TIMBER UTILIZATION BY UPPER ZAIRIAN CRAFTSMEN

by

John Frederick Carrington M.Sc.(Reading), Ph.D.(London)

A thesis submitted for the degree of Doctor of Philosophy of the University of London and for the Diploma of Membership of the Imperial College.

Timber Technology Section,
Botany Department,
Imperial College,
London S.W.7.

ABSTRACT

People of the Olombo, Lokele and other human groups living in the Upper Zaire (Central Africa) have a detailed knowledge of their rain-forest environment, many of whose species are named in the local languages and classified according to a traditional system. Earlier descriptions by Western authors of these plant-names and taxonomies are sometimes erroneous because they fail to appreciate their semantic value. It is only when this is understood that the classificatory systems used by such peoples can be properly assessed.

Men of these groups are skilled craftsmen in wood, following traditional knowledge in choosing timbers for the various artefacts which they produce for village usage. Six timbers are here selected for detailed study: Alstonia congensis Engl. (shields, resonating instruments)
Combretodendron macrocarpum (P.Beauv.) Keay (axe-hafts)
Gossweilerodendron balsamiferum (Vermoesen) Harms (large canoes)
Musanga cecropioides R.Br. (small canoes, net-floats)
Pterocarpus soyauxii Taub. (talking-drums)
Staudtia gabonensis Warb. (canoe paddles).
An attempt is made to vindicate craftsmen's choice of timbers for these artefacts.

Investigations into anatomical structure as shown by the light microscope and the S.E.M. are presented to show tissue distribution within the xylem and also vessel net-work and an attempt is made to correlate these anatomical features with timber properties as measured by micro-methods developed for the small amounts of material available: a static beam method and a dynamic vibrational method for measuring Young's Modulus of elasticity, an apparatus using a falling ping-pong ball to assess surface hardness and a falling dart method to assess penetrability. Much variability was encountered which tended to vitiate the results obtained by such micro-tests, though ways of overcoming this are suggested.

Traditional usage of these six timbers can be explained partly by their anatomical features: the quantity and distribution of xylem (microscopic features), and partly by a careful choice of timber sample on the part of the craftsman according to the position of the wood in the tree (macroscopic features).

Modern wood technology in the western world is interested in a homogeneous timber which can be treated in a controlled manner to produce material of differing qualities destined for specific uses. But there is still a demand, especially in developing countries like Zaire, for the variable timbers available in the tropical forests. Studies of tradition-

al usage can indicate valuable species not yet commercially exploited, provided such investigations are made by workers able to communicate adequately with local craftsmen, i.e. who are familiar with the culture and languages of the human groups concerned.

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My thanks are also due to the Dean of the Faculty of Biological Science at the Université Nationale du Zaïre (Dr Mulamba Wawa) who allowed me to carry out some anatomical investigations in his laboratory during a visit made to Kisangani in 1977. Staff of the Princes Risborough laboratory kindly provided me with recent information on the physical constants of tropical timbers as well as giving me much appreciated bibliographical assistance.

The work could not have been undertaken without the help of many skilled Zaïrian craftsmen who were always ready to answer my questions about their work and their culture. Nor could it have been carried through without the forbearance and patience of my wife.

...

NOTATION

Linnean binomials are underlined in the usual way in this study.

Words and texts in African languages (except for commercially accepted timber names) are printed within strokes: /botumbe/ - the Olombo name for Musanga cecropioides R.Br.

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P L A T E S

1 /likwengu/ used by Lokele and other Upper Zaïrean groups ; XS Alstonia, Combretodendron, Gossweilerodendron, Musanga.

2 Pterocarpus: drum and canoe-chair artefacts; XS xylem.

3 Pterocarpus: RS xylem; SEM photos of xylem (XS).

4 Staudtia: fibre penetration of ray tissues.

5 Staudtia: SEM photos of vessel perforations and pitting.

6 Mateus apparatus; resonance apparatus; pingpong test for surface hardness.

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1. INTRODUCTION

The present study has been pursued with three aims in view:

a. to make a contribution to the expanding corpus of ethnobotanical investigations in developing countries with special reference to the Upper Zaire where little work of this nature has so far been done. The thesis is developed that ethnobotanical studies involving assessments of folk taxonomies can only be satisfactorily done by workers possessing an intimate knowledge of the language as well as of the general culture of the people whose botanical lore is being investigated;

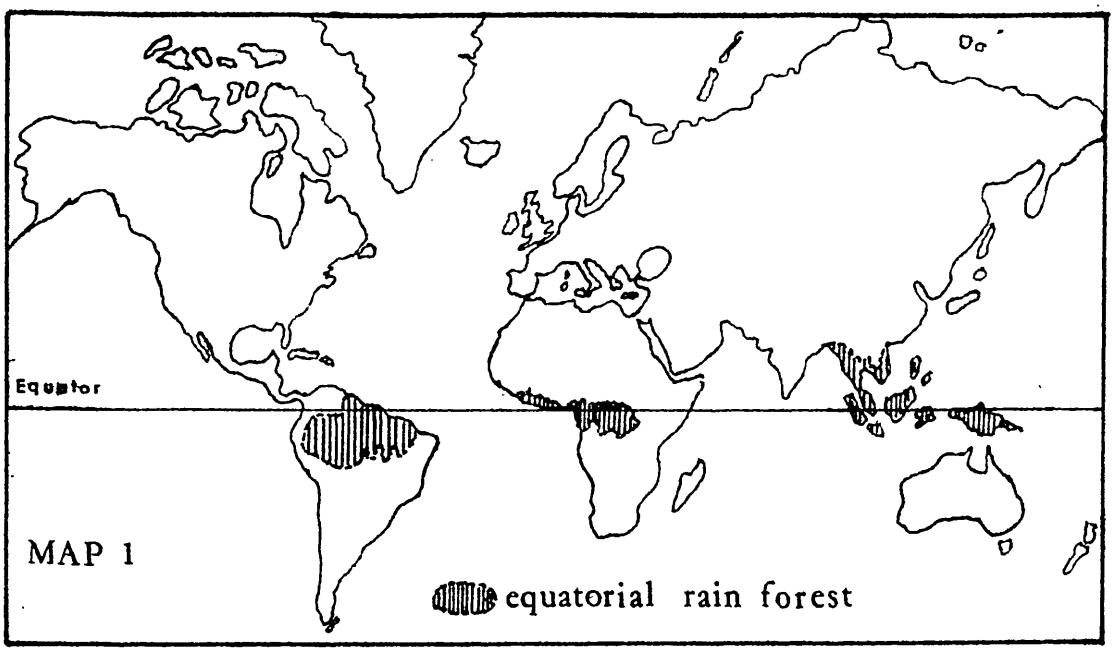
b. to attempt to answer the question: How far can traditional timber choice for specific purposes by Upper Zairian craftsmen be vindicated by the anatomical structure and the physical properties of the woods they choose?

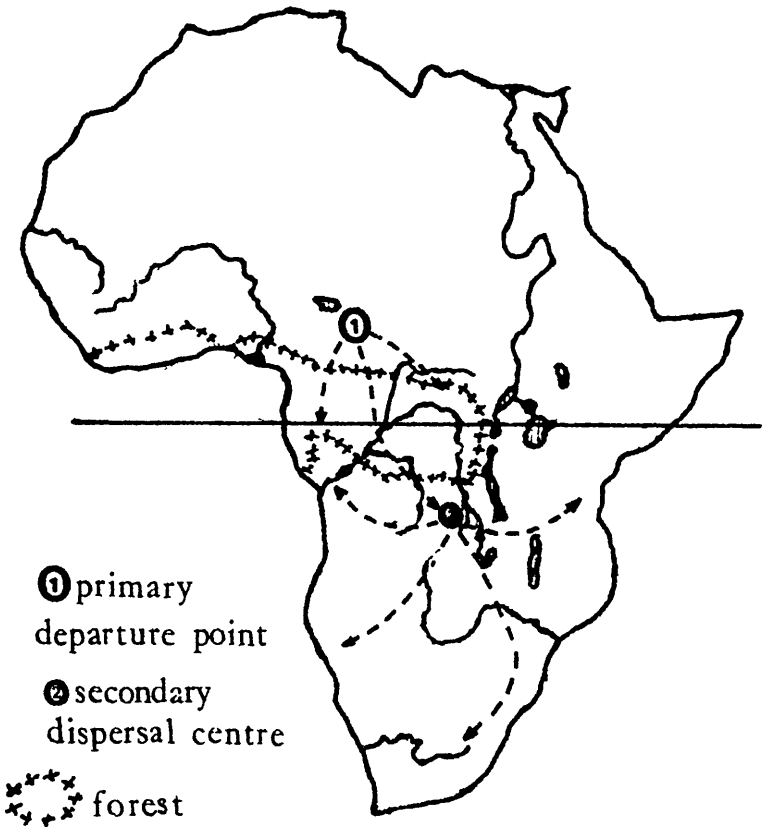
c. to answer the further question: Can traditional usage of wood by local populations in the African forest indicate possible industrial uses for secondary timber species?

In Part I we shall first give a brief account of the geographical setting of the investigation as well as present-day ideas about the early history of the territory inhabited by populations whose ethnobotanical knowledge is being appreciated. This will be followed by an account of ethnobotanical studies already published with special reference to work done in the Upper Zaire.

In Part II investigations into the anatomical structure of six timbers used by craftsmen in the Upper Zaire will be described.

The results of investigations into some physical properties of these same six timbers will be given in Part III, and in Part IV an attempt will be made to correlate physical properties and anatomical structure so as to appraise the traditional choice of timbers by Zairian crafts- for their several uses.





MAP 2 BANTU MIGRATION

Part I. ETHNOGRAPHY AND ETHNOBOTANY OF THE UPPER ZAIRE

2. The Upper Zaire and its human populations.

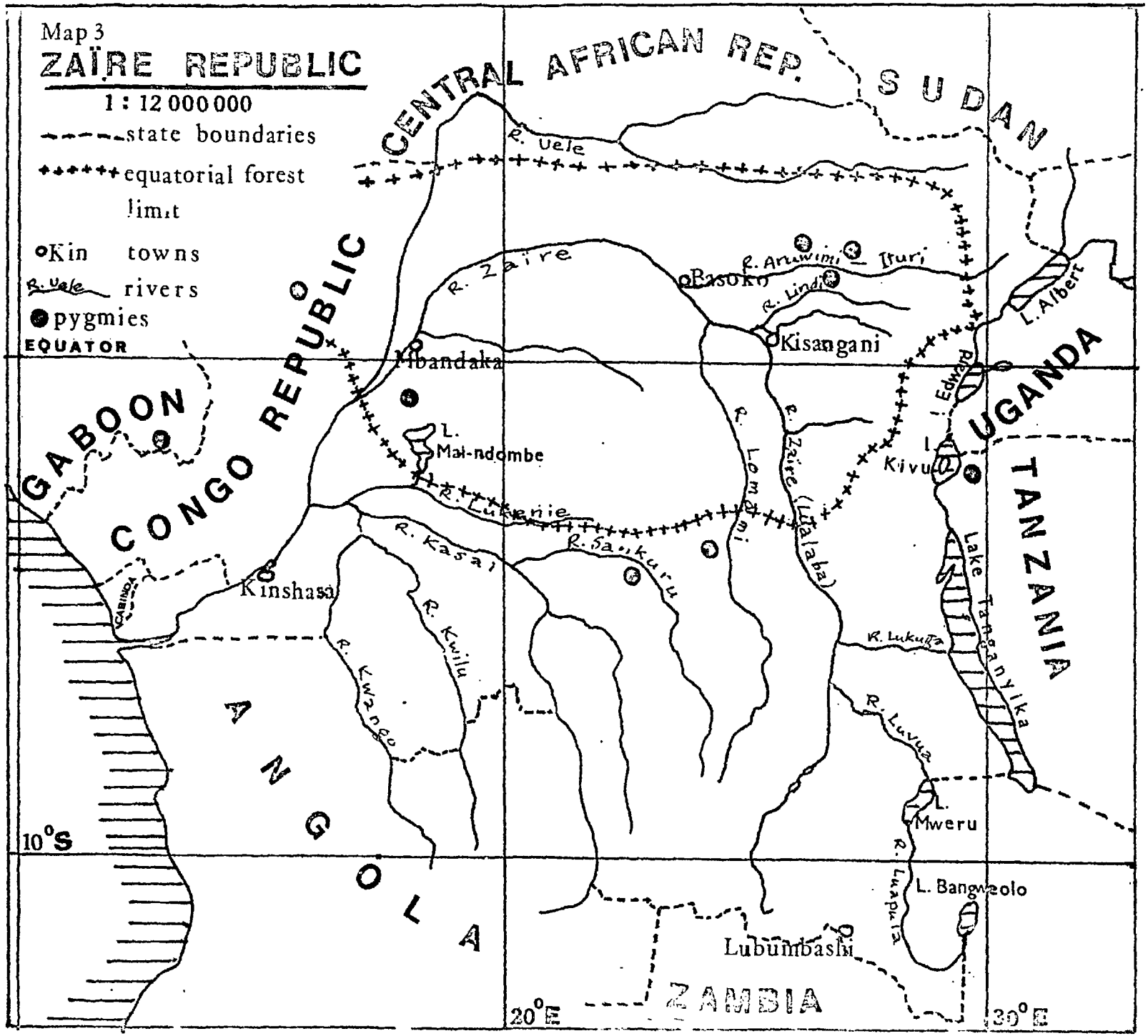
2.1 The geographical setting.

Central African vegetation comprises part of the equatorial forest belt that encircles the globe (Map 1). Though not the largest of such areas in the world and by no means possessing the largest number of species, the African equatorial forest occupies some 90 x 10^6 hectares at the present time. (Persson, 1974). More than 60% of the African equatorial forest is found in the Zaïre Republic where it occupies the central depression ("la cuvette centrale" of francophone authors) which probably represents the site of a huge lake formerly covering Central Africa in ancient times. This saucer-like depression is surrounded by a rim of high ground with the Crystal Mountains in the West (1000 m) and the Mountains of the Moon in the East (up to 5000 m). It is believed that erosion of the East and West flanks of the Crystal Mountains by rain led to a breach in the rim around the central lake so that this gradually drained into the Atlantic Ocean, a process that is continuing at the present time. With the drying out of the lake bed, this became covered with vegetation that proceeded to the Equatorial forest climax under the climatic and edaphic conditions of the centre of the continent. Savannah is found in the North and South where rainfall is less, with galeries of forest running along water-courses that drain into the central river system. This savannah is typically "orchard savannah" with Brachystegia species in the South and Lophira lanceolata Van Tieg. ex Keay. in the North (Lebrun et Gilbert, 1954). Around large human settlements, climax forest has been replaced by secondary formations. In the area near Kinshasa and Kisangani, forest burning for farming and charcoal production appears to have reduced the vegetation cover to permanent grass-land (Carrington, 1968).

2.2 Prehistory.

The prehistory of Central Africa is still only sketchily known. Stone artefacts have been found in the Kinshasa area, around the lake-like enlargement of the river just before it falls over the first of the cataracts in the Lower Zaïre region. Cleavers, points and massive hand-axes characteristic of this site have been grouped into a Lupemban culture and dated by the C^{14} method to 30,000 B P (Van Moorsel, 1944). A later industry, with very small arrow-heads, dated at only 6,500BP and called Tshitolian has been found at Kinshasa in sand deposits covering the Lupemban industry, as well as at other sites in the Republic. (Bena Tshitolo is the name of a plateau near Kananga where the first micro-lithic discoveries were made.)

Populations with a hunting-and-gathering culture similar to what must have

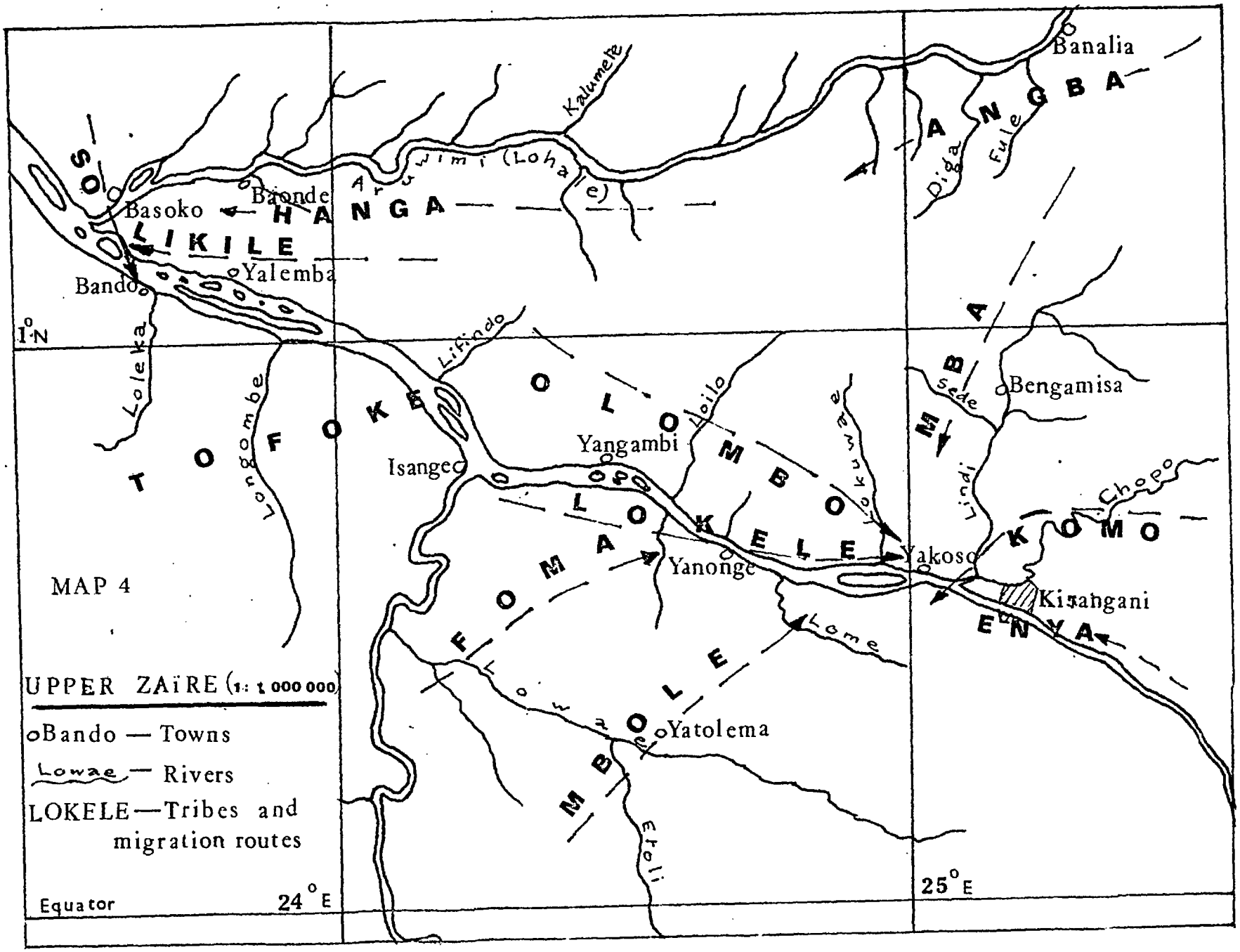

Map 3
ZAÏRE REPUBLIC
1 : 12 000 000
state boundaries
equatorial forest limit
Kin towns
R. Uele rivers
pygmies
EQUATOR
CENTRAL AFRICAN REP.
SUDAN
R. Uele
R. Zaire
R. Aruwimi
Ituri
Basoko
R. Lindi
Kisangani
L. Albert
Ybandaka
GABOON
CONGO REPUBLIC
L. Mai-ndombe
R. Lukenie
R. Kasai
R. Sankuru
R. Lomami
R. Zaire (Lualaba)
L. Edward
L. Kivu
UGANDA
TANZANIA
Lake Tanganyika
Kinshasa
CABINDA
R. Kwilu
R. Kwango
R. Lukuga
R. Luvua
L. Mweru
R. Luapula
L. Bangweolo
ANGOLA
Lubumbashi
ZAMBIA
10°S
20°E
30°E

been characteristic of the Lupemban-Tshitolian peoples are still to be found in this part of the African continent: the small, isolated groups of pygmies and pygmoids living in the equatorial rain forest (Map 3). They have various methods of hunting but all are nomadic, living in temporary camps, with huts made of bent forest branches stuck in the ground, tied together with lianas and covered with large leaves such as those of Sclerosperma and Sarcophrynium. They practise no agriculture though they consume plantain bananas, manioc, maize and sweet potatoes which they obtain from neighbouring farmers by exchanging their meat for garden produce. Since survival has depended for thousands of years on successful adaptation to their forest environment (they probably lived also in the savannah country before the negro invasions of the past thousand years), the pygmies have an intimate knowledge of plant and animal biology.

Pygmy groups are necessarily small. Subsistence in a hunting-and-gathering community needs a much larger terrain per person than in an agricultural or industrial society. The estimated pygmy population in the Ituri has been published as 35,000. This figure should be compared with that given in a recent census of population in the Zaire Republic: 21,637,776. The present-day confinement of the small pygmy groups to discrete forest localities has been explained as a retreat by them into relatively inaccessible positions before invading agricultural and pastoral populations.

Linguistic and cultural studies have shown that there was a remarkably vigorous and far-reaching expansion of Bantu-speaking and other negro peoples from territory between Lake Chad and the Cameroons some time towards the end of the first millenium of our era (Map 2). These peoples travelled South and East through and around the equatorial forest, taking with them a knowledge of iron working and also new agricultural techniques based on yams, millet, sorghum, eleusine (indigenous African crops) as well as on plantain bananas and taro (introduced from the Far East). Some authors have suggested that these plants came into the continent via Ethiopia; others prefer to postulate Madagascar and the East Coast as the route of introduction of bananas and taro. Advance groups of the Bantu-speakers are believed to have penetrated into the equatorial forest from the North, using canoes along water-courses leading to the heart of the forest area and then proceeding in the same manner up the Kasai river to the Shaba region which then became a secondary centre of expansion in all directions (Guthrie, 1962).

The development of large empires in the savannah country to the South and South-East as well as to the South-West of the equatorial forest was the direct result of this Bantu migration: Kongo in the South-West (XVth. and XVIth. centuries), Luba and Kuba in the South-East (XVIth. and XVIIth.


MAP 4
UPPER ZAÏRE (1: 1 000 000)
oBando — Towns
Lowae — Rivers
LOKELE — Tribes and migration routes
Equator
24° E
25° E
1° N
Banalia
Basoko
Baonde
Yalemba
Bando
Isange
Yangambi
Yanonge
Yakoso
Kisangani
Bengamisa
Yatolema
SO
LIKILE
HANGA
TOFOKE
OLOMBO
LOKELE
FOMA
MBOLE
ANGBA
MBA
KOMO
ENYA
Loleka
Longombe
Lifindo
Loilo
Lokuwae
Lindi
Sede
Chopo
Lome
Lowae
Etoli
Diga
Fule
Kalumete
Aruwimi (Lohale)

centuries), Lunda in the South (XVIIth. and XVIIIth. centuries). The Azande (North) and the Chwezi and Tutsi (East) were somewhat later and represent invasions of non-Bantu-speaking peoples who found the Bantu already installed when they arrived. The military expansion and conquest initiated and sustained over centuries by these empires brought further pressure to bear on remaining Bantu-speakers as well as on other migrant peoples who were forced to enter the forest where it was comparatively easy to take refuge from the invaders.

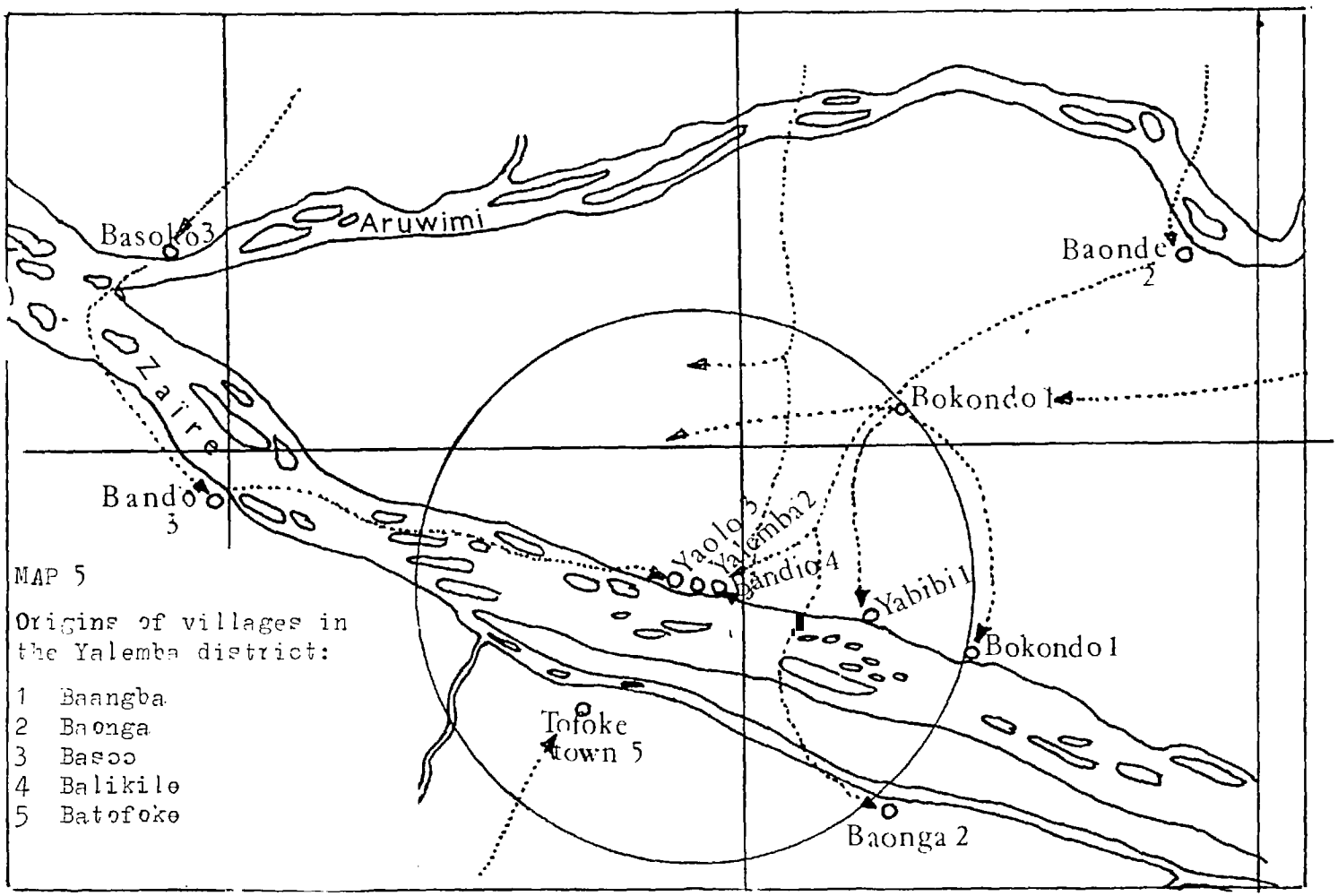
2.3 Migration and culture contacts.

Such an account of the prehistory of Central Africa ties up with the traditions of the area. So far as the Kisangani region is concerned, with which the present study deals, most peoples have knowledge of migrations within comparatively recent times before they took up the positions they occupy today. The only group which claim to have lived always in the forest where their villages are placed are the Tofoke but some of them recognize that there have been some changes of village site in the past (Map 4). This name has been given to a group of linguistically and culturally related peoples by the colonial administration and white explorers. It is often explained as being the reply to a direct question by the visitors: What is the name of your tribe? The reply by people who found it difficult to understand the strangers' speech was: We can't hear you - Tofoke! They themselves are content to use the names of smaller divisions of the group: Bakombe, Baliutua, Bembelota, Baluolambila... and say they lack a name for the whole association. Neighbouring tribes such as the Lokele give them a collective name: the Eso folk.

Other groups have traditional stories of migrations from North, East, South and West which were still in progress when history began in the sense of written records being made about the area by white explorers, missionaries and colonial administrators. The first whites to visit the Kisangani area were H.M.Stanley and his British companion, Frank Pocock, who spent 3 days passing through the area in January 1877 (Stanley, 1878 cf. Carrington, 1970).

The accompanying map (4) indicates the directions of traditional migrations as given by present-day members of the groups concerned and as can be deduced from a study of drum-language texts, songs, proverbs and other forms of oral literature in the area. All the groups mentioned are Bantu-speaking except the Mba whose language is different in structure and vocabulary from Bantu and belongs to the Sudanic group of Meinhof's classification (the Nilo-Saharan of Greenberg).

Because of this recent history of forced migration due to pressure from expanding populations on the periphery of the forest belt, groups taking refuge in the forest were small. Birth-rate is falling below the death-rate



MAP 5

Origins of villages in the Yalemba district:

1 Baangba
2 Baonga
3 Basoo
4 Balikilo
5 Batofoke

in some areas and this, coupled with the massive exodus of young people from villages into cities like Kisangani means that some villages in the Upper Zaire and elsewhere in Central Africa appear to be dying out. What seems to the writer to be an extreme case of ethnic trituration occurs in the region under study near to Basoko where today only 3 villages speak the language of Yalemba (Yalemba, Baonga, Baonde)with a total population of about 1000 only. The effects of migration are also clearly seen in this area when the linguistic field is mapped. Within a radius of 6 km of Yalemba village there are 6 towns with 5 distinct languages. They are not dialect forms of the same tongue, though all are Bantu and fairly closely related. (Map 5)

Migrations and tribal warfare did not, however, prevent mutual influence among neighbouring peoples in the pre-colonial era. That close contacts were often maintained and allowed cultural sharing is shown, for instance, by the status of drum-talking in the area. Three groups near to Kisangani: the Mba to the North, the Komo to the East and the Enya to the South-East, had no tradition of drum-talking before they moved in. They copied the system which they found in operation among the Lokele, Olombo and other groups, so that the language they use in broadcasting on their wooden instruments is quite different from the spoken languages they brought with them. These immigrants in turn passed on to the local peoples some of their own culture traits. The Lokele copied the characteristic wrestling practised by the Enya (Droogers, 1974) while the /libeli/ initiation rites of the Lokele and Olombo probably originated among the Mba (Carrington, 1947). It is well-known that manioc (Manihot esculenta Krantz) has become a staple crop in much of the forest area of Central Africa. But manioc was unknown in Africa before the XVIth. century when it was first introduced from South and Central Am erica, after the voyages of Columbus to the New World. Culture contacts among populations moving about in the area made it possible for the use of manioc to become wide-spread so that by the beginning of the colonial era it was already a traditional foodstuff in the Upper Zaire. Such possibilities of culture contact as well as migration from a common area must be born in mind when we try to study the acquisition by Central African people of timber technology and their utilisation of forest species for everyday crafts.

3. Ethnobotanical investigations.

3.1 Ethnobotany as a separate scientific discipline.

Any study involving the use of plants by human groups belongs ipso facto to the domain of ethnobotany and must use the methods appropriate to it.

Human interest in the plant world began long before the scientific study of Botany. One of the first documents available indicating this interest is

from the Magdalenian strata in France where rein-deer bone fragments have been discovered with drawings engraved into them depicting what are probably cereal plants. These have been dated as far back as ca. 20,000 BP. Parched seeds disinterred from sites in the Middle East and from Central America are at least 8,000 years old. An Egyptian papyrus is known publishing a list of medicinal plants ca. 3,600 BP and a similar document from Assyria in clay has been dated at 2,700 BP. Such authors as Theophrastus ("Enquiry into Plants") with whom the science of Botany is often said to begin, stress the utility of plant products as well as giving systematic descriptions of plant form and structure. It is well-known that the growing interest in world exploration by Western mariners in the XVth and XVIth. centuries, with its fateful consequences for world history, were initiated because of the desire to find new routes to obtain the spices which do not grow in temperate climates (pepper, cloves, nut-meg, cinnamon...). It is not a coincidence that the Linnean system came into being at a time when the discovery of plants new to the Western world was increasing exponentially as a result of maritime and continental exploration.

In the sense then that botany began with man's interest in plants for their practical value to him, botanical science has always been "ethnobotany". But the term itself is recent. A similar term:"ethnographic botany" had been used in 1879 by Rochebrune in the course of his determination and description of plants found in archaeological sites investigated by him in Peru (Rochebrune, 1879). "Ethnobotany" as such was coined by the American botanist Harshberger in 1885 in a newspaper article written by him and reprinted separately the following year with the title: The purpose of ethnobotany (Harshberger, 1886). In his view, ethnobotany should deal principally with plants used by so-called "primitive" peoples and study such matters as: investigations into the geographical distribution of plants,

more precise determinations of routes over which commercially useful plants were carried in earlier times,

possible new plant sources and new methods of using plants in present-day industry and medicine.

The term became common currency in a long series of valuable botanical investigations into plant usage among American Indians which were published in the early years of the present century by the Bureau of American Ethnography. Melvin Gilmore who had written in 1919 a long report on the use of plants by the Indians in the region of the River Missouri (Gilmore, 1919), established the first ethnobotanical laboratory in the University of Michigan. On Gilmore's death in 1929, the direction of the laboratory was taken over by Volney Jones. He later defined ethnobotany as: The study of the interrelation between primitive man and plants (Jones,

1941/1954). His list of activities to be pursued by ethnobotanists includes investigations of:

plant usage in village life - food, utensils, fuel, lighting, clothing, tool-making, housing, medicine...

plants in human thought - art, folk-lore, literature, philosophy, science, religion...

the names of plants,

plants found in archaeology, in ethnology...

the origins and dispersions of cultivated plants.

A second laboratory devoted to the pursuit of ethnobotany was opened in Paris at the National Museum of Natural History by Professor Roland Portères who had already contributed many articles of ethnobotanical interest to the Journal d'Agriculture Tropicale et de Botanique Appliquée published by the Museum. The interest aroused by American and French work in this field led to the constitution at the 8th. International Congress of Botany in Paris (1954) of a special section (No.15) devoted to Ethnobotany. Volney Jones contributed a review of the development of ethnobotanical studies in the U.S.A. and French authors discussed the status of the subject in France and French overseas territories. The subject is seen to be wider in scope than in earlier years. Regel, for instance, suggests that it comprises "all the relationships between plants and men". Such a widening of the science is evident in later definitions of ethnobotany. Rousseau (like Regel, a Canadian worker of French expression) suggests it is "the plant weft of human history" (la trame végétale de l'humanité). Millot, who contributed a chapter on Ethnobotany in the recently published "Encyclopédie de la Pléiade" volume on General Ethnology (1968) defined it as "the science of the reciprocal relationships between man and the plant world". Roland Portères' own views on the subject of his life-work are summed up in an article he contributed to the "Journal" in 1961 entitled: Ethnobotany, its place, object, method and philosophy. He writes: L'ethnobotanique est une discipline interprétative et associative qui recherche, utilise, lie et interprète les faits d'interrelations entre les Sociétés humaines et les plantes en vue de comprendre et d'expliquer la naissance et le progrès des civilisations depuis leurs débuts végétaliens jusqu'à l'utilisation et la transformation des végétaux eux-mêmes dans les sociétés primitives ou évoluées (Portères, 1961).

A free translation of this definition would be:

Ethnobotany is an interpretative and synthetic discipline which investigates, uses, groups together and interprets the factual relationships between human groups and plants so as to understand and to explain the birth and development of civilisations from their original contacts with plants

to the usage and eventual transformation of plants by primitive and developing societies.

British botanists have made valuable contributions to Ethnobotany without calling them such. The detailed work of F.R.Irvine in Ghana (1961) and the compendium on "The useful plants" published as a supplement to the West African Flora (Hutchinson and Dalziel) are monuments of this kind of research. Other books like those written by the French: Chevalier's work in French Tropical Africa and Walker and Sillans' "Useful plants of Gaboon", for instance are of this category. The massive volume on the medicinal and poisonous plants of Southern and Eastern Africa by Watt and Meyer-Brandewijk in South Africa must also be mentioned (1962).

The only volume from a British author which specifically purports to deal with ethnobotany is that of P.J.Faulks of the University of Aberdeen, entitled: An introduction to ethnobotany (1958). This book seems to carry to their extreme conclusion the French views of the wide range of studies covered by ethnobotany, for the author echoes these latter when he says that the subject is "concerned with...relationships between man and vegetation". 41 categories of plant usage are mentioned, to include almost every human activity because plants are in some way involved. Drinks are desribed, for instance, not only because plant juices serve to quench thirst but also because rubber valves are found in rams used to pump water from streams and wood is used to make water-wheels. Hazel-rods, moreover, form part of the equipment of water-diviners who discover suitable sites for digging wells. Photography is mentioned because flexible film is made from cellulose which comes from cotton fibres or from wood-pulp transformed by acid which can itself be a product of plant material. The section on packing and transport concludes: ...the organisation of transport on a large scale would be impossible without the use of tickets, labels and waybills. These are commonly made of wood pulp. Labels may be attached with string or they may be stuck on to containers with vegetable glue or resin. Such views seem to place a premium on the fertility of the imagination of the writer rather than on scientific observation. It is not surprising that while some work in America and France continues to follow the lines laid down by Jones and Portères, recent workers in both continents have sought to collect ethnobotanical data in the field in order to test out hypotheses propounded by earlier workers. One such domain of enquiry is that of folk taxonomies and human cognition and will be treated in the next section.

3.2 Plant classification in present-day anthropological study.

3.2.1 Recent interest in the cognitive aspects of human culture.

One of the expanding areas of current anthropological research is that

of "folk taxonomies" - the way in which human groups classify the plants and animals in their environment. This interest stems from 3 different sources: a. the linguistic hypothesis propounded by Sapir and Whorf,

b. the corpus of anthropological theory known as structuralism, associated with the name of Claude Lévi-Strauss,

c. researches into the extensive part played by creation myths in the symbolism of everyday life, including attitudes to vegetation.

Edward Sapir noted as long ago as 1929 that different human groups carve up their experience of the environment by means of their languages in ways that vary according to their different cultures. Thought patterns are thus culturally determined because they depend on language; linguistic concepts are in turn limited by the outlook that members of any one human group have on outside "reality". He pointed out that the natural world is a continuum and human beings receive sensations from the outside world as a continuum through the channels of their senses. But this continuum is broken down into discrete segments as it is apprehended by the individuals making up the group concerned. The size of the segments will vary with the importance to the group of the material sensed. The following table shows, for instance, the number of different segments ("words") used by 5 human groups for 6 different concepts:

concept:	"snow"	"bamboo"	"banana"	"manioc"	"milk"	"rainbow colours"
English	1	1	1	1	2	7
Lokele-Foma	0	1	50	12+	1	3
Eskimo	11					
Laos		30				
Bahema (African herdsmen)					14	

Such differences in nomenclature do not reflect differences in ability to distinguish among the various forms of objects named. Where the European has separate words to speak of red and orange as distinct colours, a Lokele person would distinguish them adequately, if required to do so, by speaking of "dark redness" and "light redness" respectively. Lenneberg (1953) states cogently: under laboratory conditions the power of human discrimination is

> probably the same for all human beings irrespective of their language background...but not all colours are named with equal ease and ambiguity.

The basis of all translation work is that concepts can be expressed in different languages. To quote Lenneberg (1953) again: A basic maxim in

> linguistics is that anything can be expressed in any language.

But often lengthy paraphrases may be necessary because the concept referred to does not have a single name. A Western observer can, for instance, adequately describe the 50 varieties of banana known to the Foma people near Kisangani; De Langhe (1961) has done just this in providing morpho-

logical keys (in French) for separating them out. But European languages do not have the specific labels that the Lokele language possesses for these vegetable forms and therefore cannot characterise them so succinctly as the Foma (Lokele) people do.

A valuable outcome of such researches into concepts about the environment and names given to them in different parts of the world has been the recognition of ethnocentricity in many earlier writings on the subject of language. Western authors confronted with the multiplicity of terms used to cover what European languages would express with a single word have sometimes concluded that so-called primitive people lack the power of abstraction. Westermann, for instance, writing about the Ewe of West Africa, suggested: The multiplicity of words arises because the speaker sees independent units in the world around him and only rarely attains the conception of a whole.

But, as Maquet has pointed out (1962), the Ewe sometimes have words to describe whole concepts where Europeans label separate units; for liquids named juice (fruit), milk, soup, wine, tears...they use /tsi/ with a qualifying word. A personal experience of such linguistic ethnocentricity may not be out of place: the writer remembers being present in a class for English-speaking people where a Belgian "professeur" was attempting to teach French language and literature. He delighted in proclaiming the superiority of French over other European tongues. When French had one word to cover several English partial equivalents, he would speak of "l'esprit synthétique de la langue française" but when French had to use several words to express one concept in English, he insisted that the class admire "l'esprit analytique et scientifique du français"! This sort of ethnocentricity vitiates unfortunately a number of anthropological studies from overseas.

Why do some groups of vegetation invite the attention of humans in a given environment whereas others do not? Some ethnobotanists have replied that only useful plants are named. Thus Vidal, commenting on the number of varietal names for bamboo among the Laos groups:

> This is no doubt because of the fact that bamboos have many usages and each species has a special use that merits giving it a distinct name (Vidal, 1963).

Experience in the Upper Zaire confirms that many named plants are indeed used by villagers but other plants are also recognized and given characteristic names even though they are not apparently employed in any way. Some may have labels because they literally thrust their attention on the villager as he walks through the vegetation: Cyathula spp. and Achyranthes aspera L, both called /bambila/ by Lokele-Olombo villagers have adherent fruits which

stick to clothes and carried objects; the term /lituwolo/ refers to plants of the village paths which are difficult to pull up because of long tap-roots: Sida rhombifolia L, Fleurya aestuans (L)Gaud. and others. Other plants have drawn attention to themselves because of their bizarre appearance; for example:Anchomanes spp., common in fallow ground, which has a yellow, elongated composite fruit bearing some resemblance to a ripe banana and hence gets the name:"banana of the spirits" /likondo lyaolimo/ in Lokele-Olombo.

3.2.2 Ethnobotany and structuralism.

The French anthropologist Lévi-Strauss has been described by Edmund Leach as "...by common consent the most distinguished exponent of this particular academic trade to be found anywhere outside the English-speaking world (1970)".

His contribution to anthropology is claimed to have revolutionised the approach of many workers to the subject along lines which have led him and his pupils to take an interest in ethnobiology. The school he has founded is referred to as "structural anthropology" and is linked at its inception with structuralism in linguistics. Just as structural linguists like Chomsky claim that their analyses of human languages reveal deep structures that may help linguists to understand psychological patterns common to all human thinking, so Lévi-Strauss maintains that human culture patterns are due to common elementary structures which generate the varied forms we discover among the peoples of the globe. The task of the anthropologist is to find the code used in each case so as to reveal the underlying common structure. One fruitful area of research has been the interpretation of myths but another, rapidly expanding field, is that of folk classifications. Lévi-Strauss maintains that in carving up into separate concepts the complex system of human relationships, man used the discrete segments which he recognises and names in the world of nature (plants, animals, stars, rocks...).

Such, for example, is Lévi-Strauss' explanation of the cognitive processes involved in totemism. This phenomenon, observed in many widely separated human groups, shows itself in the usage of species of plants and animals (more rarely inanimate objects) as symbols for categories of people. Frequently the group thus characterized does not kill the totem species (except in cases of self-defence), nor do they eat it. The totem (/botete/) of Yakoso village (Map 4) is the spitting cobra /loola/, that of neighbouring Yatumbo is the electric eel /tula/. Colonial administrators frequently made use of this classification as a means of ascertaining relationships in small village groups. Those which had a different totem

from the others were regarded as migrants or vassals. Numerous theories have been propounded to explain totemism throughout the world. Some have regarded totemic behaviour and attitudes as practices carried over from earlier stages of human evolution and indicative of childish mentality. Others maintain that the system tends to preserve useful species and ensure the conservation for other groups of any one totem organism. Lévi-Strauss argues that totemism is a cognitive phenomenon, the usage by human groups of easily recognized categories (plant and animal species or other readily identifiable natural objects such as stars) to permit them to classify other groups and distinguish them from themselves. With that felicity of expression which characterises much of his theoretical exposition, he says that natural species are used as totems by man, not because they are "bonnes à manger" (good to eat) but because they are "bonnes à penser" (good to think with).

It should perhaps b e noted in passing that this felicity of expression has led to suspicion on the part of some students of traditionally phrased anthropological theory. Leach (1970)speaks of "juggling with words" and states; "...it has to be admitted that...in Lévi-Strauss' writings there is an element of verbal sleight of hand which invites caution rather than enthusiasm."

Bulmer commenting on Lévi-Strauss' use of the word "espèce" writes: What in fact is happening is that Lévi-Strauss is performing semantic acrobatics between logic, biology and folk-taxonomy.

The interest of Lévi-Strauss' pupils' work on plant classification will be mentioned in a later section (3.2.4).

3.2.3 Creation myths and plant classification.

Creation myths of many peoples recognise a close connection between man and plants in his environment and are therefore of interest to the ethnobotanist. According to the Hebrew version of creation, plants were among the first living things to be formed (on the 3rd. day of creation, according to the first account given in Genesis 1:1 - 2:4). Animals, including humans came later (6th. day). The second account of Creation (Genesis 2:5 - 2:15) mentions human involvement in naming the created plants. In creation myths from other parts of the world, plants play a more intimate role in the origin of all things. According to the Dogon, for instance (a small group in West Africa. studied intensively by French anthropologists) Amma (God) created the world from something infinitesimally small symbolised by the seed of Digitaria exilis called by them /fonio/. This seed, the smallest plant seed known to the Dogon,

quickened by "an internal vibration", grows, bursts its coating and develops rapidly until it reaches the confines of the universe. It then divides into 2 parts which become 2 couples called /nommo/. One of these is sacrificed later by Amma in the sky and from the blood so spilt grow 2 plants: Acalypha ciliata and Khaya senegalensis. The body of the slain /nommo/ is then dismembered into 4 parts and thrown into space to fall in the 4 cardinal directions, symbolised henceforth by the appearance of 4 trees: Lannea acida, Adansonia digitata, Ochras parkii and Parkia globosa.

It must be noted, however, that French ethnographers working among the Dogon have relied for their material on local French-speaking interpreters rather than on a personal, intimate knowledge of the Dogon language. This procedure may account for some of the published results being highly abstruse and often difficult to understand. Griaule and Dieterlen's report (1954) of a conversation with the elderly Dogon informant, Ogotommeli, presumably translated from a Dogon original, contains for example the following passage explanatory of details of the Creation story:

> Inside the first seed and forming its central core was an oblong plate divided into 4 sectors in which lay the signs corresponding to the 22 categories into which the universe is classified, each placed under the direction of one of the 4 elements air, fire, earth and water. In the rotatory movement of creation, this plate turning on itself, flings off the signs into space, where they come to rest, each one on the thing it symbolises and which till then only existed potentially. At their touch...every being came into existence and is automatically placed in the predetermined category.

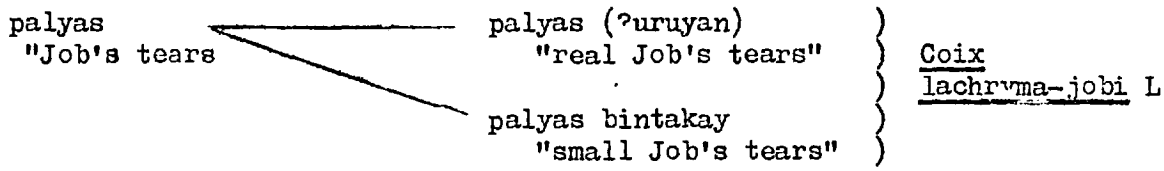
A reader conversant with other African languages cannot refrain from asking himself how far this sort of prose depends on the translation process rather than being a faithful record of the Dogon original. It would be difficult to produce a Swahili translation of the above report, especially of the last sentences,which would have meaning for Swahili-speaking people and at the same time only permit of retranslation into the erudite expressions from which the translation began.

3.2.4 Some recent work on folk taxonomies.

Plant classification among the Dogon, as mentioned in the last section, is closely associated with the creation myth described by the French anthropologists . According to the published work of these investigators, plant taxonomy is associated with human physiology so that plant groups have a recognized therapeutic value because of their position in the classification (Dieterlen, 1952).

In other parts of Africa and in other continents, however, folk classi-

fications more closely resembling the Linnean system have been found. One of the first major studies of folk taxonomies was that made by Conklin in 1954 who worked among the Hanunoo in the Philippines. He records that 1625 plant taxa are named by the Hanunoo of which 822 are what he calls "basic plant names" i.e. free morphemes or unanalysable stems. Of these, 571 refer to single taxa only and 251 are polytypic, i.e. they refer to more than one taxon and are then distinguished among themselves by the addition of a qualifier to the basic plant name much as in a typical Linnean binomial. In a later paper, Conklin distinguishes between the 2 types of names as: unitary and composite. An example of this distinction is given thus:



Berlin, Breedlove and Raven have produced a major publication in the ethnobotany of a Tzeltal-speaking group of Mexican Indians, living in and around the municipality of Tenejapa. They spent 36 months in the field and collected some 15,000 specimens which were identified by local people as well as by botanists using the Linnean system. The authors state that they

> "have strong reason to believe that the general collections represent an almost complete inventory of the flora of the area"(1974, page 54).

The list of plants comprises 17 bryophytes, 4 lycopods, 3 horse-tails, 53 ferns, 15 gymnosperms and some 1600 angiosperms. No lichens, fungi or algae are described. Two of the authors are botanists and the third an anthropologist who had done some previous work in the area and was presumably conversant in the Tzeltal language. Their treatment of plant names is more analytical than that of Conklin. They distinguish types corresponding roughly with Conklin's pair:

primary lexemes - unique expressions,

secondary lexemes - unique expressions modified by the addition of other lexemes.

The primary lexemes, however, are subdivided further into

unanalysable - semantic units which cannot be analysed further;

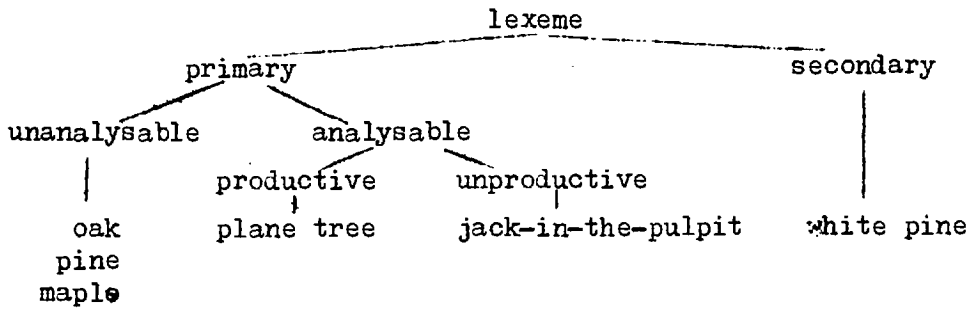
analysable - capable of being broken up into meaningful parts.

Such analysable lexemes are found to have two forms:

productive: a constituent of each term refers to a category superordinate to the one named by the term,

unproductive: the constituents of the terms do not refer to a superordinate category*

The following diagram sums up the recognised categories;



Conklin's distinction of unitary and composite folk-names is a morphological one; Berlin, Breedlove and Raven introduce a semantic differentiation in that they require an understanding of the meaning of each term before its linguistic nature can be given. This is correct. But it is just at this point that any linguist will enter a caveat as to the scientific value of their results. Properly to evaluate meaning demands an intimate knowledge of the language used by the local people engaged in naming their plants. The three authors themselves agree that: In discovering those

> linguistic expressions that actually occur as Tzeltal plant names, we have found that a rather intimate knowledge of the linguistic structure of Tzeltal in conjunction with the experience of observing actual Tzeltal naming of plants is essential for adequate analysis.

They quote approvingly a remark by Sturtevant (1964) that the investigator must be able to differentiate between lexemes and linguistic forms of similar grammatical status which do not serve as segregate (category) labels.

But more than "a rather intimate knowledge of the linguistic structure" of the language is surely needed for this purpose. Nothing less than a fluent knowledge of the spoken language will suffice. The problem is that presented to an English-speaking botanist who must realise that the term red in "red campion" does not have the same classificatory significance as the same adjective in the expression "red rose". The former is an exocentric expression referring to the Linnean species Silene dioica (L) Clairv. whereas the latter refers to one of many red-coloured forms of Rosa species. In this latter case "red" describes the colour of the flower only and the whole expression is endocentric. (It may be useful to note that the terminology exo- and endocentric is due to Nida,1951. The distinction is more easily appreciated between "greyhound" and "grey hound", and between "blackbird" and "black bird" where there is a phonological distinction because linguistic stress falls on the first syllable of the exocentric expression (a compound noun) while it is on the second element of the endocentric expression (a composite phrase)). In the two names cited: red campion and red rose, the distinction is entirely conceptual and this could well be the case with folk taxonomies such as that studied

by Berlin et al.) The team of investigators suggest that there are grammatical ways of distinguishing between exo- and endocentric labels for Tzeltal plants but they admit that these are not always utilizable and state that they were not always able to carry out the needful tests.

A pointer to the probable acceptance by them of endocentric, descriptive expressions for plant names instead of exocentric taxonomic labels is the number of Spanish-derived terms in their list of attributives used in Tzeltal specifics (25 out of 108). Some of these Spanish attributives are used as descriptions for indigenous plants, not for plants introduced after the Spanish invasion. Presumably Tzeltal folk-taxonomy was well developed before Europeans entered Mexico so that, unless the Spanish attributives have in these cases replaced Tzeltal equivalents, it is hard to accept them as true exocentric labels. We should note further that of the 145 attributives used, many are glossed "genuine"(38), "coloured"(72), "sizes" (18), "textures"(17). These are the kinds of expressions which an informant would use when being presented with a plant which is normally unnamed in the local culture. Being reluctant to acknowledge his ignorance of its name, he would denote it as another plant with a qualifier as to colour, size, texture etc. The normally-labelled plant would then be segregated as "genuine". In a later section of this study (3.2.10), it will be shown that a comparable situation exists in the nomenclature of plants among the Lokele-Olombo peoples of the Upper Zaire where many names reported by European workers were undoubtedly of the endocentric type.

A French botanist, Mlle. Claudine Friedberg, one of Lévi-Strauss' pupils, has produced a study of plant nomenclature among the Bunaq people of Timor. She is sensitive to the need for linguistic competence in ethnobotanical research. She accepts Conklin's use of the term "basic plant names" but divides them into subsidiary categories:

> termes métaphoriques - meaningful names,
>
> termes botaniques - labels having no apparent meaning.

Of the 600 plants collected, 108 belong to the former and 490 to the latter group. But she makes the following comment as to her ability to distinguish meaningful items: It is certain that research undertaken in the Bunaq

> language would have given more satisfactory results. I must have been responsible for many misinterpretations (1967.

She carried out the research using Indonesian for communication with the Bunaq through interpreters or with Bunaq people able to speak the lingua franca.

Mlle. Friedberg further comments on the necessity for any research worker in an overseas territory to be competent in cultural understanding

of the group studied: I do not think that one can obtain satisfactory results if one thinks that it is possible to go to any area and start straightway to investigate folk classification. A minimum of general understanding is required of the way the society functions and the cultural and natural contacts in which it has evolved before being able to form a framework for classificatory systems... The apprentice ethnologist comes from an urban civilisation where plants and animals now have hardly any place. Is he capable of understanding through his own culture aspects of the plant and animal world which are presented to him in the field? (1967).

3.2.5 Some results obtained in folk taxonomy studies.

Conklin completed his work on the Hanunoo folk classification in 1954. He recorded 1625 named terminal taxa recognised by this group of agriculturists in the Philippines, of which the majority (97%) belonged to 3 main categories:

kaya	trees,
ʔilamnun	herbs,
wahat	vines.

The remainder of their plants were grouped in "ambiguous taxa" regarded as not belonging to one of the 3 major groups, e.g. bamboos. Between the named major categories and the terminal labelled categories, there were no terminologically identifiable groupings. Comparing the Hanunoo classification with the Linnean system for the same plants, Conklin found that there was a remarkably close correlation, but noted a tendency to differentiate into separate, named taxa, plants which Western botanists would regard as cultivars or varietal forms of cultivated plants.

Bright and Bright, 1965, studied folk taxonomy among some Indian tribes of N.W.California as an exercise in testing the Sapir-Whorf hypothesis. They list communication problems in their elicitation of information: lapse of memory, contamination by the white man's categories, lack of attention, references to mythology, ambiguities in the English language itself (e.g. is the tomato a vegetable or a fruit?). They conclude that all Yurok and South River taxonomies are less hierarchically organised than that used by Western biologists. Noting the manner in which informants presented with an unknown plant usually said it resembled a known organism, they maintain that Indian taxonomies can best be presented as "sphere of influence" models rather than by relationships of dominance.

Diamond (1966) an ornithologist, investigated bird classification by

the Fore tribe of Highland New Guinea. He reported only 2 levels in the zoological taxonomy of this group:

1. nine higher categories such as birds, bats, small flightless mammals, large flightless mammals, frogs, lizards-snakes, insects-spiders...
2. smaller, terminal taxa corresponding with Western species.

He noted in addition that there were 2 monotypic taxa which contrasted with level 1, namely: cassowary and fish. The category "bat" had only 2 subordinate taxa. He was impressed with the extent to which the Fore classification corresponded with the Linnean system for the same birds. He suggested indeed that Fore taxonomy might serve to correct the Linnean classification at certain levels in separating into distinct taxa birds which had hitherto been "lumped" into one.

Correspondence with the Linnean system was found also by Bulmer (1970) but was looser among Karam-speaking peoples of the New Guinea highlands. He coined the word "specieme" to denote: a group of creatures marked off

> from all other known animals...by multiple distinctions of appearance, habitat and behaviour and not including recognised sub-groups marked off from each other in a similar way.

Only 60% of the Karam terminal taxa correspond to biological species as understood in the West. A single Karam name may be used for more than one Linnean species especially when one is relatively common and the other(s) rarer. Sexually dimorphic forms sometimes have 2 distinct labels, one for the male and another for the female plus the immature forms of both sexes. The author is careful to point out that the Karam are quite aware of the biological status of these forms; i.e. they are not naively separating what Western biologists subsume under one species.

Berlin, Breedlove and Raven concluded that Tzeltal plant taxonomy is structured like the Linnean system in a series of hierarchical categories which they call:

1. the unique beginner
2. life-forms
3. generics
4. specifics
5. varieties.

They claim that evidence found after inviting Tzeltal informants to compare plants in groups of three, suggests the existence of intermediate categories which do not have a linguistic label and are therefore called by the authors "covert categories".

The "unique beginner" is not named in Tzeltal i.e. there is no Tzeltal equivalent of the English word "plant". But its existence as a concept is to be inferred from linguistic structures - all names of organisms belonging to its domain govern determined grammatical forms in Tzeltal sentences.

The "life-forms" are mainly 4:

trees,

vines,

net-veined herbs,

grasses and parallel-veined herbs.

Some 25% of the total 471 generics do not, however, fall into these 4 classes but are grouped separately - 20% are called by the authors "unaffiliated generics" because they are not included in one of the 4 life-forms e.g. bamboos, beans, corn, agave..., and 5% are ambiguous in that they exhibit characters of more than one life-form, e.g. Vaccinium spp which are shrubby plants with leathery leaves (neither trees nor herbs).

Comparing Tzeltal taxa with those of the Linnean system, Berlin et al. find the following correspondences:

61% of Tzeltal taxa correspond exactly with Linnean species,

35% are undifferentiated i.e. Tzeltal botanists are "lumpers" in these cases,

4% are overdifferentiated i.e. Tzeltal taxonomists are "splitters".

The authors claim that the utilisation by Tzeltal speakers of the plants studied is closely correlated with the semantic structure of the labels attached to them. They assigned Tzeltal plants to 4 categories of cultural usage: a. cultivated e.g corn, beans, chili peppers,

b. protected e.g. guavas, custard apples,

c. significant i.e. utilised by man but not cultivated nor receiving special treatment e.g. grasses for thatching, fibre-plants for lashing,

d. unimportant plants with minimal or no utility though plants used for fuel are included here.

If the types of names given are now plotted against the percentage of content of these categories of cultural usage, we have the situation as shown in Fig.1 showing that simple lexemes are more common in cultivated plants and least common in useless plants. The authors counter any suggestion that this result is simply an example of Zipf's law (according to which the length of a word in any language varies inversely with its

frequency of usage) by demonstrating that the same trend is found if labels of only 2 syllables are considered.

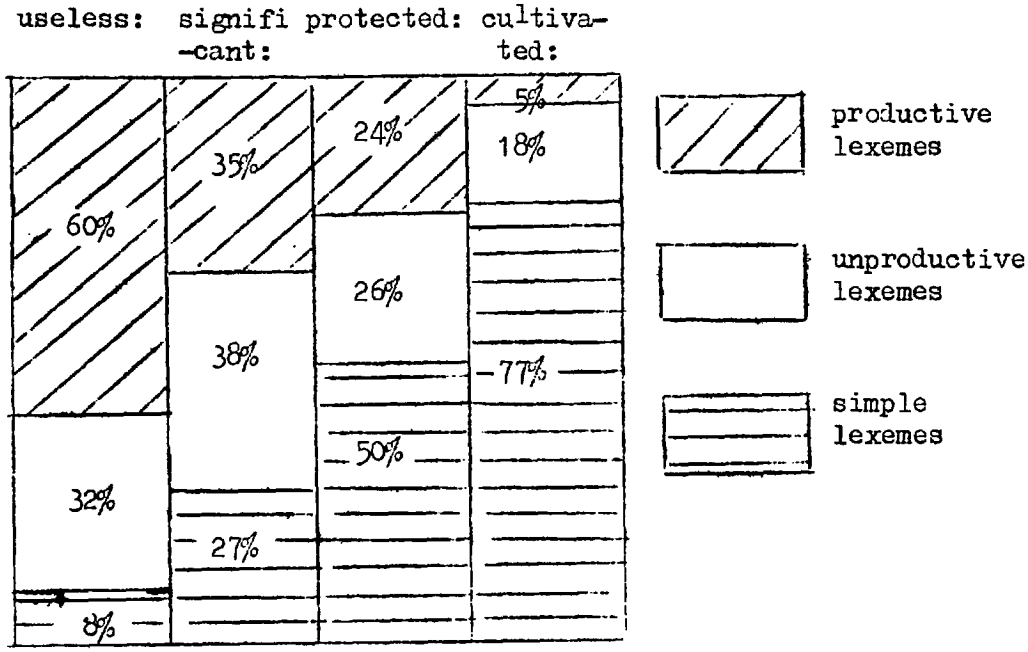


Fig.1: Relative significance of Tzeltal plant names. After Berlin et al. 1974.

It should be noted that the almost linear relationship would be upset if fuel plants were removed from the "useless" category to which the authors somewhat arbitrarily consign them and were given the status of "significant" plants.

The authors offer the explanation of these results that unanalysable primary lexemes tend to be used for frequently met, well-known plants because these are easily learned whereas semantically transparent productive lexemes are necessary to give more information in the case of names not often referred to.

They further plotted the utilisation categories against the number of sub-taxa for various groups. Their results are reproduced in Fig.2. From this they deduce the tentative principle: Polytypic taxa increase directly with the cultural significance of the plant to which they refer.

It must be pointed out, however, that if our earlier caveat over labels be accepted (page 25) namely that many composite labels are probably endocentric descriptive expressions rather than exocentric names, then the results are only what would be predicted from the well-known variability of cultivated plants and the selection of different cultivars for human use.

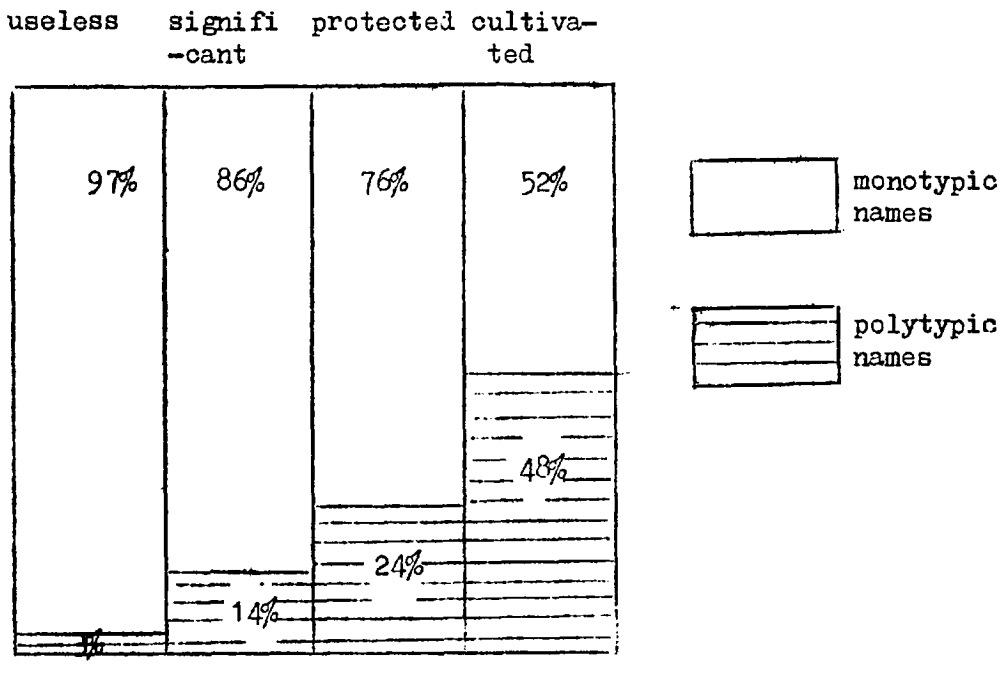


Fig.2: Percentage of polytypic generic names in each category of cultural significance. After Berlin et al., 1974.

Friedberg (1970) reports conclusions recalling those of Bright and Bright (1965): Bunaq classification seems as much based on associations between certain plants as on division based on criteria of differentiation. This distinction between 2 classificatory principles which would not make sense in scientific systematic botany (where every taxon is defined by a number of characters and the essential task of the taxonomist is to establish the exact limit between groups thus defined) is important here insofar as certain groupings, particularly the families, comprise an assembly of plants about a nucleus formed by a series of plants or by one type only, this nucleus being the reference centre... Usually we find overlapping among the groups. Thus the Bunaq classification appears to be structured more like a network than a tree.

3.2.6 Language in the Upper Zaire: orthography.

Before we record observations on Upper Zairian taxonomic categories and in view of what has already been insisted upon over a proper understanding of local languages in ethnobotanical research, it will be useful to give a short description of the structure of Lokele and related tongues.

It is difficult to compare some published ethnobotanical material with other work because authors do not always use a common method for transcribing local names. Some have adopted the script of their national language with or without accents and subscripts to indicate sounds not normally expressed therein. Much detailed and otherwise valuable observa-

tion in the Journal d'Agriculture Tropicale et de Botanique Appliquée suffers in this way because Roman script used in the French language is not adequate, as it stands, for African, Malagasy and other languages. Some authors contributing to this periodical have introduced modifications to the normal French orthography in order to overcome this difficulty. Thus Thomas (1939) recognises that in the River Lobaye area, south of Lake Chad, the sounds represented in French by the one vowel sign o cover 2 distinct phonemes which must be separated in written botanical names. Likewise the sounds of e form 2 separate phonemes. She uses upper-case O for the vowel in French motte (cf English hot) and lower-case o for that in French mot (cf. English so). Similarly, an upper-case E renders the vowel e of French mère (cf. English met) while a lower-case e serves for e in été (cf. Tynside races).

There is, however, available for research workers an internationally recognised orthography whose generalised use would make comparison far easier. This is the alphabet of the International African Institute which is itself a modified form of the Alphabet recommended by the International Phonetic Association. It is this notation that is adopted for names used in the present study.

Non-linguists are frequently unaware of the importance of tonal melody in many languages outside Europe. It would be easy to assume, for example, that Olombo speakers confuse the names of the Umbrella Tree (Musanga cecropioides R.Br) with that of mushrooms belonging to the genus Lepiota because these plants all have names printed in Roman script as /bokombo/. But the labels are linguistically distinct because they have differing tonal melodies when spoken even though the vowels and consonants are identical:

bokombo (low low low /...) Musanga cecropioides R.Br

bókombó (high low high/'.') Lepiota spp.

Similarly, Olombo people do not take Hirneola auricula-judae (L) Berk. for an inanimate stone because its name and that for "stone" are printed /batalɛ/ in Roman script. The two forms are distinguished by their music:

batalɛ (...) Jew's-ear fungus,

batálɛ (.'.) stone.

Thomas gives information which can be compared with other work because she indicates (1970) the tonal patterns of plant names by using a special orthography:

/ = high tone, - = medium tone, : = low tone.

These symbols are printed next to the plant name given in Roman script. Such an orthography is clumsy, howevever and it is to be regretted

that she does not use the much simpler method recommended by the International African Institute, namely of indicating a high tone by placing an acute accent over the vowel concerned and, if necessary, a low tone by placing a grave accent over the vowel. Medium tones (as heard by Thomas in the Lobaye region) could then be indicated by leaving the vowels unmarked or by using a vertical accent. In the present study, where languages are bitonal only, it suffices to indicate the high tones with an accent.

3.2.7 Languages in the Upper Zaire: grammar and lexicography.

Map 4 shows the present-day location of populations within the area covered by the present investigation. The Lokele-Olombo group are Bantu-speaking, as are their neighbours except the Mba to the North-East who speak a Sudanic language (to follow Meinhof and Westermann's classification of African languages).

The following short description of the Lokele language will be useful for an appreciation of later notes on timber nomenclature among human groups using wood in the Upper Zaire. This language is the same as that spoken by the Foma people who are hunters and agriculturists occupying the South bank of the river and who are frequently referred to as the "forest Lokele", the Lokéle themselves being riverine folk. Olombo groups speak a closely related language, especially those living near to Kisangani (the Yawenda and Bosala sections of the tribe). A brief, recently-published account of Likile, an Olombo dialect spoken near Basoko, is appended to this study as an additional example of one of the languages of the area. For comparison with other publications on the Upper Zaire, it is worth noting that Belgian Colonial administrators referred to this group as the Turumbu people which is unfortunately a transcription of the pejorative form /Tolombo/ given to them by some neighbouring peoples. This form of their name will not be used here.

Sounds. Lokele has 7 distinct vowel sounds represented in Roman script:

i e ɛ a ɔ o u

closed . . . . . open . . . . . closed

Western equivalents are approximately;

i, a and u as in Southern English (u as in German du)

e as in French été, ɛ as in English met,

o as in English (Northern) so, ɔ as in English hot.

It is essential to distinguish between e/ɛ on the one hand and between o/ɔ on the other hand because these different vowel qualities are correlated with different meanings - they are differing phonemes. Note, for instance: wéni handle (hoe,axe) bokolo leg

wɛ́ni seer, witness bokɔlɔ bachelor

Any vowel can be used with a high or a low tone. The resulting tonal melodies are fixed for any given word except for a few rare exceptions where tones may be modified by preceding melody. Tone alone can indicate distinct meanings as already mentioned (page 32) and as illustrated by the following examples:

lisaka	pool, puddle	énɛ́kɛ́	see!
lisaká	promise	énɛkɛ́	he saw
lisɔ́ká	poison	énɛkɛ	let him see
		énɛ́kɛ	don't let him see

Because of this alternance of tone, names of plants ought to be transcribed with their tonal patterns as well as having their vocalic qualities faithfully recorded. When words occur at the end of a normal sentence or are enunciated on their own, the general fall in sentence or word tone can mask final high tones. Names of plants should never be asked for so that the informant gives the isolated label as a reply. The required name must be listened to when it is followed by other words in a sentence so that the correct tonal pattern is heard. For instance, if the European botanist asks a Lokele person the name for a fruiting body of Lepiota which he has just picked by enquiring; What's the name of this? he will receive the reply:/Yendé bókombo/ = It is a /bokombo/. Note that the final tone is low here because the fall in sentence tone has masked the high toneme on that final syllable. If however, the botanist insists that the informant use as his reply: This is a Lepiota, or That is a Lepiota he will hear: /bọ́kombó-bo/ or /bókombó ọ́ná/; the final syllable of the label for this fungus can express its proper high tone because it is no longer the last syllable in the sentence. Some published lists of plant labels in ethnobotanical literature where the author has attempted to indicate tonal melodies show too many final low tones for this reason.

Lokele consonants are the following with English realisation except where indicated otherwise:

b, c (pronounced and often written as English ch or ty), f, h, k, l, m, n, ŋ (pronounced as ng in singing), p, s, t, w, y,

plus the nasal combinations (forming single consonantal sounds, not double or triple ones):

mb, mw, nd, ŋg, ŋgw (also heard as ŋgb) nj, ny,

plus some other combinations as: kw (often heard as kp), sy (also written sh), tw. The dialect heard opposite Yangambi in the central sector of the Lokele people called the Yaokanja area, has a glottal stop ' (written in some scripts as ?) where cognate dialects have k;

usual form; bokɔta (chief) Yaokanja form: bɔ'ɔta

usual form: likoka (Pycnanthus angolensis) Yaokanja: li'o'a

Syllables. These are formed by a vowel V plus a preceding consonant C or by a vowel on its own. The typical form is then (C)V. There are no closed syllables in Lokele with a final consonant. Vowels occurring in juxtaposition never form diphthongs but have their full values, each being a separate syllable with its appropriate tone. The name for Rauwolfia vomitoria Afz. is, for instance, /ikukaásа/ with 5 syllables; that for Ipomoea involucrata P.Beauv. is /bondombodóombe/ with 6 syllables.

Words are built up of an invariable core or kernel (radicle) to which are attached prefixes and suffixes. The commonest form of kernel is composed of consonant + vowel + consonant: C_1VC_2 but many are heard where C_1 is absent and a few where both C_1 and C_2 are absent. There are also some kernels composed of a single consonant -C-. Most of the affixes attached to these kernels have characteristic tones so that when the fundamental tone of the kernel is known (it can be high or low), then the tonal melody of the whole word is predictable. From the kernel -SUNG- (="help") we can build up a large family of words, some of which would be:

o-SUNG-a	to help	bo-SUNG-i	a helper
a-SUNG-í	he helped (recently)	ba-SUNG-i	helpers
ba-SUNG-í	they helped (idem)	li-SUNG-í	help (noun)
to-SUNG-íkí	we helped (a short time ago	li-SUNG-élá	useless help
		bo-SUNGASUNGa	idem
yá-SUNG-áká	I helped (a long time ago	e-SUNG-elo	a place of help
		ba-SUNG-elo	time of help
éla-SUNG-aka	he/she will help a long time ahead	bo-SUNG-élí	manner of helping
		SUNG-áká	help!
á-SUNG-eke	let him help		
á-SUNG-éke	don't let him help		

These examples show how verbal tenses are distinguised by prefixes and suffixes and also show how the meaning of nominal forms varies with the affixes attached to a given kernel. Note too that singular and plural number are indicated by prefix change. Further examples are seen in this list of the importance of tonal melody in giving a definite meaning to a word.

Noun classes. It is one of the distinguishing features of the family of languages known as "Bantu" that nouns fall into a number of classes according to the prefixes which are attached to their kernels. For the whole Bantu-speaking area of Africa, some 20 such classes are recognised, though no one language features them all. Lokele has 13 classes with traces of 3 others. To a limited extent, these class prefixes serve to classify objects named in the language so that there is a "built-in" classificatory system in every Bantu tongue. This will clearly be of importance in discussing folk taxonomies in these languages. The following table shows

how each prefix in Lokele refers to special groups of persons and objects:

Class number:	Prefix:	Examples:		Categories found in each class:
1	(b)o-	boto	person	persons (singular)
	w-	wána	child	
	ø	sángó	father	
2	ba-	bato	people	persons (plural)
		bána	children	
		basángó	fathers	
3	(b)o-	bokúmi	elder	a. persons (singular)
		bolondo	Chlorophora excelsa	b. trees (singular)
	w-	wéni	tool handle	c. objects (singular)
		wele	Pterocarpus soyauxii	
4	be-	bekúmi	elders	plurals of nouns in class 2
		belondó	Chlorophora trees	
	(b)y	yéni	tool handles	
		yele	Pterocarpus trees	
5	li-	likɔndɔ	plantain banana	a. fruits (singular)
		litói	ear	b. body parts in pairs
		liuma	tadpole	c. small animals, insects
		lifaéfí	gift, giving	d. actions (singular)
	ly-	lyóki	hearing	
6	ba-	bakɔndɔ	plantain bananas	plurals of nouns in class 5; also names of powders, liquids, some diseases
		batói	ears	
		bauma	tadpoles	
		bafaéfí	gifts	
		baɛlɛ	milk	
		baɛndi	leprosy	
7	e-	eyaelo	habitation	a. places (singular)
	y-	yɛ́lɔ	thigh	b. body parts
		ɛkɔlɔ	basket	c. tools
		etenga	sterile male	d. body deformities
8	bi-	biyaelo	habitations	plurals of nouns in class 7
		bikɔlɔ	baskets	
		bitenga	sterile males	
	y-	yɛlɔ	thighs	
9	nasal	ngoi	leopard	a. large animals (sing.)
		ndákɔ	hut	b. village objects
	ø	kái	paddle	c. loan words
		kíti	chair (Swahili)	
10	nasal	ngoi	leopards	plurals of nouns in classes 9 and 11; also plurals of some nouns in class 3
		ndákɔ	huts	
		kái	paddles	
		kíti	chairs	
		kásá	leaves	
11	lo-	lokásá	leaf	a. one small object out of a mass
		lofutúti	grain of dust	
	lw-	lwásɔ	palaver, talking	b. result of action
12	i-	ifí	spark	a. small objects (sing.)
		ita	twig	b. pejorative nouns
	sy-	syána	infant	
		syito	despicable person	

Table 1 continued:

Class Number:	Prefix:	Examples:		Categories in each class:
13	to-	tofí	sparks	a. plurals of nouns in class 12
		totɛ́	twigs	
		twána	little children	b. excretions
		twito	despicable persons	
		toi	faeces	
		twila	pus	

It will be seen from the above table that prefix changes indicate singular and plural number, the kernel remaining the same. Class pairs for number change are: singular 1 3 5 7 9 11 12
plural 2 4 6 8 10 10 13

A given kernel may be associated with more than 2 prefixes giving related words with slightly different meanings. Note the following series:

lokonda	forest
konda	forest
ngonda	virgin forest
tokongɛ́	a specimen of Urena lobata L (also of Triumfetta dpp)
bekongɛ́	more than one such specimen
kongɛ́	fibres extracted from Urena lobata (and other plants), used to make string and rope
bosándú	a giant tree
besándú	giant trees
isándú	a tree
tɔsándú	trees
isɔ́asándú	a shrub, small tree
tosɔ́asándú	shrubs, small trees

Notice how, in the latter pair of words having prefixes of classes 12 and 13, the first syllable of the kernel is reduplicated to give a pejorative form. In other cases the whole kernel is doubled to convey the same idea:

swi	fish	longo	irritation on the skin
iswiswi	sardine	ilongolongo	mycosis
louwo	poorly developed person	liombo	brush
iuwouwo	dwarf	iomboombo	rag (for wiping up).

Olombo nouns classes are almost the same as those of related Lokele. One or two differences heard are the following:

a) class 1 nouns sometimes have a further prefix a-, referring to some animals, birds and insects:

akɔ́lika	chimpanzee
atelu	monkey spp.
akate	horned viper
atete	humming bird spp.
atínyaitombé	praying mantis (literally "he cirumcises")

some trees:

akwakwa	Oxystigma spp.
angwabele	Celtis mildbraedii Engl.

some knives:

angɔngɔnɔ	curved war knife
ambɔtɛ	straight, double-edged knife.

These Olombo forms are often used by Lokele speakers too. Their plurals

are formed in class 2 with prefix ba-: bakɔlika, batelu ...

b) nouns in class 11 of Lokele are sometimes heard in Olombo with prefix e- or le- but govern a grammatical concord lo- as does the Lokele suffix of that class.

Adjectives have a structure similar to that of nouns, being composed of prefix + kernel + suffix. But whereas the noun prefix is constant in singular or plural forms, that of the adjective changes in agreement with the prefix of the noun it qualifies:

isándú	siná	a tall tree
tosándú	toná	tall trees
bolondó	boná	a tall specimen of Chlorophora (iroko, African teak)
belondó	besá	tall specimens of Chlorophora
lileko	lisá	a tall specimen of Pachyelasma tessmannii
baleko	basá	tall specimens of Pachyelasma tessmannii.

Here the adjectival stem -SA has a constant suffix A but the prefix varies according to the noun which is qualified.

Demonstratives may be the simple noun prefixes appended to the nouns so determined:

isándú-si	this tree	bokungú-bo	this Piptadeniastrum specimen
tosándú-to	these trees	bekungú-bi	these Piptadeniastrum specimens

In this case, the demonstrative refers to objects near the speaker and has a low tone. To refer to things away from the speaker (English:that over there), the prefixes are usually high in tone and associated with a high-toned stem -NA:

isándú síná	that tree over there
tosándú tóná	those trees over there.

Only class 9 nouns and a few "intimate" nouns in class 1 govern a low-toned demonstrative prefix: ndákɔ ená that house there
wána oná that child there.

A third demonstrative is used to refer to something that is neither here nor there but in the thoughts of those conversing. The stem is -AAO in all classes except 9 and the "intimate" nouns of 1, when it becomes -AO:

isándú-áaó	that tree we were thinking of
tosándú-áaó	those trees ...
boto-aó	that man ...

Determinatives. Nouns can be qualified by adding a determinative noun preceded by a particle with the form: noun prefix + a. The tone of this particle a is low for class 9 nouns and the " intimate" nouns of class 1 already mentioned; for all other nouns it is high:

wána waokéngé	child of the village
bána báokéngé	children of the village
ndákɔ yabɔkɔta	the chief's house
ndákɔ yábokɔta	the chief's houses

Olombo has similar determinatives but the particle a is not heard, its

place being taken by the simple noun prefix with similar characteristic tones as in Lokele:

bɔ́na aoki	child of the village
bána báoki	children of the village
mbɛlɛ ɛbɔkɔta	the chief's house
mbɛlɛ íbɔkɔta	the chief's houses.

Verbs. Prefixes and suffixes attached to a kernel serve to indicate the tenses, voices and moods of Lokele and Olombo verbs. Frequently tonal differences are the only distinctions that can be heard, but they are adequate for speakers of these languages.

Lexicography. Because of the presence in Lokele of a limited number of prefixes to the large majority of nouns, any attempt to list these in alphabetical order of the first letter (as in an English dictionary) would result in words having relating meanings being widely separated in the lexicon. It is therefore to be recommended that the kernels be listed in alphabetical order with prefixes and suffixes indicated in a subordinate manner. The timbers studied in the present investigation would be grouped thus:

w- ele	Pterocarpus soyauxii Taub.
bo- kófé	Staudtia gabonensis Warb.
bo- kuka	Alstonia congensis Engl.
bo- sɔɔ	Combretodendron macrocarpum (P.Beauv.) Keay
bo- túmbé	Musanga cecropioides R.Br.
bo- úlú	Gossweilerodendron balsamiferum (Vermoesen) Harms

The list of vernacular labels for Upper Zaire plants as found in the "Flore du Congo Belge" and appended to this present study is arranged in this recommended manner as also is the short lexicon of Likile (a dialect form of Olombo) given as an appendix.

3.2.8 Folk taxonomy in the Upper Zaire.

The preceding sketch of the Lokele and related languages has shown that there is already inherent in the language a classificatory system whereby trees are usually named by nouns with prefixes bo-/be- (singular/plural), fruits with prefixes li-/ba-, seeds with prefixes lo-/nasal or ɸ and so on. Small or useless plants tend to be characterised with the pejorative prefixes i-,sy-/to-,tw-:

bolondó	Chlorophora excelsa	a tree
lilála	Citrus autantium	a fruit
lokalánga	Arachis hypogea	a seed
syingi	a small weedy plant such as short grass or sedges.	

This classificatory system is by no means rigorous nor free from exceptions. Pycnanthus and Xylopia are large trees which do not produce edible fruit for humans, but they both have labels with a class 5 prefix: /likoka/

and /likungú/ respectively. Triumfetta and Urena are not tree-like , yet their common name has a prefix bo-, /bokongé/. Cnestis ferruginea D.C. is a shrub attaining several meters in height, yet has a prefix in class 12: /isáala/.

One interesting biological classification by prefix is heard in the name for edible caterpillars which are usually labelled by the same kernel as the name for the tree on which they are found:

bolanda	Erythrophleum guineensis G.Don.
ndanda	caterpillars from this tree
lolanda	one such caterpillar
bosaku	Bridelia spp.
saku	caterpillars found on Bridelia
losaku	one such caterpillar
bɔsɔɔ	Combretodendron macrocarpum (P.Beauv.) Keay
sɔɔ	caterpillars from this tree
lɔsɔɔ	one such caterpillar.

Categories of plants are also recognised by the Lokele and related peoples which do not depend on grammatical classes but are concepts akin to the groupings made by other peoples as shown by Conklin, Berlin et al. and other ethnobotanists. Such categories depend on morphology and are the following:

1.	tosándú (singular: isándú)	trees
2.	tosáasándú (isáasándú)	shrubs
3.	ndíki (bolíki)	lianas
4.	twingi (syingi)	weeds, herbs
5.	balɛlɛ (lilɛlɛ)	ferns
6.	totáki twálokonda (itáki syálokonda)	macroscopic fungi (literally: food from the forest, but the whole expression is exocentric)
7.	mbombó (mbombó)	mould, mildew, terrestrial algae, mosses, lichens.

Each category, except 5 and 7, is then divided into a varying number of labelled groups recognised as distinct forms. Examples of each category are the following:

tosandu;	bokumo	Ficus spp
	bombimbo	Treculia africana
	bofili	Scorodophloeus zenkeri Harms
	bolindá	Chrysophyllum lacourtianum De Wild.
	bɔkɔ́lɔndɔ	Klainedoxa gabonensis Pierre
tosaasandu	lisende	Caloncoba welwitschii Gilg.
	lomata	Manihot esculenta Krantz
	ikenya	Aidia spp.
ndiki	ilílokonda	Clerodendron splendens G.Don.
	bileli yáoyóká	Sabicea spp.
	lɔkɔlí	Eremospatha spp.
	wéngenge	Combretum spp.

twingi:	bocica	Amaranthus spp
	tolabo	Cleome ciliata Schum. & Thonn.
	bangala	Panicum maximum Jacq. + other grasses
	lyokóoko	Pennisetum purpureum Schum.
totaki twalokonda:	bókombó	Lepiota spp.
	batalɛ	Hirneola auricula-judae (L) Berk.
	isolésolé	Cantharellus spp.

Some of these smaller labelled categories (but not all) are further sub-divided into smaller groups. This is especially the case with cultivated plants, for example:

lomata (manioc):	awelo
	tabóla
	baɛ́lɛ
	kélémokɛ...
likɔndɔ (plantain-banana):	ambulu
	libanga
	bogbata ...

There is clearly a close resemblance between Upper Zairian folk taxonomy and that described by Berlin et al. for Tzeltal-speaking people in Mexico . Most named plants are of the type which Berlin et al. call "generics". These are subsumable under a much smaller number of "life-forms" (the 7 listed above). There is no higher category to which these life-forms belong, just as Berlin et al. found no label for the "unique beginner" in Tzeltal. A few of the Lokele/Olombo generics are sub-divided into "specifics"; most, if not all of these, are cultivated plants but, contrary to the Tzeltal findings, labels for these "specifics" are of the primary lexeme type. Some plant labels are analysable but are of the "unproductive" category, being exocentric expressions:

ilílokonda (Clerodendron) "little thing that climbs in the forest"
bileli yáoyóko (Sabicea) "Boyoko's tears"
totáki twálokonda (macroscopic fungi) "food from the forest"

Conversations about plants and plant products in the Lokele/Olombo region will often involve the use of what Berlin et al. call "secondary lexemes" i.e. labels qualified in some way. We frequently refer to the manioc cultivar /tabóla/ as /lomata lotelú/ - "pink manioc" (tubers have a pink layer immediately beneath the skin) or to the form /limela/ as /lomata lwíndo/ -"dark manioc" because of the colour of the whole plant above the soil surface. Similarly, to distinguish if necessary between Panicum maximum Jacq. and a smaller grass such as the equally common Eleusine indica (L)Gaertn., we should label the former/bangala afí/ "large grass" and the latter /bangala akékɛ/ "small grass". But all these secondary lexemes are not plant labels in the sense of being exocentric expressions. They are endocentric descriptive phrases like "red rose"

(page 15).

Male and female forms. Upper Zairian craftsmen use the terms "male" and "female" to distinguish between plants. This distinction may coincide with the botanical differentiation into staminate and pistillate forms of dioecious species since the form described as "female" is the one producing fruit and seeds. Thus the Mba tribe class Musanga cecropioides R.Br. into two such forms. They call the species /kombo/ (plural /kombe/, this language being non-bantu and indicating number change by differences in the suffix rather than the prefix of each noun) and then separate out:

kombo ju female Musanga,

kombo kyá male Musanga.

The former have pistillate and the latter staminate flowers.

But it must be noted that some other tribes apply the terms "male" and "female" to indicate hardness and softness of timber respectively and this may run counter to the botanical distinction. Olombo craftsmen describe the timber of the pistillate form of Musanga as "male" because it is harder than the staminate form. Their usage thus appears to be the opposite to that of the Mba tribe. (See also sections 4.3.4.5 and 6.2.3).

Growth stages. Distinctions are frequently made in folk taxonomies between successive stages in the growth of organisms. Africans are fully aware of the fact that different stages belong to one and the same plant or animal but their morphological and economic differences make a difference of nomenclature helpful in referring to them. A young plant may be described in several different ways:

a. using a label with prefix i-/sy- and perhaps kernel reduplication i.e. placing the name in class 12

ikókófé a small Staudtia gabonensis Warb (adult: bokófé)

itútúmbé a small Musanga cecropioides R.Br. (adult: botúmbé)

b. using the word "infant" before the normal label:

syána syá bokófé an infant Staudtia tree

syána syá likondo an infant plantain (adult: likondo)

c. using a different name:

look o a young plantain

bolunde a young Antiaris welwitschii Engl. (adult: lisoko).

3.2.9 Botanical terminology in Lokele/Olombo.

Lokele and related languages are adequately provided with labels for units of plant morphology so that discussions of anatomy, physiology and ecology can and often do take place. For a typical member of the category /syingi/ (weed) namely /sɛsɛ/ or Talinum triangulare (Jacq.)Willd.

we have:

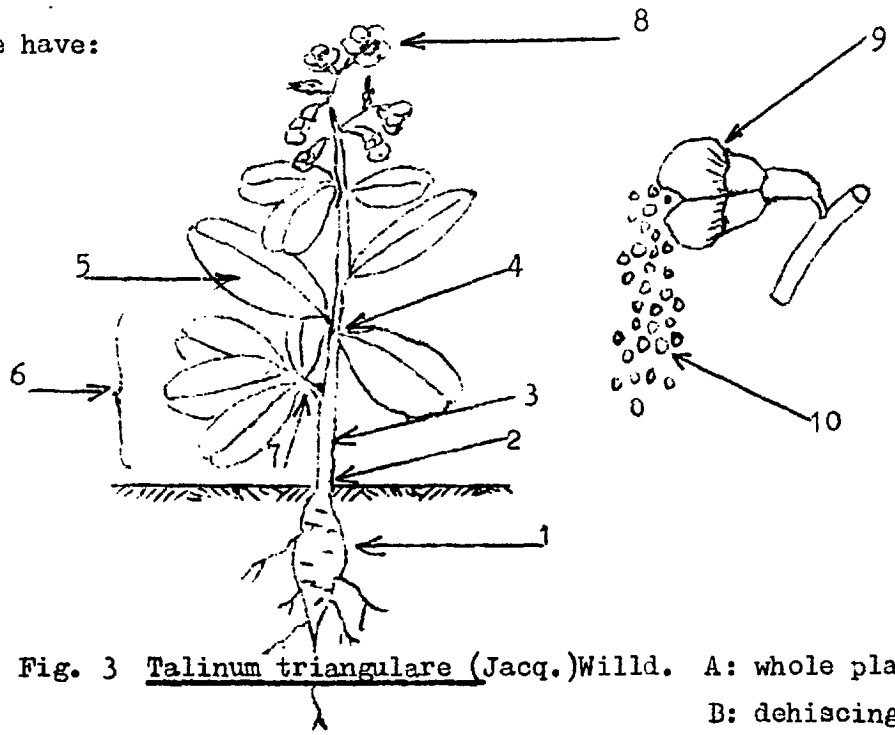


Fig. 3 Talinum triangulare (Jacq.)Willd. A: whole plant $x\frac{1}{2}$
B: dehiscing fruit x3

1-	wili/bili	root	6-	litɔ́mbɔ́/batɔ́mbɔ́	shoot
2-	litína/batína	collar	7-	botá/betá	branch
3-	bokuma/bekuma	stem, trunk	8-	lombyá/mbyá	flower
4-	likᵊkɔ́/bakᵊkɔ́	node, bud	9-	syuma/tuma	fruit
5-	lokása/kásá	leaf	10-	lokɔ́to/kɔ́to	seed

Talinum triangulare is a glabrous herb. Plants with a hairy indumentum are described as having /fuu/ (singular:/lofuu/), i.e. "body hair" while plants with spines or thorns have /kɛɛkɛ/ (singular: /bokɛɛkɛ). Some additional terms are used to describe parts of trees:

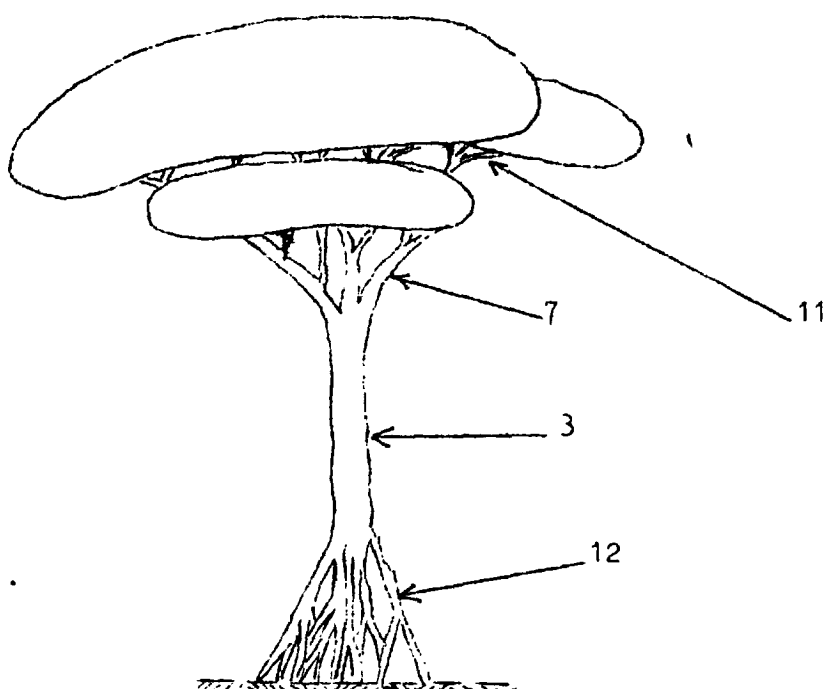


Fig 4 Musanga cecropioides R.Br (x1/200)

11-	itá/totá	twig	12-	bokolo/bakolo	prop root (lit. "leg")

Botanical terminology unique to sp ..fic plants.

Ethnobotanists who approach research into cognitive aspects of folk biology without an adequate knowledge of the local language must beware of the specificity of some terminology. Expressions given above for Talinum and Musanga can be used for all plants, but some cultivated forms in common use have specialised vocabularies:

a. plantain: Musa acuminata x balbisiana Colla

whole plant	likɔndɔ
young plant for propagation	lɔɔkɔ
bunch of fruit	likɔndɔ
peduncle and rachis	bɔilɛtɛkɛ
one banana	lomuka

b. oil palm Elaeis guineensis Jacq.

whole palm tree	litokɔ
palm frond	likángá
petiole of frond	lɔɛnjá
bunch of male flowers	lɪtifa
bunch of nuts	eíla
single nut	loíla
bunch of nuts together	mbíla
kernel of nut	boliká
palm beer	báná
palm spirit (distilled)	lotoko

c. manioc Manihot esculenta Krantz

whole plant	lomata
leaves (edible)	bombolo
stem	lokelenge
stem cutting for propagation	ikélé
root tuber	isongú

3.2.10 The process of plant identification in the Upper Zaire.

There are sharp sex differences in village occupations in the Upper Zaire, as elsewhere in Africa. Women are frequently more knowledgeable than men over labels for food and medicinal plants; obtaining these commodities occupies a large part of their daily lives. A Lokele proverb states, indeed: /Bolóme wa loó angoenó lisóo/ - A husband who falls ill never lacks for medicine (but a bachelor might well succumb for there is no wife to help him!). A woman foreign research-worker will have a better chance of getting accurate information about such plants than a man. Men have a more intimate knowledge of plants used for constructional purposes; they are the basket-makers, the net-weavers, sculptors and house-builders. Those men (some women also) who take up the profession of village healer have a wide knowledge of plants useful for medicinal purposes.

When presented with a plant to be named, a Lokele or Olombo person usually gives the name unhesitatingly as he or she recognises it. As in the case of the trained Western botanist, the overall impression made by the plant - its Gestalt - is usually sufficient to place it in a known

folk-taxon. If the plant is a strange one, then a closer examination is made in the following way:

stems and leaves are felt between the fingers to discover the presence or absence of trichomes,

the plant is lightly crushed and sniffed,

a portion of the leaf is bitten off and tasted,

root colour and fruit form and taste may also be referred to.

The local botanist rarely declares that a plant has no name. He (or she) may say that he does not know the name personally but that there will be people more expert than he in the village who do have that knowledge. Frequently an attempt is made to relate an unkown plant to one already known which it resembles in some way and then such names are given as

/kwa X/ like plant X,

/ndá bofindí wá X/ in the family of plant X.

The perplexed informant may suggest an economic, technological or ecological term rather than the taxonomic label expected by the questioner. Instead of giving the plant name he may reply:

this is medicine for the eyes,
this is a weed to be uprooted,
this is firewood,
this makes fibres,
this is a stinging plant,
this is a marsh plant...

Only a fluent knowledge of the local language used in conversation will enable the outside botanist to assess the kind of label which is being offered.

In the next section a list of plant-names used in the Lokele/Olombo area of the Upper Zaire will be presented to illustrate what has been already argued.

3.2.11 Upper Zairian folk taxonomy in the light of earlier reseach.

The detailed notes on local nomenclature for plants given in the published volumes of the "Flore du Congo" provide a valuable means of comparing taxonomy in the area studied with folk taxonomies elsewhere.

Zaire came under colonial rule in 1884 when King Leopold II of the Belgians commissioned H.M.Stanley to make treaties with chiefs all over the territory so that they placed themselves and their peoples under the King's personal protection. In 1908, King Leopold handed over authority to the Belgian Parliament and what had been the "Etat Indépendant du Congo" (the Congo Free State) became the colony "Congo Belge". In the early Free State years, botanical exploration was begun and actively pursued, important collections of living and dried plants being built up

at Kisantu and Yangambi and at the State Botanical Gardens in Brussels. After the Second World War, Belgian botanists at Yangambi, which had become one of the biggest and best equipped tropical agricultural research stations in the world, began publication of the country's Flora. The basic conception of this enterprise was so grand, with such detailed accounts of specific morphology, that by the time the "winds of change" were blowing over this part of the continent of Africa and Independence was granted to the former Belgian Colony (in 1960), the 10 large volumes published up until then had only described about a third of the higher plants (gymnosperms and angiosperms) of the area. Since 1960, publication has continued but at a slower rate and in small fascicles rather than in the large volumes of earlier years. What was entitled "Flore du Congo Belge et du Ruanda-Urundi" has been continued as "Flore du Congo" and will presumably now be given the title "Flore du Zaire" owing to recent changes in the country's name.

Belgian botanists tried to get local names for the plants they described so far as possible, either in the field as they travelled or among the large population of workmen employed at Yangambi where the main herbarium was and still is prepared and housed. There is thus an excellent data-bank of ethnobotanical material which is of great interest in view of the current research on folk-taxonomies in other parts of the world. As an exercise in the reporting of local plant nomenclature by overseas botanists and its suggestions as to plant classification by African communities, this data has been worked over by the present writer to single out names given in the first 10 volumes of the Flore by members of the Lokele and Olombo peoples. Many of the species described for Zaire do not occur in the equatorial forest area of the Upper Zaire and therefore have no label in Olombo/Lokele. But there are names for 615 species, in 295 genera and 55 families of the Linnean system. The list is appended to the present study.

The orthography used is unfortunately not that of the African Institute but a modified French orthography with the happy acceptance of /u/ (as in German du) for the usual French /ou/script. Accents are not used and there is little or no attempt to distinguish the 2 phonemes e/ɛ nor the 2 phonemes o/ɔ. Tone is not marked. Although one of the Yangambi workers made a valuable survey of plant names used by the Olombo (Capon, 1953), elicitation of these labels was done by using mainly French and Swahili as means of communication with informants. The lack of understanding of the Olombo and Lokele languages used in the area where Yangambi is situated ("Yangambi" itself is the name of a Lokele fisher village some 5 km

below the agricultural station's river-port) led to some obvious misunderstandings (cf. Carrington, 1959 for linguistic errors of this type in other documents). Examples of these are:

a. informant's comments are taken to be plant labels;

i. Cassia mimosoides L (Caesalpiniaceae) is named /kitukule kikereke/. The first element of this name is Swahili for "that thing there" while the second is an Olombo adjective meaning "small". The total label "that little thing there" was probably a question on the part of the informant rather than an attempt to state the name of the plant.

ii. Most Ficus species are named /bokumo/ or /likumo/, as shown in the "Flore". The label /taliwa/ given for F.capensis Thunb. (Moraceae) is most probably the word /tálúwá/ which means "first know" in the local language and is the call-word when a riddle is proposed. It was used by the informant with the sense; "Let's see now..." while he sought for time to think of the proper label.

b. ecological and physiological comments about the plants under observation are taken to be botanical names:

i. Jatropha curcas L (Euphorbiaceae) is labelled /sumo/ which is Swahili for "poison" of any kind;

ii. /lituwolo/ is the label given to some 20 widely divergent species including Celosia globosa Schinz (Amaranthaceae), Sida rhombifolia L (Malvaceae), Desmodium velutinum (Willd.) D.C. (Fabaceae). A character common to them all is a deeply penetrating root system which makes it difficult to pull them up. The name is indeed derived from the kernel -ÚWOL- meaning "to pull out" and the term /lituwolo/ could be satisfactorily glossed "deep-rooted weeds". It is a descriptive term rather than a plant label.

iii. /ndimo na lokonda/ for Citropsis articulata (Willd. ex Sprung) Swingler et V.Hullman (Rutaceae) means "forest lemon-tree" and is based on the common name for Arab-introduced citrus plants. The name shows the botanical perspicacity of the informant, however, in that he clearly recognises the salient characters of a citrus plant.

iv. /lokoka/ for Ficus sereti Lebrun ex Boutique is the normal Olombo term for "enema" and simply classes this species as a medicinal plant used for bowel infections and for fevers.

v, /bote/ is the general Olombo term for medicines and remedies.

Hence the following are not botanical labels but descriptive terms

based on economic usage:

/botɛ́ bɔ́ baíno/ Glyphaea brevis (Spring) Monachino (Tiliaceae); the term means "medicine for the teeth";

/botɛ́ a baíso/ Kalanchoe crenata Han (Crassulaceae), the term meaning "medicine for the eyes";

/ité í bonuka/ Olax viridis Oliv. (Olacaceae) - "oily medicine".

c. collective terms are given for individual labels:

i. /etwela/ = "that which descends upon..." and is used for different kinds of plants growing on the branches of others. Hence it is the label given to all the numerous species of Loranthaceae found in Zaire.

ii. /tɔtɔtɔ/ is derived from the kernel -ɔ́T- meaning "to germinate" (of seeds) or "to sprout" (of buds). It is a general term for any leafy or floral shoot and cannot be accepted as a botanical label for a specific taxon. The "Flore", however, gives this term as the name for Antigonum leptopus Hook. (Polygonaceae), Cardiospermum helicacabum L (Sapindaceae) and Celosia leptostachya Benth. (Amaranthaceae).

Analysis of the labels given to these 615 species by Olombo informants shows 213 basic terms (excluding the names already discussed as being errors of understanding or general terms mistaken for specific labels). Of these 61 occur without qualification and refer to only one plant each. For example:

o-be Irvingia grandiflora (Engl.) Engl. (Irvingiaceae)

w-ehu Cynometra hankeri Harms (Caesalpiniaceae)

bo-kofe Staudtia gabonensis Warb . (Myristicaceae)

e-tale Okoubaka aubrevillei Pet.& Normand (Octoknemataceae)

li-bwabwa Piper umbellatum L (Piperaceae)

Eleven other names are labels of 2 Linnean species, as recognised by Western botanists, for example:

a-foli Monanthotaxis poggei Engl. (Anonaceae)
Paullinia pinnata L (Sapindaceae)

e-lema Cissus dinklagei Gilg.&Brendt (Vitaceae)
Illigera vespertillo (Benth.) Balf. (Hernandiaceae)

bo-nama Impatiens irvingia Hook.f. (Balsaminaceae)
I. niamniamensis Gilg. (idem)

Some of the basic names are given to a larger number of related species than two. Here, as in the last 11 cases, Zairian botanists are the "lumpers" of Western botany rather than "splitters". For instance, the label /likumo/ is given to 13 species of Ficus found in the Yangambi area.

Unanalysable primary lexemes other than the 61 already mentioned are qualified in various ways to give "secondary lexemes". In this Olombo data, 102 basic terms give 349 labels attached to plants in the "Flore" which describe 575 Linnean species recognised by the Belgian taxonomists and their collaborators. Three examples of such secondary lexeme formation are:

a.	y-eto	Duboscia viridiflora (K.Schum.) Mildbr. (Tiliaceae)
	inaolo ay-eto	Nesogordonia katangaensis (K.Schum.) Capuron (Sterculiaceae)
b.	o-ngúngúna	Myrianthus arboreus P.Beauv. (Moraceae)
	o-ngúngúna boboliki	M. scandens Louis ex Haumann
	o-ngúngúna bokikeleke	M. preussii Engl.
c.	o-longo	Fagara inaequalis Engl. (Rutaceae)
	o-longo oboliki	F. laurentii De Wild.
	o-longo bokikeleke	F. poggei Engl.
	ilo-longo	F. rubescens (Planch.)Engl.
	inaolo ao-longo	Pierreodendron africanum (Hook.f.)Leothe (Simarubaceae)
	inaolo ae-longo	Ventilago africanum Engl. (Rhamnaceae)

Twenty-four labels are analysable into meaningful elements, i.e. correspond with what Berlin et al. call "unproductive analyzable primary lexemes" or with Friedberg's "termes métaphoriques". For example:

/kɔmbɛ njáka/ "parrot's claws" for Anacolosa uncifera J.Louis et Boutique (Olacaceae)

/mbɛlɛ baóngó/ "house of driver ants" for Heistera parvifolia Smith (Olacaceae)

/básáso básáso / "three by three" for Allophyl͡us spp. (Sapindaceae)

/ngingo elikebe/ "antelope's neck" for 14 spp. of Annonaceae.

Further examples of this type of plant-label (not included in the "Flore" because belonging to families as yet unpublished) could be cited:

/likɔndɔ lyáolímó/ "banana of the spirit" for Anchomanes spp.. (Araceae)

/koko yáolímó/ "arrows of the spirit" for Bidens pilosa L (Asteraceae)

/basolo ámbúli/ "goat's buttocks" for Ageratum conyzoides L (Asteraceae)

/botuta tɔná/ "swollen with ants" for Canthium dewevrei (Rubiaceae).

Such analysable labels may in turn be qualified when attached to other plants to give labels of what Berlin et al. call the "secondary lexeme" type:

/ngingo elikebe ebote/ Polyceratocarpus vermoesenii Robyns et Ghesq. (Annonaceae)

/ngingo elikebe linenu/ Enneastrum biglandulosa Boutique (Annonaceae)

/ngingo elikebe ifufo/ 1. Artabotrys palustris Louis ex Boutique (Annonaceae)

2. Oxymitra grandiflora Boutique (Annonaceae)

/inaolo engingo elikobe/ 1. Artabotrys robusta Louis ex Boutique (Annonaceae)

2. Dalbergia heudelotii Stapf (Fabaceae)

3. Popowia diclina Sprague emend. Chipp. (Annonaceae)

4. Uvaria rivularis Louis ex Boutique (Annon.)

5. U. scabrida Oliv.

Qualifying elements attached to unanalysable or to analysable lexemes in Olombo names reported in the "Flore" are arranged below in order of importance:

/inaolo/	84 labels	= "relative". An Olombo man's /inaolo/ is a member of his mother's clan.
/fufo/	35	= white
/boliki/	25	= liana, vine
/libande/	22	= riverine
/lowe/	17	= stream
/nenu/	17	= red
/kikeleke/	15	= small
/ilo/	14	= black
/bote/	7	= medicinal
/abolome/	2	= male
/isaala/	2	= twiggy
/ofili/	1	= like Scorodophleus
/ndole/	1	= path, wayside
/ngonda/	1	= virgin forest
/lifilifi/	1	= very large

These are clearly closely similar to the attributives listed (but in greater numbers) by Berlin et al. for Tzeltal plant labels (1974). In Olombo, however, the majority are descriptive words giving labels that are endocentric expressions and therefore unacceptable as botanical names. It must be asked how far this is true of the Tzeltal data too.

3.3 Folk taxonomic labels for timbers from the Upper Zaire.

Vernacular names reported for the 6 timbers featured in the present study will be of interest in this discussion of ethnobotanical data from Zaire. They are printed on the distribution map for each species. The following points are worthy of note:

1. Most names are of the "unanalyzable primary lexeme" type of Berlin et al., for example /bokuka/ for Alstonia congensis Engl.
2. A few names are analysable productive lexemes, for example: /susu menga/ for Staudtia gabonensis Warb. where /susu/ means "chicken" and /menga/ means "blood". The reference is to the red exudation from the bark and the wood of this tree.
3. At least one is probably a technological label rather than the name of the folk-species: /gigungu/ given for Pterocarpus soyauxii Taub.

closely resembles the term /bongúngú/ given in the Upper Zaire to the talking drum made from Pterocarpus timber.

4. One other may be interpreted as a folk-botanist's attempt to give a family relationship to a species he did not recognise: the name for Combretodendron macrocarpum (P.Beauv.) Keay in Angola is /dekolambunda/. This sounds like /ndeko na mbunda/ meaning "brother of /mbunda/".
5. If the labels of any one species are compared over their whole range after isolating the kernels, these latter are seen to be remarkably homogeneous:

   Alstonia: /liKUKa, iKUKa, nKUKa, muKUKa, mGUGa, aKUe.../

   Staudtia: a./boLANGa, moLANGa, boNANGa, wANGa.../

   b./boKOFe, boOFi, ngOBe, baOBe, ngOWe, KAFi.../

   Pterocarpus:/wELe, lELe, mbELi, oLILi.../
6. Some species have only one of these related name series e.g. Alstonia with /KUK/, while others have more than one. Staudtia has 2: /LANG/ and /KOF/ while Pterocarpus has 3: /EL/, /SI/ and /KOL/. Musanga also has 3: /KOMB/, /SANG/ and /TUMB/. /KOMB/ and /TUMB/ are not subsumable under the same kernel because /KOMB/ is low-toned while /TÚMB/ is high-toned.
7. The /INJ/ label given in Gaboon for Combretodendron may b e compared with Lingala /mbINJo/ meaning "edible caterpillars". This species is well-known to provide edible caterpillars all over its range in Africa. It would then appear that the name /INJ/ is a metaphorical name for the tree derived from the insect larvae found on its leaves. But it is also possible that the label for "caterpillars" in the languages concerned may be derived from the name for the tree in each case, so that this latter would be an "unanalyzable primary lexeme". This is probably the case in caterpillar trees found in the Olombo area (see page 30).

The wide-spread names for most of the timbers studied can be correlated with Bantu migration as outlined on page 13. To say that such similar labels are "explained" by migration would be to use a circular argument because the linguistic evidence for the migration was based on lists of labels for different common objects in the languages of the area where the six timbers are found. But it is worth while advancing these timber names as additional examples of correlated linguistic series, especially as plant names do not figure frequently among the items originally studied by Guthrie and Greenberg in their work on Bantu origins.

It would be an attractive hypothesis to suggest that the 4 timbers

having one or more series of common names were recognised and utilised by Bantu migrants before they separated and moved into their present-day positions. On the other hand, Combretodendron and Gossweilerodendron would be species that they have begun to use after their arrival in the areas they now occupy. It is indeed true that other timbers than these are used in the wider area of Central and West Africa for axe-hafts and canoes respectively. Much more linguistic data would be required, however, to test such a hypothesis. Research of this kind could best be done at University departments in Central Africa where trained local botanists, conversant with craft uses of plant species in their own country could cooperate with national linguists competent in their own tongue.

3.4 Comparisons between folk taxonomies and the Linnean system.

The attempts by several ethnobotanists to compare folk taxonomies with the Linnean system used in Western science are often remarkable for their lack of critical appraisal of the latter. Results are sometimes expressed as though Linnean classificatory labels were definitive and changeless. Taxonomists know how far short of reality this is. Almost every major revision of a taxon above species level results in changes of nomenclature so that the specific and generic descriptions of any standard flora usually begin with a long list of synonyms. The six timbers selected for study illustrate this. Alone of the 6 species, Pterocarpus soyauxii Taub. has not changed its denomination since Taubert first described it. The early confusion over the correct binomial for /botúmbé/ (Musanga cecropioides R.Br)will be explained later (4.3.4). All the others have had a changing nomenclatural history.

Alstonia congensis Engl. was first described by Engler in 1887. De Wildeman considered that a species of this genus which he described from the Congo (present-day Zaire) in 1914 was sufficiently different to warrant separate specific status, the differences being mainly of indumentum (glabrous calices and fruits as compared with villous organs in A. congensis Engl.) and slightly different lengths in calyx lobes and corolla tubes. He therefore named it Alstonia boonei De Wild. This separation was maintained in the 2nd. edition of the Flora of West Tropical Africa (1963) but Irvine in his Woody Plants of Ghana (1961) regards the two appellations as synonymous. Irvine's opinion is accepted in the present study; none of the trees examined by the writer was in flower so that details of inflorescence structure could not be studied.

Combretodendron macrocarpum (P.Beauv.)Keay was first reported and described in 1820 on the basis of a single fruit from a tree and named

Combretum macrocarpum P.Beauv. The tree was named by Welwitsch: Petersia africana in 1865. Exell then brought this species within the genus Combretodendron with the changed name: Combretodendron africanum (Welw.ex Benth.) Exell. Keay has recently shown that the fruit known as Combretum macrocarpum P.Beauv. is from this species and he has therefore proposed the new combination: Combretodendron macrocarpum (P.Beauv.) Keay which we shall use in this study. The Lokele/Olombo name of /bᵒsɔɔ/ has remained the same throughout these nomenclatural changes within the Linnean classificatory system.

Gossweilerodendron balsamiferum (Vermoesen) Harms was first validly described by Vermoesen in his work; Manuel des essences forestières du Congo Belge, in 1923. He regarded it as a species of the genus Pterygodium and labelled it: Pterygodium balsamiferum Vermoesen. Harms undertook a revision of this genus and in 1925 separated this species as a new genus called by him Gossweilerodendron. It was exported from West Africa under the names /agba/ and /tula/ and called /boúlú/ by the Olombo before and during the nomenclatural changes in botany.

Staudtia gabonensis Warb. was also described by Vermoesen as a new species in his publication on Congo timbers (1923) and named by him Staudtia congensis Vermoesen. Warburg had earlier (1904) separated 2 species of this genus on the basis of stipitate and non-stipitate fruits naming them S.stipitata Warb. and S. gabonensis Warb. In their West African Flora, however, Hutchinson and Dalziel merged these two forms since the character on which the difference was based proved to be unstable. S. stipitata was relegated to the synonymy and S.gabonensis was conserved. Another earlier name used in West Africa was S. niohue Pierre based on a folk taxon in that area.

It is this ever-changing pattern of Linnean nomenclature as more and more plants from new areas are collected and described botanically that led Merrill to recommend the use of vernacular names rather than Linnean labels when working in the field in overseas areas. He writes cogently:

> Sometimes a well-established native name is really more definite and more fixed in application in such a region as Malaysia as a whole than our vaunted Linnean binomials; for well-established native names do not change through the centuries. (1946, page 230)

P A R T II

4 Some useful timbers of the Upper Zaïre: utilisation and structure.

Six timbers of differing structure and mechanical properties were chosen to provide a wide spectrum for assessing the possible correlations between properties and structure which could vindicate their utilisation by local craftsmen in the Upper Zaire for specific purposes. These species were:

Alstonia congensis Engl.
Combretodendron macrocarpum (P.Beauv.) Keay
Gossweilerodendron balsamiferum (Vermoesen) Harms
Musanga cecropioides R.Br.
Pterocarpus soyauxii Taub.
Staudtia gabonensis Warb.

Specimens came from 3 different sources:

a) artefacts already prepared by craftsmen and in use locally,
b) wood from trees recently felled whose botanical identity was determined,
c) increment borings from standing trees of known botanical nature.

Samples of wood from each species were examined for anatomical structure and mechanical properties.

4.1 Levels of investigation.

Anatomical investigations were made at 3 levels:

a) macroscopic - size and age of tree used, provenance of the timber selected for a given artefact;
b) microscopic - tissue types present in the wood and their relative importance and distribution;
- presence or absence of latex- and resin-canals;
- cell-structure: size, wall thickness, inclusions;
- vessel-net density;
c) sub-microscopic - fibrillar angle in the secondary wall of fibres.

4.2 Methods used in anatomical investigation.

4.2.1 Sectioning. The softer woods (Alstonia, Musanga) were sectioned on a Reichert microtome after boiling a small prism 10mm x 5mm x 5mm in water to expel air from dried cells and subsequently pickling in 50% ethanol-water mixture with 5% glycerol added. The harder woods needed boiling for longer periods (30minutes or more) and cutting was performed under hot steam treatment using the apparatus recommended by Kisser (19). Burkart's method (1966) of softening the wood by heat-

ing small prisms in triethylene glycol was tried but abandoned when it produced extensive charring.

Transverse (X), radial longitudinal (R) and tangential longitudinal (T) sections were cut at 20μ thickness for tissue analyses. They were stained in safranin and haematoxylin, dehydrated in ethanol/water mixtures of decreasing aqueous dilution up to absolute alcohol, then taken through clove oil and xylol and mounted in balsam.

For examination of the vessel-network, sections of 25μ and 50μ thickness were prepared and mounted temporarily in glycerine-jelly containing gentian violet which was gradually absorbed by lignified tissue and gave sufficient definition for the pores to be drawn under the binocular microscope.

4.2.2 Records were made of the results of anatomical investigations in several ways:

a) up to a magnification of x50, a Wild binocular microscope was used fitted with a drawing attachment;

b) for magnifications greater than x50, it was necessary to fit a camera lucida attachment to the straight tube of a light microscope so that drawing could be done;

c) the 500w bulb of a diapositive projector was used as a powerful source of light transmitted through a light microscope set horizontally and serving to project a magnified image of the wood section on to drawing paper by means of a prism fitted over the ocular lens. Boundaries of tissues could easily be drawn in this way and even cell outlines and cell inclusions. See Clarke, 1930, for a description of this method;

d) light photographs were taken with the usual photomicrographic apparatus;

e) small blocks of timber were also prepared for microscopy with the scanning electron microscope in the Botany Department of Imperial College. These blocks were coated with gold and then examined for surface structure.

4.2.3 Macerations were made of all the timbers studied using Schultze's method: small slivers of wood were placed in concentrated nitric acid to which a few crystals of potassium chlorate were added. The maceration was watched (with the preparation in a fume cupboard because of the copious fumes of nitric oxide given off) until the wood became pulpy and showed some disintegration. Bleaching usually took place. The preparation was then washed in water until free of acid, shaken to

separate individual cells and examined microscopically in glycerine. It was sometimes necessary to bring cell-separation about by shaking the maceration with small glass beads or using dissecting needles on a small clump of tissues placed on a slide under the low power (x6) of a binocular microscope. This latter method was found to be specially useful when searching for vessel elements which could then be separated from the rest of the cells by drawing them into the tip of a glass capillary placed beside them and transferring them to a drop of glycerine on another slide.

Measurements of individual cell dimensions were made

a) by using a micrometer eye-piece calibrated against a standard 2mm graduated slide;

b) by drawing at x25 and x50 magnification under the binocular microscope and measuring the outlines drawn;

c) by projection on to squared paper as in (c) above (4.2.2) and measuring off cell dimensions directly after calibration of the squares by projecting on to the same paper an image of a graduated slide.

4.2.4 Tissue analysis. Measurement of the relative amounts of different tissues present in any one timber section should ideally be volumetric. This is difficult to achieve, however, because there is no method available to separate vessels, vertical parenchyma and wood rays in a given block of wood. Sections taken radially show a greater percentage of ray tissue than would be found in a volumetric estimate; sections taken tangentially would give too great an importance to vertical parenchyma in timber with banded or aliform parenchyma and would be inconsistent when applied to timber showing anatomical differences within a growth ring. Sections allowing measurements of tissue percentage most nearly approaching that of a volumetric estimate are those cut in a transverse plane. Table 2 shows differences in tissue analyses found in studying sections of Musanga cecropioides R.Br wood in the 3 different planes. It is clear that sections in the transverse plane give the most consistent results. Estimates of percentage areas of different tissues in any one section were made by the dot-grid method described below.

Methods for estimating the relative importance of the tissues included the following:

a) a squared grid, 100mm x 100mm was ruled on white paper and dots marked at points determined by the intersection of ordinals and abscissae given by consecutive figures in a table of random numbers. An image of the tissue to be assessed for percentage com-

Table 2: Relative importance of different tissues in sections of Musanga cecropioides R.Br. xylem. All figures in %.

A. Transverse section:

Sections:	a	b	c	d	e	means:
Parenchyma	24	26	22	23	33	25.6
Rays	15	17	21	18	18	17.8
Vessels	8	5	8	8	10	7.8
Fibres	53	52	49	51	39	48.8

B. Radial section:

Sections:	a	b	c	d	e	means:
Parenchyma	12	7	7	5	6	9.4
Rays	27	27	44	35	14	29.4
Vessels	0	0	3	24	26	8.6
Fibres	61	66	46	36	64	54.6

C. Tangential section:

Sections:	a	b	c	d	e	means:
Parenchyma	8	0	15	11	0	6.8
Rays	20	21	22	13	20	21.2
Vessels	10	18	2	22	11	12.5
Fibres	62	61	61	54	59	59.4

position was then projected on to the grid and a count made of cell types on which the randomly distributed dots fell. (See Kandeel et al. 1961, Isebrands 1972 and Quirk 1975 for descriptions of this method).

b) Drawings were made on thin card with a binocular microscope giving the outlines of tissues present in a section. The different tissues were then cut out with fine scissors and the total cut-outs for each tissue type were weighed. The relative weights gave the relative frequencies of each tissue type present. (See Boshard 1970 for this method).

4.2.5 Vessel net-work investigation.

Early work on the course of vessels through the xylem was mainly concerned with the efficiency of the vessel-system in water conduction and the ontogenetic development of cambial elements. Research was directed at estimating the lengths of single vessels and comparing these for different plants (Dixon, 1914; Holmes, 1918; Handley, 1936; Priestley et al. 1940). More recent work shows renewed interest in xylem penetrability in connection with attempts to impregnate timber with preservatives and other fluids. It is remarkable how persistent has become the theoretical model of xylem vessels as a group of parallel capillaries quite independent one of another (see also section 7.3.2). Braun's work on Populus (1959) and his extension of this later to other species, showed that xylem vessels

in wood form an anastomosing network, the density of which varies from species to species. He further found that the vessel-network was correlated with other xylem features; for instance, there is an inverse correlation between the net-work density and ray height (see fig.5). It is reasonable to suppose that fibre anastomosis is also correlated with vessel net-work density and such anastomosing of the main strength elements of the wood would influence its toughness and fissility. Work has therefore been done on the vessel network of each of the 6 timbers selected for study.

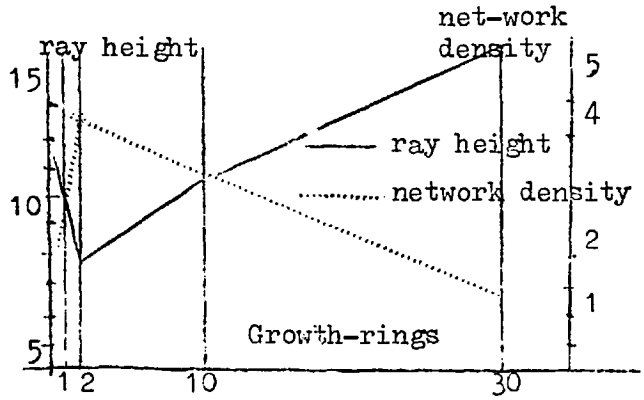


Fig 5: Correlation between ray-height and vessel network (Braun 1959)

A first attempt was made to render the course of the vessels visible by aspirating hot paraffin wax through the timber and allowing this to solidify by cooling. The surrounding wood was then dissolved away by immersion in concentrated sulphuric acid, leaving the wax casts exposed for microscopic study (as suggested by Dixon, 1914). The delicacy of the casts, however, made observation under the microscope difficult and the method was abandoned.

In a second attempt, the molten wax was first coloured with a blue dye before aspiration. Tangential longitudinal sections of impregnated wood were then cut - 500µ thick - and soaked in benzyl benzoate to clear them. They were then examined under the microscope and the course of the vessels, as shown up by the blue wax, was observed for changes in tangential position and for junctions. It was found, however, that wax penetration had not always occurred, especially in the case of narrower vessels; so that, while vessel junctions could be effectively demonstrated by the method, it was of little value for a quantitative assessment of the extent to which anastomosis was taking place. A similar criticism had to be made of attempts to use Indian ink as a means of showing up vessel position after aspiration and clearing in benzyl benzoate.

The method finally adopted was that of serial sections as used by Braun (1959, 1963) and described in detail by Burggraaf (1972). This is essentially similar to the preliminary stages of Zimmermann and Tomlinson's remarkable micro-cinematographic method (1967) whereby the variable course of vessels in wood, their junction and disjunction as they proceed through the xylem are made clear by filming.

The essential stages of the serial method are as follows: sections of a small wooden prism were cut serially in the transverse plane at intervals of 25μ or 50μ according to the density of the network being investigated. Where vessels join frequently, the thinner sections permit of easier monitoring of changes in relative positions. Four transverse sections could be mounted under one cover-slip, each orientated in the same direction, and two or three cover-slips mounted on one slide. The sections were immersed in warm glycerine jelly containing gentian violet stain which was absorbed by the lignified cell walls and hence allowed easy observation of vessel positions. A small notch cut into the wood prism before sectioning ensured that each section was orientated properly on the slide. (Fig.6)

After 2 or 3 hours, the glycerine-jelly had set sufficiently hard to hold the sections in position on the slide and the stain had begun to show up the vessels. Each section was then viewed through a Wild binocular microscope fitted with a drawing attachment and tracings were made of all the vessels visible at the chosen magnification. One or two rays were also traced to assist with later orientation of the sections during comparison of one section with another. Drawings were done on semi-transparent paper with indian ink. For macroporous woods such as Staudtia and Musanga, where the number of vessels per unit area in XS is small, a magnification of x25 was suitable. For Combretodendron, where large clusters are found and the diameter of individual vessels is smaller, it was easier to use a x50 magnification.

When one section had been drawn (Fig.7A), the following was moved into position on the microscope stage and adjusted until its pores fitted the image of the first section's tracing under the microscope. At intervals of 25μ, especially in the case of timbers with a loose vessel network, there was little change of position in the vessels in consecutive sections. Adequate comparisons could more usefully be made at every 5th section (0.01cm) or even at distances as far apart as 300μ and 500μ. There is, however, a risk in comparing sections at large intervals of axial distance because separation or junction of vessels lying close together over short distances may be overlooked and the vessel net-work quotient calculated will have too low a value.

At the end of the series of sections (Fig. 7B), the drawings were superimposed (Fig.7C) and each vessel marked with the same identifying number. The fate of each could then be followed as it moved through the wood. It was found convenient to tabulate the results in a table such

as is shown in Table 3.

Table 3: Record of serial sections scanned for vessel positions in investigations of vessel net-work density.

Vessel number:	Section: 1 (0μ)	2 (300μ)	3 (600μ)	4 (900μ)	5 (1200μ)	6 (1500μ)	7 (1800μ)	8 (2100μ)	9 (2400μ)
1	1	1	1	2	2	1	1	1	1
2	2	2	a1	1	1	1	1	1	1)
			b1	1	1	1	1	1	1). .
3	1	1	2	2	2	a1	1	1	1
						b1	1	i1	1
								ii1	1
4	1	1+5	2	2	2	2	2	2	2
5	1	1+4	. . . . .						

Vessel number:	Section: 10 (2700μ)	11 (3000μ)	12 (3300μ)	DU	FU	Total separations (S) junctions (J)
1	1	1	1	0	0	0
2a	2	2	1	2	1	1S + 1J
2b	. .	. .	.	2	1	1S + 1J
3a	1	1	1	1	1	1S
3bi	1	1	1	2	1	2S
3bii	1	1	1	1	1	1S
4	2	2	2	1	1	1J
5	. . . . .			1	1	1J
				10	8	6S + 4J

In this table, DU represents "network density unit" and is scored for the vessel each time there is junction or separation with or from another vessel. FU represents "functional unit" and refers to one length of non-anastomosing vessel.

The manner of scoring for anastomoses can be demonstrated by describing the fate of each of the vessels noted in this table;

vessel 1: a solitary vessel becomes double (section 4) and then later (section 6) becomes solitary again. This is the result of vertical juxtaposition of 2 vessel elements with oblique walls. But the pair remain one functional unity - they are elements of one vessel; this change is not scored as an anastomosis;

vessel 2: a cluster of 2 vessels separates into its individual members over a certain distance (from section 3 to section 9) and then these reunite to form a pair and later a solitary vessel. Two anastomoses are involved here and scored 1S (one separation) and 1J (one junction). Vessel 2, continued as 2a and then later as 2 again, is taken as one functional unity and vessel 2b as another functional unity even though the length of the latter is small. It is too long to represent vessel overlap and we therefore score; 1S + 1J.

vessel 3: a solitary vessel divides into 2 after 600μ, the 2 halves remaining in contact until section 6 when they separate. In section 9 one of the 2 halves divides again into 2 separate vessels. Vessel 3bi is scored as having 2 separations, a first from vessel 3a and a second from vessel 3bii.

vessels 4 and 5: these are separate at the beginning of the series but unite at section 3 to give a pair.

At the end of the series, the table is scanned for the total number of separations and junctions i.e. the net-density units. These are compared with the number of vessels (functional units) present in the sections and the result expressed as a simple percentage ratio over unit distance. Taking Braun's standard distance of 5mm, our results for Musanga give a NDQ (net-density quotient) of $\frac{10}{8} \times \frac{5000}{3300} = 189\%$

The results can also be expressed diagrammatically as in Fig.8 where each vessel is represented by a vertical line, or as a 3-dimensional model as in Fig.9.

In order to express the degree of separation of the elements from the vertical, the final drawing was superimposed on the drawing of the first section and the different positions of similarly numbered vessels noted. See Fig. 7c. In this study, the distance between 2 positions of the same vessel was measured by inspection as a number of vessel diameters. It could be more accurately measured in microns between the centre point of each vessel but since vessels tend to have similar diameters throughout their course, the former method could easily be converted to the second. Note was also made of the direction of apparent "movement" using an 8-directional scale corresponding to a wind-rose. The simple example given above would be noted thus:

vessel number:	distance travelled:	direction:
1	3 diameters	e
2	2	sw
3	2	e (average)
4	0	-
5	5	ne

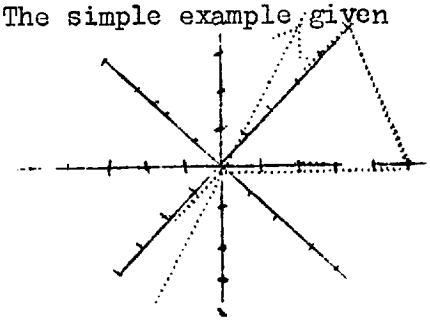


Fig.10

If the direction of the wood rays is indicated on this diagram, the final rose obtained gives an idea of how far the vessel movement is radial or tangential.

4.2.6 Sub-microscopic structure

Sub-microscopic structure was examined by observing the direction of pits in xylem fibre walls. Drawings were made of fibres under the light

microscope fitted with a drawing attachment and the pits marked. The angles made between a line passing through the longitudinal dimension of the pit and the longitudincal axis of the fibre were then measured on these drawings.(Fig.11). It is well-known that pit direction is closely correlated with fibrillar angle in the S_2 layer of the cell-wall (Bailey, 1954).

4.3 Results of timber anatomy investigation.

In the following section records will be made for each species in turn of

1. the western botanical name and description of the tree, its distribution in Africa and western commercial names where these exist;
2. its usage by Upper Zaïrian peoples with local names and other relevant ethnobotanical data;
3. the results of present investigations into wood anatomy of the species with details of the structure of vessels, vertical parenchyma, rays and fibres plus other anatomical features worthy of note;
4. tissue analysis results;
5. measurements of fibrillar angle;
6. vessel-network investigations.

It will be of interest to relate these six species to the recent classification of tropical trees proposed by Hallé and Oldeman (1970) which uses developmental stages and final "architectural structure" as criteria for separating a number of characteristic "models", named by these authors after botanists who have made major contributions to forestry research. (See Fig.12).

4.3.1 Alstonia congensis Engl. Synonym: A.boonei De Wild.
Family: Apocynaceae.

4.3.1.1 A rapidly growing tree of the secondary forest, formed by modification of the primary equatorial rain-forest (Lebrun & Gilbert, 1954). Branches of the young tree are plagiotropic and diverge close together from the trunk in a horizontal direction to give a shallow canopy. When this has developed for some time, an axillary bud below the canopy grows out vertically upwards to form a second canopy; this canopy formation is repeated to give the characteristic layered form to the tree which is recognizable at a long distance away. Hallé and Oldeman name this developmental type after Prévost(Fig. 12). The englobing of plagiotropic nodes by the developing vertical trunk sections leads to the presence in Alstonia timber of some intra-xylary bark and/or lacunae where this has broken down with age.

Bark smooth, leaves verticillate, sessile, elongated, dark green and shiny on the upper surface, leathery in texture. A white latex is present

in the veins. Fruits in paired follicles with numerous plumed seeds.

Timber: no growth rings present. Heartwood and sapwood both white and not differentiated. The cut wood exudes a white latex which when dried often appears as dark strands penetrating horizontally into the wood; the latex vessels are contained in the wood rays. Alstonia timber is marketed under the name of "emien" from francophone countries of Africa; English-speaking counntries refer to it as "Alstonia" though it must be noted that this term also covers a similar timber from Malaysia produced by Alstonia scholaris. The timber is light, and easily workable in all directions. It is easier to impregnate with preservatives than many other hardwoods.

4.3.1.2 Uses in the Upper Zaïre.

a. In pre-colonial times, this timber was preferred for making wooden shields (Fig. 14a) because of its lightness and acceptance of iron-headed arrows and spears without splitting. Other shields were made of cane tightly plaited together.

b. Alstonia was earlier and still is employed today for making resonator boxes of musical instruments such as the "hand-piano" called /likwengu/ by the Lokele/Olombo. (A more wide-spread name, well-known to ethnomusicologists is /sanza/.) This has been illustrated and described by numerous authors, e.g. by Laurenty (1962) and Söderberg (1974). See Fig. 14 and Plate 1a).

c. Small talking-drums for use over short distances as in plantations, government posts, schools,.. are frequently carved from this timber. The wedge-shaped talking-drums characteristic of the Batetela and surrounding peoples in Central Zaïre are also made of this wood (Carrington, 1949). See Fig.14c).

d. Upper Zaïre groups do not manufacture masks for ritual purposes but where these are made (West and South-West Zaïre, Gaboon, West Africa) the timber of Alstonia is used in almost every case.

e. Many village implements and utensils are carved from this wood: powder-flasks, spoons, stools... It is indeed named "stoolwood" in West Africa.

f. The whole tree has important medicinal properties. Its latex is regarded as galactogenous and, when dried, is applied to wounds caused by yaws. A leaf extract is an antidote to arrow-poisons when these latter are suspected to contain Strophanthus juice. The bark is used as a febrifuge and also administered as a remedy for gonorrhoea (Walker and Sillans, 1961).

4.3.1.3 Wood anatomy.

Vessels: some solitary, elliptical, with the larger diameter orientated radially; others in radial groups of 3, 4 or 5, or in clusters (these latter occur when vessels are anastomosing laterally or at points where vessel elements are joining with oblique walls so that elements overlap). Vessel elements 900μ - 2100μ long (average 1640μ) by 60μ - 130μ wide, frequently showing wide-based tails. Perforations simple, usually oblique. Vessel-to-vessel pitting alternate, fine. (Fig. 15, 16, 17).

Parenchyma: mostly apotracheal in circum-medullary bands, 2 or 3 cells wide. Some paratracheal, vasicentric. (Fig. 15, 16).

Rays: irregularly arranged, variable in height: 200μ - 1400μ, the smaller uniseriate, the larger biseriate. These latter often contain latex ducts, visible in TS as swollen, rounded cells containing refringent material. Both types of ray are heterocellular, with upper and lower margins of upright cells and central procumbent cells (Fig. 15, 16).

Fibres: length variable: 820μ - 1640μ (average 1130μ); width at the centre 20μ - 60μ; wall relatively thin so that the lumen is wide; ends tapering and sometimes slightly forked (Fig 16,17).

4.3.1.4 Tissue analysis. Using method (b) described above (page 47), the following results were obtained:

T A B L E 4

Test number:	vessels %:	parenchyma %:	fibres %:	rats %:
1	14.7	8.8	60.3	16.2
2	13.5	8.4	62.9	15.2
3	11.7	12.2	64.7	11.4
4	13.6	14.3	61.9	10.2
5	15.6	12.0	54.6	17.8
6	8.6	10.8	66.0	14.6
7	11.2	9.3	66.7	12.8
8	11.6	10.3	64.1	14.0
9	11.1	13.2	65.5	10.2
10	11.7	12.2	63.6	12.5
Means;	12.3	11.2	63.0	13.5
Standard deviation:	1.9	2.4	3.4	1.9

Fig. 18 shows this distribution expressed diagrammatically.

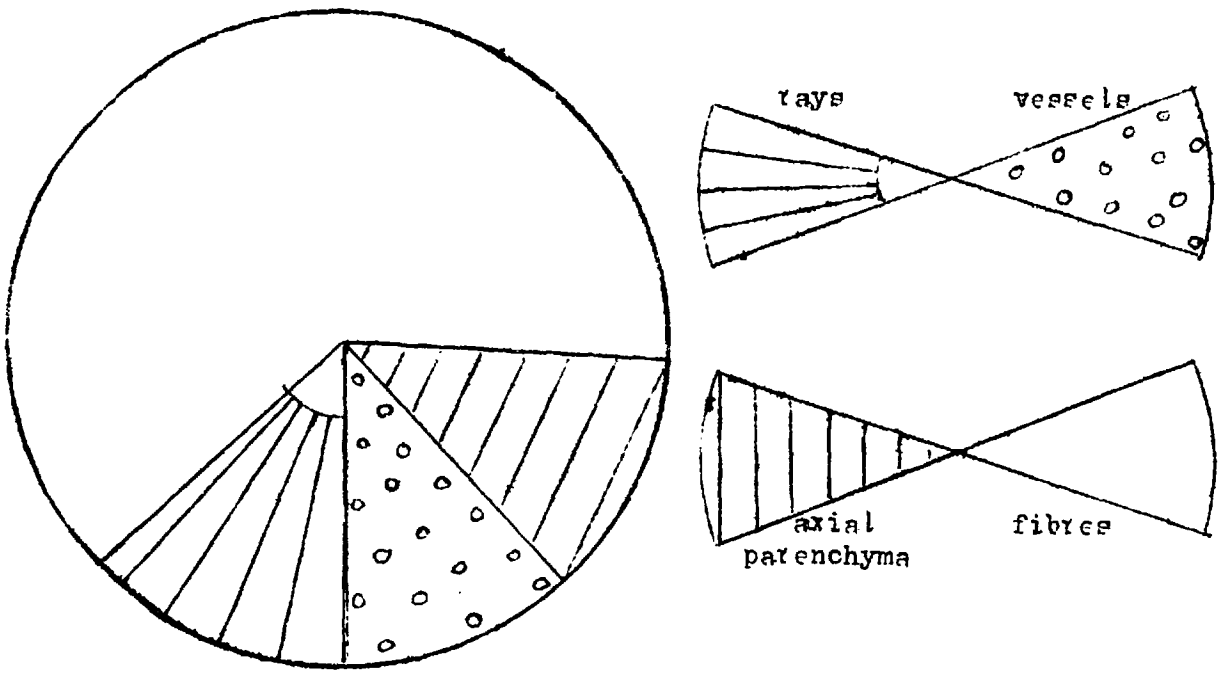


Fig. 18 Alstonia congensis. Tissue distribution in xylem.

4.3.1.5 Fibrillar angle. Two observations were made giving angles ranging from 5° to 17° with a mean value of 10° (s.d. 4°).

4.3.1.6 Tissue network. Six investigations were made on Alstonia timber to assess the consistency of results obtained for different fields of view of the same section series (3 counts from specimen A, 2 from specimen B) and for wood from different trees (A from Yakusu, B from Yangambi, C from a second Yakusu tree). Results obtained show consistency for sections from the same block of wood but some variation when different blocks are compared:

A 1	length sectioned;	5mm	
	anastomoses:	71	NDQ $\frac{71}{79} \times \frac{50}{50} \times 100\% = 90\%$
	functional units:	79	
A 2	length sectioned:	5mm	
	anastomoses:	60	NDQ $\frac{60}{66} \times \frac{50}{50} \times 100\% = 90\%$
	functional units:	66	
A 3	length sectioned:	5mm	
	anastomoses:	61	NDQ $\frac{61}{67} \times \frac{50}{50} \times 100\% = 91\%$
	functional units:	67	
B 1	length sectioned:	7.13mm	
	anastomoses:	60	NDQ $\frac{60}{83} \times \frac{500}{713} \times 100\% = 51\%$
	functional units:	83	
B 2	length sectioned:	7.13mm	
	anastomoses:	50	NDQ $\frac{50}{76} \times \frac{500}{713} \times 100\% = 46\%$
	functional units:	76	
C	length sectioned:	4.8mm	
	anastomoses:	22	NDQ $\frac{22}{35} \times \frac{50}{48} \times 100\% = 65\%$
	functional units:	35	

Directional wind-rose diagrams are given in Fig 19 for all these counts. They show most movement in a tangential direction but some in the radial direction too. B1 is somewhat anomalous largely because of the movement of three or four vessels situated in the same area of the section.

4.3.2 Combretodendron macrocarpum (P.Beauv.) Keay

Synonyms: Combretodendron africanum (Welw.ex Benth.) Exell

Petersiana africana Welw.

Family: Lecythidaceae

4.3.2.1 A tree attaining a height of 45m and up to 3.5m in girth at breast height. Bark greenish-brown with characteristic rough excrescences up to 7cm in radial depth forming anastomosing bands described felicitously by Irvine as "resembling expanded metal". The slash is cream-coloured, pulpy and smells like castor oil. Leaves simple, 15cm x 7cm, acuminate with serrate margins, glabrous. Glands frequently present in the axils of lateral nerves below. These leaves are eaten by caterpillars which are prized for food by all the peoples in Central and West Africa so that any tree of this species is always protected when forest is cleared and burned for new village sites or for gardens. Fruits 2-3cm long, bearing 4 large membranous wings which serve to distribute it (by wind) over considerable distances (Fig. 21).

Hallé and Oldeman (1970) describe Combretodendron development from the seedling as derived from equivalent monocarpic articles in which one plagiotropic branch straightens up and develops into the trunk, while the others become lateral branches. They name this type of tree architecture the model of Kwan-Koriba (Fig.12).

Sapwood yellowish and up to 7cm wide. Heartwood reddish-brown containing strands of a darker colour. The cut or sawn fresh wood has a characteristic odour ("rotten cabbage") which disappears when the wood becomes dry. Growth rings occur, some of which may be associated with caterpillar defoliation (see page 114). The timber is marketed under the name of/esia/ and /ebale/ (West Africa). It is also known (Ghana) as "stinkwood" because of the odour of green timber.

Distribution: Guinea to Cameroons, Zaïre and Angola.

4.3.2.2 Uses in Upper Zairian economy.

The timber of Combretodendron macrocarpum is regarded as especially hard and is used for constructional purposes such as the pillars of dwellings

and hangars. It is the preferred timber for axe-hafts in the Kisangani area.

Widstrand (1958) has surveyed the axes found in Africa and classifies them according to their hafting into 3 main categories:

a) slot-hafted axes, where the blade is inserted into a hole at the end of the shaft;
b) socket-hafted axes, where the blade may be inserted into a socket in the shaft but usually there is a socketed blade into which the haft fits, the latter having a knee-shape or more rarely being straight.
c) eye-socketed axes, where the blade has a hole into which the shaft is fitted.

Axes found in the Upper Zaïre are of type a, i.e.slot-hafted instruments. This is the commonest type in the continent; type c is rare and regarded by Widstrand as foreign to African techniques. In type a, the iron tang of the triangular shaped iron blade is driven through a hole in the haft at the bulbous end of the latter. The hole is usually made by burning it out with the heated tang of the axe-head. It is usually not perpendicular to the haft but makes an angle of less than 90° with the longitudinal axis (Fig.22).

4.3.2.3 Wood anatomy.

Vessels : occasionally solitary, usually in radially orientated groups of 2,3 or 4 or in clusters of 5 or more (the latter are seen in serial sections to be positions where groups are anastomosing laterally or where vessel elements with oblique end-walls are joining). Isodiametric, circular or angular in cross-section, 80µ - 160µ wide. Vessel-elements relatively short: 50µ - 170µ long (average 115µ) with horizontal and oblique ends and occasionally with short tails. Perforations simple. Pitting is alternate and fine. (See Fig.23, 24 and Plate 1a).

Parenchyma: paratracheal and banded, showing to the naked eye as wavy circum-medullary bands in a cross-section of the timber, where the similarly-shaped bands of fibres stand out in a lighter colour. Since axe-hafts are usually made of branch wood where there is little or no heartwood, the parenchyma cells normally contain large numbers of starch grains.

Parenchyma cells surrounding the vessels often show papillae on contiguous vertical walls, indicating the tensions set up during vessel enlargement from the cambial initial. Sanio (1863) and Priestley et al.(1940) describe and figure these cells in

other woods.

Rays: medium to tall in height on average (510μ) but varying considerably from low (250μ) to tall (900μ). The lowest rays are uniseriate but the majority are multiseriate with 3-10 cells in width, fusiform, heterocellular with some procumbent cells in the central, wider portion. Marginal cells upright but not much taller than the square cells of the rest of the ray (Fig.24).

Fibres: 800μ - 2700μ long (average 1580μ) with a width of 23μ in the widest, central part. Fibre walls are relatively thick so that the lumen in the tapering part of the fibre is very narrow (less than 5μ).

4.3.2.4 Tissue distribution. Using method (b) described above (page 57) the following percentages were found in timber from an axe-haft offered for sale in the Kisangani market:

Test number:	vessels %;	parenchyma %:	fibres %:	rays %
1	11.9	18.3	47.1	22.6
2	12.0	26.4	44.8	16.8
3	10.7	24.6	40.7	24.0
4	13.0	34.6	41,8	10.6
5	12.6	37.1	39.4	10.9
6	12.5	32.0	46.6	8.9
7	11.3	27.7	44.7	16.3
8	11.8	27.5	49.5	11.2
9	12.6	30.5	44.3	12.6
Means:	12.1	28.8	44.4	14.7
Standard deviation:	0.7	5.6	3.3	5.5

Method (a) was also used with sections of Combretodendron (as described on page 46) and gave the following results:

1	21	22	48	9
2	19	16	43	22
3	22	25	29	24
4	20	22	36	22
5	13	15	50	22
6	22	34	27	15
7	17	28	33	22
8	22	20	38	20
9	22	25	31	22
10	21	23	40	16
Means:	19.9	23.0	37.5	19.4
Standard deviation:	2.9	5.2	7.8	4.6

The dot-grid method gives more variable results than the weighing method. Expressed diagrammatically, the tissue analysis by weighing is seen in Fig. 26.

4.3.2.5 Fibrillar angle. Twenty measurements were made giving angles ranging from 0° to 14° with an average of 9.7° and standard deviation of 3.0°

4.3.2.6 Tissue network. Three investigations were made with this species involving lengths for sectioning from 2.35mm to 3mm. Results were more consistent than some other investigations:

A; length sectioned: 2.35mm
total anastomoses: 10
functional units: 29
NDQ: $\frac{10}{29} \times \frac{500}{235} \times 100\% = 73\%$

B: length sectioned: 2.42mm
total anastomoses: 4
functional units: 12
NDQ: $\frac{4}{12} \times \frac{500}{242} \times 100\% = 69\%$

C: length sectioned: 3mm
total anastomoses: 11
functional units: 27
NDQ: $\frac{11}{27} \times \frac{500}{300} \times 100\% = 68\%$

Rose diagrams for the 3 investigations are as follows:

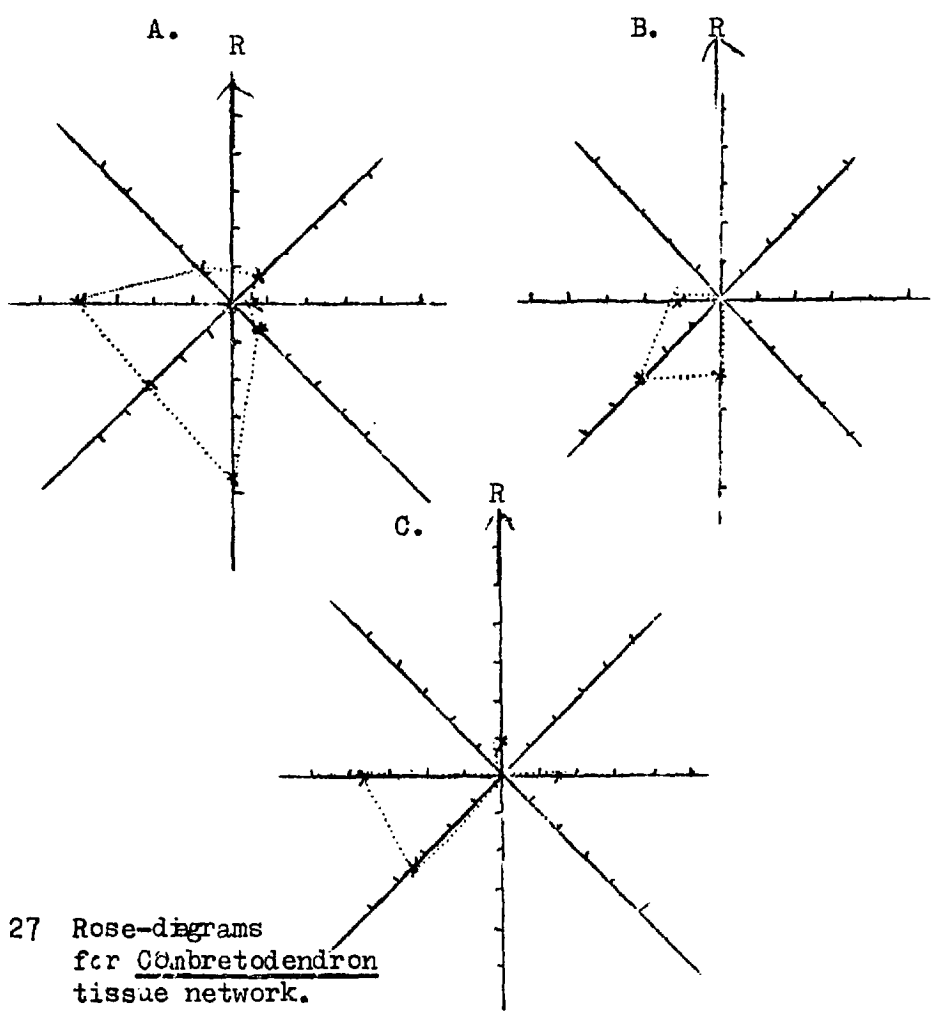


Fig. 27 Rose-diagrams for Conbretodendron tissue network.

4.3.3 Gossweilerodendron balsamiferum (Vermoesen)Harms

Synonym: Pterygodium balsamiferum Vermoesen.

Family: Caesalpiniaceae.

4.3.3 1 A tree reaching 25-50 m in height, 50-150cm in diameter at breast height, with a straight trunk 20-35m high before it branches. Bark beige-grey, slightly scaly, 0.8 - 1.5cm thick, with a brown slash. Leaves compound, imparipinnate, 5-18cm long with 6-10 oval leaflets, assymetrical at the base, obtuse at the apex, 3-13cm long by 1 -5cm wide, shiny on the upper surface. Stipules small and caducous (Fig.29).

Inflorescences axillary or terminal, paniculate, 5-15cm wide with puberulent axes. Bracts 1-1.5cm long, bracteoles very small; sepals oval, 1.5-2mm long and wide, petals absent. Stamens 10, free, 3-3.5mm long. Ovary 1.5mm long with style 2mm long. Fruit a legume oblong to oval with one side slightly rounded, 9-17cm long and 3.5cm wide at the widest part.

Hallé and Oldeman (1970) place all leguminous trees (including the Caesalpiniaceae) into the model named after Troll in which all aerial axes show plagiotropic differentiation at an early stage in their formation, growth in height being the result of continuous juxtaposition of vegetative axes in which the lower portion becomes erect after leaves are shed (Fig.12).

Timber whitish, darkening to light brown with age; little differentiation into sap- and heartwood. It contains resin and is fragrant when freshly cut. It is marketed from West Africa under the name /agba/. The resin which is liable to exude after planing is considered a disadvantage in the construction of furniture.

Distribution: Southern Nigeria, Cameroons, Cabinda, Zaïre.

4.3.3.2 Uses in the Upper Zaïre.

This is the preferred timber for canoe manufacture in the Upper Zaïre though some other species such as Vitex spp. are used also. A tree, preferably standing near to a water-course is felled and the bark and outer wood removed by ringing the trunk at intervals to a depth of 5-10cm using an axe. The outside sheathing bark and timber is then removed between the cuts, leaving an inner core from which the canoe will be made. A tempo ary shelter covered with large leaves (Sarcophrynium or Sclerosperm) is usually erected over the log to provide shelter for the debarking and hollowing operations. The central core is then excavated by means of adzes and axes, a team of workers usually sitting astride the log for this, each one hollowing a part. Fire is not used for making canoes in the Upper Zaïre. Hollowing is carried on until about three-quarters of the

depth of the wood has been removed, the sides being tapered and hollowed, the base being flattened. A raised part is left near the stern (the base of the trunk where the diameter is greatest); this will be covered with clay to form a hearth where fires can be made for cooking meals or for drying and smoking fish caught in the river. The bottom of the canoe slopes more gradually towards the prow than it does towards the stern, where a platform is left on which a paddler can sit or stand. A hole is bored in the prow tip and, when most of the excavation has been done, a rope or liana is attached to the canoe through this hole and the hollowed trunk is hauled to the shore of a water-course, rollers being used (sections of small, round, tree-trunks or branches) to facilitate its passage on land. Thence the trunk is floated to the village where further work continues on the river-bank. The front hole will serve later to moor the canoe to a post or tree-stump or to immobilise it temporarily at the shore by thrusting the haft of a paddle through it into the sand or mud of the bank. The shallow, sloping base of a large canoe makes a useful runway for a punter as the canoe is taken up-river against the current.

Canoes are liable to crack longitudinally. Such cracks are often stopped with the resin which exudes from the trunk of this same tree.

4.3.3.3 Wood anatomy

Vessels: mostly solitary, with occasional radial groups of 2 or 3; elliptical or circular in section, diameter 120µ-250µ, 6 pores per mm^2. Vessel elements 250-400µ long, sometimes shortly tailed. End-walls perpendicular to the cell-axis, perforations simple. The vessels may be partially or completely blocked with dark, resinous contents. Vessel to vessel pitting alternate, fine (Fig. 31, 32, plate 1d, 1e).

Parenchyma: axial parenchyma is paratracheal, aliform and confluent with some apotracheal bands. (Fig. 31,32).

Rays: 150-650µ high, fusiform, 3-4-seriate, homocellular, formed of procumbent cells (Fig. 31, 32).

Fibres: 640 - 2100µ long (average 1600µ) by 20-30µ wide in the central portion. Fibre walls 5µ thick in the centre but thicker at the tapering ends where the lumen is almost completely occluded.

Resin-canals: present in the axial direction, circular in cross-section, usually smaller than the pores, anastomosing, surrounded by a sheath of parenchymatous cells with heavily-staining contents. The frequency of these resin canals is about 1 per mm^2 (Fig.32).

4.3.3.4 Tissue distribution.

The method of weighing (page 47) gave the following results:

Test number:	vessels %:	parenchyma %:	fibres %:	rays %:	resin canals %:
1	10.8	26.1	52.8	9.7	0.6
2	10.6	25.7	51.9	11.1	0.7
3	12.7	25.1	50.7	9.9	1.6
4	12.5	26.2	52.9	7.9	0.5
5	12.6	26.0	52.8	8.0	0.6
6	9.1	27.7	56.0	6.9	0.3
7	11.4	26.8	54.3	7.0	0.5
8	13.5	25.0	50.5	10.4	0.6
9	13.1	25.2	51.1	9.9	0.7
10	13.1	26.0	52.6	7.9	0.4
Means:	11.9	26.0	52.7	8.8	0.6
Standard deviation:	1.4	0.8	1,7	1.5	0.4

Expressed diagrammatically, the distribution is:

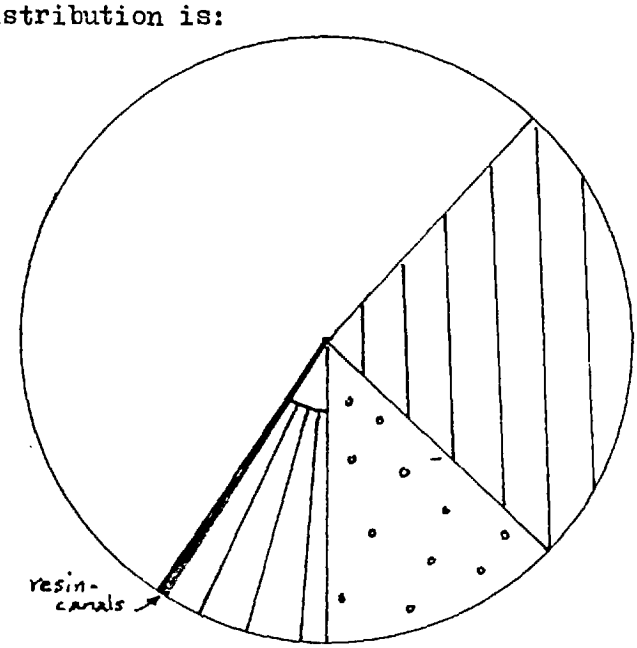


Fig. 34. Gossweilerodendron balsamiferum: tissue analysis of xylem. See fig. 18 for symbols.

4.3.3.5 Fibrillar angle. 47 observations were made on pits in 4 fibres giving angles ranging from 0° to 19° with an average of 10° (s.d. $4,5^{\circ}$). See Fig. 31. Individual fibres give results more consistently similar:

fibre A: range 6° - 19°, av erage 12°, s.d. 4.5°
B: range 7° - 14°, average 11°, s.d. 4.5°
C: range 9° - 17°, average 12°, s.d. 3.3°
D: range 0° - 8°, average 3.5°, s.d. 1.9°

4.3.3.6 Tissue network. One study was made of this timber:

length sectioned: 0.5mm
anastomoses: 6
functional units: 33

NDQ: $\frac{6}{33} \times \frac{50}{5} \times 100\ \% = 182\%$

The rose-diagram shows some movement in the radial direction as well as in the tangential direction:

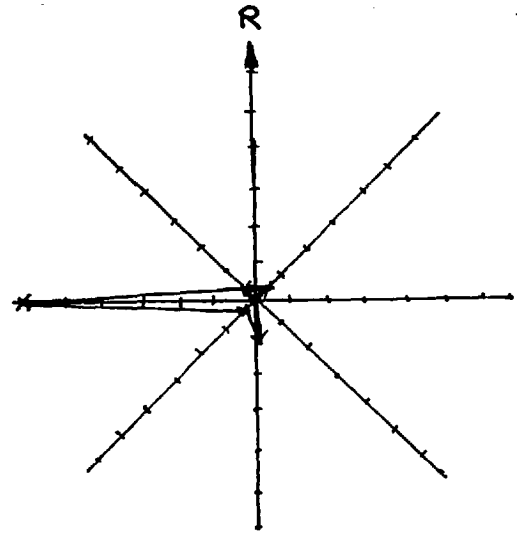


Fig 35
Rose-diagram for vessel network of Gossweilerodendron, showing vessel movement.

4.3.4 Musanga cecropioides R.Br

Synonym: Musanga smithii R.Br. Family: Moraceae

4.3.4.1 The name of this species has an interesting history. Its generic name is that given to it by Africans in the region around the mouth of the River Zaïre (Bakongo people) and was noted for the tree by Professor Smith who was botanist with the ill-fated British naval expedition of 1813 under Captain Tuckey. In 1818, Robert Brown, then Director at Kew, wrote a botanical appendix to the "Narrative of an expedition to explore the River Zaïre" and there described "a remarkable tree called by the natives Musanga...", forming a genus close to Cecropia. Brown repeatedly referred to this tree as Musanga in this appendix so that the generic name was coined by him. Later writers (Engler, De Wildeman, Rendle, Hutchinson...) began to use the specific epithet smithii, commemorating the collector of the first specimen to be brought to Europe for study. A careful bibliographical study by J.Léonard (1956) has shown, however, that Brown himself had used the epithet cecropioides and that this was first published by H. Tedlie in a list of materia medica appearing in Bowditch's "Mission to Ashannti" in 1819. This name must then take precedence over that used in modern floras, the first of which dates only from 1836. Léonard uses the form: Musanga cecropioides R.Br. apud Tedlie.

The "Umbrella Tree" is a dioecious species found in secondary forest. It attains 18-20m in height and has a diameter of 80cm above the numerous proproots which begin at 2-3m above the soil and branch frequently as they come down to the soil. It has a wide, shallow canopy, reading 30m in diameter giving the tree its characteristic umbrella-like appearance,

responsible for its name in European languages: Parasolier, Parasol-Boom Umbrella-Tree... Branch tips have short internodes bearing a large terminal bud 10cm in length, enveloped in a stipular sheath covered with shining hairs, the sheath falling off to leave a scar all round the stem at the base of the bud. Adult leaves are large, orbicular, palmatisect with 12-15 oblanceolate lobes, glabrous above and covered with dense white hairs beneath. (See Fig. 37).

Male inflorescence pedunculate, 15-20cm long and 7cm wide, formed of floral glomerules 3-4mm in diameter, these latter bearing cymes of flowers each with 1 stamen. Female inflorescences in pairs with flowers carried on a flattened green receptacle 2-3cm long. After fertilisation, the female inflorescence enlarges to produce a massive syncarp 10-13cm long and 5-8cm wide which becomes orange and fleshy at maturity (Fig.38).

Hallé and Oldeman (1970) point out that in Musanga trunk development is sympodial but the branches are identical morphologically with the trunk. Flowering takes place on the branches or on the trunk and does not affect the growth of the vegetative apparatus. They refer to this type of architecture as the model of Rauh (Fig.12).

The timber of this species does not figure to any large extent in commercial exports from Africa to the West. Where it is used, it is referred to as Umbrella Tree or Musanga. The timber is yellowish-white with sometimes a pink tinge. Growth rings are absent. There is little or no distinction between sap- and heartwood.

Distribution: exclusive to the tropical rain forest from Sierra Leone to Uganda and Angola and on the islands of San Tome and Fernando Po.

4.3.4.2 Musanga in Upper Zaïrean economy.

Musanga is one of the quickest growing timbers in the equatorial forest (Lebrun & Gilbert, 1954) and forms dense stands in fallow land after shifting cultivation around Upper Zaïrian villages. Its abundant light wood, easily split with matchet or axe, finds many uses in village life:

a) light, small canoes (/itumbe/);
b) net floats;
c) floats for moored fishing lines (/ikombo/) and freely drifting lines (/lilango/);
d) temporary constructions such as drying racks for fishing nets;
e) poles and boards for house-construction and house-doors;
f) bodies of musical instruments where hollowing is not necessary, for example the framework of the "hova guitar" /sɛsɛ/ (Fig. 38);
g) children's models where Musanga wood is carved to make model boats,

lorries, aeroplanes... as described by Söderberg (1972) and others. This activity may be seen as being derived from the wood carving which formed part of initiation rites called /libeli/ when models of axes, spears, knives and other village objects were carved and hung on liana lines around the initiation camp. Girls belonging to the /tokoke/ initiation groups of the Bambole people carved staves of this wood, which were blackened by charring the outside, and then scraped the charred surface to produce white patterns along the staff;

h) firewood which burns quickly but gives a hot flame and little smoke;

i) the use of this tree as providing drinking-water should also be mentioned. Young branches and proproots give out considerable amounts of sap when cut and this is often used by travellers in the forest where streams are not available (see De Wildeman 1903 for interesting experiments showing that proproots can produce several litres of drinking water overnight.)

The importance of this tree in village life is reflected by the numerous references to it in Upper Zaïrian oral literature. Lokele talking-drum phrases referring to /botumbe/, the local name for Musanga cecropioides R.Br. include the dollowing:

plantain bananas:	likondo libotumbela	bunch of bananas propped up when ripe by /botumbe/ branches;
house:	ndako ya tumbe elundu likolo	house of /botumbe/ wood, spacious on high;
canoe:	yato ilotumbe	small canoe of /botumbe/ wood (Yangeka area of the Olombo group)

4.3.4.3 Wood anatomy

Vessels: diffuse, mostly isolated, occasionally in groups of 2 which then take up a radial orientation rather than tangential or oblique. Circular but sometimes elliptical with the large diameter in the radial direction. Large (up to 400µ wide) and built up of elements of medium length with simple horizontal or oblique, unrimmed perforations; blunt tails are frequently present. Thin-walled tyloses often present which occlude the vessels. Vessel-to-vessel pitting is alternate, the pits being very small and elliptical. Pitting between vessels and vertical parenchyma is similar; that between vessels and ray parenchyma tends to show larger pits (Fig. 39, 41. 43 and plate 1c).

Parenchyma: circumvascular, aliform and confluent, variable in quantity

depending on the type of tree studied and the section of wood taken (see later, page 6). Parenchyma cells adjoining vessels are considerably flattened and stretched, indicating tension during development from cambial initials as the vessel enlarges and lignifies (Fig.39,plate 1c)

Rays: dispersed, variable in height (100–1000μ), up to 4 cells in width but often uniseriate, infrequent (5 / mm) Multiseriate rays have margins of several layers of upright cells (Fig .39, 40).

Fibres: these form the groundwork of the timber. They are variable in length from 300μ to 900μ (average 500μ), the wider central portion having a width of 40–50μ, the ends tapering away on either side. Walls are thin so that the fibre lumen is much greater than twice the cell-wall thickness in the central part (Fig. 39, 42, 44).

4.3.4.4 Tissue analysis. Investigations of this have already been mentioned; specimens of Musanga wood were used to assess the value of the dot-grid and weighing methods for determining percentage presence of tissues (page 45).

A second series of estimates (by weighing) was made using 10 drawings from transverse sections of Musanga. The timber from which specimens came for this determination was taken from a tree felled during preparations for new manioc plantations in the Upper Zaïre.

Test number:	vessels %:	parenchyma %:	fibres %:	rays %:
1	6.9	11.4	77.7	4.0
2	7.3	10.0	78.3	4.4
3	7.2	12.2	72.7	7.9
4	7.2	13.5	70.4	8.9
5	7.2	13.2	73.9	5.7
6	9.1	11.o	71.7	8.9
7	7.9	9.2	78.2	4.7
8	9.1	9.5	75.4	6.0
9	7.1	8.6	81.2	3.1
10	5.8	8.9	78.2	7.1
Means;	7.4	10.8	75.8	6.0
Standard deviation	1.1	1.8	~~3.6~~ 3.3	2.0

It is noteworthy that the total quantity of parenchyma (vertical + ray) is smaller and that of the fibres larger in the above table than in the specimens examined earlier (page 57). This can be seen as another example of the variability of Musanga wood anatomy. It will be shown in a later section (page78) that such variability is correlated with a) position of the timber specimen in the tree, and

b) the status of the tree as "male" or "female".

4.3.4.5 "Male" and "female" wood in Musanga cecropioides R.Br.

Olombo craftsmen distingish between 2 categories of Musanga trees to which they give the names /botúmbé olóme/ and /botúmbé wálí/. The terms /olóme/ and /wálí/ refer to "male" and "female" respectively. The criterion for distinguishing these categories is timber hardness: a "male" tree has harder wood than a "female" tree. The present writer used an increment borer to obtain specimens from 2 such trees pointed out by an Olombo friend. They were growing near together in a patch of secondary forest behind Yakusu. The boring from the "male" tree was firm and kept its cylindrical shape when removed from the tool whereas that from the "female" tree was spongy and soft and twisted when it was taken from the borer. This difference in strength between the 2 types of tree is reflected in the uses to which Musanga timber is put

/botúmbé olóme/ (male)	/botúmbé wálí/ (female)
small canoes	line floats
hut construction	net floats
bridges	musical instrument frames

But the characterisation by Olombo craftsmen of "male" and "female" Musanga trees runs counter to our Western botanical definition of sex in dioecious species. The hard-timbered /botúmbé olóme/ bears pistillate flowers whereas the soft-timbered /botúmbé wálí/ bears staminate flowers. Another Olombo villager made the same distinction between "male" and "female" trees of Macaranga; the tree he designated as "male" because of its hard wood was at the time bearing the red fruits characteristic of the species i.e. it was a tree with pistillate flowers and therefore botanically "female".

Among the Bamanga people who call themselves the Mbae and speak a language that is not Bantu, the distinction made between "male" and "female" follows that of Western science and is the opposite of what is used by their Olombo neighbours. They label pistillate trees of Musanga: /komboju/ ("female" /kombo/) and staminate trees: /kombokyá/ ("male" /kombo/). They insist that their terminology is correct because they point out that the /komboju/ trees ("female") bear fruits and produce seeds that reproduce the plant. Timber differences are recognised by them but are not made the basis of botanical differentiation.

Specimens from wood described as "male" and "female" by Olombo men were analysed for tissue quantities and the following results obtained:

A. Musanga "female" wood (/botúmbé wálí/)

test number:	vessels %:	parenchyma %:	fibres %:	rays %:
1	4.4	13.0	73.9	8.7
2	4.4	8.3	83.3	4.2
3	4.4	8.7	82.5	4.4
4.	8.3	12.5	75.0	4.2
5	8.7	8.7	78.2	4.4
6	4.3	4.2	83.3	8.3
7	8.0	12.0	76.0	4.0
8	6.0	10.0	76.0	8.0
9	8.3	12.5	75.0	4.7
10	6.5	13.0	72.9	8.7
Means:	6.3	10.3	77.5	6.0
Standard deviation:	1.8	2.7	3.9	2.3

B. "Male" wood (/botúmbé olóme/)

1	4.4	4.4	80.1	10.9
2	12.8	6.4	72.4	8.4
3	4.2	10.4	72.8	12.6
4	8.5	4.2	78.8	8.5
5	6.5	2.2	87.0	4.3
6	12.0	4.0	78.0	6.0
7	14.6	6.3	68.7	10.4
8	8.7	2.2	80.4	8.7
9	8.3	2.1	85.4	4.2
10	7.8	5.9	78.5	7.8
Means:	8.8	4.8	78.3	8.2
Standard deviation:	3.2	2.4	5.7	2.6

The differences between these tissue spectra for the 2 types of Musanga timber are shown diagrammatically in Fig.45. Student's t test applied to the parenchyma quantities shows that these are significantly different. That is to say, that "female" wood contains signifintly more vertical parenchyma than "male" wood. The differences in fibre content are not significant.

The terms "male" and "female" are sometimes used by carpenters in the Upper Zaïre to distinguish timbers that plane easily ("male") and those which "pick up" under the plane, i.e. have noticeable cross-grain. The latter are referred to as "female".

4.3.4.6 Musanga variability with position in the tree.

This subject has been investigated in some depth by Regel with 20 trees of the Northeastern States of America, including 4 ring-porous hardwoods, 8 diffuse-porous hardwoods and 8 conifers (note also chapter 6 of this study). An attempt was made by a forestry student at the University of Zaïre in 1977 working under the direction of the present writer to assess differences in anatomy in various parts of a typical Musanga specimen growing near to the University campus. Parameters examined by him were:

abundance of vessels,
width of vessels,
rays / mm cross section
ray-height (TS),
width of rays,
fibre length,
thickness of fibre walls,

He made the examinations in sections cut from 5 positions in the tree:

near the end of a branch,
towards the outside of the trunk at breast height,
near the centre of the trunk at breast height,
at the top of a proproot,
at the base of a proproot.

His results showed few significant differences for the various positions except for 2 parameters: vessels were more numerous in the branch than elsewhere and fibre length was significantly greater in the roots. The first of these was demonstrated to be true for the 12 species of American woods possessing vessels which Fegel examined while the second was shown by him to be true for tracheid length in Conifer roots.

Any anatomical investigation of timber should control timber provenance because this is an important factor in variability (see also page104).

4.3.3.7 Fibrillar angle. 13 measurements were made giving angles ranging from 0° to 13° with an average of 5°.

4.3.4.8 Vessel net-work. Three investigations were made:

A. length sectioned: 4.8mm
anastomoses: 73
total functional units: 44
NDQ: $\frac{73}{44} \times \frac{50}{48} \times 100\% = 171\%$

B. length sectioned: 2.5mm
anastomoses: 36
total functional units: 57
NDQ: $\frac{36}{57} \times \frac{55}{25} \times 100\% = 126\%$

C. length sectioned: 2.4mm
anastomoses: 54
total functional units: 51
NDQ: $\frac{54}{51} \times \frac{50}{24} \times 100\% = 220\%$

The rose-diagram for these observations shows movement in tangential an d radial directions (Fig. 47).

4.3.4.9 Anatomical notes on Musanga studies. The following points of interest were noted during anatomical investigations of timber from Musanga cecropioides specimens from the Upper Zaïre:

a) intermediate cells at vessel junction. During observation of serial sections cut to study vessel net-work in Musanga it was noticed that as vessels approach (or separate from) one another, the intermediate cells seem to undergo a change in shape and there appear to be supplementary vessels formed. Some sections were therefore cut at an angle of 45° to the vertical axis so as to facilitate examination of the side-walls of these cells. The pitting on these walls indicated that they are

parenchymatous and not formed of vessel elements; their normally isodiametric form had been modified by stretching in proximity to the two vessels or vessel clusters joining or separating. Sections above and below the junction showed parenchymatous cells in these positions with their usual shape. Similar observations were made on Combretodendron where parenchyma cells are also involved between vessels at junctions. In the case of Staudtia however (see 4.3.6) where little or no parenchyma is found, the intermediate cells were fibrous. They were again much modified by stretching tangentially (Fig.47).

b) Vessel endings. The presence of conical vessel elements with only one perforation in wood macerations was adduced by Dixon (1914) as evidence for the existence of vessels with measurable, finite length, these conical elements being regarded as the terminal elements at the ends of vessels. Zimmermann (1971) claims that "vessels practically never end in isolation, they almost always overlap". In our present study of vessel net-work in serial sections of Musanga, we have seen some undoubted cases of vessel beginnings and there have also been a number of conical, uniperforate elements in macerations of this timber. Fig 4.8 shows a series of sections indicating the enlargement and lignification of a parenchymatous cell series to give a typical vessel in Musanga. Serial sections of Staudtia wood gave another example of this, where the vertical cell-series producing the vessel appeared to originate in ray elements (Fig.49).

4.3.5 Pterocarpus soyauxii Taub. Family: Fabaceae

4.3.5.1 Pterocarpus soyauxii is a tree reaching 50m in height and 1.4m in diameter above the buttress roots which begin up to 3m from the ground and reach a total width of 2m at the base where they are up to 20cm in thickness. Bark is crevassed, light brown, peeling away in bands and containing abundant red resin.

Leaves compound, imparipinnate with linear, caducous stipules and 11-15 leaflets, 4-7cm long by 2-3cm wide, coriaceous, glabrous with a shiny lower surface (Fig. 50).

Inflorescence a terminal or axillary panicle 35cm long by 30cm wide; flowers with a basal bract 5mm long, caducous bracteoles, a hairy calyx 5mm long with subequal lobes; corolla orange, spotted with red, standard 10mm long by 8mm wide, wings 11mm long, assymetrical, keel 8mm long and 2.5mm wide. Stamens monadelphous, 7mm long. Ovary 5mm long with a glabrous style 4mm long. Fruit indehiscent and samaroid, with a central swollen portion 1.5cm in diameter containing a single seed, surrounded by a sub-orbicular wing up to 8cm in diameter.

Fabaceous treos are placed by Hallé and Oldeman (1970) in one category which they name the model of Troll because of their characteristic developmental stages (cf Gossweilerodendron for the same architectural type)

Pterocarpus timber has white sapwood and blood-red heartwood.

Distribution: West Africa, Cameroons, Gaboon, Zaïre, Angola.

4.3.5.2 Uses in the Upper Zaïre.

Pterocarpus soyauxii Taub. is the preferred wood for making talking-drums in the Upper Zaïre and throughout Central Africa and West Africa. It is also used for other resonant instruments such as xylophones and the wooden hunting bells which are hung around the necks of dogs when these are used to chase animals in the forest. The tinkling bell helps the hunter to follow as the dog chases the animal.

Dechamps has confirmed this usage of Pterocarpus in a series of articles describing the timbers used to construct the large number of artefacts from Zaire housed in the Central Africa Museum at Tervueren (Belgium). He examined 313 pieces which had been classified ethnographically as "slit-drums" (tambours à fente) and found as many as 82 different timber species among them. But many of these so-called tambours à fente were not used for telephony. When he isolated the artefacts on which messages could be transmitted, he found that the majority were of Pterocarpus soyauxii. For instance, of the large cylindrical talking-drums, 20 out of 27 were from this timber, while 4 others out of the 27 were manufactured from the related species P.lucens with similar wood.

For the xylophones examined at the Museum, Dechamps (1972) reported that Pterocarpus is again the preferred species. His results can be summarized:

xylophone type:	number of instruments:	number with wood from Pterocarpus:
1. movable slats	11	3
2. fixed slats, no resonators	28	21
3. fixed slats, 1 or more resonators	108	81

Pterocarpus soyauxii Taub.is used all over Central and West Africa to produce a red powder which is mixed with palm oil to make a paste used on the body as a cosmetic. The "camwood powder receptacles" of the Bakuba craftsmen are well-known for their intricate carving. Not only does this ointment have a pleasing look when used but also has a fragrant smell resembling that of sandal-wood. The powder is known to have medicinal properties and is often applied to wounds as a healing agent.

The timber is marketed as camwood (though this name is also applied to species of Dalbergia), redwood, coral wood, African paudouk and barwood. It was first exported from West Africa for use as a red dye. It has been claimed that the name of Angola is derived from the exportation of this timber during the early years of Portuguese colonisation; the timber is known in the Lower Zaïre area as /ngola/.

For the manufacture of talking-drums, only the red heart-wood is used. Trees felled for drum-making are allowed to lie on the forest floor until the outer, white sapwood is sufficiently decayed to be removed from the red heartwood. The drum-maker hauls a section of such a trunk to the village by putting it on rollers. Some finished drums can be seen with holes in the edges where haulage ropes were fixed. In the village, he makes a slit along the side of the log, using an adze, small axes and chisels with long handles. Occasionally drums are seen where a large hole was made in one end and heartwood removed through this, the hole being later plugged with another piece of Pterocarpus wood. This is rare, however, and unless the plugging is well filled with resin, the final resonance will be impaired.

Among the Lokele and riverine Olombo villages, many drums actually in use have been manufactured by one special drum-making clan living in the village of Yafolo, on the south bank of the river. Other groups, however, make their own instruments and do not rely on traditional specialist carvers. The Yafolo-made drums have a characteristic cross-section, as shown in Fig 52 and plate 2b, with a ridge-like /bokinini/ (= "back-bone") between the hollowed out drum-cheeks. Hollowing is differential under the two drum-lips, one side being deeper than the other. This deeper side produces a lower note when the lip above it is struck with a rubber-covered drum-stick, the shallower side giving a higher note. The 2 distinct notes, called "male" and "female" respectively, are essential for the production of speech elements in drum telephony. For an account of the basis of this system of broadcasting information and entertainment see Carrington, 1949.

Pterocarpus soyauxii is referred to by the name of /wele/ among the Lokele and Olombo (the form /lele/ given in the "Flore du Congo" comes from a western section of the Olombo tribe). This name figures in the drum-message name for the instrument among the Mbole group:

bokoko bɔ́kɔ́ wele log of /wele/-wood

Among the Lokele and Olombo, however, the talking-drum is referred to in its own message system as:

bɔkɔkɔ wáolondó log of Chlorophora excelsa wood

So far as present-day drummers are aware, the timber of Chlorophora excelsa (Welw.) Benth.& Hook. (exported from West Africa under the name of African Teak or Iroko) has never been used for drum-manufacture so that this name requires some explanation. It may be that /olondó/ was used in other areas. More probably, the term is being used here as a representative word for "wood", just as the name for any fish in Lokele drummed messages cites the names of 2 particular species even if these are not among the fish caught by men making the announcement:

yafélé layambóku all the Distichodus fish and all the Citharinids.

4.3.5.3 Wood anatomy of Pterocarpus ooyauxii Yaub.

Vessels: mostly solitary but some radial groups of 3 or 4 present. Eliiptical in form, 120–450μ (average 250μ) along the largest diameter. Infrequent - ca. 1/mm^2. Elements short: 200–400μ in length (average 260μ), with horizontal ends and simple perforations. Vessel to vessel pitting fine, alternate (Fig.52, and plate 2b).

Parenchyma: paratracheal, aliform and confluent to give a characteristic banded appearance to the wood in cross-section, the bands being 4–5 cells wide and visible to the naked eye. Some vertical strands of parenchyma contain crystals (Fig. 52, 53, 54).

Rays: uniseriate, storied; low (150–200μ), heterocellular with margins of upright cells and inner procumbent cells. Numerous, with 8–9 rays per mm (Fig.52, Plate 2c).

Fibres: 1110 - 2480μ (average 1730μ) long, with a central wide portion of fairly uniform length (400μ) and width (45μ) and long, tapering ends. The wall of the central, wide portion is 2–4μ thick so that the lumen is large. In the tapering ends, which can be as narrow as 5μ, the lumen is almost obliterated and the fibre appears to be solid. (See Plate 3a).

4.3.5.4 Tissue analysis. The following table gives percentage quantities of different cell-types present in cross-section:

test:	vessels%:	parenchyma %:	fibres %:	rays %:
1	3.2	12.7	81.9	2.2
2	4.8	16.1	76.9	2.2
3	4.0	24.8	69.1	2.1
4	3.4	29.0	65.2	2.2
5	4.0	22.9	70.9	2.2
6	5.5	26.5	65.9	2.1
7	5.2	26.0	66.7	2.1
8	5.5	29.5	62.3	2.2

test:	vessels%	parenchyma %	fibres %	rays %
9	4.2	30.7	63.0	2.1
10	4.6	35.0	58.2	2.1
Means:	4.5	25.3	68.1	2.1
Standard deviation:	0.8	6.6	7.7	0.16

The considerable variation in quantities of parenchyma and fibres reflects the heterogeneity of the tissue distribution in Pterocarpus consequent on the presence of growth rings in this species. Note however, the comparative constancy of vessel and ray quantities.

4.3.5.5 Fibrillar angle. Angles are in general low. There was some variation in the angles of the 6 fibres studied:

a. range from 0° to 14°, average 6°
b. range from 4° to 8°, average 7°
c. range from 2° to 8°, average 5°
d. range from 0° to 5°, average 2°
e. range from 3° to 19°, average 9°
f. range from 0° to 13°, average 6°

Average for the whole group of pits: 4.5^o

A maceration from the wood of another talking-drum gave even lower figures: 3 fibres with 22 pits ranging from angles of 0° to one of 7° with an average of only 2°. 8 of the pits were parallel with the fibre axis (i.e. with an angle of 0°)

4.3.5.6 Vessel net-work.

Three investigations gave somewhat variable results:

A. total length sectioned: 7.14mm
number anastomoses: 8
total functional units: 33
NDQ: $\frac{8}{33} \times \frac{500}{714} \times 100\% = 17\%$

B. total length sectioned: 7.14mm
number anastomoses: 19
total functional units: 35
NDQ: $\frac{19}{35} \times \frac{500}{714} \times 100\% = 38\%$

C. total length sectioned: 5.76mm
number anastomoses: 20
total functional units: 32
NDQ: $\frac{20}{35} \times \frac{500}{576} \times 100\% = 54\%$

The rose-diagrams show a good deal of movement in tangential direction with much less movement in a radial direction. (See Fig. 56).

4.3.6 Staudtia gabonensis Warb.

Synonym: Staudtia stipitata Warb. Family: Myristicaceae

4.3.6.1 Staudtia gabonensis Warb. is a dioecious tree attaining a height of 35m and a diameter of 75cm at breast height. The base of the trunk is sometimes fluted. Its clear-coloured bark is thin and peels off in patches; the slash is rose-coloured and exudes a red liquid which coagulates after a short time. This property is responsible for the name of the tree in some vernaculars, e.g. /sofi-menga/ in Kongo - "blood-sap".

Leaves petiolate, oval, acuminate, 8-16cm long by 2-5cm wide. Seed-bearing female inflorescences carried in axillary capitula 5-7cm in diameter. The fruit is ellipsoid and sessile, 2-3.5cm long by 2-2.5cm wide. It is yellow when ripe and contains a single seed, 1.5-2.5cm long by 1cm wide, surrounded by a brilliant scarlet aril. The seed does not show the ruminate endosperm characteristic of other genera of the Myristicaceae. (See Fig. 58).

This species and the closely related species Pycnanthus angolensis (Welw.)Exell are placed by Hallé and Oldeman in their category of architecture dedicated to Massart, in which rhythmic growth of the monopodial trunk confers a verticillate form on the branches. These latter are plagiotropic and this character, together with the sub-verticillate nodes differentiates Staudtia architecture from that of Musanga whose development is otherwise similar (Fig.12).

Timber sapwood is light yellow and the heartwood yellow-orange which darkens on exposure to the air to a rich brown-red colour. Growth-rings are absent. It is marketed in West Africa under the name of /niove/.

4.3.6.2 Usage in the Upper Zaïre

The timber of Staudtia gabonensis is regarded where it occurs as the best timber for canoe-paddles.

For making paddles, a trunk is chosen whose xylem diameter will equal the width of the widest part of the paddle blade. Usually only one paddle is made from one trunk section. This is first split into a flat, prismatic central portion and the outside pieces rejected. The paddle shape is then carved out from this prismatic, central part of the trunk. The paddle stem is generally elliptical in section and not circular (Fig.58) This anisotropy of the stem explains the use of such a canoe-paddle stem as a musical instrument in /Kabile/ ceremonies, one of the initiation rites still practised by the Bamanga and other groups in the Upper Zaire.

When an old paddle (or only the stem) is held in the left hand and struck across the two diameters with another piece of wood in the right hand, it emits 2 distinct notes which can reproduce the melody of the song which initiates are expected to strike up thereafter. This use has been described by Carrington (1954) and Droogers, 1974) for the /Kabile/ rites of the Bamanga and the Baenya people respectively. The instrument is regarded as one of the sacred "animals" of the rites by non-initiates.

Paddle-blades are often fluted, both surfaces being gouged longitudinally to permit of easier dripping away of water when the paddle is pulled up from the river surface. Corrugation may also help to preserve strength while reducing weight in the blade. A valuable paddle is often

protected with a brass knob over the stem tip and a pointed iron shoe at the tip of the blade. This latter is especially necessary when the paddle is used for punting instead of a punting pole, since constant pushing of the wooden blade tip against rocks and tree-stumps along the bank would otherwise roughen and splinter the wood.

Lokele men usually stand in their canoes to paddle (women sit down). They grasp the instrument with one hand near the stem tip and the other near the middle of the stem. The blade is plunged into the water in front of the paddler and pulled towards him (Fig.67). As he nears the end of the stroke, the paddler turns his wrist through an angle of 90° so that the blade which has been perpendicular to the direction of canoe travel during the power-stroke now becomes parallel to it and thus offers least resistance when the paddle is withdrawn from the water. Before the paddler plunges the blade into the river again, he will return it to its orientation perpendicular to the axis of the canoe. Professor Lamar Williamson of the Kisangani campus of the National University of Zaire has well expressed the characteristic rhythm of a Lokele canoe paddlers with the following lines composed while watching a canoe descending the Lindi tributary to the Zaïre just above Yakusu;

Splash, stoop, push, lift,
Splash, stoop, push, lift,
Splash...the boatman's pole
Marks a steady rhythm
As the great tree trunk
Now shaped and hollowed
Moves slowly up the shoreline...

The paddling stroke is kept close to the sides of the canoe for forward movement. When great force is suddenly applied so as to get a rapid acceleration of travel, the paddle can often be heard to scrape the side of the canoe. Steering is done from the stern of the craft. There are 2 opposing movements involved:

a. the blade is plunged into the water as far away from the canoe as the paddler can reach and then pulled towards the canoe side. This movement is known as /wambela/ and moves the canoe towards the plunged blade;

b. the blade is thrust into the water against the side of the canoe and the stem pulled against the craft so that the paddle acts as a second-class lever and pulls the canoe away from the plunged paddle. Lokele paddlers call this movement /wacela/.

When a man-and-wife team occupy the canoe, the woman sitting at the stern on the platform is mainly responsible for steering by making the

2 movements described above, though she also contributes to the forward movement with normal paddle-strokes. The husband in the prow pulls the canoe forward but can also steer by using the /wambela/ and /wacela/ strokes if his wife's action at the stern is insufficient to make the required manoevre.

Olombo canoeists and also members of the Bakomo tribe who sometimes make villages on the river-bank and use canoes for travel, sit down to paddle. Their paddles are also made of Staudtia gabonensis timber but are shorter and have wider blades than those used by the Lokele.

Speed of travel can be varied by immersing more or less of the blade in the water. This is regulated by the stance of the paddler. For very powerful strokes, the paddler immerses the whole of the blade and has to bend forward to the task. As he pulls hard with his right hand on the centre of the stem, this latter bends considerably and may break under the stress imposed. (This eventuality is frequently cited in the well-known riverine proverb: /Bóúnyelo káí, ómacéke lotáki/ -"If your canoe paddle breaks, don't leave the blade behind!" It is possible to paddle a canoe still, even if you have to sit down and use the blade alone; but the stem is useless because of its small surface in the water). To give the order to accelerate, the leader of a team of paddlers (usually in the stern where he is responsible for the steering movements) shouts the command: /Lúfyáká káí!/ -"Immerse the paddles!".

A paddle may be used for punting, as mentioned above. On a long journey, however, a special punting-pole (/wishá/) is carried. This may be 3m long or more and is usually a pole of /bombai/ wood (Xylopia spp.) with a forked tip (the lower part of a branch) to permit of easier grasping in the hand and also of contact with the shoulder as the punter bends his weight to it. The punter stands at the prow of the canoe near the mooring hole, thrusts the pole into the water or against a tree trunk lying near the bank (sometimes against an overhanging branch) and then, bending to the pole, walks down the sloping floor of the canoe as far as he can, his feet pushing the canoe in the opposite direction.

4.3.6.3 Wood anatomy

Vessels: fine, too small to be seen with the naked eye, elliptical with the larger diameter orientated radially, 60-160µ wide. Mostly solitary but with some groupings of 2 and 3. Vessel elements 400 - 1300µ long with usually oblique ends having a rimmed, often oblique perforation which is simple in most cases but occasionally (ca 1% of all vessels examined in maceration) is

reticulate-scalariform. Most of the elements are tailed, many of the tails being elongated and narrow. The tips of these latter may be sinuous or swollen where they lie alongside surrounding tissues such as xylem rays or even penetrate into them. Inter-vessel pitting is alternate, polygonal or oval with horizontal apertures. Vessel-to-ray pitting is much larger, often rounded and almost fenestroid (Plate 5c,d). Tyloses are sometimes present in the vessels (Fig.59, 60, 61; plates 5a, 6).

Parenchyma: rare to absent; a few parenchyma cells are occasionally seen in a paratracheal position.

Rays: very numerous, up to 12 /mm in XS, uniseriate or with 2-3 cells in thickness, 200 - 1400µ in height (mean: 700µ). Heterocellular with 2-3 rows of upright cells at the margins and also in the centre of the ray in some cases. Cell walls usually heavily lignified, with numerous pits. Long strands of resin-like deposits are frequently seen running horizontally through the rays (Fig. 59,60).

Fibres: long, 1300-2350µ in length, narrow (12-16µ wide) with thick walls and narrow lumen (2-5µ). Pits simple. The ends of the fibres are long and often sinuous, showing on the external walls where they are applied to the sides of the rays and have been conformed to the outer shape of the ray cells (Fig. 62-4). Some fibres are found in TS to have penetrated the ray cells. This phenomenon and the presence of fibres with forked tips will be discussed in section 4.3.6.7.

4.3.6.4 Tissue analysis. Results obtained by the weighing method are as follows. Parenchyma was so rare that it could not be included in the study.

Test number:	Vessels %:	Fibres %:	rays %:
1	7.1	33.9	59.0
2	9.1	30.3	60.6
3	7.8	33.2	59.0
4	7.8	36.1	56.1
5	9.6	36.0	54.4
6	4.8	34.0	61.2
7	5.3	37.3	57.4
8	5.4	35.9	58.7
9	5.9	36.5	57.6
10	6.7	37.0	56.3
Means:	7.0	35.0	58.0
Standard deviation:	1.6	2.2	2.1

Expressed diagrammatically, these results are as in Fig. 63.

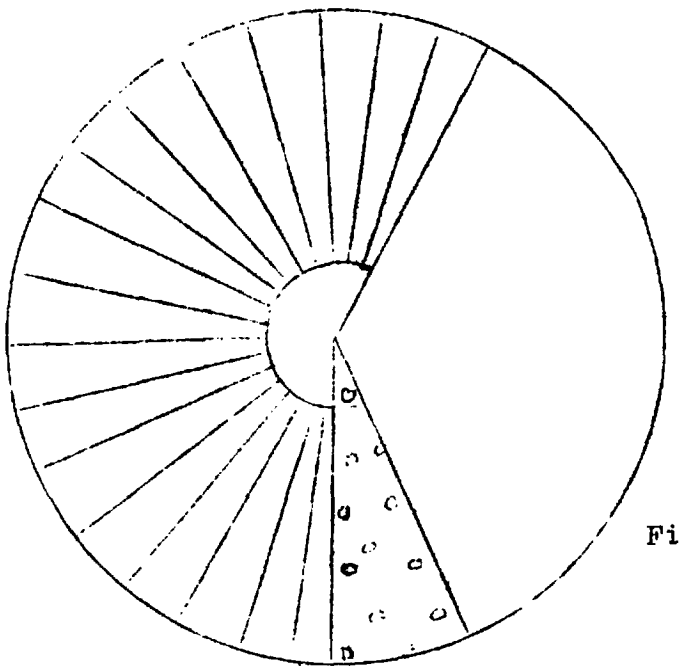


Fig. 63 Staudtia gabonensis. Tissue distribution. Symbols as in Fig. 18

4.3.6.5 Fibrillar angle. 7 fibres were studied with the following results:

a. 7 pits with angles ranging from 28° to 41°, average 32°;
b. 14 pits with angles ranging from 13° to 35°, average 17°;
c. 4 pits with angles ranging from 22° to 26°, average 24°;
d. 5 pits with angles ranging from 26° to 31°, average 28°;
e. 16 pits with angles ranging from 22° to 42°, average 33°;
f. 6 pits with angles ranging from 22° to 32°, average 28°;
g. 6 pits with angles ranging from 20° to 30°, average 25°;

mean angle for all the pits: 29°.

4.3.6.6 Vessel net-work. Three investigations were made with somewhat variable results, but all three show a much looser network than any of the other timbers studied:

A. length of timber sectioned: 1cm
number of anastomoses: 21
total functional units: 82
NDQ: $\frac{21}{82} \times \frac{\&5}{10} \times 100\% = 13\%$

B. length of timber sectioned: 5cm
number of anastomoses: 27
total functional units: 52
(Examinations made are intervals of 5mm only)
NDQ: $\frac{27}{52} \times \frac{5}{50} \times 100\% = 5\%$

C. length of timber sectioned: 3cm
number of anastomoses: 59
total functional units; 115
NDQ: $\frac{59}{115} \times \frac{5}{30} \times 100\% = 8\%$

4.3.6.7 A note on fibre penetration of rays in Staudtia.

The elongation and deformation of the tips of prosanchymatous elements in the xylem of Staudtia gabonensis Warb. has already been mentioned (4.3.6.3) and illustrated (Fig.61, 62). These findings confirm Garratt's (1933) report on elements with "deformed tips" in the secondary xylem of several species of the Myristicaceae. Some of the long tails of vessel elements in Staudtia showed this structure but it was especially common

in the fibres seen in maceration after isolation from other fibres or contiguous ray cells (Plate 4c,e,f). Fibre tips were usually corrugated on one side though sometimes blunted and hooked.

The various types of tip "deformation" found in isolated fibres after maceration were looked for in situ in XS and TS preparations as well as by dissecting out clumps of partly macerated cells. All of them were found. It became clear that the so-called "deformations" are the result of interaction in early xylem differentiation between elongating prosenchymatous elements themselves or between these latter and ray parenchyma cells already in position in the developing xylem.

A number of rays were seen in TS where the tips of libriform fibres had penetrated to varying distances within the ray tissues, separating ray cells along the middle lamella. All stages could be found from surface penetration through to complete traversal of the ray. Serial sections were cut in TS to follow more closely the ends of the penetrating fibres and it was seen that, whereas in a few cases single fibres were involved, penetration had usually been effected by a sheet of fibres, the first (or last) of these only penetrating partially into the ray, the remainder cleaving the ray entirely and passing through to the opposite side. This interpretation of the TS views was confirmed by the discovery of such fibre sheets dividing rays in XS and RS (Plate 4).

The debate on secondary fibre development by sliding growth (Krabbe), symplastic growth (Priestly) and intrusive growth (Zimmermann and Sinnott & Bloch) is of historical interest only. Schoch-Bodmer and Huber (1952) reviewing these different explanations showed that the formation of forked fibres as seen by them in Sparganniа xylem can only be satisfactorily explained by postulating intrusive growth. They refer to the lateral interposition of fibre ends into medullary rays "so that sometimes the rays are cleft entirely",
but they do not illustrate this phenomenon. It is perhaps worth while to record the present findings of such fibre penetration in Staudtia.

When the penetration of rays by libriform fibres and the hooking of similar elements over some medullary ray margins was first observed, it was tentatively suggested that this anatomical structure might serve to increase the tensile strength of the wood and thus account for the use of Staudtia timber for making canoe paddles where resistance to snapping is essential. But the comparative rarity of such hooked fibres or bent fibres actually penetrating into rays compared with the simple serrate fibre tips militates against such an explanation. Further, experiments

on the weathering of these 6 timber species from Zaïre showed that Staudtia was the first to develop checking (cf. section 5.6).

P A R T III

5 Some useful timbers from the Upper Zaïre: physical properties.

5.1 The six timbers chosen for study were tested for the following physical properties:

a. density,

b. elasticity as measured by Young's Modulus,

c. surface hardness,

d. penetrability,

e. weathering.

In all cases, micro-methods were developed in order to handle the small sizes of wood available. It is realised that the results obtained with such methods are not comparable with those of standard wood-testing equipment where large experimental pieces are used. But it is suggested that micro-methods as used in this study give results that are comparable among themselves and enable the 6 timbers to be ranked for any one physical property. Such ranking will be sufficiently accurate to enable an assessment to be made of correlations with anatomical and other properties in order to see how far timber choice by Zaïrian craftsmen depends upon a knowledge of their suitability.

5.1.1 Density.

Density was determined by direct measurement of geometrically accurate prisms of wood (air-dried) followed by weighing. Results are shown in the following table:

Timber:	specimen number:	dimensions of prism (cm):	volume cm^3:	weight g:	density:	means:
Alstonia	1	8.00x1.05x0895	7.98	2.69	0.337	
	2	6.70x0.95x0.97	6.17	1.90	0.307	0.322
Combreto-	1	7.9 x0.9 x0.91	6.79	4.88	0.719	
dendron	2	8.00x0.93x0.93	6.92	5.56	0.798	
	3	7.96x0.99x0.96	7.57	5.88	0.777	
	4	7.97x0.97x0.92	7.11	5.88	0.743	
	5	8.00x1.00x0.96	7.68	5.60	0.729	0.753
Gossweilero- dendron	1	15.00x7.00x1.95	205.75	110.00	0.534	(0.534)

Musanga	1	8.07x1.01x0.98	7.99	3.82	0.478	
	2	7.90x0.89x1.00	7.43	3.90	0.525	
	3	8.10x0.89x0.92	6.63	3.37	0.508	
	4	8.17x0.91x0.93	6.91	3.70	0.535	0.512
Pterocarpus	1	7.95x0.96x0.94	7.17	4.21	0.587	
	2	7.86x0.89x0.93	6.51	3.97	0.609	
	3	8.01x0.93x0.92	6.85	4.19	0.612	
	4	7.85x0.93x0.94	6.88	4.06	0.590	0.600
Staudtia	1	8.01x0.99x0.90	7.13	5.88	0.825	
	1	8.01x0.96x1100	7.37	6.23	0.845	
	3	7.94x0.96x0.94	7.17	5.88	0.820	
	4	7.95x0.93x0.91	6 73	5.82	0.864	
	5	7.95x1.05x1.02	8.51	7.14	0.839	
	6	8.01x0.93x0.94	7.00	5.65	0.807	0.833

5.2 Elasticity by Young's Modulus.

Young's Modulus is defined by the ratio: stress / strain and is constant for a perfectly elastic solid (Hook's Law). Experimental measurements of strain for increasing stress on wood show that the two parameters are proportional up to a certain limiting stress but thereafter the linear relationship ceases and further increase in stress leads to deformation and to rupture of the solid.

A standard testing apparatus produces measurable deflections in a beam of wood on which pressure is applied at a constantly increasing rate. It utilises wood in prisms with dimensions 30"x2"x2" (76.3cmx5cm x5cm). Wood of this size was not available for the present study based on objects in actual use in Upper Zairian villages. Micro-methods were therefore developed and tested, namely:

a) a static beam test based on pressure applied to a small beam,

b) a dynamic test using a vibrational method.

5.2.1 Tests of Young's Modulus using a Mateus miniature beam apparatus.

A test was proposed by Mateus in 1954 to assess the decay of timber by fungi, this being measured by the decrease in physical strength (as measured by E values) consequent on fungal invasion of the wood tissues. As modified at the Princes Risborough Laboratory (Bravery and Lavers 1971), this apparatus consists of a long steel beam B over which a measured weight M can move to apply variable pressure on a miniature beam of wood W through a double knife-edge K. The deflection produced by the pressure is measured by a gauge sensitive to 0.0001". The beam was accommodated during the test on 2 glass rods GG cemented to a heavy glass petri dish at a known distance one from the other (Fig 65 and plate 6). Longer test beams were supported on the sides of petri dishes 10cm and 15cm in diameter.

Young's Modulus can be calculated from the deflection of the beam of known dimensions produced by a known pressure, using the theoretical relationship for the deflection of a cantilever:

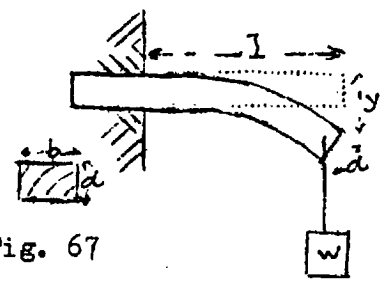


Fig. 67

$$y = \frac{4w.g.l^3}{E.b.d^3} \rightarrow E = \frac{4w.g.l^3}{y.b.d^3} \quad \ldots\ldots(1)$$

where w = mass applied to beam
l = beam length
b = beam width
d = beam depth (in the direction of deflection)
g = the gravitational constant

The relationship between E and experimental parameters when a load W is applied at the centre of a beam of breadth b and depth d resting on knife edges distant L one from the other (Fig 81) can be deduced from formula (1) by assuming that the beam is a double cantilever fixed at the point of application of W and being deflected by 2 forces, each equal to W/2 acting upwards at each knife edge. The length of each deflected beam will then be L/2. Hence:

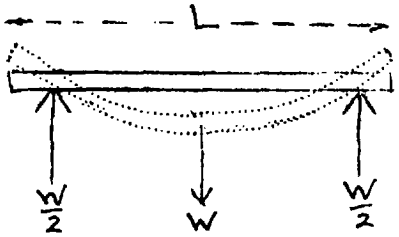


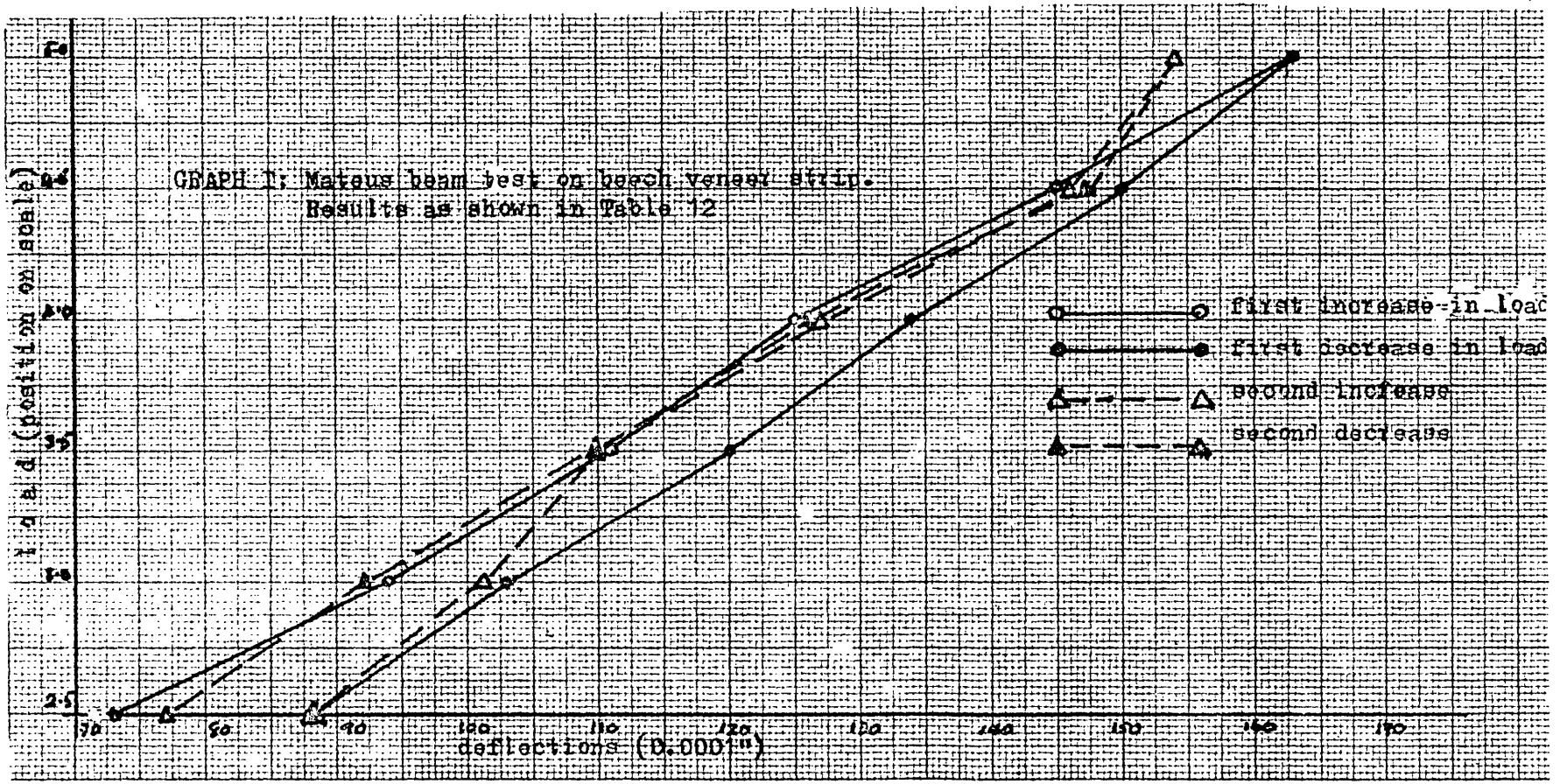
Fig. 68

$$E = \frac{4w/2.g.L^3/8}{y.b.d^3} \rightarrow \frac{w.g.L^3}{4y.b.d^3} \quad \ldots\ldots(2)$$

Some experimental results were obtained using a single knife-edge cemented beneath the stress applicator of the Mateus apparatus as used at Princes Risborough. These were processed by formula 2. Other results were obtained using the double knife-edge and applying formula 1 to the half-beam deflected by the increasing pressure.

Experiments to assess the value of the method.

Preliminary experiments were performed using a lollipop stick made of thin beech veneer of uniform thickness and width, placed on the glass-rod supports distant 6cm one from the other. The pressure applicator with its 2 knife edges distant 2.5cm one from the other was centred on this miniature beam and the movable weight of the Mateus apparatus moved along the steel arm to 5 positions of increasing distance from the fulcrum. Deflections were noted at each position of the weight. The weight was then moved back towards the fulcrum and fresh reading of deflection noted. A second set of readings was taken in this way. Results were as follows:



GRAPH 1: Matous beam test on beech veneer strip.
Results as shown in Table 12

Table 12: deflections of beech veneer for load of 253.7g

position of weight:	2.5	3.0	3.5	4.0	4.5	5.0
deflections (0.0001")	73	94	111	125	145	163
	88	103	120	134	150	163
	88	101	110	127	146	154
	77	92	110	126	147	154
mean deflections:	82	98	113	128	147	159

Plotted on a graph (Graph 1), these deflections show a linear relationship with weight increase (within the limits of experimental error) indicating that the elastic behaviour of the wood is following Hook's Law. These results can be used to calculate E for beech:

dimensions of test beam: 79.5mm x 9,5mm x 2.0mm i.e. b = 9.5mm
d = 2.0mm

deflection (y) between load at position 2.5 and at position 5.0 is
(159-82)x0.0001" = 77x0.0001" = 77x0.00254mm.

This deflection is produced by a load W equal to half the difference between that at position 2.5 and that at position 5.0 i.e. 253.7g.

Substituting these values in formula (1) we have:

$E = 4x253.7x9812x17.5^3/(77x0.00254x9.5x2^3)$ dynes/mm^2

$= 532.1x10^8/1463x10^{-2}$ dynes/mm^2

$= \underline{3.64x10^9 \text{ dynes/mm}^2}$

It is interesting to compare this result with the value of E given for beech in the FPRL Bulletin No.52, namely 12.600N/mm^2 i.e. 1.26 x 10^9 dynes / mm^2. Our result is higher but of the same order.

5.2.2 Factors affecting results for E with the static beam apparatus.

In the determination of Young's Modulus by standard static beam testing apparatus, it is known that comparable results can only be obtained if specifications are adhered to for:

a) dimensions of test materials; beams should always measure 30"x2"x2";

b) the distance between supports must be 28" with 1" of the beam beyond the support at each end;

c) load applications must be at the centre of the test beam via a curved metal head of fixed radius;

d) load should be applied at a constant rate: 0.015" movement / minute.

Any variations from these standards will affect the values of E obtained. Other factors known to affect E-values are:

e) grain angle. Strength (as reflected in E-values) decreases as the angle between the wood grain and the long axis of the beam increases;

f) proportion of summerwood in timber with growth rings. For ring-porous woods such as oak, where the summerwood contains more fibres than springwood and is therefore harder, E is higher for greater proportions of summerwood. For diffuse-porous hardwoods, such % differences affect only slightly the value of E;

g) moisture content: E decreases with increasing moisture in the wood.

Experiments were performed to assess the degree to which the Mateus beam equipment would show the importance of some of these factors influencing E-values. Would it be sensitive to them?

A. To test the effect of grain-angle on E.

A small beam of Pinus sylvestris was used measuring 4.4mm x 3.2mm in cross-section. This was first inserted in the Mateus testing apparatus with the wider dimension horizontal and readings of deflections obtained when the load was applied. The beam was then turned through 90° so that the load could be applied on the narrower side and further deflection readings were noted. Results were as follows:

Position I	Position II
End-grain of beam: 	End-grain of beam: 
Deflection for full load; 164 x 0.0001	Deflection for full load: 146 x 0.0001
Calculated E-value: 2.004×10^9 dynes / mm^2	Calculated E-value: 1.164×10^9 dynes / mm^2

Results show that the equipment is sensitive to differences in grain direction.

B. A second experiment was performed using 2 strips of the same wood in which growth rings were (a) perpendicular to the applied load and (b) in the direction of the load. Results obtained were:

Position I	Position II
End-grain of timber: 	End-grain of timber: 
Deflection for full load: 120 units	Deflection for full load: 88 units
Calculated E-value: 1.139×10^9 dynes/mm^2	Calculated E-value: 1.646×10^9 dynes/mm^2

These results again show sensitivity to the factor of grain direction and like the former results are in accordance with what would be found on larger test equipment.

B. To test the response to increasing moisture content.

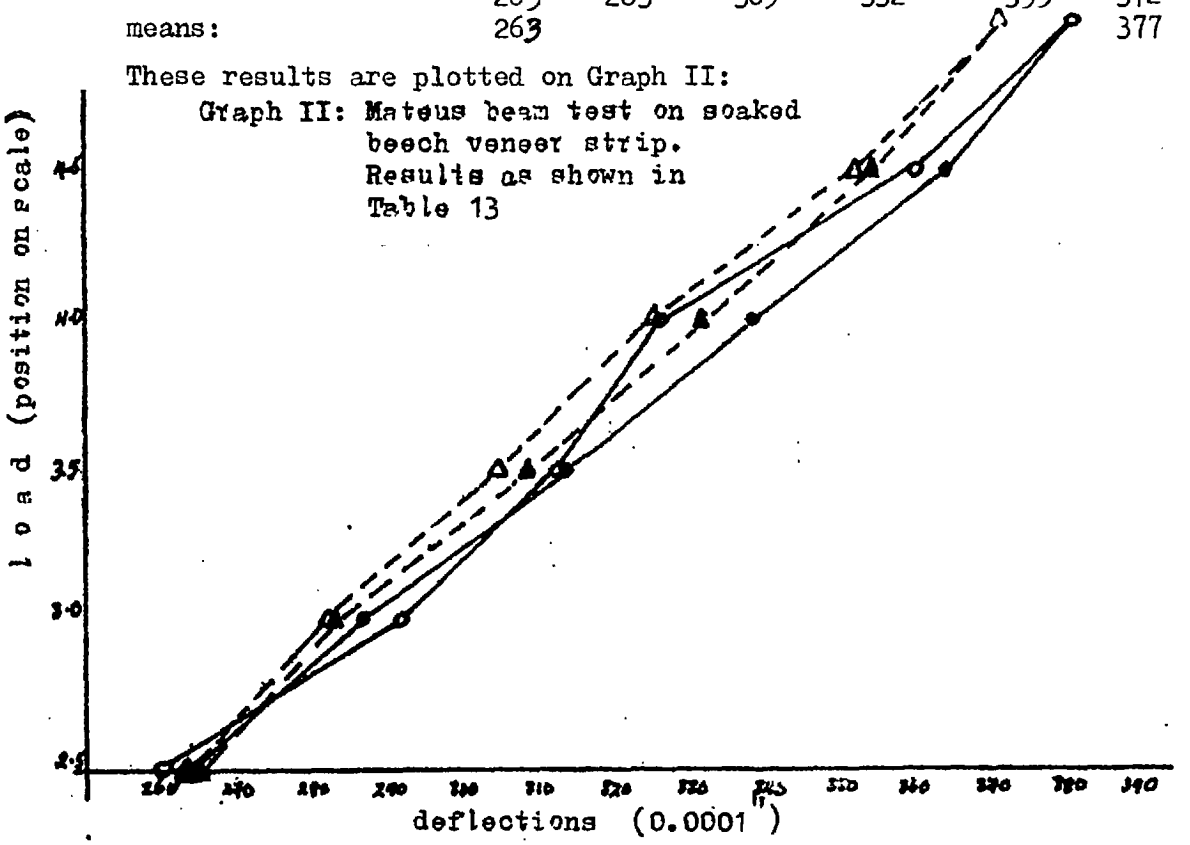
The same specimens of wood used for determining E on the Mateus beam apparatus were re-tested after thorough soaking in water at room temperature. Results for the beech strip already used were as follows:

Table 13: deflections of beech veneer soaked in water.

position of weight:	2.5	3.0	3.5	4.0	4.5	5.0
deflections (0.0001")	260	292	313	327	382	382
	263	287	314	339	365	382
	263	282	305	326	353	372
	265	283	309	332	355	372
means:	263					377

These results are plotted on Graph II:

Graph II: Mateus beam test on soaked beech veneer strip. Results as shown in Table 13



Calculation of E from these values:

Dimensions of the beam as before (page 84).

Deflection produced by a load of 253.7g: (377-26)x0.0001" = 0.2895mm

$E = 4 \times 253.7 \times 9812 \times 17.5^3 / (0.2895 \times 9.5 \times 2^3) = 533.7 \times 10^8 / (2.2001 \times 10)$

$= \underline{2.42 \times 10^9}$ dynes/mm^2

This value is lower than that found for dry beech (3.64×10^9 dynes/mm^2). This is in accordance with results obtained on standard test equipment. Decrease in E-values with increasing moisture content was found by Kersavage (1973) using individual Douglas fir tracheids.

5.2.3 Elasticity using a dynamic method.

The frequency of vibration of a bar fixed at one end (a cantilever) is given by the formula

$$f = \frac{0.5996}{l^3}\sqrt{\frac{Ea^2}{12d}}$$

(after Olson, 1952)

where f = fundamental frequency,
a = thickness of bar in the direction of vibration,
l = length of bar,
d = density of the material,
E = Young's Modulus

For a given value of f, E can be calculated when the other parameters are measured: $E = 38.22 \times f^2 \times l^4 \times d / a^2$ .....(3)

A vibrational method was used successfully by Hearmon (1957) who fixed a light iron plate to the end of a beech-wood bar and forced it to vibrate by placing it near an electromagnet through which an alternating current of known frequency was passing. By changing this frequency, he was able to find its value when maximum vibration of the bar took place. Further experiment showed that frequency of vibration depended on grain direction and calculated E-values for these different grain directions were in accordance with results obtained from static testing machines using much larger samples of wood.

In the present study, an attempt has been made to replace Hearmon's electrical apparatus by simple acoustic determination. The wooden bar, as accurately planed to required dimensions as is possible, is clamped to a sounding-box and plucked at its free end to produce a musical note (Fig. 66, plate 5b). This note is then compared with the note emitted by a standard tuning-fork and the vibrating length of the bar changed until it produces the same note as that of the tuning fork. Further determinations can be made with the same bar by finding the bar-length required to produce a note which is the exact octave of the vibrating fork note, above or below.

Typical results for a beech lollipop stick measuring 9.4mm in width and 1.6mm in thickness were the following:

Table 14: frequencies of vibration and lengths of beech strip.

frequencies:	lengths:
880 cycles/sec.	34.1mm
440	53.5
220	75.3

Consistency of results can be checked since, for a given piece of material of the same density and section, the multiple $l^2 \times f$ should be constant (see formula 3). For the results shown above we have:

$34.1^2 \times 880 = 1.022 \times 10^6$

$53.5^2 \times 440 = 1.259 \times 10^6$

$75.3^2 \times 220 = 1.247 \times 10^6$

Taking the value of l corresponding to the fundamental note of the fork, viz. 440 cycles/second, we can calculate E by formula 3 above.

$E = 38.22 \times 440^2 \times 53.5^4 \times 0.76 / 1.6^2 = \underline{1.79 \times 10^9 \text{ dynes / mm}^2}$.

This figure is higher than that given for beech in FPRL Bulletin No.52 viz. 1.26×10^9 dynes / mm^2 but closer than the value we obtained by the Mateus test equipment.

Disadvantages of the method. While this method is convenient for the type of material available, viz. specimens of wood from artefacts in use in Upper Zaïrian villages, the small size of these makes for increased error in measurement, especially when there are small variations in the thickness of the bar tested and when slight errors occur during measurement of vibrating length (thickness enters into the final calculations to the second power and length to the 4th power). Planing to sufficient accuracy on such small specimens is difficult. Milling was tried, but the high temperature created is liable to alter the structure of the wood and hence change the elastic constant.

Another factor militating against accuracy of E-detemminations will be variations in tissue content of the wood which is rarely homogenous (see later, section 6). These variations will be all the more important as the size of the specimen decreases. The following experiment confirms this:

Experiment to evaluate E by reversal of the specimen in the dynamic test apparatus.

A strip of Musanga cecropioides R.Br.timber with a thickness of 3.5mm was clamped on the sounding-box and its length adjusted until the note emitted by it was the same as that of the standard tuning-fork. Lengths were measured for frequencies of 110, 220, 440 and 880 cycles/second. The strip was then reversed in the clamp so that the erstwhile clamped end now became the free end. Fresh readings were taken of the lengths required to produce the same notes as before. If the vibrating bar were homogenous, the observed lengths should be the same. Experimental results indicate small differences:

Table 15: lengths of Musanga strip for differing frequencies of vibration.

frequency:	110	220	440	880
side A;	15.40cm	10.40cm	7.58cm	4.9cm
side B:	15.45cm	10.55cm	7.63cm	5.2cm

The multiples fxl^2, which should also be constant, are as follows:

side A:	2609	2338	2528	2113	$x10^4$
side B:	2826	2449	2562	2289	$x10^4$

Taking the mean length of sides A and B for the fundamental frequency of the tuning fork: 7.60cm at 440 cycles/second, we can evaluate E from formula (3) on page 87:

$$E = 38.22 \times 440^2 \times 7.6^4 \times 0.52 / 0.35^2 = \underline{1.05 \times 10^{11} \text{dynes} / \text{cm}^2}.$$

5.2.4 Comparison of E-values by the static and the dynamic methods.

In order to compare the 2 methods on the same timber specimen, a strip of Pinus sylvestris timber was tested using first the Mateus beam method and then the resonance-box method. The following results were obtained:

Dimensions of test strip: 22.53cmx1,56cmx0.30cm.

Weight of specimen: 5.04g. Density of wood: 0.52.

A. Mateus test. The strip was placed over a petri dish support with a distance of 10.1cm between the glass sides. The load was applied at the centre using a single knife-edge cemented beneath the applicator. The following deflections were noted for different positions of the weight on the steel arm of the apparatus:

Table 16. Mateus beam test on Pinus sylvestris.

position of weight:	2.5	3.0	3.5	4.0	4.5	5.0
deflections: '(0.0001")	942	953	968	983	1002	1023
	927	949	964	982	1001	1022
	927	946	963	982	996	1023
	927	947	963	982	996	1023
means:	932	(difference: 91)				1023

Using formula (2) on page 83, we have

$$E = 507.5 \times 981 \times (10.1)^3/(4 \times 91 \times 0.00254 \times 0.3^2) = 51.28/38.99 \times 10^{11} = \frac{1.32 \times 10^{11}}{\text{dynes / cm}^2}$$

B. Resonance test. The same strip was placed on the resonance-box and tuned against the standard tuning-fork. Results:

Table 17. Tuning-fork test on Pinus sylvestris.

frequency:	110 cycles/sec.	220	440
length vibrating:	14.8cm	10.6cm	7.58cm
fxl^2:	24094	23328	25141

Taking the vibrating length for the frequency of 220 cycles/second we have, from the formula (3) page 87:

$$E = 38.22 \times 10.6^4 \times 220^2 \times 0.52 / 0.3^2 = \underline{1.13 \times 10^{11}} \text{ dynes / cm}^2$$

The results by the two methods are similar, the dynamic method giving a lower result again as in the first experiments with these two types of apparatus.

5.2.5 Results for Zairian timbers by the methods described.

A. Mateus beam tests. Strips of four of the timbers studied were available as test specimens in this apparatus and also later in the vibrational apparatus. In each case, deflections were noted as the load applicator rested on one side of the strip; this was then reversed on the supports and the load reapplied on the other side to

give another set of readings. These two sets were consistent in every case. Table 18 gives a summary of experimental results with the 4 timbers.

Table 18: E-values for Zaïrian timbers using the Mateus beam apparatus.

Strip dimensions (cm)	deflections: (0.0001")	load: (g)	length between supports (cm):	E-value (dynes/cm^2 x10^{11})
Combretodendron:				
1. 14.00x1.15x0.40	20	405	10.1	1.353
2. 17.60x1.00x0.30	436	405	14.8	1.077
3. 12.50x2.05x0.200	76	405	10.1	1.193
			Mean:	1.208
Musanga:				
1. 19.10 x1.75x0.36	99	304	14.8	1.177
2. 20.00 x1.52x0.35	99	304	14.8	1.474
			Mean:	1.325
Pterocarpus;				
1. 20.90x0.91x0.30	141	405	10.1	1.166
2. 21.05x1.60x0.20	434	304	14.8	1.373
3. idem	200	507	10.1	1.855
4. 21.15x0.91x0.41	77	507	10.1	1.113
			Mean:	1.377
Staudtia:				
1. 14.70x1.30x0.21	76	200	10.1	2.18
2. 14.80x2.00x0.29	205	507	10.1	2.81
			Mean:	2.50

There is considerable variation among results for any one timber.

Ranking by order of decreasing strength (taking the average figures) is:

Staudtia - Pterocarpus - Musanga - Combretodendron.

But the small number of specimens tested and the variability of results obtained renders this ranking of little significance.

B. Vibrational tests. The same strips were submitted to the vibrational tests described above and the following results recorded:

Table 19: E-values for Zaïrian timbers using a vibrational technique.

Strip dimensions (cm):	weight:	density:	length for vibration at 440 cycles/sec.		E (dynes/cm^2 x10^{11})
Combretodendron:					
1. 14.00x1.15x0.40	5.11	0.79	6.90		0.858
2. 17.60x1.00x0.30	3.33	0.74	5.90		0.821
3. 12.50x2.05x0.20	4.11	0.80	5.30		1.167
				Mean:	0.949
Musanga:					
1. 19.10x1.75x0.36	6.83	0.55	7.30		0.910
2. 20.00x1.52x0.35	5.24	0.49	7.6		0.980
				Mean:	0.945

Pterocarpus:					
1. 20.90x0.91x0.30	3.02	0.83	6.9		0.988
2. 21.05x1.60x0.20	4.38	0.65	5.7		1.269
				Mean:	1.129
Staudtia:					
1. 14.70x2.30x0.21	3.22	0.80	6.98		3.187
2. 14.80x2.00x0.19	4.47	0.79	6.70		3.259
				Mean:	3.223

These values for Young's Modulus show the same variability as those obtained by using the static beam method. Like the results for Pinus, the vibrational values of E are lower (except in the case of Staudtia) than those obtained by the Mateus method. Because of the variability, little significance can be attached to the final values, nor to the ranking which in this case is:

Staudtia - Pterocarpus - Combretodendron - Musanga.

It will be of interest to compare the average values given above with those determined from standard tests:

Table 20. E-values of Zairian timbers from standard tests (in N / mm^2) compared with tests done for this study.

	Mateus:	Vibrational:	Standard:
Combretodendron:	12 080	9 490	14 500
Musanga:	13 200	9 450	3 700
Pterocarpus:	13 770	11 290	12 400
Staudtia:	25 000	32 230	15 800

Ranking according to the standard tests is:

Staudtia - Combretodendron - Pterocarpus - Musanga.

The micro-methods could be expected to give more consistent results if the following conditions were observed:

a) specimen strips of standard size should be used, say: 15cmx1cmx 0.2cm, accurately planed to thickness but in machines where heat development during planing would not injure the wood structure. Accurate thicknessing is essential, but the thickness has to be kept small to permit of as great deflections as possible in the static test and as long a vibrating length as possible in the dynamic test;

b) all specimens should have grain running in the same direction e.g. prepared with the 3 faces corresponding to the 3 xylem planes with the end face transverse, the broad face tangential and the narrow face radial;

c) a large number of identical strips should be tested before mean values are proposed.

5.3 Surface hardness .

5.3.1 Some earlier methods of investigation.

Impact methods have frequently been used to determine the hardness of materials. Walzel (1934) allowed a heavy pendulum bearing a steel sphere to fall from a known height and strike a plate of material whose hardness was to be determined. The recoil of the pendulum after impact was measured. This apparatus was shown to give replicable results and could be calibrated against metals of known Brinell hardness value.

Edwards and Willis (1918) allowed a heavy hammer, bearing a steel ball at its tip, to fall freely on a plate of test material from a measured height. The indent produced was then measured and found to be indicative of the hardness of the material.

Sauveur (1926) developed a testing apparttus in which a steel ball was allowed to fall on the test material fixed at an angle of 45° to the horizontal. After impact, the ball rebounded in an initially horizontal direction and then fell on to calibrated paper over which a sheet of carbon paper was superimposed so that the falling ball made a mark on the paper at the point of impact. The distance of this mark from the point of rebound was then measured and shown to depend on the surface hardness of the test material; harder materials gave greater distance of rebound.

Narayanamurti (1965) recorded the results of impact-testing using a ping-pong ball which was allowed to fall from a known height and to rebound successively until movement ceased. The height of rebound was measured and also the logarithmic decrement for materials of differing thickness and surface types.

5.3.2 Present experimental work.

The present experiments record an attempt to extend Narayanamurti's method to test woods from Zaïre after preliminary tests on birch and other materials of known hardness. Height of rebound was determined by a photographic method. A white ping-pong ball was held by suction at a measured height above the material to be tested and then allowed to fall freely. Its height of rebound was measured photographically by opening the shutter of a camera trained laterally on the white ball as it fell. Behind the falling ball was an illuminated scale, so that the moving white sphere left a line on the exposed photographic film whose height on the scale could easily be read off after development. The dark line on the developed negative got denser at the point where vertical movement of the ball ceased momentarily. (See Fig. 72, 73 and Plate 5c)

Newton showed that for colliding, perfectly elastic bodies, the ratio recoil velocity/impact velocity was constant and dependent on the materials in collision. He called this ratio the restitution coefficient. When one of the materials is fixed, the coefficient is equal to the ratio of the recoil and impact velocities of the moving body. For the assessment of replicability, the ratio of the square-roots of initial and rebound heights was calculated, since velocity is proportional to the square root of height fallen. We have:

$v^2 = 2gh$ where g is the gravity constant.

Then, for falling and rebounding :

restitution coefficient $\underline{e} = \sqrt{2gh_2} / \sqrt{2gh_1}$ where h_1 and h_2 are the height from which the body falls and to which it rebounds respectively.

Hence $e = \sqrt{h_2/h_1}$.

Experiment 1: to test the replicability of results using a Halex plastic ping-pong ball bouncing from the floor (wooden blocks with a polyurethane surface coating.)

Table 21: results of this experiment.

Initial height of fall in every case: $H_o = 80$cm.

Negative number;	first rebound H_1(cm)	second rebound H_2(cm)	$\sqrt{H_1/H_o}$	$\sqrt{H_2/H_1}$
1	60.8		0.872	
2	58.1		0.852	
3	60.3		0.868	
4	60.3		0.868	
5	60.3		0.868	
6	59.3	44.6	0.862	0.868
7	59.4	43.8	0.862	0.861
8	59.8	44.4	0.864	0.861
9	58.5	43.7	0.851	0.861
10	58.7		0.858	
11	60.6	45.1	0.870	0.861

It is clear that, within the limits of experimental error which seems to be small, the ratios $\sqrt{H_1/H_o}$ and $\sqrt{H_2/H_1}$ give constant values.

Experiment 2: to test the effect of differing initial heights on the values of $\underline{e}$ as determined by the falling ping-pong ball.

The ball was dropped on to a glass plate (4mm thick) resting on the laboratory bench from heights approximately 100cm, 80cm and 60cm above the plate. Results are shown in Table 22.

Table 22. Restitution coefficient of ping-pong ball falling on glass from differing heights.

Negative number:	H_o	H_1	H_2	$\sqrt{H_1/H_o}$	$\sqrt{H_2/H_1}$
1	79.6cm	53.8cm	36.7cm	0.820	0.817
2	79.6	-	38.6		0.825
3	99.6	62.8	43.7	0.797	0.811
4	99.6	63.0	-	0.798	-
5	59.6	42.9	-	0.848	-
6	59.6	42.3	-	0.837	-

It appears that the value of the restitution coefficient decreases with increasing height of fall. This is probably due to air resistance to the light ping-pong ball as it falls freely from a greater height. Hence any further use of the method for comparing differing materials should use a constant height of initial fall.

Experiment 3: to test method of fixing material during tests, as well as the importance of material thickness.

Specimens of birch wood of differing thicknesses were clamped in a wooden jig laid on the floor of the laboratory. The height of initial fall of the ping-pong ball was adjusted so that whatever the thickness used, the trajectory of the falling ball was always 80cm. In a final test, a block of birch measuring 3.5cm x 5cm in section was used unclamped but with first the larger dimension (5cm) and then the smaller dimension (3.5cm) in contact with the floor.

Table 23: e-values for materials of differing thickness, clamped and unclamped during the fall of the ping-pong ball.

Specimen thickness(cm)	Negative number:	H_1(cm)	H_2(cm)	e_1	e_2
0.5cm	1	57.5		0.848	
	2	57.1		0.845	
	3	57.3		0.846	
	4	57.5		0.848	
	5	57.8		0.849	
1.0	6	57.5		0.848	
	7	57.3		0.846	
	8	57.4		0.847	
1.5	0	56.9		0.843	
	10	56.0		0.837	
	11	56.1		0.837	
2.0	12	57.6		0.848	
	13	57.6		0.848	
	14	57.7	41.3	0.848	0.847
3.5	15	56.0	38.9	0.837	0. 831
	16	55.2	39.6	0.835	0.847
	17	55.3	39.8	0.835	0.848

Table 23 (continued)

birch block with 5cm face on floor	18	55.0	38.2	0.829	0.832
idem with 3,5 cm face on floor	19	53.3	33.6	0.824	0.787

These results show that $\underline{e}$ values remain constant, within the limits of experimental error, provided differing thicknesses of the material are firmly fixed so that there is no movement during impact (even with a light ball). The lower values for $\underline{e}$ when even a heavy block is placed unclamped on the floor are probably due to slight movement as the ping-pong ball contacts the wood surface. It is noteworthy that $\underline{e}$ is lowest when the smaller surface of the block is in contact with the floor and presents less friction with it than the larger face.

This experiment suggests that any comparison of timber surfaces for e-values using this method would not need to have wood specimens of the same thickness but they should be fixed firmly to prevent movement during impact.

Experiment 4: to test the sensitivity of the method by using differing materials.

The following materials were clamped in the jig and the trajectory of a ping-pong ball determined as in previous experiments:

glass (4mm)	brass strip (3mm)	polystyrene block
aluminium (3mm)	copper strip (1.5mm)	steel strip (6.5mm)
perspex (6.5mm)		

The glass surface was free and not clamped but a large sheet was used so that the friction between it and the laboratory bench prevented any movement during impact by the ping-pong ball. The results were as follows:

Table 24: ping-pong ball impact with differing materials.

specimen	negative number:	H_0(cm)	H_1(cm)	H_2(cm)	e_1	e_2
glass plate	2	79.6	58.3	42.3	0.854	0.852
idem	3	79.6	58.2	41.7	0.854	0.846
aluminium strip	4	77.0	53.6	32.0	0.837	0.770
idem	5	77.0	54.0		0.837	
idem	6	77.0	53.8	30.5	0.835	0.753
steel strip	7	76.7	53.5		0.835	
	8	76.7	55.9		0.854	
	9	76.7	55.5		0.851	
perspex	10	76.7	52.6		0.830	
idem	11	76.7	52.6		0.830	
	12	76.7	53.0		0.831	

brass strip,	16	76.7	54.6	0.844
idem	17	76.7	54.7	0.844
copper strip	18	76.9	53.2	0.832
idem	19	76.9	53.0	0.830
polystyrene	20	71.2	34.8	0.698

The apparatus serves to rank these materials in the same order as traditional hardness-testing machines:

glass - steel - brass - aluminium - copper - perspex - polystyrene. But the differences in e-values are small. Tests with a heavier ball (glass, steel) might give e-values with greater scattering provided the effects of indenting the material did not vitiate the results obtained (such effects are negligible when a ping-pong ball is used). Firm clamping to prevent specimen movement would also be critical if a heavier ball was used.

5.3.3 Results for Zaïrian timbers.

The results obtained in the preliminary experiments described in the last section were sufficiently accurate to suggest that the method be used for comparing the surface hardness of Zaïrian timbers selected for study. Results for clamped specimens of these are as follows:

Table 25

Specimen:	H_0(cm)	H_1	e		
Pterocarpus	76.7	48.3	0.794		
idem	76.7	49.4	0.803		
idem	76.7	48.2	0.793	Average:	0.797
Gossweilero-dendron	76.7	43.7	0.755		
idem	76.7	42.0	0.737		
	76.7	43.2	0.751	Average:	0.748
Staudtia:	76.7	49.3	0.802		
	76.7	49.7	0.805		
	76.7	50.2	0.809	Average:	0.805

The other 3 timbers were not available in large enough specimens for this test.

The scattering of e-values is sufficient to rank the timbers in decreasing order of hardness (surface):

Staudtia - Pterocarpus - Gossweilerodendron.

5.4. Penetrability.

5.4.1 A simple micro-method was set up to assess the ranking of the Zaïrian timbers studied according to their penetrability by solids. It consisted of a standard dart with a small piece of soft iron attached (by means of solder) to the feathered end so that it

could adhere to an electromagnet when current from a battery was passing through this. The dart was suspended over the wood to be tested and allowed to fall from a known height by interrupting the electric current passing through the magnet. The dart penetrated into the wood and produced a circular hole. Since the tip of the dart was conical in shape, the diameter of the hole produced varied according to the depth of penetration and could therefore be used as a measure of penetration depth (Fig. 70).

To measure the hole diameter, the piece of wood with a number of holes was placed on the stage of a binocular microscope fitted with a drawing attachment and the holes were outlined on thick paper. The diameter could then be measured directly. In practice it was found that the holes were not perfectly circular so that their magnified images (x12) were cut out from the paper on thich they were drawn and weighed.

Two precautions were found useful:

a) owing to the grain of the timber, the edge of the hole produced by the falling dart was not always clear enough to be drawn accurately under the microscope. A thin sheet of brown paper (gummed label) was therefore lightly pasted over the surface of the wood so that the dart first made a hole in the paper and gave a sharper edge than in the wood surface;

b) holes produced near the edge of the wood were not included in measured observations because the resistance to penetration by the dart was less at such points and splitting tended to occur.

Experiment 1. To test penetration on different surfaces of a given timber block.

A block of birch wood with faces in the transverse, radial and tangential planes was used. The dart was allowed to fall from a distance of 100cm from the block face and diameters of holes made were measured directly with a millimeter scale after magnification by drawing under the binocular microscope. Results are shown in Table 26.

Table 26. Dart-holes in different faces of a birch block.

Direction of penetration:	diameter of holes produced in mm (x12 magnification)						
axial	13.5	14.0	15.5	15.0	15.5		
radial	12.5	12.5	12.5	12.5	13.0	12.0	
tangential	9.0	12.0	9.5	10.0	11.0	12.0	12.0
	12.0	12.0					

Mean values: axial direction: 14.7mm s.d. 0.69
radial direction: 12.5mm s.d. 0.32
tangential direct: 10.9mm s.d. 1.22

It should be noted that penetration in the radial direction occurs when the dart falls on the tangential face, while penetration in a tangential direction occurs when it falls on the radial face of the block. The results are significantly different and give the following ranking in decreasing resistance to penetration:

tangential direction - radial direction - axial direction.

Or, in terms of the xylem planes:

radial face - tangential face - travsverse face.

Student's t test applied to these results shows that the difference in penetrability between the transverse face and the other 2 planes is significant at less than 1%, while that between the radial and tangential faces is not significant.

Experiment 2: to test penetration in different directions on some Zaïrian woods.

The same experimental technique was used as in Experiment 1. Table 27 shows the results obtained.

Table 27: penetration of Pterocarpus and Staudtia wood blocks by darts.

Direction of penetration;	Diameter of holes produced (x12) in mm by dart falling on Pterocarpus block							
axial:	16.0	16.0	14.0	15.0	13.5	16.5	15.0	16.0
	16.0	14.5	Mean value: 15.25mm					
radial:	12.5	12.5	12.5	13.0	12.5	Mean: 12.6mm		
tangential:	16.0	14.5	15.5	15.5	16.5	Mean: 15.6mm		
	Diameter of holes produced in mm by dart falling on Staudtia block							
axial:	14.0	15.0	14.5	16.0	14.0	Mean: 14.7mm		
radial:	10.5	11.5	12.5	11.0	12.0	Mean: 11.5mm		
tangential	12.0	11.0	11.5	12.5	12.0	Mean: 11.8mm		

The results show a difference between the 2 timbers. In Staudtia, penetration is easiest in an axial direction and there is no significant difference between penetration in either of the other directions. In Pterocarpus however, penetration in the tangential direction is as easy as it is in an axial direction.

5.4.2 Penetrability of the Zaïrian woods studied.

The same apparatus was used for this investigation but comparison of penetrability was made only on the tangential face (i.e. darts fell in a radial direction) for all woods tested, except for Alstonia where timber size made it advisable to use the radial face in order to prevent splitting. Hole sizes were measured by weighing so that they figure in the table as areas.

Table 28. Penetrability of Zairian woods by a steel dart - Alstonia on the radial face, all the others on the tangential face.

Timber;	surface of holes produced (x12) cm^2;					Mean (cm^2):
Alstonia	2.97	3.33	3.23	3.64	3.80	3.32
	3.44	3.49	3.23	3.13	2.92	
Combreto-dendron	2.34	2.26	2.34	1.58	1.76	2.08
	2.12	2.16				
Gossweilero-dendron	2.88	3.02	2.93	2.61	2.75	2.95
	3.11	3.05	3.02	3.15		
Musanga	3.64	3.23	3.95	3.03	3.75	3.48
	4.00	3.28	3.23	3.23		
Pterocarpus	2.30	2.78	3.05	2.78	2.39	2.72
	2.85	2.70	2.88	2.84	2.70	
	2.70	2.70				
Staudtia	2.56	2.62	2.82	2.56	2.56	2.58
	3.17	2.31	2.41	2.51	2.26	

These observations were compared in pairs to test the significance of their means by Student's t test, with the following results:

Table 29. t-values for pairs of means from observations of timber penetrability

	Alstonia	Combretodendron	Gossweilerodendron	Musanga	Pterocarpus
Combretodendron	8.76 3.79				
Gossweilerodendron	3.39 2.14 3.79	7.37 3.85			
Musanga	1.04 2.12	8.35 3.85	4.00 3.61		
Pterocarpus	5.79 3.58	5.64 3.79	2.71 2.10 3.61	6.18 3.61	
Staudtia	5.61 3.65	2.67 2.14 3.79	3.16 2.12 3.69	5.89 3.69	1.17 2.19

In the above table. the central figure in each rectangle shows the t-ratio as calculated from the observations; the figures to the right show t-values from the table (Pearson and Hartley), the upper being that for P = 5% and the lower that for P = 0.2%.

Inspection of the table shows that the means are not signficantly

different in the pairs: Musanga - Alstonia
Pterocarpus - Staudtia

Differences significant at 5% but not at 0.2%:

Pterocarpus - Gossweilerodendron
Combretodendron - Staudtia
Gossweilerodendron - Alstonia
Gossweilerodendron - Staudtia

Differences significant at less than 0.2%: all the other pairs.

These results give a suggested ranking in order of decreasing resistance to penetration by the dart:

Combretodendron - Staudtia + Pterocarpus - Gossweilerodendron - Alstonia + Musanga.

5.4.4 Penetrability by the Pilodyn wood-tester.

After these results of dart-penetration had been obtained, a new instrument for measuring penetrability called the Pilodyn was made available in Denmark (Bechgaard nd). This utilises the energy of a steel spring to drive a blunt pin into the wood to be tested, the depth of penetration being measured on a scale at the side of the instrument. It is of special interest in assessing strength loss following on wood degradation in, for example, standing poles or in beams in situ.

The timber specimens from the Upper Zaïre were not sufficiently large to try out this instrument except in the case of Gossweilerodendron. For comparison with this timber, some blocks of Alstonia scolaris were tested with the same instrument under the same conditions. (Alstonia scolaris has a very similar anatomical structure and similar physical properties). Results are as follows, Table 30:

Timber:	Penetration(mm)
Gossweilerodendron:	14, 16, 17, 14, 16, 16, 16, 14, 15, 15, 14 Mean value: 15.2mm.
Alstonia:	18, 21, 18,5, 16.5, 22, 18, 18, 18.5, 19, 18.5.Mean value: 17.8mm.

The difference is in the same direction as that found by using the dart apparatus.

5.5 Weathering.

The standard apparatus for testing resistance to weathering consists of a rotating steel drum in which the test materials (surfaced wooden panels) pass every 20 minutes through air heated by an arc lamp, dry air from a fan and a fine spray of distilled water. The wood surfaces are examined after periods of 7 days in this apparatus (B.S.3900). Panels

used in the apparatus measure 15cm x 10cm.

For the present study a simpler method was used to assess resistance to weathering on small amounts of wood. Prisms measuring 8cmx1cmx1cm were alternately immersed in tap-water for 24 hours and then allowed to dry out on the laboratory bench for 24 hours. This was continued for a period of 80 days. The available timber was sufficient for

6 prisms of Combretodendron
6 prisms of Staudtia
4 prisms of Pterocarpus
4 prisms of Musanga
4 prisms of Gossweilerodendron
2 prisms of Alstonia.

One prism of each timber was kept in air all the time as a control. In addition to the Zairian woods and for comparative purposes, 4 prisms of Scots Pine and 3 prisms of birch were included in the experiment.

The prisms were examined at regular intervals for the appearance of checks on their surfaces. These were recorded diagrammatically as lines corresponding to the length of the checks on the wood surfaces (Fig.74). Results are also summarized in the following table where numerical expression is given to the size of checks appearing:

s = a sectional check, seen at the end of the prism but not extending to the radial or tangential surfaces;
2s indicates that there are 2 such checks at the end(s),
3s5 indicates that there are 3 such checks with a total length of 5mm;

l = a check in a longitudinal direction visible on one or other of the radial or tangential surfaces,
4l indicated four such checks in a prism,
5415 indicated 5 checks with a total length of 15mm.

For these records the number of checks on all the surfaces of any prism are totalised.

Table 31. Weathering of wooden prisms alternately wetted and dried.

Specimen:	Prism number:	End checks:	Longitudinal checks:
Alstonia	A1	0	0
Control	A2	0	0
Combretodendron	C1	3s15	1140
	C2	1s6	0
	C3	1s5	0
	C4	0	0
Controls	C5/C6	0	0

Gossweilerodendron	C1	0	0	
	C2	0	0	
	C3	0	0	
Control	C4	0	0	
Musanga	M1	1s6	0	
	M2	1s7	0	
	M3	1s3	0	
Control	M4	0	0	
Pterocarpus	P1	0	0	
	P2	0	0	
	P3	0	0	
Control	P4	0	0	
Staudtia	S1	8s15	91110	All checks
	S2	7s22	71 95	on the
	S3	5s19	61 81	tangential
	S4	5s15	71 60	surface only
Controls	S5/S6	0		
Birch	B1	0	0	
	B2	0	0	
	B3	0	0	
Control	B4	0	0	
Scots Pine	SP1	3s12	0	Most checks
	SP2	3s10	3153	on the tang-
	SP3	4s13	3114	ential surface;
Control	SP4	0	0	a few on radial.

The order of decreasing resistance to checking as a result of alternate wetting and drying is (for Zairian woods only):

Alstonia+Pterocarpus+Gossweilerodendron - Musanga - Combretodendron - Staudtia.

P A R T IV

6 Variability in wood.

6.1 The significance of experimental differences found among samples of any (statistical) population depends on the extent of the variation to be found within the population studied. This must be borne in mind in any discussion of timber properties because wood is known to be a highly varibble material.

6.2 Variation is wood is associated with such factors as:

the environmental conditions of individual tree growth,
the age and position of the wood sample studied within the tree,
possible "male" and "female" differences,
the presence of reaction wood,
evolutionary factors affecting the species.

6.2.1 Environmental factors in variability.

6.2.1.1 Orientation has been shown to affect the wood of some trees.

Liese and Dadswell (1959) found that the fibres and tracheids of Populus robusta and of Douglas Fir were shorter on the south side when grown in Germany (3.3% and 8.1% respectively). Trees grown south of the equator had shorter elements on the north side (4.6% and 26.1%).

Süss and Mühler-Stoll (1973) compared the numbers of xylem elements in varying orientations of beech trees and found considerable variation though figures from different growth rings did not give consistent results from year to year. Typical findings were as in Table 32:

Growth ring:	Number of vessels / mm^2				Ratio maximum/minimum:
	S	W	N	E	
1055	104	101	88	87	18.2
1948	109	146	114	127	30.7
1932	129	123	97	115	32.0
1915	140	135	122	126	14.8
1870	162	167	180	146	23.5

For average measurements of 16 growth rings they found: (Table 33)

number of vessels / mm^2:	S	W	N	E
number of vessels / mm^2:	135.3	129.2	114.1	120.3
tangential vessel diameter:	52.5	54.1	48.9	51.3
% vessels in cross-section:	45.3	44.2	35.4	43.4
% fibres in cross-section:	34.0	34.1	42.3	47.0

These latter figures clearly agree with Liese and Dadswell's findings that vessel size (in the case of beech this refers to diameter rather than vessel-length as in Populus) varies with orientation, being smallest on the North side of the tree. It is reasonable to suppose that such orientational differences would not occur on the equator but, so far as we

are aware, no investigations have yet been done to show such lack of variability resulting from orientation in the equatorial area.

6.2.1.2 Annual changes in environmental conditions are known to affect tree growth in temperate climates with the characteristic production of growth rings. Trees grown in the tropical rain forest area show considerable variation in the pattern of growth ring formation. Philipson, Ward and Butterfield (1971) report that 85% of Malaysian species have rings, even though the majority "are evergreen", 57% of American species and only 25% in the Indian Rain Forest. Figures for Zaïre are not available but half of the species studied here do not show rings: Gossweilerodendron, Musanga and Staudtia. Alstonia rarely shows such rings but they are typical of Combretodendron and of Pterocarpus. Mariaux (1967) and others have shown that such growth-rings in rain-forest timbers may be correlated with changes in cambial activity associated with defoliation because of genetic factors, climatic changes or through the depradations of caterpillars.
Pterocarpus soyauxii Taub.has a developmental cycle with a short period (often only a few days) of complete defoliation, even in the equatorial forest area. Lebrun and Gilbert (1954) designate this species as typical of the "semi-deciduous, subequatorial and periguinnean forest". In the case of Combretodendron macrocarpum (P.Beauv.)Keay, growth rings may be the result of annual defoliation by caterpillars which attack the leaves every August in the Upper Zaire region.

Anatomical changes leading to growth-ring formation vary. In temperate conifers, the clear-cut differences between early- and latewood tracheids is the result of differences in radial diameter of these wood-elements together with changes in cell-wall thickness. In ring-porous broad-leaved trees of temperate regions, vessel diameter changes annually as well as the number of vessels per unit area: early wood has more numerous vessels which are much larger than in the latewood so that growth rings become visible to the naked eye. Among tropical trees this is rare but it does occur in, for example, Tectona grandis L (fide Mariaux). A fine band of terminal parenchyma may indicate cessation of cambial activity and recommencement after a period of inactivity (Entandophragma and numerous Fabaceous trees). Changes in fibre-wall thickening seem to be responsible for growth-ring appearance in Pterocarpus soyauxii.

6.2.2. Age and position of wood samples in the tree.

The terms "juvenile" and "adult" are applied to xylem elements

produced by younger and older cambial initials respectively. Rendle (1960) to whom we owe the terms "juvenile" and "adult" as applied to wood, summarises the characteristics of juvenile wood as follows:

a) there is a progressive increase in cell dimensions from the centre outwards, together with some change in form and structure and relative arrangements;
b) softwoods show a less abrupt change than hardwoods from spring to summer wood within the growth ring, with the latter occupying a smaller proportion of the growth ring and being less dense than is the case with adult wood;
c) where spiral grain is present, this is more obvious in the earlier formed wood near the centre (juvenile wood).

Sanio (1883) was one of the first anatomists to investigate variation of xylem elements within a given tree. He worked with Pinus sylvestris and published results which have frequently been referred to as "Sanio's Laws". Some of these are the following:

1. In the trunk and branch, tracheids increase in size from within outwards until a definite size is reached that remains constant.
2. The constant final size changes from below upwards, reaching its maximum at a definite height and thereafter diminishing toward the apex of the tree.
3. The size of the mature tracheids of the branch wood is smaller than that of the mature tracheids of the trunk, although dependent upon the latter in that branches arising from the trunk at points where tracheid size approaches its maximum develop larger tracheids than branches arising at points where the trunk wood tracheids are smaller.
4. In the root, the width of the elements first increases, then falls,, and then rises to a constant figure. An increase in length also occurs from within outward.
5. Within each growth ring, early wood had shorter tracheids than late wood.

Anatomists working with species other than Pinus sylvestris have sometimes reported that "Sanio's Laws" are not always valid. But Bailey and his colleagues (1954) confirmed them for cambial activity in several species. Dadswell (1958) further confirmed them and noted that the constant length of xylem elements was attained after period characteristic of the species investigated; this was 12+ years in the case of Pinus sylvestris but increase in element length continued to 20 years

in Eucalyptus gigantea. Rendle (1960) reports that increase in length may go on further, even in the case of species with stratified cambium initials such as Robinia pseudacacia because of intrusive growth of prosenchymatous elements.

Hale, 1958, gives a useful diagram summarising variation in "fibre length" in different parts of softwood tree trunks.

Sapwood and heartwood differences should be noted here. In many timbers colour differences lessen the possibility of confusion between them when properties and anatomical structure are being investigated. But a number of timbers have no such colour differences and when weathering has occurred in made-up artefacts, it is not always possible to distinguish immediately which kind of timber has been used for their production. Anatomically, sapwood is often recognised by the presence of inclusions such as starch-grains. Chemically, the heartwood may contain extractives which give determinative reactions. There is little difference in physical strength between sapwood and heartwood (the moisture content being equal) but sapwood is often less durable because the presence of starch and other inclusions attracts insect and fungal attack. Heartwood is much less permeable to fluids than sapwood (see section 7.3.3) so that the latter can be made more resistant to insect and fungal attack than can heartwood by appropriate preservative treatment.

Buttress-roots are a feature of many trees in the equatorial rain forest and show specialised timber. An interesting investigation of their anatomical properties has been made by Stahel (1971) who compared tissue distribution in the buttress-wood wood and the trunk wood of Piptadeniastrum africanum and Khaya ivorensis. He found considerable differences as shown in his published diagrams (Fig. 7.1).

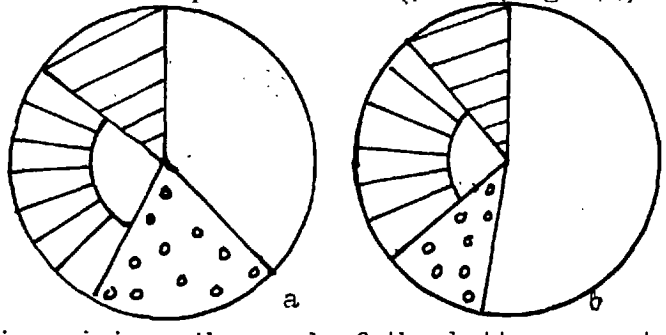


Fig.71. Tissue distribution in Khaya ivorensis:
a. stem wood
b. buttress-root wood
(after Stahel)
Symbols as in Fig.18.

In his opinion, the wood of the buttress-root is an adaptation to the mechanical needs of the tree rather than to water-conduction requirements since the fibrous tissue is increased at the expense of vessels.

Wood sample position and timber properties were investigated for 20 species of trees in North America by Fegel (1941) who looked at anatomical variability at the same time. He studied 4 ring-porous woods, 8 diffuse

porous wood and 8 softwoods, investigating anatomy and properties in branches, in the trunk and in roots. Among his results, of interest for the present study, are the following:

property:	branches;	trunk:	roots:
density:	highest	intermediate	lowest
shrinkage on drying:	greatest	intermediate	lowest
strength in compression perpendicular to the grain:	strongest	intermediate	weakest
strength in compression parallel to the grain:	strongest when green	strongest when dry	weakest green or dry
growth rate:	slowest	most rapid	intermediate
number of vessels:	greatest	intermediate but total volume greatest	smallest
element length:	shortest fibres, vessel elements, tracheids	longest elements in most species	longest tracheids in red and white pines
ray frequency:	most frequent	least frequent in hardwoods and lowest ray volume	least frequent in conifers; highest ray volume in hardwoods

Taylor (1977) has recently confirmed many of Fegel's findings for 8 mid-southern hardwoods but could find no statistically significant differences in fibre length and specific gravity between branches from the top and the bottom of the crown.

The work already mentioned of a forestry student at Kisangani University (4.3.4.6) shows that Musanga cecropioides is similar to red and white pines (fide Fegel) and to Southern Pine (fide Manwiller, 1972) in having the longest elements in roots.

6.2.3 "Male" and "female" wood.

This subject has already been discussed on an earlier section (4.3.4.4) where experimental evidence was presented showing that timber from botanically "male" trees (staminate) of Musanga cecropioides has more axial parenchyma than the wood of "female" or pistillate-flower bearing trees. Olombo craftsmen use these same terms "male" and "female" to distinguish the softer and harder timber produced by them, but it was pointed out that their labels are the opposite of the western botanist's since it is the Olombo craftsman's "male" timber which comes from trees bearing pistillate flowers. In the nearby Bamanga region, trees are

labelled "male" or "female" according to the presence of absence of fruits and seeds and hence labels accord with botanical descriptions as given b y the Western botanist. Sex differences may be correlated with antom ical and property differences of timber.

6.2.4 Reaction wood.

This term is used to described the tension wood produced in hardwoods and the compression wood formed in softwoods when trees are displaced from the vertical. This is known to be a response to gravity. The two types of xylem tissue are similar in that they have wider growth rings (in species growing in temperate climates). There are, however, many differences between the two which can be summarized as follows:

	compression wood	tension wood
produced in:	softwoods	hardwoods
site:	lower side of leaning trunk or branch	upper side of leaning trunk or branch
shrinkage in drying:	considerable, up to 10%	moderate, less than 5%
mechanical properties:	impact strength lower than normal wood	density higher than normal wood; brittle; "woolly" when planed
histology:	cells rounded with intercellular spaces; elements often shorter than in normal wood; S_3 layer lacking	S_3 layer sometimes present but with a gelatinous layer within it or replacing it
chemical: properties:	higher lignin content than in normal wood	less lignin than normal wood; higher cellulose and hemicellulose content in cell-wall.

6.2.5 Genetic variation.

In addition to the phenetic factors of timber variation so far mentioned, there is always the possibility that trees of the same species belong to different genetic races or show genetic variation because of inter-breeding of such distinct races. Differences of this kind are well known in forestry and have led to the development of plantation techniques using seedlings of known genetic constitution or clones produced by vegetative propagaiion so as to select timber trees having required characteristics.

Botanists interested in correlating anatomy with probable evolutionary trends within the plant kingdom have used timber technology as evidence for correct taxonomic position within an evolutionary classi-

fication. Bailey (1954), for instance, succeeded in establishing a correlation between the size of cambial initials and the taxonomic position of the groups in which different sized initials were found. In order of decreasing cambial-initial lengths he lists:

gymnosperms e.g. Sequoia sempervirens	average length:	6600μ
vessel-less dicotyledons e.g. Trochodendron aralioides		4400μ
dicotyledons with unspecialised vascular tissue e.g. Liriodendron tulipifera		1100μ
dicotyledons with specialised vascular tissue e.g. Mangifera monandra		570μ
dicotyledons with stratified cambia e.g. Robinia pseudacacia		170μ

Carlquist (1975) has recently reviewed Bailey's work as well as that done by other anatomists and has added new evidence to suggest the influence of xeromorphy in the evolutionary development of xylem. It seems clear from studies of this kind that the taxonomic position within the Linnean system of any timber species investigated can predict some of the xylem featuore it will show and that timber variability between any two species may reflect their different taxonomic positions.

6.3 Summary on timber variability.

It is clear that timber is far from being a homogenous material of accurately predictable structure and behaviour under testing. Any attempt to correlate timber usage with its observed properties and structure (such as this present study) will have to take into account the high variability which it shows. For this reason, Rendle and Clarke (1934) recommend that measurements of anatomical features used for timber diagnosis should be accepted as valid only when the measured figures for an element in two timbers supposedly not identical differ by at least 3.5 times their standard deviation.

7 Wood structure and properties: the general problem.

7.1 Early writers on the relationship between structure and properties.

The writings of Theophrastus (370-285BC), sometimes called the "Father of botanical science", show that craftsmen of the ancient world acquired a detailed knowledge of wood properties which dictated the usages to which timbers were put. In his "Enquiry into Plants", this author devotes a chapter to the discussion "Of differences in the texture of different plants" and explains among other things that:

-box and cherry wood make excellent dagger-handles and drinking cups

(produced on a lathe) because they have the closest, heaviest wood;
-ivy and bay are "hot woods" and used for making fire-sticks;
-elm-wood is the least likely to warp, "therefore they make the hinges of doors out of elm wood";
-the wood of willow and vines is tough, "wherefore men make their shields of these woods for they close up again after a blow; but that of willow is lighter, they use this for choice...";

Roger Ascham (1515-1568) in his book "Toxophilus", describes in detail the art of the bowyer and the fletcher and refers to the various woods preferred in his day for making bows and arrows:

"These woodes as they be mooste commonly vsed, so they be mooste fit to be vsed; yet some one fytter than an other for diuers mennes shotinge, as shalbe toulde afterwarde."

Nehemiah Grew (1682) gave examples of traditional European timber usage in his "Anatomy of Plants" and claimed to be able to give an explanation of the various qualities of different woods on the basis of his newly discovered anatomical structures. He lists such qualities as: hardness and softness,
stability ("fastness"),
fissibility ("cleavesomeness"),
toughness,
brittleness,
durability,
and suggests that the "visible causes" of these reside

a) partly in the anatomical structure of the wood and the size and position of its various elements,
b) partly in the "nature" of these divers elements in the wood.

In his opinion: "according to our clear and distinct understanding of all which causes we may understand whereof any wood is made use of for any certain purpose. And alsc wherein fitly to apply it to further uses."

As examples, he mentions that sallow makes excellent charcoal for "painters' scribbets" because of the regular distribution of vessels in this wood; deal is an equally soft wood but because of the differential denaity of the parts of the growth-rings, the wood of deal is unsuitable for charcoal sticks. Lime (kinn) also has regularly distributed xylem elements and being moderately soft is useful for small sculptures. Elm is "the most crossgrain'd timber...it cleaveth the most difficultly, even when it is without any knots". Hence elm is valuable in making waggon-wheel hubs, water pipes and pumps, boat keels and coffins... Oak is durable and useful for pales stuck in the ground but

it splits easily "the cause whereof is partly the largeness of the insertions (=wood rays) and partly the diameter and radial positions of most of the aer-vessels (= vessels), upon both which accounts, wherever a crack is once begun, 'tis easily continued throughout the Diameter of the trunk."

Ash and beech are tough like elm but "not from the structure but from the nature of theparts whose Principles are united in a more exact proportion. Wherefore London-cabs have the Rings of their wheels of Beech, because it tears more difficultly than even Ash itself... Beech, Birch and the like, though strong enough, yet (are) unfit to make Standing Parts of Buildings or of Furniture, especially in moist places. Because these woods, having a less proportion of Oyl than there is in Oak, they are apter to imbibe the moisture even of a dank Aer; by which moisture, they either Rot or breed worms which destroy them ."

In this description, Grew is clearly seeking to explain timber properties in terms of

a) overall tissue distribution (diffuse-porous versus ring-porous wood),

b) the presence of certain elements in large proportions in the xylem (vessles, fibres, rays...),

c) extractives ("oyl").

7.2 Recent opinions on the structure/properties correlation.

Later writers on the relationship between anatomical structure and wood properties are less sanguine than Grew at finding explanations. Desch (1947) writes:

> A knowledge of wood anatomy does not supply all the answers to every timber problem, but as much that is of practical use may be deduced from the examination of the structure of a timber, time spent on acquiring an understanding of the subject is well spent. For the rest, we must recognise that structure gives no clue in many cases.

Jane (1956, 1970) voices a similar opinion:

> The notion that the properties of timbers should be explicable in terms of their structure is both plausible and attractive. But relationships between anatomy and properties can be demonstrated only in special instances..

Jane insists that attempts to discover explanations of timber properties must go beyond histology as studied under the (Light) microscope. As examples of timber characteristics which seem to defy anatomical

explanation he notes:

a) rock maple used for flooring blocks and the treads of escalators because it is resistant to abrasion is not unique in its anatomical structure. Other timbers are known which show closely similar form and distribution of fibres but which are not so resistant as rock maple;

b) blue willow (Salix alba varicaerulaea Sw.) is the preferred timber for making cricket bats because of its high resilience under repeated impact. "Judged on anatomy alone, sound wood of any member of the Salicaceae, provided it came from a tree of suitable growth and had the required density should be suitable for the purpose."

7.3 Recent experimental work on the relationship between structure and properties.

7.3.1 Density has long been known to be highly correlated with mechanical strength. Evelyn (1789) expresses his opinion in his forestry work "Sylva":

> For all uses, that timber is esteemed the best which is most ponderous.

Density is mainly a function of cell-wall thickness. Except for slight variations due to the presence or absence of extractives (e.g. lignin), the cell-wall substance has a density of ca. 1.5 for all woods (Skaar, 1972). The densest timber known to foresters almost reaches this value, viz. wood from Krugiodendron ferreum (Valk.)Urban, found in South Florida, there it is known locally as "black ironwood" and also in British Honduras where it is called "axemaster"(Record,1926). Its microporous wood with fine uniseriate or at most biseriate rays and rare parenchyma has a density of 1.42. All the cells of the xylem are thick-walled. Other timbers have densities below this figure varying down to the lightest wood known, that of Aeschynomene hispida (D: 0.04) where the ground tissue is thin-walled aerenchyma formed of large air-filled cells (Jane, 1970).

Strength as measured by Young's Modulus increases in general with increasing density. If we plot the values of E given in a recently published FPRL bulletin (1969), we have the linear relationship shown in the annexed diagram (Fig. 79). It should be noted that the ratio E/D is not constant. The differences can sometimes be explained by differences in tissue distribution between one species and another because the different cell-types composing xylem have cell-walls of different

thickness and hence of different strengths. This has been shown experimentally by James (1973) who isolated tracheids (called "fibres" in his study) of Douglas Fir from early-wood and late-wood and investigated their strengths by a vibrational method. 2mm lengths of individual tracheids were attached at one end to a metal stub and at the other to a steel ball which was set in vibration electrically so that its period of resonance could be measured. Typical results were the following:

Table 34. Resonance frequency of individual Douglas Fir tracheids.

	Frequency at 5°	15°	50°
early-wood:	145.8hz	144.3hz	140.3hz
late-wood:	186.1	183.4	179.8

Such a difference between wood densities was adduced by Armstrong (1949) to explain why some softwoods such as Pinis sylvestris and Pseudotsuga taxifolia make poor floor blocks, especially when flat-sawn. He found that ridging was common after abrasion of these timbers by wear (quarter-sawn) and also "shelling-out" (in flat-sawn wood) and this was due to the weaker early-wood being abraded more rapidly than the stronger late-wood. Timbers grown in equatorial areas where lack of seasonal change leads to absence of growth-rings do not show such differential abrasion during wear.

Clarke, 1933 showed experimentally that the mechanical strength of ash (ring-porous) decreases with increasing amount of summer-wood. But for timbers with a given amount of summer-wood, mechanical strength in ash increases with the density, the summer-wood tissues having thicker walls as density gets greater.

7.3.2 Permeability has been shown to depend on anatomical structure in some timbers. It is known experimentally that flow through wood in an axial direction is of the order of 10^3 times greater than that in the radial or tangential directions. In soft-woods this is explicable because the tracheids through which liquids and gases pass are elongated axially (average length 3500μ and width 35μ in Pinus strobus) so that liquids passing in an axial direction cross tracheid walls 2 or 3 times per cm of flow; in the perpendicular direction they have to make 400 or more crossings. At each crossing, whether axial or radial, the fluid must pass through the pit-membranes.

Experiments with hardwoods show the importance of vessel diameter and number per unit of cross-sectional area as well as the type of

distribution of vesssls within the growth-ring. Tesoro et al. (1974) forced liquids through wood specimens 7/8" in diameter, having first classed them in 4 categories according to their anatomical structure:

I ring-porous: Robinia pseudacacia, Ulmus europeana, Quercus spp. Celtis occidentalis;

II semi-ring-porous: Salix nigra, Populus deltoides;

III diffuse-porous: Platanus occidentalis, Liquidambar styraciflua, Acer spp.;

IV non-porous: Taxodium distichum, Pinus spp., Sequoia sempervirens.

Values of the conductance (=specific permeability) were greatest in the ring-porous hardwoods and least in the diffuse-porous species and in the softwoods, There was, however, a great variation among the species used, one of the diffuse-porous timbers (Platanus) having higher permeability than a low-value ring-porous timber (Quercus). One of the softwoods (Taxodium) had higher permeability than the lowest hardwood (Acer). In every case except Populus , sapwood was more permeable than heartwood, in some cases e.g. Pseudacacia, more than 20 times as permeable.

The difference in permeability between sapwood and heartwood may sometimes be explained as due to the presence of tyloses in the latter, these blocking the vessels and preventing liquid flow. In other cases, however, it is not known why this difference occurs. Douglas Fir grown on the Pacific coast of America is moderately permeable to preservative fluids for instance, whereas another variety of the same species growing in the mountain region and having similar anatomical structure, is hard to penetrate.

An apparently anomalous situation was discovered by Holmes (1918,1919) working with ash and hazel, this being confirmed by Rivett (1920) who also used Rhododendron and Holly. Vessel diameter is higher in ash than in hazel but specific conductance in the latter is more than twice that in the former. The authors suggest differences of vessel lengths and perforation plates between vessel elements to explain these differences in conductivity.

Anatomy has been successfully cited to explain the increase in permeability when many woods are "ponded", i.e. allowed to stay for a period of time in stagnant water prior to use. It has been shown microscopically that such wood is attacked by bacteria in the water which destroy pit membranes as well as the tori (in such conifers as Pinus) that close pits by aspiration as timber dries out. Liquids can then pass much more rapidly through the degraded pits (Dunleavey, Moroney and

Russel,1973).

From a perusal of the literature on permeability, one factor seems to have been overlooked in attempts to explain anomalous differences among timbers. Models of wood structure submitted to mathematical treatment so as to get theoretical equation s of flow which can then be tested experimentally, always postulate hardwood xylem as being made of parallel tubes for conducting purposes. Observation shows, however, that the vessels anastomose, sometimes forming a fairly dense network system (Zimmermann, Burggraaf, this study section 4.2.5). It seems clear that permeability through a network of vessels will not have such a high value as that through a system of parallel tubes with the same cross-sectional area owing to frictional and other factors introduced by the vessel anastomoses.

7.3.3 Wood shrinkage on drying. Anatomical structure has been cited to explain shrinkage phenomena. It is well-known that radial shrinkage is greater than tangential shrinkage. An anatomical explanation of this has been offered by Simpson (1973) after experimental work on the differential changes between fibres and ray parenchyma during water evaporation from drying timber. He isolated the ray parenchyma and the prosenchyma and removed water from them slowly, calculating the time taken for them to dry out. Ray parenchyma showed water diffusion to take place at a greater rate than prosenchyma. For white oak and northern red oak, factors of 1.9 and 3.0 were found. Since water diffuses more rapidly through the radially orientated ray parenchyma than through the axially orientated prosenchyma, tensions will be set up during drying-out of timber and this is suggested as a partial explanation of the differences in shrinkage in the two directions and also of the formation of surface checks in sawn lumber. It would further serve to explain the fact that flat-sawn laumber (where rays are short) dries more quickly than quarter-sawn lumber (where rays are longer because parallel with the width of the plank).

Much recent work has suggested that sub-microscopical phenomena may explain shrinkage behaviour. Present-day concepts of cell-wall structure propose the association of cellulose molecules in parallel chains to form "elementary fibrils" or "molecular strands" with a diameter of 35Å. These consist of crystalline regions (67-70%) with alternate amorphous areas. The elementary fibrils are further grouped in bundles to form microfibrils with a diameter of ca 250Å and the microfibrils are further associated in macrofibrils which make up the several

layers of the typical cell-wall.

Cell-wall layers have been extensively studied with the electron microscope and by X-ray methods. In normal wood, 3 layers have been clearly distinguished; they are deposited over the primary layer which lies immediately inside the middle lamella. These have been named the S_1, S_2 and S_3 layers according to increasing distance from the primary layer. Of these the S_2 layer is 4-10 times thicker than the S_1 and S_3, the higher figure being reached in latewood fibres of timbers having growth-rings. The orientation of microfibrils in these primary layers is characteristically different. According to Preston (1959), the primary layer has fibrils running in different directions at varying angles one to another. The S_1 and S_3 layers have fibrils orientated at a high angle with the cell axis and parallel with one another, the S_2 showing similar parallel fibrils but orientated at a lower angle with the cell axis. Wardrop (1964) found that the orientation of fibrils in the S_2 layer is in the opposite direction from that in the other layers and it is convenient to distinguish these by referring to fibrils in the S_2 as "S"-fibrils while in the S_1 and S_3 layers we have "Z"-fibrils.

A report by Dunning (1969) working with Long-leaf Pine latewood should be noted in any discussion of the S layers. He found that adjacent lamellae in the cell-wall differ by only small changes in fibril orientation and suggests that this indicates continuity in secondary wall deposition. Thus the S_1, S_2 and S_3 layers are not ontogenetically separate structures, but these are useful terms, nevertheless.

It is believed that, when timber absorbs water, the water molecules penetrate between the microfibrils to occupy the "microvoids" and become adsorbed there, producing swelling in the wood. This is the explanation of the difference in specific volume of the cell-wall found when water or another polar liquid is used (e.g. ethanol) and when non-swelling liquids such as mineral oil penetrate the wood.

When shrinkage occurs owing to the evaporation of water from between the microfibrils, these are thought to be pulled together in a direction perpendicular to the cell-axis if the fibril angle is 0°. As this angle increases from 0°, there will be a component of shrinkage becoming more and more important in the axial direction. Since in most timbers, the S_2 layer (which is thicker than the others) has fibrils where the fibrillar angle is low, this would explain why shrinkage occurs more in radial and tangential directions than in an axial one.

7.3.4 Strength properties. Cowdrey and Preston (1966) were able to correlate the elastic properties of Pinus sylvestris with microfibrillar angle. Thin strips of wood were mounted between clamps in a micro-extensometer and a load applied by means of a clock-spring. The fibrillar angle in each strip was then measured by X-ray apparatus an d by polarisation methods. Their results showed a decrease in fibrillar angle as the strips were obtained nearer the outside of the stem. At the same time the value of Young's Modulus increased, as in Table 35.

Table 35. Elasticity of Pinus sylvestris wood and microfibrillar angle (after Cowdrey and Preston, 1966.

ring from pith:	E:	θ
4	5.09	
7	6.19	21.8^{o}
10	13.71	11.8^{o}
16	27.96	8.9^{o}
19	26.07	6.5^{o}

A similar result has recently been obtained by Kyanka (1977) with Scots Pine fibres, using a S.E.M. method for determining fibrillar angle after rupture of individual fibres subjected to increasing loads. Such rupture has been shown to take place along the fibres so that fibrillar angle can be measured directly on the S.E.M. photograph.

Tissue distribution can sometimes explain strength differences between timbers. Softwoods grown in temperate climates show characteristic growth-rings where the quickly growing early wood has thin-walled cells while the more slowly growing late wood has tracheids with thicker walls. Because of this difference in amount of cell-wall substance, density is greater in the latewood and also strength properties are greater here than in the earlywood. For a given width of transverse section, quickly grown pine trees with few growth-rings where the proportion of early- to latewood is large, are therefore weaker than slow growing trees where the number of growth rings is greater per unit of sectional area and there is a greater total proportion of latewood. This has important repercussions for conifer planting (Brazier et al. 1976). When young trees are planted, distance between them has little effect on total timber production because trees planted at greater distances grow more rapidly and produce more wood per tree than those planted close together. For pulp production, it is therefore more economical to have wide spacing since this needs less seedlings per acre and the wide spacing facilitates cleaning and clearing. But for timber production this method of planting is not to be recommended because the strength value of the quick-growing tree is lower

than that of trees grown more closely together.

Diffuse-porous hardwoods show little difference between rapidly grown and slowly grown timber so far as strength properties are concerned. In the case of ring-porous hardwoods, however, the denser, stronger latewood occupies a large part of each growth-ring so that rapidly grown timber is actually stronger than slowly grown timber.

7.3.5 Plywood manufacture. Anatomical considerations may indicate useful hardwoods for inner plies. Other things being equal, adhesives bond more firmly to inner ply faces when these latter are macroporous. Pressure applied to the veneers after coating with adhesive causes the latter to enter the vessel openings and penetrate to a certain distance within the vessels. As the adhesive solidifies, a minute peg of adhesive material is formed within the vessel opening which helps to retain the veneer more firmly than if the adhesive sheet were smooth. Macroporous woods have longer anchoring "pegs" than microporous species or softwoods.

8 Wood structure and properties in the Upper Zaïre.

8.1 Earlier investigations.

Few botanical or forestry studies have attempted to correlate wood properties and structure with traditional usage of timber in Africa. One notable exception is the series of investigations carried out by R. Dechamps at the department of wood anatomy in the Central Africa Museum at Tervueren in Belgium (formerly the Belgian Congo Museum). His publications range from 1970 until the present time and contain for the most part studies on artefacts housed at Tervueren, though a recent addition to the series includes sculptured pieces from ex-Portuguese territories in Africa to be found in museums in Lisbon, Coimbra and Oporto.

Dechamps first classifies the artefacts ethnographically into categories such as: statuettes, chairs and stools, mortars and boxes, masks, skin-topped drums, slit-drums, head-rests, pipes, ornamental staves... Then he identifies the woods from which each artefact has been made, using anatomical determinations based on a large collection of known timber sections at the department and finally he seeks to make correlations between timber species used and the types of object produced.

At the beginning of his enquiries, he asks the question: Is the craftsman's choice of wood deliberate or does he accept any timber that he finds during his travels through the forest or the savannah? In his

first study which centred on the remarkably fine carvings of the Bakuba people in Central Africa, he discovered that the renowned "royal figurines" portraying Bakuba kings from 1650 up to the time of the colonial governe ment, were invariably carved from Crossopteryx febrifuga Benth. He concluded that the former alternative was the more likely and goes on to state:

> (this) presupposes a knowledge of forest trees and their properties which derives from tradition (1971).

This same species was found to be preferred for carving other artefacts such as powder-boxes (for conserving the red cosmetic powder prepared from the wood of Pterocarpus soyauxii as mentioned on page 71), pipes and cups. Dechamps concludes:

> If, as a result of the laboratory investigations carried out here, we had been asked to choose a timber suitable for sculpture, namely a wood warping only slightly, not easily split, able to be carved equally well in all directions, not too hard to cut across and sufficiently abundant in the area, we should have indicated without hesitation: Crossopteryx febrifuga. Traditional wisdom, coupled with a keen sense of observation, showed long before we could have done, which way to go.

A later study of sculptured art among the Babemba who live in the highlands to the East of Zaïre showed that some artefacts were poorly carved and showed none of the fine finish of the Bakuba specimens because timber from such species as Ficus had been used. This wood has abundant banded parenchyma so that it splits easily in a tangential direction and sculptured figures soon become chipped. The author is of the opinion that carvers of such pieces are not aware of the properties of the wood they use "nor even of the local names of the timbers used". This Babemba study showed, moreover, little specificity of timber for particular ethnographical categories. Dechamps suggests that this underlines the lack of traditional knowledge of timber properties which is found among other peoples like the Baluba and the Bakuba and points to a relatively late development of sculptured art among the Babemba.

Availability of suitable timbers is also a factor in dictating which tree a craftsman used. In areas covered by tropical rain forest, a much greater choice is possible than among groups living in savannah country. Dechamps publishes an interesting correlation between the number of pieces sculptured in any wood and the groups producing them, each in its characteristic biotope (Fig. 73).

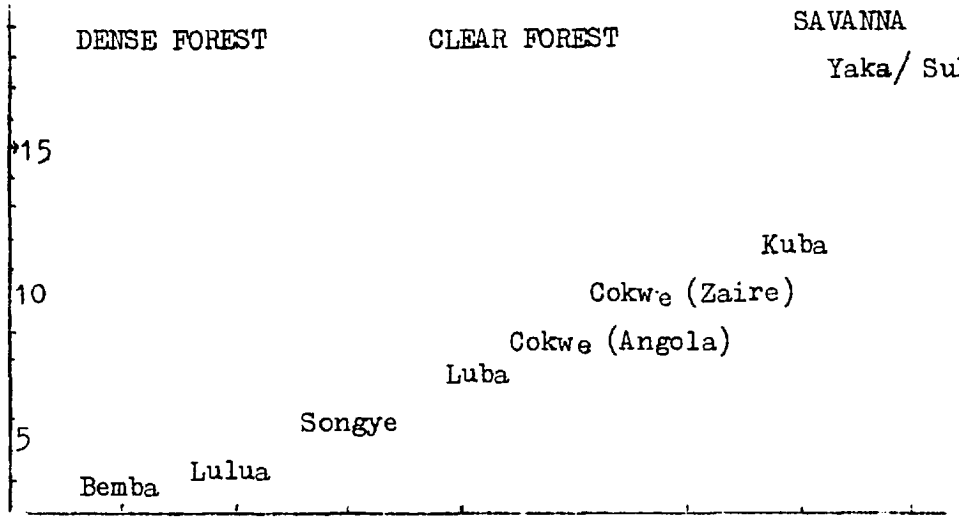


Fig.73: Correlation between Biotope and number of timber species utilised by Central African sculptors (after Dechamps, 1977)

A further factor judged responsible for specffic timber usage is symbolism. Croton spp. and Ficus spp., according to Dechamps, would be used where these seem to be unsuitable for the purpose technolpgically because of the need to use "sacred" trees, i.e. trees venerated for cultural reasons.

E.A.Weiss (1973) made a study of trees used by fishermen on the East African coast and recorded how western products such as nylon and plastic are replacing traditional materials in the manufacture of nets and floats. Some traditional usages are still to be found, however, and he remarks:

> The many indigenous plants that were in daily use by the villagers were a fascinating example of the integration of available material into a traditional way of life.

He lists timbers used professionally for boat construction and notes that ribs made from Zizyphus mauritianus, Avicenna marina or Acacia tortilis were chosen only "after finding trees growing with the right shape". The East African craftsmen knew how to bend planks by heating them over a fire after treatment of the wood with shark oil and so producing the correct amount of curvature for the sides of boats.

Data presented in the present study of Upper Zairian timber usage show that timber choice depends on a detailed traditional knowledge of wood properties, as Dechamps has already postulated. No cases have come to the knowledge of the present writer where special "sacred" trees are venerated by the population so that timber usage may be dictated by the need to use such wood before any others. It is well known that Central African peoples show a remarkable diversity in cultural patterns so that such condiderations cannot be ruled out a priori. Moreover, trees having a symbolical function in village life are found in many parts of

the Upper Zaïre. But the foreign suudent working in this field, especially if unable to converse fluently in the language used by craftsmen studied, must beware of reading into ethnological date the conclusions reached by earlier generations of overseas students whose reports have been shaped around generalisations of the Fraserian and Freudian types. Sculptures made by /libeli/ acolytes during initiation ceremonies among the Lokele (see 4. 3.4.2.g) are not intended to be functional in the sense that they are artefacts destined for use in village daily life. They are models restricted to these ceremonies which could be regarded as "sacred rites" but there is no veneration of the Musanga cecropioides tree from which they are carved.

8.2 Present investigations into correlations between usage and properties.

Each timber studied in this investigation will now be presented and an attempt made to correlate the data from anatomical observations and that gained from the experimental study of its physical properties and usages in the Upper Zaire.

8.2.1 Alstonia congensis Engl.

In the Upper Zaire, this wood was used traditionally for shield manufacture and is being still used today for carving talking-drums of the /longombe/ type (page 52, fig.14c), hollow resonators for musical instruments and village utensils such as spoons and stools. It is further the preferred wood for making masks in areas where these artefacts are found.

Alstonia is one of the lightest timbers to be found in the Equatorial Rain Forest and has the lowest density (0.32) of the 6 timbers studied in the present investigation. This low density recommends it for use in shields where as large a surface as possible must be presented to spears and arrows in order to ensure adequate protection and also where the warrior must be able to manipulate his shield with the left hand to ward off missiles from the flanks as well as ahead.

Experimental work on penetrability (5.4.2) ranks Alstonia as one of the most easily penetrated woods among those studied (only Musanga seems to be penetrated more readily by darts) and this property would be valuable in a shield because missiles caught on the wood surface would be absorbed by it rather than ricocheting dangerously to the side or to the feet.

Low density is further important in modern usage of Alstonia as a timber suitable for the manufacture of /longombe/-type talking-drums

which are the communications instrument characteristic of Central Zaïrian peoples like the Bakuba and the Bambole. These are usually carried by the drummer suspended from a fibre strap around his neck.

A further property of Alstonia which recommends it for the production of wedge-shaped talking-drums and musical resonator-boxes is the manner in which it can be readily carved in tangential as well as in radial and vertical directions. This same property is useful in carving details of masks, though in these artefacts, the lightness of the timber is important because the masks must be worn during lengthy ceremonies. The banded vertical parenchyma of Alstonia xylem explains why carving in a tangential direction is possible (plate 1c).

8.2.2 Combretodendron macrocarpum (P.Beauv.)Keay

In the Upper Zaïre, Combretodendron macrocarpum is the preferred timber for making axe-hafts.

The most important property in timber used for tool handles is its resilience on repeated impact. The wood must be cabable of withstanding the sudden stresses of impact and also of undergoing temporary deformations during a short period from which it must recover completely. The well-known resilience of ash and hickory, which are the preferred timbers for tool-handles in the West, has been correlated with their ring-porous structure where layers of earlywood with wide vessels (200-300μ) alternate with layers of latewood containing thick-walled fibres. The air-content of the former, it has been suggested, will allow temporary deformation during impact but the elasticity of the latter prevents breakage during deformation and permits a full return to the initial position of the xylem cells at the cessation of stress. For a similar reason, one can explain the superior performance of Pinus sylvestris (D:0.43-0.46) for railway sleepers over the denser and stronger Eucalyptus timber (D:0.9). In the case of Pinus, the air-filled cells that become deformed on impact are earlywood tracheids rather than vessels, the elastic tissue being the thick-walled latewood tracheids.

Combretodendron has a high density (0.73), the second densest of the 6 timbers studied, and has vessels half as wide as ash. It does not possess a ring-porous structure but some growth-rings occur and the wood fibres form concentric rings of wavy lines similar to, though narrower than those of temperate ash and hickory. This timber is also the second strongest of those studied (fide standard testing equipment results, section 5.2.5).

A further point should be noted in assessing the performance of this

timber for axe-hafts. As mentioned in section 4.3.2.2, the metal axe-head of Upper Zaïrian axes is hafted in a manner similar to that of paleo- and neolithic stone tools: the tang is driven through a hole in the tip of of the haft where the wood is wider to accommodate it. This hole is usually made by heating the tang to redness in a fire and burning a hole in the required direction (Fig.22). When the axe is used, the tang will be driven further into the hole and the axe-haft must withstand a tendency to split on impact. The possibility of splitting is, however, lessened by the choice of the piece of timber from a branch of the tree (or the main stem of a small tree) where forking occurs. In this region, the xylem elements are diverging and this is made into the swollen end of the haft where the tang penetrates. This region of the timber will offer greater resistance to cleavage than a piece of straight-grained wood.

Widstrand (1958) points out in his monograph on African axes that the craftsman is concerned to find a haft where forking occurs:

> The piece of the tree or branch chosen should include the fork or knot i.e. the grain of the wood in the shaft-head must not run parallel with the shaft but should preferably be irregular. This concerns especially the slot-hafted axes where the impact of the axe would tend to split the wood were the grain to run parallel with the shaft.

A further macroscopic feature of Zaïrian axe-hafts which makes for increased resilience is that the haft is shaped from a single branch so that the timber consists of concentric rings of fibrous tissues even where growth-rings are not prominent. This would hardly ever be the case if sawn timber were made up into hafts.

8.2.3 Gossweilerodendron balsamiferum (Vermoesen) Harms is the preferred timber for canoe-making among the Olombo and Lokele of the Upper Zaïre. Other woods are sometimes used, notably species of Vitex for durable canoes and Musanga cecropioides ("male" form among the Olombo) for quickly made canoes that will be serviceable for a few years only. Features of the wood which make Gossweilerodendron timber suitable for canoe-making include the following:

a) the relatively abundant aliform-confluent vertical parenchyma provides lines of weakness which permit of easier hollowing-out of the tree-trunk with adzes and chisels;
b) the presence of resin, carried in the numerous vertical resin-canals of the xylem may be a factor in making the wood resistant to constant immersion in water; experimental work on weathering (secton 5.5)

shows it to be one of the most resistant to checking of the 6 timbers studied;

c) it is noteworthy that this timber has the highest vessel-network density of all the timber studied (182%). If this be an indication of cross-grain, it is reasonable to suppose that the timber of this species will be more resistant than the others studied to sudden spliting on impact when the canoe hits an underwater snag such as a submerged tree-trunk, root or stump or a large stone at the water's edge when the canoe is brought to the bank;

d) the comparatively low density means that the canoe made from this species floats with a considerable free-board above the water surface. Not all Zaïrian canoes float when overturned; some are carved from species of Dalbergia where density is greater than 1. But Lokele fishermen prefer to use a timber which permits them to reboard a capsized canoe in the middle of the river. They swim to the overturned craft, turn it keel downwards in the water and then force the water out by alternately pushing upwards and pulling downwards the end of the canoe so that waves are set up which splash the water over the upturned end until sufficient buoyancy is obtained for the canoeist to climb in and bale out the remaining water with his cupped hands or with a specially carved wooden scoop which will be floating on the surface of the river nearby and can be retrieved.

8.2.4 Musanga cecropioides R.Br. has many uses in Upper Zaïre culture. The main reason for this is probably its relative abundance since it is often the dominant species in secondary forest forming after plantations (manioc, plantain bananas) have been allowed to revert to fallow land. Lebrun et Gilbert (1954) classify the secondary forests in this area, following the Braun-Blanquet ecological school as forming an order Musangetalia with one alliance which they name Musangion cecropioidis.

The comparatively low density of Musanga (ca 0.5 for the "male" wood and lower for the "female" wood) makes it convenient for handling in constructional work and in manufacturing instruments which are held in the hands and household utensils which must be carried about.

The differing anatomical structure of "male" and "female" wood of this species has already been described (section 4.3.4.5) and can be suggested as an explanation for the different traditional usages to which the timber is put. The thin-walled vertical parenchyma occurring in greater quantities in "female" wood will make for lower density of this and hence be the basis for its use as net- and line-floats, for

temporary drum-sticks (when the rubber-covered sticks normally used are not available) and children's toys. The stronger "male" wood with less parenchyma is denser and serves for making temporary canoes, for house construction and for net-drying-racks.as well as for the frames of musical instruments.

Wood anatomy can also be suggested to explain the resonance of this timber which accounts for its frequent use in xylophones where these are found (North and South Zaïre). The fibres of Musanga, while not storied like those of Pterocarpus (q.v.) are relatively thin-walled in the wider, central portion and resemble those of Pterocarpus which is the most resonant of the species studied.

8.2.5 Pterocarpus soyauxii Taub. This is the preferred timber for talking-drum manufacture and wood anatomy can suggest an explanation for this traditional preference on the part of craftsmen over a wide are in the Continent. Two reasons can be adduced:

a) ease of working. Pterocarpus xylem contains banded vertical parenchyma which is present in quantity up to 12 times that of the uniseriate, low, storied rays. This means that the timber presents lines of weakness in a tangential direction so that, when the drum-carver cuts away at the inner region of the log (through the side slit or more rarely through a hole at the end of the log), the wood tends to split along a curve parallel to the outside of the log and not perpendicular to this. Such a tendency to follow a curved split is all the more valuable to the carver as he approaches the outer surface of the "male" cheek which must be more deeply hollowed and is often thinner than the "female" cheek. (See section 4.3.5.2 for this terminology). Craftsmen in the Bamanga region to the North of Kisangani are aware of this property of Pterocarpus when they manufacture the so-called "canoe-chairs" from the red-coloured timber (Plate 2c and d). The name applied to these articles of furniture may be derived from their use as canoe seats but it is also explained is due to the use in earlier times of naturally curved canoe boards to manufacture the chairs. Bamanga craftsmen produce the curved boards from trunks of Pterocarpus wood by driving wedges into the end of a log along the circum-medullary lines and then tapping these consecutively until the carved board springs away.

The low vessel-network density of Pterocarpus (30%) is a further indication of the straight grain of this timber which makes for easier carving of the interior during drum-manufacture. It is

well-known that the tendency of this wood to split in a vertical direction -greater in straight-grained than in cross-grained woods - does sometimes lead to the splitting of the broadcasting instrument whose resonance disappears if a crack spreads right through it.

b) Resonance. The high resonance of Pterocarpus wood is one reason why it is the preferred timber for talking-drums and xylophone manufacture. Research on the acoustic properties of timbers has been mainly directed towards finding the best woods for use in violin and piano manufacture. E.Fukada (1950 a,b) and D.Holz (1954) investigated the physical properties of timber adjudged by piano manufacturers to be the best for their instruments, while R.Meinel (1954) did the same for violin manufacturers, examining 17 "Strad" violins during his investigation. The results of these workers show that the most suitable timber has a high Young's Modulus (correlated, as is well-known from other data with a high density) and a low damping effect. This latter is dependent on the regularity of the xylem structure, knots and other irregularities of grain reducing the resonant qualities of the wood. Hardwoods were found to have a 10% higher damping effect on sound than softwoods at low frequencies, though the reverse was found to be the case at high frequencies which must be eliminated as far as possible to give a good acoustical timbre.

Because of its storied structure and the comparatively wide central portion of its fibres where the lumen is large, Pterocarpus xylem shows the kind of regularity found in tracheid-bearing softwoods (cf. Plate 3a). Vessels are comparatively few in this timber (4% of the transverse section, the lowest vessel fraction of any of the 6 timbers studied) and show a low vessel-network density quotient, thus showing less irregularity in overall structure than other woods. The low, uniseriate, storied rays contribute to the regularity of this timber structure.

8.2.6 Staudtia gabonensis Warb. Though other timbers are used to make paddles throughout Central and West Africa (Irvine lists 9 for Ghana, where Staudtia gabonensis is not recorded), this species is the preferred timber for paddles in every part of its range and its local name of "paddle-wood" indicates this in the West of the Continent.

When the characteristic behaviour of the wood fibres of this species was first seen in XS (page 77), namely the penetration of ray tissues

by elongating fibre tips (and occasionally by elongating vessel element tails), the hypothesis was formulated that such "anchoring" of fibres in the rays might account for the timber's rigidity and strength and perhaps explain in this way the value of Staudtia for its particular application. Further in vestigations, however, showed that two considerations oppose such an explanation:

a. the comparative rarity of fibre-penetration into rays; less than 1% of rays in any one XS field under the microscope show such penetration;

b. weathering experiments show that Staudtia wood splits along the rays more readily than any of the other timbers investigated (section 5.5).

We therefore make the following suggestions as to structural reasons for African preference for Staudtia in paddle manufacture:

a. anatomical structure. Staudtia has little or no vertical parenchyma but its very numerous rays (58% of the XS) are embedded in closely apposed laminae of fibres. Little irregularity is introduced into the fibre laminae because of vessel anastomosis (the vessel-net density quotient is the lowest of all the timbers studied). Hence, although splitting occurs during weathering because of alternate wetting and drying of the wood during usage, this is always radial rather than tangential or transverse.

b. Macroscopic structure. The manner of paddle manufacture helps to conserve strength because only 1 (rarely 2) paddle is carved from one length of young Staudtia tree so that the stem is formed from the centre of the xylem with rays radiating from the interior to the outside rather than directly across the wood and the blade will be carved with rays parallel to its two surfaces where the load is applied during paddling.

c, Physical properties. This timber has the highest value of E for any of the timbers studied (as determined by the Mateus bending test, the vibrational test and as confirmed by standard tests). It also has the highest density value of all. This strength property is of importance in withstanding bending during animated canoe paddling The laminate structure of Staudtia wood fibres, as divided up in the xylem by very numerous wood rays, may also be correlated with its high strength in bending.

8.3 The following table summarises our attempts to suggest reasons for the choice of specific timbers for wood usage in the Upper Zaire:

TIMBER and common usages:	abundance:	macroscopic features:	microscopic features: vessel network:	vertical parenchyma:	rays:	fibres:	physical properties density:	E-value:	weather-ing:	chemical factors:	penetrabi-lity:
ALSTONIA shields, hollowed resonators carved usensils, spoons, stools... masks	abundant			narrowly banded	numerous, narrow		low				high
COMBRETODENDRON axe-hafts		forking stems used to insert axe tang	fairly dense, vessels moderately wide	banded			high	high			
GOSSWEILERODENDRON durable canoes,			very dense	paratracheal, aliform, confluent			medium		none	high resin content	
MUSANGA "male" temporary canoes, house building, musical instrument framework, "female": floats	very abundant			paratracheal, aliform-confluent and banded	infrequent, uniseriate, fairly low	wide lumen in centre	fairly low				
				more abundant			lower				
PTEROCARPUS talking drums, xylophone slats		growth rings usually visible	low	banded	low, uniseriate, storied	wide lumen in centre	high	high			
STAUDTIA canoe paddles		one paddle per stem section	very low	rare or absent	very numerous	form anastomosing laminae	high	high	marked but producing laminae		

Table 36: Wood anatomy, physical properties and traditional usage of selected Upper Zafrian timbers.

9. Traditional timber lore and modern world needs.

It has been estimated recently that there are 2800 x 10^6 ha of natural forest in the world divided among

the tropical zone	1456 x 10^6 ha
the subtropical zone	244
the temperate zone	488
the boreal zone	672. (Brazier et al., 1976).

Plantation forest is growing in area because this allows of easier handling of felled trees, permits the forester to produce increased yields from genetically controlled seedlings and uses the land more economically since only required trees are grown. At 11.8 x 10^6 ha however, it is small in area compared with the natural forest.

The total forest coverage is believed to contain some 400 x 10^9 m^3 of timber. Such a figure for a source that is theoretically renewable (while sunshine and chlorophyll exist) would seem to provide enough wood in the foreseeable future. But there are several reasons against adopting a complacent attitude towards this apparent plenty. Many of the forests included in the above estimate are difficult of access so that their timber is uneconomical to export. This is true of much of Zaïre's important forest resources owing to the necessity for all logs and sawn timber to be transported from the interior by rail between Kinshasa and and the sea (except for the forest area in the hinterland of Boma , at the mouth of the river). There is, moreover, a rapid annual increase in world requirements for timber for constructional purposes, for paper manufacture and for fuel. This latter is still the greatest factor in wood consumption throughout the world, especially in the so-called "under-developed" countries. And as Western "civilization" reaches these also, there is a marked increase in energy requirements per capita of population. Wood, especially in the form of charcoal, is the most easily available source of energy and so the forest resources are attacked and destroyed. A recent estimate for Brazil has put the figure of forest destruction per annum as high as 3 x 10^6 ha. A similar point is made poetically in the lines:

So Leo gazed, absorbed, a timeless glance,
And thought of all the trees that nature held
(Strange instance of trance within a trance):
Cedars of Lebanon, green beechwoods delled
With sapphire; sombre newsprint forest felled
At such a rate each Sunday men were able
To read ten acres at the breakfast table.

"Return of Arthur" by Martin Skinner.
(Quoted in Farrar, 1970).

African cities, such as Kinshasa and Kisangani have grown at such a rate within the past two decades that there has been rapid destruction of the forest biotope around them for food production based in swidden agriculture and the felling of all but a few of the regenerated woody species for charcoal production.

Even where tropical forests seem to present the typical aspect of climax forest, in parts of the continent close to ports or within easy access to them, the so-called "primary" species of timber-producing trees have already been removed to such an extent that it is becoming more and more difficult to obtain them. It is therefore important to assess the value of the "secondary" species which are still available in quantity and which might be able to provide useful timber. One way of doing this would be a careful survey of timbers deliberately chosen by African craftsmen who inherit a centuries-old tradition of wood usage. The present study suggests that this choice of wood is based on an intimate, rational knowledge of timber properties.

In pressing traditional African lore into helping with the assessment of timber values for modern needs in Africa itself or overseas, the following points will, however, have to be born in mind:

a. African wood-usage may be for ritual purposes rather than for the production of articles of lasting durability. Timber so used will probably disappoint wood technologists not conversant with local African culture. (Note the use of Musanga timber during the /libeli/ ceremonies of Lokele and Olombo peoples).

b. African craftsmen, like those of the West before the advent of machine tools, choose timbers for use in artefact production because of their macroscopic features as well as on account of known physical qualities dependent on microscopic structure and chemical composition. Woods used by Upper Zairian craftsmen for axe-hafts and canoe-paddles are examples of this. Modern timber requirements in the West, however, are for wood as a material which is homogeneous and of predictable

quality whatever its origin. Tests done by timber technologists using standardised testing equipment on a large number of specimens having identical dimensions (so as to ob tain a statistically reliable result) will rarely, if ever, take account of such macroscopic features and will fail to show how choice based on macroscopic features can produce useful material.

c. Western technology, using tools powered by energy resources not available to craftsmen in Central Africa, is able to manufacture materials from wood whose physical properties depend as much or more on the processing involved as on the qualities inherent in the raw materials used: impregnated timber, peel veneers, plywood, laminates, chip-board, fibre-board... The suitability of timber for a particular purpose in African village life may therefore only be of interest in indicating its general availability in that area and perhaps some overall physical properties (lightness, ease of carving, fissibility) which may be valuable for new timbers in Western-style technology. J.D.Brazier expresses a present-day technological attitude when he writes that timber variability is a "nuisance" to the modern user:

> The user derives little benefit from the great variability which occurs in timber from the tropical resources; indeed, variability can only add to the problems of its production.(1976).

The same author goes on to suggest that timber processors would be "more than satisfied" with wood of uniform character which is:

- light in weight so that it could be densified artificially as required,
- pale in colour so as to take any required dye,
- permeable so as to be capable of impregnation with preservative salts or coloured dyes.

Because of such considerations, interest in African traditional timber usage which recognises variation among timber species and exploits this in its application to local technological problems, will perhaps only be of limited value to the West.

The relative cost of processed wood is high, however, compared with that of the natural raw product. While this remains true (and the increasing costs of labour and energy in the West mean that processed-wood prices will rise rather than fall) there may still be a demand for secondary species from the tropics. This is perhaps especially the case among emergent African nations, for the machinery required to process wood is costly and few installations other than for plywood manufacture

are yet to be found in the continent outside South Africa. These nations are currently engaged in vast building projects and need to utilise their own timber resources to the full. Anomalous economic operations such as transporting softwood pit-props from North America to Central Africa for use in copper-mining underline the need for an adequately researched inventory of useful secondary species in developing countries of Africa.

It is unfortunate that few ethnologists and anthropologists working in Africa have given detailed accounts of rural technology in their published writings. C.M.Meighan deplores this:

> To students of technological history, it is amazing that travellers, missionaries, ethnologists, colonial agents and other who have lived in close contact with primitive peoples have almost universally failed to record fundamental information...(1959).

Reasons for this are not difficult to find. The eclectic nature of some anthropological investigation, especially of recent years, where the research worker is less concerned with recording "fundamental information" about a human group than in testing the current academic hypotheses of his colleagues in a Western University department, means that only a restricted area of a group's culture is described. Subjects such as kinship networks (with mathematical treatment), transition rites, classificatory principles, symbolism, ideas of the sacred...have, very properly, occupied the energies and the time of the field worker; but all too often little or nothing is noted about the material culture of the area studied.

A further reason for this neglect lies in the training of the overseas visitor who records his studies. Explorers, colonial agents, anthropologists and many missionaries have only reached Africa after years of preparation for their chosen life-work involving, in our present Western educational system, lengthy academic studies which have separated them at an early age from the material world of modern technology. As they come to African rural surroundings with little understanding of the material culture of their own civilisation, it is hardly surprising that they show little appreciation of the intricacies and ingenuities of African material culture. (Compare Friedberg's comment on ethnobotanical investigators in overseas countries, page 17).

There is, therefore, still a need for more detailed investigations into timber usage in traditional African rural life as well as in other areas of the world where the resources of the tropical forest have been tapped by human groups for centuries. These could still be

effectively made by ex-patriate workers, qualified in the parallel technologies of their own country as well as in general anthropological methods of research. Much valuable work remains to be done on the lines of R.Dechamp's anatomical researches into timber used for museum artefacts and these should be followed up on the field. It must be remembered, however, that an adequate knowledge of the general culture of the human population studied is necessary for such investigations and the researcher must be able to converse fluently with the people in their own language in order to interpret accurately the information he or she acquires.

It seems clear that the best results in describing the technology of a human group (as indeed, in describing any facet of their culture) will be achieved by members of that group who have been able to assimilate Western scientific methods as well as to retain a knowledge of ancestral tradition. Until recently this was almost impossible in most parts of Africa because the few nationals who had the opportunity to reach positions where they could write authoritatively in internationally recognised journals had had to divorce themselves from their own milieu in order to benefit from the educational system of Western colonial powers. Today, however, in most independent African states, there is a growing interest in, and respect for, ancestral "ways and wisdom" (the Zairian government's insistence on "authenticity" is an example of this). More and more students are entering national educational systems who are still closely associated with their own family life in the rural areas. It is to be hoped that the lead already given by competent African scholars in such fields as traditional African education, Art, Religion, Political Structures, History... will be followed by national investigations into traditional technologies.

Olombo labels given in the FLORE DU CONGO BELGE ET DU RUANDA-URUNDI

Vernacular label:	Botanical determination:	Family:
f- aka	Copaifera mildbraedii Harms	Caesalpin.
w- aka	1. Baikiea insignis Benth.	Caesalpin.
	2. Tessmannia africana Harms	Caesalpin.
	3. T. anomala (Micheli) Harms	Caesalpin.
	4. T. yangambiensis Louis ex Léonard	Caesalpin.
w- aka bo fufow	1. Cynometra pedicellata De Wild.	Caesalpin.
	2. Guibourtia demeusei (Harms) J. Léonard	Caesalpin.
w- aka boilo	Baikiea insignis Benth. subsp. minor (Oliv.) J.Léonard	Caesalpin.
w- aka bokeke	Tessmannia africana Harms	Caesalpin.
w- aka bo lowe	1. Baikiea insignis Benth. subsp. minor (Oliv.) J.Léonard	Caesalpin.
	2. Cynometra pedicellata De Wild.	Caesalpin.
w- aka bo ofili	Tessmannia anomala (Micheli) Harms	Caesalpin.
li- ala li boliki	Rhaphiostylis beninensis (Hochf.) Planch. ex Benth.	Icacin.
inaolo a li- ala li boliki	Securidea welwitschii Oliv.	Polygal.
lo- baka	Gilbertiodendron mildbraedii (Harms) Vermoesen	Caesalpin.
i- bambe	Lecaniodiscus cupanioides Planch.	Sapind.
o- be	Irvingia grandiflora (Engl.) Engl.	Irvingi.
o- be bo boliki	Dalbergia louisii Cronquist	Fab.
i- belande	1; Irvingia grandiflora (Engl.) Engl.	Irvingi.
	2. I. robur Mildbr.	Irvingi.
o- bele	Canarium schweinfurthii Engl.	Burser.
i- bele saw	Dacryodes yangambiensis Louis ex Troupin	Burser.
li- biabia	1. Cissus adenopoda Sprague	Vit.
	2. C. aralioides (Welw. ex Baker) Planch.	Vit.
	3. C. barteri (D.C.) Planch.	Vit.
	4. C. dasyantha Gilg. et Brandt	Vit.
	5. C. diffusiflora (Bak.) Planch.	Vit.
	6. C. dinklagei Gilg. et Brandt	Vit.

	7.	C. goossweileri Exell & Mendonça	Vit.
	8.	C. ibuensis Hook.f.	Vit.
	9.	C. louisii Descoings.	Vit.
	10.	C. myrianthaa Gilg. et Brandt	Vit.
	11.	C. petiolata Hook.f.	Vit.
	12.	C. planchoniana Gilg.	Vit.
	13.	C. producta Afzel.	Vit.
	14.	C. smithiana (Bak.) Planch.	Vit.
li- biabia li fufow		Cissus gilletii De Wild. et Th. Dur.	Vit.
li- biabia li nenu		Ampelocissus bombycina (Bak.) Planch.	Vit.
li- biabia li ndole		Cissus polyantha Gilg. et Brandt	Vit.
li- biabia li tokembe	1.	Cissus adenopoda Sprague	Vit.
	2.	C. pynaertii De Wild.	Vit.
inaolo a li- bila		Erioscema psoraleoides G.Don.	Fab.
to- linda		Desmodium ramosissimum G.Don.	Fab.
o- bolukola		Dichapetalum mombuttensis Engl.	Dichapetal.
bumbanama		Thonneria congolana De Wild.	Annon.
to- bundaka sula	1.	Boerhaavia diffusa L	Nyctagin.
	2.	Desmodium adscendens (Sw.) var. robusta Schubert	Fab.
li- bundukulu	1.	Macrolobium acuminatum De Wild.	Caesalpin.
	2.	M. fragrans Bak.	Caesalpin.
	3.	M. macrophyllum (P.Beauv.) Macbride	Caesalpin.
	4.	M. pynaertii De Wild.	Caesalpin.
li- bundukulu li ifololo		Pseudomacrolobium mengei (De Wild.) Haumann	Caesalpin.
li- bundukulu li kikeleke		Macrolobium gilletii De Wild.	Caesalpin.
li- bundukulu li lowe		Berlinia grandiflora (Vahl) Hutch.& Dalz.	Caesalpin.
inaolo a li- bundukulu		Pseudomacrolobium mengei (De Wild.) Haumann	Caesalpin.
inaolo a li- bundukulu li lowe		Kaoue germainii Vilczek	Caesalpin.
li- bwabwa		Piper umbellatum L	Piper.
bo- cangala		Cissus aralioides (Welw.ex Bak.) Planch.	Vit.
inaolo a bo- cangala		Ampelocissus cavicaulus (Bak.) Sprague	Vit.
bo- cefola	1.	Crotalaria axillaris Dryand.	Fab.
	2.	C. retusa L	Fab.

w- ehu		Cynometra hankei Harms	Caesalpin.
bo- ela bosa		Piptostigma mortehani De Wild.	Annon.
inaolo a bo- ela bosa		Piptostigma mortehani De Wild.	Annon.
y- ela		Apanocalyx cynometroides Oliv.	Caesalpin.
l- ele		Pterocarpus soyauxii Taub.	Fab.
w- ele		Lovoa trichiloides Harms	Meli.
w- engenge	1.	Bridelia atroviridis Müll. Arg.	Euphorbi.
	2.	Dalbergia hostilis Benth.	Fab.
inaolo a w- engenge		Bridelia atroviridis Müll.Arg.	Euphorbi.
w- ese		Cissus dinklagei Gilg.& Brandt	Vit.
y- eto		Duboscia viridiflora (K.Schum.) Mildbr.	Tili.
inaolo a y- eto		Neoboutonia kabungaensis (K.Schum.) Capuron	Sterculi.
faka		Copaifera mildbraedii Harms	Caesalpin.
bo- falo		Angylocalyx pynaertii De Wild.	Fab.
o- fambu		Maesopsis eminii Engl.	Rhamn.
feta		Aeschynomene nilotica Taub.	Fab.
i- fembembo		Klaineanthus gaboniae Pierre ex Prain	Euphorbi.
lo- fembembo lo fufow	1.	Dewevrea bilabiata Mich.	Fab.
	2.	Leptoderris glabrata var. glaberrima Harms	Fab.
lo- fembembo lo ilo	1.	Milletia gossweileri Bak.	Fab.
	2.	Leptoderris ferruginea De Wild.	Fab.
lo- fembembo lo nenu		Ostryoderris gabonica (Baill.) Dunn.	Fab.
o- fili		Scytodophloeus zenkeri Harms	Caesalpin.
lo- fiongi		Hua gaboni Pierre	Hu.
li- fofa		Ficus capensis Thun.	Mor.
bo- fofonge	1.	Trichilia heudelotii Planch. ex Oliv.	Meli.
	2.	T. gilgeana Harms	Meli.
	3.	T. gilletii De Wild.	Meli.
	4.	T. welwitschii C.D.C.	Meli.
bo- fofonge bo libande		Trichilia retusa Oliv.	Meli.
a- foli	1.	Monanthotaxis poggei Engl.	Annon.
	2.	Paullinia pinnata L	Sapind.

i- fololo	1. Baphia marcel_iana De Wild.	Fab.
	2. B. pubescens Hook. f.	Fab.
	3. Carpolobia delvauxii Petit	Polygal.
	4. Craiba grandiflora (Micheli) Harms	Fab.
	5. Crudia laurentii De Wild.	Caesalpin.
	6. Millettia drastica Welw.	Fab.
	7. M. macrocrotra Harms	Fab.
	8. Platysepalum chevalieri Harms	Fab.
	9. P. violaceum Welw. ex Bak.	Fab.
i- fololo i boliki	Dalbergia heudelotii Stapf.	Fab.
i- fololo i fufow	1. Millettia cetveldeana (Micheli) Haumann	Fab.
	2. M. limbutuensis De Wild.	Fab.
i- fololo i isaala	Millettia hyalobia Louis ex Haumann	Fab.
i- fololo i libande	Millettia hyalobia Louis ex Haumann	Fab.
i- fololo i lowe	1. Baphia laurifolia Baill.	Fab.
	2. Lonchocarpus griffonianus (Baill.) Dunn	Fab.
inaolo a i- fololo	1. Baphiopsis parviflora Benth. ex Bak.	Fab.
	2. Craiba laurentii (De Wild.	De Wild. Fab.
inaolo a i- fololo i libande	Cassia mannii Oliv.	Caesalipin.
fombi c boliki	1. Campylostemon laurentii De Wild.	Hippocrat.
	2. Cuervea macrophylla (Vahl) R.Wilczek ex Hallé	Hippocrat.
	3. Hippocratea myracantha	Hippocrat.
	4. Loeseneriella apiculata (Welw. ex Oliv.) R.Wilczek	Hippocrat.
	5. L. clematoides (Loes.) R.Wilczek ex Hallé	Hippocrat.
	6. L. yaundina (Loes.) R.Wilczek	Hippocrat.
	7. Reissantia indica (Willd.) Hallé	Hippocrat.
	8. Simirestis andogensis (Welw.& Oliv.) Hallé ex R.Wilczek	Hippocrat.
	9. S. isangiensis (De Wild.) R. Wilczek	Hippocrat.
	10. S. pr[illegible]ii (Loes.) Hallé	Hippocrat.
	11. Tristemonanthus mildbraedi	Loes. Hippocrat.
inaolo a fombi c boliki	Simirestis welwitschii (Oliv.)	

lo- fondonda	1. Grewia pinnatifida Meisen.	Tili.
	2. Scaphopetalum dewevrei De Wild. & Th.Dur.	Sterculi.
	3. S. thomsoni De Wild.& Th.Dur.	Sterculi.
li- fonji	Guarea laurentii De Wild.	Meli.
li- fonji li kikeleke	G. glomerulata. Harms	Meli.
li- fonji lifilifi	G. thompsonii Sprague et Hutch.	Meli.
lo- fongi lolembe lo boliki	Flabellaria particulata Cav.	Malpighi.
e- fufuko	1. Beilschmiedia alata Robyns & Wilczek	Laur.
	2. B. auriculata Robyns & Wilczek	Laur.
	3. B. insularum Robyns & Wilczek	Laur.
	4. B. lemansii Robyns & Wilczek	Laur.
	5. B. louisii Robyns & Wilczek	Laur.
	6. B. manii (Meisen,) Benth. et Hook.f.	Laur.
	7. B. mannioides Robyns et Wilczek	Laur.
	8. B. variabilis Robyns et Wilczek	Laur.
	9. B. yangambiensis Robyns et Wilczek	Laur.
e- fufuko lo ilo	B. mannioides Robyns et Wilczek	Laur.
e- fufuko lo lowo	B. auriculata Robyns et Wilczek	Laur.
li- fula	Entangophragma utile (Dawe et Sprague) Sprague	Meli.
e- fulungu	Fagara tubescens (Planch.) Engl.	Rut.
li- fuma la booka	Lasiodiscus mannii Hook.f.	Rhamn.
inaolo a li- fuma la booka	Lasiodiscus fasciculiflor Engl.	Rhamn.
wa- holo (= w-aolo)	Ficus exasperata Vahl.	Mor.
wa- holo bo boliki	1. Ficus asperifolia Miq.	Mor.
	2. F. ulcolaris Welw. ex Hiern.	Mor.
inaolo a wa- holo	Croton sylvaticus Hochst ex Kraus	Euphorbi.
inaolo a li- huma	Ekebergia mildbraedii Engl.	Meli.
e- hungu (cf. e-ungu)	1. Ochthocosmus africanus Hook.	Lin.
	2. Parinari glabra Oliv.	Ros.
e- hungu lo nonu	Ochthocosmus africanus Hook.	Lin.
inaolo a bo- ili la ngema	1. Acridocarpus smeathmannii (D.C.) Guill. et Perr.	Malpighi.
	2. Triaspis emarginata De Wild.	Malpighi.
bo- ito a likeke	Macrolobium coeruleum (Taub.) Harms	Caesalpin.

bɔ- itɔ a likeke lilɔwe	Julbernardia seretii (De Wild.) Troupin		Caesalpin.
inaɔlɔ a bɔ- itɔ a likeke lilɔwe	Gilbertiodendron ogoumbe (Pellegr.) J.Léonard		Caesalpin.
inaɔlɔ a bɔ- itɔ a likeke	Lebruniodendron leptanthum (Harms) J.Léonard		Caesalpin.
li- jaka	Phytolacca dodecandra l'Hérit.		Nyctagin.
li- jɔu	Phytolacca dodecandra l'Hérit.		Nyctagin.
i- kaina (=tɔ- kaina)	1. Nesogordonia kabungaensis (K.Schum.) Capuron		Sterculi.
	2. Pterygota bequaertii De Wild.		Sterculi.
i- kaina i libande	Nesogordonia dewevrei (De Wild. et T.Dur.) Capuron		Sterculi.
li- kalanga	Amphimas pterocarpoides Harms		Caesalpin.
a- kale	Panda oleosa Pierre		Pand.
li- kamba	1. Glyphaea brevis (Spring) Monachino		Tili.
	2. Desplatsia dewevrei (De Wild. et Th. Dur.) Burret		Tili.
	3. Cleistopholis glauca Pierre ex Engl.& Diels		Annon.
	4. C. patens (Benth.) Engl. & Diels		Annon.
li- kamba li bɔliki	1. Ancistrocarpus bequaertii De Wild.		Tili.
	2. Grewia malacocarpoides De Wild.		Tili.
	3. Grewia seretii De Wild.		Tili.
	4. Turraea vogelii Hook. f. ex Benth.		Meli.
li- kamba li fufɔw	Grewia ugandensis Sprague		Tili.
inaɔlɔ a ɔ- kamba	1. Desplatsia chrysochlamys (Mildbr. et Burret) Mildbr. et Burret		Tili.
	2. Isolona congolana (De Wild. et Th. Dur.) Engl. & Diels		Annon.
i- kamba i fufɔw	Majidea fosteri (Sprague) Radlk.		Sapind.
bɔ- kanga	Xylia ghesquieri Robyns		Mim.
li- kanga	Glyphaea brevis (Spring.) Monachino		Til.
e- kage	1. Apodostigma pallens (Planch. et Oliv.) R. Wilczek		Hippocrat.

	2. Elachyptera holtzii (Loes. ex Harms) R.Wilczek ex Hallé		Hippocrat.
	3. Hippocratea myrianthа Oliv.		Hippocrat.
	4. Simirestis andogensis (Welw. ex Oliv.) Hallé ex R.Wilczek		Hippocrat.
	5. Loeseneriella clematoides (Loes.) R.Wilczek ex Hallé		Hippocrat.
	6. Simirestis proussii (Loes.) Hallé		Hippocrat.
e- kase lo fufow	Simirestis fimbriata (Exell) Hallé ex R.Wilczek		Hippocrat.
e- kase lo nenu	Acridocarpus smeathmanii (D.C.) Guill. et Perr.		Malpighi.
e- kase lo kikeleke	Reissantia indica (Willd.) Hallé		Hippocrat.
kasendo	Sorindeia africana (Engl.) Van der Kerken		Anacardi.
kasendo e boliki	1. Trichoscypha altiscandens Van der Kerken		Anacardi.
	2. T. scandens Van der Kerken		Anacardi.
	3. T. volubilis Van der Kerken		Anacardi.
kasendo e libande	Sorindeia sparanoi De Wild.		Anacardi.
kasendo ndilo	S. gilletii De Wild.		Anacardi.
i- kelena i boili	Acridocarpus smeathmannii (D.C.) Guill et Perr.		Malpighi.
inaolo a o- kelele	Maprounea membranacea Pax ex K. Hoffm.		Euphorbi.
o- kelele bo libande	Maprounea membranacea Pax ex K. Hoffm.		Euphorbi.
lo- kema	Carpolobia delvauxii Petit		Polygal.
to- kesu	Piper guineense Schum. & Thonn.		Piper.
li- kile	Urera cameroonensis Willd.		Urtic.
li- kile li nenu	U. thonneri De Wild. et Th.Dur.		Urtic.
li- kile li bote	Croton sylvaticus Hochst. ex Kraus		Euphorbi.
a- kila lowa	Celtis brieyi De Wild.		Ulm.
bo- kofe	Staudtia gabonensis Warb.		Myristic.
li- koka	Pycnanthus angolensis (Welw.) Exell		Myristic.
i- koka	Citharanthus congolensis J. Léonard		Euphorbi.
i- koka i bokembe	Klaineanthus gaboniae Pierre ex Prain		Euphorbi
li- koka li boliki	Ancistrocarpus bequaertii De Wild.		Tili.

li- koka lilowe		Pycnanthus marchalianus Ghesq.	Myristic.
i- kokakoka		Heckeldora staudtii (Harms) Stancy	Meli.
li- koka mbongo	1.	Coelocaryon botryoides Vermoesen	Myristic.
	2.	C. preussii Warb.	Myristic.
lo- koka		Ficus seretii Lebrun	Mor.
i- koko (i- kolo)		Trichilia prieureana Juss.	Meli.
bo- kolo		Trichilia prieureana Juss.	Meli.
li- kolo liambia		Ochthocosmus africanus Hook.	Lin.
li- kolo liambia li libande		Chrysobalanus atococensis A.Chev.	Ros.
bo- kolo bo ilo		Buchholzia microphylla Pax.	Capparid.
bo- kombo		Musanga smithii R. Br.	Mor.
i- konde		Hibiscus rostellatus Guill. et Perr.	Malv.
bo- konde		Lannea welwitschii (Hiern.) Engl.	Anacardi.
i- konge	1.	Triumfetta rhomboidea Jacq.	Tili.
	2.	Abutilon mauritianum (Jacq.) Medic	Malv.
bo- konge		Abelmoschus moschatus Medic.	Malv.
i- kongo i tokembe		Hibiscus physalioides Guill.et Perr.	Malv.
bo- kongele	1.	Urena lobata L	Malv.
	2.	Triumfetta cordifolia A.Rich.	Tili.
bo- kongele bo fufow	1.	Wissadula rostrata (P.Schumach.) Hook.f.	Malv.
	2.	Abutilon mauritianum Medic.	Malv.
bo- kongele bo libande	1.	Hibiscus rostellatus Guill. et Perr.	Malv.
	2.	Clappertonia ficifolia (Willd.) Dun	Tili.
	3.	C. polyandra (K.Schum.) Bechener	Tili.
bo- lu- konge		Abutilon mauritianum (Jacq.)Medic.	Malv.
o- kongo		Antrocaryon	Anacardi.
bo- kongo		Chlorophora excelsa Benth.	Mor.
o- kosolo		Carapa procera D.C.	Meli.
inaolo a			
o- kosolo		Santiria trimera (Oliv.) Aubréville	Burser.
li- koke		Hugonia spicata Oliv. var. grandiflora P Wilczek	Lin.
kolekole		Polygonum salicifolium Brown ex Willd.	Polygon.
li- kolekole		P. senegalense Meisen.	Polygon.
li- kolekole li fufow		P. lanigerum R.Br. var. africanum Meisen.	Polygon.

o-	kolondo	Klainedoxa gabonensis Pierre	Irvingi.
	kombe njaka i fufow	Anacolosa uncifera J.Louis ex Boutique	Olac.
li-	kujwa	Clappertonia polyandra (K.Schum.) Bechenet	Tili.
li-	kuko	1. Campylostemon laurentii De Wild.	Hippocrat.
		2. Hippocratea myrianthe Oliv.	Hippocrat.
		3. Salacia elegans Welw. ex Oliv.	Hippocrat.
		4. Simirestis androgenous (Welw. ex Oliv.) Hallé ex R. Wilczek	Hippocrat.
li-	kuko li nenu	1. Campylostemon laurentii De Wild.	Hippocrat.
		2. Simirestis isangiensis (De Wild.) R. Wilczek	Hippocrat.
o-	kukuloka	1. Coelocaryon botryoides Vermoesen	Myristic.
		2. C. preussii Warb.	Myristic.
o-	kukuloka li lowe	Coelocaryon botryoides Vermoesen	Myristic.
li-	kulu	1. Carpolobia delvauxii Petit	Polygal.
		2. Microdesmis yafungana J. Léonard	Euphorbi.
li-	kulu li soku inaolo a	Microdesmis yafungana J. Léonard	Euphorbi.
i-	kumba esomba	1. Aristolochia congolana Haumann	Aristolochi.
		2. A. triactina Hook.f.	Aristolochi.
		3. A. zenkeri Engl.	Aristolochi.
bo-	kumbo lo bahototo inaolo a	Ritchiea aprevaliana (De Wild. et Th. Dur.) Wilczek	Capparid.
lo-	kumbo lo bahototo	1. Ritchiea aprevaliana (De Wild. et Th. Dyr.) Wilczek	Capparid.
		2. Capparis duchesnei De Wild.	Capparid.
bo-	kumo	Ficus recurvata De Wild.	Mor.
li-	kumo	1. Ficus amadiensis De Wild.	Mor.
		2. F. ardisioides De Wild.	Mor.
		3. F. artocarpoides Warb.	Mor.
		4. F. barteri Sprague	Mor.
		5. F. burretiana Mildbr. & Hutch.	Mor.
		6. F. conraui Warb.	Mor.
		7. F. cyathistipulata Warb.	Mor.
		8. F. leprieurii Miq.	Mor.
		9. F. louisii Boutique & Léonard	Mor.
		10. F. luteda De Wild.	Mor.
		11. F. ottoniaefolia (Miq.) Miq.	Mor.
		12. F. persicifolia Welw. ex Warb.	Mor.
		13. F. subacuminata (De Wild.) Lebrun	Mor.
li-	kumo li fufow	Ficus lukanda Welw. ex Fialho	Mor.

inɔɔlɔ a			
ɛ- kundu		Pseudoagrostistachys ugandaensis (Hutch.) Pax et K. Hoffm.	Euphorbi.
ɛ- kungu lɔ lowɛ		Hirtella butayei (De Wild.) Brenan	Ros.
li- kungu		Xylopia aethiopica (Dumas) A.Rich.	Annon.
li- kungu li ilɔ	1.	Xylopia aurantiiodora De Wild. et Th. Dur.	Annon.
	2.	X. rubescens Oliv.	Annon.
bɔ- kungu		Piptadenia africana Hochf.	Mimos.
ɛ- kungusɛlɛ	1.	Fagara macrophylla var. preussii Engl. ex De Wild.	Rut.
	2.	F. rubescens (Planch.) Engl.	Rut.
i- kungusɛlɛ	1.	Fagara lemairei De Wild.	Rut.
	2.	F. rubescens (Planch.) Engl.	Rut.
i- kungusɛlɛ i libandɛ		Fagara laurentii De Wild.	Rut.
a- kutɔkɔ	1.	Baphia calophylla Harms	Fab.
	2.	B. polygalacea Bast.	Fab.
	3.	Baphiastrum boonei (De Wild.) Vermoesen	Fab.
	4.	Bauhinnia goeswileri Bak.	Caesalpin.
	5.	Leptoderris congolensis (De Wild.) Donn.	Fab.
	6.	Ostryoderris gabonica (Baill.) Donn.	Fab.
a- kutɔkɔ ɛ bɔtɛ		Baphiopsis parvifolia Benth. ex Bak.	Fab.
a- kutɔkɔ bɔ fufɔw	1.	Millettia dubia De Wild.	Fab.
	2.	Platysepalum pulchrum Louis ex Haumann	Fab.
a- kutɔkɔ bɔ ɑɛnu	1.	Baphiastrum spathaceum (Hook.f.) Stan.	Fab.
	2.	Dalbergia heudelotii Stapf	Fab.
	3.	D. ngoungensis Pellegr.	Fab.
	4.	Millettia psilopetala Harms	Fab.
a- kutɔkɔ i tɔkɛmbɛ		Diocles reflexa Hook. f.	Fab.
inɔɔlɔ a			
a- kutɔkɔ		Millettia theuszii (Büchn.) De Wild.	Fab.
li- kwa		Cleistanthus polystachya Hook.f. ex Planch.	Euphorbi.
tɔ- kwakwa		Glinus oppositifolius (L) A.D.C.	Molluginɔ.

a- kwakwa	1.	Oxystigma gilbertii J. Léonard	Caesalpin.
	2.	O. oxyphyllum (Harms) J.Léonard	Caesalpin.
a- kwakwa bo'libandc		Oxystigma buchholzii Harms	Caesalpin.
kwakwa	1.	Mucuna flagellipes Vogel ex Benth.	Fab.
	2.	Vigna campestris (Mart.) Wilczek	Fab.
	3.	V. vexillata (L) Benth.	Fab.
kwakwa i fufou		Mucuna urens (L) Medic.	Fab.
kwakwa kikelekc	1.	Phaseolus adenanthus D.C.	Fab.
	2.	Vigna maranguensis(Taub.) Harms	Fab.
kwakwa lo lowe		Vigna multiflora Hook.f.	Fab.
kwakwa ndilo		Physostigma venenosum Desc.	Fab.
boliki bo kwaka inaolo a		Rhynchosia mannii Bak.	Fab.
kwakwa	1.	Crotalaria mucronata Hook.f.	Fab.
	2.	Desmodium salicifolium (Poir. ex Lam.) D.C.	Fab.
	3.	Dioclea reflexa Hook.f.	Fab.
	4.	Phaseolus adenanthus	Fab.
	5.	Psophocarpus palustris Desv.	Fab.
	6.	Vigna lutcola (Jacq.) Benth.	Fab.
	7.	V. vexillata (L) Benth.	Fab.
c. kwalanganga	1.	Dichapetalum angolense Chad.	Dichapetal.
	2.	D. flaviflorum Engl.	Dichapetal.
	3.	D. griesiepalum De Wild.	Dichapetal.
	4.	D. mundense Engl.	Dichapetal.
	5.	D. palustre Louis ex Haumann	Dichapetal.
	6.	D. schweinfurthii Engl.	Dichapetal.
e- kwalanganga lo boliki	1.	Dichapetalum acuminatum De Wild.	Dichapetal.
	2.	D. congolense Engl. et Ruhl	Dichapetal.
	3.	D. dundusanense De Wild.	Dichapetal.
	4.	D. mortehani De Wild.	Dichapetal.
	5.	D. thonneri De Wild.	Dichapetal.
	6.	D. zenkeri Engl.	Dichapetal.
e- kwalanganga lo bote	1.	Dichapetalum germainii Haumann	Dichapetal.
	2.	D. mombongense De Wild.	Dichapetal.
e- kwalanganga lo fufou		Dichapetalum dundusanense De Wild.	Dichapetal.
e- kwalanganga lo fufou lo bote		Dichapetalum malchairii De Wild.	Dichapetal.
e- kwalanganga lo tokembe		Dichapetalum germainii Haumann	Dichapetal.

lɔ- kwamisa		Iodes yangambiensis Louis ex Boutique	Icacin.
kwelekwele	1.	Amaranthus dubius Mart. ex Thell.	Amaranth.
	2.	A. gracilis Desf.	Amaranth.
	3.	A. hybridus L	Amaranth.
	4.	Gynandropsis gynandra (L)Briq.	Capparid.
	5.	Talinum triangulare (Jacq.) Willd.	Portulac.
inaɔlɔ a kwelekele		Octoknema affinis Pierre ex Van Tiegh.	Octoknem.
ɔ- kwɔɛɔlɔ	1.	Afzelia bella Harms	Caesalpin.
	2.	A. bipindensis Harms	Caesalpin.
inaɔlɔ a ɔ- kwɔɛɔlɔ		Sapium cornutum Pax	Euphorbi.
e- kwundu		Cavacoa guintasii (Pax et K.Hoffm.) J.Léonard	Euphorbi.
li- lamba		Lecaniodiscus guineensis G.Don.	Lecan.
ɔ- landa		Erythrophleum guineense G.Don.	Caesalpin.
e- lasila		Trichilia tubeseens Oliv.	Meli.
e- lasila lɔ boliki		Turraea vogelii Hook.f.	Meli.
ɔ- le		Afrormosia elata Harms	Fab.
inaɔlɔ a ɔlɛ		Zanha gobingensis Harms	Sapind.
inaɔlɔ a ɔ- lekalɛka		Impatiens mannii Hook. f.	Balsamin.
inaɔlɔ a ɔ- lekɛ		Leptaulus daphnoides Benth.	Icacin.
li- lekɔ		Pachyclasma tessmannii (Harms)Harms	Caesalpin.
ba- lele		Rorippa humifusa (Guill.& Perr.) Hiern.	Brassic.
bɔ- leli		Tetrorchidium didymostemon (Baill.) Pax et K.Hoffm.	Euphorbi.
inaɔlɔ a bɔ- leli		Tetrorchidium congolense J.Léonard	Euphorbi.
e- lema	1.	Cissus dinklagei Gilg.& Brandt	Vit.
	2.	Illigera vespertillo (Benth.)Bak.f.	Hernandi.
e- lendalenda	1.	Cola acuminata Engl.	Sterculi.
	2.	C. griseiflora De Wild.	Sterculi.
	3.	Octolobus spectabilis Welw.	Sterculi.
e- lendalenda lɔtɔlɔmɛ		Cola louisii R.Germain	Sterculi.
e- lendalenda lɔ kikelekɛ		Cola sciaphylla Louis ex R.Germain	Sterculi.
inaɔlɔ a e- lendalenda		Cola louisii R.Germain	Sterculi.
ɔ- lendɛ		Helictonema velutina (Afz.) R.Wilczek ex Hallé	Hippocrat.

ɔ- lende bɔilɔ	Iɔdes africana Welw. ex Oliv.	Icacin.
ɔ- lende bɔ kikeleke	Iɔdes klaineana Pierre	Icacin.
inaɔlɔ a ɔ- lende	Iɔdes seretii (De Wild.) Boutique	Icacin.
bɔ- liki bɔ kikeleke	Ochthocosmus africanus Hook.	Lin.
bɔ- liki bɔ lɔkele	Milletia duchesnei De Wild.	Fab.
bɔ- liki bɔ tulu	Ficus wildemaniana Warb.	Mor.
i- liki i sɔlɔ	Pyrenacantha acuminata Engl.	Icacin.
inaɔlɔ a ɔ- liki	Rhopalopilia pallens Pierre	Opili.
inaɔlɔ a bɔ- liki bɔ bɔliki	Opilia celtidifolia (Guill.& Perr.) Endl.	Opili.
li- lila	Cleome ciliata Schumach. et Thonn.	Capparid.
li- lila li bɔliki	1. Dalbergia afzeliana G.Don.	Fab.
	2. D. calaensis De Wild.	Fab.
	3. D. grandibracteata De Wild.	Fab.
	4. D. hostilis Benth.	Fab.
	5. D. laxiflora Micheli	Fab.
	6. D. saxatilis var. isangaensis (De Wild.) Cronquist	Fab.
li- lila li ilɔ	Dalbergia calaensis De Wild.	Fab.
li- lila li lɔbe	Ormocarpum sennoides (Willd.) D.C.	Fab.
li- lila likekeleke	Tephrosia barbigera Welw. ex Bak.	Fab
inaɔlɔ a li- lila	Cassia occidentalis L	Caesalpin.
inaɔlɔ a li- lilila li bɔliki	Leptoderris reygaertii De Wild.	Fab.
ɔ- lili	Irvingia gabonensis (Aubrey Lecomte ex O.Lowk.) Baill.	Irvingi.
bɔ- lili bɔ kikeleke	Crotogyne georgii De Wild.	Euphorbi.
ɔ- lɔkɔ	1. Blighia welwitschii (Hiern.) Radlk.	Sapind.
	2. B. unijugata Bak.	Sapind.
e- lɔkɔlɔlɔ	1. Eriocaulon microspermumRadlk. ex De Wild.	Sapind.
	2. Lecaniodiscus cupanoides Planch.	Sapind.
e- lɔkɔlɔkɔ lɔ fufɔu	Laccodiscus pseudostipulatus Radlk.	Sapind.
e- lɔkɔlɔkɔ lɔ kikeleke	Haplocoelum congolanum Haumann	Sapind.
li- lɔlɔ	1. Grewia pinnatifida Meist.	Tili.
	2. G. mildbraedii Burret	Tili.
	3. Leptonychia multiflora K.Schumm.	Sterculi.
	4. L. toleana R. Germain	Sterculi.
	5. Grewia malacocarpoides De Wild.	Tili.

i- lolɔ i lɔwe		Trichilia etusa Oliv.	Meli.
li- lolɔ li bɔliki		Ancistrocarpus bequaertii De Wild.	Tili.
bɔ- lɔmbɔ	1.	Leptoderris ferruginea De Wild.	Fab.
	2.	Ostryocarpus riparis Hook.f.	Fab.
bɔ- lɔmbɔ bɔ fufɔw	1.	Milletia harmsiana De Wild.	Fab.
	2.	Ostryoderris lucida (Welw.) Bak.f.	Fab.
bɔ- lɔmbɔ bɔ nenu	1.	Leptoderris nobilis var. latifoliata Haumann	Fab.
	2.	Milletia batteri (Benth.) Dunn	Fab.
	3.	Milletia elakensii De Wild. var. stenophylla Haumann	Fab.
	4.	Ostryoderris gabonica (Baill.) Dunn	Fab.
li- lɔmekɔ		Croton haumanianus J.Léonard	Euphorbi.
ɔ- lɔngɔ	1.	Fagara inaequalis Engl.	Rut.
	2.	F. laurentii De Wild.	Rut.
	3.	F. macrophylla var. preussii Engl. ex De Wild.	Rut.
	4.	F. rubescens (Planch.) Engl.	Rut.
i- lɔlɔngɔ		F. rubescens (Planch.) Engl.	Rut.
ɔ- lɔngɔ ɔ bɔliki		Fagara poggei Engl.	Rut.
ɔ- lɔngɔ bɔ kikeleke		Fagara rubescens (Planch) Engl.	Rut.
bɔ- lɔngɔ bɔ libande		Fagara laurentii De Wild.	Rut.
inaɔlɔ a ɔ- lɔngɔ		Pierreodendron africanum (Hook.f.) Lecthe	Simarub.
inaɔlɔ a e- lɔngɔ		Ventilago africana Engl.	Rhamn.
li- lɔmbɔ		Croton haumannianus J. Léonard	Euphorbi
inaɔlɔ a li- lɔmbɔ		Cissus adenopoda Sprague	Vit.
bɔ- lumbe likɔlɔ	1.	Trichilia gilgeana Harms	Meli.
	2.	T. welwitschii C.D.C.	Meli.
inaɔlɔ a - lumbalumba		Pouzolzia guineensis Benth.	Urtic.
ɔ- lunda		Piptadenia africana Hook.f.	Mimos.
bɔ- lundɔ		Antiaris welwitschii Engl. (young)	Mor.
i- makisaka		Talinum portulacaeifolium (Forsk.) Ascher & Schweinf.	Portulac.
i- mbambali		Entada planoseminata (De Wild.) Gilbert & Boutique	Mimos.
li- mbambali		Pseudoprosopis claessensii (De Wild.) Gilbert & Boutique	Mimos.

li- mbambali li libande	Entadopsis mannii (Oliv.) Gilbert & Boutique	Mimos.
li- mbamba	Grewia oligoneura Sprague	Tili.
i- mbambe	1. Deinbollia longiacuminata Haumann	Sapind.
	2. D. pynaertii Haumann	Sapind.
	3. Gilbertiodendron mildbraedii (Harms) Vermoesen	Caesalpin.
i- mbambe i lowe	Klaineanthus gaboniae Pierre ex Prain	Euphorbi.
bo- mbai	Polyalthia suaveolens Engl. ex Diels	Annon.
bo- mbai bo fufo	1. Xylopia chrysophylla Louis ex Boutique	Annon.
	2. X. acutiflora (Dunn) A.Rich.	Annon.
	3. X. gilbertii Boutique	Annon.
	4. X. katangensis De Wild.	Annon.
	5. X. phloiodora Mildbr.	Annon.
bo- mbai bo ilo	Polyalthia suaveolens Engl. ex Diels	Annon.
i- mbambai	Ormocarpum sennoides (Willd.) D.C.	Fab.
lo- mbaya	1. Agelaea duchesnei De Wild. et Th.Dur.	Connar.
	2. Byrsocarpus viridis (Gilg.) Schellenb.	Connar.
	3. Dalbergia ngoungensis Pellegr.	Fab.
	4. Jaundea pinnata (P.Beauv.)Schnellenb.	Connar.
	5. J. pubescens (Bak.) Schnellenb.	Connar.
	6. Leptoderris laurentii De Wild.	Fab.
	7. Manotes pruinosa Gilg.	Connar.
	8. Paxia soyauxii (Gilg.) Pierre ex Schnellenb.	Connar.
	9. Rourcopsis thonneri (De Wild.) Schnellenb.	Connar.
lo- mbaya lo bototo	Hugonia obtusifolia C.A.Wright	Lin.
lo- mbaya lofufou	1. Hugonia spicata Oliv. var. glabrescens Keay	Lin.
	2. H. spicata Oliv. var. grandiflora R. Wilczek	Lin.
	3. H. platysepala Welw. ex Oliv.	Lin.
	4. H. obtusifolia C.A.Wright	Lin.
lo- mbaya lo ilo	1. Santaloides splendidum (Gilg.) Schnellenb.	Connar.
	2. Hugonia obtusifolia C.A.Wright	Lin.
	3. Agelaea hirsuta De Wild.	Connar.
lo- mbaya lo isaala	Santaloides splendidum (Gilg.) Schnellenb.	Connar.

lɔ- mbaya lɔ libande	Dalbergia heudelotii Stapf.	Fab.
lɔ- mbaya lɔ lɔwɛ	Hugonia obtusifolia C.A.Wright	Lin.
lɔ- mbaya lɔ nɛnu	Hugonia obtusifolia C.A.Wright	Lin.
lɔ- mbaya lɔ tɔkɛmbɛ	1. Agolaca hirsuta De Wild.	Connar.
	2. Hugonia talbotii De Wild.	Lin.
	3. Santaloides gilletii Schnellenb.	Connar.
inaɔlɔ a lɔ- mbaya	Salacia elegans var. pynaertii (De Wild.) R. Wilczek	Hippocrat.
i- mbambaya	1. Byrsocarpus coccineus Schum.& Thonn.	Connar.
	2. Manotes pruinosa Gilg.	Connar.
inaɔlɔ a i- mbambaya	Rourcopsis thonneri (De Wild.) Schnellenb.	Connar.
i- mbea	Scytopetalum pierreanum (De Wild.) Van Tieghem	Scytopetal.
mbele baongo	Heisteria parvifolia Smith	Olac.
bɔ- mbi	Grewia mildbraedii Burret	Tili.
li- bila	Alternanthera sessilis (L) R.Br.	Amaranth.
	2. Celosia leptostachys Benth.	Amaranth.
	3. C. trigyna L	Amaranth.
	4. Cyathula achyranthoides (HBK) Moq.	Amaranth.
	5. Psilotrichum axilliflorum Suesenguth.	Amaranth.
li- mbila li bɔliki	Sericostachys scandens Gilg. et Lep.	Amaranth.
li- mbila li libande	Achyranthes aspera L	Amaranth.
li- mbila li nɛnu	1. Celosia laxa Schum. et Thonn.	Amaranth.
	2. Cyathula prostrata (L) Blume	Amaranth.
li- mbiti	Cyathula achyranthoides (HBK) Moq.	Amaranth.
li- mbiti li tɔkɛmbɛ	Caperonia fistulosa Baill.	Euphorbi.
ɔ- mbimbɔ	Treculia africana Decne	Mor.
mbɔlu	Gilbertiodendron dewevrei (De Wild.) J. Léonard	Caesalpin.
tɔ- mbɔmbɔ	1. Dorstenia scapigera Bureau	Mor.
	2. Craterogyne kameruniana	Mor.
i- mɛɛu	Trema guineensis (Schum.et Thonn.) Ficalho	Ulm.
li- mɛɛu	Trema guineensis (Schum. et Thonn.) Ficalho	Ulm.
lɔ- mwɛmwɛ	1. Afroguatteria bequaertii (De Wild.) Boutique	Annon.
	2.Atopostema angustifolia Boutique	Annon.
	3. Oxymitra grandiflora Boutique	Annon.

	4.	Oxymitra poyauxii Sprague et Hutch.	Annon.
	5.	Popowia congensis (Engl.et Diels) Engl.	Annon.
	6.	P. louisii Boutique	Annon.
	7.	P. lucidula (Oliv.) Engl.	Annon.
lo- mwemwe lo bote	1.	Neostenantheria bequaertii (De Wild.) Exell	Annon.
	2.	Polyceratocarpus germainii Boutique	Annon.
	3.	Popowia diclina Sprague emend.Chiff.	Annon.
bo- nama		Impatiens irvingii Hook.f.	Balsamin.
bu- nama		Impatiens niamniamensis Gilg.	Balsamin.
ndembu	1.	Leptonychia multiflora K.Schum.	Sterculi.
	2.	L. toleana R.Germain	Sterculi.
ndimo na lokonda		Citropsis articulata (Willd. ex Spring.)Swingl.et Kellerman	Rut.
ndolo	1.	Desplatsia dewevrei (De Wild. et Th.Dur.) Burret	Tili.
	2	Glyphaea brevis (Spring.)Monachino	Tili.
ndolo e boliki		Grewia malacocarpoides De Wild.	Tili.
ndola (=ndolo?)	1.	Grewia pinnatifida Must.	Tili.
	2.	G. oligoneura Sprague	Tili.
inaolo a ndolo		Grewia trinervis De Wild.	Tili.
inaolo a ndembo		Ancistrocarpus bequaertii De Wild.	Tili.
a- nduwa		Leptaulus holstii (Eng.) Engl.	Icacin.
lo- nenge	1.	Amaranthus gracilis Desf.	Amaranth.
	2.	A. viridis subsp. adscendens (L)Thell.	Amaranth.
	3.	Basella alba L	Basell.
o- nee a boliki		Entadopsis mannii (Oliv.) Gilbert et Boutique	Mimos.
nganga kikeleke		Haplocoelum congolanum Haumann	Sapind.
i- ngaolo	1.	Hibiscus rostellatus Guill. et Perr.	Malv.
	2.	H. surattensis L	Malv.
e- ngangate		Cavacoa quintasii (Pax et Hoffm.) J. Léonard	Euphorbi.
e- ngangato		Klaineanthus gaboniae Pierre ex Prain	Euphorbi.
ngangu	1.	Klaineanthus gaboniae Pierre ex Prain	Euphorbi.
	2.	Crudia laurentii De Wild.	Caesalpin.
	3.	Cleistanthus tripicolus J. Léonard	Euphorbi.
	4.	C. polystachyus Hook.f. ex Planch.	Euphorbi.

	5. C.mildbraedii G.Jubl.		Euphorbi.
	6. Acioa gilletii De Wild.		Ros.
	7. A. dewevrei var ruggaertii (De Wild.) Hauman		Ros.
ngangu e fufou	Cleistanthus polystachy·s Hoof.f. ex Planch.		Euphorb.
ngangu ki.eleke	1. Cleistanthus polystachyus Hook.f. ex Planch.		Euphorbi.
	2. C. ripicola J. Léonard		Euphorbi.
ngangu e libande	1. C. ripicola J.Léonard		Euphorbi.
	2. Acioa gilletii De Wild.		Ros.
.ngangu e lowe	Cleistanthus polystachyus Hook.f. ex Planch.		Euphorbi.
ngangu etolome	Acioa gilletii De Wild.		Ros.
li- ngangule	Cola acuminata Engl.		Sterculi.
bo- nge bo libande	Sapium ellipticum (Hochst.ex Kraus)Pax		Euphorbi.
inaolo a bo- nge	1. Lppidobotrys staudtii Engl.		Lin.
	2. Sapium cornutum Pax		Euphorbi.
ngelese	Dorstenia psilurus Welw.		Mor.
ngingo e likebe	1. Artabotrys insignis Engl. et Diels		Annon.
	2. A. likimensis De Wild.		Annon.
	3. A. rufus De Wild.		Annon.
	4. A. thomsonii Oliv.		Annon.
	5. Dalbergia heudelotii Stapf.		Fab.
	6. Enneastemon biglandulosa Boutique		Annon.
	7. Gilbertiella congolana Boutique		Annon.
	8. Oxymitra grandiflora Boutique		Annon.
	9. O. soyauxii Sprague et Hutch.		Annon.
	10. Popowia bicornis Boutique		Annon.
	11. P. cauliflora Chipp.		Annon.
	12. P. congensis (Engl.et Diels) Engl.		Annon.
	13. Uvaria mocoli De Wild. et Th.Dur.		Annon.
	14. U. suaveolens Louis ex Boutique		Annon.
ngingo e likebe e bote	Polycerantocarpus vermoesenii Robyns et Gheeq.		Annon.
ngingo e likebe i fufou	1. Artabotrys palustris Louis ex Boutique		Annon.
	2. Oxymitra grandiflora Boutique		Annon.
ngingo e likebe li nenu	Enneastemon biglandulosa Bputique		Annon.

ngingɔ e likebe i tɔkembe	Artabotrys boonei De Wild.	Annɔn.
inaɔlɔ a ngingɔ e likebe	1. Artabotrys robustus Louis ex Boutique	Annɔn.
	2. Dalbergia heudelotii Stapf	Fab.
	3. Popowia dicling Sprague emend. Chipp.	Annɔn.
	4. Uvaria rivularis Louis ex Boutique	Annɔn.
	5. U. scabrida Oliv.	Annɔn.
inaɔlɔ a bɔ- ili la ngema	Acridocarpus smeathmannii (DC) Guill. et Perr.	Malpighi.
ngɔnda ɔselu	1. Byrsocarpus dinklagei (Gilg.) Schnellenb.	Connar.
	2. B. viridis (Gilg.) Schnellenb.	Connar.
	3. Santaloides splendidum (Gilg.) Schnellenb.	Connar.
ngɔsa	Manniphyton fulvum Müll.Arg.	Euphorbi.
ɔ ngunguna	Myrianthus arboreus P.Beauv.	Mor.
ɔ- ngunguna bɔ bɔliki	Myrianthus scandens Louis ex Hauman	Mor.
ɔ- ngunguna bɔ kikeleke	Myrianthus preussii Engl.	Mor.
a- ngwabele	Celtis mildbraedii Engl.	Ulm.
inaɔlɔ a a- ngwabele a libande	Celtis durandii Engl.	Ulm.
bɔ- ngwingwi	1. Aleodeiopsis poggei Engl.	Icacin.
	2. Carpolobia delvauxii Petit	Polygal.
	3. Desmostachys brevipes(Engl.) Schum. var. oblongifolia(Engl.)Boutique	Icacin.
bɔ- ngwingwi bɔ ilɔ	Desmostachys brevipes(Engl.) Schum. var. oblongifolia(Engl.)Boutique	Icacin.
inaɔlɔ a bɔ- ngwingwi	Carpolobia delvauxii Petit	Polygal.
a- ngwɔngwɔ	Cola acuminata (P.Beauv.)Schott et Endl.	Sterculi.
ngwɔngɔle	Cola acuminata(P.Beauv.) Schott et Endl.	Sterculi.
ngwɔkɔle	1. Dialium corbisieri Staner	Caesalpin.
	2. D. pachyphyllum Harms	Caesalpin.
ngwɔkɔle i fɔfɔu	D. zenkeri Harms	Caesalpin.

nienic	1. Glinus oppositifolius (L) R.Br.	Kollugin.
	2. Portulaca oleracea L	Portulac.
	3. P. quadrifida L	Portulac.
inaolo a nienic	Peperomia pellucida (L)H.B.	Piper.
o- niningo	1. Monodora angolensis Welw.	Annon.
	2. M. tenuiflora Benth.	Annon.
	3. M. myristica (Gaertn.) Dun.	Annon.
o- niningo bo boliki	Uvaria suaveolens Louis ex Boutique	Annon.
inaolo a oniningo	1. Hexalobus crispiflorus A.Rich.	Annon.
	2. Monodora louisii Boutique	Annon.
i- nongo	Copaifera mildbraedii Harms	Caesalpin.
i- nuka	Olax viridis Oliv.	Olac.
ite i bo- nuka	Olax viridis Oliv.	Olac.
inaolo a bonuka	Opilia sparsiflora Engl.	Opili-
li- oko	Hannoa klaineana Pierre et Engl.	Simarub.
inaolo a y- oko	Gynandropsis gynandra (L) Briq.	Capparid.
nd- olo	1. Desplatsia dewevrei (De Wild. et Th.Dur.) Burret	Tili.
	2. Glyphaea brevis (Spring.)Monachino	Tili.
y- ololo	1. Fleurya podocarpa Wedd.	Urtic.
	2. Dalechampia ipomoeifolia Benth.	Euphorbi.
inaolo a t- olo	Sorindeia sparanoi De Wild.	Anacardi.
li- ombombo	1. Peperomia bangroana C.D.C.	Piper.
	2. Trietichia alternifolia (Willd.) Thomas ex Sprague	Podostemon.
lo- ona	Parinari holstii Engl.	Ros.
inaolo a bo- onio	Entadopsis mannii (Oliv.) Gilbert et Boutique	Mimos.
bo- onge	Bosqueia angolensis (Welw.) Ficalho	Mor.
lo- opa	1. Isolona bruneelii De Wild.	Annon.
	2. I. thonneri (De Wild et Th.Dur.) Engl. et Diels	Annon.
lo- opa lo lowe	Uvariopsis congensis Robyns et Ghesq.	Annon.
lo- opa lo nenu	Uvariastrum germainii Boutique	Annon.
inaolo a lo- opa	1. Uvaria laurentii De Wild.	Annon.
	2. Uvaria elliotianum (Engl.et Diels) Sprague et Hutch.	Annon.

	3. Uvariopsis congensis Robyns et Ghesq.	Annon.
	4. Uvariastrum solheidii (De Wild.) Haumann	Annon.
y- oto ya yaosaka	1. Dichapetalum glandulosum var. fulviolatum (De Wild.) Haumann	Dichapetal.
	2. D. mombuttense Engl.	Dichapetal.
	3. D. zenkeri Engl.	Dichapetal.
	4. Salacia rivulare Louis ex R.Wilczek	Hippocrat.
li- oye	Icacina claessensii De Wild.	Icacin.
inaolo a liɔye	Icacina mannii Oliv.	Icacin.
l- owa	1. Ficus ardisioides Warb.	Mor.
	2. F. capensis Thunb.	Mor.
	3. F. polita (Miq.) Vahl	Mor.
	4. F. vallis-choudae Del.	Mor.
l- owa fufow	Ficus mucuno Welw. ex Ficalho	Mor.
inaolo a lowa	Ficus zenkeri Warb. ex Mildbr. et Burret	Mor.
inaolo a l- owa lo ndombe	Bersama yangambiensis Toussaint	Melianth.
t- ototo	1. Antigonum leptopus Hook.	Polygon.
	2. Cardiospermum helicacabum L	Sapind.
	3. Celosia leptostachya Benth.	Amaranth.
i- saala	1. Pseudopteropsis claessensii (De Wild.) Gilbert et Boutique	Mimos.
	2. Routeopsis obliquifoliata (Gilg.) Schnellenb.	Connar.
	3. R. thonneri (De Wild.) Schnellenb.	Connar.
i- saala i bote	Ormocarpum senegoides (Willd.) D.C.	Fab.
i- saala lo lowe	1. Leptoderris reynaertii De Wild.	Fab.
	2. L. saxatilis var. preussii (Harms) Cronquist	Fab.
i- saali	1. Dialium pentandrum Louis ex Stoy	Fab.
	2. D. reygaertii De Wild.	Fab.
i- saali i fufou	Dalbergia saxatilis Hook.f.	Fab.
e- saka	1. Entandophragma angolense C.D.C.	Meli.
	2. E. candollei Harms	Meli.
	3. E. cylindricum (Sprague)Sprague	Meli.
	4. E. palustre Staner	Meli.
e- saka boliki	1. Ancistrocarpus bequaertii De Wild.	Tili.

	2. Campylostemon bequaertii De Wild.	Hippocrat.
	3. C. laurentii De Wild.	Hippocrat.
	4. Curvea macrophylla (Vahl) R.Wilczek ex Hallé	Hippocrat.
	5. Loeseneriella apiculata (Welw.ex Oliv.)R.Wilczek	Hippocrat.
	6. L. guineensis (Hutch.et M.E.Moss) Hallé	Hippocrat.
	7. L. yaundeana (Loes.) R.Wilczek	Hippocrat.
	8. Salacia lebrunii R.Wilczek	Hippocrat.
	9. Salacighia letestuana (Pellegr.) R. Wilczek	Hippocrat.
	10. Salacia rivularis Louis ex R.Wilczek	Hippocrat.
	11. S. elegans Welw. ex Oliv.	Hippocrat.
	12. S mirestis ardogensis (Welw. ex Oliv.) Hallé ex Boutique	Hippocrat.
e- saka oliki lo lowe	Atroxima congolana Petit	Polygal.
e- saka oliki lo nenu	S mirestis preussii(Loes.) Hallé	Hippocrat.
e- saka lo lowe	Entandophragma palustre Staner	Meli.
lo- sakani	1. Cola bruneelii De Wild.	Sterculi.
	2. C. urceolata K.Schum.	Sterculi.
lo- sakani lo kikeleke	Cola congolana De Wild. et Th.Dur.	Sterculi.
lo- sakani lo libande	1. Euadenia eminensis Pax	Capparid.
	2. Cola selengana R.Germain	Sterculi.
lo- sakani lo lowe	1. Cola congolana De Wild. et Th.Dur.	Sterculi.
	2. C. selengana R.Germain	Sterculi.
	3. Crotogyne poggei Pax	Euphorbi.
lo- sakani lo tokembe	Cola marsupiana K.Schum.	Sterculi.
inaolo a losakani	Octoknema affinis Pierre ex Van Tieg	Octoknem.
o- saku	1. Bridelia atroviridis Müll. Arg.	Euphorbi.
	2. B. stenocarpa Müll.Arg.	Euphorbi.
o- saku bo libande	Bridelia tipicola J.Léonard	Euphorbi.
o- saku bo ngonda	Bridelia stenocarpa Müll.Arg.	Euphorbi.
li- sangisa	Entada gigas (L) Fawcett & Rendle	Mimos.
bo- sasango	Pseudospondias microcarpa (A.Rich.) Engl.	Anacardi.
inaolo a bo- sasango	1. Deinbollia pynaertii De Wild.	Sapind.
	2. Pseudospondias longifolia Engl.	Anacardi.
	3. Sorindeia spatanoi De Wild.	Anacardi.

ba- saso basaso	1. Allophylus africanus P.Beauv. f. acuminatum Robyns ex Haumann	Sapind.
	2. A. lastourvillensis Pellegr.	Sapind.
	3. A. schweinfurthii Gilg.	Sapind.
ba- saso basaso baoliki	Allophylus hamatus Vermoesen ex Haumann	Sapind.
ba- saso basaso bo nenu	Allophylus longicuncatus Vermoesen ex Harms	Sapind.
bo- sau	Dacryodes edulis (G.Don) H.J.Lam.	Burser.
ibele sau	Dacryodes yangambiensis Louis ex Troupin	Burser.
lo- selesele	1. Crotogyne giorgii De Wild.	Euphorbi.
	2. C. poggei Pax	Euphorbi.
lo- selesele lo lowe	1. Klaineanthus gaboniae Pierre ex Prain	Euphorbi.
	2. Crotogyne poggei Pax	Euphorbi.
lo- selesele lo tokembe	Klaineanthus gaboniae Pierre ex Prain	Euphorbi.
inaolo a lo- selesele	Crotogyne poggei Pax	Euphorbi.
o- sengele	Monopetalanthus microphyllus Harms	Caesalpi.
to- sisi	1. Drymaria cordata (L) Willd. ex Rocher et Schult.	Caryophyl.
	2. Fleurya aestuans (L) Gard.	Urtic.
	3. Mollugo medicantis Lam.	Molluginac
	4. Oxalis corniculata L	Oxalid.
	5. Rorippa indica (L) Hiern.	Brassic.
	6. Peperomia pellucida (L) H.B.	Urtic.
ba- soke	1. Urera camerooneneis Willd.	Urtic.
	2. U. thonneri De Wild. et Th.Dur.	Urtic.
inaolo a basoke	Bauhinnia gossweileri Bak.	Caesalpin.
li- soko	Antiaris welwitschii Engl. (adult)	Mor.
e- sole lo libande	Etismadelphus exeul Mildbr.	Vochysi.
inaolo a esole	Etismadelphus exeul Mildbr.	Vochysi.
esolo	1. Chlamydocarya thomsoniana Baill.	Icacin.
	2. Leptoderris congolensis (De Wild.) Stanet	Fab.
	3. Polycephalum lotatum (Pierre) Pierre ex Engl.	Icacin.
	4. Pyrenacantha sylvestris S.Moore	Icacin.
	5. P.vogelii Baill.	Icacin.
	6. Iodes seretii (De Wild.) Boutique	Icacin.

lo- ɛomba	1. Beilschmiedia alata Robyns et Wilczek	Laur.
	2. B. congolana Robyns et Wilczek	Laur.
	3. B. louisii Robyns et Wilczek	Laur.
inaolo a loɛomba	1. Beilschmiedia alata Robyns et Wilczek	Laur.
	2. B. variabilis Robyns et Wilczek	Laur.
	3. Octoknema affinis Pierre et Van Tieg.	Octoknem.
bo- ɛombo	1. Irvingia smithii Hook.f.	Irvingi.
	2. Sapium ellipticum (Hochst. ex Kraus) Pax	Euphorbi.
inaolo a boɛombo	1. Maprounea membranacea Pax ex K. Hoffm.	Euphorbi.
	2. Scytopetalum pierreanum (De Wild.) Van Tieg.	Scytopetal.
e- ɛonea	Icacina claessensii De Wild.	Icacin.
inaolo a eɛonea	1. Pyrenacantha klaineana Pierre ex Exell et Mendonça var. congolana Boutique	Icacin.
	2. Rhopalopilia bequaertii (De Wild.) J. Léonard	Opili.
li- ɛongo	Ricinodendron heudelotii (Baill.) Pierre ex Hackel subsp. africanum (Müll.Arg.) J.Léonard	Euphorbi.
e- ɛoɛe	1. Brachystegia laurentii (De Wild.) Louis	Caesalpin.
	2. Hannoa klaineana Pierre et Engl.	Simarub.
e- ɛoɛe lo libande	Brachystegia laurentii (De Wild.) Louis	Caesalpin.
i- ɛowe i nenu	Impatiens niamniensis Gilg.	Balsamin.
inaolo a iɛowe	1. Corchorus olitorius L	Tili.
	2. Peperomia dubia Balle	Piper.
e- tale	Okoubaka aubrevillei Pell. et Normand	Octoknem.
taliwa	Ficus capensis Thunb.	Mor.
i- tanda la isende	Cleistanthus polystachya Hook.f. ex Planch.	Euphorbi.
i- tandia moko	Celosia laxa Schum. et Thonn.	Amaranth.
i- tando	Neoboutonia kameruniana Engl.	Mor.
a- tangao	1. Entadopsis scleratus (A.Chev.) Gilbert et Boutique	Mimos.
	2. Mezoneurum angolense Welw.ex Oliv.	Caesalpin.
	3. M. welwitschianum Oliv.	Caesalpin.
	4. Mimosa pudica L	Mimos.

a- tangaɔ a libandɛ		Mɛzɔncuɾum wɛlwitschianum Oliv.	Cɑɛsalpin.
a- tangaɔ bɔ nɛnu		Entadɔpsis mannii (Oliv.) Gilbɛɾt ɛt Boutiqué	Mimɔs.
bɔ- tɛ bɔ bainɔ		Glyphaea bɾɛvis (Spɾing.) Mɔnachinɔ	Tili.
bɔ- tɛ bɔ bitɔkɔ		Sapium ɛllipticum(Hɔchst.ɛx Kɾaus)	Pax Euphɔɾbi.
i- tɛ ɛ bɔnuka		Olax viɾidis Oliv.	Olac.
bɔ- tɛ a lisɔ		Kalanchɔɛ ɛɾɛnata Haw	Cɾassul.
ɛ- tɛkɛlɛ lɔ niɛlɛ		Pɛntadiplandɾa bɾazzɛana Bail.	Cappaɾid.
ɛ- tɛkɛlɛ lɔ niɛlɛ lɔ bɔliki		Pɛntadiplandɾa bɾazzɛana Bail.	Cappaɾid.
i- tɛndɛ		Pancɔvia haɾmsigna Gilg.	Sapind.
inaɔlɔ a itɛndɛ	1.	Aphania sɛnɛgalɛnsis (Jussɛ.) Radlk.	Sapind.
	2.	Chytɾanthus ɛaɾnɛus Radlk. ɛx Mildbɾ.	Sapind.
	3.	Dɛinbɔllɛa cauliflɔɾa Haumann	Sapind.
	4.	D. pynaɛɾtii De Wild.	Sapind.
ba- tina ba baka		Clɛɔmɛ ciliata Schum. ɛt Thɔnn.	Cappaɾid.
inaɔlɔ a ɔ- titɔ		Sɛcuɾidɛa wɛlwitschii Oliv.	Polygal.
a- tɔb		Chlamydɔɛɔla chlamydantha(K.Schum.) Bɔɛlaɾd	Stɛɾculi.
bi- tɔbi bitɔkɔ		Cɛlɔsia tɾigyna L	Amaɾanth.
i- tɔbitɔbi	1.	Dɔɾstɛnia bɾiɛyi De Wild.	Mɔɾ.
	2.	D. sɔlhɛidi De Wild.	Mɔɾ.
a- tɔka		Cɔla digitata Mast.	Stɛɾculi.
bi- tɔkɔ	1.	Cɛntɾɔstachys aquatica(R.Bɾ.)Willd.	Amaɾanth.
	2.	Psilɔtɾichum axilliflɔɾum Susseng.	Amaɾanth.
i- tɔkɔ		Psilɔtɾichum axilliflɔɾum Susseng.	Amaɾanth.
inaɔlɔ a i- tɔkɔ		Impatiɛns iɾvingii Hɔɔk. f.	Balsamin.
ɔ- tɔkɔ		Chytɾanthus maɛɾɔbɔtɾys (Gilg.) Exell ɛt Mɛndɔnça	Sapind.
ɔ- tɔkɔlɔ lɔ fufɔ		Chytɾanthus mɔɾtɛhanii (Dɛ Wild.) dɛ Vɔldɛɾ ɛx Haumann	Sapind.
inaɔlɔ a ɔ- tɔkɔlɔ	1.	Radlkɔfɛɾa calɔdɛndɾɔn Gilg.	Sapind.
	2.	Chytɾanthus ɛaɾnɛus Radlk. ɛx Mildbɾ.	Sapind.
	3.	C. mɔɾtɛhanii (Dɛ Wild.) dɛ Vɔldɛɾ ɛx Haumann	Sapind.
	4.	C. sɛtɔsus Radlk.	Sapind.
	5.	Chytɾanthus stɛnɔphyllus	Sapind.
li- tɔlɔ		Nymphaea lɔtus L	Nymphac.
lɔ- tɔmbɔ		Vigna ɔblɔngifɔlia A.Rich.	Fab.
bɔ- tɔnɛ	1.	Dalbɛɾgia afzɛliana G.Dɔn.	Fab.
	2.	Dicɾɔstachys pɔlycaɾpa Wɛlw.	Mimɔs.
bɔ- tɔnɛ bɔ bɔliki		Dalbɛɾgia hɔstilis Bɛnth.	Fab.

to- toto (et t- ototo)		
inaolo a li- tsutsu	Urera cameroonensis Willd.	Urtic.
li- tuku	1. Aeschynomene cristata Vatke	Fab.
	2. Ac. nilotica Taub.	Fab.
	3. Ac. uniflora E.Mey	Fab.
	4. Cassia kirkii var. guineensis Steyaert	Fab.
	5. C. occidentalis L	Fab.
i- tuku	Biophytum zenkeri Guill.	Oxalid.
li- tuku li tokembe	Aeschynomene elaphroxylon (Guill. et Perr.) Taub.	Fab.
inaolo a li-tuku	Aeschynomene sensitiva Schwartz	Fab.
a- tukulu	Sterculia subviolacea K.Schum.	Sterculi.
inaolo a i- tula	Cola sciaphylla Louis ex Germain	Sterculi.
tulu e nicle	1. Ficus bubu Warb.	Mor.
	2. F. vogelii (Miq.) Miq.	Mor.
tulu e likolo	1. F. ottoniaefolia (Miq.) Miq.	Mor.
	2. F. stipitata Lebrun	Mor.
	3. F. wildemaniana Warb.	Mor.
e- tundo	Dichapetalum acuminatum De Wild.	Dichapetal.
e- tunc	Apanocalyx cynometroides Oliv.	Caesalpin.
inaolo a e- tunu	Schotia tomii De Wild.	Caesalpin.
e- tutu	Brazzeia congolensis Baill.	Scytopetal.
o- tutu	1. Cola gigantea A.Chev.	Sterculi.
	2. C. lateritia K. Schum.	Sterculi.
inaolo a o-tutu	Cola lateritia K.Schum.	Sterculi.
inaolo a e-tutu	C. sciaphylla Louis ex R.Germain	Sterculi.
li- tuwolo	1. Acrva lunata (L) Juss.	Amaranth.
	2. Cassia kirkii var. guineensis Steyaert	Caesalpin.
	3. Celosia globosa Spring.	Amaranth.
	4. Corchorus olitorius L	Tili.
	5. Desmodium salicifolium (Poir.ex Lam.) D.C.	Fab.
	6. D. velutinum (Willd.) D.C.	Fab.
	7. Fleurya aestuans (L) Gard.	Urtic.
	8. Melochia corchorifolia L	Sterculi.
	9. M. melissaefolia Benth.	Sterculi.
	10. Sida acuta Burm.	Malv.
	11. S. rhombifolia L	Malv.

	12.	Triumfetta rhomboidea Jacq.	Tili.
	13.	Urena lobata L	Malv.
li- tuwolo lifufo	1.	Celosia laxa Schum. et Thonn.	Amaranth.
	2.	Uraria picta (Jacq.) Desv.	Fab.
li- tuwolo li nenu	1.	Hibiscus acetosella Welw.	Malv.
	2.	Melochia corchorifolia L	Sterculi.
i- tuwolo i fufo		Kosteletzkya buettneri Gürke	Malv.
inaolo a li-tuwolo	1.	Desmodium velutinum (Willd.)D.C.	Fab.
	2.	Capronia fistulosa Baill.	Euphorbi.
inaolo a lituwolo litokombo		Sida urens L	Malv.
o- twela	1.	Loranthus albizzanc De Wild.	Loranth.
	2.	L. blantyrcanus Engl.	Loranth.
	3.	L. braunii Engl.	Loranth.
	4.	L. buchneri Engl.	Loranth.
	5.	L. brunneus Engl.	Loranth.
	6.	L. djurensis Engl.	Loranth.
	7.	L. flamignii De Wild.	Loranth.
	8.	L. ituriensis Engl.	Loranth.
	9.	L. marginatus De Wild.	Loranth.
	10.	L. ugowensis Engl.	Loranth.
	11.	L. sereti De Wild.	Loranth.
	12.	Viscum congolense De Wild.	Loranth.
	13.	V. decurrens (Engl.) Bak.et Sprague	Loranth.
bo- ulu		Gossweilerodendron balsamiferum (Vermoesen) Harms	Caesalpin.
y- uma i bongolo		Turraea vogelii Hook.f. ex Benth.	Caesalpin.
y- uma i bongolo		Carpolobia delvauxii Petit	Meli.
li- uma	1.	Bombax buonopozense P.Beauv. subsp. reflexum (Sprague) Robyns	Bombac.
	2.	Ceiba pentandra (L) Gaertn.	Bombac.
o- we		Tetrapleura tetraptera (Thonn.) Taub.	Mimos.
i- mesu		Trema guineense (Schum.& Thonn.) Ficalho	Ulm.
li- woyo		Pyrenacantha klaineana Pierre ex Exell et Mendonça var. congolana Boutique	Icacin.
inaolo a liwoyo		Stachyanthus zenkeri Engl.	Icacin.
bo- wa bo ndombo		Turraeanthus africana (Welw.) Pellegr.	Meli.
bo yenge		Entada gigas (L) Fawcett et Rendle	Mimos.
bo- yonge		Gouania longipetala Hemsl.	Rhamn.
Not classified:			
kitukulo kikoloko		Cassia mimosoides L	Caesalpin.
sumo		Jatropha curcas L	Euphorbi.

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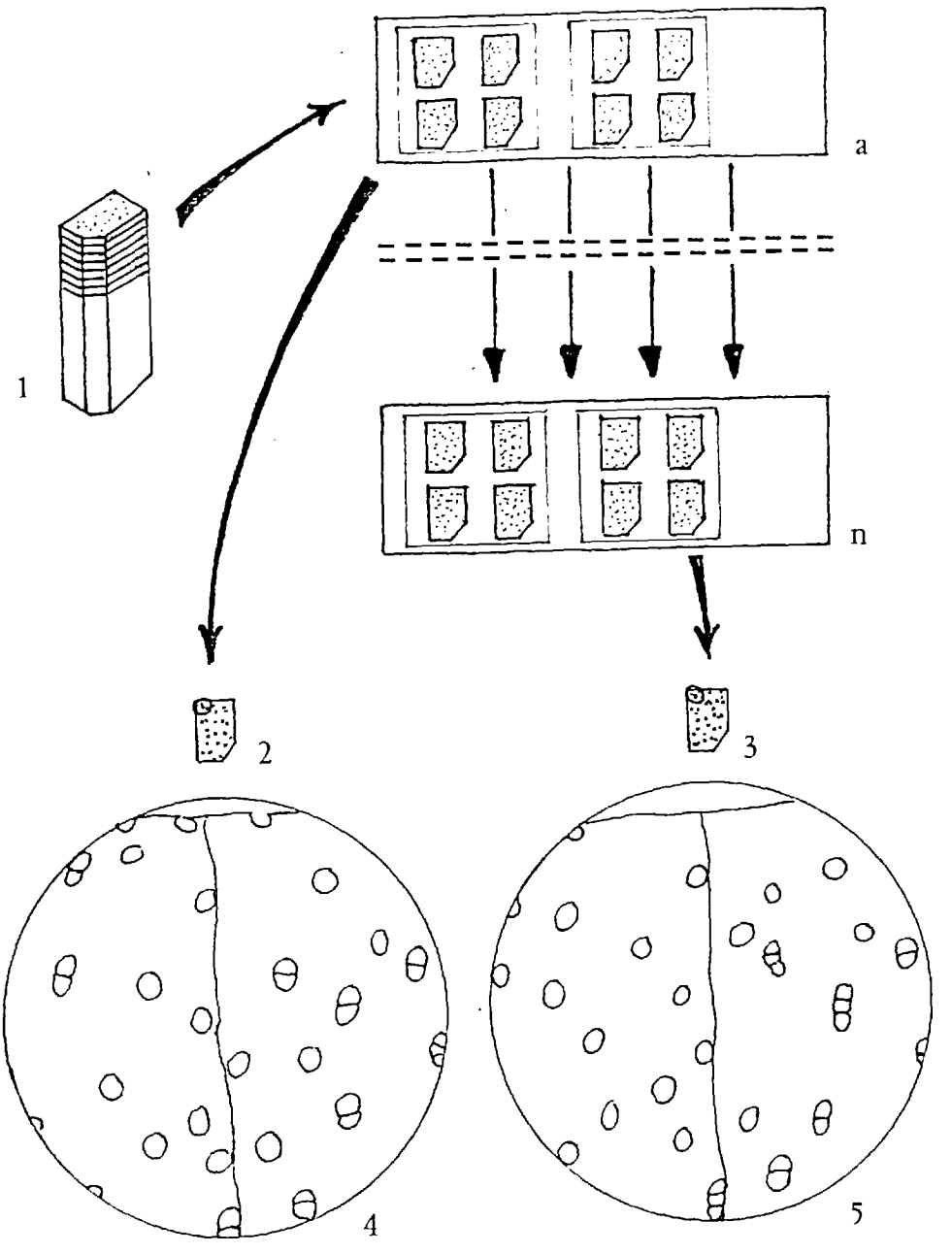


Fig.6: Vessel-network investigation.

Transverse sections of selected block 1 are mounted on a series of slides a...n and examined at known intervals 2,3 to give vessel positions 4,5 which can be compared for position changes.

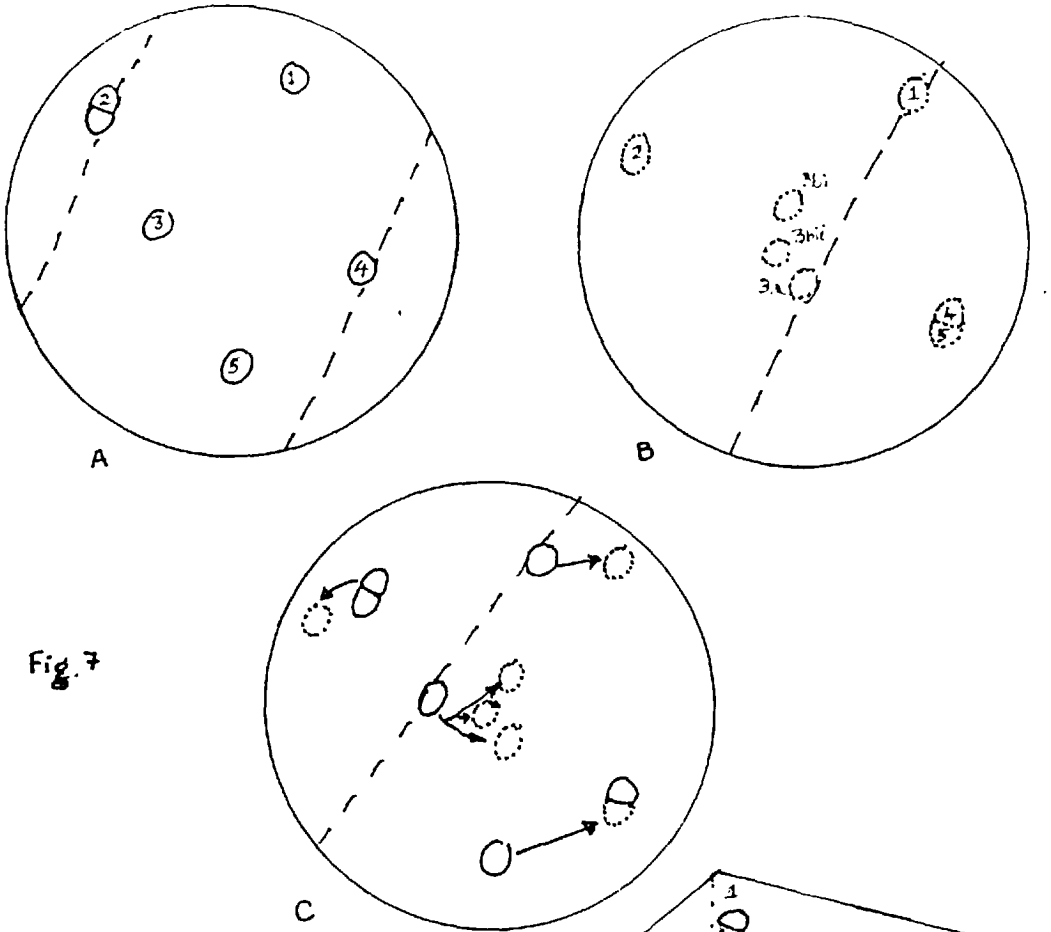


Fig. 7

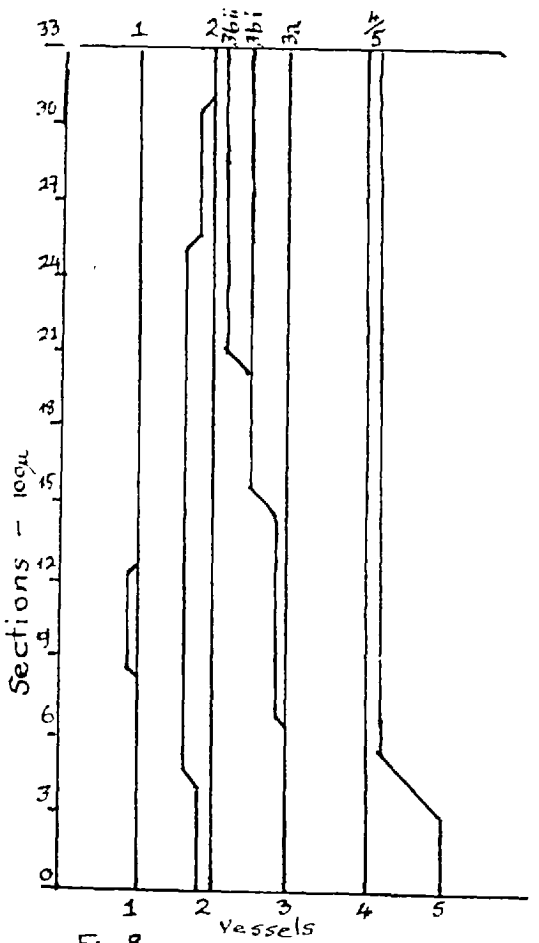


Fig. 8

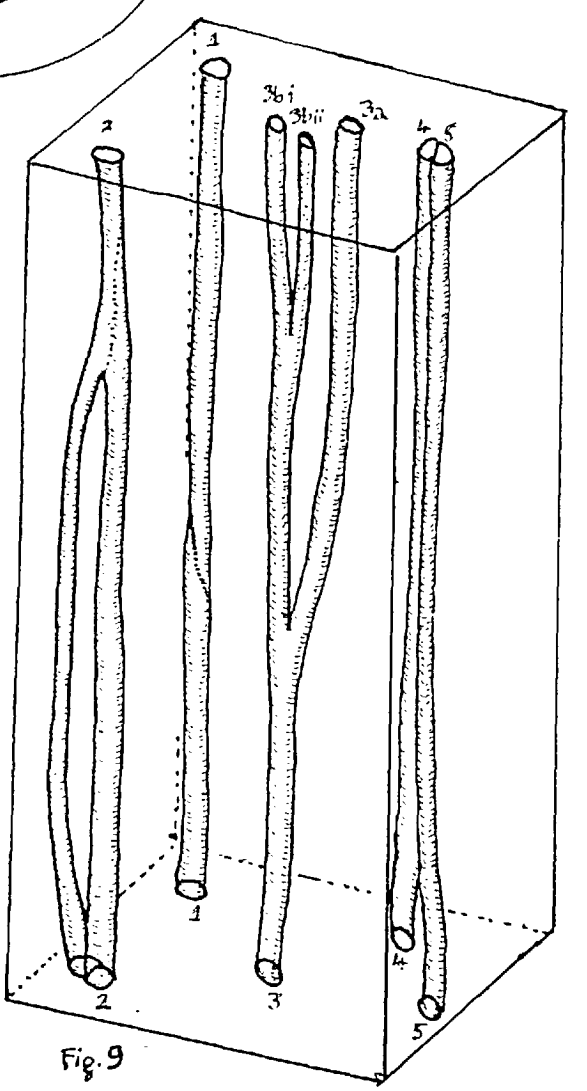


Fig. 9

Figs. 7,8,9: stages in vessel-network investigation.
For explanation, see text.

Fig.11 Determination of microfibrillar angle from fibre pits

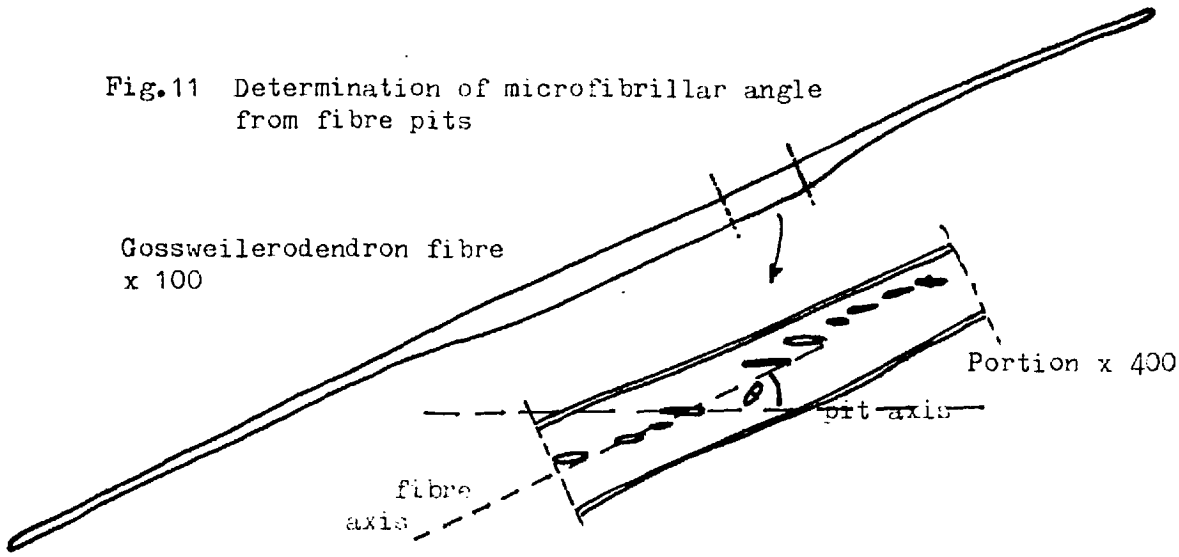


Fig.12 Diagrams of the six species studied

I comparative height, trunk length and canopy type;
II architectural models according to Hallé and Oldeman (1970).

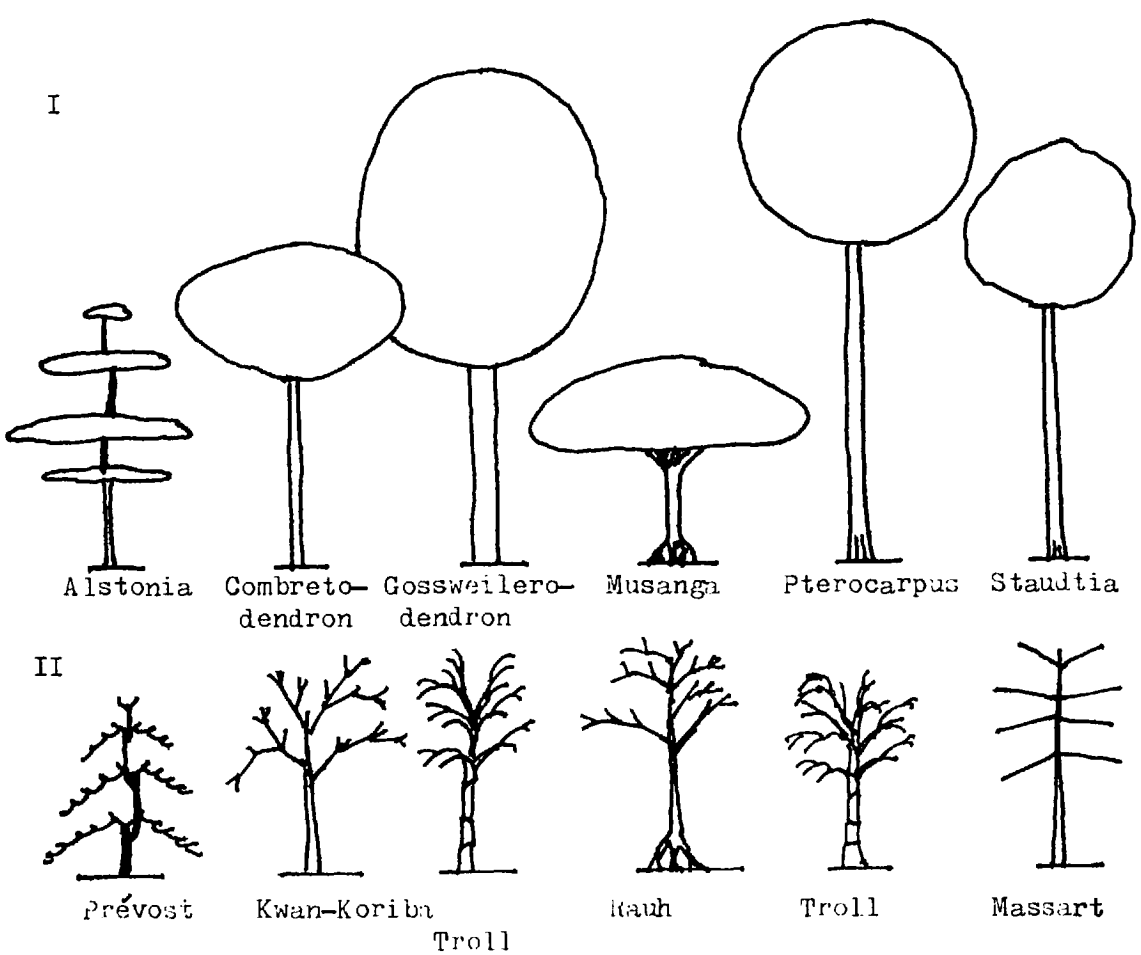
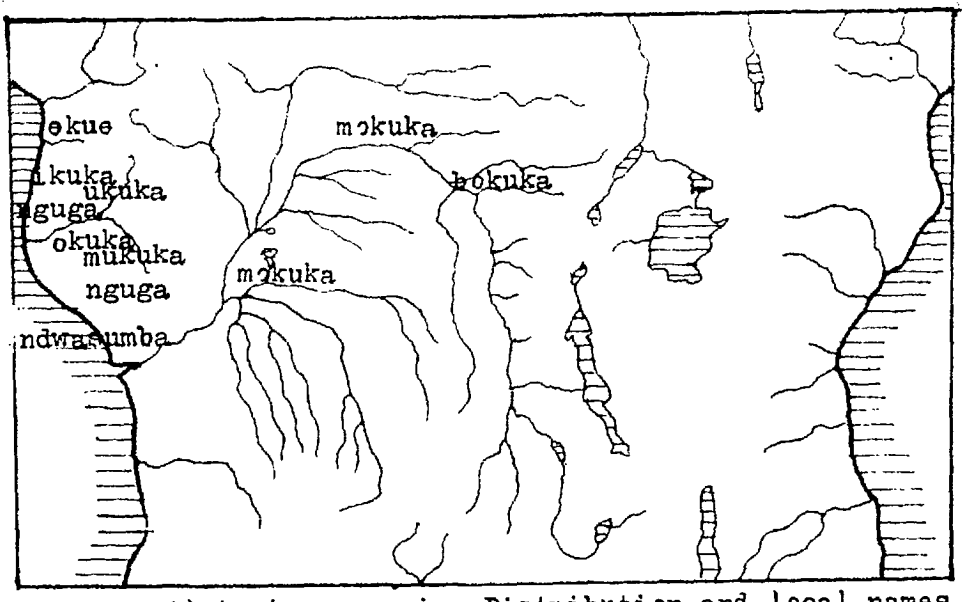
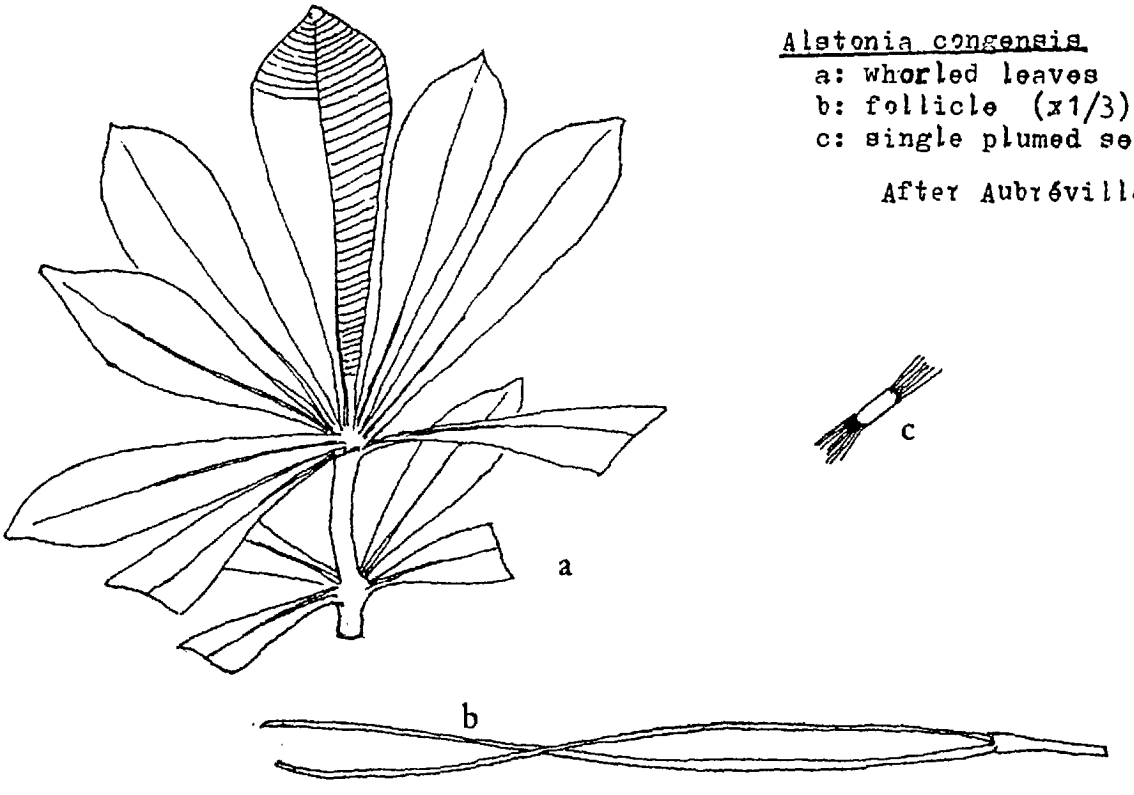


Fig. 13



Alstonia congenis Distribution and local names



Alstonia congensis
a: whorled leaves (x1/3)
b: follicle (x1/3)
c: single plumed seed (x1)

After Aubréville

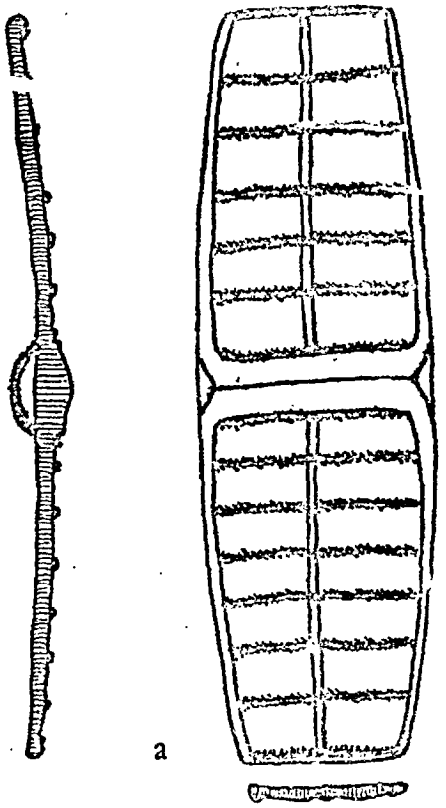


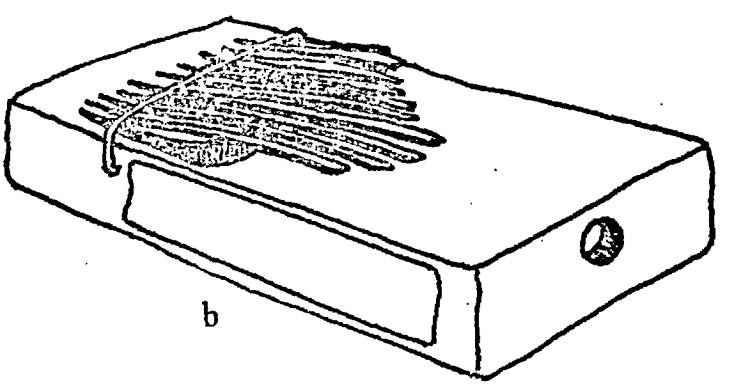
Fig. 14

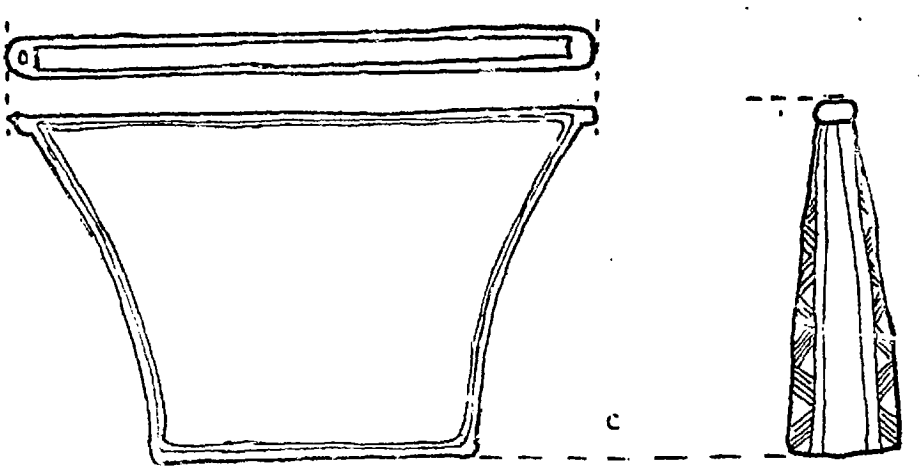
Alstonia artefacts from the Upper Zaïre

a: shield with cane reinforcement x1/10

b: /likwengu/ or "hand piano" x1/2

c: /longombe/-type talking-drum x1/10





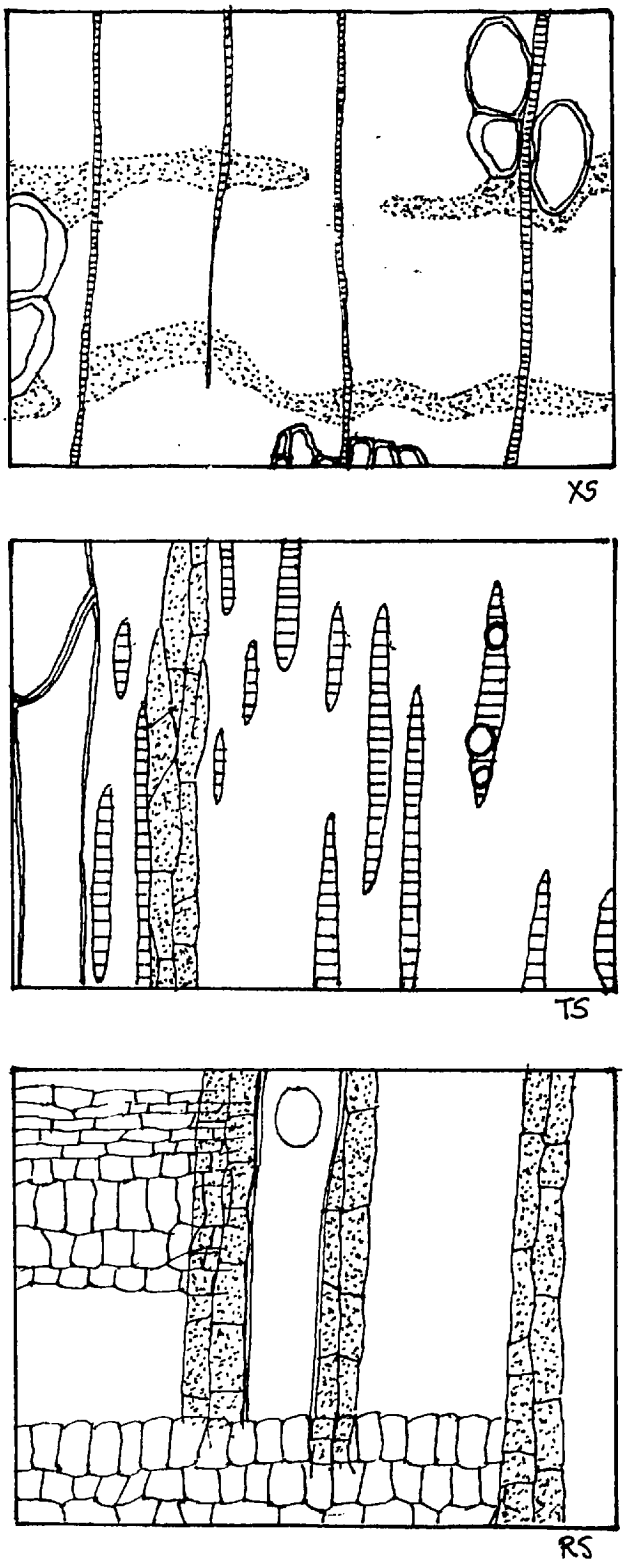


Fig.15. Alstonia congensis: diagrams of xylem sections; all x80.

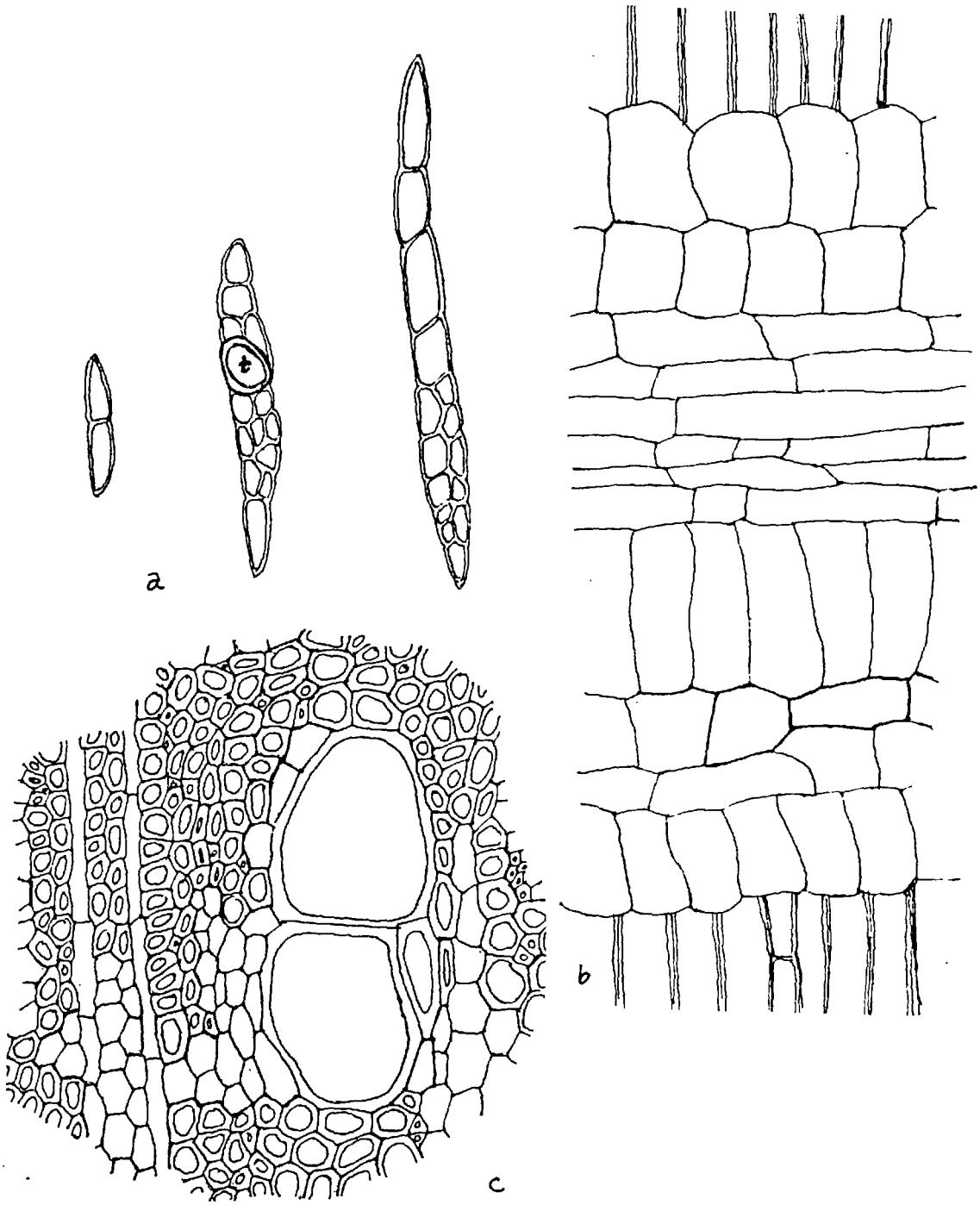


Fig. 16

Alstonia congensis: camera lucida drawings of xylem tissues.
a: uniseriate and multiseriate rays, one with latex tube t; TS x250
b: heterocellular ray RS x250
c: XS with vessels, parenchyma, fibres and rays (x200)

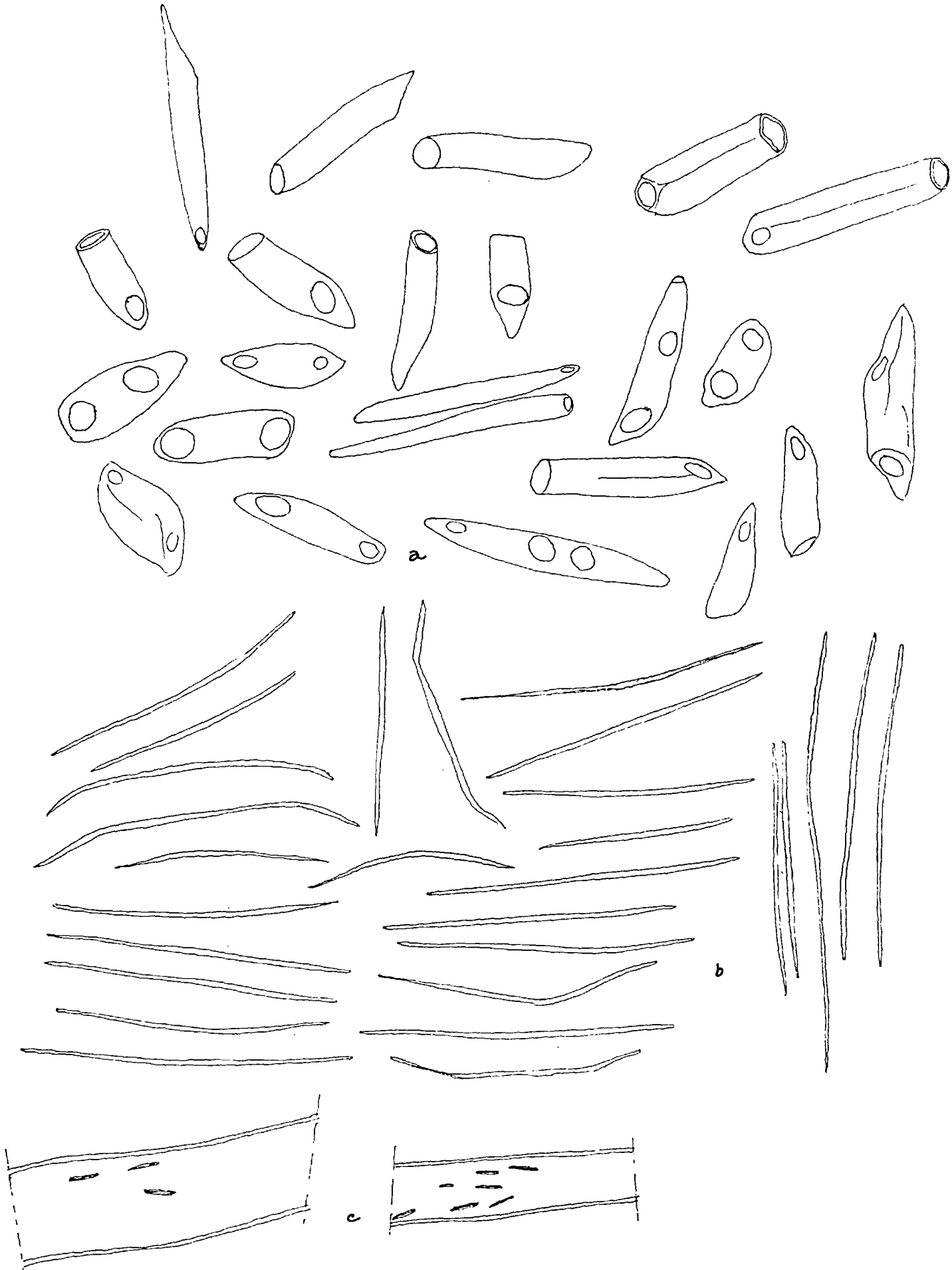


Fig. 17 Alstonia congensis: a. vessel elements x50
b. fibres x50
c. parts of fibres x400
with pitting

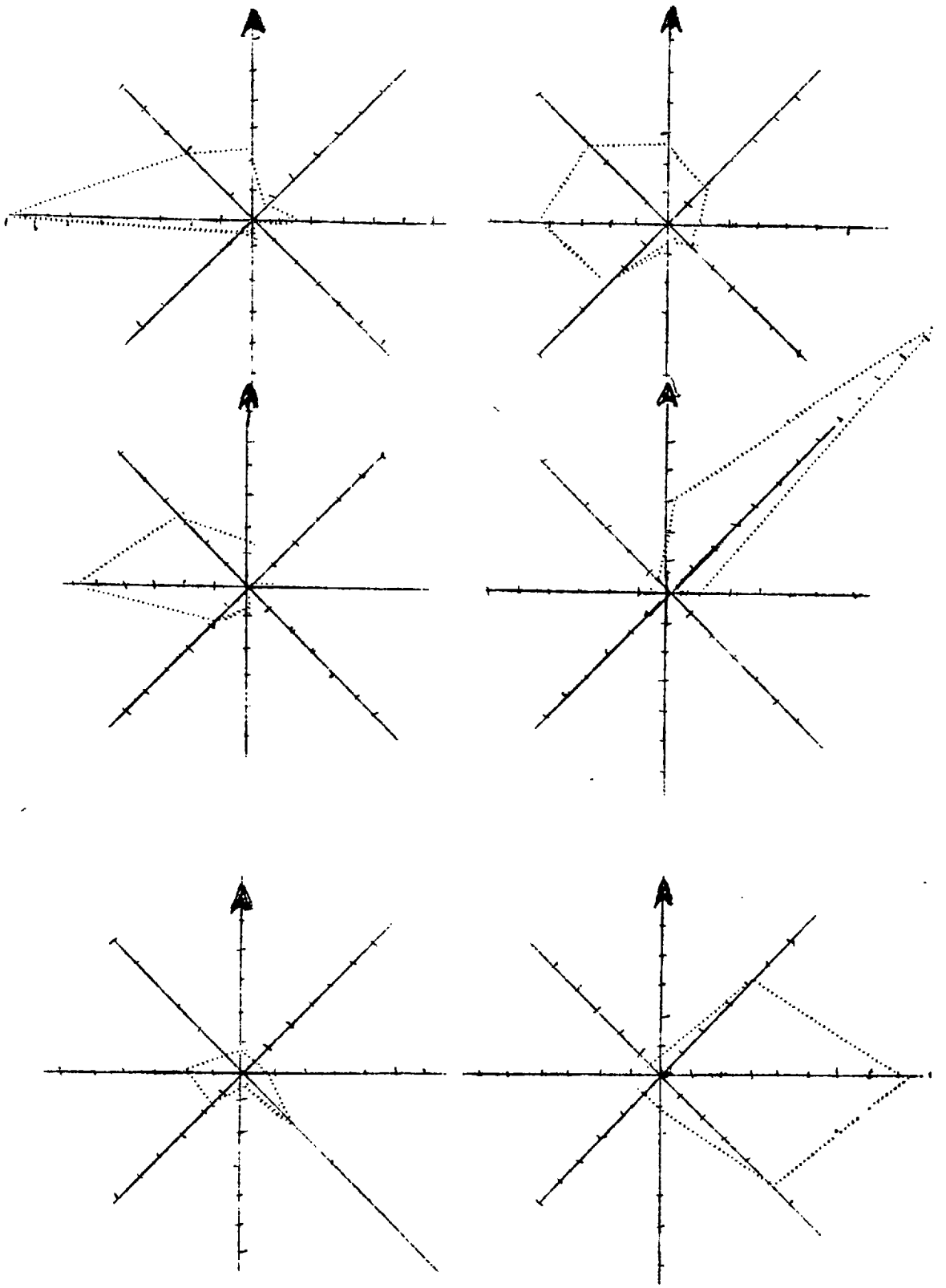


Fig. 19 Alstonia: rose-diagrams of vessel movement

Fig. 20 Combretodendron macrocarpum. Local names

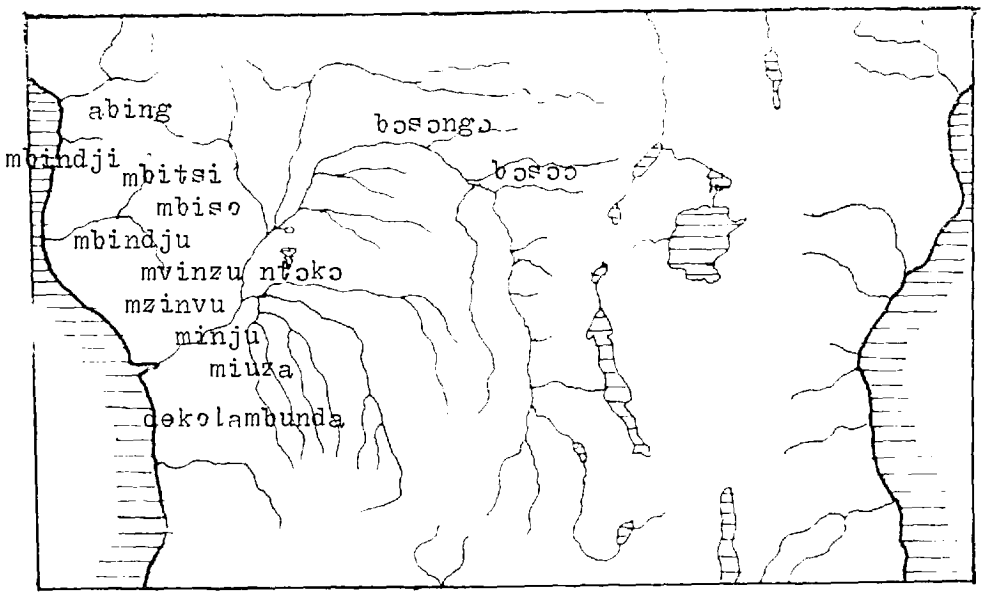
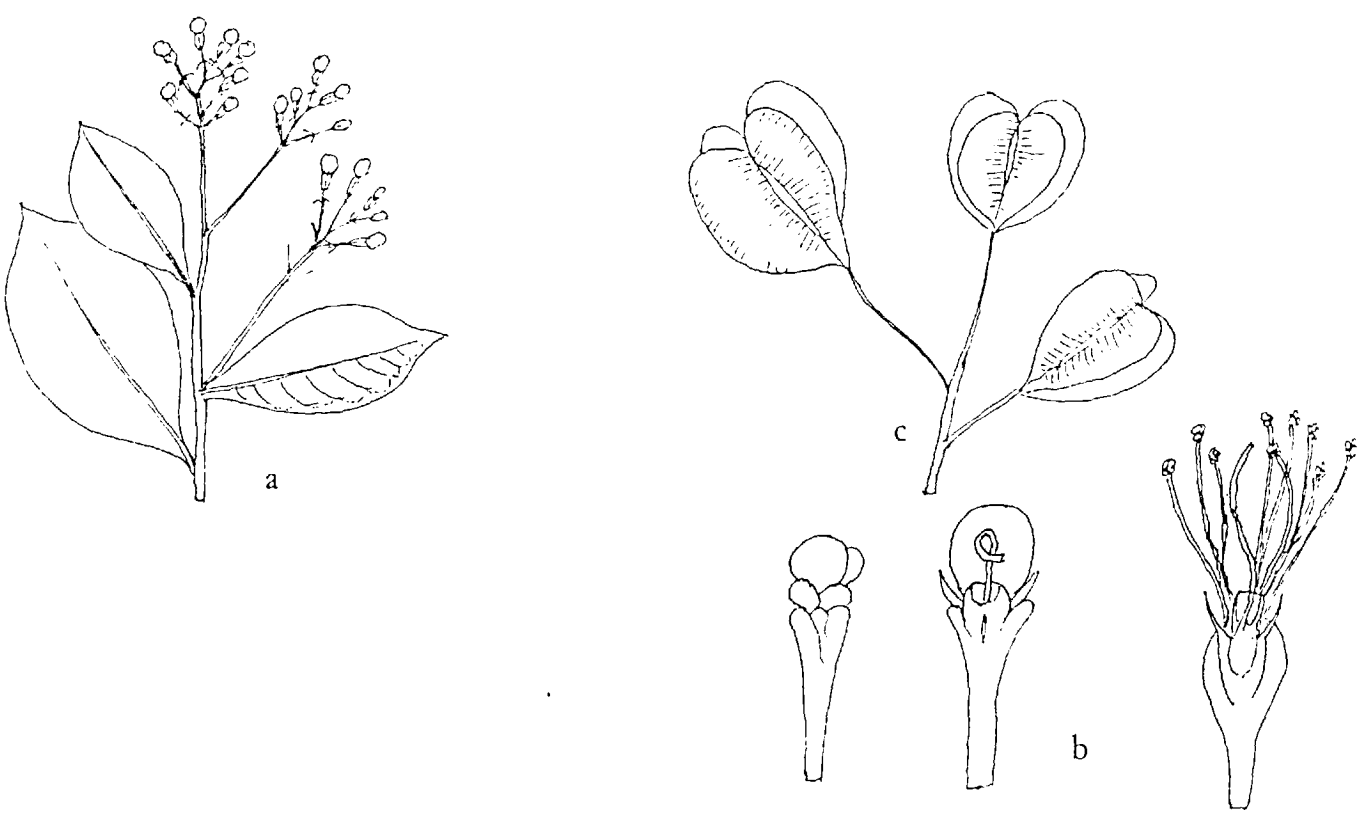


Fig. 21. Combretodendron macrocarpum: morphology.

a. inflorescence $x\frac{1}{2}$

b. flowers x2

c. fruiting branch x 1/3. All after Aubréville.



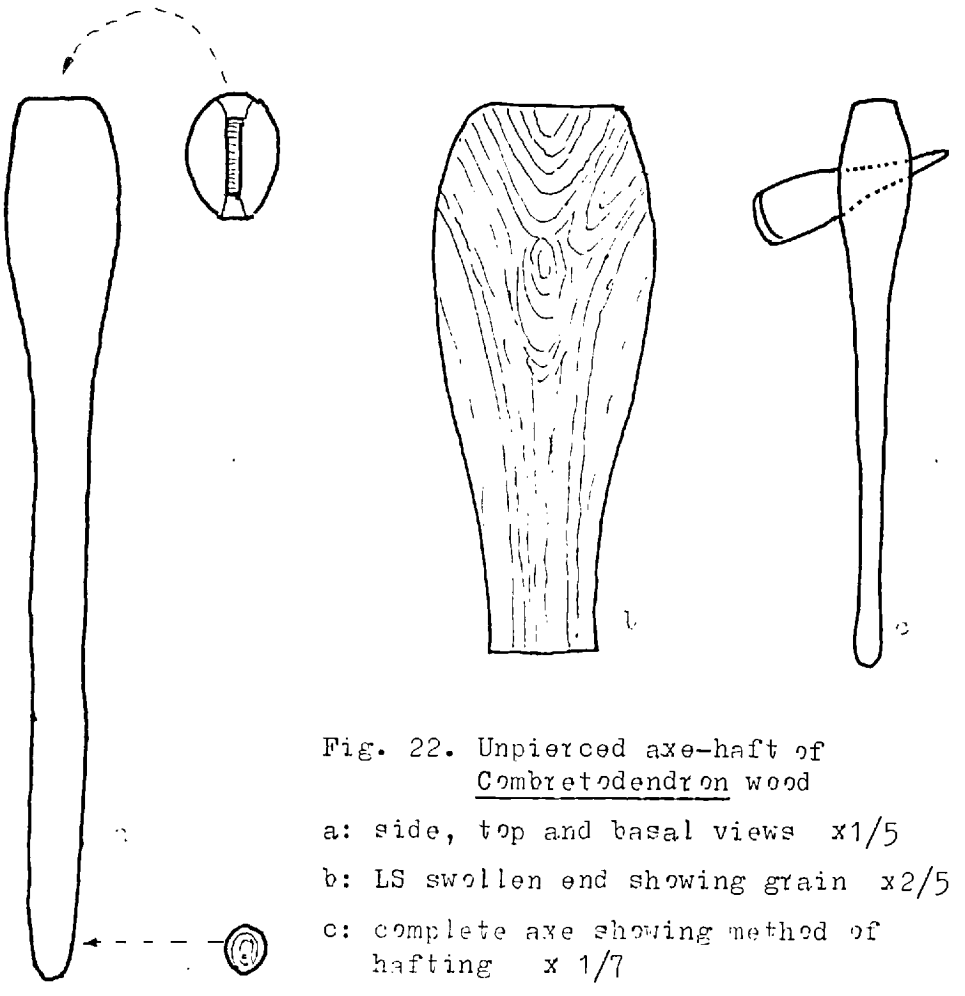


Fig. 22. Unpierced axe-haft of Combretodendron wood

a: side, top and basal views x1/5

b: LS swollen end showing grain x2/5

c: complete axe showing method of hafting x 1/7

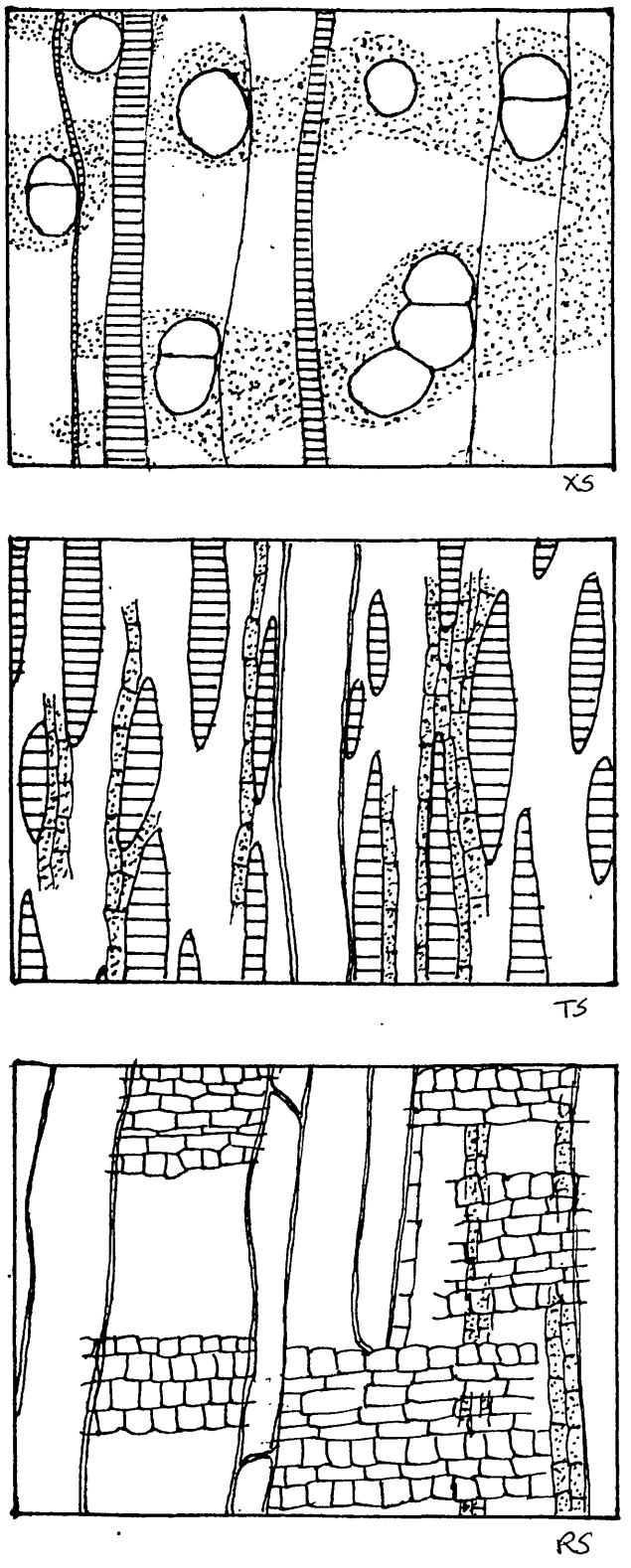
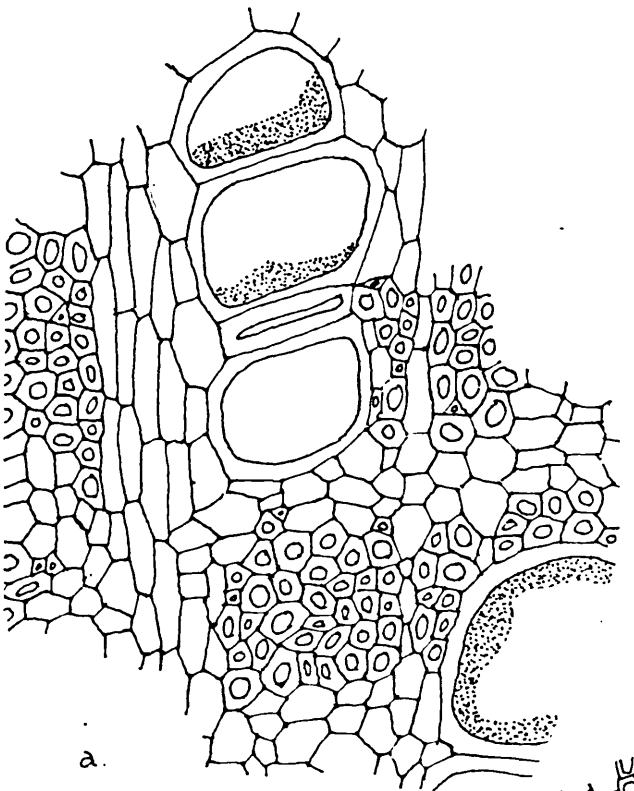
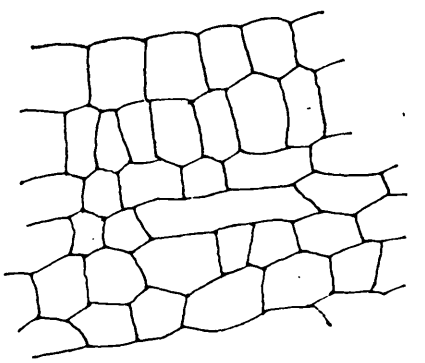


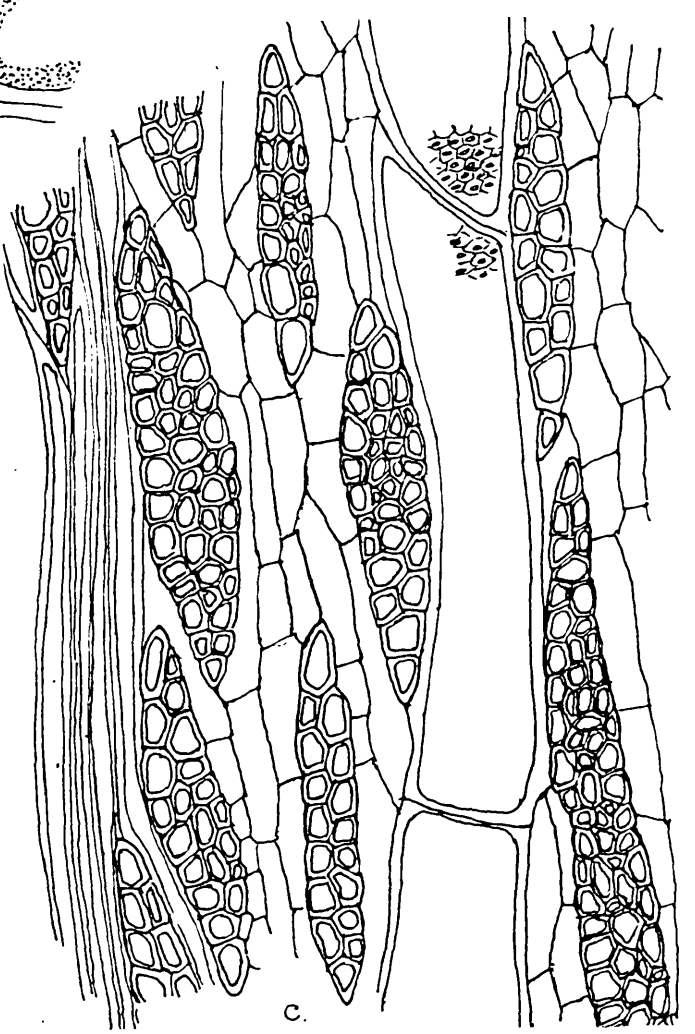
Fig. 23. Combretodendron macrocarpum: diagrams of xylem sections; all x80.



a.



b.



c.

Fig. 24

Comretodendron macrocarpum.
Detailed sections x300
a. cross section
b. ray in radial section
c. tangential section

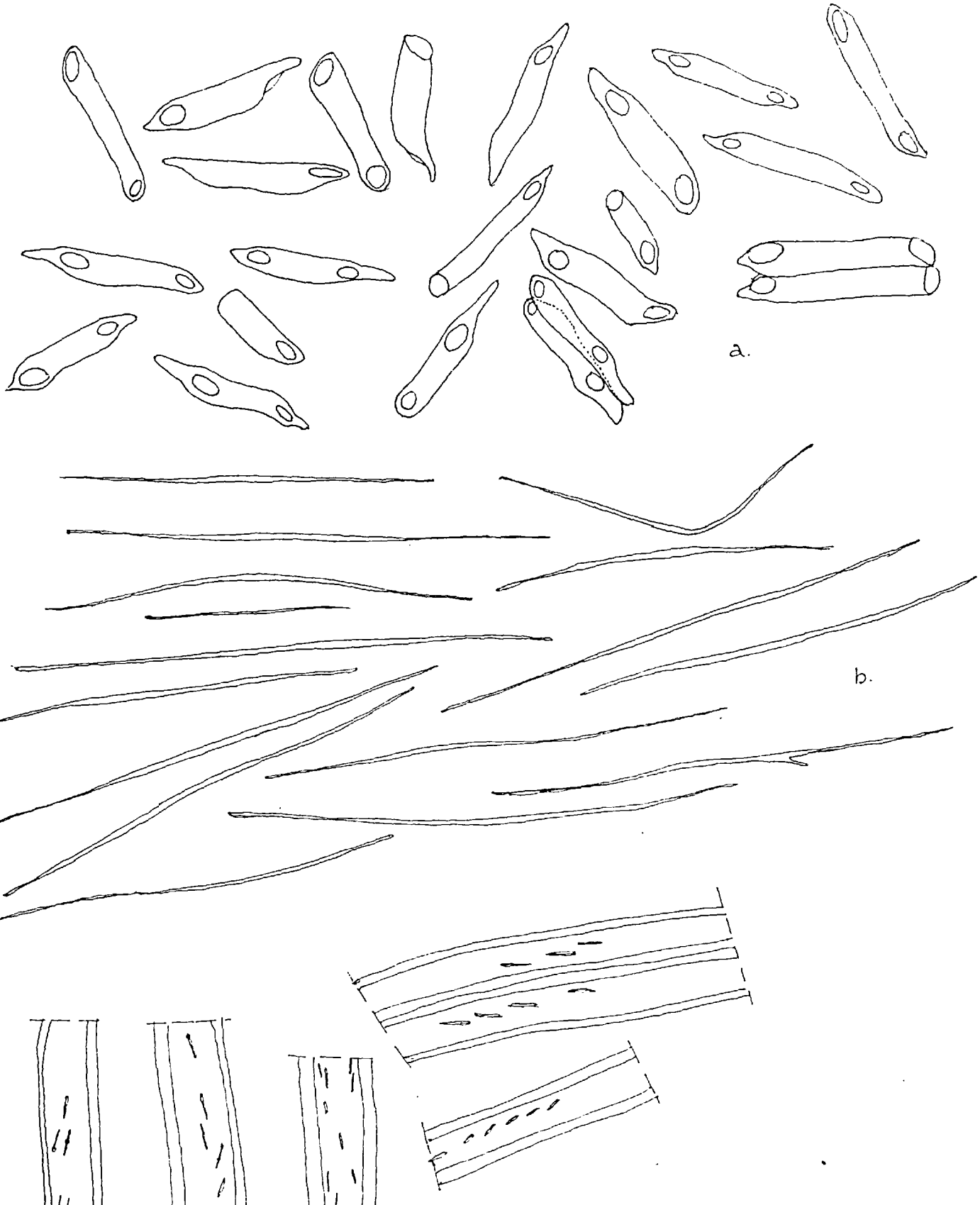


Fig. 25

Combretodendron macrocarpum:
a. Vessel elements x50
b. Fibres x50
c. Portions of fibres x400 with pitting

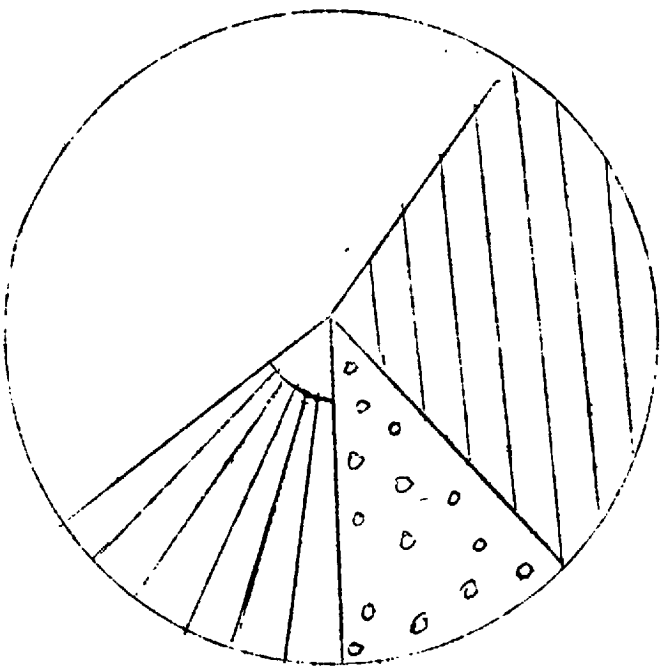


Fig. 26 Tissue distribution in Combretodendron xylem.

Symbols as in Fig. 18

Fig. 28 Gossweilerodendron balsamiferum. Local names

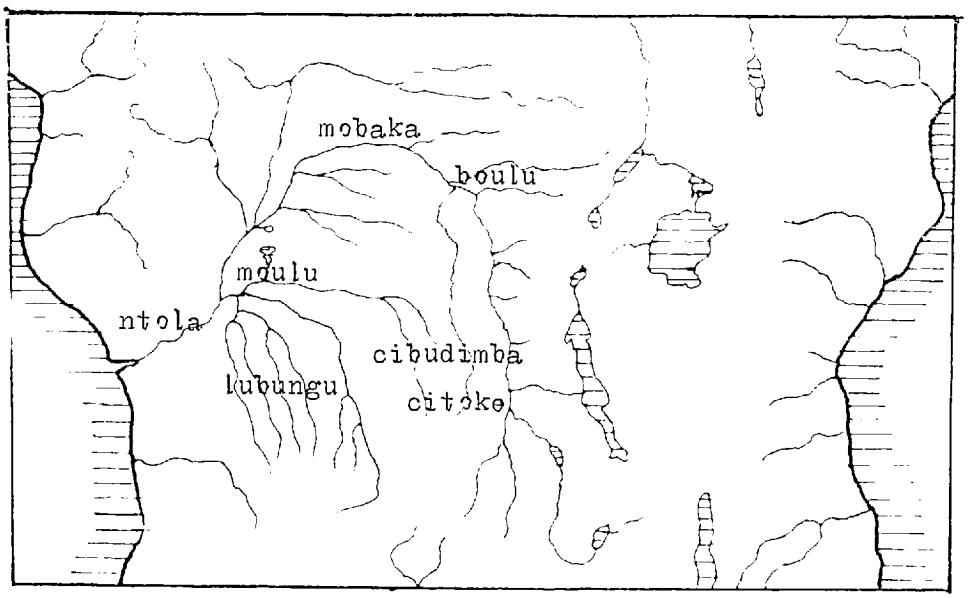


Fig. 29. Gossweilerodendron balsamiferum: morphology;

a. flowering branch x$\frac{1}{4}$,

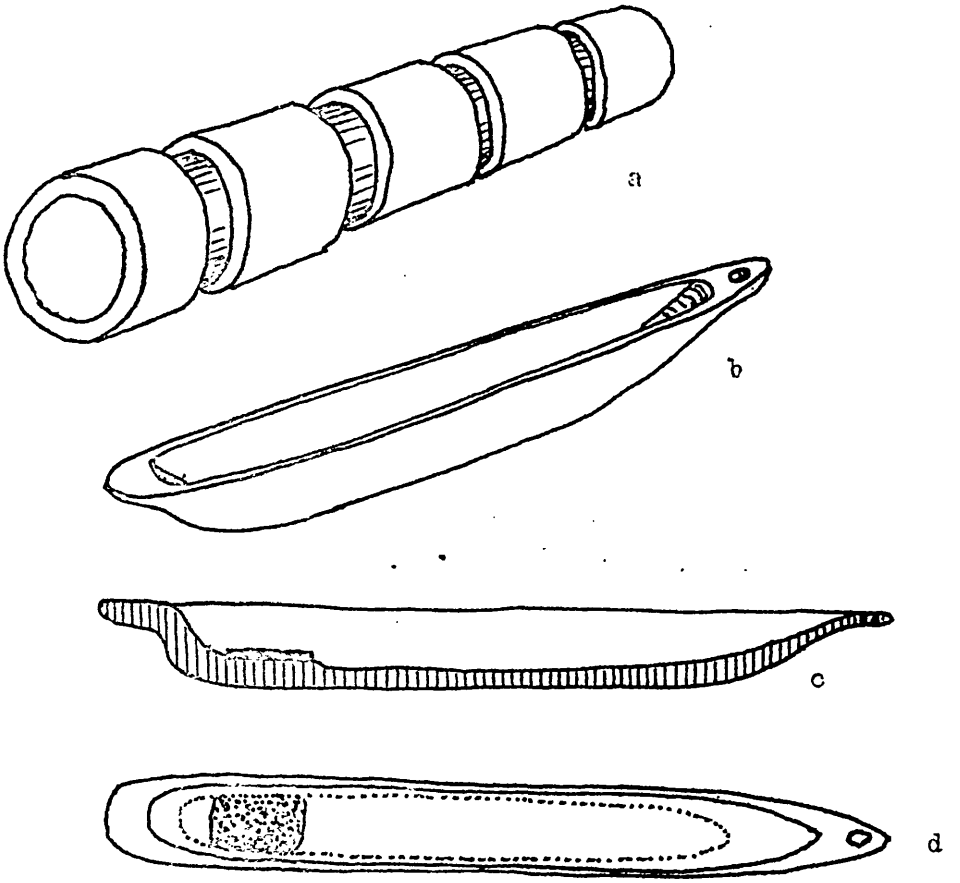
b. flower x8,

c. flower section x8,

d. flower bud x8,

e. fruit x$\frac{1}{4}$. All after La Flore du Congo Belge.





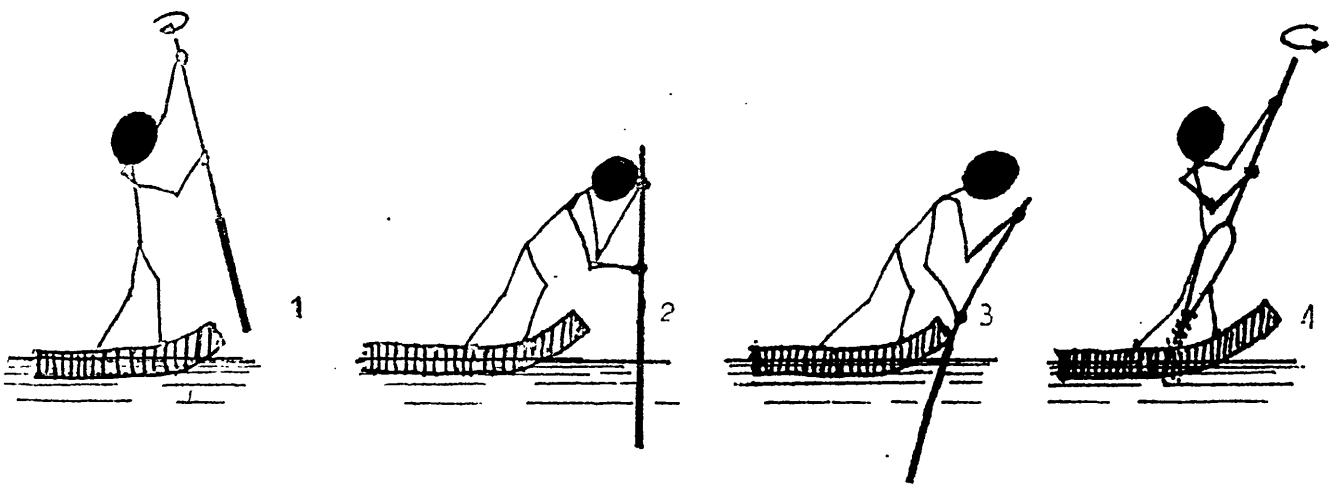


Fig. 30 Gossweilerodendron balsamiferum. Canoe manufacture and handling

a: method of removing bark and sapwood
b: side view of finished canoe
c: section of canoe
d: view from above showing hearth covered with clay
1-4 stages in paddling stroke

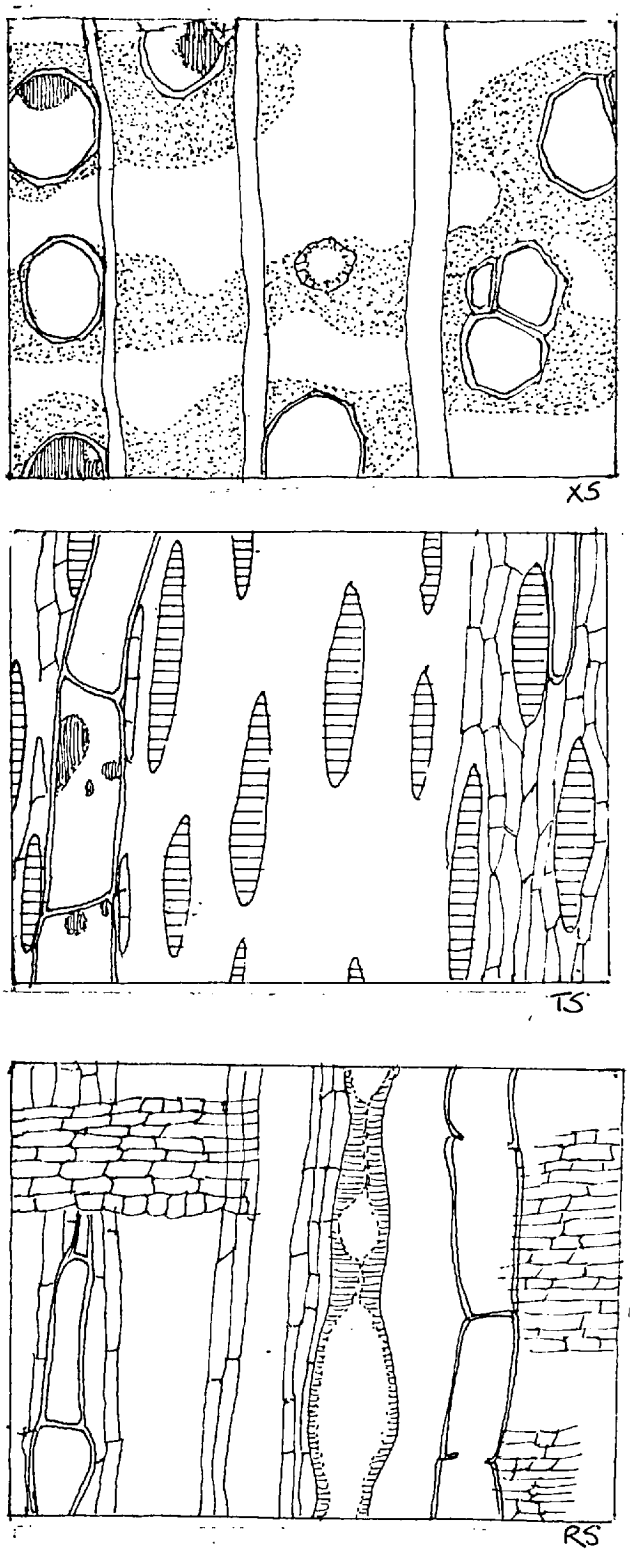


Fig.31. Gossweilerodendron balsamiferum: diagrams of xylem tissues. [x50]

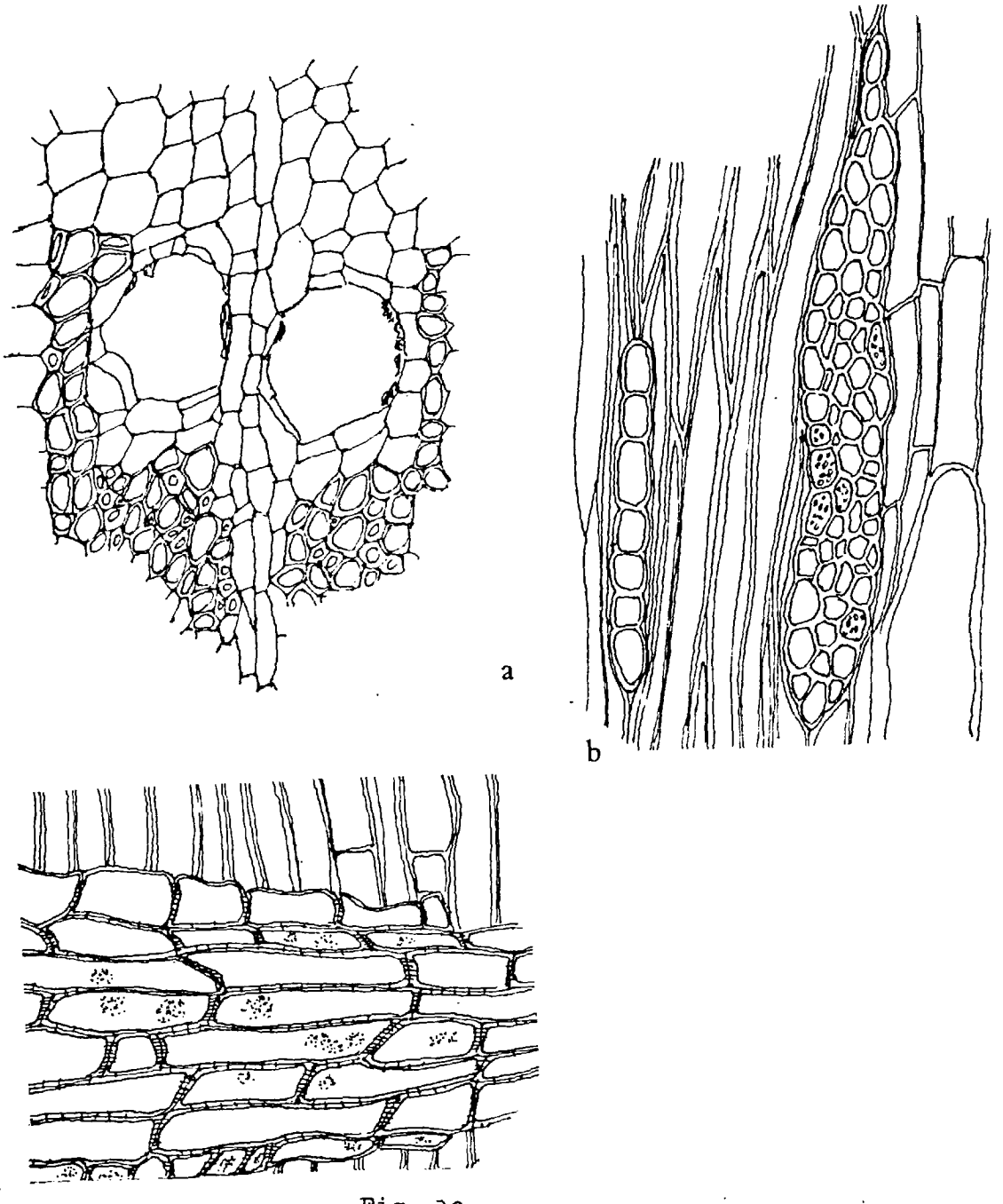
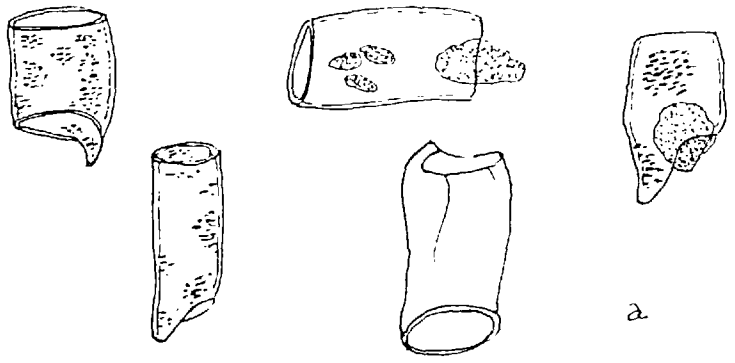
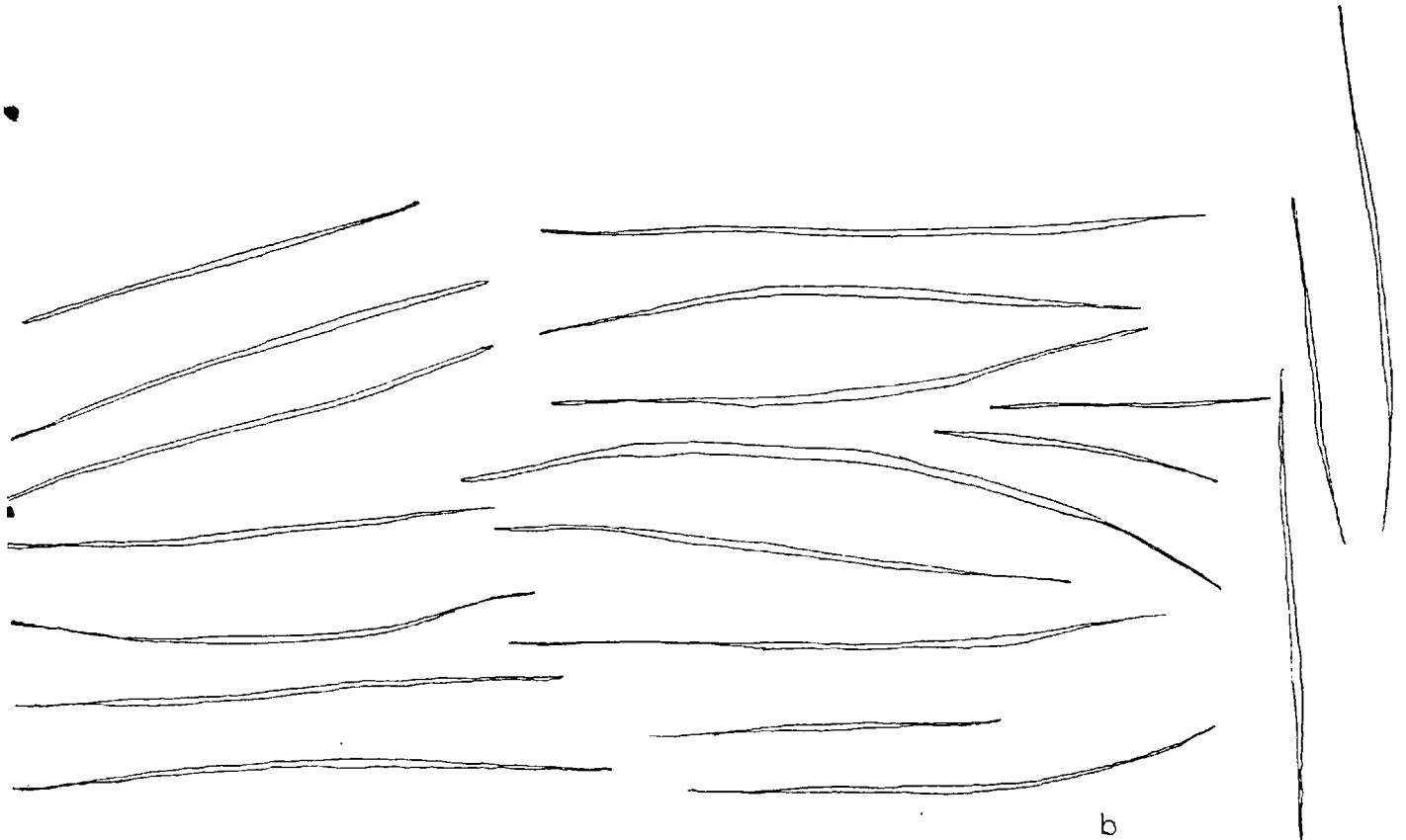


Fig. 32

Gossweilerodendron balsamiferum

a: XS showing resin ducts,
b: TS - uniseriate and multiseriate rays,
c: RS - heterocellular ray.
All x250





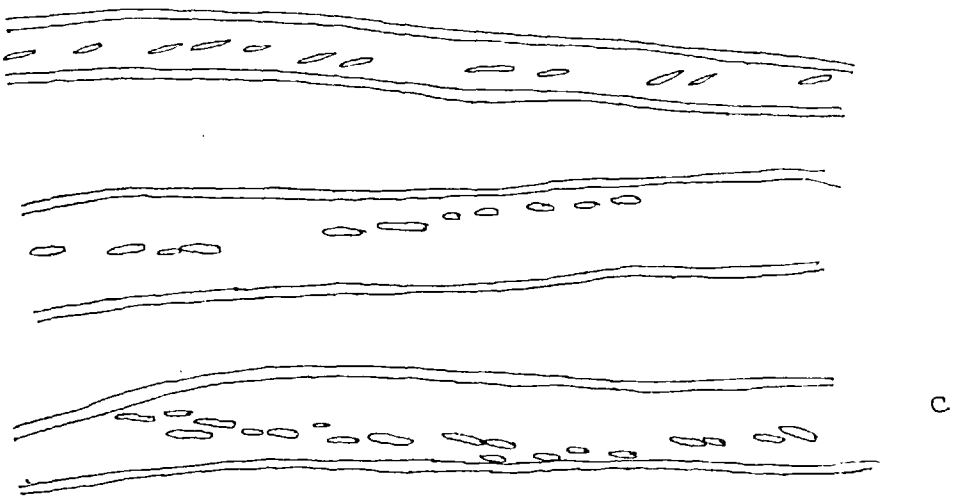


Fig. 33 Gossweilerodendron balsamiferum

Camera lucida drawings of a. vessel elements x50
b. fibres x50
c. fibre portion x400 with pitting

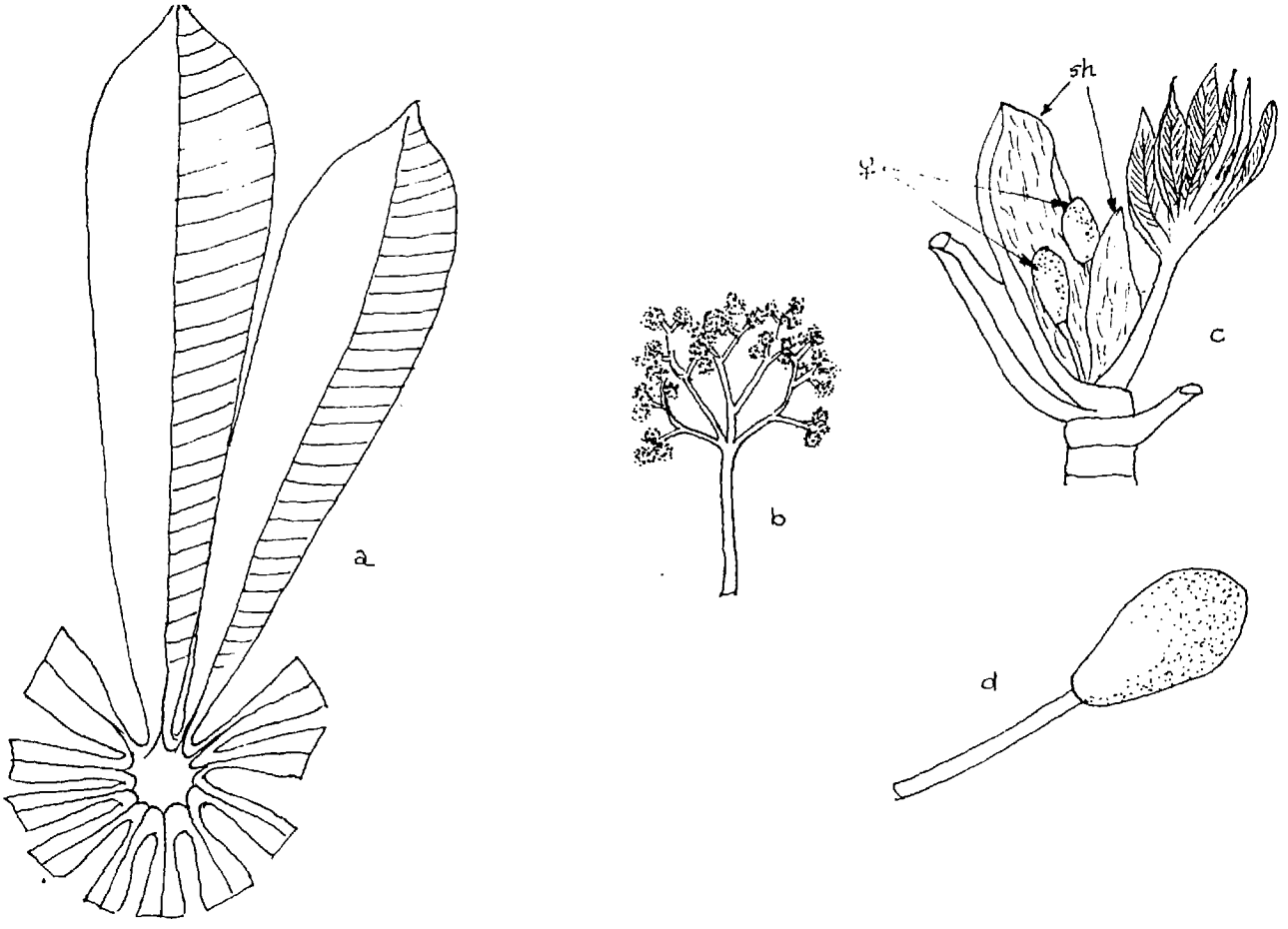


Fig. 37. Musanga cecropioides: morphology;

a. part of leaf x1/3,

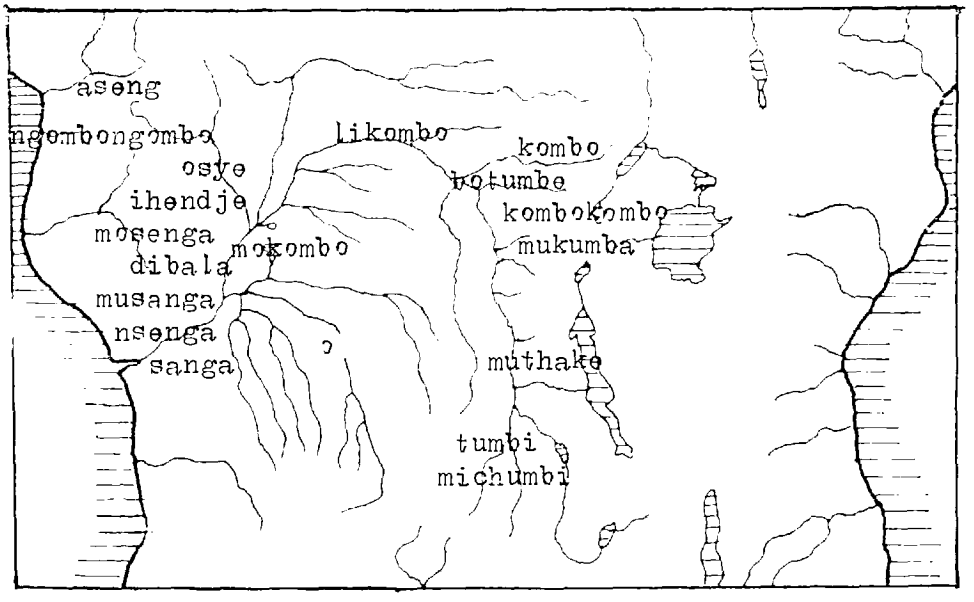
b. male inflorescence x1/3,

c. branch tip with female inflorescence and stipules x1/3,

d. compound fruit x1/3.

All after Aubréville.

Fig. 36 Musanga cecropioides. Local names



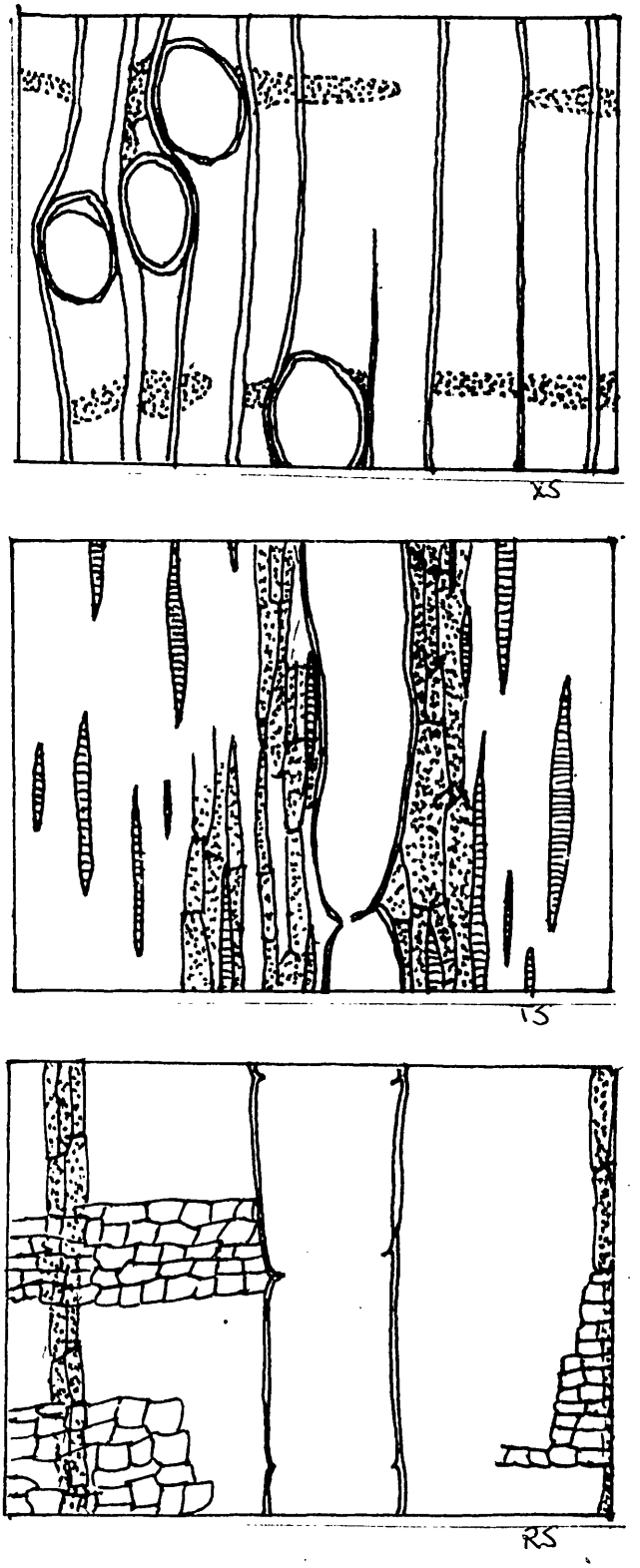


Fig. 39. Musanga cecropioides: diagrams of xylem sections. [x 50]

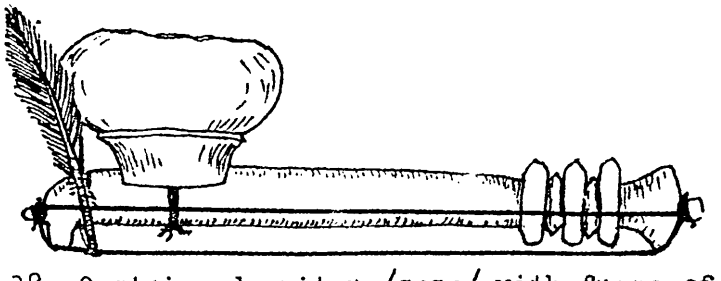
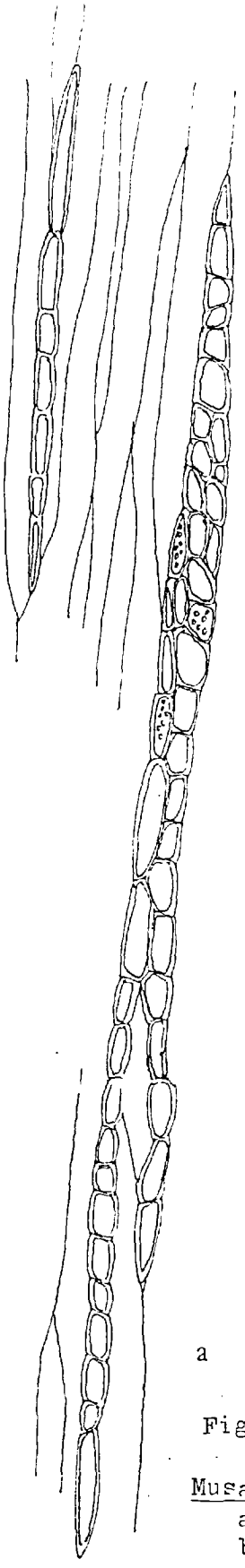
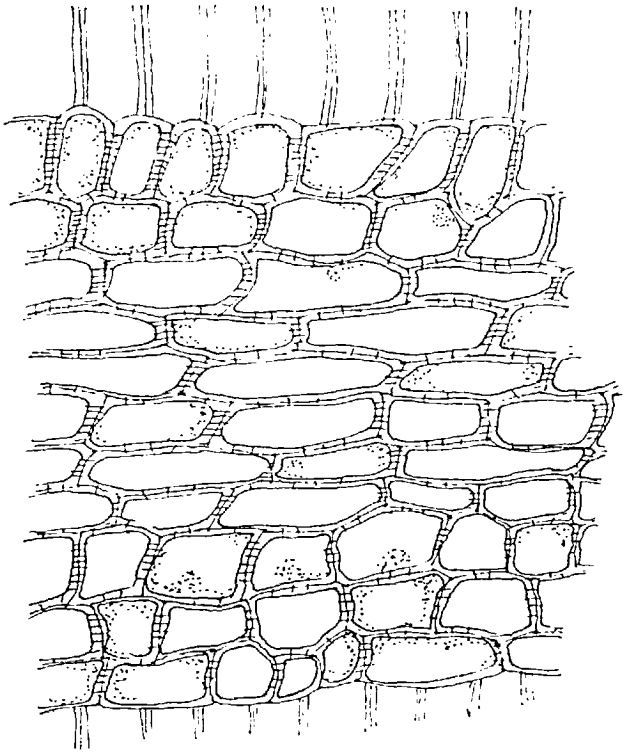


Fig.38 2-stringed guitar /sesɛ/ with frame of Musanga wood [x 1/6]



a



b

Fig.40

Musanga cecropioides: camera lucida drawings of xylem tissues.
a: TS uniseriate and multiseriate rays
b: RS heterocellular ray

[All × 250]

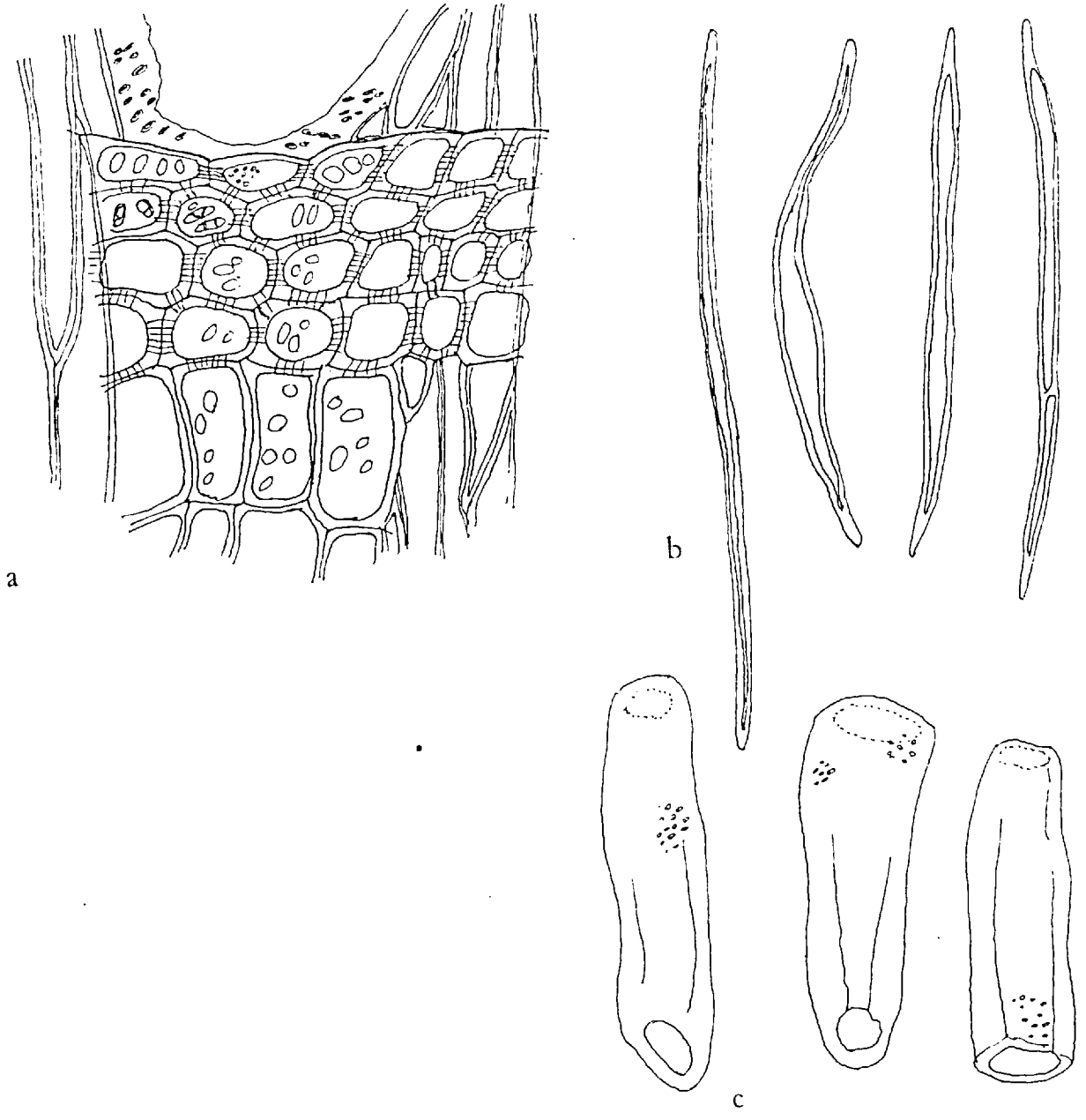
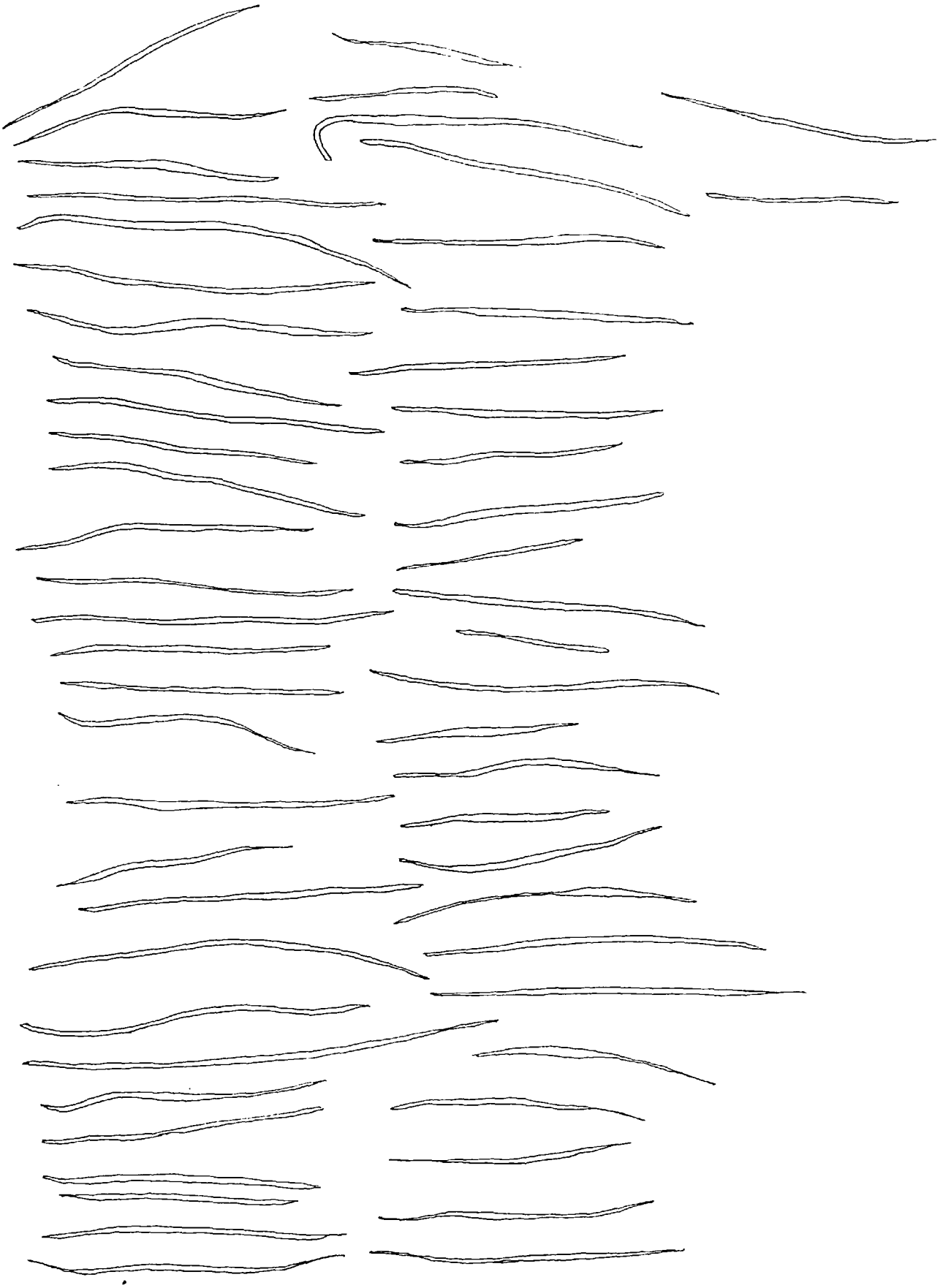


Fig. 41

Musanga cecropioides. Camera lucida drawings
a: RS showing vessel-ray pitting (x200)
b: typical fibres (x 100)
c: vessel elements (x100)

Fig. 42

Musanga cecropioides- fibres (x50)



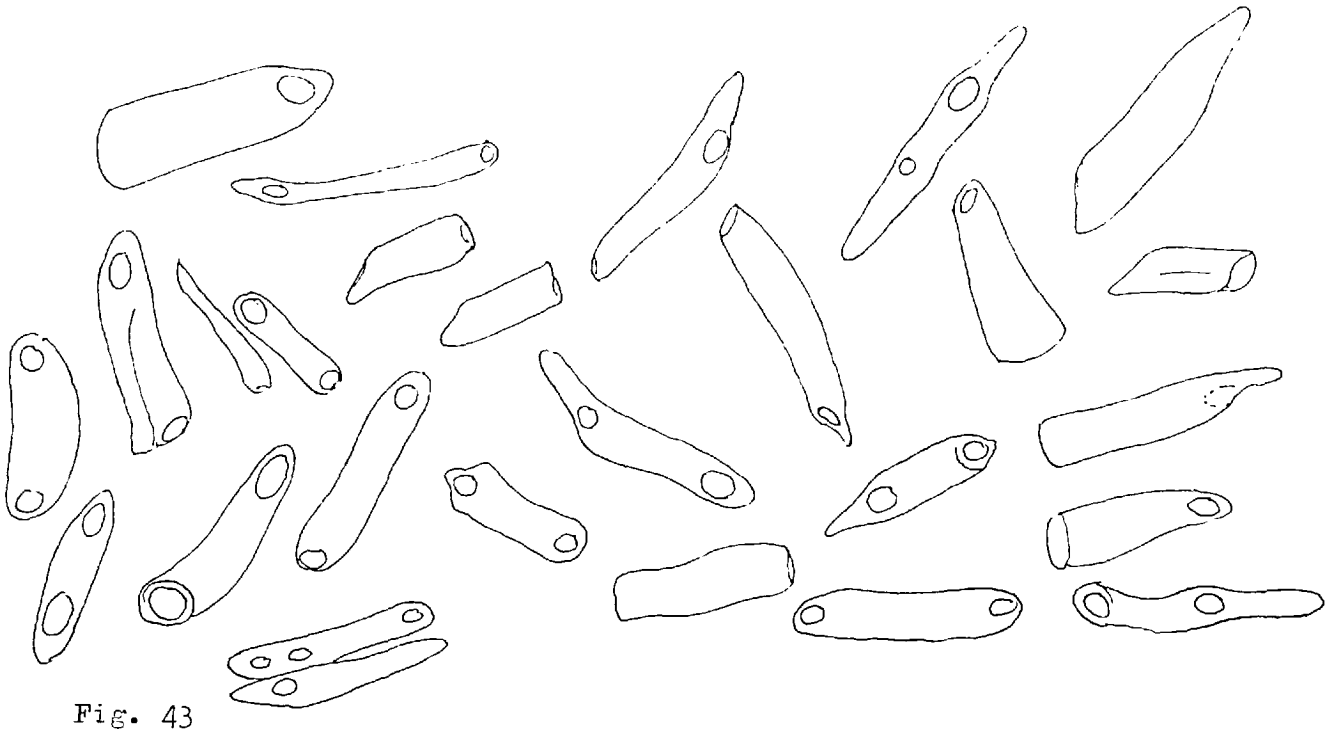


Fig. 43

Musanga cecropioides – vessel elements (x50)

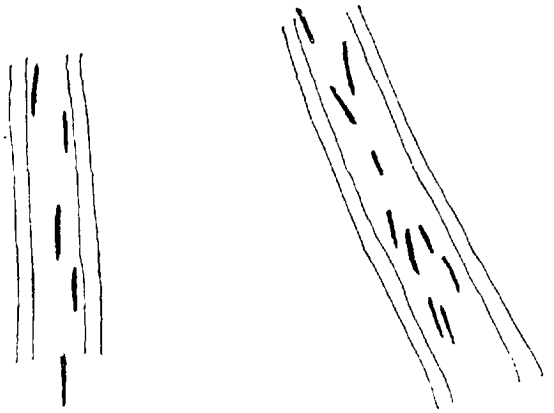
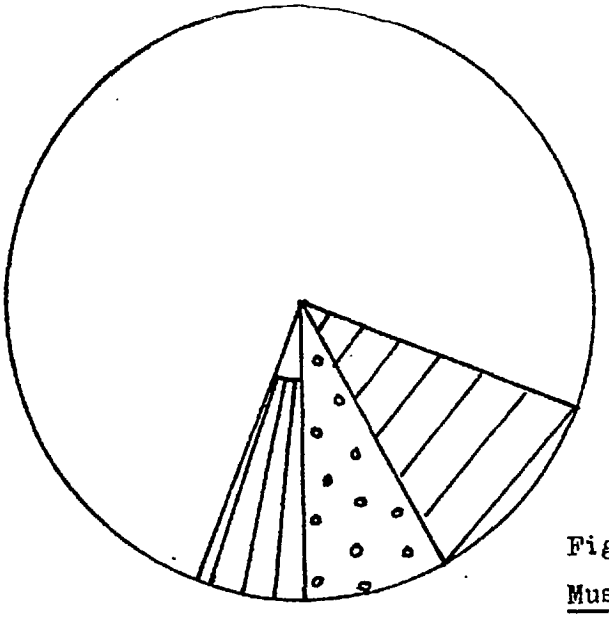


Fig. 44

Musanga cecropioides: pits in fibres (x200)



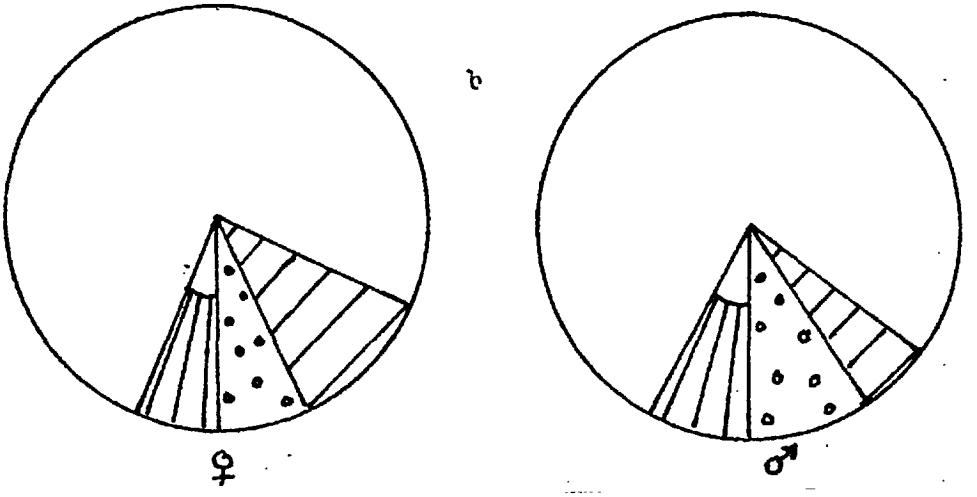
a

Fig. 45

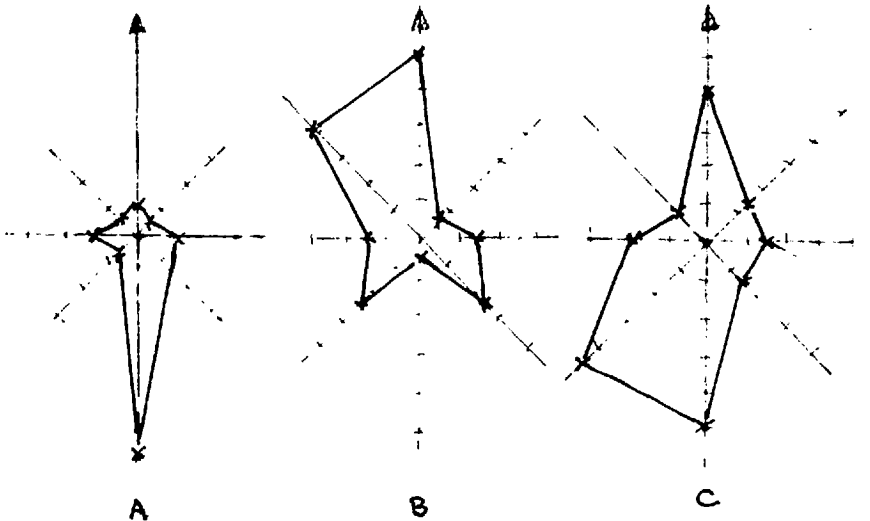
Musanga cecropioides: tissue distribution.

a: timber from a /sese/ musical instrument
b: "male" and "female" wood

Symbols as in fig. 18



b



A B C

Fig. 46 Rose-diagrams of Musanga vessel movement.

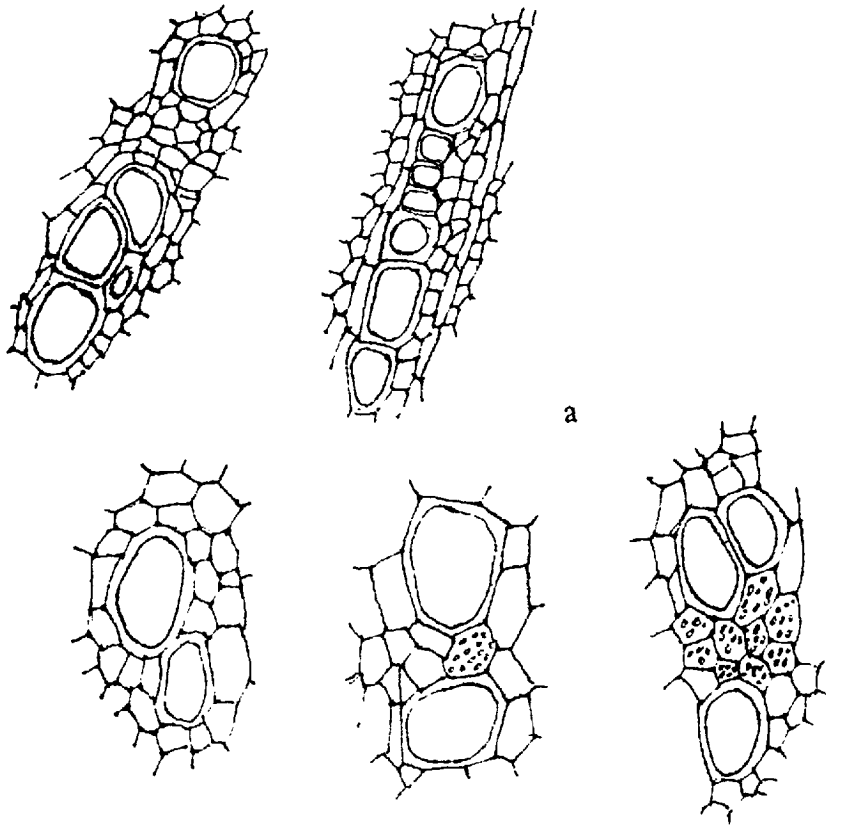


Fig.47 Intermediate cells between anastomosing vessels

a: Musanga cecropioides

b: Staudtia gabonensis

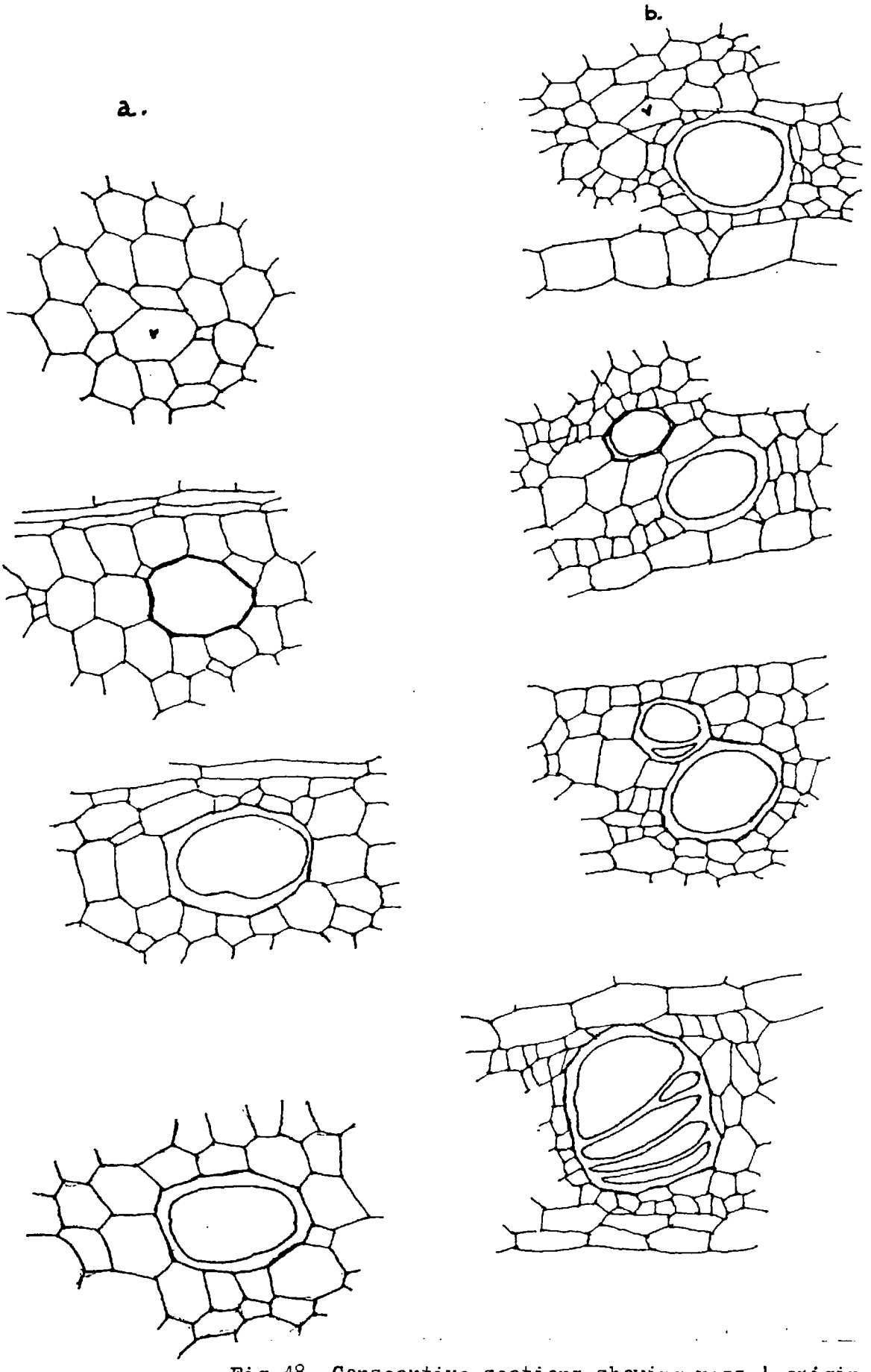
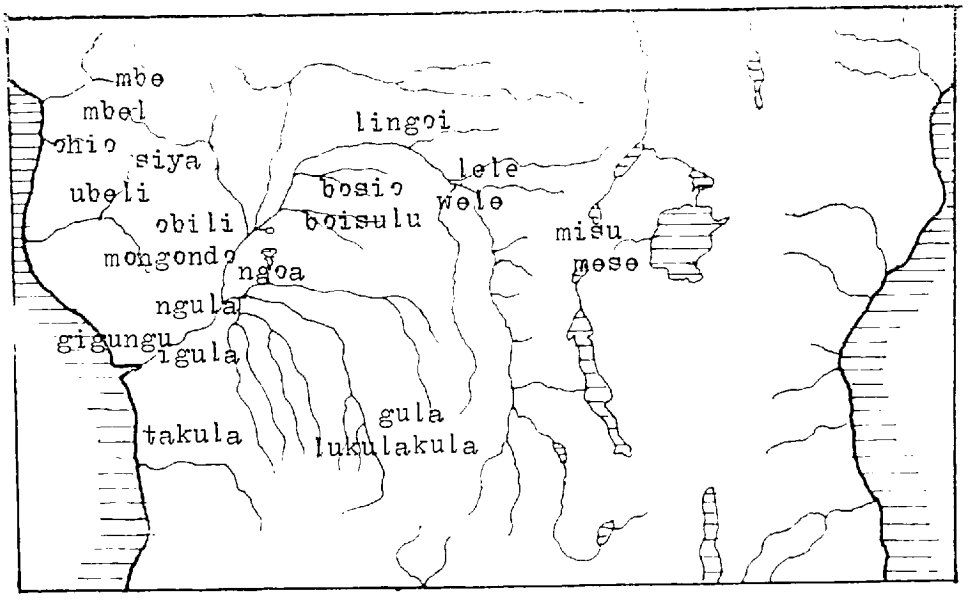


Fig.48 & 49 Consecutive sections showing vessel origin.

a: Musanga cecropioides

b: Staudtia gabonensis; note the scalariform perforation in the joined vessel.

Fig. 50 Pterocarpus soyauxii. Local names



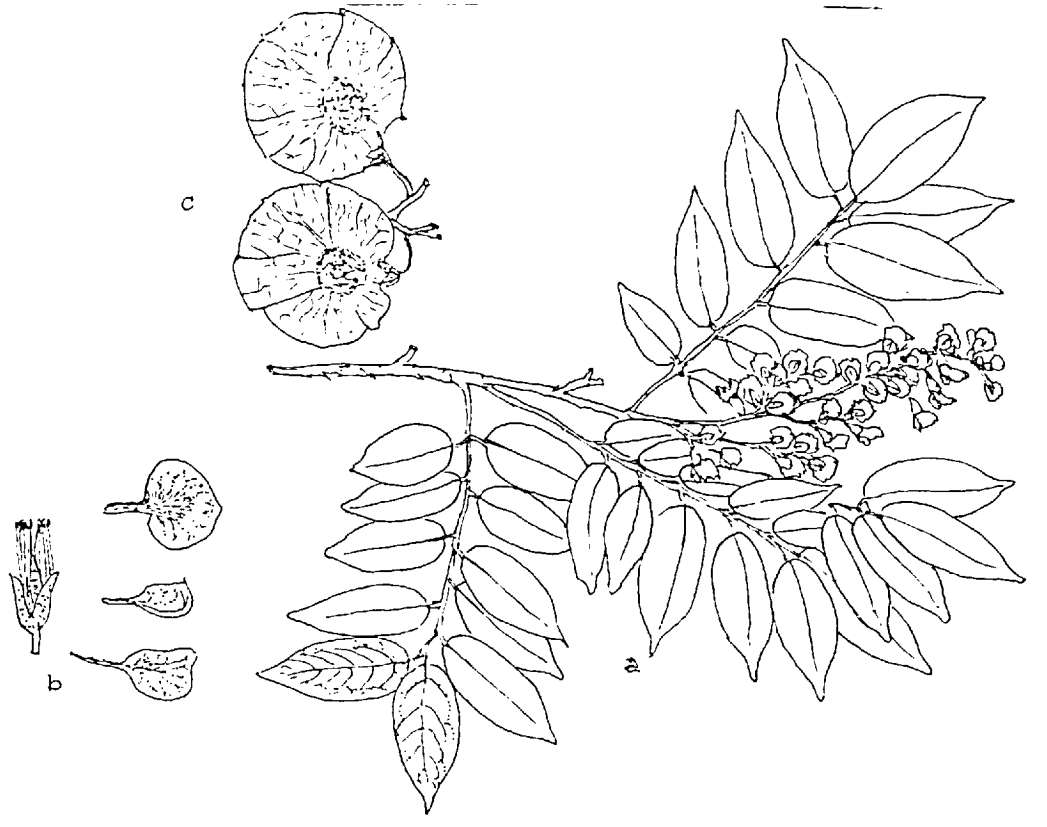
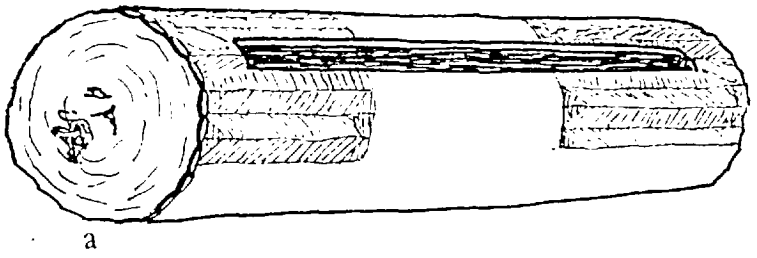


Fig. 51. Pterocarpus soyauxii: morphology;

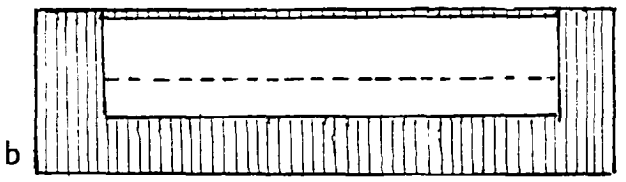
a. flowering branch x1/3,

b. flower x1,

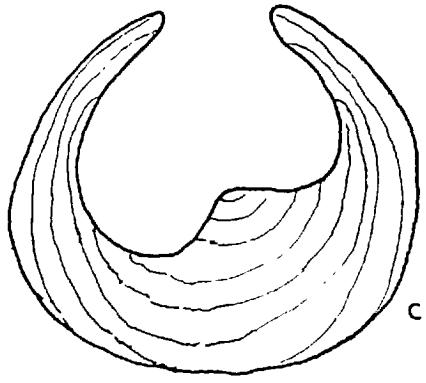
c. fruit x1/3. All after La Flore du Congo Belge.



a



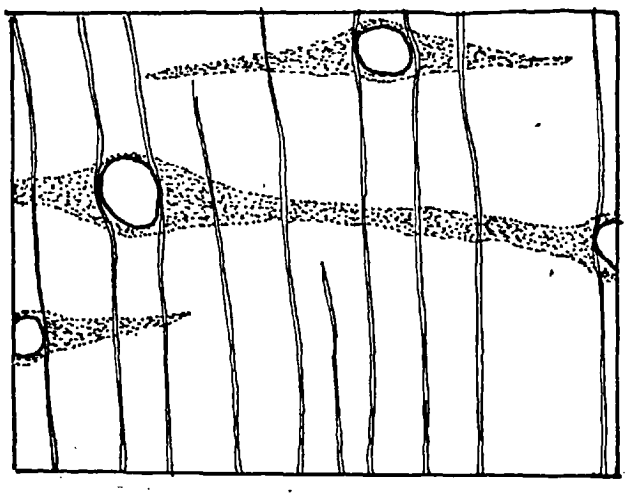
b



c

Fig. 52 Lokele talking-drum

a: general view x1/10
b: longitudinal section x1/10
c: cross-section x1/5

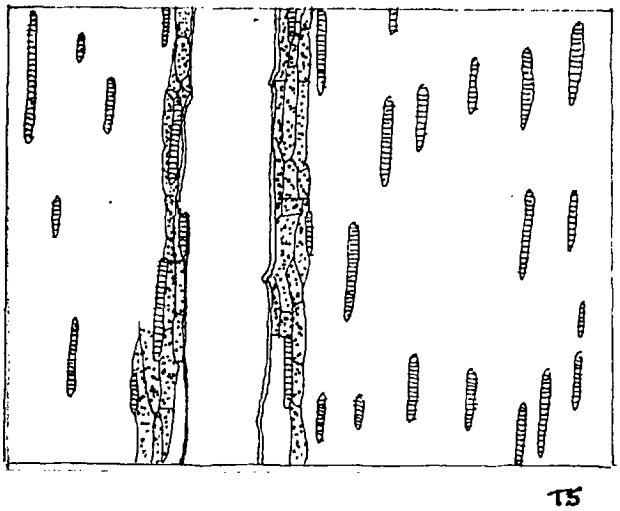


XS

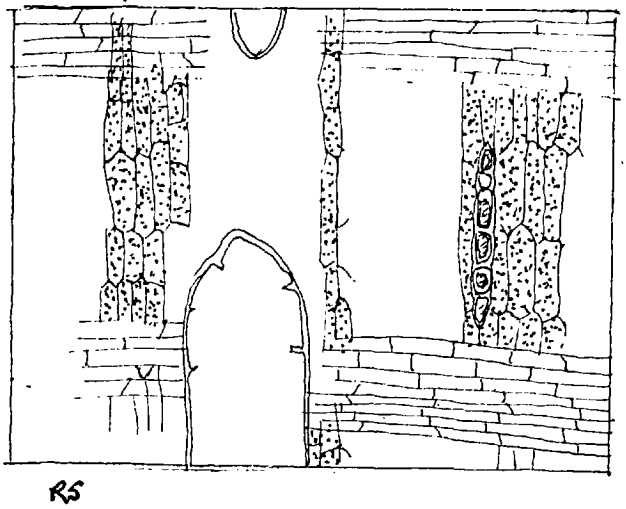
Fig. 53. Pterocarpus soyauxii

Diagrams of xylem structure:

XS x80, TS x100, RS x150.



TS



RS

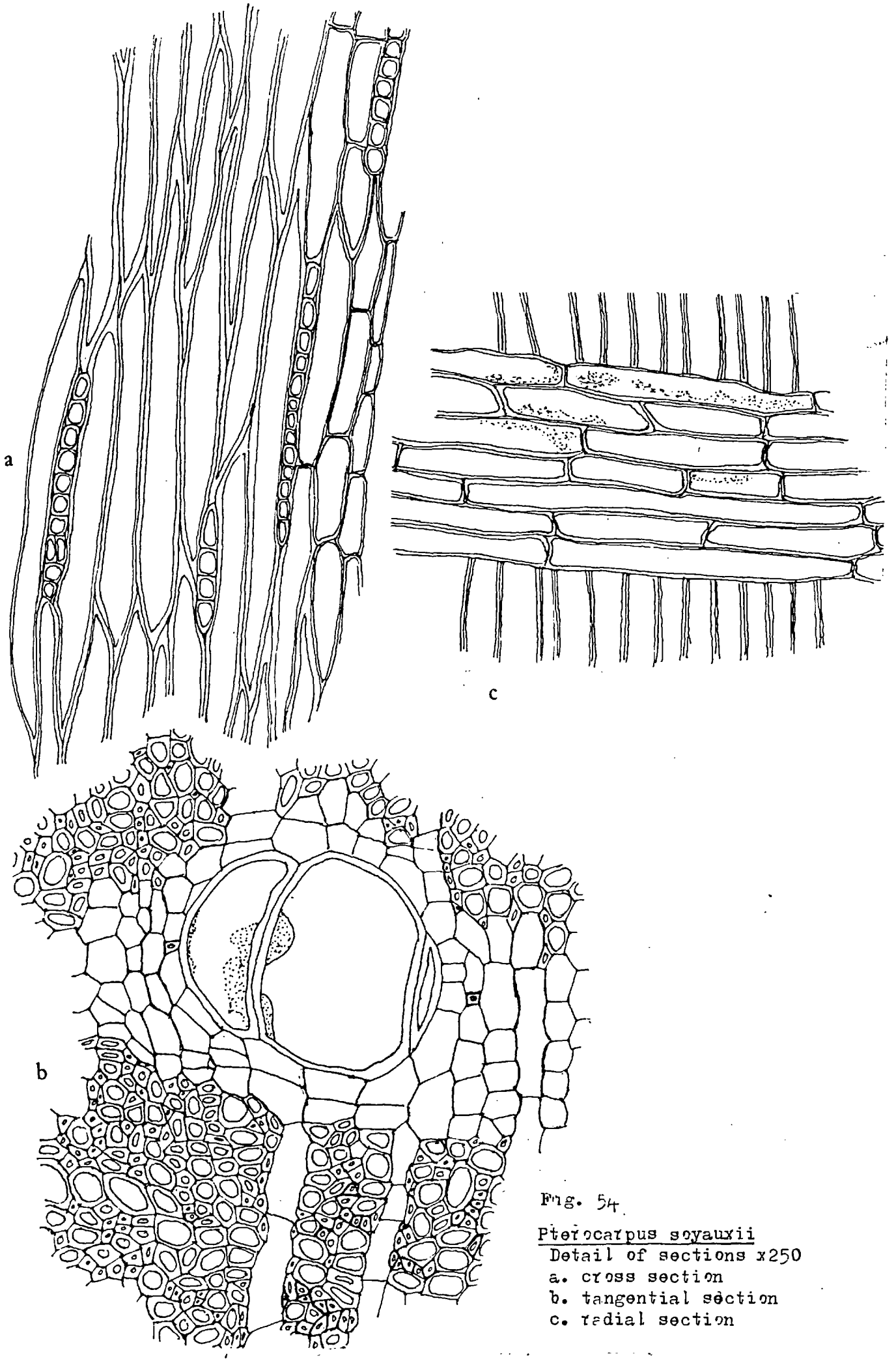


Fig. 54

Pterocarpus soyauxii

Detail of sections x250

a. cross section

b. tangential section

c. radial section

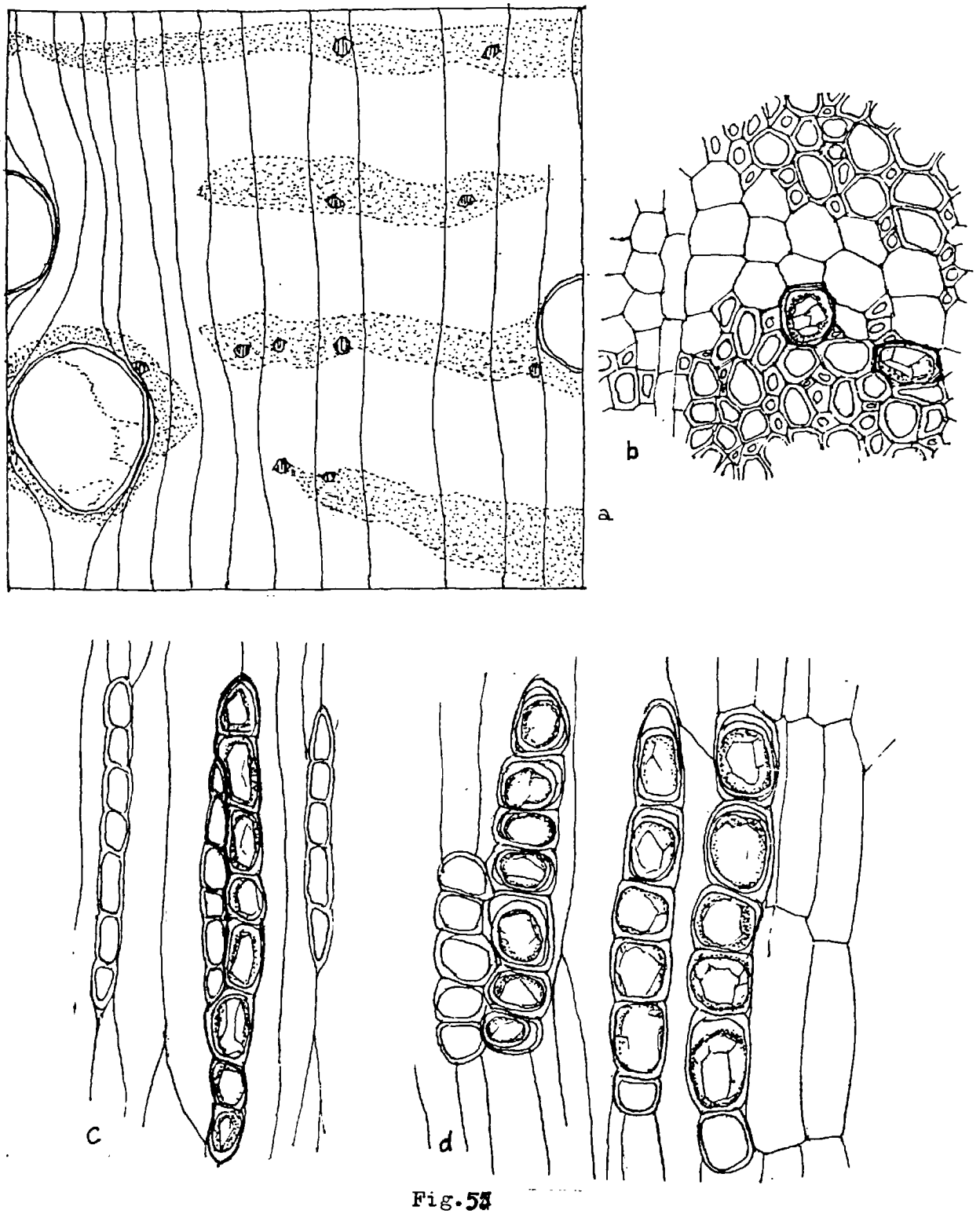


Fig.58

Pterocarpus soyauxii.

a. TS x100 showing crystal strands in parenchyma;
b. TS x250 in detail;
c. and d. Tangential sections showing complete crystal strands.

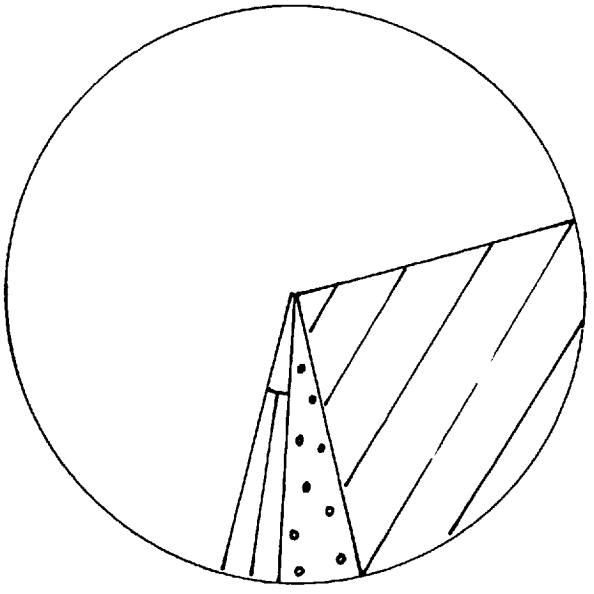
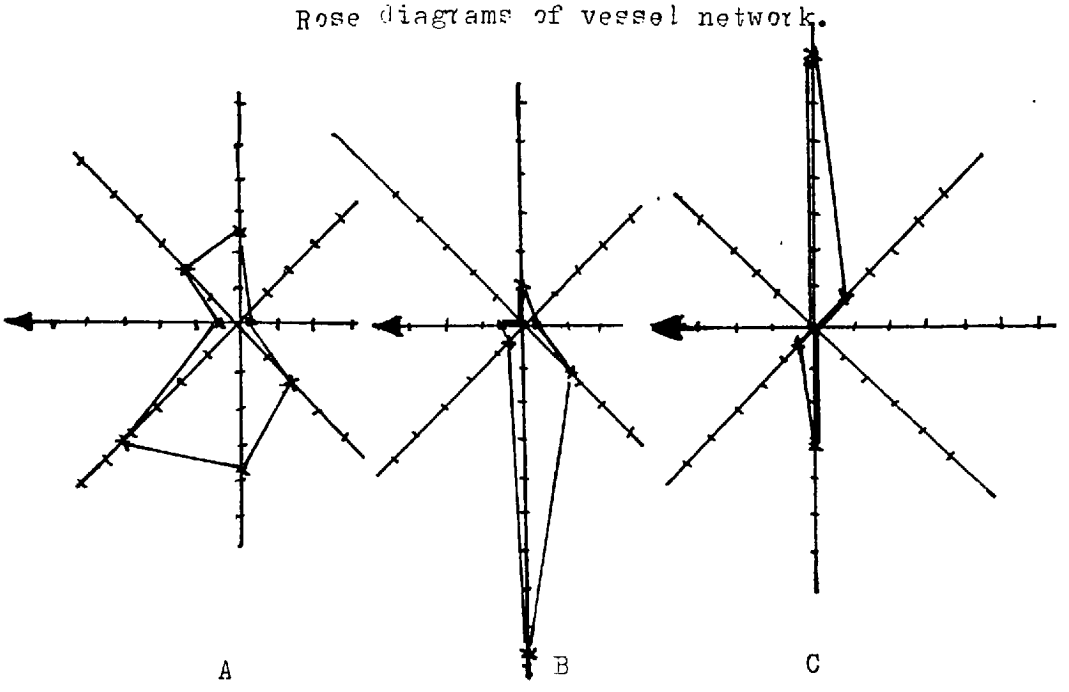


Fig.55b. Pterocarpus soyauxii

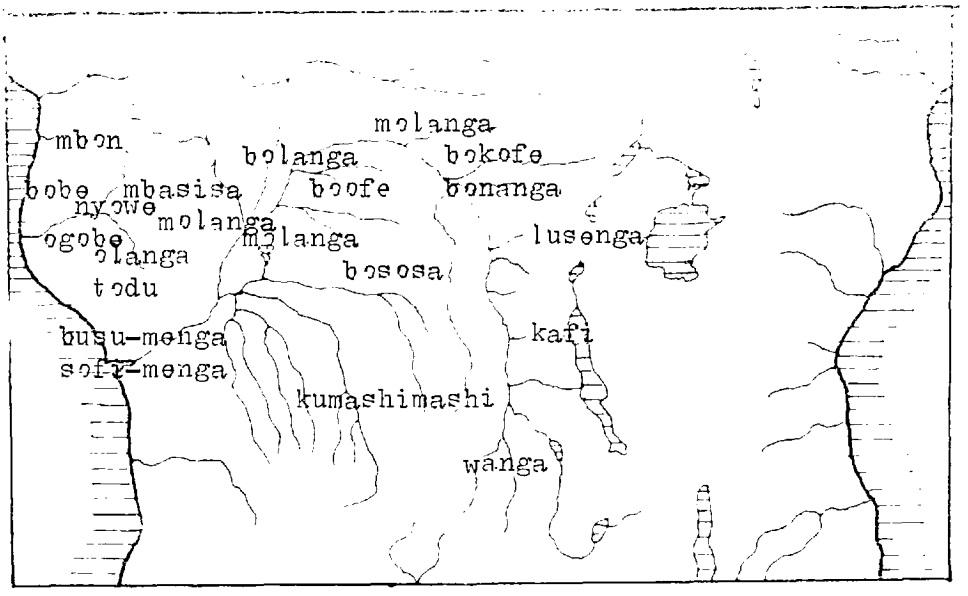
Tissue distribution:
symbols as in Fig.18.

Fig.56 Pterocarpus soyauxii

Rose diagrams of vessel network.



Gif. 57 Staudtia gabonensis. Local names.



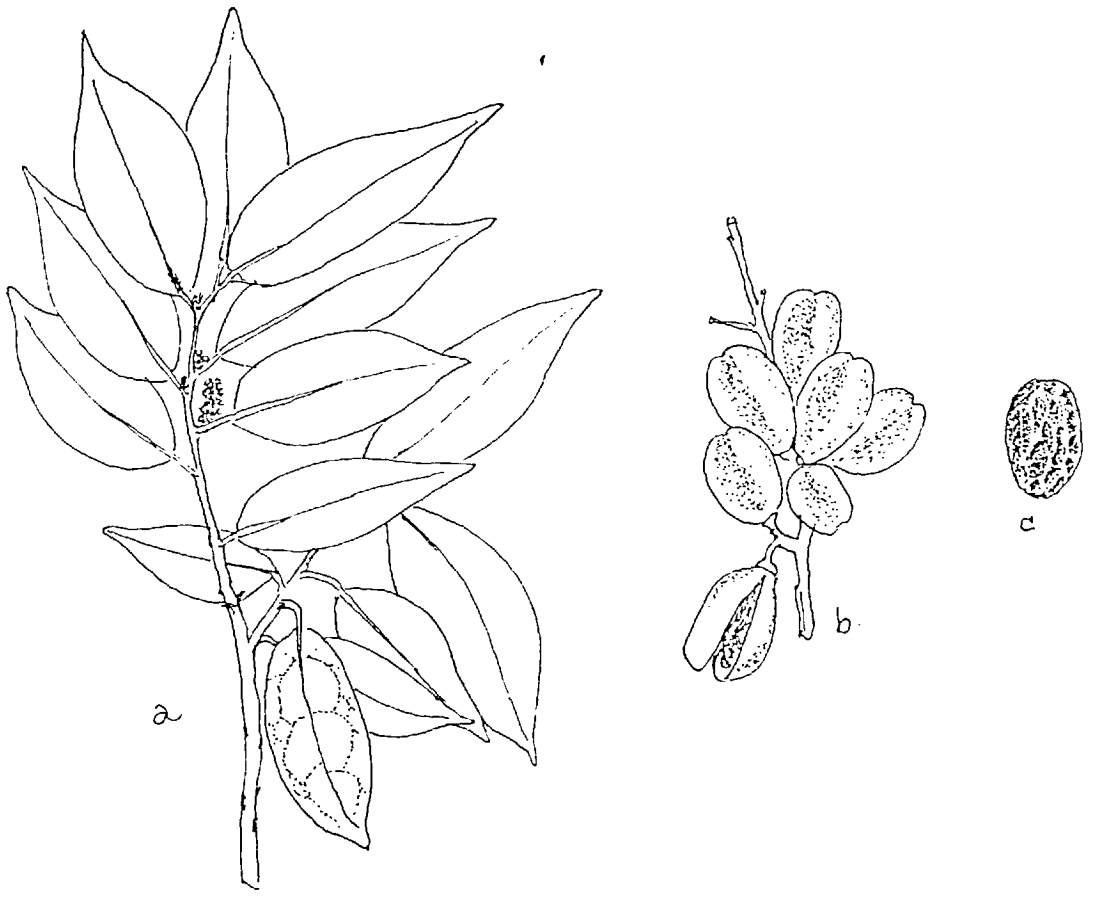


Fig. 58. Staudtia gabonensis: morphology;
a. flowering branch x1/3; b. fruiting branch x1/3;
c. seed with aril x½. All after Aubreville.

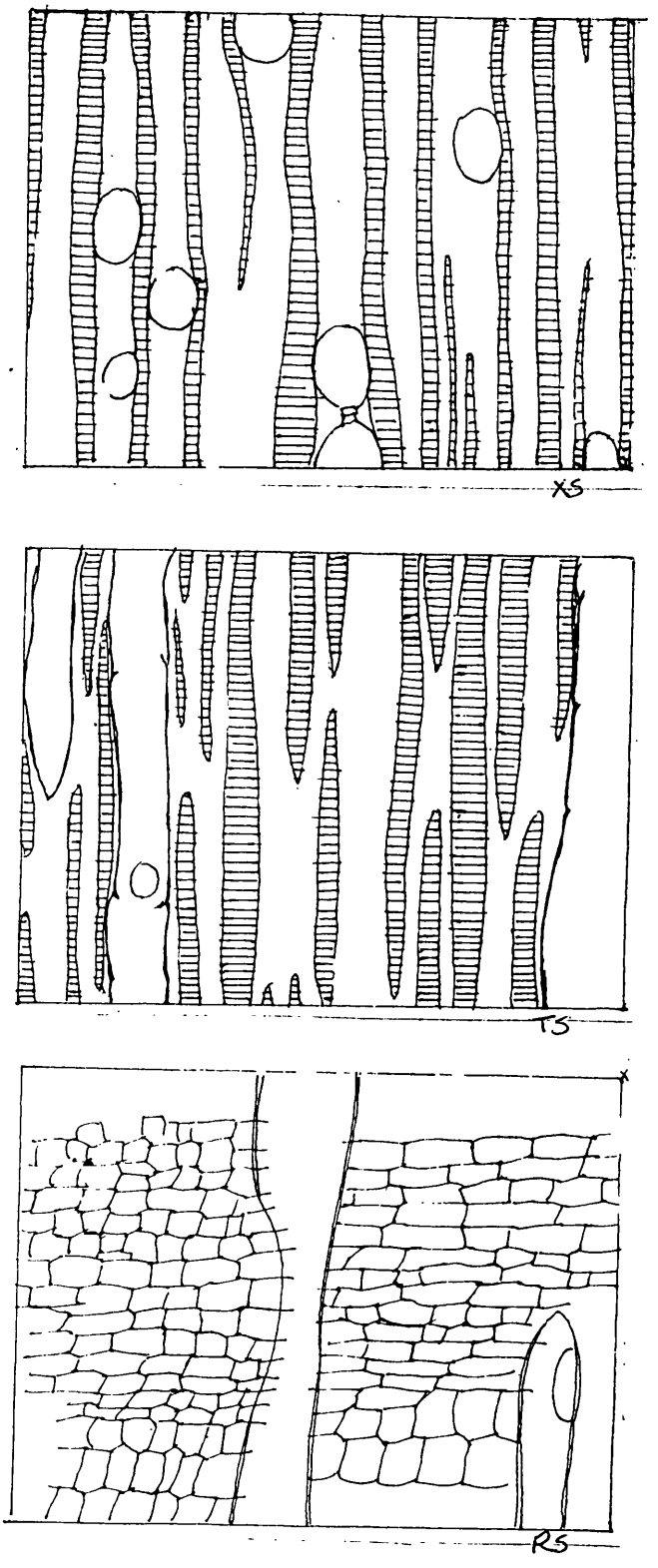


Fig. 59. Staudtia gabonensis: diagrams of xylem sections. [×80]

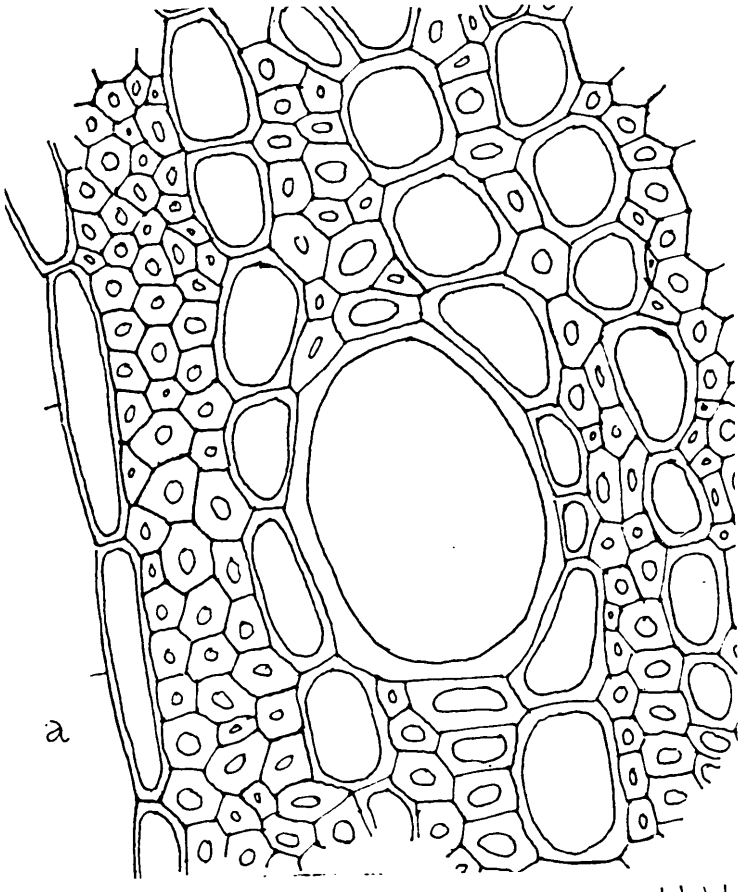


Fig 60

Staudtia gabonensis

Details of sections

a. TS x250

b. TLS ray portions x250

c. RLS showing upright and procumbent ray cells x100

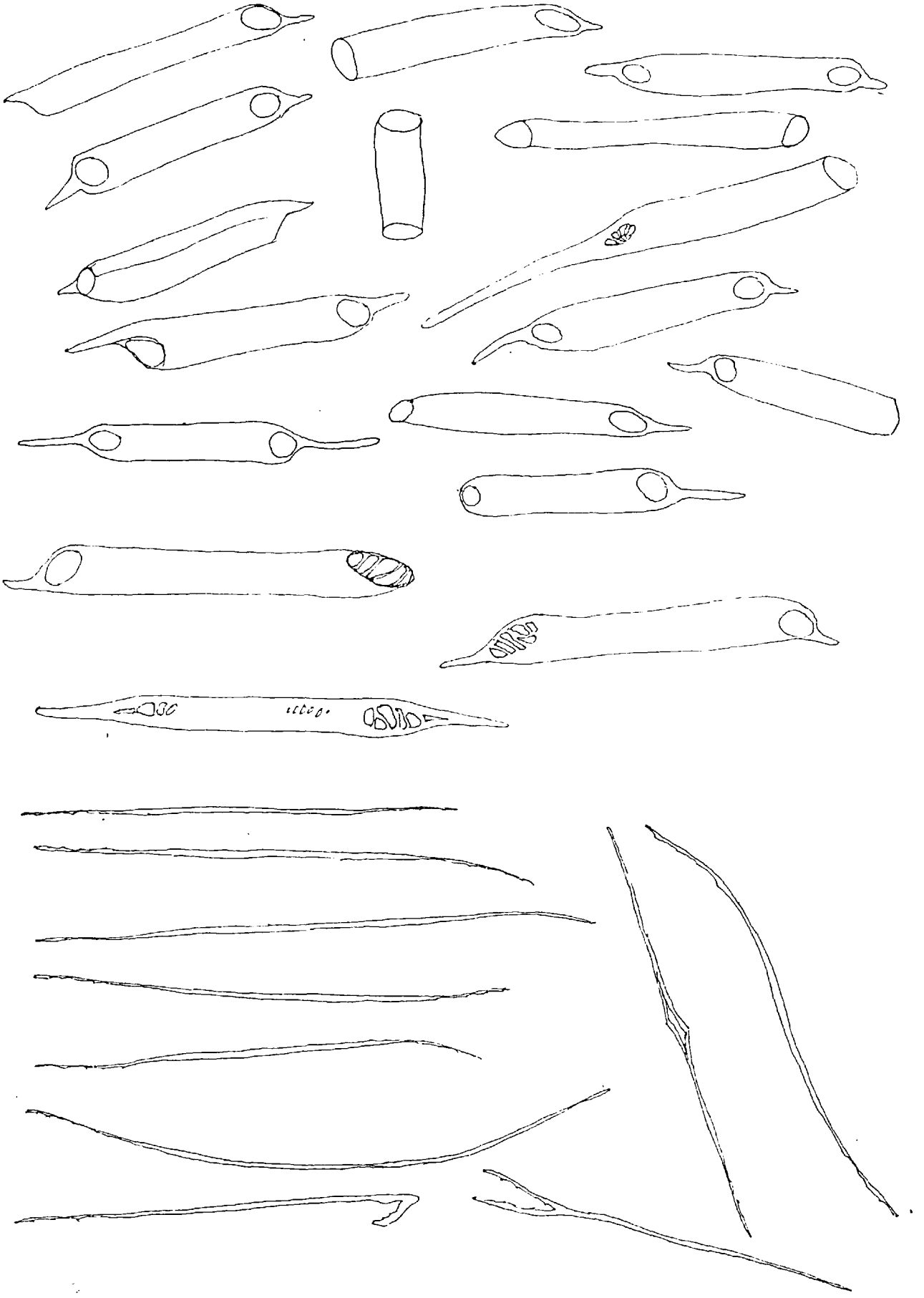


Fig. 61

Staudtia gabonensis

Vessel elements and fibres x50

Note scalariform perforations of vessels and irregular fibre tips

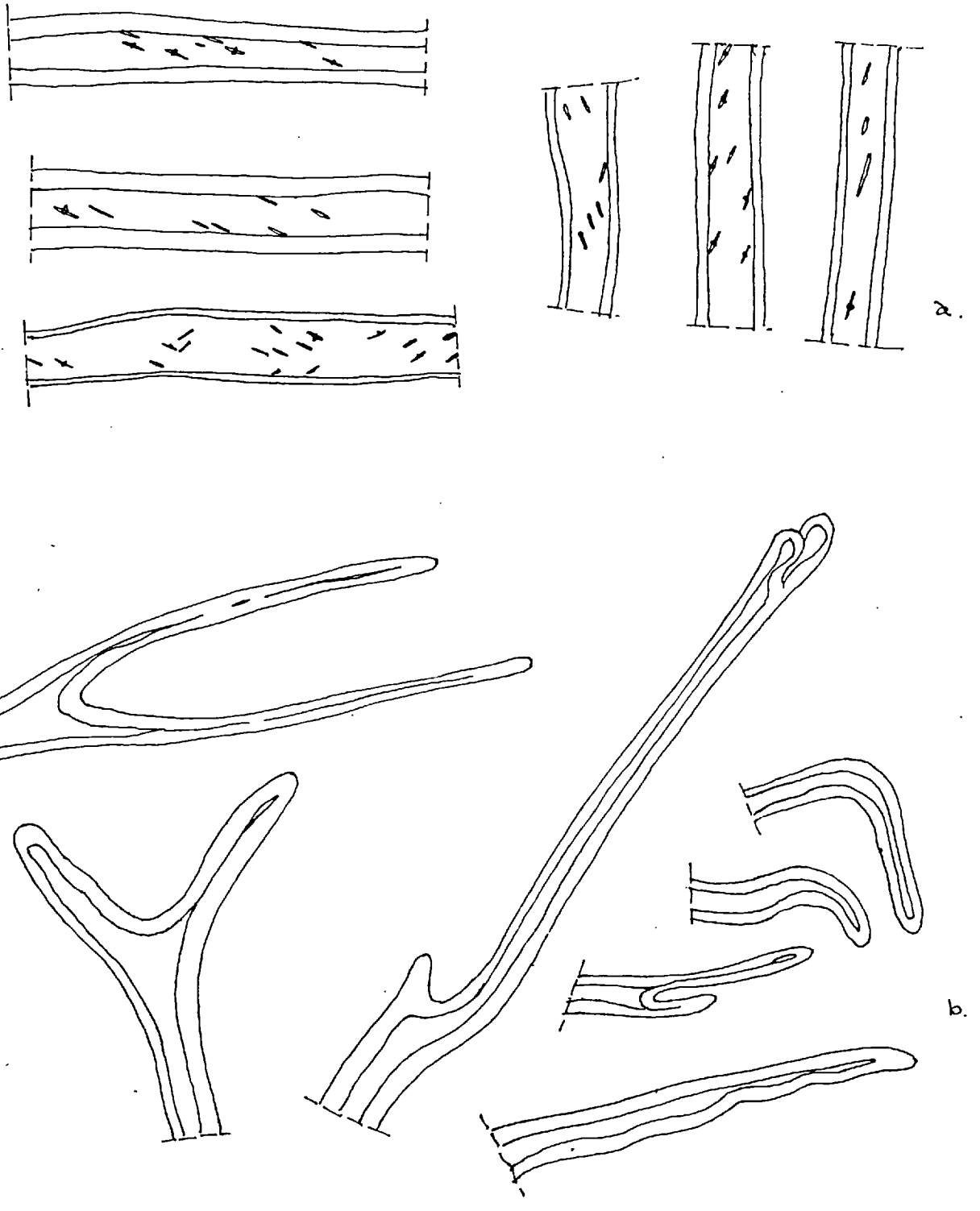


Fig. 62

Staudtia gabonensis:
a. portions of fibres with pitting;
b. deformed fibre tips.
All x250

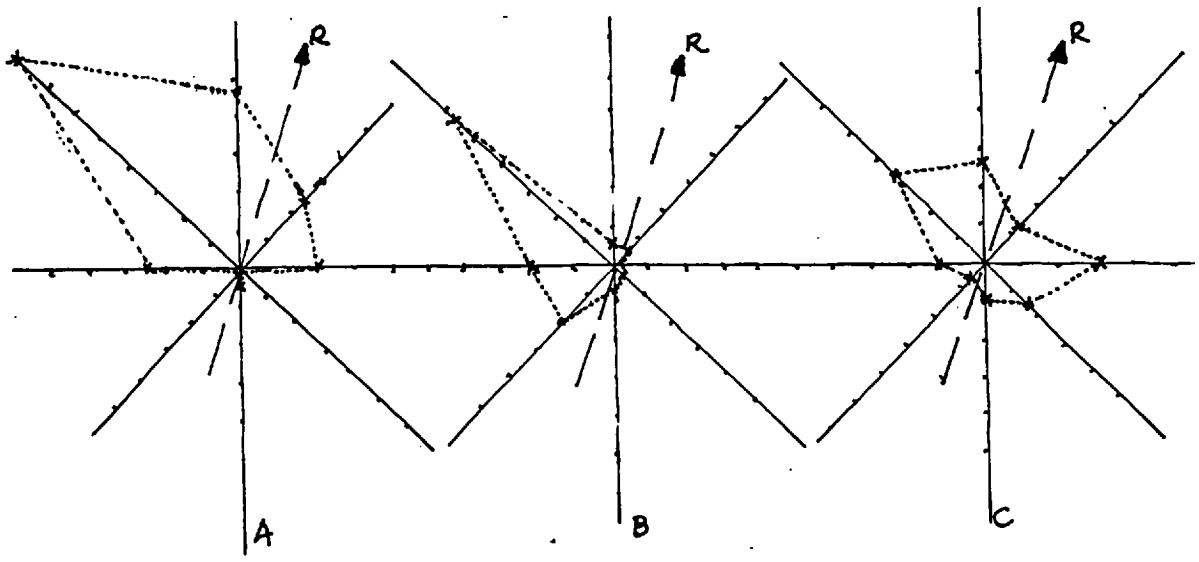


Fig.64. Staudtia: rose-diagrams showing vessel movement

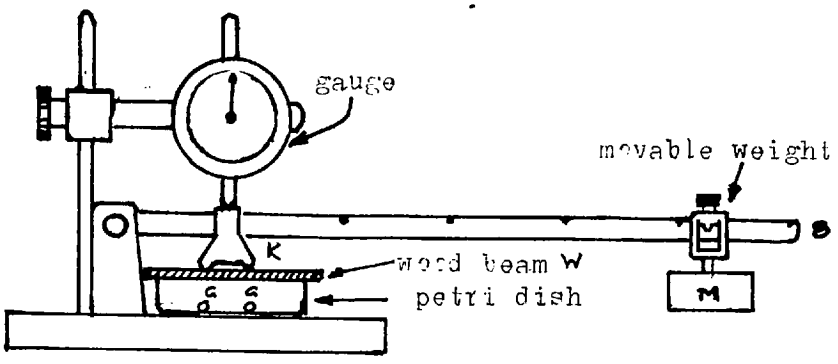


Fig. 65 Mateus beam apparatus x1/4

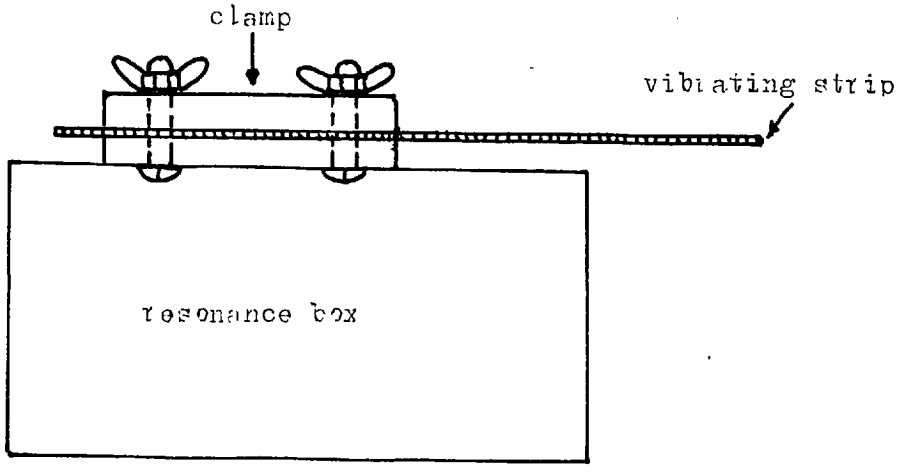


Fig. 66 Apparatus for measuring E by a dynamic method

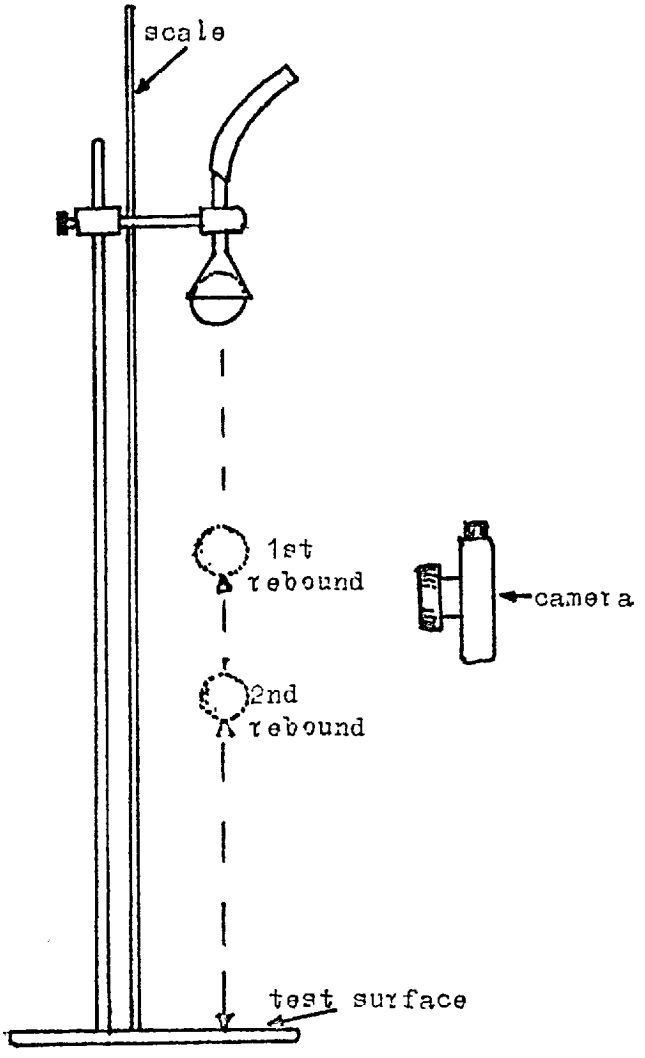


Fig. 69 Apparatus to measure surface hardness by ping-pong ball impact.

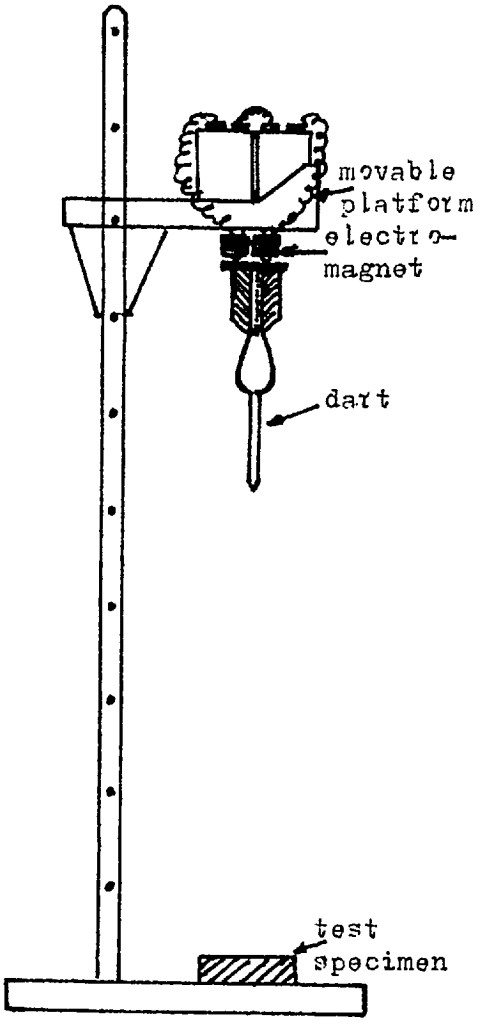
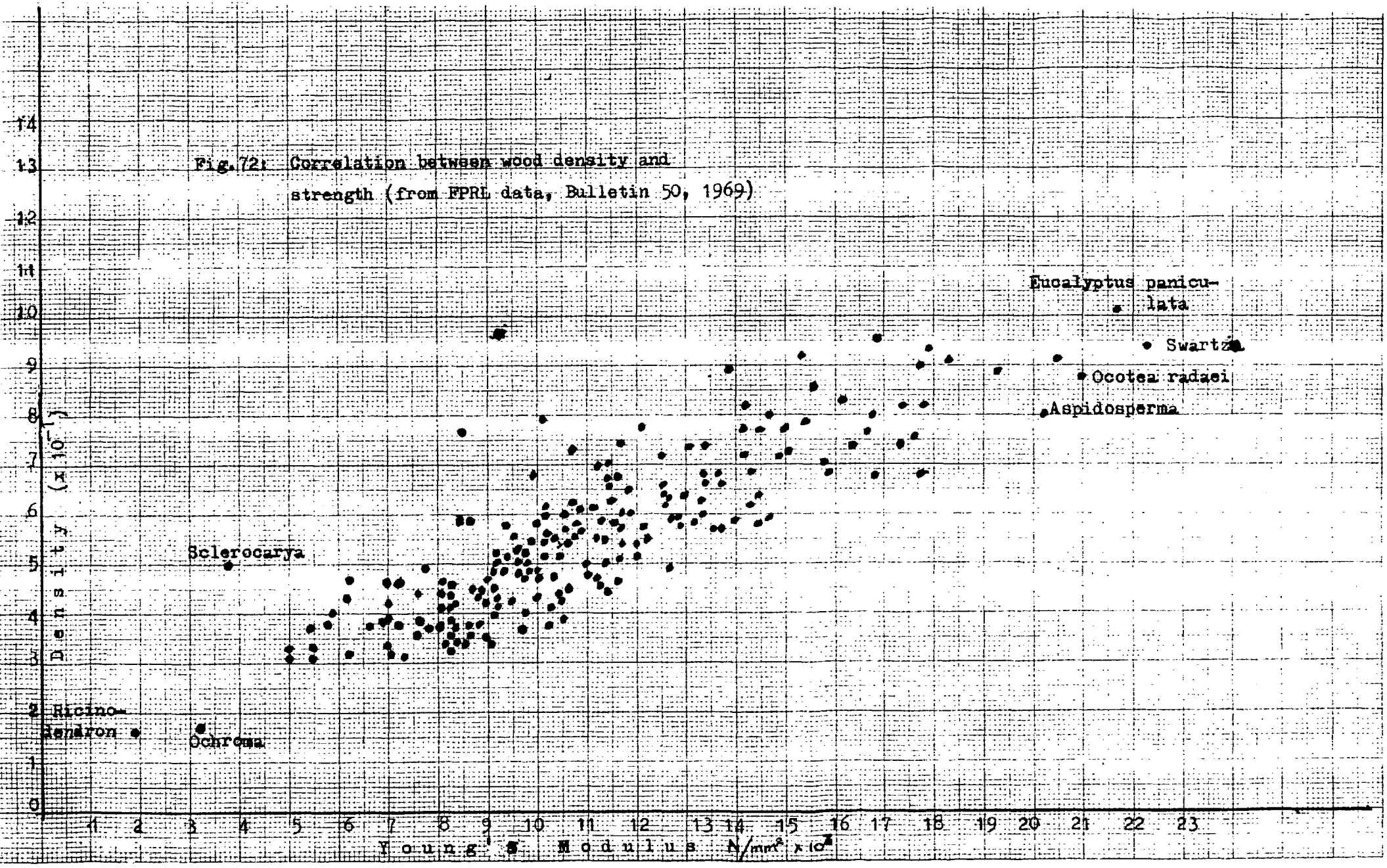


Fig.70 Apparatus to measure penetrability of wood

Fig.72: Correlation between wood density and strength (from FPRL data, Bulletin 50, 1969)



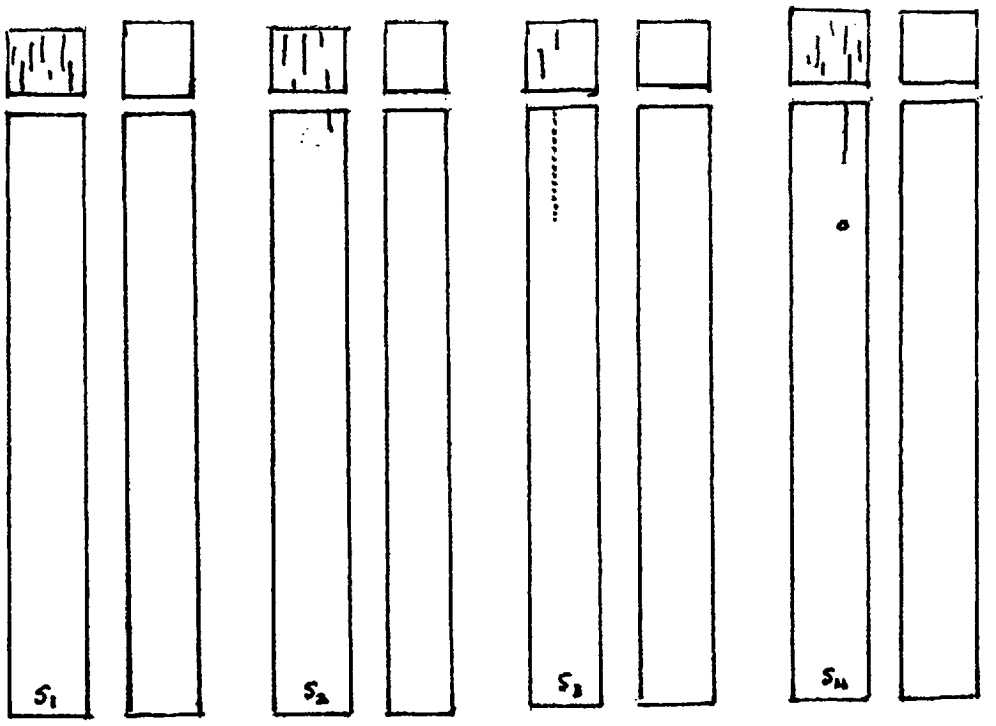
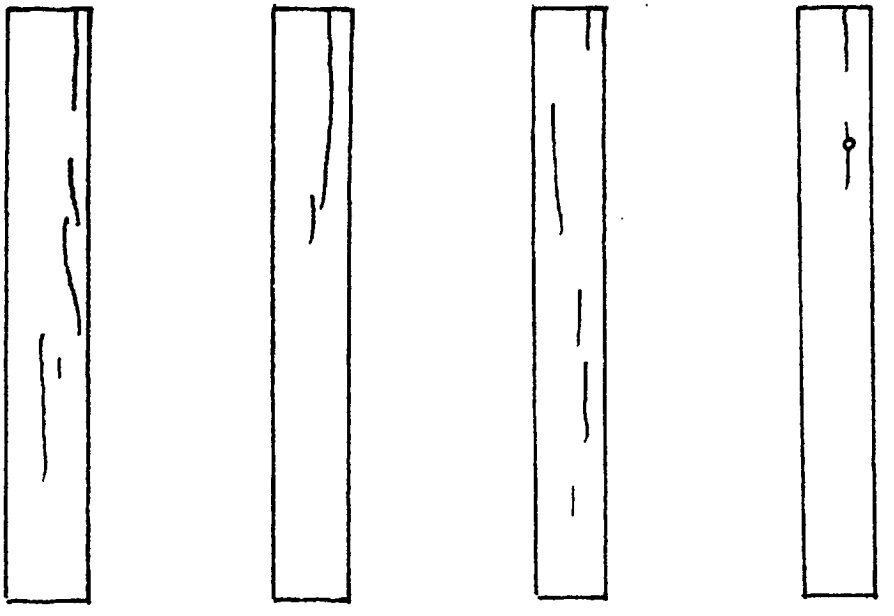
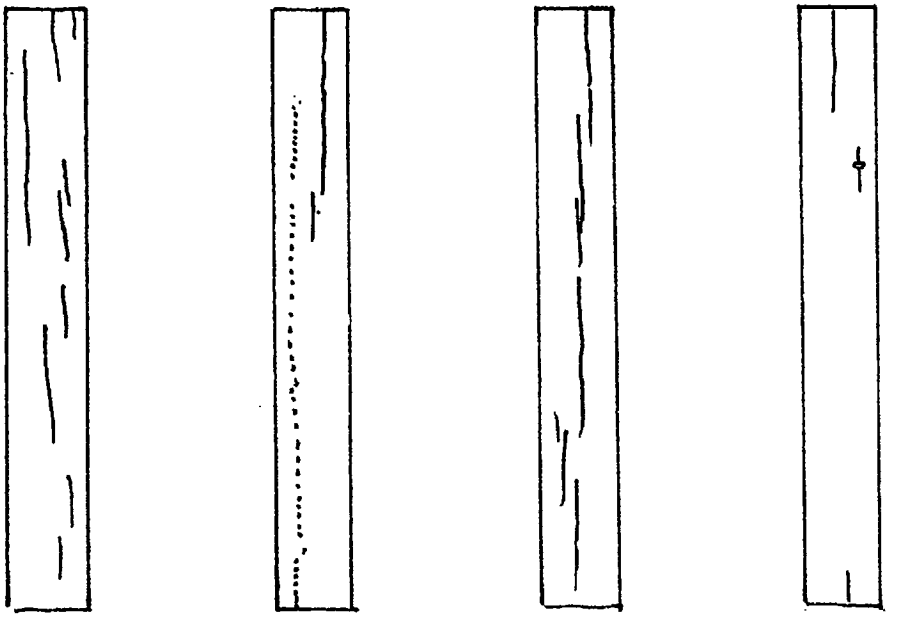


Fig. 74
Weathering experiments
Staudtia.

After 42 days



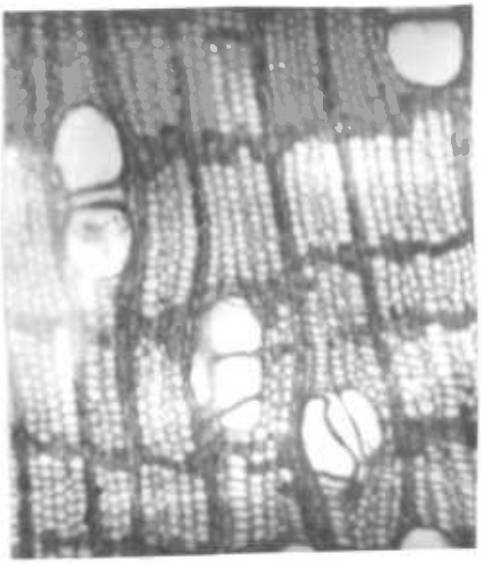
After 67 days



After 80 days



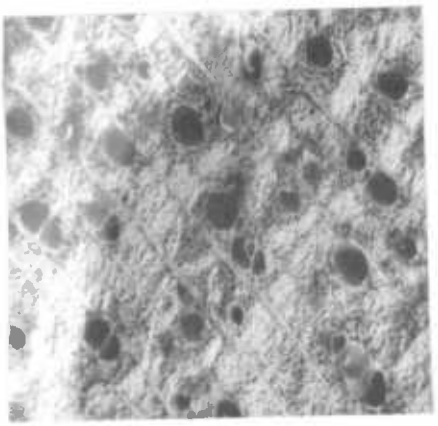
a



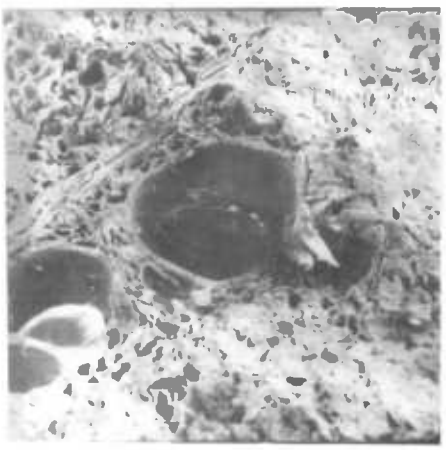
b



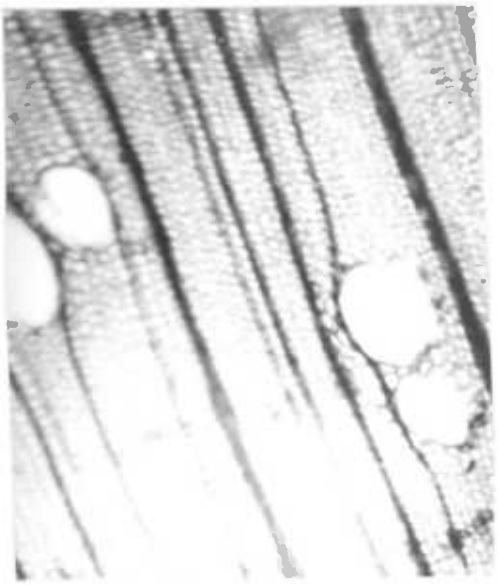
c



d



e



f

Plate 1.

a: /likwengu/ hand-piano with resonator-box of Alstonia wood x1/4

b: XS Alstonia congensis xylem x100

c: XS Combretodendron macrocarpum xylem x100

d: SEM XS Gossweilerodendron balsamiferum xylem x40

e: idem x 150, showing perforation rims of vessel elements

f: XS Musanga cecropioides xylem x100









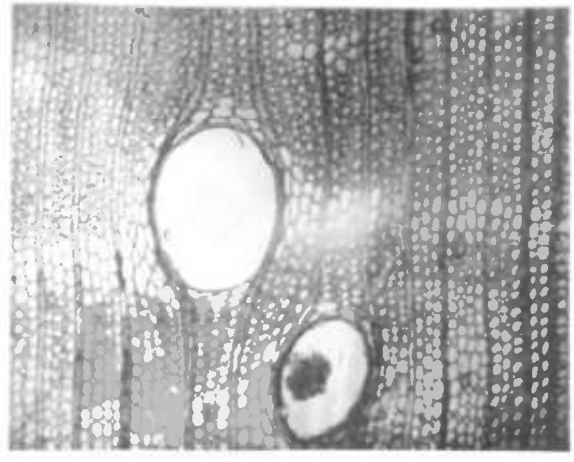


Plate 2.

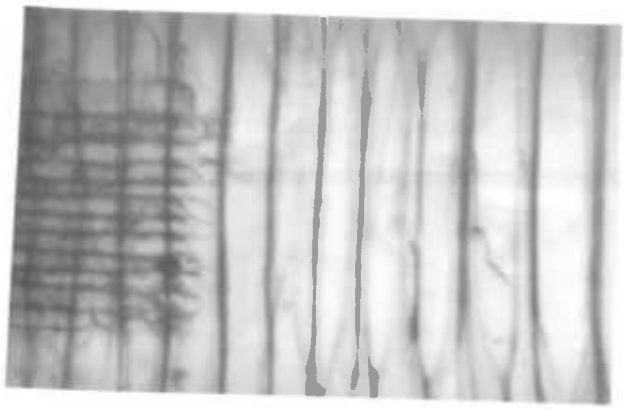
a: /boungu/ talking-drum of *Pterocarpus soyauxii* wood x1/10

b: idem sectioned x1/7

c: "canoe chair" parts x1/15

d: idem assembled

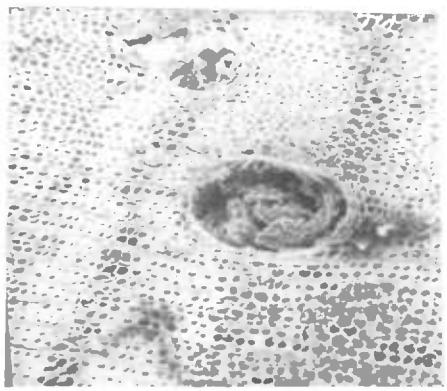
e: XS *Pterocarpus soyauxii* xylem x150



a



b



c

Plate 3.

a: RS Pterocarpus soyauxii xylem x300

b: SEM XS and RS planes x40

c: SEM XS surface showing tyloses in vessels x100

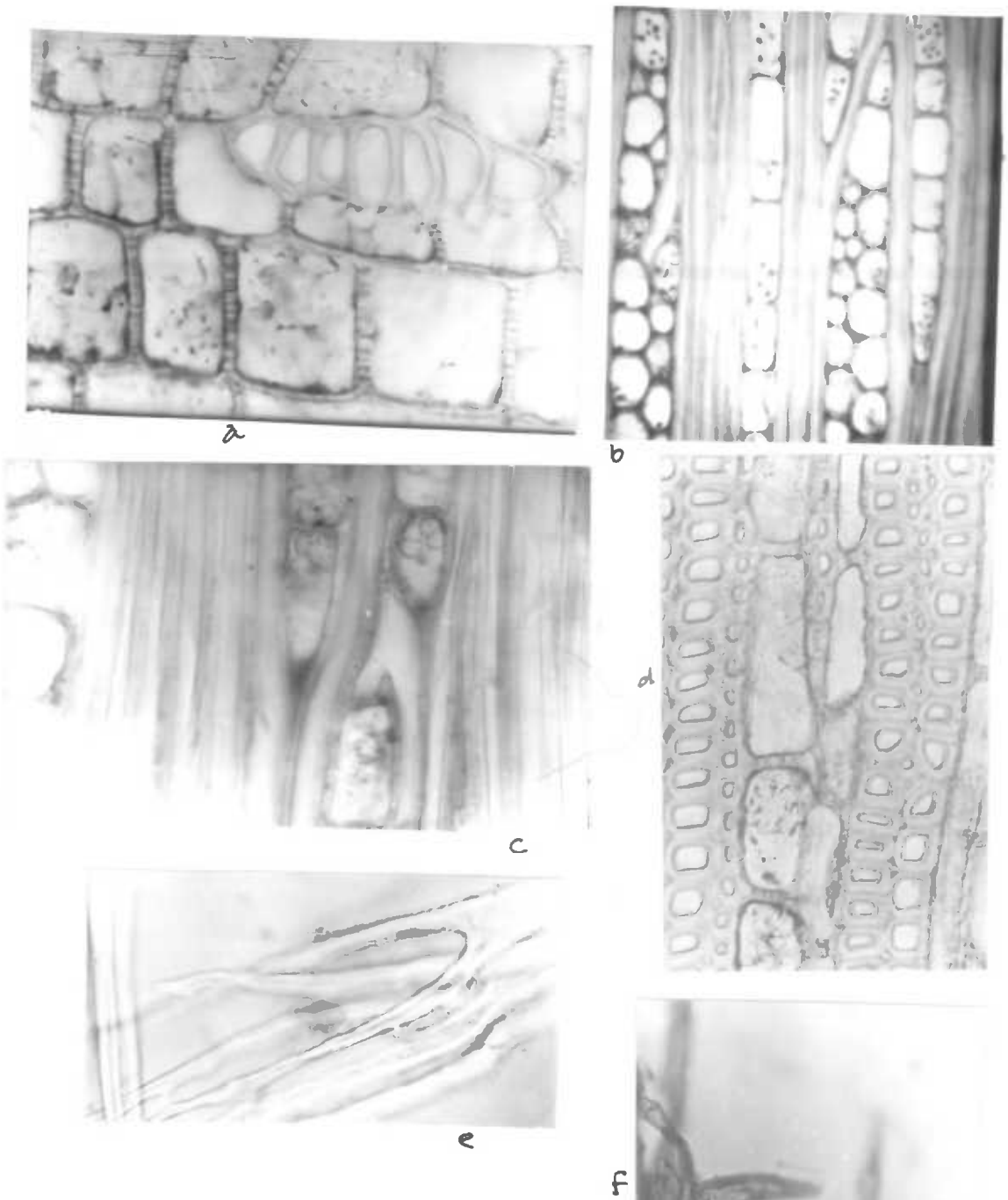


Plate 4. Interpenetration of ray tissue by fibres in Staudtia gabonensis.

a: RS showing plate of fibres penetrating laterally into a ray x300

b: TS with fibre entering a ray (left) x200

c: TS showing a hooked fibre in situ x300

d: XS with fibre plate dividing a ray x300

e,f: forked and deformed fibres seen in tissue maceration x300

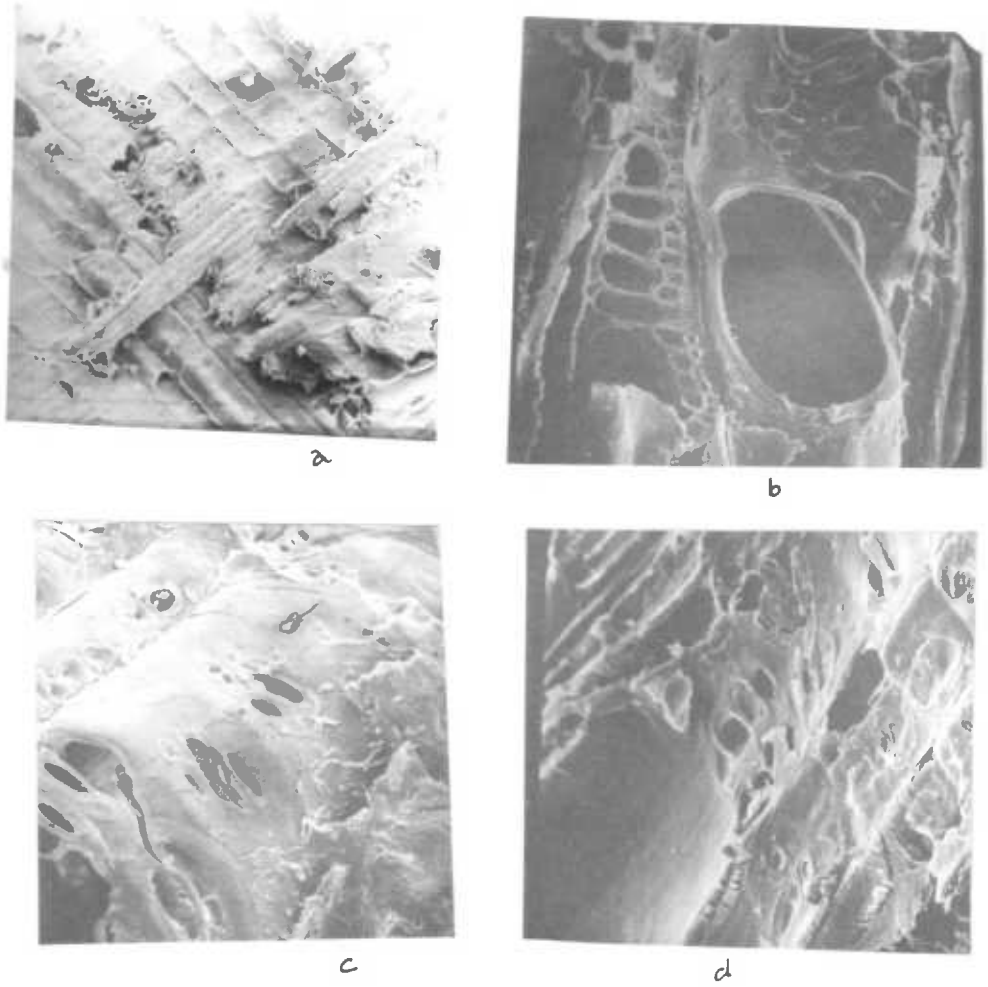


Plate 5. SEM photographs of Staudtia gabonensis.

a: RS x100

b: TS showing vessel element perforations: simple perforation plate on right and scalariform plate on left x300

c,d: RS showing vessel-to-ray pitting x300

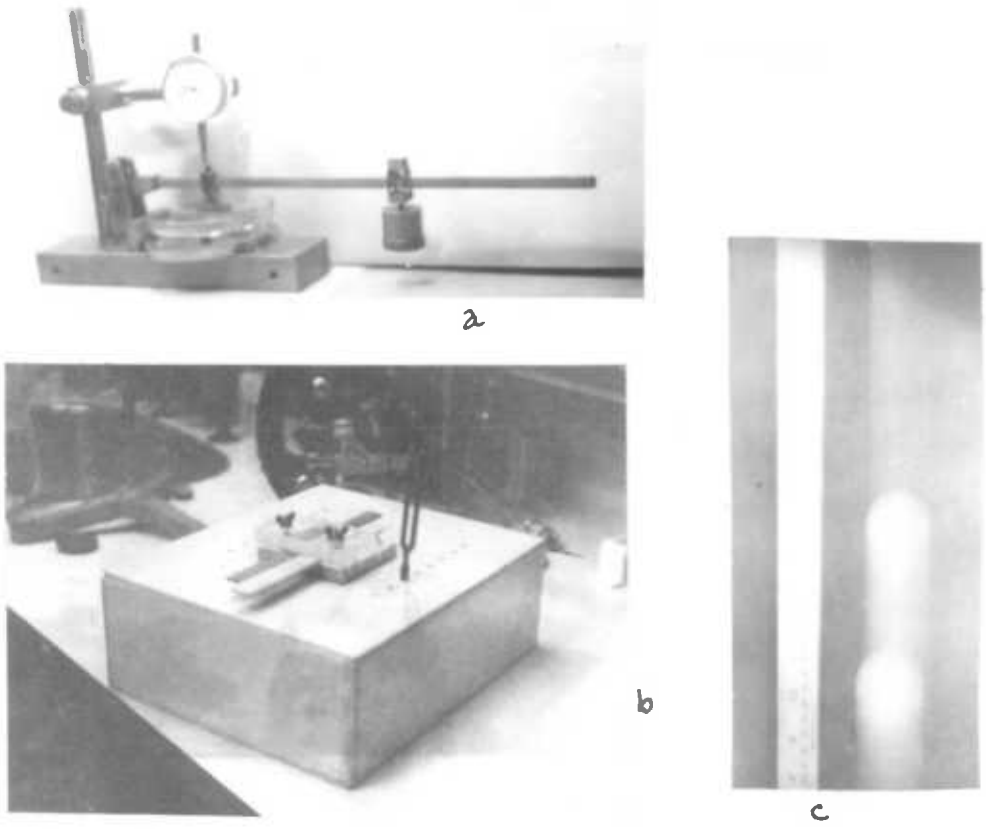


Plate 6. Apparatus used to measure physical properties of Zairian timbers

a: Mateus beam test

b: vibrational apparatus with timber strip clamped in position on sounding box

c: exposed film after pingpong ball surface hardness test showing first and second rebound positions of ball

ESQUISSE MORPHOLOGIQUE DE LA LANGUE LIKILE (HAUT-ZAÏRE)

par

J.F. CARRINGTON

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INTRODUCTION

La langue likile est parlée dans une vingtaine de villages près du confluent de la rivière Aruwimi et du fleuve Congo (Zaïre) dans la zone (territoire) de Basoko, région (province) du Haut-Zaïre. Cette rivière est connue des autochtones sous le nom de Lohale. La plupart des villages se trouvent entre le fleuve et la rivière; deux sont à l'ouest du confluent.

Selon leurs traditions, les Balikile sont venus du nord, après avoir été refoulés par les invasions des Zande. Ils racontent qu'il y avait d'autres populations dans la forêt de l'Aruwimi quand ils sont arrivés mais que ces groupes ont disparu sans laisser de traces. Certains désignent encore la région du nord d'où ils viennent par le vocable : olombo, d'où le nom employé par l'Administration coloniale pour désigner les villages de la rive droite du fleuve entre Kisangani et Basoko : les Turumbu. Ce dernier est dérivé du mot olombo par l'emploi d'un préfixe péjoratif donnant tolombo et d'une déformation vocalique o/u plus un changement de consonne l/r. On sait que dans d'autres langues de la région le mot olombo signifie : homme.

Les derniers chiffres démographiques donnent une population totale pour les villages Olombo/Likile de 2.169 âmes. A ce chiffre, il faut ajouter plusieurs centaines de villageois à Lokutu (plantations Lever) et encore un petit nombre de familles installées à Kisangani. Plusieurs administrateurs ont signalé la forte dénatalité parmi ces populations turumbu. Celle-ci est, en effet, reflétée par les sobriquets de gong donnés aux instruments de communication dans la région.

Les notes qui suivent ont été rédigées à la mission baptiste (BMS) de Yalemba, près du village likile appelé Bandio où l'auteur a résidé comme missionnaire pendant une douzaine d'années. Il a été beaucoup aidé par la famille d'un garçon de Bandio, Bolingo John, élevé par Madame Carrington, après la mort de sa maman lors de sa naissance.

Bien que cette description de la langue likile soit fort sommaire, elle est présentée maintenant parce qu'il existe encore des lacunes dans nos connaissances des langues bantoues de la région du Bas Aruwimi [à noter la remarque dans ce sens de Van Bulck (4, p. 66)]. La langue est nettement apparentée à la langue olombo (Guthrie, C 54).

1. LES PHONEMES DU LIKILE.

1.1. Les voyelles. Nous entendons, en likile, 7 phonèmes vocaliques que nous pouvons représenter, suivant l'alphabet "Africa" : a e ɛ i o ɔ u.

1.2. Le phénomène constaté dans plusieurs langues de la région et appelé "harmonie vocalique" se trouve en likile. Il y a une association étroite entre les voyelles fermées e et o d'une part et entre les voyelles ouvertes ɛ et ɔ d'autre part. De plus, une voyelle a entraîne souvent l'ouverture d'une voyelle e en ɛ et o en ɔ.

Exemples :

moto ôbé	un homme mauvais	moto ɔ̂kɛ́	un petit homme
mɔ́na óhã̌	mon enfant	mɔ́na ɔ́hɛ̌	son enfant

Comparons encore :

nékelese moto likwa ?	Dois-je faire travailler cet homme ?
nɛ́yɔɛsɛ moto mɔyɔ́ ?	Dois-je donner à manger à cet homme ?

A noter aussi la voyelle finale de plusieurs noms ayant a dans le noyau :

lolãmɛ	langue	bátáanɔ	cinq (hommes)
bwátɔ	pirogue	ngámbɔ	autre rive
ngandɔ	hutte	ísátɔ	trois

1.3. Les consonnes. Nous entendons en likile les consonnes suivantes :

explosives	: p	apá	père (intime)	d	batímɔdɛ́	ils ne le frappent pas
	b	libé	genou	k	lokáhá	feuille
	t	lɔtɔ́tɔ́fi	étoile	kp	akpomí	il parlait
				gb	agbomí	il aboyait (chien)
fricatives	: f	ífé	feu	s	mosué	cheveu
	h	hé	lui, elle			
latérale	: l	kaálé	aussi, comme			
nasales	: m	moto	personne	mb	mbélɛ	maison
	n	ané	ici	nd	ndolé	chemin
	ŋ	-ndoŋban-	se heurter	ny	-luhany-	penser
		ŋgandɔ	hutte			
		ŋkusu	médicament			
semi-voyelles	: y	mɔyɔ́	aliment			
	w	wakelá	tu fais			

A noter que la fricative vélaire s'entend comme [ˈχ]. Nous la représentons ici par le symbole h, car il n'y a pas d'opposition h/χ dans la langue. Encore pouvons-nous représenter la nasale ŋ par n car elle ne s'entend que devant b, g et k.

2. LES TONEMES DU LIKILE

2.1. La langue a deux tonèmes : haut et bas. Il suffit dans les notes qui suivent d'indiquer les tons hauts par un accent aigu; les voyelles sans accent seront prononcées avec un ton bas. Deux voyelles de valeur phonétique égale mais dont les tonèmes sont différents donnent lieu à des tons montants et descendants :

lisaá marché ndɔ́ɔ serpent mɛ́ɛ eau

Si les deux voyelles ainsi juxtaposées ont le même tonème, on entend une voyelle allongée : lofoo, souris.

2.2. Il faut noter, cependant, que la langue likile réalise des tons montants et descendants que l'on ne peut point expliquer par la juxtaposition de deux tonèmes différents. Ils sont plutôt le résultat d'une interrelation des tons, phénomène déjà constaté par plusieurs auteurs dans les langues zaïroises (1, 5, 6). Par exemple, le préfixe d'accord nominal devant un adjectif ayant un ton bas sur la première voyelle est réalisé sur un ton haut simple :

bato básiáká d'autres personnes.

Si la première syllabe de l'adjectif a un ton haut, le ton du préfixe nominal est descendant et non haut :

bato bâsúngú de grandes personnes

D'autres exemples de cette modification tonale se trouvent en présence du préfixe régime (3.36.). Comparez :

akpésá il fait tomber
amɔkpésá hɛ́ il le fait tomber
abɔ́kpɛ̌sɛ bɔ́ il les fait tomber

On constate ici que le changement du ton du préfixe : mɔ/bɔ́ entraîne un changement du ton du radical : kpé/kpɛ̌.

2.3. Quelques exemples de la valeur lexicale des tons en likile :

maína	noms	sué	cheveux	mafsé	jours
maíná	huile	súe	poisson	máisé	tante paternelle
ngúlu	porc			moto	personne
ngulu	force, puissance			motó	tête

2.4. Bien que la langue tambourinée employée dans les villages likile soit celle des Basɔkɔ, les Balikile utilisent leur propre langue dans beaucoup de sobriquets personnels faisant référence à des membres du village et aux gongs qui envoient les messages. Ces gongs n'ont que deux tons ("voix mâle" et "voix femelle") qui suffisent à envoyer les périphrases employées par le batteur du gong. Les enfants emploient également ces deux tons haut et bas en sifflant des messages entre eux. Un garçon qui se rend chez son ami Noele siffle la suite tonale :˙˙.˙.˙. pour caractériser la phrase :

nékákya hú Noële je vais chez Noele

3. GRAMMAIRE

3.1. Les noms

3.11. Les noms sont groupés en <u>classes</u> selon leurs préfixes caractéristiques :

N° de classe	Préfixe	Nom-type	Signification
1	mo-	moto	personne
1a	zéro	kanga	guérisseur
1b	a-	ákúkú	lézard
2	ba-	bato	personnes
		bakanga	guérisseurs
		bákúkú	lézards
3	mo-	moláma	esclave
4	mi-	miláma	esclaves
5	li-	libé	genou
6	ma-	mabé	genoux
7	e-	etíkóló	colline
8	bi-	bitíkóló	collines
9	nasal	ndolé	chemin
	ou zéro	kai	village
10	nasal	ndolé	chemins
	ou zéro	kai	villages
11	lo-	lokáhá	feuille
12	to-	tokulu	cordes
14	bo-	bokpándi	bras
19	i-	ikulu	corde

La numérotation suivie ici est celle de Bleek-Jacottet. Les classes locatives 16, 17 et 18 ne sont représentées que par des préfixes (cf. section 3.22).

3.12. Comme on le voit déjà dans le tableau des noms, les classes s'apparient lors de la formation singulier/pluriel :

1/2	motúli	batúli	forgeron
3/4	mɔndélɛ́	mindélɛ́	blanc
3/10	mosué	sué	cheveu
5/6	líno	maíno	dent
7/8	esínda	bisínda	étoffe
9/10	tele	tele	siège
19/12	isɛi	tosɛi	doigt, orteil
14/6	bwátɔ	mátɔ	pirogue

Les classes suivantes renferment des noms qui ne s'apparient pas :

3	mobángání	peur;	moóndání	amour (réciproque)		
6	maíná	huile;	mɛ́ɛ	eau;	mahwa	pitié
14	boónde	amour				

3.21. Les adjectifs possèdent un thème invariable précédé de préfixes dont la forme dépend de la classe du nom auquel l'adjectif est associé. Le ton du préfixe dépend du ton de la première syllabe du thème adjectival; si ce dernier est haut, le préfixe adjectival a un ton descendant; si la première syllabe du thème possède un ton bas, le ton du préfixe est haut.

Classe	Nom-type	Signification	"grand"	"autre"
1	moto	personne	ôsúngú	ósiáká
2	bato	personnes	bâsúngú	básiáká
3	moté	arbre	môsúngú	mósiáká
4	mité	arbres	mîsúngú	mísiáká
5	líno	dent	lîsúngú	lísiáká
6	maíno	dents	mâsúngú	másiáká
7	etíkóló	colline	êsúngú	ésiáká
8	bitíkóló	collines	bîsúngú	bísiáká
9	kíngó	cou	êsúngú	ésiáká
10	kíngó	cous	îsúngú	ísiáká
11	lokáhá	feuille	lôsúngú	lósiáká
12	tokulu	cordes	tôsúngú	tósiáká
14	bokpándi	bras	bôsúngú	bósiáká
19	ikulu	corde	îsúngú	ísiáká

D'autres thèmes adjectivaux fréquents sont :

láa	bon;	sá	long;	tói	tout
bé	mauvais;	kúe	court;	ké	petit

Plusieurs adjectifs sont invariables :

moto kwá	homme blanc
mɛ́ɛ pi	eau noire

3.22. Les démonstratifs se réfèrent à 4 notions distinctes :

I ici, près du locuteur
II là-bas, éloigné du locuteur
III référence proche
IV référence éloignée

Le tableau suivant montre ces 4 formes pour les différentes classes nominales:

Classe	Nom-type	I (ici)	II (là-bas)	III (réf.pro.)	IV (réf.él.)
1	moto (personne)	ɔnɔ́	óte	ɔhɔ́	ótoó
2	bato	banɛ́	báte	bahɔ́	bátoó
3	motɛ́ (arbre)	mɔnɛ́	móte	mɔhɔ́	mótoó
4	mitɛ́	minɛ́	míte	mihɔ́	mítoó
5	líso (oeil)	linɛ́	líte	lihɔ́	lítoó
6	maíso	manɛ́	máte	mahɔ́	mátoó
7	esínda(étoffe)	ɛnɛ́	éte	ɛhɔ́	étoó
8	bisínda	binɛ́	bíte	bihɔ́	bítoó
9	ndolɛ́ (chemin)	ɛnɛ́	éte	ɛhɔ́	étoó
10	ndolɛ́	inɛ́	íte	ihɔ́	ítoó
11	lokáhá (feuille)	lɔnɛ́	lóte	lɔhɔ́	lótoó
12	tɔtɔkɔ́ (nattes)	tɔnɛ́	tóte	tɔhɔ́	tótoó
14	bokolo (jambe)	bɔnɛ́	bóte	bɔhɔ́	bótoó
19	itɔkɔ́ (natte)	inɛ́	íte	ihɔ́	ítoó

Les demonstratifs suivants ont des préfixes locatifs :

16	anɛ́ (ici)	áte (là)	ahɔ́ (ici)	átoó (là-bas)
17 ?				hótoó(alors)
18	múna(dedans)			koótoó (jusque là)

3.23. Les déterminatifs (connectifs) sont formés d'un nom précédé d'un élément comprenant le préfixe de classe du nom déterminé plus a. Le ton de ce dernier dépend de la classe du préfixe d'accord. Pour les classes 1, 7 et 9, le ton est descendant : â. Pour les autres classes, il est montant : ǎ. Ces tons sont indépendants du ton du nom qui suit. Exemples :

moto ângulu, âbwɛlí, âlɔkɔni	un homme fort, sage, malade
bato bǎngulu, bǎbwɛlí, bǎlɔkɔni	(pluriels)
esínda ângulu, âmokondi	une étoffe solide, du chef
bisínda byǎngulu, byǎmokondi	(pluriels)
ndíko ângulu, âmɛ́ɛ	un pot solide, à eau
ndíko yǎngulu, yǎmɛ́ɛ	(pluriels)
bokpándi bwǎngulu	un bras fort
tokulu twǎngulu	des cordes solides

motó mămbɔ́	la tête du chien
lofoso lănda	la peau de l'abdomen

3.24. Les pronominaux des classes 1 et 2 sont :

eme moi, ɔhɛ toi, hɛ́ lui, elle

esú nous, enú vous, bɔ́ eux, elles

Pour les autres classes, on emploie les démonstratifs de référence.

3.25. Les possessifs sont formés d'un élément pronominal précédé d'un préfixe d'accord dépendant de la classe de l'objet possédé. Le ton de ce préfixe varie selon le pronom : pour les 3 personnes du singulier, il est haut, tandis que le ton de l'élément pronominal est montant; pour les personnes du pluriel, le préfixe a un ton descendant, tandis que le ton de l'élément pronominal est haut :

mɔ́na (enfant)	óhă	óhŏ	ɔ́hɛ̌	ôsó	ônó	ɔ̂bɔ́
	mon	ton	son	notre	votre	leur
bána (enfants)	báhă	báhŏ	báhɛ̌	bâsó	bânó	bâbɔ́
	mes	tes	ses	nos	vos	leurs
mbélɛ(maisons)	íhă	íhŏ	íhɛ̌	îsó	înó	îbɔ́
	mes	tes	ses	nos	vos	leurs

3.26. Les numéraux. Les cinq premiers nombres s'accordent avec les noms qu'ils déterminent :

Classe	Exemple	un	deux	trois	quatre	cinq
1	moto (personne)	ɔ́mɔi				
2	bato	bámɔi	báélé	básátɔ	bánɛi	bátáanɔ
3	moté (arbre)	mɔ́mɔi				
4	mité	mímɔi	míélé	mísátɔ	mínɛi	mítáanɔ
5	líso (oeil)	límɔi				
6	maíso	mámɔi	máélé	másátɔ	mánɛi	mátáanɔ
7	etíkóló (colline)	émɔi				
8	bitíkóló	bímɔi	bíélé	bísátɔ	bínɛi	bítáanɔ
9	ndolé (chemin)	émɔi				
10	ndolé	ímɔi	íélé	ísátɔ	ínɛi	ítáanɔ
11	lokáhá (feuille)	lɔ́mɔi				
12	tokulu (cordes)	tɔ́mɔi	tóélé	tósátɔ	tɔ́nɛi	tótáanɔ
14	bokpándi (bras)	bɔ́mɔi				
19	ikulu (corde)	ímɔi				

Notez qu'il est parfaitement possible d'employer le noyau -mɔi au pluriel. Le sens en est "quelques". Répété, son sens devient : "certains... d'autres": bato bámɔi ... bato bámɔi certaines personnes... d'autres personnes.

Notez encore que le ton bas de la syllabe finale du thème -mɔi est remarquable quand on le compare avec son homologue dans les langues avoisinantes (ex. lokele) où elle a un ton haut. En olombo, cependant, ce ton est aussi bas.

"Six", "sept", "huit" et "neuf" sont aujourd'hui exprimés par des nombres empruntés à la langue lingala : motóbá, nsambo, mwambe, libwá. On m'a assuré qu'avant l'extension de la langue lingala comme lingua franca en Afrique Centrale, la langue likile avait un système quinaire de numération :

6 ítáanɔ na émɔi, 7 ítáanɔ na íélé, 8 ítáanɔ na ísátɔ

9 ítáanɔ na ínɛi

"Dix" est rendu par liyɔ́ɔ (que l'on entend parfois : diyɔ́ɔ); "vingt" par mitúkú míélé; "cent" par mokámá (cf. lingala).

3.27. Les interrogatifs "qui", "quel" et "combien" sont variables :

classe 1	:	qui ?	ndá ?		
classe 2	:	qui ?	bandá ?	combien ?	bángaá ?
classe 3	:	quel arbre ?	moté mwínandá ?		
classe 4	:	quels arbres ?	mité mínandá ?	combien ?	míngaá ?
classe 5	:	líso línandá ?	quel oeil ?		
classe 6	:	maíso mínandá ?	quels yeux ?	combien ?	mángaá ?
classe 14	:	bokpándi bwínandá ?	quel bras ?		
classe 12	:	tokulu twínandá ?	quelles cordes ?	combien ?	tóngaá ?

3.3. Les formes verbales

3.31. La structure du noyau verbal.

Nous distinguons entre :

a) Les verbes à noyau C : -d- frapper -ky- aller
-f- donner -ŋb- mourir
-y- manger
-kp- tomber

b) Les verbes à noyau CV : -lɔ́- venir -tɔ cracher, mordre
-no- boire

c) Les verbes à noyau VC : -ɔ́k- entendre, sentir -ɔ́b- savoir
-ík- bâtir -ɔ́nd- aimer
-ɛ́n- voir -úm- arriver
-íb- voler

d) Les verbes à noyau CVC sont de loin les plus nombreux; en voici quelques exemples :

-bín-	danser	-lál-	dormir
-fol-	entrer	-tén-	couper (à travers)
-kel-	faire	-tól-	porter

avec C_2 comme consonne double :

-kɛnd-	voyager	-lámb-	cuire
-kúmb-	rentrer	-sómb-	acheter

avec C_2 suivie d'une semi-voyelle :

-limw-	disparaître	-sisw-	s'éveiller

3.32. Les formes verbales affirmatives.

A. Le nomino-verbal (infinitif) : nô + R + a (R est le noyau verbal) :

neóndí nôlála — je désire dormir

baóndí nôbila — ils désirent suivre

B. Le verbe sans préfixe pronominal (impératif) : R + á :

kelá likwa ! — fais du travail !

bíná ! — dansez !

L'impératif du pluriel s'exprime aussi par cette forme simple. On peut insister sur l'idée du pluriel en ajoutant -ye :

keláye ! faites ! bínáye ! dansez !

Préfixes pronominaux.

Les formes verbales qui suivent ont des préfixes pronominaux qui sont :

classe 1 : ne (je), o (tu), a (il, elle)

classe 2 : to (nous), bo (vous), ba (ils, elles)

Les autres classes régissent des préfixes pronominaux qui sont identiques à ceux des démonstratifs de positions I ou III.

C. PP (ton bas) + le : la copule au temps présent :

nele, ole, ale, tole, bole, bale (je suis, tu es ... ils sont)

ale na likuwa il a du travail (il est avec du travail)

D. PP + ékámbá : la copule au temps futur. A noter que l'élément e ne s'entend pas après la voyelle o du PP :

nékámbá, ókámbá, ékámbá, tókámbá, bókámbá, békámbá

je serai, tu seras, ...

E. PP (ton bas) + mbákí : la copule au temps passé :

nembákí, ombákí, ambákí, tombákí, bombákí, bambákí

j'étais, tu étais... ils étaient

F. PP + à + R + á : présent, sens progressif. A noter que la voyelle o disparaît à la première personne du pluriel devant l'élément a :

nakelá	je fais maintenant	nabíná	je danse maintenant
wakelá	tu fais	wabíná	tu danses
akelá	il fait	abíná	il danse
takelá	nous faisons	tabíná	nous dansons

bwakelá	vous faites	bwabína	vous dansez
bakelá	ils font	babína	ils dansent

G. PP + R + í : sens passé, action achevée :

nekelí likwa pɔsɛ âfelo	je travaillai la semaine passée
abíní pɔsɛ âfelo	il dansa la semaine passée

On peut préciser le temps d'hier en ajoutant à cette même forme le suffixe -nò :

nekelíno likwa	je travaillai hier

On peut encore ajouter le mot pour "hier" : bóniíno :

nebíníno bóniíno	je dansai hier

De même, cette forme en -í exprime le temps passé éloigné quand on y ajoute le suffixe ndɛɛ́ :

abíníndɛɛ́	il dansa(l'année passée,par exemple)

H. PP + éká + R + à : sens futur. A noter que la voyelle e ne s'entend pas après la voyelle o du préfixe pronominal, mais le ton haut qu'elle porte est retenu :

nékákela	je ferai	tókábína	nous danserons
ókákela	tu feras	békábína	ils danseront

I. PP (ton toujours haut) + R + è : sens "subjonctif", action souhaitée, demandée :

nékele likwa ?	dois-je travailler ?
aóndí ngoó tóbine	il désire que nous dansions

A noter, dans ce dernier exemple, que le ton de la première syllabe du noyau est bas, même quand il s'agit d'un noyau portant normalement un ton haut (-bín-).

J. PP (ton toujours haut) + R + é : sens narratif. On entend cette forme verbale dans les fables et les histoires (section 4.4.) :

nékelé likwa ...	et je travaillais
bákelé likwa ...	et ils travaillaient
tóbíné ...	et nous dansions

3.33. Les formes verbales négatives.

La plupart de ces formes sont caractérisées par la présence d'un préfixe -tí-. Ce préfixe modifie le préfixe pronominal de la première personne : ne + tí- → indí-.

K. PP + tí + e : sens négatif de la copule au présent :

indíe	je ne suis pas	totíe	nous ne sommes pas
otíe	tu n'es pas	botíe	vous n'êtes pas
atíe	il n'est pas	batíe	ils ne sont pas

L. PP + tí + kámbá : sens négatif de la copule au futur :

indíkámbá é mbɛ́lɛ	je ne serai pas à la maison (é = à, sur)
batíkámbá	ils ne seront pas

M. PP + tí + mbákí : sens négatif de la copule au passé :

totímbákí é kai	nous n'étions pas au village

N. PP + tí + ká + R + à : sens futur négatif :

indíkákela likwa efífí	je ne travaillerai pas demain
batíkábína efífí	ils ne danseront pas demain

O. PP + tí + R + í : sens négatif du passé :

atíkelí likwa é mingá	il n'a pas travaillé au champ
totíbíní é kai	nous n'avons pas dansé au village

P. PP + tí + ná + R + í : sens d'une action projetée mais pas encore réalisée:

indínákelí likwa	je n'ai pas encore travaillé (mais j'ai l'intention de le faire)

On ajoute souvent nɔ́ɔ́ (encore) :

batínábíní nɔ́ɔ́	ils n'ont pas encore dansé

Q. PP (ton bas) + á + R + à : sens négatif de la forme "subjonctive" :

naóndí ngoó aákela likwa na búsé	je désire qu'il ne travaille pas aujourd'hui
baóndí ngoó toábína na búsé	ils veulent que nous ne dansions pas aujourd'hui

Ce temps sert aussi à exprimer le négatif de l'impératif :

waóka !	n'entendez pas !	wakela !	ne faites pas !

A noter que le ton haut du noyau verbal n'est pas masqué ici comme c'était le cas à la forme affirmative.

3.34. Les extensions verbales.

Le noyau verbal en likile s'allonge en ajoutant des suffixes ayant des significations caractéristiques :

i. -es- causatif :	nékele likwa ?	dois-je travailler ?
	nékelese mɔ́na likwa ?	dois-je faire travailler l'enfant ?
ii. -el- applicatif:	nékelele apá likwa ?	dois-je travailler pour papa ?
iii. -an- associatif:	tókelelane likwa !	travaillons ensemble !

Un préfixe ayant cette même forme exprime un sens statif :

	likwa lyakeláná	le travail a été fait
iv. -ak- continuatif:	nékelake likwa !	que je travaille toujours !

3.35. Le redoublement du noyau verbal sert à exprimer une action intensive ou inutile :

bákelakele ?	doivent-ils travailler en vain ?

3.36. Le préfixe régime.

Le complément personnel est souvent représenté par un préfixe entendu immédiatement avant le noyau verbal :

akpésá	il fait tomber
aikpésé eme	il me fait tomber
aɔkpésá ɔhɛ	il te fait tomber
amɔkpésá hɛ́	il le fait tomber
atɔkpésé esú	il nous fait tomber
aɔkpésé enú	il vous fait tomber
abɔ́kpɛ̌sá bɔ́	il les fait tomber

A noter le changement tonal de la première syllabe du noyau verbal précédé d'un préfixe régime bɔ́ : kpé devient kpɛ̌.

La présence d'un préfixe régime annule la restriction tonale imposée sur le verbe par la forme verbale I (sect. 3.32.) :

bátome	qu'ils envoient
bátotómé (esú)	qu'ils nous envoient (nous)
bábɔ́tómé (bɔ́)	qu'ils les envoient (eux)

Les classes autres que 1 et 2 ne sont pas représentées de cette manière. On dirait,par exemple :

akpésá mité	il fait tomber les arbres
akpésá mihɔ́	il les fait tomber

3.4. Les idéophones.

Beaucoup de verbes et d'adjectifs renforcent leur sens par l'emploi d'idéophones. En voici quelques exemples :

ale hai	il est tranquille
likwa lasílá ngíá (aussi kpá)	le travail est tout à fait fini
moté makpá kpu (aussi gbi)	l'arbre tombe avec fracas
saáni etání pá	l'assiette est très propre
takyá téé (aussi hílílílí)	nous allons très loin (sans nous arrêter)

3.5. Les adverbiaux.

Nous groupons ici plusieurs mots invariables que nous pouvons classer comme :

a) adverbiaux de lieu :

éfelo	devant, avant	likolo	au-dessus
émbúsa	derrière, après	mbáayó	en amont
eésé	au-dessous	mbóle	en aval

b) adverbiaux de temps :

bónííno hier, efífí demain, kɔ́kɔ́ maintenant

c) adverbiaux de manière :

fweéfweé	vraiment	índo !	non !
koótoó	alors	ɛɛ !	oui !

3.6. Les conjonctifs.

índé	si	na	et, avec
ngo	que	ndé	mais
sóngó	cependant, si		

4. QUELQUES TEXTES LIKILE

4.1. Devinettes.

a) Mohálí âmokondi, batímɔdé likófi ... mokau.
La femme du chef, on ne lui frappe pas le visage ... la liane rotang.
Tout comme on a peur de toucher à la liane Ancistrophyllum à cause de ses épines, ainsi n'ose-t-on pas toucher à la femme du chef.

b) Moto ómɔi, sóngó móna ámɔdɛ, kpáko ngo álele ... lélo / iléngé.
Un homme, quand même un enfant le frappe un peu, il pleure ... le nez/le gong.

c) Moto ékɛnda na mɔkɔngɔ ... bwátɔ.
Un homme voyage sur le dos ... la pirogue.

4.2. Proverbes.

a) Ekemba, sóngó ósunge ndé mwéngé motólí ɔhɛ.
Cuisse, même quand tu es grosse, c'est le petit mollet qui te porte.

b) Bangoya békpome ngandi itíóki.
Les petites antilopes naines parlent, les grandes antilopes n'y font pas attention.

c) Epɔlú etíe na boóndé bôláa.
Un couteau n'est pas bon camarade.

d) Tofímbilí totíbángí moto ôsúngú.
Les petites mouches ne craignent pas un homme important.

4.3. Chansons.

Comme ailleurs dans la région du Haut-Zaïre, la mélodie d'une chanson suit de près la tonalité des paroles dont elle se compose. Les exemples suivants sont connus de tous les enfants likile :

a) Chanson de pêche :

álúmbé o olé	celui qui n'attrape pas de poissons
tómokasélé beke	allons emballer pour lui des feuilles "beke"
beke lifólóló e	les paquets n'ont rien dedans !

La mélodie de cette chanson est la suivante :

m m m r d r d l l d d l l
d d d r r r d

b) Chanson de cuisine :

tótute mókíndá a na iyambo	pilons les feuilles de manioc avec les carottes
iyambo ihɔ́ yakpéndá e	les carottes sont dures
kookundu e	elles ne servent à rien

La mélodie :

s m m s s s m r r r r
f f f f s m f f r
d d d d

Gamme ascendante : l. d r m f s.

4.4. Une fable.

Mosékélé na Angoya	Le Rat et l'Antilope naine
Mosékélé na Angoya bakɛndákíndɛɛ	Rat et Antilope se liaient d'amitié.
lokóta. Búsé bɔ́mɔi, Angoya hótoó	Un jour, Antilope alors
ákpomé na Mosékélé ngo : Moínaá	dit à Rat (que) : Mon ami
naoláa ngo tɔ́kɛ ikéɛ molukání	il serait bien d'aller un peu chercher
mbíla na búsé. Mosékélé ngo :	des noix aujourd'hui. Rat dit :
Tɔ́kɛ tókaluke mbíla, moínaá.	Allons chercher des noix, ami.
Bɔ́ bátoó bátómbé bipɔlú na bikau.	Ils prennent leurs couteaux et courroies.
Koótoó báúmé émesehani mǎndolé.	Ils arrivent donc à une bifurcation du
Mosékélé áké éhě eáti; Angoya	chemin. Rat va son chemin; Antilope

kaálé áké éhɛ̌ eáti.	va son chemin aussi.
Angoya ngo áke na éfelo;	Antilope avança un peu;
aɛ́nésí motó mwă ebíla molangálí.	il vit un régime de noix couché par terre.
Mosékélé hótoó alɔ́í.	Rat vient alors.
Babendákí motó mɔhɔ́.	Ils soulèvent ce régime-là.
Mosékélé ngo : Tɔ́kɛ na ebíla ɛnɛ́ éte ɛ̌ likolo lă etíkólo likita loísama.	Rat dit : Allons avec ce régime sur la colline en haut pour (le) cacher.
Koótoó báúmé na mɔhɔ́.	Ainsi ils arrivent avec cela.
Mosékélé ámotómé Angoya ngo átene mité măotúta na mbíla ngo báfɔtɛ maíná.	Rat envoie Antilope pour qu'il coupe des bâtons pour piler les noix afin d'extraire l'huile.
Embáki Angoya éténa mité,	Quand Antilope coupe les bâtons,
Mosékélé épuka fanda.	Rat creuse un trou.
Mângéné ăebíla ábɔluké téé ákábwɛ̌né.	Le propriétaire des noix les cherche... il les voit.
Akúmbí ékai likita lămotómbání bato na mbɔ́.	Il rentre au village chercher des hommes et des chiens.
Mbɔ́ ítoó íkábobilé Angoya na Mosékélé.	Ces chiens chassent Antilope et Rat.
Koótoó Mosékélé áfólé éfanda éhɛ̌,	Donc Rat entre dans son trou, il se cache.
áísámé.	
Mbɔ́ ímobilé Angoya téé.	Les chiens suivent Antilope...
Koótoó ákátalé até âboóya.	donc il tombe dans un filet.
Bato bámobóláké Angoya.	Les hommes tuent Antilope.
Bosío bwă litátá : Ema âboíba otíyé na motéma mómɔi.	Le sens de la fable : Une chose volée, tu ne la manges pas avec un coeur net.

5. LEXIQUE

Les éléments du lexique sont arrangés en ordre alphabétique de leur noyau ou de leur thème.

Un nom est reconnu par la présence d'un préfixe de classe au singulier et au pluriel : bw -átɔ ma- pirogue. Une exception à cette règle est le cas des noms des classes 9/10. Ici, le nom au singulier ne porte pas de trait d'union et il est répété à gauche comme la forme au pluriel :

fanda fanda trou.

Un adjectif aura un thème précédé d'un trait d'union sans préfixe d'accord; il n'y aura pas de forme de pluriel : -láa bon.

Un mot invariable sera seul, sans trait d'union.

Un verbe porte un trait d'union devant et encore un autre derrière :

-bót- donner naissance à.

	amá	ba-	maman
li	-anga	má-	tabac
e	-áti	bi-	endroit, côté
bw	-átɔ	ma-	pirogue
li	-bangé	ma-	fleuve
li	-bé	ma-	genou
	-bé		mauvais
e	-bendé	bi-	fer, métal
li	-bélɛ	ma-	sein
ma	-bélɛ		lait
	-bil-		suivre
e	-bíla	bi-	palmier Elaeis
m	-bíla		noix de palme
	-bín-		danser
	bitá	bitá	guerre
	-ból-		tuer
li	-bóo	ma-	plantain
	-bót-		donner naissance à
e	-búlú	bi-	lèvre
	-bún-		briser
	-d-		frapper
	-donban-		rencontrer
l	-élo	ma-	nez
	-émal-		se tenir debout
	-ét-		appeler
	-én-		voir
mw	-éngé	mi-	mollet
li	-étéké	ma-	boue
	-f-		donner
li	-falɛ	ma-	foie
	fanda	fanda	trou, presse à huile
lo	-fanga	fanga	mouche
	felo		devant, avant
	fɛ́lɔ		fer à repasser
e	-fífí		demain
	fiɔ		froid
li	-fofe	ma-	araignée
li	-fofela	ma-	vent
	-fok-		respirer
	-fól-		entrer
i	-fondo	to-	entonnoir(à lavement)
lo	-foo	foo	souris
lo	-foso	foso	peau
	-fɔl-		pourrir
	-fɔt-		presser
lo	-funga		riz
	-gbom-		aboyer
li	-hála	ma-	charbon
mo	-hálí	ba-	femme
	-héles-		vendre
	-hénak-		être fatigué
li	-hɛ́ti	ma-	brouillard
mo	-hili	mi-	terre, pays
a	-hóla	ba-	gong
i	-hɔ́li	tɔ-	épervier
li	-hɔmbi	ma-	ombre
li	-hɔ́mbɔ́	ma-	brosse
ma	-hwa		pitié,tristesse
	-íb-		voler, dérober
	ífé	to-	feu
e	-íkó	bi-	porc épic
mw	-ili	mi-	racine
	ina	ba-	mère
ma	-íná		huile
l	-ína	ma-	nom
mo	-ínaá	ba-	ami
l	-índí	ma-	saleté
b	-ingi		herbes, déchets
l	-íno	ma-	dent
	-ís-		cacher
mí	-ísá		guêpes
	isé	ba-	père
má	-isé		tante paternelle
bo	-ísé (=búsé)	ma-	jour
li	-kaá	ma-	crapaud
	kaálé		aussi, comme

lo -káhá	nkáhá	feuille	
kai	kai	village	
mo -kákế	mi-	foudre, fusil	
lo -kalánga	nkalánga	arachide	
li -kalo	ma-	main	
kanga	ba-	guérisseur	
e -kau	bi-	courroie	
mo -kau	nkau	liane Ancistrophyllum	
mo -keế	mi-	oeuf	
e -kelékelé	bi-	épaule	
e -kemba	bi-	cuisse	
-kesol-		tousser	
-kế		petit	
li -kɛlɛkɛ	ma-	palmier "ndele"	
i -kɛmbɛ	tɔ-	petit couteau	
-kɛnd-		voyager	
é -kíli	bí-	corbeille	
li -kita	ma-	raison, affaire	
mo -kó	mi-	écureuil (grand)	
mo -kóbi	mi-	chimpanzé	
bo -kolo	ma-	jambe	
lo -kóta		amitié	
mo -kondi	mi-	chef	
li -kongá	ma-	lance	
kɔi	kɔi	léopard	
lí -kɔkɔ	má-	maïs	
kɔ́kɔ́	kɔ́kɔ́	coq, poule	
lɔ -kɔ́ni	nkɔ́ni	maladie	
mɔ -kɔngɔ	mi-	dos	
kɔ́kɔ́		maintenant	
á -kúkú	bá-	lézard	
i -kúla	to-	bois à brûler	
i -kulu	to-	corde	
-kumb-		rentrer	
-kunduk-		courir	
mo -kungi	nkungi	poil	
e -kúpa	bi-	poumon	
bo -kusa	ma-	arc	
mo -kpá	mi-	sel	
i -kpakpa	to-	scorpion	
a -kpákpálikpá	ba-	cigale	
-kpal-		balayer	
mo -kpala	mi-	tortue	
bo -kpándi	ma-	bras	
mo -kpángá	mi-	bracelet	
-kpom-		dire, parler	
-kpɔlɔlɔ	kpɔlɔlɔ	pipeau	
li -kpú	ma-	pétiole de palmier	
-kúe		court	
-láa		bon	
-lál-		se coucher	
mo -láma	mi-	esclave	
-lámb-		cuire	
lo -lámɛ	ndámɛ	langue	
mo -lánga	mi-	crocodile	
-lel-		pleurer	
i -léngé	to-	gong (petit)	
mo -liká	ndiká	noix palmiste	
-limw-		disparaître	
e -lombe	bi-	cour, partie du village, clan	
mo -lóme	ba-	époux	
mo -londo	mi-	marteau	
e -longi	bi-	visage	
-lɔ-		venir	
-lɔngw-		s'en aller	
-luhany-		penser	
-luk-		chercher	
é -ma		objet, chose	
mbángo		vite	
lo -mbaya	mbaya	plantain	
li -mbembe	ma-	plume	
mbɛ́lɛ		maison	
-mbimb-		jeter	
li -mbímbá	ma-	palmier à vin	
mbóngó		éléphant	
mbɔ́		chien	
li -mbɔkɔ	ma-	miel	
mbúki	mbúki	mortier	

mbulú	mbulú	oiseau	
mbúsa		derrière, après	
bo -mbúsa	ma-	frère cadet	
méɛ		eau	
méme		chèvre	
-mɔi		un	
mo -na (aussi: muna)	mi-	bouche	
mɔ́ -na	bá-	enfant	
má -nale		frère de l'épouse	
nama	nama	viande, animal	
-nandá		lequel	
-nb-		mourir	
nbá	nbá	argent	
nbe	nbe	matin	
-nbuluk-		ronfler	
mo -nbumo	mi-	tonnerre	
nda	nda	ventre	
lo -ndála	ndála	ongle	
ndále	ndále	buffle	
ndiko	ndiko	pot	
-ndim-		être d'accord	
ndɔ́i	ndɔ́i	abeille	
ndolé	ndolé	chemin	
-ndonb-		heurter	
ndɔ́ɔ	ndɔ́ɔ	serpent	
-nɛi		quatre	
mí -ngá		champ	
-ngaá		combien	
-ngál-		briller	
ngálímá		ciel	
lo -ngánga	ngánga	feuille de palmier	
li -ngéka	ma-	corne	
a -ngelé	ba-	cuiller	
ngélo		sang	
mo -ngélémba	mi-	avant-bras	
a -ngoya	ba-	antilope naine	
a -ngɔmbɛ	ba-	grenouille	
mo -ngúa	mi-	os	
ngubó	ngubó	hippopotame	
ngulu	ngulu	force	
ngulú	ngulú	porc	
bo -niíno		hier	
nkándá	nkándá	colère	
nkóngo	nkóngo	joue	
nkusu	nkusu	médicament	
e -njoká	bi-	bec d'oiseau	
-no-		boire	
-ɔ́b-		savoir	
-ɔ́k-		entendre,sentir	
li -ɔ́ké	ma-	sable, banc de sable	
-ɔ́nd-		vouloir	
a -ongó		Dieu,Créateur	
-ɔ́ng-		mendier	
bo -óya	ma-	filet (chasse)	
li -ɔndɔ	ma-	palmier à raphia	
li -ɔpí	ma-	pierre	
páá		rouge	
lo -pépelé	pépelé	papillon	
e -pɔlú	bi-	couteau	
-puk-		creuser,houer	
-sá		long, haut	
li -saá	ma-	marché	
-san-		jouer	
sasya	sasya	sable (petits grains)	
-sátɔ		trois	
sé		sous, en bas	
eé -sé		au-dessous de	
mo -sékélé	mi-	rat de forêt	
i -séni	to-	lieu	
e -séndé	bi-	écureuil	
i -sɛi	tɔ-	doigt	
-sɛk-		rire	
lɔ -sɛ́lɛ́	nsélé	tisserin	
-sɛm-		rêver	
sɛma	sɛma	rêve	
-siáká		autre	

mo -síkpá	mi-	éternuement	
-síl-		finir	
e -sínda	bi-	étoffe	
bo -sío	ma-	sens, signification	
e -sisi	bi-	spectre, fantôme	
-sisw-		s'éveiller	
-sómb-		acheter	
-sóngé	sóngé	lune	
mɔ -sɔkɔ́	mi-	pagne	
mɔ -sɔlɔ́	mi-	intestin	
mo -sué	sué	cheveu	
-súngú		grand	
-táanɔ		cinq	
mo -tái	mi-	branche	
-tál-		crier cocorico	
li -táma	ma-	joue	
li -tátá	ma-	table	
mo -té	mi-	arbre	
tele	tele	siège	
mo -téma	mi-	coeur	
-tén-		couper	
téndé	téndé	aigle	
tɛngu	tɛngu	aiguille	
-tíkal-		rester	
e -tíkóló	bi-	colline	
li -tíndí	ma-	pied	
bo -tío	ma-	nuit	
mo -to	ba-	personne	
mo -tó	mi-	tête	
li -tói	ma-	oreille	
-tói		tout	
-tól-		porter	
-tóm-		envoyer	
-tómb-		prendre	
i -tɔkɔ́	tɔ-	natte	
li -tɔɔ́	ma-	hache	
lɔ -tɔ́tɔ́fi	tɔ́tɔ́fi	étoile	
mo -túfu	mi-	poussière	
mo -túkú	mi-	dizaine	
mo -túli	ba-	forgeron	
mo -túndulú	mi-	coude	
-tút-		piler	
a -úká		pluie	
-úm-		arriver	
-y-		manger	
a -yaka	ba-	perle	
-yal-		s'asseoir	
i -yambo	to-	manioc(carottes)	
li -yɔɔ		dix	

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