii. Density----Very dense when present.

b. Adaxial surface----Glabrous.

8. Venation----Actinodromous (Perfect, Basal, Marginal).

9. Primary vein----Markedly curved, branched. Presence of **Megaprimary vein.**

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Mixture of right and obtuse angles, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Percurrent

i. Course----Forked, convex, few recurved.

ii. Relation to midvein----Oblique and right angle in about equal proportions.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Pentagonal and quadrangular.

15. Bark

a. Texture, & features----Fibrous, soft. Outside smooth. Faint hoop marks. Prominent eyemarks at short distances. Lenticels arranged along prominent, white, vertical streaks.

b. Color----Light gray or gray to dark.

16. Slash

a. General color----White or pale yellow.

b. Characteristics----Light brown or white, bottleneck-shaped streaks. Cover of outer bark greenish. Brown ring develops in inner bark near sapwood after 15 mins; cream-colored sapwood darkens to gray after 5 mins. Strong, pleasant smell.

c. Exudate----None. **d. Thickness**----2-6 mm.

17. Wood----White, soft to moderately hard.

18. Height category----H. Up to 37 m.

19. Buttressing----Small to large, thin buttresses, with chracteristic many, thin, elevated, parallel lines perpendicular to edges of buttresses.

20. Bole----Round, often crooked, sometimes straight.

21. Additional remarks----Leaves usually 7-nerved at base. Twigs have elevated, vertical ridges of grayish-white cork (horizontally aligned at base of brnches). Dry leaves very fragile, commonly found damaged mechanically, by insect bites, or by fungi infection. Very clear venation pattern and good areolation. Characteristic scar on lower side of petiole, usually nearer base of blade, sometimes near base of petiole on the side, about 3 mm wide. Petiole and megaprimary vein appear very dark brown and shiny as if covered by wax.

Family	Species	Vernacular name
Sterculiaceae	*Sterculia oblonga*	ohaa

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate.

3. Margin----Entire to crenate. **4. Glands**----Absent.

5. Leaf size----7-16 x 4-8 cm.

6. Petiole----Normal. **Fluted** apically and basally. Rugose and bumpy at swollen ends, 2-7 cm long.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Stellate hairs with 4-12 arms (5 and 7 most common) mixed with erect ones, most pronounced in domatia (up to 0.6 mm long) at primary-sec apical junctions. Stellate hairs on primary and sec veins have more and shorter arms than for higher order veins. Other types of shorter, mixture of erect and appressed hairs (0.1-0.2 mm long) on veins and intercostal areas. Mixture of

the different types also on petioles, buds, and young twigs.

ii. **Density**----Abundant at all locations; very dense on buds and twigs. Older leaves sometimes have copious cover of stellate hairs.

b. **Adaxial surface**----Glabrous except cluster of hairs at base of primary vein and few erect hairs in domatia at primary-sec apical junctions at 15x. No stellate hairs.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute; enclosed by sec and tertiary arches.

d. **Inter-secondary vein**----Absent.

e. **Number**----10-14.

11. **Tertiary veins**

Pattern----Percurrent.

i. Course----Mostly forked, some simple, mixture of sinuous and convex.

ii. Relation to midvein----Oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order venation obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular and pentagonal.

15. Bark

a. Texture, & features----Very fibrous. Outside smooth. Characteristic, irregular, rough patches (up to 8 mm deep), sometimes circling trunk. Prominent eyemarks (up to 40 x 13 cm), and hoop marks. Big, brown, clumped lenticels, some scattered but mostly arranged along white, shallow, vertical slits that turn brown with age, on bark of buttresses too.

b. Color----Light gray, gray-brown, or light brown with whitish tint. Grayish-green when young.

16. Slash

a. General color----Cream-colored, grayish-white, yellowish, or reddish-brown with one or two red rings.

b. Characteristics----Orange or white streaks. Brown streaks in inner bark. Sometimes deeper brown after 2 mins. Gray ring in inner bark after 30 mins. No other color changes after 24 hours. Strong, pleasant smell. Visited by fleas, flies and beetles.

c. Exudate----Scanty, slightly sticky exudate.

d. Thickness----2.5-10 mm.

17. Wood----Creamy-light yellow, soft. Moderately hard when old.

18. Height category----H. Up to 37 m.

19. Buttressing----Tall, slender buttresses, or fluted at base.

20. Bole----Straight, round, clean.

21. Additional remarks----Tree with whorled branches. Top of crown appear white from a distance. Sapling common in understory of semi-deciduous forest.

PLATES 118 & 119

Sterculia rhinopetala (Sterculiaceae)

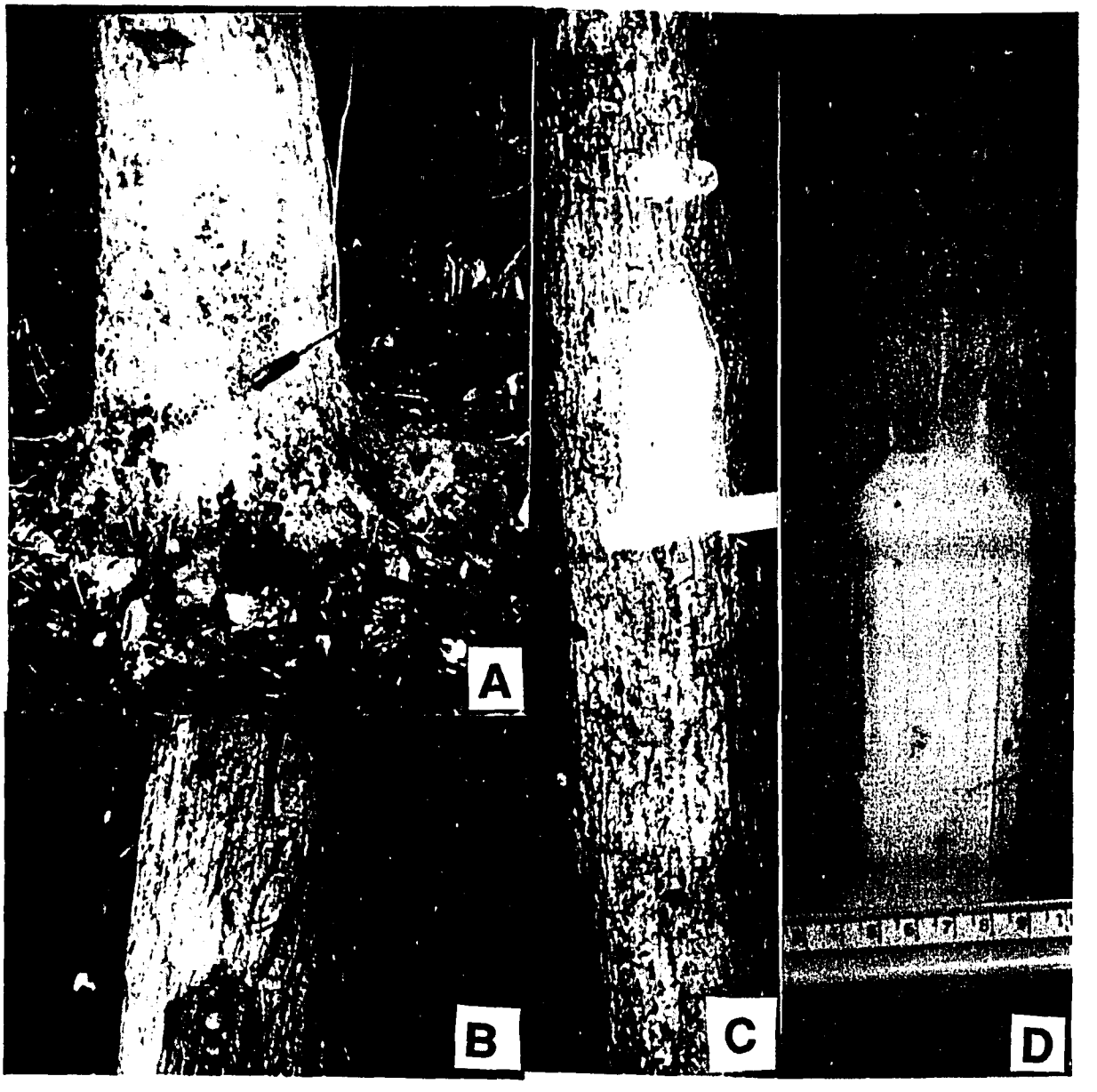
118A----Bole and buttresses.

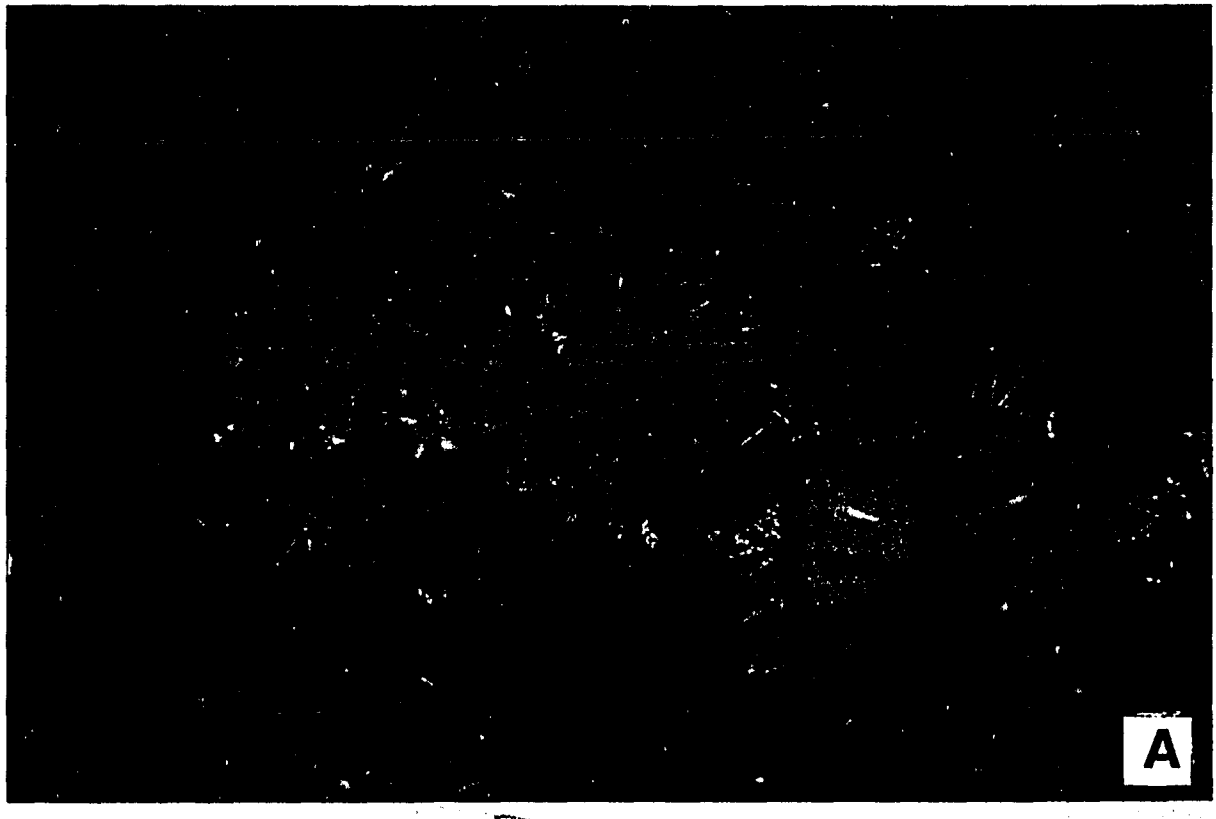
118B----Bark.

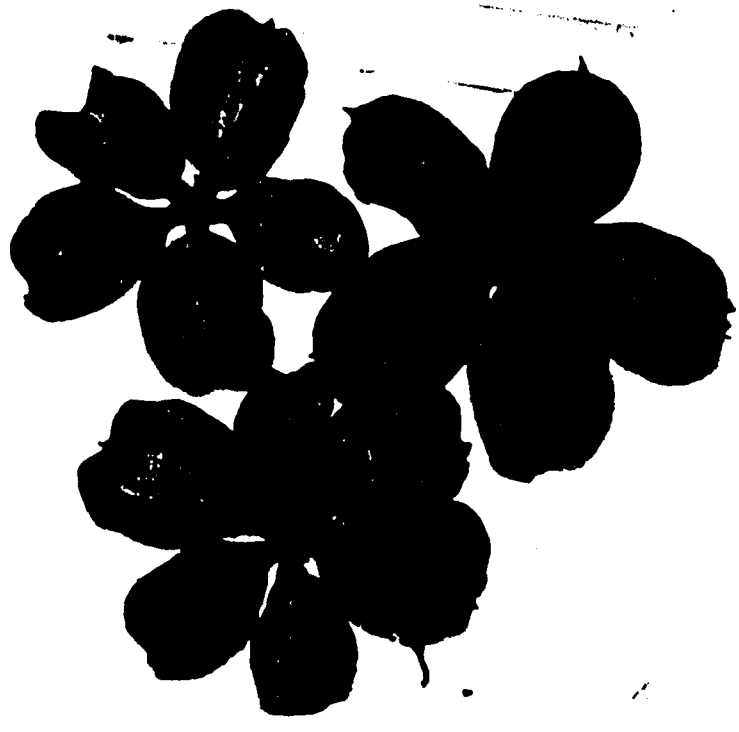
118C & D----Bark and slash.

119A----Fresh fruit and seeds.

119B----Dry fruit.


A
B
C
D


A


B

Family	Species	Vernacular name
Sterculiaceae	*Sterculia rhinopetala*	wawabima

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**-----Alternate.

2. Shape

a. Form----Lanceolate. **b. Apex**----Acuminate.

c. Base----Rounded to obtuse. **3. Margin**----Entire.

4. Glands----Dark brown, tiny swellings and slits on primary and some sec veins, looking glandular.

5. Leaf size----10-30 x 4-16 cm.

6. Petiole----Normal. **Fluted** at apex and base. Base rugose, with brown, vertical ridges, crossing horizontal splits.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Simple hairs (0.5-0.8 mm long) at 20x, at primary-sec vein junctions, and buds. Stellate hairs, only on new leaves.

ii. **Density**----Simple hairs scanty; stellate hairs abundant.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute, enclosed by sec, tertiary, and quaternary arches.

d. **Inter-secondary vein**----Composite.

11. **Tertiary veins**

Pattern----Random reticulate.

12. **Higher order venation**----Quaternary veins random; rest of higher order veins obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**

a. **Development**----Well developed.

b. **Shape**----Pentagonal and polygonal.

15. Bark

a. Texture, & features----Fibrous and fissured. Outside smooth, with rough spots from flaking when old. Shallow, light brown, vertical lines. Eyemarks, and very prominent, scattered lenticels, sometimes in vertical rows.

b. Color----Gray-brown, light gray, or light brown to whitish.

16. Slash

a. General color----Brownish purple, orange, reddish purple, or cream-colored to yellowish.

b. Characteristics----Grouped lines of vertical fibers. Cover of outer bark green. Outer bark brittle; inner bark spongy, with cream-colored ring near sapwood. Slash becomes brown after 5 mins, with gray streaks, sometimes with faint purple tint and dark brown ring near sapwood. Inner bark near wood becomes yellowish after 5 mins. Slash of juvenile tree same after 24 hours. Slash visited by many, tiny, dipteran insects. Meaty and bitter. Faint, agreeable smell.

c. Exudate----Copious, white, slightly sticky exudate (especially

in young trees).

d. Thickness----2.5-6 mm.

17. Wood----Cream-colored or light yellow, soft to moderately hard.

18. Height category----H. Up to 37 m.

19. Buttressing----Narrow buttresses.

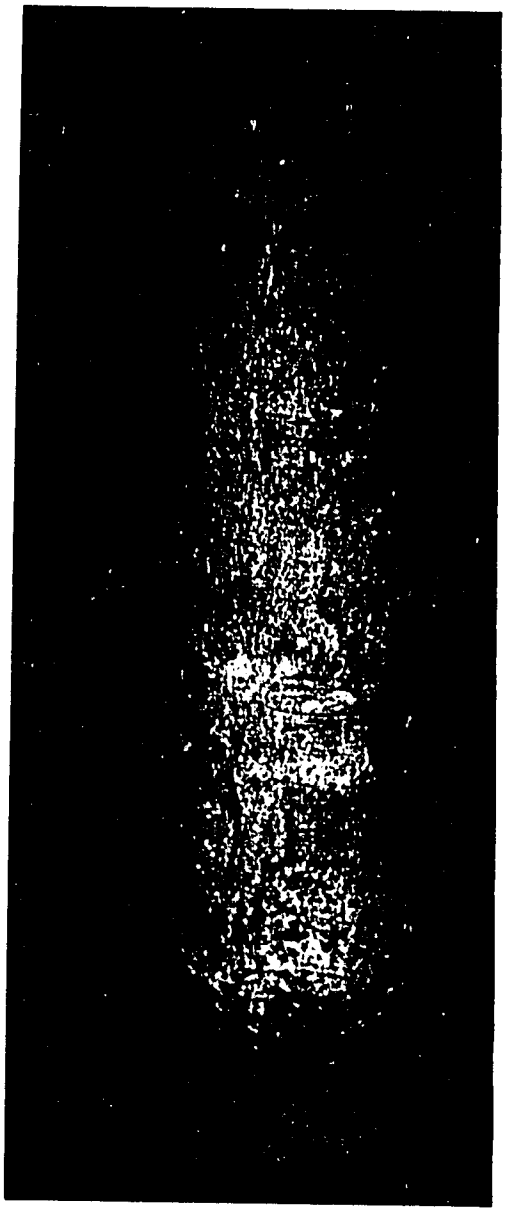
20. Bole----Straight, occasionally crooked, round.

21. Additional remarks----Leaves very much resemble those of *Theobroma cacao*. Commonly known locally in Ghana therefore as "the fool's cocoa". A lot of slender twigs. Slash heals very well after 6 months, with callus growing to cover all of exposed wood.

PLATE 120

Sterculia tragacantha (Sterculiaceae)

Bole, bark, and eyemarks.



Family	Species	Vernacular name
Sterculiaceae	*Sterculia tragacantha*	sofo

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to narrowly elliptic.

b. Apex----Acuminate. **c. Base**----Cordate to lobate.

3. Margin----Entire to crenate.

4. Glands----Tiny, dark brown, glandular-like dots on petiole and young twigs.

5. Leaf size----10-18 x 5-11 cm.

6. Petiole----Normal. **Fluted** and rugose at apex and base. Glabrous.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Erect hairs, 0.4-0.6 mm long in domatia at primary-sec vein apical junctions. Rest of blade glabrous. Other, shorter, tiny, erect hairs, 0.2-0.4 mm long

on buds. Juvenile leaves have stellate hairs.

ii. **Density**----Abundant. Stellate hairs dense on juvenile leaves but disppear with age.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute wide, nearly uniform, upper angles sometimes more obtuse.

b. **Course**----Curved abruptly, unbranched. Infrequently forked near junction with primary vein.

c. **Loop-forming branches**----Acute, enclosed by sec and tertiary arches.

d. **Inter-secondary veins**----Absent.

11. **Tertiary veins**

Pattern----Random reticulate.

12. **Higher order venation**----Quaternary veins random; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Pentagonal and polygonal.

15. Bark

a. Texture, & features----Thick, very fibrous. Outside rough; smooth when young. Flakes when old, leaving patches up to 8 cm deep. Many, vertical slits on prominent gray or brown cork. Very prominent eyemarks. Some hoop marks.

b. Color----Gray with greenish tint, brown, or light gray with whitish tint.

16. Slash

a. General color----Light purple, brownish-pink, cream-colored, or reddish-purple with one or two red rings.

b. Characteristics----Cover of outer bark with faint purple tint. Outer bark has light reddish-purple marks, and becomes deeper brown after 2 mins. Inner bark light brownish-cream. Whole slash becomes light brown after 30 secs. Strong,

agreeable smell.

c. Exudate----Gummy exudate. Sometimes no exudate.

d. Thickness----2-5 mm.

17. Wood----Cream-colored, or creamy-yellow, very soft.

18. Height category----h. Up to 25 m.

19. Buttressing----Often with slender, small buttresses. Sometimes unbuttressed.

20. Bole----10-14 m, Crooked to straight, round, sometimes flattened.

21. Additional remarks----Tree of open parts of forest fringes, widespread in tropical Africa. Branches whorled. Large, clustered leaves, commonly used commercially to wrap food (especially kenkey) in Ghana. Slash heals very well, with creamy, pulpy exudate still on it after 10 months.

PLATES 121 & 122

Triplochiton scleroxylon (Sterculiaceae)

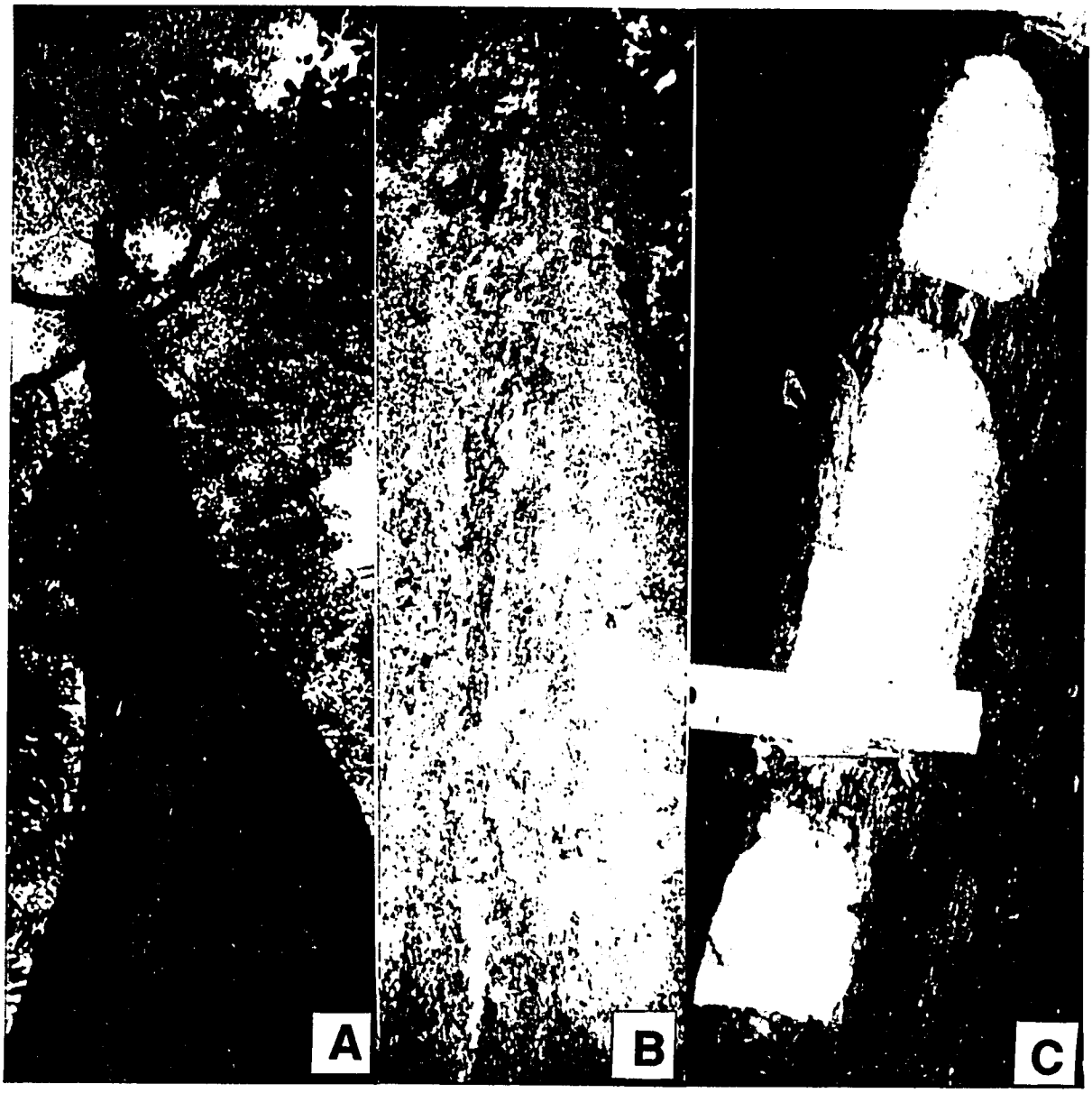
121A----Seedling and leaves. 121B----Old bole and buttresses.

122A----Bole and crown (tree measured 70.8m).

122B----Bark.

122C----Slash (below--after 15 seconds; above--after one minute).


A
B


A
B
C

Family	Species	Vernacular name
Sterculiaceae	*Triplochiton scleroxylon*	wawa

---

1. Organization

a. Leaf type----Compound, Palmate. Mature leaves 5-7-lobed.

b. Phyllotaxy----Alternate.

2. Shape (lobes)

a. Form----Narrowly elliptic. **b. Apex**----Acuminate.

c. Base----Hastate.

3. Margin----Entire to crenate. **4. Glands**----Absent.

5. Lamina size----Average 10-15 x 4-6 cm.

6. Petiole----Normal. Apex flattened. Base and apex **fluted.**

7. Hairs

a. Abaxial surface----Glabrous.

b. Adaxial surface----Glabrous.

8. Venation----Actinodromous (Perfect, Marginal, Basal).

9. Primary vein----Straight to markedly curved, branched.

10. Secondary veins

a. Angle of divergence----Right angle. Acute moderate near apex and base.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Right angle to obtuse; enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Composite.

11. Tertiary veins

Pattern----Random reticulate.

12. Higher order venation----Quaternary veins orthogonal. Rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Thick, fibrous, fissured. Otside smooth but rough and flaky with age. Shallow, vertical slits. Lenticels in vertical rows. Prominent eyemarks.

b. Color----Gray, gray-brown, or brown.

16. Slash

a. General color----Light yellow, grayish-yellow with brown vertical bands, or cream-colored.

b. Characteristics----Slash and sapwood change to light brown with purple tint after 30 secs, and deeper brown after 3 mins. Inner bark more fibrous than outer bark. Faint, pleasant smell. Slash visited by ants and other insects.

c. Exudate----Non-sticky, initially scanty exudate, that collects into copious, transparent, colloid with white tint.

d. Thickness----2-9 mm.

17. Wood----White, moderately hard.

18. Height category----H. Up to 71 m.

19. Buttressing----Large, tall, narrow buttresses.

20. Bole----Straight, infrequently crooked, cylindrical, sometimes flattened halfway.

21. Additional remarks----Large, deciduous tree with glabrous twigs that have rings at nodes, and maple-like leaves. Leaves

5-7-nerved at base. Leaves of seedlings larger and more deeply lobed. Veins pale green on abaxial side of dry leaf, and reddish-brown on adaxial side. Abaxial side of dry lamina pale green; adaxial side very dark green with brownish tint. Intercostal area divided into tiny grids of length 0.2-0.3 mm.

ULMACEAE

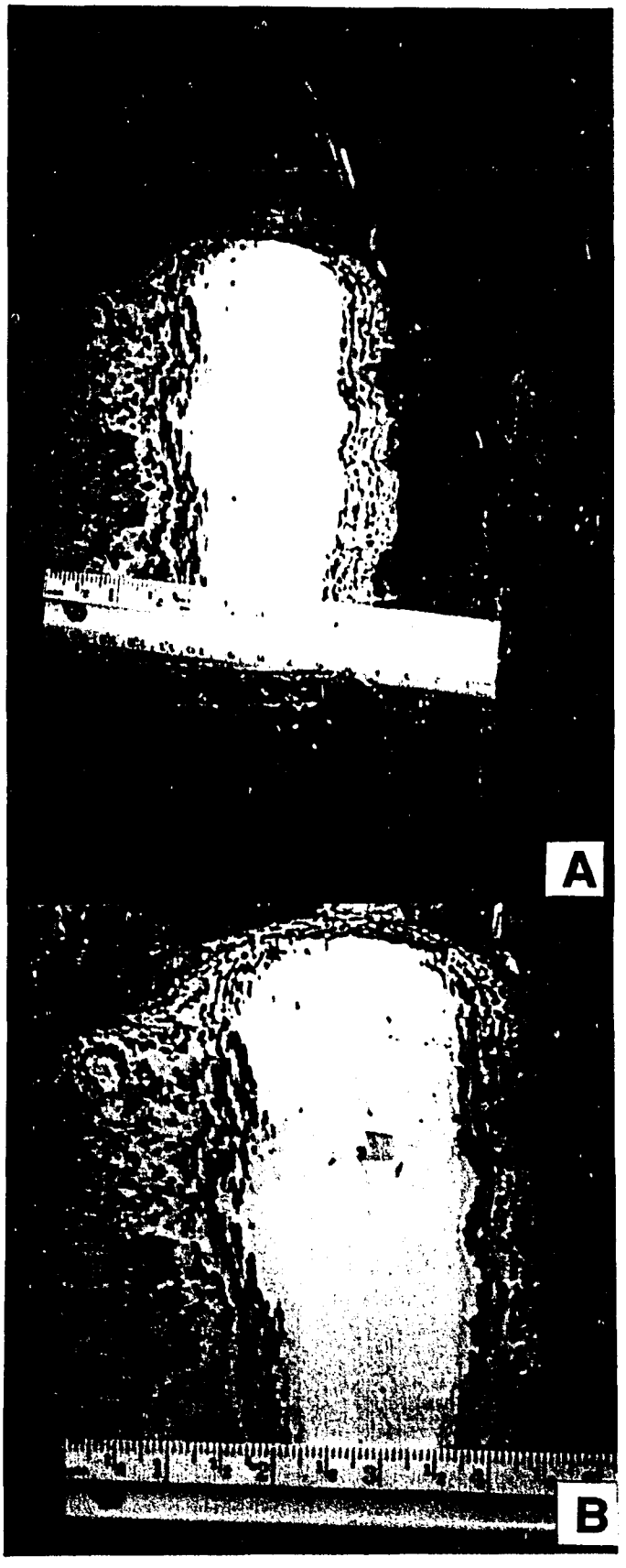
Trees or shrubs. Leaves alternate, simple, often unequal sided. Stipules paired, caducuous.

A family of 4 genera and 10 species in West Africa. The family is mainly in the Northern Hemisphere. There are one genus and four species in the Bobiri forest reserve.

PLATE 123

Celtis adolfi-friderici (Ulmaceae)

A & B----Slash.


A
B

Family	Species	Vernacular name
Ulmaceae	*Celtis adolfi-friderici*	esakosua

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Cuneate to decurrent, very assymetrical.

3. Margin----Entire.

4. Glands----Round glands, about 0.3 mm in diameter, connected to veins.

5. Leaf size----8-18 x 5.5-10 cm.

6. Petiole----Normal; sometimes slightly winged. Shiny, vertical ridges on abaxial side, often traversed by few, horizontal, shallow splits on the epidermal layer. Midrib channel continues on adaxial side.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Characteristic transparent hairs, 0.2-0.3 mm long in domatia at primary-sec and primary-tertiary apical vein junctions (not found in *Celtis zenkeri* or *Celtis mildbraedii*). Similar hairs on primary vein. Tiny hairs, about 0.1 mm long at 20x, on whole blade and petiole. Scabrid, at least when young.

ii. Density----Hairs in domatia abundant. Tiny hairs on blade abundant, sparse on primary vein and petiole.

b. Adaxial surface----Glabrous.

8. Venation----Actinodromous (Perfect, Marginal, Basal).

9. Primary vein----Markedly curved, branched. **Megaprimary vein** bigger.

10. Secondary veins

a. Angle of divergence----Acute wide, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse; enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Percurrent.

i. Course----Forked, some sinuous or retroflexed.

ii. Relation to midvein----Mostly right angle. Tertiaries originating exmedially as arches are slightly oblique.

iii. Arrangement----Predominantly alternate.

12. Higher order venation----Obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

a. Texture, & features----Hard, brittle. Outside rough. Wide eyemarks and several hoop marks. Scattered lenticels, majority in vertical rows.

b. Color----Gray to gray-brown.

16. Slash

a. General color----Cream colored.

b. Characteristics----Several, dark brown blotches, mostly in concentric rings in inner bark; blotches scattered in outer

bark. Cover of outer bark light yellow, becoming dark gray after 5 mins, preceded by dark brown, brittle cork layer. Inner bark and sapwood darken to gray after 2 min. Moderate, agreeable odor.

c. Exudate----Clear, non-sticky exudate.

d. Thickness----2-6 mm.

17. Wood----Light yellowish-cream, hard, with moderate smell.

18. Height category----H. Up to 34 m.

19. Buttressing----Medium-sized, narrow buttresses.

20. Bole----Straight, round, sometimes flattened near base.

21. Additional remarks----Tree with dark green crown. Leaves 3-nerved, basal nerves almost raching apex. Slash heals quite poorly after 6 months.

PLATES 124 & 125

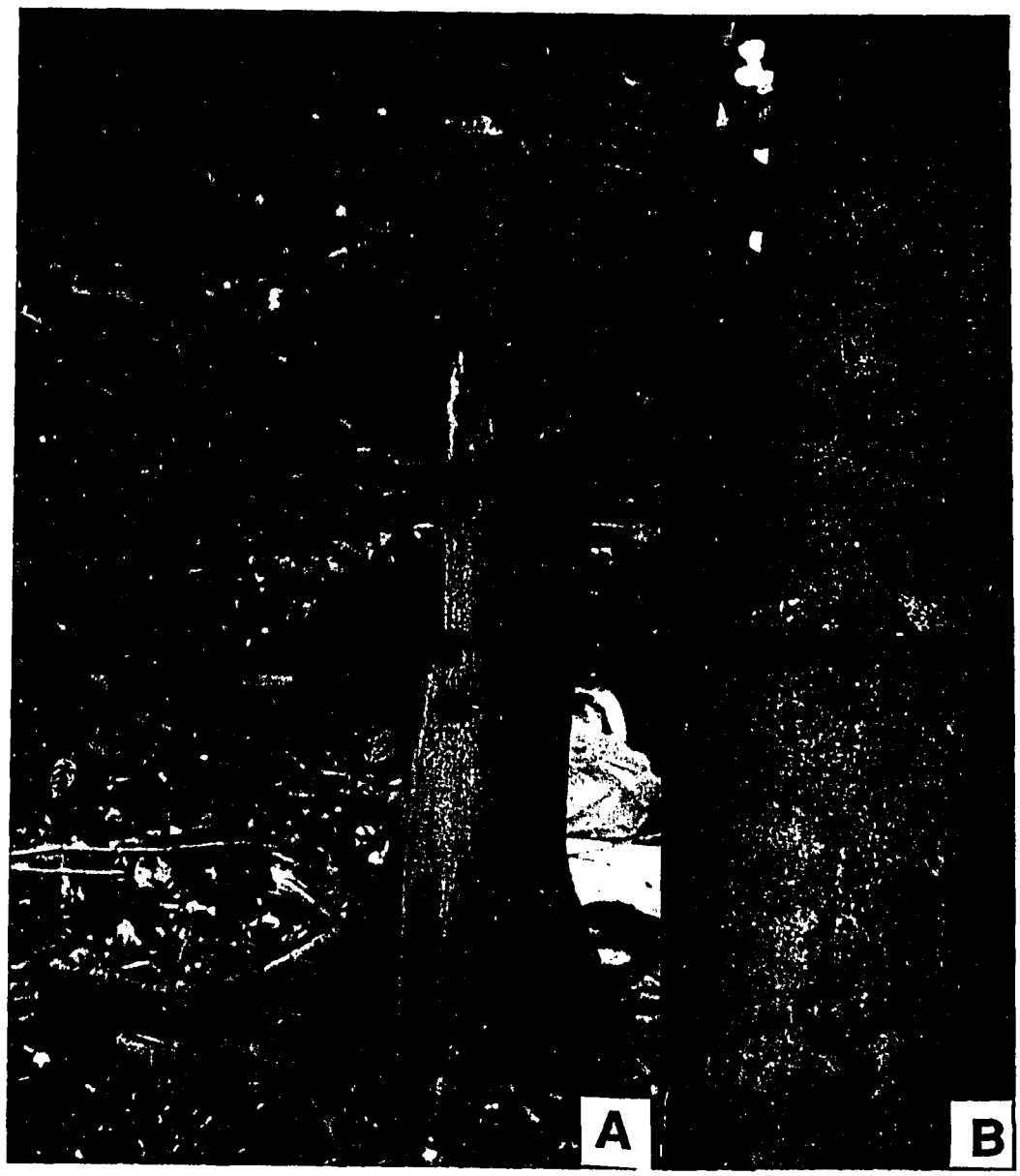
Celtis brownii (Ulmaceae)

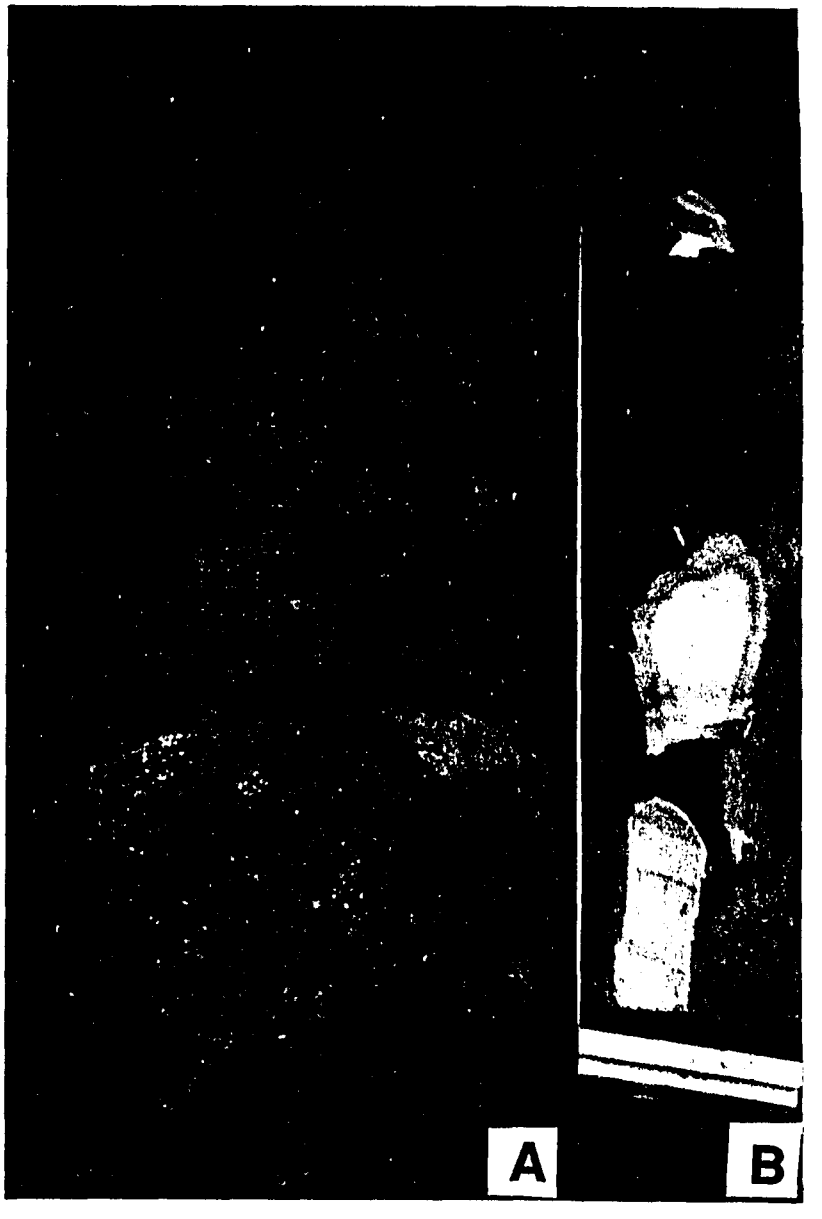
124A----Bole and buttresses.

124B----Bole and bark.

125A----Bark and hoop marks.

125B----Slash (middle--after 15 seconds; above and below--after one minute).


A
B


A
B

Family	Species	Vernacular name.
Ulmaceae	*Celtis brownii*	

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Acuminate.

c. Base----Acute.

3. Margin----Serrate. Teeth not many, usually not more than 10 on one side of blade. Irregular spacing, simple series, angular sinuses, apical convex, basal convex.

4. Glands----Absent. **5. Leaf size**----5.5-15 x 2-6.5.

6. Petiole----Normal, short, flattened dorsoventrally, with tiny , many, vertical ridges.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Mixture of erect and appressed hairs, 0.1-0.2 mm long at 20x, on primary, and some sec

veins. Appressed, closely packed hairs on buds at 20x.

b. Adaxial surface----Glabrous.

8. Venation----Actinodromous (Perfect, Marginal, Basal).

9. Primary vein----Straight, unbranched.

10. Secondary veins

a. Angle of divergence----Acute moderate, nearly uniform.

b. Course----Curved abruptly, unbranched.

c. Loop-forming branches----Obtuse, enclosed by tertiary and quaternary arches.

d. Inter-secondary vein----Absent.

11. Tertiary veins

Pattern----Orthogonal reticulate.

12. Higher order venation----Quaternary veins orthogonal, rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles

a. Development----Well developed.

b. Shape----Quadrangular.

15. Bark

a. Texture, & features----Brittle. Outside rough. Very prominent lenticels, some scattered but mostly in vertical rows. Prominent eyemarks.

b. Color----Gray with greenish tint.

16. Slash

a. General color----Light brownish-yellow.

b. Characteristics----Scattered brown dots in outer and inner barks. Slash quickly darkens to very deep brown after one min.

c. Exudate----None.

d. Thickness----4-5 mm.

17. Wood----Moderately hard.

18. Height category----h. Up to 18 m.

19. Buttressing----Small, branched, smooth buttresses, sometimes anastomosing.

20. Bole----Crooked, round.

21. Additional remarks----Understory tree with short bole and

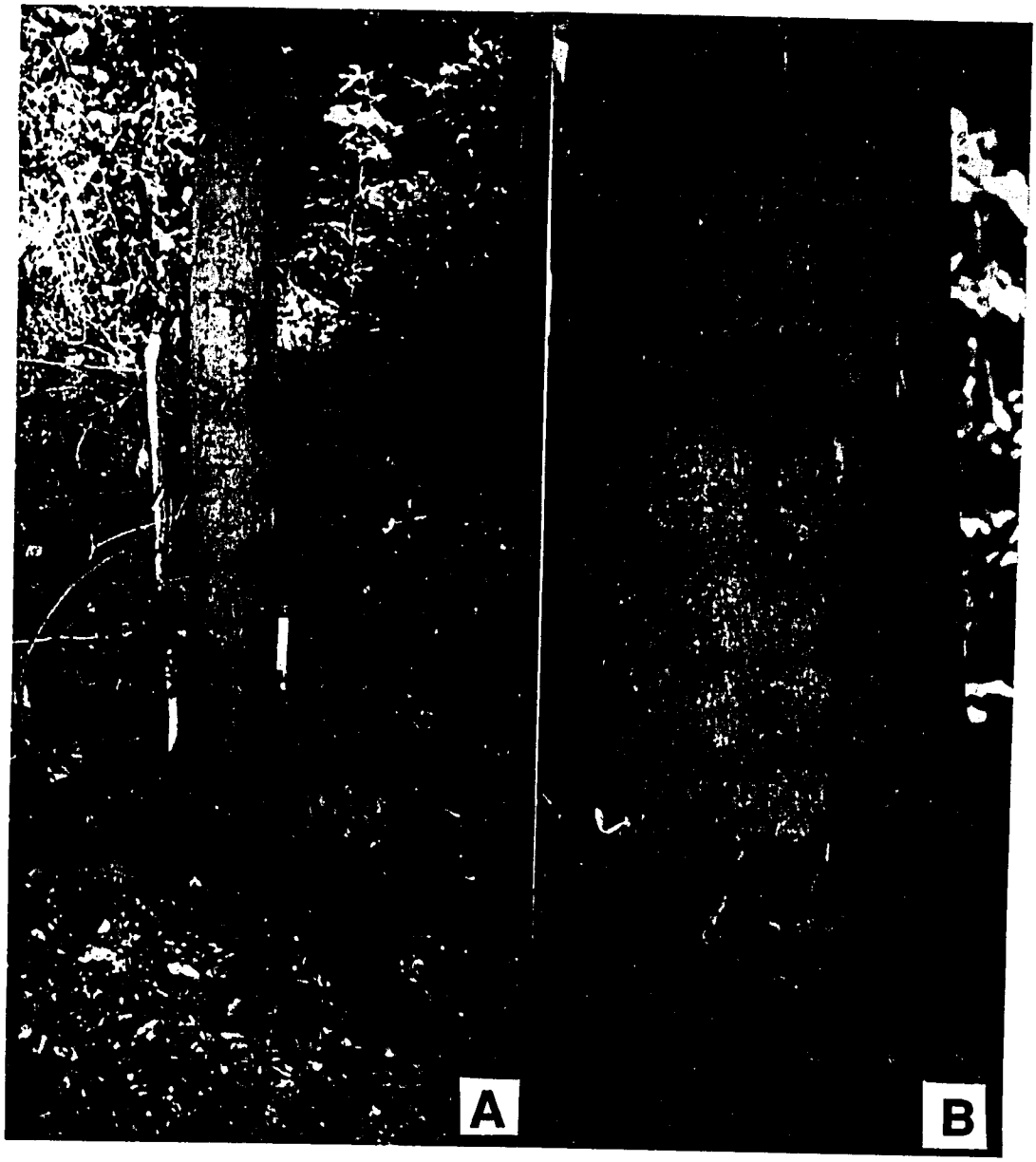
spreading crown. Usually found in dry forest. Andoh (In : Hutchinson & Dalziel,1954-72) collected flowered specimens in the Bobiri reserve in March. Young twigs shiny and glabrous. Leaf papery; blade and veins all shiny under microscope.

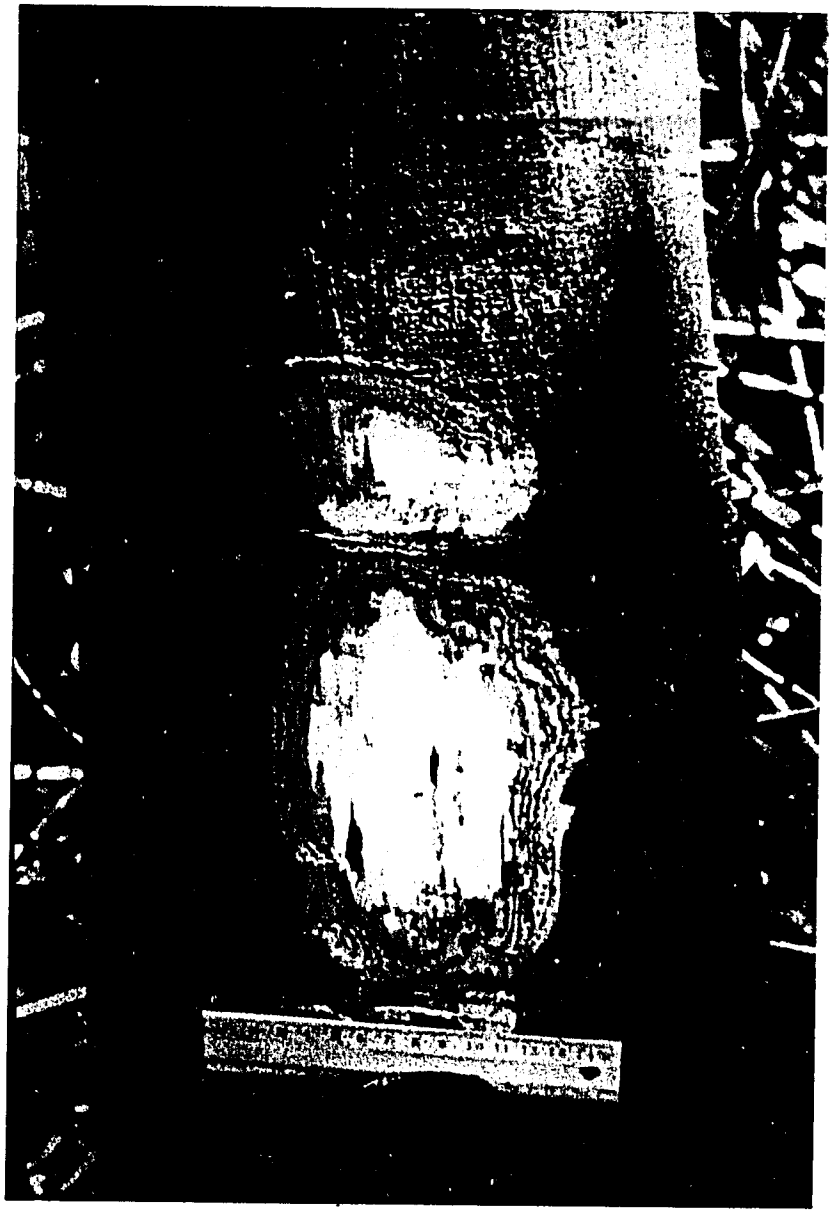
PLATES 126 & 127

Celtis mildbraedii (Ulmaceae)

126A----Bole and buttresses. 126B----Bark and eyemarks.

127---Slash (above--after 15 seconds; below--after one minute).


A
B



Family	Species	Vernacular name
Ulmaceae	*Celtis mildbraedii*	esa

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic to narrowly elliptic.

b. Apex----Acuminate. **c. Base**----Acute to cuneate.

3. Margin----Entire to serrate. Juvenile leaves serrate or crenate near apex. Serrations with irregular spacing, simple series, rounded to erose sinuses, apical side straight to convex, basal side concave to straight.

4. Glands----Absent. **5. Leaf size**----3.5-15.5 x 1.5-7 cm.

6. Petiole----Normal. **Fluted.**

7. Hairs

a. Abaxial surface

i. Type, color, & location----Appressed, whitish hairs (brown on petiole and young twigs), 0.2-0.7 mm long, on

veins, petiole, buds, and young twigs. Erect hairs of similar size in intercostal areas, near base of petiole, and on young twigs. Hairs can be as long as 5 mm on terminal buds.

ii. **Density**----Abundant at all locations.

b. **Adaxial surface**----Relatively glabrous, with very few appressed hairs.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight to markedly curved, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute narrow, nearly uniform.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute, enclosed by tertiary and quaternary arches.

d. **Inter-secondary vein**----Absent.

e. **Number**----3-5 pairs.

11. **Tertiary veins**

Pattern----Percurrent.

i. **Course**----Many forked, some straight.

ii. Relation to midvein----Right angle.

iii. Arrangement----Alternate and opposite in about equal proportions.

12. Higher order venation----Quaternary veins orthogonal; rest of higher order veins obscure.

13. Marginal ultimate venation----Looped.

14. Areoles----Imperfect.

15. Bark

i. Texture, & features----Hard and brittle. Smooth to rough (Smoother than in *Celtis zenkeri*). Many, tiny lenticels, some scattered or in spiral arrangement, but mainly in vertical rows.

ii. Color----Dark gray or brown.

16. Slash

a. General color----Light yellow to orange, or cream-colored.

b. Characteristics----Brown, continuous bands, less darker than in *Celtis zenkeri*. Becomes reddish-brown to gray after two mins. Moderate, agreeable smell.

c. Exudate----None.

d. Thickness----2-6 mm.

17. Wood----Light yellow, hard.

18. Height category----H. Up to 37 m.

19. Buttressing----Narrow buttresses, well developed.

20. Bole----Straight, round, sometimes flattened near base.

21. Additional remarks----Tall tree with narrow crown and slender, clean bole. Sometimes with low branching. Slash heals moderately after 6 months. Juvenile leaves sometimes larger than older leaves. Very clear venation pattern.

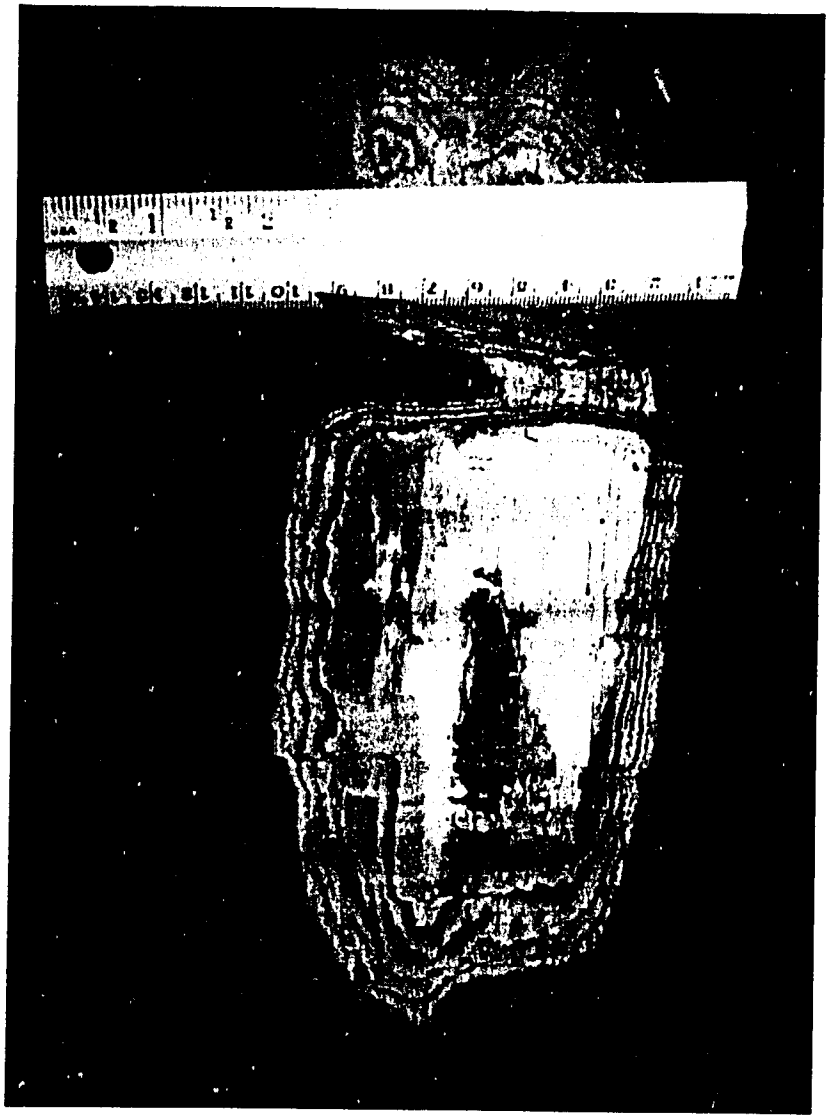
PLATES 128 & 129

Celtis zenkeri (Ulmaceae)

128A----Bole and crown. 128B & C----Bole and buttresses.

129----Slash (above--after 15 seconds; below--after one minute)


A
B
C



Family	Species	Vernacular name
Ulmaceae	*Celtis zenkeri*	esakoko

---

1. Organization

a. Leaf type----Simple. **b. Phyllotaxy**----Alternate.

2. Shape

a. Form----Elliptic. **b. Apex**----Attenuate.

c. Base----Cuneate to decurrent; assymetric.

3. Margin----Toothed-serrate. Simple series, regular spacing, rounded sinuses, apical angle acute, apical concave, basal convex.

4. Glands----Many, tiny, glandular-like swellings in intercostal area, 0.2-0.5 mm in diameter.

5. Leaf size----6-15 x 3-7.5 cm.

6. Petiole----Normal.

7. Hairs

a. Abaxial surface

i. Type, color, & location----Stiff, appressed, apically-pointing brown hairs, 0.2-0.6 mm long, on veins,

especially primary and sec. Similar hairs on young petioles, buds and young twigs.

ii. **Density**----Abundant; especially dense on buds and young petioles.

b. **Adaxial surface**----Glabrous.

8. **Venation**----Camptodromous (Brochidodromous).

9. **Primary vein**----Straight, unbranched.

10. **Secondary veins**

a. **Angle of divergence**----Acute moderate; lowest pair more acute.

b. **Course**----Curved abruptly, unbranched.

c. **Loop-forming branches**----Acute, enclosed by tertiary and quaternary arches.

d. **Inter-secondary vein**----Usually absent; few cases present, joining primary and sec vein.

e. **Number**----3-6 pairs.

11. **Tertiary veins**

Pattern----Percurrent.

i. **Course**----Mainly simple, few forked, some convex.

ii. **Relation to midvein**----Right angle and oblique in about equal proportions.

iii. **Arrangement**----Alternate and opposite in about equal proportions.

12. **Higher order venation**----Quaternary veins orthogonal; rest of higher order veins obscure.

13. **Marginal ultimate venation**----Looped.

14. **Areoles**

a. **Development**----Well developed.

b. **Shape**----Quadrangular.

15. **Bark**

a. **Texture, & features**----Fibrous, pliable. Outside smooth to rough. Several hoop marks and few eyemarks. Ellipsoid, horizontally-oriented lenticels (up to 6 cm in length) arranged in vertical, scalariform-like rows that traverse the trunk spirally. Sometimes flakes when old, leaving several, round holes.

b. Color----Gray to gray-brown, or dark gray.

16. Slash

a. General color----Light yellow or cream-colored.

thin, brown rings alternating yellowish bands in inner bark. Slash begins to darken after 5 secs, light brown after 30 secs, purplish-gray or gray-brown after 3 mins, and dark brown after 5 mins. Brown ring near sapwood after 10 mins. Moderate, agreeable smell.

c. Exudate----Clear, slightly sticky, scanty exudate.

d. Thickness----3-7 mm.

17. Wood----Cream-colored to light yellow, hard.

18. Height category----H. Up to 57 m.

19. Buttressing----Long, plank buttresses.

20. Bole----Straight, round; base sometimes crooked or flattened.

21. Additional remarks----Tree with pale yellowish-green crown. Leaves with markedly scalariform venation. Stipules ovate-lanceolate, about one cm long. Slash heals moderately after 6 months, with relatively narrow callus.

CONCLUSIONS

The present study of the Bobiri forest reserve has provided information on the composition and, structure, of the Moist Semi-deciduous Forest of Ghana. This work has also provided detailed descriptions of the trees of the Bobiri forest. The descriptions will facilitate tree identification, especially from sterile material.

Calculations of species importance values now enables us to classify the Bobiri forest, based on species importance values, as a Celtis-Triplochiton-Sterculia Association. This is a more scientific, repeatable, and quantitative approach to forest classification, as in contrast to previous classifications which were based on the casual observation of dominant trees. This method should be extended to cover other forests in West Africa and Africa as a whole.

The importance value of 41.4 for *Celtis zenkeri*, the most important and most dominant tree in the Bobiri forest, ranks quite high in comparison with other tropical forests. Although diversity in the Bobiri forest is low, the density of 735 trees per hectare is high when

compared with other Neotropical forests.

The family importance value of 59.8 for the most important family, the Sterculiaceae, is also high when compared with the FIV's of Neotropical forests. The results indicate that the most important families usually contain the most important species. In the Bobiri forest, the Ulmaceae and the Apocynaceae, which are among the first four most important families, also contain the four most important species, *Celtis zenkeri, Funtumia africana, Sterculia rhinopetala,* and *Triplochiton scleroxylon.*

In the Bobiri forest, the majority of the trees fall into the 10-29 cm. DBH class and the 20-39 m. height class. The Bobiri forest contains 7.7% megaphanerophytes (heights exceeding 30 m) and 88% mesophanerophytes (heights 8-30 m). This makes it predominantly a medium-sized tree forest. The emergent trees are, however, among the tallest in the world, reaching up to 70 meters or more in height. Majority of the trees have straight boles and hardwood, providing some of the most useful timber species in West Africa.

The Bobiri forest might be stratified, with three possible layers of the canopies. This stratification is accounted for primarily by the pattern of distribution of the varied mixture of tall, medium-sized, and short trees in the forest. This is affirmed by graphs of the tree heights in my 1000 tree sample that suggest groupings of the tree crowns at three separate heights in the forest. The distribution of the crowns at different levels, gives a characteristic physiognomy of the forest to an observer from a distance.

One half of the sampled trees were significantly buttressed, and one quarter had incipient buttresses. Therefore, about 77% of the trees of the Bobiri forest are buttressed. The extent of buttressing is higher than up to date recorded buttressing for Neotropical forests.

Buttresses have value in tree identification. The buttresses encounterd in the Bobiri forest are so varied that I have classified them into at least 20 categories. Some long and tall buttresses are found in the Bobiri forest, reaching seven meters long or tall.

The bark of the trees of the Bobiri forest generally ranges between

one and four millimeters thick, but a few species like, *Cola gigantea,* have thick bark to 14 or more mm in thickness. Generally, there is a gradual increase in bark thickness as a trees grows bigger. Many trees, however, do not show appreciable increases in bark thickness with age. The phellem (cork) is usually a very thin part of the bark of the trees of the Bobiri forest, and the outer bark is usually thicker than the inner bark.

The bark provides useful taxonomic features for separating families, genera, and species. Most barks of the Bobiri forest are smooth. A minority of the species have rough bark. Very few species possess spines.

Morphological examination and measurements, combined with digitized computer imagery, indicates that a typical leaf of the trees of the Bobiri forest is mesophyllic (Figs. 203-207 and Tables XXIII & XXIV). The leaf shape is predominantly elliptic or narrowly elliptic (Fig. 207). The majority of the leaves are simple and the tips are usually acute, or acuminate. This is not surprising in a moist forest because of the

frequent need to drain off excess water from the leaves. The leaf base is usually acute or cuneate. Almost all the leaves of the trees of the Bobiri forest have Camptodromous (Brochidodromous) venation. The majority possess simple hairs, although few species have stellate hairs. Leaves that are glabrous abaxially and adaxially are very few. The leaves of few species have glands.

TABLE I

LOCATION	SIZE (Ha.)	NO. OF SPP
1. West Africa (entire flora)	-----	7,000
2. Ivory Coast (rain forest trees)	-----	~600
3. Ghana (entire flora)	-----	~2,000
4. Ghana (forest trees)	-----	~650
5. Uganda (forest trees & large shrubs)	-----	400
6. Mpanga, E. Africa (flowering plants)	-----	200
7. New Caledonia (entire flora)	-----	3,000
8. Maleysia (all vegetation types)	-----	25-30,000
9. Malay Peninsula	-----	9,000
10. Malaya (trees)	1 ha	200
11. Jengka, Malaya (canopy trees)	1 ha	115
12. Jengka, Malaya (canopy trees)	22 ha	2,633
13. Malaysia (Dipterocarpaceae)	-----	380
14. Malaysia (Wild figs)	-----	380

15. New Guinea (trees)	1 ha	100-150
16. Mpane, Surinam (trees)	5.6 ha	206
17. Badas, Brunei (trees)	2 ha	144
18. Western Ecuador (vascular plants)	0.1 ha	365

Sources (as arranged in table)

Richards, 1973 (1, 2, 9).

Hall and Swaine, 1981 (3, 4).

Langdale-Brown et al, 1964 (5).

Richards, 1952 (6).

Myers, 1980 (7).

Van Steenis, 1948 (8).

Whitmore, 1975 (10, 15).

Poore, 1968 (11, 12).

Jacobs, 1988 (13, 14).

Schulz, 1960 (16).

Ashton, 1964 (17).

Gentry, 1986 (18).

TABLE II

Plot size = **PL** Tree size = **TS** Number of species = **SPP**

LOCALITY	PL	TS	SPP
1. Bobiri forest, Ghana.	4 km tr.	>10 cm DBH	104
2. Cameroon forest, W. Africa.	15.6 ha	>10 cm DBH	109
3. Bugoma forest, Uganda.	45 km^2	Canopy trees	80
4. Mpanga, Uganda, E. Africa.	-----	>10 ft girth	60
5. Kibale, Uganda, E. Africa.	-----	>10 ft girth	30
6. Jengka, Central Malaya.	22 ha	>30 cm DBH	357
7. Rengam forest, Malaya.	1 ha	>10 cm DBH	227
8. Lowlands, Western Malaya.	1.6 ha	>30 cm DBH	227
9. Andulan forest, Brunei.	2 ha	>10 cm DBH	220
10. Brunei forest (trees).	-----	>10 cm DBH	2,000
11. Mpane, Suriname.	1 ha	>35 cm DBH	32
12. Neotropics (forest trees).	7,614	Canopy trees	186
13. Amazon forest.	2.5 acres	>2 ins DBH	235

14. Brazil, Manaus (350 trees).	1 ha	>15 cm DBH	179
15. Brazil, Camaipi, Amapa.	4 km tr.	>10 cm DBH	100
16. Peru, (forest trees).	1 ha	----------	283
17. Amazonia Peru (600 trees).	1 ha	>10 cm DBH	300
18. Western Ecuador.	0.1 ha	Trees & herbs	365

Source (numbers as arranged in table)

Kisseadoo 1993 (1).

Jacobs, 1988 (2, 7, 9).

Lind & Morrison, 1974 (3).

Langdale-Brown et al, 1964 (4, 5)

Poore, 1968 (6).

Ashton, 1964 (10).

Schulz, 1960 (11).

Hubbel & Foster, 1983 (12).

Prance, In : Caufield,1986 (13).

Prance et al, 1976 (14).

Mori et al, 1989 (15).

Whitmore, 1990 (16, 17).

Gentry, 1986 (17, 18).

TABLE III

List Of Importance Values Of The 104 Species In The 1000 Tree Sample Of The Bobiri Forest Reserve, Ghana, West Africa.

FR = Frequency. **N** = Number of trees. **Do** = Dominance (Basal area/cm). **IV** = Importance Value.

SPECIES	FAMILY	FR	N	Do (cm^2)	IV
Celtis zenkeri	Ulmaceae	96	130	85341.2	41.40
Funtumia africana	Apocynaceae	85	114	23149.0	25.87
Sterculia rhinopetala	Sterculiaceae	74	82	35919.0	24.03
Triplochiton scleroxylon	Sterculiaceae	45	51	50945.6	20.70
Strombosia glaucescens	Olacaceae	34	37	10913.3	9.89
Ricinodendron heudelotii	Euphorbiaceae	21	21	19801.2	8.62
Guarea cedrata	Meliaceae	28	32	8995.6	8.31
Nesogordonia papaverifera	Sterculiaceae	16	19	16790.0	7.24
Terminalia superba	Combretaceae	19	20	10663.7	6.43
Funtumia elastica	Apocynaceae	20	25	5880.8	6.07

Ficus exasperata	Moraceae	17	18	10263.8	5.92
Cola gigantea	Sterculiaceae	21	22	52221.0	5.74
Sterculia tragacantha	Sterculiaceae	19	22	5336.0	5.55
Celtis adolfi-friderici	Ulmaceae	13	15	11299.2	5.38
Pterygota macrocarpa	Sterculiaceae	17	20	4795.2	5.01
Cylicodiscus gabonensis	Mimosaceae	7	7	1534.6	4.72
Blighia welwitschii	Sapindaceae	9	10	12041.0	4.58
Crudia gabunensis	Caesalpiniaceae	16	16	5222.6	4.58
Celtis mildbraedii	Ulmaceae	25	26	5872.2	4.40
Trichilia prieuriana	Meliaceae	17	18	2583.6	4.36
Turraenthus africanus	Meliaceae	11	13	8054.3	4.29
Piptadeniastrum africanum	Mimosaceae	10	10	9980.8	4.28
Sterculia oblonga	Sterculiaceae	13	14	4793.8	3.96
Aningeria robusta	Sapotaceae	6	6	11849.6	3.80
Albizia zygia	Mimosaceae	7	7	10491.6	3.74
Bussea occidentalis	Caesalpiniaceae	8	8	6813.0	3.20
Khaya ivorensis	Meliaceae	9	9	4976.7	3.03

Petersianthus macrocarpa	Lecythidaceae	8	8	5705.1	2.97
Entandrophragma cylindric.	Meliaceae	6	7	7266.2	2.96
Rauvolfia vomitoria	Apocynaceae	11	11	2397.4	2.94
Alstonia boonei	Apocynaceae	11	11	2108.9	2.88
Hannoa klaineana	Simaroubaceae	8	8	3516.0	2.53
Carapa procera	Meliaceae	10	11	1845.2	2.72
Pycnanthus angolensis	Myristicaceae	7	7	4056.8	2.42
Myrianthus libericus	Moraceae	7	10	2572.8	2.41
Myrianthus arboreus	Moraceae	9	9	1420.8	2.31
Antiaris toxicarium	Moraceae	7	7	2121.4	2.02
Ceiba pentandra	Bombacaceae	6	6	2381.3	1.87
Amphimas pterocarpoides	Caesalpiniac.	5	6	2359.2	1.75
Macaranga heudelotii	Euphorbiaceae	5	5	2546.2	1.59
Albizia adianthifolia	Mimosaceae	4	4	3481.2	1.51
Musanga cecropioides	Moraceae	3	3	3284.3	1.31
Celtis brownii	Ulmaceae	1	1	373.3	1.29
Baphia nitida	Papilionaceae	5	5	679.1	1.21

Cleidion gabonicum	Euphorbiaceae	5	5	545.1	1.18
Morus mesozygia	Moraceae	4	4	1115.5	1.08
Discoglypremna caloneura	Euphorbiaceae	4	4	798.7	1.01
Cola nitida	Sterculiaceae	4	4	755.7	1.00
Cola millenii	Sterculiaceae	4	4	496.7	0.95
Chrysophyllum subnudum	Sapotaceae	2	2	2327.3	0.90
Ongokea gore	Olacaceae	2	2	2165.7	0.87
Hymenostegia afzelii	Caesalpiniaceae	3	3	885.0	0.82
Berlinia tomentella	Caesalpiniaceae	1	1	2734.3	0.77
Lannea welwitschii	Anacardiaceae	3	3	511.7	0.74
Mischogyne elliotiana	Annonaceae	2	3	903.6	0.71
Entandrophragma angolense	Meliaceae	11	13	3439.7	0.70
Baphia pubescens	Papilionaceae	3	3	273.0	0.70
Berlinia confusa	Caesalpiniaceae	1	1	2376.1	0.69
Ficus variifolia	Moraceae	2	2	1125.8	0.66
Maniophyton fulvum	Euphorbiaceae	2	2	1115.0	0.66
Mammea africana	Guttiferae	2	2	1125.0	0.66

Dalbergiella welwitschii	Papilionaceae	2	2	1069.4	0.65
Entandrophragma candollei	Meliaceae	2	2	1013.0	0.64
Leptaulus daphnoides	Icacinaceae	2	2	749.8	0.58
Nauclea diderrichii	Rubiaceae	2	2	739.8	0.58
Drypetes aframensis	Euphorbiaceae	2	2	702.4	0.57
Blighia sapida	Sapindaceae	2	2	432.6	0.52
Erythrina senegalensis	Papilionaceae	2	2	311.6	0.49
Ficus sur	Moraceae	2	2	296.1	0.49
Calpocalyx brevibracteatus	Mimosaceae	2	2	226.2	0.48
Trilepisium madagascariense	Moraceae	1	1	1256.8	0.47
Psydrax paviflora	Rubiaceae	1	1	1182.5	0.45
Drypetes gilgiana	Euphorbiaceae	1	1	794.6	0.37
Strombosia zenkeri	Olacaceae	1	1	764.6	0.37
Blighia unijugata	Sapindaceae	1	1	498.8	0.31
Ficus barterii	Moraceae	1	1	471.5	0.31
Daniella ogea	Caesalpiniaceae	1	1	463.8	0.30
Diospyros soubreana	Ebenaceae	1	1	452.4	0.30

Enantia polycarpa	Annonaceae	1	1	452.4	0.30
Lecaniodiscus cupanioides	Sapindaceae	1	1	426.4	0.30
Chrysophyllum beguei	Sapotaceae	1	1	320.5	0.28
Distemonanthus benthamianus	Caeasalpi.1	1	339.8	0.28	
Leptonychia pubescens	Sterculiaceae	1	1	301.8	0.28
Aulacocalyx jasminiflora	Rubiaceae	1	1	298.7	0.27
Diospyros viridicans	Ebenaceae	1	1	299.6	0.27
Trichilia tessmannii	Meliaceae	1	1	283.6	0.27
Erythrina vogelii	Papilionaceae	1	1	227.0	0.26
Anthonotha macrophylla	Caesalpiniaceae	1	1	138.9	0.24
Berlinia grandiflora	Caesalpiniaceae	1	1	136.9	0.24
Copaifera salikounda	Caesalpiniacae	1	1	147.4	0.24
Lovoa trichiloides	Meliaceae	1	1	154.0	0.24
Spathodea campanulata	Bignoniaceae	1	1	132.7	0.24
Xylopia quintasii	Annonaceae	1	1	132.7	0.24
Antrocaryon micraster	Anacardiaceae	1	1	96.8	0.23
Aptandra zenkeri	Olacaceae	1	1	91.6	0.23

Corynanthe pachyceras	Rubiaceae	1	1	102.1	0.23
Diospyros monbuttensis	Ebenaceae	1	1	113.1	0.23
Drypetes principum	Euphorbiaceae	1	1	113.1	0.23
Greenwayodendron oliveri	Annonaceae	1	1	113.1	0.23
Kigelia africana	Bignoniaceae	1	1	86.6	0.23
Mareya micrantha	Euphorbiaceae	1	1	78.6	0.23
Pleiocarpa mutica	Apocynaceae	1	1	145.0	0.23
Strombosia grandifolia	Olacaceae	1	1	118.8	0.23
Zanthoxylum gilletii	Rutaceae	1	1	78.6	0.23

TABLE IV

Comparison Of Species Diversity And Tree Density Of The Bobiri Forest With 4 Other Neotropical Forests

SS = Sample size (number of trees). **DE** = Density (trees/ha).

ABA = Average basal area/tree (cm^2). **BA** = Basal area/ha (m^2).

NS = Number of species/800 trees.

Locality	SS	DE	ABA	BA	NS
1.Saul, Fr. Guiana	800	619	856.7	53.0	295
2.Anangu, Ecuador	800	728	462.9	33.7	244
3.Camaipi, Brazil	1000	546	643.6	35.1	188
4. Bahia, Brazil	600	819	519.1	46.3	239*
4. Bobiri, Ghana	1000	735	443.0	32.6	93

*Extrapolated from a 600 tree sample.

Sources : 1 (Mori & Boom, 1987) 2 (Balslev et al., 1987)

3 (Mori et al., 1989) 4 (Mori & Boom, 1983)

TABLE V

Comparison Of The Most Important Species Of The Bobiri Reserve With Those Of 3 Neotropical Forests

Locality	Most Important Species	IV
1.Camaipi, Brazil	Geissospermum argenteum (Apocynaceae)	51.1
2.Bobiri Forest, Ghana	Celtis zenkeri (Ulmaceae)	41.4
3.Anangu, Ecuador	Iriartea detoidea. R. & R. (Arecaceae)	27.1
4.Saul, French Guiana	Tetragastris altissima (Burseraceae)	17.9

Sources : 1 (Mori et. al., 1989) 3 (Balslev et al., 1987)

4 (Mori & Boom, 1987)

TABLE VI

Dominant Plant Families For The Bobiri Forest And Some Tropical Forests

(Families are arranged in descending order of dominance).

1. The Bobiri Forest Reserve, Ghana.

Type : Moist semi-deciduous.

1. Sterculiaceae	5. Moraceae	9. Olacaceae
2. Ulmaceae	6. Caesalpiniaceae	10. Sapindaceae
3. Meliaceae	7. Euphorbiaceae	11. Sapotaceae
4. Apocynaceae	8. Mimosaceae	12. Papilionaceae

2. Forest Of Uganda, East Africa

Type : Semi-deciduous

1. Ulmaceae	3. Meliaceae	5. Combretaceae
2. Sapotaceae	4. Mimosaceae	6. Moraceae

3. Lowland Forest, West Africa, Emergent And Upper Canopies

Type : Moist evergreen.

1. Bombacaceae
2. Caesalpiniaceae
3. Guttiferae
4. Meliaceae
5. Mimosaceae
6. Rubiaceae
7. Sapotaceae
8. Sterculiaceae

4. Lowland Forest, West Africa, Lower Canopy

Type : Moist evergreen, and dry forest.

1. Annonaceae
2. Apocynaceae
3. Bignoniaceae
4. Caesalpiniaceae
5. Euphorbiaceae
6. Guttiferae
7. Moraceae
8. Rubiaceae
9. Sapindaceae
10. Sterculiaceae

5. Dry Lowland Forest, West Africa, Emergent And Upper Canopies

Type : Peripheral semi-evergreen (semi-deciduous).

1. Bombacaceae
2. Combretaceae
3. Meliaceae
4. Mimosaceae
5. Moraceae
6. Sterculiaceae
7. Ulmaceae

6. River Banks, West Africa

Type : Riverain forest

1. Annonaceae
2. Caesalpiniaceae
3. Euphorbiaceae
4. Mimosaceae
5. Moraceae
6. Papilionaceae
7. Rubiaceae

7. Amazonian Forest

Type : Evergreen

1. Leguminosae (60%)
2. Lauraceae
3. Moraceae
4. Lecythidaceae
5. Myristicaceae

8. Eastern Amazonian Forest, Brazil

Type : Evergreen.

1. Apocynaceae
2. Sapotaceae
3. Mimosaceae
4. Buseraceae
5. Lecythidaceae
6. Caesalpiniaceae
7. Chrysobalanaceae
8. Melastomaceae
9. Lauraceae

9. Bahian Forest, Eastern Brazil

Type : Evergreen.

1. Sapotaceae
2. Myrtaceae
3. Lauraceae
4. Chrysobalanaceae
5. Leguminosae

10. Guianan Forest, French Guiana

Type : Evergreen

1. Buseraceae	5. Caesalpiniaceae	9. Chrysobalanaceae
2. Sapotaceae	6. Rubiaceae	10. Meliaceae
3. Lecythidaceae	7. Euphorbiaceae	11. Bombacaceae
4. Mimosaceae	8. Moraceae	12. Myristicaceae

Sources : (2) Langdale-Brown et al., 1964. (9) Boom and Mori, 1982. (10)Mori & Boom, 1987 (3, 4, 5, & 6) Steentoft, 1988. (7) Jacobs, 1988. (8) Mori et al.,1989.

TABLE VII

Family Importance Values (FIV) For The 25 Families In The 1000 Tree Sample Of The Bobiri Forest Reserve

SP = Number of species. **N** = Number of trees per family.

TF = Trees per species in a family. **BA** = Basal area (cm. sq.)

Family	FIV	SP	N	TF	BA(cm^2)
1. Sterculiaceae	59.8	10	239	23.9	125,354.8
2. Ulmaceae	42.6	4	172	43.0	102,885.9
3. Meliaceae	28.4	10	107	10.7	38,611.9
4. Apocynaceae	27.9	5	161	32.2	33,656.9
5. Moraceae	20.3	10	57	5.7	23,928.8
6. Caesalpiniaceae	19.1	11	40	3.6	21,617.0
7. Euphorbiaceae	18.5	9	43	4.8	26,494.6
8. Mimosaceae	13.2	5	30	6.0	25,714.4
9. Olacaceae	12.0	5	42	8.4	14,054.0
10. Sapindaceae	8.1	4	14	3.5	13,398.8
11. Sapotaceae	6.7	3	8	2.7	14,497.4
12. Papilionaceae	6.6	5	13	2.6	2,560.1

13. Combretaceae	5.2	1	20	20.0	10,663.7
14. Rubiaceae	4.8	4	5	1.3	2,323.1
15. Annonaceae	4.8	4	6	1.5	1,601.8
16. Ebenaceae	3.4	3	3	1.0	865.1
17. Lecythidaceae	3.0	1	8	8.0	5,705.1
18. Myristicaceae	2.5	1	7	7.0	4,056.8
19. Simaroubaceae	2.5	1	8	8.0	3,516.0
20. Anacardiaceae	2.5	2	4	2.0	608.5
21. Bignoniaceae	2.2	2	2	1.0	219.3
22. Bombacaceae	2.1	1	6	6.0	2,381.3
23. Guttifereae	1.4	1	2	2.0	1,125.0
24. Icacinaceae	1.3	1	2	2.0	749.8
25. Rutaceae	1.1	1	1	1.0	78.6
Totals	300.0	104	1000		443,011.8

TABLE VIII

Comparison Of Family Importance Values For The 5 Most Important Families Of The Bobiri Forest With FIV's Of 6 Neotropical Localities

SP = Number of species. **N** = Number of individuals.

BA = Basal area (m^2).

1. Bobiri Forest Reserve, Ghana (Kisseadoo, 1993)

Family	FIV	SP	N	BA(m^2)
Sterculiacae	59.8	10	239	12.54
Ulmaceae	42.6	4	172	10.29
Meliaceae	28.4	10	107	3.86
Apocynaceae	27.9	5	161	3.37
Moraceae	20.3	10	57	2.39
Totals	300	104	1000	44.30m^2

2. Saul, French Guiana (Mori & Boom, 1987)

Family	FIV	SP	N	BA(m^2)
Buseraceaea	34.9	12	141	9.1
Sapotaceae	31.5	36	71	7.1
Lecythidaceae	23.2	15	65	7.1
Mimosaceae	22.4	25	45	5.1
Caesalpiniaceae	21.5	17	53	5.9
Totals	300	295	800	53.0

3. Nouragues, French Guyana (Sabatier & Prevost, 1990)

Family	FIV	SP	N	BA(m^2)
Lecythidaceae	37.5	17	86	3.9
Sapotaceae	50.0	25	72	7.9
Caesalpiniaceae	31.9	6	38	7.7
Buseraceae	14.4	8	28	1.6
Mimosaceae	12.5	6	25	1.5
Totals	300	177	501	36.67

4. Unflooded Forest, Amazonian Ecuador (Balslev et al., 1987)

Family	FIV	SP	N	BA(m^2)
Arecaceae	30.73	8	134	3.63
Moraceae	30.52	22	72	4.23
Meliaceae	19.25	15	34	2.99
Mimosaceae	17.33	8	36	3.23
Caesalpiniaceae	13.52	10	39	1.54
Totals	300	244	804	33.7

5. Camaipi, Brazil (Mori et al., 1989)

Family	FIV	SP	N	BA(m^2)
Apocynaceae	57.8	8	207	21.36
Sapotaceae	30.1	20	99	6.78
Mimosaceae	24.9	21	57	5.76
Buseraceae	20.8	9	88	4.91
Lecythidaceae	18.2	9	80	3.73
Totals	300	205	1000	64.36

6. **Bahia, Brazil** (Boom & Mori, 1982)

Family	FIV	SP	N	BA(m^2)
Myrtaceae	52.2	27	128	4.93
Sapotaceae	39.4	20	86	4.33
Caesalpiniaceae	28.5	14	52	3.72
Lauraceae	20.8	9	47	2.50
Chrysobalanaceae	15.4	8	24	2.14
Totals	300	179	600	31.15

7. **Manaus-Itacoatiara, Amazonia** (Prance et al., 1976)

Family	FIV	SP	N	Trunk vol.(m^3)
Lecythidaceae	54.5	18	77	68.15
Moraceae	23.1	14	28	21.41
Sapotaceae	20.1	12	28	16.13
Buseraceae	19.0	10	27	17.06
Caesalpiniaceae	17.9	10	24	16.18
Totals	300	167	376	293.88

TABLE IX

Comparison Of The Importance Of Some Families In The Bobiri Forest Reserve With Families In Six Neotropical Forests

Study sites : **A** = Bobiri forest. **B** = Saul, French Guiana.

C = Nouragues, French Guiana. **D** = Amazonian Ecuador.

E = Camaipi, Amapa, Brazil. **F** = Bahia, Brazil.

G = Manaus-Itacoatiara, Amazonia.

Numbers = the rank of importance of the family in the particular study site.

Family	A	B	C	D	E	F	G
Anacardiaceae	20	--	--	29	12	--	--
Annonaceae	15	14	4	17	11	--	--
Apocynaceae	4	--	--	37	1	--	--
Arecaceae	--	--	--	1	29	--	--
Bignoniaceae	21	--	--	36	--	--	--
Bombacaceae	22	12	--	14	--	7	10
Buseraceae	--	1	5	13	4	--	4

Caesalpiniaceae	6	5	3	5	6	3	5
Chrysobalanaceae	--	10	2	22	7	5	6
Combretaceae	13	--	--	42	21	--	--
Ebenaceae	16	--	--	45	--	--	--
Euphorbiaceae	7	7	--	10	28	6	--
Guttiferae	23	--	--	26	--	--	--
Icacinaceae	24	--	--	34	--	--	--
Lauraceae	--	--	4	6	--	4	8
Lecythidaceae	17	3	1	8	5	8	1
Malphigiaceae	--	--	--	44	22	--	--
Melastomaceae	--	--	--	19	8	9	--
Meliaceae	3	11	--	3	30	--	--
Mimosaceae	8	4	5	4	3	--	9
Moraceae	5	8	--	2	17	10	2
Myristicaceae	18	13	--	7	13	--	--
Myrtaceae	--	--	--	31	14	1	--
Olacaceae	9	--	--	28	--	--	--
Rubiaceae	14	6	--	9	15	--	--

Rutaceae	25	--	--	49	--	--	--
Sapindaceae	10	--	--	33	--	--	--
Sapotaceae	11	2	2	16	2	2	3
Simaroubaceae	19	--	--	46	--	--	--
Sterculiaceae	1	--	--	15	--	--	--
Ulmaceae	2	--	--	32	--	--	--
Vochysiaceae	--	--	--	24	18	--	7

Table X

Family/species-buttress relationship in the Bobiri Forest Reserve

SP = No. of species in family.

SB = No. of species in family with measurable buttresses.

N = No. of trees in family with buttresses.

TB = Total no. of buttresses for family.

B/T = No. of buttresses per tree.

Family	SP	SB	N	TB	B/T
1. Ulmaceae	4	4	86	459	5.3
2. Sterculiaceae	10	7	80	397	5.0
3. Moraceae	10	9	45	346	7.7
4. Mimosaceae	5	4	20	108	5.4
5. Euphorbiaceae	9	4	18	101	5.6
6. Combretaceae	1	1	13	55	4.2
7. Caesalpiniaceae	11	3	13	55	4.2

8. Meliaceae	10	6	12	44	3.7
9. Apocynaceae	5	2	4	14	3.5
10. Sapindaceae	4	3	4	73	18.3
11. Sapotaceae	3	2	4	24	6.0
12. Papilionaceae	5	1	2	10	5.0
13. Bombacaceae	1	1	2	6	3.0
14. Olacaceae	5	1	1	15	15.0
15. Lecythidaceae	1	1	1	4	4.0
16. Myristicaceea	1	1	1	2	2.0

Table XI

Nature of trunk bases for some tree species in the Bobiri Forest

NS = No significant buttressing.

SB = Significant buttressing observed.

Numbers = Various tree diameters in cm.

Species	NS	Fluted	Incipient	SB
Albizia adianthifolia	10	47	12	32
Carapa procera	22.6	10.6, 14.2	13.8, 14.5	20
Cola gigantea	15	25	10, 30	20
Cola nitida	10	22.5	10.8	20

Table XII

Tree size (DBH) at which buttresses begin to develop in some Ghanaian forest trees

Species	Family	DBH (cm)
1. Alstonia boonei	Apocynaceae	14
2. Amphimas pterocarpoides	Caesalpiniaceae	17
3. Blighia welwitschii	Sapindaceae	35
4. Bussea occidentalis	Caesalpiniaceae	18
5. Entandrophragma cylindricum	Meliaceae	20
6. Nesogordonia papaverifera	Sterculiaceae	20
7. Ongokea gore	Olacaceae	48
8. Petersianthus macrocarpum	Lecythidaceae	40
9. Piptadeniastrum africanum	Mimosaceae	20
10. Sterculia rhinopetala	Sterculiaceae	20
11. Triplochiton scleroxylon	Sterculiaceae	20

Table XIII

Species with the widest, tallest, and thickest buttresses for the 1000 tree sample in the Bobiri Forest.

1. Widest buttresses

Species	Width of buttress (m)
Piptadeniastrum africanum	7.0
Terminalia superba	9.5
Khaya ivorensis	6.0

2. Tallest buttresses

Species	Height of buttress (m)
Terminalia superba	9.5
Aningeria robusta	7.7
Nesogordonia papaverifera	5.4

3. Thickest buttresses

Species	Thickness of buttress (cm)
Terminalia superba	8.0
Nesogordonia papaverifera	6.0
Cylicodiscus gabunensis	4.0

Table XIV

Species with the greatest numbers of buttresses (total counted in individual tree) in the Bobiri forest reserve

Species	Family	No. of butts.
1. Lecaniodiscus cupanioides	Sapindaceae	> 50
2. Macaranga heudelotii	Euphorbiaceae	15
3. Musanga cecropioides	Moraceae	15
4. Myrianthus arboreus	Moraceae	12
5. Myrianthus libericus	Moraceae	12
6. Sterculia rhinopetala	Sterculiaceae	12
7. Ficus exasperata	Moraceae	10
8. Sterculia oblonga	Sterculiaceae	9
9. Hymenostegia afzelii	Caesalpiniaceae	8
10. Nesogordonia papaverifera	Sterculiaceae	8
11. Cylicodiscus gabunensis	Mimosaceae	8
12. Aningeria robusta	Sapotaceae	7
13. Terminalia superba	Combretaceae	7

14. Celtis zenkeri	Ulmaceae	7
15. Piptadeniastrum africanum	Mimosaceae	7
16. Bussea occidentalis	Caesalpiniaceae	7
17. Crudia gabonensis	Caesalpiniaceae	7
18. Celtis mildbraedii	Ulmaceae	7
19. Morus mesozygia	Moraceae	7

Table XV

Comparison of buttressing for some tropical localities

WB = Widest buttress; **TB** = Tallest buttress; **N** = Number of trees.

B = % of trees buttressed; **UN** = % of trees unbuttressed.

Locality	WB(m)	TB(m)	N	B	UN
Ghana (Bobiri Forest)	7.0	9.5	1000	64	36
Ghana (*Ceiba pentandra*, Accra)	---	---	-----	100	0
Ghana (Kade Forest)	----	15	-----	---	---
Costa Rica	----	6.3	-----	---	---
Brazil (State of Bahia)	----	---	360	17	83
Guyana (Moraballi)	6.0	6.0	-----	---	---
French Guiana (La Fumee Mt.)	----	----	800	34	66

Sources : Davis and Richards (1934); Baker (1973); Hall and Swaine (1981); Boom and Mori (1982); Mori & Boom (1987).

TABLE XVI

THE 20 TALLEST TREES IN THE BOBIRI FOREST RESERVE

(Height > 35m)

Species	Family	Height (m)
1. Triplochiton scleroxylon	Sterculiaceae	70.79
2. Aningeria robusta	Sapotaceae	57.60
3. Celtis zenkeri	Ulmaceae	56.55
4. Albizia zygia	Mimosaceae	56.55
5. Entandrophragma cylindricum	Meliaceae	56.55
6. Khaya ivorensis	Meliaceae	56.55
7. Terminalia superba	Combretaceae	56.55
8. Petersianthus macrocarpa	Lecythidaceae	56.55
9. Nesogordonia papaverifera	Sterculiaceae	55.00
10. Sterculia rhinopetala	Sterculiaceae	52.30
11. Piptadeniastrum africanum	Mimosaceae	51.42

12. Ricinodendron heudelotii	Euphorbiaceae	50.92
13. Albizia adianthifolia	Mimosaceae	48.31
14. Musanga cecropioides	Moraceae	47.54
15. Turraenthus africanus	Meliaceae	43.00
16. Pterygota macrocarpa	Sterculiaceae	42.61
17. Cylicodiscus gabonensis	Mimosaceae	42.61
18. Berlinia tomentella	Caesalpiniaceae	39.74
19. Blighia welwitschii	Sapindaceae	37.97
20. Bussea occidentalis	Caesalpiniaceae	35.16

TABLE XVII

The 30 Trees With The Largest DBH In The Bobiri Forest Reserve (DBH > 40 cm)

Species	Family	DBH (cm)
1. Celtis zenkeri	Ulmaceae	180
2. Aningeria robusta	Sapotaceae	110
3. Cylicodiscus gabunensis	Mimosaceae	110
4. Sterculia rhinopetala	Sterculiaceae	100
5. Nesogordonia papaverifera	Sterculiaceae	100
6. Blighia welwitschii	Sapindaceae	100
7. Triplochiton scleroxylon	Sterculiaceae	90
8. Albizia zygia	Mimosaceae	86
9. Celtis adolfi-friderici	Ulmaceae	85
10. Entandrophragma cylindricum	Meliaceae	80
11. Ricinodendron heudelotii	Euphorbiaceae	80

12. Terminalia superba	Combretaceae	65
13. Piptadeniastrum africanum	Mimosaceae	60
14. Funtumia elastica	Apocynaceae	60
15. Berlinia tomentella	Caesalpiniaceae	59
16. Petersianthus macrocarpa	Lecythidaceae	57
17. Musanga cecropioides	Moraceae	56
18. Turraenthus africanus	Meliaceae	56
19. Berlinia confusa	Caesalpiniaceae	55
20. Chrysophyllum subnudum	Sapotaceae	54
21. Bussea occidentalis	Caesalpiniaceae	53
22. Ficus exasperata	Moraceae	50
23. Funtumia africana	Apocynaceae	50
24. Ongokea gore	Olacaceae	49
25. Albizia adianthifolia	Mimosaceae	48
26. Pycnanthus angolensis	Myristicaceae	45

27. Crudia gabonensis	Caesalpiniaceae	45
28. Guarea cedrata	Meliaceae	45
29. Entandrophragma angolense	Meliaceae	44
30. Trilepisium madagascariense	Moraceae	40

TABLE XVIII

DBH And Height Classes For The 1000 Tree Sample In The Bobiri Forest Reserve

Class	DBH Class	No. Of Trees
1	10-19	615
2	20-29	216
3	30-39	96
4	40-49	27
5	50-59	22
6	60-69	8
7	70-79	1
8	80-89	5
9	90-99	2
10	100-109	5
11	110-119	2

.	.	.
.	.	.
12	180-189	1
	Total	**1000**

Class	Height Class	No. Of Trees
1	0-10	193
2	10-19	580
3	20-29	149
4	30-39	47
5	40-49	17
6	50-59	12
7	60-69	1
8	70-79	1
	Total	**1000**

TABLE XIX

Sizes Of The Largest Trees In The 25 Families Sampled In The Bobiri Forest Reserve

ANACARDIACEAE

Species	DBH (cm)	Height (m)
Antrocaryon micraster	11.1	13.9
Lannea welwitschii	15.5	11.3

ANNONACEAE

Species	DBH (cm)	Height (m)
Enantia polycarpa	24	19.4
Greenwayodendron oliveri	12	8.8
Mischogyne elliotiana	29	23.3
Xylopia quintasii	13	24.9

APOCYNACEAE

Species	DBH (cm)	Height (m)
Alstonia boonei	23.8	19
Funtumia africana	50	36.3
Funtumia elastica	60	33.1
Pleiocarpa mutica	12.5	14
Rauvolfia vomitoria	24	16.2

BIGNONIACEAE

Species	DBH (cm)	Height (m)
Kigelia africana	10.5	11.3
Spathodea campanulata	13	11.7

BOMBACACEAE

Species	DBH (cm)	Height (m)
Ceiba pentandra	37	28

CAESALPINIACEAE

Species	DBH (cm)	Height (m)
Amphimas pterocarpoides	35	27.2
Anthonota macrophylla	13.3	14.6
Berlinia confusa	55	35.4
Berlinia grandiflora	13.2	14.4
Berlinia tomentella	59	39.7
Bussea occidentalis	52.5	35.2
Copaifera salikounda	13.7	12
Crudia gabonensis	45	25.5
Daniella ogea	24.3	19.4
Distemonanthus benthamianus	20.8	13.1
Hymenostegia afzelii	26	16.3

COMBRETACEAE

Species	DBH (cm)	Height (m)
Terminalia superba	65	56.6

EBENACEAE

Species	DBH (cm)	Height (m)
Diospyros monbuttensis	12	7.9
Diospyros soubreana	24	25.4
Diospyros viridicans	12	20

EUPHORBIACEAE

Species	DBH (cm)	Height (m)
Cleidion gabonicum	16.2	18.4
Discoglypremna caloneura	19.5	14.6
Drypetes aframensis	27.6	13.6
Drypetes gilgiana	31.8	22.4
Drypetes principum	12	9.6

Macaranga heudelotii	35	34
Maniophyton fulvum	30	24.4
Mareya micrantha	10	7.3
Ricinodendron heudelotii	80	50.9

GUTTIFERAE

Species	DBH (cm)	Height (m)
Mammea africana	27.5	26.7

ICACINACEAE

Species	DBH (cm)	Height (m)
Leptaulus daphnoides	28	33.7

LECYTHIDACEAE

Species	DBH (cm)	Height (m)
Petersianthus macrocarpa	57	56.6

MELIACEAE

Species	DBH (cm)	Height (m)
Carapa procera	22.6	19.7
Entandrophragma candollei	27.5	15.8
Entandrophragma cylindricum	80	56.6
Guarea cedrata	45	33.5
Khaya ivorensis	65	56.6
Lovoa klaineana	14	16.2
Trichilia tessmannii	19	9.3
Trichilia prieuriana	26.5	21.9
Turraenthus africanus	56	43

MIMOSACEAE

Species	DBH (cm)	Height (m)
Albizia adianthifolia	47.7	48.3
Albizia zigia	86	56.6
Calpocalyx brevibracteatus	13.5	11.4
Cylicodiscus gabonensis	110	42.6
Piptadeniastrum africanum	60	51.4

MORACEAE

Species	DBH (cm)	Height (m)
Antiaris toxicarium	32	27.3
Ficus barteri	24.5	15
Ficus exasperata	50	27.7
Ficus sur	16.2	11.2
Ficus variifolia	32.6	22.7
Morus mesozygia	20.2	17.9

Musanga cecropioides	56	47.5
Myrianthus arboreus	20	16.1
Myrianthus libericus	25.3	17.1
Trilepisium madagascariense	40	17.9

MYRISTICACEAE

Species	DBH (cm)	Height (m)
Pycnanthus angolensis	45.2	32.4

OLACACEAE

Species	DBH (cm)	Height (m)
Aptandra zenkeri	10.8	9
Ongokea gore	48.5	19.6
Strombosia glaucescens	38	31.6
Strombosia grandifolia	12.3	14
Strombosia zenkeri	31.2	27.1

PAPILIONACEAE

Species	DBH (cm)	Height (m)
Baphia nitida	21.5	16.2
Baphia pubescens	12.1	9.9
Dalbergiella welwitschii	33	23.9
Erythrina senegalensis	15.7	12.5
Erythrina vogelii	17	12

RUBIACEAE

Species	DBH (cm)	Height (m)
Aulacocalyx jasminiflora	19.5	15.5
Corynanthe pachyceras	11.4	8.9
Nauclea diderichii	28	21.1
Psydrax paviflora	38.8	25

RUTACEAE

Species	DBH (cm)	Height (m)
Zanthoxylum gilletii	10	6.1

SAPINDACEAE

Species	DBH (cm)	Height (m)
Blighia sapida	18.8	19.3
Blighia unijugata	25.2	24.5
Blighia welwitschii	100	38
Lecaniodiscus cupanioides	23.3	11.7

SAPOTACEAE

Species	DBH (cm)	Height (m)
Aningeria robusta	110	57.6
Chrysophyllum beguei	20.2	15.1
Chrysophyllum subnudum	53.5	31.6

SIMAROUBACEAE

Species	DBH (cm)	Height (m)
Hannoa klaineana	30	23.6

STERCULIACEAE

Species	DBH (cm)	Height (m)
Cola gigantea	30	23.7
Cola millenii	15.5	16.8
Cola nitida	22.5	14.3
Leptonychia pubescens	19.6	11.3
Nesogordonia papaverifera	100	55
Pterygota macrocarpa	35	42.6
Sterculia oblonga	40	29.4
Sterculia rhinopetala	100	52.3
Sterculia tragacantha	30	28.5
Triplochiton scleroxylon	90	70.8

ULMACEAE

Species	DBH (cm)	Height (m)
Celtis adolfi-friderici	85	30.5
Celtis brownii	21.8	13.5
Celtis mildbraedii	38.2	30
Celtis zenkeri	180	56.6

TABLE XX

AVERAGE TREE SIZE FOR THE LARGEST SPECIES IN EACH OF THE 25 FAMILIES IN THE 1000 TREE SAMPLE OF THE BOBIRI FOREST RESERVE

AD = Average tree diameter for a family.

SD1 = Diameter Standard Deviation within a family.

AH = Average tree height for a family.

SD 2 = Height Standard Deviation within a family.

* = Families with only one species in sample.

Family	AD	SD 1	AH	SD 2
Anacardiaceae	13.3	3.1	12.6	1.8
Annonaceae	19.5	8.3	19.1	7.2
Apocynaceae	34.1	20	23.7	10.2
Bignoniaceae	11.8	1.8	11.5	0.3
Bombacaceae*	37	---	28	---

Caesalpiniaceae	32.5	17.6	23	10.1
Combretaceae*	65	---	56.6	---
Ebenaceae	16	6.9	17.8	9.0
Euphorbiaceae	29.1	21.1	21.7	13.7
Guttiferae*	27.5	---	26.7	---
Icacinaceae*	28	---	33.7	---
Lecythidaceae*	57	---	56.6	---
Meliaceae	39.5	23.1	30.3	18
Mimosaceae	63.4	36.8	42.1	17.9
Moraceae	31.7	13.3	22	10.4
Myristicaceae*	45.2	---	32.4	---
Olacaceae	28.2	16.4	20.3	9.2
Papilionaceae	19.9	8.1	14.9	5.5
Rubiaceae	24.4	11.7	17.6	7.0
Rutaceae*	10	---	6.1	---

Sapindaceae	41.8	38.9	23.4	11.1
Sapotaceae	61.2	45.4	34.8	21.4
Simaroubaceae*	30	---	23.6	---
Sterculiaceae	48.3	34.3	34.5	19.9
Ulmaceae	81.3	71.1	32.7	17.8

TABLE XXI

Some Of The Tallest Trees Reported In The World, Compared With The Largest Trees Of The Bobiri Forest Reserve

Locality	Species/Family	Height(m)
1.California, USA	Sequoia sempervirens (Coniferae)	111
2.Victoria, Australia	Eucalyptus regnans (Myrtaceae)	107
3.California, USA	Sequoiadendron giganteum (Coniferae)	96
4.New Guinea	Araucaria hunsteinii (Coniferae)	89
5.Washington, USA	Abies nobilis (Coniferae)	85
6.Sarawak, Malaya	Koompassia excelsa (Leguminosae)	84
7.New Zealand	Agathis australis (Coniferae)	75
8. New Britain	Eucalyptus deglupta (Myrtaceae)	71
9. Bobiri forest, Ghana	Triplo. scleroxylon (Sterculiaceae)	71
10. Sulawesi, Indonesia	Agathis dammara (Coniferae)	70

11. Amazonian forest	Aspidosperma spp. (Apocynaceae)	60
12. Uganda forest	Entandro. cylindricum (Meliaceae)	57

Sources : 1-8 & 10 (Whitmore, 1990) 11 (Jacobs, 1988)

12 (Langdale-Brown et al., 1964)

TABLE XXII

Additional Terms For Leaf Morphology

1. **Lanceoelliptic** : Elliptic leaf forms of l/w ratios between 4 : 1 and 5 : 1. Fig. 96a.

2. **Fluted rachis** or **Fluted petiole :** Rachis or petiole enlarged at base, e.g., *Zanthoxylum gilletii.* Figs. 96a and 96b.

3. **Corrugated rachis** or **petiole :** Rachis or petiole with ridges or bumps, e.g., *Musanga cecropioides* and *Guarea cedrata.* Fig. 96d.

4. **Apiconstrict/Basiconstrict rachis** or **petiole :** Rachis or petiole conctricted at apex or near base, e.g., *Discoglypremna caloneura.* Fig. 96e and 96f.

5. **Megaprimary vein :** The largest primary vein for Actinodromous venation from which other smaller primary vein branches are given off. Fig. 97a.

6. **Basal tertiary loops :** Tertiary vein branches given off as loops near the leaf base, e. g., *Ficus sur.* Fig 97b.

7. **Secondary bridges :** Secondary veins that directly join two adjacent primary veins in Actinodromous venation. Fig 97a.

8. **Angular tertiaries :** Straight tertiary veins whose relation to the midvein does not fit any of Hickey's three categories (right angle, parallel, oblique) as described. This is the case when tertiary veins are attached directly to the midvein at an acute or obtuse angle, e. g. *Aptandra zenkeri* and *Zanthoxylum gilletii.* Fig 97c.

9. **Stalked** or **Sessile secondary vein :** A secondary vein is attached to a primary vein in two ways : either in a straight manner with the base emanating from the primary without curving (**Sessile**), or the basal part of the secondary vein bends into a form of "stalk" and attaches to the midvein at an angle (**Stalked**). Examples of the latter, which is less common, are found in *Kigelia aethiopica* and *Erythrina senegalensis.* Fig 97d.

10. **Mixed angle of divergence :** Varied angles of divergence for secondary veins all on same leaf, e. g. *Discoglypremna caloneura.* Fig 97e.

11. **Circumpubescent vein :** Situation where the intramarginal vein (vein along the edges of a leaf but positioned a short distance from the margin) is carpeted by hairs. Fig 97e.

TABLE XXIII

The Numbers And Percentages Of Species And Trees Possessing The Major Vegetative Characters Enumerated For The 1000 Tree Sample In The Bobiri Forest Reserve

N = Total number of individual trees out of the 1000 in sample.

SP = Number of species out of the 104 species in sample.

%N = % of individual trees out of the 1000 in sample.

%SP = % of species out of the 104 species in sample.

Leaf Type

	N	%N	SP	%SP
Simple	697	69.7	57	54.8
Pinnately Compound	155	15.5	34	32.7
Bipinnately Compound	54	5.4	7	6.7
Palmately Compound	94	9.4	6	5.8

Leaf Margin

	N	%N	SP	%SP
Entire	517	51.7	63	60.6
Entire to serrate	26	2.6	1	1
Entire to crenate	122	12.2	20	19.2
Serrate	35	3.5	8	7.6
Serrate to crenate	4	.4	1	1
Crenate	165	16.5	10	9.6
Toothed to serrate	130	13	1	1

Leaf Size

(Some species possess more than one category of leaf size)

	N	%N	SP	%SP
Leptophyll	0	0	0	0
Nanophyll	7	.7	2	1.9
Microphyll	391	39.1	37	35.6
Notophyll	818	81.8	71	68.3
Mesophyll	955	95.5	92	88.5
Macrophyll	493	49.3	36	34.6

Megaphyll	0	0	0	0

Leaf Form

	N	%N	SP	%SP
Narrowly elliptic	351	35.1	38	36.5
Elliptic	380	38	34	32.7
Elliptic to narrowly elliptic	65	6.5	12	11.5
Elliptic to narrowly ovate	1	.1	1	1
Elliptic to obovate	1	.1	1	1
Elliptic to oblong	3	.3	2	1.9
Widely elliptic	6	.6	2	1.9
Widely elliptic to elliptic	1	.1	1	1
Narrowly ovate	1	.1	1	1
Widely ovate	42	4.2	2	1.9
Ovate to lanceolate	6	.6	1	1
Lanceolate	82	8.2	1	1
Lanceolate to lorate	13	1.3	1	1
Oblanceolate	1	.1	1	1
Narrowly oblong	15	1.5	2	1.9

Oblong	10	1	1	1
Narrowly obovate	19	1.9	2	1.9
Orbiculate	1	.1	1	1
Suborbiculate	2	.2	1	1

Glands

	N	%N	SP	%SP
Present	625	62.5	34	32.7
Absent	375	37.5	70	67.3

Hairs On Leaf

	N	%N	SP	%SP
Simple hairs only	646	64.6	66	63.5
Stellate and simple	178	17.8	13	12.5
Glabrous (both sides)	176	17.6	25	24

Venation

	N	%N	SP	%SP
Actinodromous	119	11.9	8	7.7
Brochidodromous	846	84.6	91	87.5
Craspedodromous	25	2.5	4	3.8

Semicraspedodromous	10	1	1	1

Secondary Veins (Angle Of Divergence)

	N	%N	SP	%SP
Acute	920	92	99	95.2
Obtuse	0	0	0	0
Right angle	74	7.4	3	2.9
Mixed	6	.6	2	1.9

Inter-Secondary Veins

	N	%N	SP	%SP
Present	481	48.1	62	59.2
Absent	519	51.9	42	40.4

Tertiary Veins

	N	%N	SP	%SP
Obscure	10	1	1	1
Ramified (Admedial)	11	1.1	1	1
Orthogonal reticulate	50	5	18	17.2
Random reticulate	302	30.2	31	29.8
Random to orthogonal	1	.1	1	1

Percurrent	626	62.6	52	50

Areoles

	N	%N	SP	%SP
Lacking	194	19.4	8	7.7
Incomplete	222	22.2	44	42.3
Well developed	584	58.4	52	50

Bark

	N	%N	SP	%SP
Outside rough	187	18.7	35	33.7
Outside smooth	770	77	64	61.5
Outside smooth to rough	43	4.3	5	4.8
Texture brittle	350	35	45	43.3
Texture fibrous	650	65	59	56.7
Presence of hoop marks	222	22.2	26	25
Presence of eyemarks	295	29.5	32	30.8

Exudate

	N	%N	SP	%SP
Absent	302	30.2	44	42.3
Present and scanty	248	24.8	25	24
Present and copious	450	45	35	33.7
Present and sticky	518	51.8	36	34.6
Present and non-sticky	180	18	24	23.1

Wood

	N	%N	SP	%SP
Hard	487	48.7	60	57.7
Moderately hard to soft	292	29.2	28	26.9
Soft	221	22.1	16	15.4

Buttressing

	N	%N	SP	%SP
Present	770	77	68	65.4
Absent	230	23	36	34.6

Height Category

H = > 30 m. h = 10-29 m. hh = < 10 m.

	N	%N	SP	%SP
H	498	49.8	28	26.9
h, or h to H	388	38.8	45	43.3
hh to H	13	1.3	4	3.8
hh, or hh to h	101	10.1	30	28.8

Bole

	N	%N	SP	%SP
Straight	771	77.1	70	67.3
Crooked	229	22.9	34	32.7
Cylindrical	979	97.9	100	96.2
Twisted and irregular	21	2.1	4	3.8

TABLE XXIV

The Form, Apex, Base, And Margin Of Average Digtized Leaf Images Of The 25 Families In The Bobiri Forest Sample

Family	Form	Apex	Base	Margin
Anacardiaceae	Elliptic	Acuminate	Rounded	Entire
Annonaceae	Elliptic	Acuminate	Acute	Entire
Apocynaceae	Elliptic	Acute	Cuneate	Entire
Bignoniaceae	Elliptic	Acute	Acute	Entire
Bombacaceae	Obovate	Obtuse	Cuneate	Entire
Caesalpiniaceae	Elliptic	Acute	Obtuse	Entire
Combretaceae	Elliptic	Obtuse	Cuneate	Entire
Ebenaceae	Elliptic	Acuminate	Acute	Entire
Euphorbiaceae	Obovate	Acuminate	Cuneate	Entire
Guttiferae	Elliptic	Acute	Acute	Entire
Icacinaceae	Entire	Acuminate	Acute	Entire
Lecythidaceae	Obovate	Acuminate	Cuneate	Entire
Meliaceae	Elliptic	Obtuse	Acute	Entire

Mimosaceae	Elliptic	Obtuse	Acute	Entire
Moraceae	Elliptic	Obtuse	Obtuse	Entire
Myristicaceae	Oblong	Acute	Truncate	Entire
Olacaceae	Elliptic	Acumunate	Acute	Entire
Papilionaceae	Elliptic	Acute	Obtuse	Entire
Rubiaceae	Elliptic	Acute	Acute	Entire
Rutaceae	Oblong	Acuminate	Obtuse	Entire
Sapindaceae	Elliptic	Acute	Acute	Entire
Sapotaceae	Elliptic	Acumunate	Acute	Entire
Simaroubaceae	Obovate	Rounded	Cuneate	Entire
Sterculiaceae	Ovate	Acute	Rounded	Crenate
Ulmaceae	Elliptic	Acute	Obtuse	Entire

Summary Of Family Average Leaf Characters

N = Number of families out of the 25 possessing the character.

Character	N
Elliptic form	18
Ovate form	1

Obovate form	4
Acute apex	10
Obtuse apex	5
Acuminate apex	9
Rounded apex	1
Acute base	11
Obtuse base	5
Cuneate base	6
Rounded base	2
Truncate base	1
Entire margin	24
Crenate margin	1

FIG. 1. MAP SHOWING FOREST AND OTHER VEGETATION OF AFRICA (BENNEH, 1987)

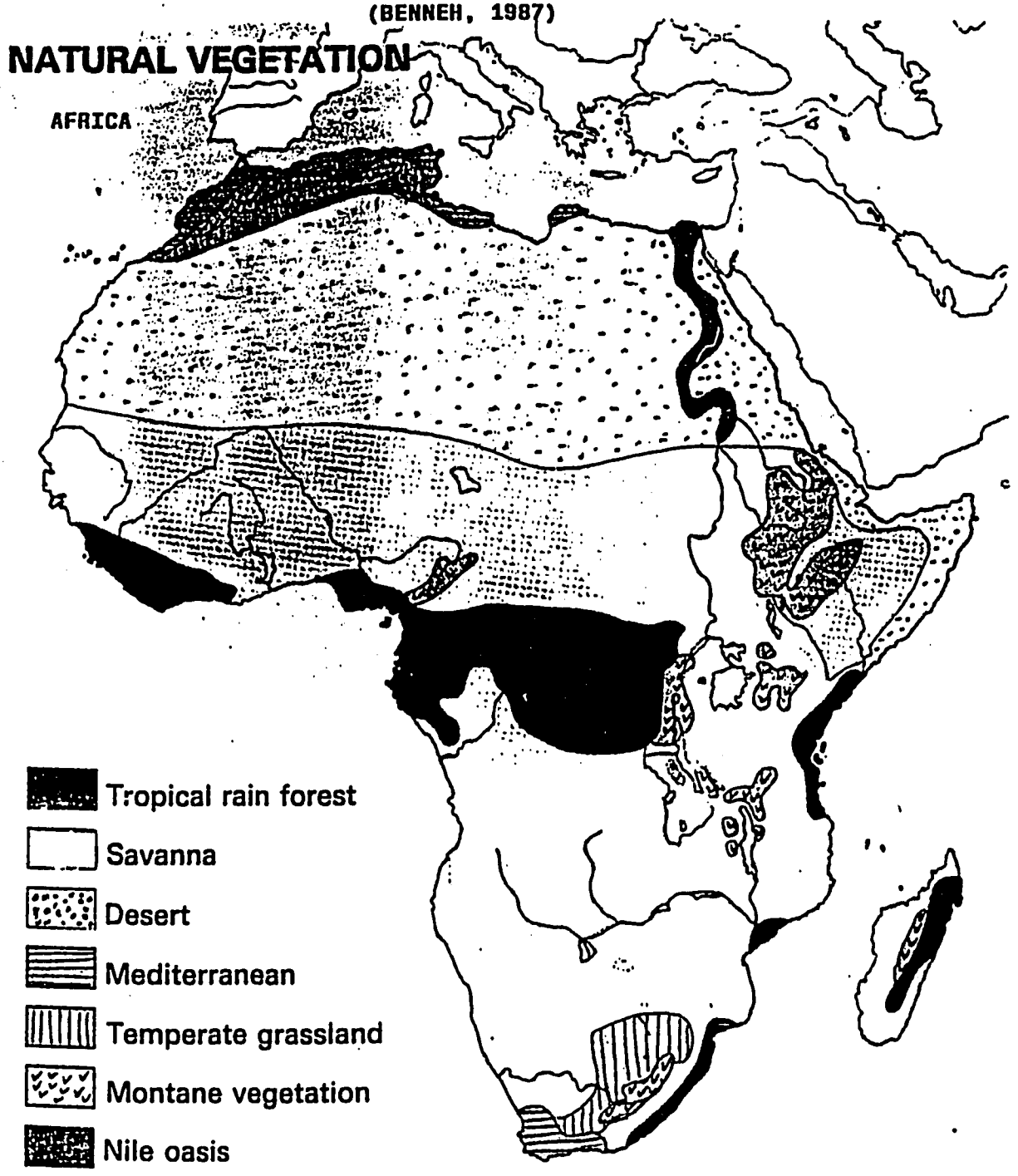


Fig. 2 . The vegetation zones of West Africa. Guin. Biss., Guinea-Bissaū.
(Adapted version of the map 'Northwestern Africa', *The Vegetation of Africa*,
© UNESCO 1981.)

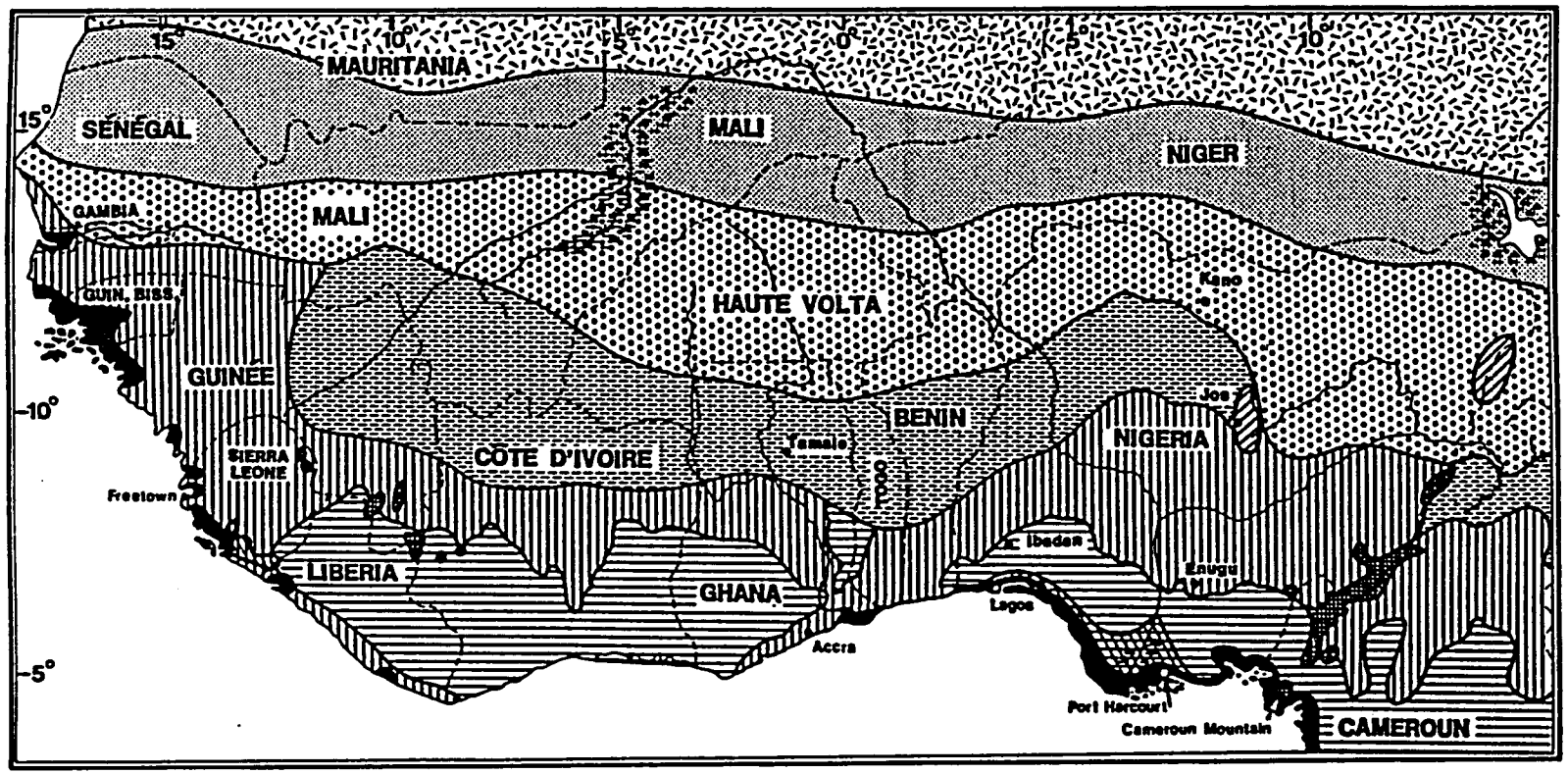
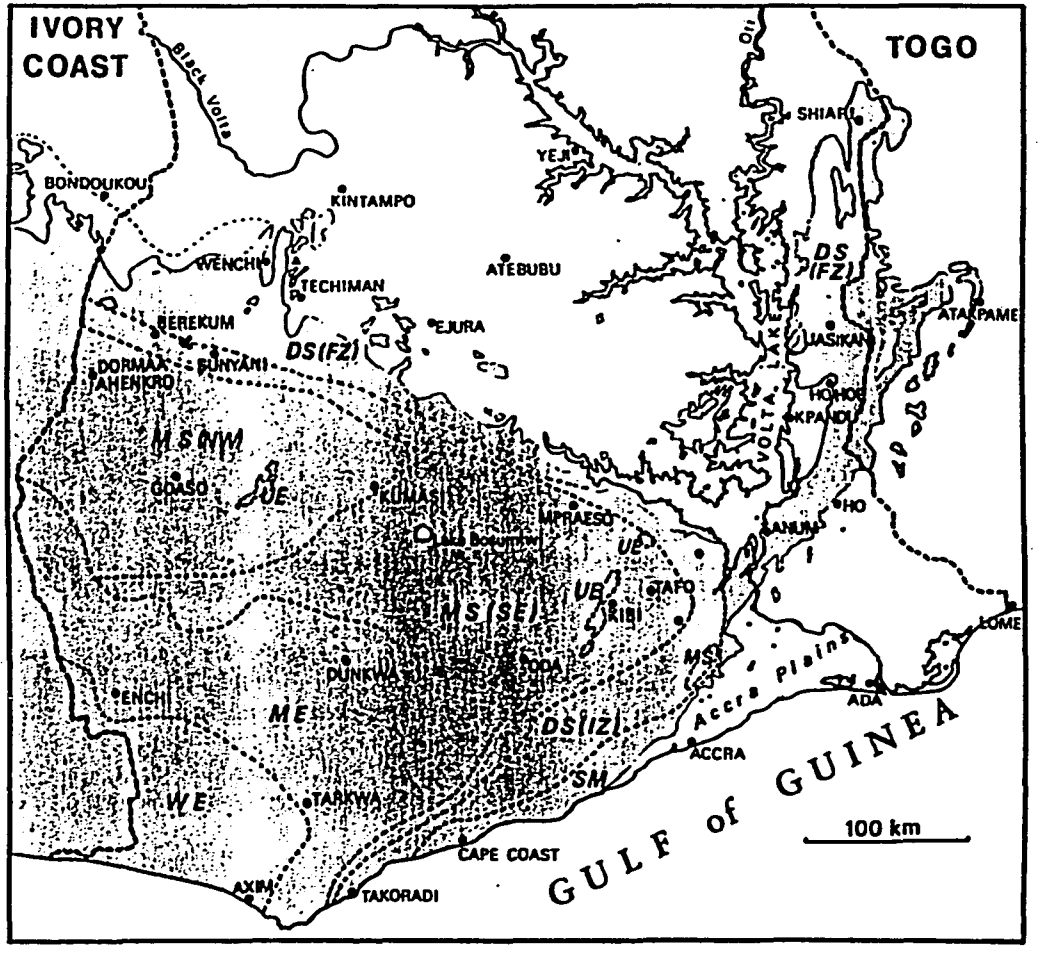
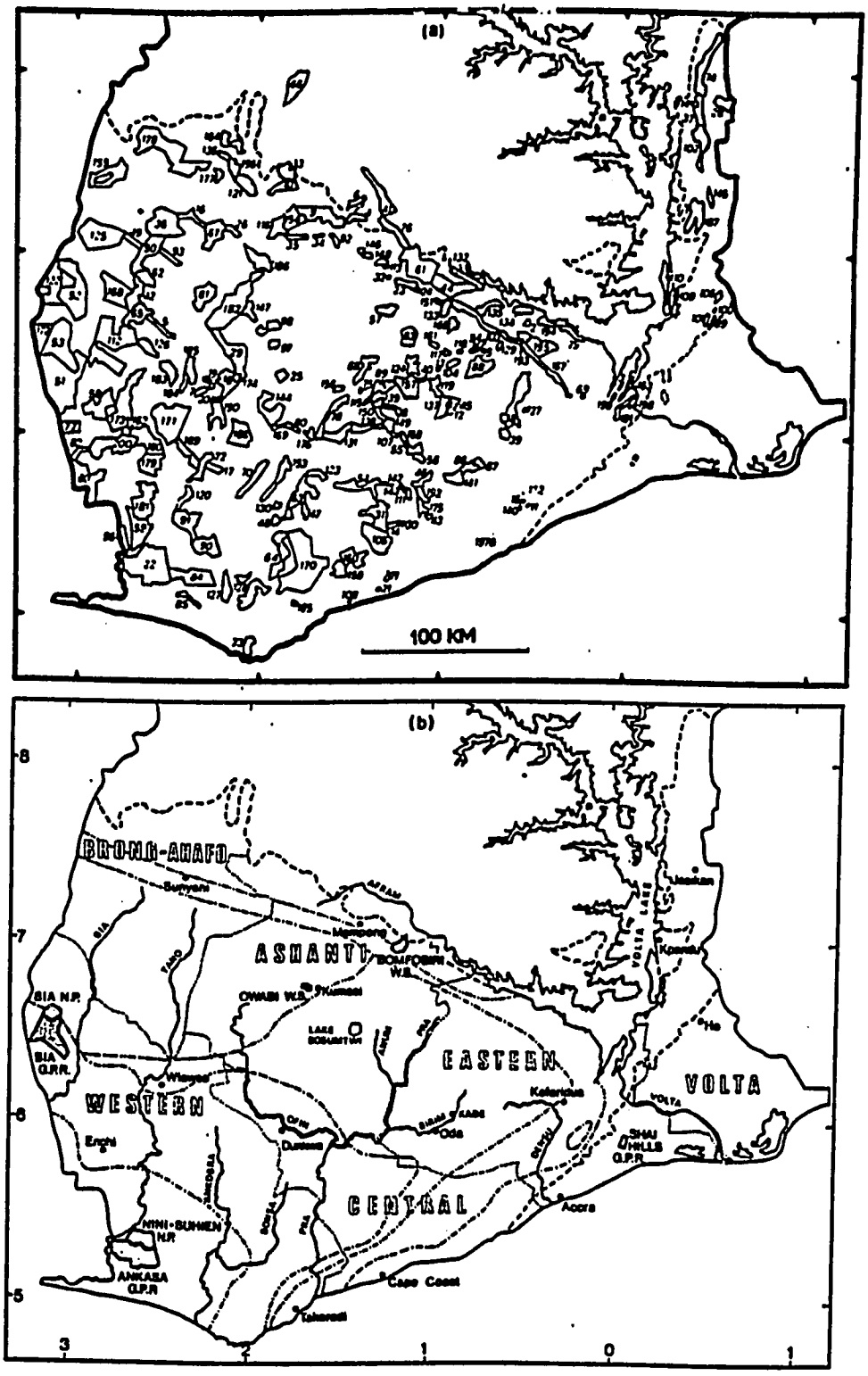


FIG. 3. FOREST TYPES IN GHANA (From : HALL & SWAINE, 1981)



Distribution of forest types (Hall & Swaine 1976) in southern Ghana. Forest is stippled. Forest-type and subtype boundaries shown by broken line (- - -). Forest-type abbreviations: WE = Wet Evergreen; ME = Moist Evergreen; MS = Moist Semi-deciduous (NW = North-west subtype; SE = South-east subtype); DS = Dry Semi-deciduous (FZ = Fire Zone subtype; IZ = Inner Zone subtype); SM = Southern Marginal. Limits of the Volta Lake and forest margin mapped from LANDSAT imagery.

FIG. 4. . FOREST AND WILDLIFE RESERVES IN GHANA
(HALL & SWAINE, 1981)



Forest zone of Ghana. Forest-savanna boundary indicated by broken line.
(a) Forest Reserves – for key to numbers see Appendix I(a).
(b) Wildlife Reserves (shaded): National Parks (N.P.), Game Production Reserves (G.P.R.), Wildlife Sanctuaries (W.S.)

Names of administrative regions in open capitals; boundaries dotted. Boundaries of forest-types – · –; of subtypes – · · –.

FIG. 5. MAP OF GHANA SHOWING RESEARCH AREA

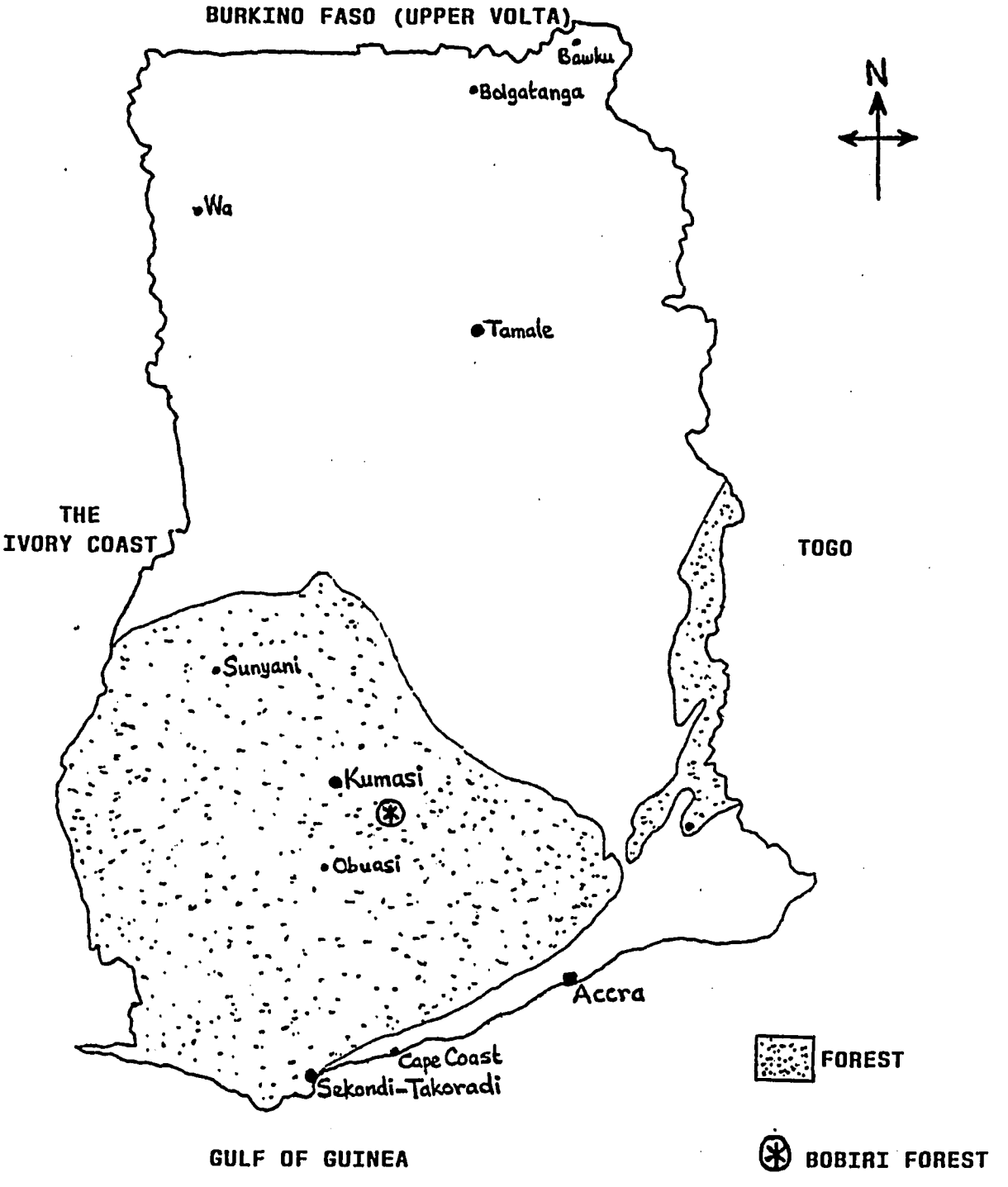


FIG. 6
THE RESEARCH SITE IN THE BOBIRI FOREST RESERVE

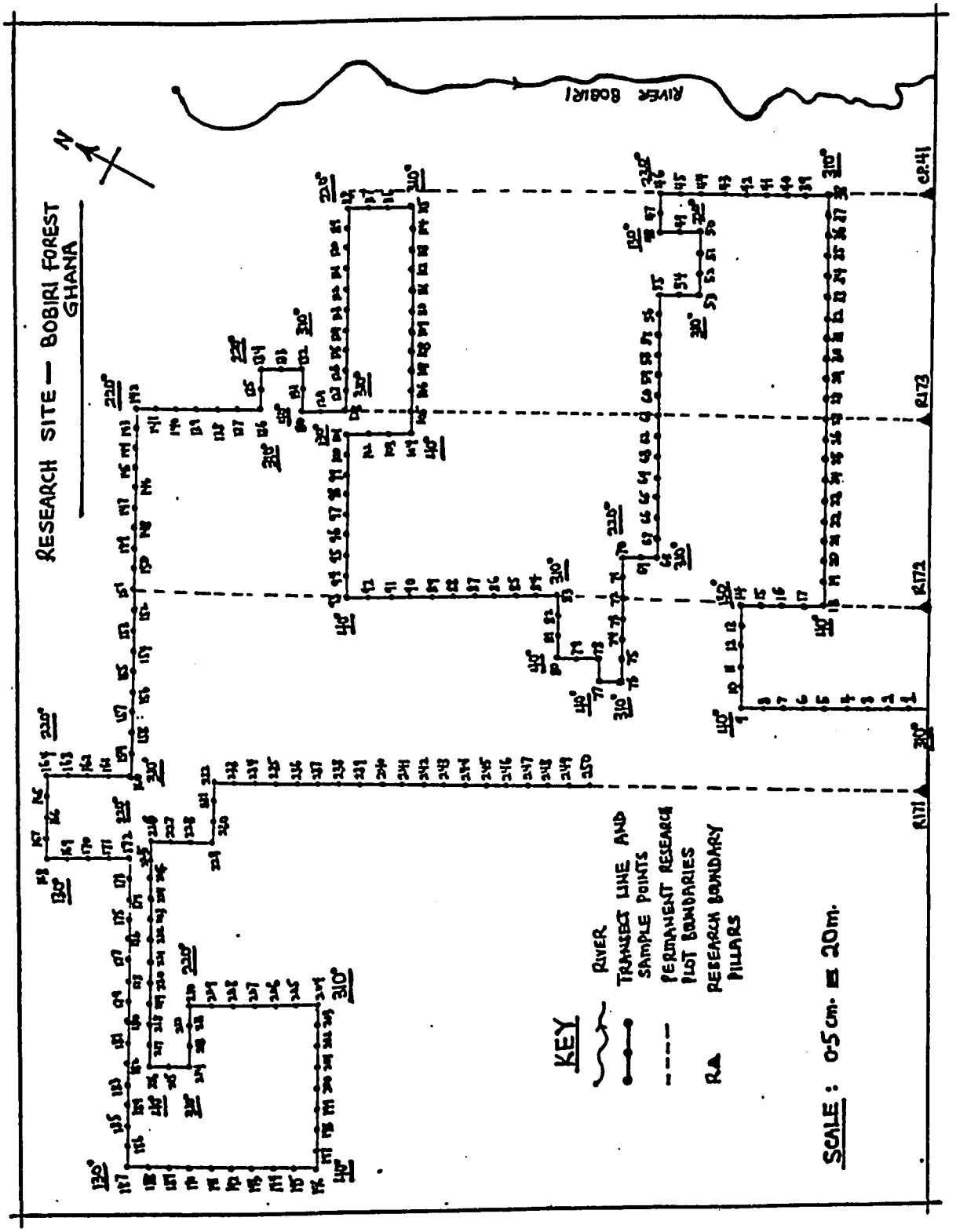
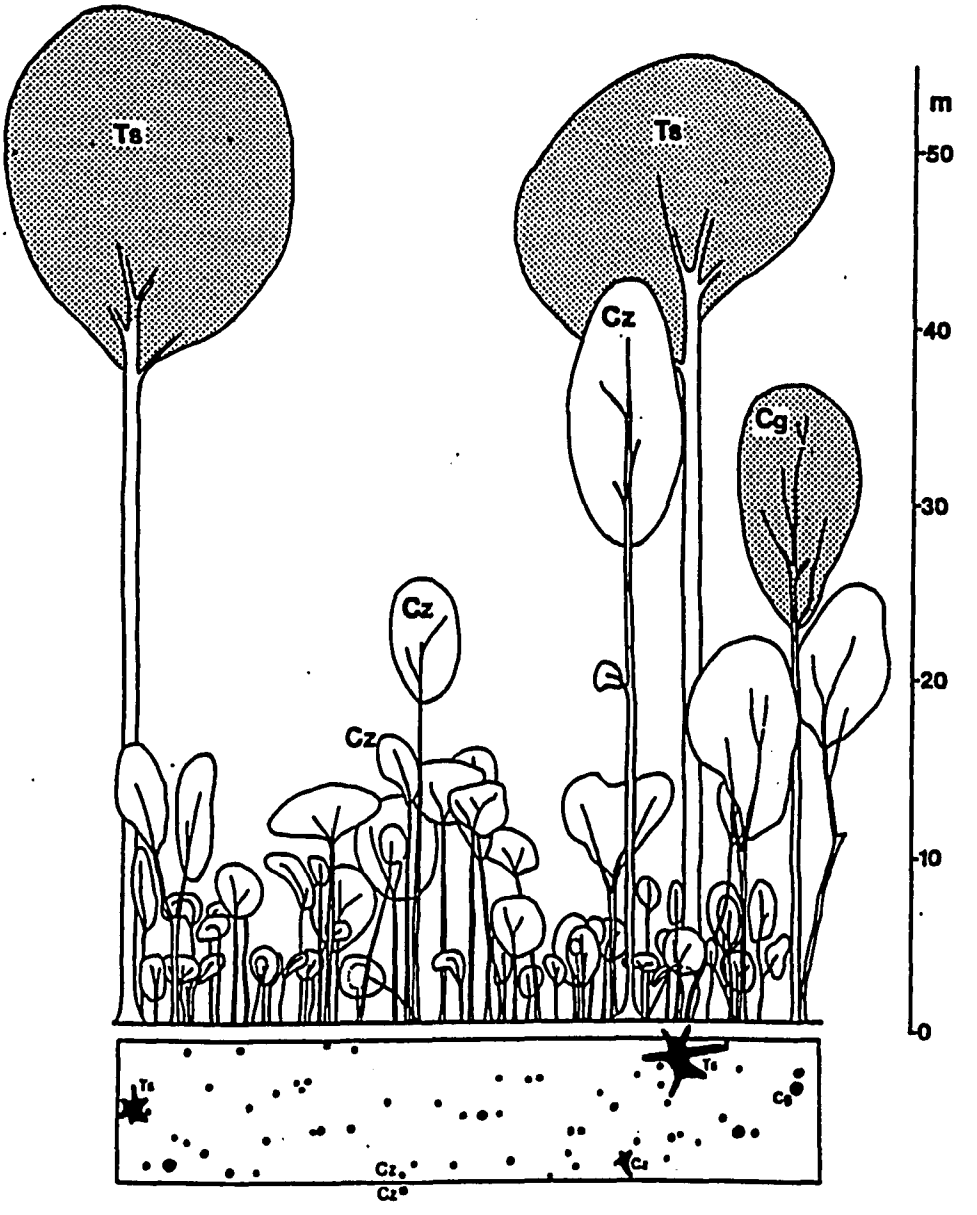


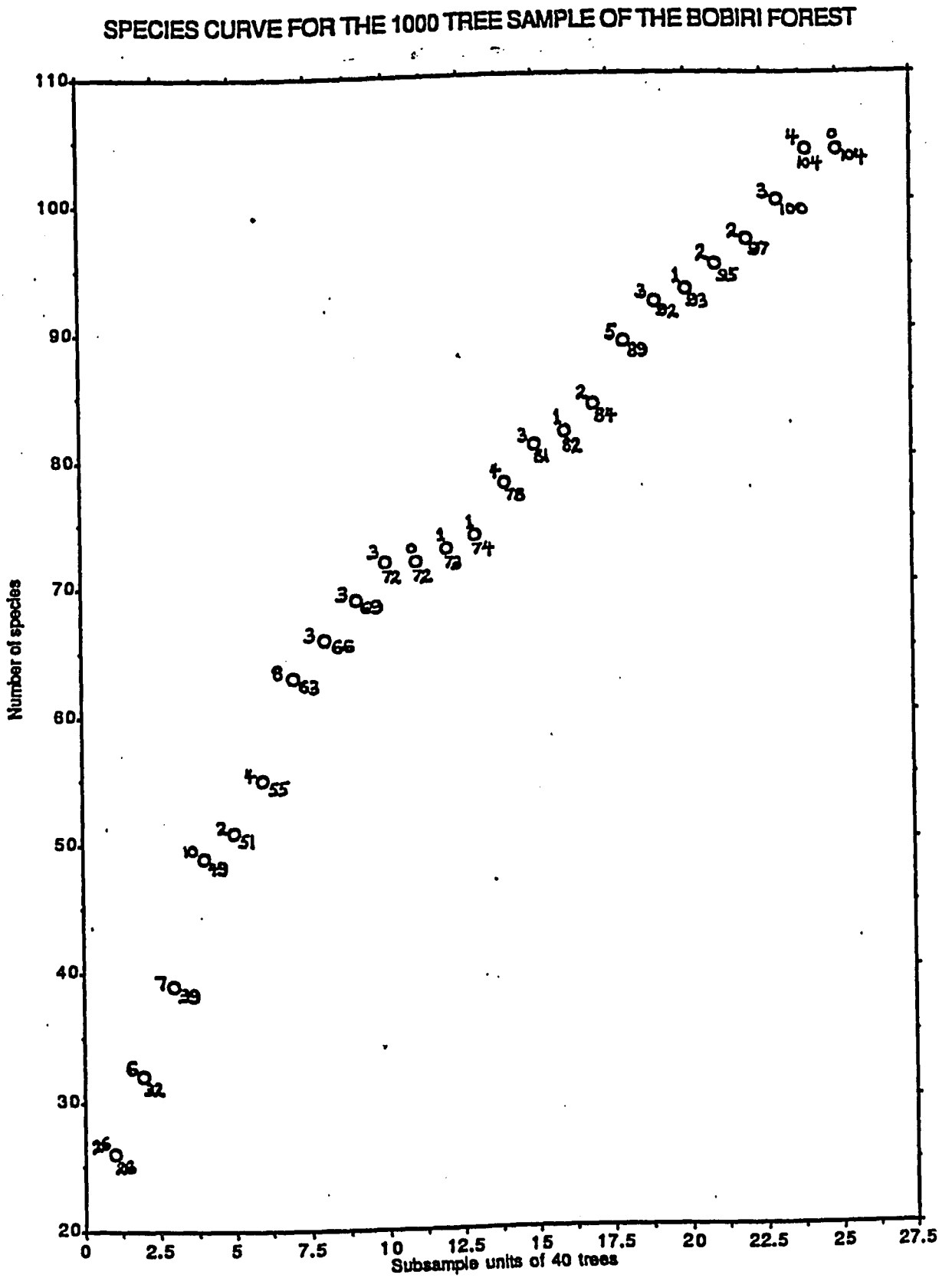
FIG.7

(after Hall & Swaine, 1981)



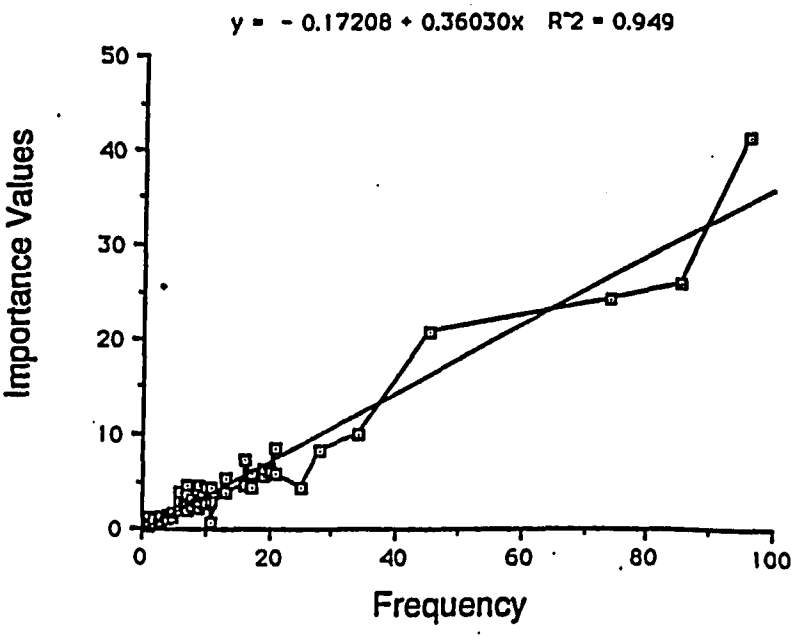
Profile diagram of strip 8 m × 40 m in Moist Semi-deciduous forest in Bobiri F.R. Species with stippled crowns are not represented by seedlings or saplings ≤3 m high on the strip. All individuals of species represented in the canopy are named. Abbreviations: Cg = *Cylicodiscus gabunensis*, Ts = *Triplochiton scleroxylon*, Cz = *Celtis zenkeri*.

FIG. 8



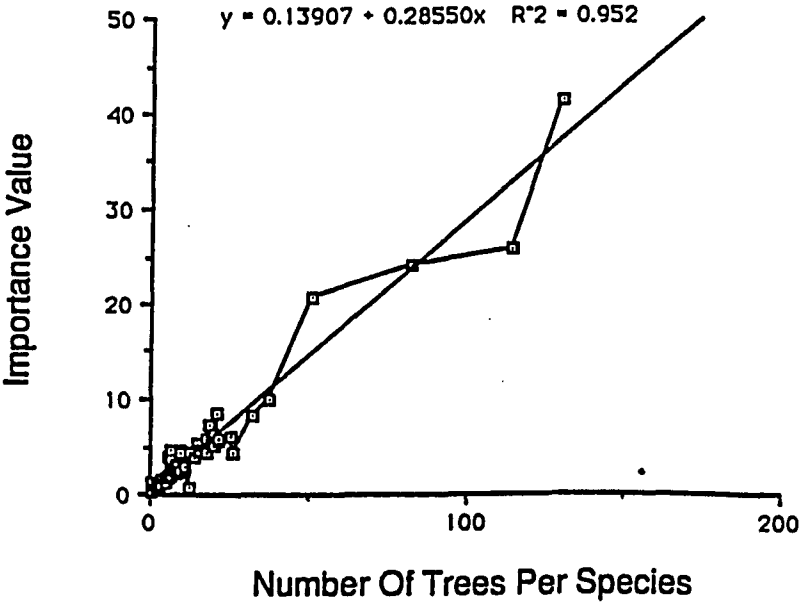
The first sample unit contained 25% of the 104 species. There were new species for each sample unit except the last one.

FIG. 9



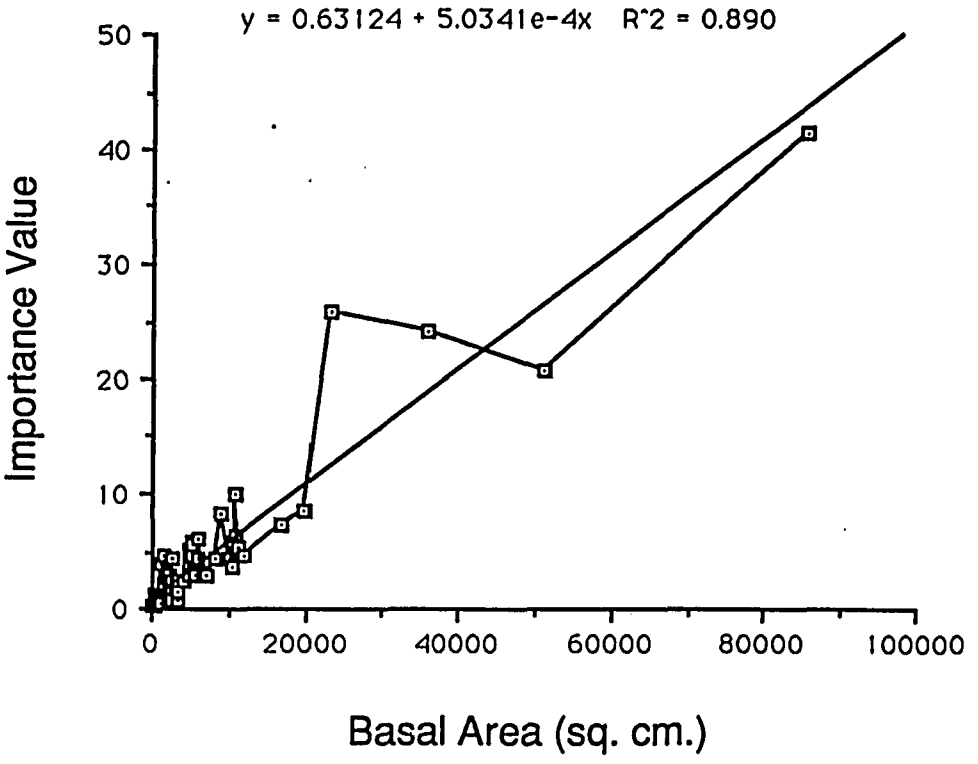
Relation between the frequency (number of occurrences of a species) and the Importance Value of the species in the Bobiri forest reserve.

FIG. 10



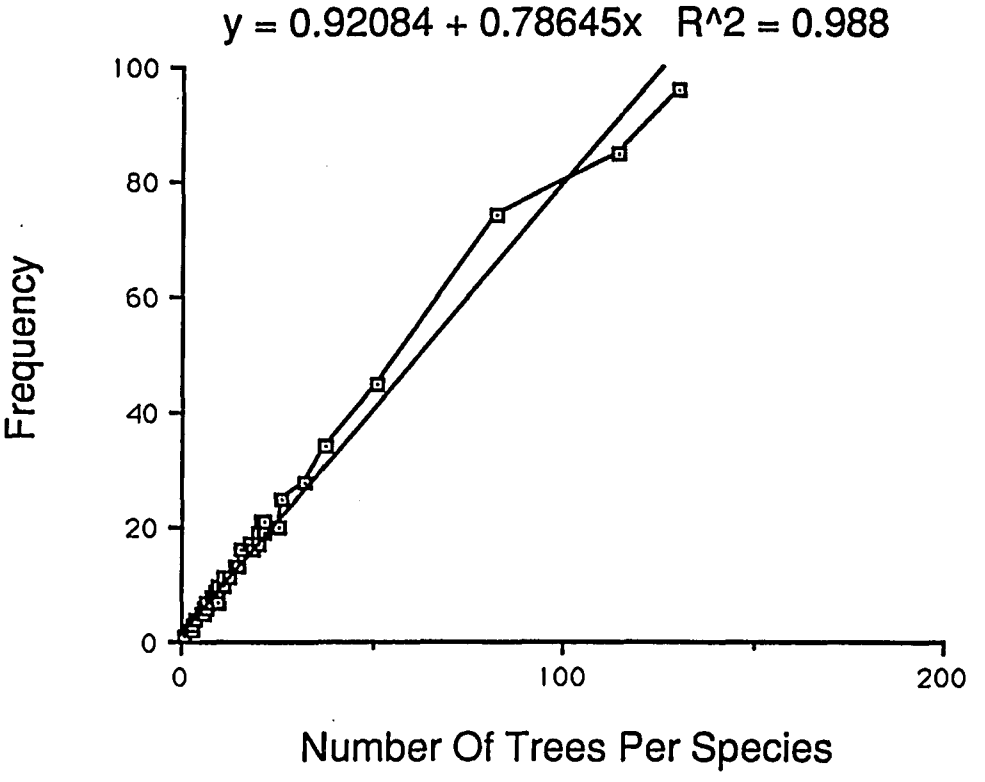
Relation between the number of trees in a species and the Importance Value of the species in the Bobiri forest.

FIG. 11



The relation between trunk basal area and the Importance Value of a species in the Bobiri forest reserve

FIG. 12



Relation between the numbers of trees per species (density) and the frequency in the 104 species in the 1000 tree sample of the Bobiri forest reserve.

FIG. 13

RELATION BETWEEN FIV AND NO. OF SPECIES IN A FAMILY

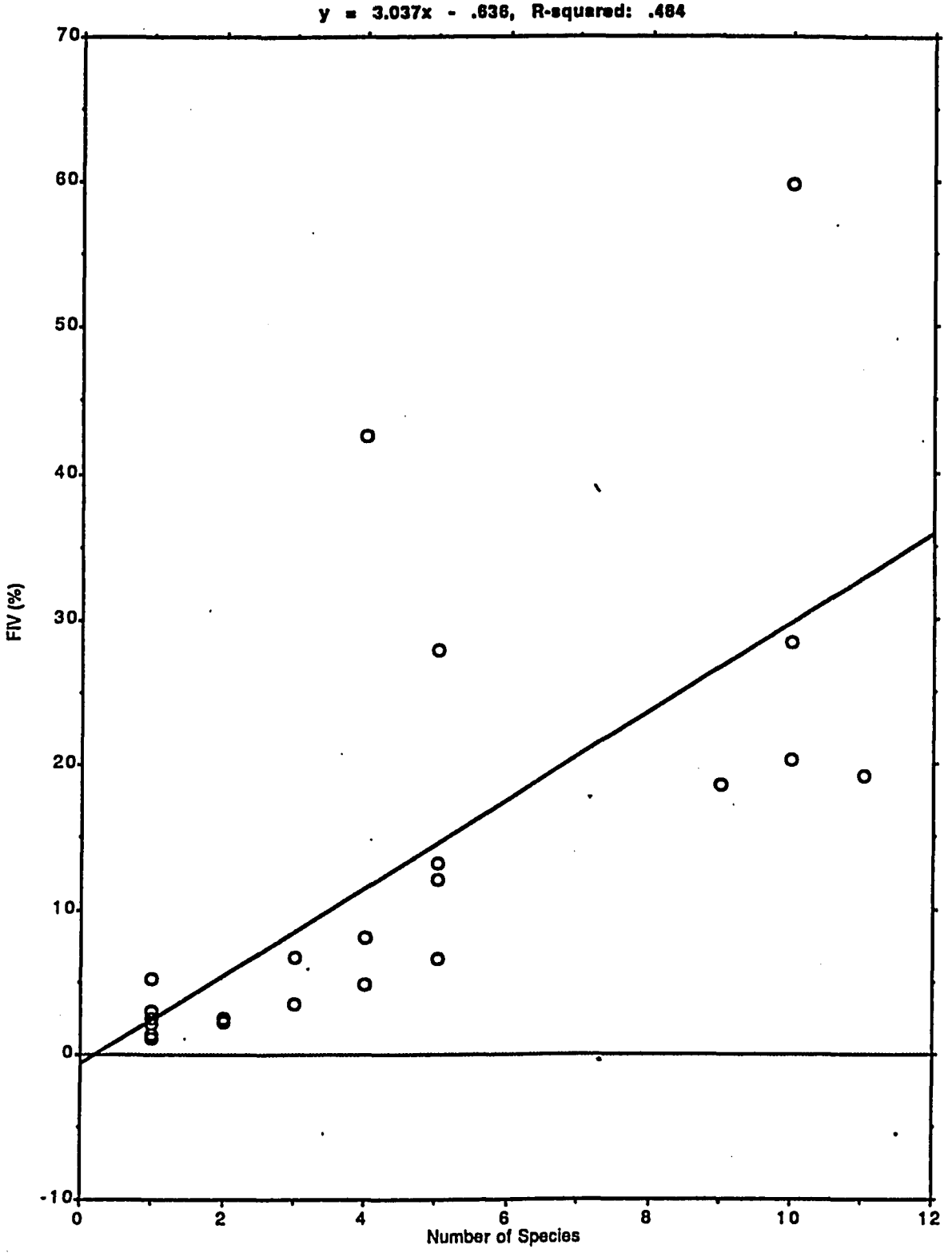
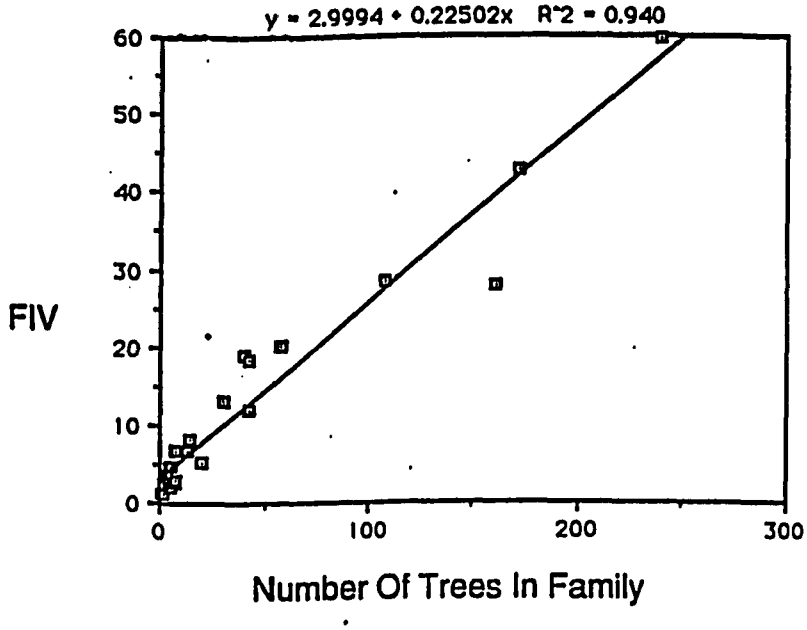
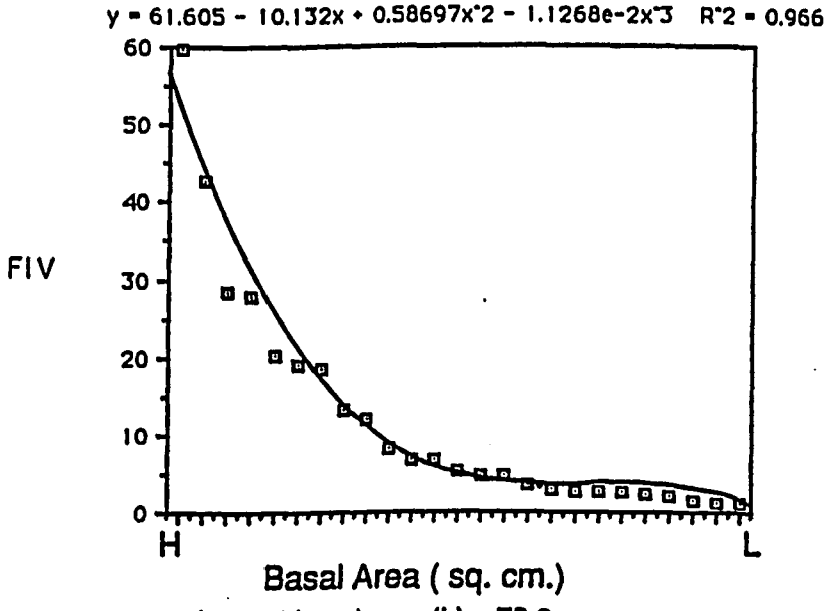


FIG. 14



Variation Of Family Importance Values With Respect To Numbers Of Trees In Each Of The 25 Families In The 1000 Tree Sample

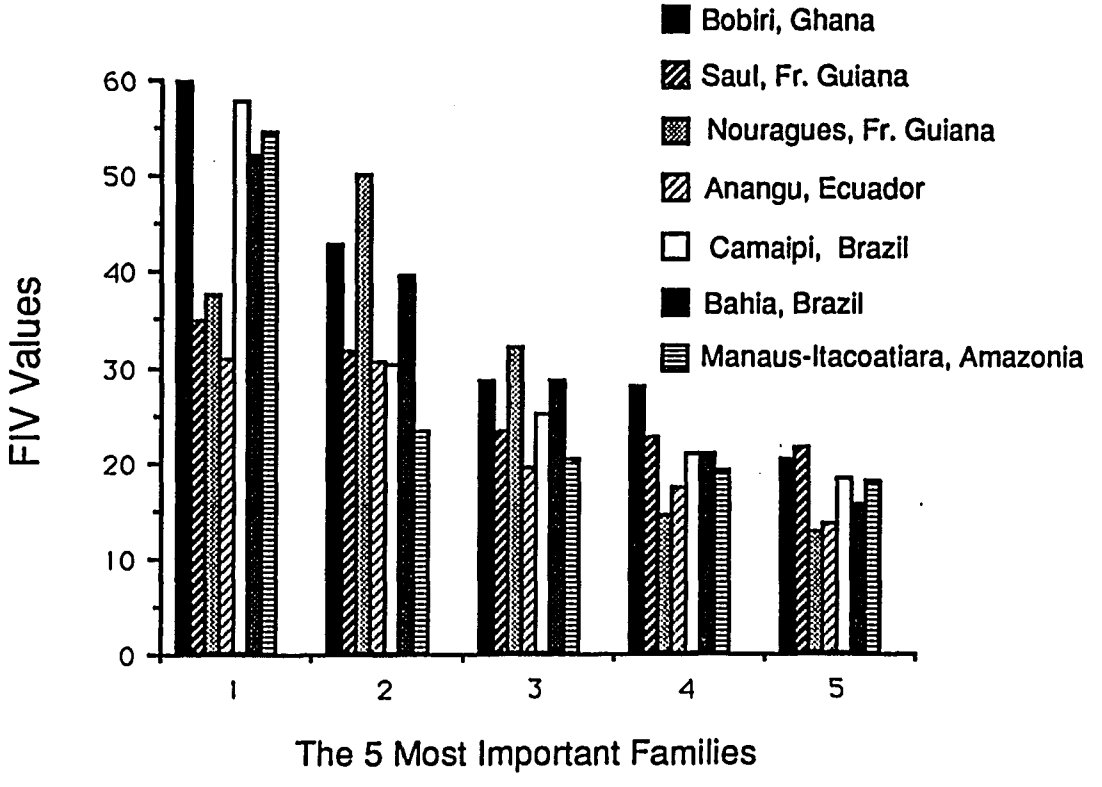
FIG. 15



Lowest basal area (L) = 78.6 sq. cm.
Highest basal area (H) = 125,354 sq. cm.

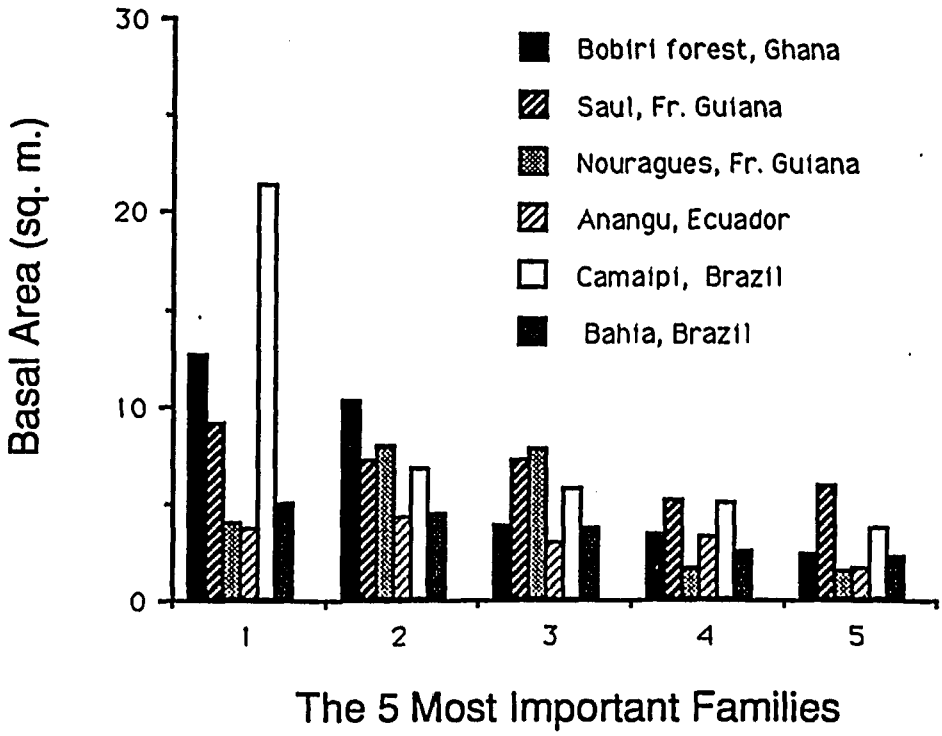
The Influence Of Total Trunk Basal Area On Family Importance Values For The 25 Families In The 1000 Tree Sample Of The Bobiri Forest

FIG. 16



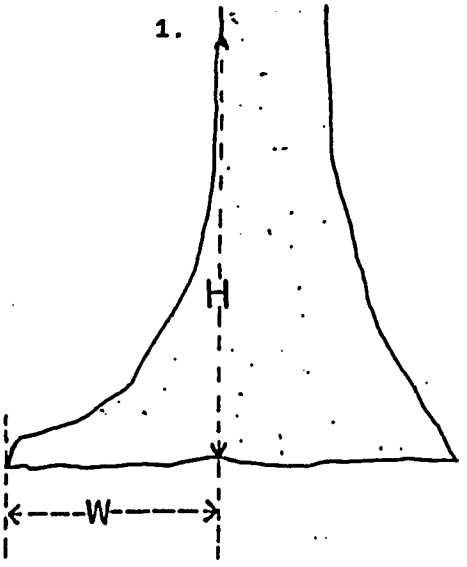
Comparison Of Family Importance Values Of The 5 Most Important Families Of The Bobiri Forest With The 5 Most Important Families Of 6 Neotropical Forests.

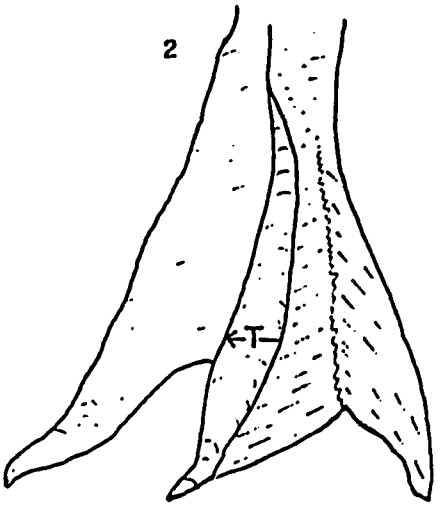
FIG. 17



Comparison Of The Total Basal Areas Of The 5 Most Important Families Of The Bobiri Forest, With Values Of 5 Neotropical Forests.

FIG.18. TERMINOLOGY FOR BUTTRESSES

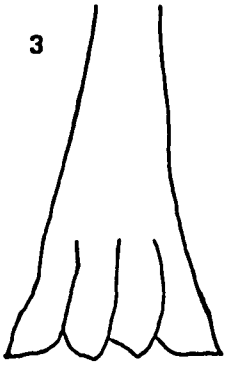




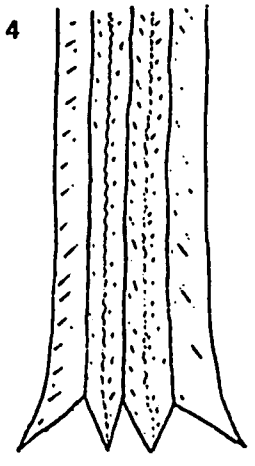
T = THICKNESS OF BUTTRESS

H = Height of buttress (vertical)
also referred to as Tallness

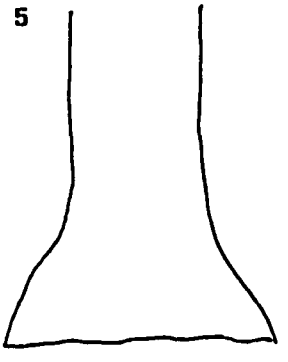
W = Width of buttress (horizontal)
also referred to as : Wide,
Extended, Long buttress.



INCIPIENT BUTTRESSES

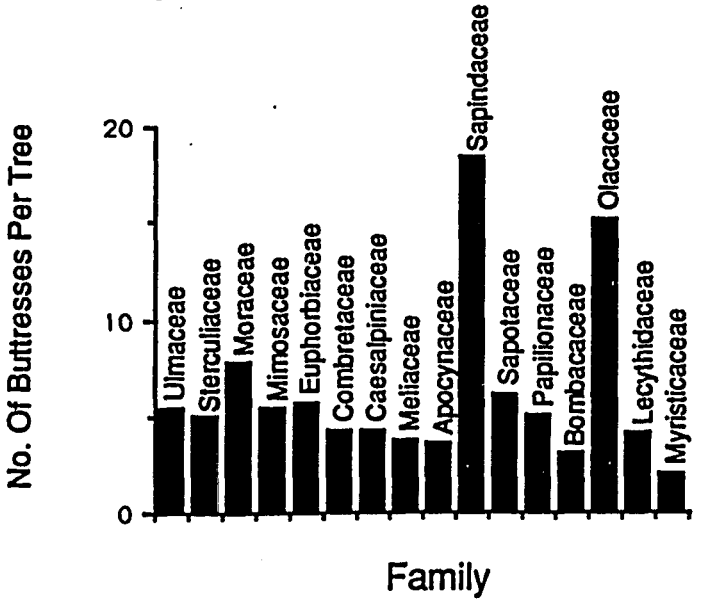


FLUTED TRUNK OF A TREE



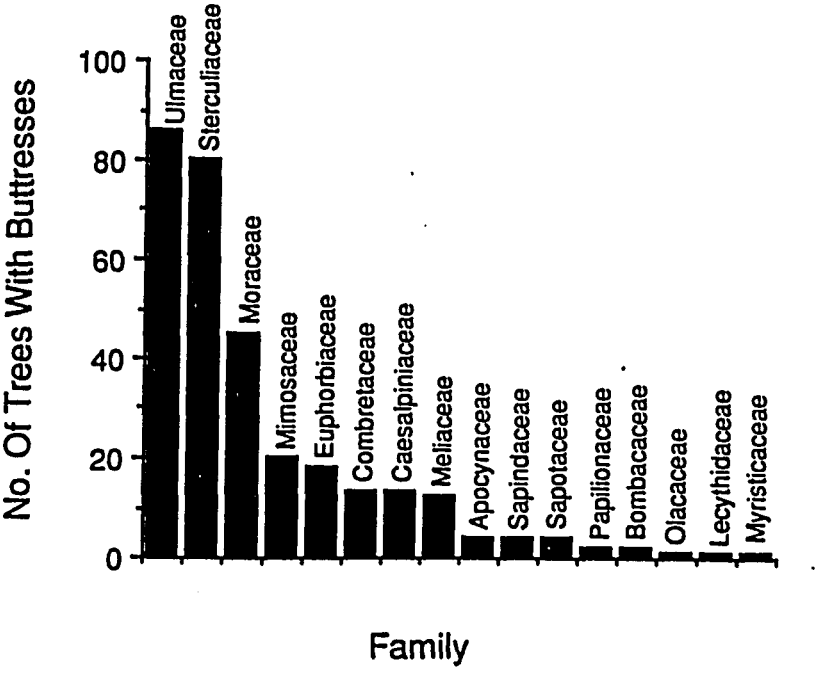
FLUTED BASE OF TRUNK

FIG. 19



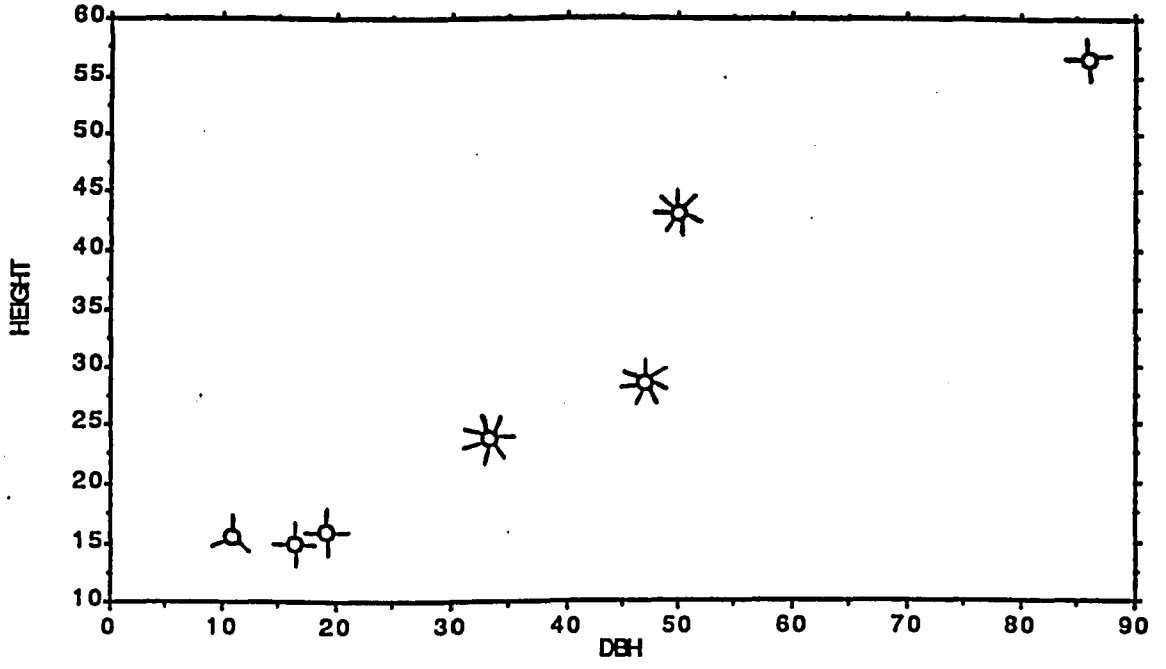
The number of buttresses per tree in each of the 25 families of the 1000 tree sample of the Bobiri forest reserve.

FIG. 20



The number of trees with buttresses in the 16 buttressed families in the 1000 tree sample of the Bobiri forest.

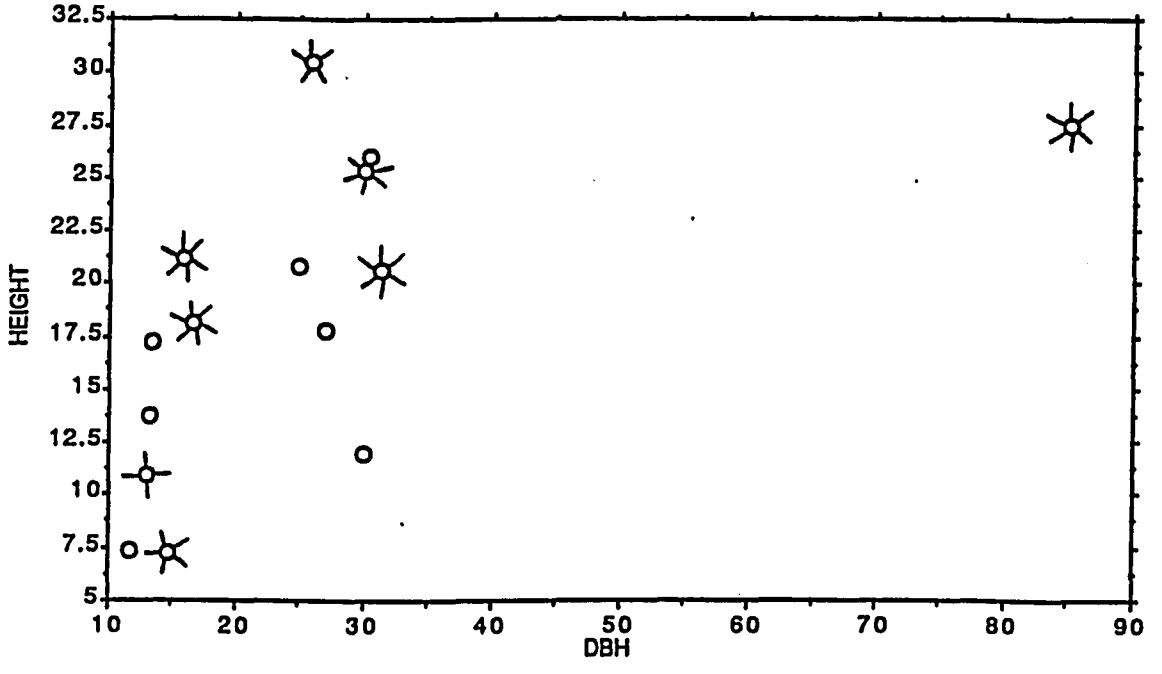
FIG.21 BUTTRESS DEVELOPMENT FOR ALBIZIA ZIGIA



DBH (cm) Height (m). All trees in sample were buttressed.

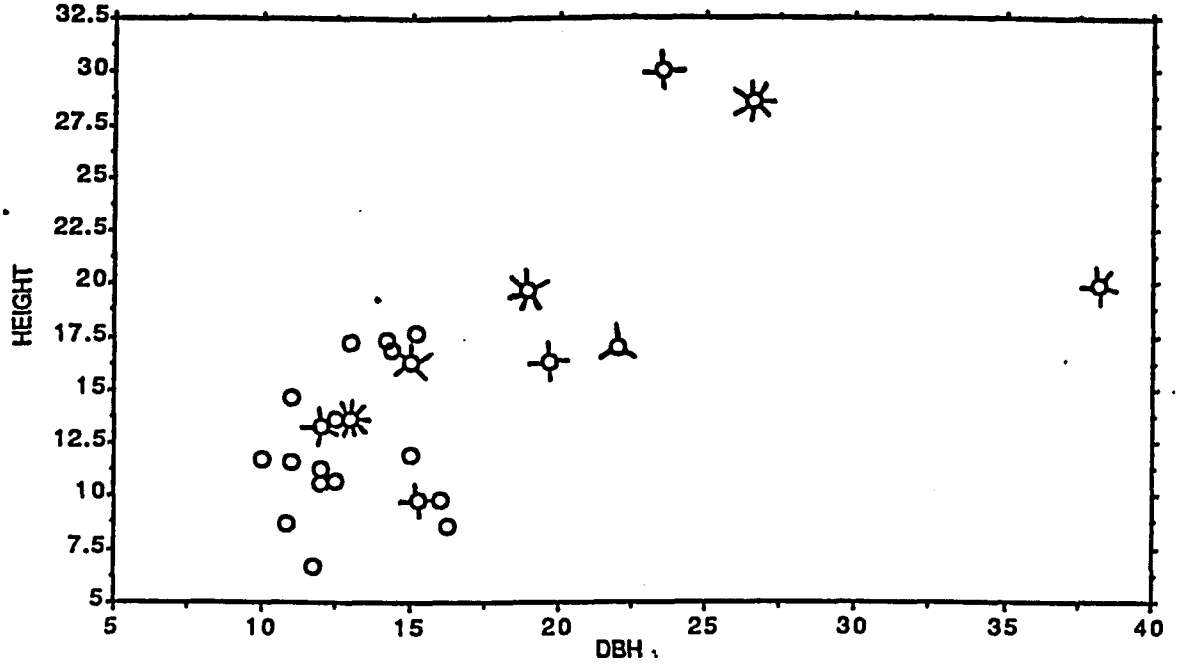
FIG. 22

BUTTRESS DEVELOPMENT FOR CELTIS ADOLFI-FRIDERICI



DBH (cm) Height (m). About 50% of trees in sample were buttressed.

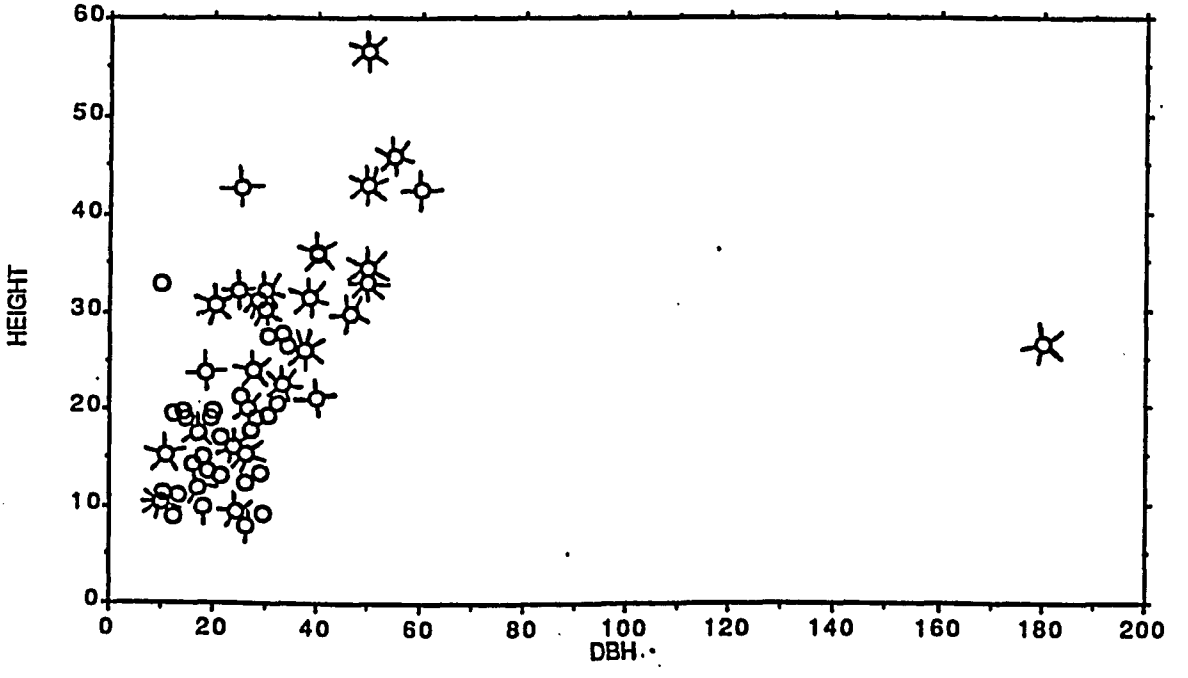
FIG. 23 BUTTRESS DEVELOPMENT FOR CELTIS MILDBRAEDII



DBH (cm) Height (m). About 38% of trees in sample were buttressed.

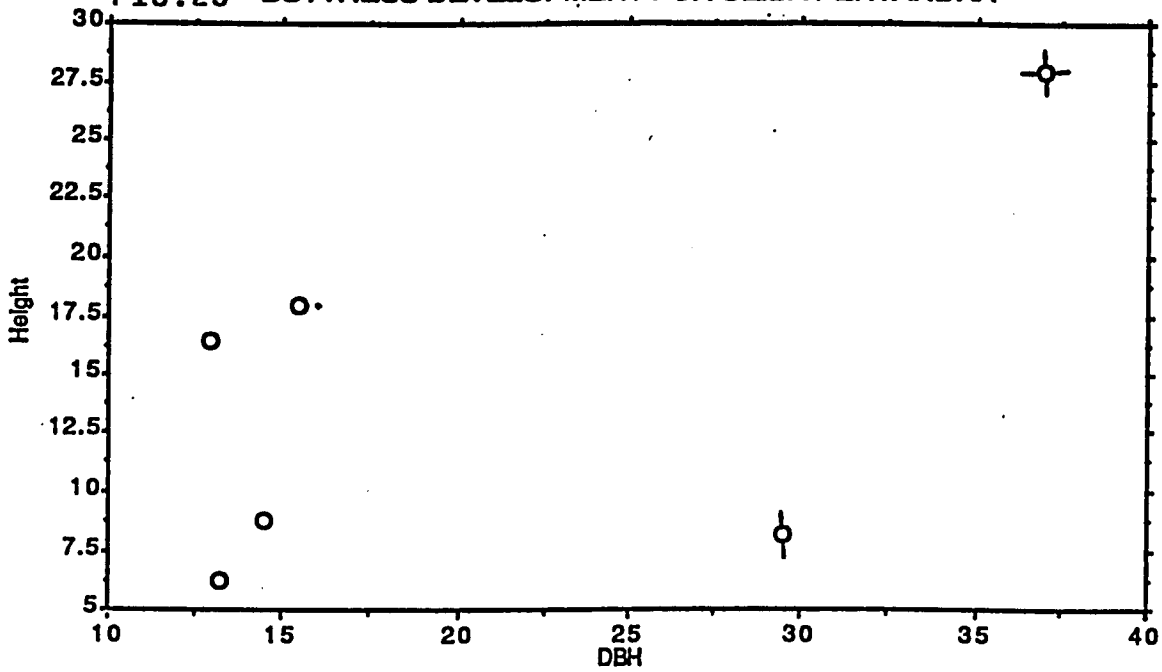
FIG. 24

BUTTRESS DEVELOPMENT FOR CELTIS ZENKERI



DBH (cm) Height (m). About 70% of trees in sample were buttressed.

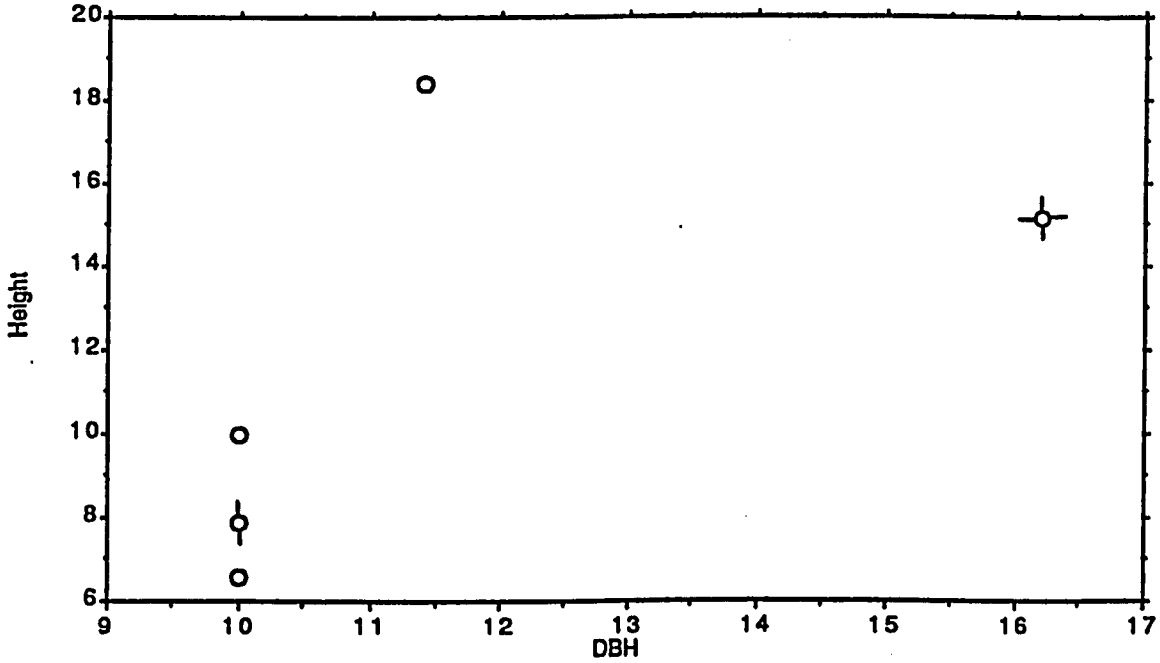
FIG.25 BUTTRESS DEVELOPMENT FOR CEIBA PENTANDRA



DBH (cm) Height (m). About 33% of trees in sample were buttressed.

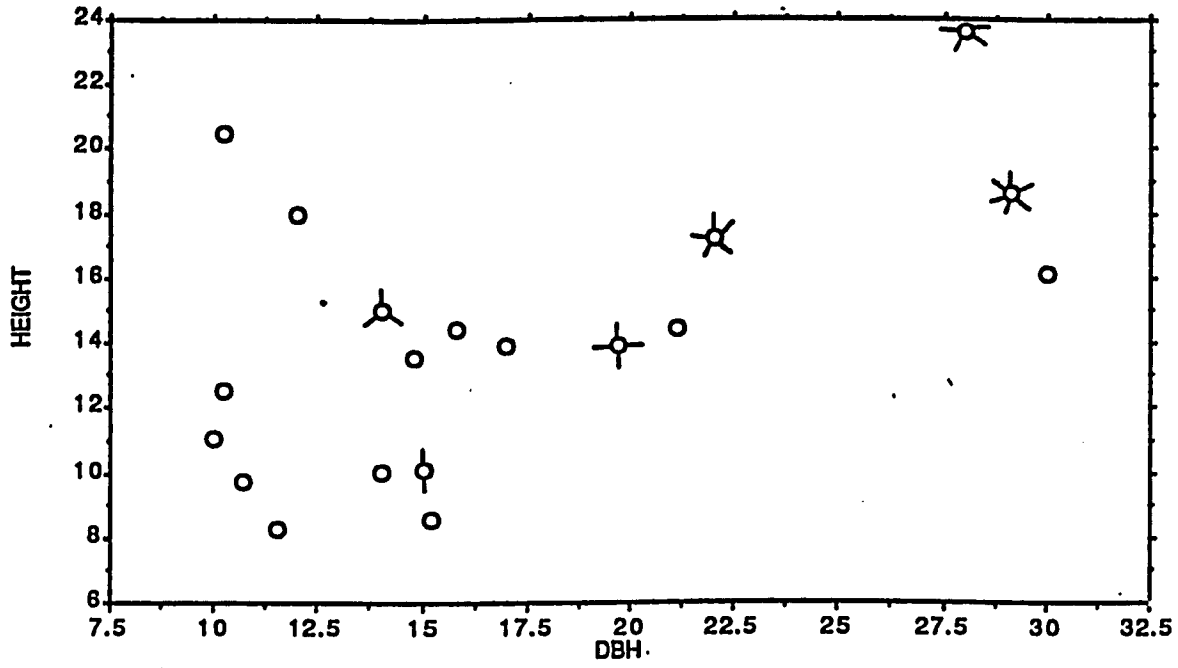
FIG. 26

BUTTRESS DEVELOPMENT FOR CLEIDION GABONICUM



DBH (cm) Height (m). About 40% of trees in sample were buttressed.

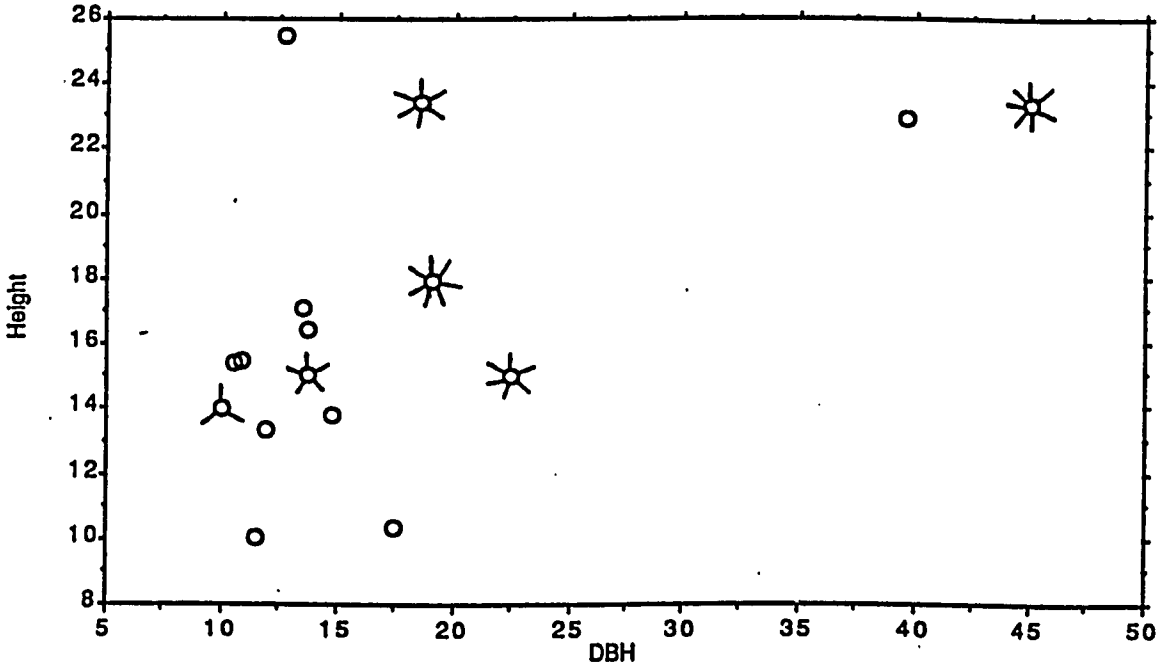
FIG.27 BUTTRESS DEVELOPMENT FOR COLA GIGANTEA



DBH (cm) Height (m). About 30% of trees in sample were buttressed.

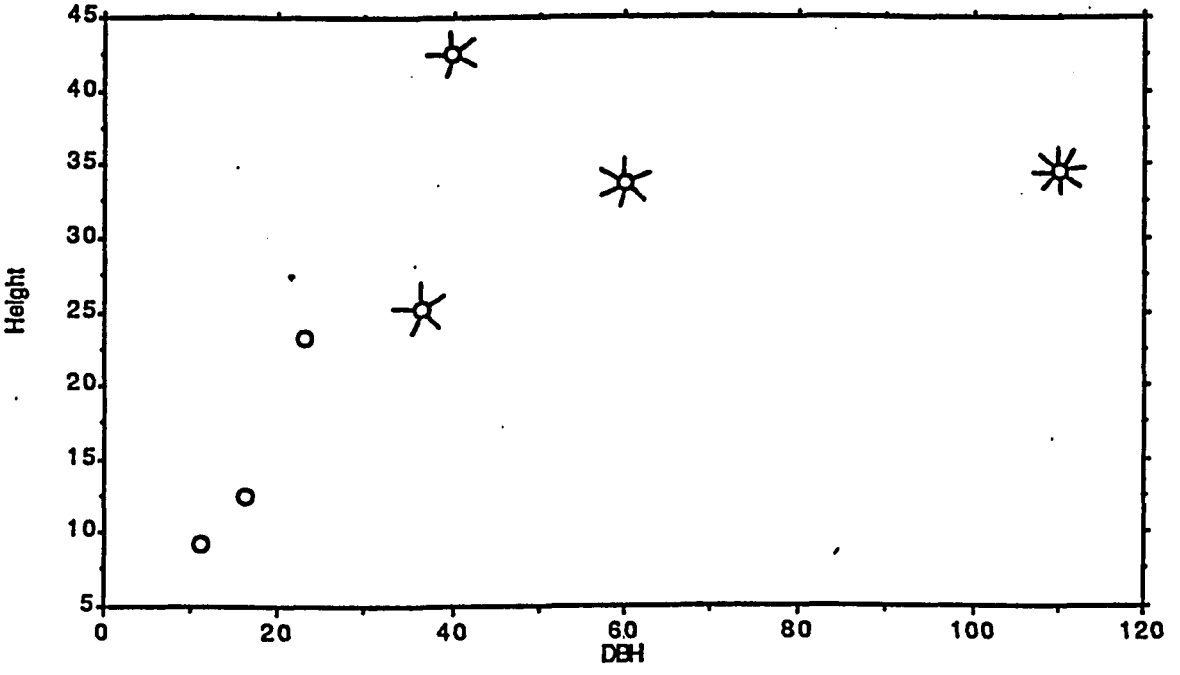
FIG. 28

BUTTRESS DEVELOPMENT FOR CRUDIA GABUNENSIS



DBH (cm) Height (m). About 40% of trees in sample were buttressed.

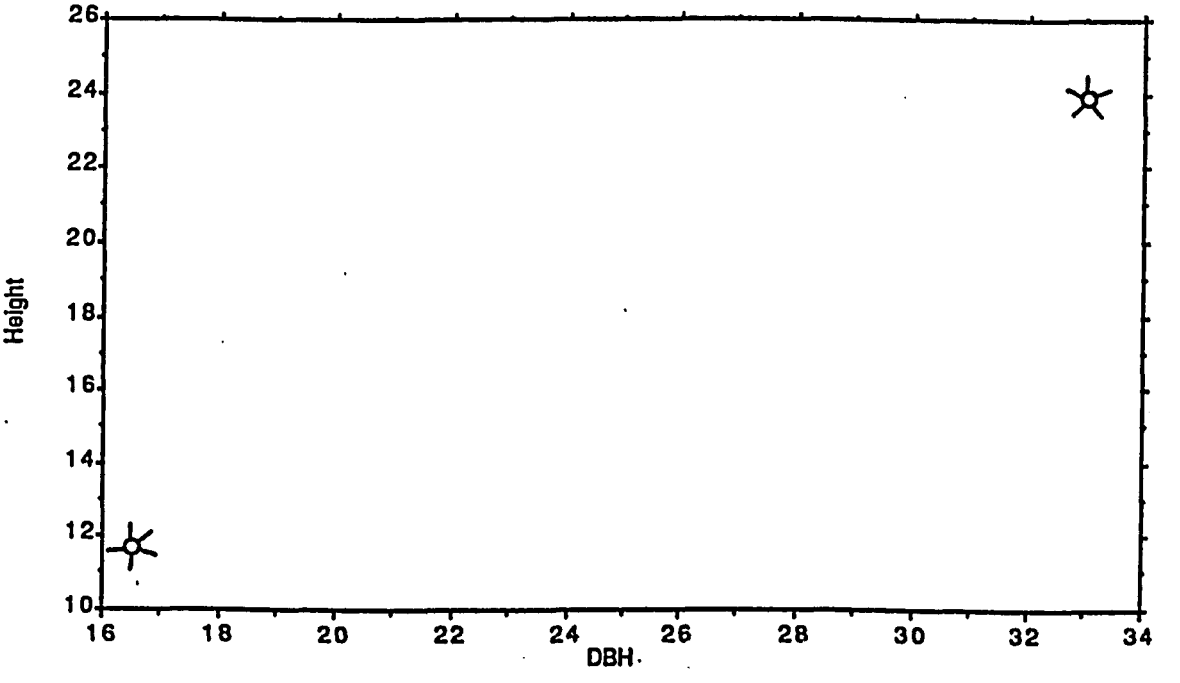
FIG.29 BUTTRESS DEVELOPMENT FOR CYLICODISCUS GABUNENSIS



DBH (cm) Height (m). About 60% of trees in sample were buttressed.

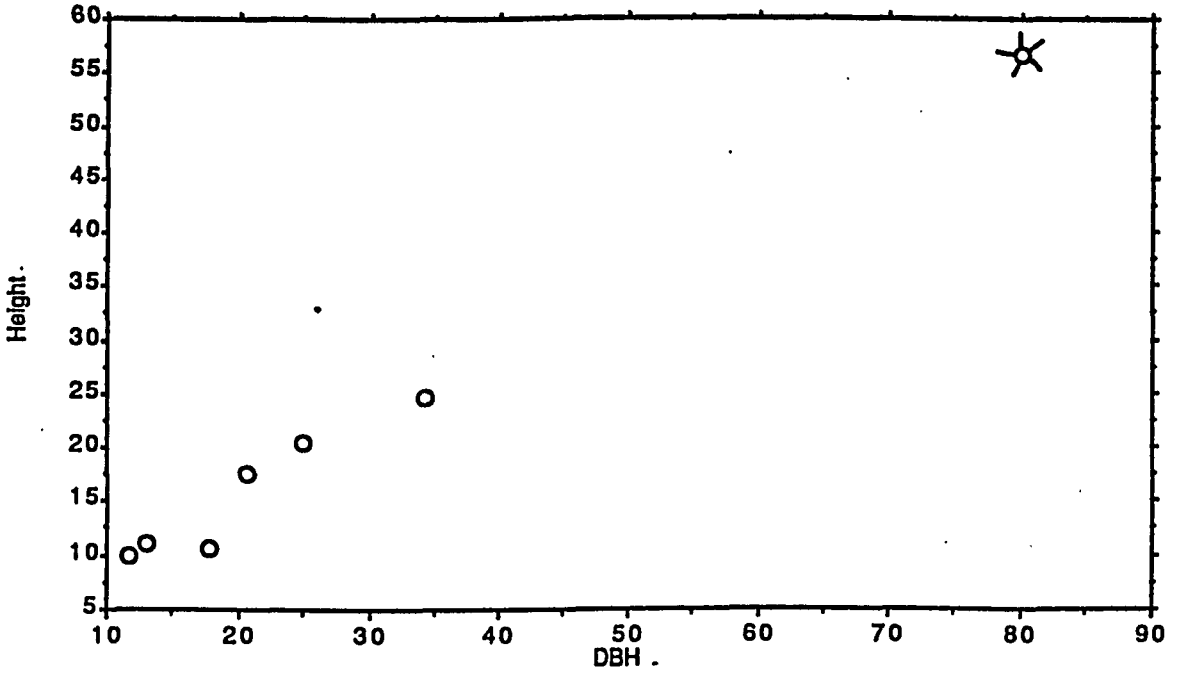
FIG. 30

BUTTRESS DEVELOPMENT FOR DALBERGIELLA WELWITSCHII



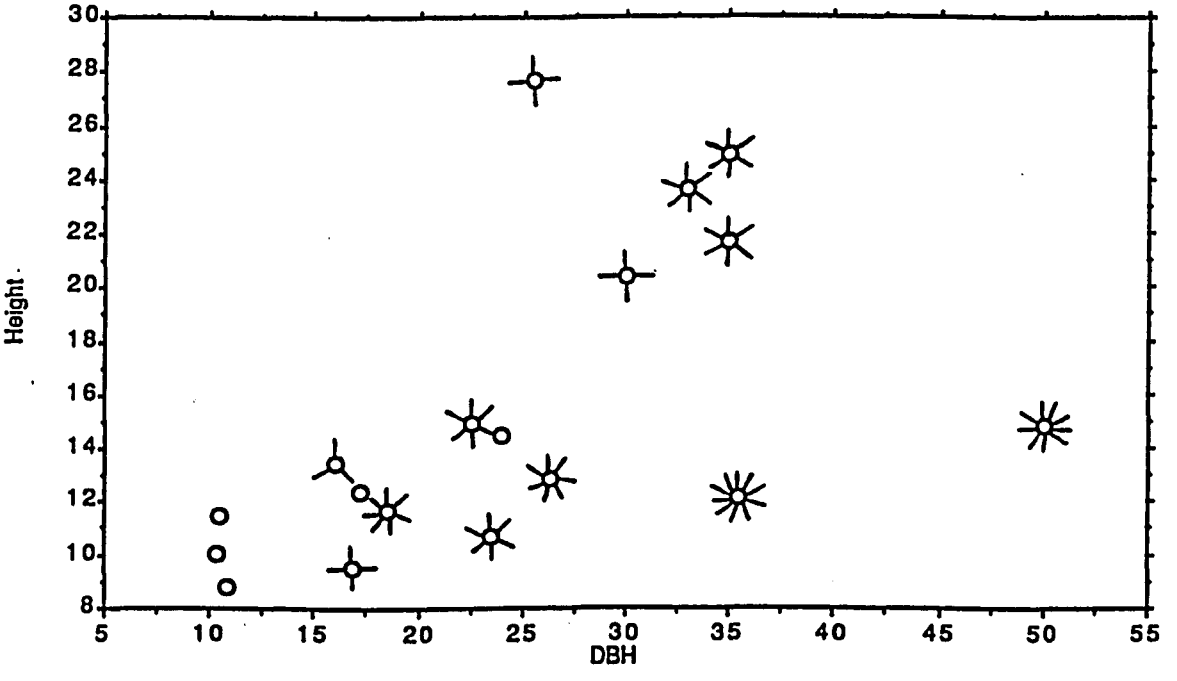
DBH (cm) Height (m). All trees in sample were buttressed.

FIG.31 BUTTRESS DEVELOPMENT FOR ENTANDROPHRAGMA CYLINDRICUM



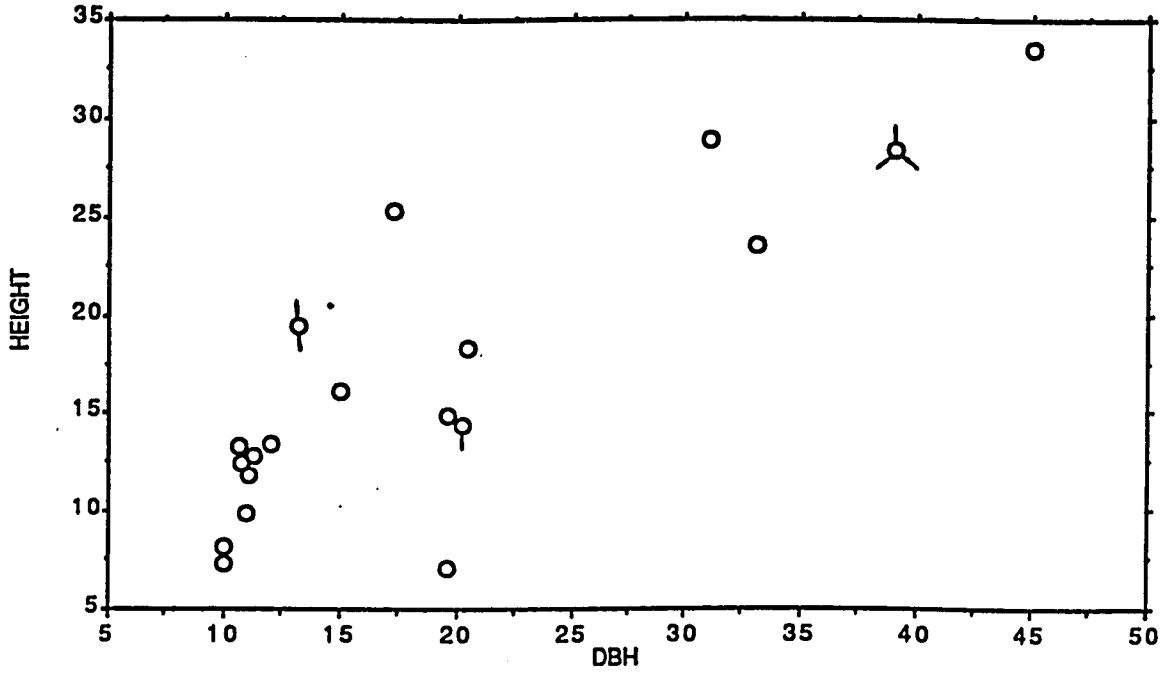
DBH (cm) Height (m). About 15% of trees in sample were buttressed.

FIG. 32
BUTTRESS DEVELOPMENT FOR FICUS EXASPERATA



DBH (cm) Height (m). About 85% of trees in sample were buttressed.

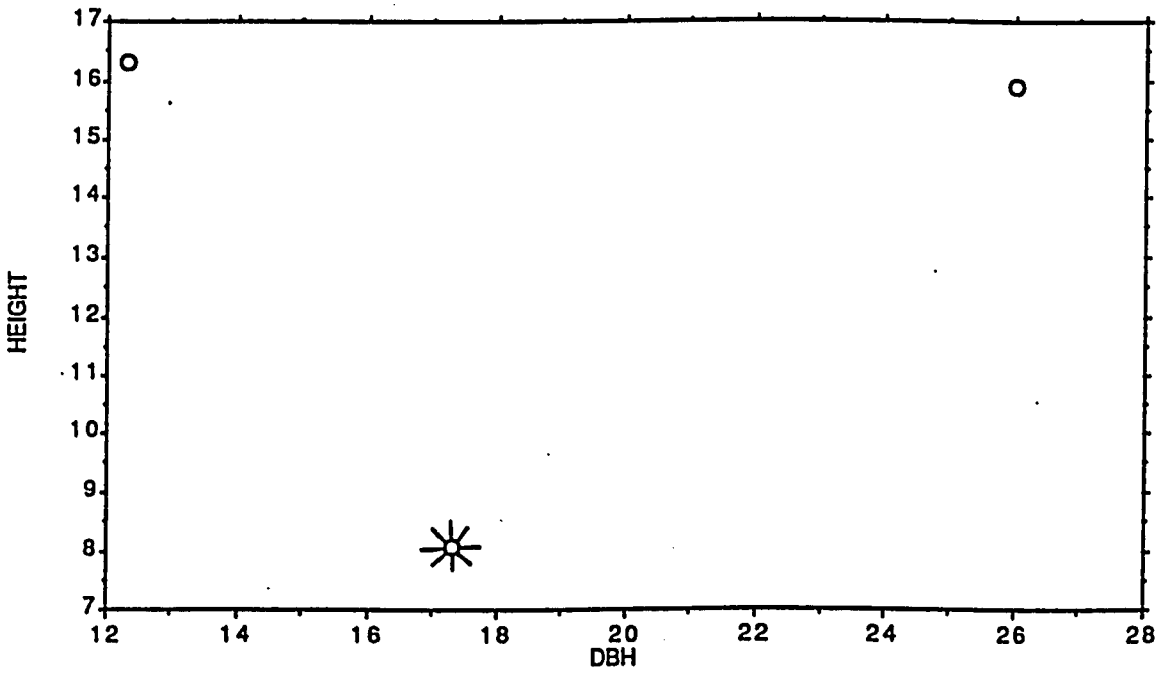
FIG.33 BUTTRESS DEVELOPMENT FOR GUAREA CEDRATA



DBH (cm) Height (m). Only 10% of trees in sample were buttressed.

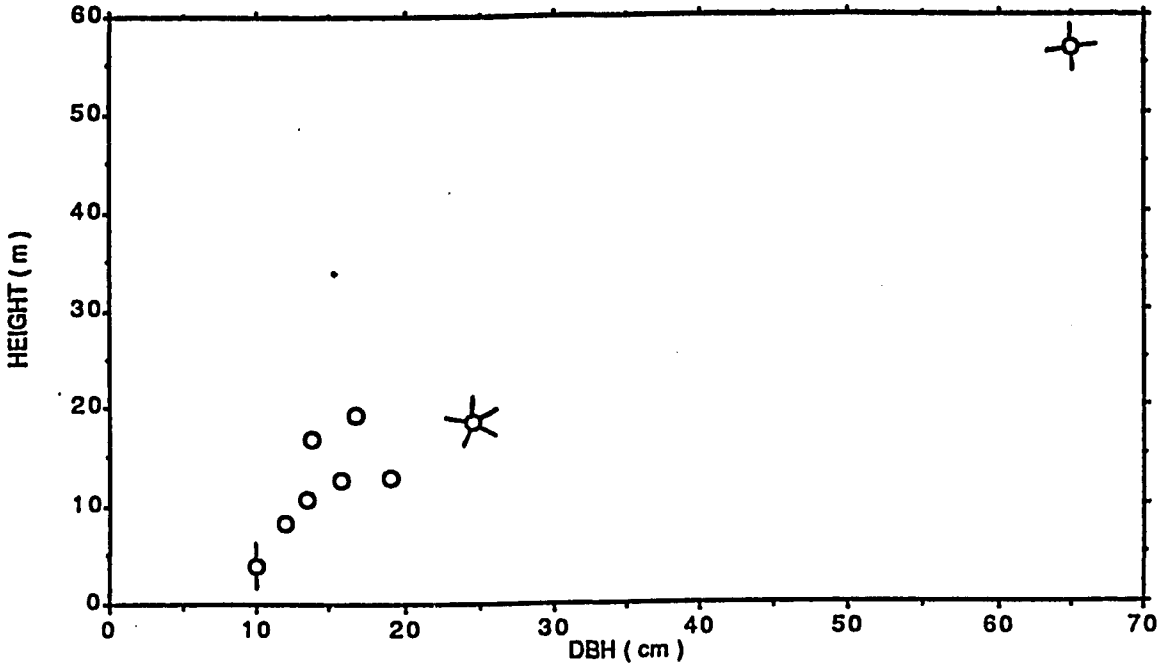
FIG. 34

BUTTRESS DEVELOPMENT FOR HYMENOSTEGIA AFZELII



DBH (cm) Height (m). About 70% of trees in sample were buttressed.

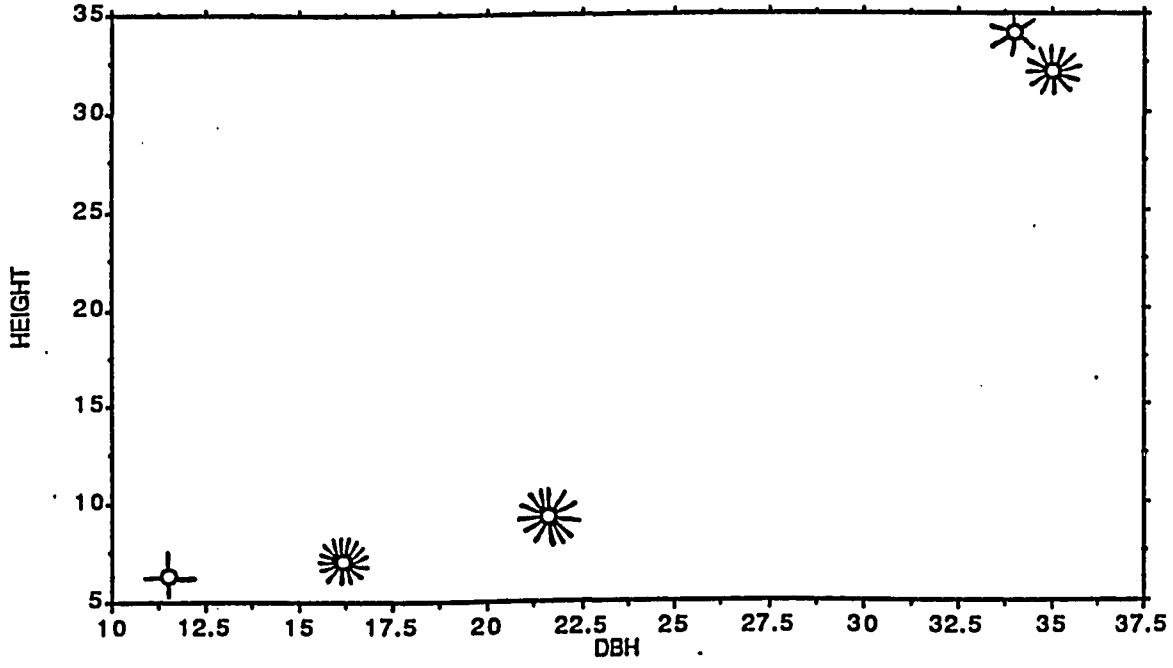
FIG.35 BUTTRESS DEVELOPMENT FOR KHAYA IVORENSIS



About 22% of trees in sample were buttressed.

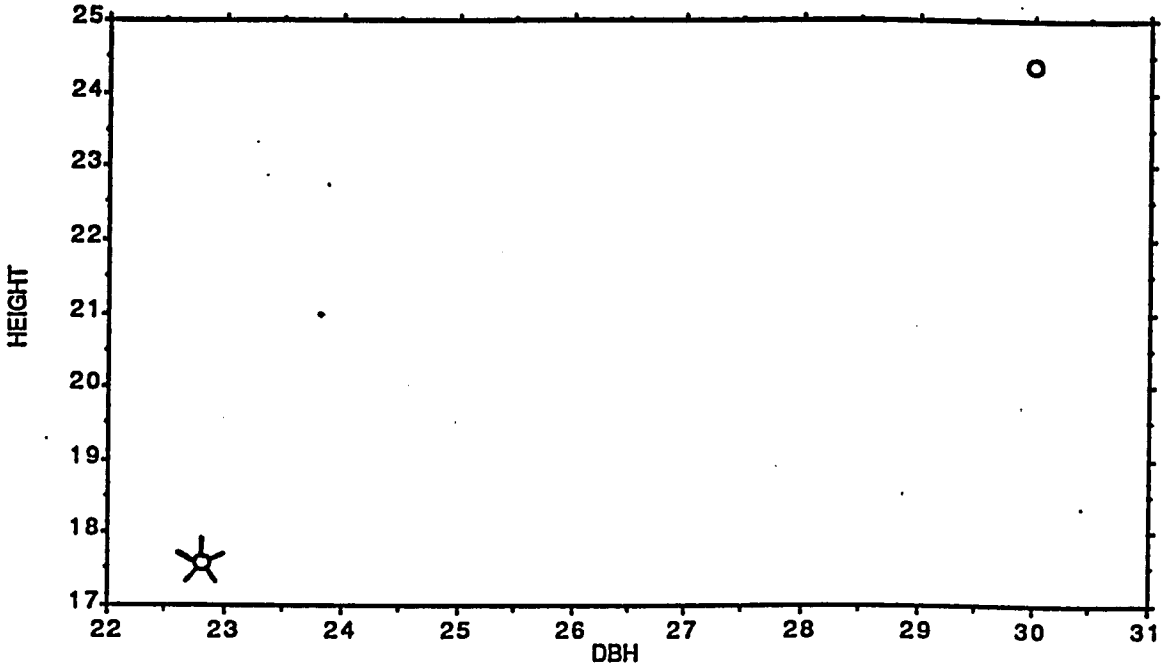
FIG. 36

BUTTRESS DEVELOPMENT FOR MACARANGA HEUDELOTII



DBH (cm) Height (m). 80% Of trees in sample were buttressed.

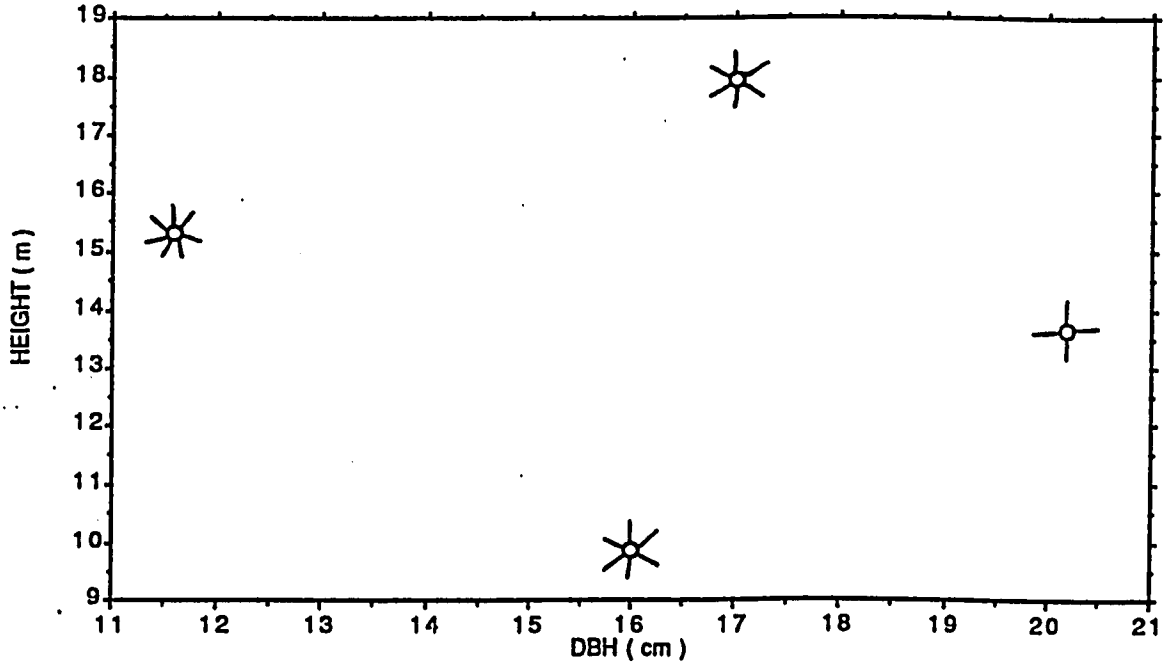
FIG.37 BUTTRESS DEVELOPMENT FOR MANIOPHYTON FULVUM



DBH (cm) Height (m). 50% Of trees in sample were buttressed.

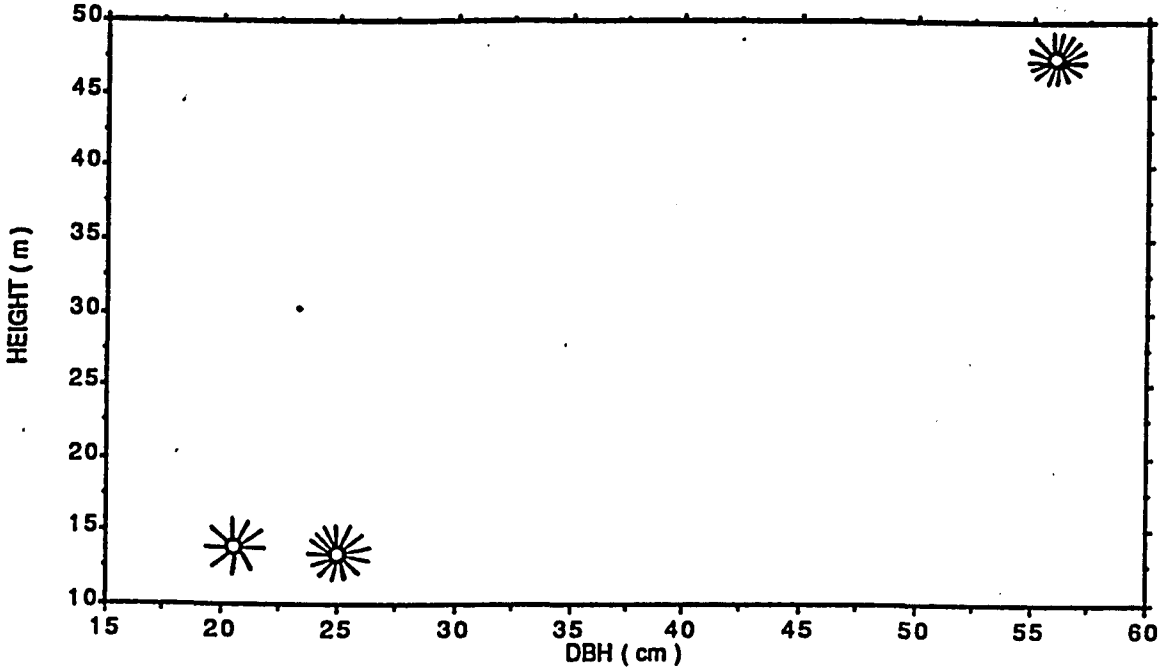
FIG. 38

BUTTRESS DEVELOPMENT FOR MORUS MESOZYGIA



All trees in sample were buttressed.

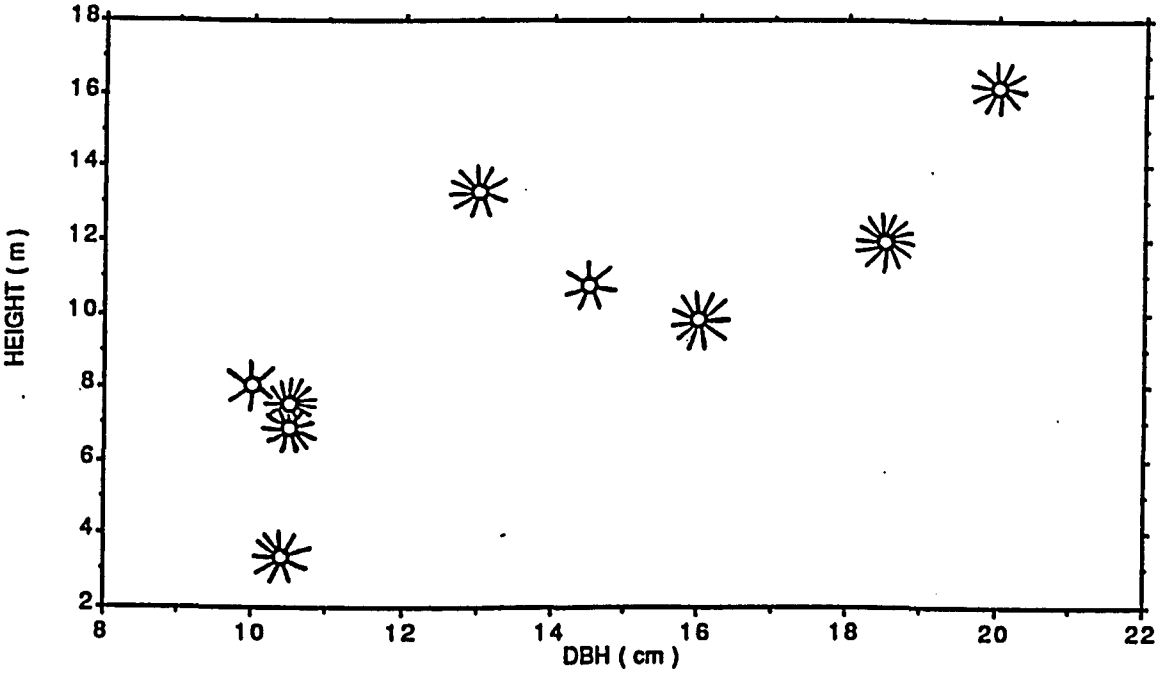
FIG.39 BUTTRESS DEVELOPMENT FOR MUSANGA CECROPIOIDES



All trees in sample were buttressed.

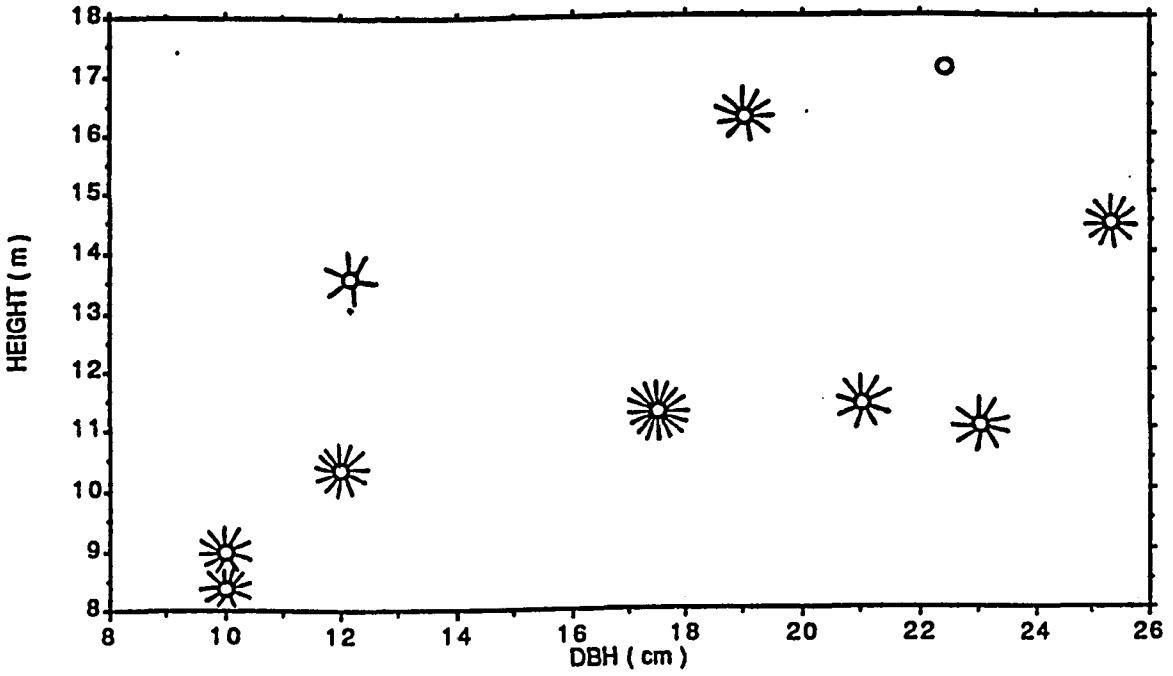
FIG. 40

BUTTRESS DEVELOPMENT FOR MYRIANTHUS ARBOREUS



All trees in sample were buttressed.

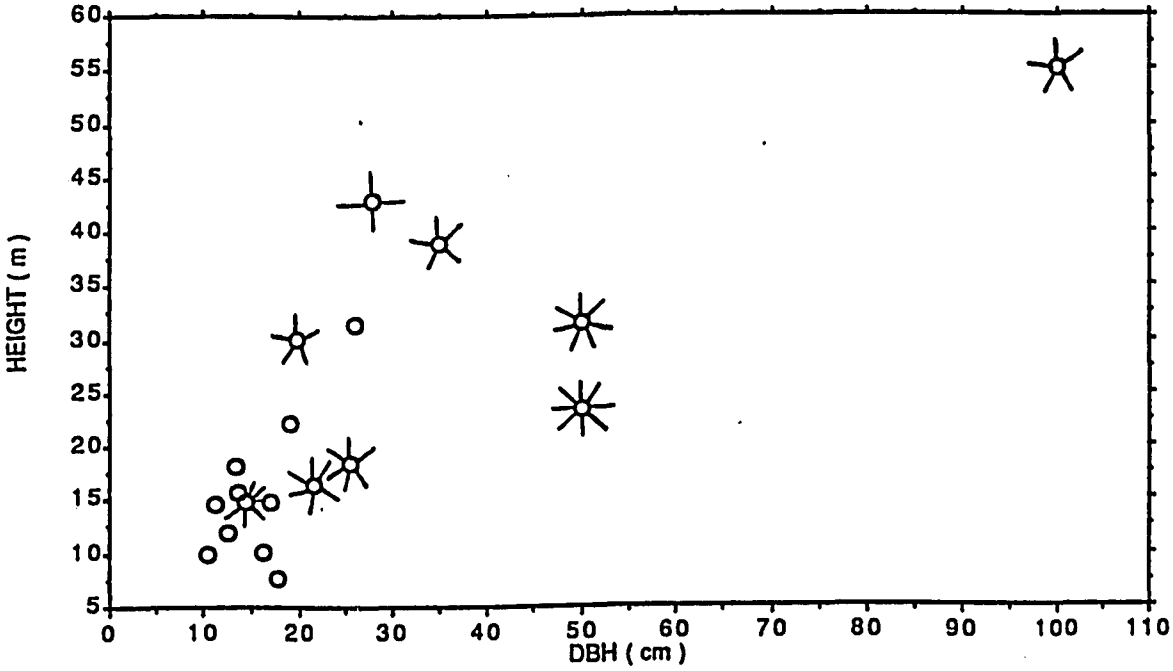
FIG.41 BUTTRESS DEVELOPMENT FOR MYRIANTHUS LIBERICUS



90% of trees in sample were buttressed.

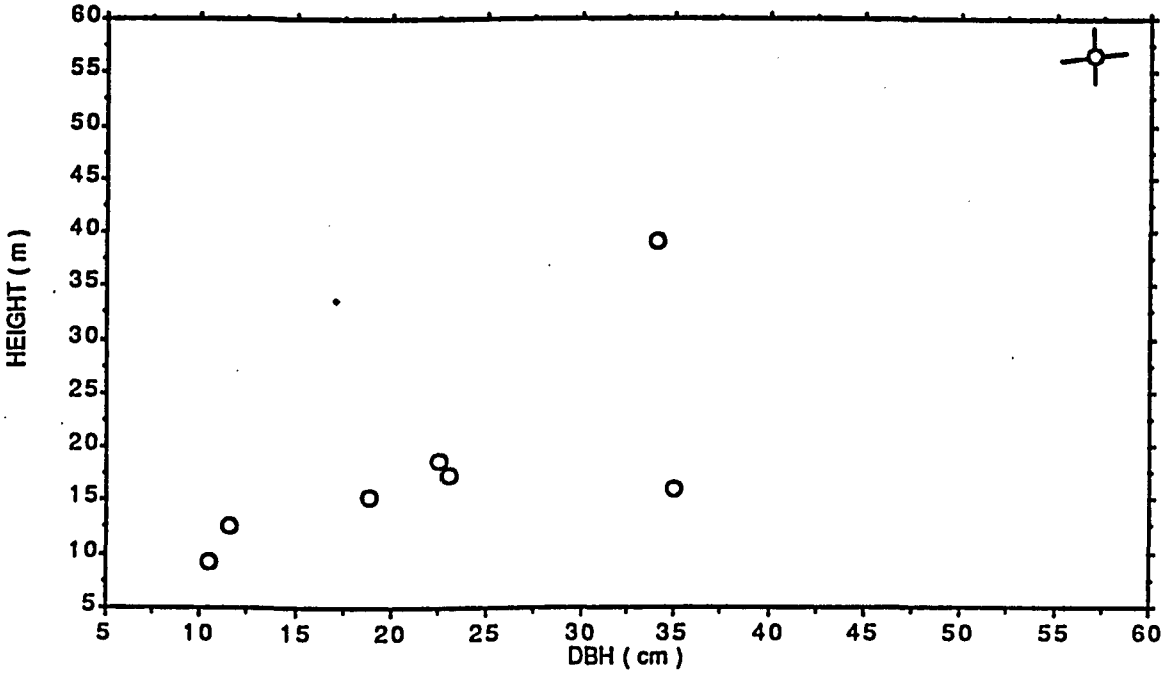
FIG. 42

BUTTRESS DEVELOPMENT FOR NESOGORDONIA PAPAVERIFERA



About 50% of trees in sample were buttressed.

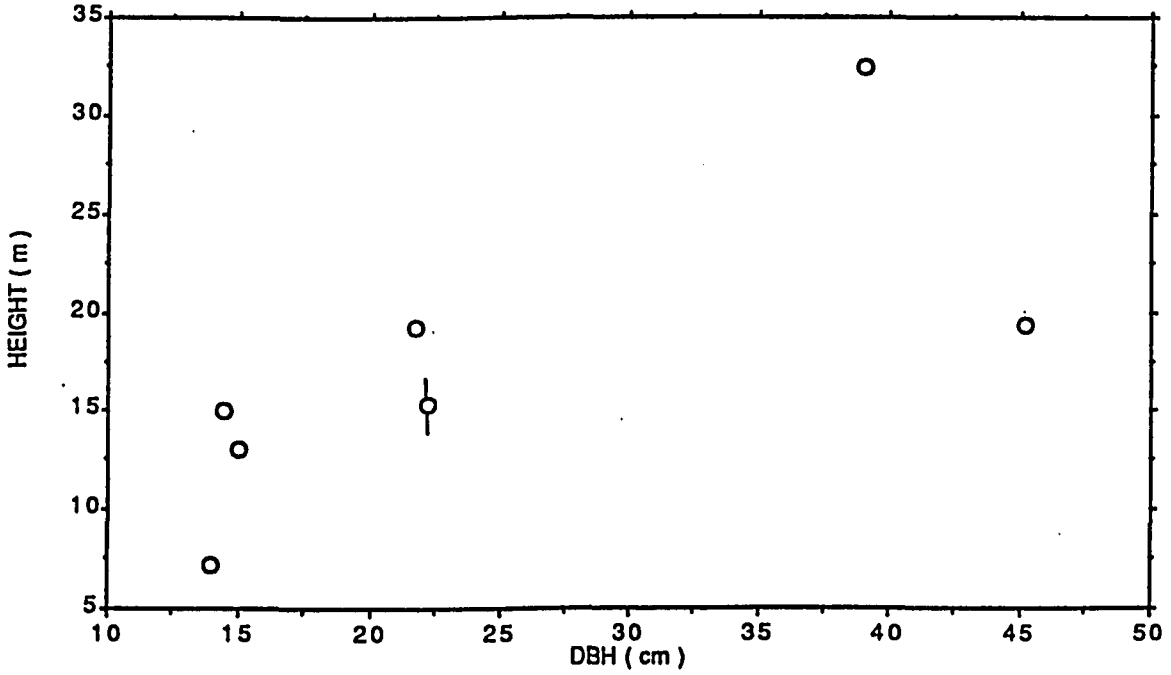
FIG.43 BUTTRESS DEVELOPMENT FOR PETERSIANTHUS MACROCARPA



About 13% of trees in sample were buttressed.

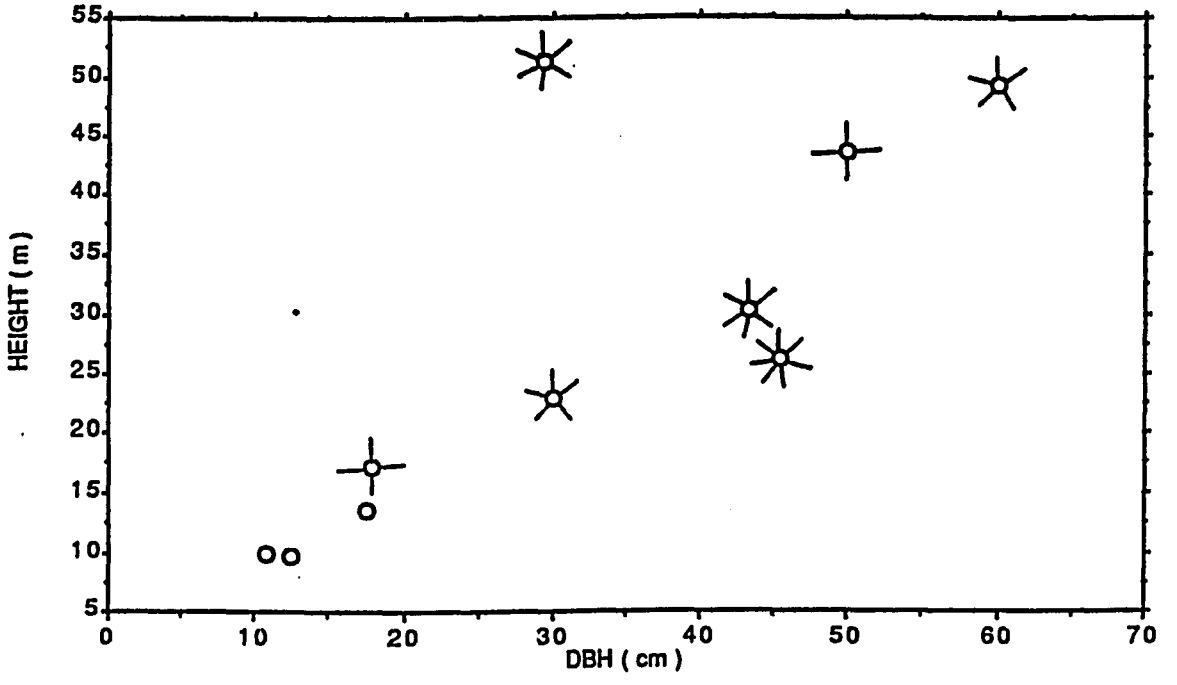
FIG. 44

BUTTRESS DEVELOPMENT FOR PICNANTHUS ANGOLENSIS



About 15% of trees in sample were buttressed.

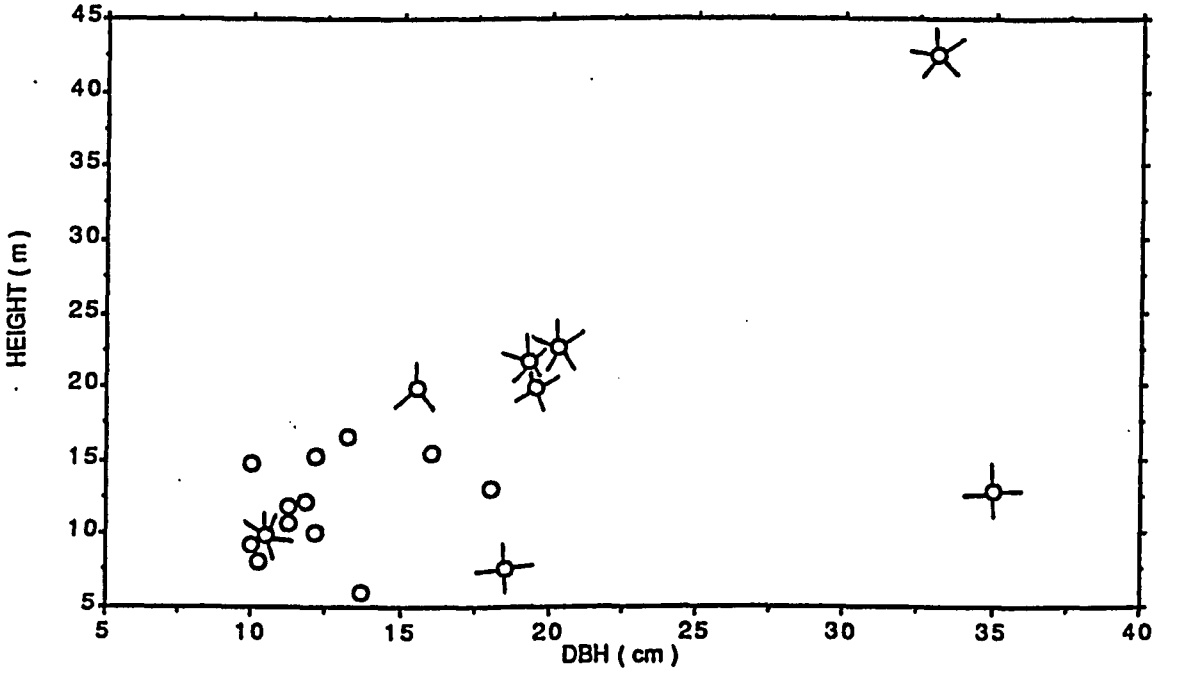
FIG.45 BUTTRESS DEVELOPMENT FOR PIPTADENIASTRUM AFRICANUM



About 70% of trees in sample were buttressed.

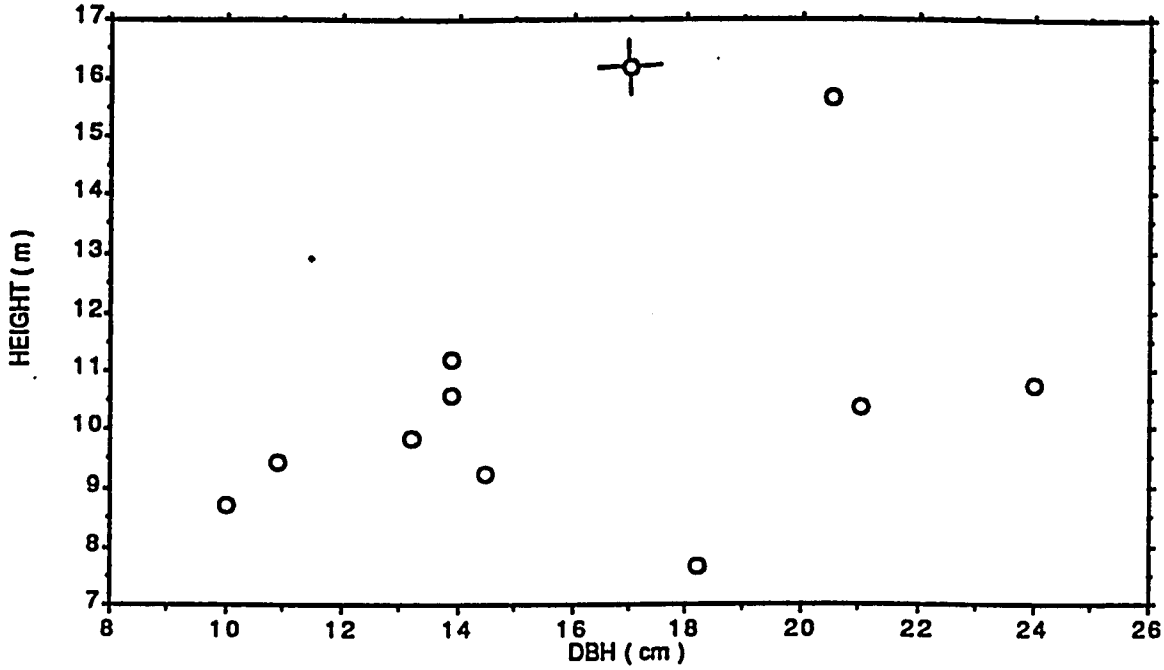
FIG. 46

BUTTRESS DEVELOPMENT FOR PTERYGOTA MACROCARPA



About 40% of trees in sample were buttressed.

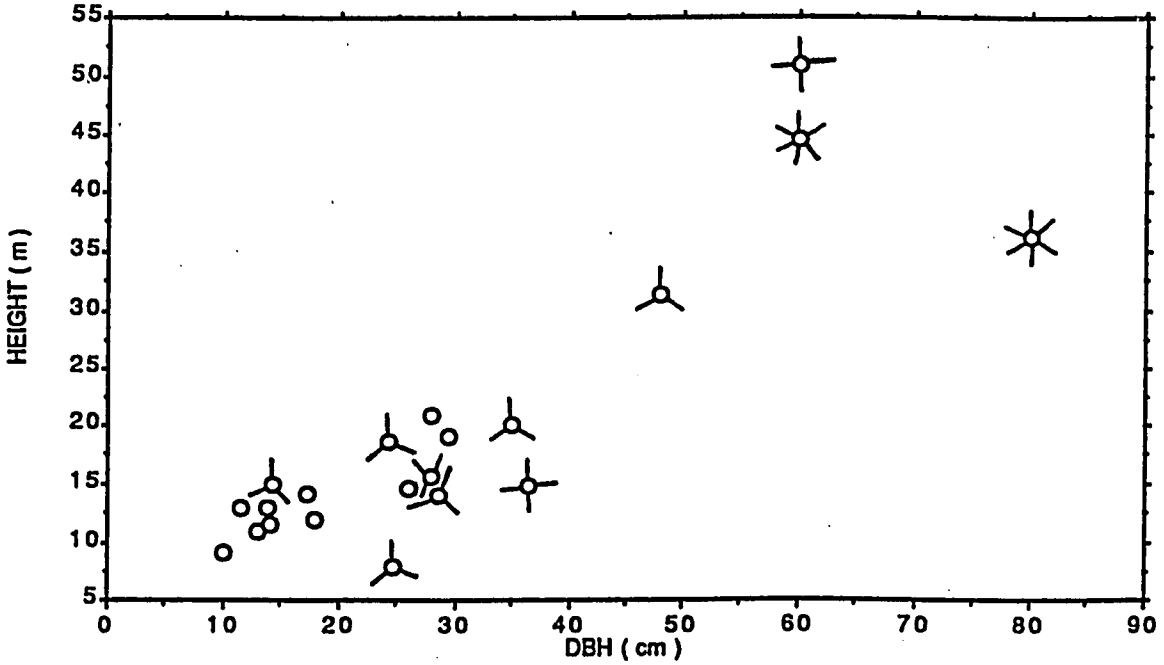
FIG.47 BUTTRESS DEVELOPMENT FOR RAUVOLFIA VOMITORIA



About 10% of trees in sample were buttressed.

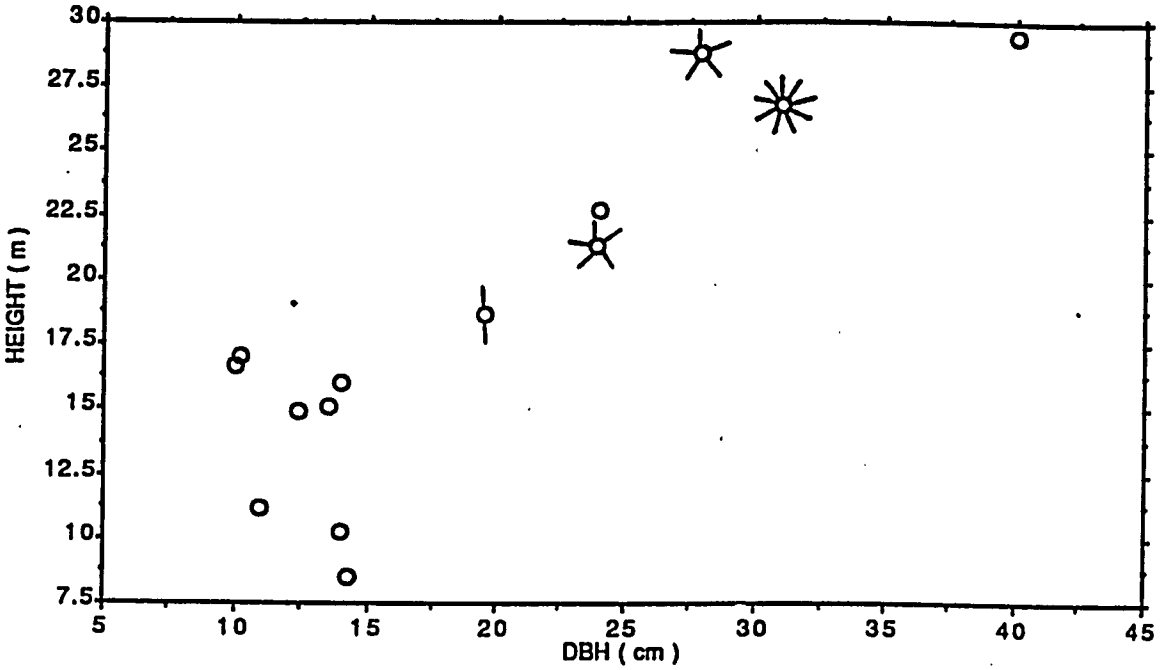
FIG. 48

BUTTRESS DEVELOPMENT FOR RICINODENDRON HEUDELOTII



About 50% of trees in sample were buttressed.

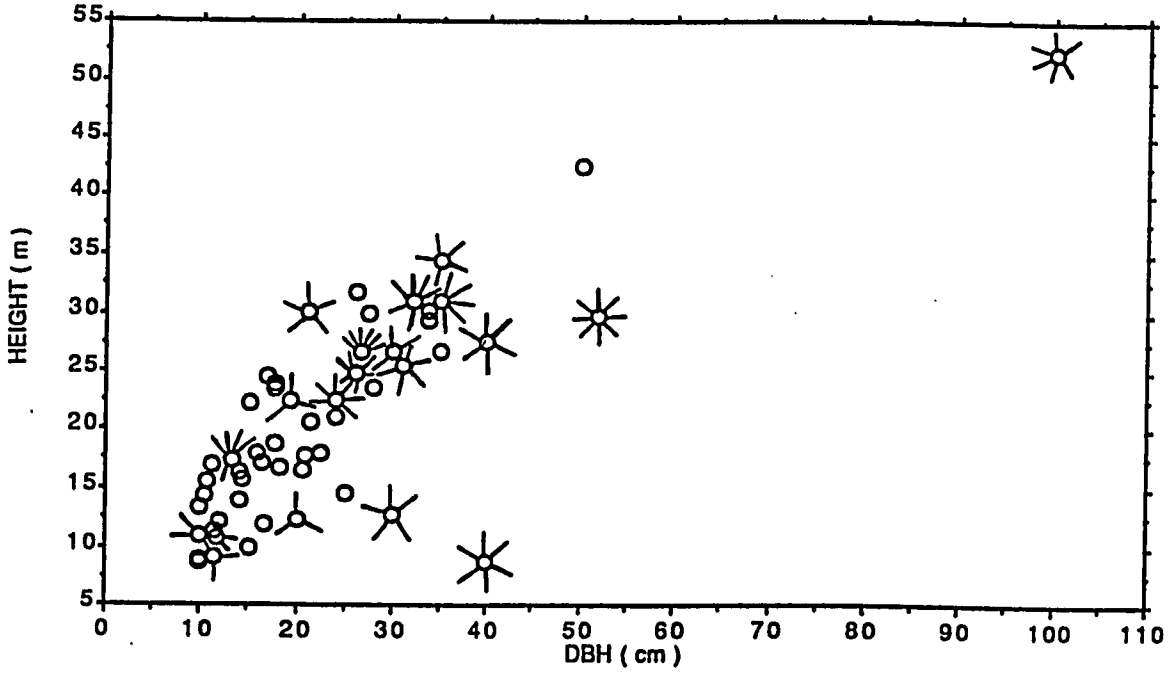
FIG.49 BUTTRESS DEVELOPMENT FOR STERCULIA OBLONGA



About 36% of trees in sample were buttressed.

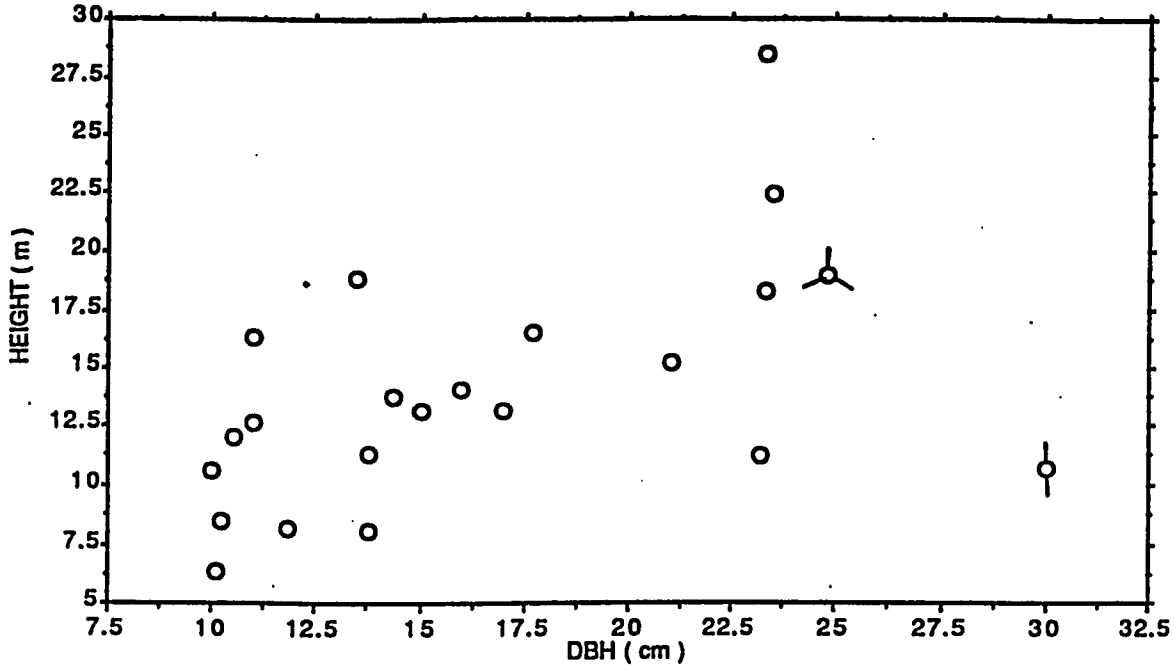
FIG. 50

BUTTRESS DEVELOPMENT FOR STERCULIA RHINOPETALA



About 40% of trees in sample were buttressed.

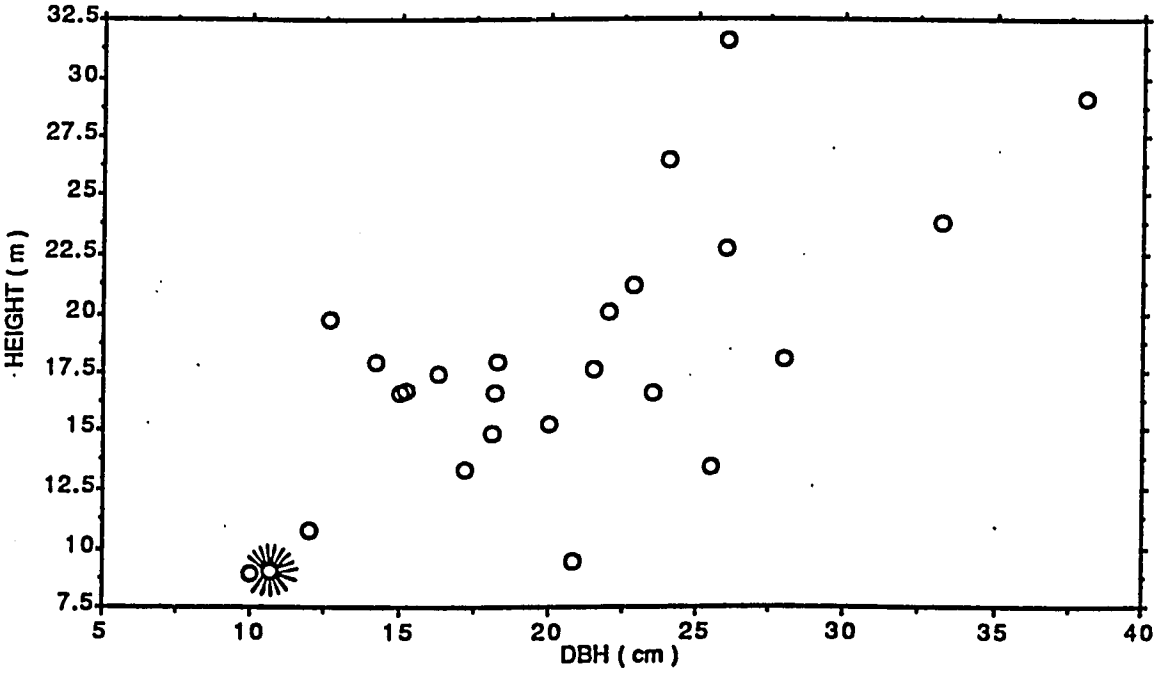
FIG.51 BUTTRESS DEVELOPMENT FOR STERCULIA TRAGACANTHA



About 5% of trees in sample were buttressed.

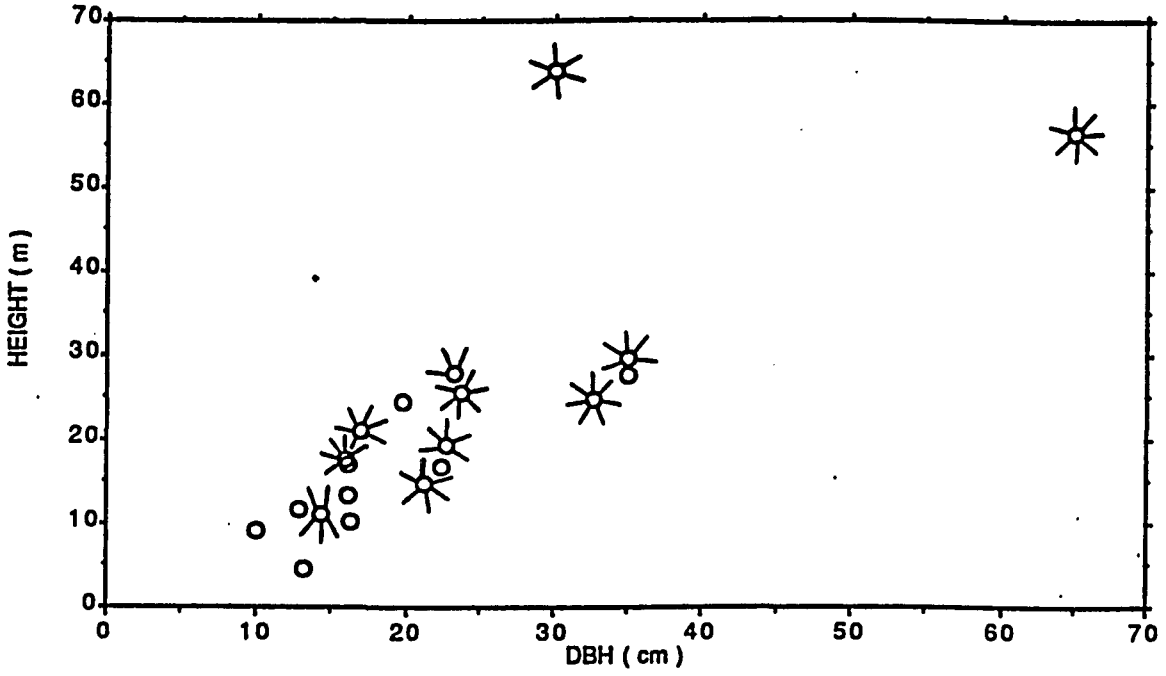
FIG. 52

BUTTRESS DEVELOPMENT FOR STROMBOSIA GLAUCESCENS



About 3% of trees in sample were buttressed.

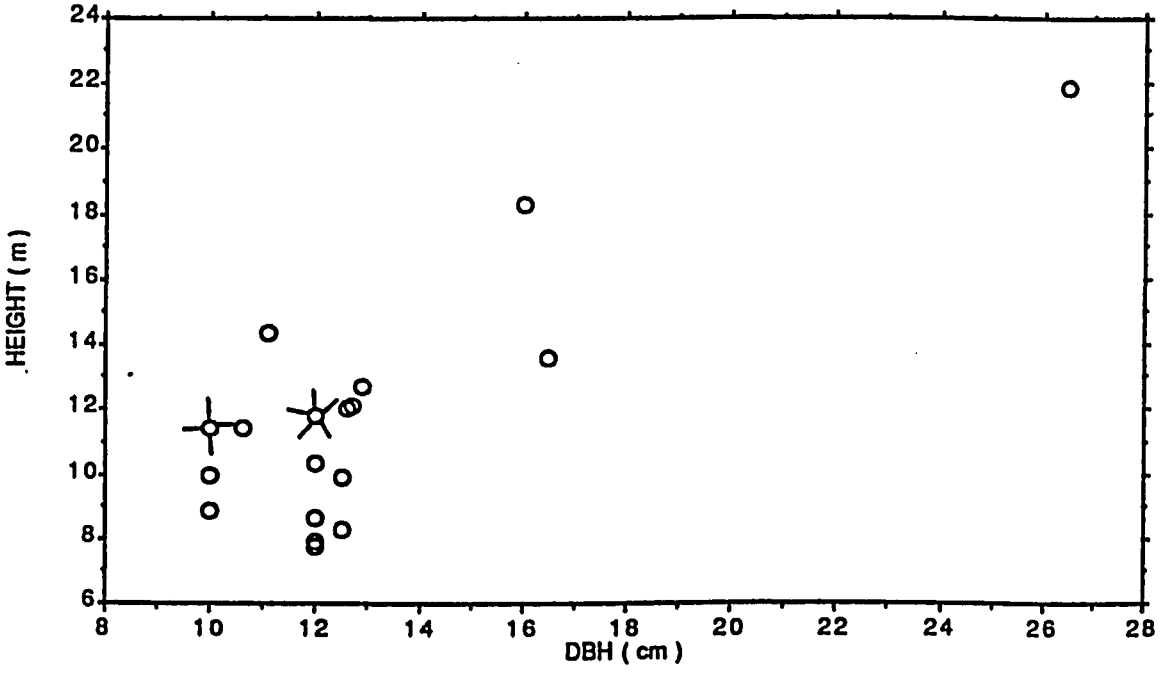
FIG.53 BUTTRESS DEVELOPMENT FOR TERMINALIA SUPERBA



About 65% of trees in sample were buttressed.

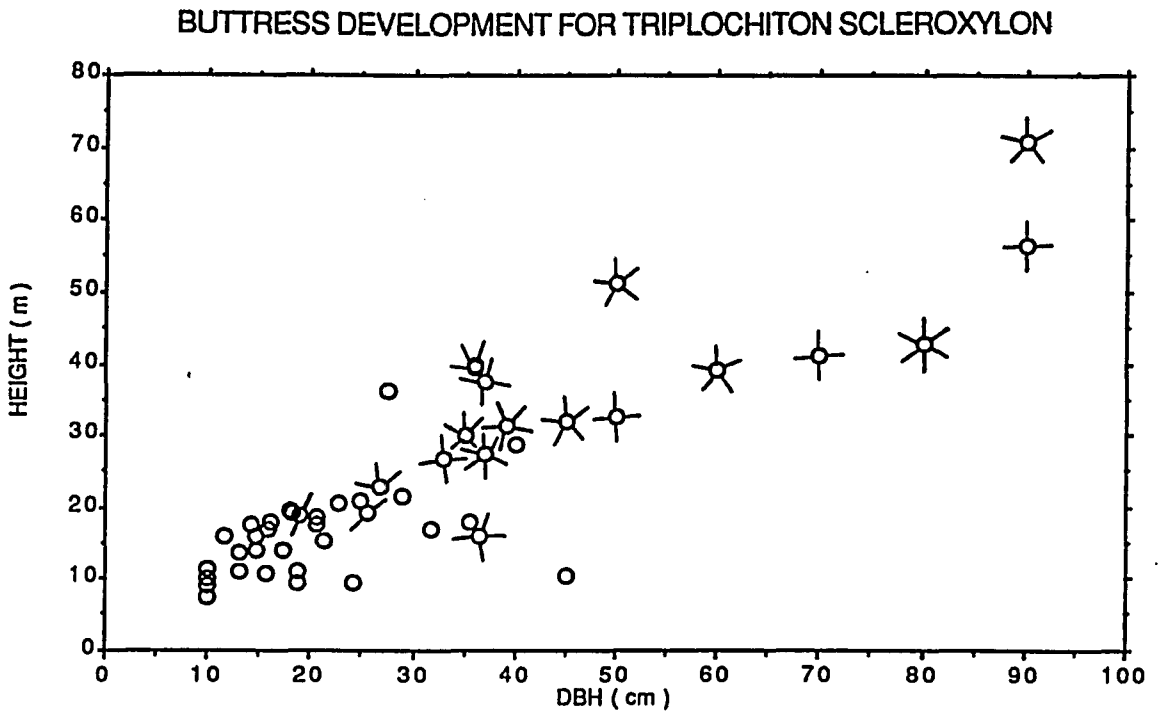
FIG. 54

BUTTRESS DEVELOPMENT FOR TRICHILIA PRIEURIANA



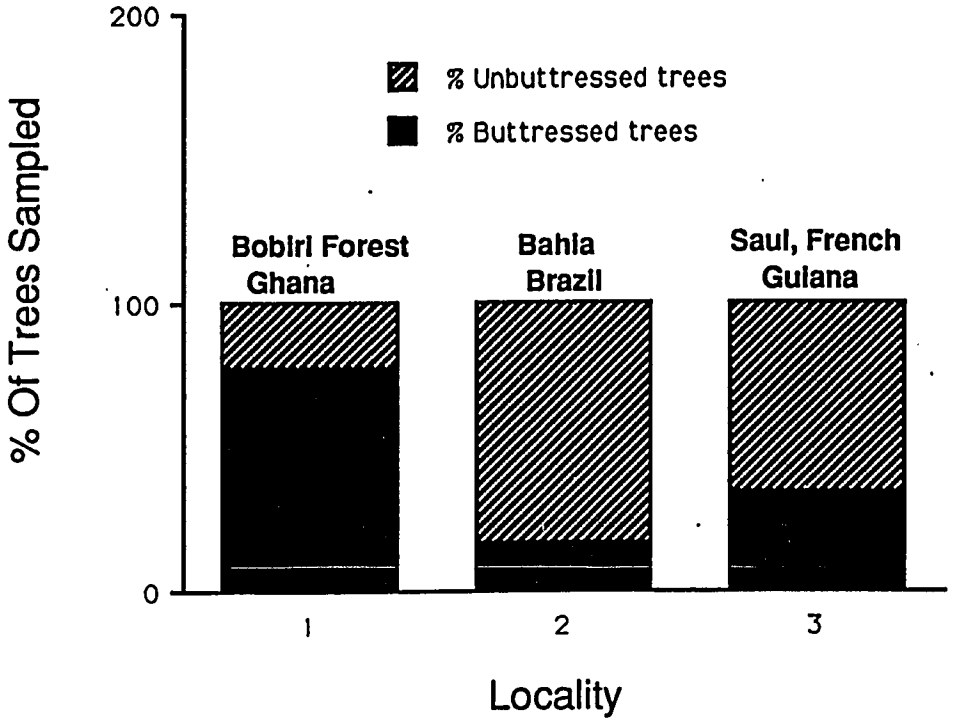
About 12% of trees in sample were buttressed.

FIG. 55



About 50% of trees in sample were buttressed.

FIG. 56



Comparison Of Buttrressed And Unbuttressed Trees In The Bobiri Forest, With Buttrressing In Two Neotropical Forests.

FIG. 57

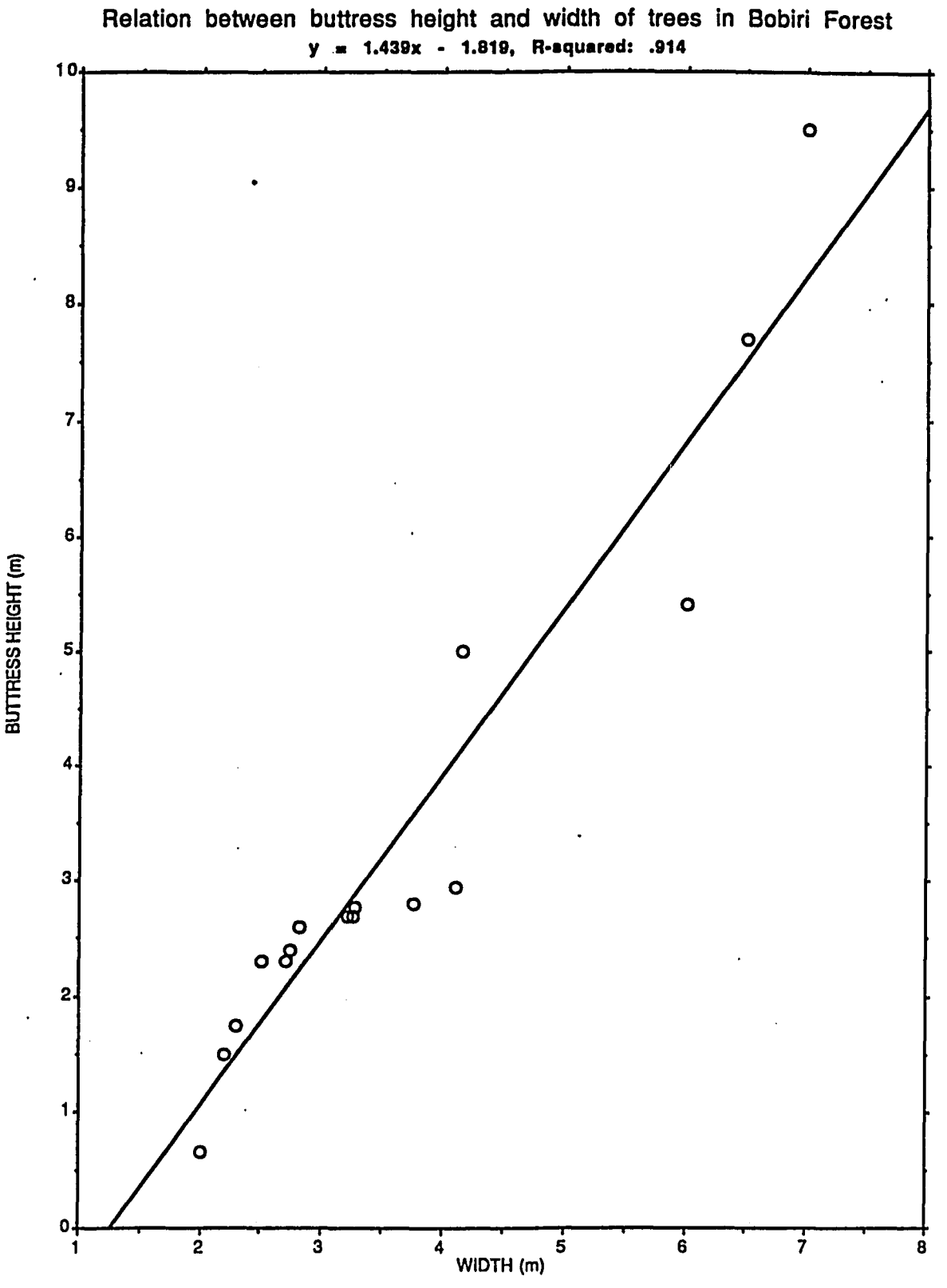

Relation between buttress height and width of trees in Bobiri Forest
y = 1.439x - 1.819, R-squared: .914
BUTTRESS HEIGHT (m)
WIDTH (m)
0
1
2
3
4
5
6
7
8
9
10
1
2
3
4
5
6
7
8

FIG. 58

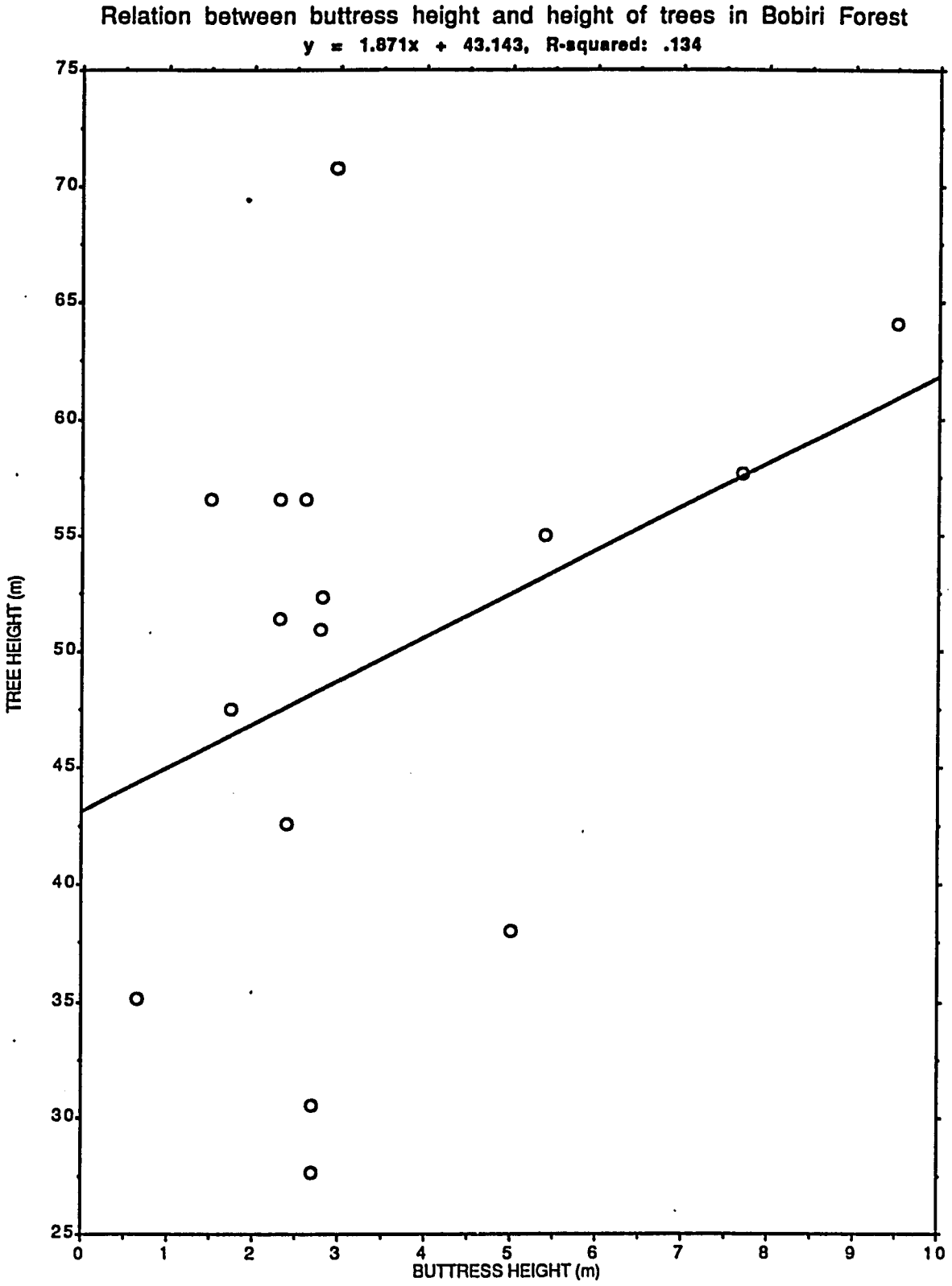
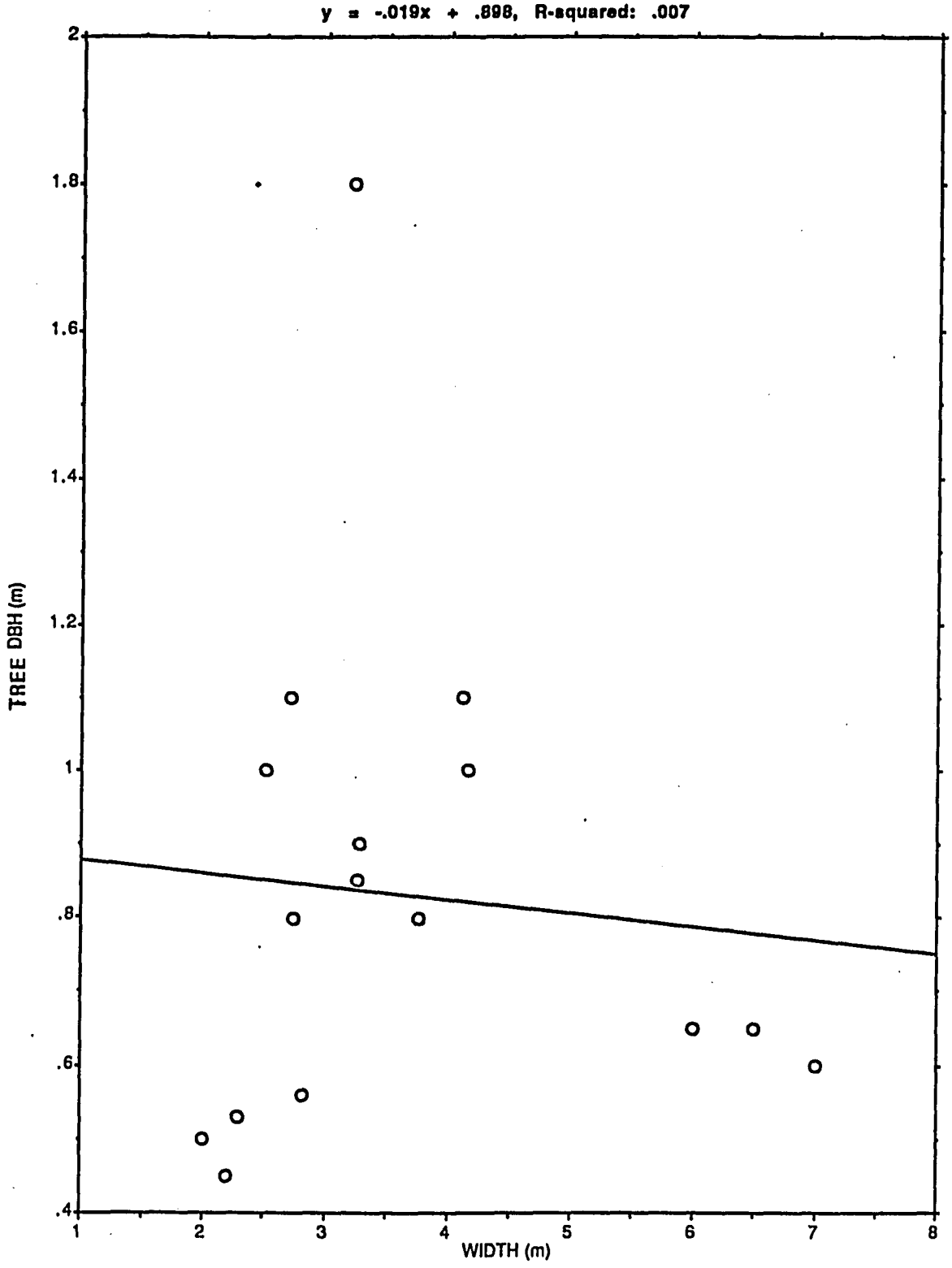

Relation between buttress height and height of trees in Bobiri Forest
y = 1.871x + 43.143, R-squared: .134
TREE HEIGHT (m)
BUTTRESS HEIGHT (m)
75
70
65
60
55
50
45
40
35
30
25
0
1
2
3
4
5
6
7
8
9
10

FIG. 59

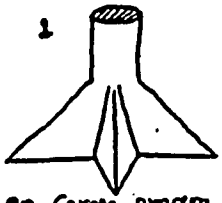
Relation between buttress width and DBH of trees in Bobiri Forest



CLASSIFICATION OF BUTTRESSES OF THE FOREST TREES OF GHANA

Standard Regular Triangular Buttress

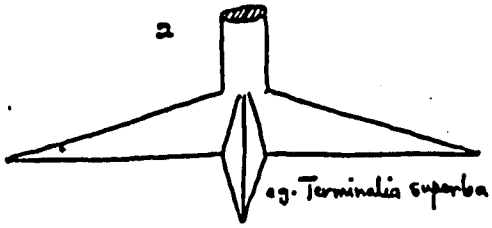
1



eg. Carapa procera

Extended Regular Triangular Buttress

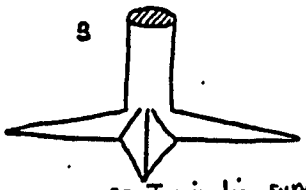
2



eg. Terminalia superba

Lanceolate Regular Triangular buttress.

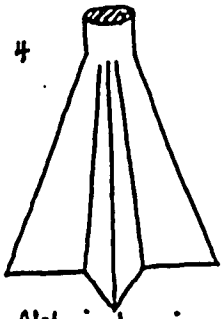
3



eg. Terminalia superba
Bussea occidentalis

Elevated Regular Triangular Buttress

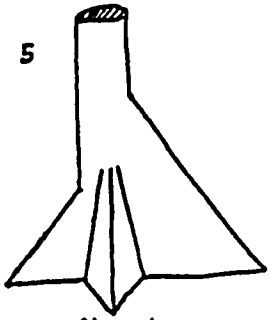
4



eg. Alstonia boonei
Celtis zenkeri

Irregular Triangular Buttress

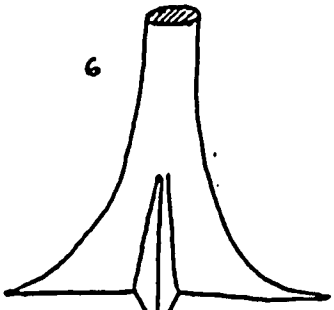
5



eg. Pterygota macrocarpa

Regular Concave Buttress.

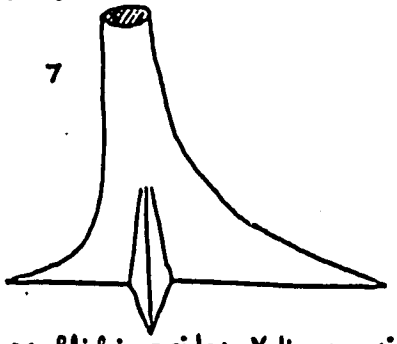
6



eg. Ceiba pentandra

Irregular Concave Buttress

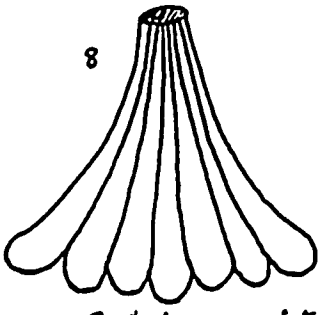
7



eg. Blighia sapida; Xylia evansii

Clubbed-Fluting Buttress

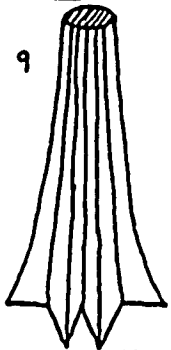
8



eg. Spathodea campanulata

Concave-Fluting Steep Buttress

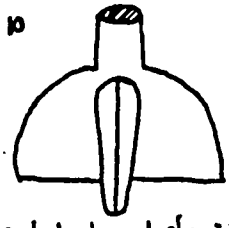
9



eg. Treculia africana
Ricinodendron heudelotii

Regular Arched Buttress

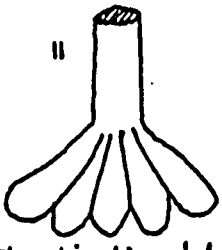
10



eg. Letaulus daphnoides

Clubbed Fan Buttress

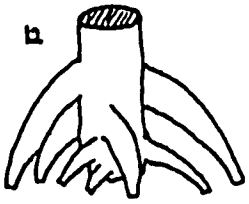
11



eg. Sterculia rhinopetala

Flying Buttress

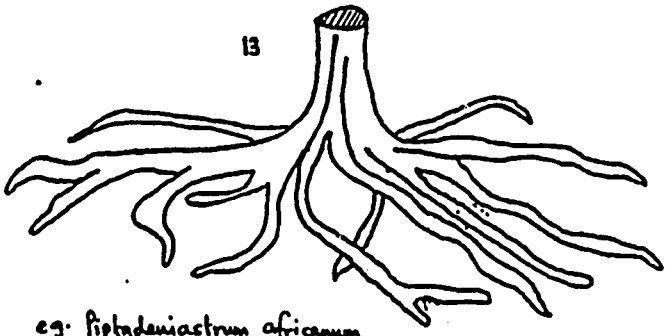
12



eg. Myrianthus arboreus

Wandering Branched Buttress

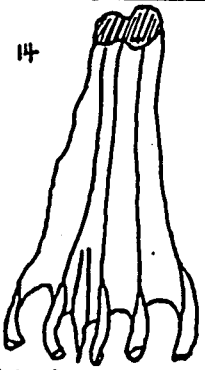
13



eg. Piptadeniastrum africanum
Aningeria robusta

Flexuous-Fluting Branched Buttress

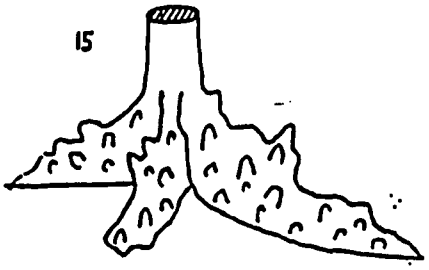
14



eg. Alstonia boonei
Rauvolfia vomitoria

Knobbed Buttress

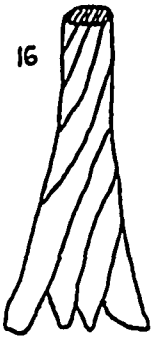
15



eg. Cylicodiscus gabonensis

Spiral Fluting Steep Buttress

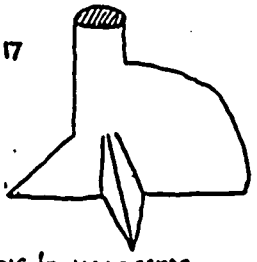
16



eg. Buboscia viridiflora

Irregular Arched Buttress

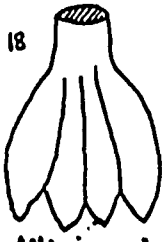
17



eg. Pterygota macrocarpa

Clubbed Convex Buttress

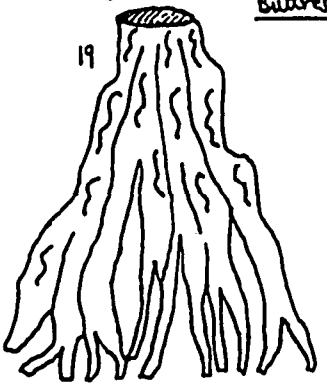
18



eg. Albizia zygia

Sinewy-Branched Random Buttress

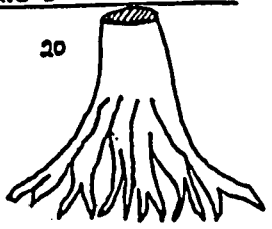
19



eg. Ficus capensis

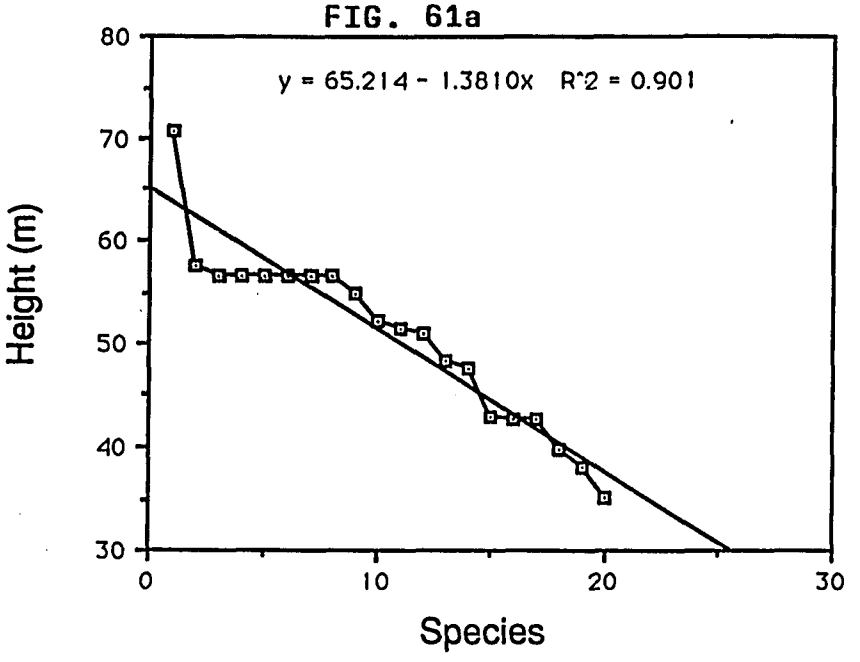
Concave Branched Buttress

20



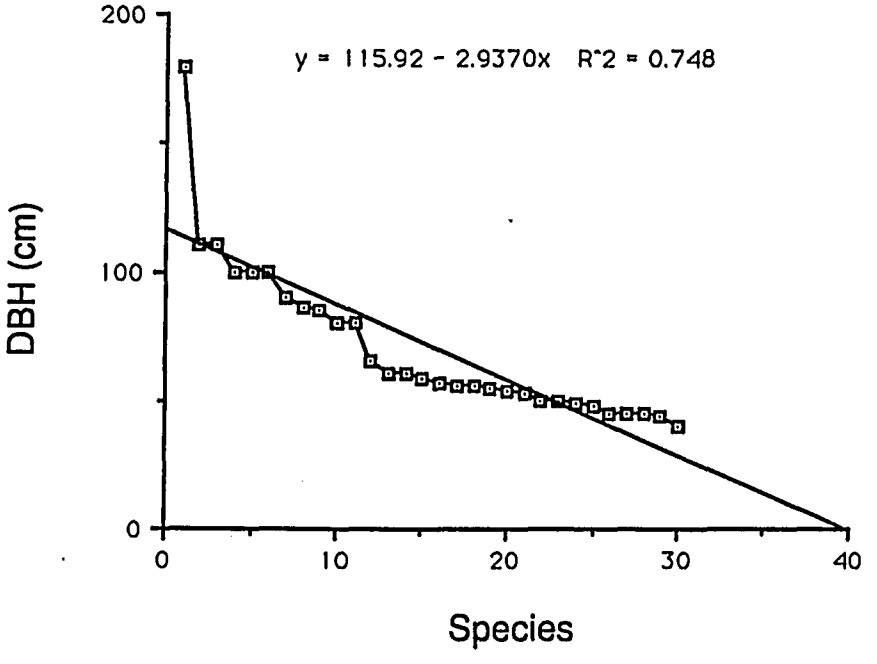
eg. Aningeria robusta

FIG. 61a



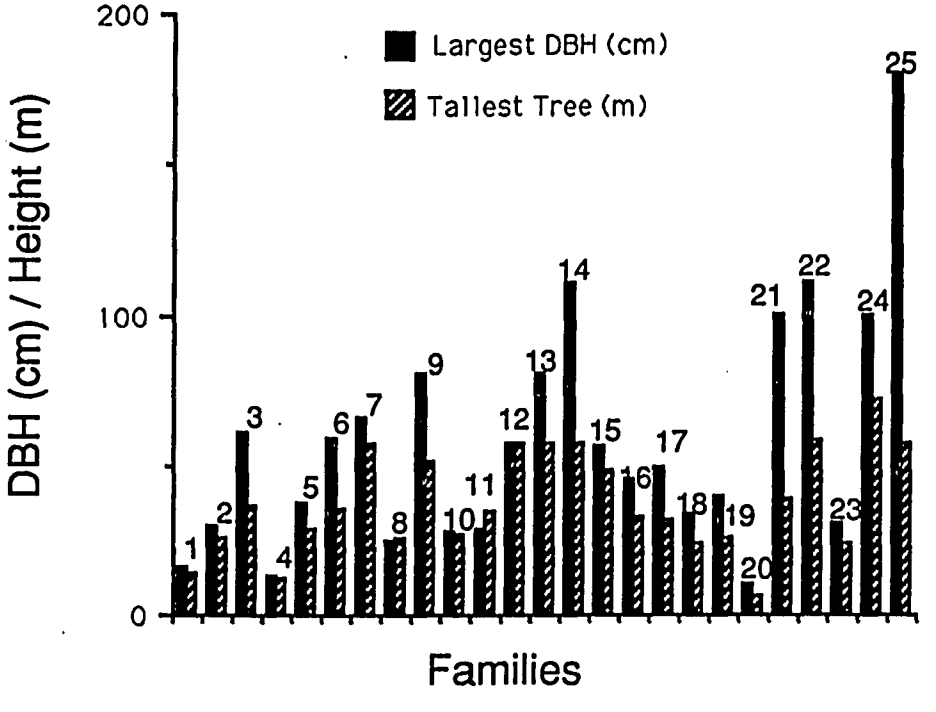
Height Variation For The 20 Tallest Species In The Bobiri Forest

FIG. 61b



Variation In Diameter Size For The 30 Largest Species In The Bobiri Forest Reserve

FIG. 62

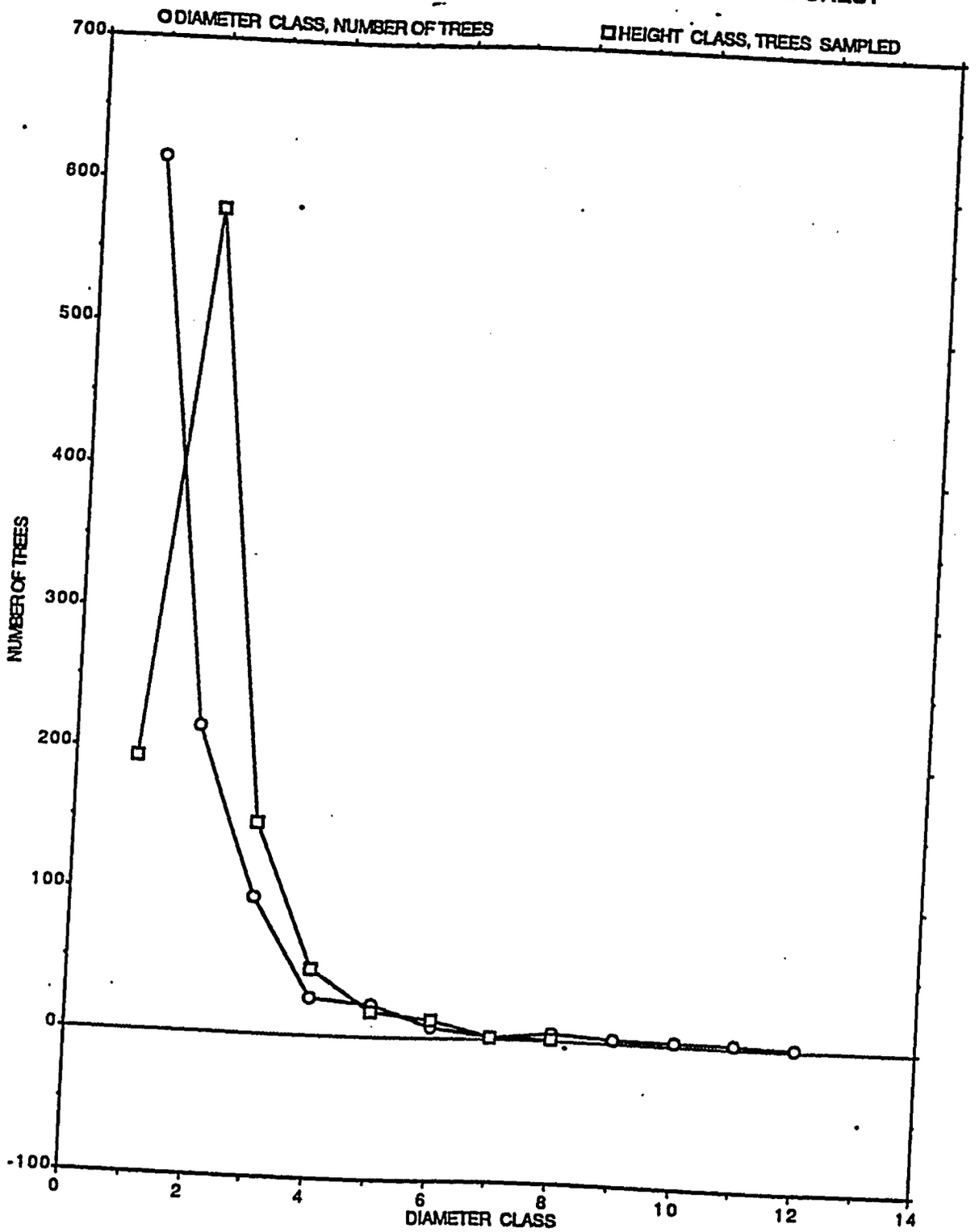


1. Anacardiaceae
2. Annonaceae
3. Apocynaceae
4. Bignoniaceae
5. Bombacaceae
6. Caesalpiniaceae
7. Combretaceae
8. Ebenaceae
9. Euphorbiaceae
10. Guttifereae
11. Icacinaceae
12. Lecythidaceae
13. Meliaceae
14. Mimosaceae
15. Moraceae
16. Myristicaceae
17. Olacaceae
18. Papilionaceae
19. Rubiaceae
20. Rutaceae
21. Sapindaceae
22. Sapotaceae
23. Simaroubaceae
24. Sterculiaceae
25. Ulmaceae

Comparison of the largest trees in the 25 families of the 1000 tree sample in the Bobiri forest reserve.

FIG. 63

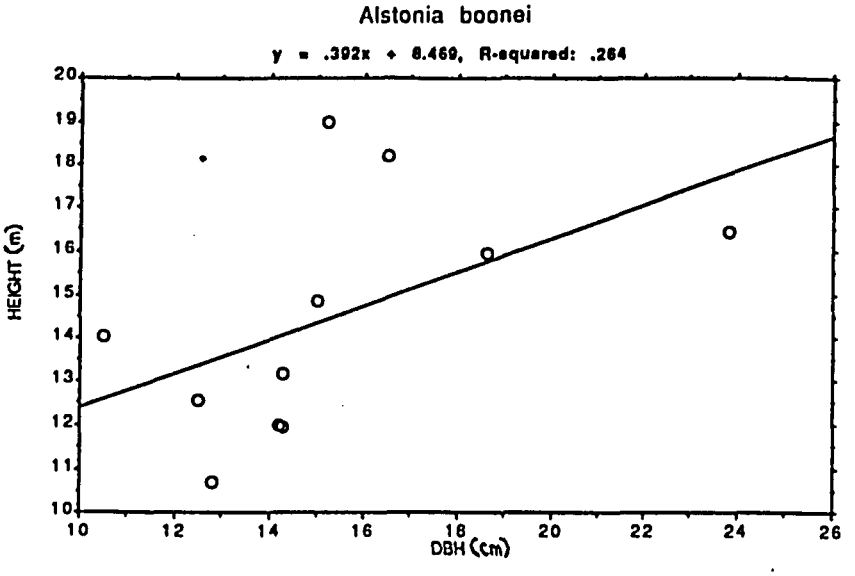
DBH AND HEIGHT CLASS DISTRIBUTION IN THE BOBIRI FOREST



For 1000 tree sample

FIG. 64

DBH-HEIGHT RELATION FOR APOCYNACEAE



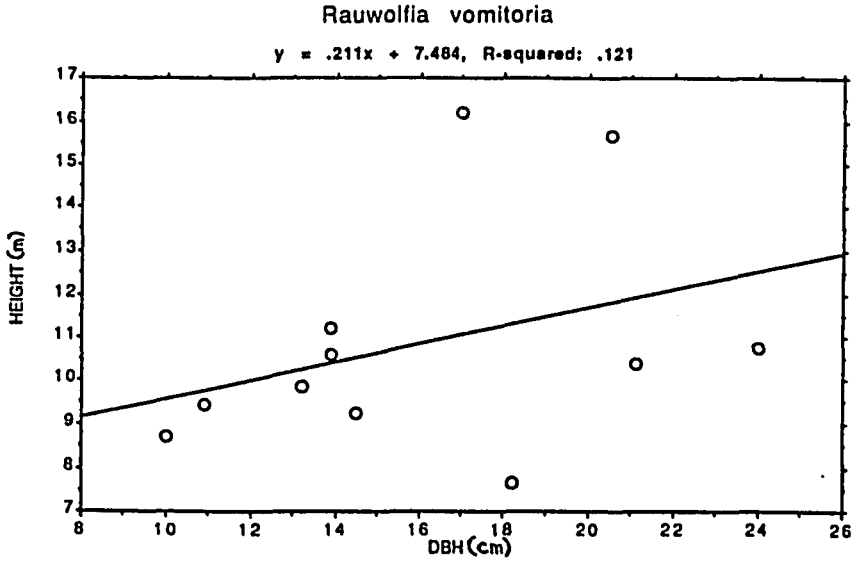
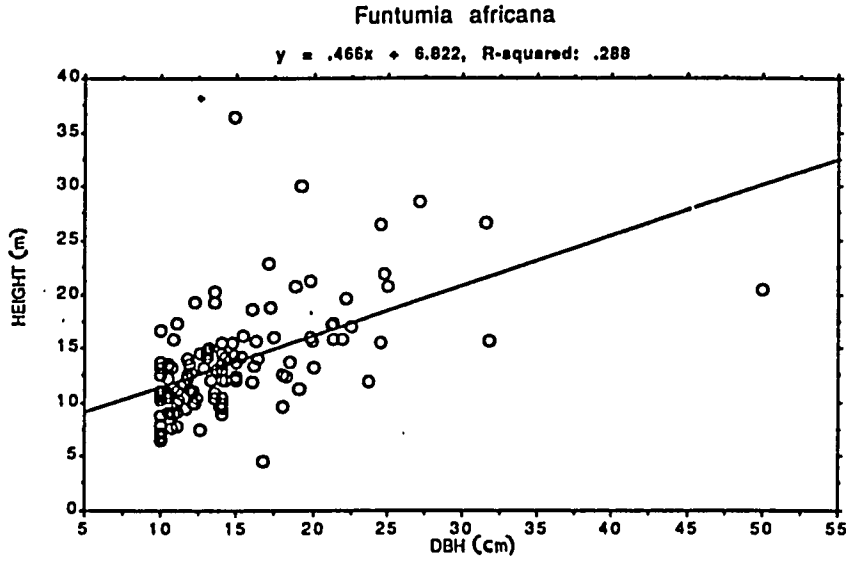


FIG. 65

DBH-HEIGHT RELATION FOR APOCYNACEAE



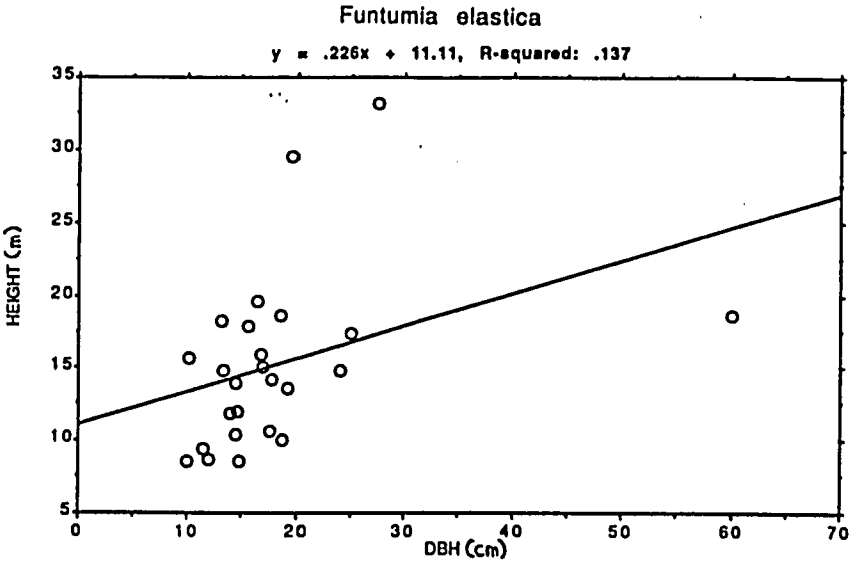


FIG. 66

DBH-HEIGHT RELATION FOR CAESALPINIACEAE

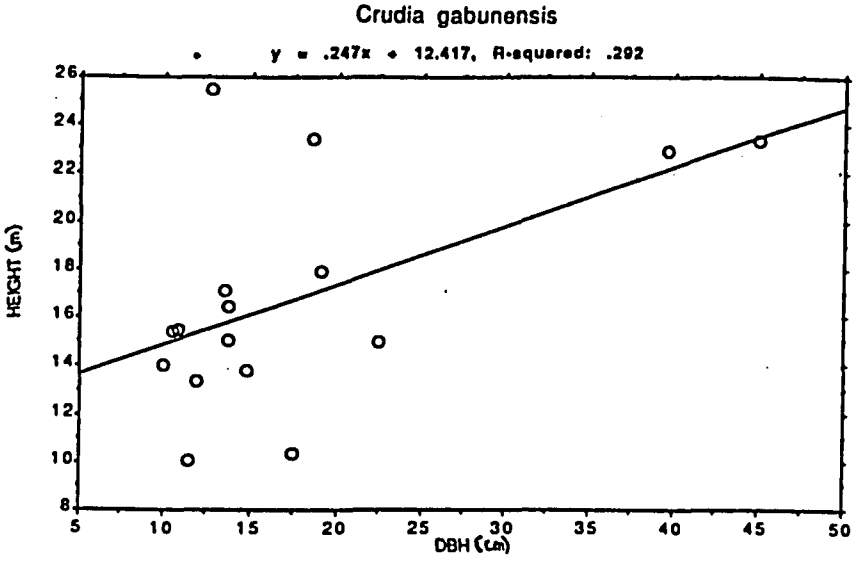


FIG. 67

DBH-HEIGHT RELATION FOR COMBRETACEAE

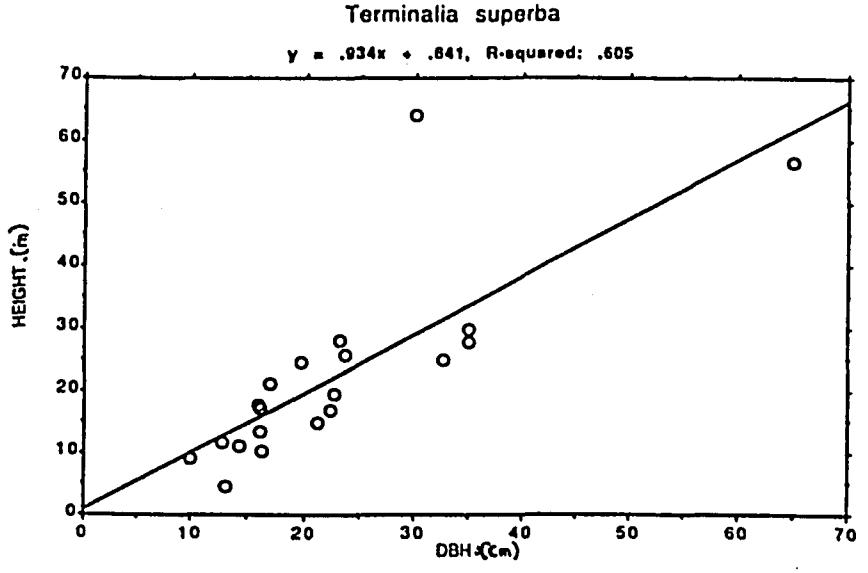


FIG. 68

DBH-HEIGHT RELATION FOR EUPHORBIACEAE

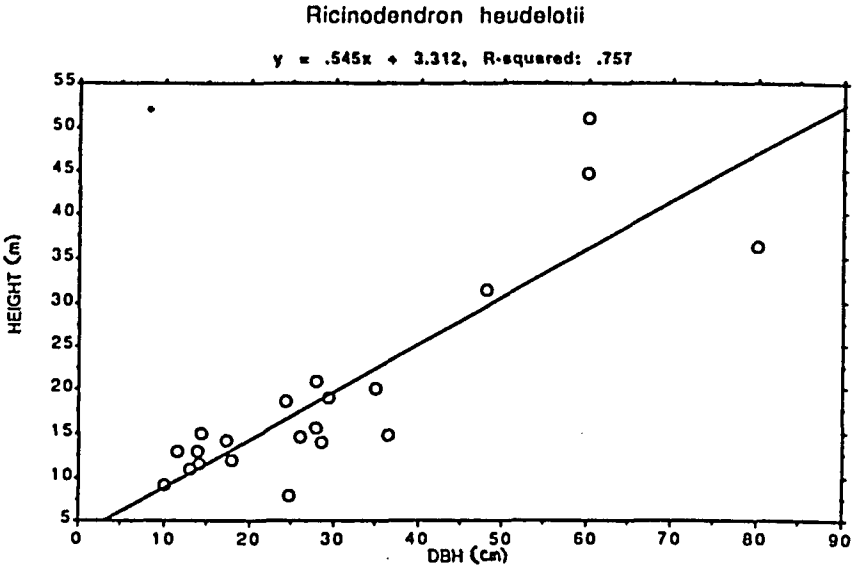


FIG. 69

DBH-HEIGHT RELATION FOR SAPINDACEAE

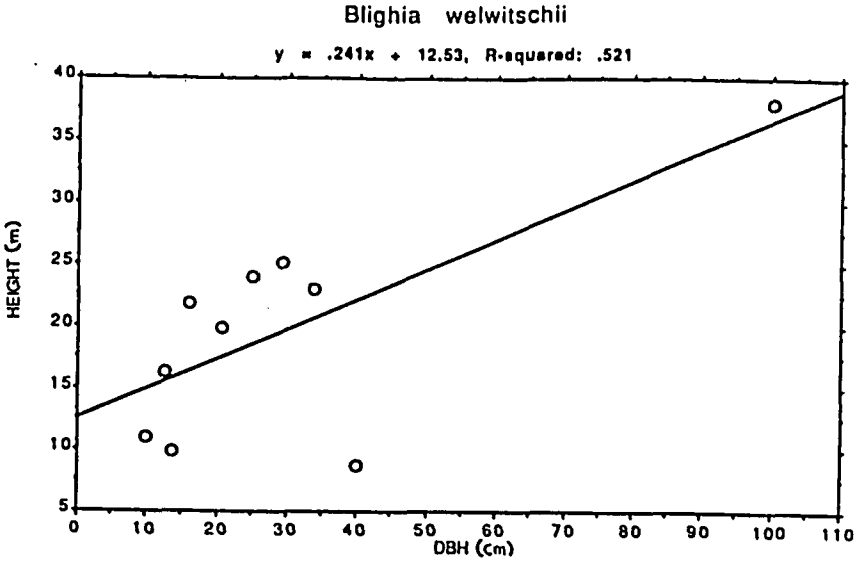
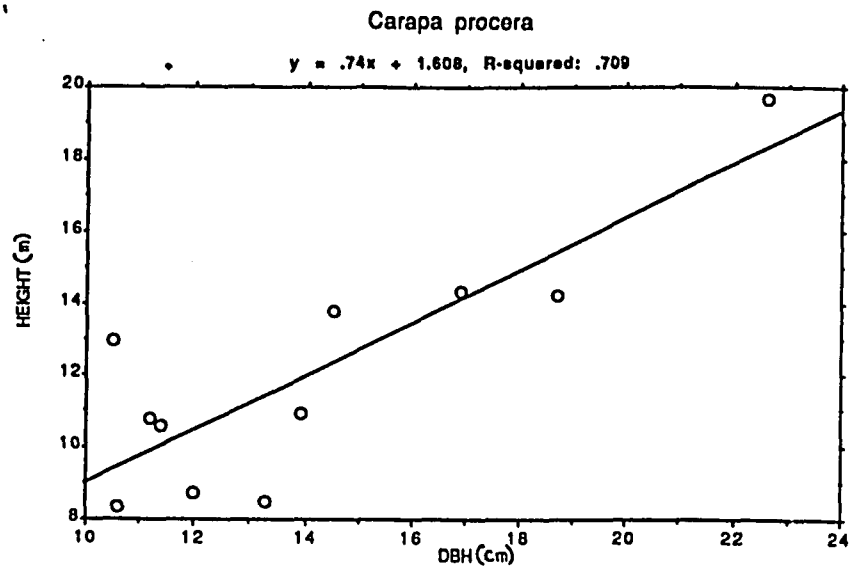


FIG. 70

DBH-HEIGHT RELATION FOR MELIACEAE



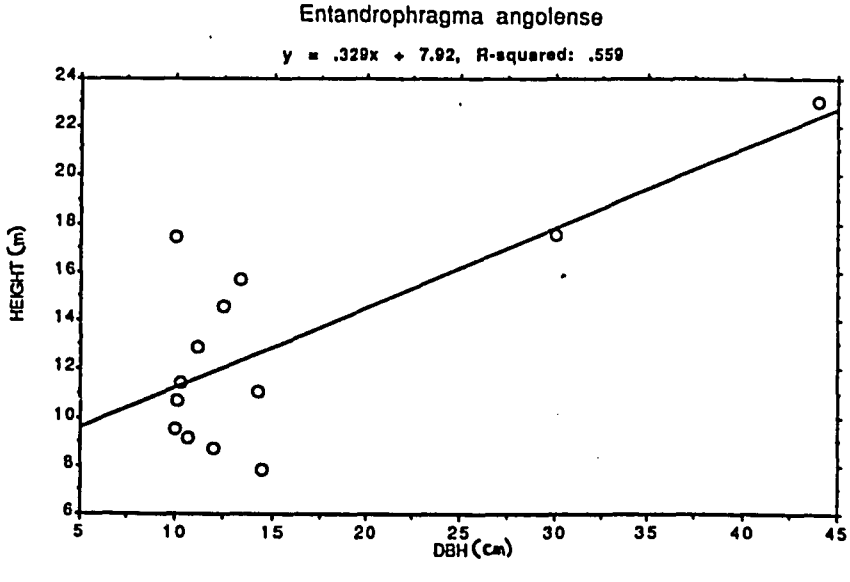
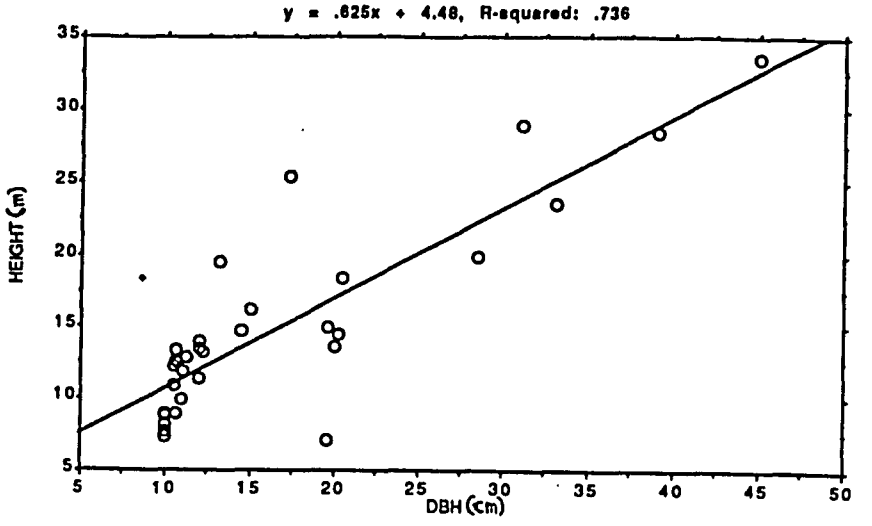
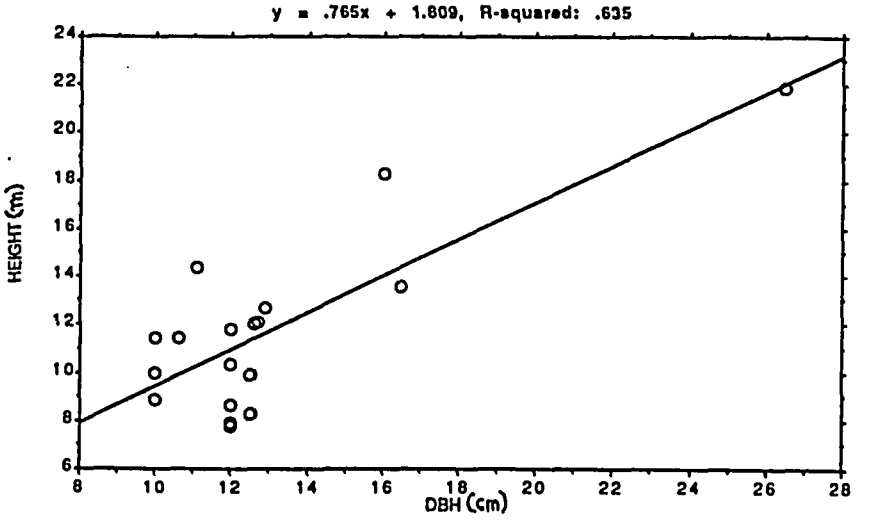


FIG.71 DBH-HEIGHT RELATION FOR MELIACEAE

Guarea cedrata



Trichilia prieuriana



Turraenthus africanus

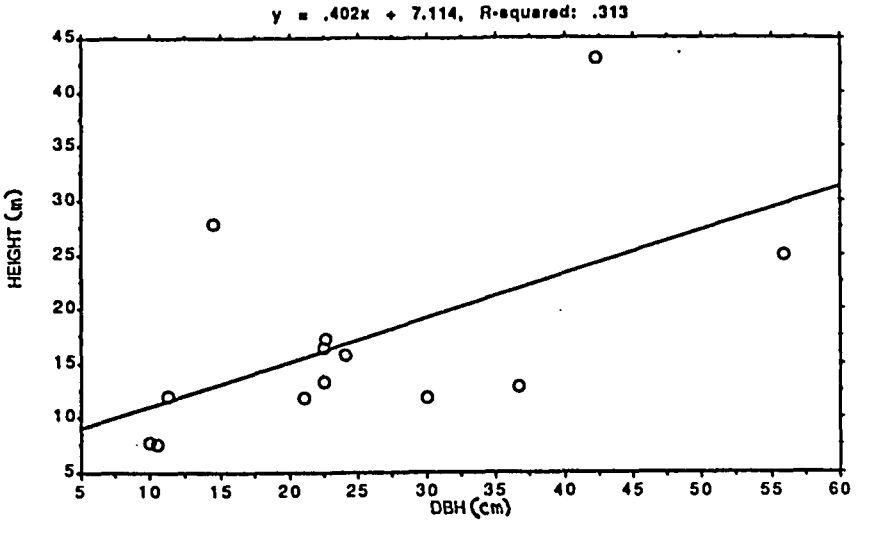


FIG. 72

DBH-HEIGHT RELATION FOR MIMOSACEAE

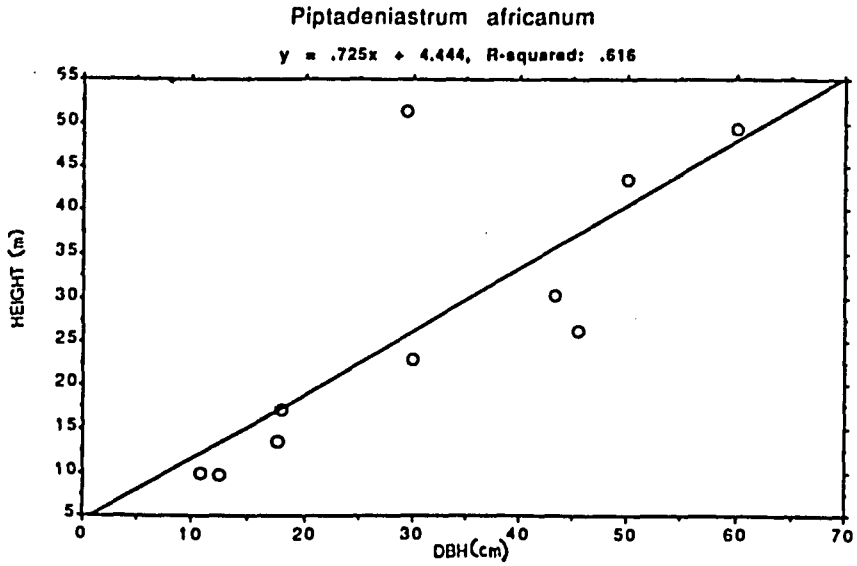


FIG. 73

DBH-HEIGHT RELATION FOR OLACACEAE

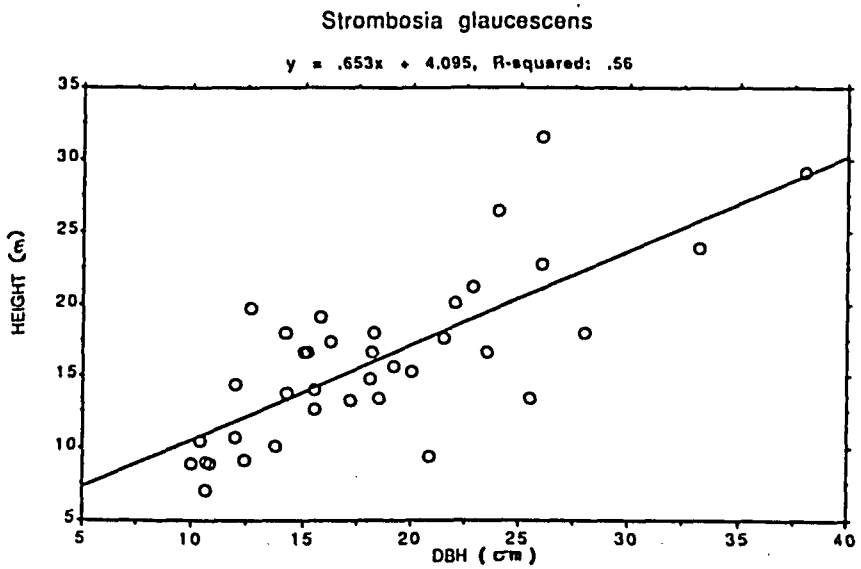
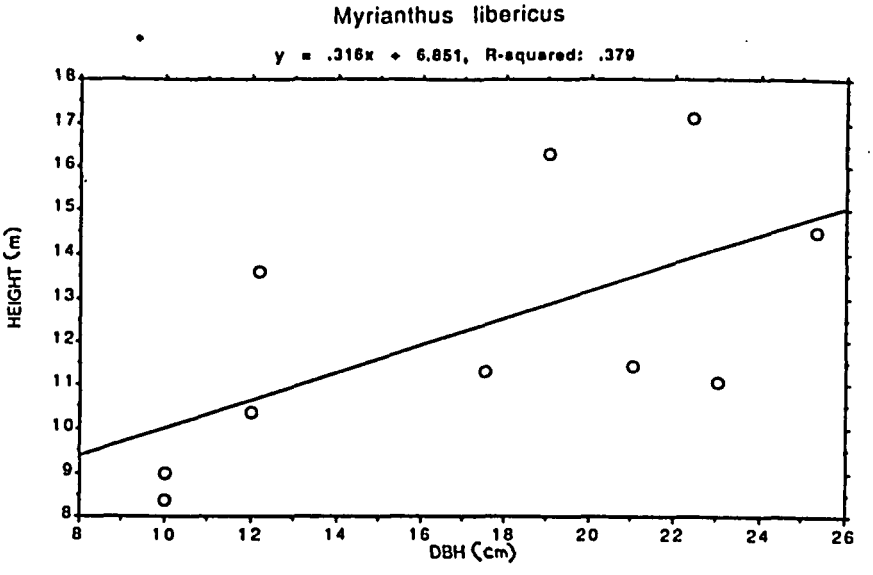


FIG. 74

DBH-HEIGHT RELATION FOR MORACEAE



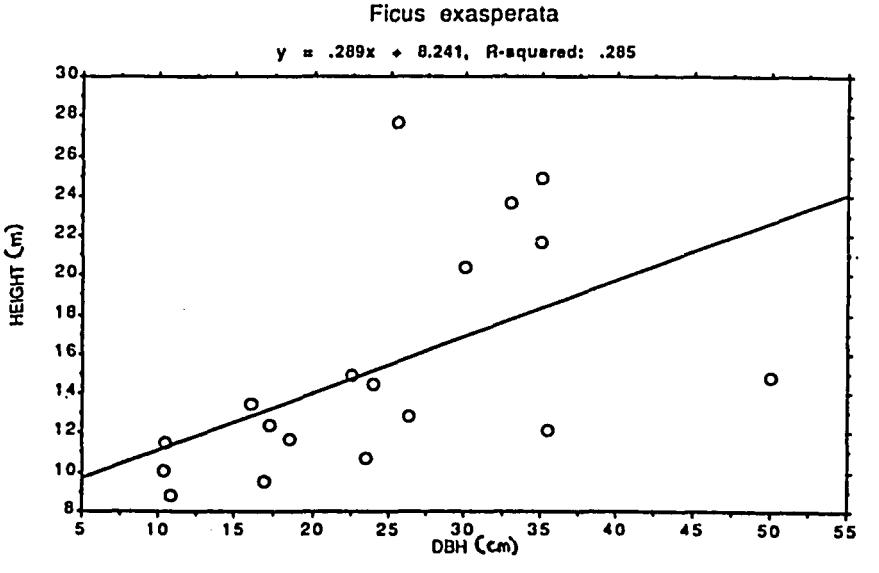
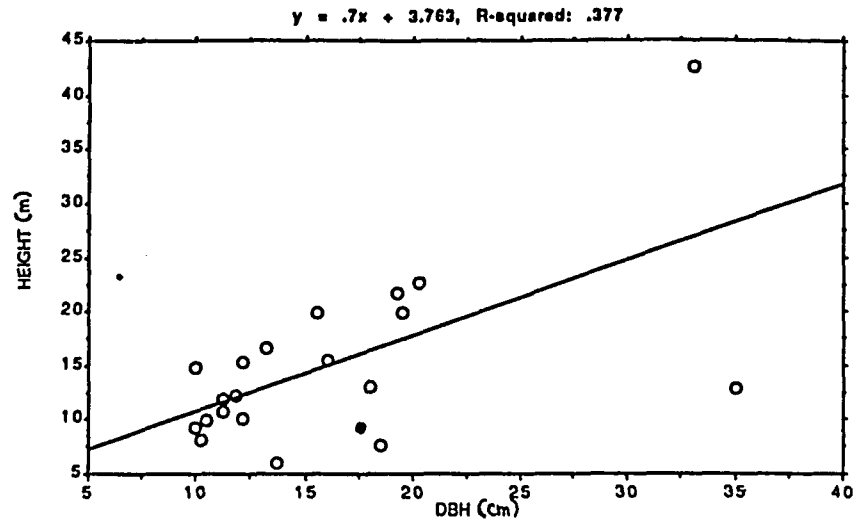
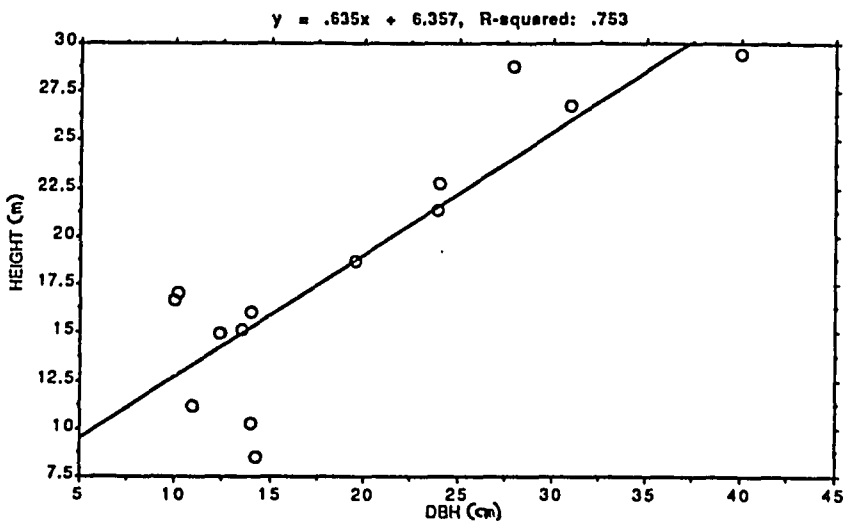


FIG. 75 DBH-HEIGHT RELATION FOR STERCULIACEAE

Pterygota macrocarpa



Sterculia oblonga



Sterculia tragacantha

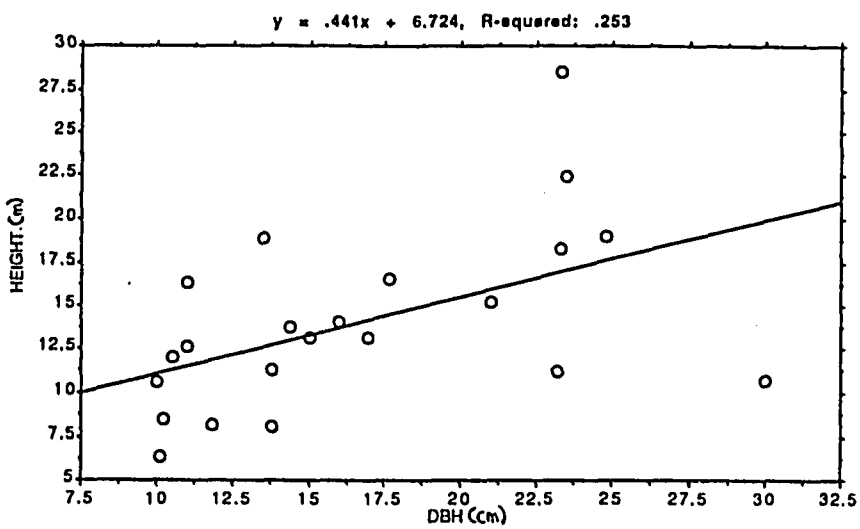
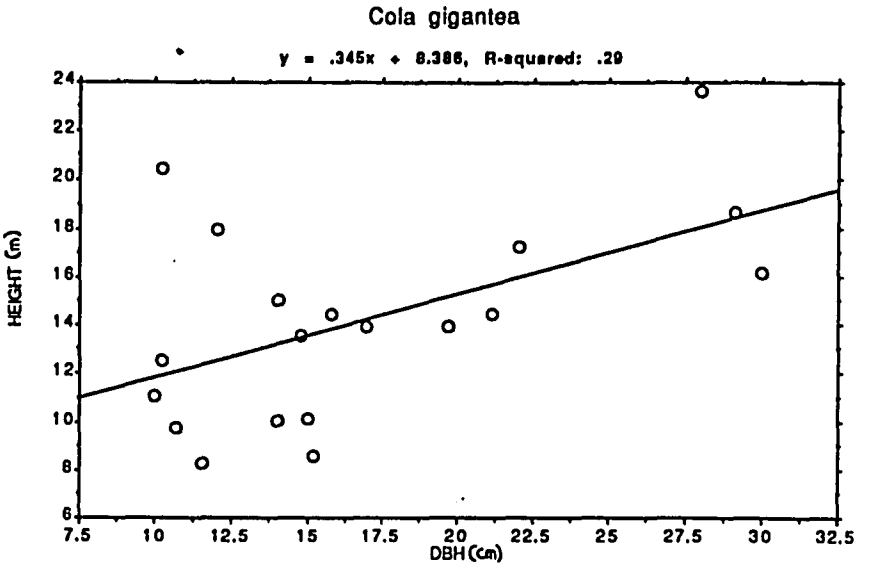


FIG. 76

DBH-HEIGHT RELATION FOR STERCULIACEAE



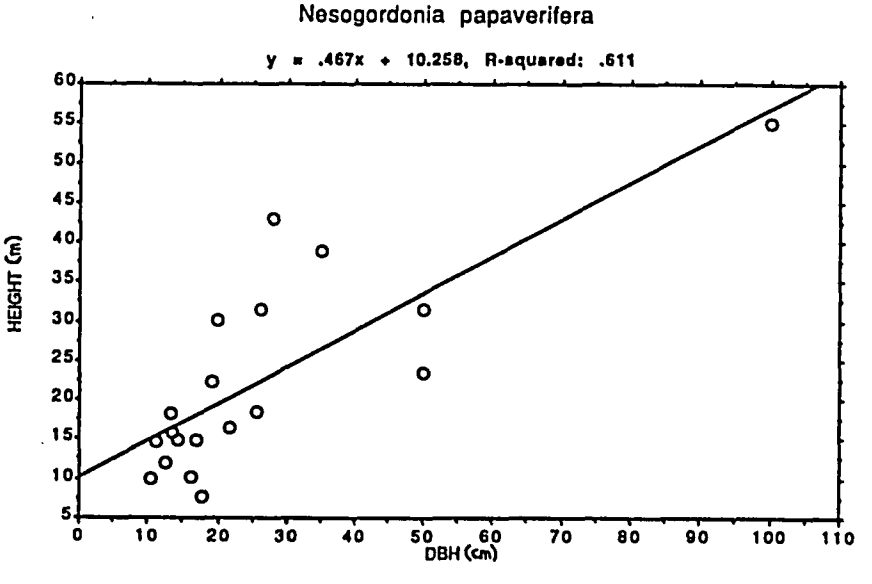
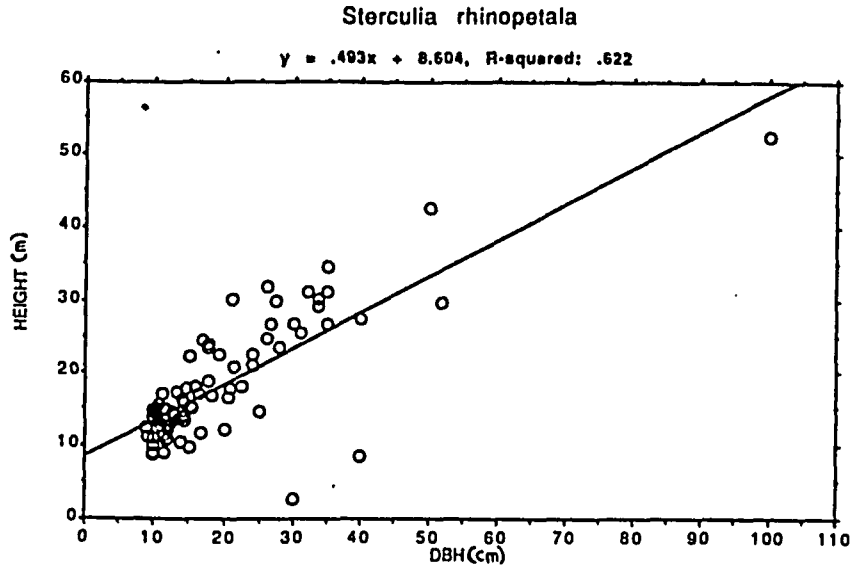


FIG. 77

DBH-HEIGHT RELATION FOR STERCULIACEAE



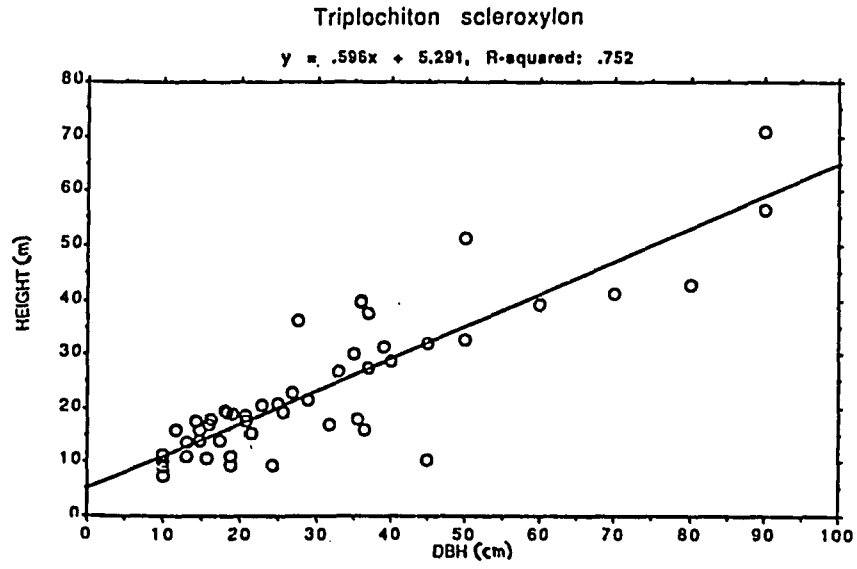
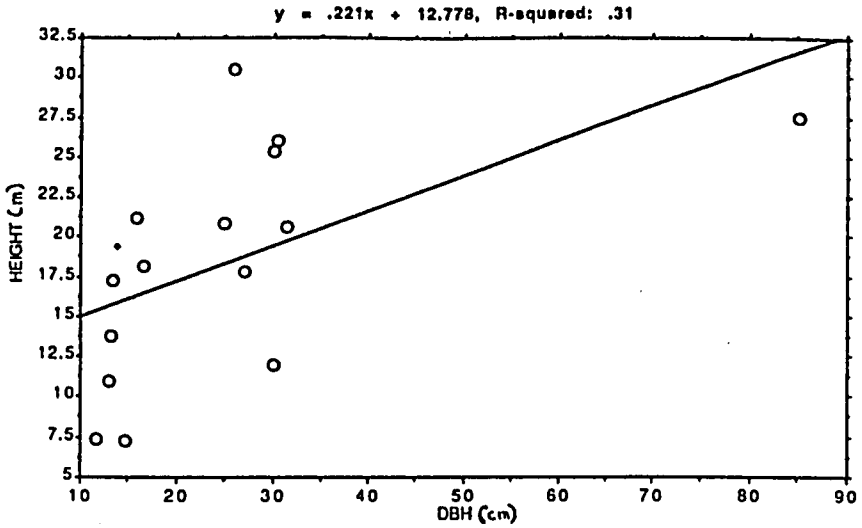
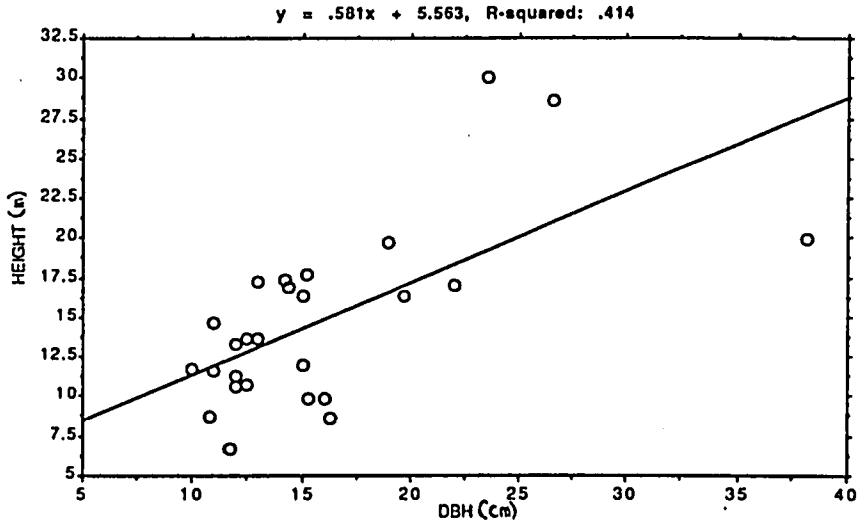


FIG. 78 . DBH-HEIGHT RELATION FOR ULMACEAE

Celtis adolfi-friderici



Celtis mildbraedii



Celtis zenkeri

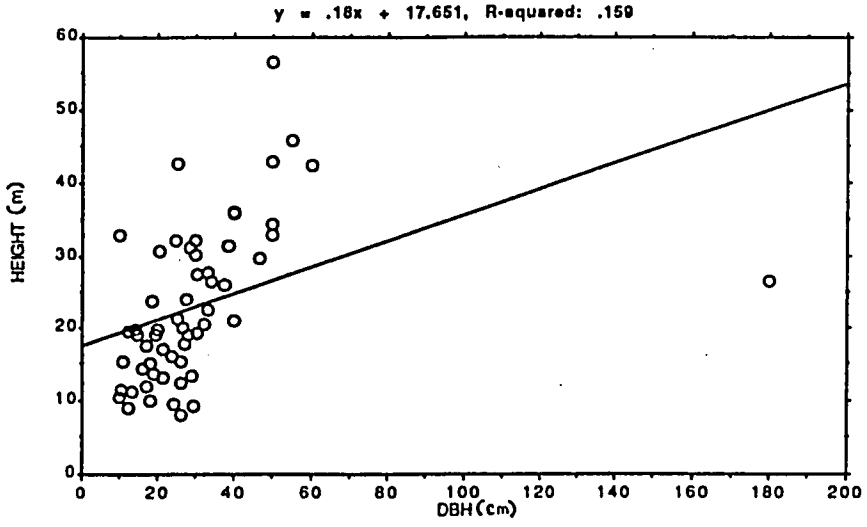
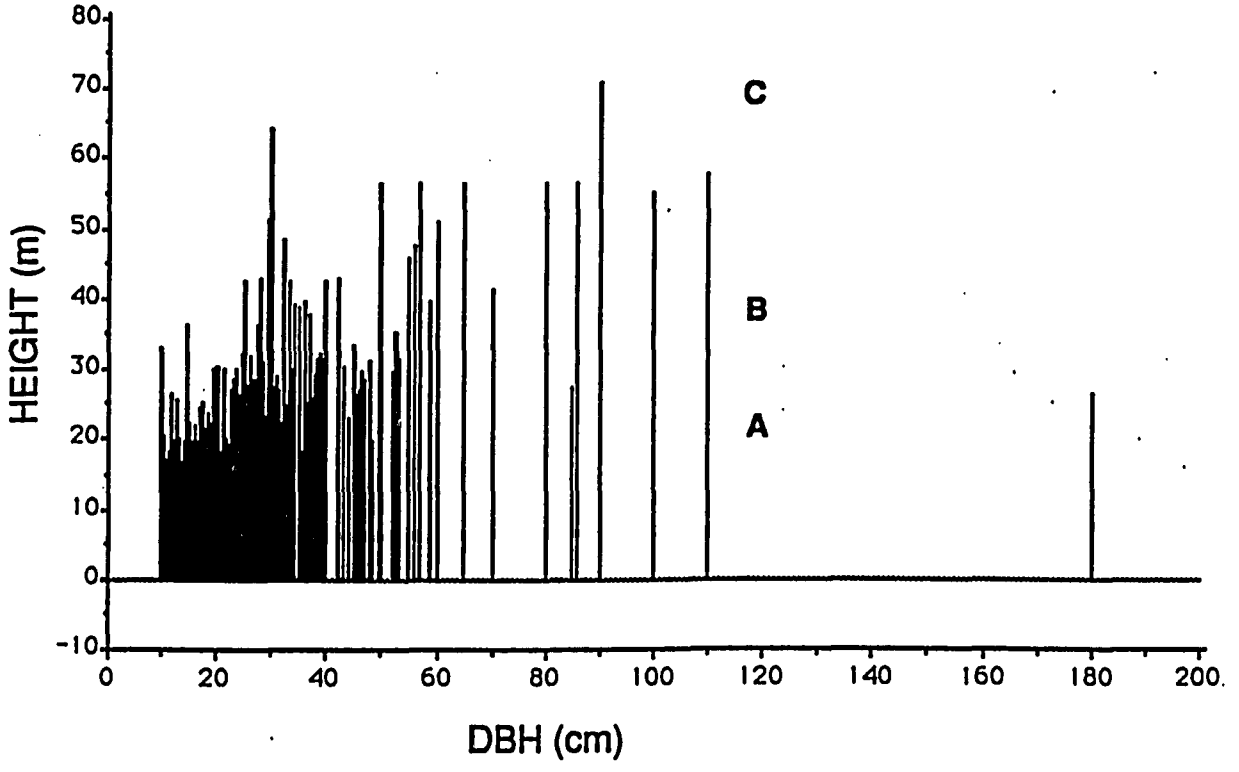
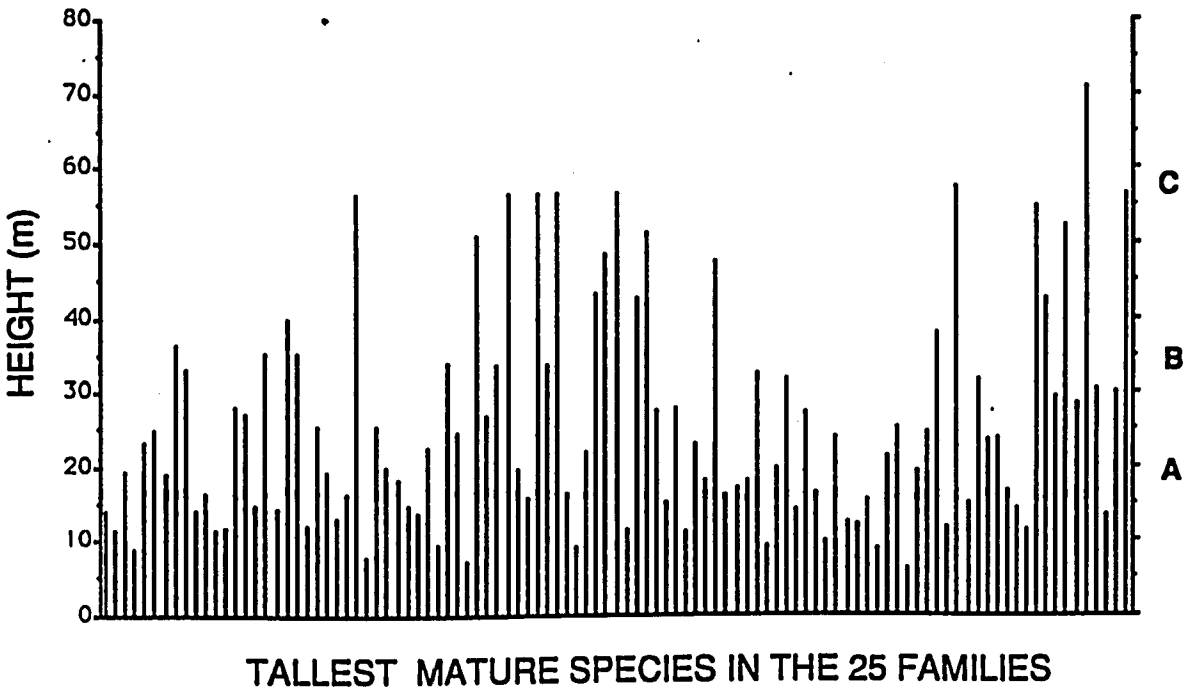


FIG. 79



Diameter-Height Relation For The 1000 Trees In The Bobiri Forest, To Show Stratification. A, B, & C Represent The Canopies Of 3 Possible Strata : 1) Lower Canopy Below A (5-20 m. Tall), 2) Upper Canopy Between A And B (20-40 m. Tall), And 3) Emergents Between B And C (>40 m. Tall). These Divisions Agree With Those Of Taylor (1960) And Lawson (1966)

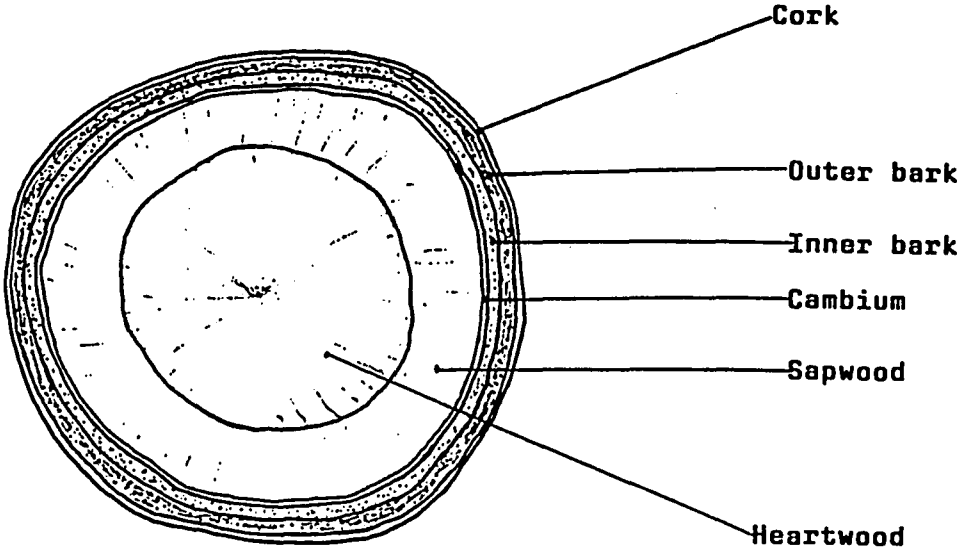
FIG. 80



Bar Chart For The Tallest Species In The 25 Families Of The 1000 Tree Sample Of The Bobiri Forest, To Show Possible Stratification. A, B, & C Represent 3 Possible Strata. Selected Species Were Mature (Reproductive) Individuals.

FIG. 81

BARK AND WOOD DESCRIPTIONS



TRUNK OF TREE SHOWING EYEMARKS AND HOOP MARKS

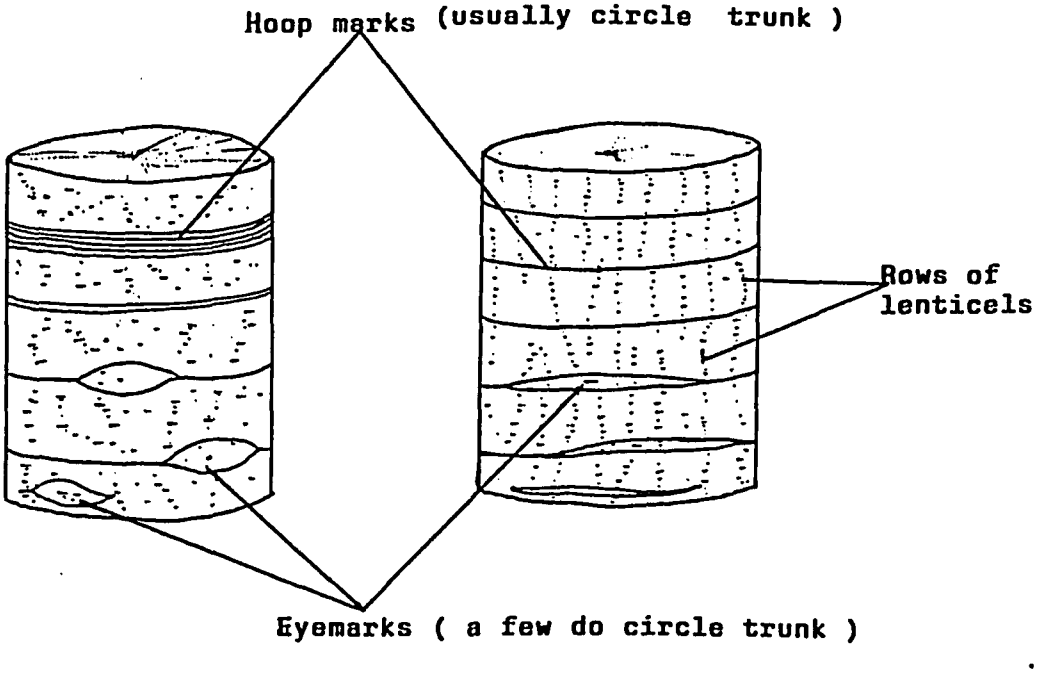
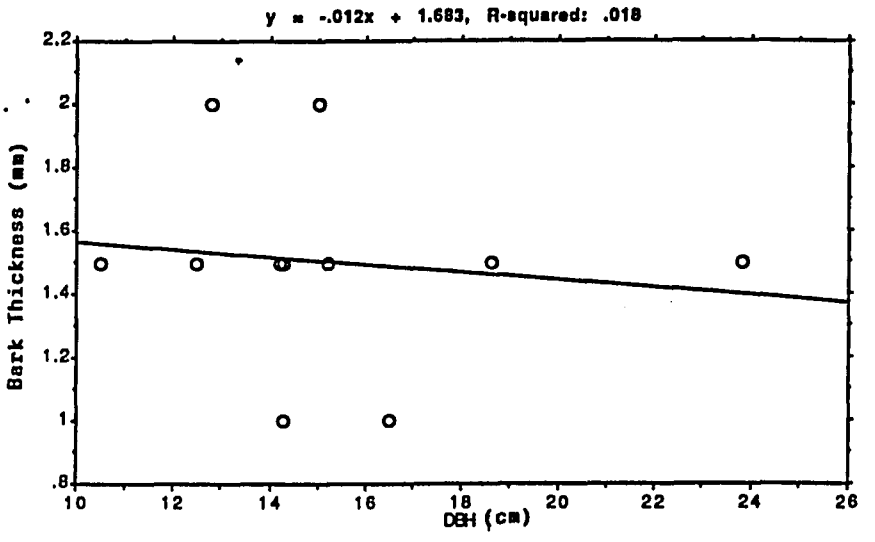


FIG. 82

APOCYNACEAE

VARIATION OF BARK THICKNESS IN ALSTONIA BOONEI



VARIATION OF BARK THICKNESS IN FUNTUMIA AFRICANA

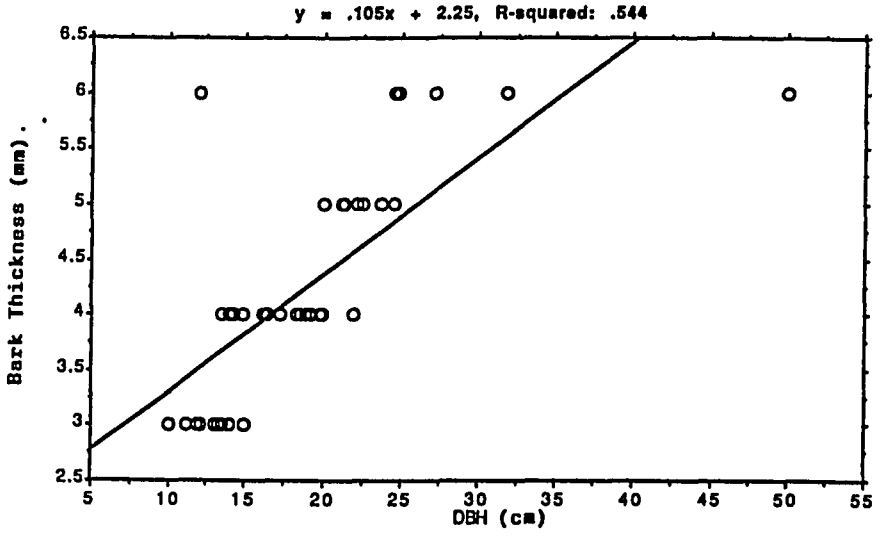
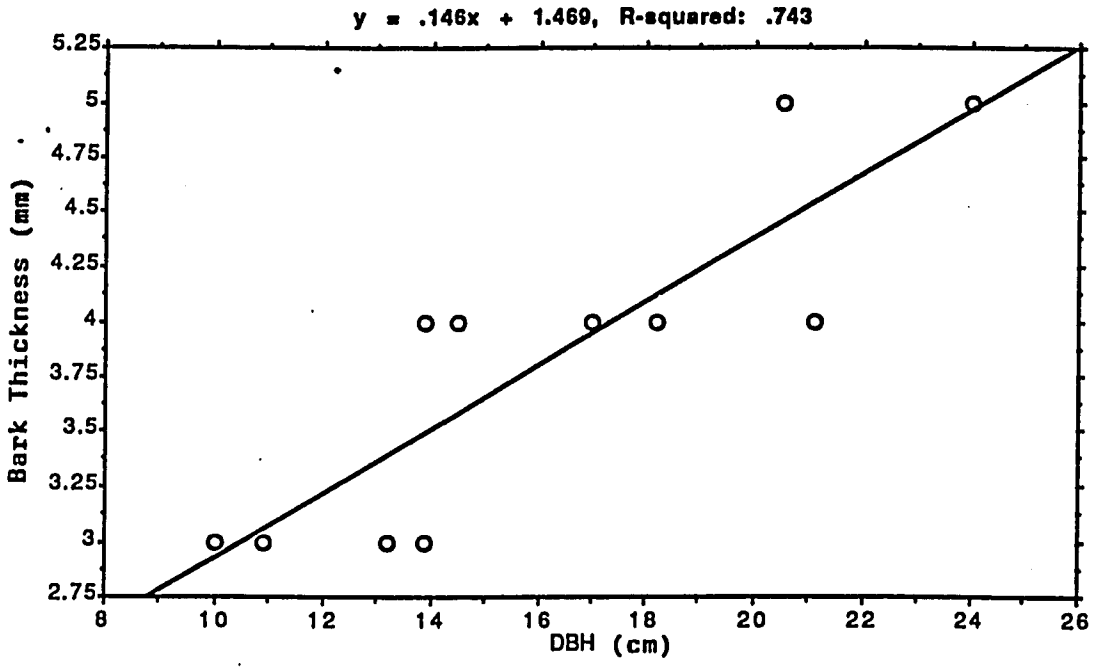


FIG. 83

APOCYNACEAE

VARIATION OF BARK THICKNESS IN RAUVOLFIA VOMITORIA



VARIATION OF BARK THICKNESS IN FUNTUMIA ELASTICA

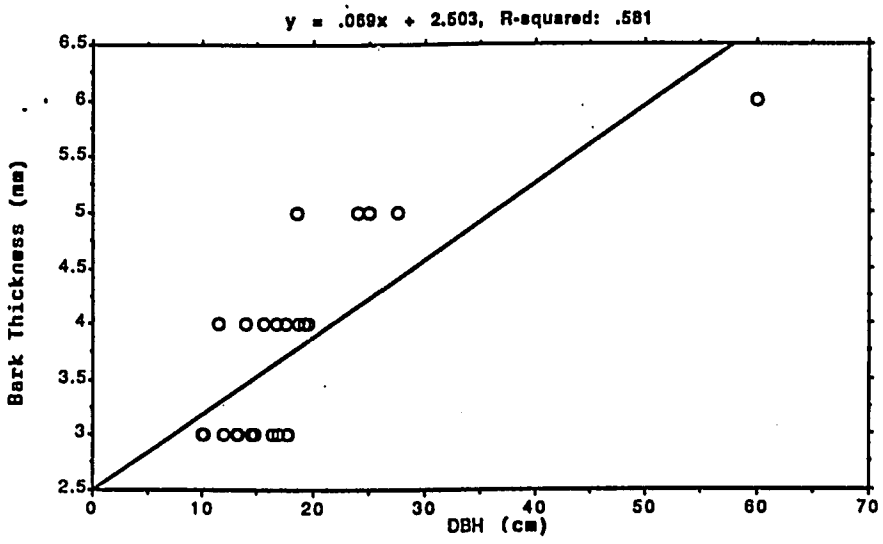


FIG. 84

COMBRETACEAE

VARIATION OF BARK THICKNESS IN TERMINALIA SUPERBA

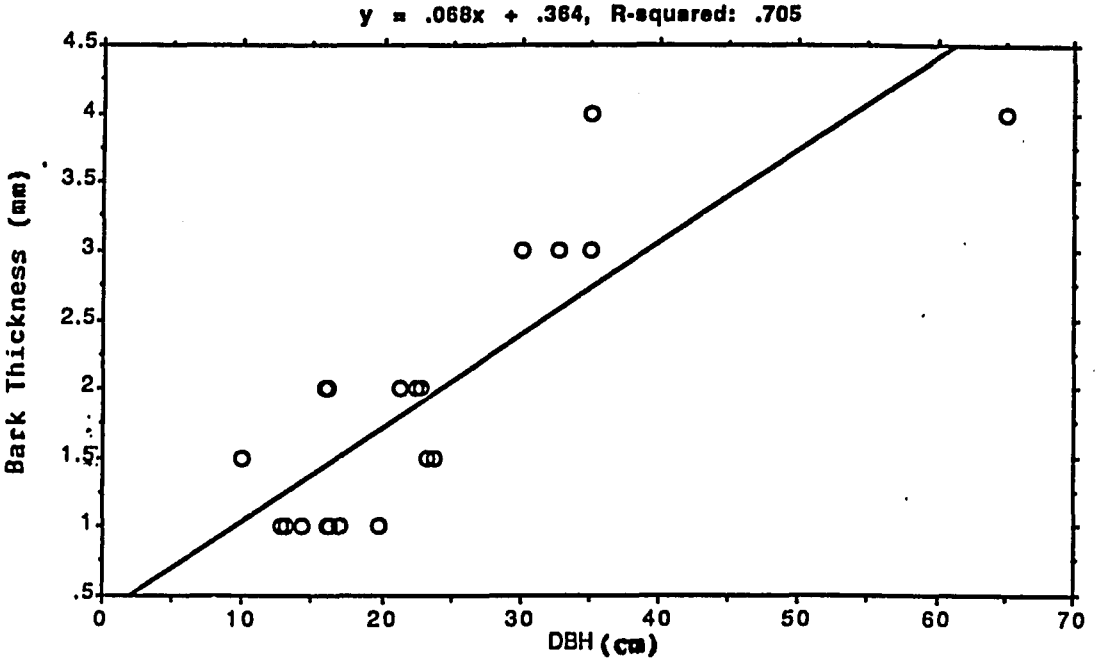


FIG. 85

EUPHORBIACEAE

VARIATION OF BARK THICKNESS IN RICINODENDRON HEUDELOTII

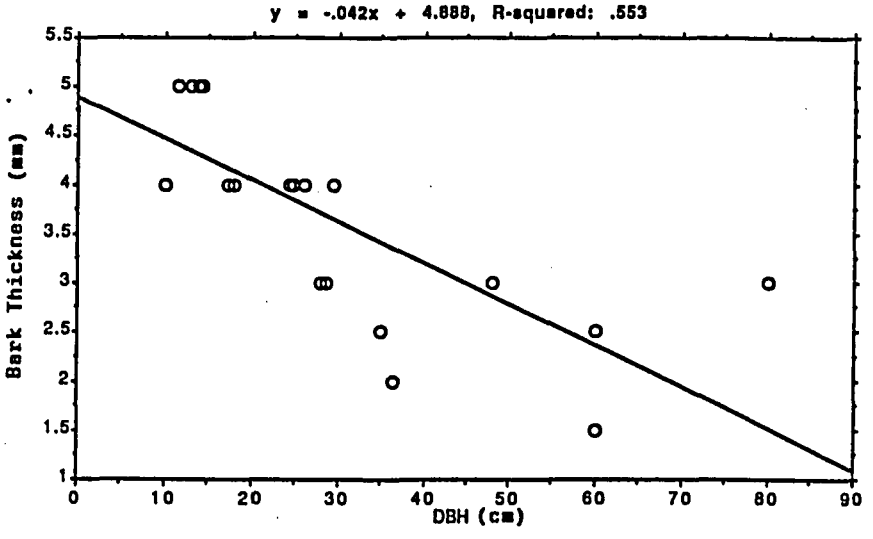


FIG. 86

LECYTHIDACEAE

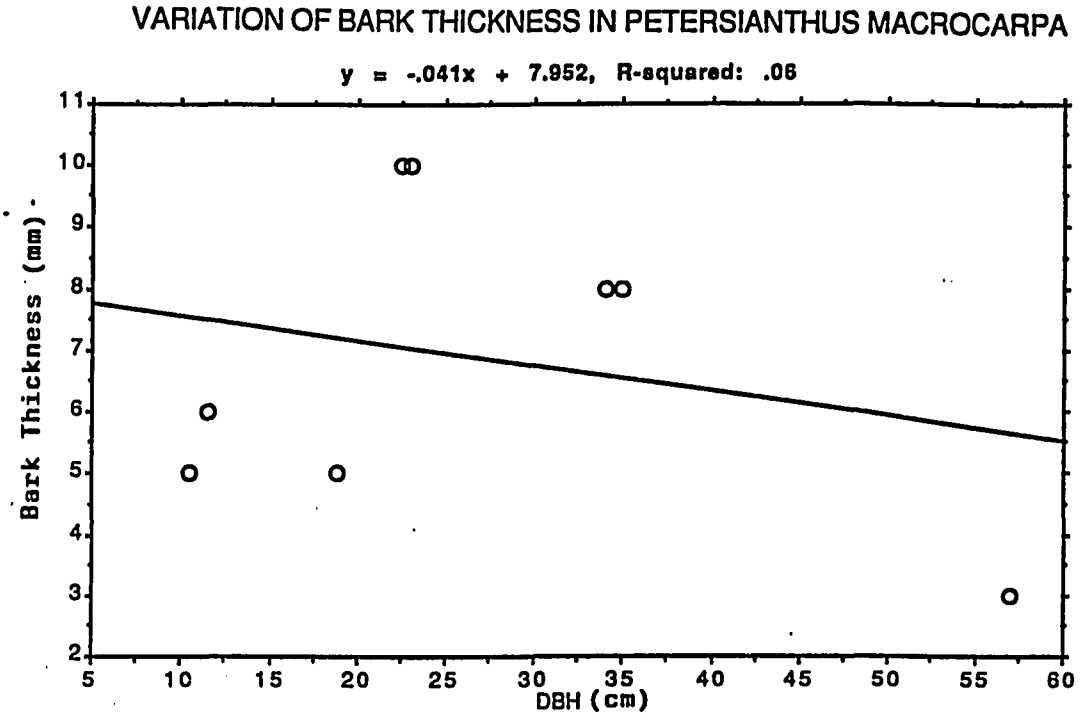
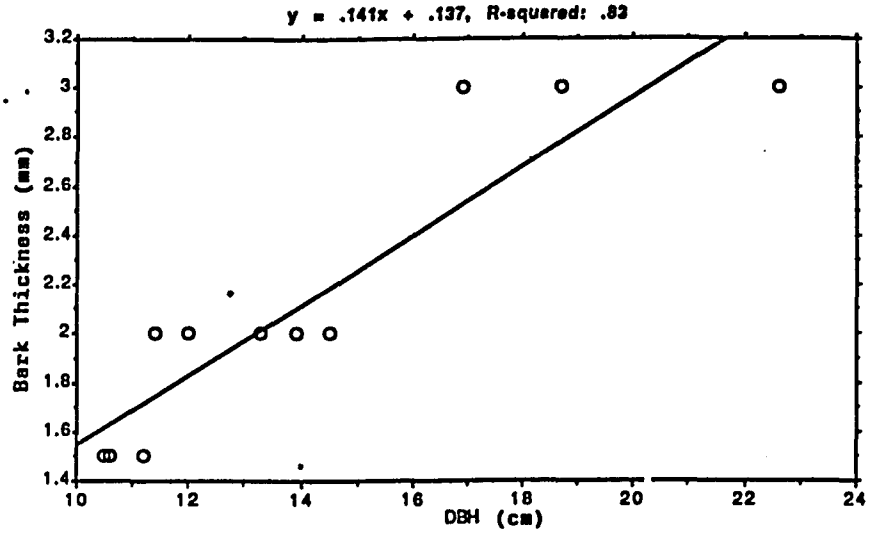


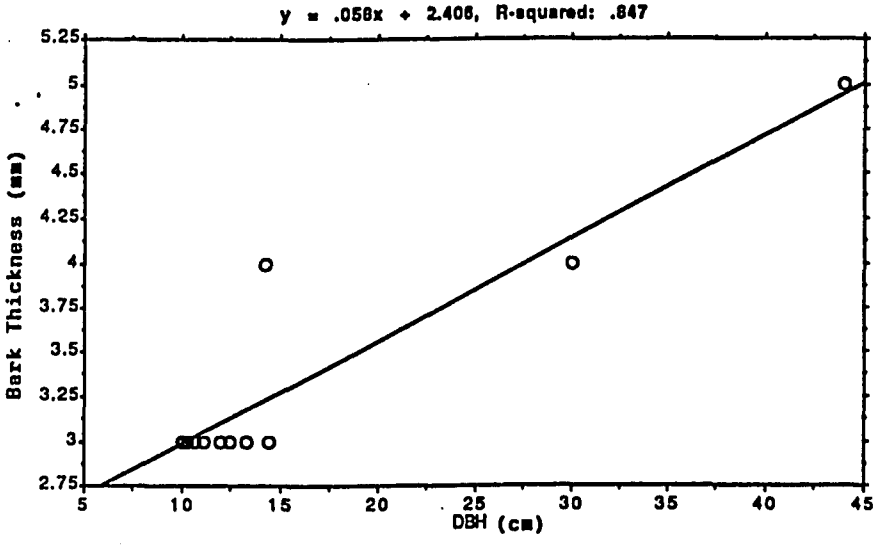
FIG. 87

MELIACEAE

VARIATION OF BARK THICKNESS IN CARAPA PROCERA



VARIATION OF BARK THICKNESS IN ENTANDROPHRAGMA ANGOLENSE



VARIATION OF BARK THICKNESS IN TURRAENTHUS AFRICANUS

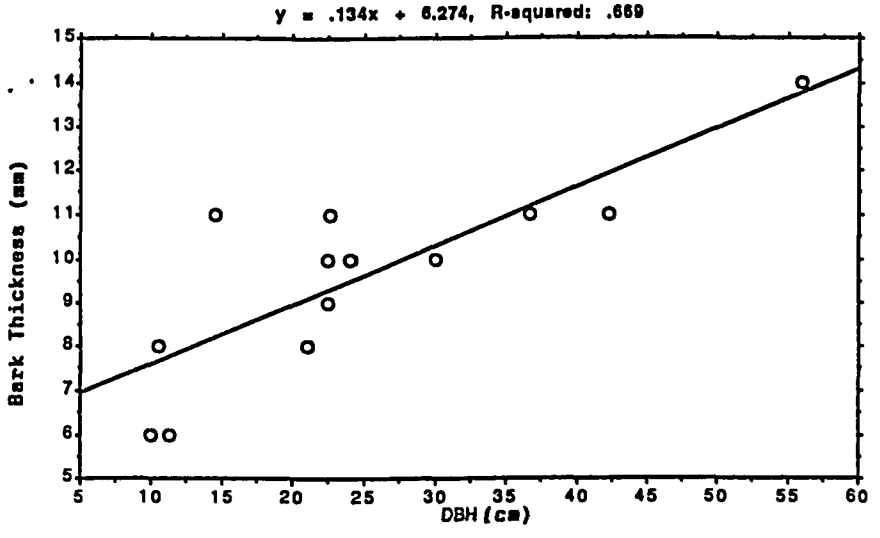
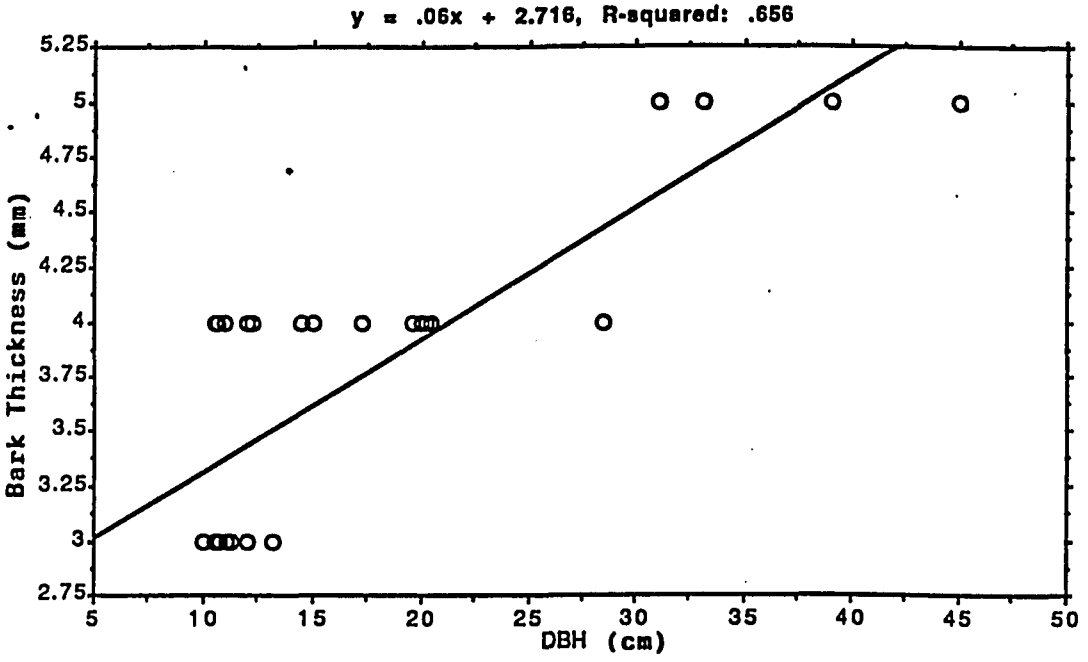


FIG. 88
MELIACEAE

VARIATION OF BARK THICKNESS IN GUAREA CEDRATA



VARIATION OF BARK THICKNESS IN TRICHILIA PRIEURIANA

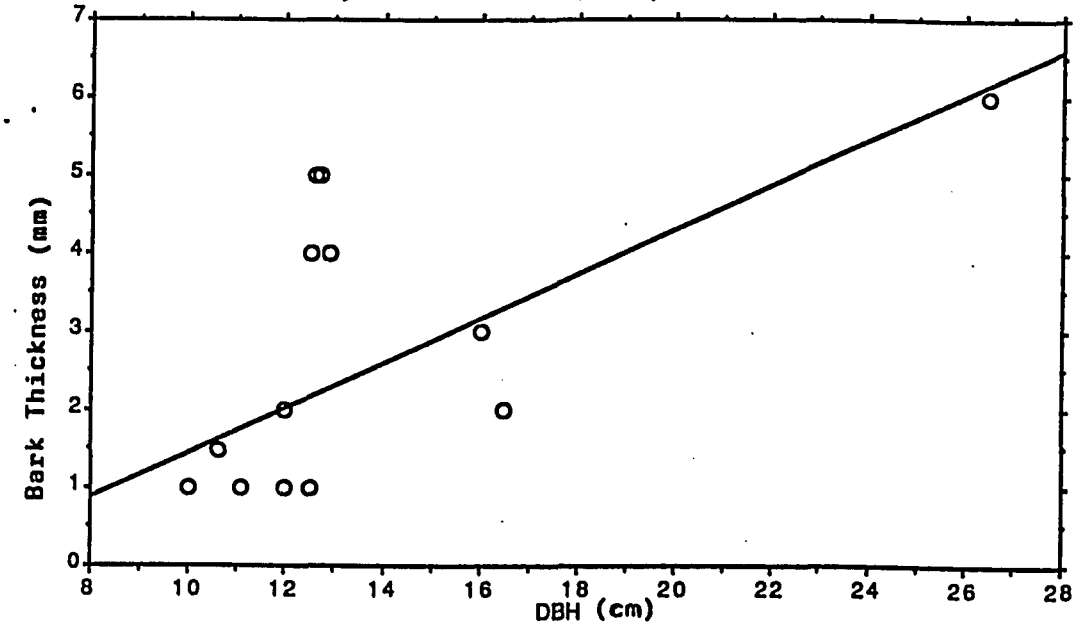
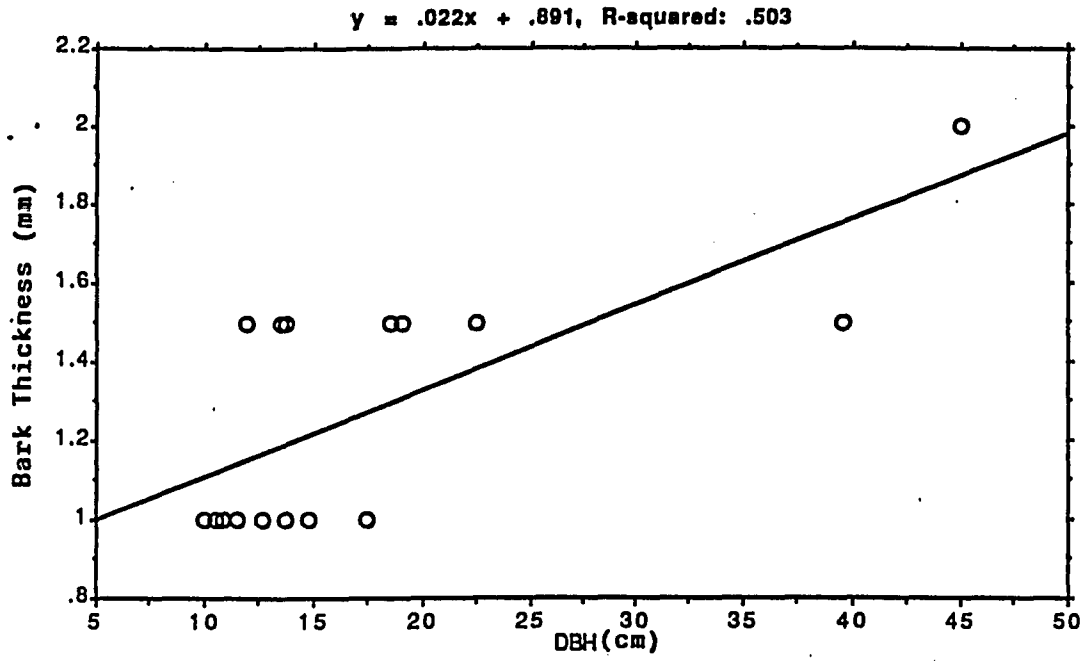


FIG. 89

MIMOSACEAE

VARIATION OF BARK THICKNESS IN CYLICODISCUS GABUNENSIS



VARIATION OF BARK THICKNESS IN PIPTADENIASTRUM AFRICANUM

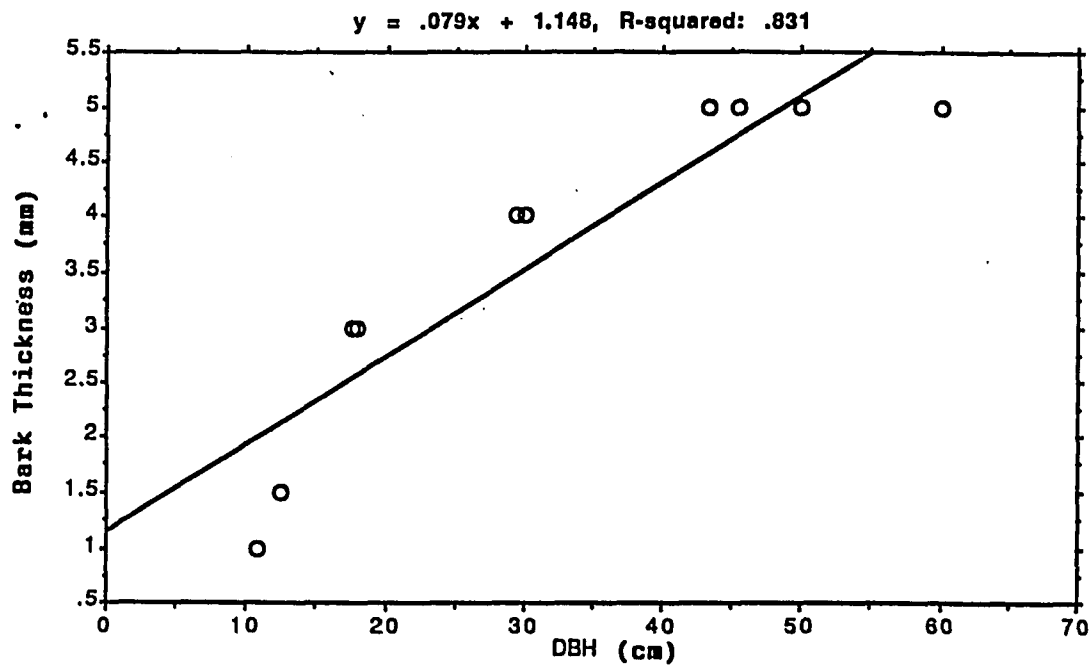
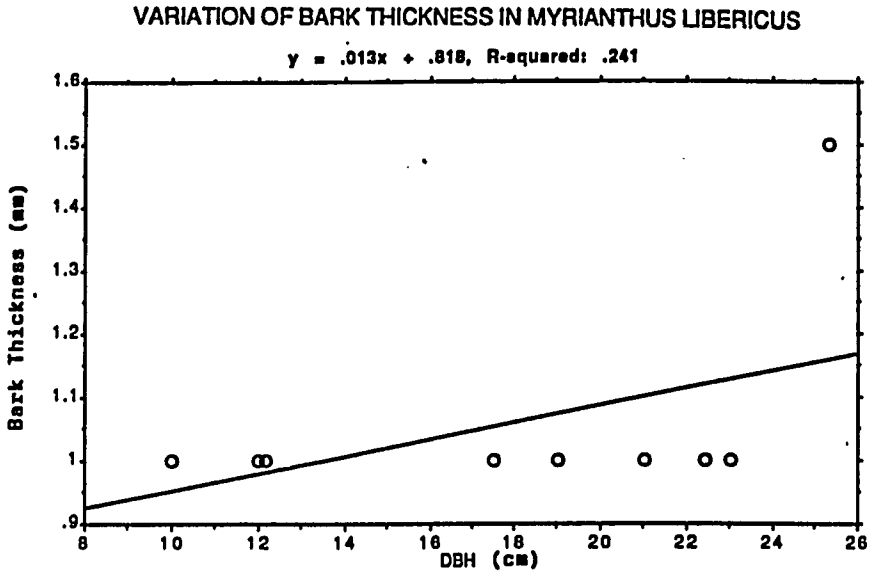


FIG. 90

MORACEAE



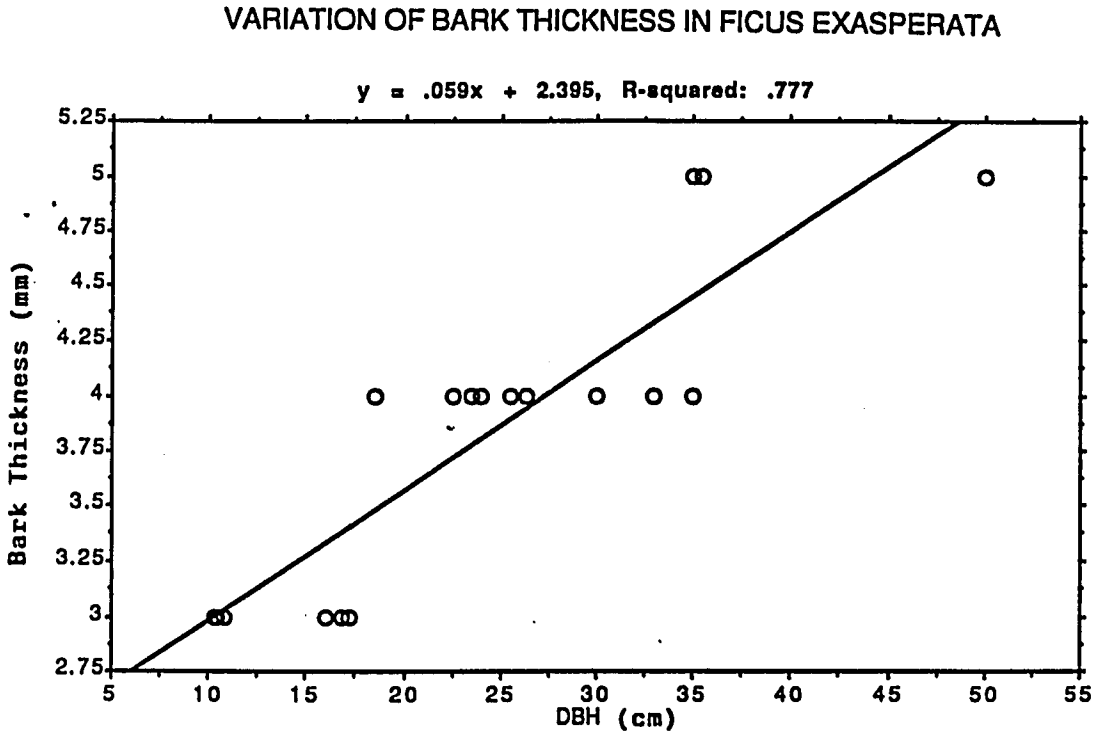
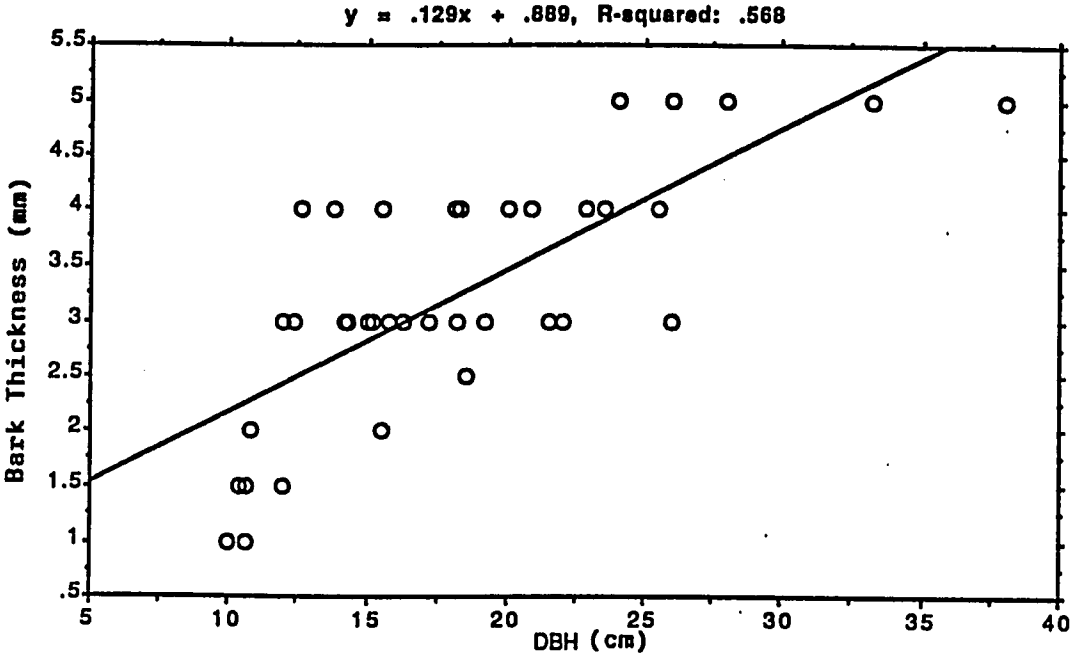


FIG. 91
OLACACEAE

VARIATION OF BARK THICKNESS IN STROMBOSIA GLAUCESCENS



VARIATION OF BARK THICKNESS IN BLIGHIA WELWITSCHII

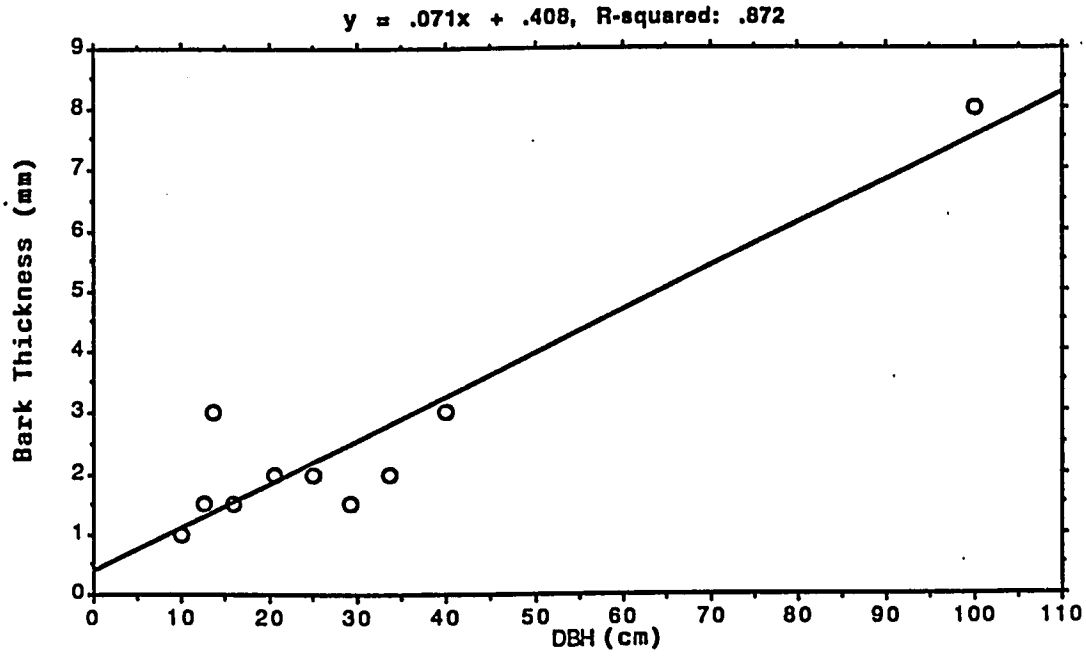
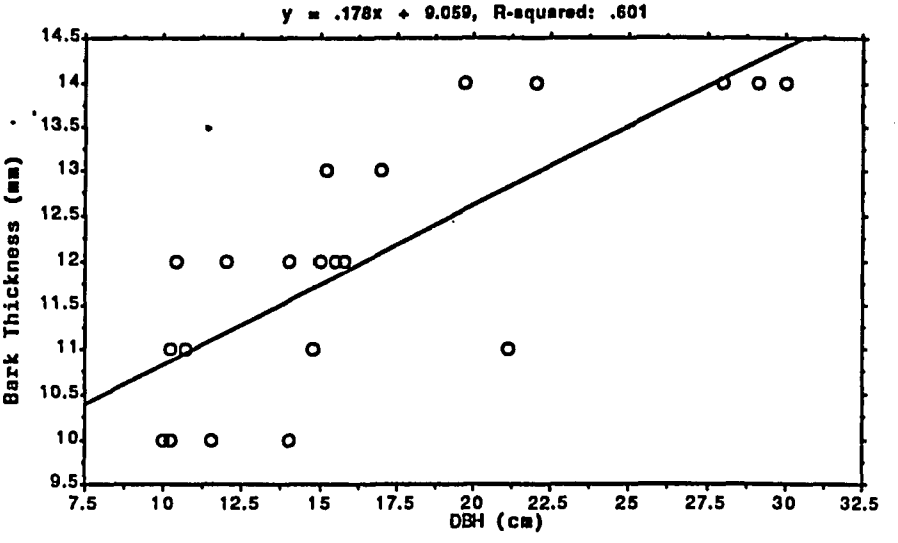


FIG. 92

STERCULIACEAE

VARIATION OF BARK THICKNESS IN COLA GIGANTEA



VARIATION OF BARK THICKNESS IN NESOGORDONIA PAPAVERIFERA

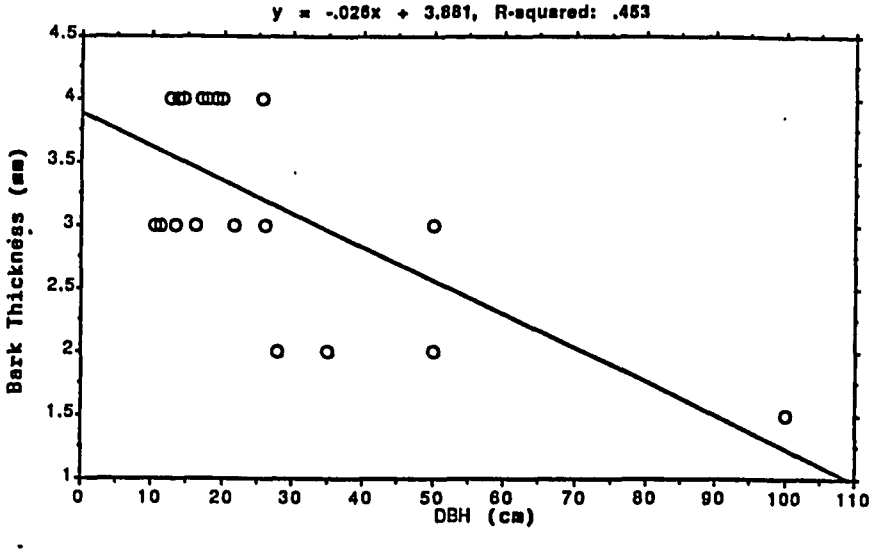
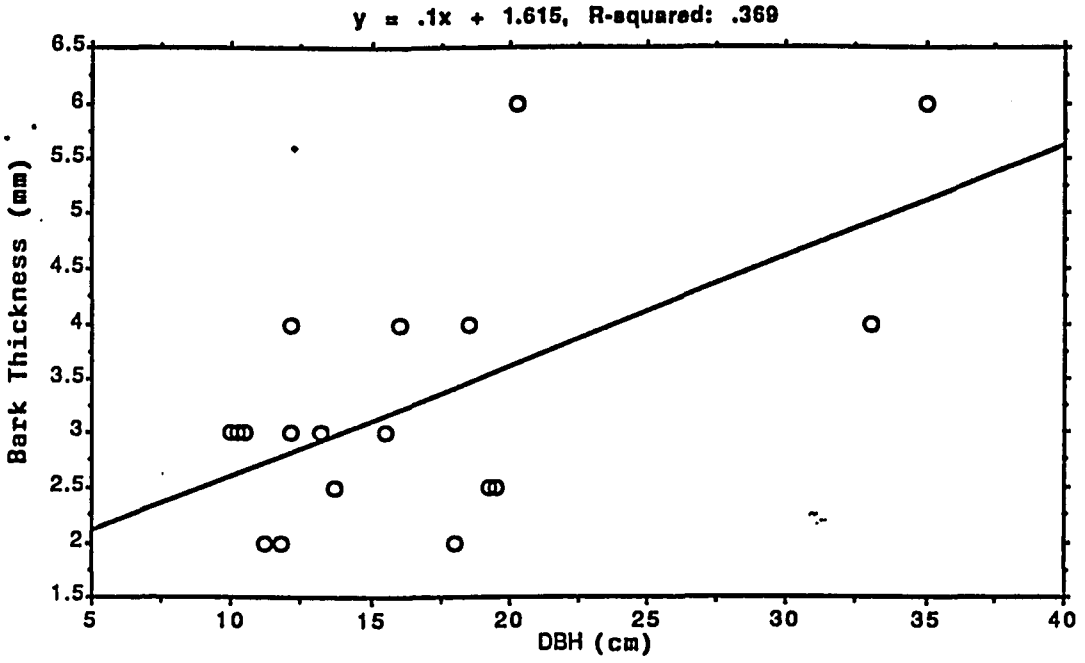


FIG. 93

STERCULIACEAE

VARIATION OF BARK THICKNESS IN PTERYGOTA MACROCARPA



VARIATION OF BARK THICKNESS IN STERCULIA OBLONGA

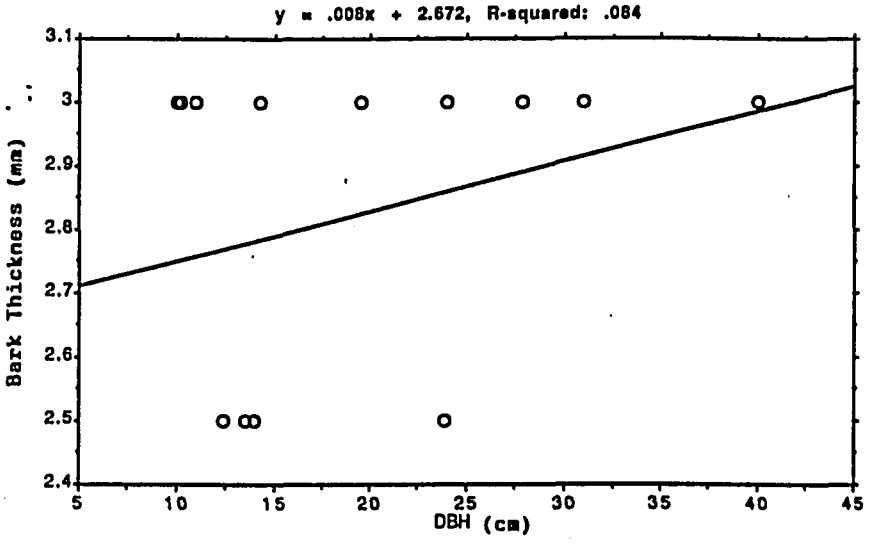
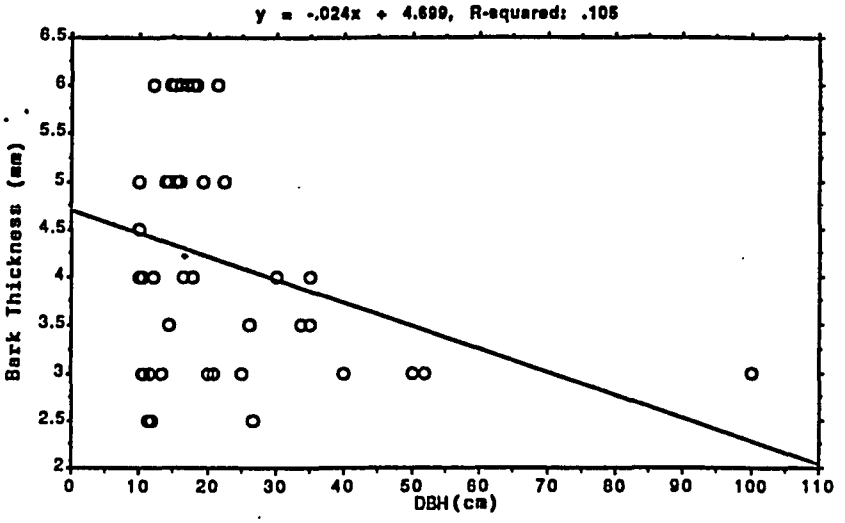
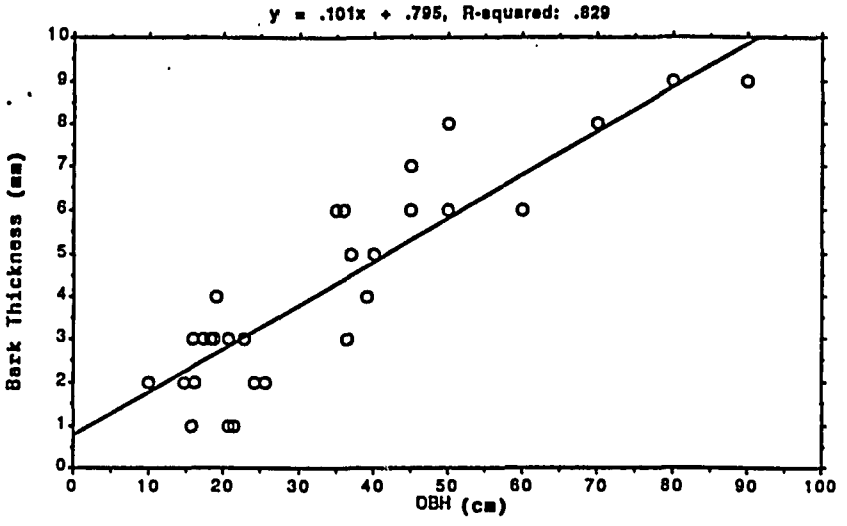


FIG. 94 STERCULIACEAE

VARIATION OF BARK THICKNESS IN STERCULIA RHINOPETALA



VARIATION OF BARK THICKNESS IN TRIPLOCHITON SCLEROXYLON



VARIATION OF BARK THICKNESS IN STERCULIA TRAGACANTHA

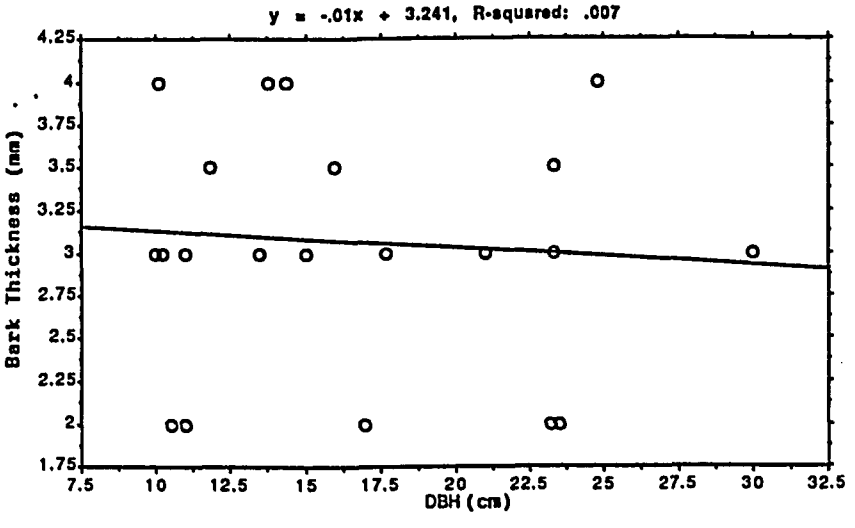
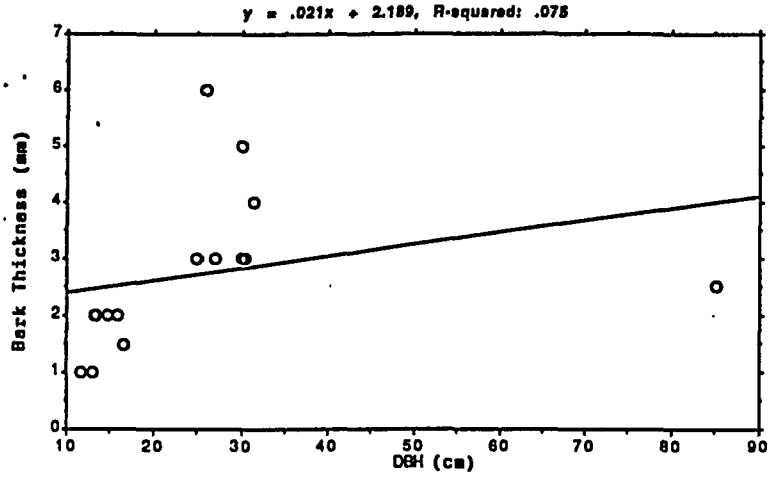
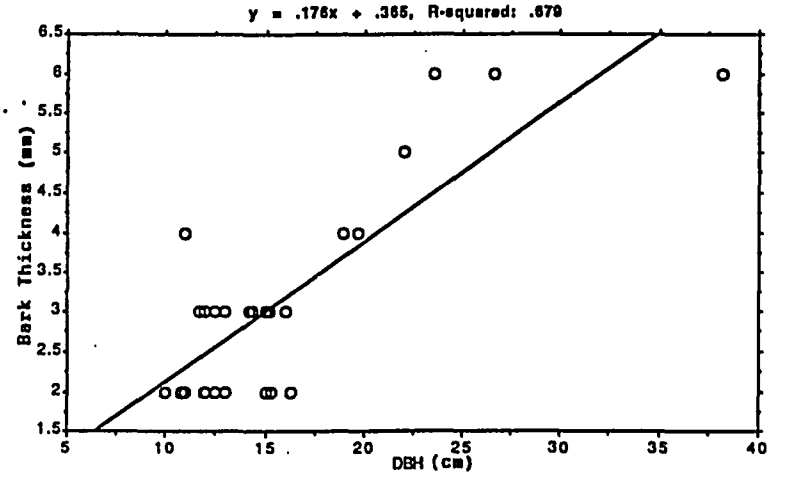


FIG. 95 ULMACEAE

VARIATION OF BARK THICKNESS IN CELTIS ADOLFI-FRIDERICI



VARIATION OF BARK THICKNESS IN CELTIS MILDBRAEDII



VARIATION OF BARK THICKNESS IN CELTIS ZENKERI

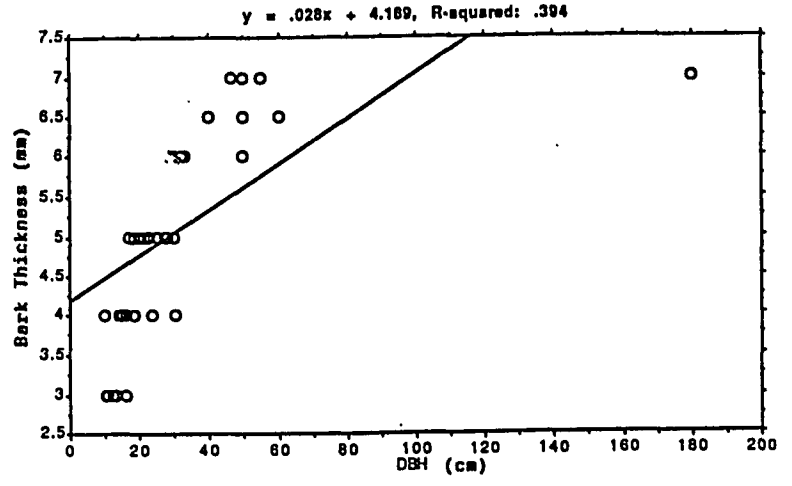
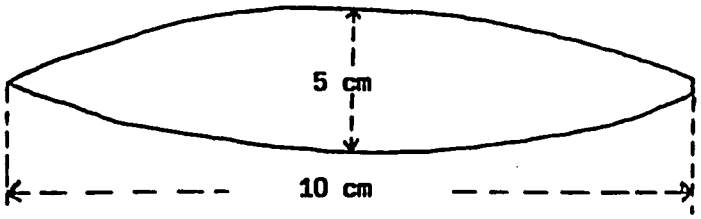
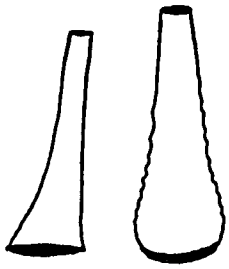


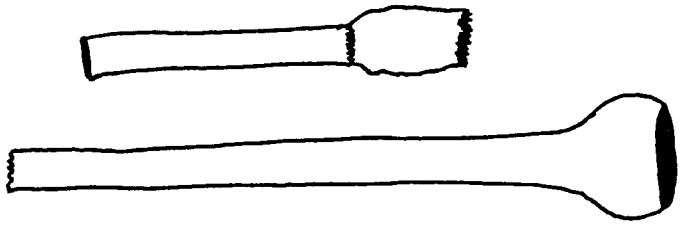
FIG.96 ADDITIONAL TERMS FOR LEAF MORPHOLOGY



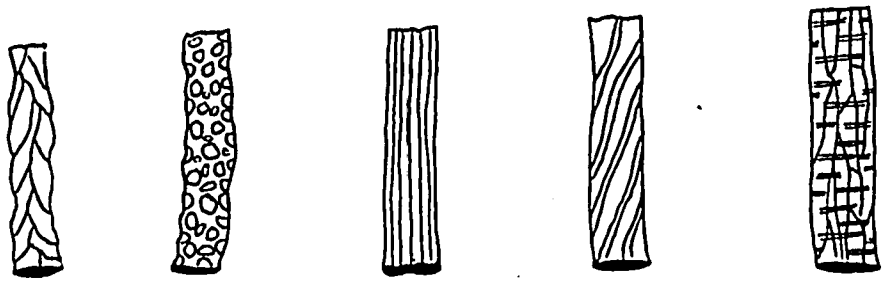
a Lanceoelliptic leaf form



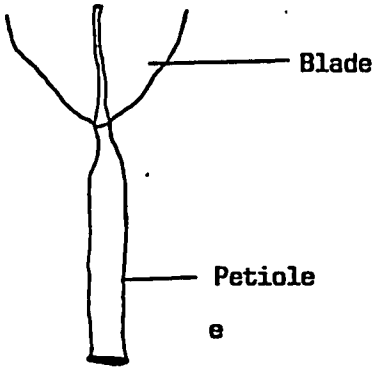
b Fluted Petiole



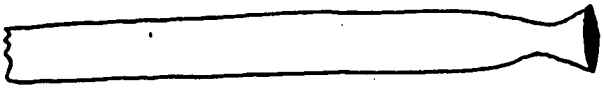
c Fluted Rachis



d Various forms of Corrugated Rachis or Petiole



e Apiconstrict Petiole



f Basiconstrict Rachis

FIG. 97 ADDITIONAL TERMS FOR LEAF MORPHOLOGY

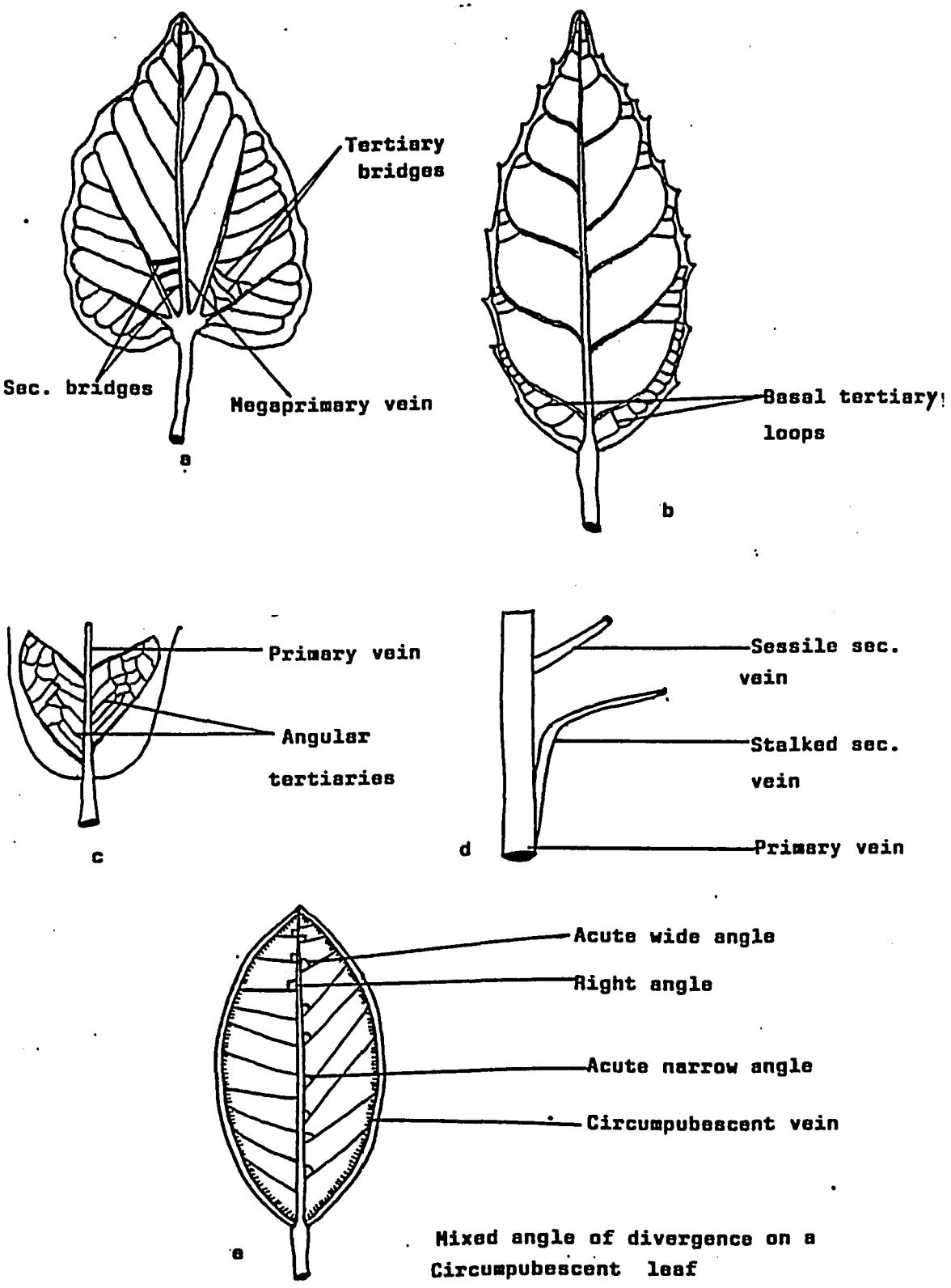
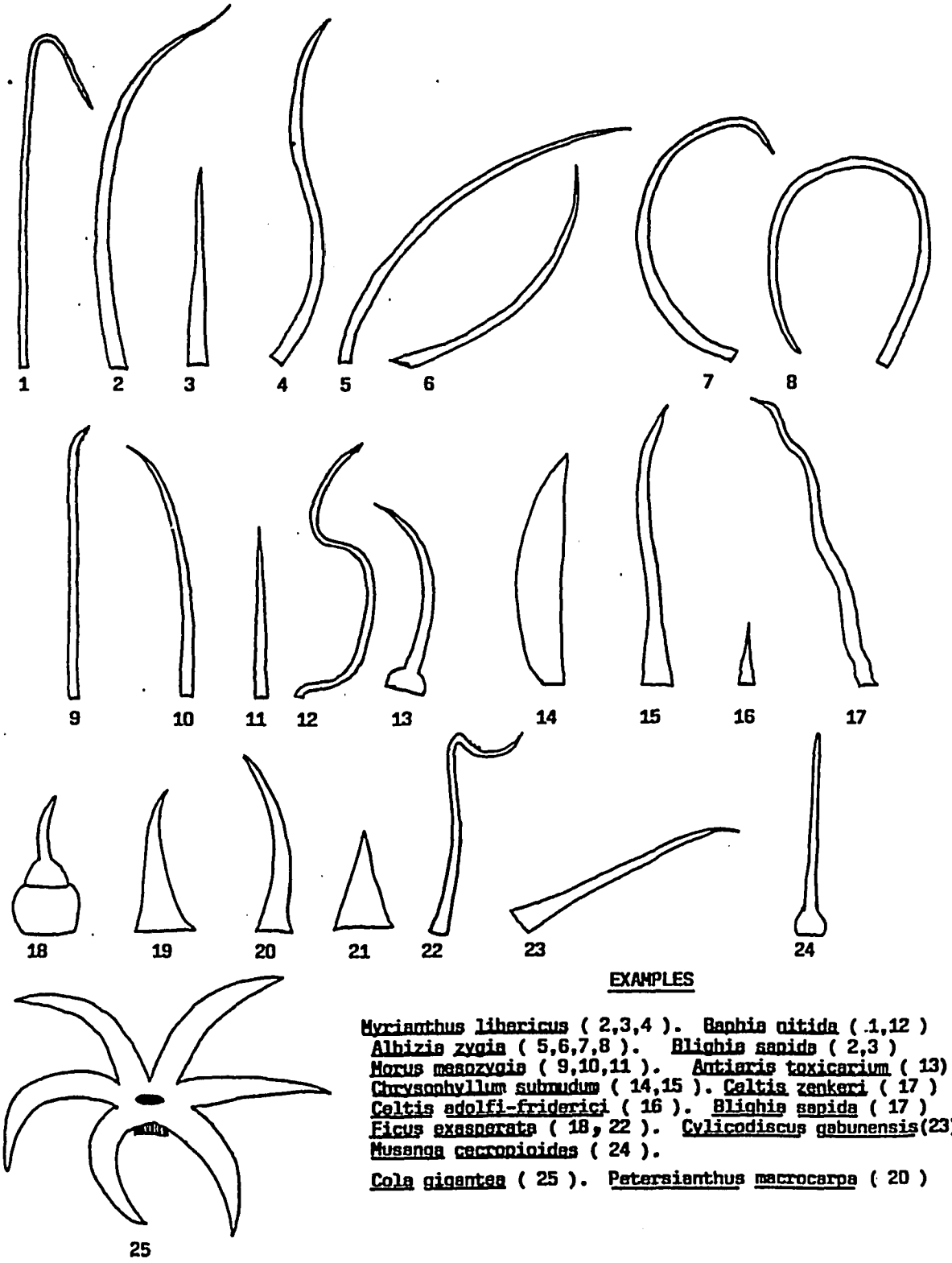


FIG. 98

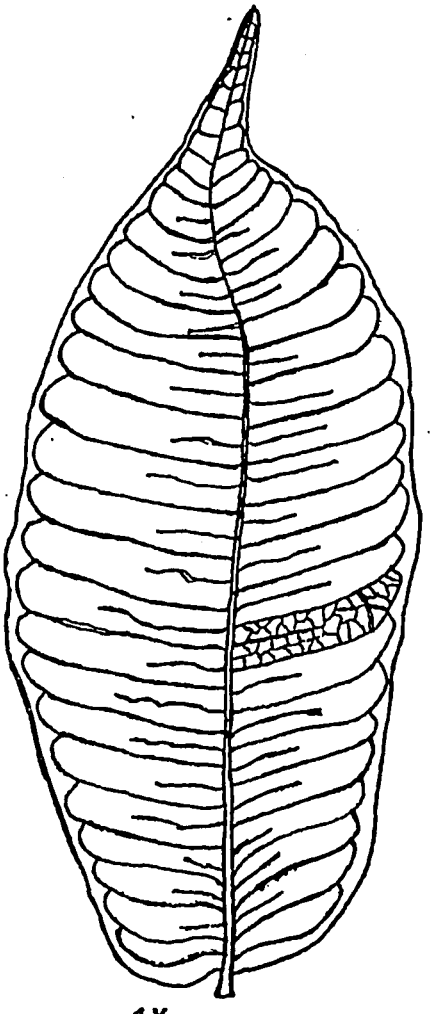
Types of hairs on the leaves of trees of Bobiri forest (x20)



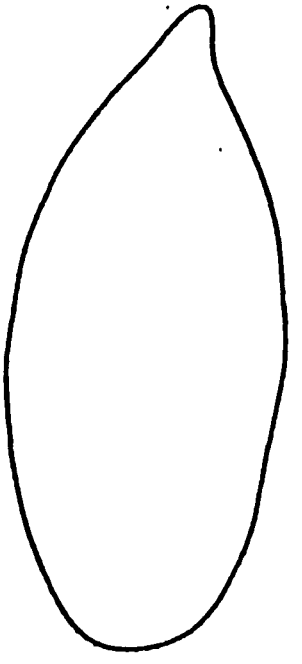
EXAMPLES

Myrianthus libericus (2,3,4). Baphia nitida (1,12)
Albizia zygia (5,6,7,8). Blighia sapida (2,3)
Morus mesozygia (9,10,11). Antiaris toxicarium (13)
Chrysophyllum subnudum (14,15). Celtis zenkeri (17)
Celtis adolfi-friderici (16). Blighia sapida (17)
Ficus exasperata (18, 22). Cylicodiscus gabunensis(23)
Musanga cecropioides (24).
Cola gigantea (25). Petersianthus macrocarpa (20)

FIG. 99



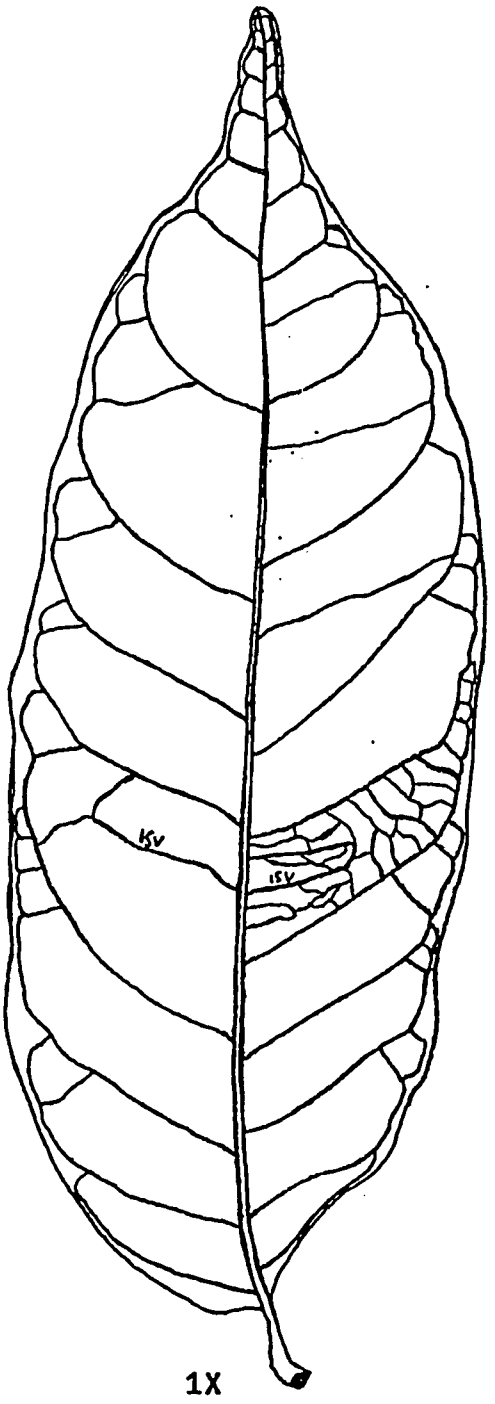
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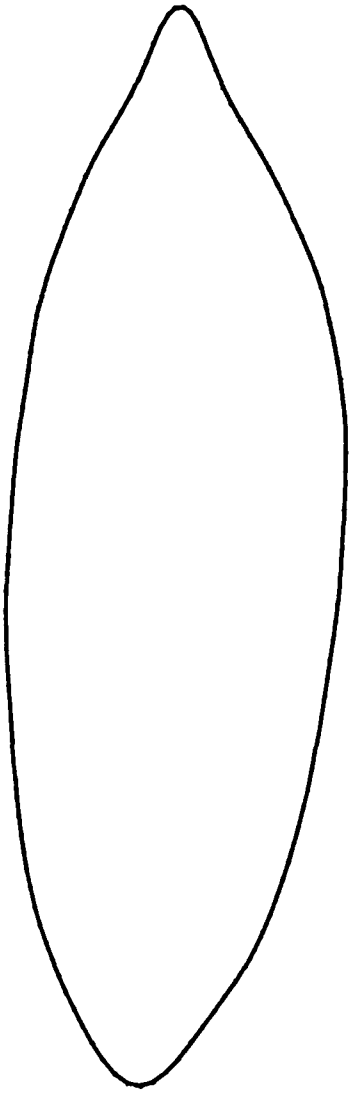
Average leaf image
BF = 15

Antrocaryon micraster

FIG. 100



1X

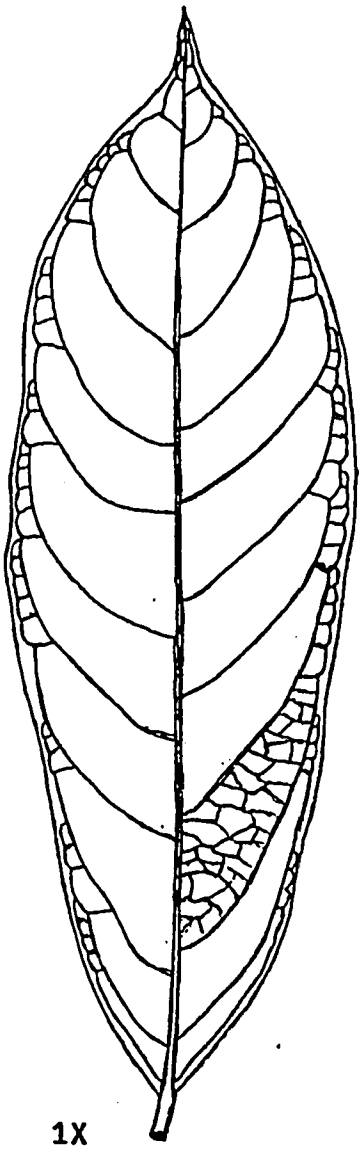


Average leaf image

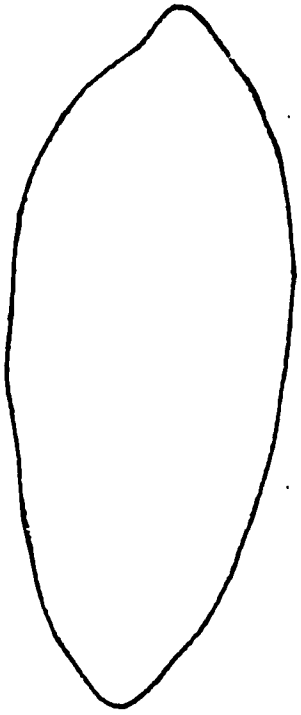
BF = 15

Lannea welwitschii

FIG. 101



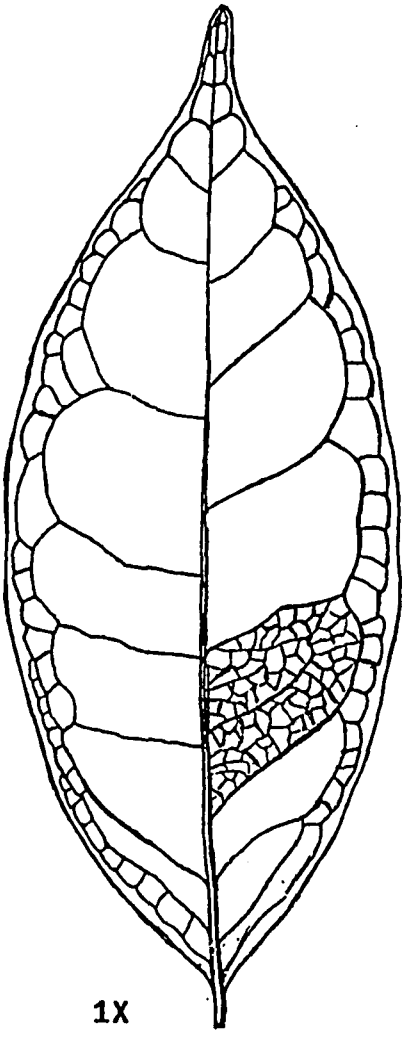
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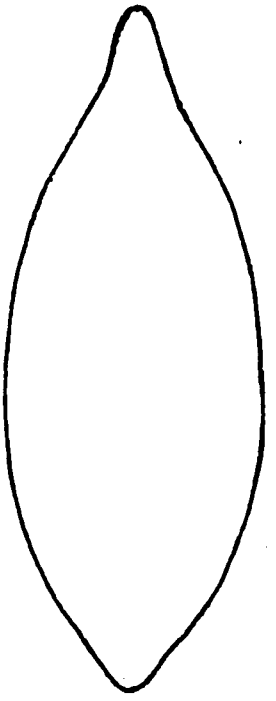
Average leaf image
BF = 15

Enantia polycarpa

FIG. 102



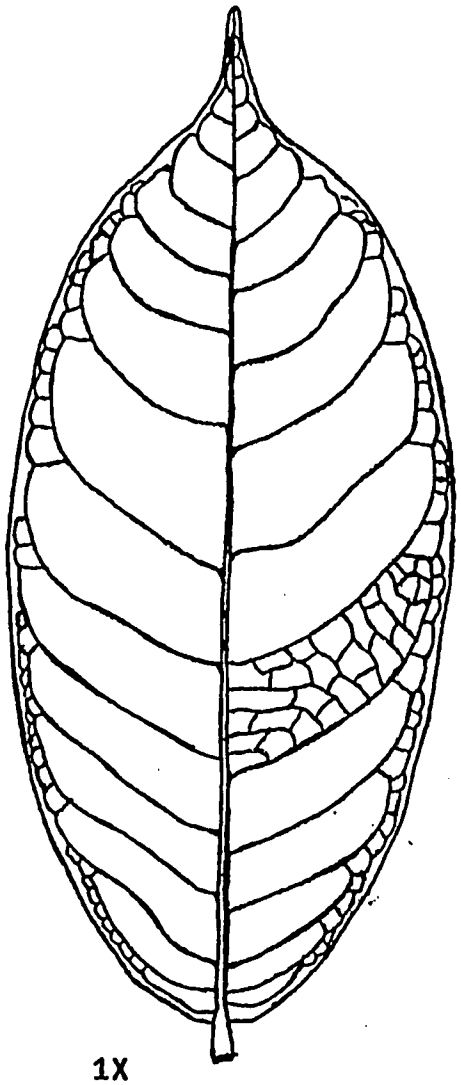
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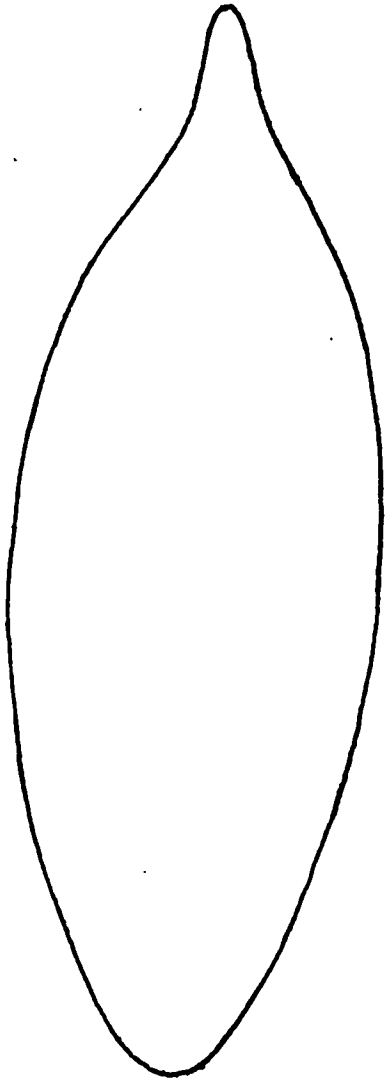
Average leaf image
BF = 15

Greenwayodendron oliveri

FIG. 103



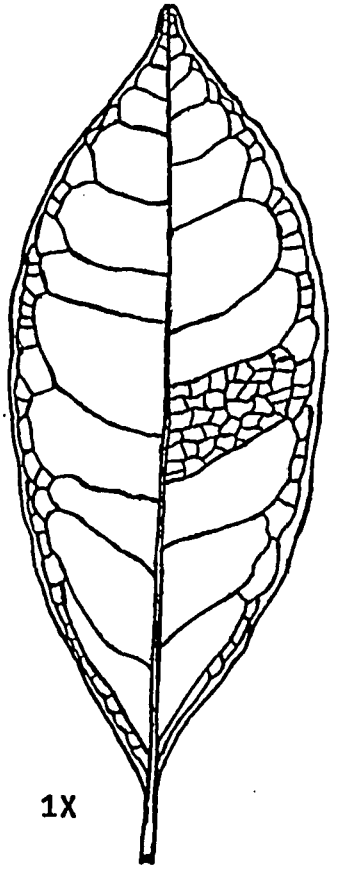
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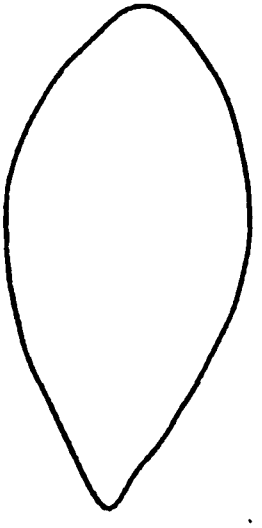
Average leaf image
BF = 20

Mischogyne elliotiana

FIG. 104



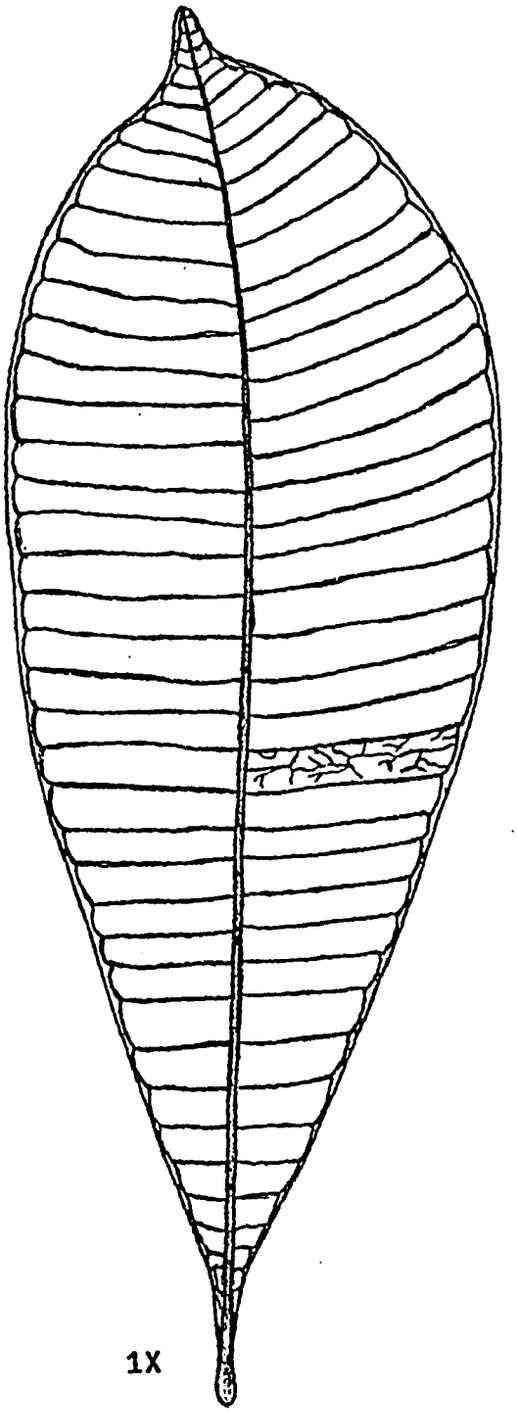
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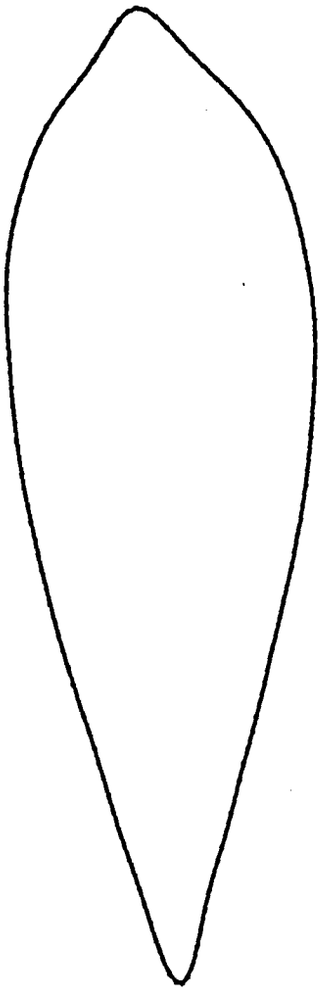
Average leaf image
BF = 15

Xylopia quintasii

FIG.105



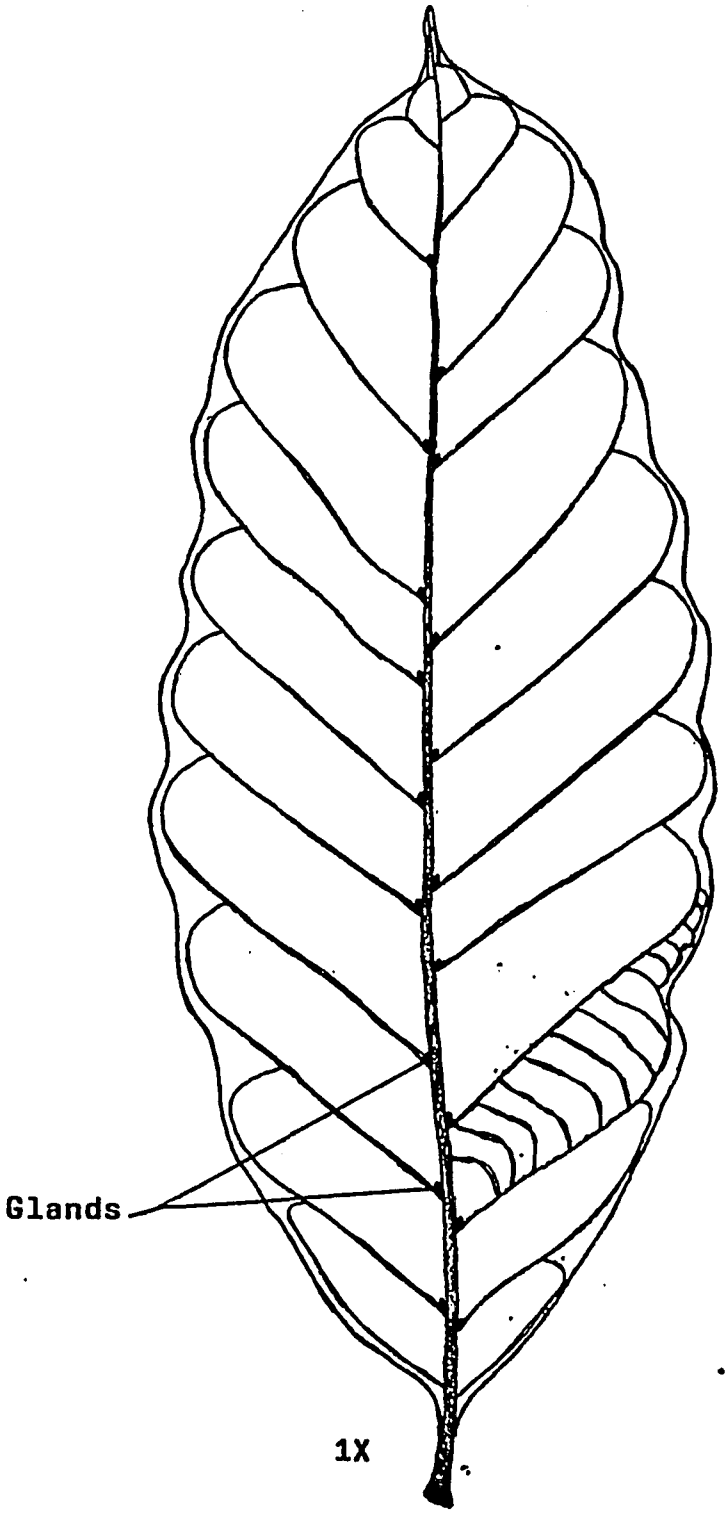
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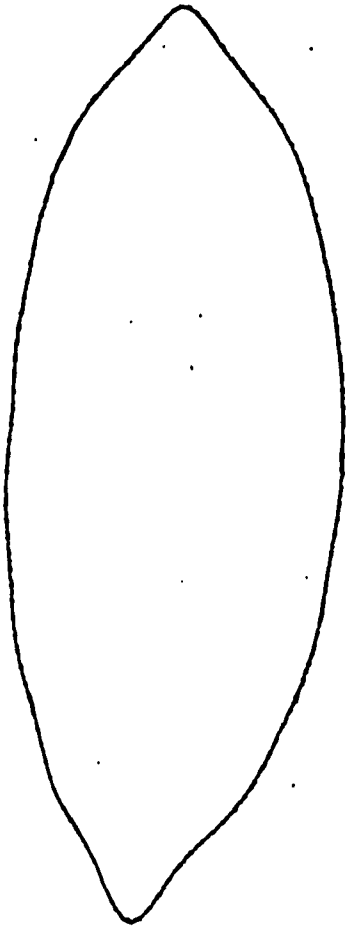


Average leaf image
BF = 15

Alstonia boonei

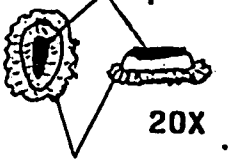
FIG. 106





Average leaf image
BF = 15

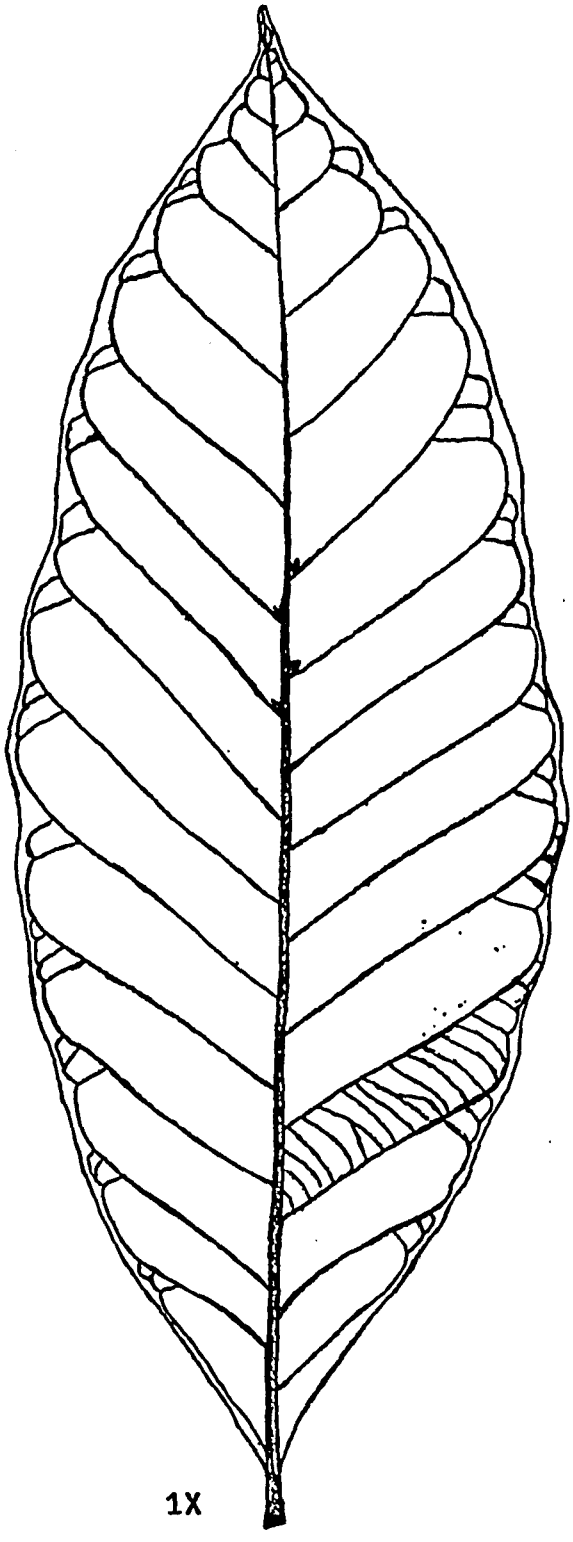
Hole on top of gland



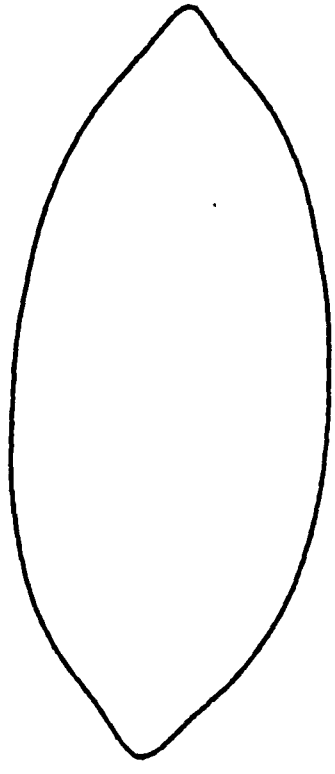
Dark exudate around gland

Funtumia africana

FIG. 107



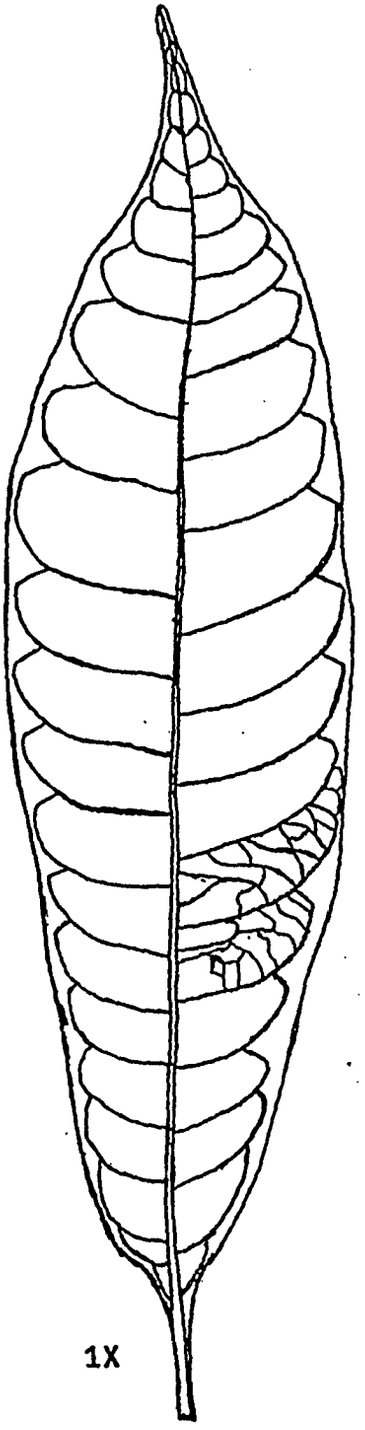
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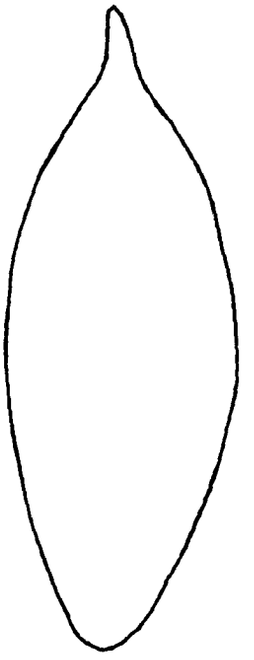
Average leaf image
BF = 10

Funtumia elastica

FIG. 108



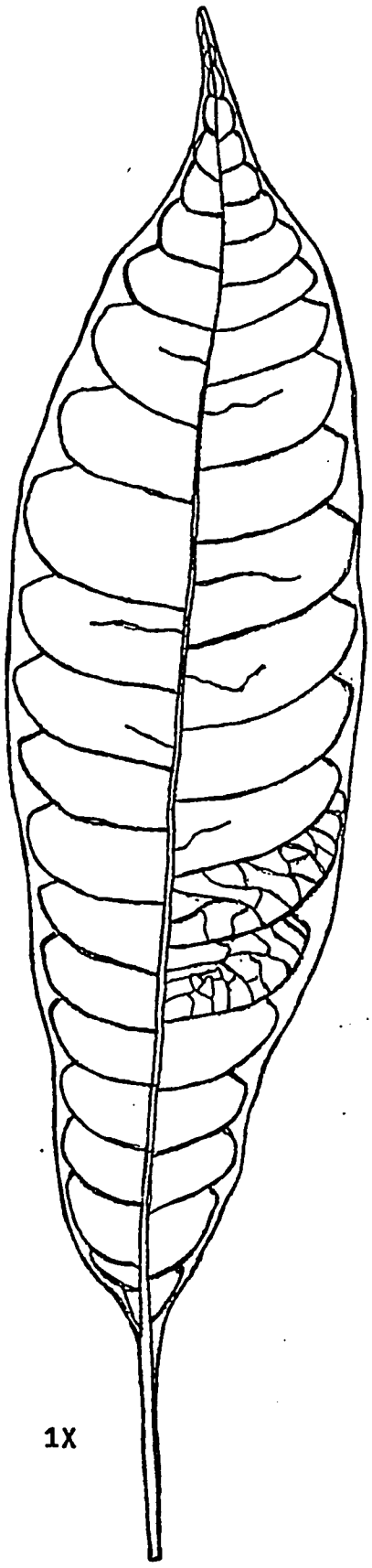
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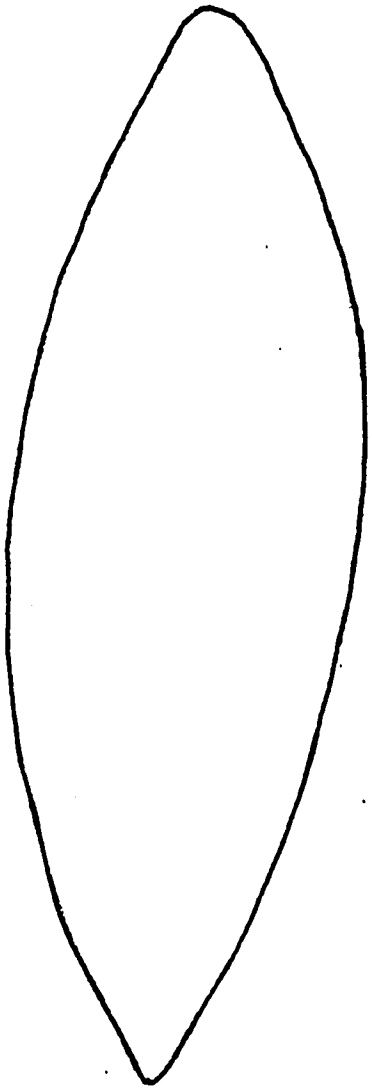
Average leaf image
BF = 15

Pleiocarpa mutica

FIG. 109



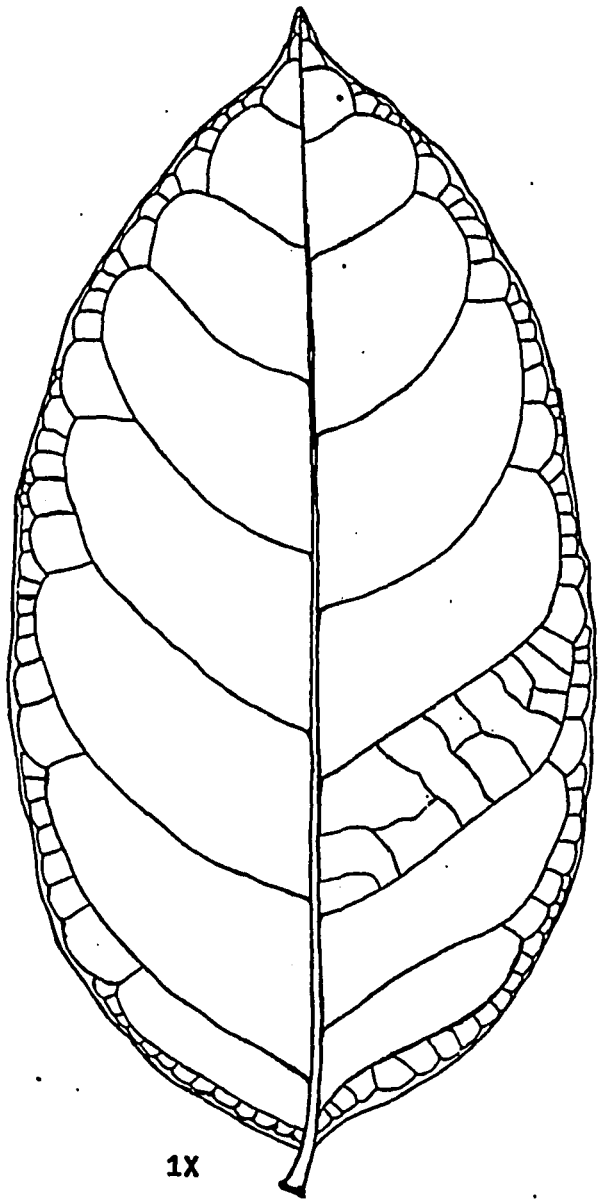
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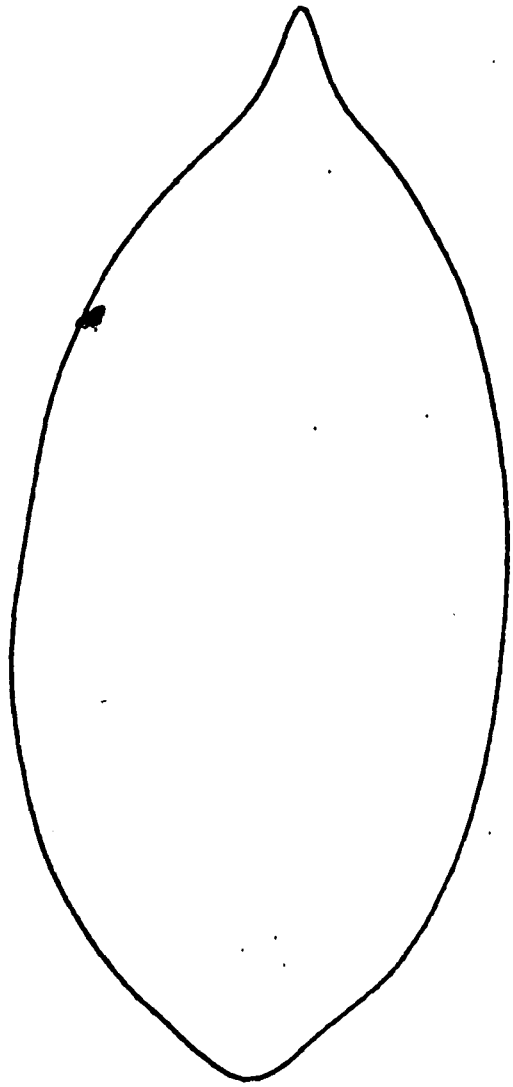
Average leaf image
BF = 15

Rauvolfia vomitoria

FIG. 110



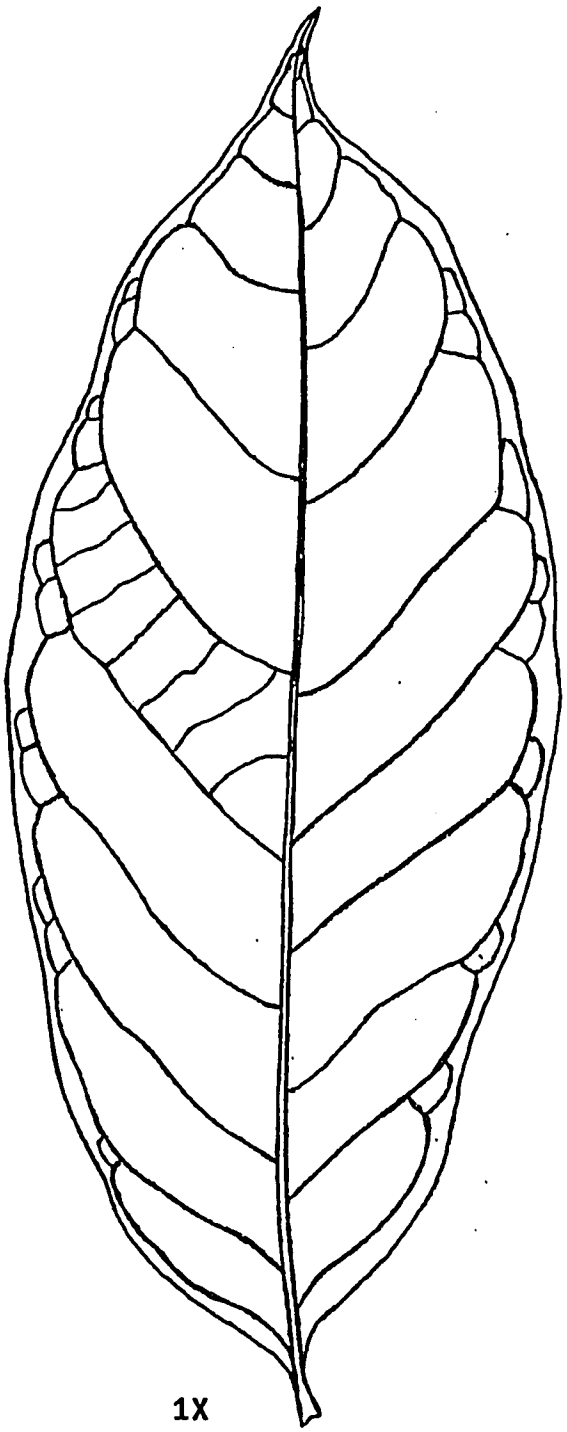
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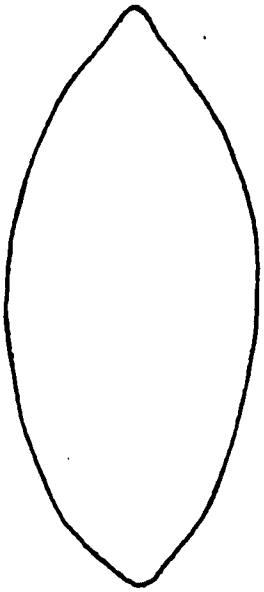
Average leaf image
BF = 15

Kigelia africana

FIG. 111



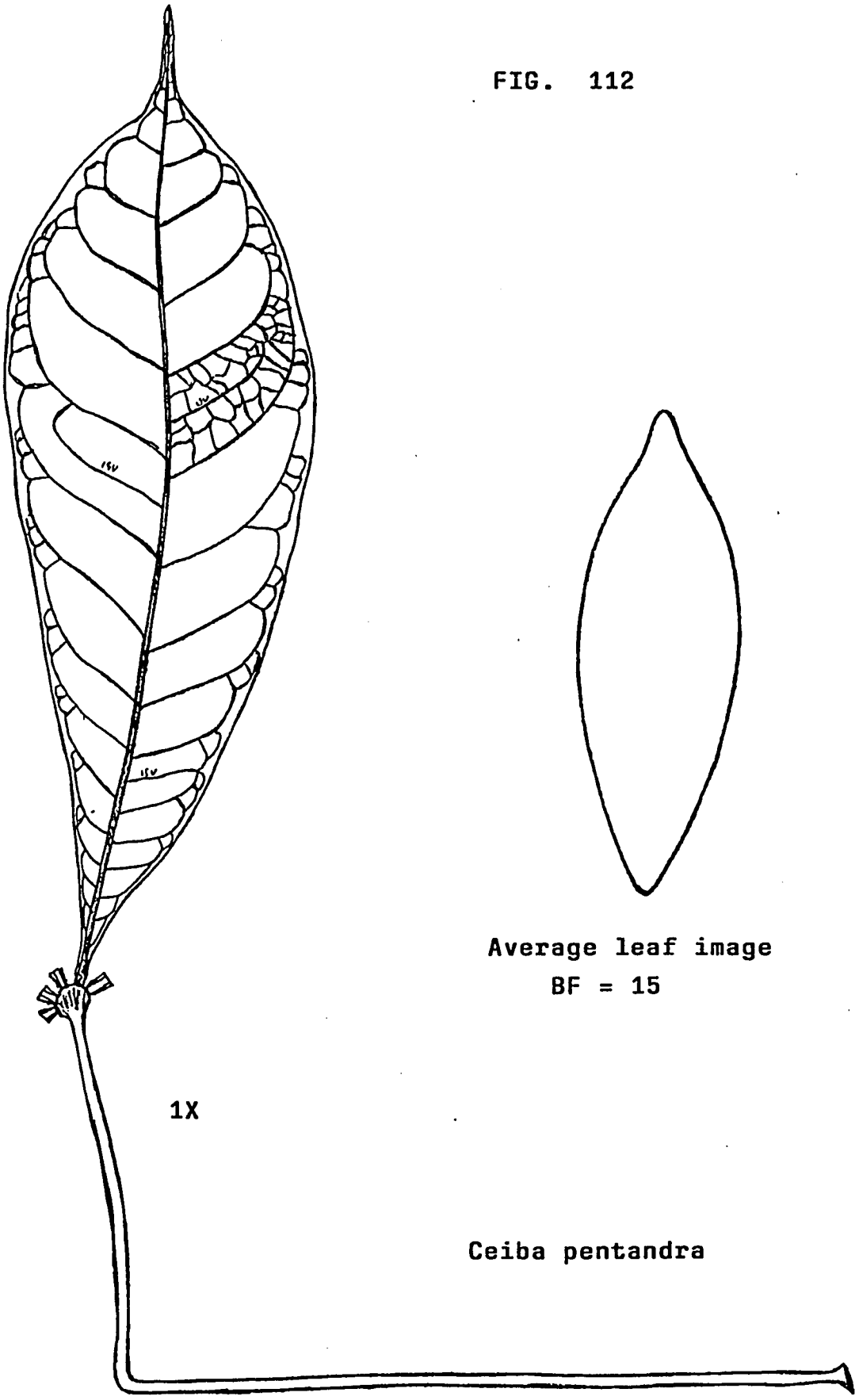
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Average leaf image
BF =. 10

Spathodea campanulata

FIG. 112

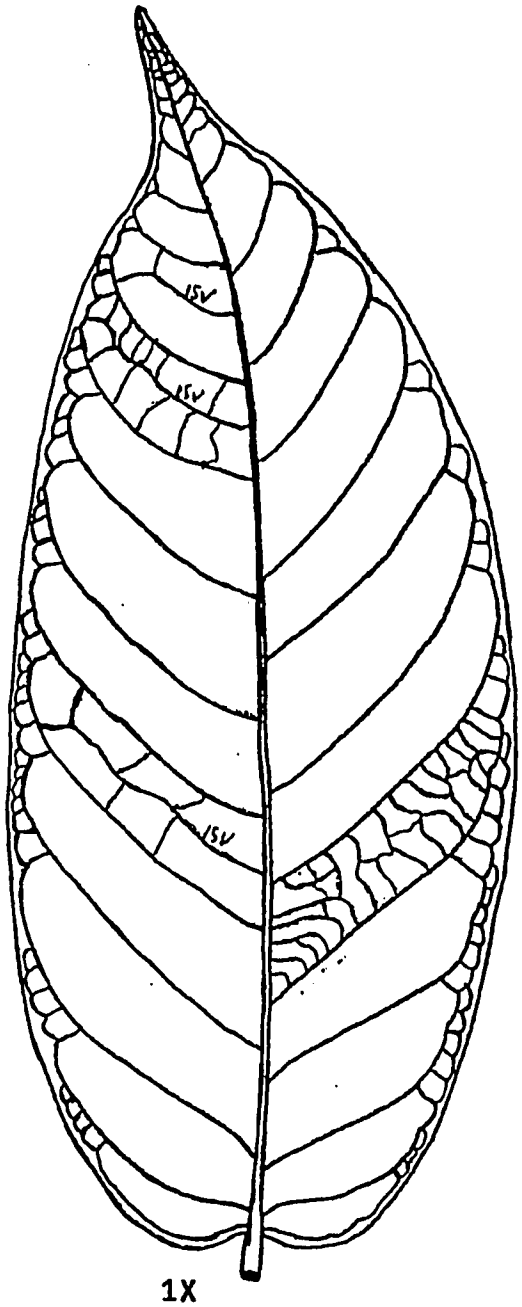


Average leaf image
BF = 15

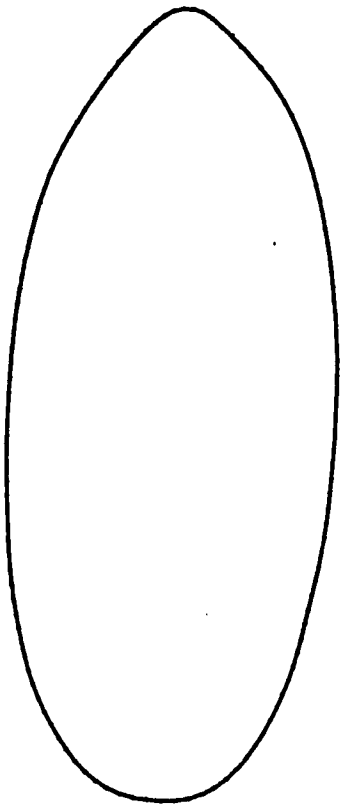
1X

Ceiba pentandra

FIG. 113



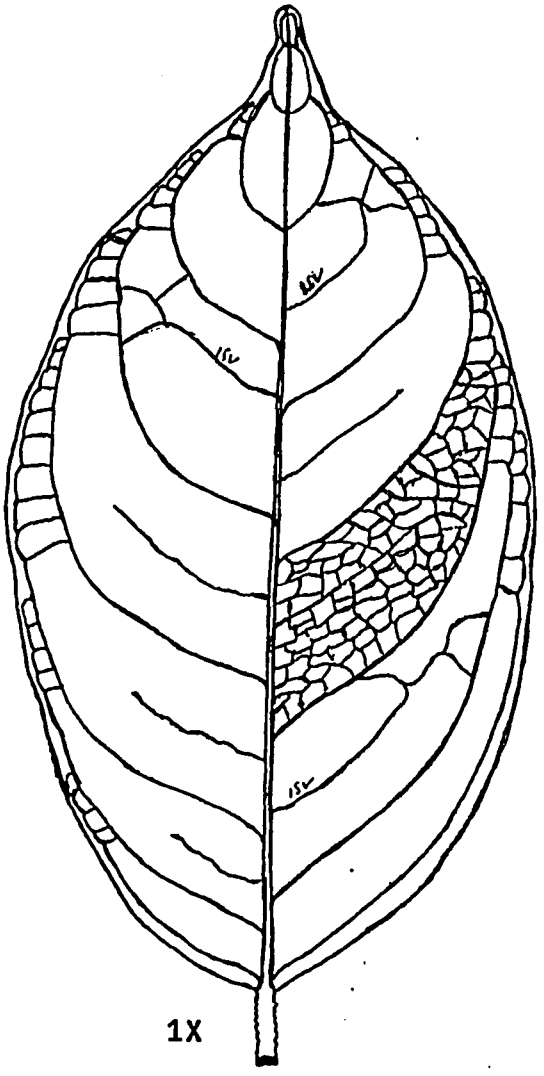
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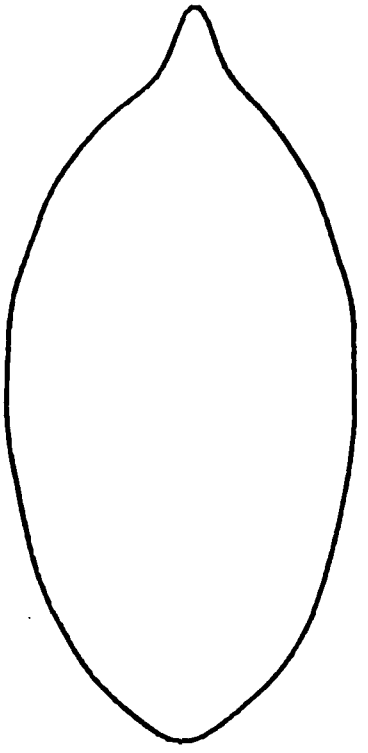
Average leaf image
BF = 15

Amphimas pterocarpoides

FIG. 114



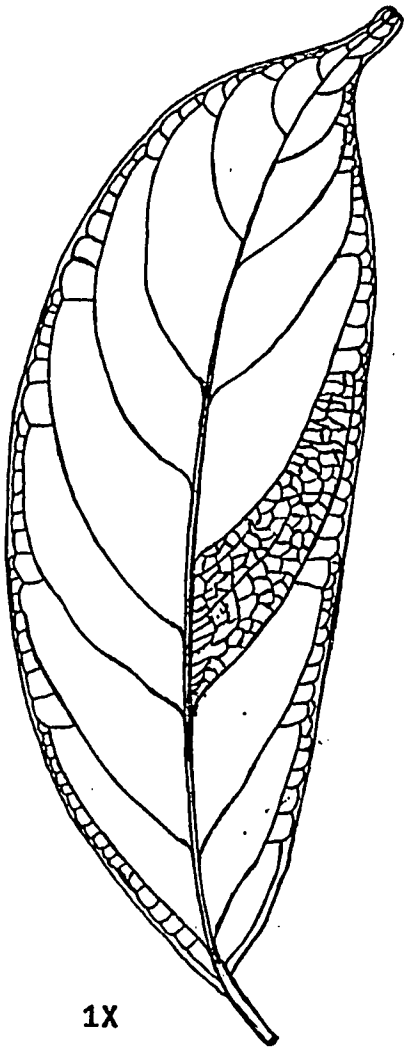
1X



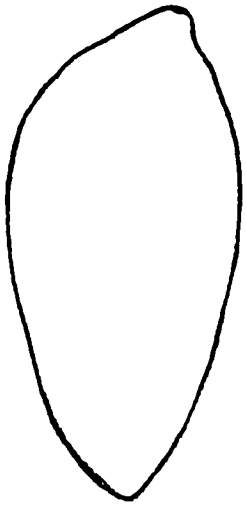
Average leaf image
BF = 15

Anthonota macrophylla

FIG. 115



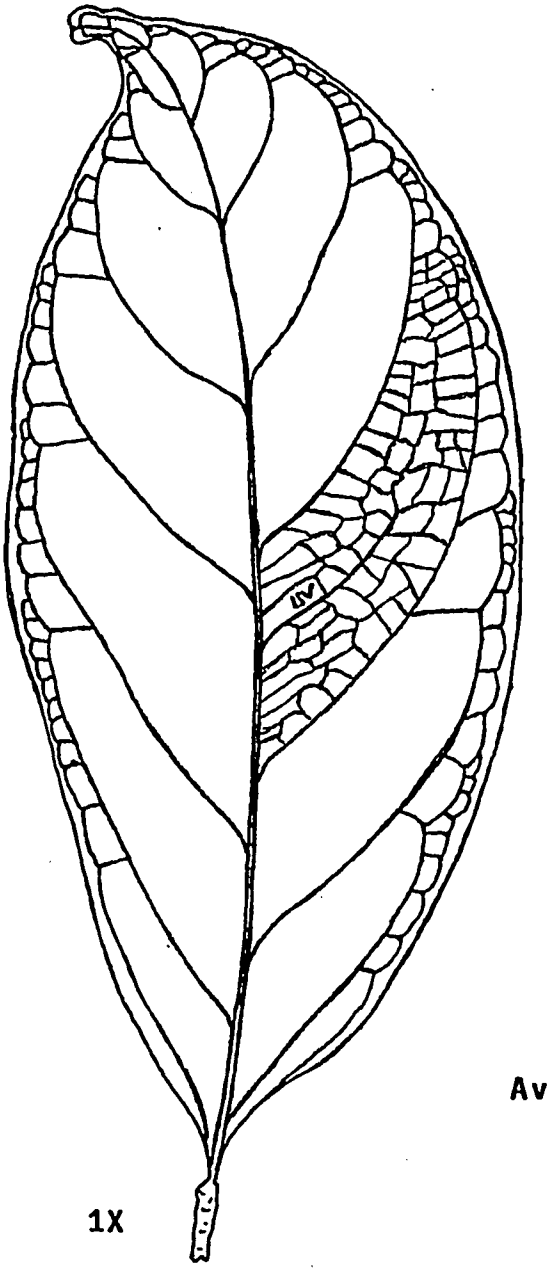
1X



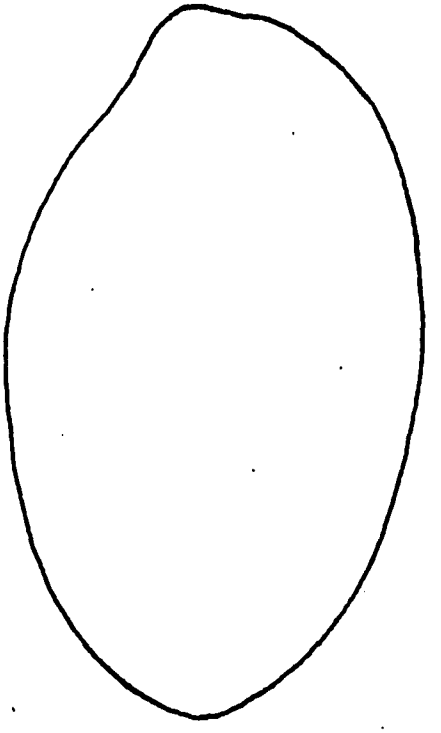
Average leaf image
BF = 15

Berlinia confusa

FIG. 116



1X

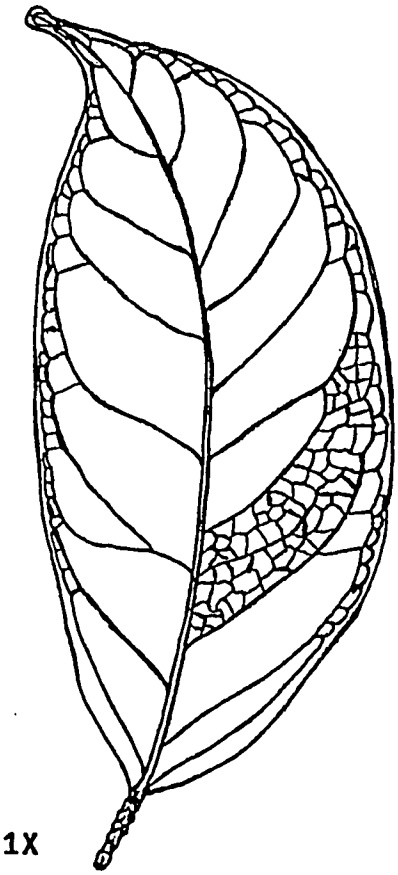


Average leaf image

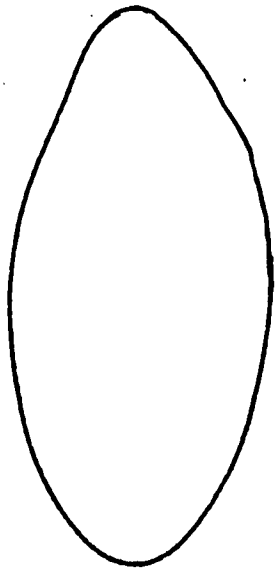
BF = 15

Berlinia grandiflora

FIG. 117



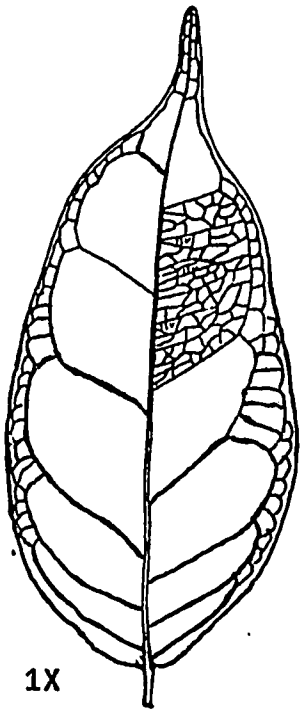
1X



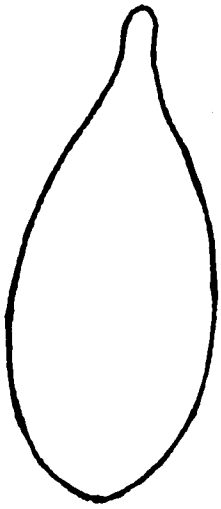
Average leaf image
BF = 15

Berlinia tomentella

FIG. 118



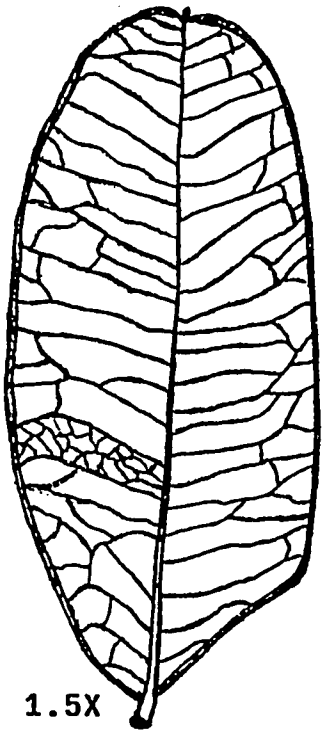
1X



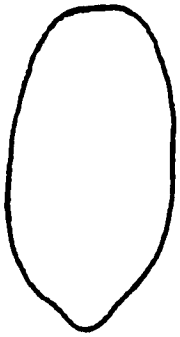
Average leaf image
BF = 15

Bussea occidentalis

FIG. 119



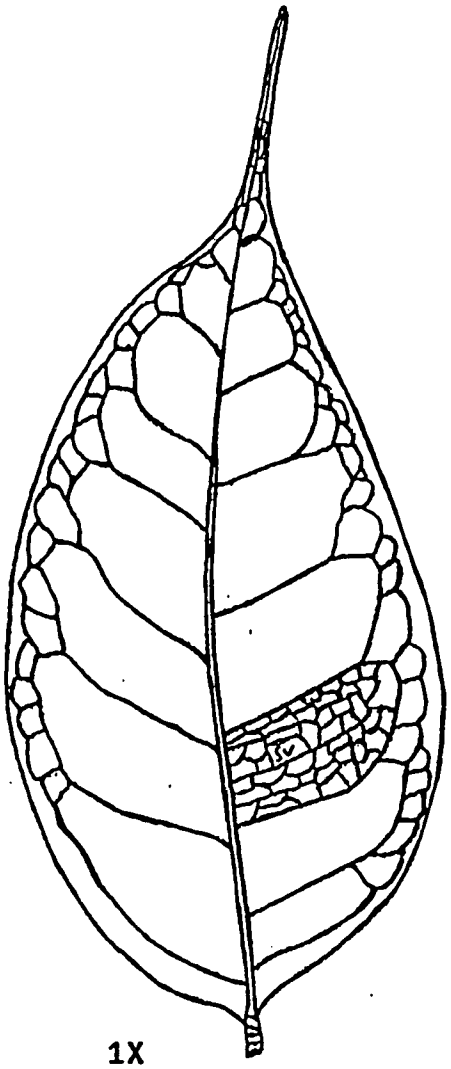
1.5X



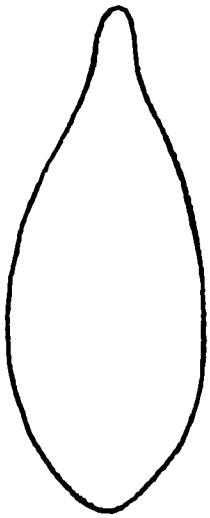
Average leaf image
BF = 20

Copaifera salikounda

FIG. 120



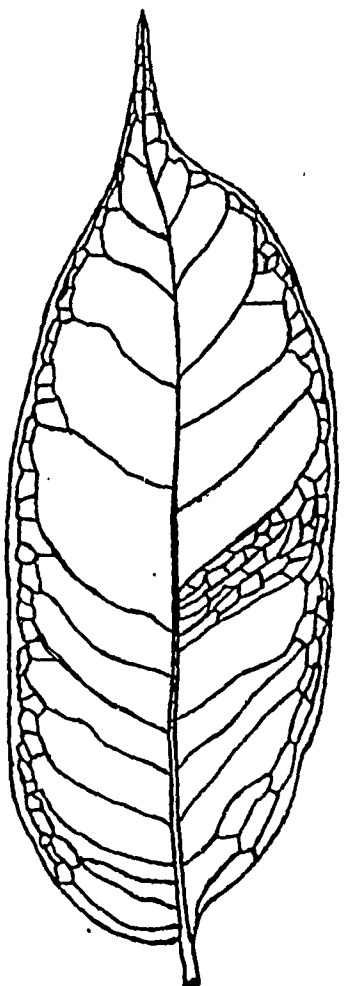
1X



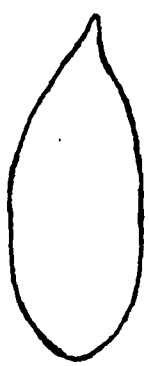
Average leaf image
BF = 15

Crudia gabonensis

FIG. 121



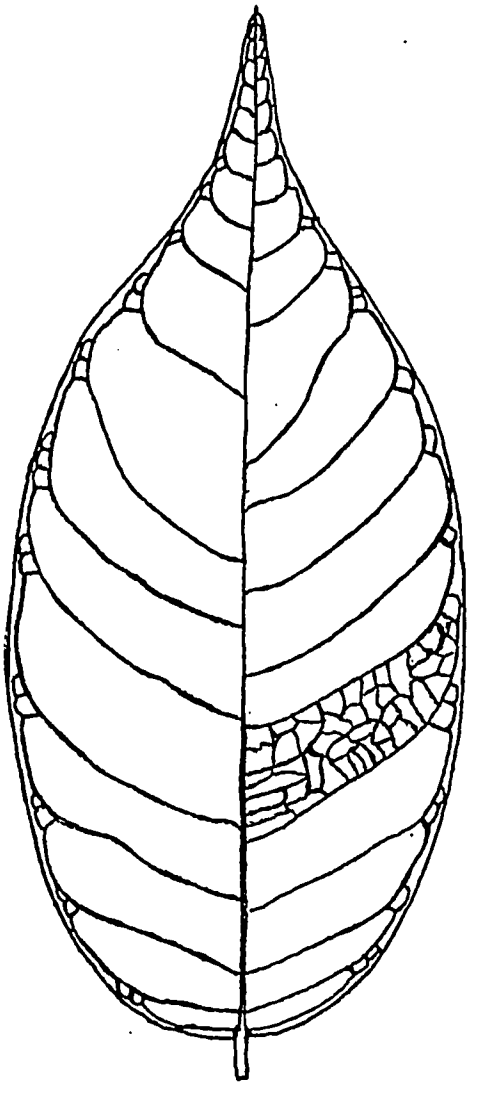
1X



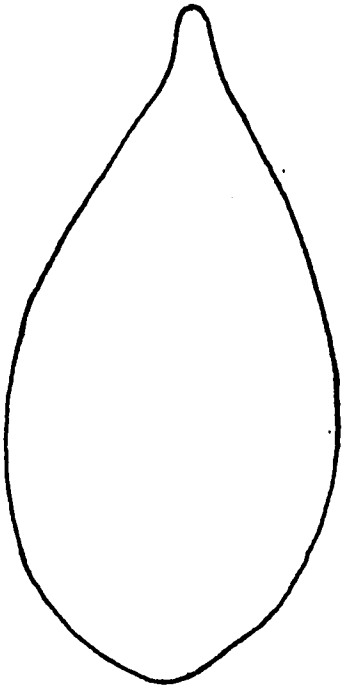
Average leaf image
BF = 10

Daniella ogea

FIG. 122



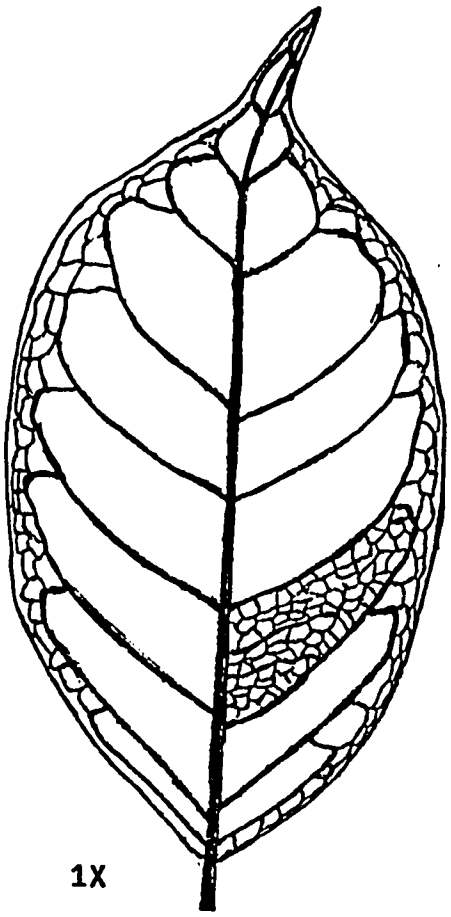
1X



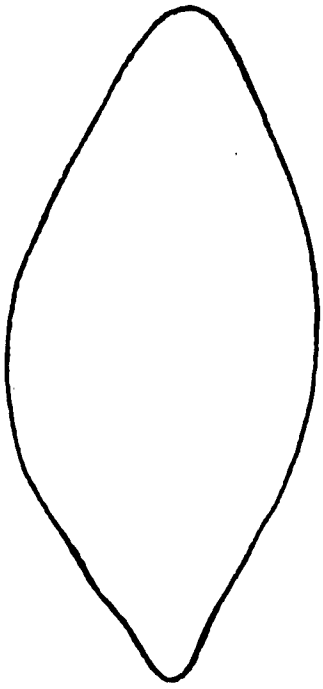
Average leaf image
BF = 15

Distemonanthus benthamianus

FIG. 123



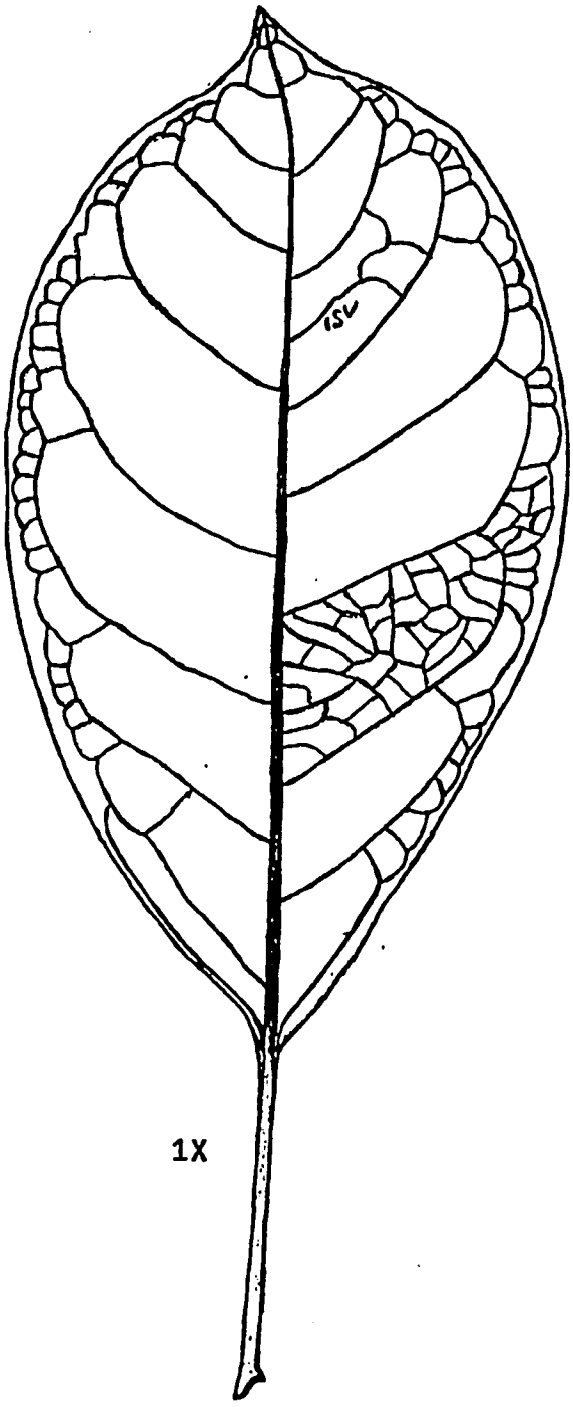
1X



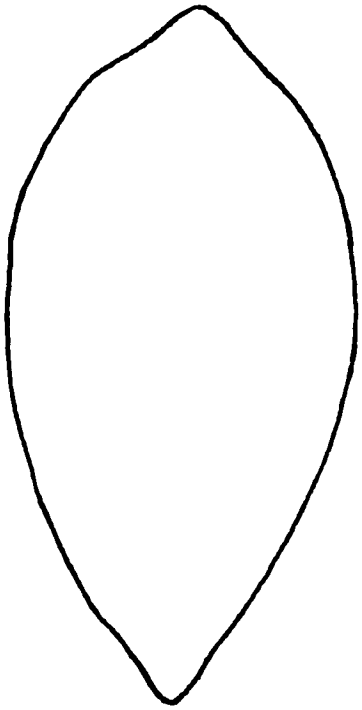
Average leaf image
BF = 15

Hymenostegia afzelii

FIG. 124



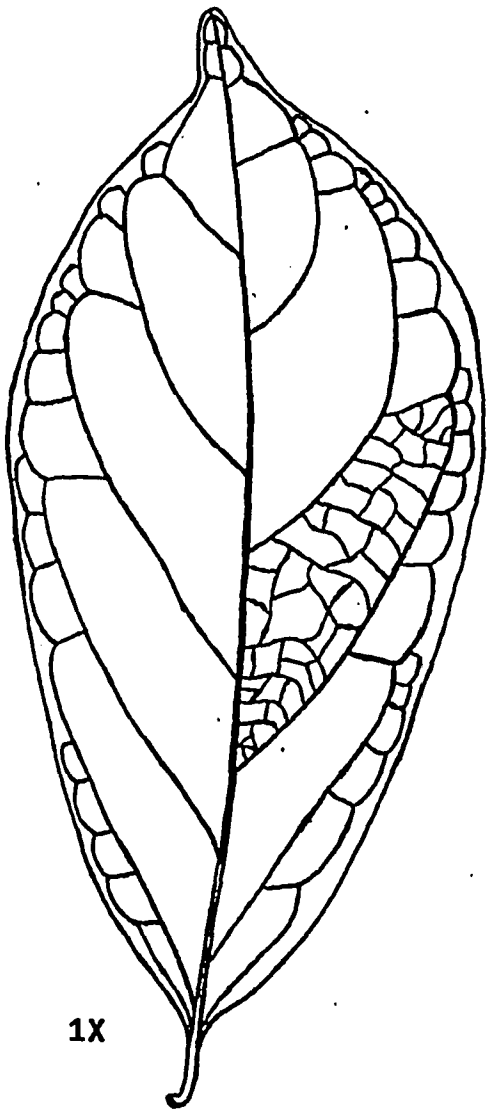
1X



Average leaf image
BF = 15

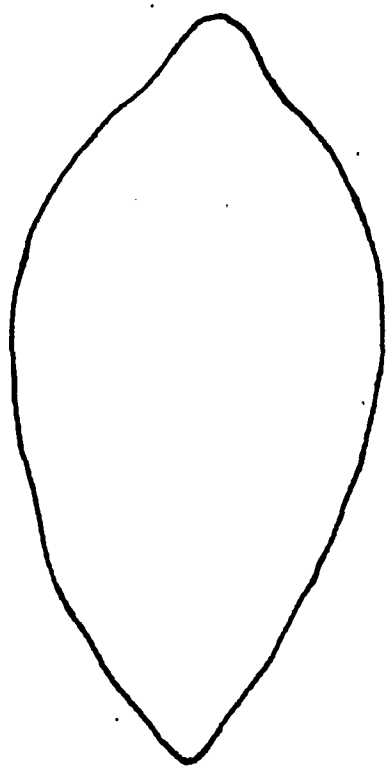
Terminalia superba

FIG. 125



1X

Diospyros monbuttensis



Average leaf image
BF = 15

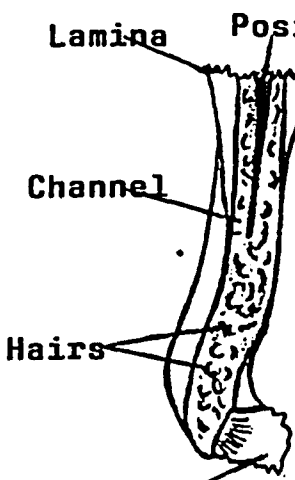
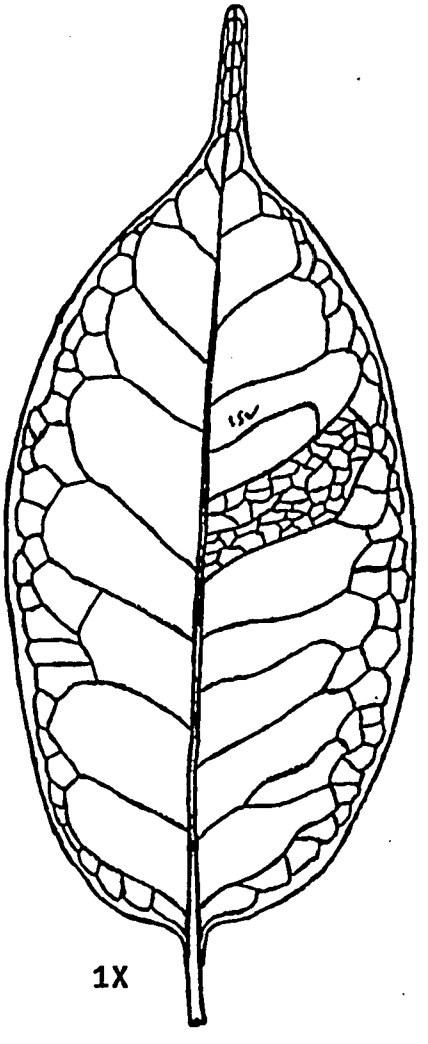
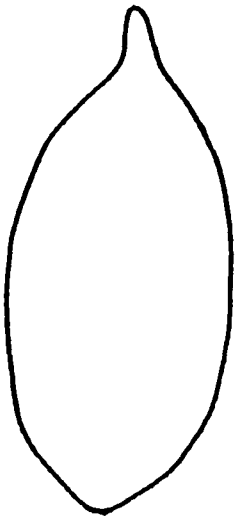


FIG. 126



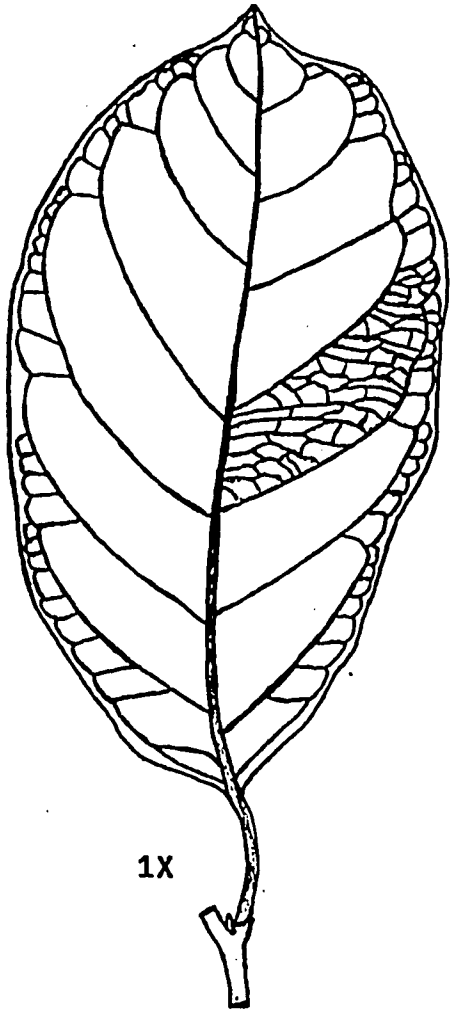
1X



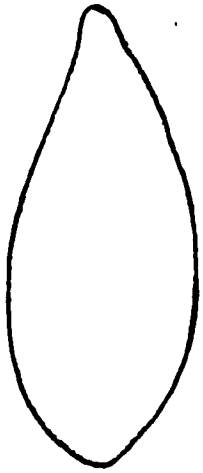
Average leaf image
BF = 15

Diospyros soubreana

FIG. 127



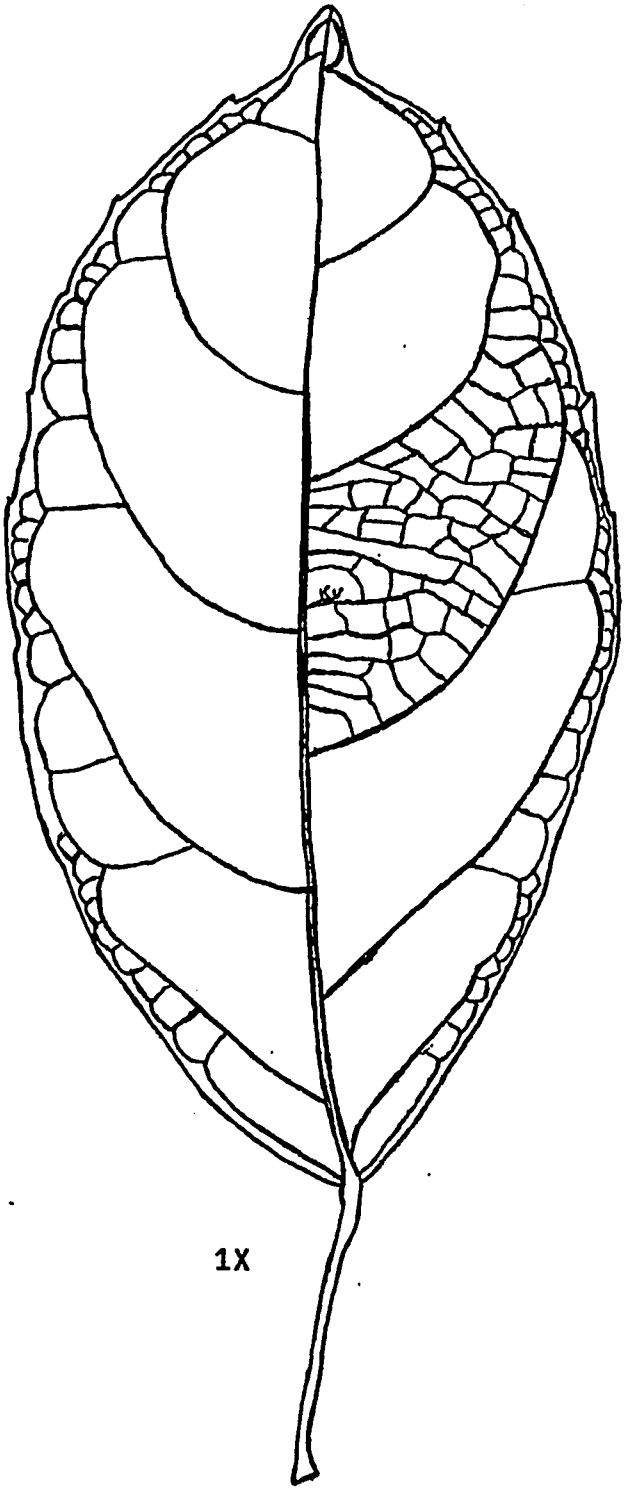
1X



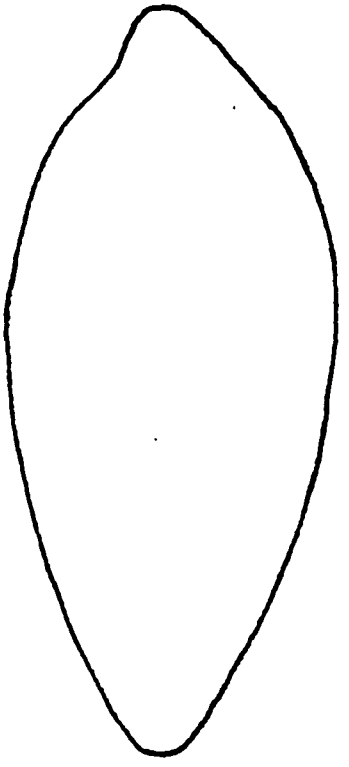
Average leaf image
BF = 15

Diospyros viridicans

FIG. 128



1X

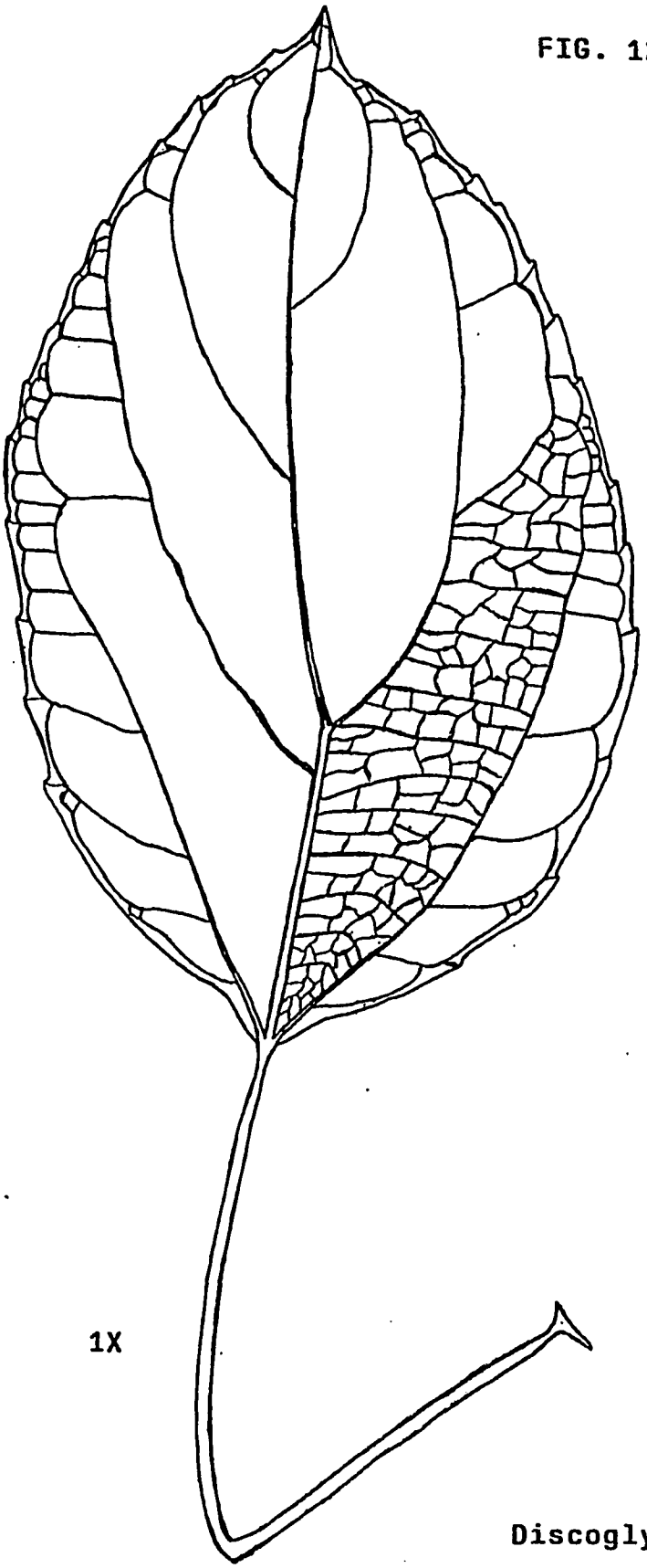


Average leaf image

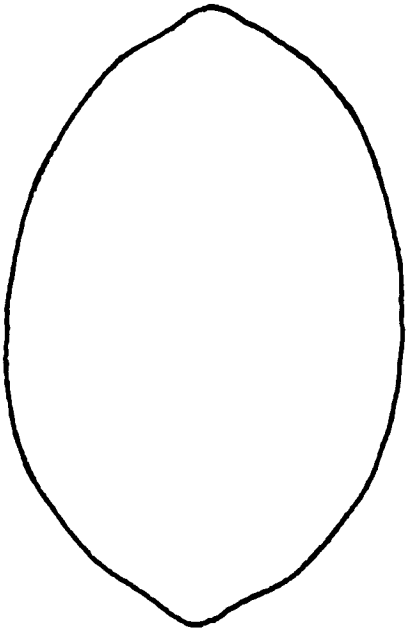
BF = 15

Cleidion gabonicum

FIG. 129



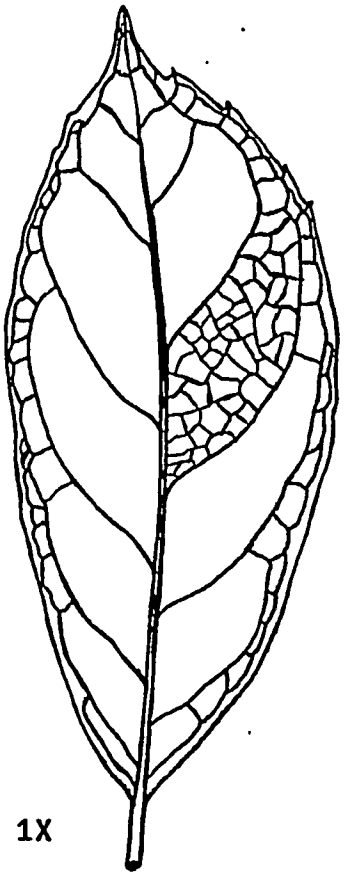
1X



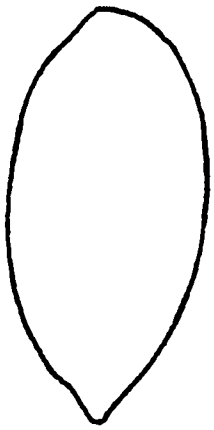
Average leaf image
BF = 10

Discoglypremna caloneura

FIG. 130



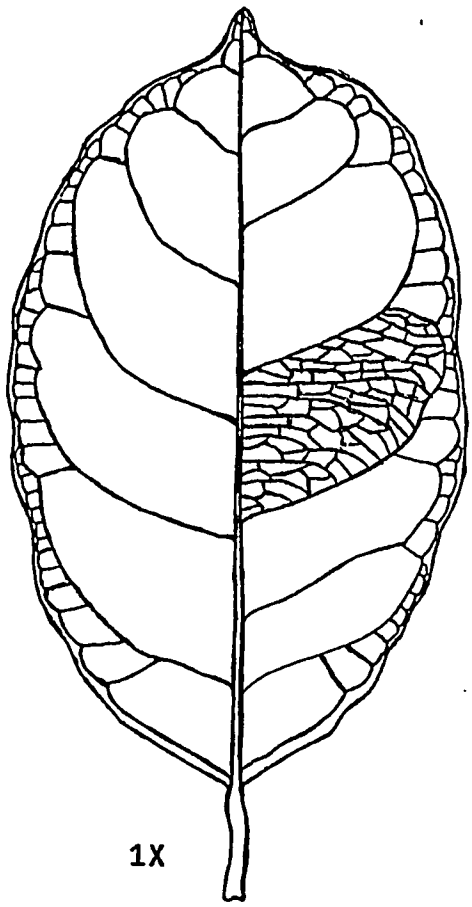
1X



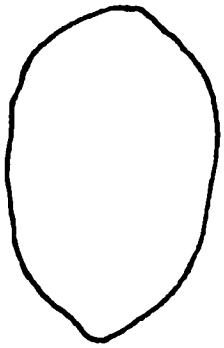
Average leaf image
BF = 10

Drypetes aframensis

FIG. 131



1X

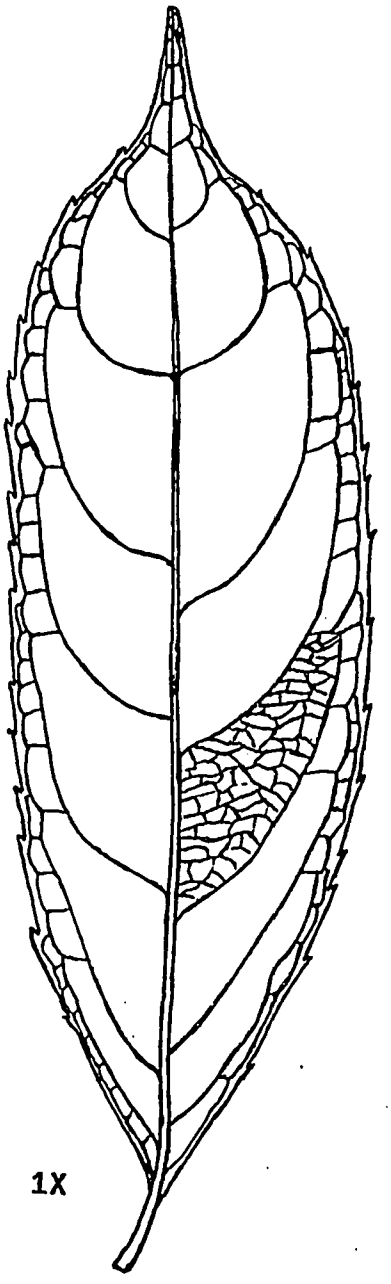


Average leaf image

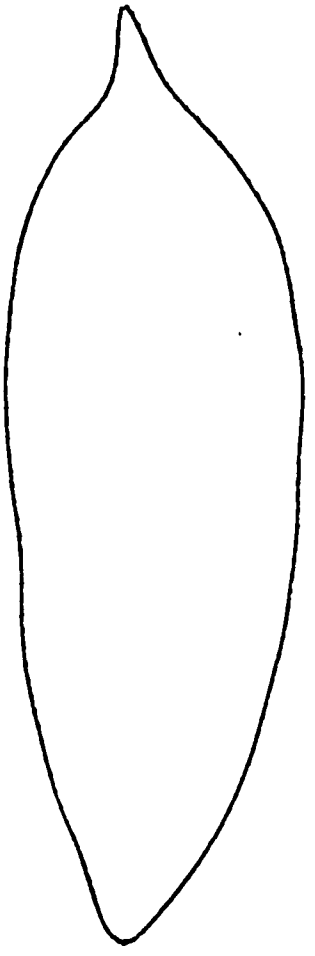
BF = 10

Drypetes gilgiana

FIG. 132



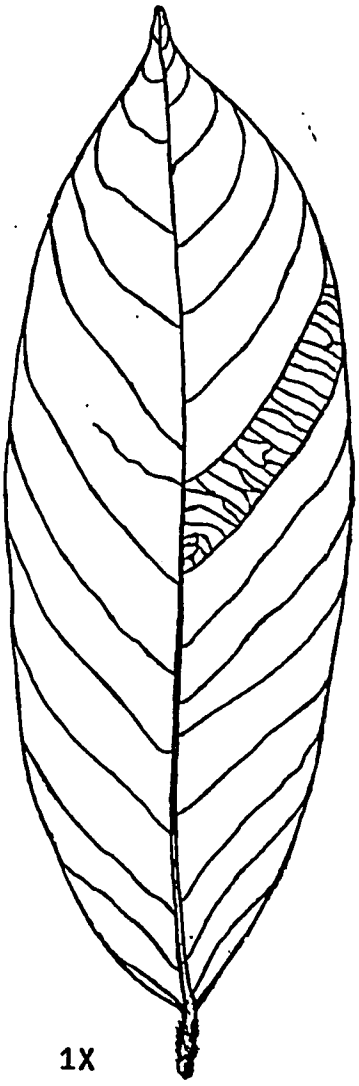
1X



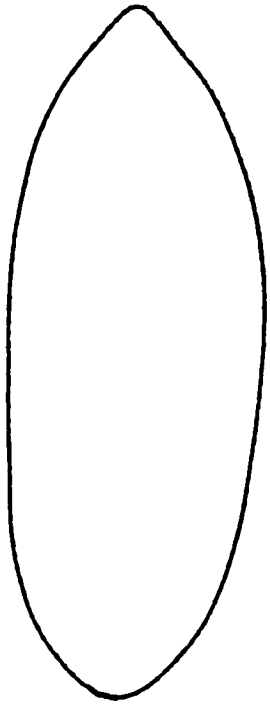
Average leaf image
BF = 15

Drypetes principum

FIG. 133



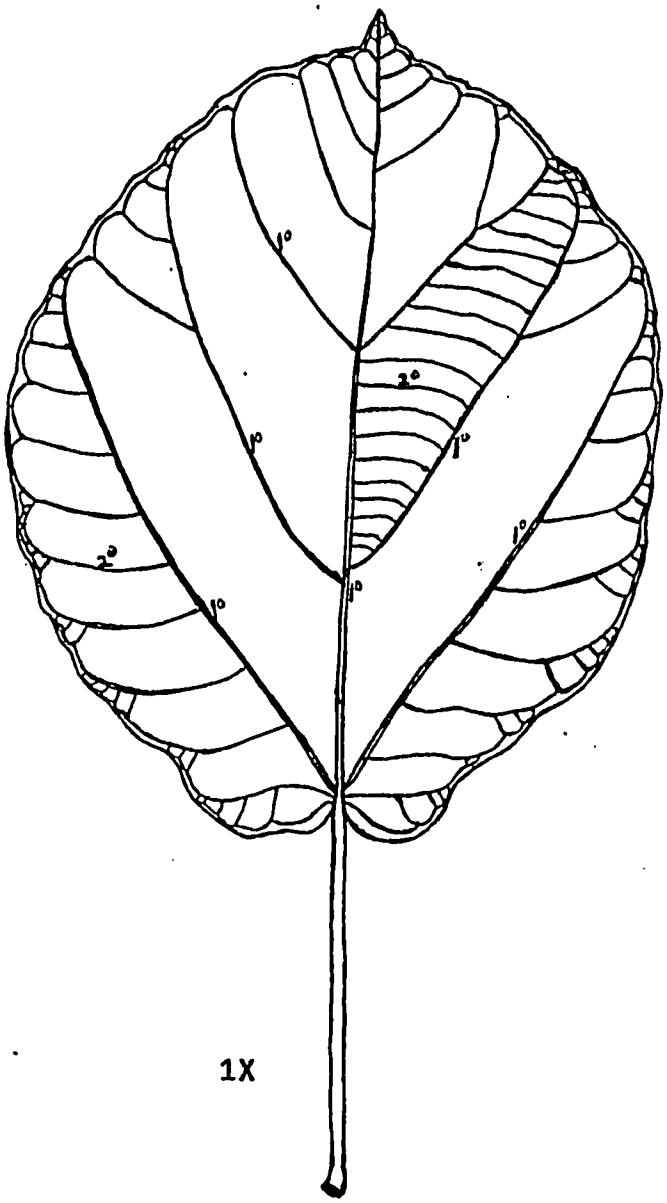
1X



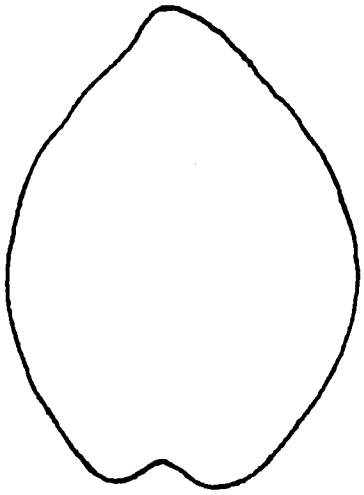
Average leaf image
BF = 10

Macaranga heudelotii

FIG. 134



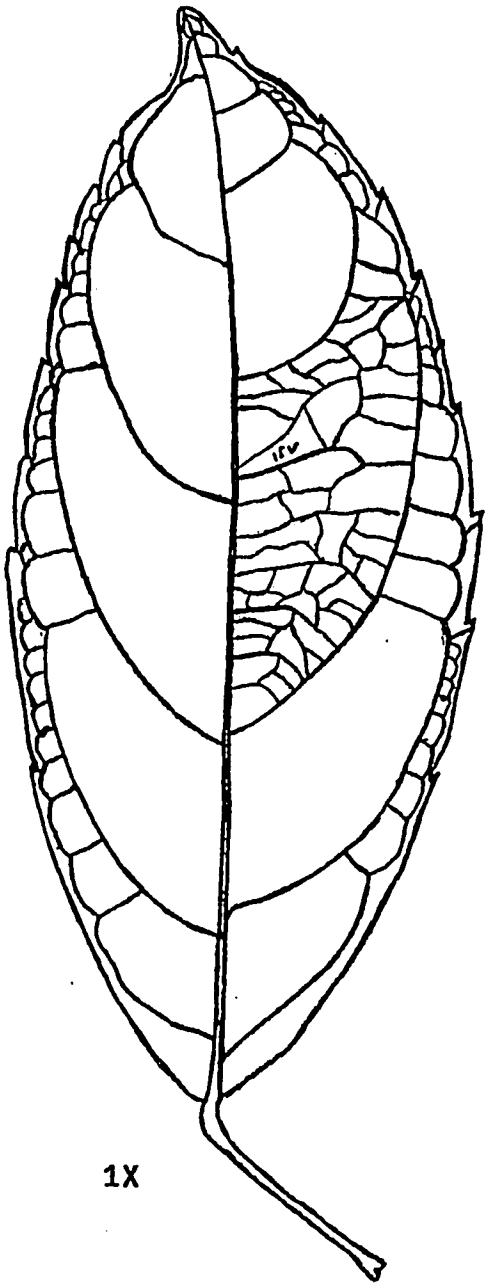
1X



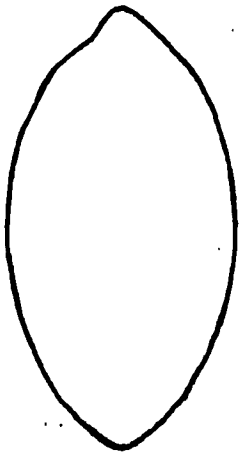
Average leaf image
BF = 10

Maniophyton fulvum

FIG. 135



1X

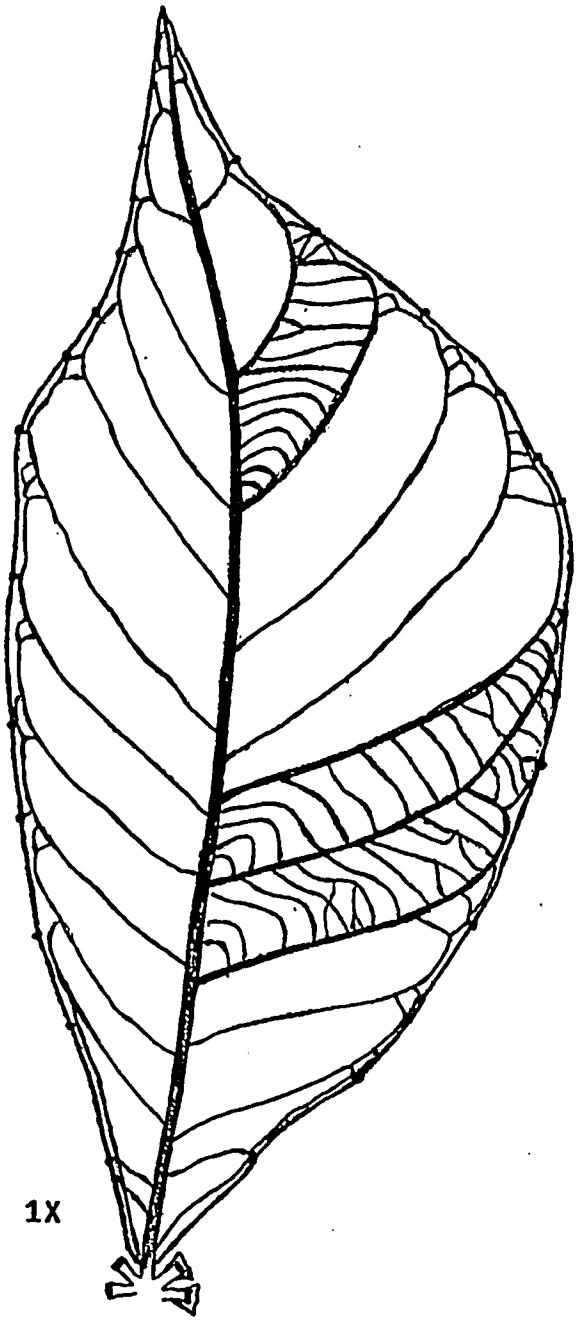


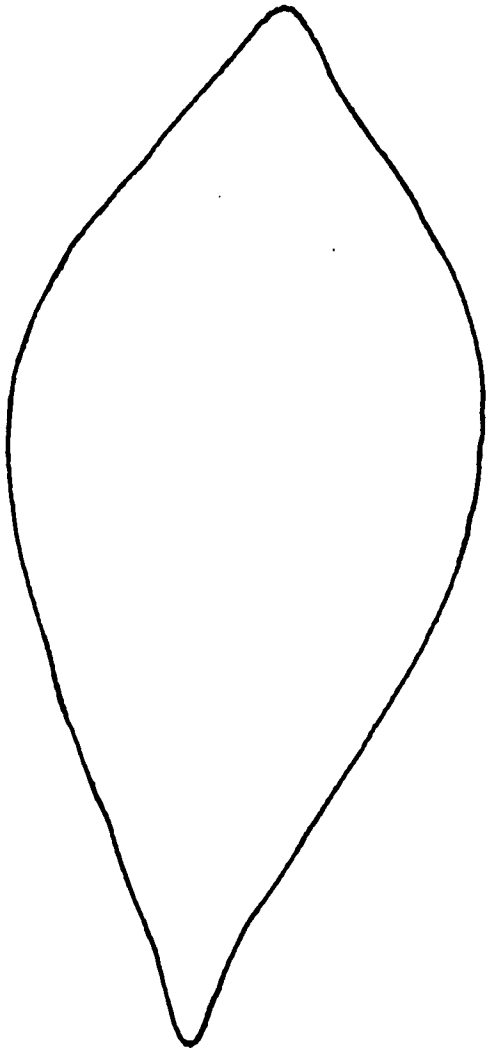
Average leaf image

BF = 10

Mareya micrantha

FIG. 136

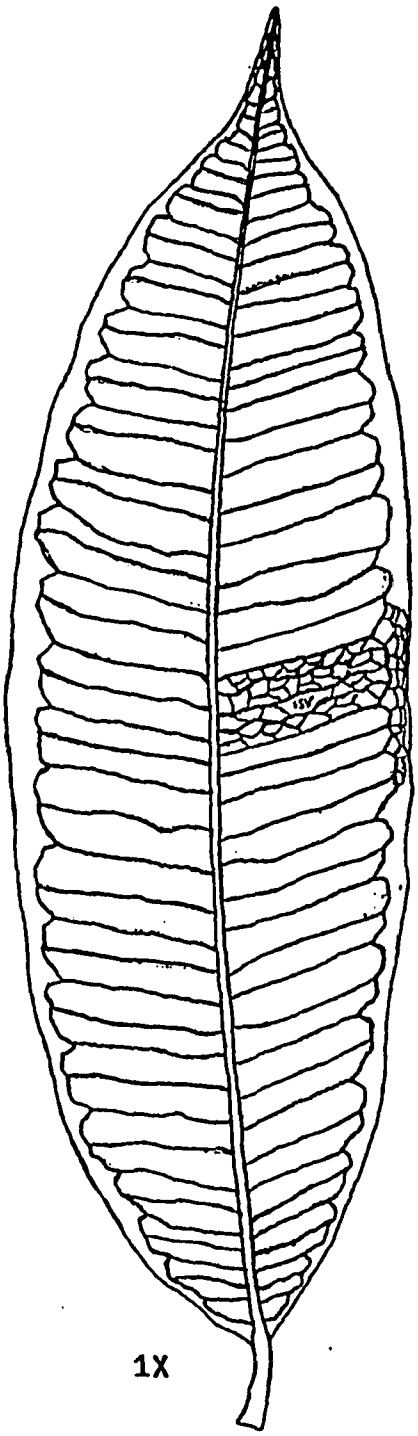




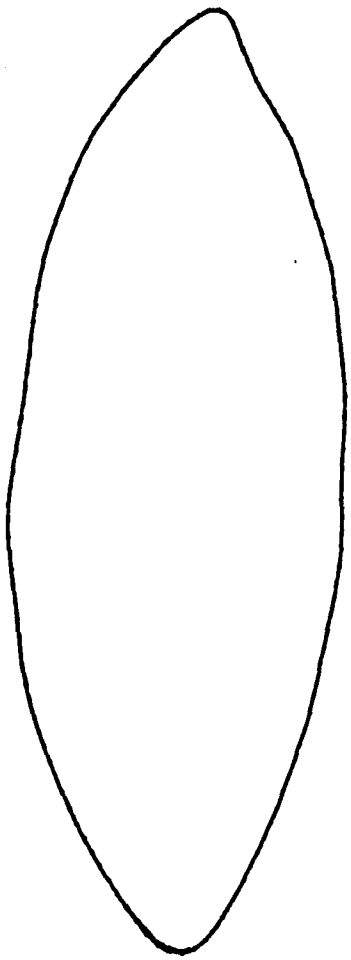
Average leaf image
BF = 15

Ricinodendron heudelotii

FIG. 137



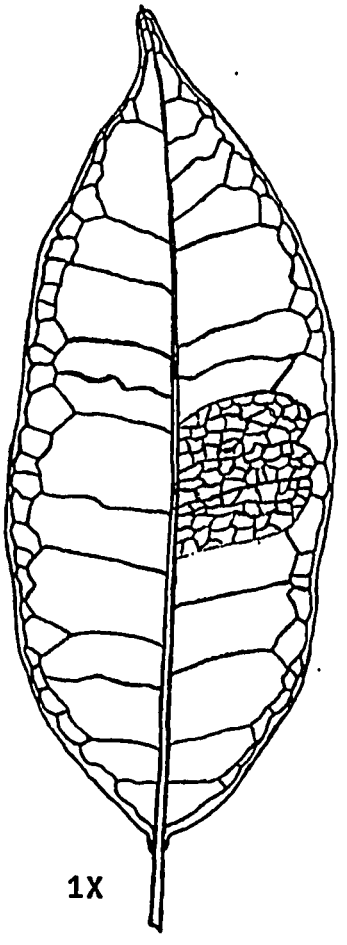
1X



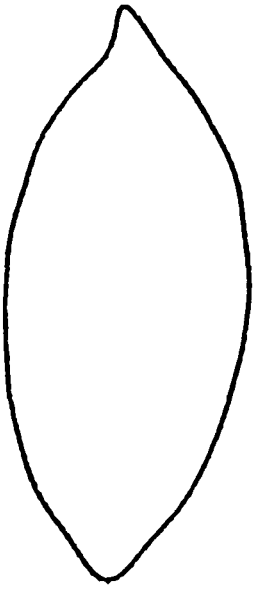
Average leaf image
BF = 10

Mammea africana

FIG. 138



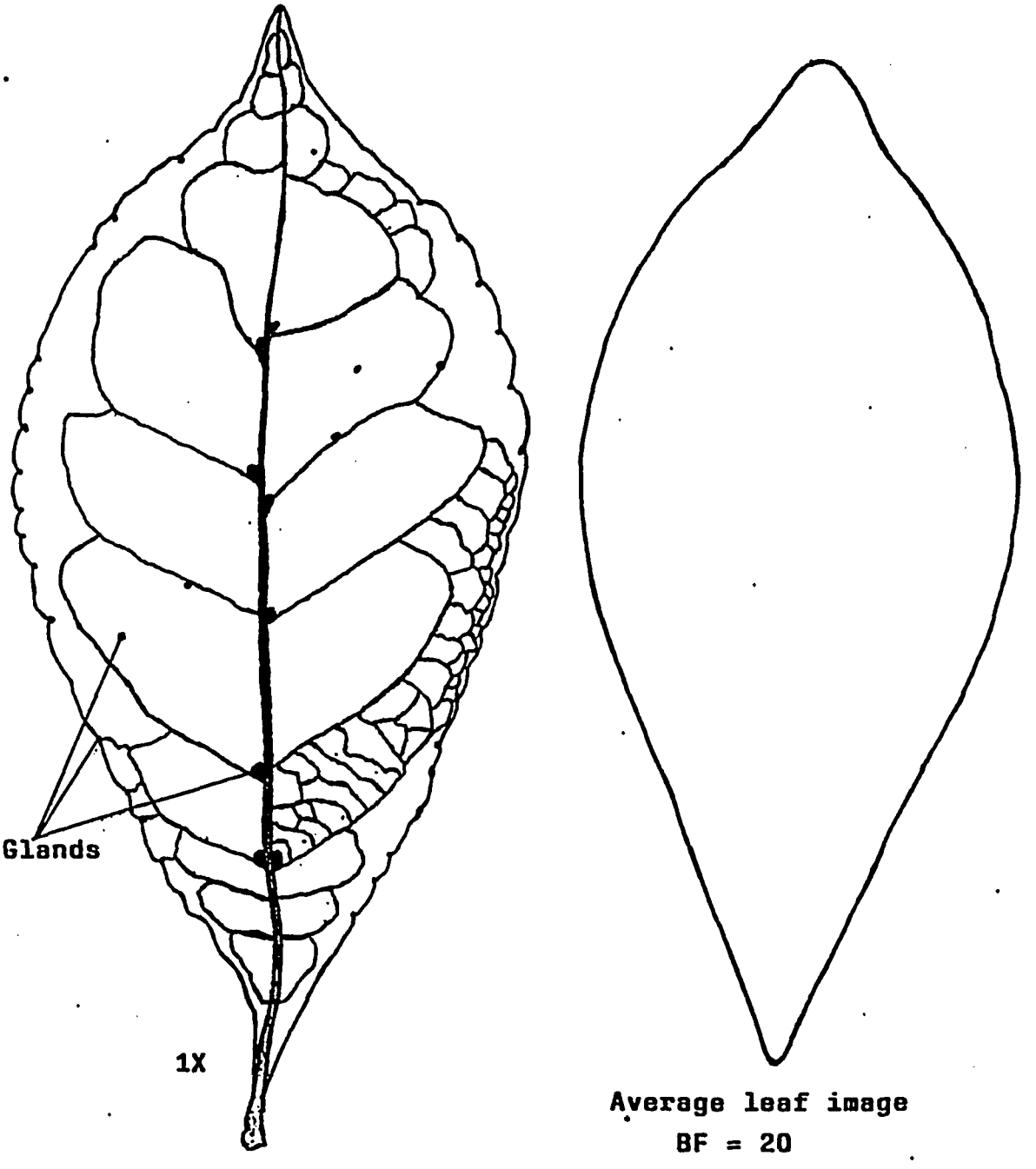
1X



Average leaf image
BF = 15

Leptaulus daphnoides

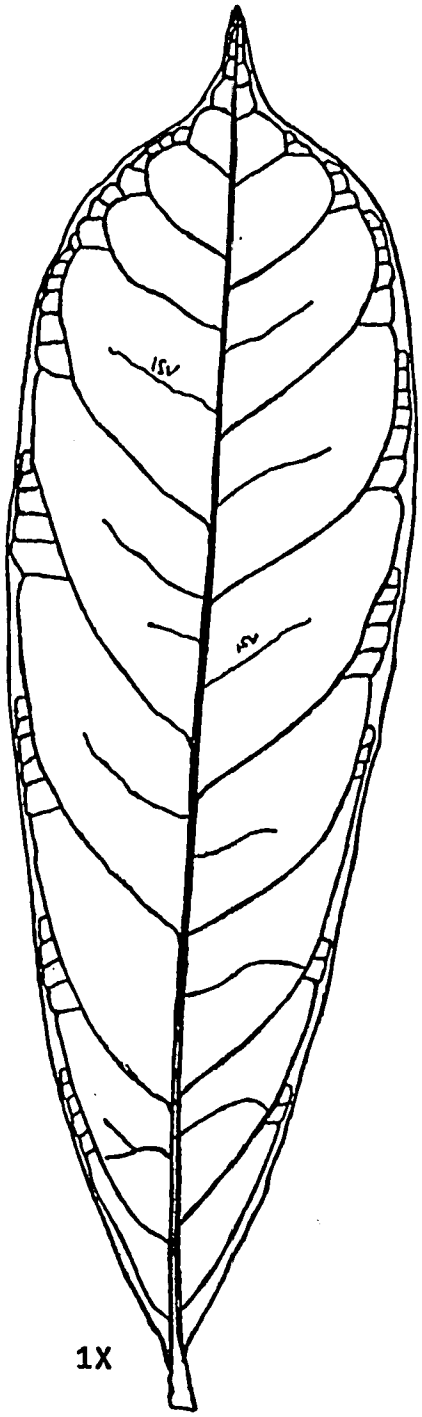
FIG. 139



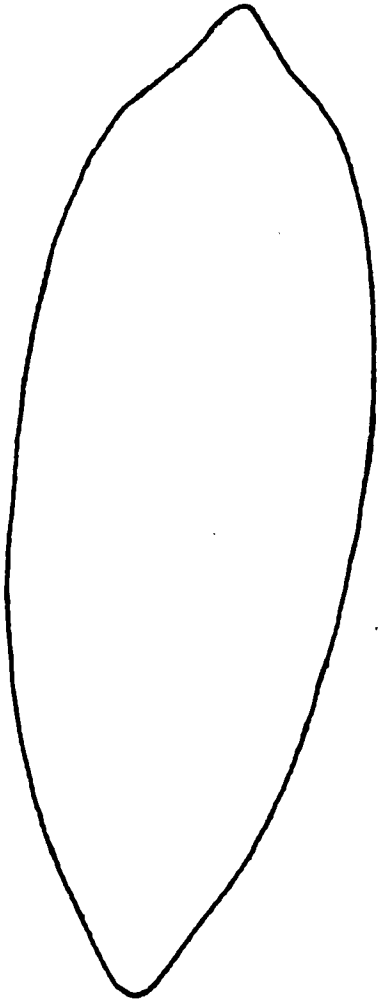
Average leaf image
BF = 20

Petersianthus macrocarpa

FIG. 140



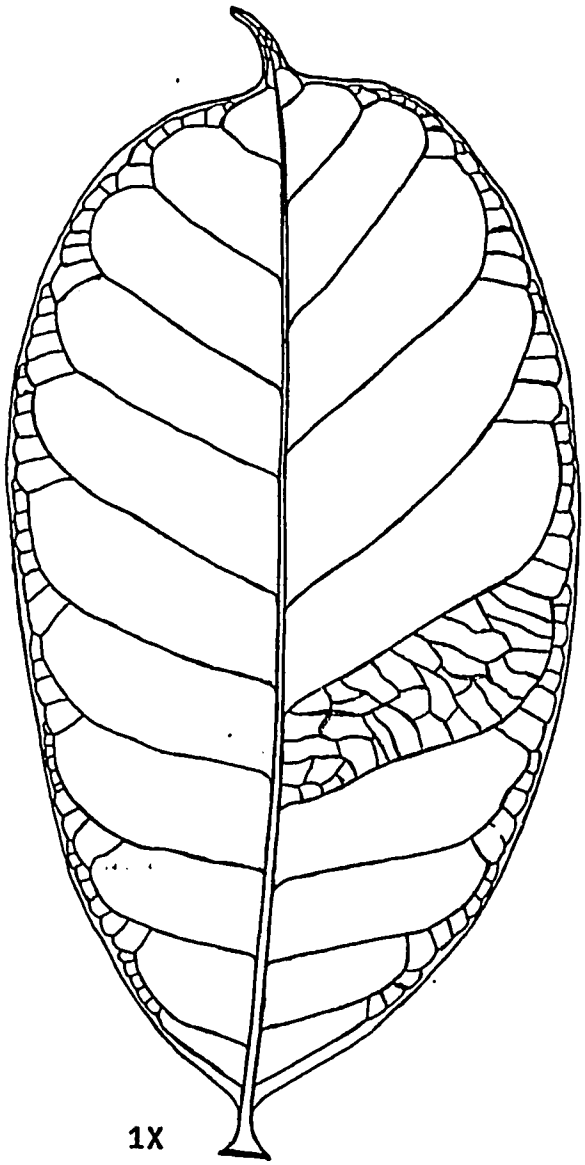
1X



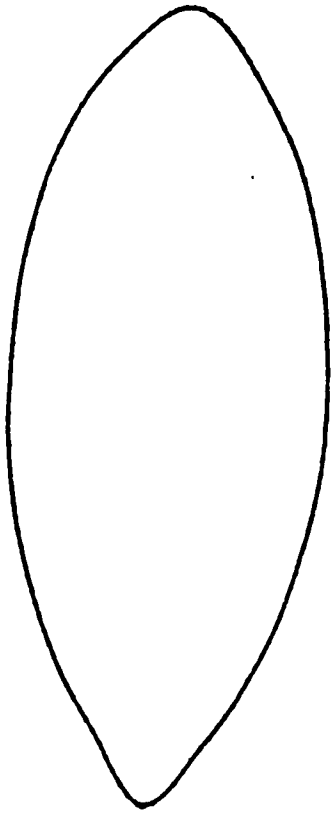
Average leaf image
BF = 15

Carapa procera

FIG. 141



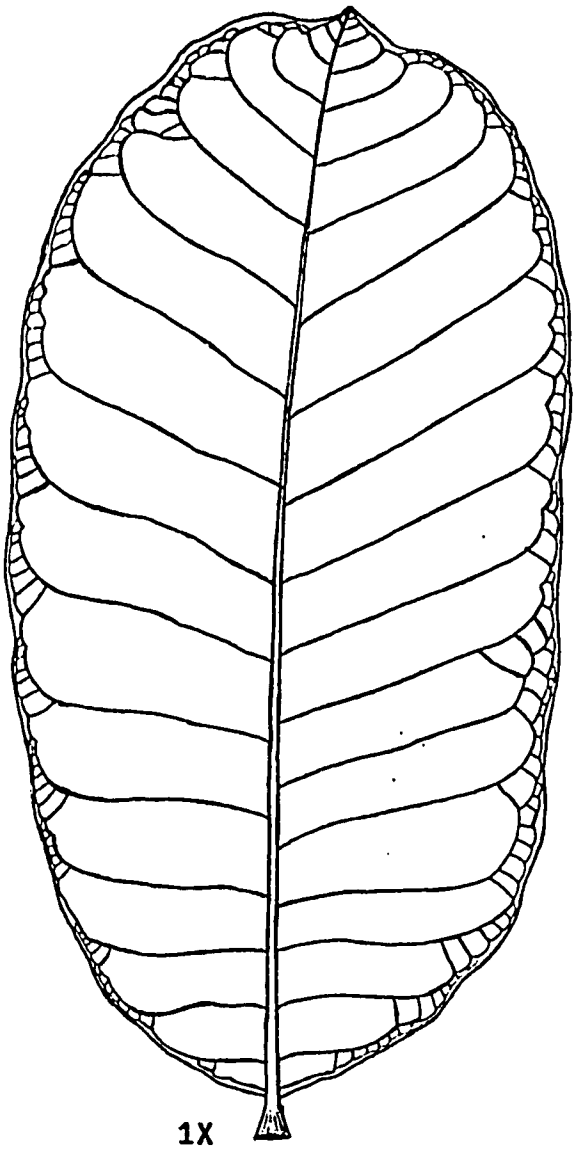
1X



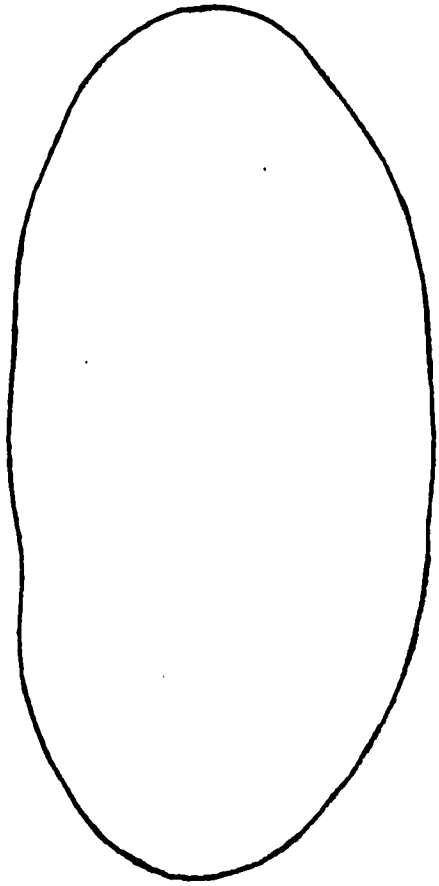
Average leaf image
BF = 10

Entandrophragma angolense

FIG. 142



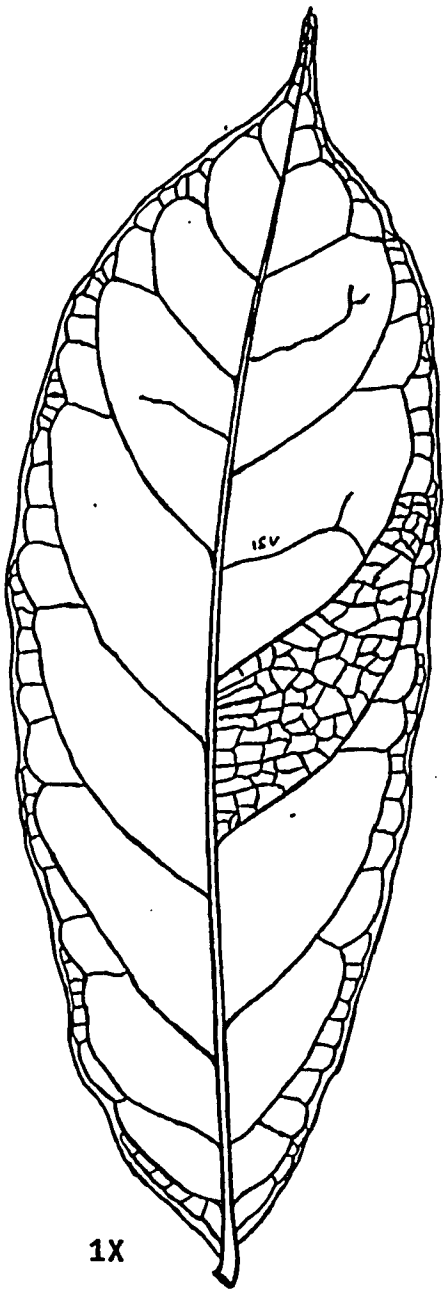
1X



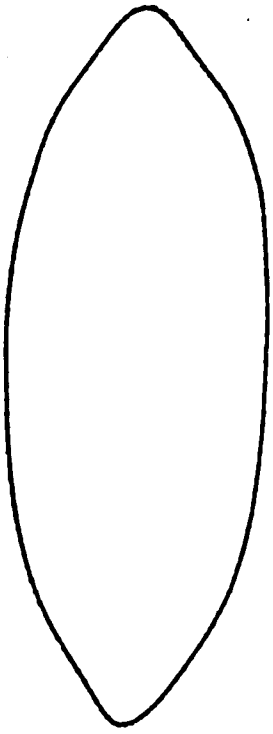
Average leaf image
BF = 10

Entandrophragma candollei

FIG. 143



1X



Average leaf image
BF = 15

Entandrophragma cylindricum

FIG. 144

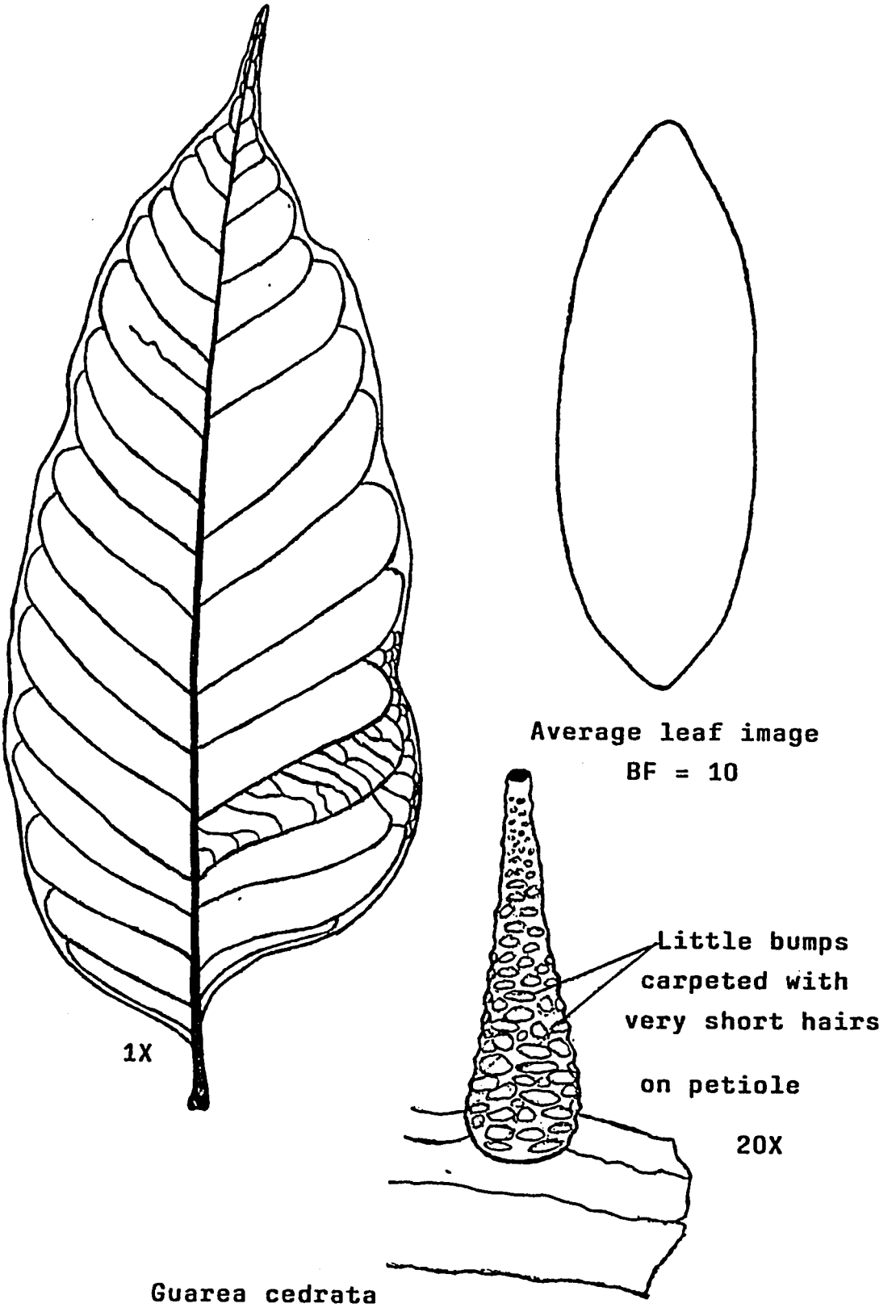
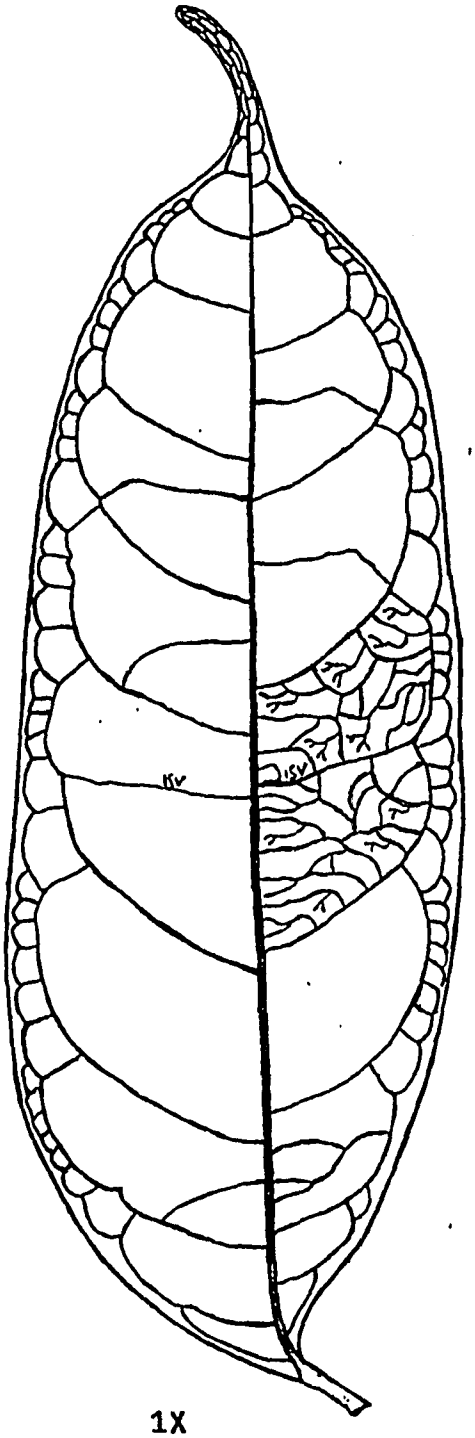
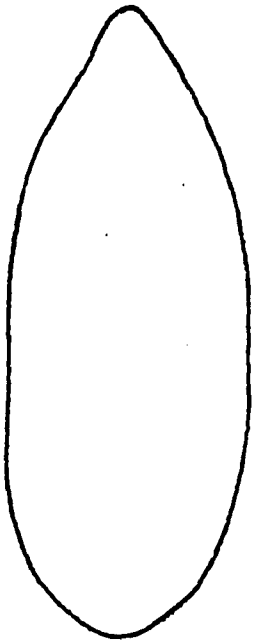

Average leaf image
BF = 10
1X
Little bumps
carpeted with
very short hairs
on petiole
20X
Guarea cedrata

FIG. 145



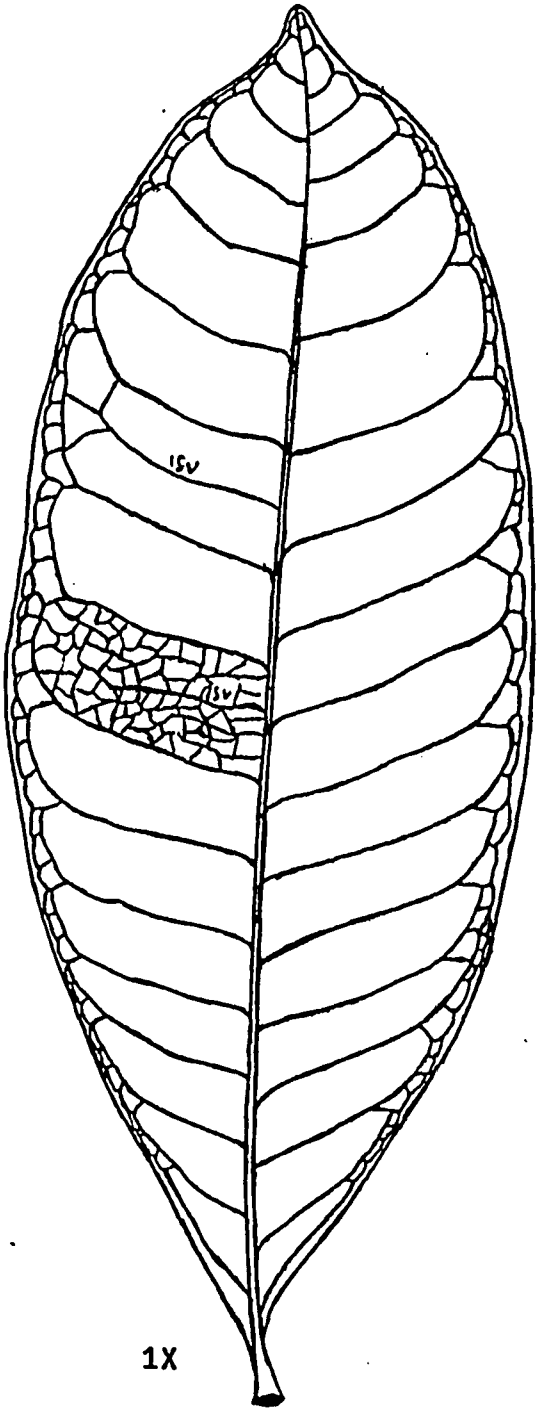
1X



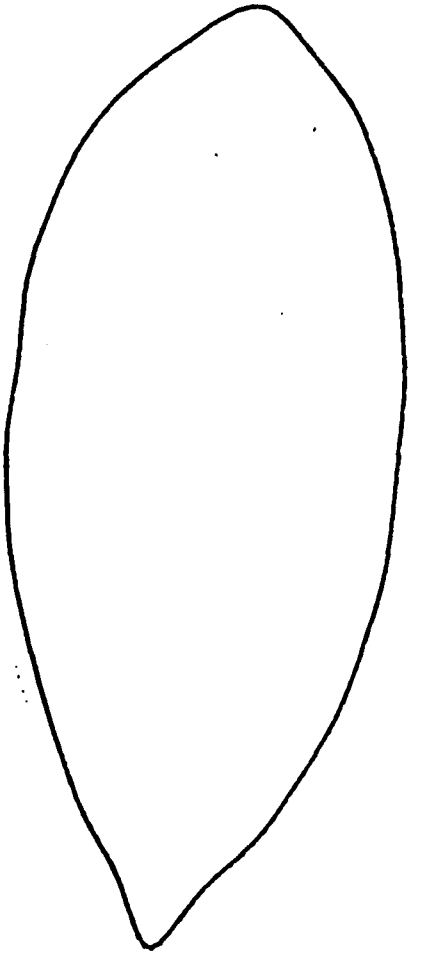
Average leaf image
BF = 15

Khaya ivorensis

FIG. 146



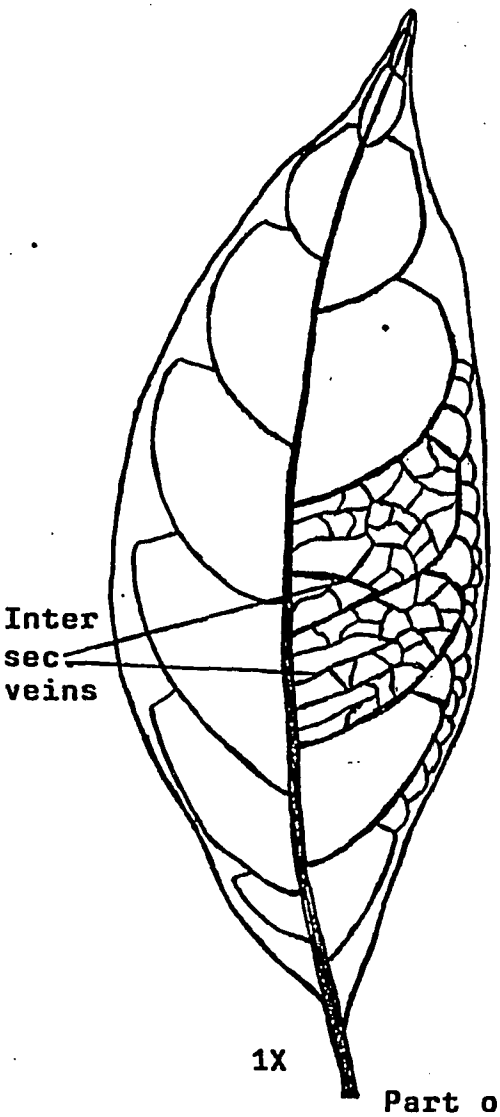
1X



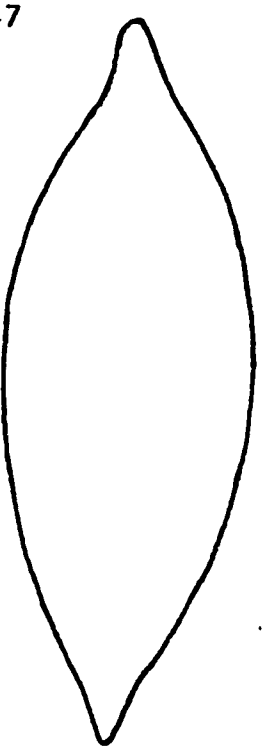
Average leaf image
BF = 15

Lovoa trichiloides

FIG. 147

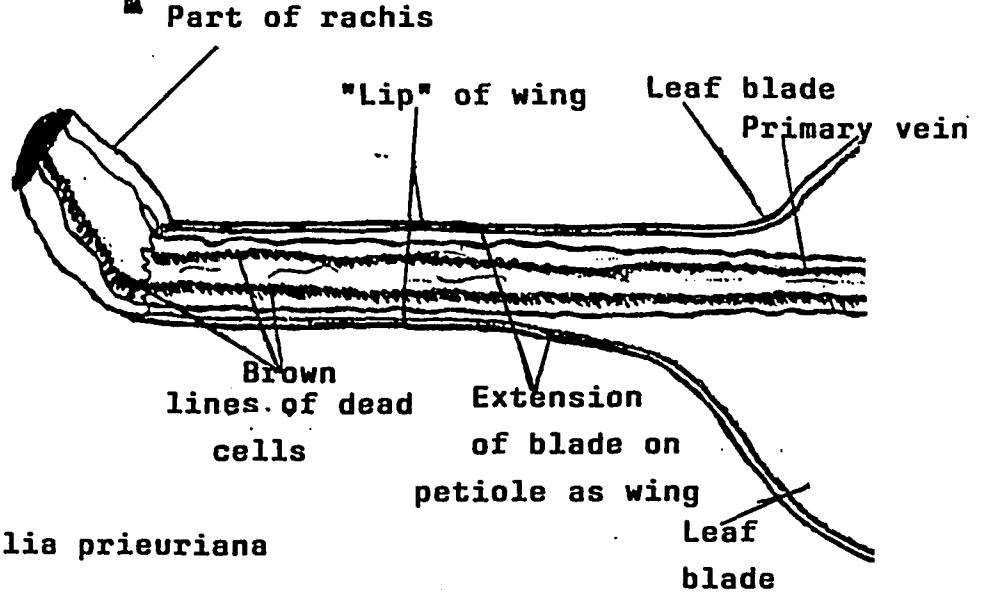


1X



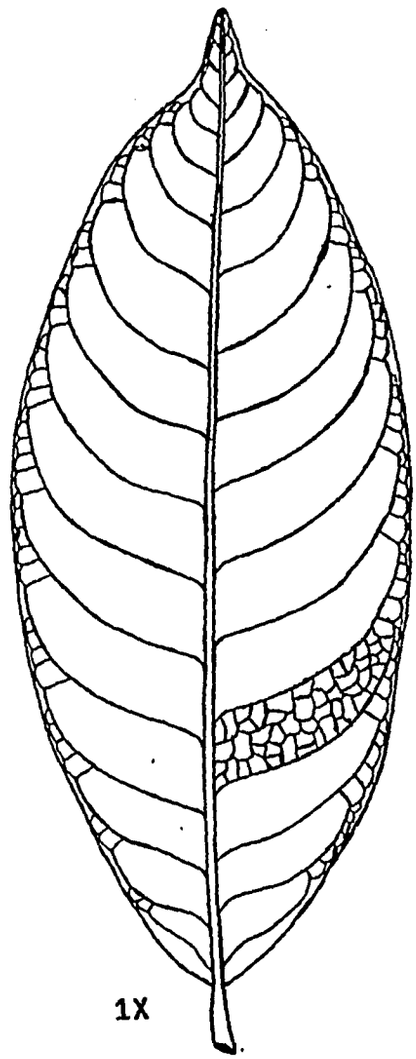
Average leaf image

BF = 15

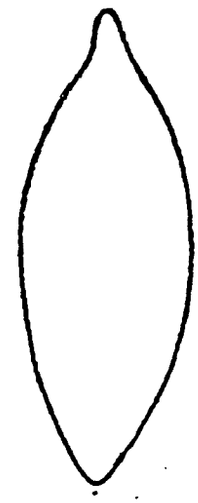


Trichilia prieuriana

FIG. 148



1X

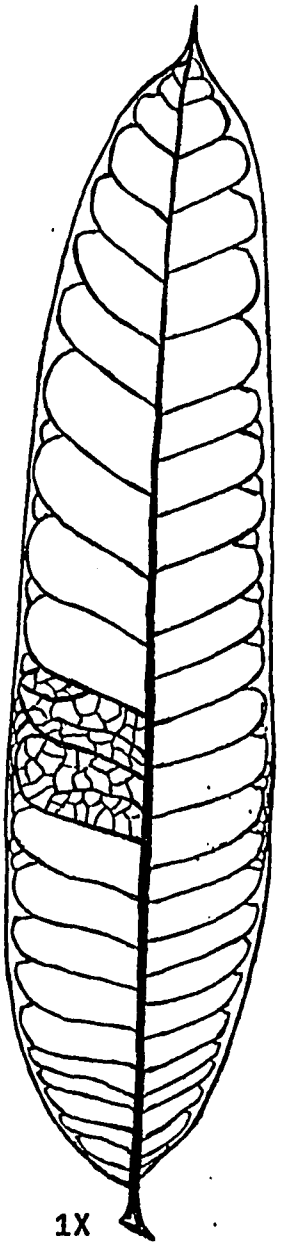


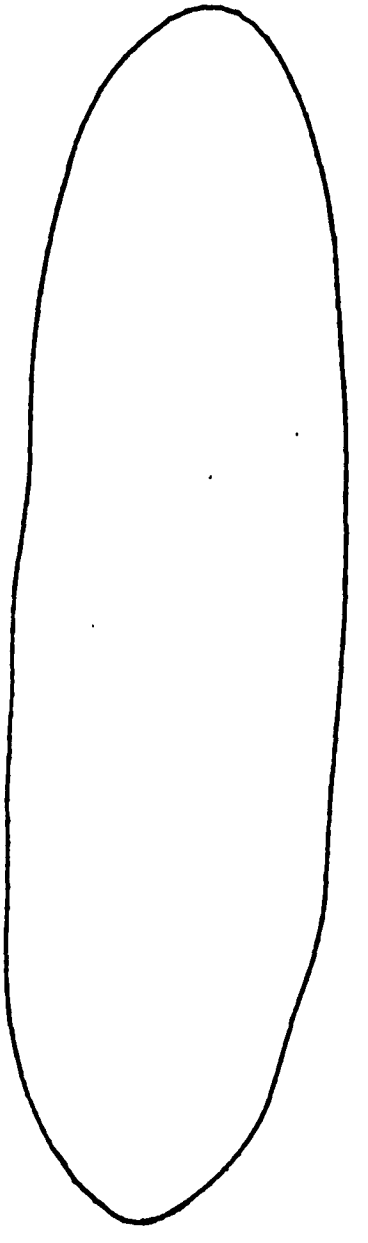
Average leaf image

BF = 10

Trichilia tessmannii

FIG. 149

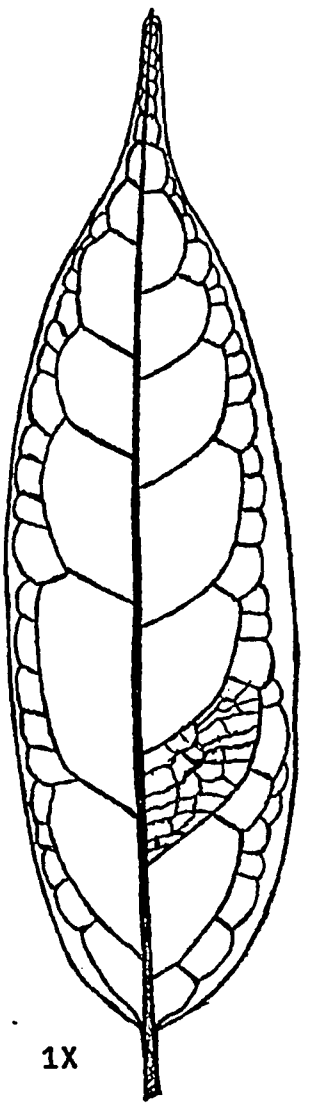




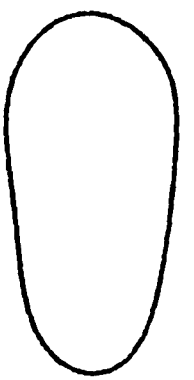
Average leaf image
BF = 15

Turraenthus africanus

FIG. 150



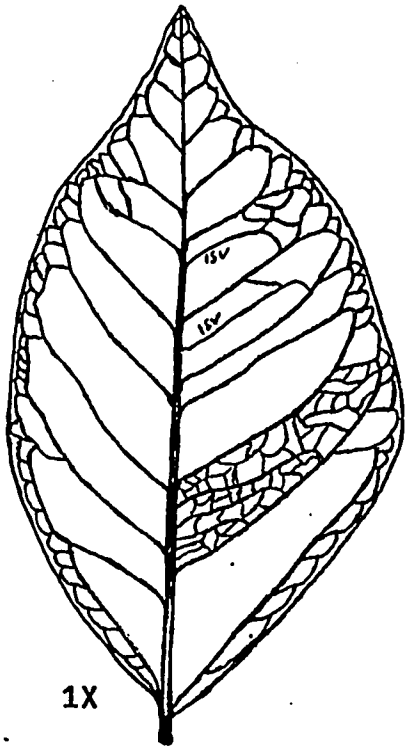
1X

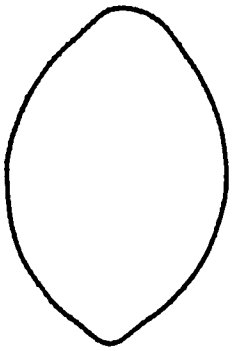


Average leaf image
BF = 15

Albizia adianthifolia

FIG. 151

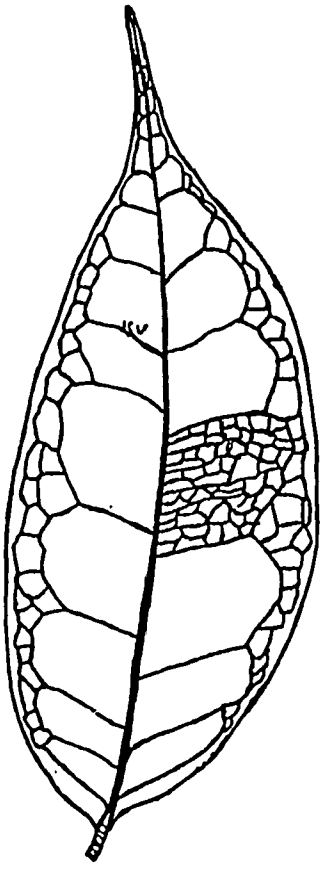




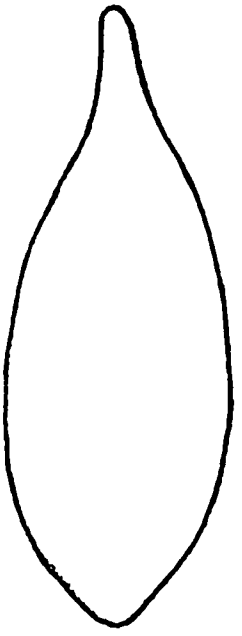
Average leaf image
BF = 15

Albizia zygia

FIG. 152



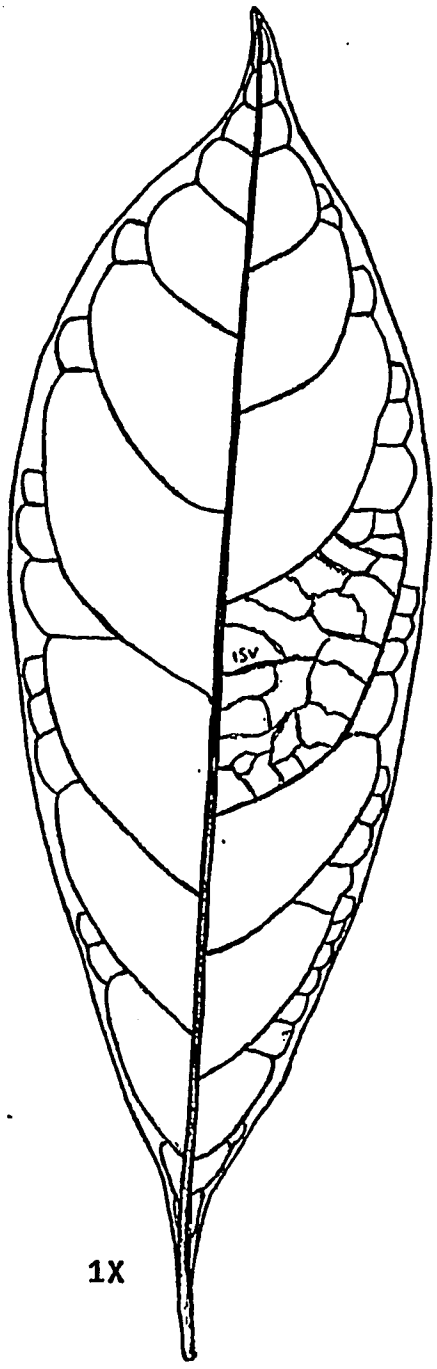
1X



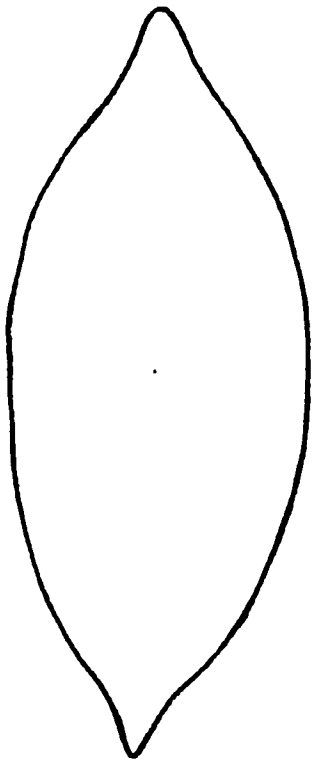
Average leaf image
BF = 15

Calpocalyx brevibracteatus

FIG. 153



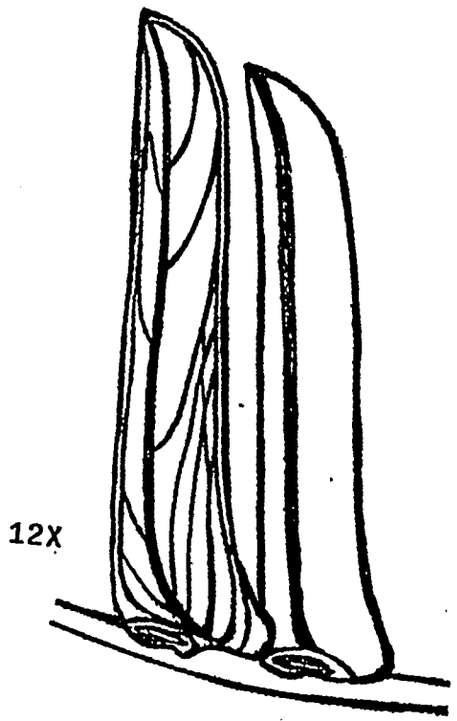
1X



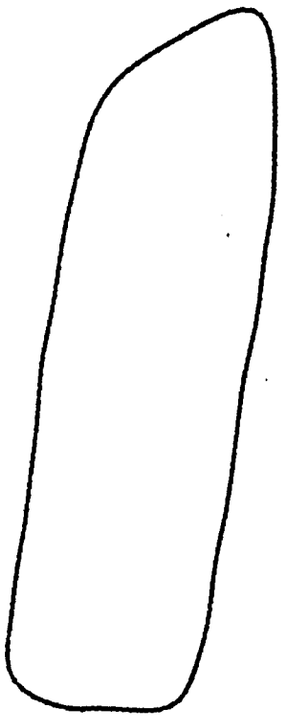
Average leaf image
BF = 15

Cylicodiscus gabonensis

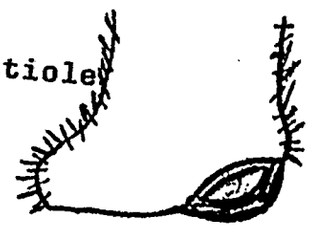
FIG. 154



12X



Average leaf image
BF = .38

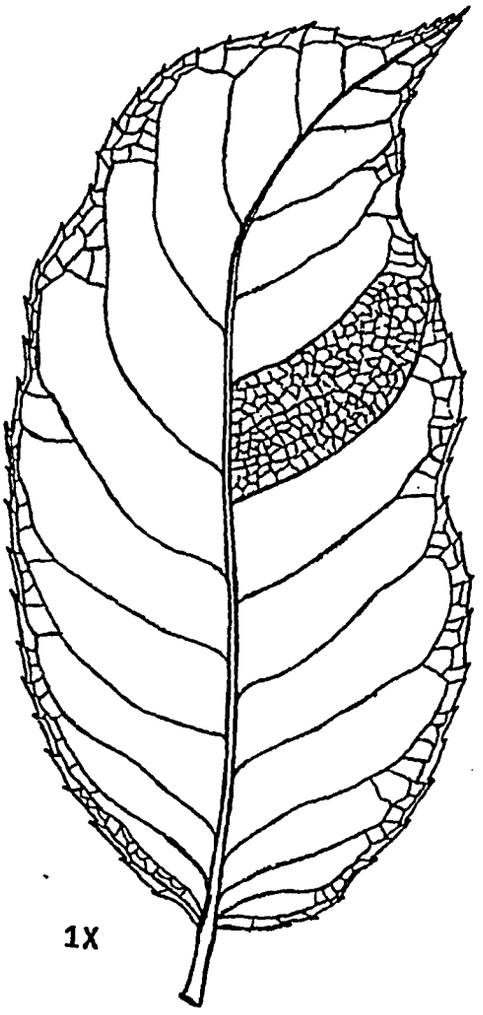


Short petiole

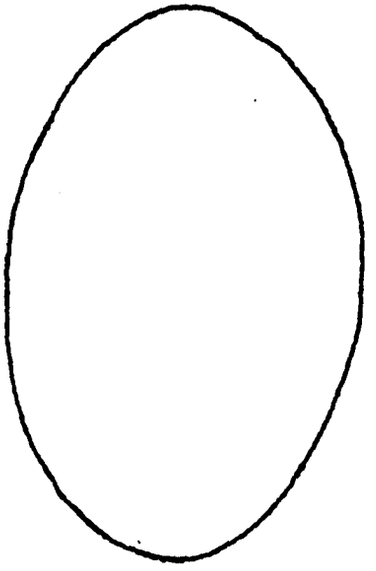
20X

Piptadeniastrum africanum

FIG. 155



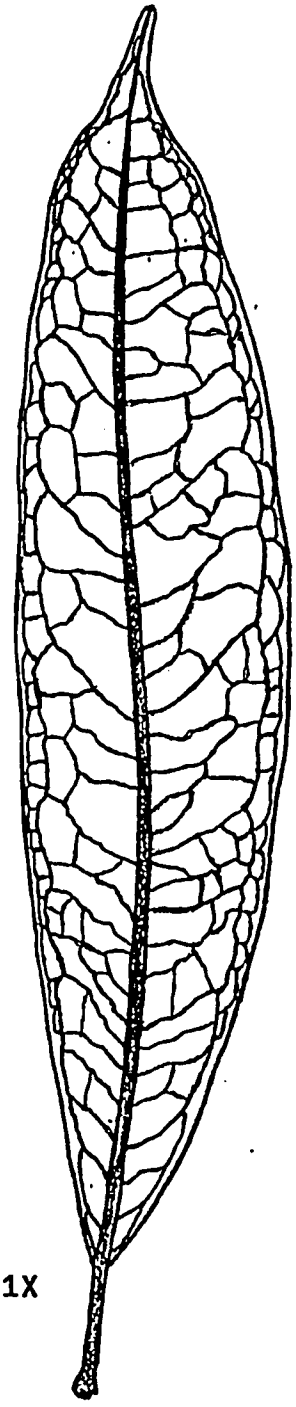
1X



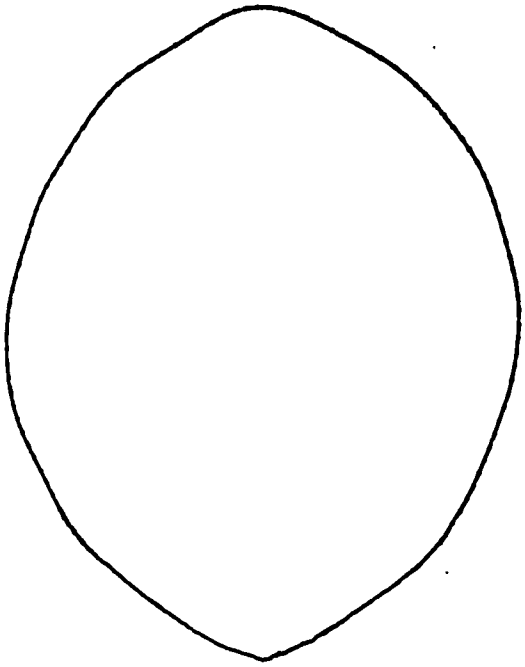
Average leaf image
BF = 15

Antiaris toxicarium

FIG. 156



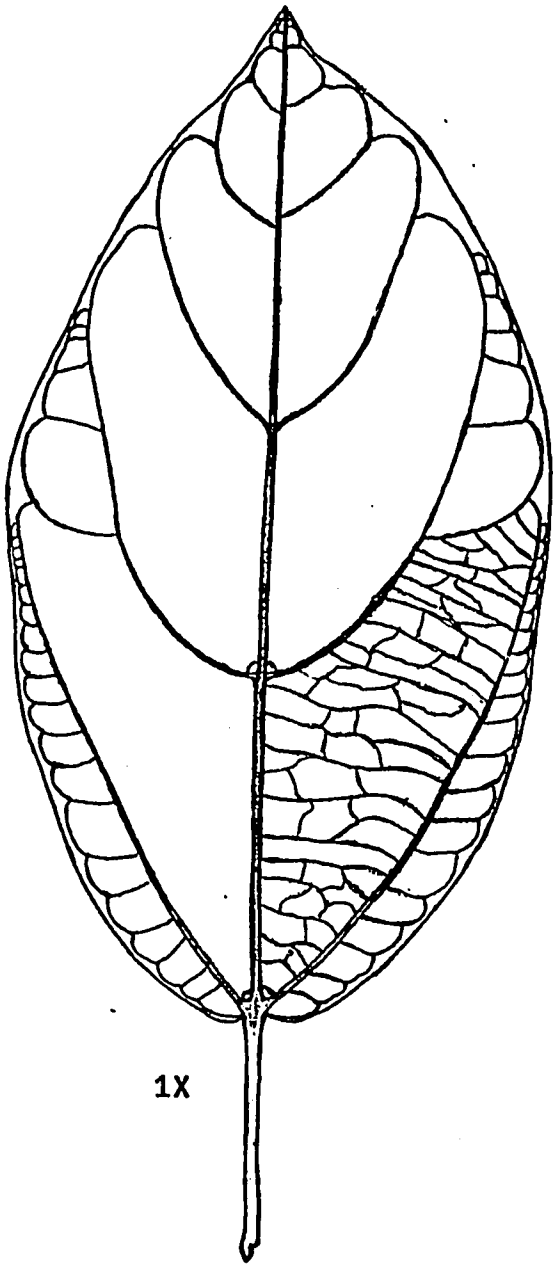
1X



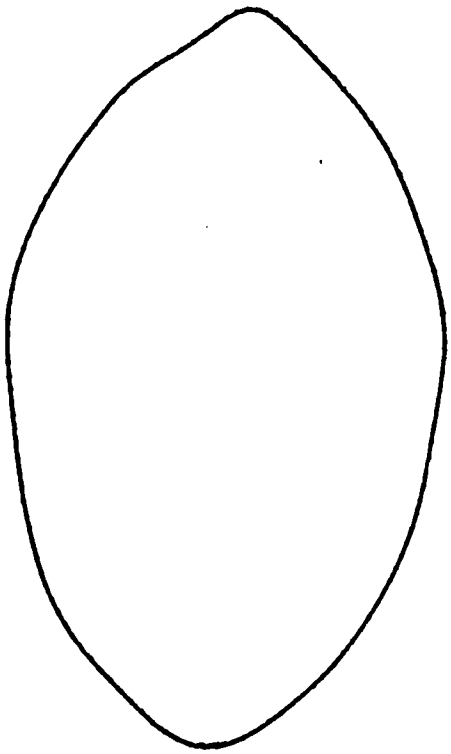
Average leaf image
BF = 15

Ficus barteri

FIG. 157



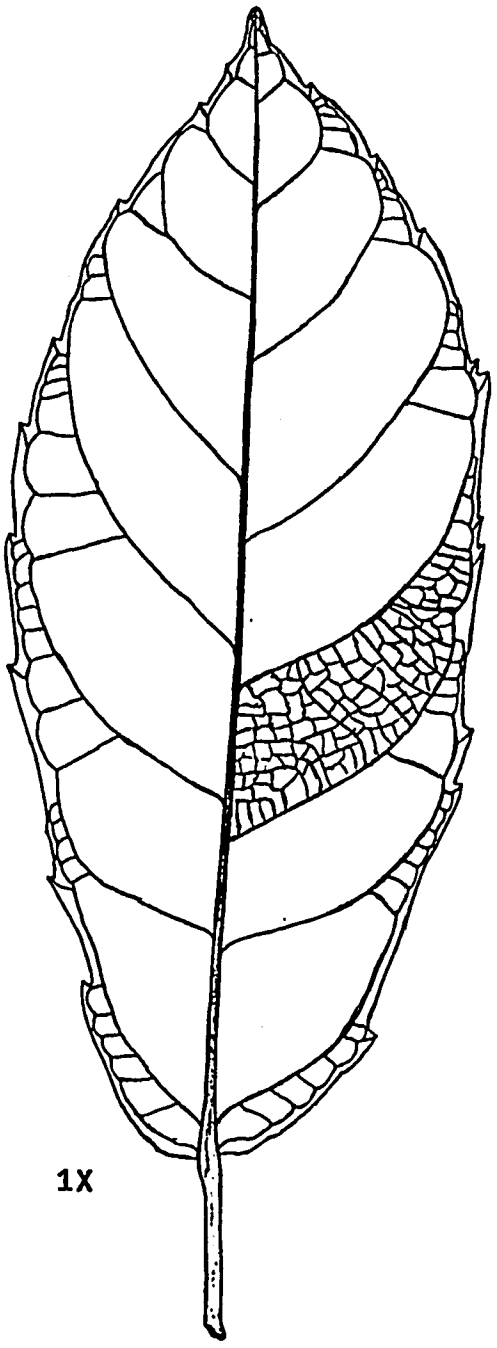
1X



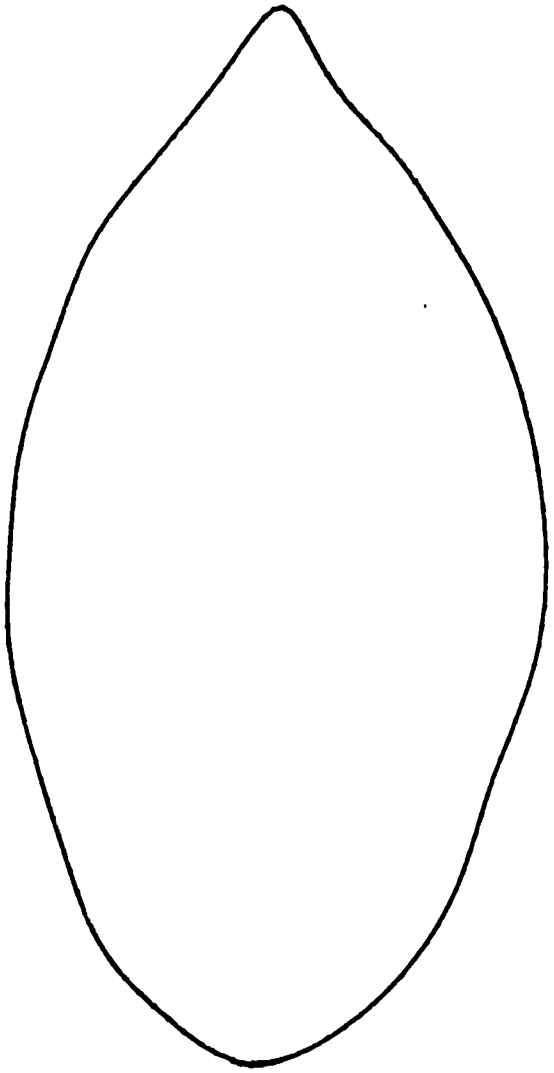
Average leaf image
BF = 15

Ficus exasperata

FIG. 158



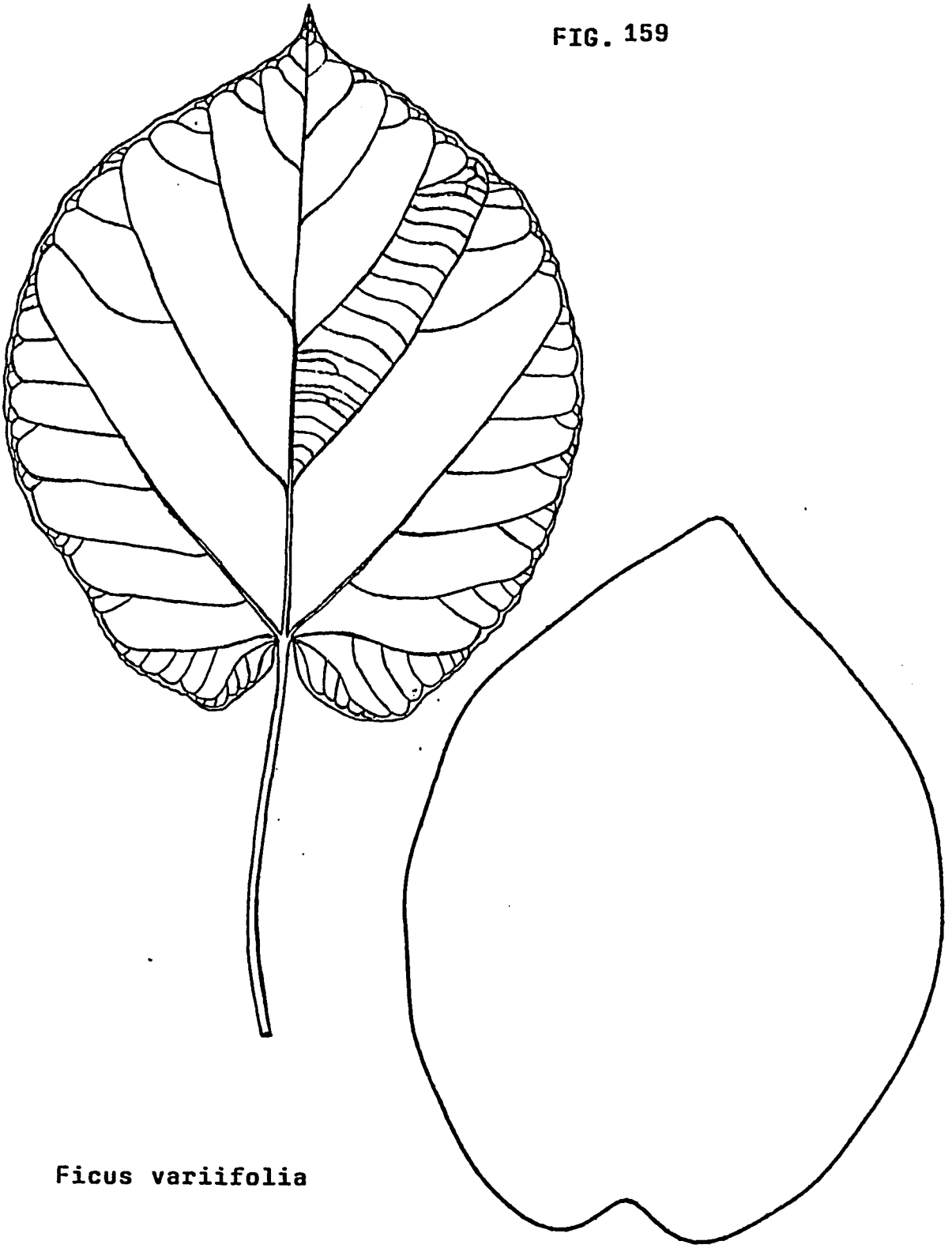
1X



Average leaf image
BF = 15

Ficus sur

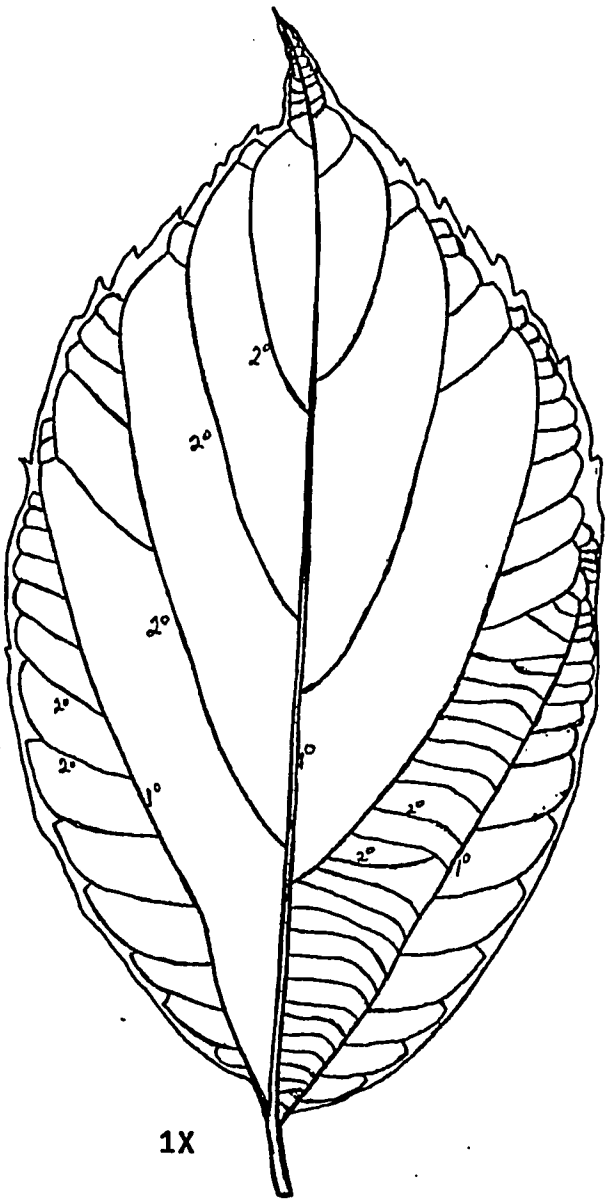
FIG. 159



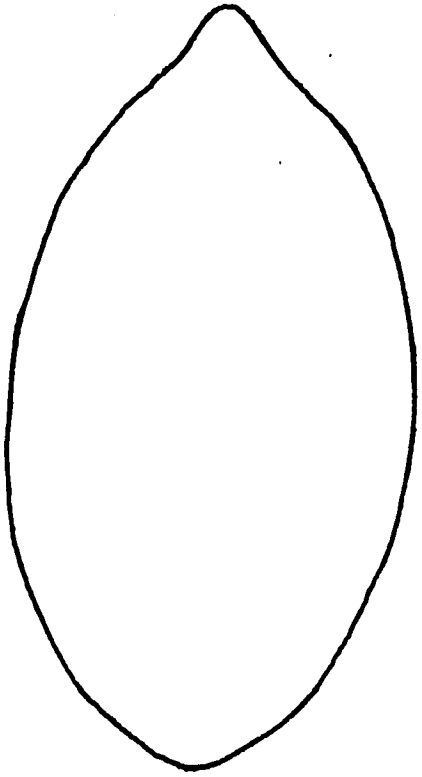
Ficus variifolia

Average leaf image
BF = 15

FIG. 160



1X



Average leaf image
BF = 15

Morus mesozygia

FIG. 161

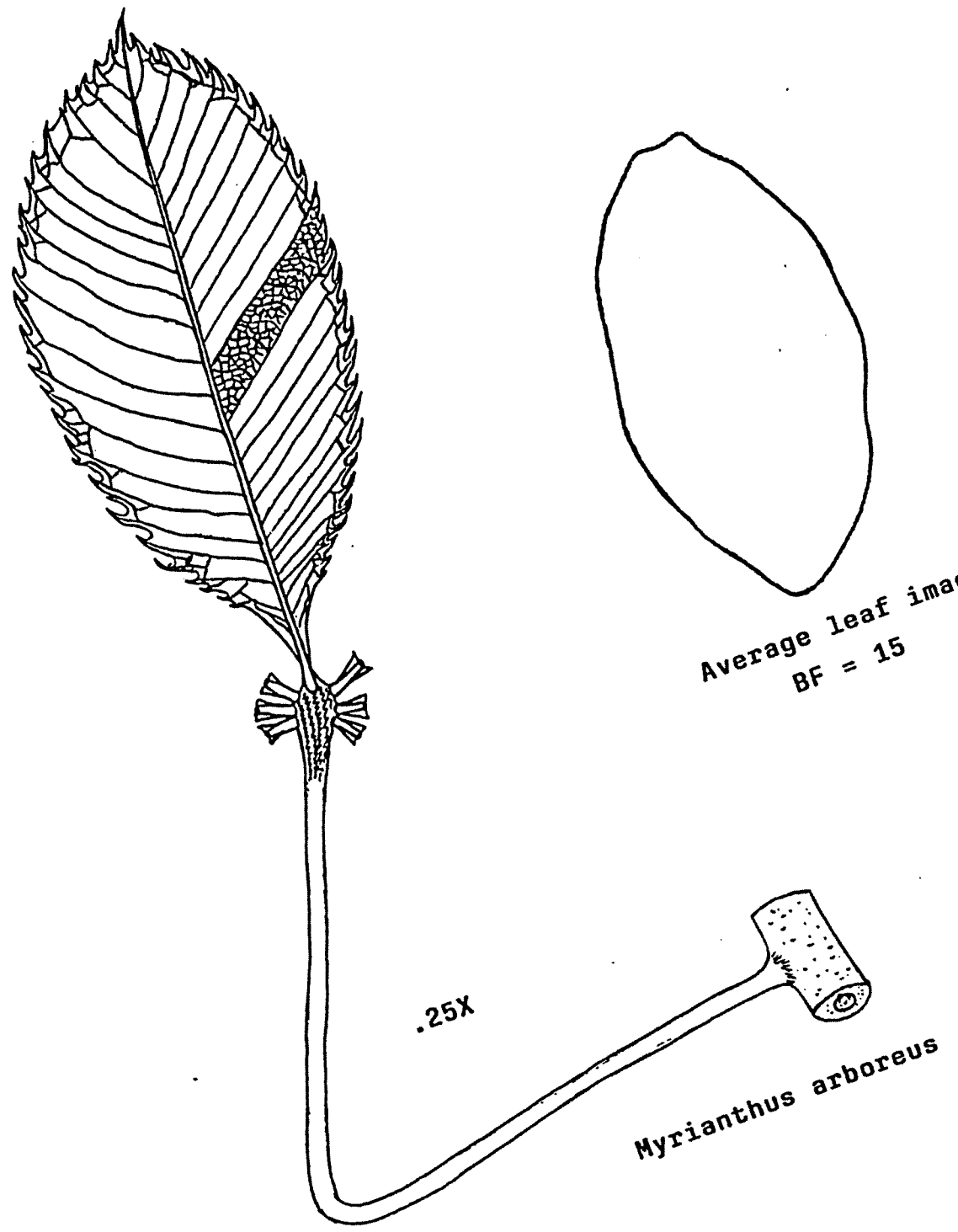
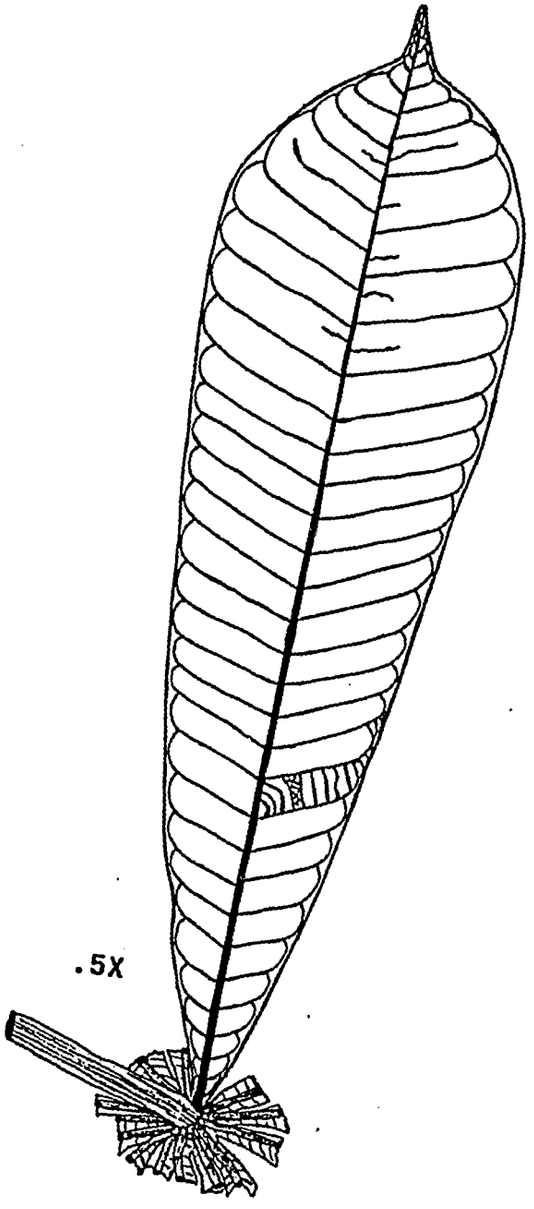
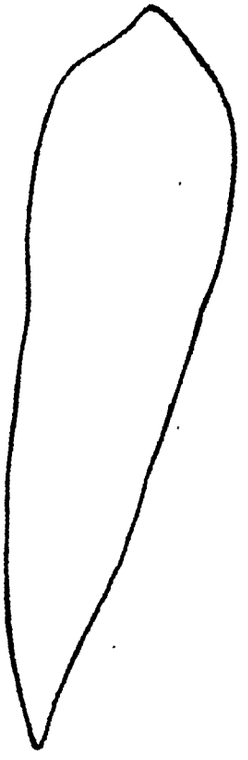


FIG. 162

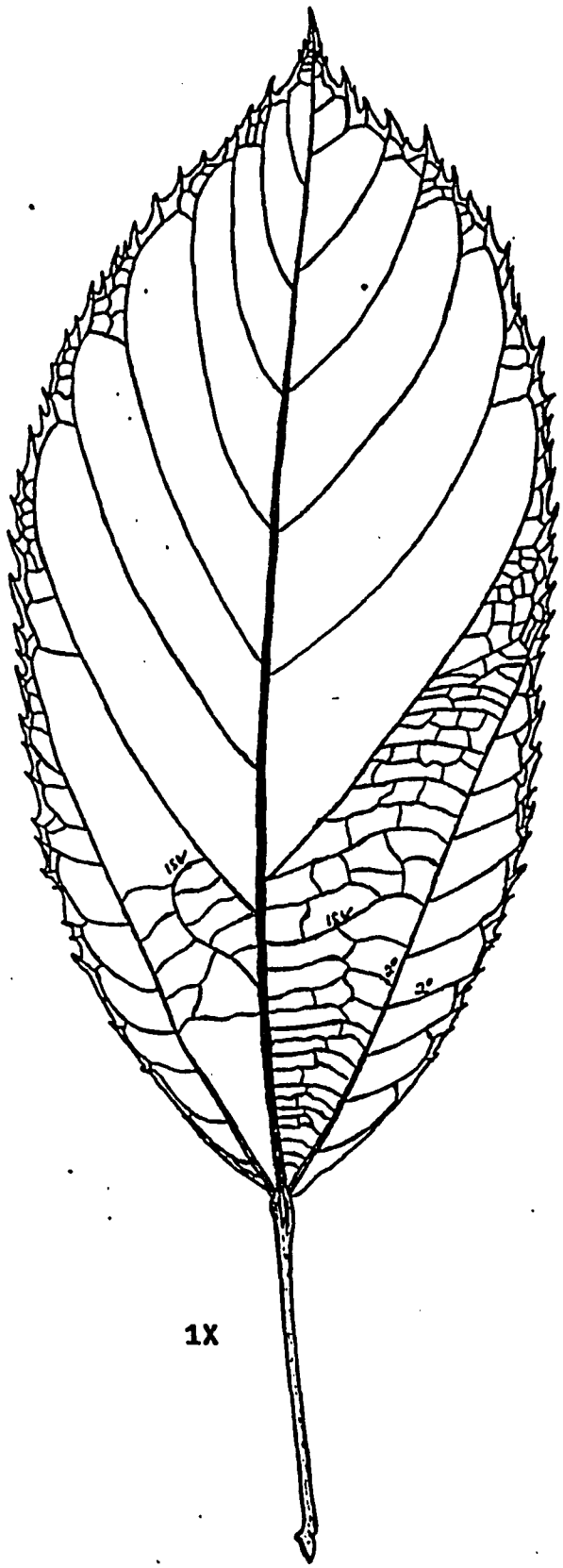




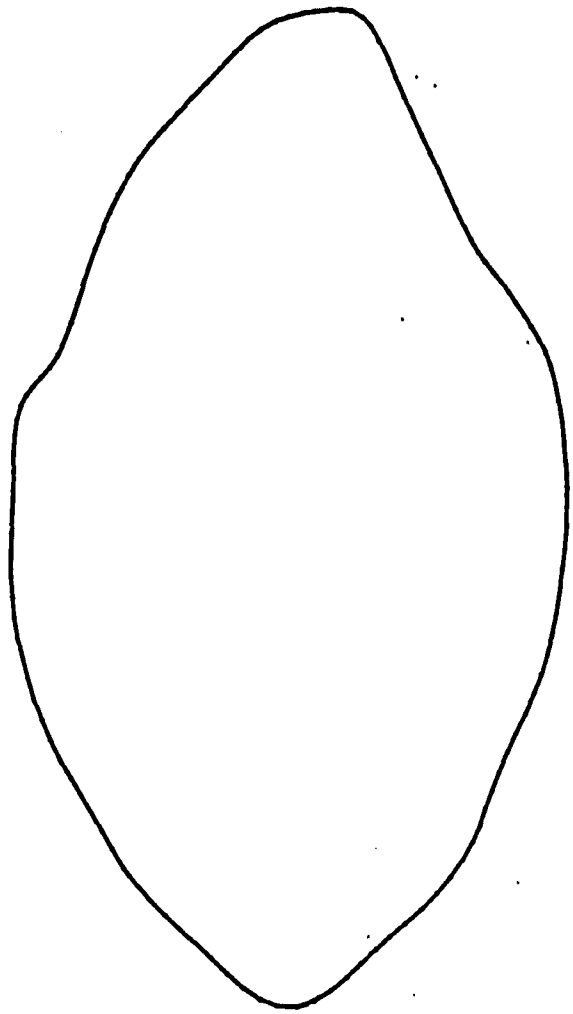
Average leaf image
BF = 15

Musanga cecropioides

FIG. 163



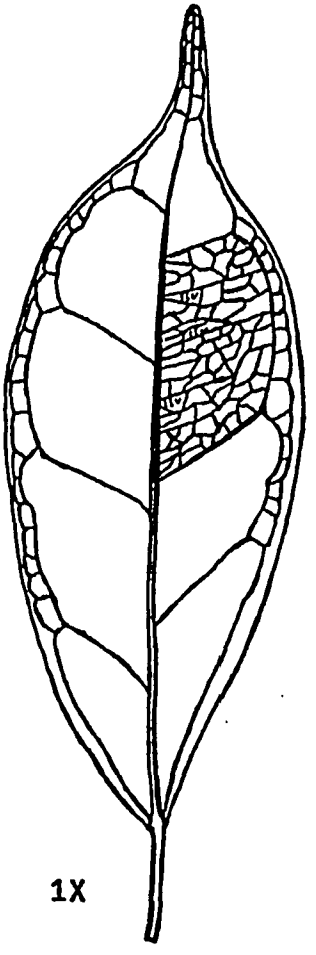
1X



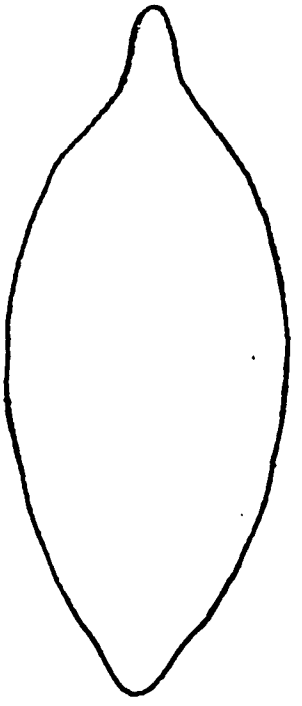
Average leaf image
BF = 15

Myrianthus libericus

FIG. 164



1X



Average leaf image
BF = 15

Trilepisium madagascariense

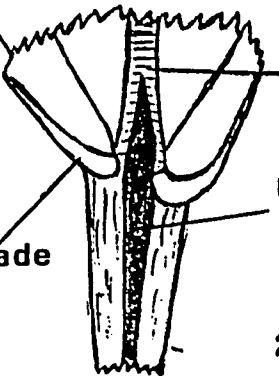
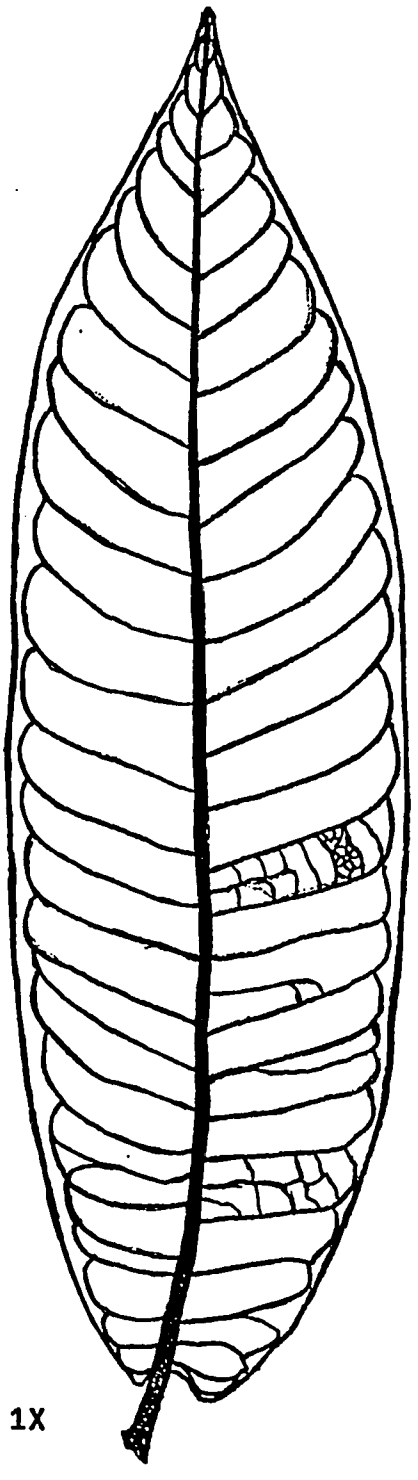
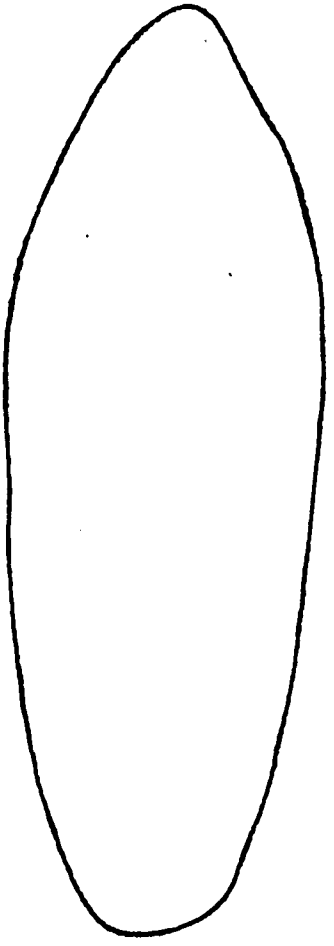


FIG. 165



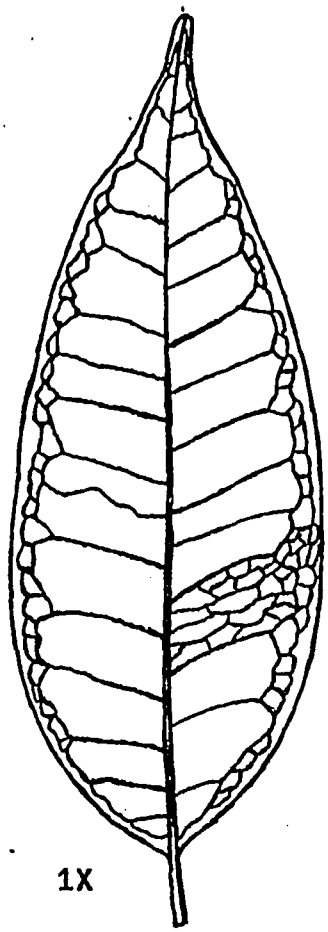
1X



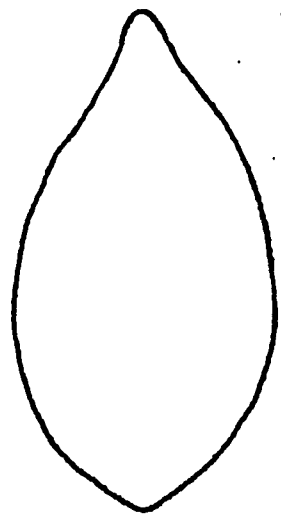
Average leaf image
BF = 15

Picnanthus angolensis

FIG. 166



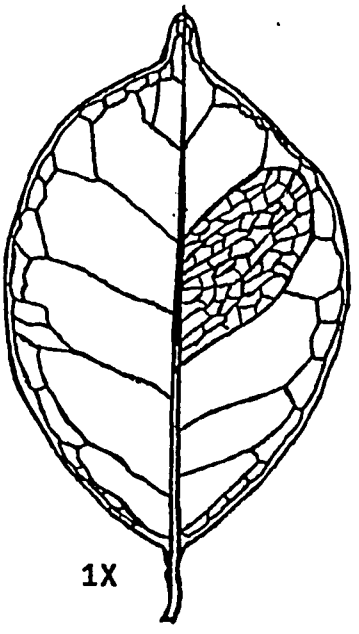
1X



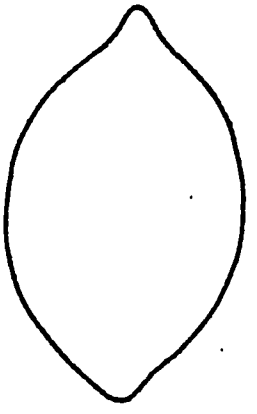
Average leaf image
BF = 15

Aptandra zenkeri

FIG. 167



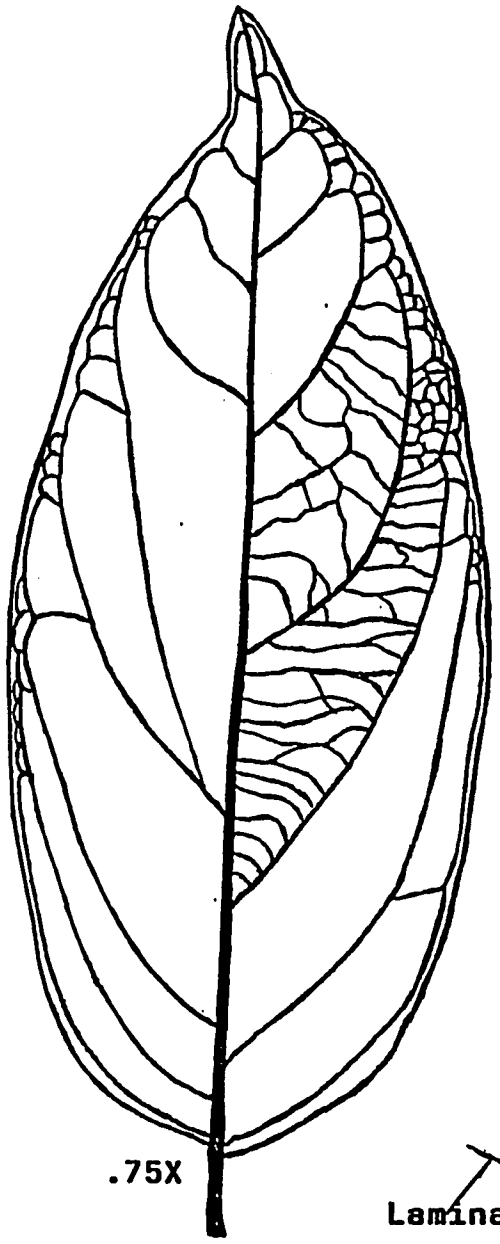
1X



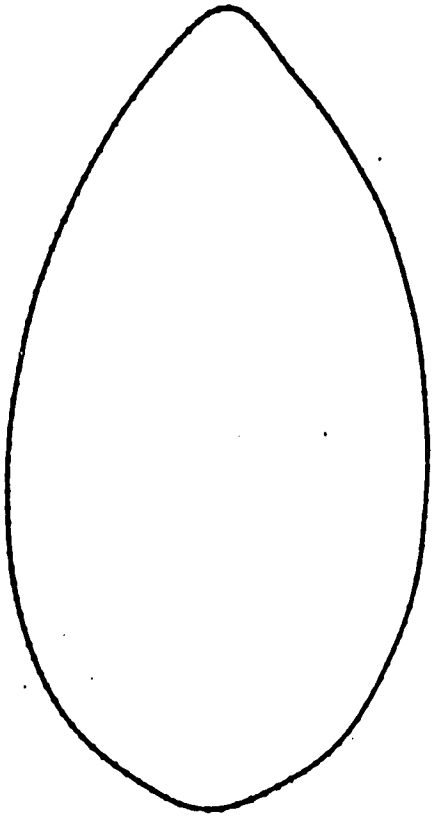
Average leaf image
BF = 15

Ongokea gore

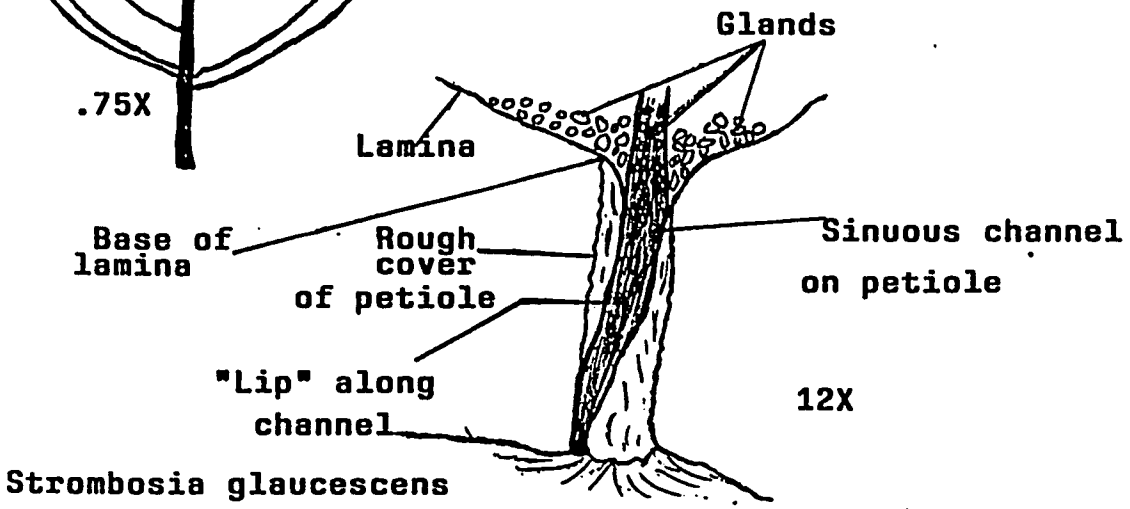
FIG. 168



.75X

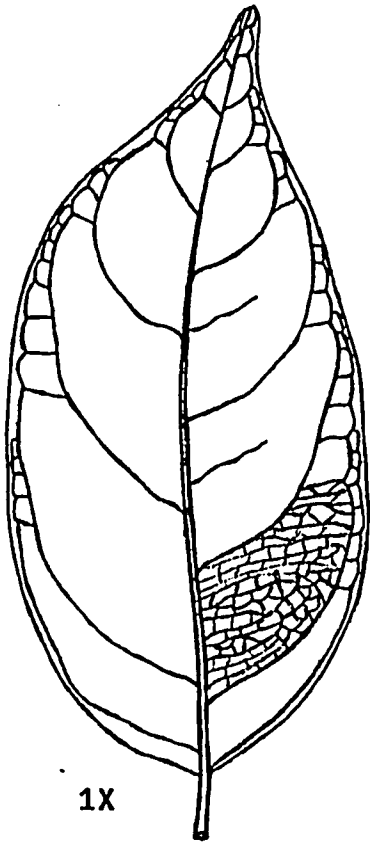


Average leaf image
BF = 15

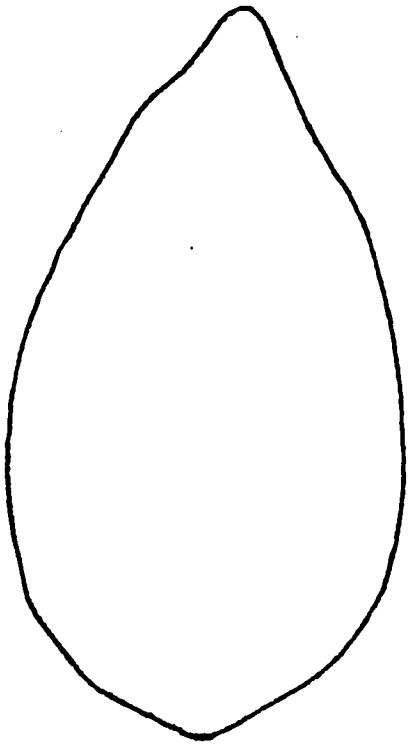


Strombosia glaucescens

FIG. 169



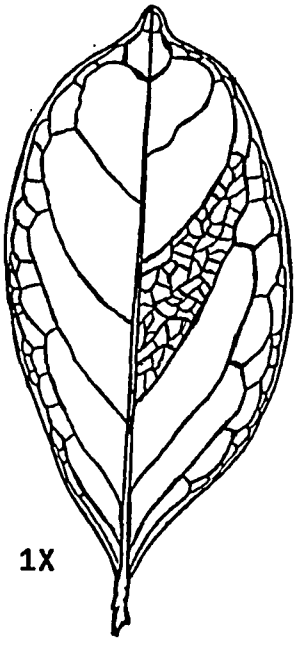
1X



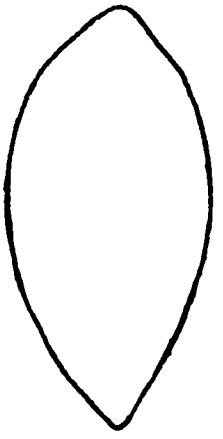
Average leaf image
BF = 15

Strombosia grandifolia

FIG. 170



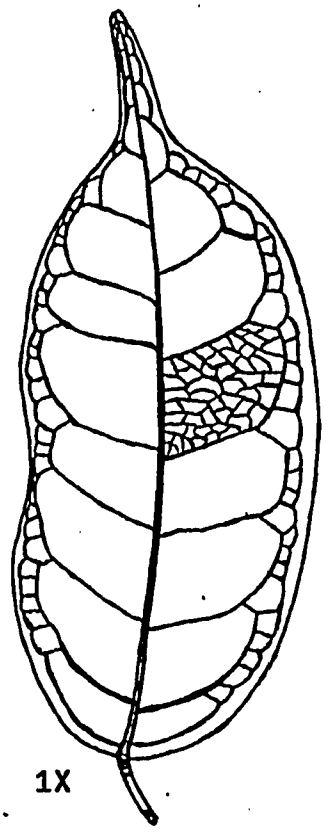
1X



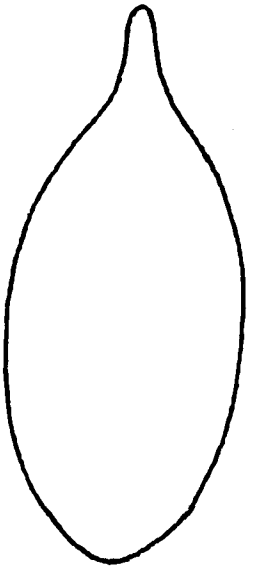
Average leaf image
BF = 15

Strombosia zenkeri

FIG. 171



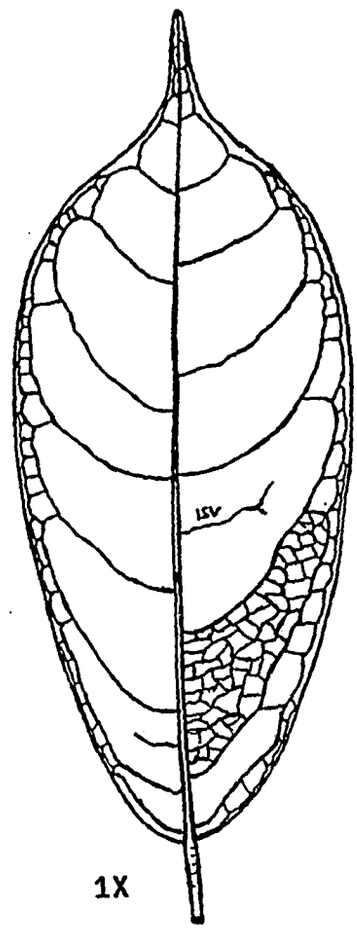
1X



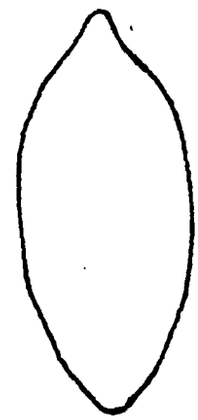
Average leaf image
BF = 15

Baphia nitida

FIG. 172



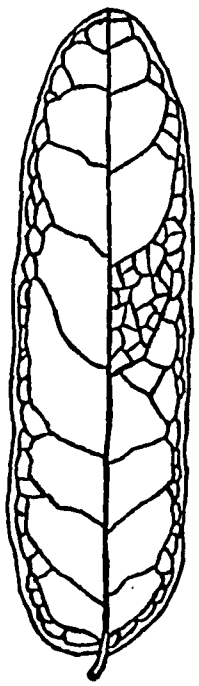
1X



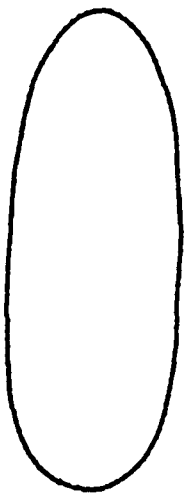
Average leaf image
BF = 15

Baphia pubescens

FIG. 173



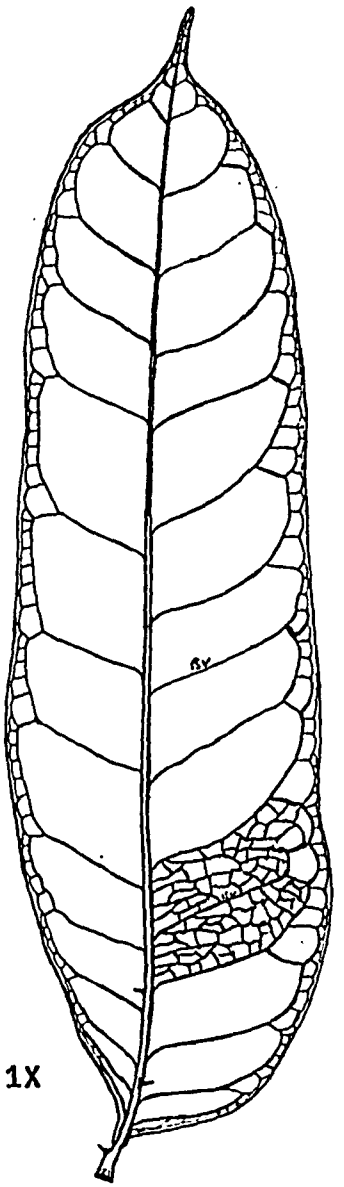
1X



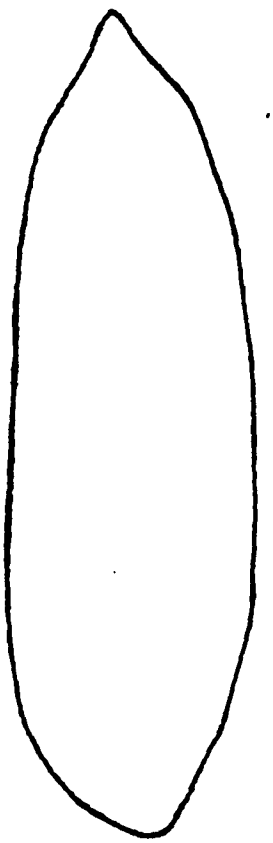
Average leaf image
BF = 20

Dalbergiella welwitschii

FIG. 174



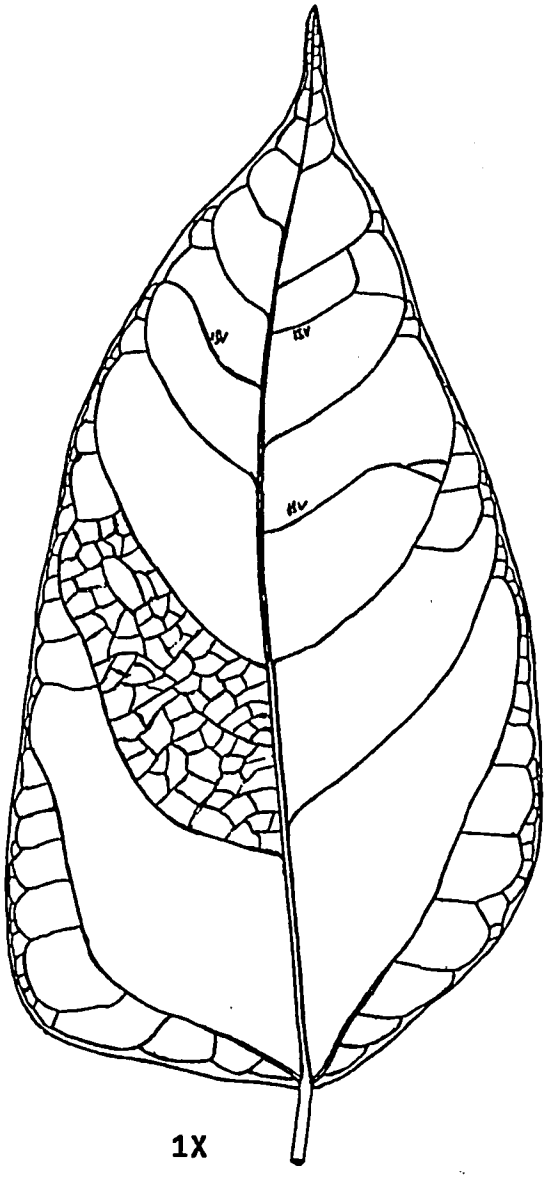
1X



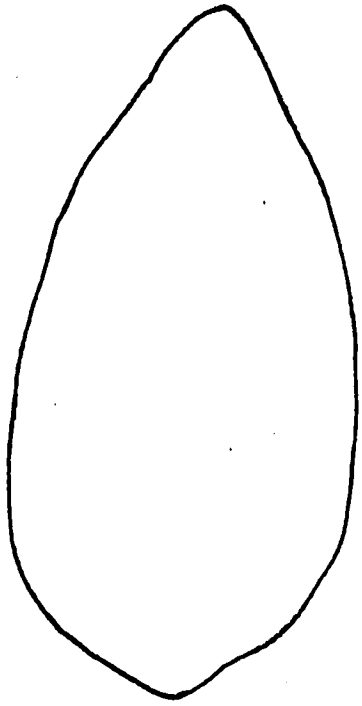
Average leaf image
BF = 10

Erythrina senegalensis

FIG. 175



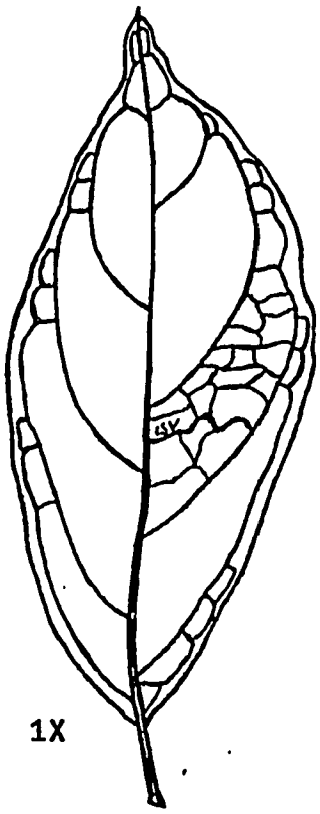
1X



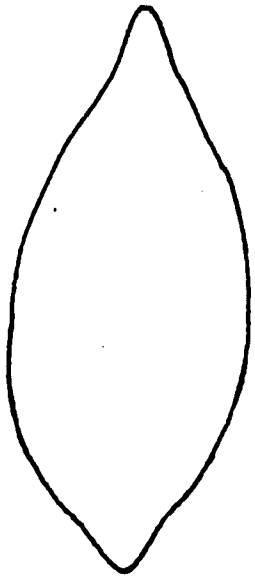
Average leaf image
BF = 10

Erythrina vogelii

FIG. 176



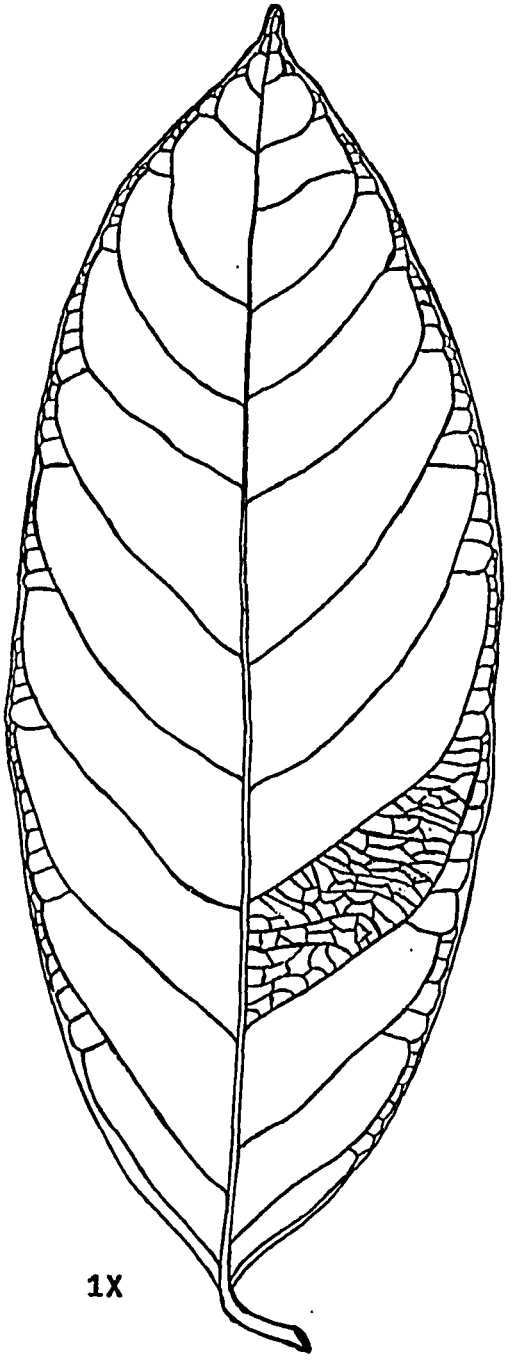
1X



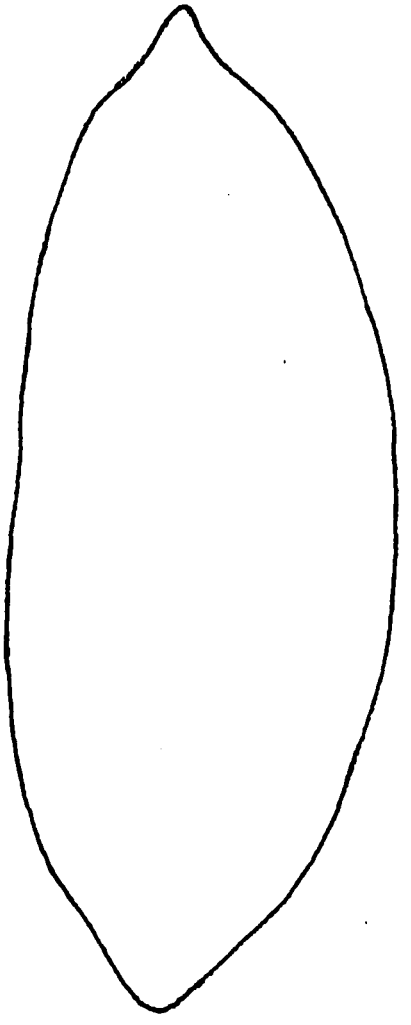
Average leaf image
BF = 15

Aulacocalyx jasminiflora

FIG. 177



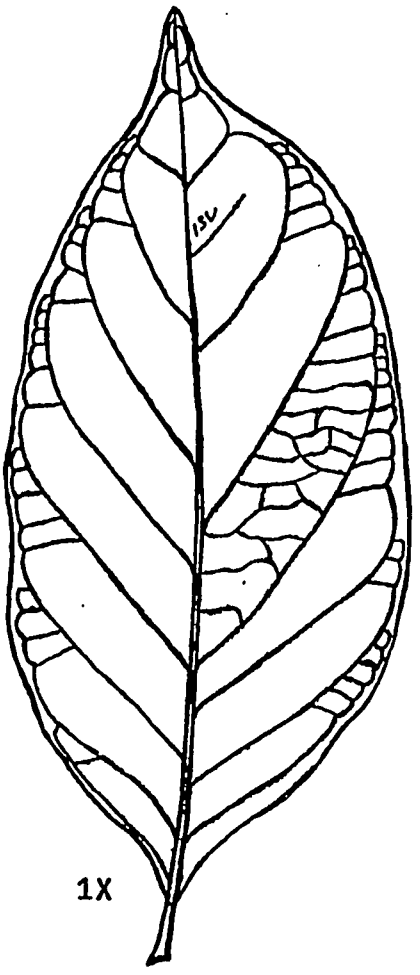
1X



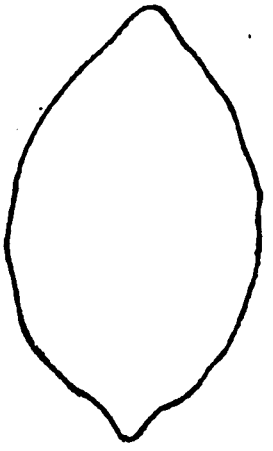
Average leaf image
BF = 10

Corynanthe pachyceras

FIG. 178



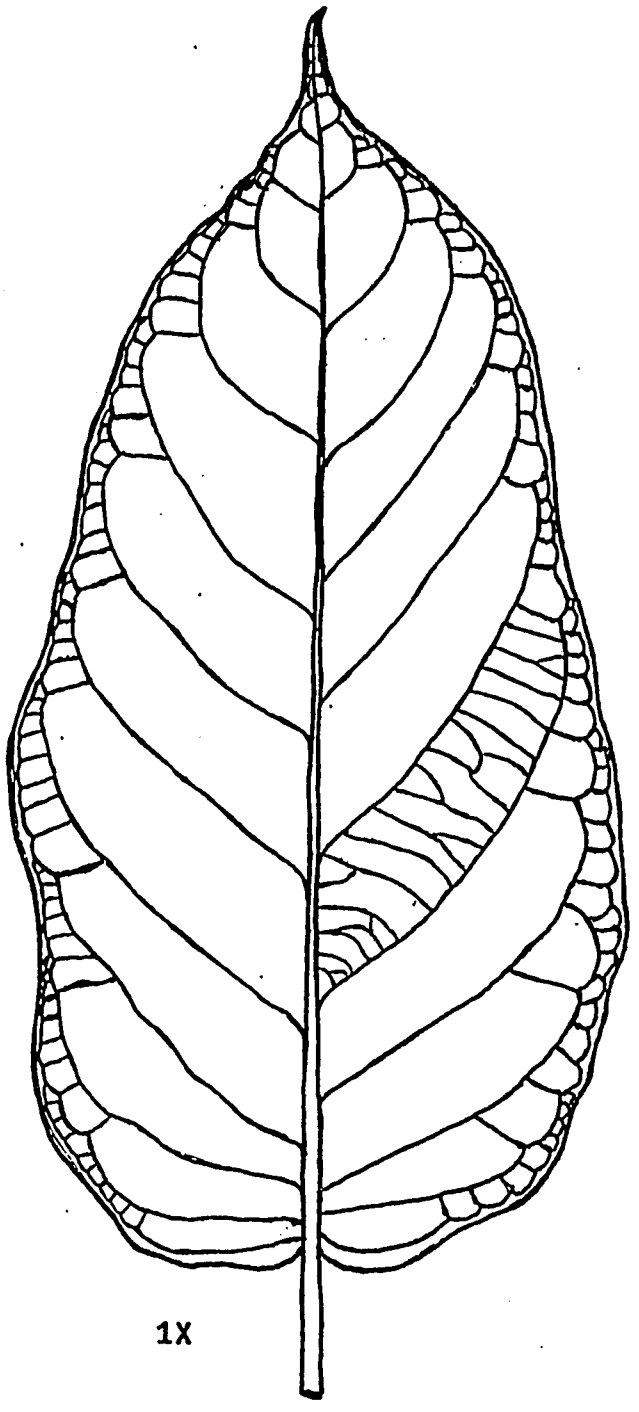
1X



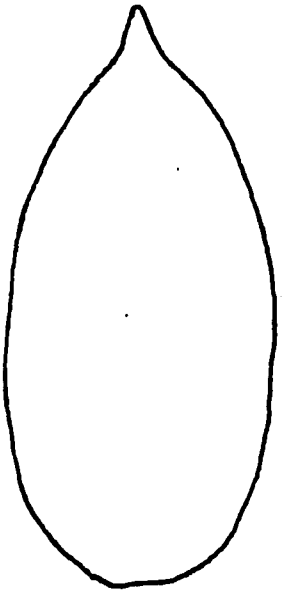
Average leaf image
BF = 10

Nauclea diderrichii

FIG. 179



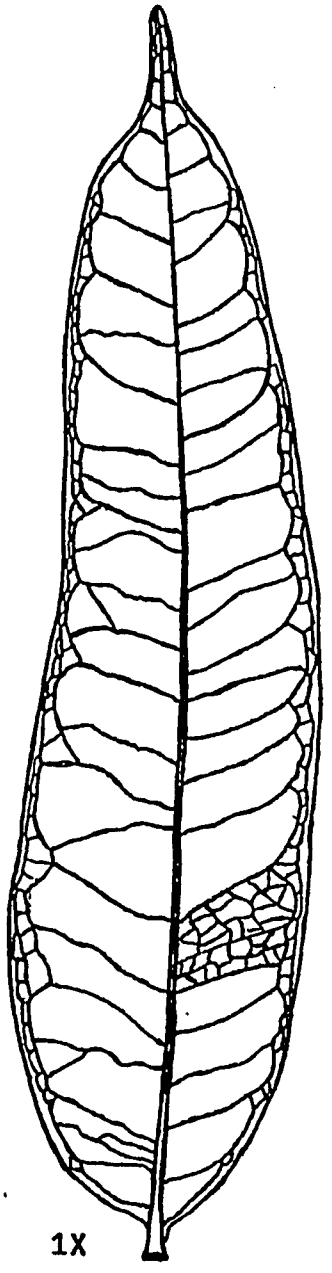
1X



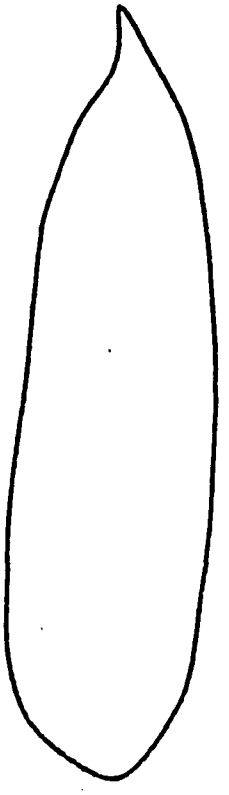
Average leaf image
BF = 15

Psydrax paviflora

FIG. 180



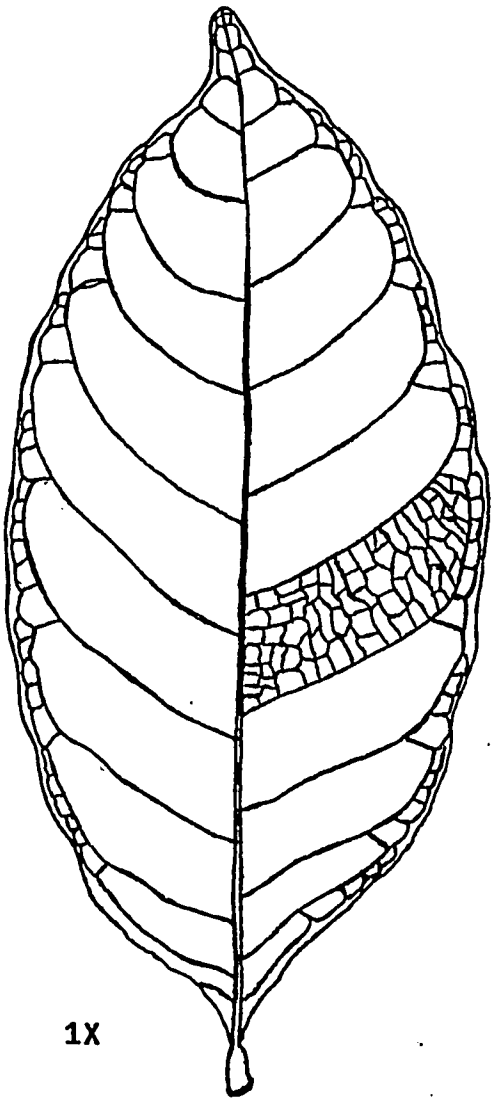
1X



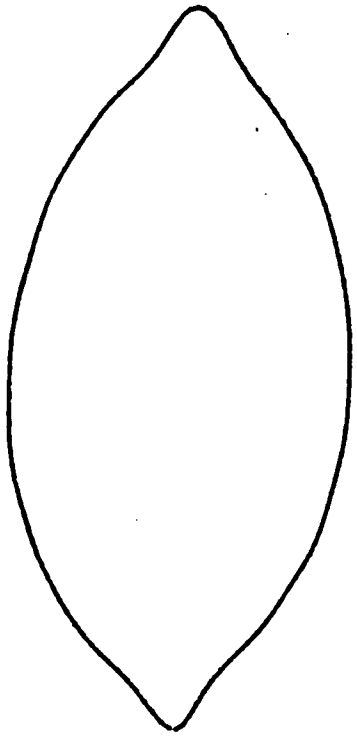
Average leaf image
BF = 10

Zanthoxylum gilletii

FIG. 181



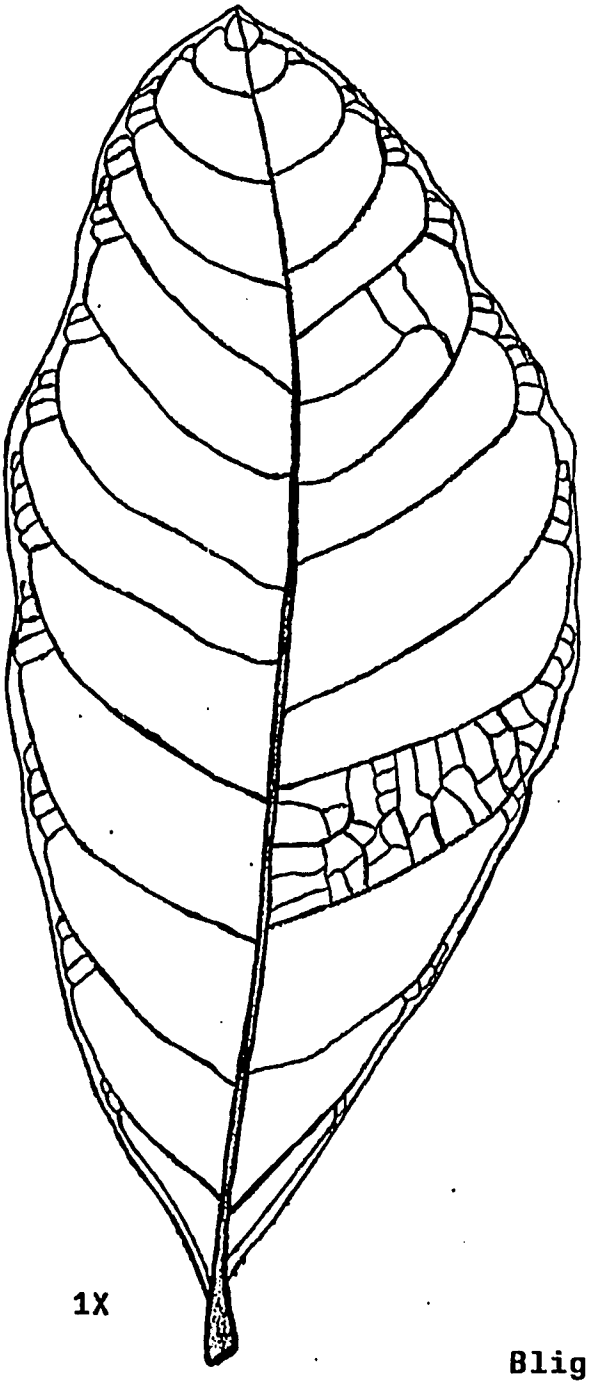
1X



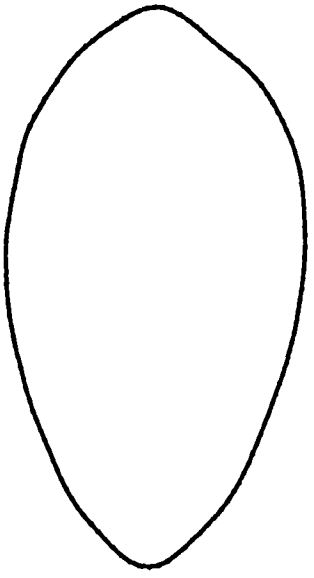
Average leaf image
BF = 15

Lecaniodiscus cupanioides

FIG. 182



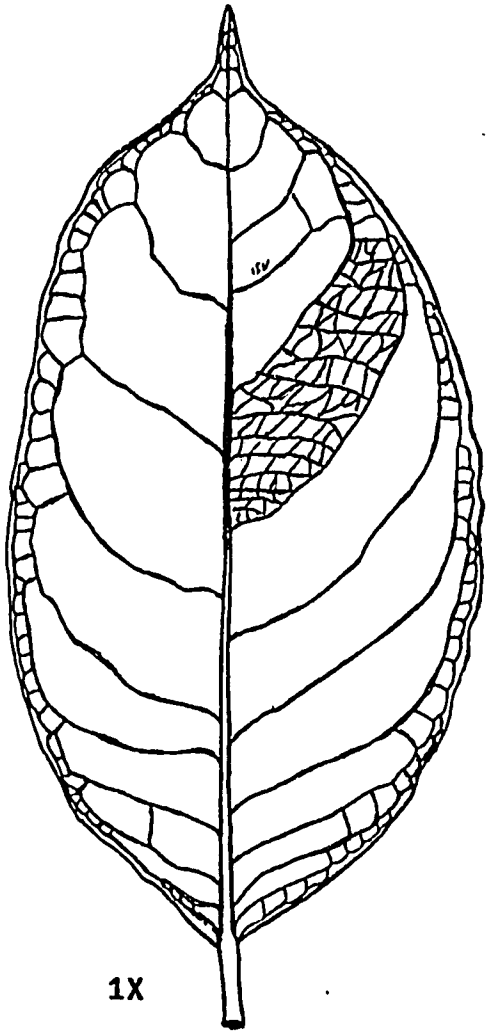
1X



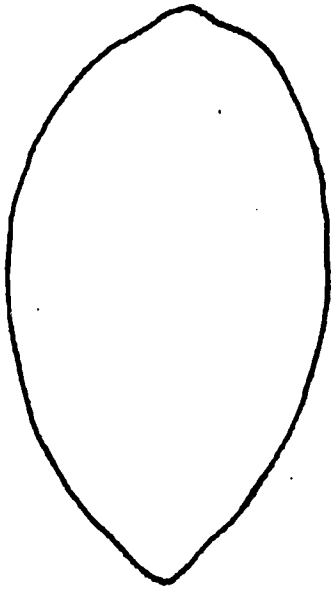
Average leaf image
BF = 15

Blighia sapida

FIG. 183



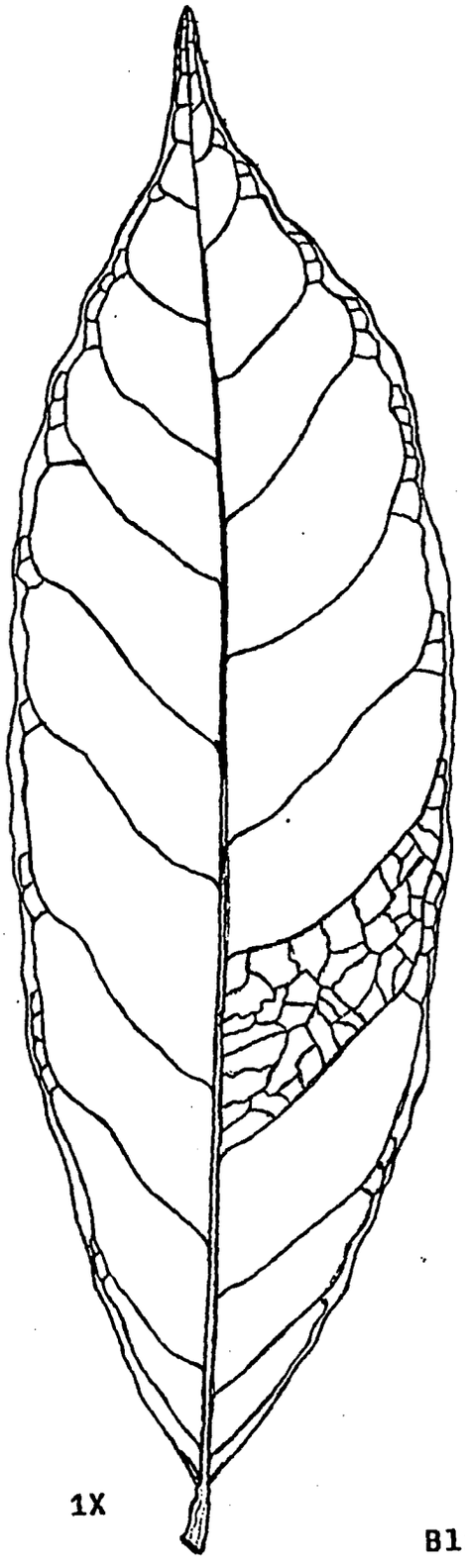
1X



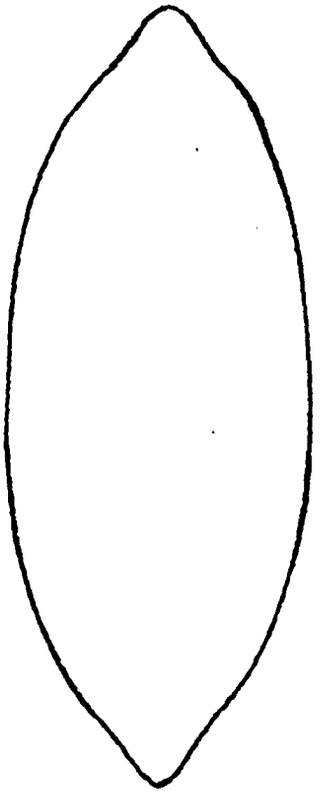
Average leaf image
BF = 15

Blighia unijugata

FIG.184



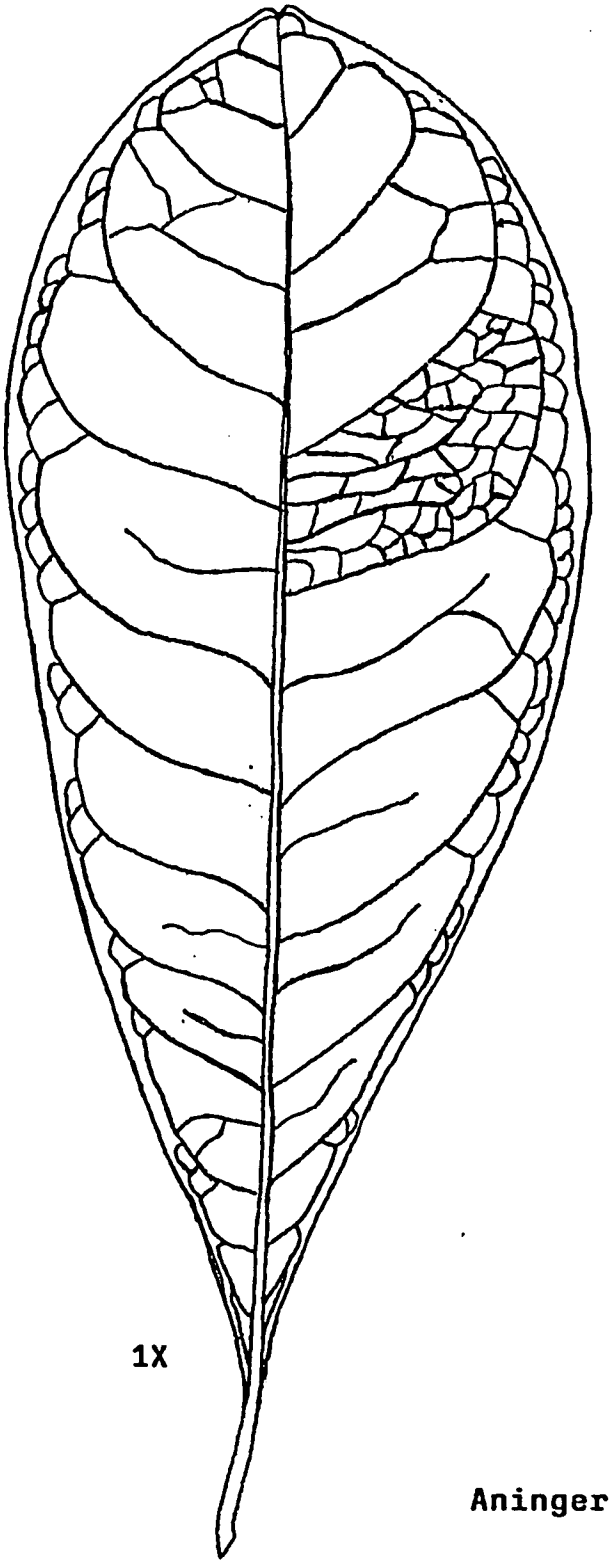
1X



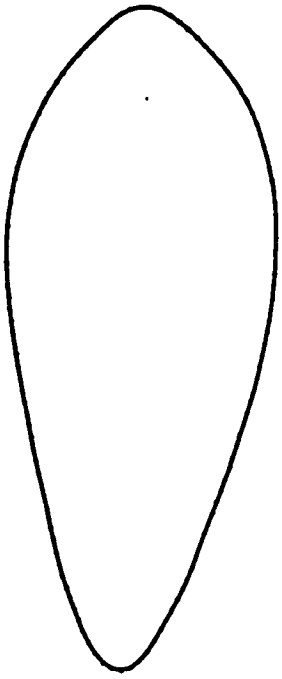
Average leaf image
BF = 15

Blighia welwitschii

FIG. 185



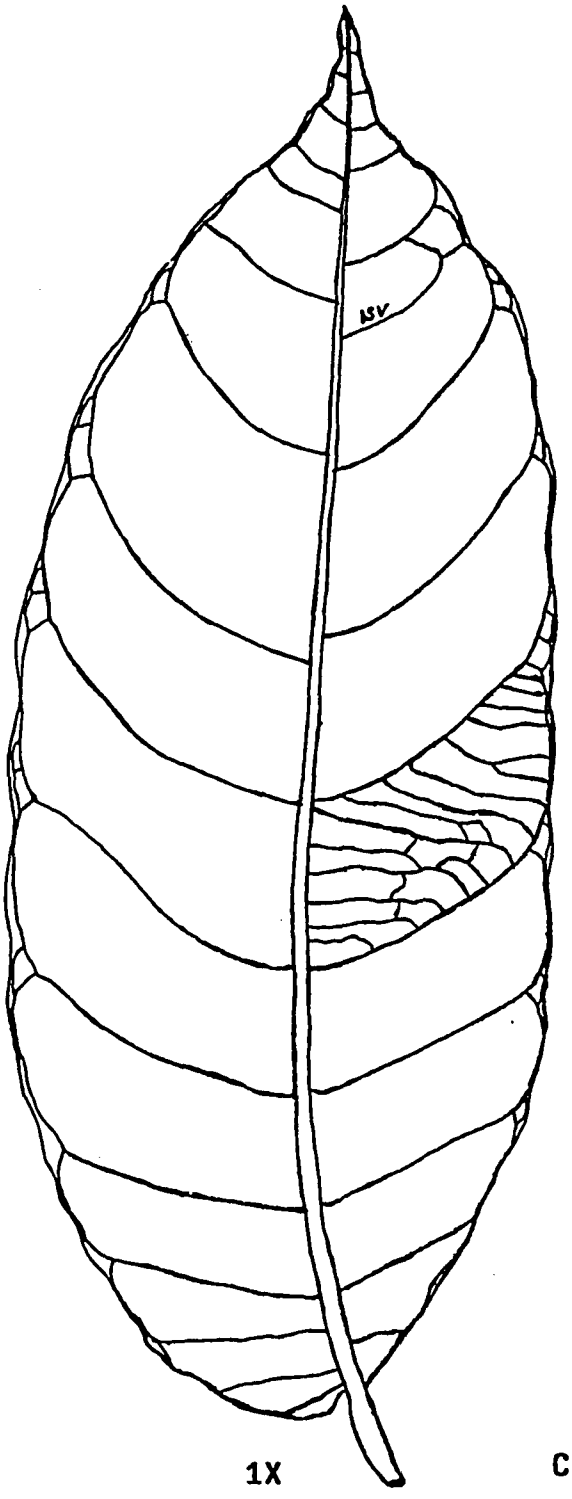
1X



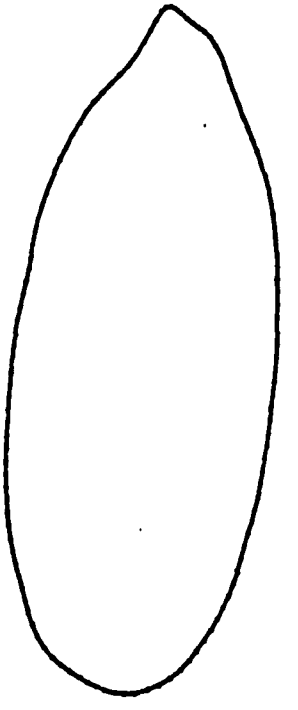
Average leaf image
BF = 15

Aningeria robusta

FIG. 186



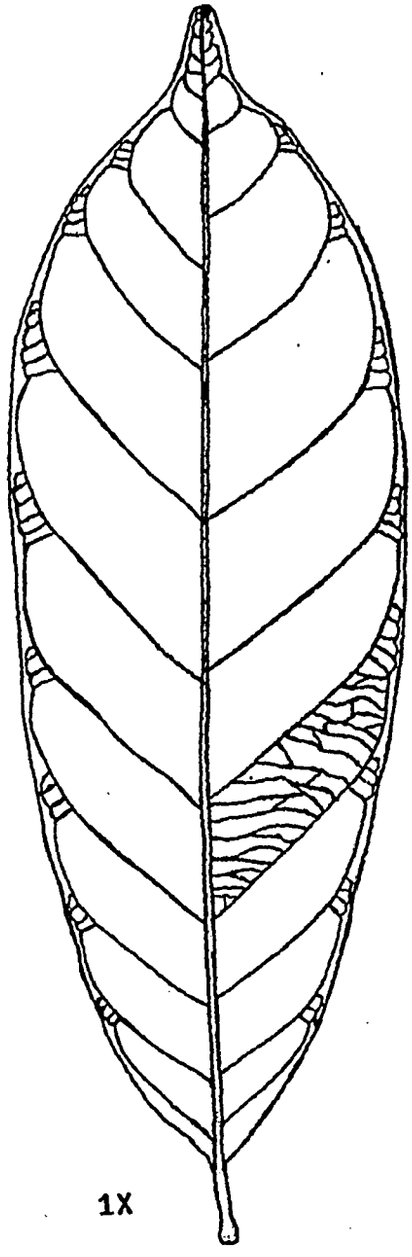
1X



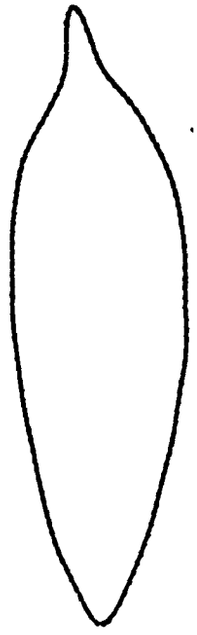
Average leaf image
BF = 15

Chrysophullum beguei

FIG. 187



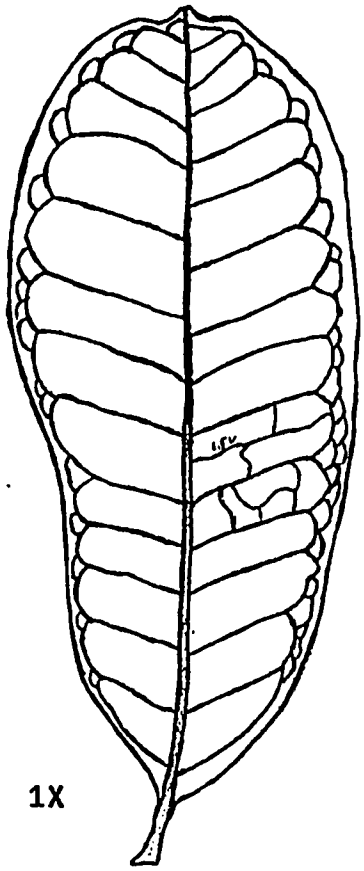
1X



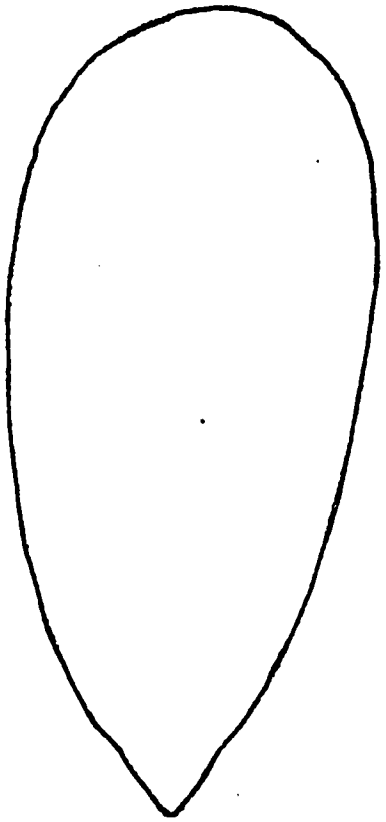
Average leaf image
BF = 15

Chrysophyllum subnudum

FIG. 188



1X

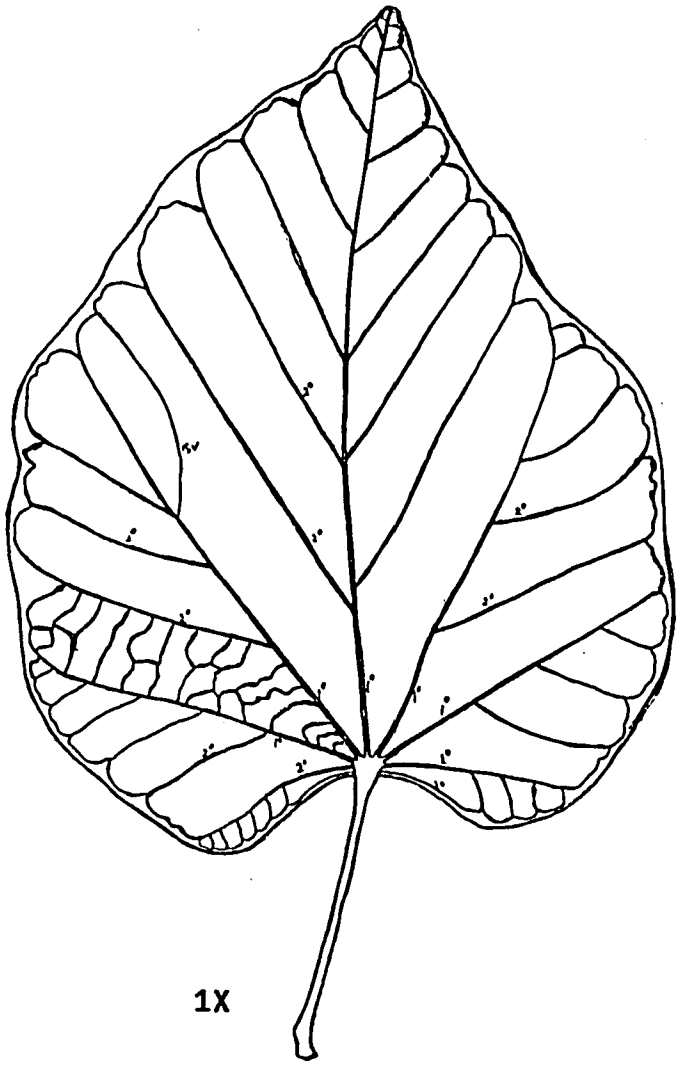


Average leaf image

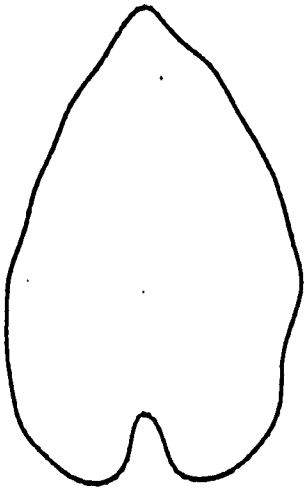
BF = 15

Hannoa klaineana

FIG. 189



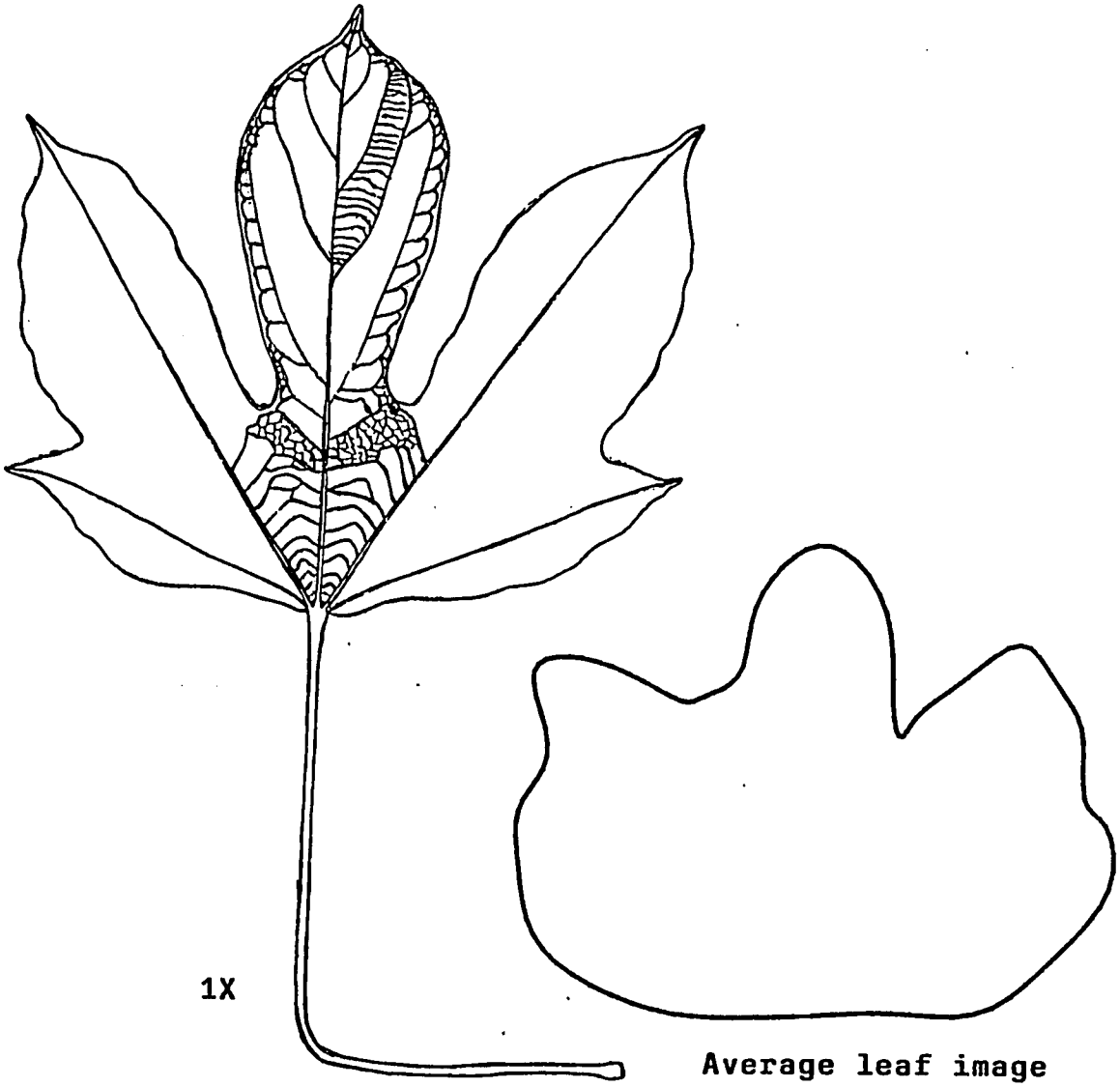
1X



Average leaf image
BF = 40

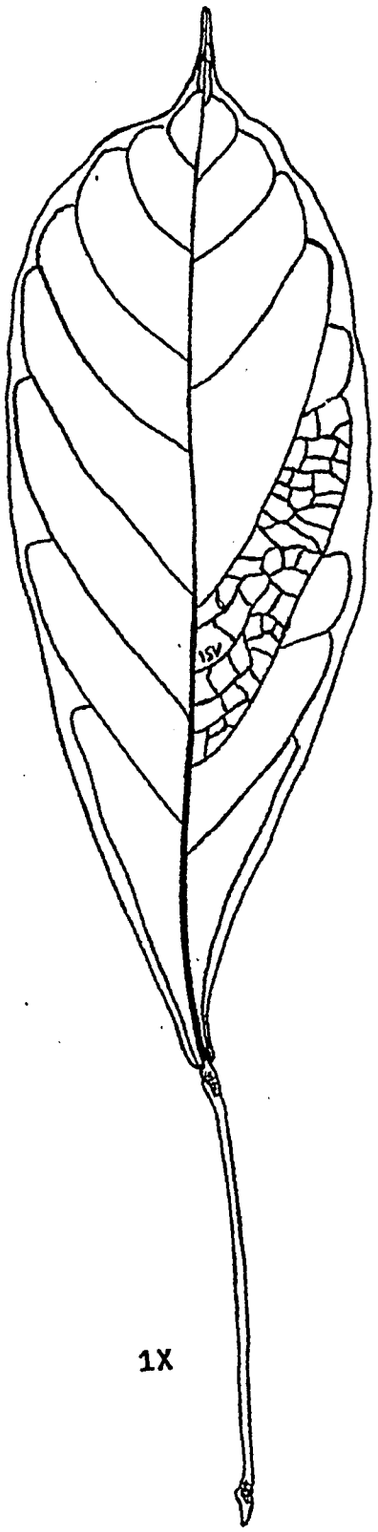
Cola gigantea

FIG. 190

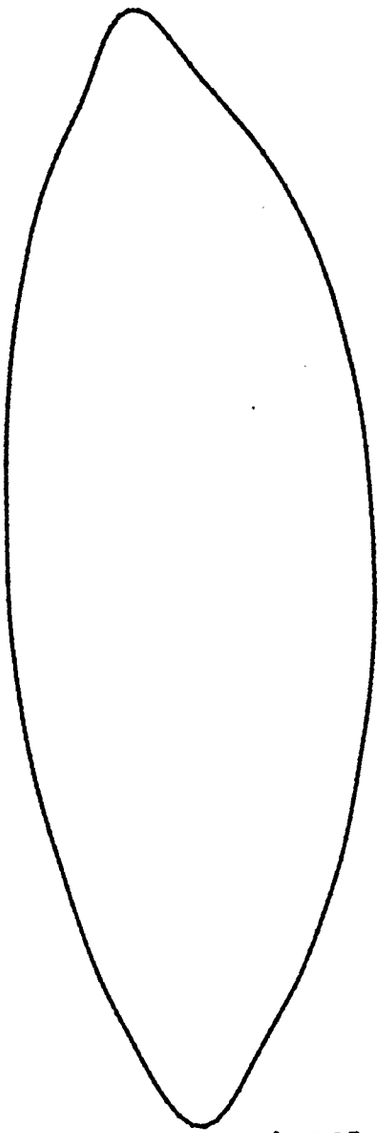


Cola millenii

FIG. 191



1X

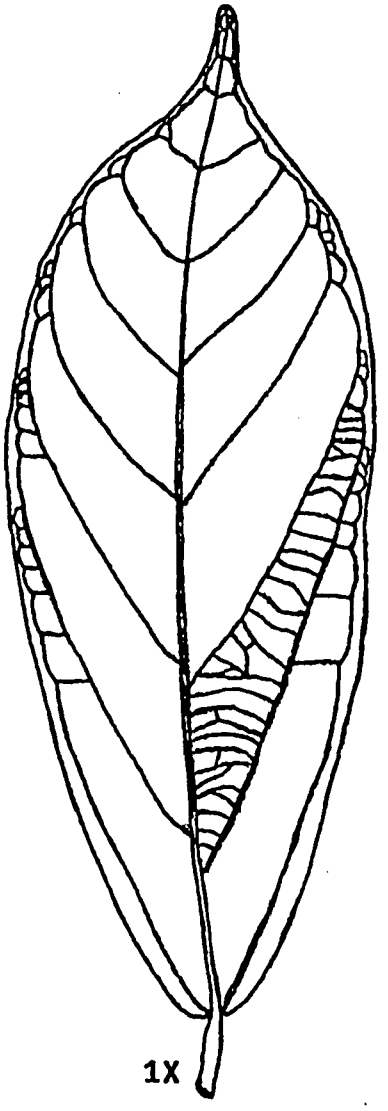


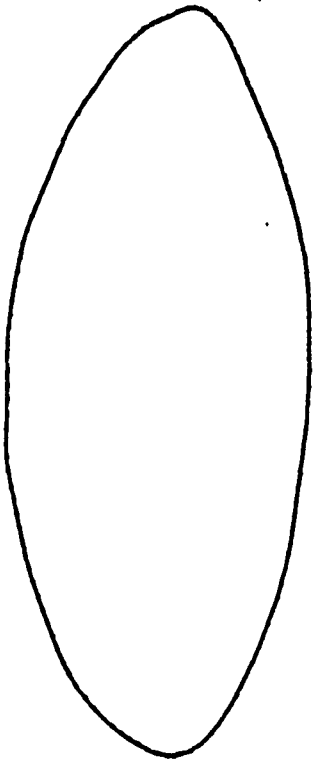
Average leaf image

BF = 15

Cola nitida

FIG. 192

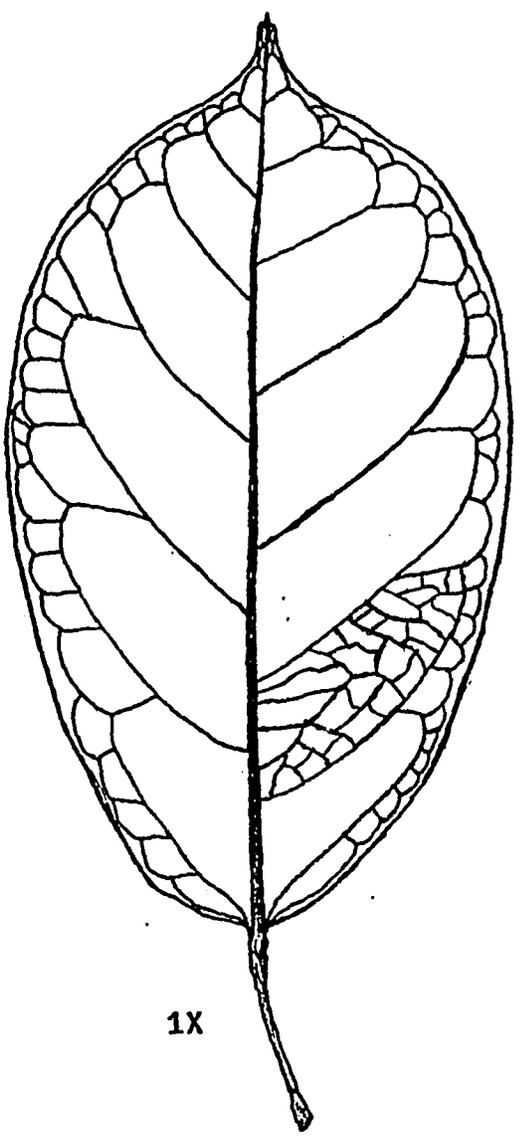




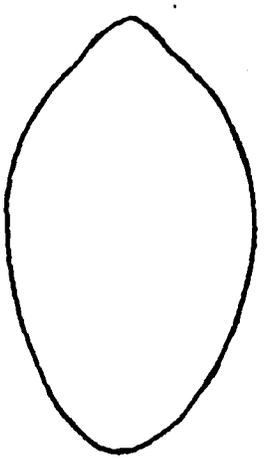
Average leaf image
BF = 20

Leptonychia pubescens

FIG. 193



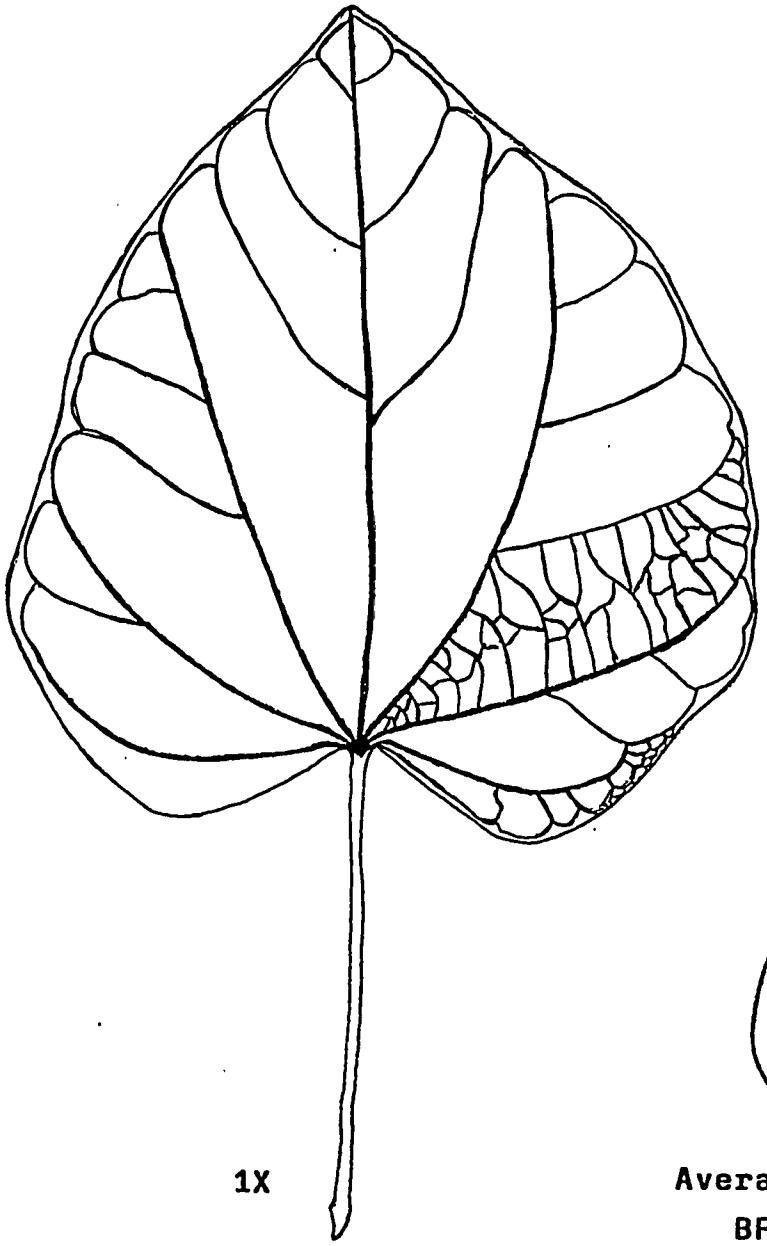
1X



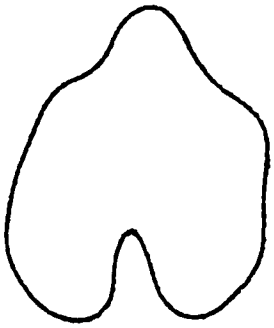
Average leaf image
BF = 10

Nesogordonia papaverifera

FIG. 194



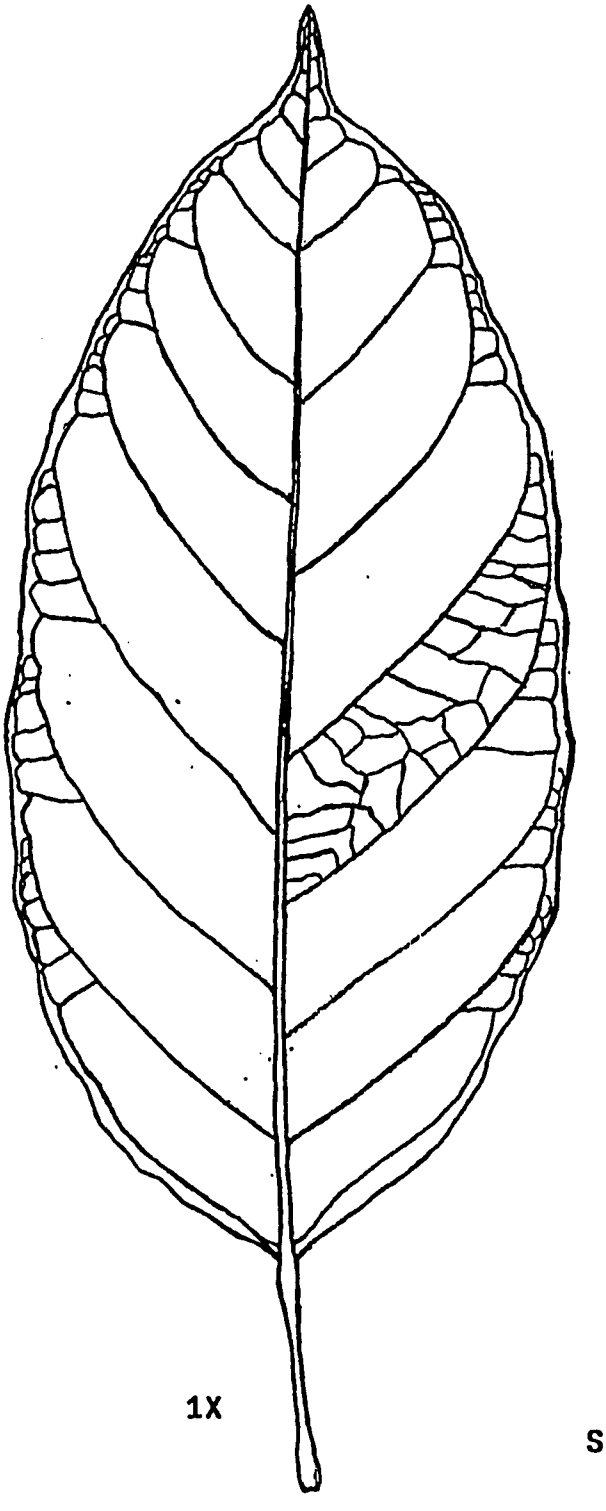
1X



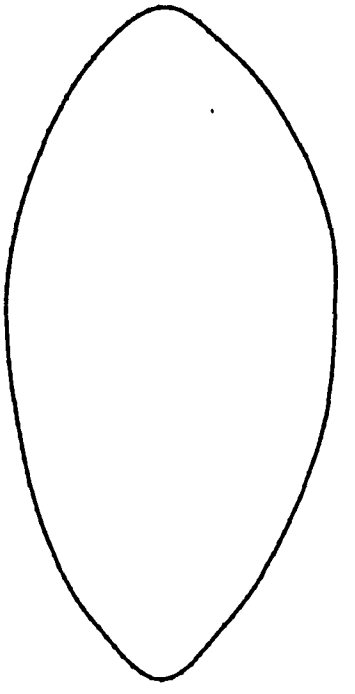
Average leaf image
BF = 15

Pterygota macrocarpa

FIG. 195



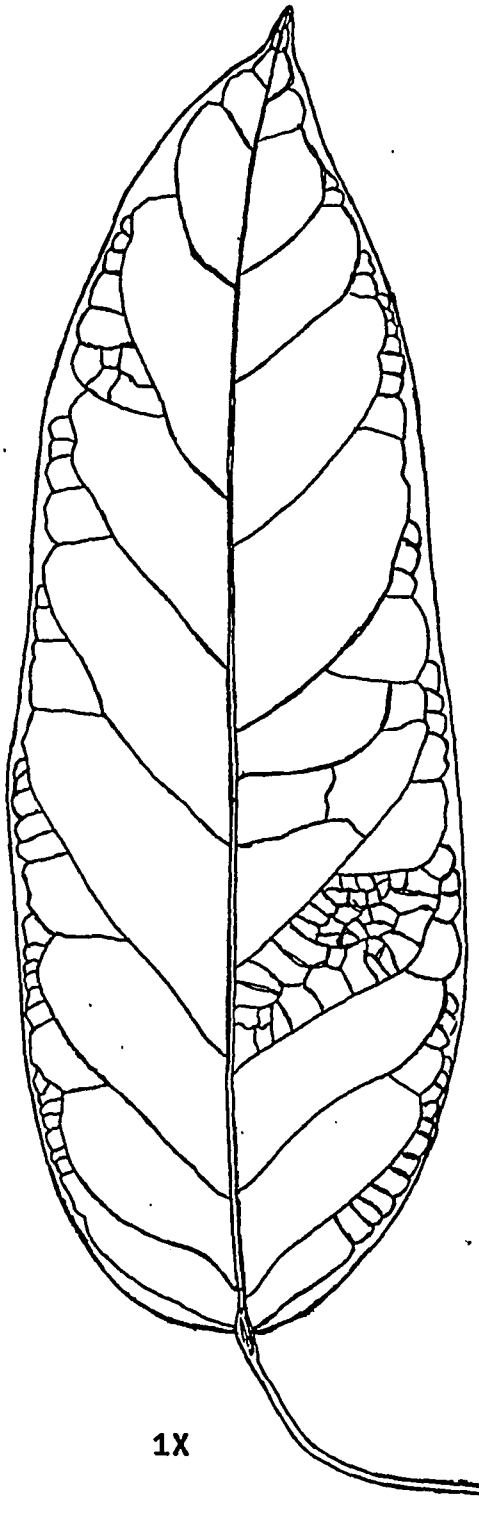
1X



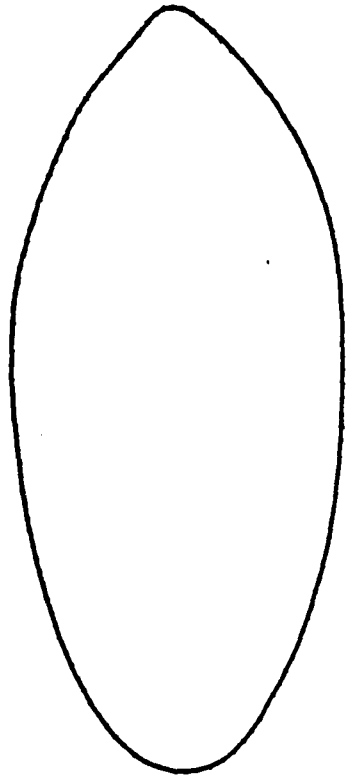
Average leaf image
BF = 15

Sterculia oblonga

FIG. 196



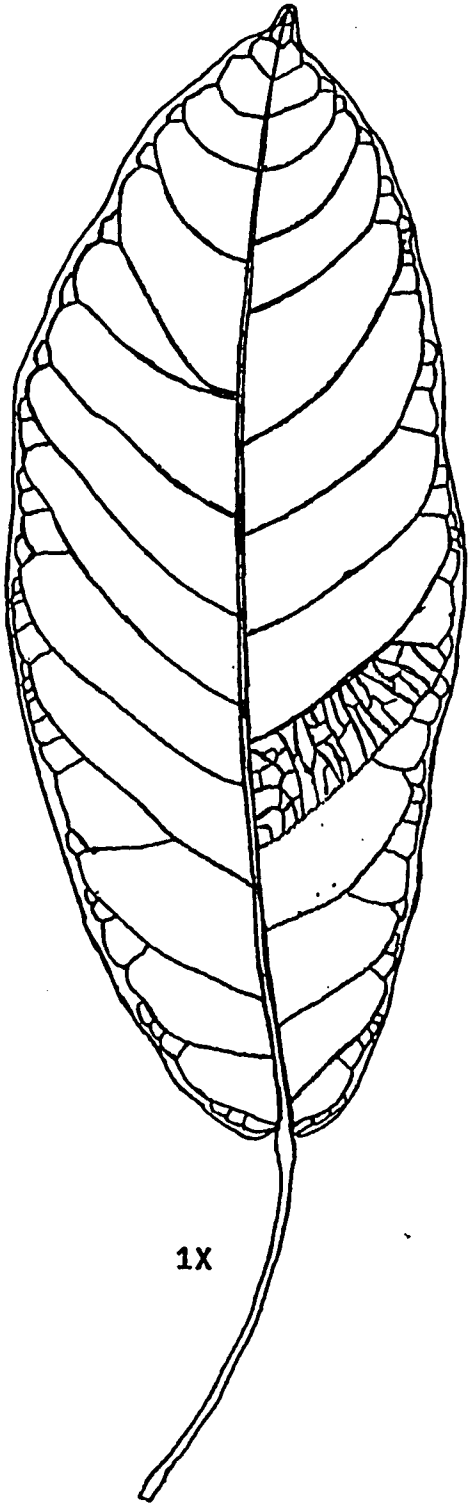
1X



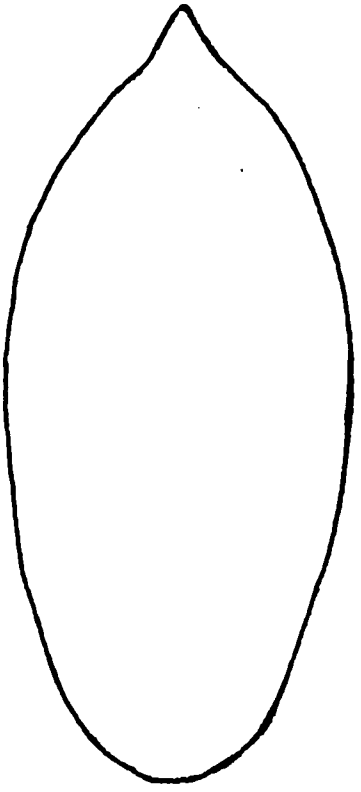
Average leaf image
BF = 10

Sterculia rhinopetala

FIG. 197



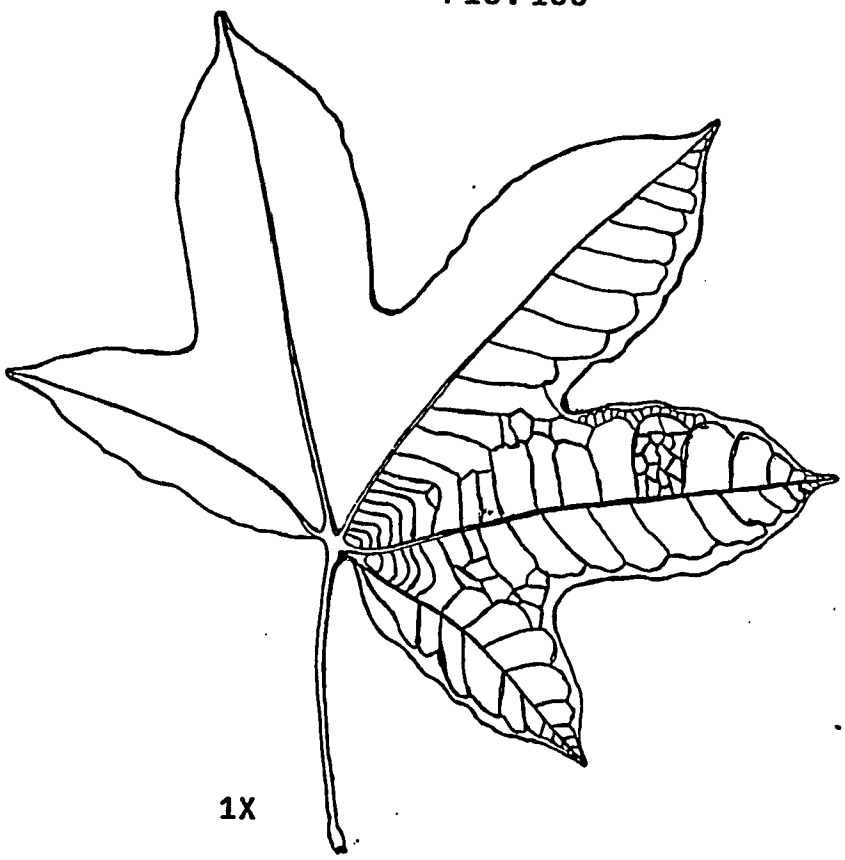
1X



Average leaf image
BF = 15

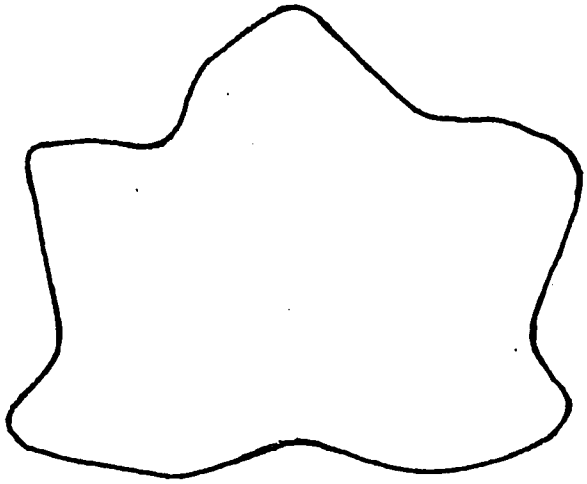
Sterculia tragacantha

FIG. 198



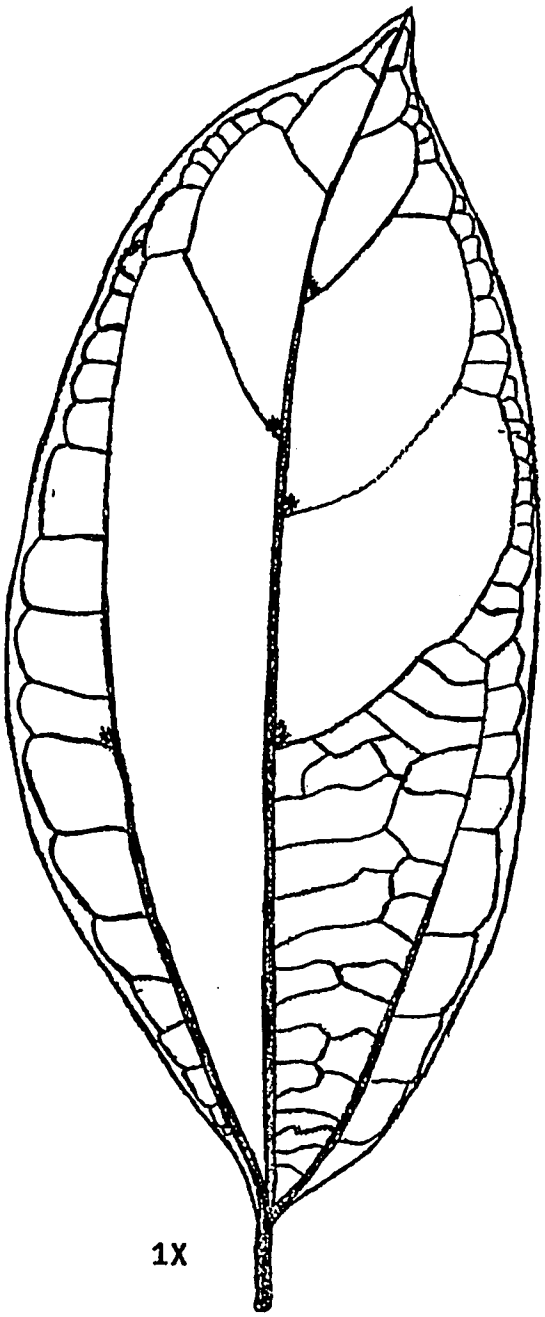
1X

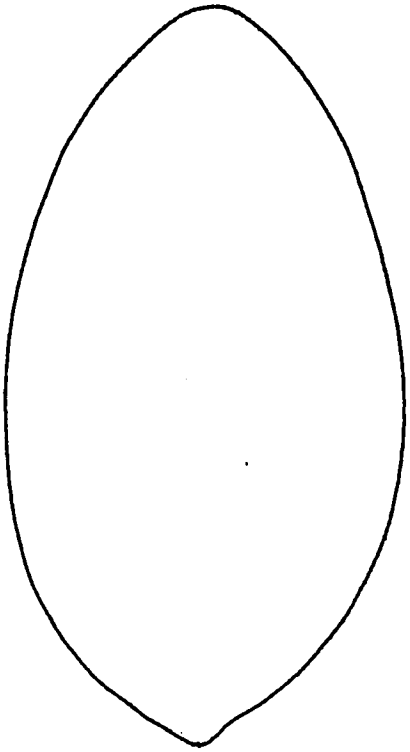
Average leaf image. BF = 15



Triplochiton scleroxylon

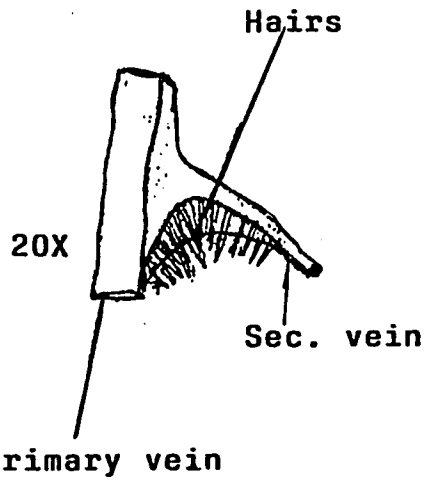
FIG. 199





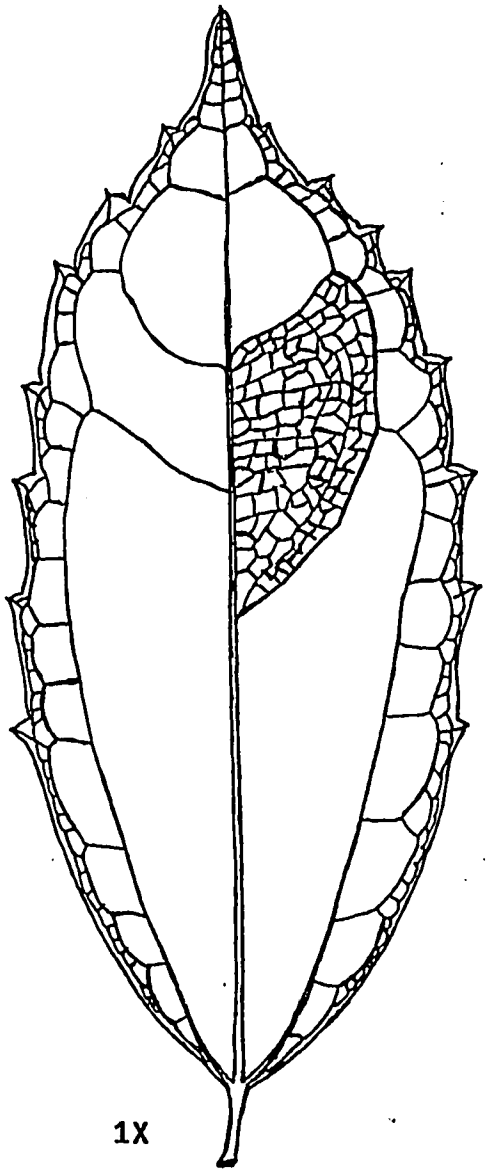
Average leaf image

BF = 15

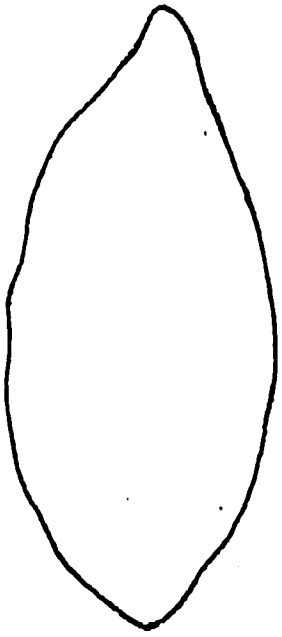


Celtis adolfi-friderici

FIG. 200



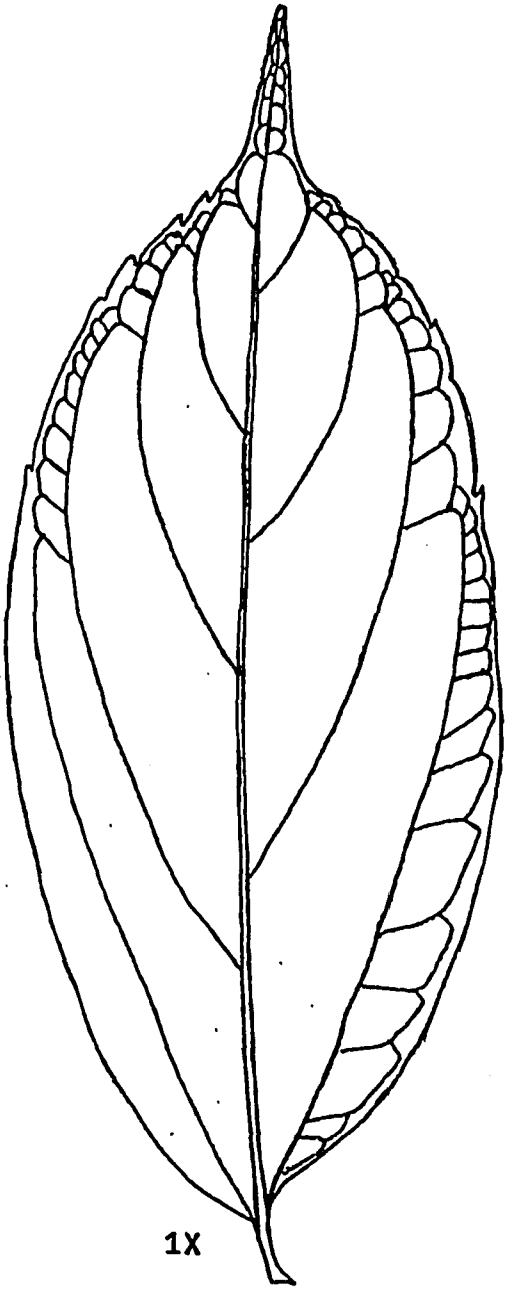
1X



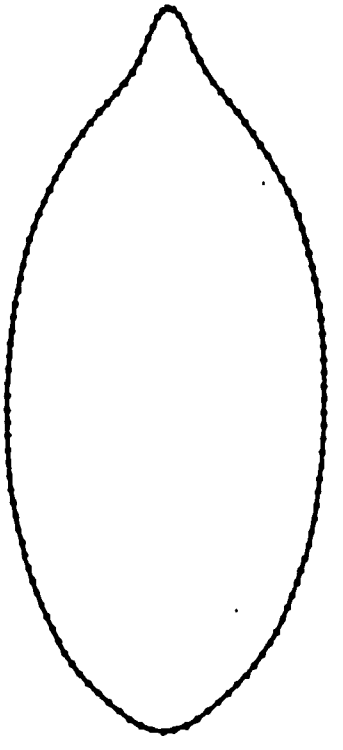
Average leaf image
BF = 15

Celtis brownii

FIG. 201



1X



Average leaf image
BF = 15

Celtis mildbraedii

FIG. 202

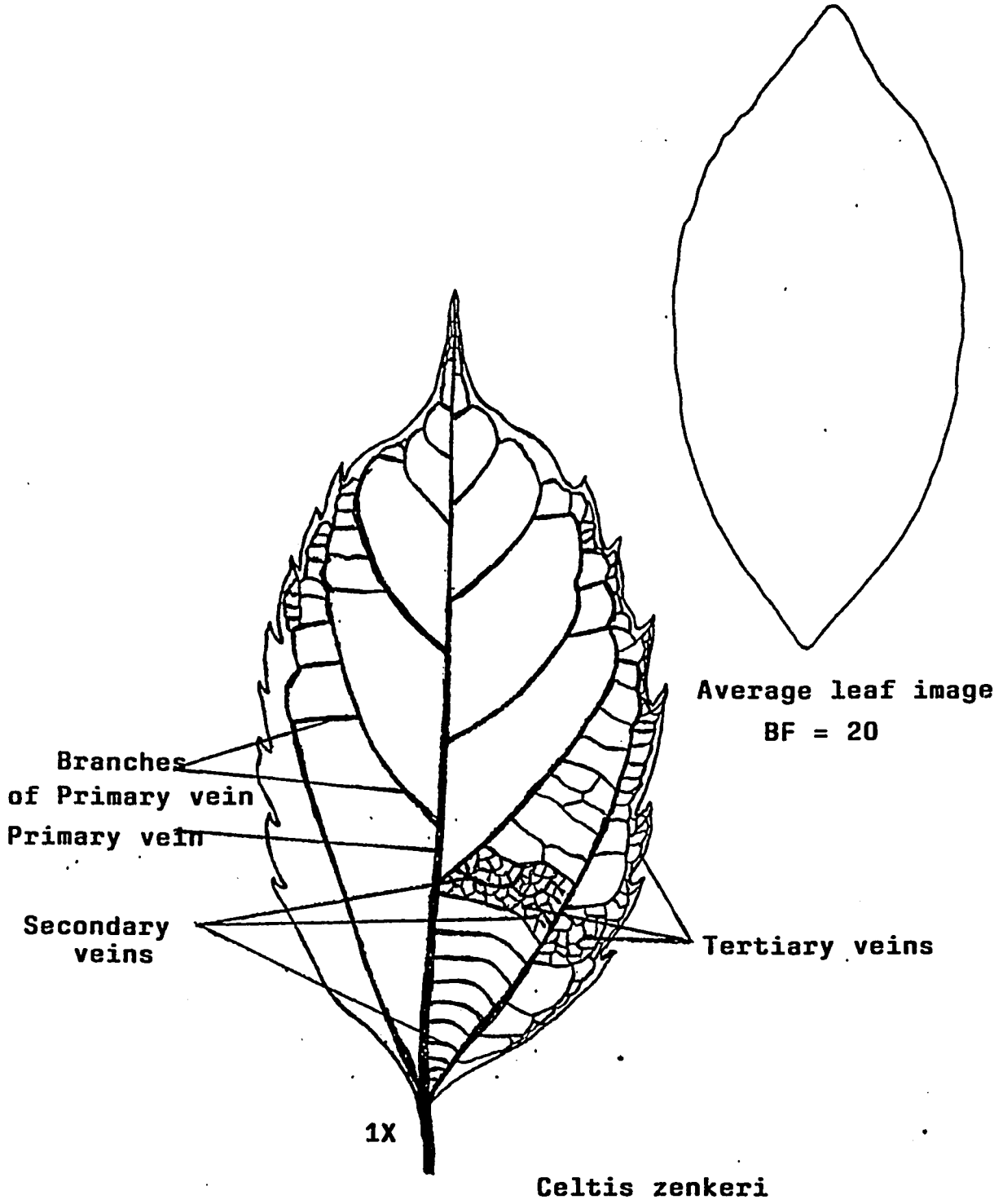
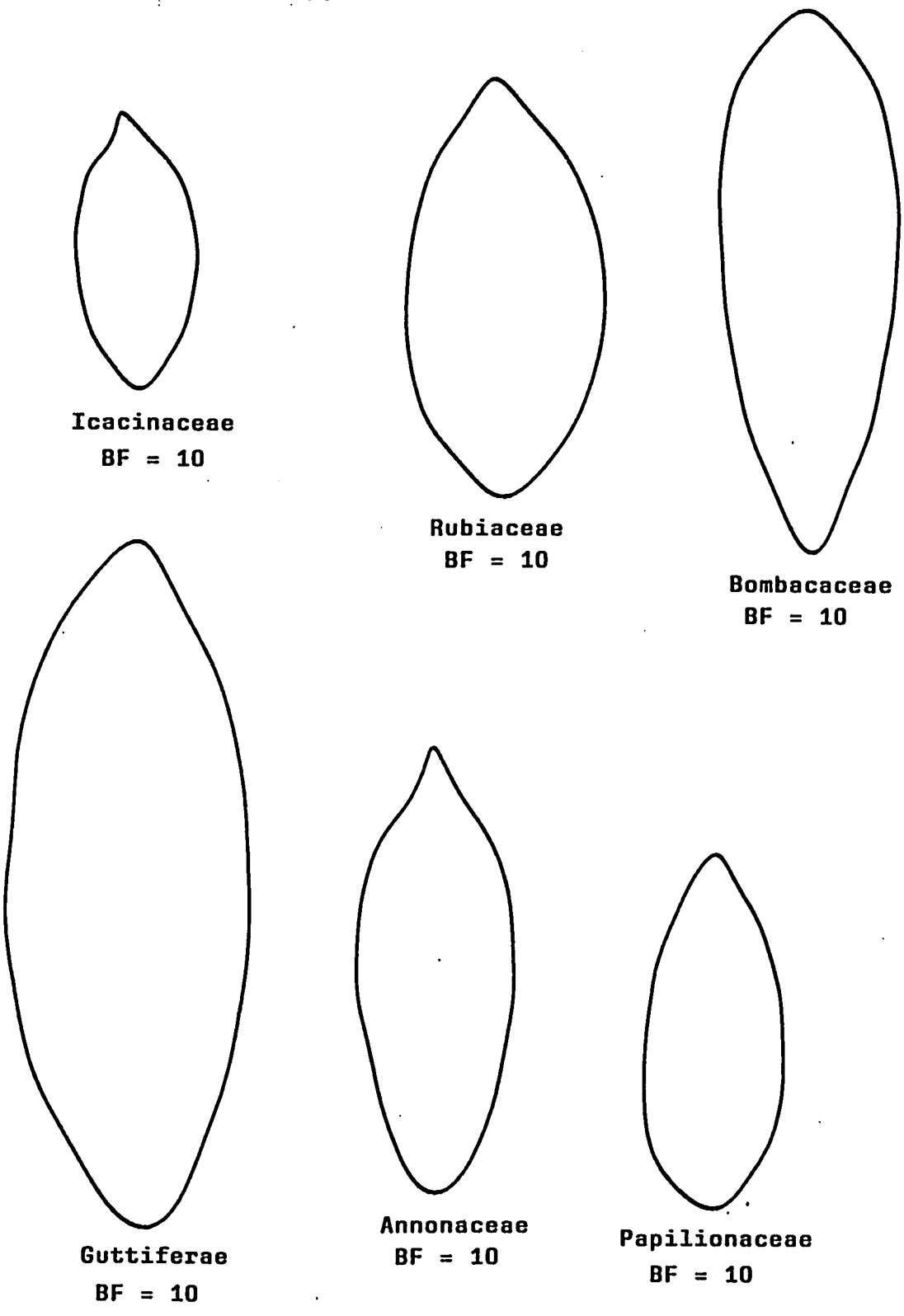

Average leaf image
BF = 20
Branches
of Primary vein
Primary vein
Secondary
veins
Tertiary veins
1X
Celtis zenkeri

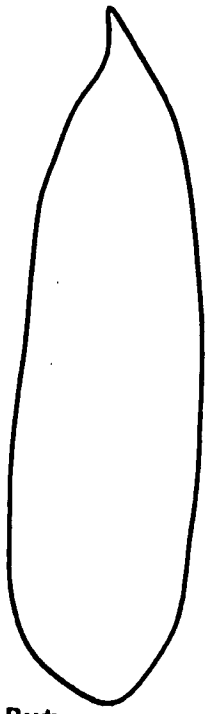
FIG. 203



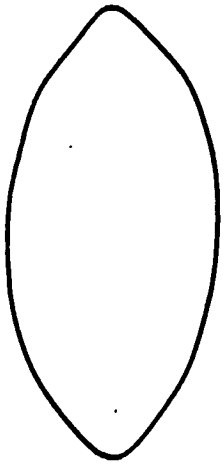
Leaf apices point upwards.

AVERAGE LEAF IMAGES FOR FAMILIES

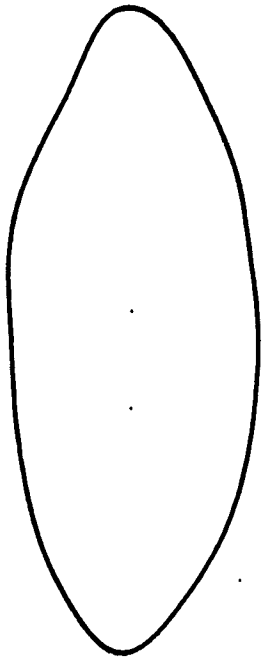
FIG. 204



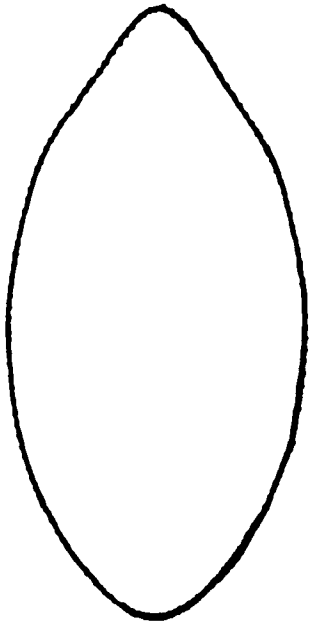
Rutaceae
BF = 10



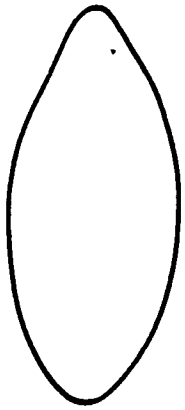
Sapindaceae
BF = 10



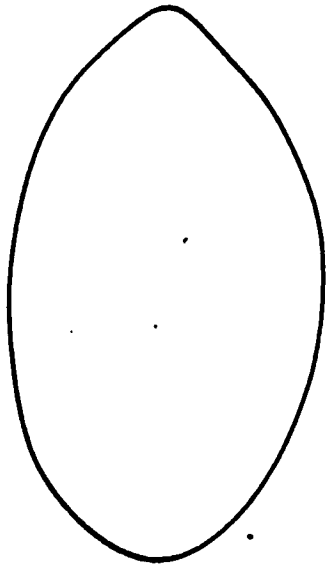
Mimosaceae
BF = 16.1



Ulmaceae
BF== 15



Caesalpiniaceae
BF = 10

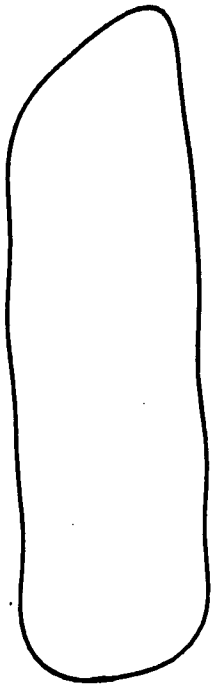


Moraceae
BF= = 10

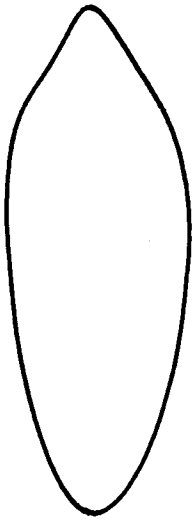
Leaf apices point upwards.

AVERAGE LEAF IMAGES FOR FAMILIES

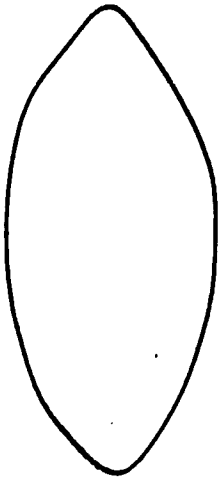
FIG. 205



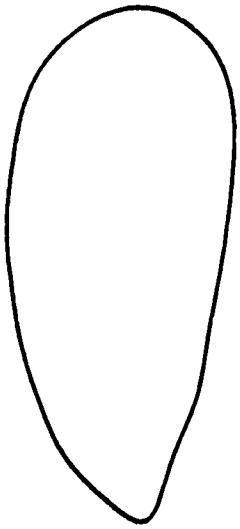
Myristicaceae
BF = .42



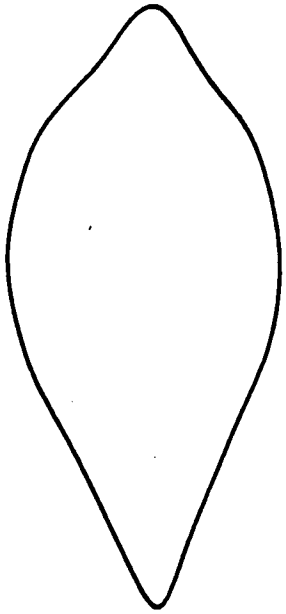
Sapotaceae
BF = 10



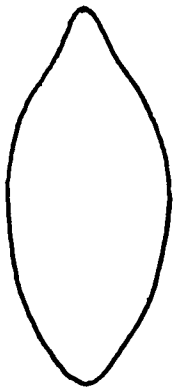
Bignoniaceae
BF = 10



Simaroubaceae
BF = 10



Lecythidaceae
BF = 10

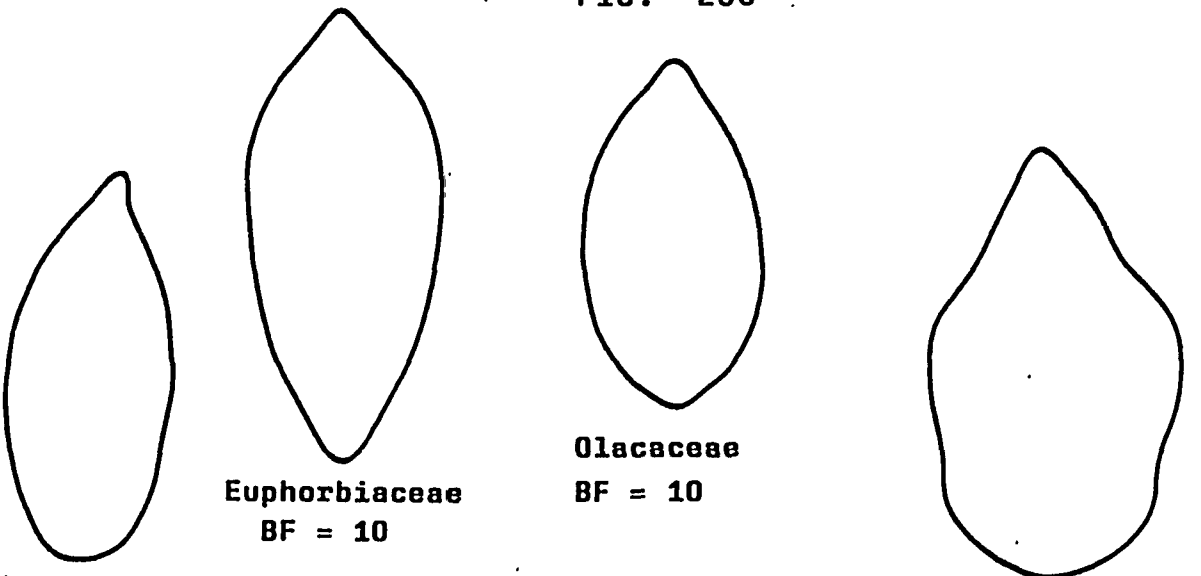


Ebenaceae
BF = 10

Leaf apices point upwards.

AVERAGE LEAF IMAGES FOR FAMILIES

FIG. 206

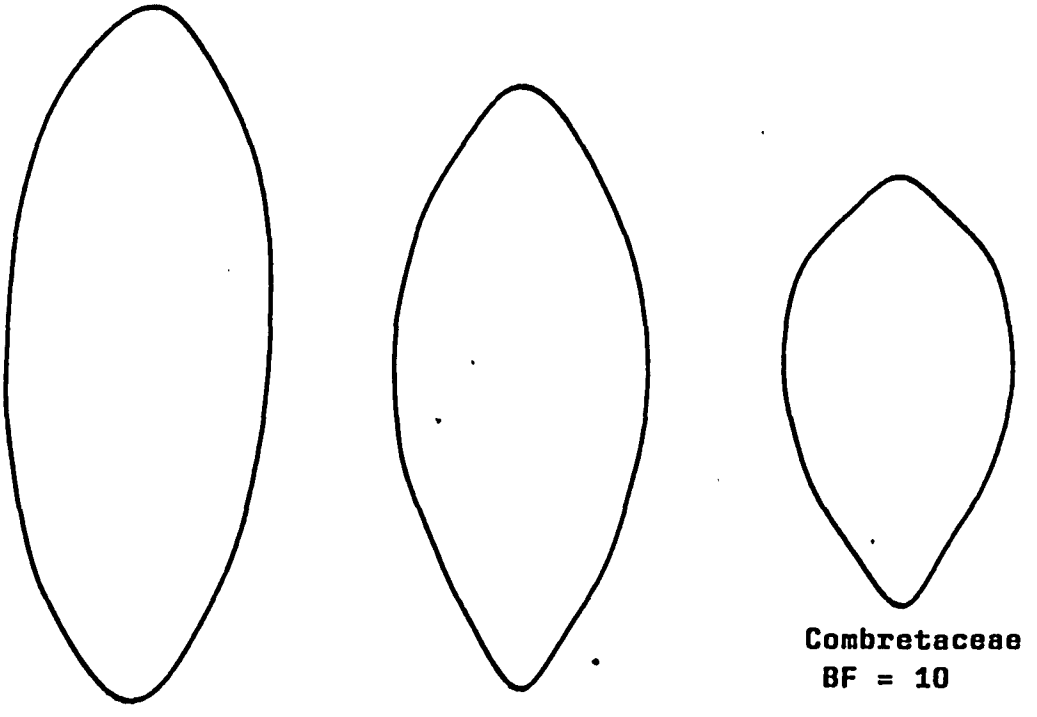


Anacardiaceae
BF = 10

Euphorbiaceae
BF = 10

Olacaceae
BF = 10

Sterculiaceae
BF = 10



Meliaceae
BF = 10

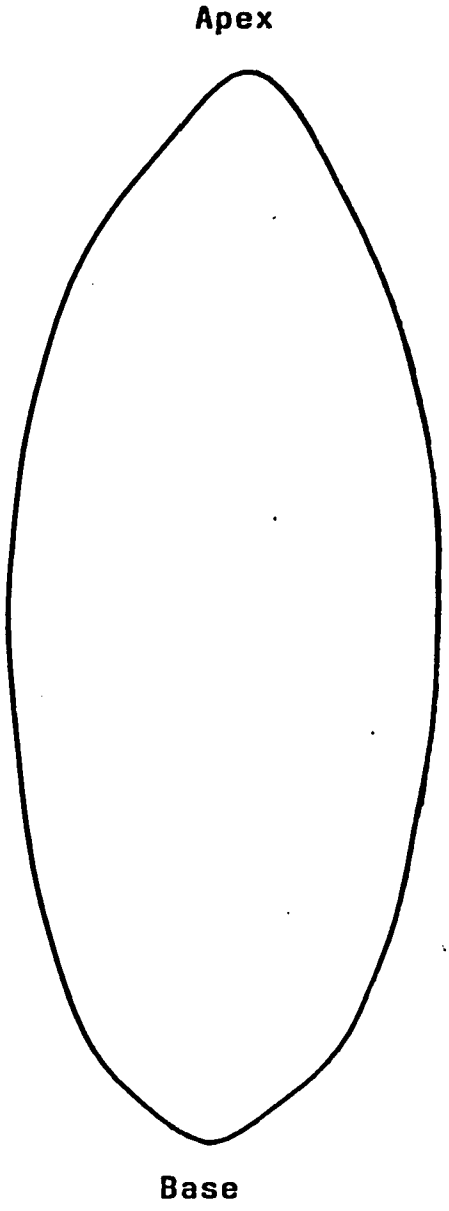
Apocynaceae
BF = 10

Combretaceae
BF = 10

Leaf apices point upwards.

AVERAGE LEAF IMAGES FOR FAMILIES

FIG. 207



AVERAGE LEAF IMAGE OF THE BOBIRI FOREST RESERVE
(For all the 104 species in the 1000 tree sample).

PLATE 1

The forest-savanna boundary at the foot of the Akwapim Hills near Aburi, Ghana. In the far distance is Accra, the capital. One can see short trees scattered among grasses, characteristic of savanna. The savanna of the Accra plains is a continuation of the Dahomey gap.



PLATE 2

2A----Deforestation of the previous lush forest of the Akwapim Ranges as a result of uncontrolled farming. There are no large trees left.

2B----This moist semi-deciduous forest has been extensively cleared for the cultivation of cocoa. The seedligs are nursed under the shade of banana trees.

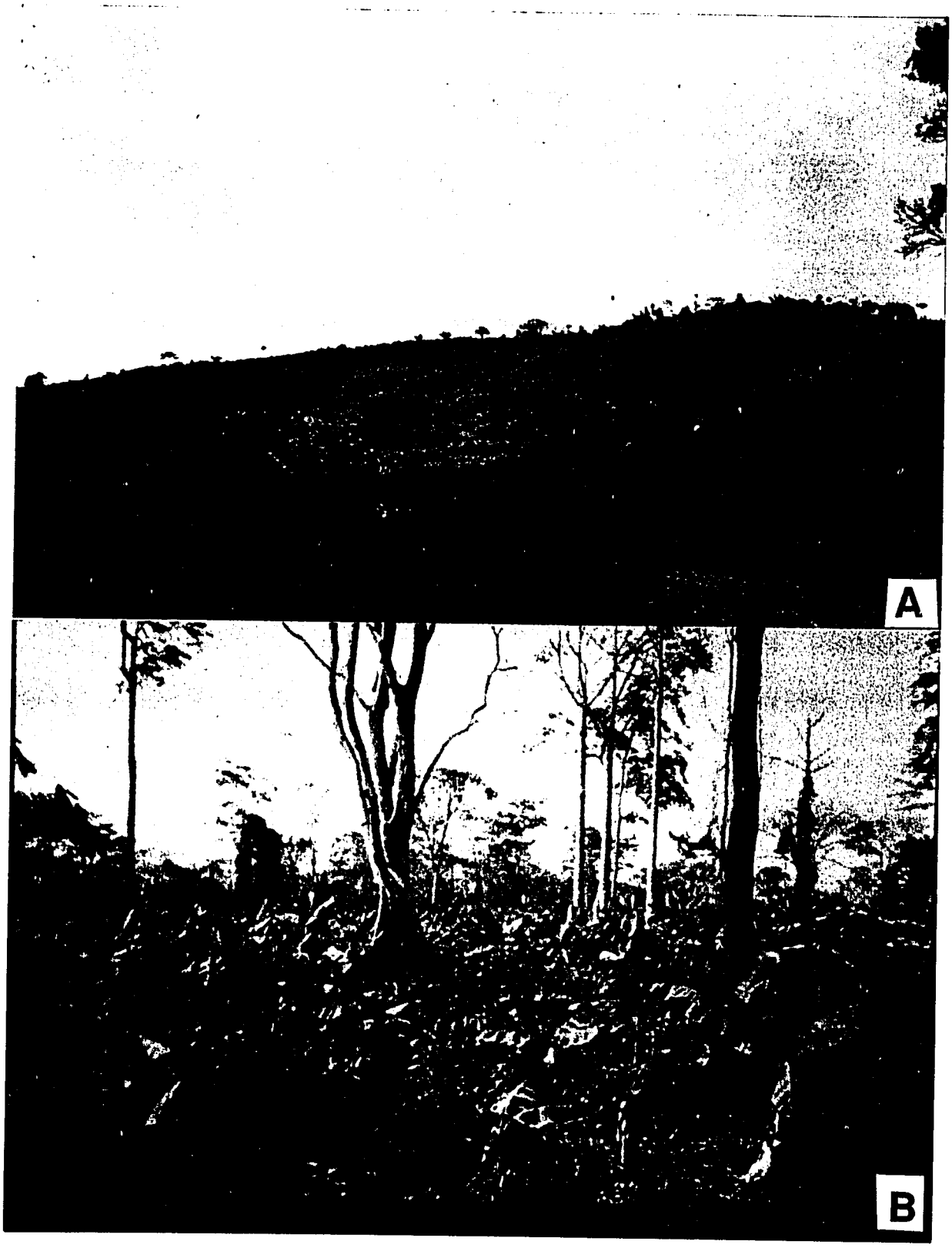

A
B

PLATE 3

3A----Slash and burn agriculture is a common farming practice in West Africa that results in the destruction of forest vegetation. This picture was taken in the semi-deciduous forest zone near Kumasi.

3B----Teak (*Tectona grandis*) cultivated as afforestation measure and for timber in the semi-deciduous forest of Ghana about 50 km from the Bobiri forest.


A

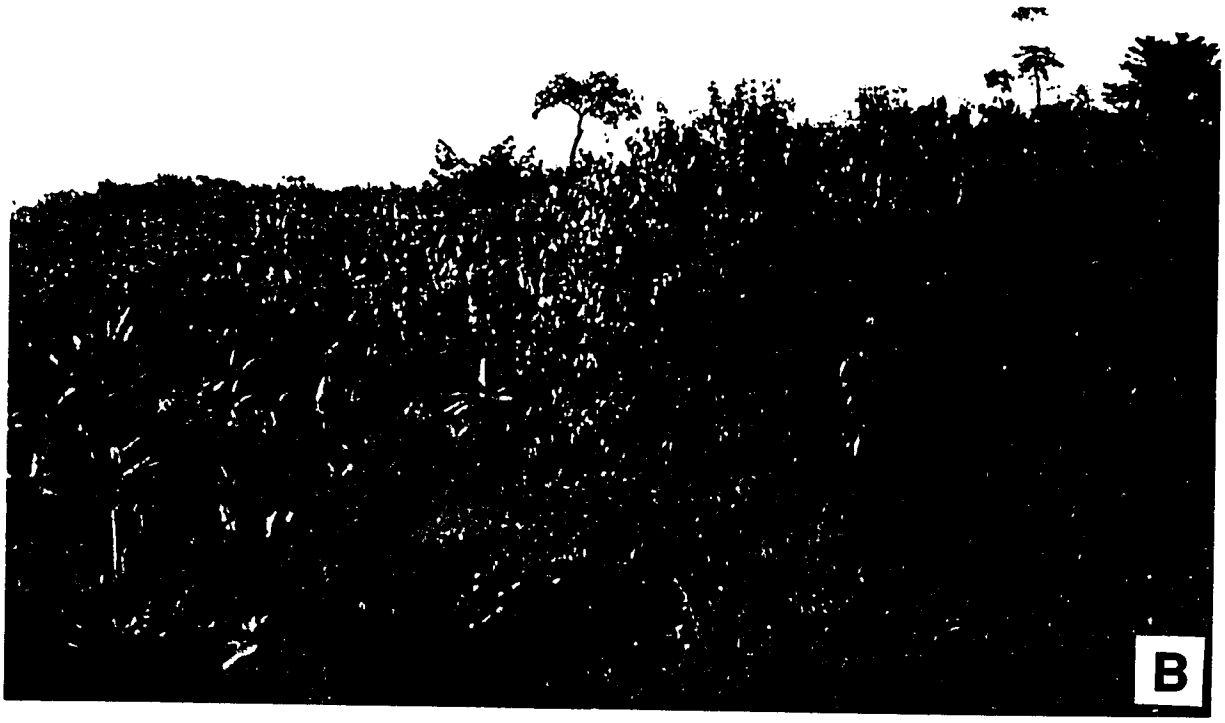

B

PLATE 4

4A & B----Some of the lianas that characterize the Bobiri forest. The lianas around the *Funtumia africana* tree in 4B made it difficult to study the tree. This was common along the transect.

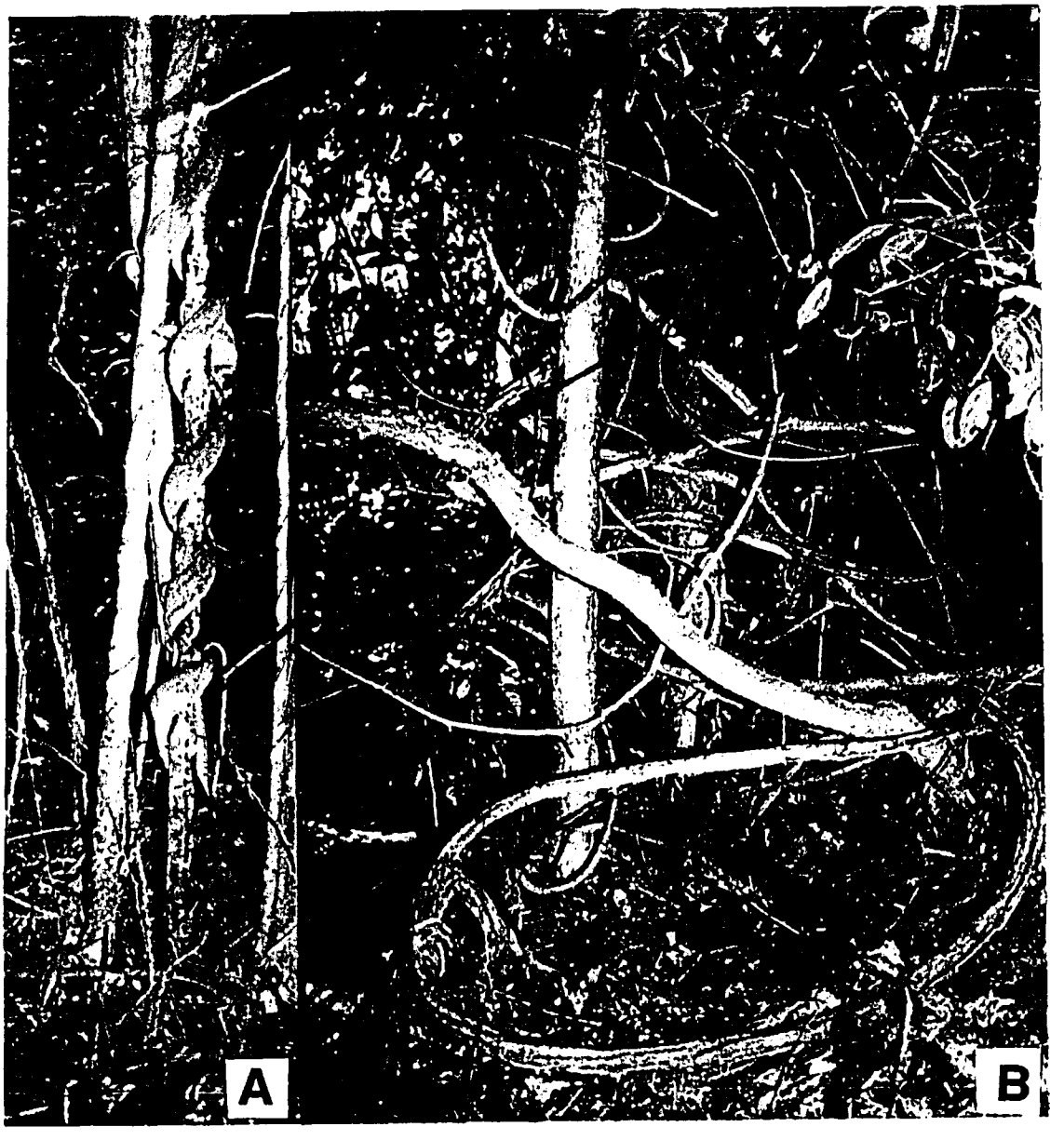

A
B

PLATE 5

5A & B----The lianas can grow and obstruct the expansion of tree crowns, but occasionally they fall to the ground and give room for the crown to grow (as is the case for the tree of *Pterygota macrophylla* in 5A).

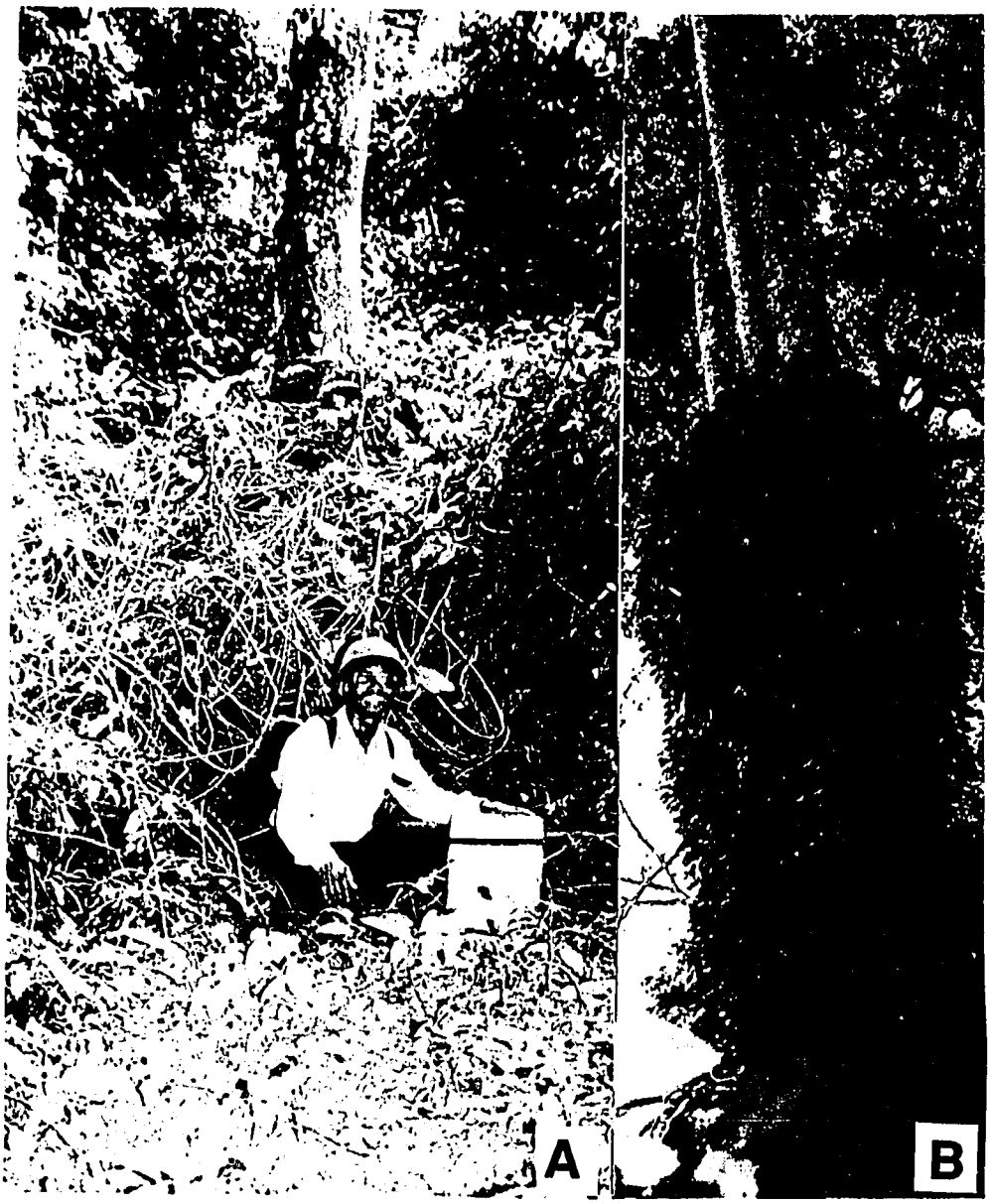

A
B

PLATE 6

6A-C----Lianas in the Bobiri forest contribute in creating the characteristic, impenetrable "jungle" of popular literature. Lianas are commonly used as rope and bathing sponge by local inhabitants.

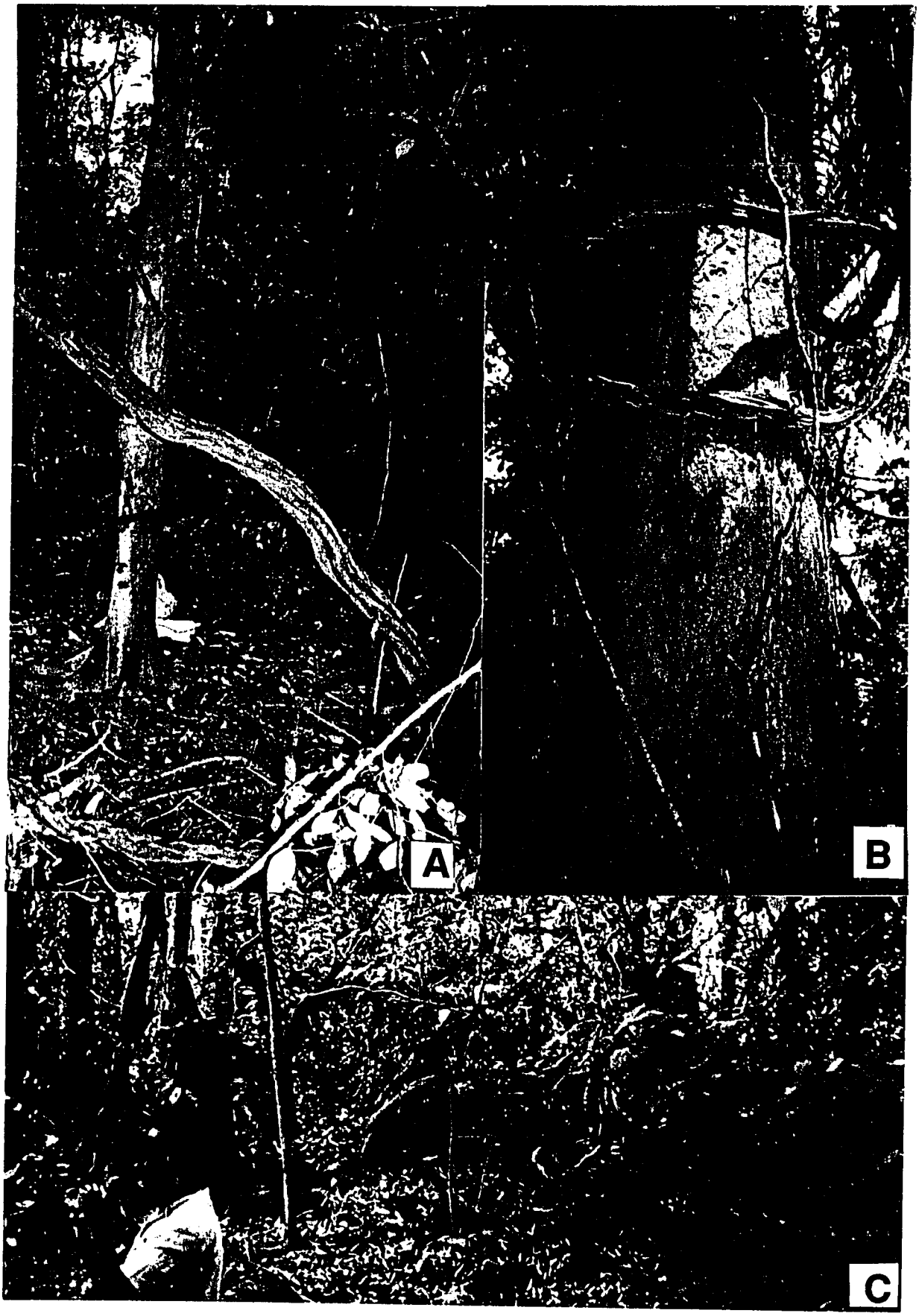

A
B
C

PLATE 7

7A----When the forest is relatively undisturbed , tree crowns and associated vines block sunlight and give little chance for undergrowth.

7B----When the trees are cut and the forest floor is exposed to sunlight, weeds, shrubs, and seedlings spring up (as on the left in photograph); the adjacent area in darkness still has little undergrowth.


A
B

PLATE 8

8A----*Olyra latifolia* is the main grass that thrives in the understory of the Bobiri forest (as well as in most forests in Ghana---Hall and Swaine, 1981).

8B & C----Species of Marantaceae (8B) and *Costus spp.* (8C) are among the other herbaceous plants that grow where the Bobiri forest is more open.


A
C

Major disturbances in the Bobiri forest----PLATES 9-11

PLATE 9

9A-Creation of a forest gap----A fallen *Triplochiton scleroxylon* has broken the branches of an adjacent *Pterygota macrocarpa.*

9B---- Gap in forest after a tree fall. This gap has not regenerated even after the passage of considerable time as evidenced by the decayed trunk.

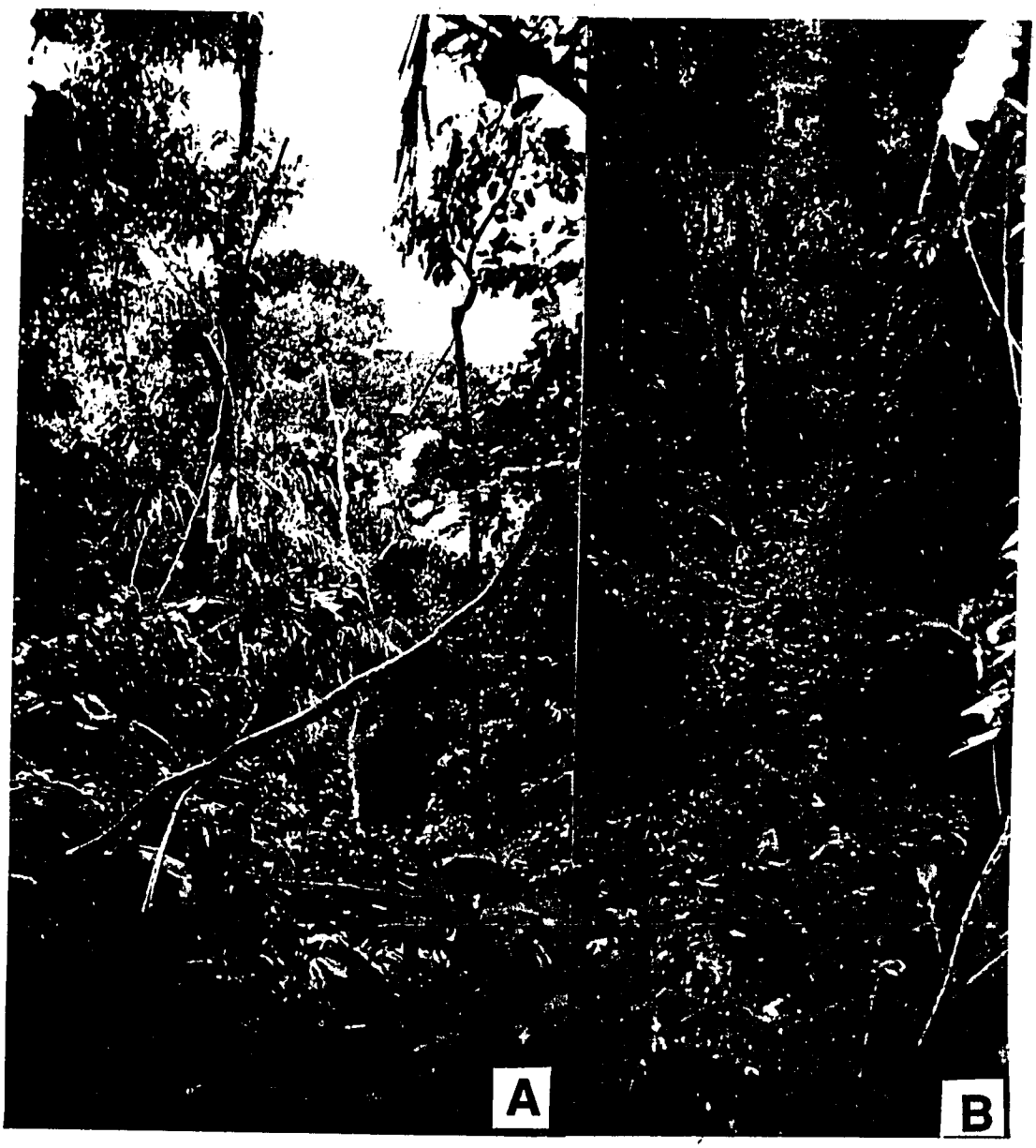

A
B

PLATE 10

10A----Use of the forest for local industry (distillation of alcohol) in the Bobiri forest has deprived the area of even herbs.

10B----Construction of trails and constant trampling along farm roads encourages the growth of weeds and grasses.


A
B

PLATE 11

11A----Construction of highways through the forest destroys trees and encourages further deforestation through anthropogenic activities.

11B----Extensive deforestation near Kubease village because of overcultivation and animal grazing. Only fast-growing weeds like *Eupatorium odoratum* and grasses thrive around this weather station near to the Bobiri forest.


A


B

PLATE 12

12A----Roads for timber trucks and repeated farming permits only shrubs like *Alchornea cordilfolia* to grow along this road to the Bobiri forest.

12B----Inhabitants of Kubease village carrying home firewood from the Bobiri forest. Unrestrained use of forest trees as fuelwood depletes the forest of large trees.

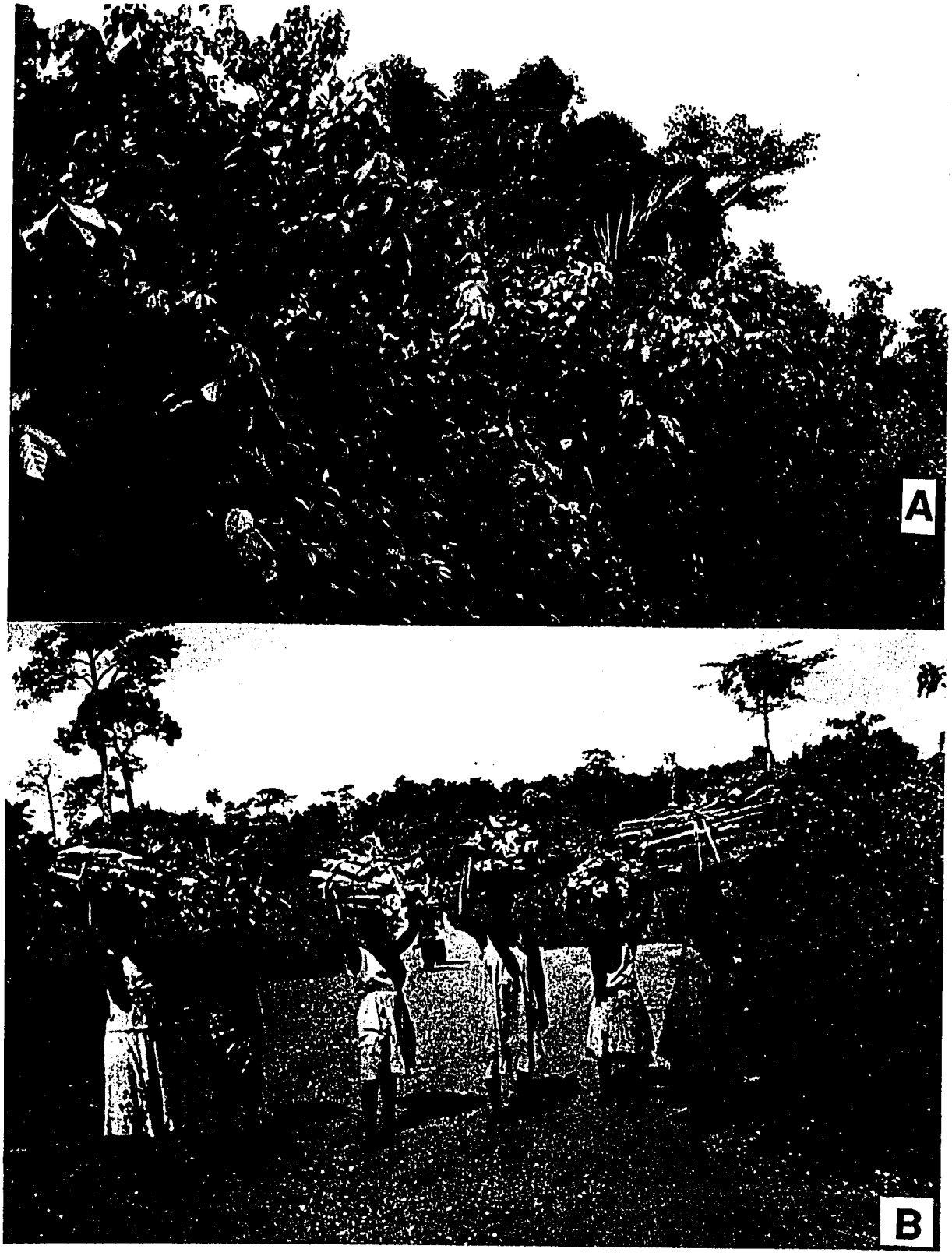

A
B

PLATE 13

Indescriminate cultivation of crops along the borders of the Bobiri reserve results in farmers destroying trees and unlawfully invading the reserve.



PLATE 14

14A----The official residence and research center for the ranger and his assistants in Kubease village which is next to the Bobiri forest.

14B----Research post in the Bobiri forest used in the past by the Botany Dept. of Oxford University (UK) and other botanists during studies of this forest

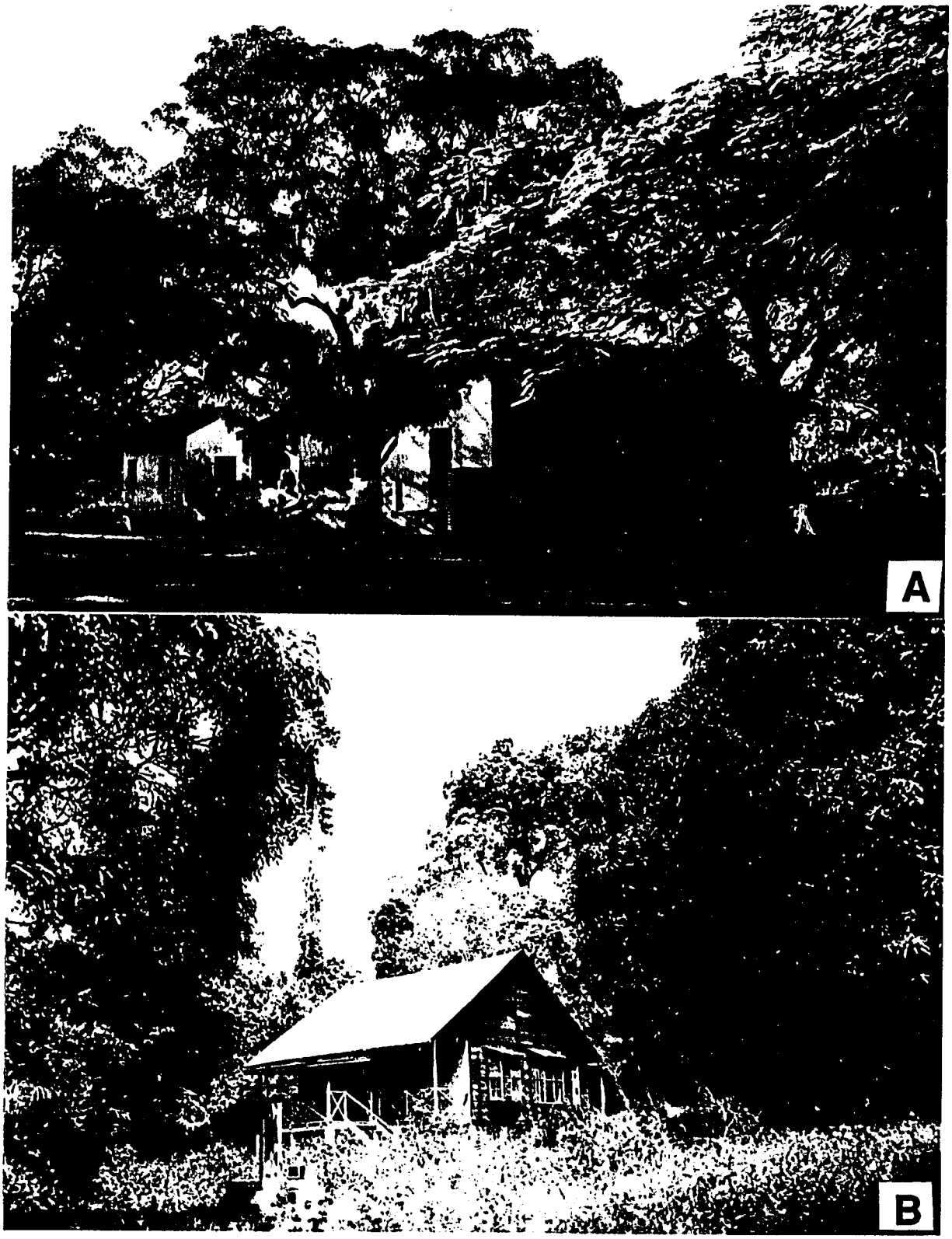

A
B

PLATE 15

15A----The Bobiri River (in the wet season) after which the Bobiri forest was named.

15B---- The very dry harmattan winds in December-February dries up several sections of the Bobiri River downstream.

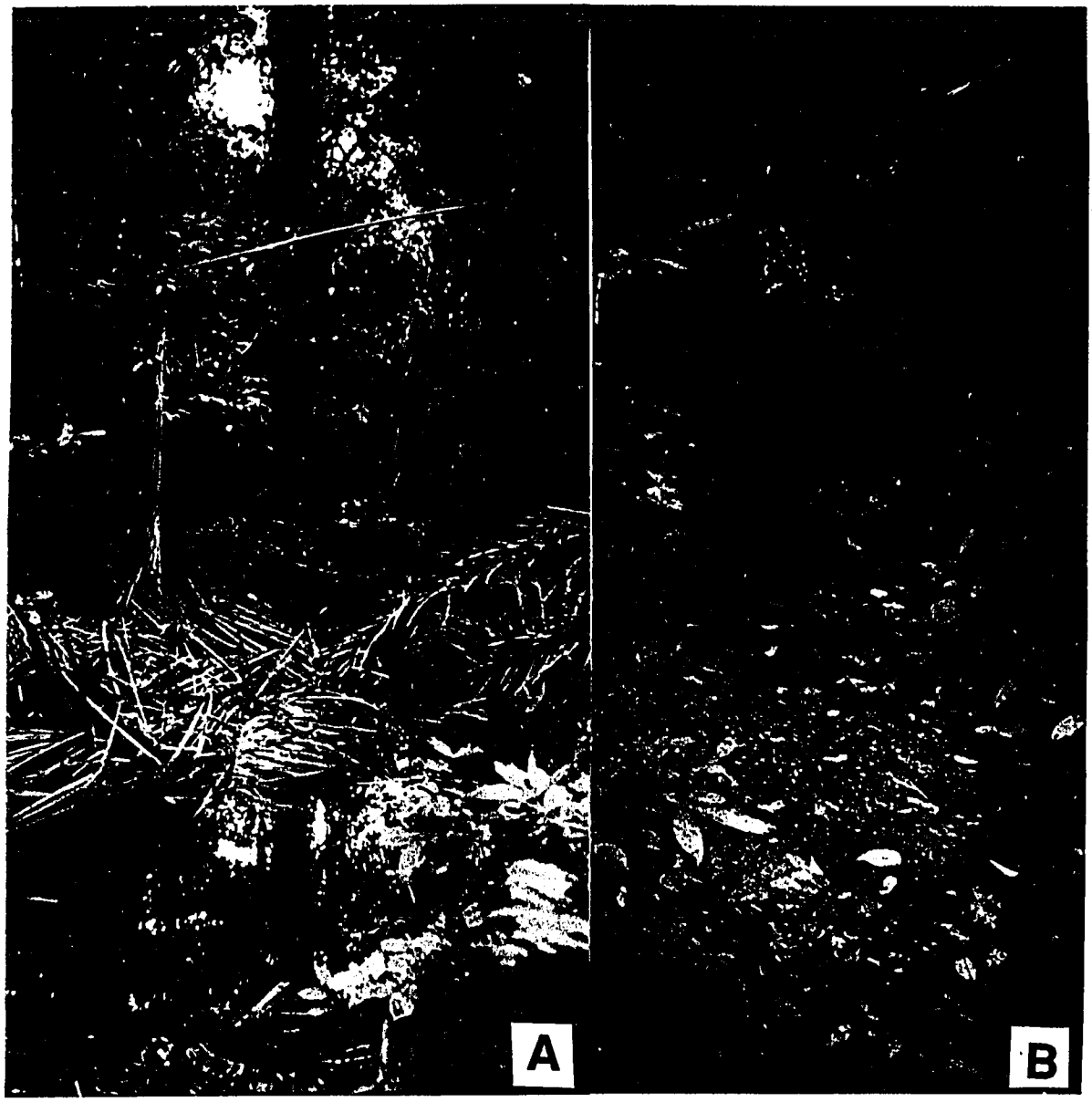

A
B

PLATE 16

Climbing spikes were used to gain access to leaves in the Bobiri reserve during the collection of leaves of the 1000 tree sample.



PLATE 17

17A----Trunk of *Khaya senegalensis* which is extensively fluted as a result of repeated debarking for medicinal purposes along a principal street of Accra, Ghana

17B----A normal, unfluted trunk of *Khaya senegalensis* on the campus of the University of Ghana, Accra.


A
B

PLATE 18

Profile of a relatively undisturbed section of the Bobiri forest showing different heights of mature trees.

Trees in the photograph are :

Triplochiton scleroxylon ----1, 7, 10

Cola gigantea----2, 8

Guarea cedrata----3

Nesogordonia papaverifera----4

Aningeria robusta----5

Antrocaryon micraster----6

Amphimas pterocarpoides----9


1
2
3
4
5
6
7
8
9
10

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