MOLECULAR SYSTEMATICS AND DNA BARCODING OF AFRICAN SAPINDACEAE

BY

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CERTIFICATION

This is to certify that the thesis:

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submitted to the School of Postgraduate Studies, University of Lagos
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is a record of original research carried out

By

ADEYEMI, TEMITOPE OLABISI
in the Department of Botany

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DEDICATION

This work is dedicated to God Almighty for its success and to my loving and supportive parents (Late) Mr. Obafemi Adeyemi and Mrs. I.A. Adeyemi.

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ABSTRACT

Sapindaceae Jussieu is a family of flowering plants in the order Sapindales. They exist as trees and shrubs, and tendril-bearing vines with about 140-150 genera and 1400-2000 species worldwide. Sapindaceae is economically, medicinally and aesthetically useful. This aims of this research are to carry out systematic study on African Sapindaceae and generate DNA barcodes for each species with a view to sharing the DNA barcode sequence in a public database. The taxonomy of the family was re-examined using both classical and modern approaches; essentially, the phylogeny of the family was expounded. The methodology employed included: herbaria studies, morphological and anatomical characterization, species distribution modelling and molecular studies. These revealed that in Africa, the family is represented by twenty eight (28) genera and a hundred and six (106) species. They are geographically distributed in the temperate and tropical regions of the world and their distribution is mostly affected by the minimum temperature of the coldest month (35.4%) and least affected by minimum temperature of driest quarter (0.2%). In the family, exo-morphological features recorded were compound leaves (paripinnate, imparipinnate or trifoliate); flowers are in spirits, fruits occur as berry, drupe or capsule and contain seed with white or orange aril. Taxonomically useful endo-characteristics were rectangular, polygonal and irregular cell shapes, smooth, curved and undulate anticlinal wall patterns, amphistomata distinguished *Dodonaea viscosa* and *Sapindus saponaria* from other species in the family. Generally, two stomatal types were recorded and these were anomocytic and paracytic. Trichome types found in the family included acicular, filiform, uniseriate, glandular and stellate types and they proved useful in taxa delimitation. Epicuticular wax is granular in all taxa especially on the adaxial surface. For molecular studies, silica gel dried specimens' yielded good quality DNA unlike the old dried herbarium leaf samples. Two hundred and four (204) DNA sequences and sixty-nine (69) DNA barcodes were generated. Barcode data which was hinged on matK and rbcL sequence data have been in the Barcode of Life database (BOLD) website for public use. The phylogenetic analyses revealed that Sapindaceae is monophyletic but paraphyly and polyphyly were shown at subfamilial and tribal levels. The recent suggestion on the taxonomic position of *Xanthoceras sorbifolia*, Aceraceae and Hippocastanaceae as belonging in the family is corroborated. The family can therefore be classified and supported as follows: Sapindoideae (100% bp), Dodonaeoideae (57% bp), Hippocastanoideae (including Aceraceae) (66% bp) and the monotypic Xanthoceroideae (< 50% bp) comprising *Xanthoceras* is sister to the family. Furthermore, based on only molecular data, Sapindaceae can be subdivided into subfamily Sapindoideae with twelve tribes and subfamily Dodonaeoideae with three tribes.

CHAPTER ONE

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

Sapindaceae **A.L. de Jussieu**, also known as the soapberry family, is a family of flowering plants in the order Sapindales. The family can be divided into 5 or 6 subfamilies depending on the method of classification. They are mostly trees and shrubs, and tendril-bearing vines comprising about 140-150 genera with 1400-2000 species worldwide many of which are lactiferous, i.e. they contain milky sap, and many contain mildly toxic saponins with soap-like qualities in the foliage and/or in the seeds or roots. The largely Neotropical Paullineae Kunth (Sapindoideae Burnett), with 8 genera including *Serjania* Miller and *Paullinia* L., contain one third of the species in the family. Members include maple, horse chestnut, guarana, rambutan, ackee and lychee but the largest genera are *Serjania, Paullinia, Acer* L. and *Allophylus* L.

Geographical Distribution of Sapindaceae

Members of the family are widely distributed throughout the warm sub-tropical and tropical regions of the world (Figure 1.1). The majority of species are native to Asia, although there are a few in South America, Africa and Australia (APG II, 2003). New species are still being described. The most specialized growth forms are the rather strange unbranched palm-like trees such as *Talisia* Aublet and woody climbers like *Serjania* and *Paullinia*. The largest trees including *Schleichera oleosa* Willd and *Pometia pinnata* Forst & Forst (‘Tuan’, ‘Dawa’ or ‘Fiji’, ‘Longan’) which may reach up to 60 m in height (Heywood, 1978).

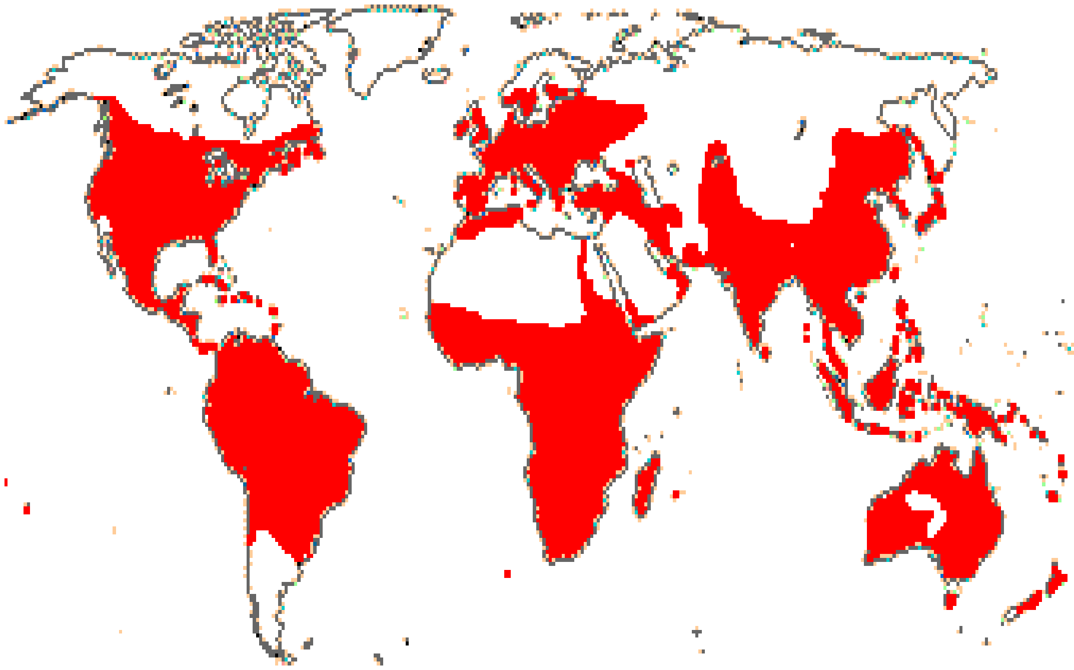


Figure 1.1: Geographical Distribution of Family Sapindaceae

(Sites of occurrence are shown in red colour)

Source: Angiosperm Phylogeny Group (APG II) (2003)

In Africa, 25 genera are represented in the East with 61 species between them; 14 species are regarded as endemic to the area while about 18 (Hutchinson and Daziel, 1958) to 22 (Burkhill, 2000) genera are represented in West with only about 13 genera found widely spread throughout Nigeria (Keay *et al.,* 1964).

Morphology of Sapindaceae

Habit

Members of the family Sapindaceae occur as either trees, shrubs or climbing vines.

Leaves

Usually Sapindaceae are recognizable by their often spiral, alternate, simple, or more commonly pinnately compound leaves (in *Acer, Aesculus* L., and a few other genera) that often have sub-opposite leaflets and a terminal rachis tip, although many taxa have ternately/palmately-compound leaves or just palmate leaves (*Acer*, *Aesculus*). The leaflets may be coarsely serrate and the fine venation is often prominent when it is dry. Stipules are absent except in the climbing forms, the petiole base is quite strongly swollen and the stem is ridged (*Singh, 2004)*. However, some are simple, non-sheathing, often gland-dotted without marked odour and often pulvinate in nature (Watson and Dallwitz, 2008).

Stem

The stem is either erect and self supporting, or climbing. The climbing taxa are usually tendril climbers.

Flowers

Members of family Sapindaceae possess small and unisexual flowers which are aggregated to form 'inflorescences' grouped in cymes although plants may either be dioecious or monoecious. The inflorescences are paniculate, and the flowers are often borne in congested groups along the axis. The perianth typically is biseriate, consisting of calyx and corolla. The calyx comprises 4 or 5 distinct or sometimes basally connate sepals. The corolla consists of 4 or 5 distinct petals or sometimes absent as in *Dodonaea* Miller. The petals commonly have basal appendages on the inner side. The perianth usually has distinct calyx and corolla and it is usually double whorled though sometimes the corolla may be lacking (APG II, 2003). The stamens are distinct, i.e. free of perianth, double-whorled, often have hairy filaments, and in quantity, usually are equal to or twice the number of calyx lobes (8-10). They usually have 4-5 stamens which are isomerous with perianth. The gynoecium consists of a single compound pistil of usually 3 carpels, commonly an equal number of styles or style lobes, and a superior ovary usually with 3 locules, each containing 1 or 2 axile or axile-apical ovules. Most species have an extrastaminal, often asymmetrical nectary disk situated between the stamens and corolla. Most often they are pollinated by birds or insects, with a few species pollinated by wind (Singh, 2004).

Fruits

The fruits are fleshy or dry; dehiscent, or indehiscent or schizocarpic fruits in form of nuts, berries, drupes, capsules as in *Bridgesia* Bertero ex Cambess, or samaras as in *Acer* often red, containing seeds (Heywood, 1978). The embryos are bent or coiled, without endosperm in the seed, but frequently with an aril *and* with two cotyledons (Singh, 2004).

Anatomy of Sapindaceae

The family exhibits a diverse range of characters, with no one feature being diagnostic. Four basic stomatal types can be recognized. Trichomes, glands and papillae are often present (Pole, 2010). The abaxial leaf epidermis is often papillose and mucilaginous usually with anomocytic, or paracytic stomata. The stomata, usually confined to the lower surface, are ranunculaceous except in *Chonopetalum* Radlk and *Harpullia* Roxb (Metcalfe and Chalk, 1957). On the adaxial surface, hypodermis is often present with dorsiventral (usually), or isobilateral to centric lamina; without secretory cavities and minor leaf veins lack phloem transfer cells as in *Cardiospermum* L., *Dodonaea*, *Melicoccus* P. Browne (Metcalfe and Chalk, 1979).

The stem contains superficial or deep-seated cork cambium with tri-lacunar nodes and internal phloem is absent as seen in *Dodonaea*. They have secondary thickening which develops from a conventional cambial ring, or anomalous; sometimes via concentric cambia as in *Serjania*. The xylem contains libriform fibres; with simple vessels lacking vestured pits and narrow primary medullary rays. They have storied wood e.g. *Diplokeleba* N.E. Br., or partially storied wood e.g. *Sapindus* L. with paratracheal, or apotracheal and paratracheal parenchyma. Typically, they have small and numerous vessels with many multiples of 2-3 cells but without any definite pattern. Very occasionally, they are ring porous or with spiral thickening ranging from short to medium length (Metcalfe and Chalk, 1957).

Chemistry of Sapindaceae

Members may be cyanogenic, or non cyanogenic and the cyanogenic constituents are leucine-derived and CN lipids. They possess flavonols in form of quercetin, or kaempferol and quercetin, or quercetin and myricetin, or kaempferol, quercetin, and myricetin and pro-anthocyanidins in form of cyanidin, or cyanidin and delphinidin. Alkaloids may also be present or absent while saponins is commonly present in the tissues. Sugars are transported as sucrose in nine genera and the C_3 physiology is recorded directly in *Cardiospermum* while (CAM) is recorded directly in *Dodonaea* (Watson and Dallwitz, 2008).

Evolution of Sapindaceae

It has been suggested that all subfamilies of Sapindaceae diverged in the early Cretaceous between (very approximately) 116-98 million years ago, spreading initially from Laurasia, with South East Asia remaining an important area in the evolution of the family (Buerki *et al.,* 2010). *Cupaniopsis* Radlk-type pollen is widespread in fossil record, including several sites in Africa, although Sapindaceae with such pollen are no longer found (Coetzee and Muller, 1984). Fossils ascribable to Sapindaceae are known from the later Cretaceous, while *Wehrwolfea*, with striate pollen and a floral formula of K_4 C_4 A_{10} $\underline{G}_{3-4}$, is known from the middle Eocene of Western Canada (Erwin and Stockey, 1990). The split between *Acer* and *Dipteronia* Oliver has been dated to (98-) 78 (-63.5) million years ago (Renner *et al.,* 2007). The very widespread *Dodonaea viscosa* has spread and diversified within the last two million years (Harrington and Gadek, 2009).

Economic Importance of Family Sapindaceae

Many species are of economic value. Several genera in the family Sapindaceae are grown as shade trees or cultivated for their showy fruit or reddish new growth i.e. they include useful ornamentals such as *Sapindus saponaria*, a small tree up to 10 m high in Florida, the West Indies and South America; *Koelreuteria paniculata* Laxmann (golden rain tree), a round-headed species up to 10 m high in China, the Republic of Korea and Japan; *Xanthoceras sorbifolia* Bunge, a small tree up to 5 m high in northern China planted for its attractive flowers; *Ungnadia speciosa* Endl. (Mexican buckeye), a shrub and *Cardiospermum halicacabum* (balloon-vine), an annual vine planted in southern USA is grown for its small balloon-like fruits in many areas, where it sometimes escapes and becomes naturalized. Some yield valuable timber, the most widely used is Tulipwood (*Harpullia pendula*). Hop bush (*Dodonaea viscosa*), a widespread tropical shrub, is cultivated in warmer areas for its colourful foliage. The ackee is grown not only for its fruits but also as a shade tree.

Many other members of the Sapindaceae are important nuts, or sources of beverages, or oils (e.g. *Amesiodendron chinense*, *Delavaya toxocarpa* Franchet and *Xanthoceras sorbifolium*). *Schleichera trijuga* is the source of macassar oil used in ointments. *Paullinia cupana* is a vine from South America, the source of guarana, used as drinks in Brazil and elsewhere.

Many produce edible fruit; the Lychee (*Litchi chinensis* Sonn.), in which the aril is eaten, is cultivated in tropical areas (Chapman, 1984). The aril of the Native Tamarind (*Diploglottis australis* Hook f.) and of other species of *Diploglottis* is used for making jams and drinks. *Blighia sapida* Koenig, ackee is a fruit from West Africa, with an edible aril, but poisonous if not eaten at the correct stage of ripeness (Metcalfe and Chalk, 1957). The mamoncillo or Spanish lime, *Melicocca bijuga* is also grown for its fruit in South America. *Pometia pinnata* is sometimes grown in Papua New Guinea and the Pacific for its edible aril. Other minor species worthy of evaluation for their fruit include: *Cubilia bancoi* Blume, ‘kubili’ from low to medium elevations in the Philippines; *Diploglottis cunninghamii*, native tamarind from sub-tropical Australia; *Talisia olivaeformis* Aublet, ‘talisia’ from tropical America; *Alectryon micrococcus* Gaertn, ‘mahoe’ from Hawaii; and *Chytranthus macrobotrys* Hook f., ‘ndgulu’ from Central Africa (Yeap, 1987).

Saponins are present in the fruits, seeds, barks, twigs, leaves, pericarp and other tissues of several species; the bark of *Jagera pseudorhus* Blume contains large amounts and is used as a foaming agent and as a fish poison. Some types such as *Sapindus saponaria* are used as soap substitutes in the tropics.

The most important members of the Sapindaceae are the attractive, eye-catching fruit of the sub-family *Nepheleae* Radlk from the orient (Leenhouts, 1978). *Litchi chinensis* (Lychee), *Euphoria longan* Radlk (longan), *Nephelium lappaceum* L. (rambutan) and *Nephelium mutabile* L. (pulasan) are similar trees, but differ in fruit morphology and ecology. Lychee is the most economically significant member of the group and it is regarded as one of the kings of tropical fruits having a very long history in Asia. The fruits are very attractive, with bright red skin covered by angular or conical protuberances (Chapman, 1984). Longan resembles lychee, but the fruit are smaller, smoother, yellow-tan to brown, milder in flavour and less acid. About a third of people in Asia prefer longan to lychee, whereas in Australia, America and Europe, lychee is more popular. Canned longans are more acceptable than canned lychee. Rambutan and pulasan are similar to lychee, with red or yellow skin; however, long hairs or spinterns replace the protuberances. Rambutan and pulasan are strictly tropical, cropping only in warm, wet, lowland areas, whereas lychee and longan are found in the warm sub-tropics or above 500 m in the tropics (Leenhouts, 1986).

The best-known member of the previously recognized family Aceraceae is *Acer saccharum* (sugar maple). It has sugar-rich sap that is tapped in the early spring in eastern North America in order to make maple syrup and maple sugar. Sugar maple has been described as the most valuable hardwood in North America. Its figured wood (curly maple and bird's-eye maple) is valued for cabinetry and furniture; the plain wood is used for construction, flooring, and interior finishing. The hard, strong, heavy close-grained wood is often beautifully patterned. The sugar maple is a valuable ornamental and shade tree because of its thick shapely crown and the bright yellow, orange, and red autumnal coloration. In addition, it yields valuable firewood. Other North American maple species are less important as timber, paper pulp, sugar-producing, and ornamental trees. A few European species, and more Asian species, are sources of timber or grown as ornamentals for their foliage and leaf colours.

The fruit of the *Blighia sapida* is not edible in its entirety. It is only the fleshy arils around the seeds that are edible while the remainder of the fruit and seeds are poisonous. The fruit must only be picked after it has opened naturally, and it must be fresh and not overripe. Immature and overripe ackee fruit are also poisonous. The fruit, even when ripe, is a cause of Jamaican vomiting sickness, characterized by vomiting and hypoglycemia. The unripe or inedible portions of the fruit contain the toxins hypoglycin A and hypoglycin B. Hypoglicin A is found in both the seeds and the aril, while hypoglycin B is found only in the seeds. Hypoglycin is converted in the body to methylenecyclopropyl acetic acid (MCPA). Hypoglycin and MCPA are both toxic. MCPA inhibits several enzymes involved in the breakdown of acyl CoA compounds. Hypoglycin binds irreversibly to coenzyme A and carnitine reducing their bioavailability and consequently inhibiting beta oxidation of fatty acids. Beta oxidation normally provides the body with ATP, NADH and acetyl CoA which is used to supplement the energy produced by glycolysis. Glucose stores are consequently depleted leading to hypoglycemia. The oil of the ackee arils contains many important nutrients, especially fatty acids. Linoleic, palmitic and stearic acids are the primary fatty acids found in the fruit. Ackee oil makes an important contribution to the diet of many Jamaicans. Ackee and salt fish (cod) is the national dish of Jamaica (DeMers, John and Norma, Benghiat, 1998). Salt cod is sauced with ackee, pork fat, onions, peppers, tomatoes, herbs, and may be garnished with crisp bacon and fresh tomatoes. The dried seeds, fruit bark and leaves are used medicinally. The fruit is used to produce soap in some parts of Africa. It is also used as a fish poison.

The fruit of *Dodonaea viscosa* (hop bush) has been used as a substitute for hops in the brewing of beer (True hops, *Humulus lupulus*, are in an unrelated family). The Seri (from Mexico) use it as an external remedy for aches. It is used extensively in desert landscapes because there are very few fast-growing, evergreen, native shrubs.

Members of the family Sapindaceae are of great medicinal importance. For example, the leaves of *Allophylus africanus* are used to relieve headache and migraine, the root is used in treating dysentery, pile, diarrhoea while the bark is used in treatment of arthritic conditions. The bark of *Blighia sapida* Koenig is used in treating intercostals pain, the leaves are used for headache and the fruits serve as mordant dye. Roots of *Blighia unijugata* are used as purgative while the leaves are used in treating rheumatism and kidney pain. *Cardiospermum halicacabum* L. is commonly taken as vegetable in beef soup and the leaves and roots stimulate action for dropsy, orchitis, rheumatism and nervous disorder. *Deinbollia pinnata* Schumach & Thonn is used in the treatment of bronchitis, cough, intestinal pain, and it could be snuffed or drunk as aphrodisiac. The root of *Paullinia pinnata* L. is used as chewing stick, for cough and stomach ulcer, the leaf extract is applied in treating bruises, pains and burns while the seeds serve as fish poison (Odugbemi and Akinsulire, 2006). Also, *Dimocarpus longan*, *Litchi chinensis* L. and *Sapindus saponaria* L. are of medicinal importance.

Deoxyribonucleic acid (DNA)

Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic instructions used in the development and functioning of all known living organisms (with the exception of RNA viruses). The main role of DNA molecules is the long-term storage of information. DNA is often compared to a set of blueprints, like a recipe or a code, since it contains the instructions needed to construct other components of cells, such as proteins and RNA molecules. The DNA segments that carry this genetic information are called genes, but other DNA sequences have structural purposes, or are involved in regulating the use of this genetic information.

DNA consists of two long polymers of simple units called nucleotides, with backbones made of sugars and phosphate groups joined by ester bonds. These two strands run in opposite directions to each other and are therefore anti-parallel. Attached to each sugar is one of four types of molecules called bases. It is the sequence of these four bases along the backbone that encodes information. This information is read using the genetic code, which specifies the sequence of the amino acids within proteins. The code is read by copying stretches of DNA into the related nucleic acid RNA, in a process called transcription.

Within cells, DNA is organized into long structures called chromosomes. These chromosomes are duplicated before cells divide in a process called DNA replication. Eukaryotic organisms (animals, plants, fungi, and protists) store most of their DNA inside the cell nucleus and some of their DNA in organelles, such as mitochondria or chloroplasts. In contrast, prokaryotes (bacteria and archaea) store their DNA only in the cytoplasm. Within the chromosomes, chromatin proteins such as histones compact and organize DNA. These compact structures guide the interactions between DNA and other proteins; helping control which parts of the DNA gets transcribed.

In living organisms, DNA does not usually exist as a single molecule, but instead as a pair of molecules that are held tightly together (Watson and Crick, 1953). These two long strands entwine like vines, in the shape of a double helix. The nucleotide repeats contain both the segment of the backbone of the molecule, which holds the chain together, and a base, which interacts with the other DNA strand in the helix. A base linked to a sugar is called a nucleoside and a base linked to a sugar and one or more phosphate groups is called a nucleotide. If multiple nucleotides are linked together, as in DNA, this polymer is called a polynucleotide. The backbone of the DNA strand is made from alternating phosphate and sugar residues (Ghosh and Bansal, 2003). The sugar in DNA is 2-deoxyribose, which is a pentose (five-carbon) sugar. The sugars are joined together by phosphate groups that form phosphodiester bond between the third and fifth carbon atoms of adjacent sugar rings. These asymmetric bonds mean a strand of DNA has a direction. In a double helix the direction of the nucleotides in one strand is opposite to their direction in the other strand: the strands are anti-parallel. The asymmetric ends of DNA strands are called the 5' (*five prime*) and 3' (*three prime*) ends, with the 5' end having a terminal phosphate group and the 3' end a terminal hydroxyl group. One major difference between DNA and RNA is the sugar, with the 2-deoxyribose in DNA being replaced by the alternative pentose sugar ribose in RNA. The DNA double helix is stabilized primarily by two forces: hydrogen bonds between nucleotides and base-stacking interactions among the aromatic bases (Yakovchuk *et al.,* 2006).

The four bases found in DNA are adenine (abbreviated A), cytosine (C), guanine (G) and thymine (T). These four bases are attached to the sugar/phosphate to form the complete nucleotide, as shown for adenosine monophosphate. These bases are classified into two types; adenine and guanine are fused five- and six-membered heterocyclic compounds called purines, while cytosine and thymine are six-membered rings called pyrimidines. A fifth pyrimidine base, called uracil (U), usually takes the place of thymine in RNA and differs from thymine by lacking a methyl group on its ring. Uracil is not usually found in DNA, occurring only as a breakdown product of cytosine. In addition to RNA and DNA, a large number of artificial nucleic acid analogues such as peptide nucleic acid (PNA), Morpholino and locked nucleic acid (LNA), as well as glycol nucleic acid (GNA) and threose nucleic acid (TNA) have also been created to study the proprieties of nucleic acids, or for use in biotechnology (Verma and Eckstein, 1998).

Deoxyribonucleic acid (DNA) Barcoding

Generally, biodiversity is being threatened globally by climate change as well as human activities and this has aroused concerns about the conservation status. Although biodiversity is disappearing at a very fast rate, technological development that can help reverse biodiversity loss is also on the increase but limited by the fact that it is not easily accessible by countries rich in biodiversity but constrained in resources. In order to resolve this problem, the use of DNA barcoding technique is being employed. 'DNA barcoding' is a revolutionary diagnostic technique in which short DNA sequence(s) can be used for species identification. The DNA barcode sequence includes about 650 DNA “base-pairs” (represented by the letters A, C, G and T) which is a tiny portion of the billions of base pairs that make up the entire genome of many organisms. The goal of barcoding is that anyone, anywhere, anytime be able to identify quickly and accurately any species whatever its condition.

Barcoding is done with a well known gene, not a newly discovered gene and it is used for identifying specimens, not for biomedical purposes such as developing pharmaceuticals (Stoeckle *et al.,* 2005). This technology is being promoted by the International Consortium for Barcoding of Life (CBOL), which comprises major natural history museums, herbaria and other scientific organizations, to enable the rapid and inexpensive identification of the estimated 10 million species on earth (Stoeckle *et al.,* 2005). The stages involved in flora barcoding are shown in figure 1.2.

The scientific benefits of DNA barcoding are enormous, including: enabling rapid species identification, including any life stage or fragment, facilitating species discoveries based on cluster analyses of gene sequences (e.g. *cox1* in animals; *rbcL* and *matK* in plants), promoting the development of handheld DNA sequencing technology that can be applied in the field for biodiversity inventories and providing insight into the diversity of life. The advantages that countries rich in biodiversity can gain are huge, namely: the ability to identify specimens quickly and cheaply, better ability to control the movement of species across national borders, opportunity for training of students/researchers, involvement of local researchers in global networks and biodiversity initiatives, and opportunity to improve the national research infrastructure of specimen collections, molecular labs, and biodiversity databases (Stoeckle *et al.,* 2005). Due to the high rate of speciation and hybridization of plant species leading to the formation of new form and change in the genetic composition of plant species, it is important to reconsider their classification and evolutionary relationships especially by the use of gene sequences and biological molecules in the study of variation that is inherent in the population.

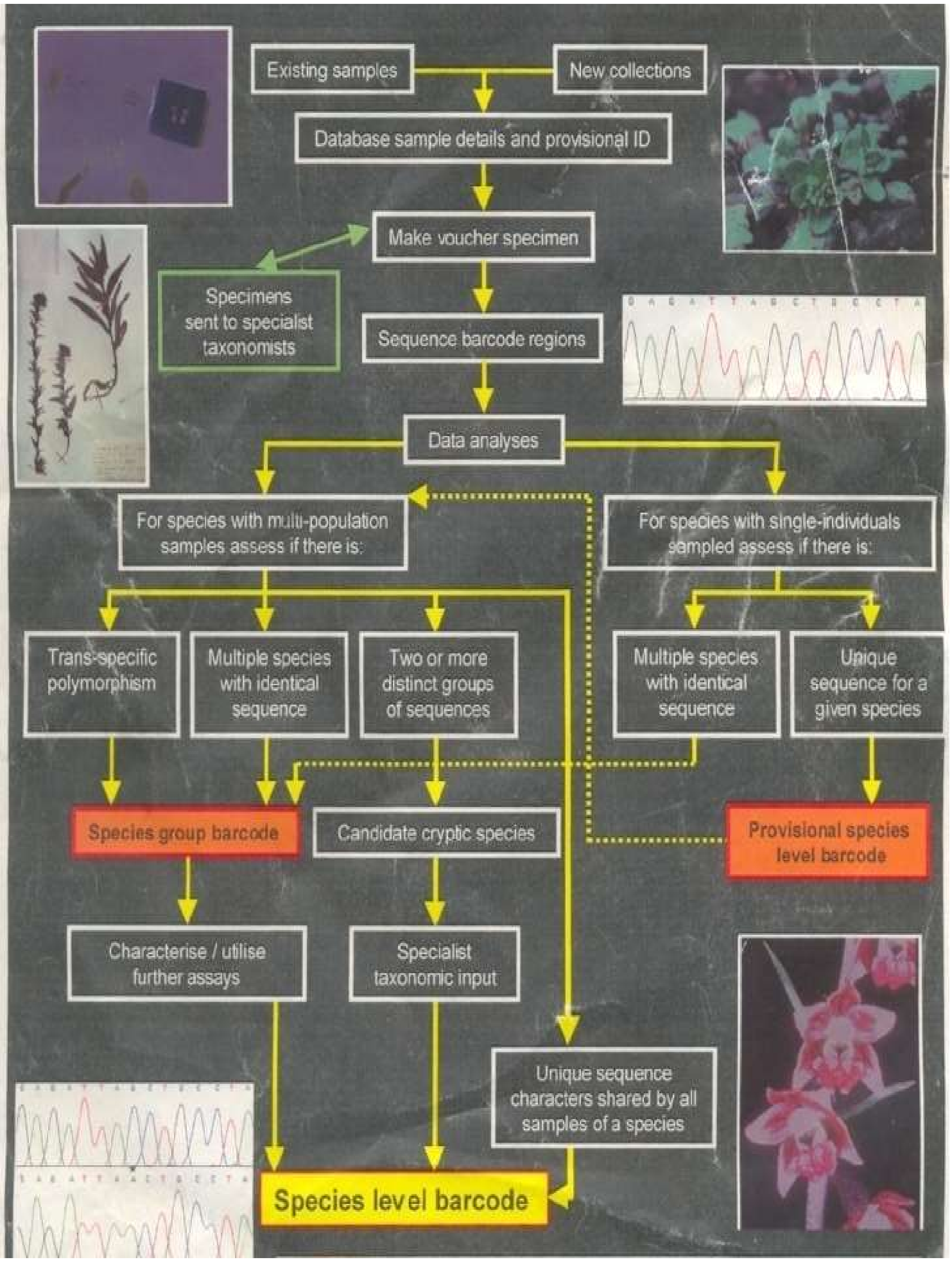


Figure 1.2: Stages involved in Flora Barcoding

Source: Stoeckle *et al.*, 2005

1.2 Statement of Problem

The majority of African representatives of the family Sapindaceae were not used in previous taxonomic treatments. In order to produce a reliable and good taxonomic account, data from as many sources as possible such as morphology, anatomy, breeding, molecular biology, geography, cytology, genetics should be employed (Buerki *et al.*, 2009). Therefore, sources that were insufficiently investigated in the past are now utilized in revising the taxonomy of the group so as to ease adequate identification of the various taxa due to their intrinsic values. Moreover, the family has problems of synonymy, taxa misidentification, doubtful specific status and grouping dissimilar taxa in the same higher taxonomic rank.

In addition, the amplification of molecular markers in Sapindaceae s.l. is made difficult by several mutations occurring in flanking regions of widely used plastid and nuclear regions such as matK (Harrington *et al*., 2005) and ITS (Edwards and Gadek, 2001). Those mutations complicate the compilation of multilocus data sets without missing data (Buerki *et al.,* 2009).

1.3. Aims and Objectives

The aims of this research are to carry out systematic study on family Sapindaceae in Africa and generate DNA barcodes for each species with a view to sharing the DNA barcode sequence in a public database.

The objectives are to:

1. Explore the diversity of African Sapindaceae, with emphasis on the collection, identification and preservation of voucher specimens in secure repositories.
2. Provide lucid information on the variation pattern and model the species distribution of the family Sapindaceae in Africa using climatic data.
3. Assess the level of genetic diversity among individuals of the same species and between species by the use of DNA markers.
4. Develop DNA barcodes for the rapid identification of species in the family Sapindaceae.
5. Examine phylogenetic relationships among taxa, their consistency with earlier classifications and propose a new preliminary infra-familial classification for Sapindaceae s.l.

Operational terms and acronymns and abbreviations used in this thesis are defined in Appendices 1 and 2 respectively.

1.4 Significance of the Study

Generally, biodiversity is being threatened globally by climate change as well as human activities and this has aroused concerns about the conservation status. Members of Sapindaceae are of great economic values especially in medicine however, according to the International Union for Conservation of Nature (IUCN) Red List (2008), the status of most members of the family (up to 60%) is either vulnerable or endangered and their habitat is unique (tropics). Hence, there is need for the conservation of the family.

This study is significant in:

- Resolving the problem of threatened plant biodiversity.
- Providing a systematic understanding of the family Sapindaceae in Africa.
- Identifying wild and domesticated plant species for industrial purposes.

1.5. Research Questions

This study was designed as an effort to support the conservation of family Sapindaceae in Africa by giving answers to the following questions:

1. How diverse is the family Sapindaceae in Africa?
2. What are the environmental variables contributing to species distribution of Sapindaceae in Africa?
3. What kinds of phylogenetic relationship exist in the family Sapindaceae?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Classification of Family Sapindaceae

Sapindaceae was first proposed by Jussieu in 1789 in his *Genera Plantarum* as a family distinct from Aceraceae (including *Aesculus*). This family concept (of Sapindaceae) has been followed by numerous workers such as de Candolle (1824, who proposed Hippocastanaceae as a separate family) and Cambessedes (1828). Later work such as Bentham and Hooker (1862) included Aceraceae, Hippocastanaceae and various genera currently recognized in other families as Staphyleaceae, Sabiaceae and Melianthaceae with Sapindaceae.

The concept of Sapindaceae held by the end of the 19^{th} century and through most of the 20^{th} century as a family distinct from Aceraceae and Hippocastanaceae is as the result of the monumental work by Radlkofer (1890, 1933). He provided the first worldwide system of classification for the family, recognizing two subfamilies (Table 2.1) and 14 tribes, and although outdated, his work is still a useful framework for the identification of taxa and the understanding of phylogenetic relationships within Sapindaceae. His system considered the uniovulate Sapindaceae to be the most basic members within the family.

In 1964, Scholz provided modern names for the two recognized subfamilies (i.e. Dodonaeoideae Burnett and Sapindoideae Burnett) and inverted their sequence i.e. considering the multiovulate Dodonaeoideae as basal within the family. This rearrangement was followed by Capuron (1969), who in addition, modified some of the generic concepts.

Muller and Leenhouts (1976) independently proposed a rearrangement to Radlkofer's system that agreed with Scholz's general rearrangement but proposed more substantial changes. They reduced tribe Aphanieae into Lepisantheae Radlk, and suggested the inclusion of families Aceraceae and Hippocastanaceae into subfamily Dodonaeoideae, Aceraceae in its own tribe and Hippocastanaceae as part of tribe Harpullieae. A comparison of different classification systems is given in table 2.4.

General Classification of Family Sapindaceae

Kingdom: Plantae

Sub Kingdom: Embryobionta

Division: Magnoliophyta

Class: Magnoliopsida

Subclass: Rosidae

Super order: Rosanae

Order: Sapindales

Family: Sapindaceae

SOURCE: APG III (2009)

2.2 Evolutionary Relationships of Family Sapindaceae

Sapindaceae are related to Rutaceae and both are usually placed in an order Sapindales or Rutales, depending on whether they are kept separate and which name is used for the order (Singh, 2004). The most basal member appears to be *Xanthoceras*.

Some authors maintain some or all of Hippocastanaceae and Aceraceae, although this may result in paraphyly (Singh, 2004; Harrington *et al.,* 2005). The former Ptaeroxylaceae, now placed in Rutaceae, were sometimes placed in Sapindaceae (Watson and Dallwitz, 2008).

2.3 Phylogeny of Family Sapindaceae

In 1862 and 1867, Bentham and Hooker referred to Sapindaceae as an order with five suborders. However, the first detailed systematic study was not published until 1890. Radlkofer (1890) based his classification on a wide range of evidence, including the presence or absence of a terminal leaflet, the number of ovules per carpel, the structure of the fruit, presence or absence of an aril, and pollen morphology.

The circumscription of the family as well as the relationships among subfamilial entities have been widely challenged since the very first worldwide treatment of Sapindaceae sensu stricto (s.s.) (including subfamilies Sapindoideae and Dodonaeoideae) proposed by Radlkofer (1890, 1933). For instance, several genera within the Sapindoideae (e.g., *Tinopsis* and *Plagioscyphus* from Madagascar) were shown to be morphologically transitional between tribes described by Radlkofer (1933), which prevented the recognition of unequivocal tribes. There have been several revisions of the Sapindaceae, but the scheme of Radlkofer is essentially accepted, with only minor modification. Within Sapindaceae s.s. the higher taxonomic entities (subfamilies and tribes) were originally defined by Radlkofer (1933) based on the number and type of ovules per locule, the fruit morphology, the presence or not of an arillode, the leaf type and the cotyledon shape.

According to plant characteristics, pollen morphology and geography, the Sapindaceae are split into two sub-families - Dodonaeoideae (Austral distribution) and Sapindoideae. The latter can be separated into three main groups, centred on Sapindeae DC. (pantropical), or Cupanieae Reichenb (pantropical), and a third group separating into Thiouinieae Bl. and Paullinieae Kunth, both predominantly American.

Historically, Radlkofer (1933) recognized fourteen tribes within Sapindaceae s. str., five in Dodonaeoideae and nine in Sapindoideae. Within Dodonaeoideae, however, he encountered difficulty assigning nine genera to the four previously described tribes, ultimately deciding to place them in a new tribe, Harpullieae Radlk. Within this heterogeneous assemblage, he recognized two informal groups according to the presence (*Delavaya* Franchet, *Ungnadia* Endl. and *Xanthoceras* Bunge) or absence (*Arfeuillea* Pierre, *Conchopetalum*, *Eurycorymbus* Hand.-Mazz., *Harpullia* Roxb., *Magonia* A.St.-Hil. and *Majidea* J.Kirk ex Oliv.) of a terminal leaflet. While revising Radlkofer's infrafamilial system, largely on the basis of pollen and other morphological features, Müller & Leenhouts (1976) discussed the possible expansion of Harpullieae to include the three genera comprising Hippocastanaceae, viz. *Aesculus* L., *Billia* L. and *Handeliodendron* Rehder (these authors did not, however, comment on the taxonomic status of Aceraceae). In their revised classification, Müller & Leenhouts (1976) concluded that the connection between Hippocastanaceae and Harpullieae might involve two genera in particular, *Handeliodendron*, originally described in Sapindaceae (Rehder, 1935), and *Delavaya*, which has always been placed in Sapindaceae. Müller &

Leenhouts (1976) also regarded Harpullieae as a "heterogeneous assemblage, with several genera difficult to connect to the others.

On the basis of macro-morphological and palynological characters, Müller and Leenhouts (1976) revised the classification of Radlkofer (1933). They recognized eight major pollen types (A-H) (Figure 2.1) and several subtypes mainly based on their shape and characteristics of the aperture. They classified *Harpullia* pollen as both type-A and type-H and *Magonia* pollen as type-E, whereas other members of the tribe exclusively exhibit the more common type-A pollen (Buerki *et al*., 2009). Moreover, Harpullieae Radlk ranges from tropical (e.g. *Conchopetalum*, *Delavaya*, *Magonia*) to temperate (*Xanthoceras*) regions and include both evergreen and deciduous species (Radlkofer, 1933; Müller and Leenhouts, 1976).

Generally, the pollen grains in Sapindaceae are triporate [the diporate type-D pollen of *Lophostigma* Radlk recognized by Müller and Leenhouts (1976) was wrongly identified; Acevedo-Rodríguez (1993a). Spherical pollen shape occurs in the majority of species, whereas a triangular or oblate shape is more restricted. The colpi may be absent or parasyncolporate to syncolporate. Based on those characters Müller and Leenhouts (1976) rearranged the nine tribes of Sapindoideae recognized by Radlkofer (1933) into three taxonomically unranked groups characterized by their distribution, the presence or absence of an arillode surrounding the seed and the pollen types [i.e., group A comprised Sapindeae, Lepisantheae Radlk (incl. Aphanieae) and Melicocceae Blume; group B comprised Schleichereae Radlk, Nephelieae Radlk and Cupanieae; group C comprised Paullinieae and Thouinieae]. They did not, however, modify the classification within the Dodonaeoideae and maintained the five tribes described by Radlkofer (i.e., Cossinieae Bl., Dodonaeeae, Doratoxyleae Radlk, Harpullieae Radlk and Koelreuterieae Radlk, 1933). Furthermore, Müller and Leenhouts (1976) kept the predominantly temperate families Aceraceae and Hippocastanaceae separate from the rest of Sapindaceae.

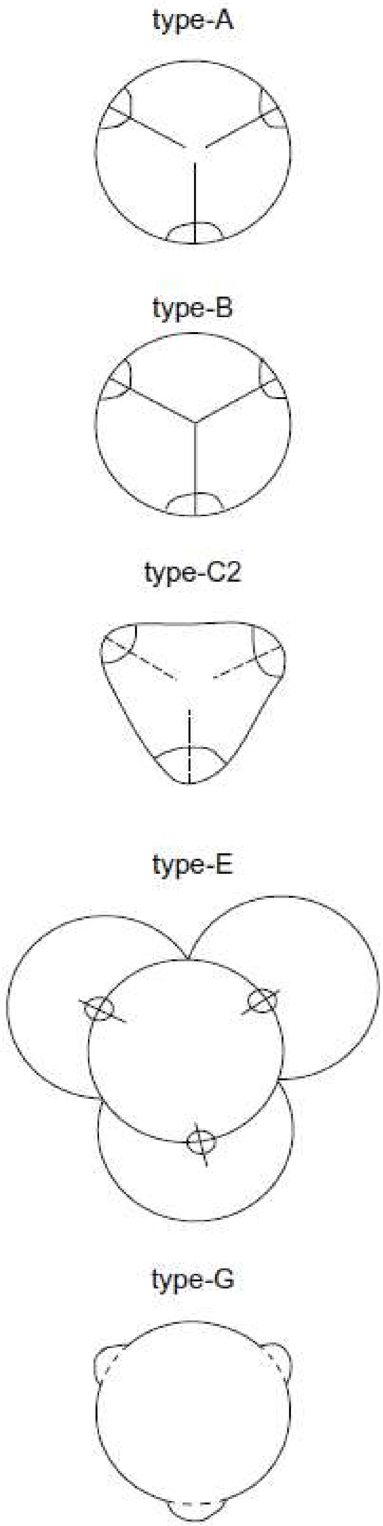


Figure 2.1: Schematic representation of pollen types in Sapindaceae

Source: Muller and Leenhouts, 1976.

Based on wood anatomy, Klaassen (1999) noted a difference between the temperate and tropical genera in the tribe, and among the tropical ones he indicated that *Delavaya* and *Ungnadia* stood out because their wood is similar to that of members of tribe Cupanieae Reichenb (Sapindoideae). The circumscription of Sapindaceae has been debated ever since.

Preliminary studies suggested that *Xanthoceras*, with simply 5-merous, polysymmetric flowers, ovules arranged in parallel, and complex, golden nectaries borne outside the eight stamens, might be sister to all other Sapindaceae. Also, the genera included in the erstwhile Aceraceae and Hippocastanaceae formed monophyletic sister taxa, the combined clades being sister to the remainder of the family (Klaassen, 1999; Savolainen *et al.,* 2000a). Recent two-gene studies by Harrington *et al.* (2005, 2009) have largely confirmed these results. Takhtajan (1987), Cronquist (1988) and Dahlgren (1989) maintained Aceraceae and Hippocastanaceae separate from Sapindaceae, whereas broader concepts of the family have been adopted by several workers including Umadevi and Daniel (1991), Judd *et al*. (1994), Gadek *et al.* (1996), Savolainen *et al.* (2000b), Thorne (2000), APG II (2003), Harrington *et al.* (2005), Thorne (2007), APG III (2009) and Buerki *et al.* (2009).

Based on several studies including Müller and Leenhouts (1976), and more recently those based on a large-scale molecular phylogenetic analysis of Sapindales (Gadek *et al*., 1996), Harrington *et al*. (2005), published the first molecular phylogeny of Sapindaceae sensu lato (s.l.) which supported the recognition of a broadly defined Sapindaceae (including Aceraceae and Hippocastanaceae) inferred from the plastid genes rbcL and matK. Their phylogeny recognized the subdivision of Sapindaceae s.l. into four supported lineages, a monotypic Xanthoceratoideae Thorne and Reveal, Hippocastanoideae Burnett (including Aceraceae, Hippocastanaceae and *Handeliodendron*), a more narrowly defined Dodonaeoideae and Sapindoideae (including *Koelreuteria* Laxmann and *Ungnadia* Endlicher).

There is some support for "Xanthoceratoideae" being the first lineage to diverge within the broadly defined Sapindaceae assemblage; hence *Xanthoceras* was not sister to the rest of the family in single gene analyses, being somewhat embedded. However relationships between these four lineages remained weakly supported; it was only in the joint analysis that *Xanthoceras* is sister to all other Sapindaceae (70% bootstrap, 95% posterior probability) (Buerki *et al.,* 2009). The sequence of genera reflects Muller and Leenhouts (loc. cit.) as modified by recent analyses based on molecular and morphological data, rather than following the order developed by Radlkofer (1890).

Muellner *et al.* (2007) presented a two-gene tree with quite good sampling; their results suggested the poorly supported basal relationships in the trees. Harrington *et al.* (2005) highlighted the paraphyletic or polyphyletic nature of several tribes described by Radlkofer (1933) thus confirming previous works based on morphological features. According to the new assessment of the Sapindaceae s.l. proposed by Thorne (2007; mainly based on Harrington *et al.,* 2005) and a broad review of currently described taxa by Buerki *et al.* (2009, 2010), it is now widely accepted that the 1900 species of this cosmopolitan family are divided into 141 genera distributed among four subfamilies: Dodonaeoideae Burnett, Hippocastanoideae Burnett, Sapindoideae Burnett and Xanthoceroideae Thorne & Reveal.

Recently, Buerki *et al.,* (2009) demonstrated the para-/polyphyly of all tribes as defined by Radlkofer (1933), with a single exception, Paullinieae Kunth. Although they sketched an informal system that recognizes a dozen monophyletic groups, they did not propose new tribal limits within the four subfamilies as many potentially important genera of Sapindaceae were not included in their study due to the lack of sequenceable material. They also found Harpullieae to be polyphyletic, with *Xanthoceras* occupying a basal position within Sapindaceae s. lat., *Arfeuillea* Pierre ex Radlk, *Eurycorymbus* Handel-Mazzetti, *Harpullia* and *Majidea* placed in Dodonaeoideae, *Delavaya* occupying a basal position within Sapindoideae, and *Conchopetalum* resolved in the *Macphersonia* Blume group (Sapindoideae; Buerki *et al*., 2009) closely related to the newly described endemic Malagasy genus *Gereaua* Buerki & Callm (Buerki *et al.,* 2010).

TABLE 2.1: PROPOSED TAXONOMIC AFFINITIES OF SAPINDACEAE

Authors (Date)	**Taxonomic position of Sapindaceae**
Radlkofer (1890)	Sapindaceae can be divided into: Sapindoideae and Dodonaeoideae (including Sapindeae or Cupanieae and a third group separating into Thiouinieae and Paullinieae)
Hutchinson (1959)	Sapindaceae and Hippocastanaceae are the same
Müller and Leenhouts (1976)	Sapindaceae can be divided into: Sapindoideae and Dodonaeoideae with eight (8) and five (5) tribes respectively
Takhtajan (1987)	Aceraceae and Hippocastanaceae are separate from the rest of Sapindaceae
Cronquist (1988)	Aceraceae and Hippocastanaceae are separate from the rest of Sapindaceae
Dahlgren (1989)	Aceraceae and Hippocastanaceae are separate from the rest of Sapindaceae
Gadek *et al.* (1996)	Sapindaceae is sister to Malvales
Klaassen (1999)	Aceraceae and Hippocastanaceae form monophyletic sister taxa to the remainder of Sapindaceae.
Thorne (2007)	Sapindaceae is a family in the order Rutales
Buerki *et al.* (2009)	Sapindaceae is monophyletic

TABLE 2.2: Proposed Taxonomic Position of Sapindaceae based on Molecular Data

Authors (Date)	**Taxonomic Position**
Harrington *et al.* (2005)	Sapindaceae is paraphyletic or polyphyletic. *Xanthoceroideae* is monotypic and Xanthoceratoideae" is the first lineage to diverge within the broadly defined Sapindaceae.
Thorne (2007)	The 1900 species of this cosmopolitan family Sapindaceae are divided into 141 genera distributed among four subfamilies: Dodonaeoideae Burnett, Hippocastanoideae Burnett, Sapindoideae Burnett and Xanthoceroideae Thorne & Reveal.
Buerki *et al.* (2009)	All tribes within the family are para-/polyphyletic as defined by Radlkofer (1933), with exception to Paullinieae Kunth
Buerki *et al.* (2010)	*Xanthoceras* is confirmed as sister to all other sampled taxa of Sapindaceae s. lat. Aceraceae and Hippocastanaceae together form a clade sister to the largely tropical Sapindaceae s. str., which is monophyletic and morphologically coherent provided *Xanthoceras* is excluded.

Table 2.3: Infrafamilial Classification of Sapindaceae Sensu Lato

	Genera	Author	Taxa	Habit	Distribution
Sapindaceae Jussieu 104/141 genera, 205/1886 species					
Dodonaeoideae Burnett Cossinieae Bl. (Cos) 2/2 genera, 3/7 species	*Cossinia*	Comm. ex Lam.	4	s-st	Mascarenes, New Caledonia, E Australia, Fiji
	Llagunoa	**Ruiz & Pavón**	3	s-st	W tropical South America
Dodonaeeae Kunth (Dod) 3/5 genera, 5/78 species	***Diplopeltis***	**Endl.**	5	s-t	NW Australia
	Distichostemon	F. Muell.	6	s	Australia
	Dodonaea	**Miller**	c. 65	s-st	Mainly in Australia, Malesia, New Guinea, Carribean and Madagascar
	Hirania	Thulin	1	s	Somalia
	Loxodiscus	**Hook. f.**	1	s	New Caledonia
Doratoxyleae Radlk. (Dor) 6/9 genera, 8/22 species	***Averrhoidium***	**Baillon**	2	t	South America
	Doratoxylon	**Thou. ex Hook. f.**	5	st-t	Madagascar and Mascarenes Islands
	Euchorium	Eckman & Radlk.	1	t	Cuba
	Exothea	Macfad.	3	t	West Indies, Central America and Florida
	Filicium	**Thw ex Hook. f.**	3	s-st	E Africa, Madagascar and SE India
	Ganophyllum	**Blume**	2	t	W and C Africa, Andamans and Nicobars to NE Australia and Solomon Islands to Malesia
	Hippobromus	Ecklon & Zeyher	1	t	South Africa
Dodonaeoideae Burnett Harpullieae Radlk. (Har) 6/6 genera, 8/34 species	*Hypelate*	P. Browne	1	s-st	West Indies and Florida
	Zanha	Hiern	4	t	Tropical Africa and Madagascar
	Arfeuillea	**Pierre ex Radlk.**	1	t	SE Asia
	Conchopetalum	**Radlk.**	2	st-t	Madagascar
	Eurycorymbus	**Handel-Mazzetti**	1	t	China
	Harpullia	**Roxb.**	26	s-st	India, SE China, Malesia to Australia, New Caledonia and Pacific Islands
	Magonia	A. St. Hil.	1	t	South America
	Majidea	**J. Kirk ex Oliver**	3	t	Tropical Africa and Madagascar
Hippocastanoideae Burnett 5/5 genera, 18/129 species	***Acer***	**L.**	111	s-t	N temperate & tropical mountains
	Aesculus	**L.**	13	t	SE Europe, India, E Asia and N America
	Billia	Peyr.	2	s-t	S Mexico to Tropical South America
	Dipteronia	**Oliver**	2	s-st	C&S China
	Handeliodendron	Rehder	1	s-t	China – deciduous
Sapindoideae Burnett Cupanieae Reichenb. (Cup) 36/48 genera, 79/462 species	***Amesiodendron***	Hu	1	t	China, Indo-China and Malesia
	Aporrhiza	Radlk.	6	t	Tropical Africa
	Arytera	**Blume**	c. 28	s-t	Indo-Malesia to E Australia and Pacific
	Blighia	**Koenig**	4	t	Tropical Africa
	Blighiopsis	Van der Vecken	1	t	Tropical Africa
	Blomia	**Miranda**	1	t	Mexico
	Cnesmocarpon	Adema	4	s-st	Australia and Papua New Guinea
	Cupania	**L.**	c. 45	s-t	Tropical America
	Cupaniopsis	**Radlk.**	60	s-st	Malesia, New Guinea, N-E Australia, Pacific islands, New Caledonia
	Dictyoneura	**Blume**	3	s-st	Malesia
	Dilodendron	Radlk.	1	t	South America
	Diploglottis	**Hook.f.**	12	t	NE Australia and Papua New Guinea
	Diplokeleba	N.E. Br.	2	st	South America
	Elattostachys	**(Blume) Radlk.**	c. 20	s-t	Malesia to Australia, W Pacific
	Eriocoelum	**Hook. f.**	c. 10	t	Tropical Africa
Sapindoideae Burnett Cupanieae Reichenb. (Cup)	***Euphorianthus***	**Radlk.**	1	t	E Malesia
	Gloeocarpus	Radlk.	1	t	Philippines
	Gongrodiscus	**Radlk.**	3	s-t	New Caledonia
	Gongrospermum	Radlk.	1	t	Philippines
	Guioa	**Cav.**	65	s-t	SE Asia, Malesia to E Australia; Pacific and New Caledonia
	Haplocoelopsis	**F.G. Davies**	1	s-t	E Africa
	Jagera	**Blume**	2	t	New Guinea and Australia

	Genera	Author	Taxa	Habit	Distribution
	Laccodiscus	**Radlk.**	4	s-st	W Africa
	Lepiderema	**Radlk.**	8	t	Australia and New Guinea
	Lepidopetalum	**Blume**	7	s-t	India, NE Australia and Solomon Islands
	Lynchodiscus	Radlk.	6	t	W Tropical Africa
	Matayba***	**Aublet.**	c. 56	s-t	Tropical America
	Mischarytera	(Radlk.) H. Turner	3	t	Australia, Papua New Guinea
	Mischocarpus	**Blume**	15	s-t	SE Asia, Malesia to Australia
	Molinaea	**Comm. ex. Juss.**	9	s-t	Madagascar, Mascarenes
	Neotina	**Capuron**	2	t	Madagascar
	Paranephelium	**Miq.**	4	s-t	SE Asia and W Malesia
	Pavieasia	Pierre	3	t	S China, N Vietnam
	Pentascyphus	Radlk.	1	t	Guyana
	Phyllotrichum	Thorel ex Lecompte	1	t	SE Asia
	Pseudima	**Radlk.**	3	t	South America
	Rhysotoechia	**Radlk.**	14	s-t	Australia, New Guinea, Malesia
	Sarcopteryx	**Radlk.**	12	s-t	Malesia, New Guinea and E Australia
	Sarcotoechia***	**Radlk.**	11	t	NE Australia and New Guinea
	Scyphonychium	Radlk.	1	t	NE Brazil
	Sisyrolepis	Radlk.	1	s-st	Thailand
	Storthocalyx	**Radlk.**	4	s	New Caledonia
	Synima	**Radlk.**	2	t	Australia and SE New Guinea
	Tina	**Roem. & Schult.**	6	s-st	Madagascar
	Toechima	**Radlk.**	7	t	Australia and New Guinea
	Trigonachras	Radlk.	8	t	Malesia
	Tripterodendron	Radlk.	1	t	Brazil
	Vouarana	**Aublet.**	1	t	NE South America
Sapindoideae Burnett Koelreuterieae Radlk. (Koe) 2/4 genera, 2/15 species	*Erythrophysa*	E. Mey ex Arnott	9	s	Africa and Madagascar
	Koelreuteria	**Laxmann**	3	t	S China, Japan
	Sinoradlkofera	F.G. Mey	2	st	China and N Vietnam
	Stocksia	Benth.	1	s	E Iran, Afghanistan
Lepisantheae Radlk. (Lep) 4/10 genera, 7/97 species	*Chonopetalum*	Radlk.	1	t	Tropical W Africa
	Chytranthus	**Hook. f.**	c. 30	st	Africa
	Glenniea	**Hook. f.**	8	t	Tropical Africa, Madagascar, Sri Lanka, Malesia
	Lepisanthes	**Blume**	24	s-t	Tropical Africa, Madagascar, S-SE Asia, Malesia and NW Australia
	Namataea	D.W. Thomas & D.J. Harris	1	st	Cameroon
	Pancovia	**Willd.**	c. 13	st	Tropical Africa
	Placodiscus	Radlk.	c. 15	t	Tropical W Africa
	Pseudopancovia	Pellegrin	1	t	Tropical W Africa
	Radlkofera	Gilg.	1	s-st	Tropical Africa
	Zollingeria	Kurz	3	t	SE Asia and Malesia
Melicocceae Blume (Mel) 5/5 genera, 8/67 species	*Castanospora*	F. Muell.	1	t	NE Australia
	Melicoccus	**P. Browne**	10	t	Tropical America
	Talisia	**Aublet**	52	s-t	Tropical America
	Tristira	Radlk.	1	t	Malesia
	Tristiropsis	**Radlk.**	3	t	Pacific Ocean, Australia, Solomon Islands and Malesia
Nephelieae Radlk. (Nep) 11/12 genera, 15/77 species	***Alectryon***	**Gaertn.**	c. 30	s-st	E Malesia, Australia, New Zealand, New Caledonia, to Hawaii
	Cubilia	**Blume**	1	t	Malesia
	Dimocarpus	**Lour.**	6	s-t	S and SE Asia and Australia
	Litchi	**Sonn.**	1	t	Tropical China to W Malesia
	Nephelium	**L.**	22	t	SE Asia and Malesia
	Otonephelium	Radlk.	1	t	India
Sapindoideae Burnett Nephelieae Radlk. (Nep)	***Pappea***	**Eckl. & Zeyh.**	1	s-t	Tropical E to S Africa
	Podonephelium	**Baillon**	4	s-t	New Caledonia
	Pometia	**Forst. & Forst.**	2	t	Malesia and Pacific Islands
	Smelophyllum	Radlk.	1	t	South Africa
	Stadmania	Lam.	6	t	Tropical E Africa, S Africa, Madagascar and Mascarenes Islands
	Xerospermum	**Blume**	2	s-st	Indochinese Peninsula and Malesia
Paullinieae Kunth (Pau) 4/7 genera, 15/466 species	***Cardiospermum***	**L.**	c. 12	l	Tropical and subtropical America; 1 sp. extending to Africa
	Houssayanthus	Hunz.	3	s-l	South America
	Lophostigma	Radlk.	2	l	South America
	Paullinia	**L.**	c. 200	l	Tropical America
	Serjania	**Miller**	c. 226	l	Tropical America

	Genera	Author	Taxa	Habit	Distribution
Sapindeae DC (Sap) 3/7 genera, 12/89 species	***Atalaya***	**Blume**	12	st	Australia, New Guinea and S Africa
	Deinbollia	**Schumach. & Thonn.**	c. 40	t	Tropical Africa and Madagascar
	Hornea	Baker	1	s-t	Mauritius
	Porocystis	Radlk.	2	s-t	Tropical South America
	Sapindus	**L.**	13	t	Tropical to warm temperate regions
	Thouinidium	Radlk.	7	s-t	Mexico and West Indies
	Toulicia	Aublet	14	t	South America
Schleichereae Radlk. (Sch) 8/12 genera, 12/55 species	***Beguea***	**Capuron**	1	t	Madagascar
	Bizonula	Pellegrin	1	t	Tropical Africa
	Camptolepis	Radlk.	4	t	E Africa and Madagascar
	Chouxia	Capuron	6	s-st	Madagascar
	Haplocoelum*	**Radlk.**	c. 6	st-t	Tropical Africa and Madagascar
	Lecaniodiscus	**Planch. ex Benth.**	3	st	Tropical Africa
	Macphersonia	**Blume**	8	s-t	Tropical E Africa and Madagascar
	Plagioscyphus	**Radlk.**	10	st-t	Madagascar
	Pseudopteris	Baill.	3	s	Madagascar
Sapindoideae Burnett Schleichereae Radlk. (Sch)	***Schleichera***	**Willd.**	1	t	Tropical SE Asia to Indo-China and Malesia
	Tinopsis	**Radlk.**	11	t	Madagascar
	Tsingya	Capuron	1	t	Madagascar
Thouinieae Bl. (Tho) 6/6 genera, 10/285 species	*Allophylus*	L.	c. 250	s-st-l	Pantropical
	Athyana	**(Griseb.) Radlk.**	1	t	South America
	Bridgesia	**Bertero ex Cambess.**	1	s-st	Chile
	Diatenopteryx	**Radlk.**	2	t	South America
	Guindilia	Hook & Arn.	3	s	South America
	Thouinia	**Poit.**	28	l	Mexico and West Indies
Sapindoideae unplaced taxa 2/2 genera, 2/2 species	***Delavaya***	**Franchet**	1	s-st	SW China and N Vietnam
	Ungnadia	Endl.	1	s-st	S North America
Xanthoceroideae Thorne & Reveal 1/1 genera, 1/1 species	***Xanthoceras***	**Bunge**	1	s-st	N-NE China and Korea

Source: Buerki *et al.,* 2009. (Adapted from Radlkofer, 1933; Müller and Leenhouts, 1976; Thorne, 2007)

Information on the number of taxa, habit and distribution of genera were taken from literature (Radlkofer, 1933; Acevedo-Rodríguez, 1993a, 1993b, 2003; Adema *et al*., 1994; Ferrucci, 1998; Davies, 1997; Klaassen, 1999; Thomas and Harris, 1999; Xia and Gadek, 2007). Abbreviations are as follows: s, shrub; st, small tree; t, tree; l, liana. Genera sampled for the phylogenetic analysis of Sapindaceae are indicated in bold and genera found to be either paraphyletic or polyphyletic are identified by an asterisk (*).

Table 2.4: Comparison of different classification systems within Sapindaceae

Bentham and Hooker (1862)	Radlkofer (1933)	Muller and Leenhouts (1976)	Umadevi and Daniel (1991)	Thorne (2000)
Sub ordo:	Subfamily I: Eusapindaceae	Subfamily II: Sapindoideae	Sapindoideae	Sapindoideae
Sapindeae	Eusapindaceae nomophyllae	Group C	(incl. Hippocastanaceae)	(incl. Hippocastanaceae)
Acerineae	1. Paullinieae	1. Paullinieae		
Dodonaeae	2. Thouinieae	2. Thouinieae		
Meliantheae	Eusapindaceae anomophyllae	Group A		
Staphyleae	3. Sapindeae	3. Sapindeae,		
	4. Aphanieae	4. Lepisantheae (incl. Aphanieae)		
	5. Lepisantheae	6. Melicocceae;		
	6. Melicoccaeae	Group B		
	7. Schleichereae	7. Schleichereae,		
	8. Nepheleae	8. Nephelieae		
	9. Cupanieae	9. Cupanieae		

Bentham and Hooker (1862)	Radlkofer (1933)	Muller and Leenhouts (1976)	Umadevi and Daniel (1991)	Thorne (2000)
	Subfamily II: Dyssapindaceae	Subfamily I: Dodonaeoideae		
	Dyssapindaceae nomophyllae			
	1. Koelreuterieae	10. Koelreuterieae	Koelreuterioideae	Koelreuterioideae
	2. Cossignieae	11. Cossinieae,	Koelreuterioideae	Koelreuterioideae
	3. Dodonaeae	12. Dodonaeeae,	Dodonaeoideae	Dodonaeoideae
	Dyssapindaceae anomophyllae			
	4. Doratoxyleae	13. Doratoxyleae	Koelreuterioideae	Koelreuterioideae
	5. Harpullieae	14. Harpullieae (including Hippocastanaceae)	Koelreuterioideae	Koelreuterioideae
	(Aceraceae)	(Aceraceae)	Aceroideae	Aceroideae
	(Hippocastanaceae)			Hippocastanoideae

Source: Adapted from Harrington *et al.,* 2005.

Enumeration schemes for subfamilies and tribes assigned to Sapindaceae. The numerical sequence of Radlkofer (1890, 1933) and Muller and Leenhouts (1976) classification systems is intended to generally reflect phylogeny with the lowest numbered tribe considered to be the more primitive. Nomophyllae = tips of leaf completely developed (in compound leaves a small terminal leaflet is present), anomophyllae = tip of leaf (apart from simple leaves) incompletely developed (normally the actual terminal leaflet is missing)

CHAPTER THREE

3.0 METHODOLOGY

3.1 Taxonomic Concepts

The Systematics used in this study is centered on morphological (vegetative and reproductive), anatomical and molecular characteristics of the plants collected, which were as far as possible obtained from herbaria and field studies. Also, species is taken as a definable group of organisms showing sharp discontinuity in vegetative and reproductive characters and variety is regarded as any considerable change in the ordinary state or appearance of a species as a result of influence of external circumstances (Davis and Heywood, 1963; Stuessy, 1990).

3.2 Sources of Plant Material

Herbarium and fresh specimens were used for the study (Appendix 3). Plant material used for DNA extraction was obtained from field, botanical garden, forest reserves sources in Cameroon, Ghana, Nigeria, Madagascar and Togo and this was complemented with herbarium samples (Appendix 4). Specimens were collected from the field and garden with the aid of secateurs and cutlasses. These were dried and stored in silica gel prior to DNA isolation. From herbarium specimens, 0.5 cm^2 of plant tissue was removed and either stored in plastic tubes or used immediately. Plant parts used included leaves, stems and seeds. Twenty eight (28) genera were examined to obtain comparative photomicrographs and DNA sequences of the matK and rbcL coding region as well as non-coding regions.

3.3 Species Distribution Modelling

For each plant sample, GPS coordinates of the collection sites were recorded and subjected to modelling using the Maximum Entropy Programme (MAXENT) (Phillips and Dudik, 2008; Robert and Hijmans, 2009). Map and climatic variables (19) were collected from the WorldClim database and used in the modelling analysis.

3.4 Herbarium Preparation

A part (usually branch) of each plant sample was placed in between each old newspapers and this was kept in a plant press. The press was tied with twines and the newspapers were changed at intervals of two days in order to prevent the decomposition of the plant material. Moisture was removed as the newspapers were changed and this was carried out until the plant was thoroughly dried. Each of the dried specimens was then removed from the old newspaper and pasted using white gum (glue) on the white cardboard papers. Label was attached to each of the herbarium specimen in order to give a full description of the plant, its location in the University of Lagos, the date of collection and the name of collector. This was then authenticated at the Forestry Herbarium, Ibadan and deposited at the University of Lagos Herbarium for reference purposes (Ogundipe *et al.,* 2009).

3.5 Morphological Characterization

3.5.1 Vegetative Characterization

Qualitative features such as leaf apex, leaf base, leaf shape and surfaces of leaf and stem were visually assessed or sometimes aided by x10 magnifying hand lens. Quantitative characteristics like leaf size, petiole length, leaf blade length, and plant height were determined using thread and meter rule.

3.5.2 Reproductive Characterization

Qualitative characters such as bract colour, bract margin, bract surface, colour of style and seed, seed shape and fruit surface were determined with naked eyes and sometimes aided by x10 magnifying hand lens. Quantitative features such as length of inflorescence and other cells, sizes of fruit and seed were determined with meter rule while inflorescence number per plant was estimated by direct counting.

Pair wise distances (similarity) matrices were computed for all the morphological data using sequential, hierarchical and nested (SAHN) clustering option of the NTSYS-pc 2.02j software package (Rohlf, 1993). The program generated dendograms, which grouped the test lines on the basis of Nei genetic distances using unweighted pair group method with arithmetic average (UPGMA) cluster analysis (Sneath and Sokal, 1973).

3.6 Anatomical Characterization

Foliar epidermal morphological methods follow the approaches of Stace (1965), Radford *et al.* (1974), Ahmad (1976), Wilkinson (1983), Olowokudejo and Nyananyo (1986), Olowokudejo and Pereira-Sheteolu (1988), Wilkinson (1989), Ogundipe and Olatunji (1991), Rejdali (1991), Olowokudejo (1993), Olowokudejo and Obi-osang (1993), Ugborogbo *et al.* (1993) Fortenelle *et al.* (1994), Kotresha and Seetharam (1995), Khatijah *et al.* (1996), Akhil and Subhan (1997), Inamdar and Gangadhara (1997), Olowokudejo and Ayodele (1997), Khatijah and Zaharina (1998), Ogundipe and Akinrinlade (1998), Ogundipe and Daramola (1998), Sasikala and Narayanan (1998), Ayodele (2000), Kotresha and Seetharam (2000), Kadiri (2003), Kadiri and Ayodele (2003), while leaf architecture terminologies follow Hickey (1973) and Dilcher (1974). Other vegetative anatomical studies take after the methods of Cutler and Sheahan (1993) and Bhandari and Mukhopadhyay (1997). For scanning electron microscopy, a modification of the methods of Claugher (1990) and Hitachi S-4700 SEM protocol were adopted.

3.6.1 Light Microscopy

Leaf epidermal preparations were carried out using herbarium, dried un-mounted or fresh plants. One of five centimetres square portions were cut from the standard median portion of the leaf lamina near the mid-rib or the whole leaf was used. Dried leaves were hydrated by boiling in water for thirty minutes and they were either soaked in concentrated trioxonitrate (v) acid (HNO_3) in capped specimen bottles for about eight to twenty four hours to macerate the mesophyll or irrigated in sodium hypochlorite solution (commercial bleach) for thirty minutes to two hours to bleach the leaf portions. Tissue disintegration was indicated by bubbles and the epidermises were transferred into Petri dishes containing water for cleansing and then, epidermises were separated with forceps and mounting needle. In case of fresh leaves, leaves were scraped with razor blade to separate epidermises. Tissue debris was cleared off the epidermises with fine-hair brush and washed in several changes of water. Drops of different grades of Ethanol: 50%, 70%, 75% were added in turn to harden the cells. Preparations were later stained with Safranin O in 50% alcohol for about five minutes before mounting in glycerine on the glass slide. The epidermises were mounted with the uppermost surfaces facing up, covered with cover-slips and ringed with nail varnish to prevent dehydration. Then the slides were approximately labelled. Slides were examined with light microscope at x160 and x640 magnifications. Photomicrographs were taken using Moticam 2300.

3.6.2 Scanning Electron Microscopy (SEM)

Approximately 8 mm^2 of the preserved dried leaves was cut with knifes under an OPTECH microscope and the surfaces were cleansed with a soft brush. With the aid of forceps, this was placed on labelled aluminium stubs covered with sticky tapes so that both adaxial and abaxial surfaces faced upward; they were placed in a sputter coater stub holder and coated with argon for 2-5 min. The samples were exposed to infrared radiation and observed using Hitachi S-4700 Scanning Electron Microscope. Photographs were taken with the computer using the Hitachi program. The Study was carried out at Jodrell laboratory, Royal Botanic Gardens, Kew, UK.

3.7 Molecular Characterization

This was achieved following Doyle and Doyle (1987), Soltis and Soltis (1998b), Savolainen *et al*. (2000a), Savolainen *et al*. (2000b), Harrington *et al.* (2005), Buerki *et al*. (2009), Ogundipe and Chase (2009) and Ronquist *et al*. (2009).

3.7.1 Source of Plant Material

Silica-gel dried samples (Chase and Hills, 1991) were collected in the field and from herbaria (Appendix 3) and complemented with materials from the DNA bank of the Royal Botanic Gardens, Kew (London, UK). The sampling strategy was designed to encompass the majority of subfamilies, tribes and genera of the family as recognized by the existing classifications of Radlkofer (1933), Müller and Leenhouts (1976) and Thorne (2007). In-group sampling comprised 120 specimens representing 40% of the generic diversity. The out-group included Anacardiaceae defined as out-group in all analyses (Savolainen *et al.,* 2000a; Muellner *et al*., 2007) and Simaroubaceae (Buerki *et al.,* 2009).

3.7.2 DNA Extraction

Genomic DNA was extracted from fresh and silica dried samples using 2-cetyltrimethylammonium bromide (CTAB) procedure of Doyle and Doyle (1987, 1990) with modifications followed by additional purification.

Approximately 0.3-0.5 g of plant material was ground in a mortar with 1ml 10X CTAB extraction buffer (containing 100mM Tris-HCl (Trizma Hydrochloric Acid) pH 8.0, 1.4 M NaCl, 20 mM EDTA and 10% CTAB). The buffer was pre-heated in a water bath at 65^0 C for 30mins. The slurry was poured into a tube and incubated at 65^0 C for 20 min with occasional gentle swirling. The incubated materials were de-proteinized once with equal volume (1ml) of SEVAG (24:1 chloroform: isoamylalcohol) mixing gently but thoroughly. The cap of the tubes were opened to release gas and retightened. They were then rocked using an orbital shaker (100-150 rpm) for 60 min. After rocking, the samples were centrifuged at 4000 rpm at 25^0 C for 20 min and the samples were separated into 2 layers. The upper layer (aqueous layer) was carefully pipetted into a freshly labelled tube and the nucleic acid was precipitated by addition of ice cold isopropanol for herbarium samples (two-third volume of supernatant) or absolute ethanol for fresh samples (twice the volume of supernatant) down the side of each tube and mixed by gently inverting the tubes 6 - 10 times. The tubes were allowed to stand undisturbed in a rack and stored at -20^0 C for 24 h. After this re-precipitation, the tubes with contents were centrifuged at 3000 rpm for 5 min at 4^0 C. The supernatant was discarded gently with great care not to dislodge pellets from the bottom of the tube. The tubes were allowed to drain inverted on a clean paper towel overnight at room temperature.

3.7.3 Caesium Chloride Gradient and Dialysis

The pellet DNA was dissolved in caesium chloride/ethidium bromide solution and allowed to stay for 24 h. This was then transferred into rotor tubes in an ultracentrifuge and subjected to high speed centrifugation at 45,000 rpm for 24 h. A density gradient was formed where compounds were separated according to their density; DNA was concentrated as a distinct band within the gradient. Ethidium bromide intercalate between the stacked bases of nucleic acids and fluoresces red-orange when illuminated with UV light, allowing the band containing DNA to be removed from the solution with a pipette and transferred into duly labelled transparent tubes. Excess ethidium bromide was removed from the solution by adding equal volume of saline-sodium citrate (SSC) saturated butanol in which ethidium bromide is more miscible than in water. This was then transferred into dialysis tubes, clamped at each end and stirred with a magnetic stirrer in 5 L of milli-Q water for not more than four hours so as to remove the caesium chloride from the samples. This was further concentrated in sucrose for 20-40 min, rinsed and stirred in 5 L milli-Q water containing 80X dilution of dialysis buffer for about 24 h in order to stabilize the DNA samples. The resultant samples were transferred into labelled Eppendorf tubes and stored at -20^{o} C/ -80^{o} C.

3.7.4 Gel Electrophoresis

The integrity and purity of the DNA samples were checked by preparing 1% agarose gel (1.5g agarose with 150 ml 1X TBE buffer). This was boiled in a microwave oven until the Agarose is completely dissolved (about 1-2 min) and cooled under running water then, 4 µl ethidium bromide was added to the solution and swirled to mix. After the Agarose was cooled to 56˚ C, it was poured in a gel plate, affixed with combs to create wells in the gel in which the DNA will be run and allowed to solidify. The comb in the gel was removed to expose the wells formed and the gel was immersed into the gel electrophoresis tank containing Tris-borate-EDTA (TBE) buffer.

3.7.5 Loading of Samples and Running the Gel

A drop of (3 µl) of loading buffer (0.25% bromophenol blue, 0.25% xylene cyanol FF and 30% glycerol in water) was spotted on a parafilm for each 10 µl aliquots of the extracted genomic DNA and mixed with a pipette. The mixture was introduced into the well in the gel using a 1-20 µl range pipette. A standard DNA marker (1 kb DNA lambda) was treated in a similar manner. This was allowed to electrophorese at 60 V for 30 min at 110 Milli Amps. The gel was then visualized under an ultraviolet transilluminator attached to a computer system and photographed with gel documentation units (UVitec).

3.7.6 Quantification of DNA Samples

This involved the determination of the concentration and relative absorbance of each of the DNA samples using a biophometer. It was achieved by measuring 55 µl of the diluent i.e. sterile water into a cuvette followed by 2 µl of the DNA sample. The cuvette was then placed in a biophotometer and readings were documented.

3.7.7 Polymerase Chain Reaction (PCR) Amplification

Polymerase Chain Reaction (PCR) can be referred to as the enzymatic synthesis of multiple copies of a specific DNA sequence in a cyclical manner. It involves initiation, denaturation, annealing, elongation and final elongation of the DNA fragment over varying temperatures of 94^o C, 94^o C, 65^o C, 72^o C and 72^o C respectively. The reaction mixture is then held at 4^o C.

Here, two coding plastid DNA regions, one non-coding plastid DNA region and the other non coding nuclear ribosomal DNA region were amplified. Primer for the plastid regions is as described in Edwards and Gadek, (2001) 390F> and 1326R<for maturase K (matK) (specific primer for the Dodonaeoideae was designed by Harrington *et al*., 2005), 1F> and 1460R< for ribulose 1,5, biphosphate carboxylase large subunit (rbcL) (Savolainen *et al.,* 2000b), trnC> and trnD< intron, trnE> and trnF < spacer (for non coding plastid region, Taberlet *et al.,* 1991) while primer for the nuclear intergenic transcribed spacer (ITS) region AB101> and AB102< (White *et al.,* 1990; Sun *et al.,* 1994) were used. The fragment size amplified was between 870 – 910 bp for matK, 1436 – 1460 bp for rbcL, 750 – 800 bp for trnL (transfer RNA gene for tRNA Leucine), and 1236-1280 bp for ITS.

Amplification of selected regions were achieved in a 25 µl reaction mixtures containing 22.5 µl PCR premix, 0.5 µl BSA (bovine serum albumin), 0.5 µl forward primer, 0.5 µl reverse primer and 1.0-2.0 µl total genomic DNA. The amplification of the matK and ITS regions was improved by the addition of 4% DMSO in the total volume of the PCR mix. Polymerase chain reaction (PCR) amplification was carried out in a Gene Amp® PCR System 9700 thermal cycler (Applied Biosystems Inc. (ABI), Foster City, U.S.A.) using the following programme: initial denaturation for 3 min at 94° C followed by one cycle of denaturation for 1.00 min at 94° C, followed by 35 cycles of annealing for 45 s at 52° C and extension for 2min 30 s at 72° C. The amplification was completed by holding the reaction mixture for 7 min at 72° C to allow complete extension of the PCR products and a final hold of 4° C. PCR products were visualized on Agarose gel followed by purification on QIA quick silica column (QIAGEN Ltd) following manufacturers protocol.

3.7.8 Gel Electrophoresis

The integrity and purity of the amplified DNA samples were checked by preparing 2% agarose gel (3.0 g agarose with 150 ml 1X TBE buffer). This was boiled in a microwave oven until the agarose is completely dissolved (about 1-2 min) and cooled under running water then, 4 µl ethidium bromide was added to the solution and swirled to mix. After the agarose was cooled to 56˚ C, it was poured in a gel plate, affixed with combs to create wells in the gel in which the DNA will be run and allowed to solidify. The comb in the gel was removed to expose the wells formed and the gel was immersed into the gel electrophoresis tank containing Tris-borate-EDTA (TBE) buffer.

3.7.9 Loading of Samples and Running the Gel

A drop of (3 µl) of loading buffer (0.25% bromophenol blue, 0.25% xylene cyanol FF and 30% glycerol in water) was spotted on a parafilm for each 3 µl amplified DNA mixed with it. The mixture was introduced into the well, in the gel using a 1-20 µl range pipette. A standard DNA marker (1 kb DNA lambda) was treated in a similar manner. This was allowed to electrophorese at 60 V for 30 min at 110 Milli Amps. The gel was then visualized under an ultraviolet transilluminator attached to a computer system and photographed with gel documentation units (UVitec).

3.7.10 Cleaning and Quantifying PCR Products

This was achieved using QIA quick silica column (QIAGEN Ltd) following manufacturers protocol. To 20 µl of the PCR reaction product, 5X volume of binding buffer (i.e. 100 µl PB buffer) was added and placed onto a vacuum manifold. This was loaded into silica columns and vacuum was applied. The samples were washed by adding 0.75 ml of wash buffer (buffer PE) to each column and vacuum was applied. The tubes were centrifuged for 2 min at 3000 rpm to remove excess alcohol from the samples. Each of the columns was then transferred into a clean labelled lidless 1.5 ml Eppendorf tube and 20 µl of elution buffer was added directly into the membrane and incubated at room temperature for 10 min to elute the DNA. The tubes were then centrifuged for 2 min at 3000 rpm. To determine the concentration of the DNA obtained, 2 µl of the clean PCR product was added to 55 µl of sterile water in a cuvette and the quantity was verified on the spectrophotometer.

3.7.11 Cycle Sequencing

This was carried out following a modification dideoxy cycle sequencing with dye terminators (Sanger *et al.,* 1977). Amplification of selected regions was achieved in a 10 µl reaction mixtures containing 0.5 µl pink juice (Big Dye Terminator, Applied Biosystems Inc.), 3.0 µl 5X sequencing buffer (Bioloine), 0.75 µl primer (1:10 dilution: forward or reverse for each primer pair) and varying quantities of purified PCR products depending on the strength of the reaction, made up to 10 µl with sterile distilled water. The amplification of the matK and ITS regions was improved by the addition of 4% dimethyl sulfoxide (DMSO) in the total volume of the sequencing mix. Cycle sequencing was carried out in a Gene Amp® PCR System 9700 thermocycler (Applied Biosystems Inc.) using the following programme: initial denaturation for 30 s at 95º C followed by one cycle of denaturation for 1.00 min at 95° C, annealing for 30 s at 55º C and extension for 60 s at 72º C this was ran for 30 cycles and the cycle was completed by holding the reaction mixture for 7 min at 72° C to allow complete extension of the PCR products with a final hold of 4º C.

3.7.12 Purification of Cycle sequencing product

This was achieved following a modification of ABI protocol (2009). It involved alcoholic precipitation of the DNA in which 30 µl of a mixture of 100 % ethanol and sodium acetate was added to 10 µl of the cycle sequencing product and spun at 4ºC for a few seconds and left on ice for about 30 min. This was followed by spinning in a centrifuge at 23000 rpm for 45 min and emptying plates over the sink to remove the solutions. The plate was dried by centrifuging upside down for 5 min and 70% ethanol was added for further purification and centrifuged for 15 min at 23000 rpm, the solution was emptied and plate was dried by centrifuging upside down.

The plate was then dried in the oven for 15 min in order to ensure the complete removal of the alcohol. Finally, the DNA samples were eluted in 40 µl sterile distilled water and centrifuged briefly.

3.7.13 DNA Sequencing, Editing and Alignment

Deoxyribonucleic acid (DNA) sequencing is the determination of all or part of the nucleotide sequence of a specific deoxyribonucleic acid molecule. In this study, purified cycle sequencing products were sequenced in an automated sequencer (ABI PRISM® 3730 DNA Analyzer) following the manufacturer's instructions. The program Sequencher version 4.5 was used to assemble complementary strands and verify software base-calling on a Macintosh computer.

3.7.14 Phylogenetic Analyses

Cladistic analyses were performed using the parsimony algorithm of the software package PAUP* version 4.0b10 (Swofford and Sullivan, 2009). Phylogenetic Analysis Using Parsimony (PAUP) is used to create and manipulate trees that are based on protein or DNA alignments. PAUP is usually used because it infers and interprets phylogenetic trees by analyzing molecular sequence, morphological data and other data types using maximum likelihood, parsimony and distribution methods.

Maximum parsimony search was conducted for separated and combined analyses. The partition homogeneity test was performed with PAUP 4.0b10 using heuristic search methods and 1000 replications, simple stepwise addition, tree bisection-reconnection (TBR) branch swapping, and MULTREES on (Keeping multiple shortest trees), but holding only 10 trees per replicate to reduce the time spent in swapping on large numbers of suboptimal tress. After the 1000 replicates, the shortest trees from the first round were used as starting trees for a search with a tree limit of 10,000.

Robustness of clades was estimated using the bootstrap (Felsenstain, 1985) involving the use of 1000 replicates with simple sequence addition and SPR branch swapping. For visual assessment of the data sets, the bootstrap trees were considered incongruent only if they displayed "hard" (i.e. with high bootstrap support > 85%) rather than "soft" (with low bootstrap support < 85%) incongruence (Seelanan *et al.,* 1997; Wiens, 1998). The following arbitrary scale for describing bootstrap support was applied: 50 - 74% weak, 75 - 84% moderate and 85 - 100% high.

3.7.15 DNA Barcoding

This followed largely Powell *et al.,* 2009. DNA samples were sent to International Barcode of Life (IBOL) Centre in Guelph, Canada for analysis of the barcode region using matK and rbcL primers. Sequences and DNA barcodes obtained are deposited on the Barcode of Life Database (BOLD) for public use.

CHAPTER FOUR

4.0 RESULT ANALYSES

4.1 Morphological Characterization

Sample exploration revealed that members of the family generally occur as small trees (shrubs) or climbers (*Paullinia, Cardiospermum*) (Plates 4.1.1-4.1.6).

They have compound leaves; some are trifoliate with serrated margin i.e.*Allophylus* and *Cardiospermum* while others are compound paripinnate with entire margin however, *Dodonaea* has simple leaves with entire margin. Leaf arrangement is either sub-opposite or alternate; petiole is present, pubescent in some members and bulbous in nature. Some members possess leaves with glabrous glossy surface as in *Litchi chinensis* while others have pubescent papery surface e.g. *Laccodiscus ferrugineus* and *Allophylus hirtellus*.

Flowers are arranged in groups, usually creamy white but sometimes pinkish white as in *Dodonaea*. Inflorescence is usually in form of raceme. Fruits are green in colour turning orange or red as they become ripe however they are brown in *Dodonaea* species. They occur in form of berry (Plates 4.1.7a, 4.1.8e-f), drupe (Plates 4.1.7e, 4.1.8b-d) or capsule (Plates 4.1.7b, 4.1.7f, 4.1.8a) with black colour seed usually with ovoid or sub-globose shape (Plates 4.1.7b, 4.1.7d, 4.1.8c).

Pair-wise analysis showing similarity between the species based on morphological data is represented in Figure 4.1.1. However, detailed result of morphological characters is shown in Appendix 5.1-5.2. In addition, list of characters used in the numerial analysis of the morphological data is given in Appendix 7 while the corresponding encoding of the characters is shown in Appendix 6. All photographs were taken by the author.

Plate 4.1.1: Photographs of *Allophylus* and *Blighia* species.

(a) *Allophylus africanus* showing berry fruit;

(b) *Allophylus africanus* showing flower;

(c) *Allophylus spicatus* showing trifoliate leaves and fruits*;*

(d) *Allophylus* sp showing trifoliate leaves;

(e) *Allophylus welwitschii* showing trifoliate leaves*;*

(f) *Blighia sapida* showing leaves and fruits

Plate 4.1.1: Photographs of *Allophylus* and *Blighia* species.

Magnification x1.0

Plate 4.1.2: Photographs of some Sapindoideae.

(a) *Blighia unijugata* showing compound paripinnate leaves

(b) *Cardiospermum grandiflorum* showing flower

(c) *Cardiospermum halicacabum* showing inflated fruit

(d) *Chytranthus macrobotrys* showing compound paripinnate leaves with bulbous petiole

(e) *Chytranthus setosus* showing compound paripinnate leaves with slender stem

(f) *Chytranthus* sp showing compound paripinnate leaves *a* 

b 

c 

d 

e 

f 

Plate 4.1.2: Photographs of some Sapindoideae. **Magnification x1.0**

Plate 4.1.3: Photographs of some Sapindaceae showing leaves.

(a) *Chytanthus* sp 2 showing leaves;

(b) *Chytranthus talbotii* showing leaves*;*

(c) *Deinbollia voltensis* showing inflorescence*;*

(d) *Dodonea viscosa showing* simple leaves and inflorescence;

(e) *Eriocoelum macrocarpum* showing leaves

(f) *Harpullia pendula* showing plant habit

Plate 4.1.3: Photographs of some Sapindaceae showing leaves.

Magnification x1.0

Plate 4.1.4: Photographs of some members of Sapindaceae.

(a) *Haplocoelum* sp showing leaves;

(b) *Laccodiscus ferrugineus* showing leaves

(c) *Lecaniodiscus cupanioides* showing leaves*;*

(d) *Melicoccus bijugatus* showing berry fruit*;*

(e) *Majidea fosterii* showing leaves and white flowers;

(f) *Glenniea africanus* showing leaves

a


b


c


d


e


f


Plate 4.1.4: Photographs of some members of Sapindaceae.

Magnification x1.0

Plate 4.1.5: Photographs of some members of subfamily Sapindeae showing leaves.

(a) *Placodiscus* sp 1 showing leaves;

(b) *Litchi chinensis* showing leaves and cymose inflorescence

(c) *Pancovia atroviolaceus* showing leaves*;*

(d) *Pancovia sp 1* showing leaves*;*

(e) *Pancovia sp 2* showing leaves*;*

(f) *Pancovia leptostachyus* showing leaves*;*

Plate 4.1.5: Photographs of some members of subfamily Sapindeae showing leaves.

Magnification x1.0

Plate 4.1.6: Photographs of some Sapindaceae showing leaves, trunk, and fruits.

(a) *Placodiscus* sp 2 showing paripinnate leaves

(b) *Paullinia pinnata* showing imparipinnate leaves

(c) *Radlkofera calodendron* showing paripinnate leaves

(d) *Sapindus saponaria* showing berry fruit

(e) *Sapindus trifolatus* showing paripinnate leaves

(f) *Zanha golugensis* showing paripinnate leaves and trunk

Plate 4.1.6: Photographs of some Sapindaceae showing leaves, trunk, and fruits.

Magnification x1.0

Plate 4.1.7: Fruit and Seed Types in Sapindaceae.

(a) *Allophylus africanus* showing globose berry,

(b) *Blighia sapida* showing trilobed capsule and black seed

(c) *Cardiospermum grandiflorum* showing inflated trilobed fruit,

(d) *Cardiospermum grandiflorum* showing inflated fruit with black globose seeds

(e) *Deinbollia pinnata* showing drupe,

(f) *Dodonaea viscosa* showing ripe trilobed capsule

a

b

c

d

e

f


Plate 4.1.7: Fruit and Seed Types in Sapindaceae.

Magnification x1.0

Plate 4.1.8: Fruits, Seeds and Aril of some Sapindoideae.

(a) *Dodonaea viscosa* showing clusters of capsule,

(b) *Harpullia pendula* showing drupe,

(c) *Litchi chinensis* showing drupe with black shining seed,

(d) *Nephelium lappaceum* showing ripe hairy drupe with seeds containing aril,

(e) *Sapindus saponaria* showing berry,

(f) *Sapindus trifoliatus* showing berry

Plate 4.1.8: Fruits, Seeds and Aril of some Sapindoideae.

Magnification x1.5

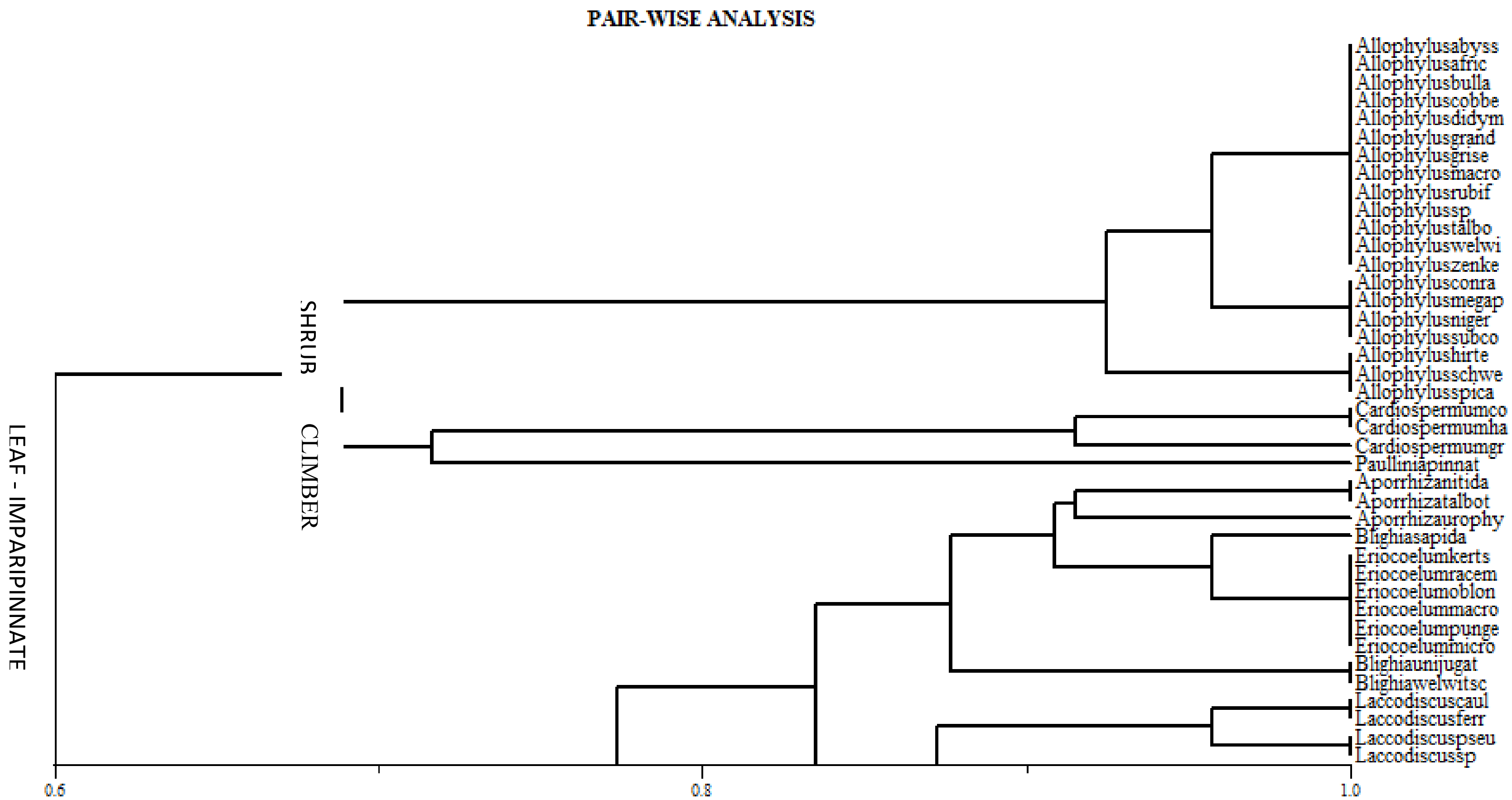


Figure 4.1.1: Pair-wise (Similarity) Analysis showing Relationships within Sapindaceae based on Morphological Data.

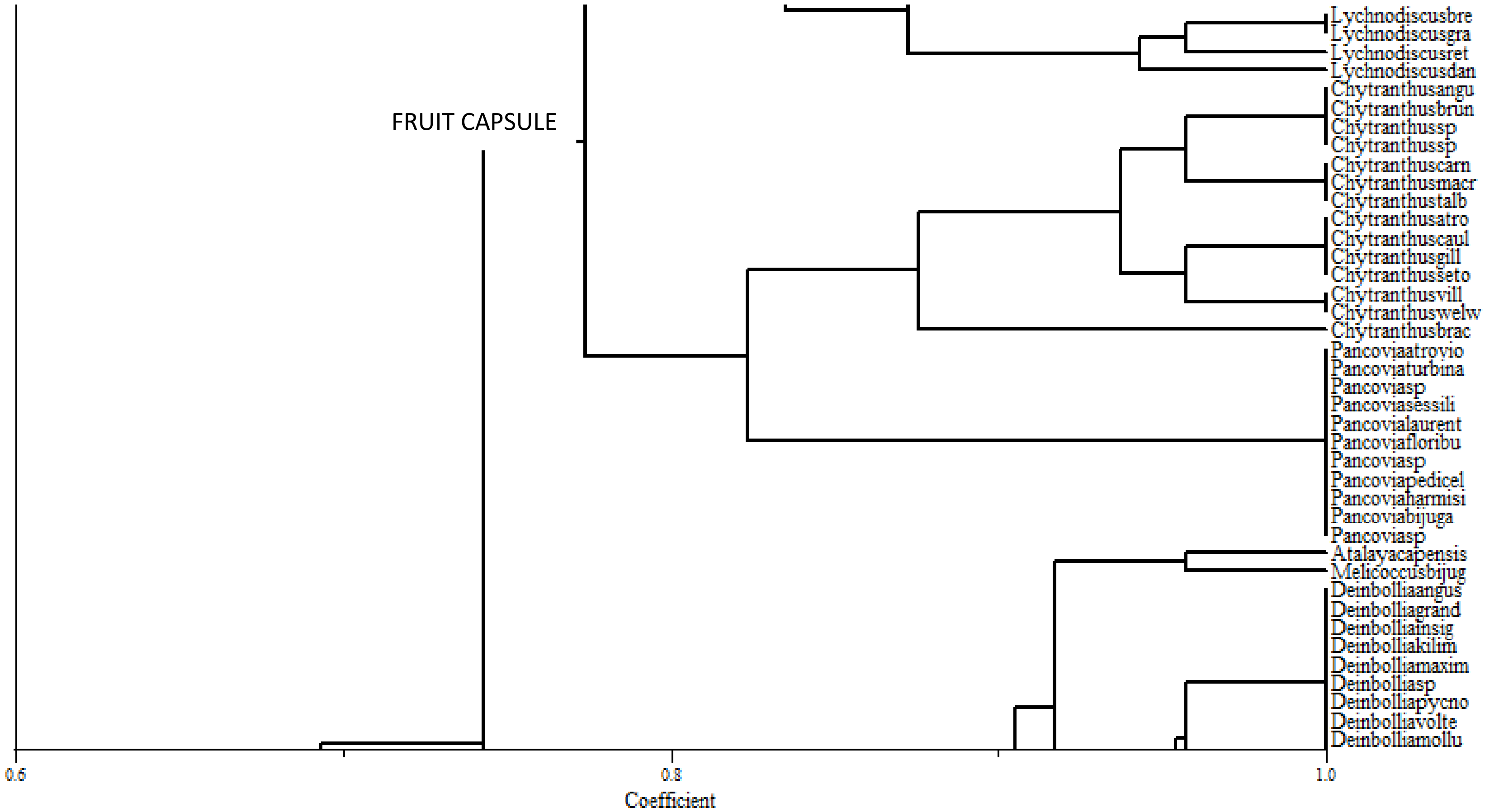


Figure 4.1.1: Pair-wise (Similarity) Analysis showing Relationships within Sapindaceae based on Morphological Data (cont'd).

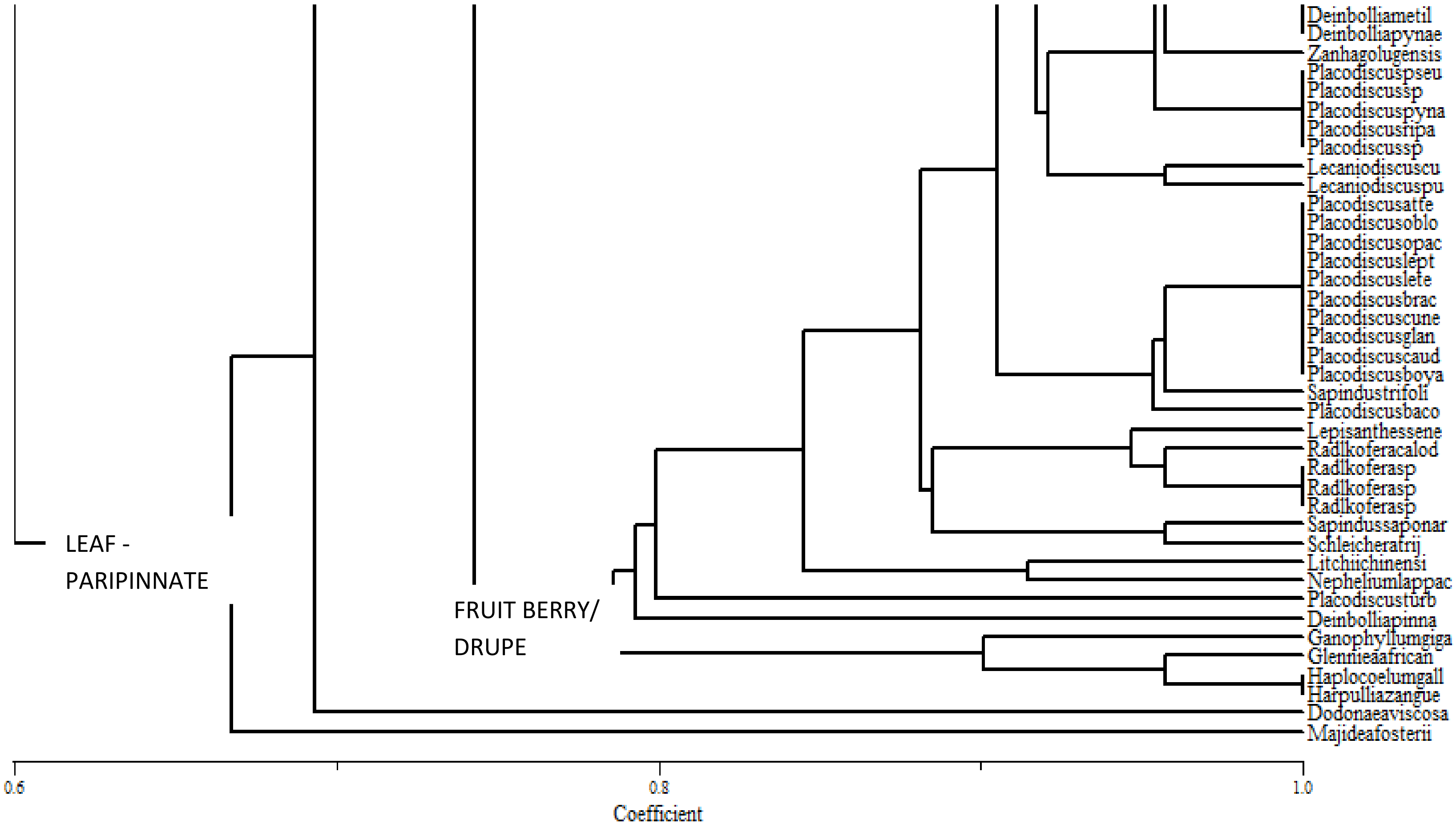


Figure 4.1.1: Pair-wise (Similarity) Analysis showing Relationships within Sapindaceae based on Morphological Data (cont'd).

Plate 4.1.9: Some Herbarium Preparations of Sapindaceae showing leaf forms.

4.2. SPECIES DISTRIBUTION MODELLING

Global positioning system (GPS) coordinates were recorded for the various sampling points and they were used to model the species distribution of the family sapindaceae in Africa (Figure 4.2.1). The following settings were used during the run: 123 presence records used for training, 30 for testing (Appendix 8). 10107 points used to determine the Maxent distribution (background points and presence points).

Nineteen (19) variables were used in this model namely:

- Bio1 (Annual Mean Temperature),
- Bio2 (Mean Diurnal Range (Mean of monthly (max temp - min temp),
- Bio3 (Isothermality (P2/P7) (* 100),
- Bio4 (Temperature Seasonality (standard deviation *100),
- Bio5 (Max Temperature of Warmest Month),
- Bio6 (Min Temperature of Coldest Month),
- Bio7 (Temperature Annual Range (P5-P6)),
- Bio8 (Mean Temperature of Wettest Quarter),
- Bio9 (Mean Temperature of Driest Quarter),
- Bio10 (Mean Temperature of Warmest Quarter),
- Bio11 (Mean Temperature of Coldest Quarter),
- Bio12 (Annual Precipitation),
- Bio13 (Precipitation of Wettest Month),

- Bio14 (Precipitation of Driest Month),
- Bio15 (Precipitation Seasonality (Coefficient of Variation)),
- Bio16 (Precipitation of Wettest Quarter),
- Bio17 (Precipitation of Driest Quarter),
- Bio18 (Precipitation of Warmest Quarter),
- Bio19 (Precipitation of Coldest Quarter)

Also, omission rate and predicted area were tested as a function of the cumulative threshold and the omission rate is calculated both on the training presence records, and on the test records (Figure 4.2.2). The receiver operating characteristic (ROC) curve for the sample data is represented in Figure 4.2.3.

As each environmental variable is varied, keeping all other environmental variables at their average sample value, the logistic prediction changes. The marginal effect of changing exactly one variable revealed that the probability of occurrence of the samples increases with varying Bio 1, 4, 17 and 19; decreases with varying Bio 3, 14, 16 and 18; remains constant with varying Bio 5, 6, 7, 8, 9, 12 and 15; but decreases after a certain range with varying Bio 2 and 11. These are represented in Figure 4.2.4

A Maxent model created using only the corresponding variable showed the dependence of predicted suitability both on the selected variable and on dependencies induced by correlations between the selected variable and other variables (Figure 4.2.5).

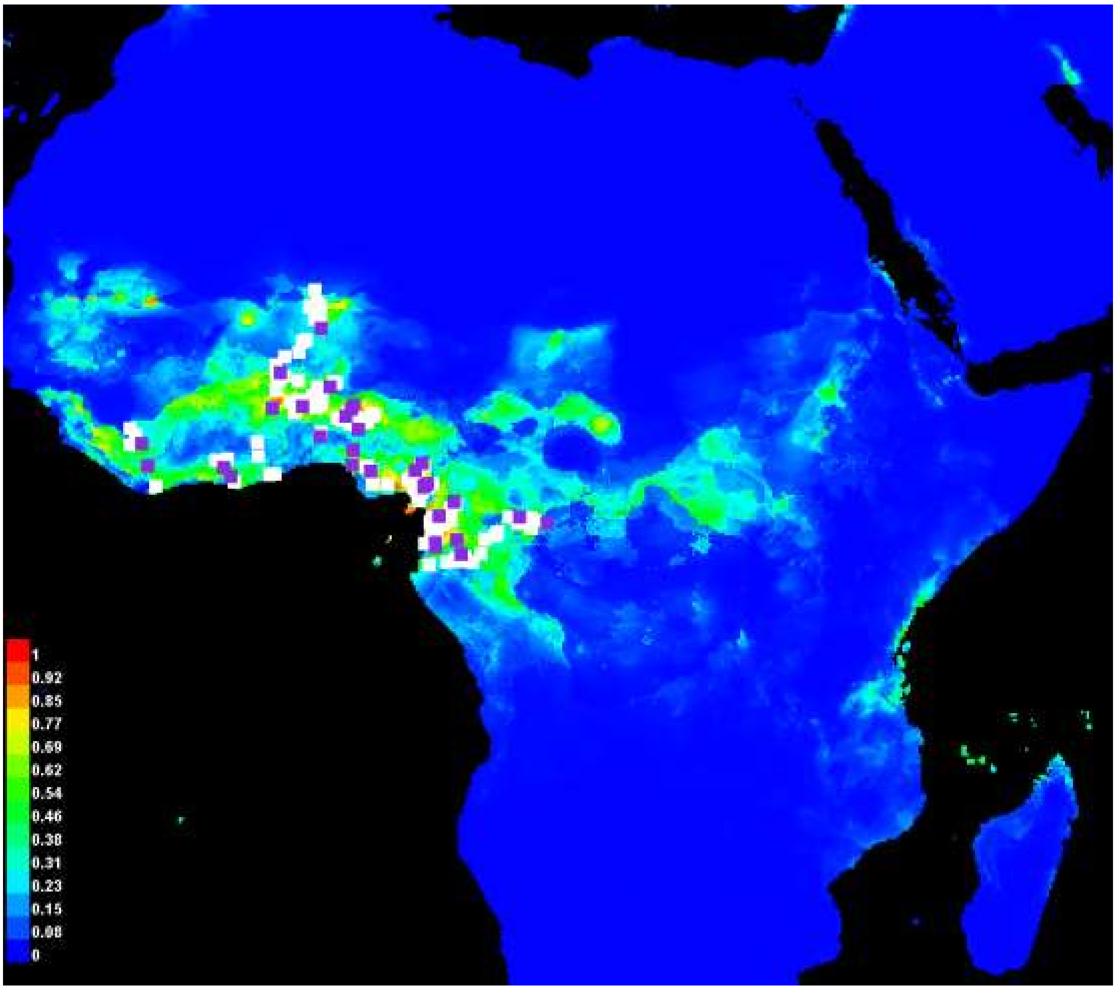


FIGURE 4.2.1: Species Distribution: Training Vs Test Locations

(Green colour shows the typical condition of where species are found, blue colour represents low probability of suitable condition, red colour represents high probability of suitable condition, white dots show the presence locations used for training, while violet dots show test locations).

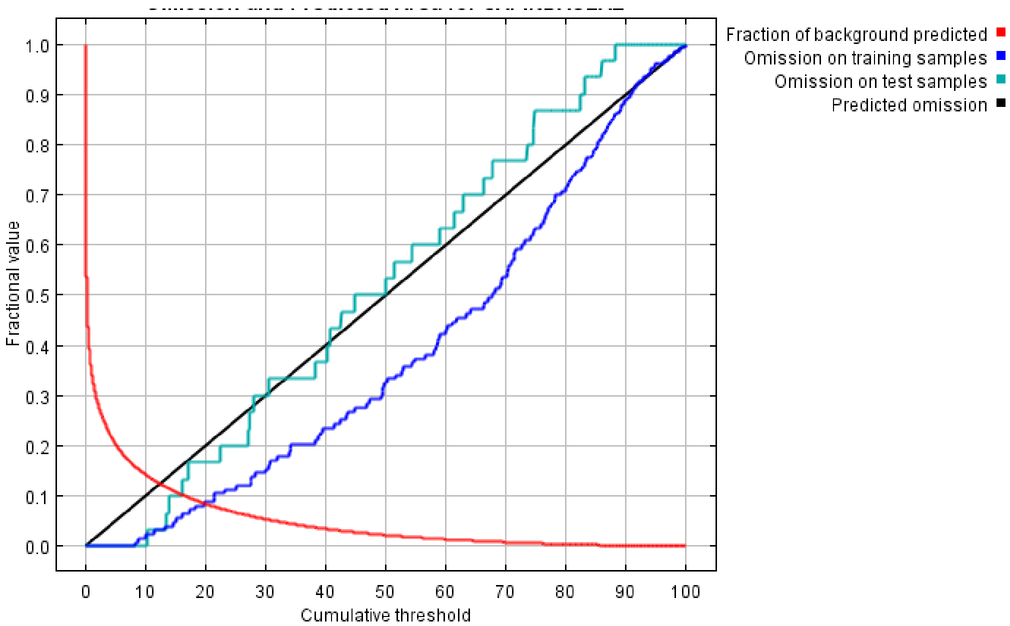


FIGURE 4.2.2: Omission and Predicted Area of Sapindaceae.

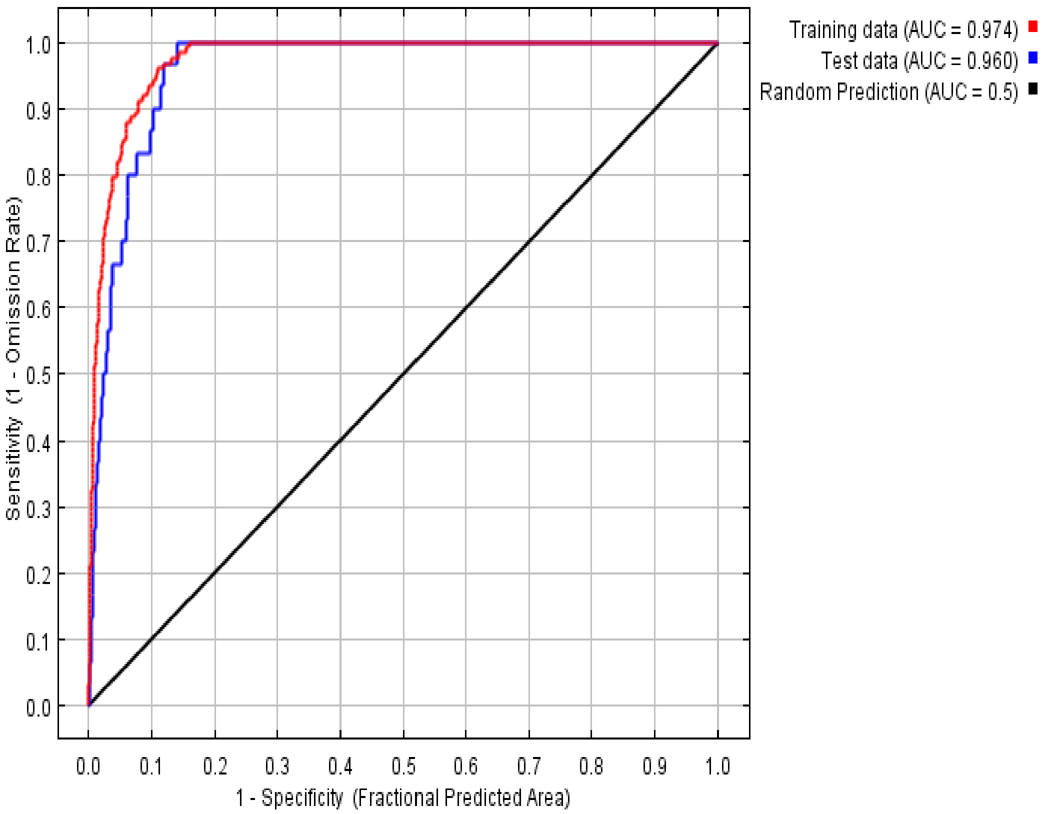


FIGURE 4.2.3: Sensitivity Vs Specificity Test on Sapindaceae

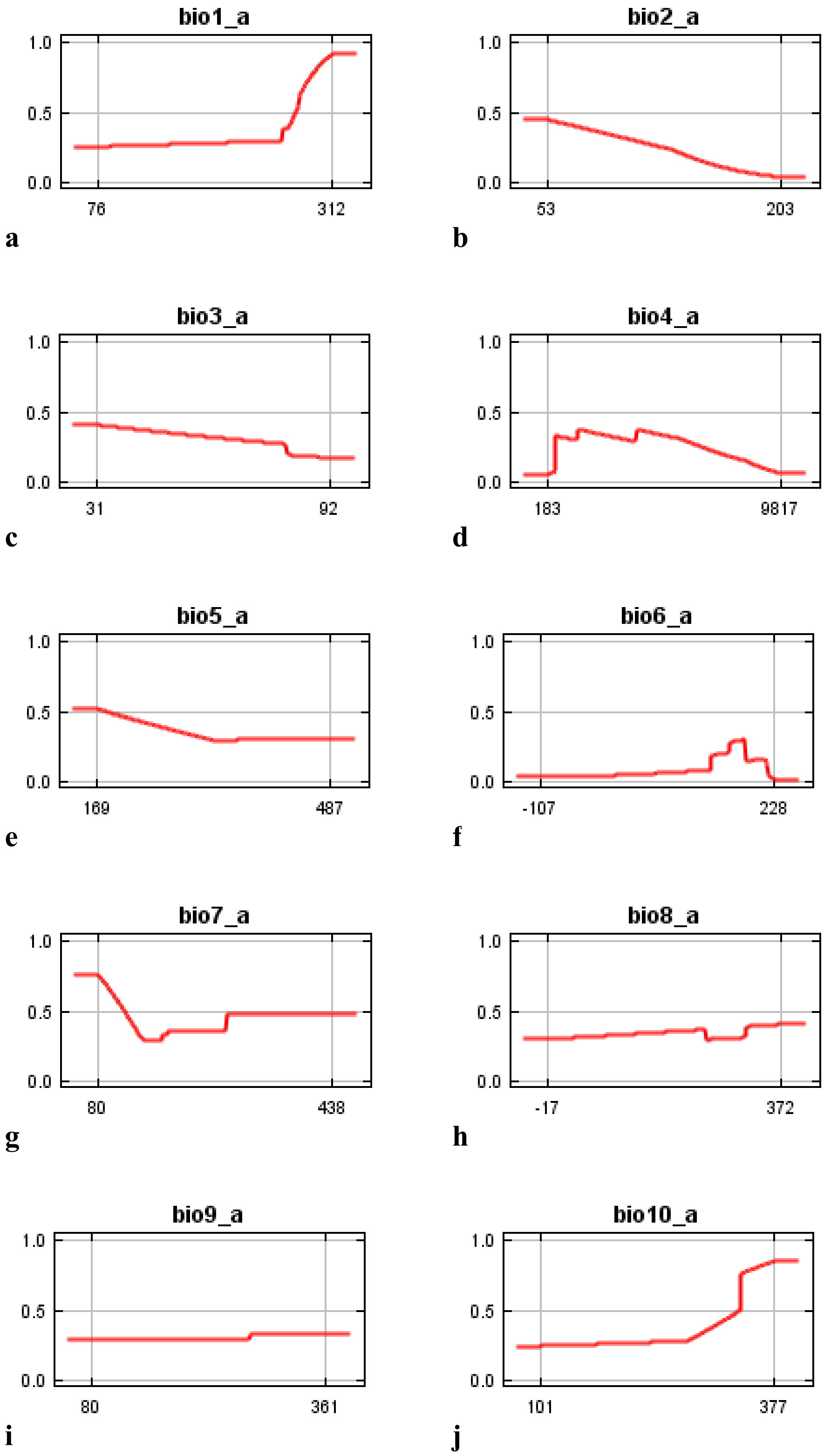


Figure 4.2.4 (a-s): The marginal effects of changing exactly one environmental variable

X axis: Environmental variables

Y axis: Fractional value of Location

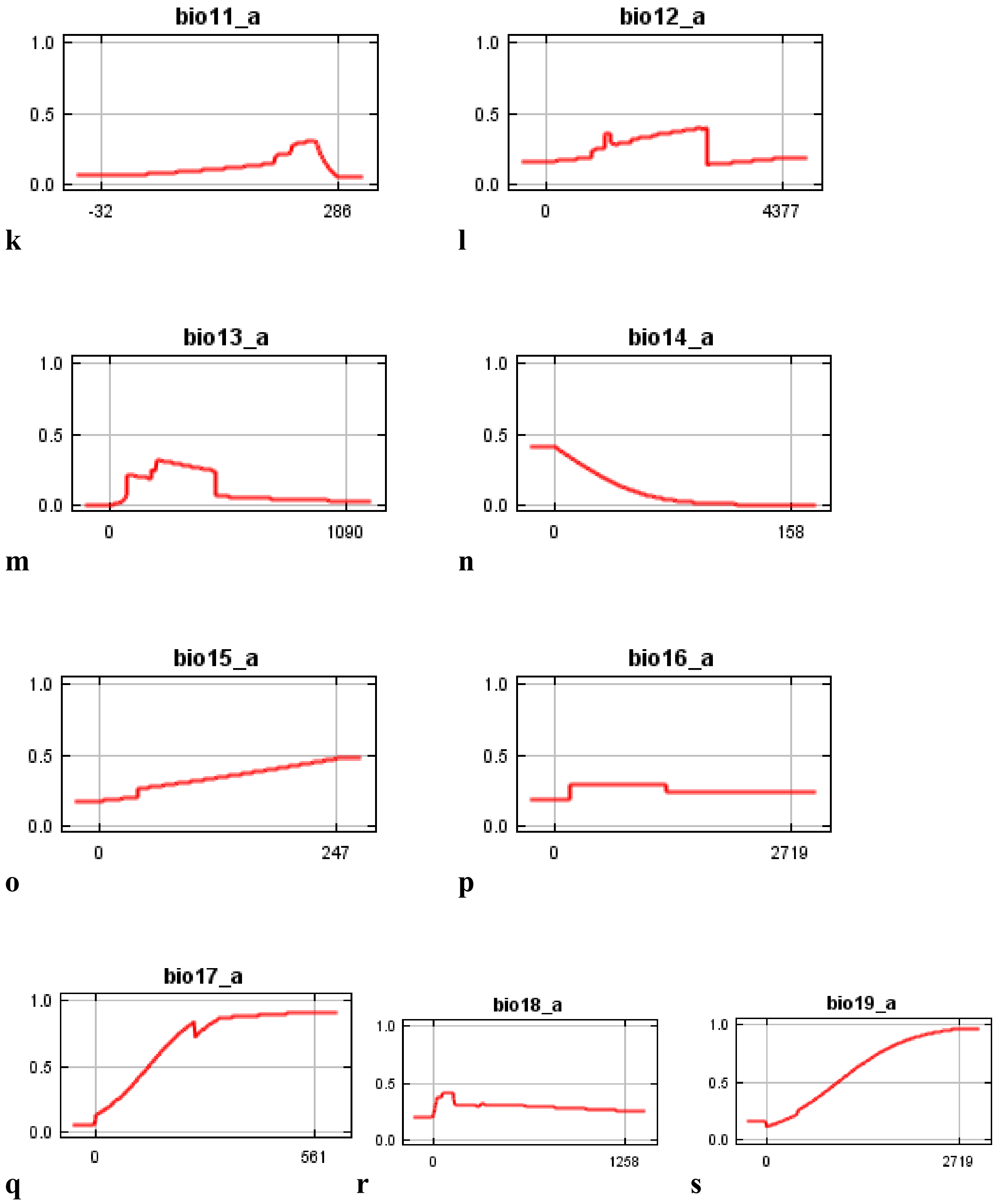


Figure 4.2.4 (a-s): The marginal effects of changing exactly one environmental variable (cont'd)

X axis: Environmental variables

Y axis: Fractional value of Location

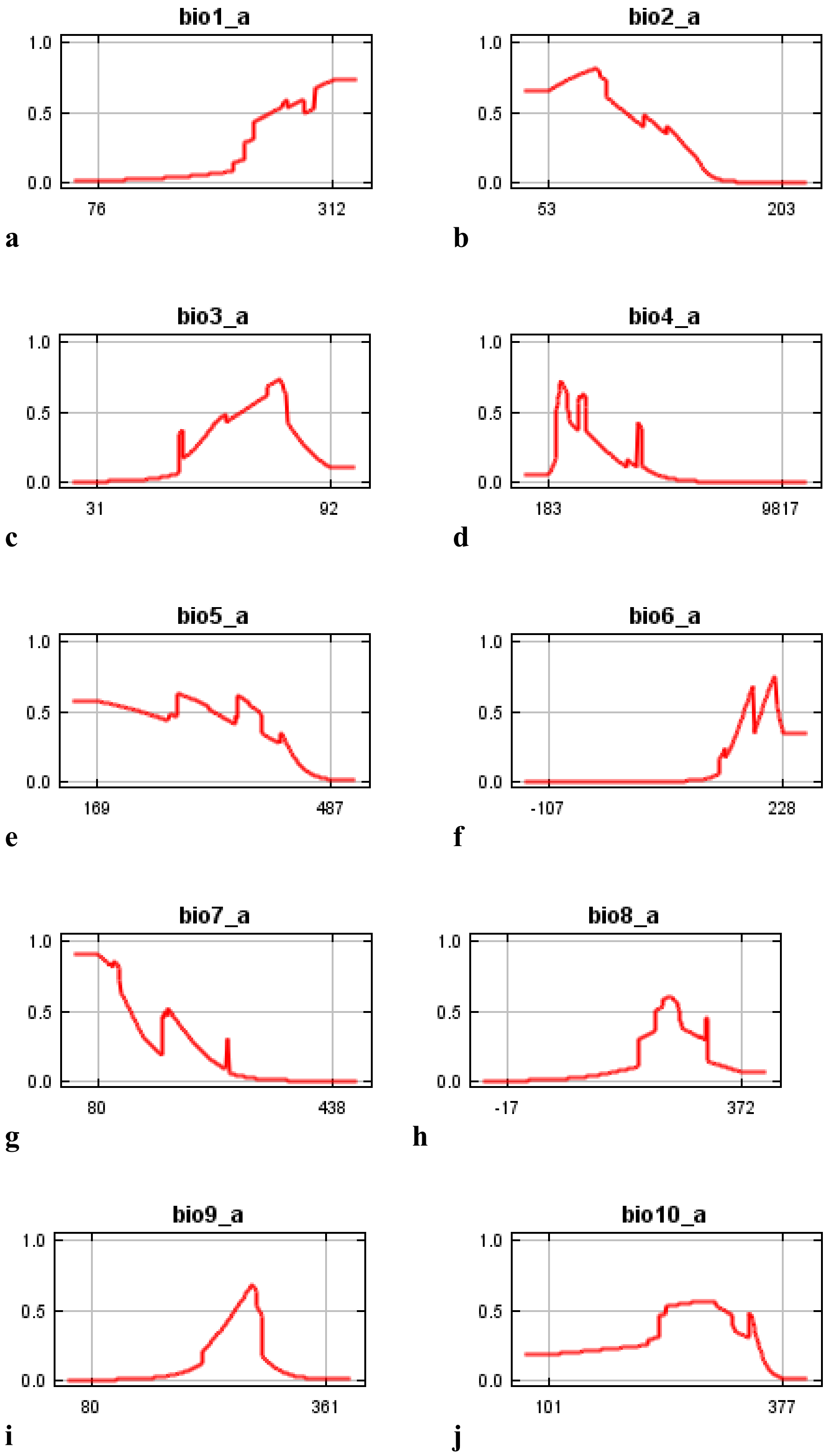
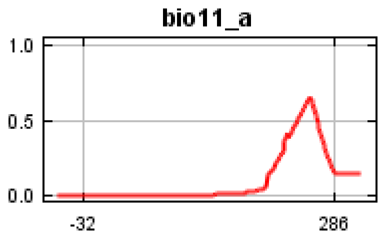


Figure 4.2.5 (a-s): The marginal effects of changing corresponding variables

X axis: Environmental variables

Y axis: Fractional value of Location



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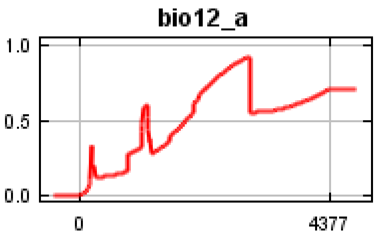

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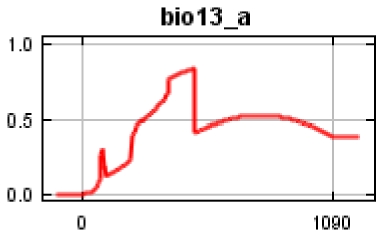

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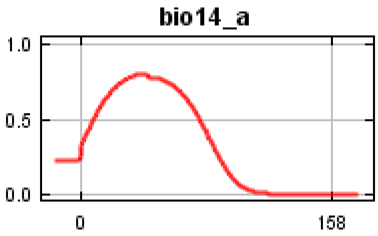

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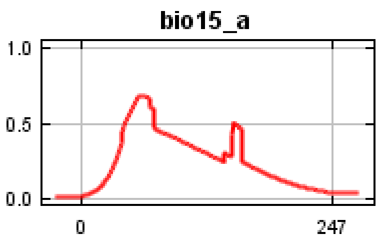

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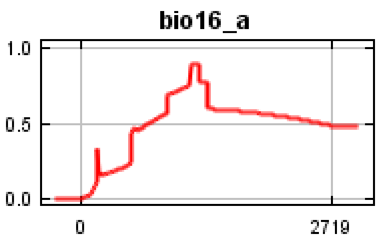

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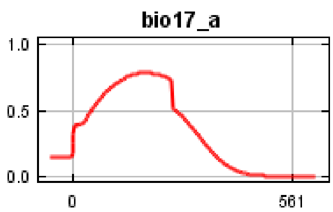

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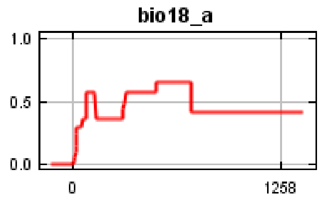

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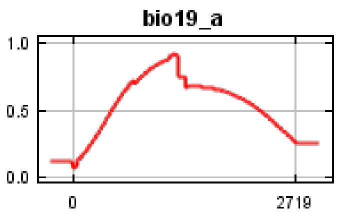

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Figure 4.2.5 (a-s): The marginal effects of changing corresponding variables (cont'd)

X axis: Environmental variables

Y axis: Fractional value of Location

A heuristic estimate of relative contributions of the environmental variables to the Maxent model revealed that Bio 6 has the highest percentage contribution to the model while Bio9 has the least contribution to the Maxent model (Table 4.1).

To determine the estimate in iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. The regularized training gain in this model is 2.139, training AUC is 0.974, unregularized training gain is 2.668. Unregularized test gain is 2.117, test AUC is 0.960 and standard deviation is 0.007. Algorithm terminated after 500 iterations (37 seconds).

The results of the jack-knife test of variable importance revealed that the environmental variable with highest gain when used in isolation is bio6_a, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is bio4_a, which therefore appears to have the most information that isn't present in the other variables.

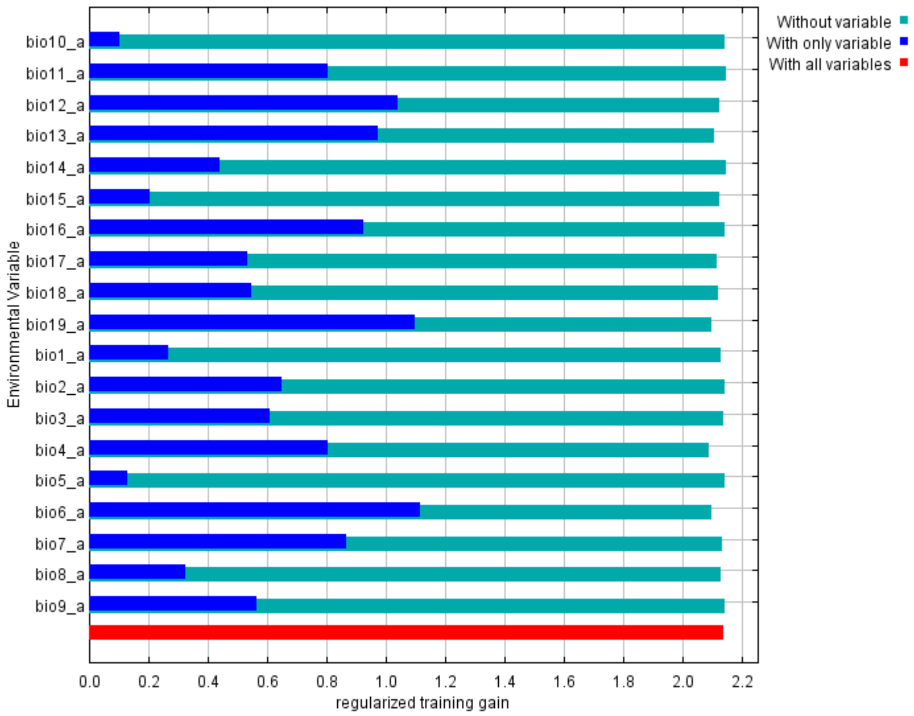


Figure 4.2.6: Jack-knife of regularized training gain for Sapindaceae

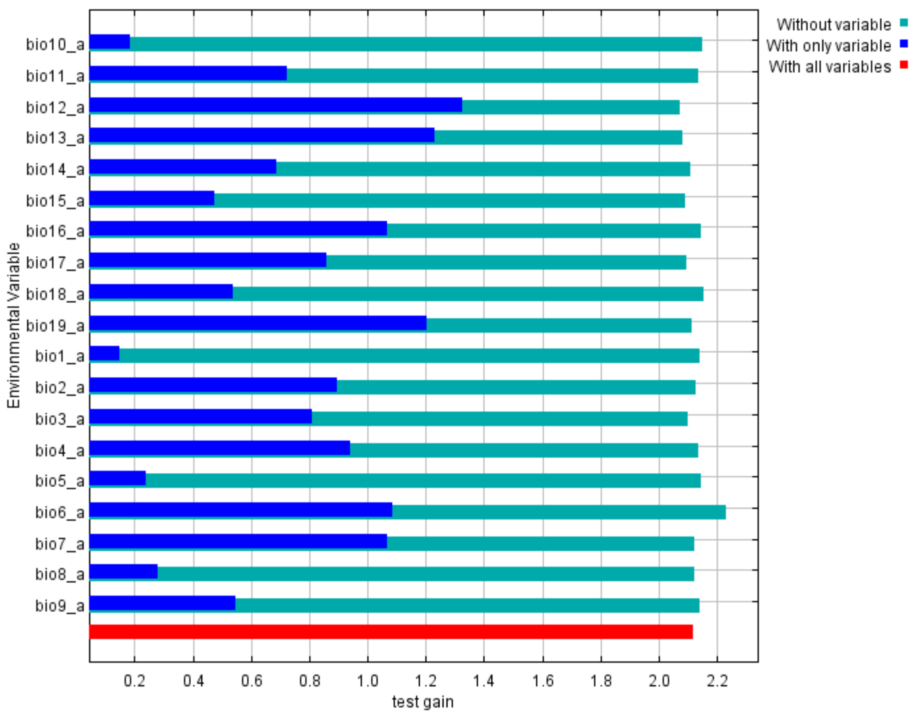


Figure 4.2.7: Jack-knife of regularized test gain for Sapindaceae

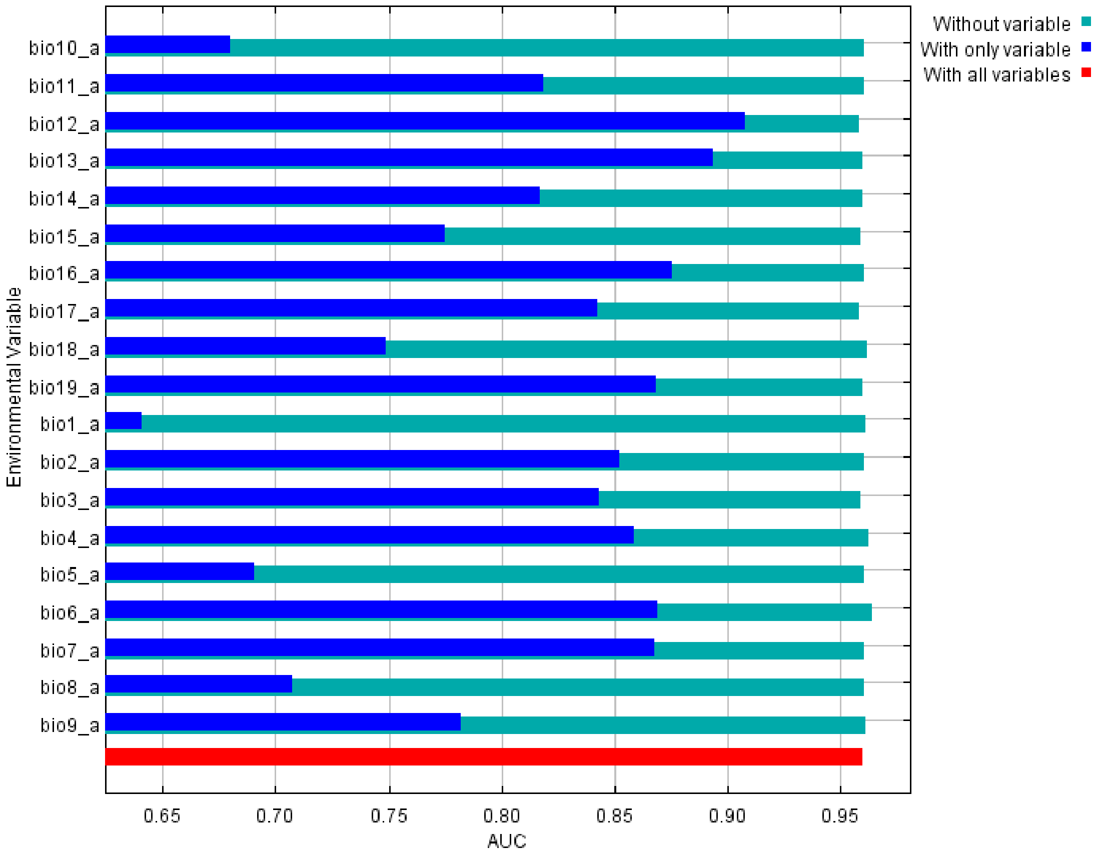


Figure 4.2.8: Jack-knife of AUC for Sapindaceae

TABLE 4.1: VARIABLE CONTRIBUTIONS TO THE MAXENT MODEL

Variable	Percentage Contribution
Bio1_a	2.3
Bio2_a	1.7
Bio3_a	0.6
Bio4_a	4.3
Bio5_a	1.1
Bio6_a	35.4
Bio7_a	4.6
Bio8_a	1.9
Bio9_a	0.2
Bio10_a	2.3
Bio11_a	2.3
Bio12_a	3.6
Bio13_a	14.9
Bio14_a	0.3
Bio15_a	1.7
Bio16_a	2.3
Bio17_a	2.6
Bio18_a	1.2
Bio19_a	16.9

4.3 ANATOMICAL CHARACTERIZATION

4.3.1 LIGHT MICROSCOPY

Examination of foliar epidermal characters revealed that members of the family have cells with rectangular, polygonal and irregular shapes. Anticlinal wall pattern ranges from smooth, curved, to wavy in nature (Plate 4.3.1.1 and 4.3.1.3).

Members are hypostomatic with exception to *Dodonaea viscosa* and *Sapindus saponaria* which are amphistomatic. Stomata of two major types were observed i.e. anomocytic and paracytic stomata and they are restricted to the abaxial surface in the hypostomatic species (Plate 4.3.1.2 and 4.3.1.4). Trichomes are also present on the epidermal surfaces in some taxa and they are of unicellular (Plate 4.3.1.1b), glandular (Plate 4.3.1.3a) and stellar types.

4.3.2. SCANNING ELECTRON MICROSCOPY

Studies on the leaf epidermal surfaces of the different samples collected revealed that all members of the family assessed in this research are hypostomatic with exception to *Dodonaea viscosa* (Plate 4.3.2.6b, 4.3.2.14d), *Chytranthus sp* (Plate 4.3.2.4f, 4.3.2.13d) *and Sapindus saponaria* (Plate 4.3.2.10b, 4.3.2.18e) which are amphistomatic. Epidermal features are restricted to the abaxial layer in the hypostomatic taxa.

Stomata types ranges from anomocytic to paracytic and they are either flat or raised. Peristomatal ridges are present in *Lepisanthes senegalensis* (Plate 4.3.2.7d). In some species, the stomata are covered by papillae on the leaf suface e.g. *Litchi chinensis* and *Cardiospermum grandiflorum*.

Plate 4.3.1.1: Light Micrographs showing Adaxial Epidermal Surfaces of members of subfamily Sapindoideae

(a) *Allophylus africanus* showing polygonal epidermal cells with straight anticlinal wall pattern

(b) *Allophylus talbotii* showing epidermal cells with irregular shape, straight anticlinal wall pattern and glandular trichome

(c) *Allophylus schweinfurthii* showing rectangular and polygonal epidermal cells with straight anticlinal wall pattern

(d) *Blighia sapida* showing irregular epidermal cells with wavy anticlinal wall pattern

(e) *Blighia unijugata* showing irregular epidermal cells with wavy anticlinal wall pattern

(f) *Chytranthus setosus* showing irregular epidermal cells with wavy anticlinal wall pattern and cellular deposits

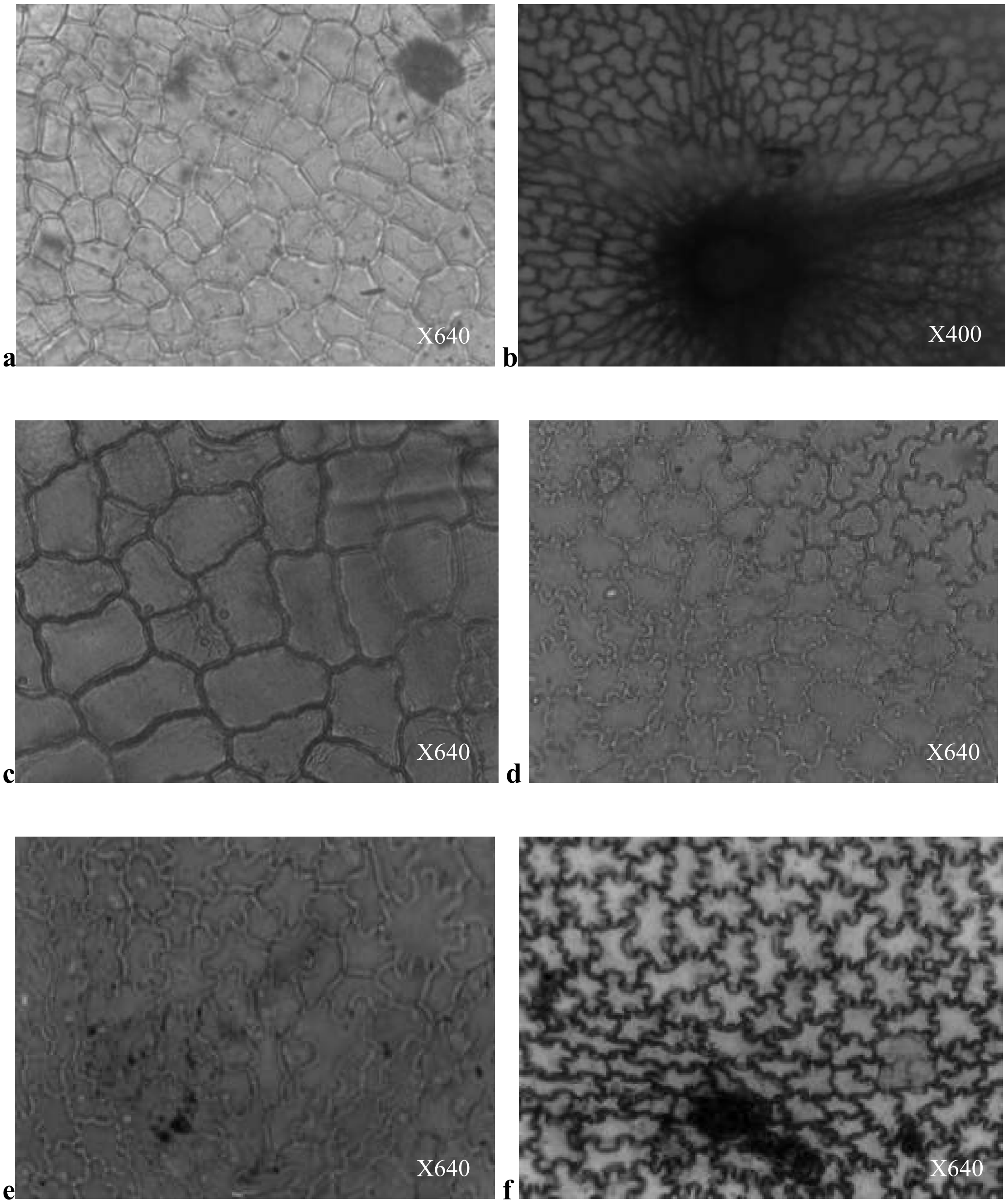


Plate 4.3.1.1: Light Micrographs showing Adaxial Epidermal Surfaces of members of subfamily Sapindoideae

Plate 4.3.1.2: Light Micrographs showing Abaxial Epidermal Surfaces of members of subfamily Sapindoideae

(a) *Allophylus africanus* showing irregular epidermal cells with straight anticlinal wall pattern and anomocytic stomata

(b) *Blighia sapida* showing irregular epidermal cells with wavy anticlinal wall pattern and anomocytic stomata

(c) *Chytranthus setosus* showing irregular epidermal cells with wavy anticlinal wall pattern and anomocytic stomata

(d) *Lecaniodiscus cupanioides* showing irregular epidermal cells with straight anticlinal wall pattern and anomocytic stomata

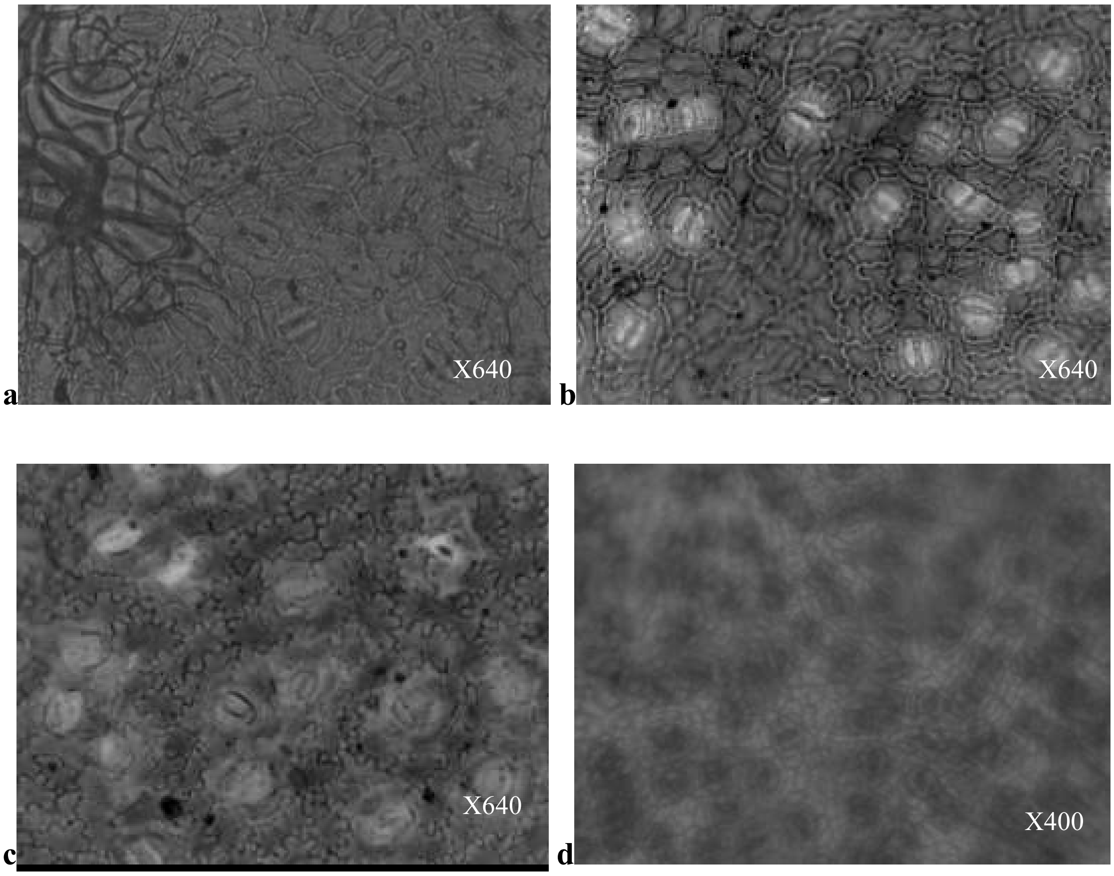


Plate 4.3.1.2: Light Micrographs showing Abaxial Epidermal Surfaces of members of subfamily Sapindoideae

Plate 4.3.1.3: Light Micrographs showing Adaxial Epidermal Surfaces of some Sapindaceae

(a) *Lecaniodiscus cupanioides* showing irregular epidermal cells with straight anticlinal wall pattern and silica deposits
(b) *Litchi chinensis* showing polygonal epidermal cells with straight anticlinal wall pattern
(c) *Majidea fosterii* showing irregular epidermal cells with wavy anticlinal wall pattern
(d) *Glenniea africanus* showing irregular epidermal cells with wavy anticlinal wall pattern
(e) *Sapindus saponaria* showing rectangular and polygonal epidermal cells with straight anticlinal wall pattern

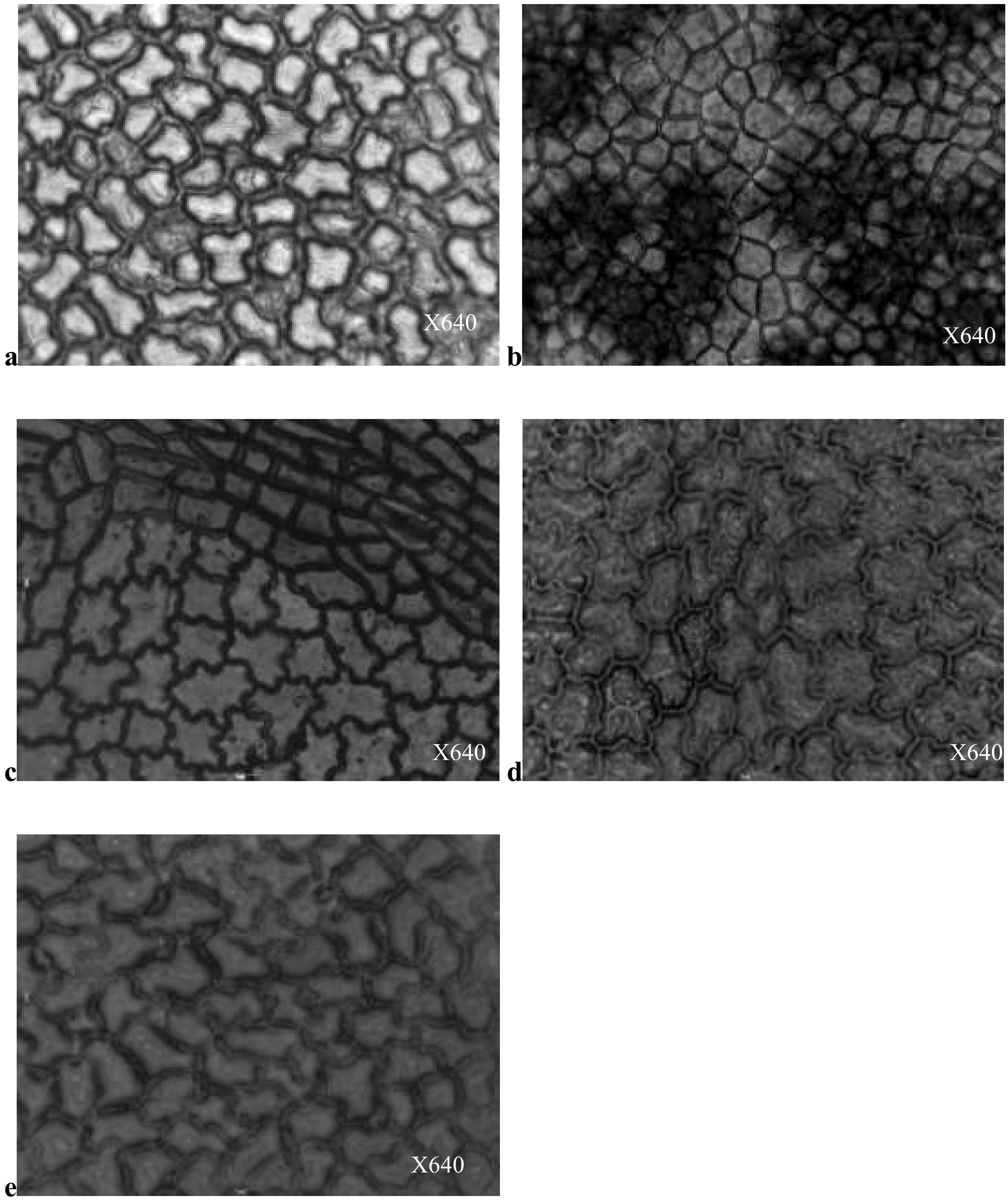
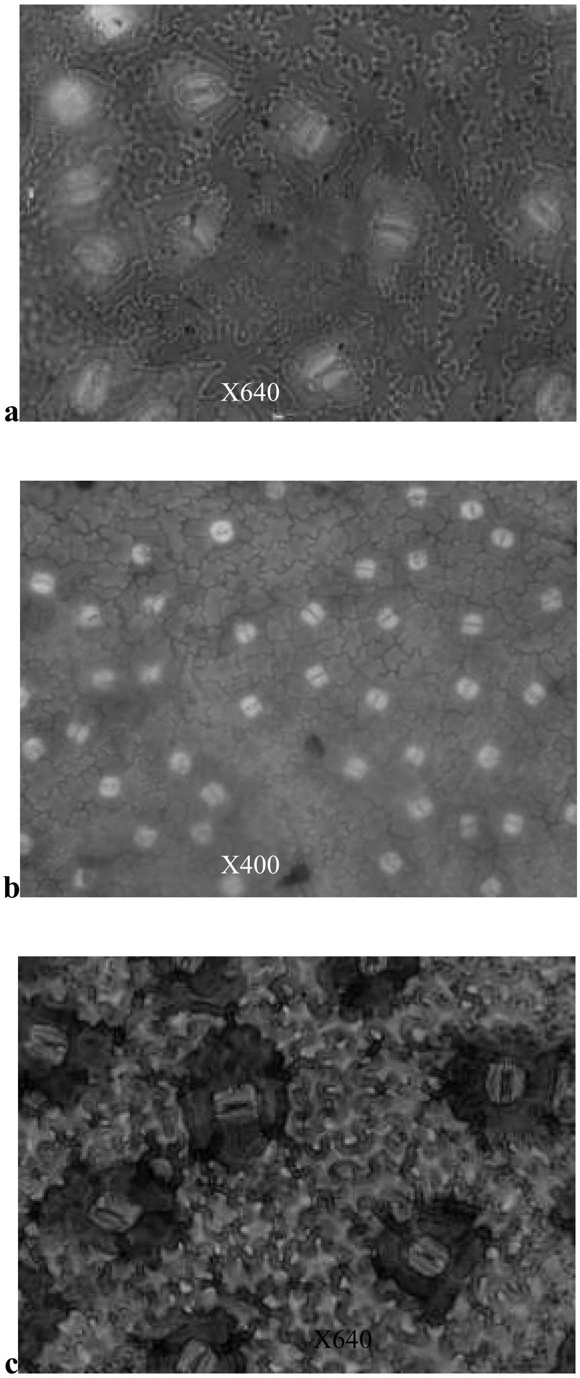


Plate 4.3.1.3: Light Micrographs showing Adaxial Epidermal Surfaces of some Sapindaceae



a
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c

Plate 4.3.1.4: Light Micrographs showing Abaxial Epidermal Surfaces of some Sapindaceae

(a) *Majidea fosterii,* (b) *Glenniea africanus,* (c) *Sapindus saponaria* showing paracytic stomata

Epicuticular wax is present and granular in all taxa especially on the adaxial surface (Plate 4.3.2.10d - 4.3.2.18e). The cuticle is ridged or smooth on the adaxial surface but on the abaxial surface it is striated as in *Allophylus niger* (Plate 4.3.2.2b), *Cardiospermum grandiflorum* (Plate 4.3.2.4a-b), *Deinbollia pinnata* (Plate 4.3.2.5e-f), *Deinbollia pycnophylla* (Plate 4.3.2.6b), *Eriocoelum macrocarpum* (Plate 4.3.2.6c), *Laccodiscus ferrugineus* (Plate 4.3.2.6f), *Litchi chinensis* (Plate 4.3.2.7e) and *Zanha golugensis* (Plate 4.3.2.18e).

Trichomes are either present or absent. They could be acicular or filiform as in *Allophylus africanus* (Plate 4.3.2.1a), *Allophylus griseotomentosus* (Plate 4.3.2.1e), *Allophylus macrobotrys* (Plate 4.3.2.2a), *Allophylus spicatus* (Plate 4.3.2.2f, 4.3.2.11f), *Cardiospermum grandiflorum* (Plate 4.3.2.4c) and *Deinbollia pinnata* (Plate 4.3.2.5e). They could also be glandular in nature as shown in *Allophylus griseotomentosus* (Plate 4.3.2.1d), *Allophylus hirtellus* (Plate 4.3.2.1f), *Allophylus schweinfurthii* (Plate 4.3.2.2c) and *Allophylus spicatus* (Plate 4.3.2.3a).

Some members possess trichomes which are adpressed to the surface of the leaf for example *Allophylus niger* (Plate 4.3.2.2b), *Allophylus welwitschii* (Plate 4.3.2.12b), *Chytranthus angustifolius* (Plate 4.3.2.4d) and *Pancovia* sp (Plate 4.3.2.8c) while others bear superficial trichomes as seen in *Allophylus* sp (Plate 4.3.2.2d), *Blighia welwitschii* (Plate 4.3.2.3f), *Cardiospermum grandiflorum* (Plate 4.3.2.4a)*Chytranthus macrobotrys* (Plate 4.3.2.5b), *Lecaniodiscus cupanioides* (Plate 4.3.2.7c), *Pancovia* sp (Plate 4.3.2.8e) and *Radlkofera* sp (Plate 4.3.2.9f).

Details of the samples assessed are represented in Plates 4.3.2.1 - 4.3.2.18.

PLATE 4.3.2.1: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of some *Allophylus* Species

a- *Allophylus africanus* showing trichome adpressed to the epidermal surface,

b- *Allophylus bullatus* showing stomata*,*

c- *Allophylus grandifolius* showing epicuticular wax deposits*,*

d- *Allophylus griseotomentosus* showing glandular trichome

e- *Allophylus griseotomentosus* showing filiform trichome on the midrib*,*

f- *Allophylus hirtellus* showing glandular trichome and flat stomata

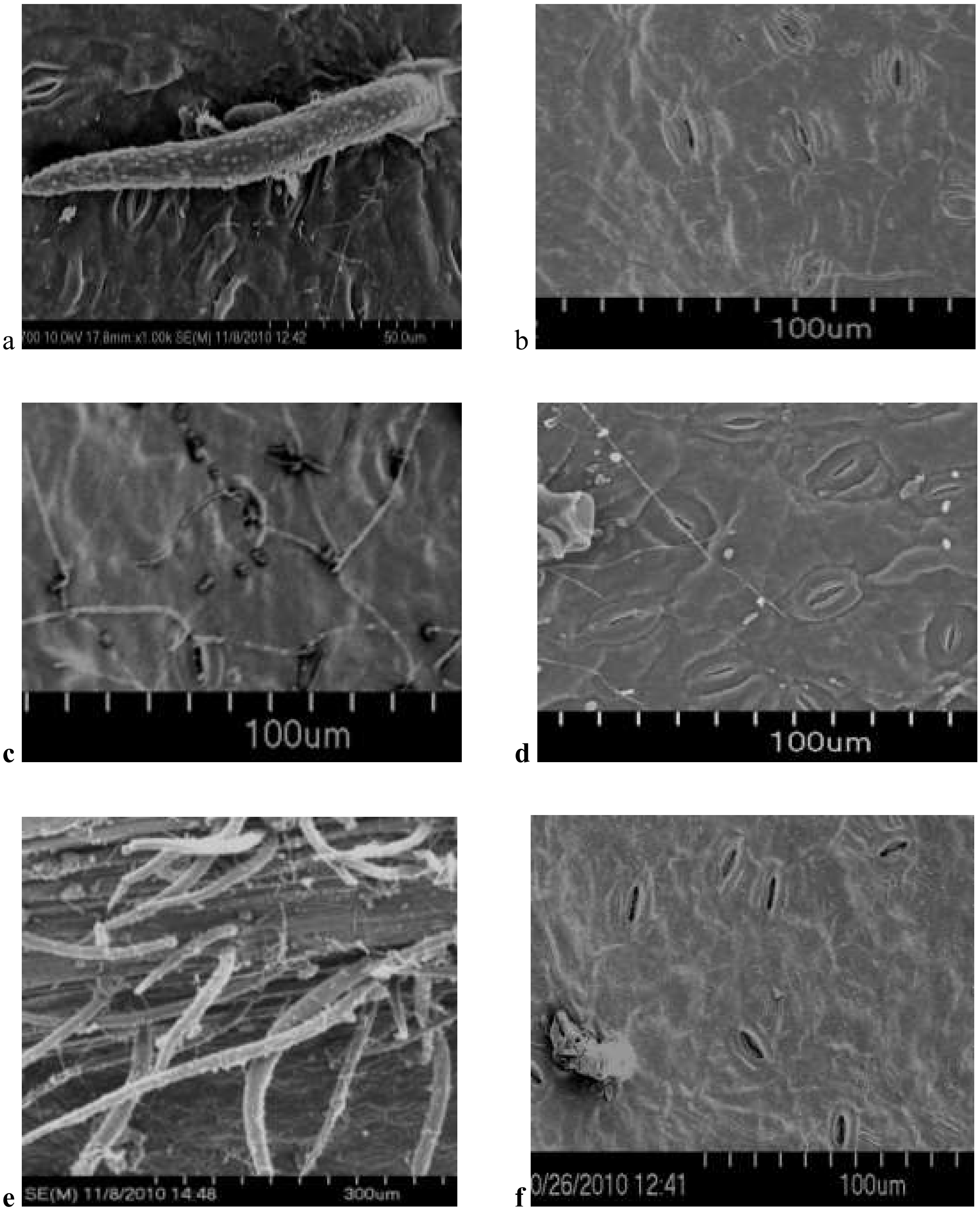


PLATE 4.3.2.1: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of some *Allophylus* Species

PLATE 4.3.2.2: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of some *Allophylus* Species

a- *Allophylus macrobotrys* showing filiform unicellular trichomes covering the stomata*,*
b- *Allophylus niger* showing filiform trichomes adpressed to the epidermal surface
c- *Allophylus schweinfurthii* showing a glandular trichome
d- *Allophylus* sp showing conical superficial trichomes
e- *Allophylus* sp showing stomata
f- *Allophylus spicatus* showing short fliform trichomes

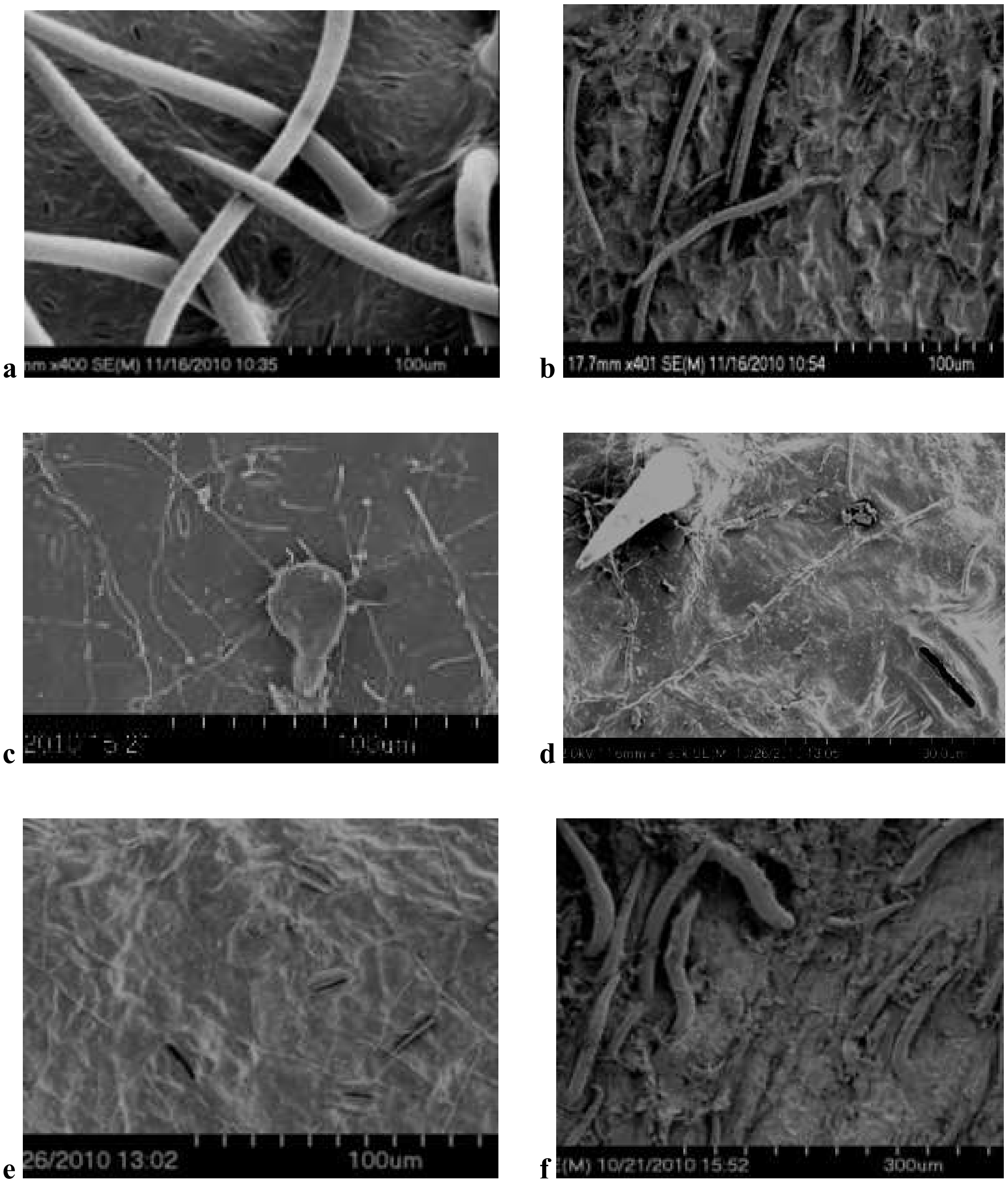


PLATE 4.3.2.2: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of some *Allophylus* Species

PLATE 4.3.2.3: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of some *Allophylus* and *Blighia* Species

a- *Allophylus spicatus* showing glandular trichomes and wax granules*,*

b- *Allophylus talbotii* showing stomata*,*

c- *Allophylus welwitschii* showing stomata*,,*

d- *Blighia sapida* showing wax granules,

e- *Blighia unijugata* showing stomata covered by wax granules

f- *Blighia welwitschii* showing trichomes,

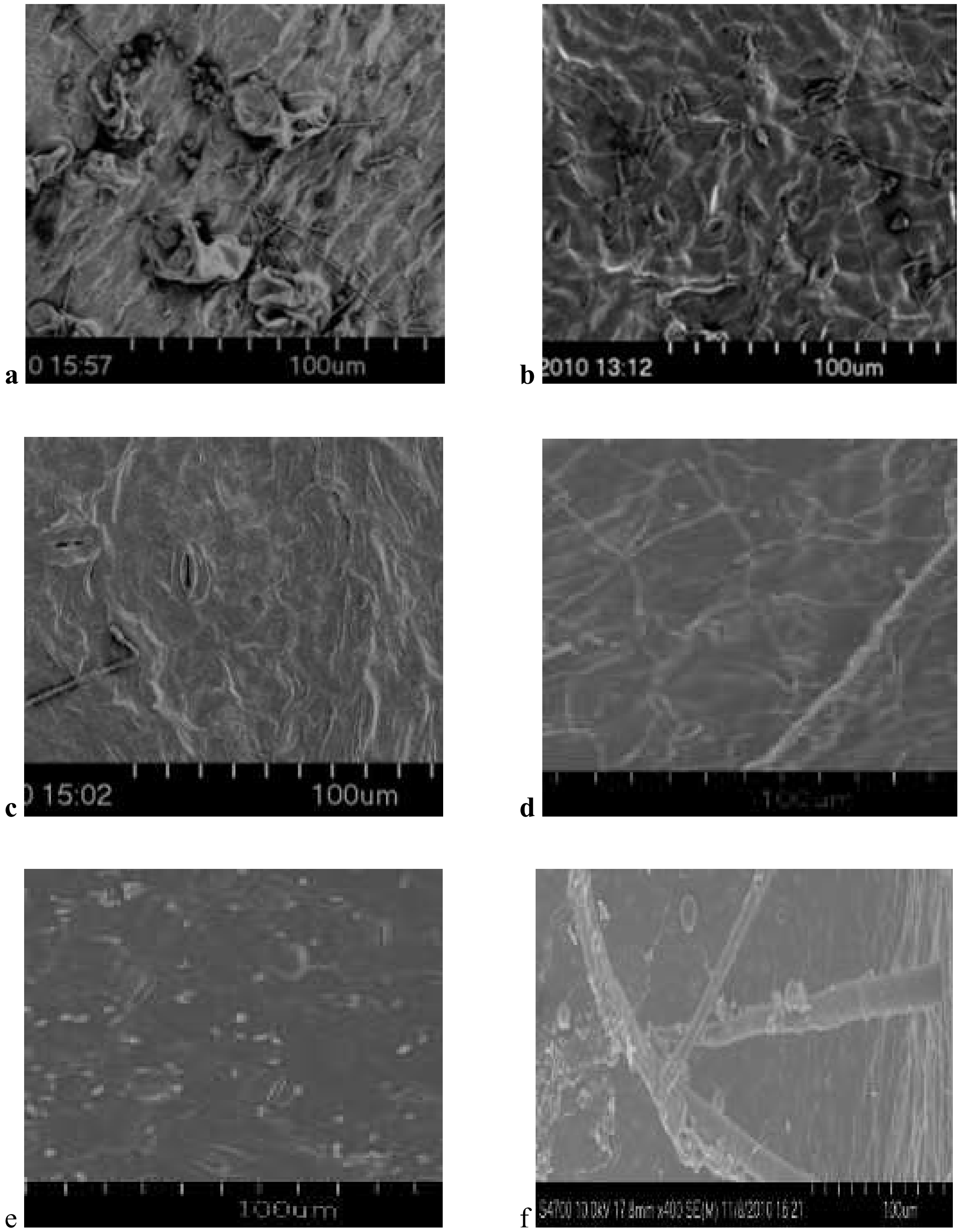


PLATE 4.3.2.3: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of some *Allophylus* and *Blighia* Species

PLATE 4.3.2.4: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of *Cardiospermum* and *Chytranthus* Species

a-c *Cardiospermum grandiflorum* showing:

a- Superficial stomata of conical shape

b- Stomata with striations on the cell surface

c- Filiform trichomes

d- *Chytranthus angustifolius* showing acicular trichomes adpressed to the cell surface

e- *Chytranthus macrobotrys* showing raised stomata*,*

f- *Chytranthus talbotii* showing raised stomata

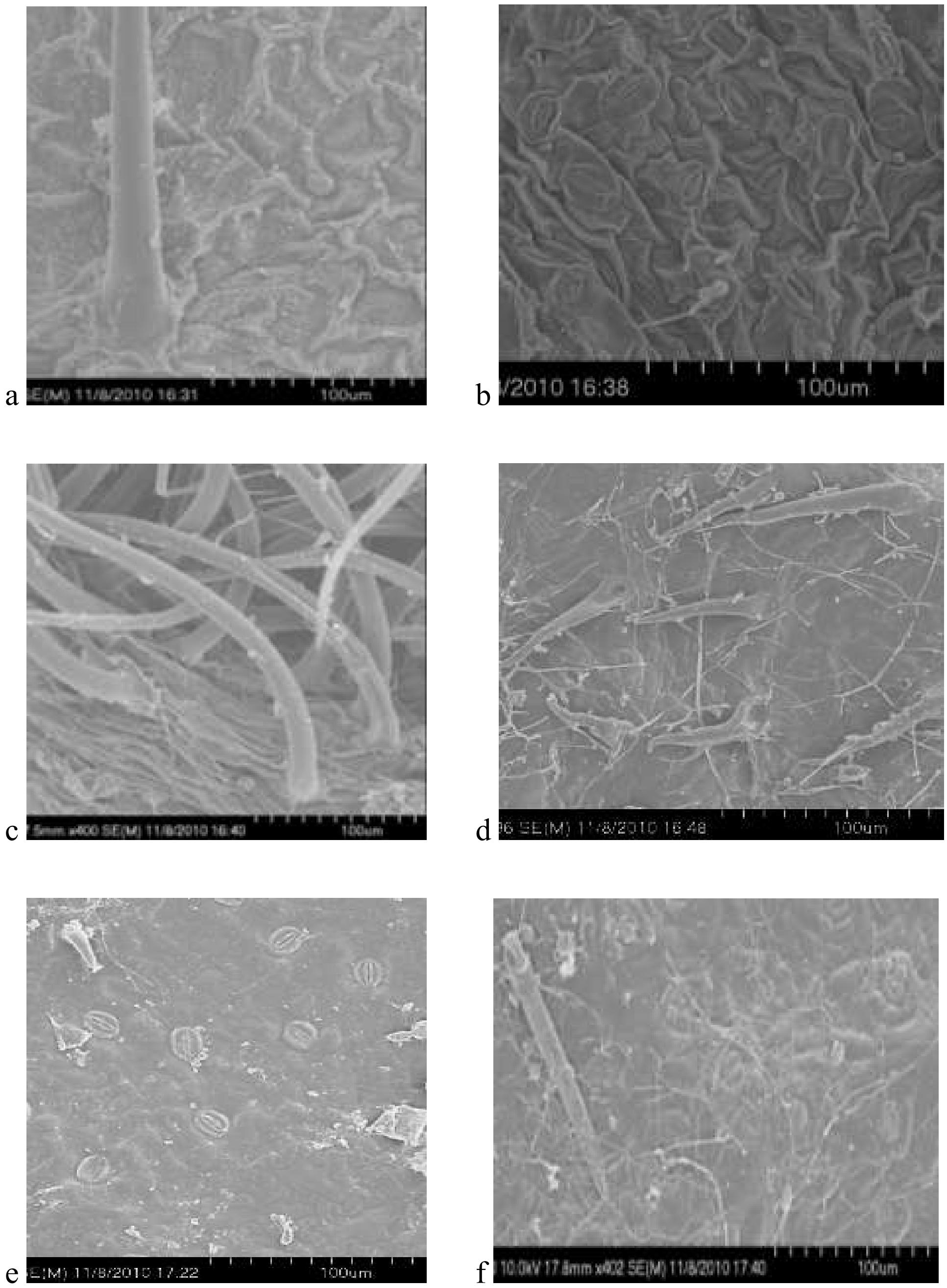


PLATE 4.3.2.4: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of *Cardiospermum* and *Chytranthus* Species

PLATE 4.3.2.5: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of *Chytranthus* and *Deinbollia* species

a- *Chytranthus* sp1,
b- *Chytranthus* sp2 showing superficial trichome,
c- *Deinbollia grandifolia,*
d- *Deinbollia maxima* showing wax deposits,
e- *Deinbollia pinnata* showing acicular trichome
f- *Deinbollia pinnata* showing stomata

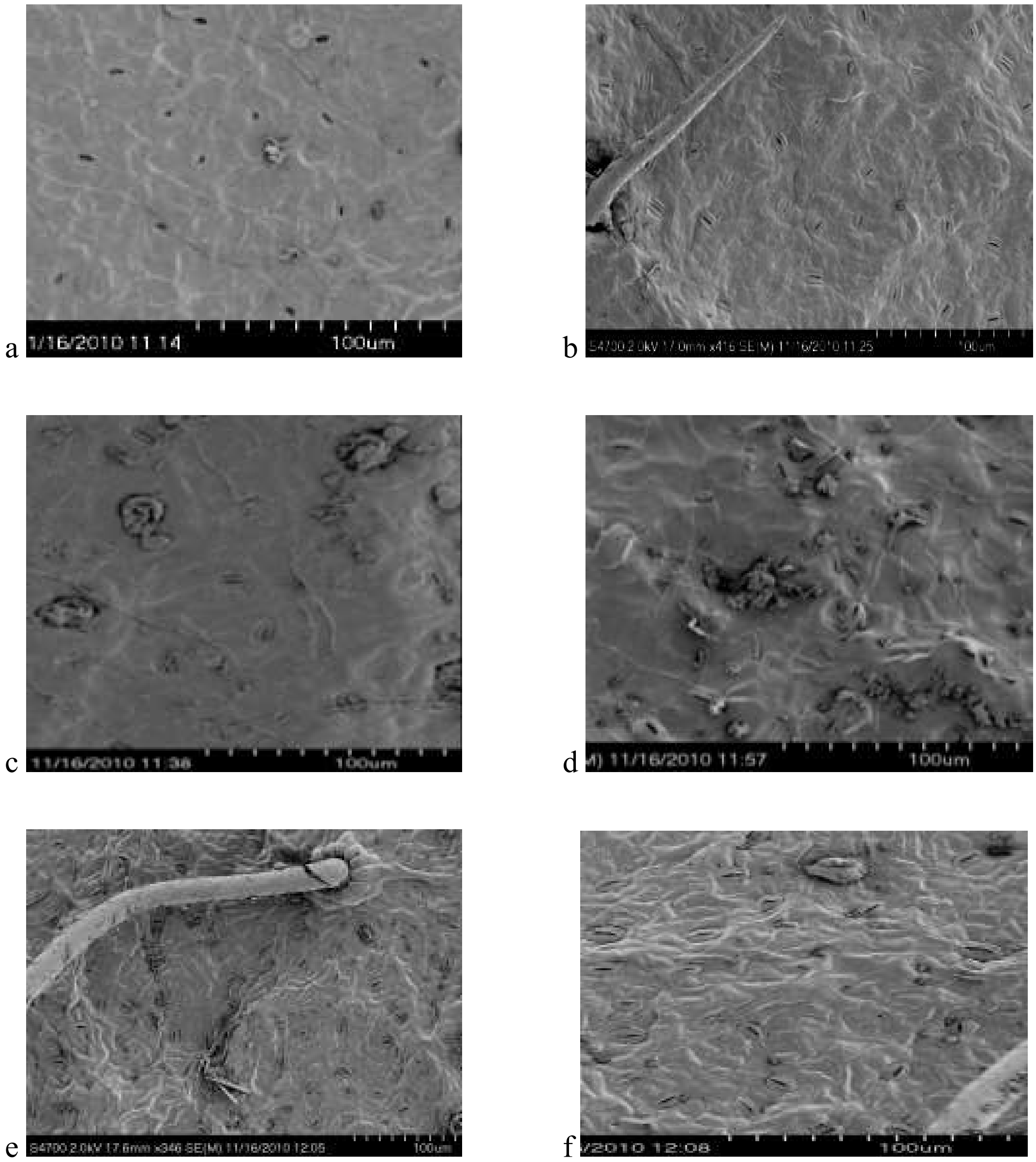
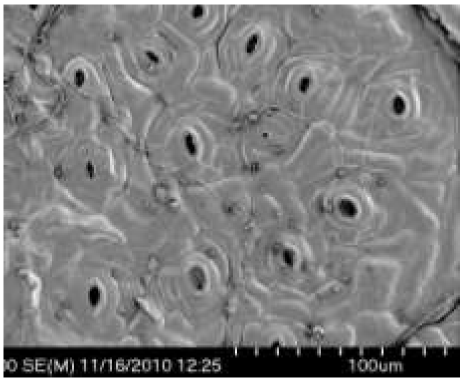
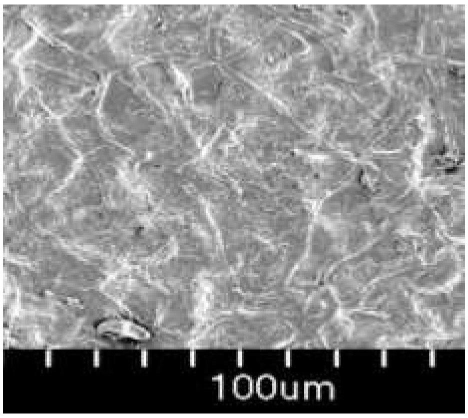


PLATE 4.3.2.5: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of *Chytranthus* and *Deinbollia* species

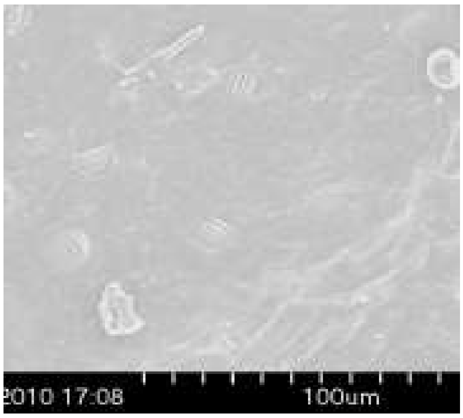
a



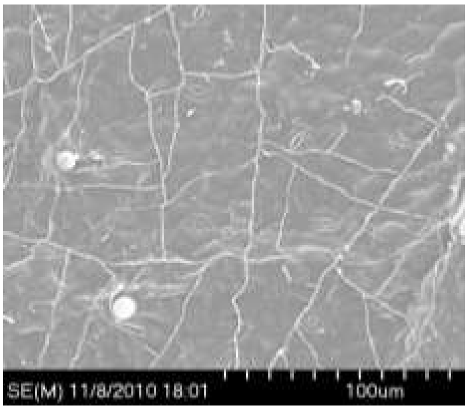
b



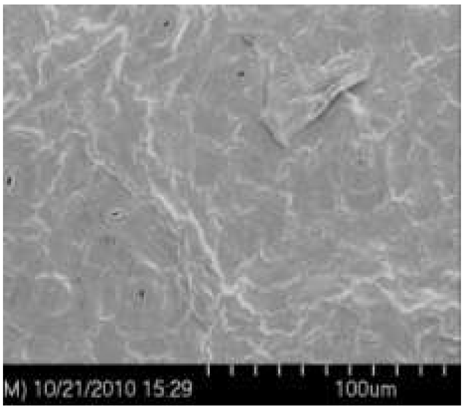
c



d



e



f

PLATE 4.3.2.6: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces Showing Stomata

a- *Deinbollia pycnophylla,* b- *Dodonaea viscosa,* c- *Eriocoelum macrocarpum,* d- *Eriocoelum oblongum,* e- *Glenniea africanus,* f- *Laccodiscus ferrugineus*

PLATE 4.3.2.7: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces Showing members of Sapindoideae

a- *Laccodiscus* sp showing stomata covered by epicuticular wax granules,

b- *Lecaniodiscus cupanioides* showing stomata

c- *Lecaniodiscus cupanioides* showing trichome on the mid rib

d- *Lepisanthes senegalensis* showing raised stomata

e- *Litchi chinensis* showing papillae covering the epidermal surface,

f- *Majidea fosterii* showing stomata

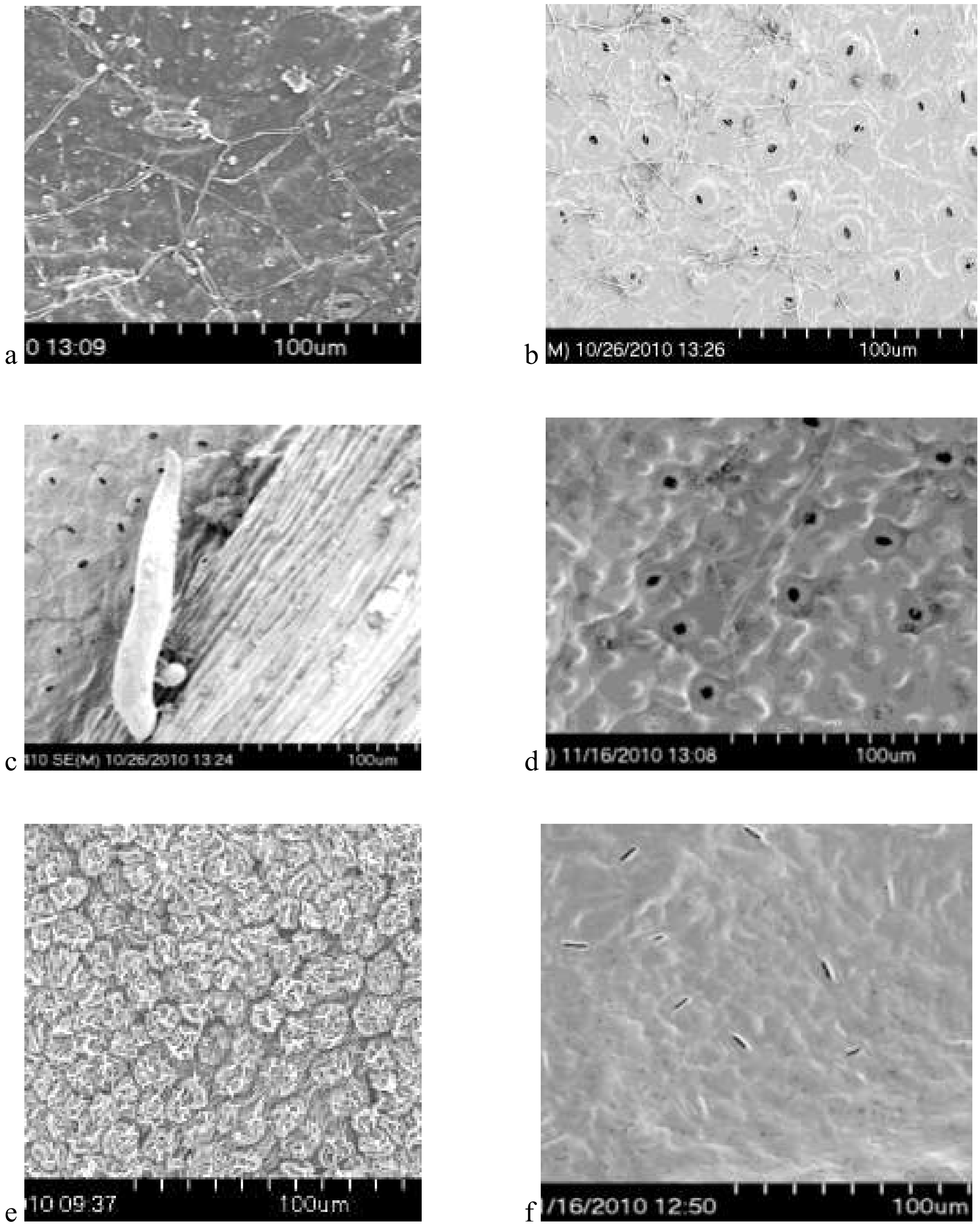


PLATE 4.3.2.7: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces Showing members of Sapindoideae

PLATE 4.3.2.8: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of *Pancovia, Paullinia* Species showing stomata

a- *Pancovia atroviolaceus,*

b- *Pancovia turbinata,*

c- *Pancovia* sp1,

d- *Pancovia* sp2,

e- *Pancovia* sp3 showing acicular trichome,

f- *Paullinia pinnata*

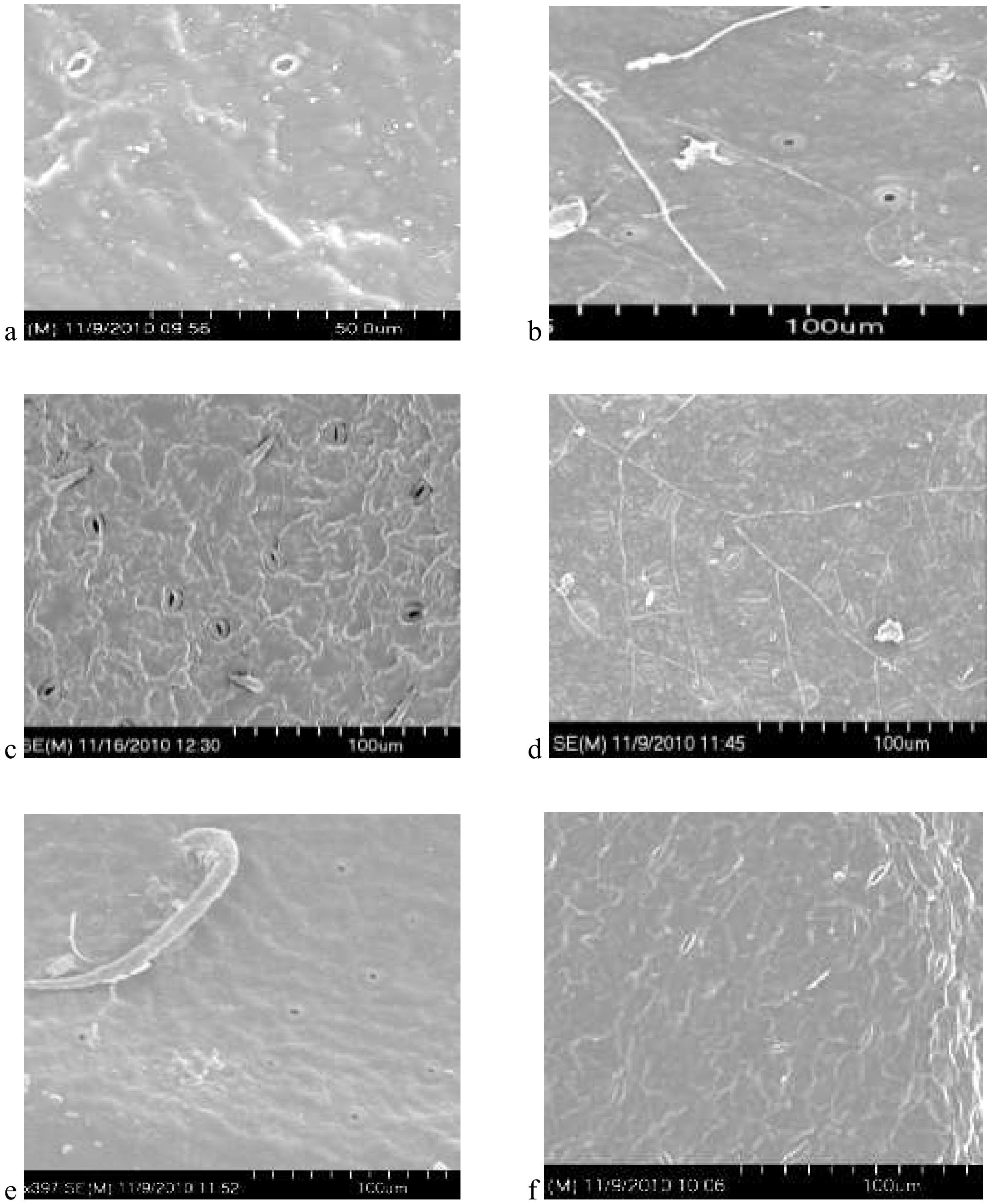


PLATE 4.3.2.8: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of *Pancovia, Paullinia* Species

PLATE 4.3.2.9: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of *Placodiscus* and *Radlkofera* Species with stomata

a- *Placodiscus leptostachys,*
b- *Placodiscus* sp1,
c- *Placodiscus* sp2,
d- *Radlkofera calodendron,*
e- *Radlkofera* sp1,
f- *Radlkofera* sp2 showing superficial trichome of conical shape and some secretory cells

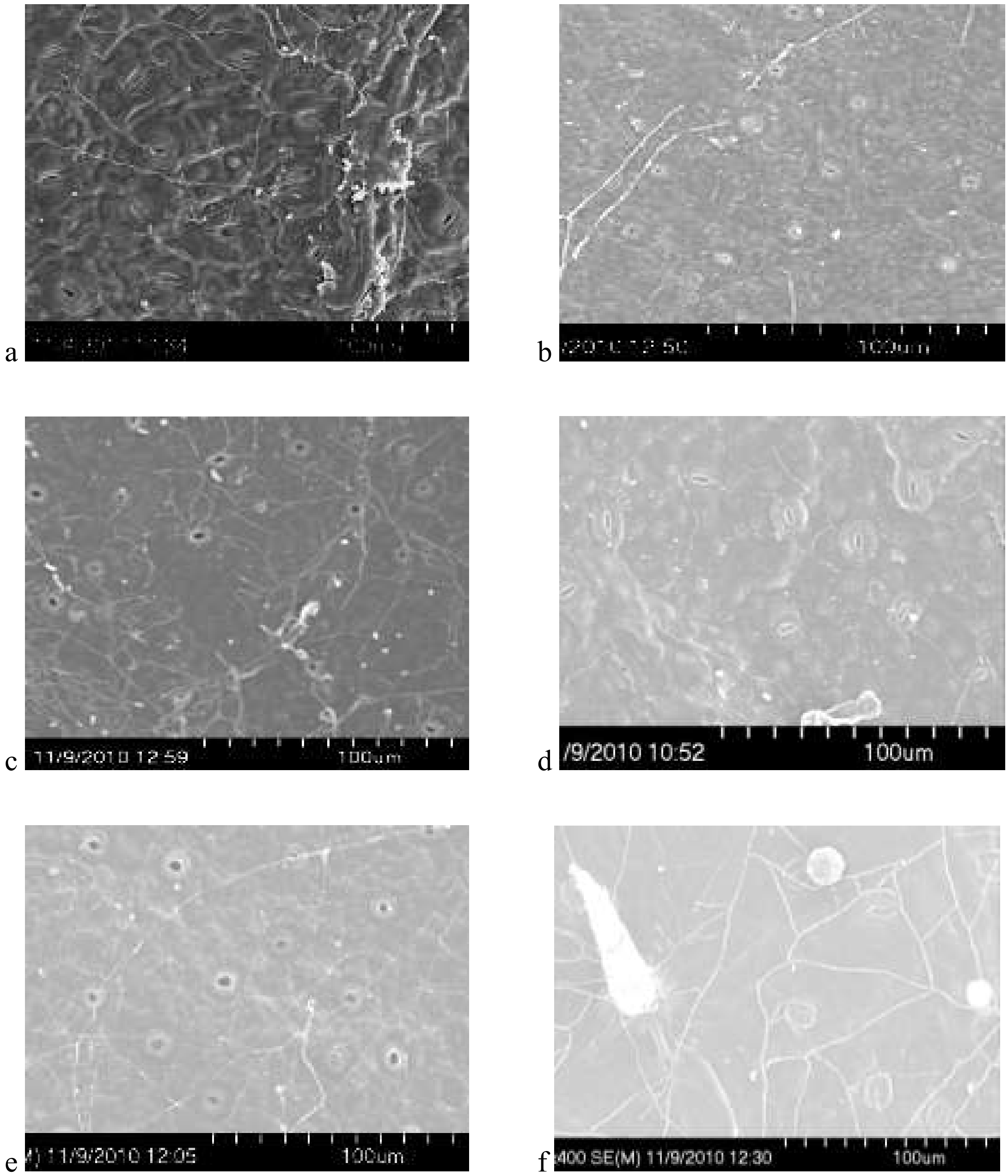


PLATE 4.3.2.9: Scanning Electron Micrographs Showing Abaxial Epidermal Surfaces of *Placodiscus* and *Radlkofera* Species

PLATE 4.3.2.10: Scanning Electron Micrographs Showing Abaxial and Adaxial Epidermal Surfaces of some Sapindaceae with stomata and wax deposits respectively.

a- *Radlkofera* sp3,

b- *Sapindus saponaria,*

c- *Zanha golugensis,*

d- *Allophylus africanus*,

e- *Allophylus bullatus,*

f- *Allophylus grandifolius*

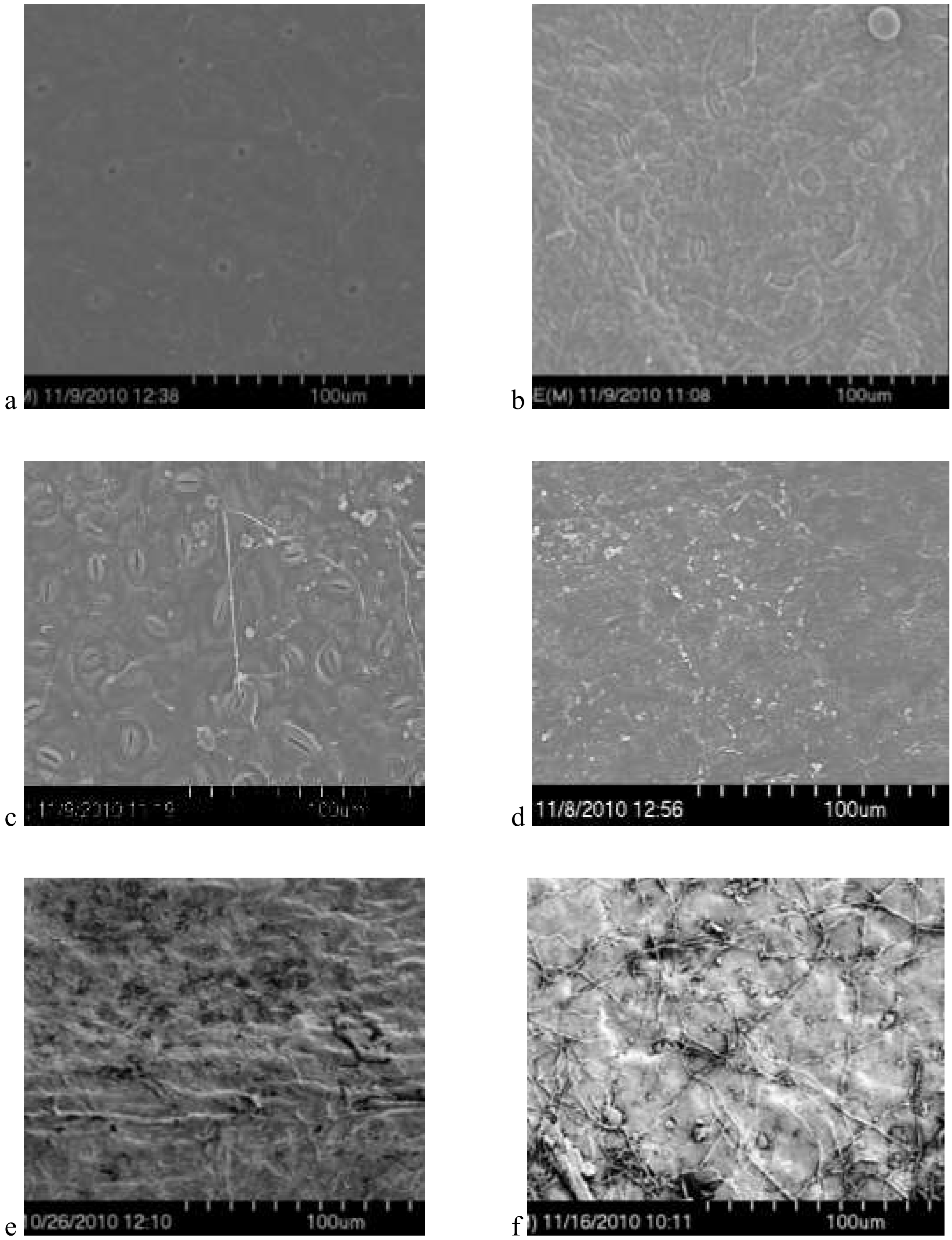


PLATE 4.3.2.10: Scanning Electron Micrographs Showing Abaxial and Adaxial Epidermal Surfaces of some Sapindaceae

PLATE 4.3.2.11: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of *Allophylus* Species

a- *Allophylus griseotomentosus,*

b- *Allophylus hirtellus,*

c- *Allophylus niger,*

d- *Allophylus schweinfurthii,*

e- *Allophylus* sp,

f- *Allophylus spicatus* showing conical trichome

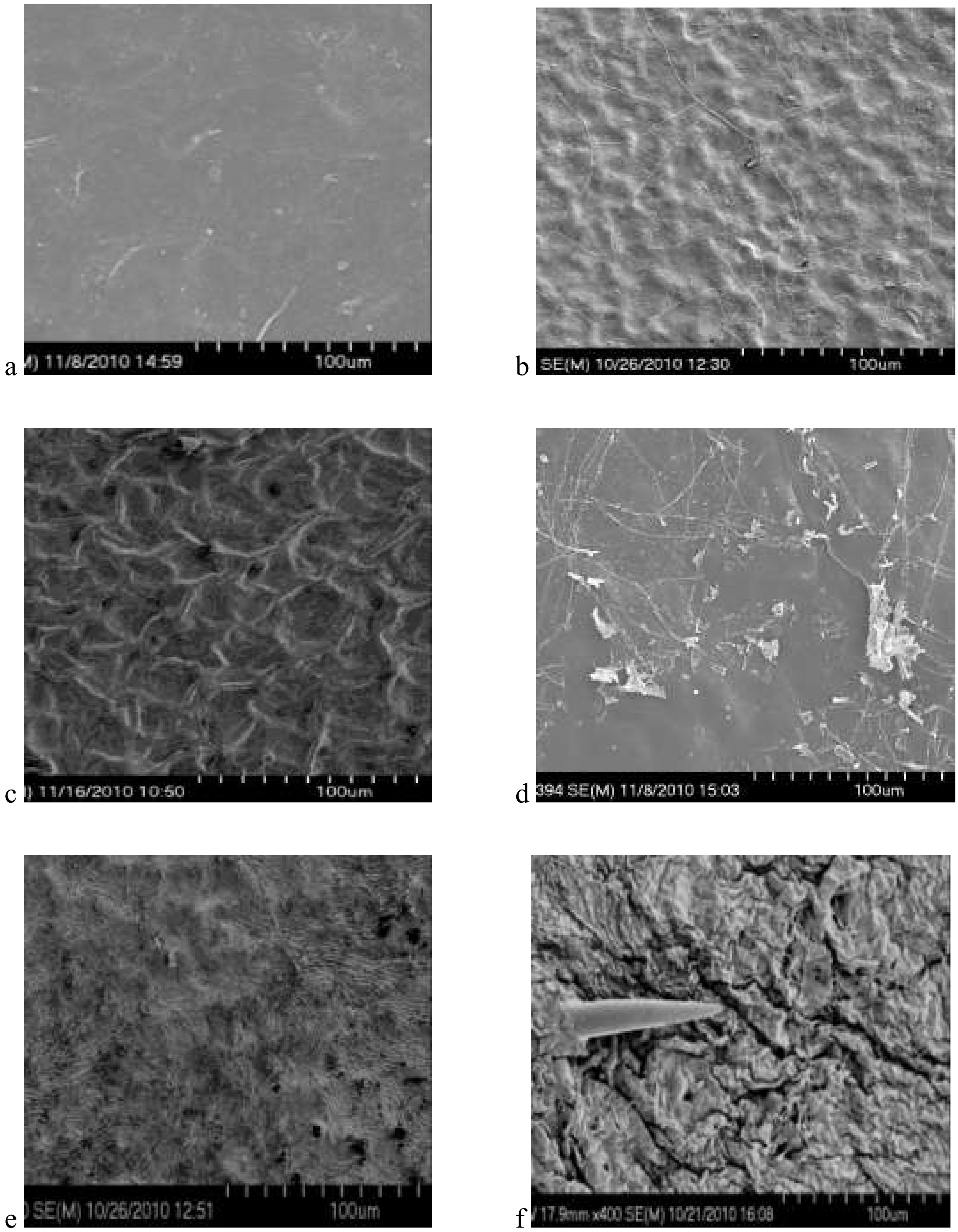


PLATE 4.3.2.11: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of *Allophylus* Species

PLATE 4.3.2.12: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of *Allophylus, Blighia* and *Cardiospermum* Species

a- *Allophylus talbotii,*

b- *Allophylus welwitschii* showing filiform trichome,

c- *Blighia sapida,*

d- *Blighia unijugata,*

e- *Blighia welwitschii* showing wax deposits*,*

f- *Cardiospermum grandiflorum* covered by papillae

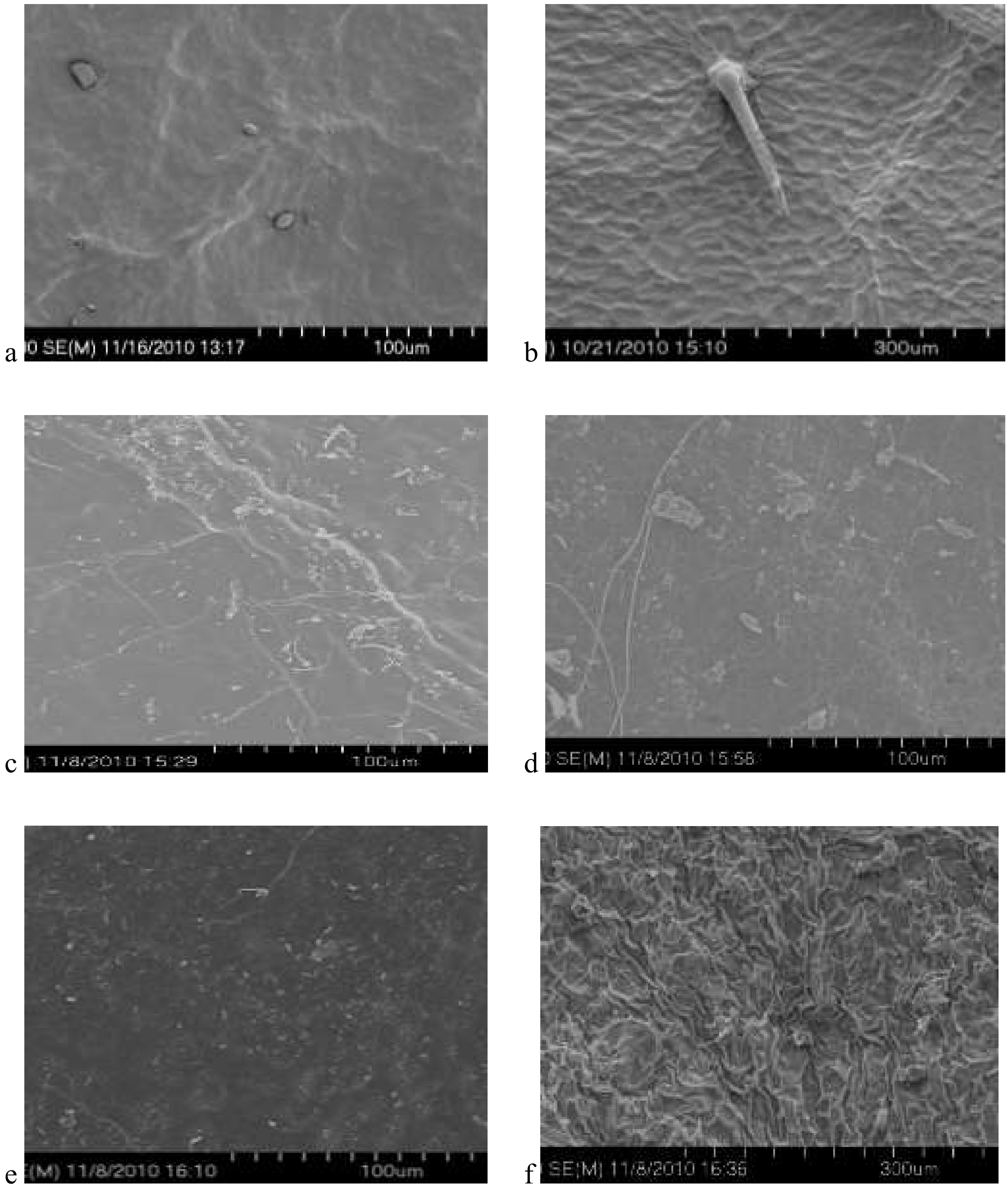


PLATE 4.3.2.12: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of *Allophylus, Blighia* and *Cardiospermum* Species

PLATE 4.3.2.13: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of *Chytranthus* and *Deinbollia* species

a- *Chytranthus angustifolius* showing secretory cells,

b- *Chytranthus macrobotrys,*

c- *Chytranthus talbotii* showing wax deposits*,*

d- *Chytranthus sp1,*

e- *Chytranthus sp2*,

f- *Deinbollia grandifolia* showing wax granules*,*

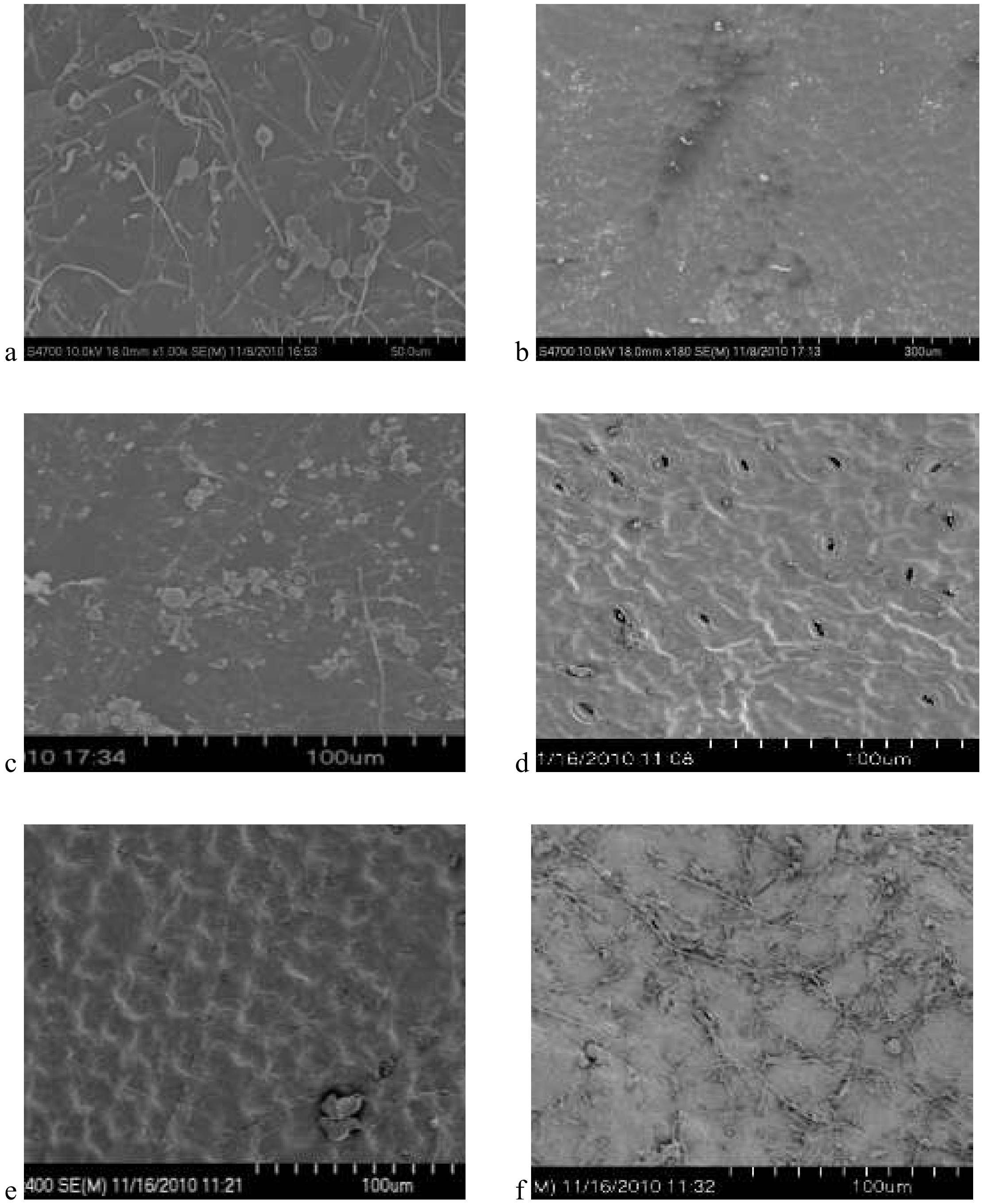


PLATE 4.3.2.13: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of *Chytranthus* and *Deinbollia* species

PLATE 4.3.2.14: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of members of tribe Sapindeae

a- *Deinbollia maxima,*

b- *Deinbollia pinnata,*

c- *Deinbollia pycnophylla* showing striations*,*

d- *Dodonaea viscosa* showing stomata

e- *Eriocoelum macrocarpum,*

f- *Eriocoelum oblongum*

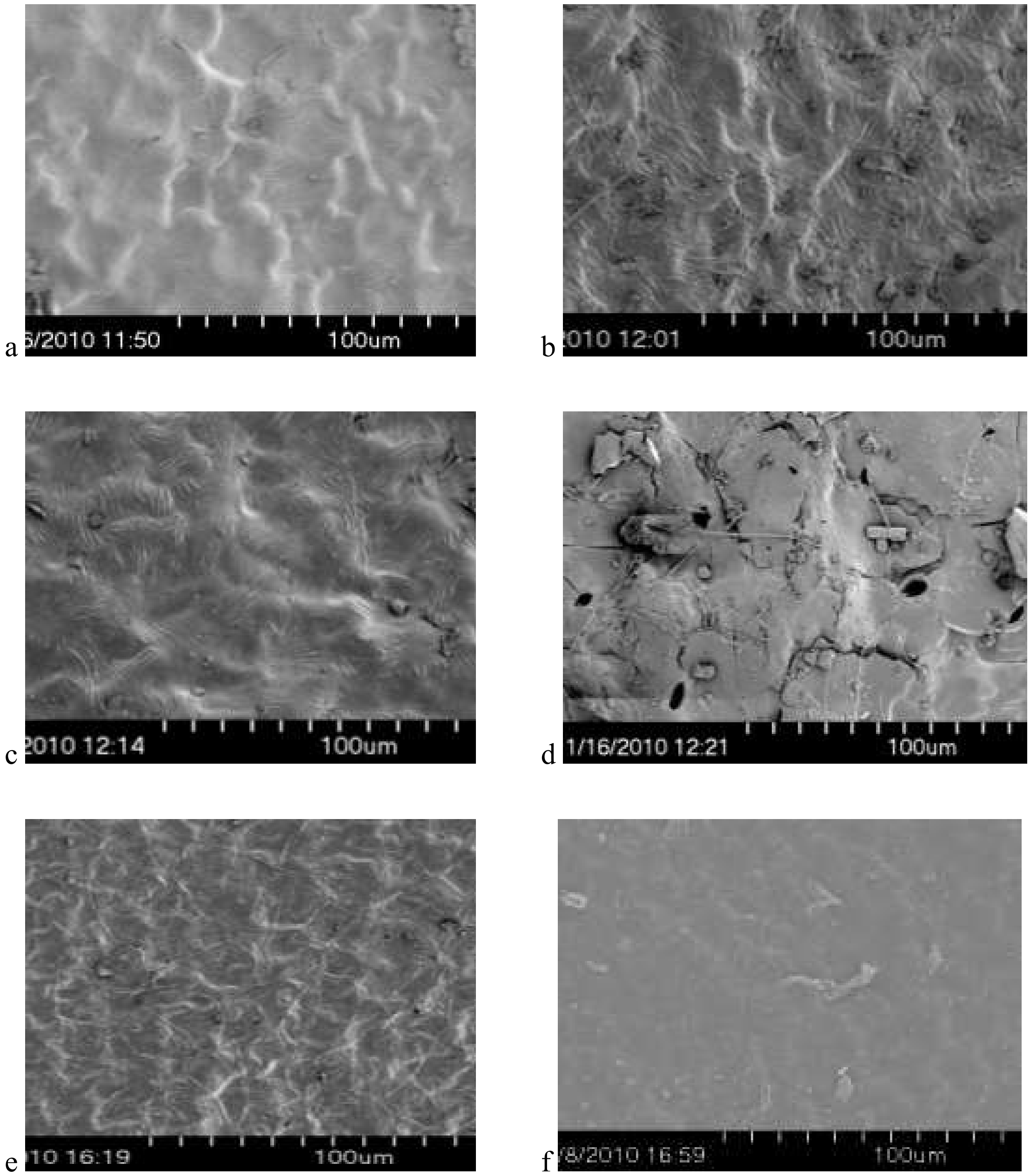


PLATE 4.3.2.14: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of members of tribe Sapindeae

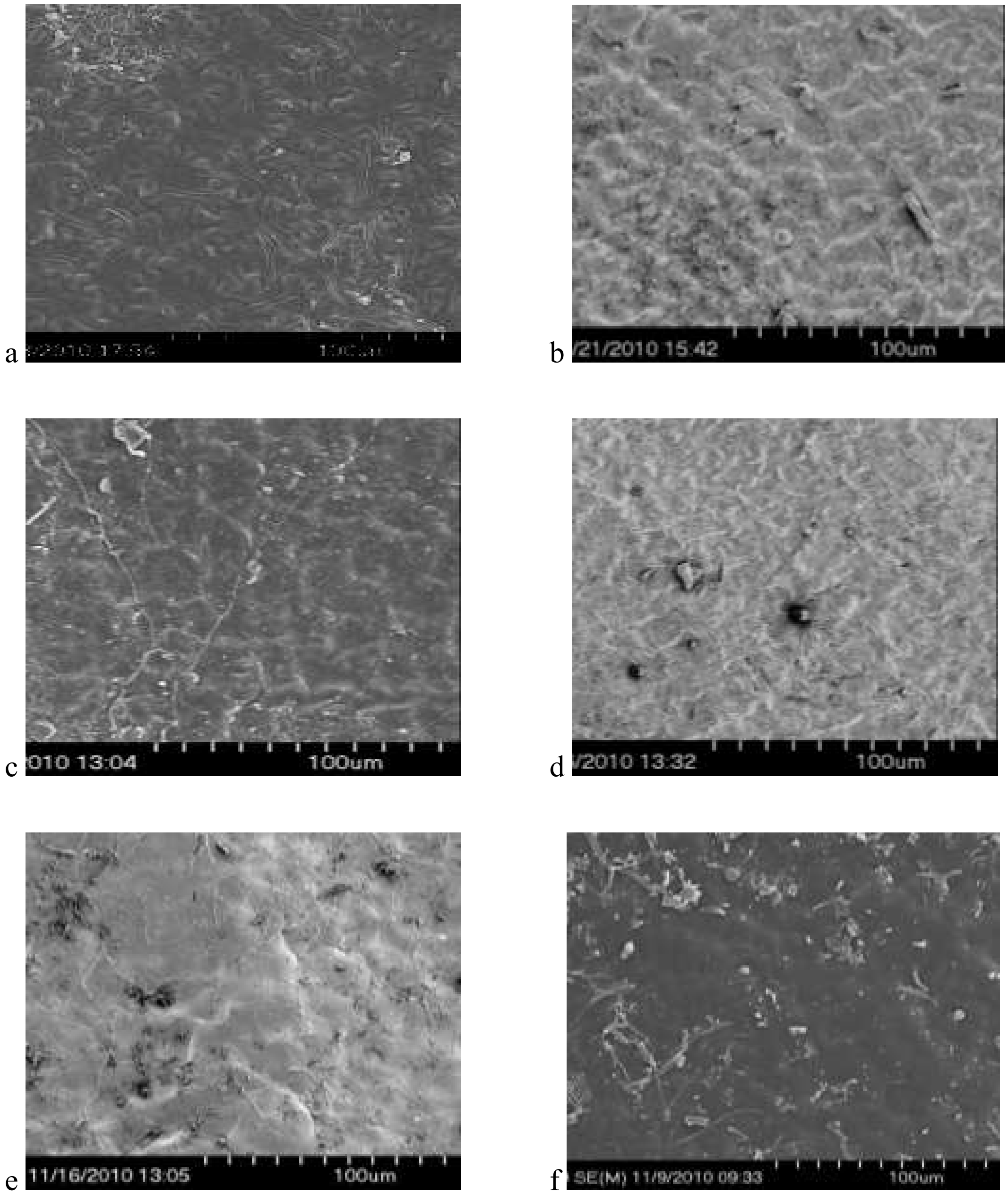


PLATE 4.3.2.15: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of some members of Sapindaceae

a- *Glenniea africanus,* b- *Laccodiscus ferrugineus,* c- *Laccodiscus* sp, d- *Lecaniodiscus cupanioides, e- Lepisanthes senegalensis*, f- *Litchi chinensis*

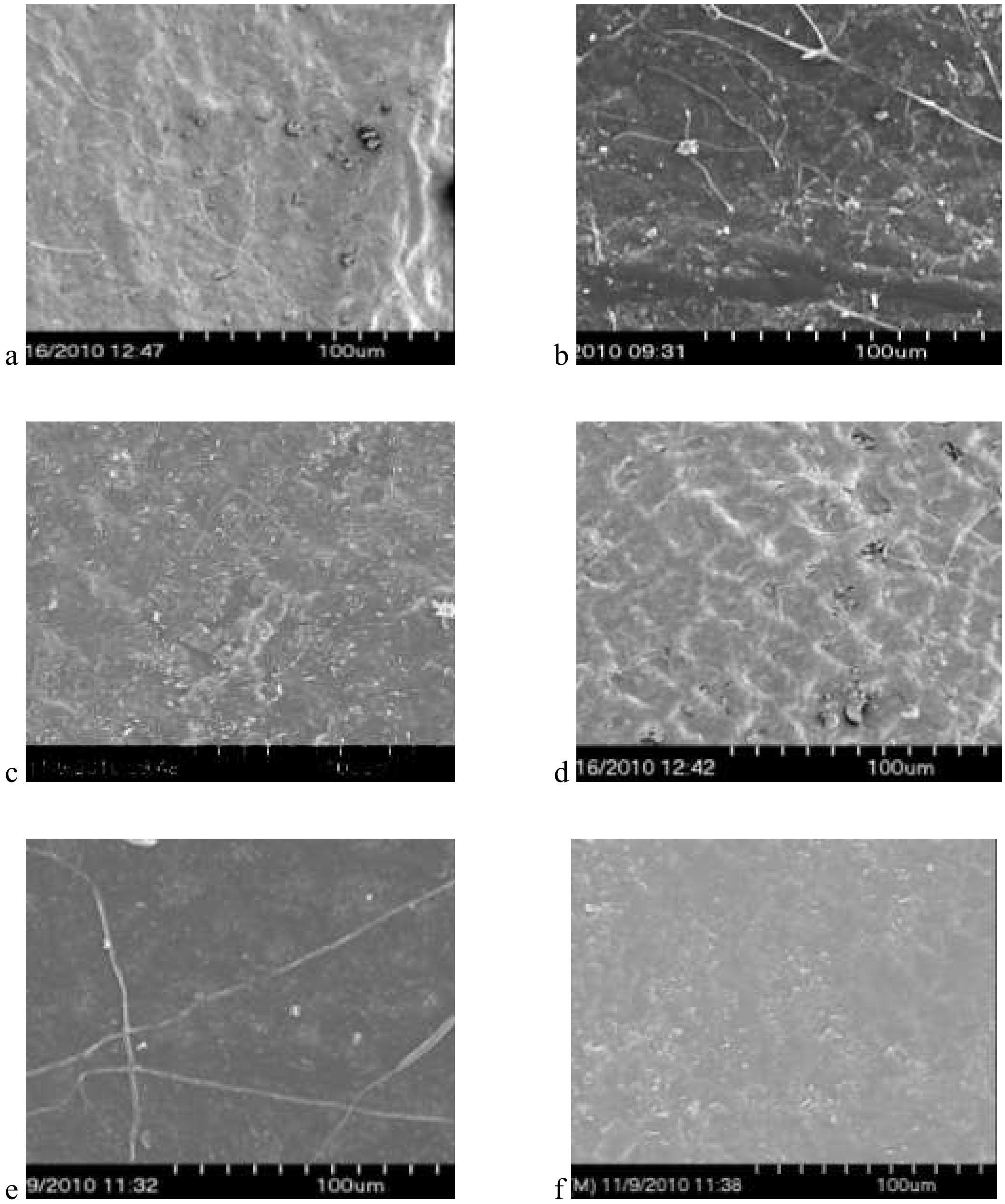


PLATE 4.3.2.16: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of *Majidea* and *Pancovia* species

a-b *Majidea fosterii,* c- *Pancovia atroviolaceus,* d- *Pancovia turbinata,* e- *Pancovia* sp1, f- *Pancovia* sp2

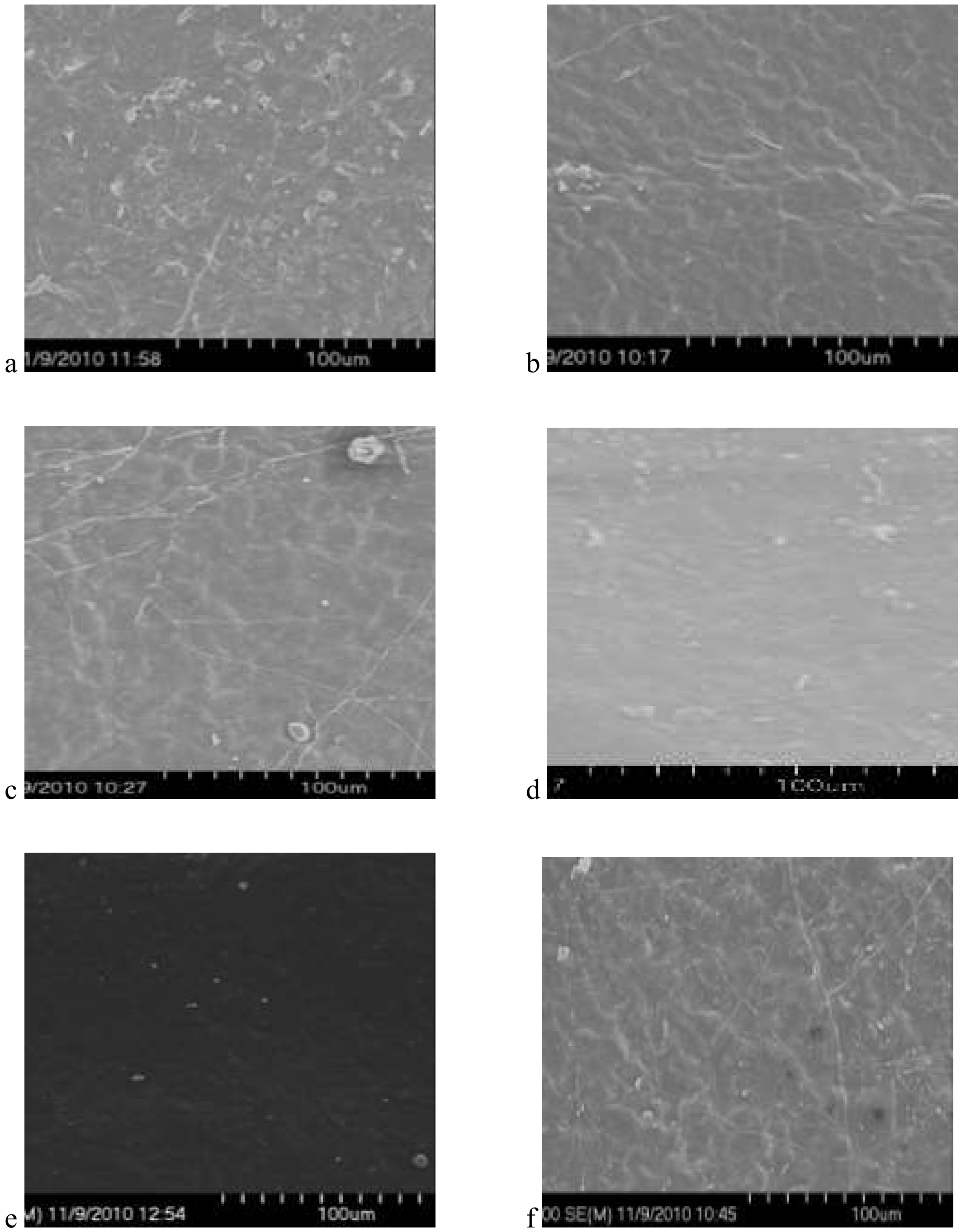


PLATE 4.3.2.17: Scanning Electron Micrographs Showing Adaxial Epidermal Surfaces of *Pancovia, Placodiscus* and *Radlkofera* Species

a- *Pancovia* sp3, b- *Paullinia pinnata,* c- *Placodiscus leptostachys,* d- *Placodiscus* sp1, e- *Placodiscus* sp2, f- *Radlkofera calodendron*

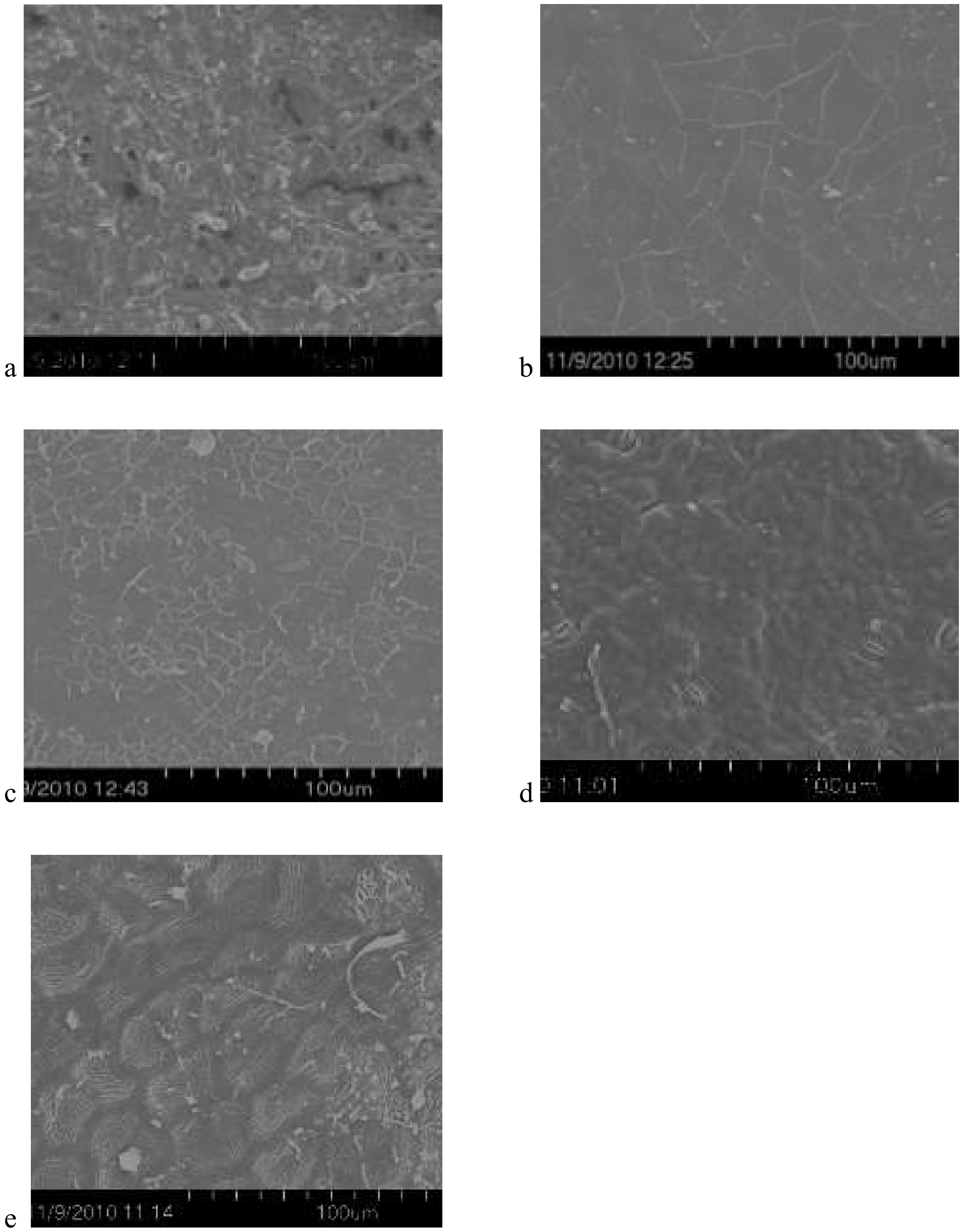


PLATE 4.3.2.18: Scanning Electron Micrographs showing Adaxial Epidermal Surfaces of *Radlkofera, Sapindus* and *Zanha* Species

a- *Radlkofera* sp1, b- *Radlkofera* sp2, c- *Radlkofera* sp3, d- *Sapindus saponaria,* e- *Zanha golugensis*

4.4 MOLECULAR CHARACTERIZATION

Deoxyribonucleic acid (DNA) samples were extracted from all the samples collected and deposited in the DNA bank at the Royal Botanic Gardens Kew, London. A list of the samples and their DNA Bank number are shown in Appendix 4.

The quality of extracted DNA samples was determined using Agarose gel electrophoresis and this revealed both DNA of high and low molecular weights. The electrophorogram of the DNA samples is shown in Plate 4.4.1.

The DNA samples were also quantified using spectrometry and the result in represented in appendix 9. This revealed that the concentration of the DNA samples ranges from 20 – 2261 ng/µl. Also, purity of the DNA samples were measured at 260 nm (Figure 4.4.1) and 280 nm (Figure 4.4.2) and the absorbance ratio ($A_{260/280}$) ranges from 0.87 – 2.01 (Figure 4.4.3). The low absorbance ratio values can be attributed to highly degraded quality of some of the extracted DNA samples.

Agarose gel electrophoresis of the PCR products using different primers revealed DNA with distinct bands (Plate 4.4.2 – 4.4.5).

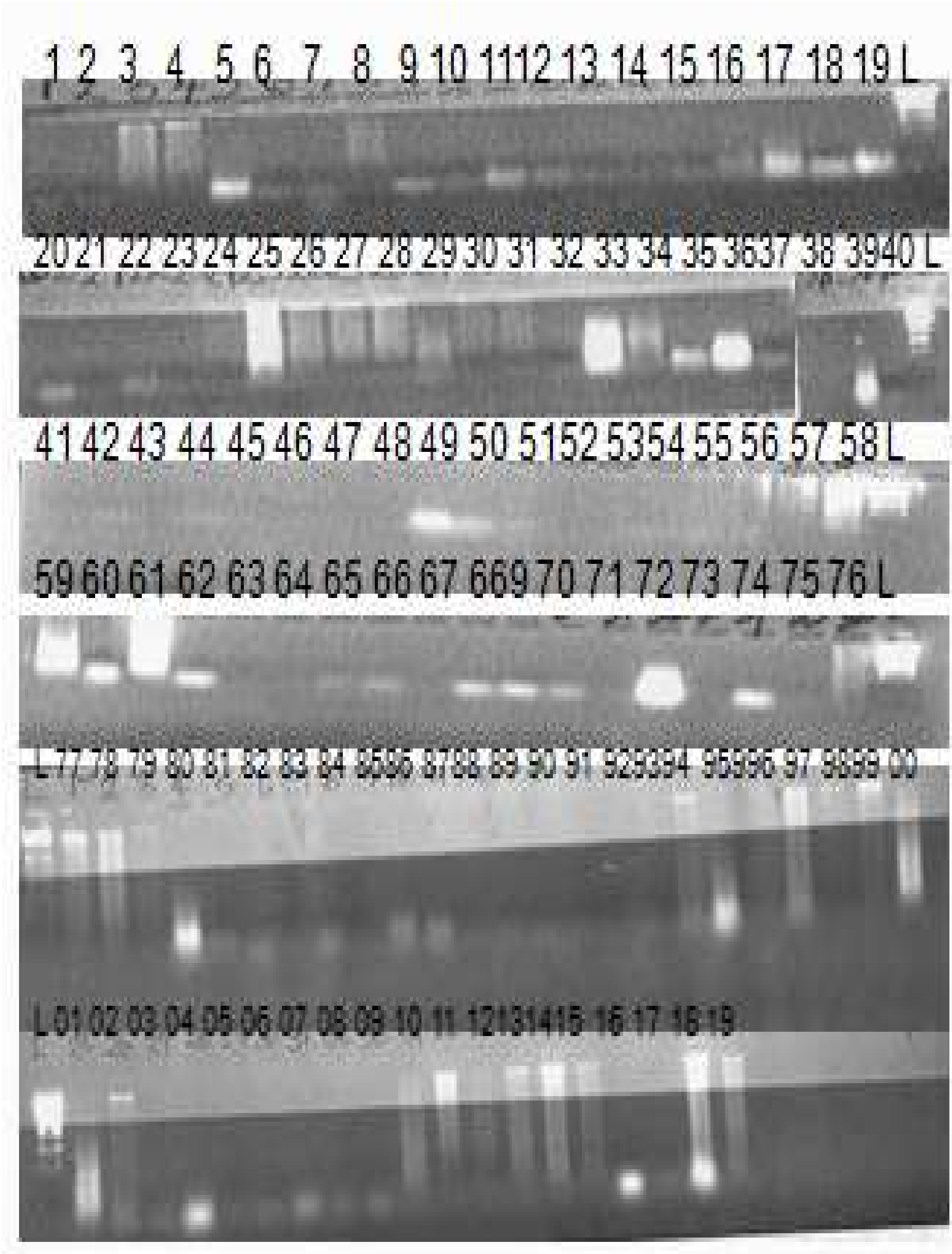


Plate 4.4.1: Electrophorogram of extracted DNA samples

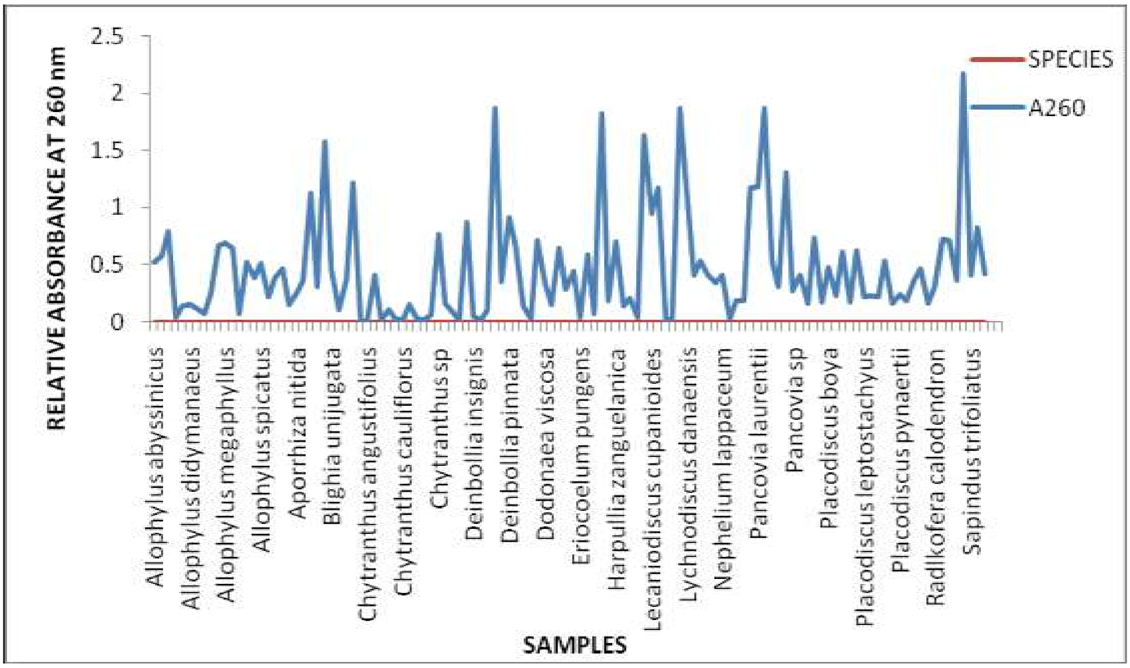


Figure 4.4.1: Relative Absorbance of DNA Samples of Members of Family Sapindaceae at 260 nm

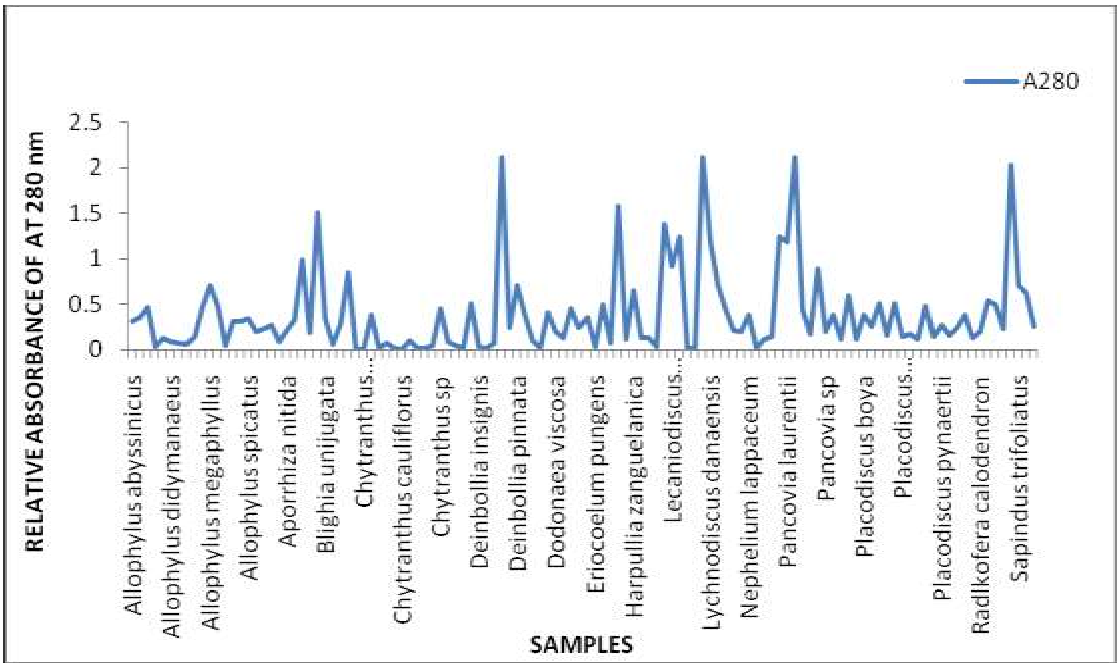


Figure 4.4.2: Relative Absorbance of DNA Samples of Members of Family Sapindaceae at 280 nm

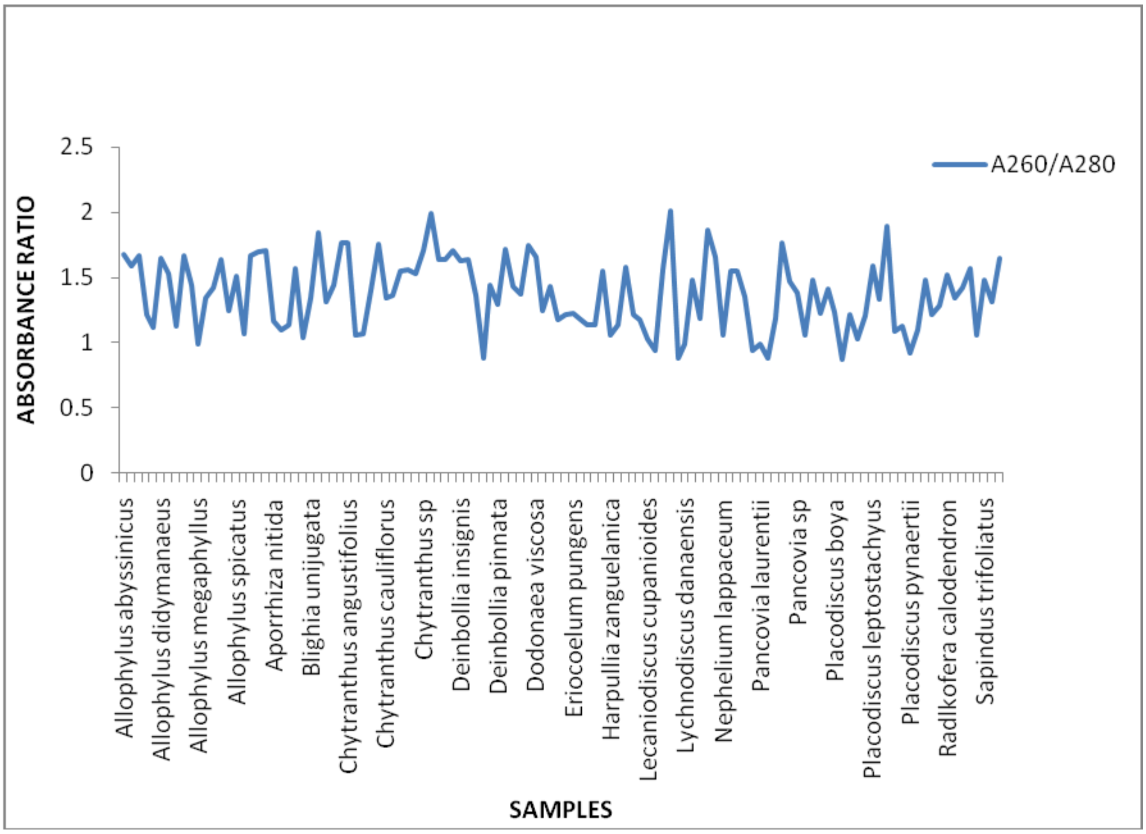


Figure 4.4.3: Relative Absorbance Ratio of DNA Samples

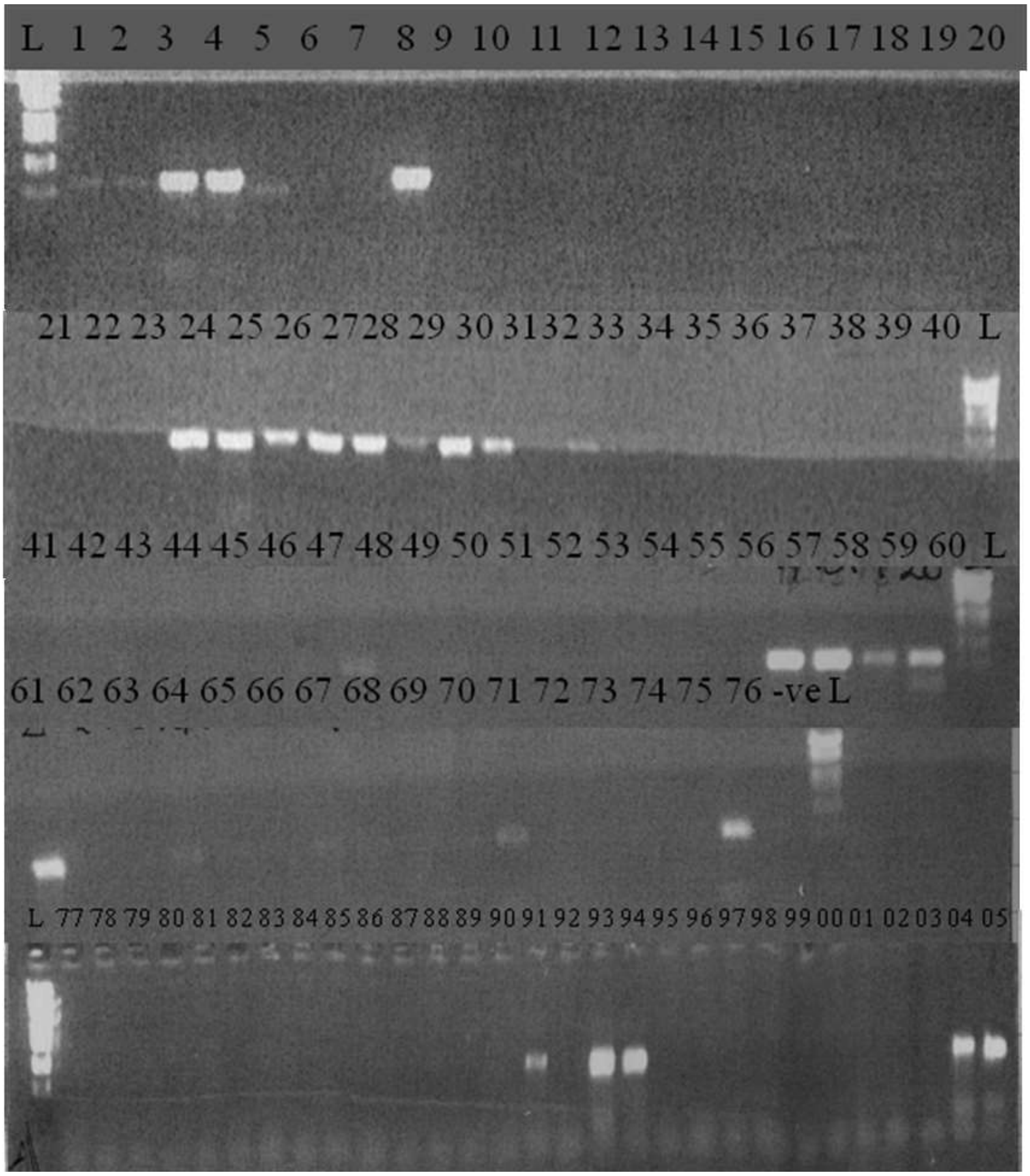


PLATE 4.4.2: Electrophorogram of trnC - trnD amplification

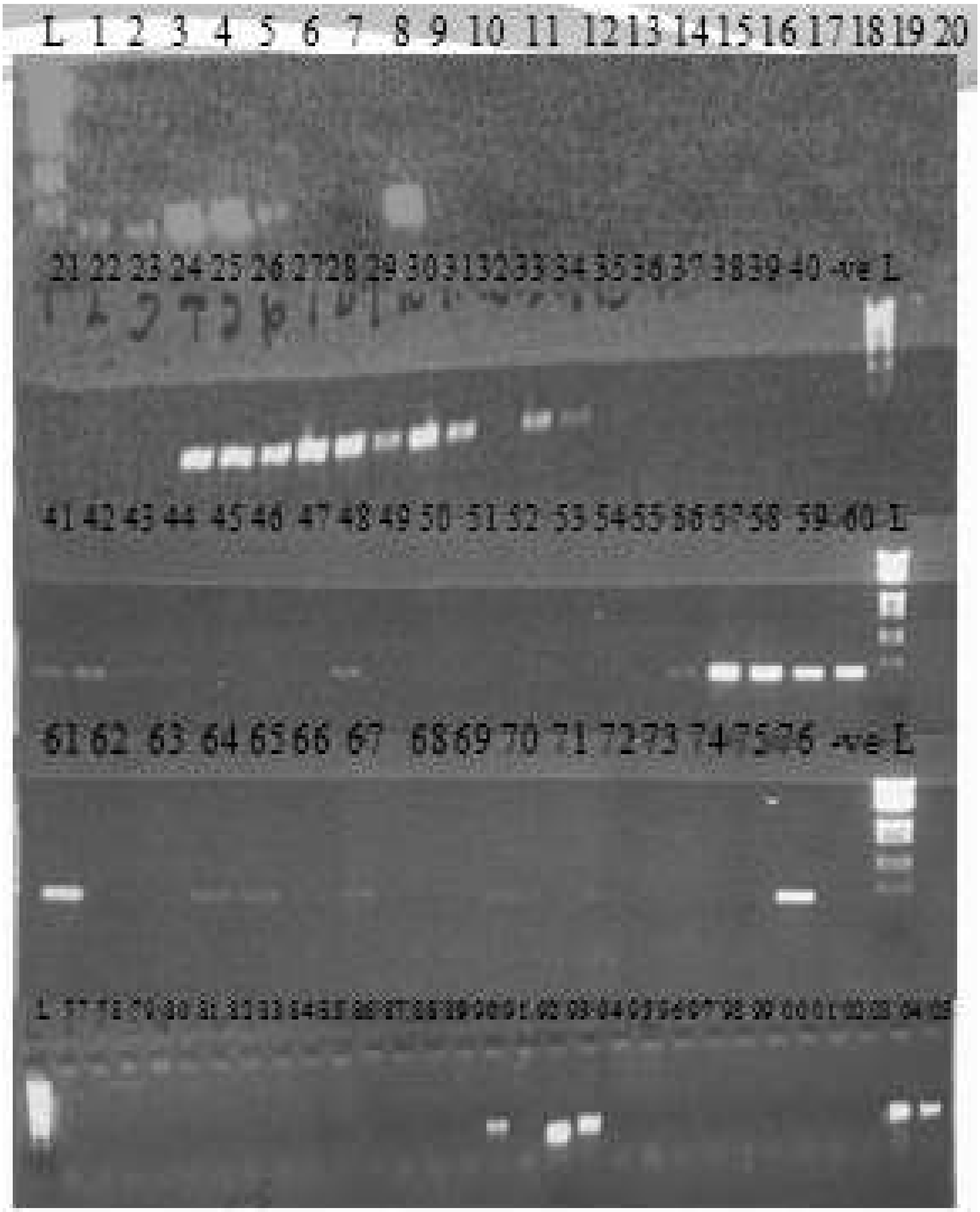


PLATE 4.4 .3: Electrophorogram of trnE - trnF amplification

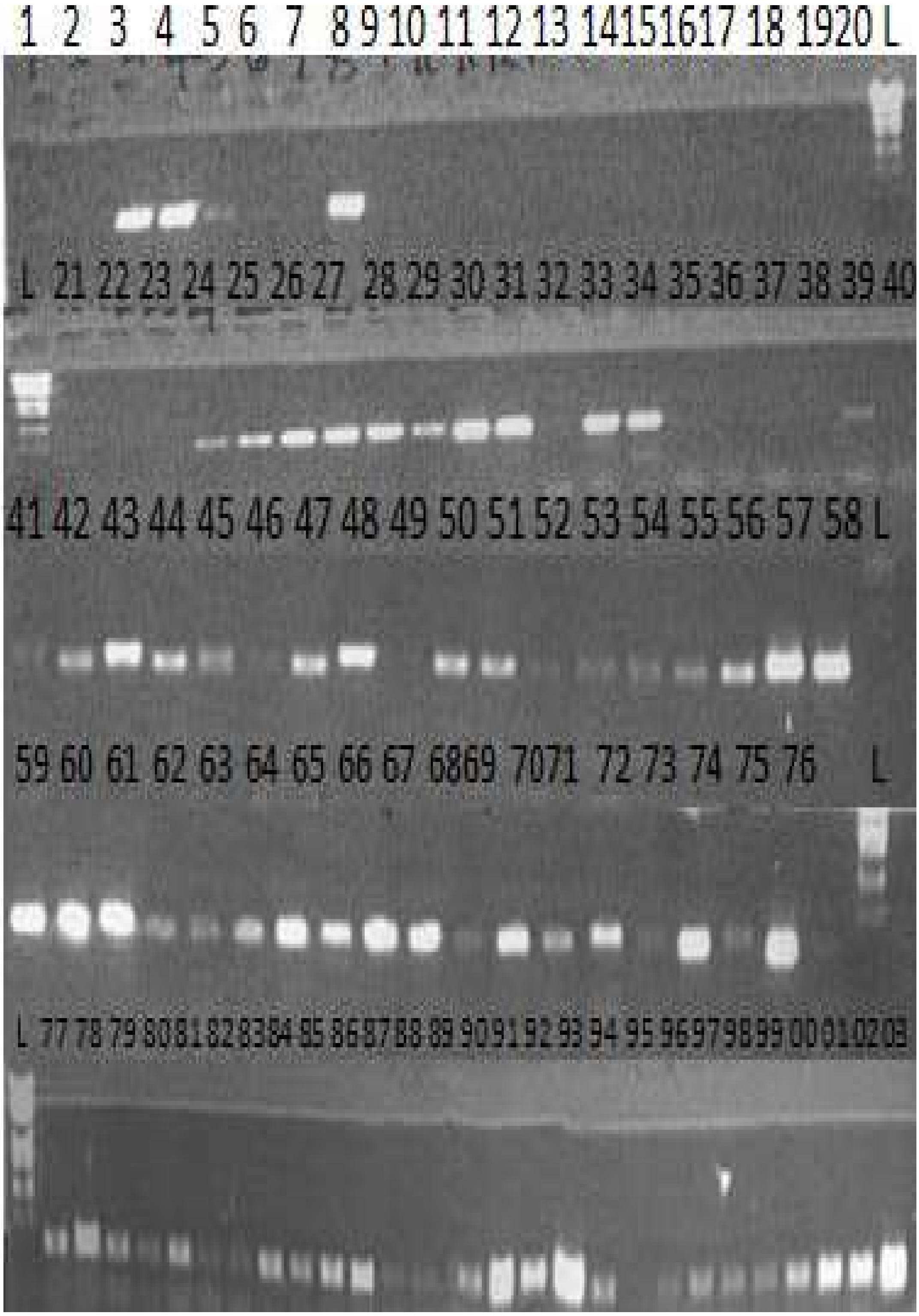


PLATE 4.4.4: Electrophorogram of ITS 2 - ITS 5 amplification

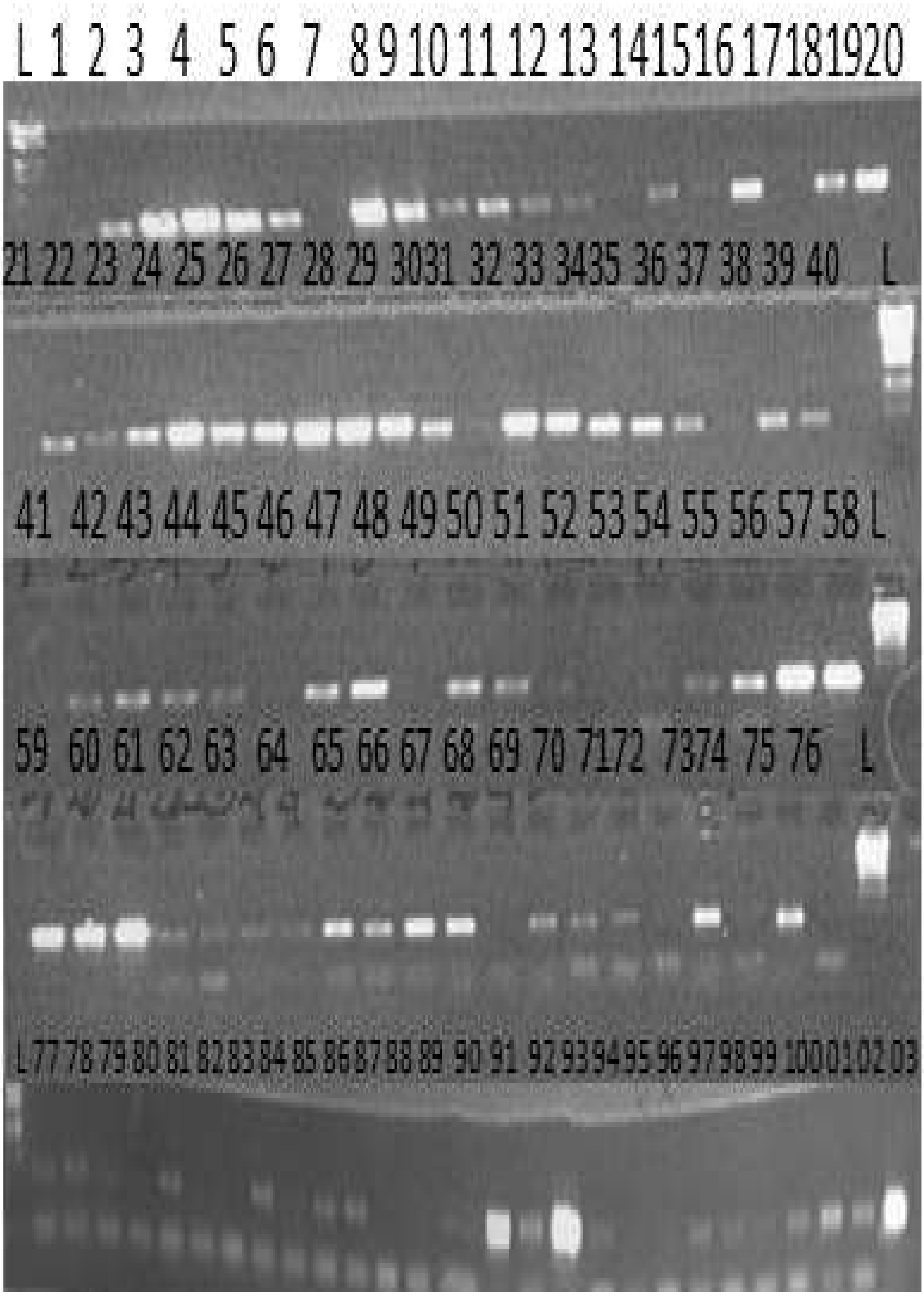


PLATE 4.4.5: Electrophorogram of ITS 3 - ITS 4 amplification

4.4.1. PHYLOGENETIC ANALYSES

Of all the 119 DNA samples extracted, only 60 yielded DNA sequences for the various coding and non-coding region analysed. A total of 204 DNA sequences were generated (Table 4.4.1.) and these were supported with DNA sequences from the previous analyses by Buerki *et al.,* 2009 (Appendix 10).

Single gene analyses (Figure 4.4.4a – 4.4.6b), two-gene analysis (Figure 4.4.7.) and combined gene analysis (Figure 4.4.8 – 4.4.9) were carried out on the sequence data generated using maximum parsimony method. These revealed varying degree of relationships among the different taxa in the family Sapindaceae.

Combined trnL and ITS parsimony analysis revealed that the total number of characters represented in the matrix is 9888, all of which are of type 'unord' and they have equal weight. Of all these characters, 5697 characters are constant, 1670 variable characters are parsimony-uninformative while 2521 characters are parsimony-informative. Maximum parsimony analysis of these characters resulted in 210 most parsimonious tree with consistency index (CI) of 0.60 and retention index (RI) of 0.78. In the strict consensus tree, Sapindaceae is supported by 66 bootstrap percentages (bp). Bootstrap percentages consistent with the strict consensus tree are shown above each branch but groups with bp less than 50 are not indicated (Figure 4.4.10).

Table 4.4.1: Voucher information and GenBank accession number of taxa used in the phylogenetic analysis of family Sapindaceae s.l.

Abbreviations: FHI – Forestry Research Institute, Ibadan, Nigeria; LUH – University of Lagos, Lagos, Nigeria; SFRK/HNC – National Herbarium Yaounde, Cameroon; ABU – Ahmadu Bello University, Zaria, Nigeria, GCH – University of Ghana, Legon, Ghana.

Species	Voucher	Country	Herbarium	Gen Bank Accession Nos.				
				ITS	trnL	trnF	matK	rbcL
Allophylus africanus	Adeyemi, T.O 1194	Cameroon	LUH	JN190965	JN191056	JN191015	JN191100	JN191136
Allophylus bullatus	Adeyemi, T.O 1185	Cameroon	LUH	JN190966	JN191057	JN191016	JN191101	JN191137
Allophylus conraui	Chapman, 78107	Nigeria	FHI	-	JN191058	-	JN191102	JN191138
Allophylus griseotomentosus	ATO 043	Cameroon	FHI	JN190967	-	-	JN191103	JN191139
Allophylus hirtellus	Adeyemi, T.O 1190	Cameroon	LUH	JN190968	JN191059	JN191017	-	JN191140
Allophylus macrobotrys	Reekmans, 95067	Cameroon	FHI	JN190969	-	-	-	-

Table 4.4.1 (continued)

Species	Voucher	Country	Herbarium	Gen Bank Accession Nos.				
				ITS	trnL	trnF	matK	rbcL
Allophylus rubifolius	Reekmans, 98646	Cameroon	FHI	JN190970	-	-	-	-
Allophylus schweinfurthii	Bos, J.J 30321	Cameroon	HNC	JN190971	-	-	-	-
Allophylus sp	Adeyemi, T.O 3441	Cameroon	LUH	JN190972	JN191060	JN191018	-	JN191135
Allophylus spicatus	Adeyemi, T.O 3442	Nigeria	LUH	JN190973	JN191061	JN191019	JN191104	JN191141
Allophylus welwitschii	Adeyemi, T.O 1192	Cameroon	LUH	JN190974	JN191062	JN191020	JN191105	JN191142
Blighia sapida	Adeyemi, T.O 1196	Nigeria	LUH	JN190975	JN191063	JN191021	JN191106	-
Blighia unijugata	Adeyemi, T.O 3443	Nigeria	LUH	JN190976	-	-	-	-
Blighia welwitschii	Adeyemi, T.O 3315	Cameroon	LUH	JN190977	JN191064	JN191022	JN191107	JN191143

Table 4.4.1 (continued)

Species	Voucher	Country	Herbarium	Gen Bank Accession Nos.				
				ITS	trnL	trnF	matK	rbcL
Cardiospermum corindium	Daramola, B.O 049		FHI	-	-	-	JN191108	JN191144
Cardiospermum grandiflorum	Adeyemi, T.O 1189	Nigeria	LUH	JN190978	JN191065	JN191023	JN191109	JN191145
Cardiospermum halicacabum	Ohaeri, A.O. 947	Nigeria	ABU	JN190979	-	-	-	-
Chytranthus carneus	Abbiw & Hall, J.B. 4650	Ghana	GCH	JN190980	JN191066	JN191024	-	JN191148
Chytranthus cauliflorus	Abbiw & Hall, J.B. 44715	Ghana	GCH	-	JN191067	JN191025	-	-
Chytranthus macrobotrys	Adeyemi, T.O 1187	Cameroon	LUH	JN190981	JN191068	JN191026	JN191110	JN191149
Chytranthus setosus	Adeyemi, T.O 3444	Cameroon	LUH	JN190982	JN191069	JN191027	JN191111	JN191150

Table 4.4.1 (continued)

Species	Voucher	Country	Herbarium	Gen Bank Accession Nos.				
				ITS	trnL	trnF	matK	rbcL
Chytranthus sp1	Adeyemi, T.O 3445	Cameroon	LUH	JN190983	JN191070	JN191028	JN191112	JN191147
Chytranthus sp2	Adeyemi, T.O 3446	Cameroon	LUH	JN190984	JN191071	JN191029	JN191113	JN191146
Chytranthus talbotii	Adeyemi, T.O 3447	Nigeria	LUH	JN190985	JN191072	JN191030	JN191114	JN191151
Deinbollia grandifolia	Hall, J.B. 47068	Ghana	GCH	JN190986	JN191073	JN191031	JN191115	JN191153
Deinbollia insignis	Ariwaodo, J.O & Odewo, T.K. 102216	Nigeria	FHI	JN190987	-	-	-	-
Deinbollia kilimandscharia	De WILDE, J.J & De WILDE, B.E 7781.	Ethiopia	GCH	-	JN191074	JN191032	JN191116	JN191154
Deinbollia maxima	Thomas, D.W & Mcleod, H.L. 56603	Cameroon	HNC	JN190988	-	-	-	-

Table 4.4.1 (continued)

Species	Voucher	Country	Herbarium	Gen Bank Accession Nos.				
				ITS	trnL	trnF	matK	rbcL
Deinbollia mezilii	De WILDE, J.J 44613	Cameroon	GCH	JN190989	-	-	-	-
Deinbollia sp	Adeyemi, T.O 3448	Cameroon	LUH	JN190990	JN191075	JN191033	JN191117	JN191152
Dodonaea viscosa	Adeyemi, T.O 037	Nigeria	LUH	JN190991	JN191076	JN191034	JN191118	-
Eriocoelum kertstingii	Ibhanesebhor 77683	Nigeria	FHI	JN190992	JN191077	JN191035	JN191119	-
Eriocoelum macrocarpum	Adeyemi, T.O 1195	Cameroon	LUH	JN190994	JN191079	JN191037	JN191121	-
Eriocoelum microspermum	Adeyemi, T.O 069	Cameroon	FHI	JN190993	JN191078	JN191036	JN191120	JN191155
Glenniea africanus	Adeyemi, T.O 3449	Nigeria	LUH	JN190995	JN191080	JN191038	-	-
Laccodiscus ferrugineus	Adeyemi, T.O 1183	Cameroon	LUH	-	JN191081	-	-	JN191156

Table 4.4.1 (continued)

Species	Voucher	Country	Herbarium	Gen Bank Accession Nos.				
				ITS	**trnL**	**trnF**	**matK**	**rbcL**
Laccodiscus pseudostipularis	Florey, J.J. 39252	Cameroon	FHI	JN190996	JN191082	JN191039	JN191122	JN191157
Laccodiscus sp	Adeyemi, T.O 3450	Cameroon	LUH	-	JN191083	-	-	-
Lecaniodiscus cupanioides	Adeyemi, T.O 3451	Nigeria	LUH	JN190997	JN191084	JN191040	JN191123	JN191158
Lepisanthes senegalensis	Ohaeri, A.O. 2619	Nigeria	ABU	JN190998	JN191085	JN191041	-	-
Litchi chinensis	Adeyemi, T.O 3452	Madagascar	LUH	JN191001	JN191088	JN191044	JN191125	JN191160
Majidea fosterii	Adeyemi, T.O 1718	Cameroon	LUH	JN190999	JN191086	JN191042	JN191124	JN191159
Melicoccus bijugatus	Ogu, 52431	Cameroon	FHI	JN191000	JN191087	JN191043	-	-

Table 4.4.1 (continued)

Species	Voucher	Country	Herbarium	Gen Bank Accession Nos.				
				ITS	trnL	trnF	matK	rbcL
Pancovia atroviolaceus	Adeyemi, T.O 1182	Cameroon	LUH	JN191002	JN191089	JN191045	JN191126	JN191162
Pancovia laurentii	Letouzey, R 2926	Cameroon	SFRK	JN191003	-	-	-	-
Pancovia sp1	Adeyemi, T.O 1188	Cameroon	LUH	JN191004	JN191090	JN191046	JN191127	-
Pancovia sp2	Adeyemi, T.O 1186	Cameroon	LUH	JN191005	JN191091	JN191047	JN191128	JN191161
Pancovia turbinata	Abbiw & Hall, J.B. 45363	Ivory coast	GCH	JN191006	-	-	-	-
Paullinia pinnata	Adeyemi, T.O 1193	Cameroon	LUH	JN191007	JN191092	JN191048	JN191129	JN191163
Placodiscus leptostachys	Adeyemi, T.O 3454	Cameroon	LUH	-	JN191093	JN191049	JN191130	JN191165
Placodiscus sp1	Adeyemi, T.O 3455	Cameroon	LUH	JN191008	JN191094	-	JN191131	JN191164

Table 4.4.1 (continued)

Species	Voucher	Country	Herbarium	Gen Bank Accession Nos.				
				ITS	trnL	trnF	matK	rbcL
Placodiscus sp2	Adeyemi, T.O 3456	Nigeria	LUH	JN191009	-	JN191050	-	-
Radlkofera calodendron	Adeyemi, T.O 3457	Cameroon	LUH	JN191010	JN191095	JN191051	-	-
Radlkofera sp1	Adeyemi, T.O 3458	Nigeria	LUH	JN191011	JN191096	JN191052	-	-
Radlkofera sp2	Adeyemi, T.O 3459	Nigeria	LUH	JN191012	JN191097	JN191053	JN191132	JN191167
Radlkofera sp3	Adeyemi, T.O 3460	Cameroon	LUH	JN191013	JN191098	JN191054	JN191133	JN191166
Zanha golugensis	Adeyemi, T.O 3462	Nigeria	LUH	JN191014	JN191099	JN191055	JN191134	JN191168

ITS

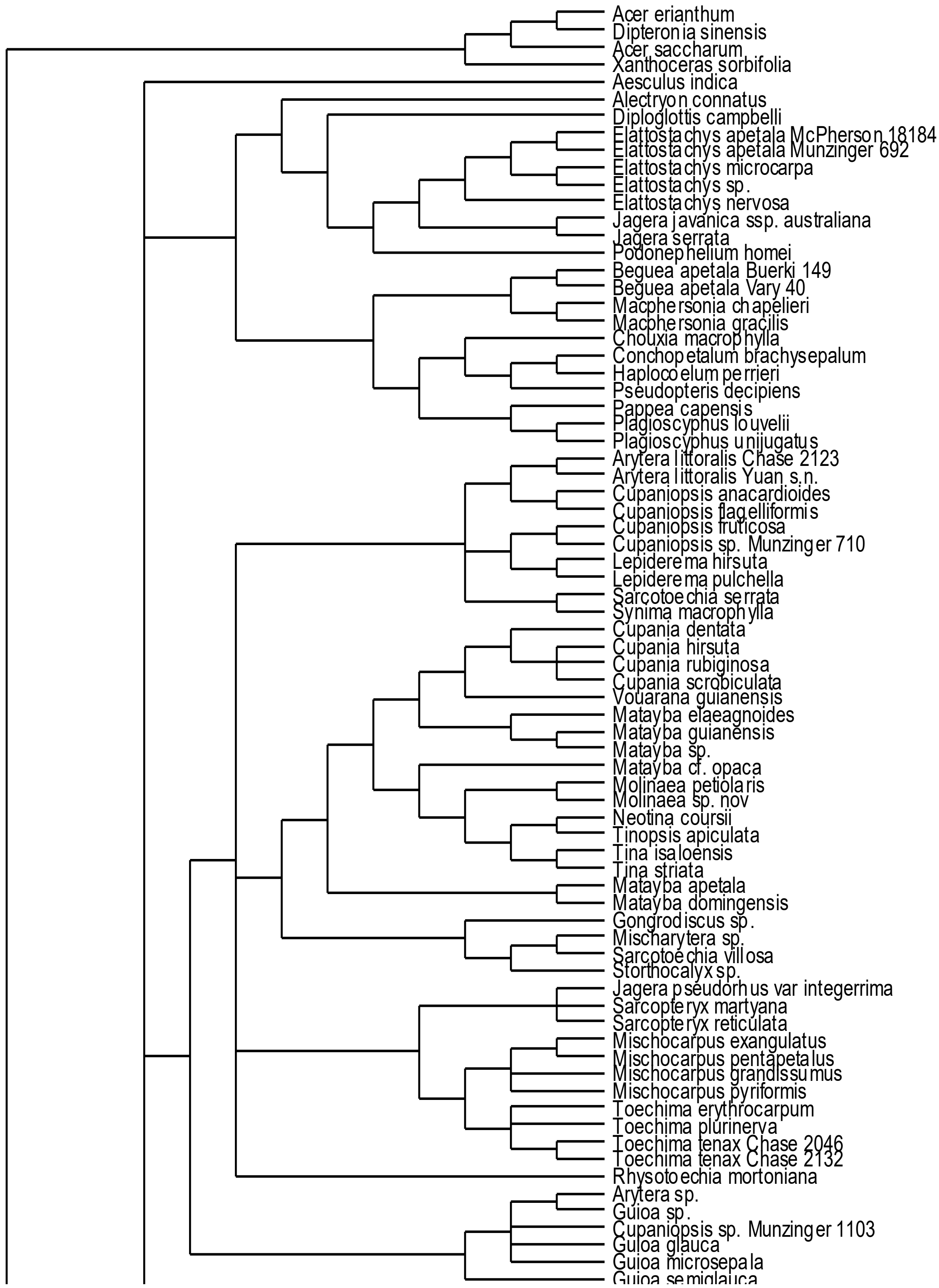


Figure 4.4.4a: Strict Consensus Tree from the Parsimony analysis based on ITS sequence data.

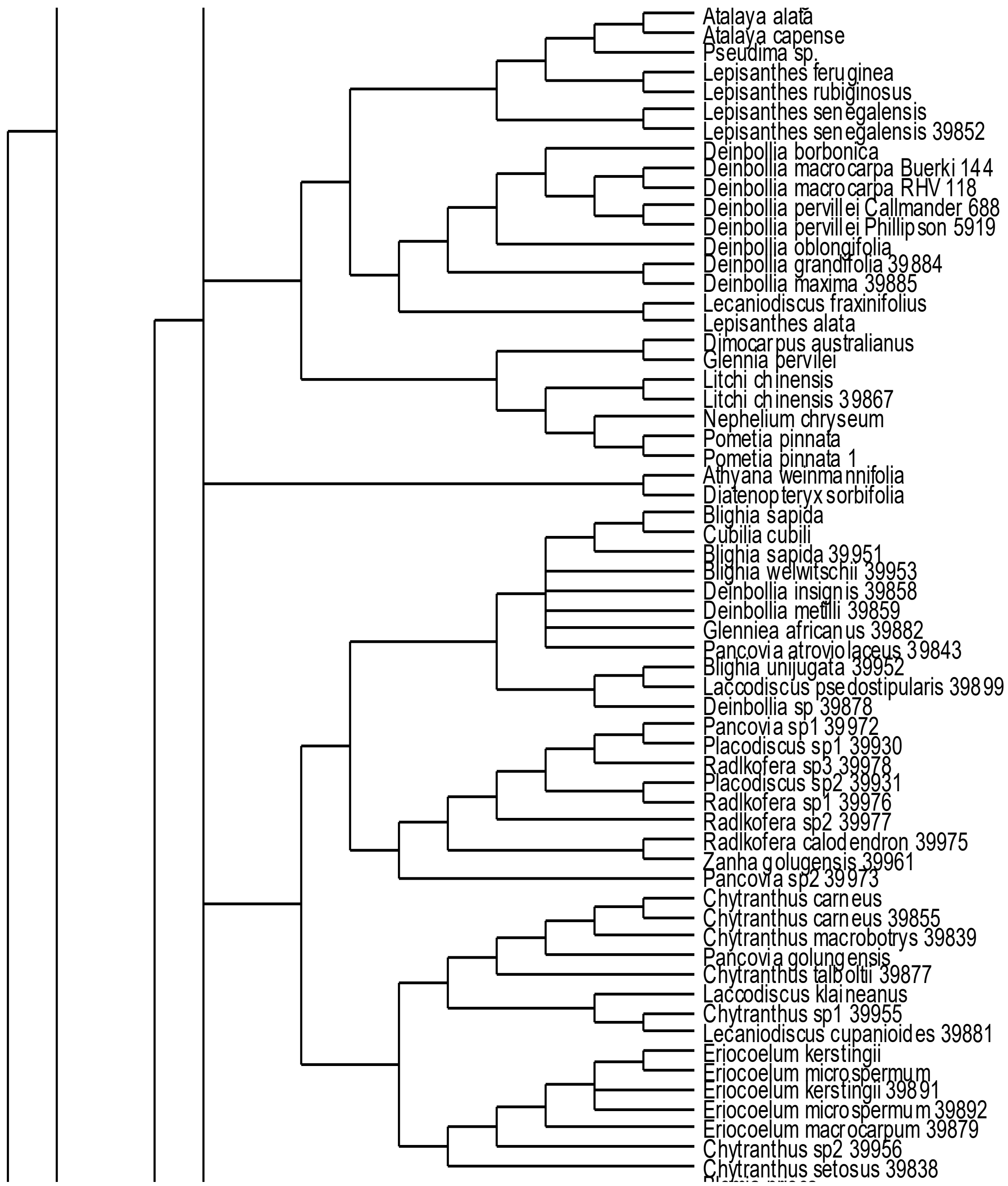


Figure 4.4.4a: Strict Consensus Tree from the Parsimony analysis based on ITS sequence data (cont'd).

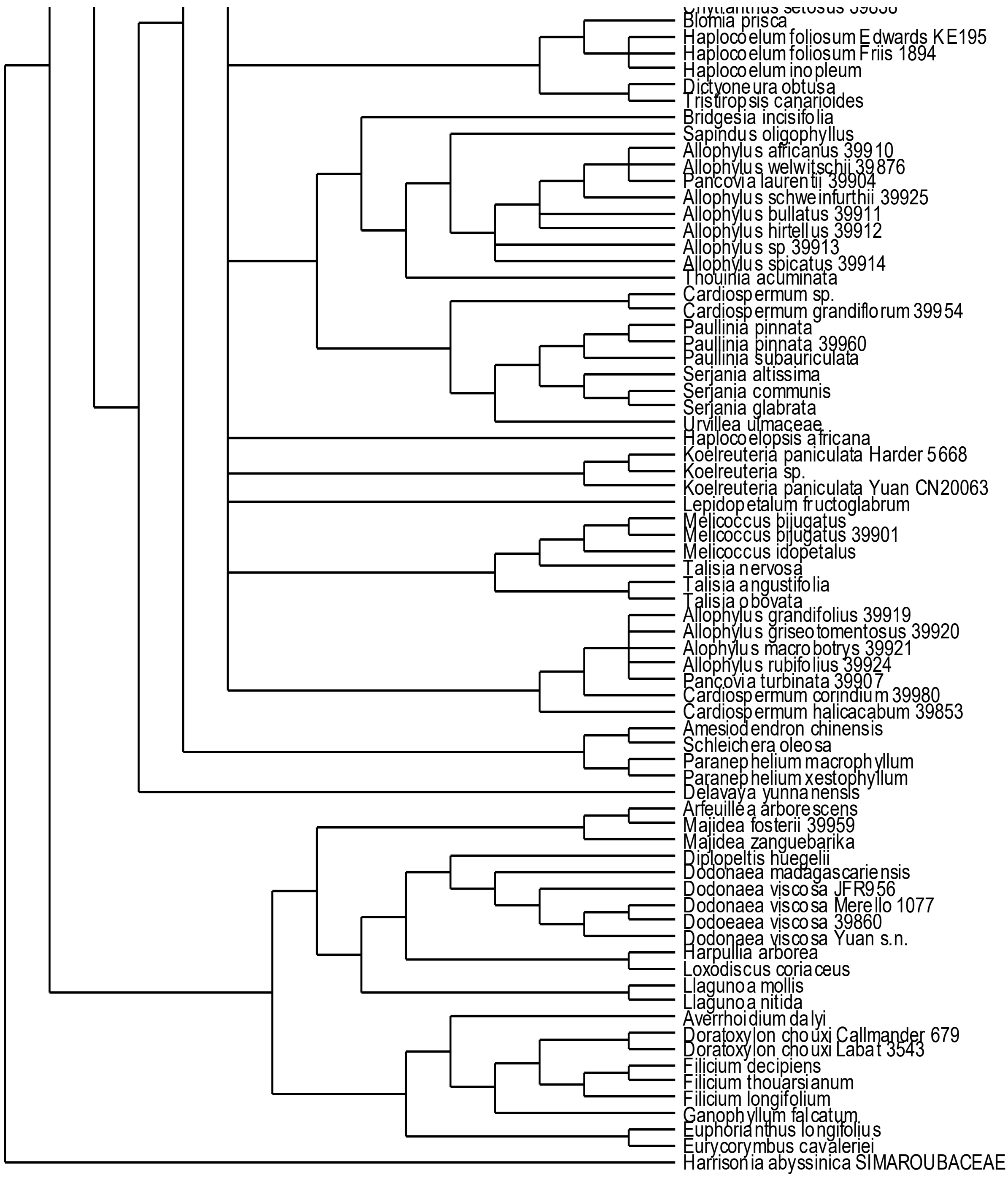


Figure 4.4.4a: Strict Consensus Tree from the Parsimony analysis based on ITS sequence data (cont'd).

BOOTSTRAP ANALYSIS - ITS

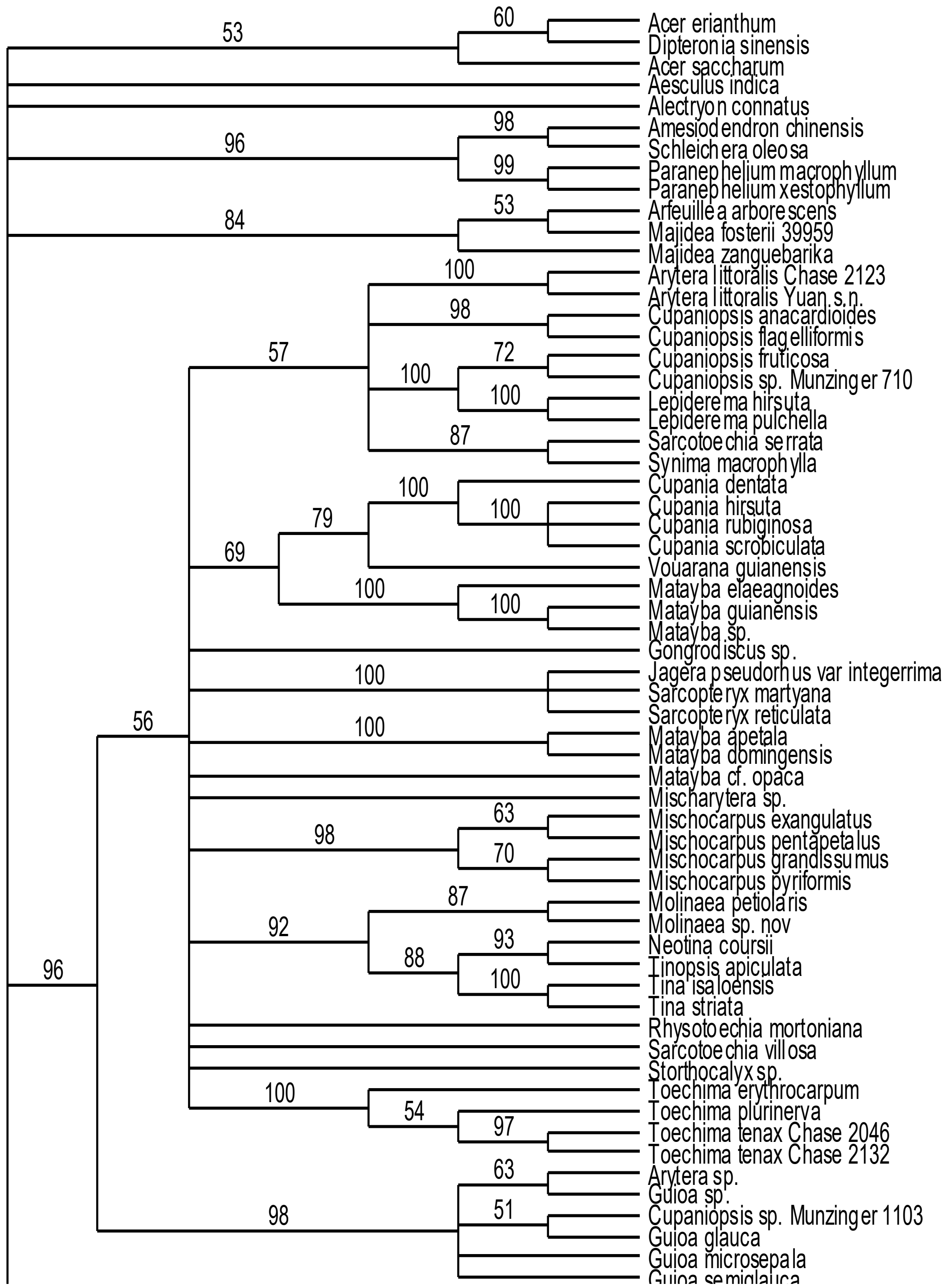


Figure 4.4.4b: Phylogenetic Relationships within Sapindaceae based on ITS data.

Bootstrap supports are indicated above branches.

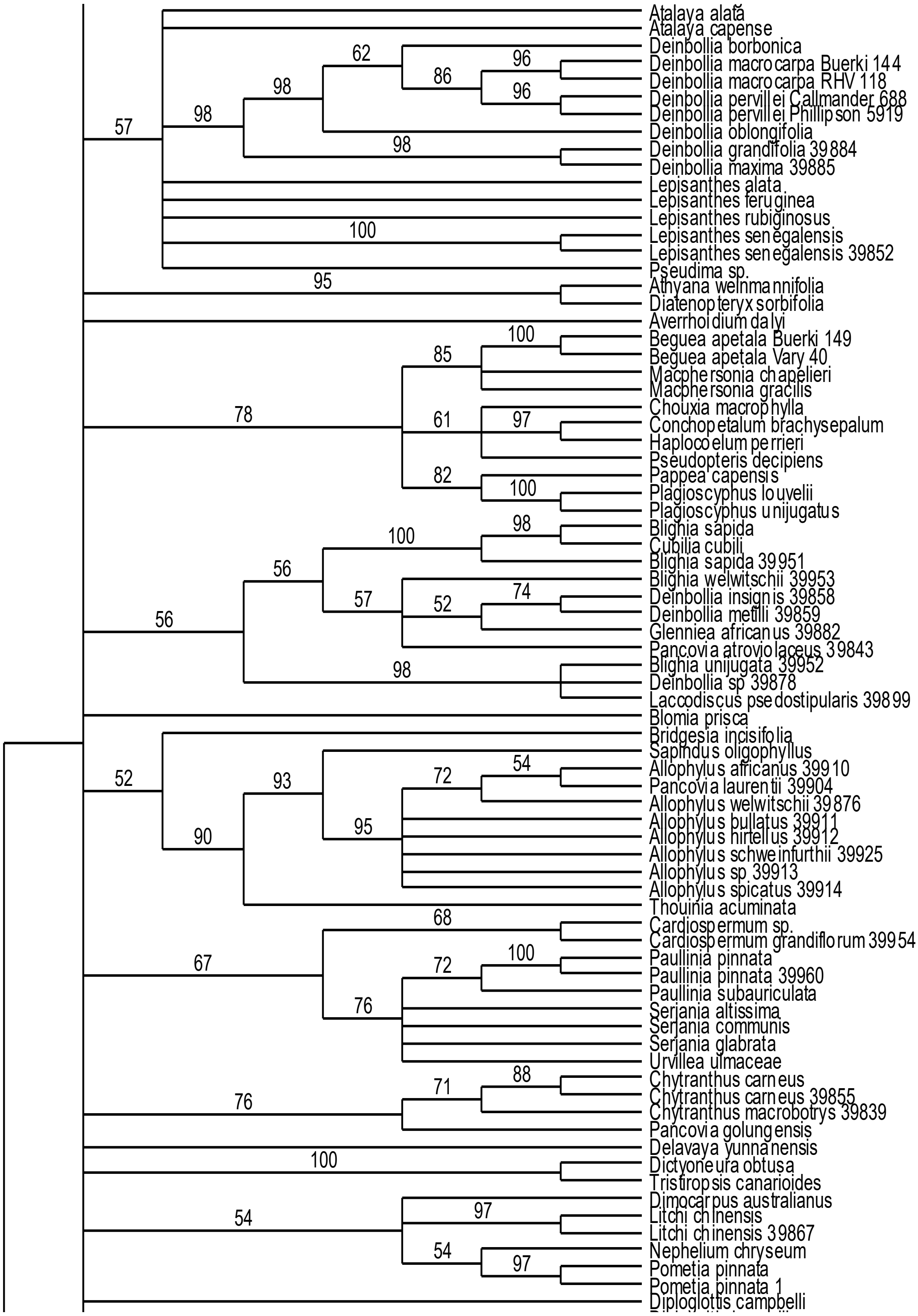


Figure 4.4.4b: Phylogenetic Relationships within Sapindaceae based on ITS data.

Bootstrap supports are indicated above branches (cont'd).

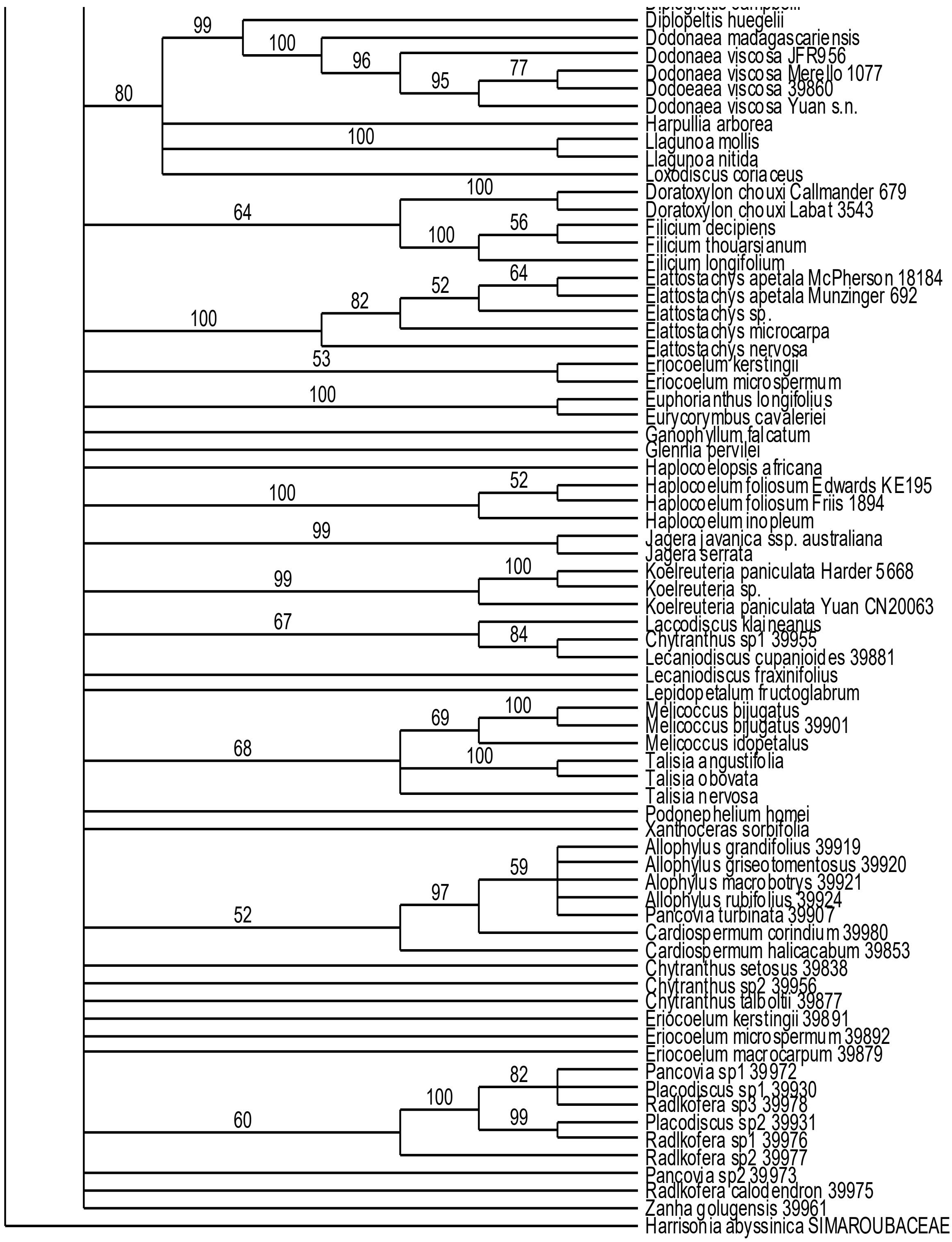


Figure 4.4.4b: Phylogenetic Relationships within Sapindaceae based on ITS data.

Bootstrap supports are indicated above branches (cont'd).

trnL

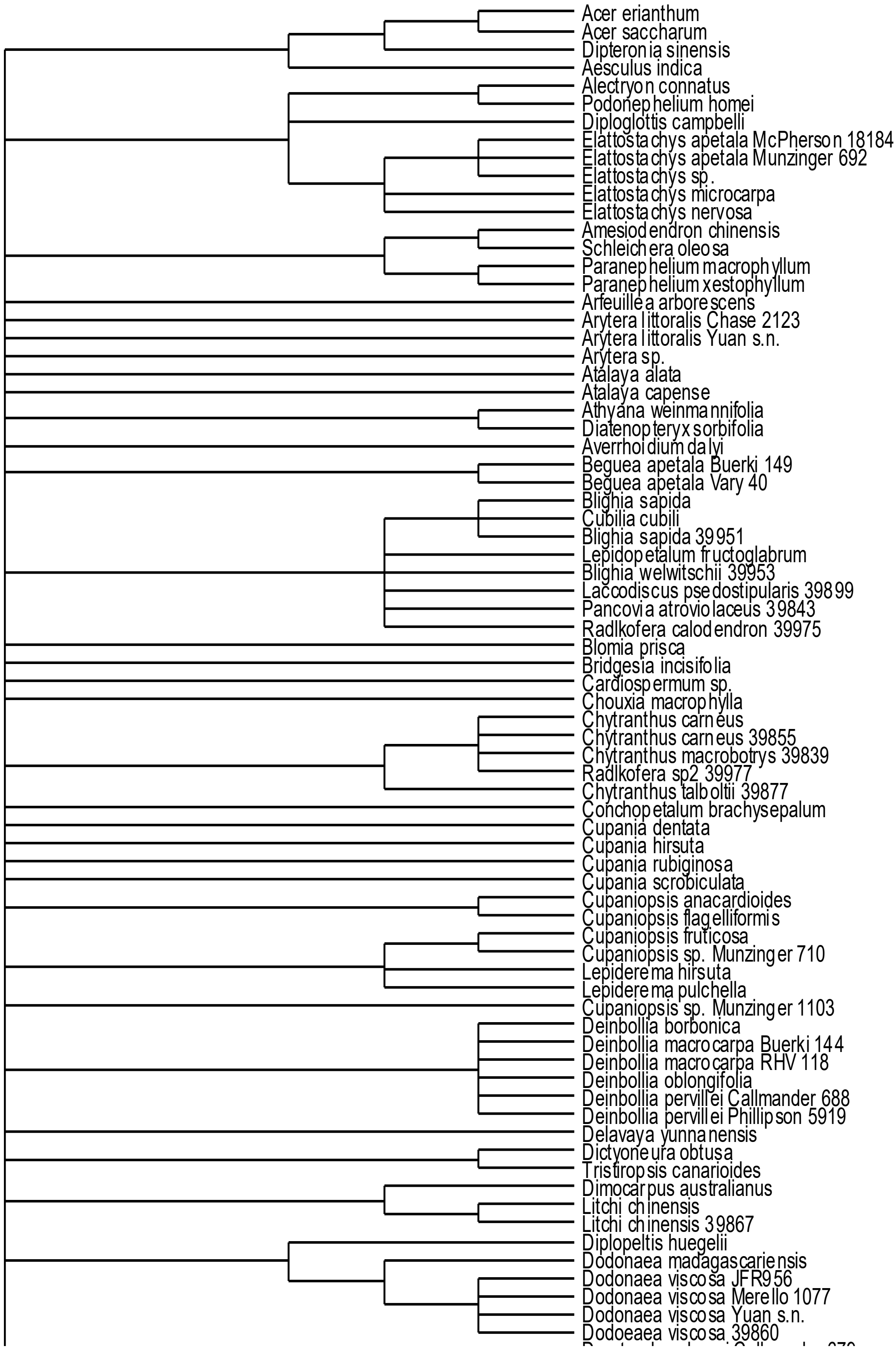


Figure 4.4.5a: Strict Consensus Tree from the Parsimony analysis based on trnL sequence data.

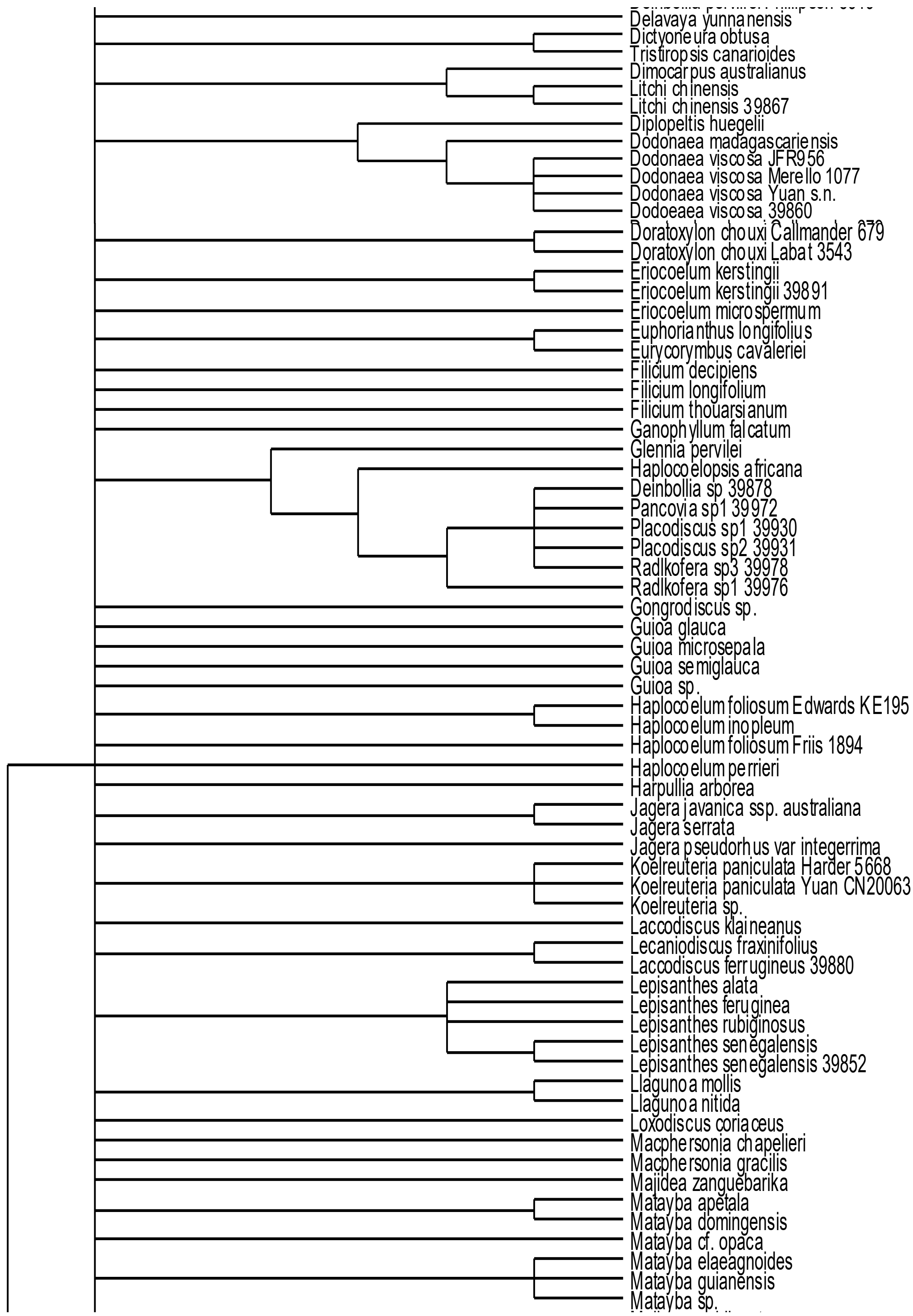


Figure 4.4.5a: Strict Consensus Tree from the Parsimony analysis based on trnL sequence data (cont'd).

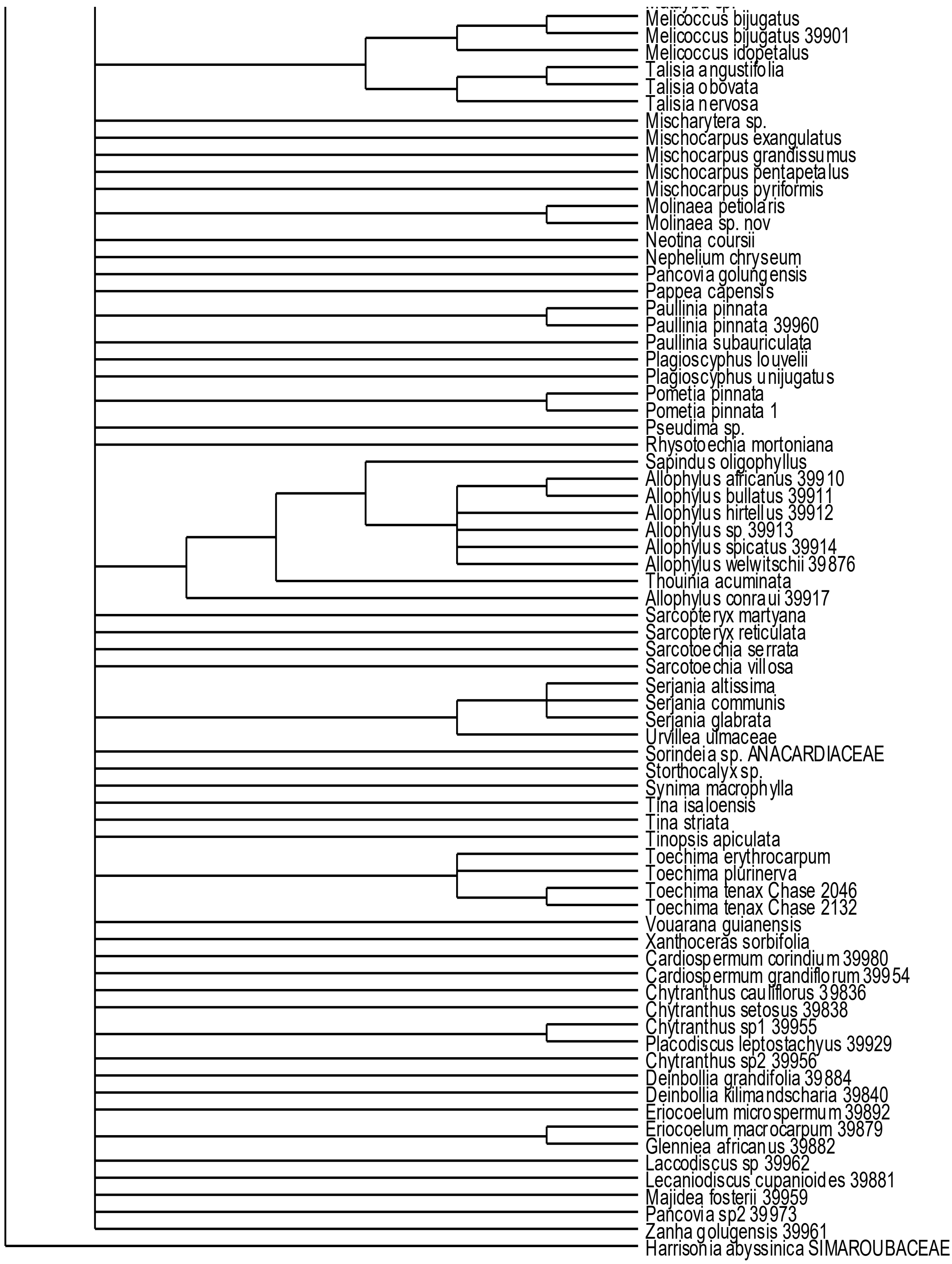


Figure 4.4.5a: Strict Consensus Tree from the Parsimony analysis based on trnL sequence data (cont'd).

BOOTSTRAP ANALYSIS – trnL

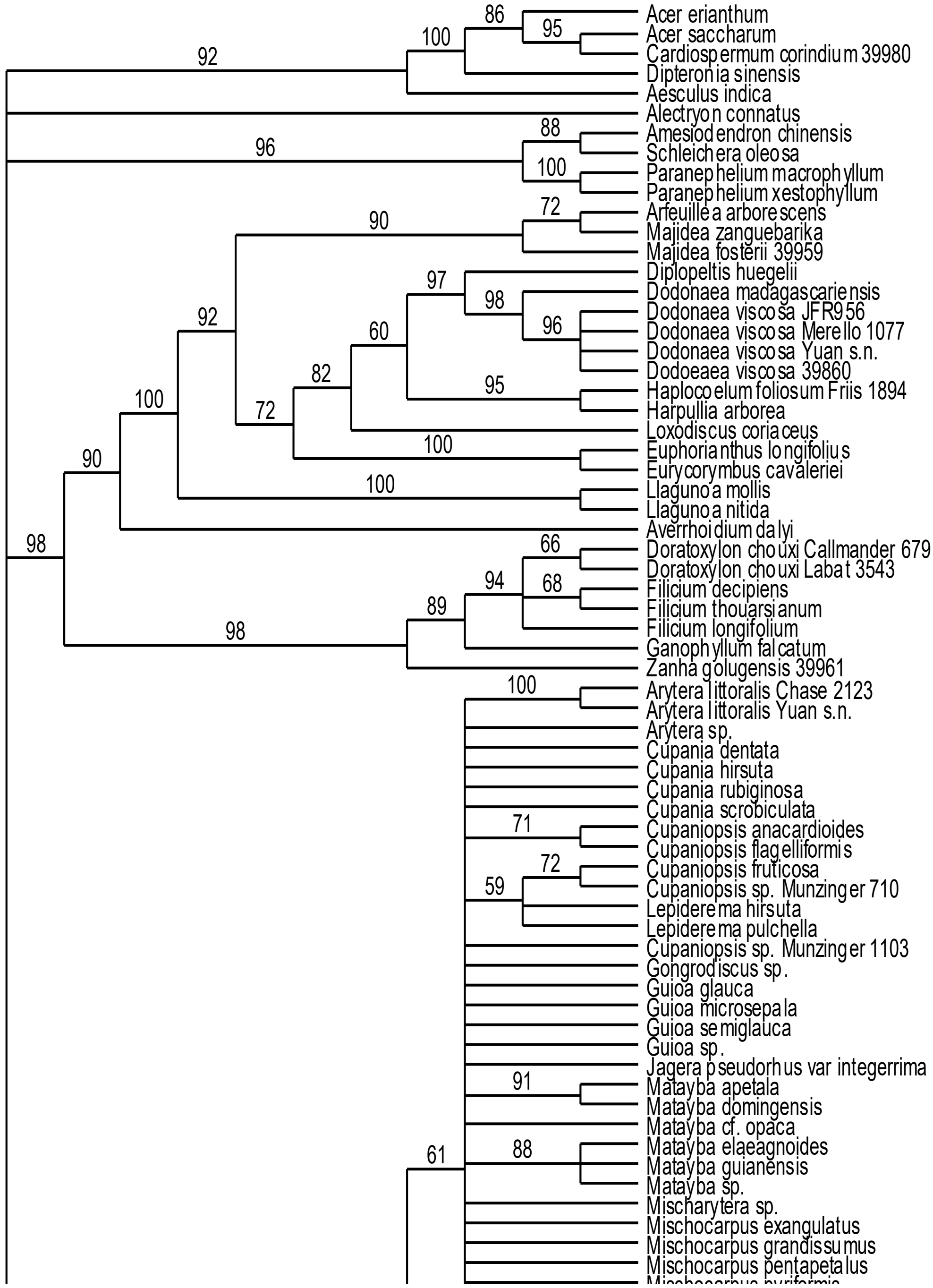


Figure 4.4.5b: Phylogenetic Relationships within Sapindaceae based on trnL data.

Bootstrap supports are indicated above branches.

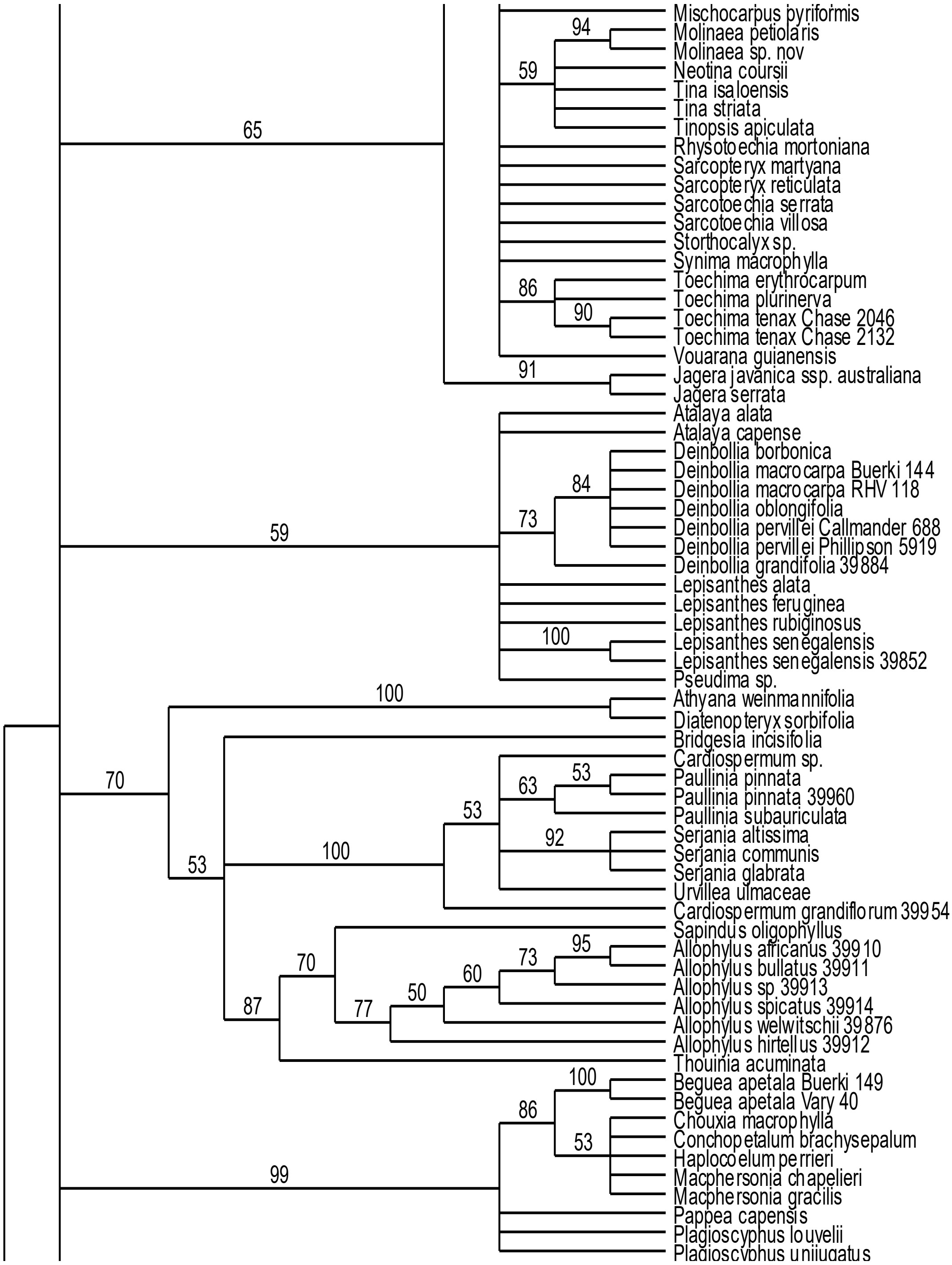


Figure 4.4.5b: Phylogenetic Relationships within Sapindaceae based on trnL data.

Bootstrap supports are indicated above branches (cont'd).

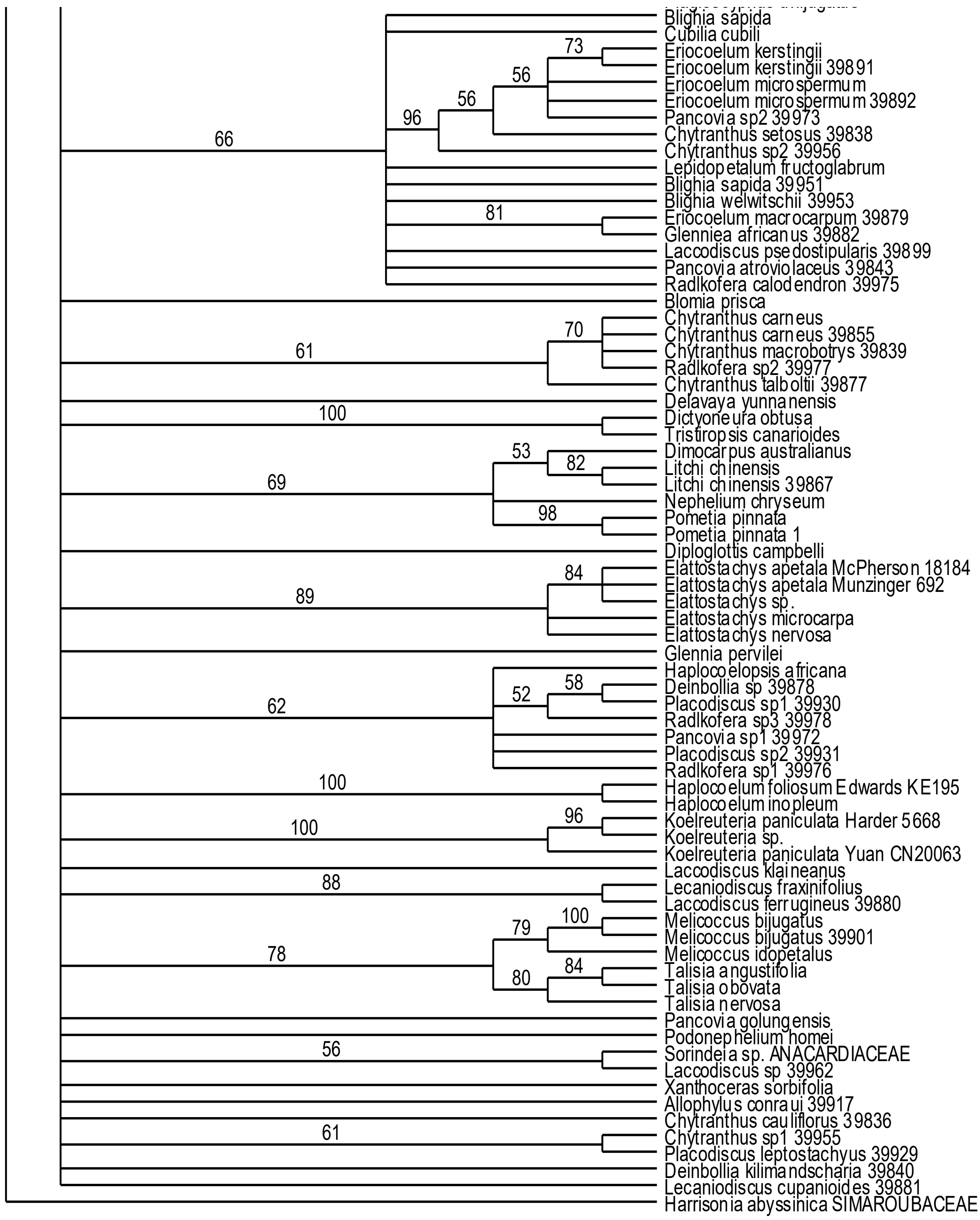


Figure 4.4.5b: Phylogenetic Relationships within Sapindaceae based on trnL data.

Bootstrap supports are indicated above branches (cont'd).

MatK

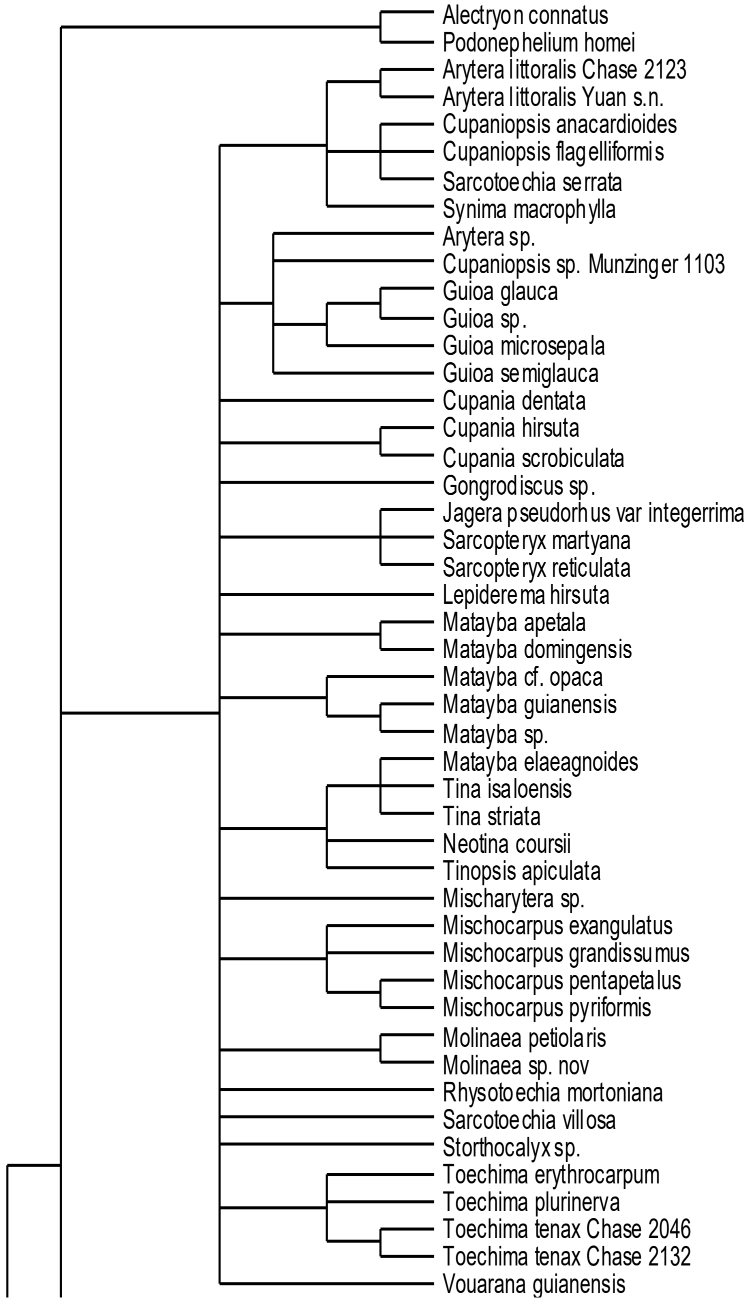


Figure 4.4.6a: Strict Consensus Tree from the Parsimony analysis based on matK sequence data.

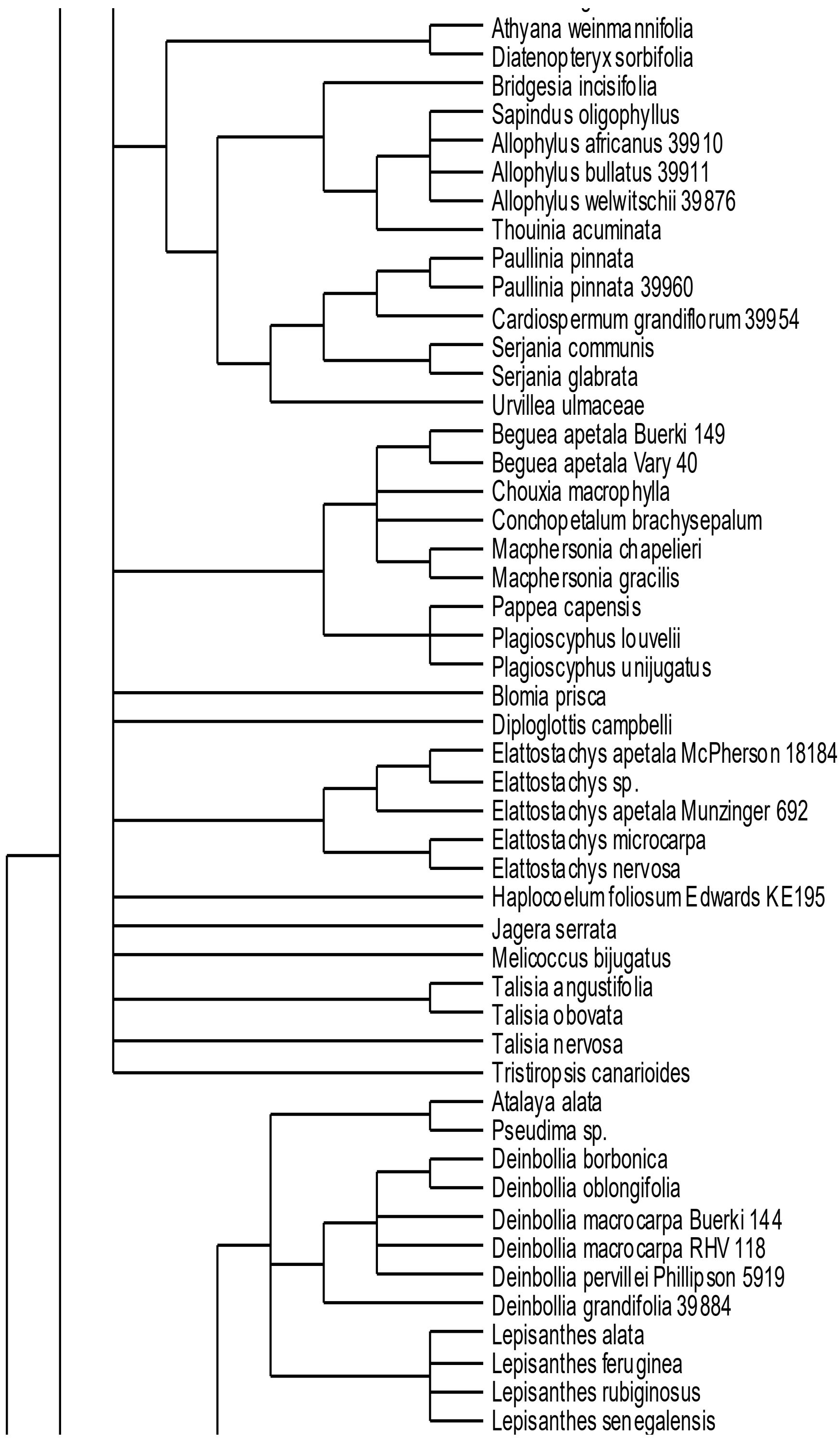


Figure 4.4.6a: Strict Consensus Tree from the Parsimony analysis based on matK sequence data (cont'd).

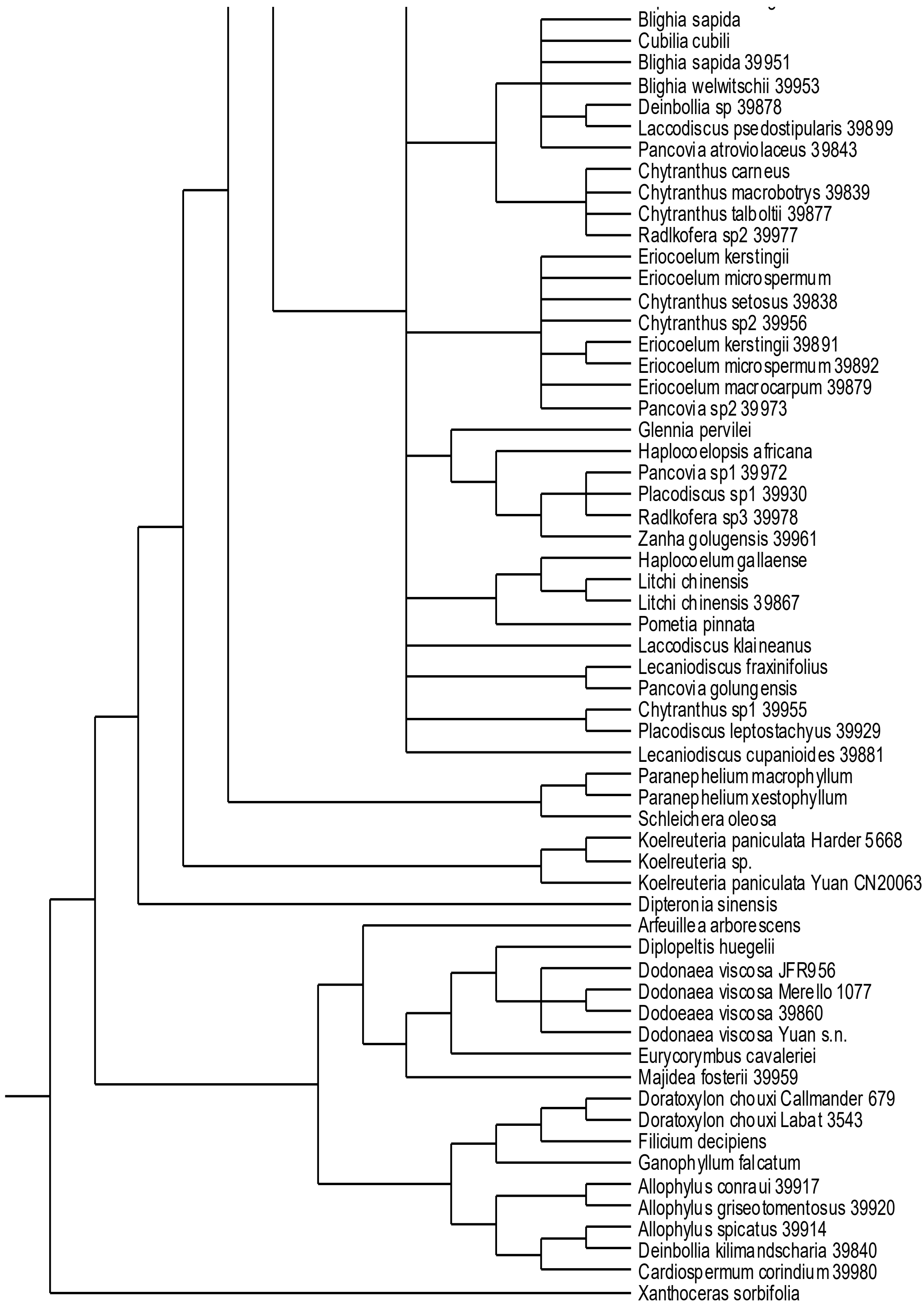


Figure 4.4.6a: Strict Consensus Tree from the Parsimony analysis based on matK sequence data (cont'd).

BOOTSTRAP ANALYSIS – matK

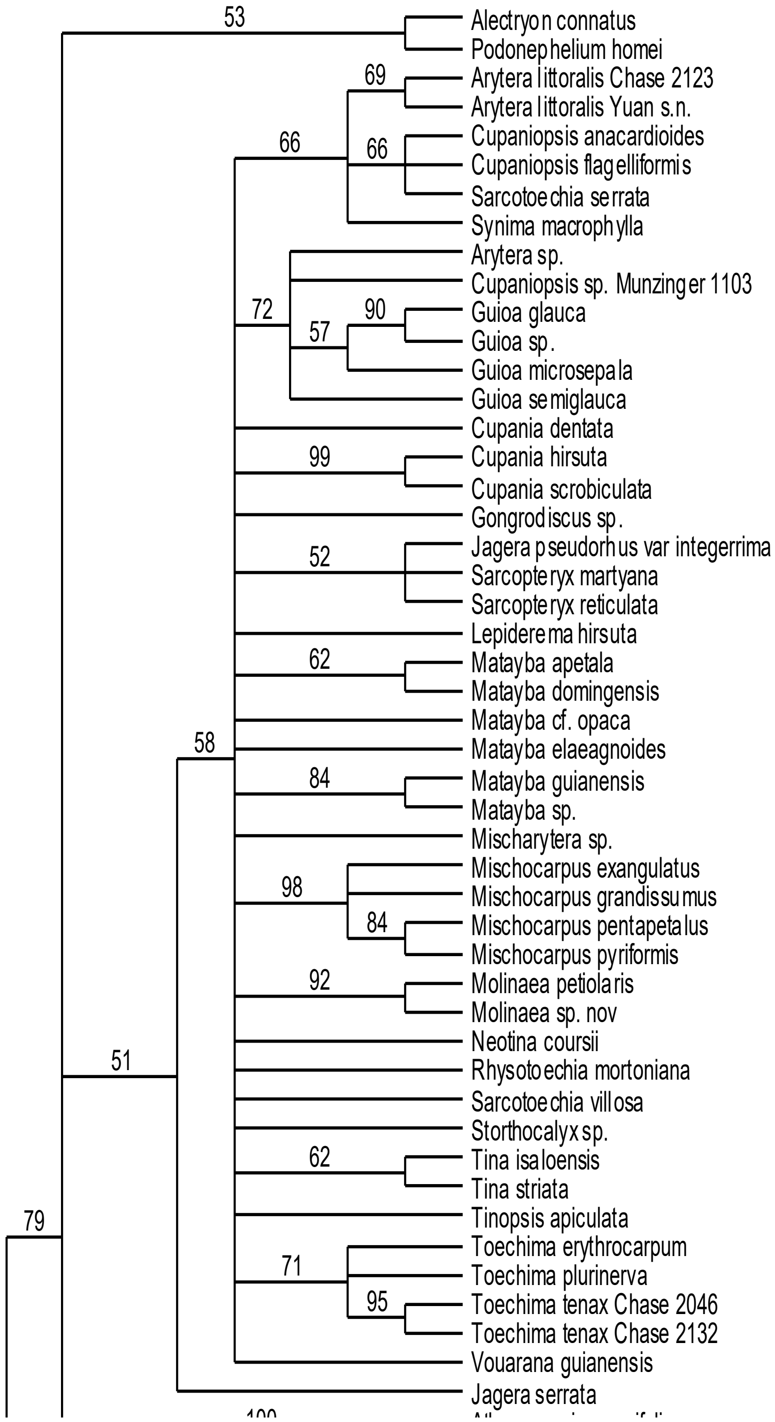


Figure 4.4.6b: Phylogenetic Relationships within Sapindaceae based on matK data.

Bootstrap supports are indicated above branches.

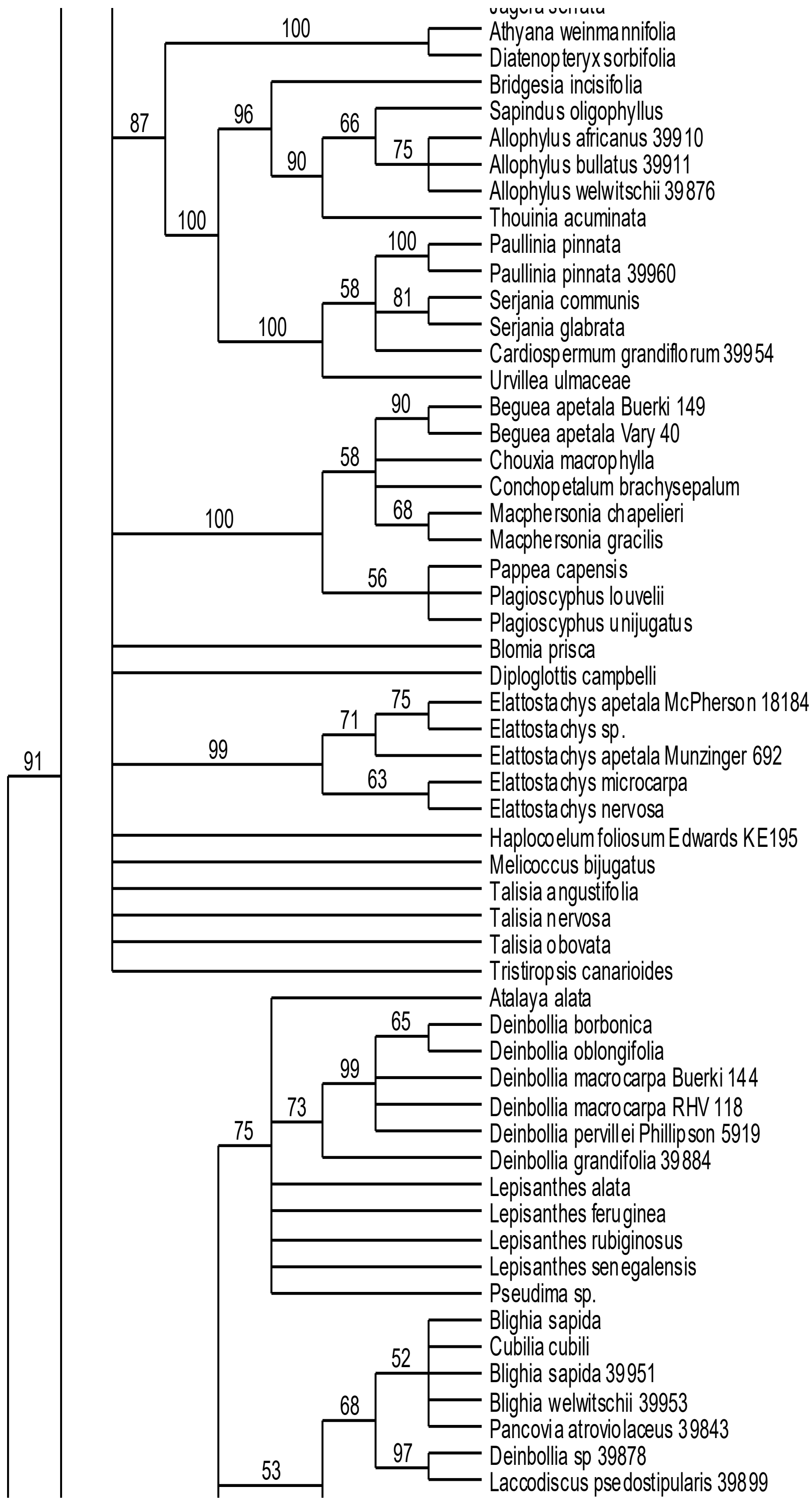


Figure 4.4.6b: Phylogenetic Relationships within Sapindaceae based on matK data. Bootstrap supports are indicated above branches (cont'd).

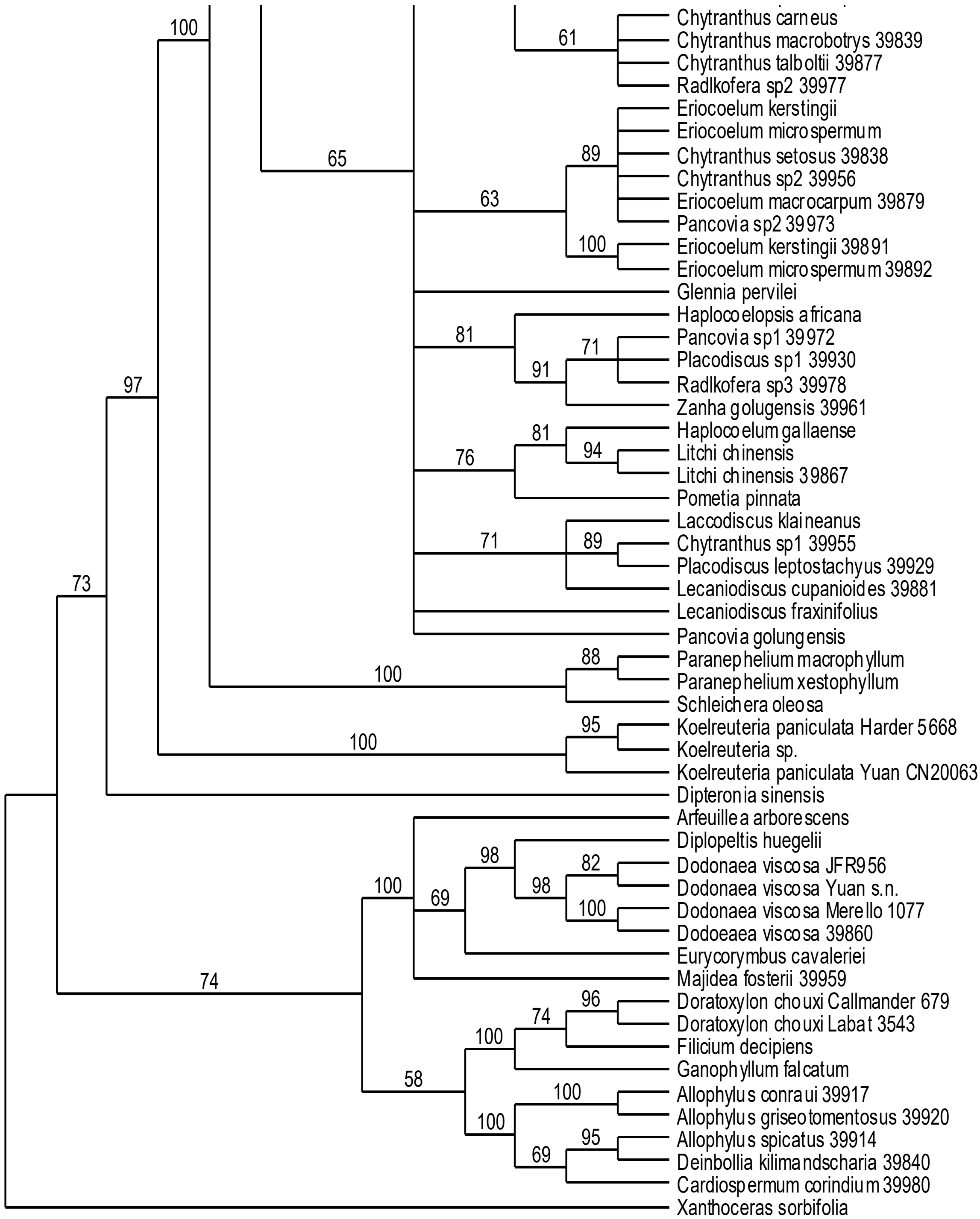


Figure 4.4.6b: Phylogenetic Relationships within Sapindaceae based on matK data.

Bootstrap supports are indicated above branches (cont'd).

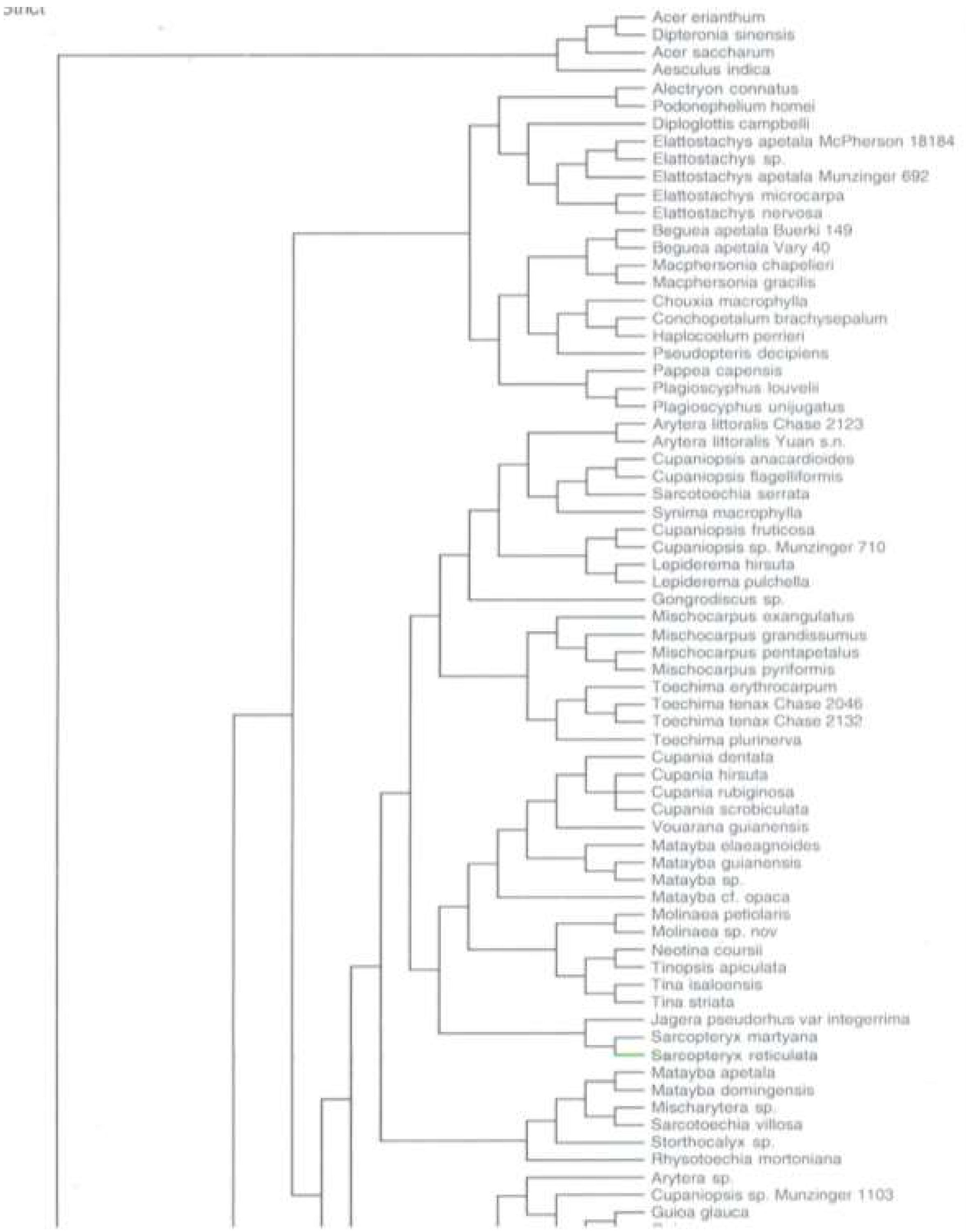


Figure 4.4.7: Two-gene Strict Consensus Tree from the Parsimony analysis based on ITS and trnL sequence data.

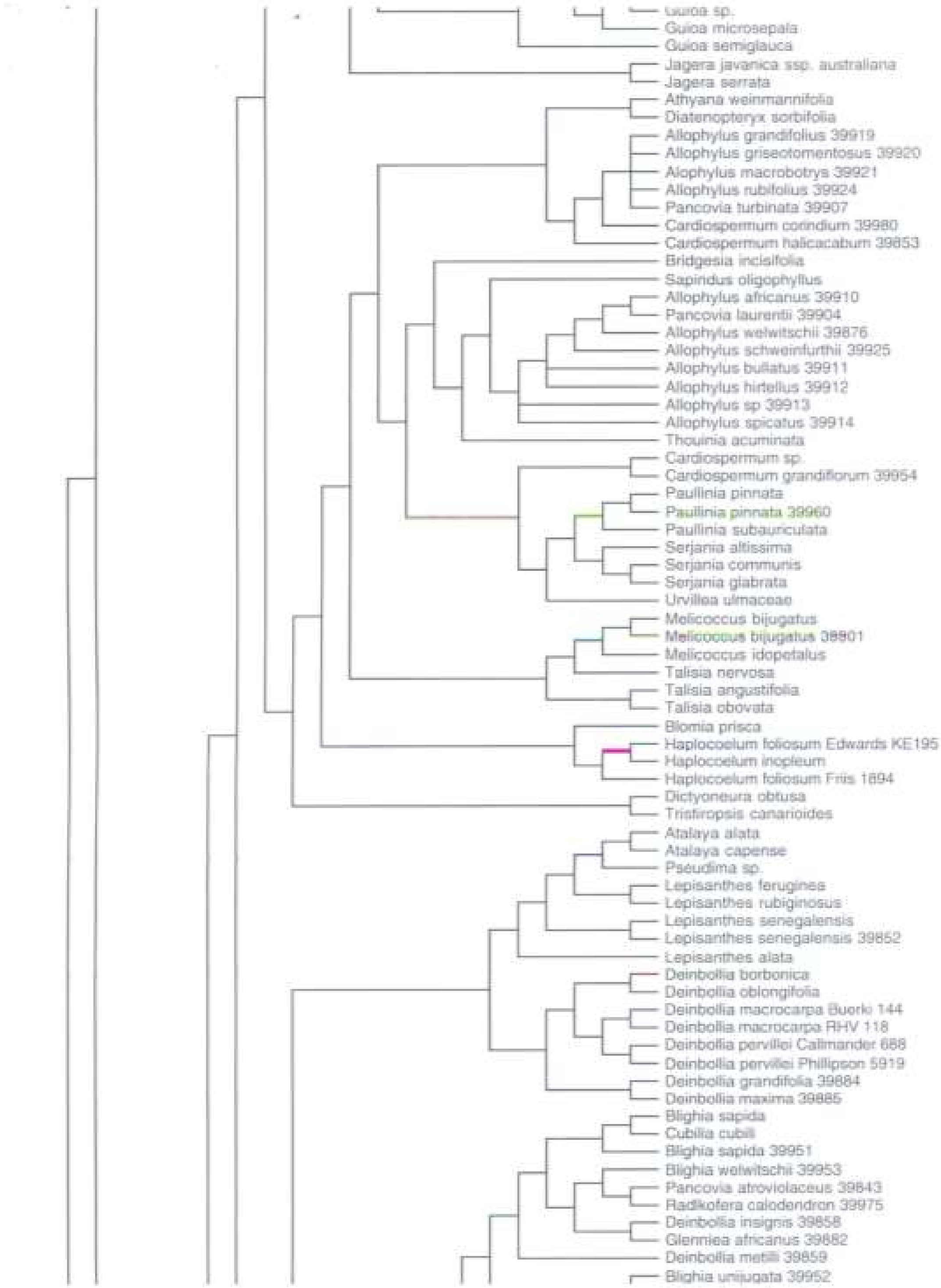


Figure 4.4.7: Two-gene Strict Consensus Tree from the Parsimony analysis based on ITS and trnL sequence data (cont'd).

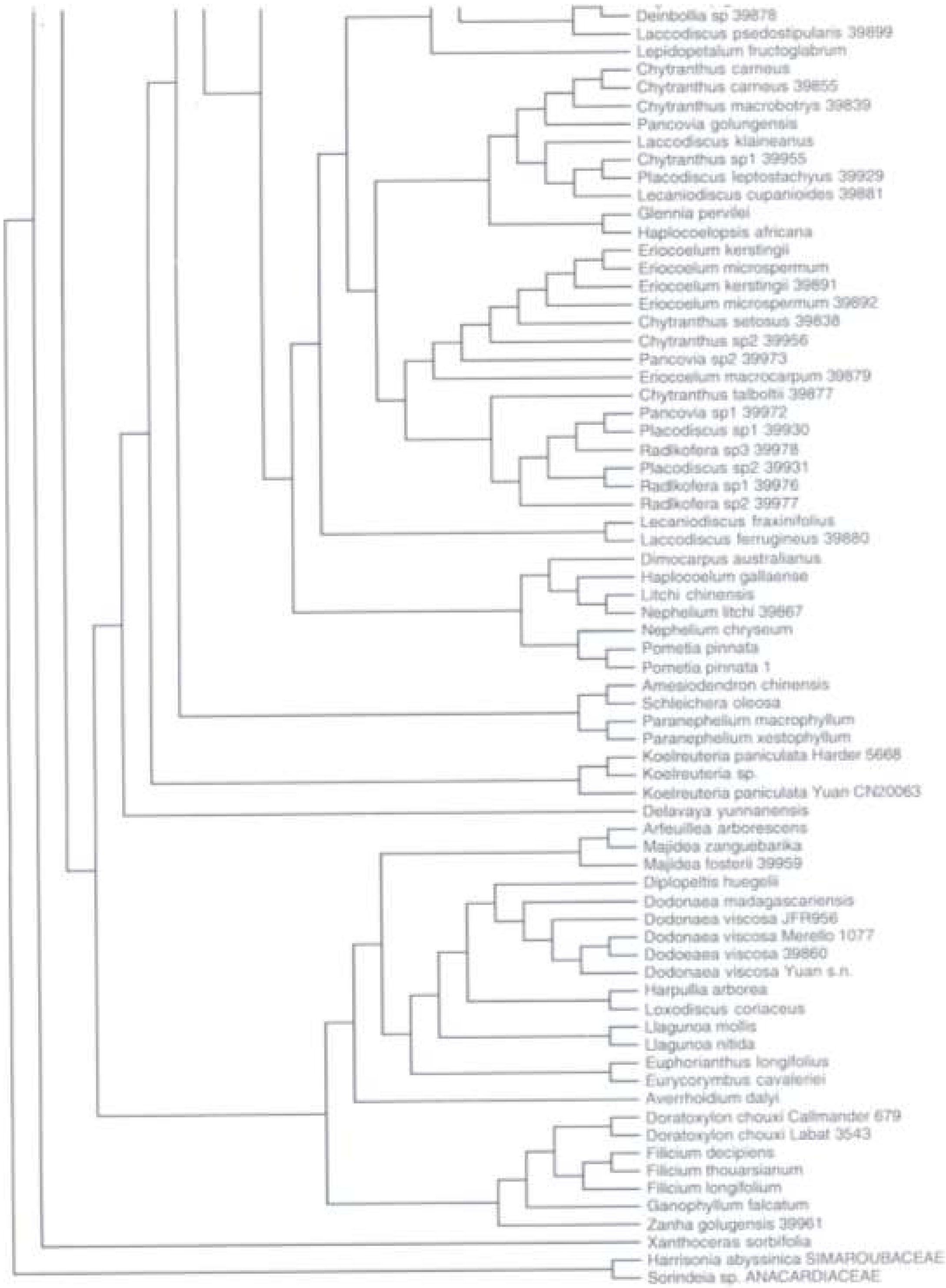


Figure 4.4.7: Two-gene Strict Consensus Tree from the Parsimony analysis based on ITS and trnL sequence data (cont'd).

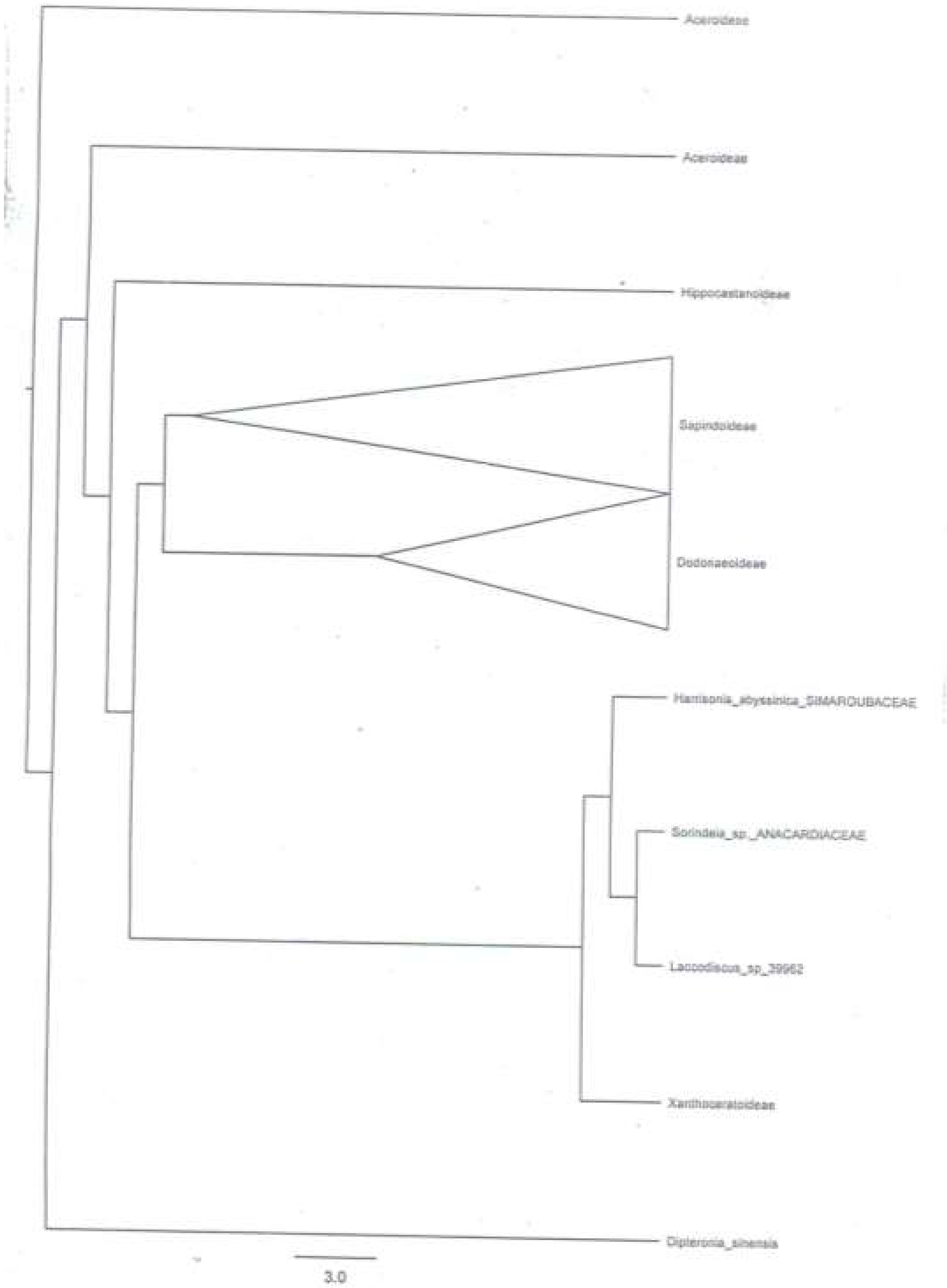


Figure 4.4.8: Combined Strict Consensus Tree from the Parsimony analysis based on ITS, trnL and matK sequence data.

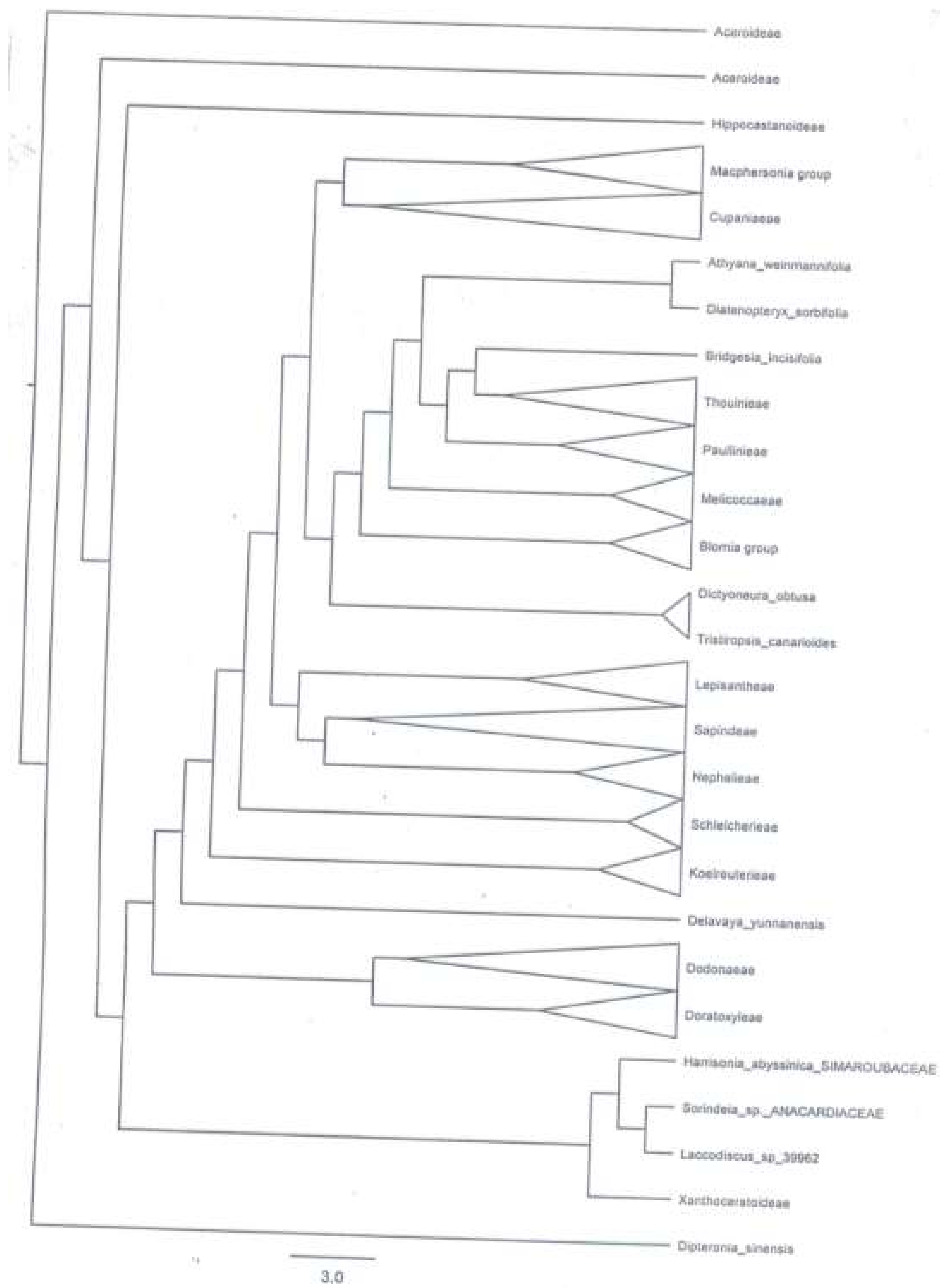


Figure 4.4.9: Combined Strict Consensus Tree from the Parsimony analysis showing sub clades.

BOOTSTRAP ANALYSIS FOR COMBINED DATA

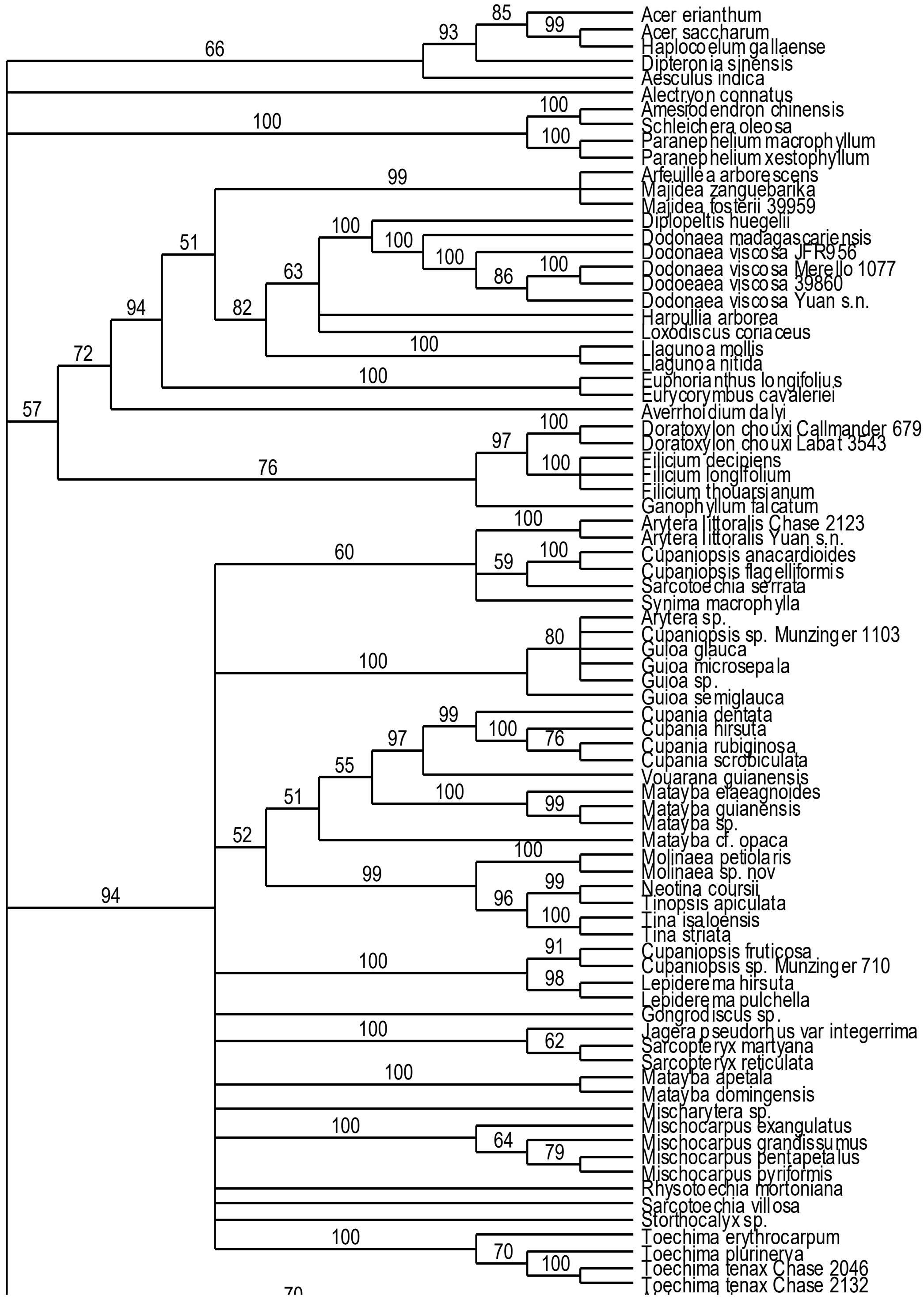


Figure 4.4.10: Phylogenetic Relationships within Sapindaceae based on combined ITS, trnL and matK sequence data. Bootstrap supports are indicated above branches

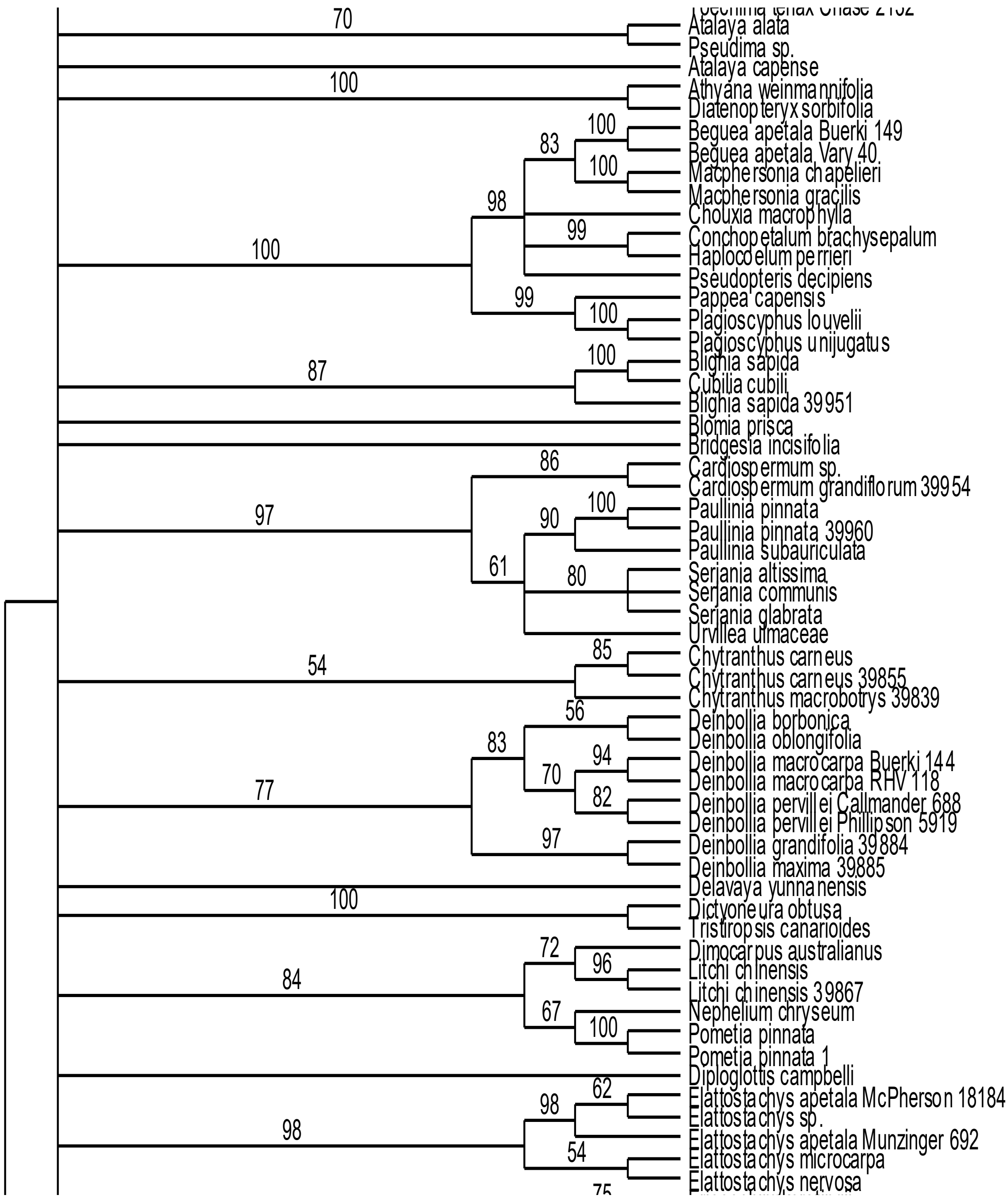


Figure 4.4.10: Phylogenetic Relationships within Sapindaceae based on combined ITS, trnL and matK sequence data. Bootstrap supports are indicated above branches (cont'd)

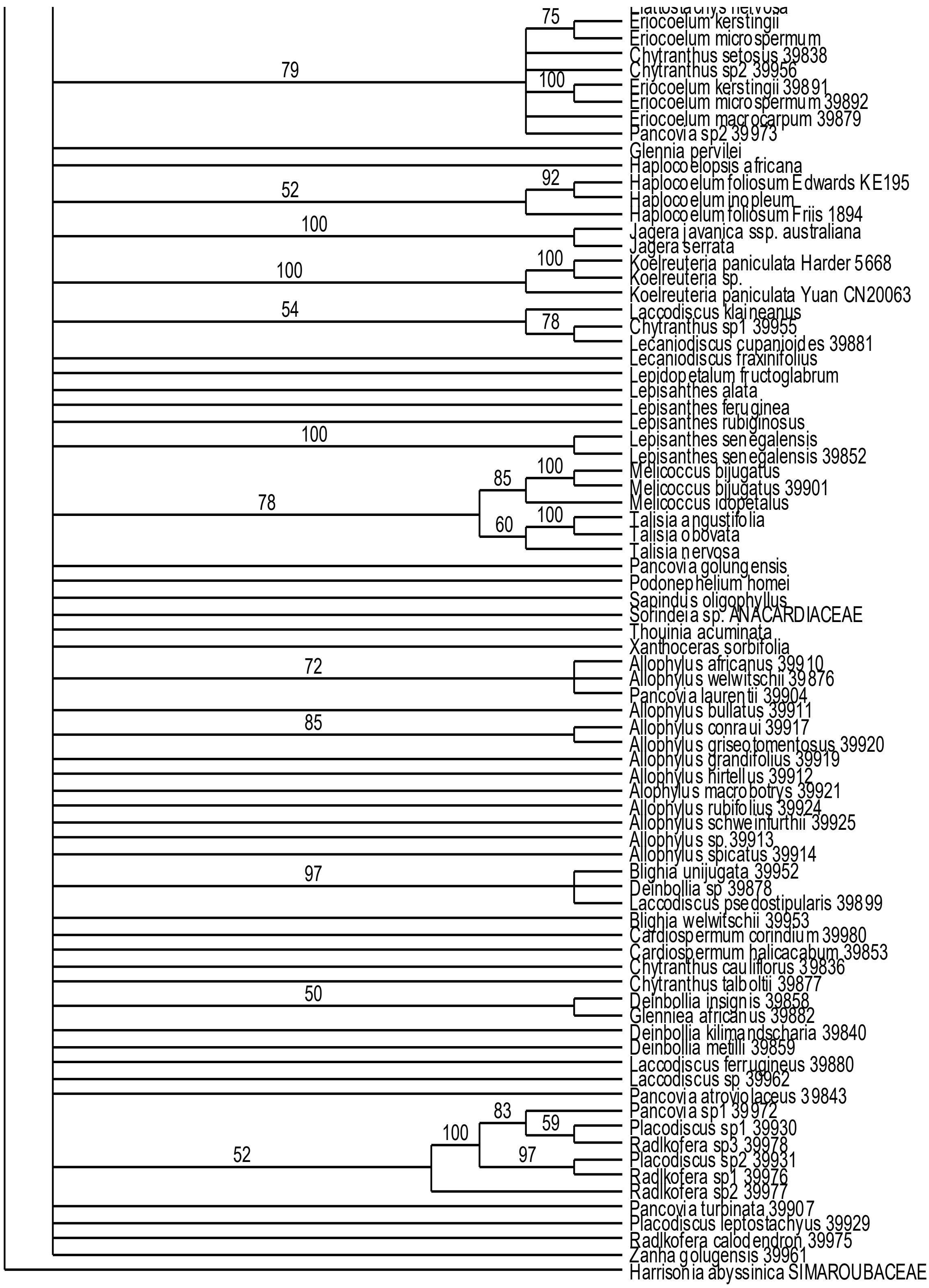


Figure 4.4.10: Phylogenetic Relationships within Sapindaceae based on combined ITS, trnL and matK sequence data. Bootstrap supports are indicated above branches (cont'd).

4.4.2. DNA BARCODING ANALYSIS

Of the seventy (70) DNA samples sent for analysis, thirty-four (34) DNA barcode sequences were generated from the matK region while thirty-five (35) barcode sequences were generated from the rbcL region. In total, sixty-nine (69) DNA barcode sequences were generated. The DNA barcode sequences were 833bp long in the matK region and 555bp in the rbcL region.

From these sequences, phylogenetic trees were generated to show the relationships existing between each taxa in the family Sapindaceae and closely related taxa of family Fabaceae (Figure 4.4.11 -4.4.12). The analysis revealed the same kind of relationships irrespective of the barcode region i.e. either matK or rbcL. *Allophylus conraui, Allophylus griseotomentosus, Cardiospermum corindum, Chytranthus carneus* and *Deinbollia kilimandscharia* were shown to be more distantly related to *Lessertia* species than other members of the family Sapindaceae.

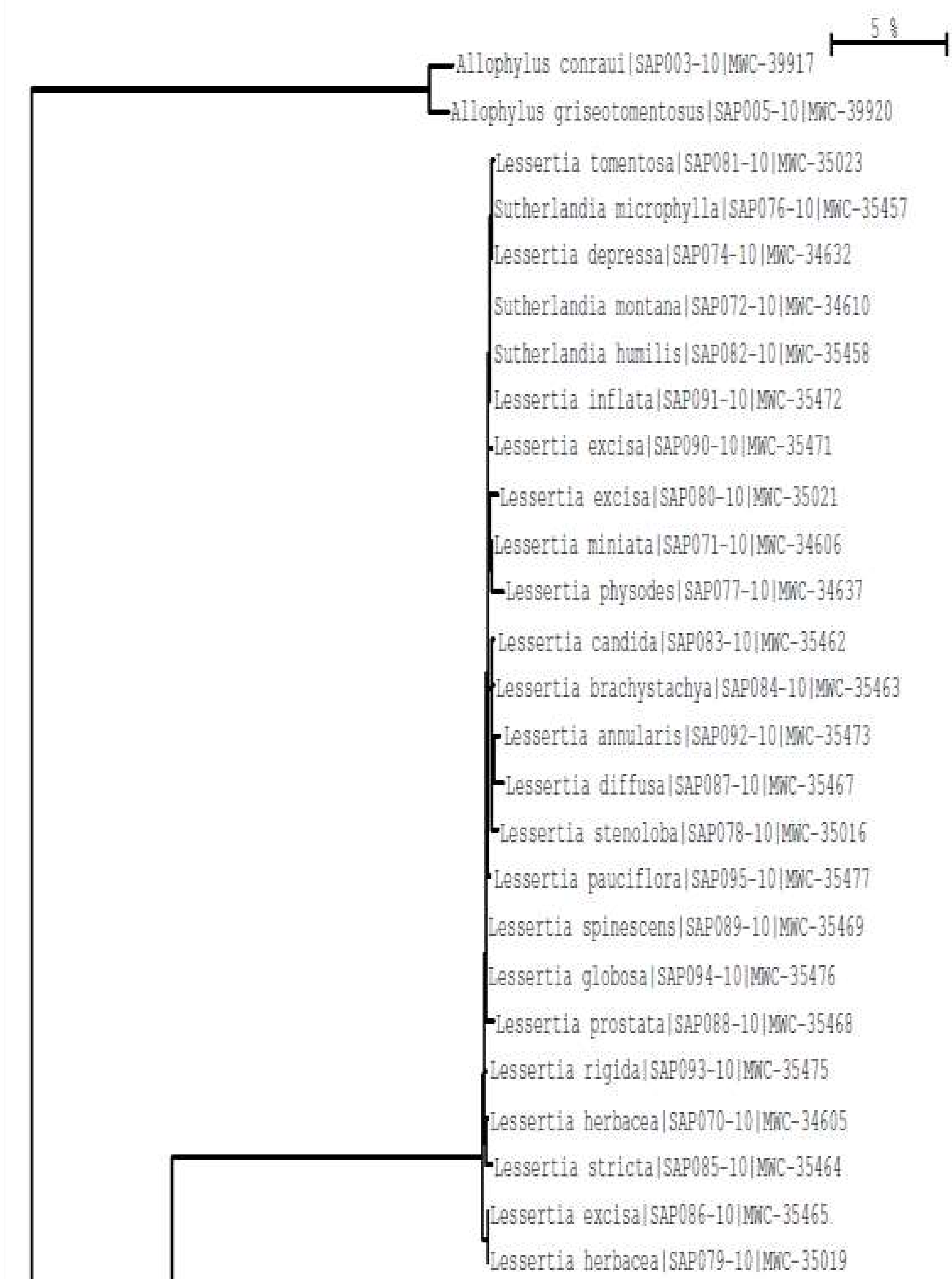


Figure 4.4.11: Phylogenetic relationship within Sapindaceae based on matK barcode sequence data

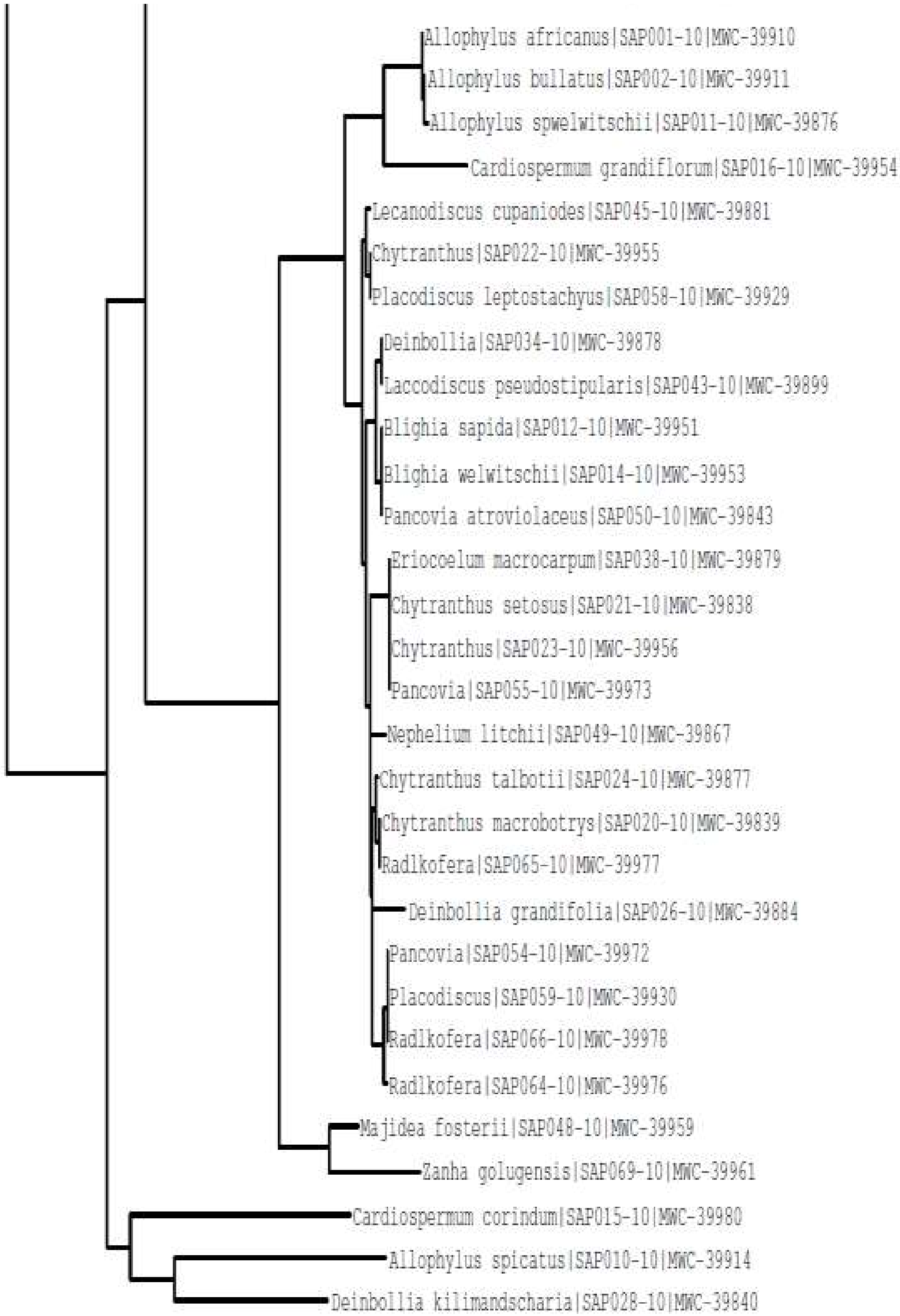


Figure 4.4.11: Phylogenetic relationship within Sapindaceae based on matK barcode sequence data (cont'd).

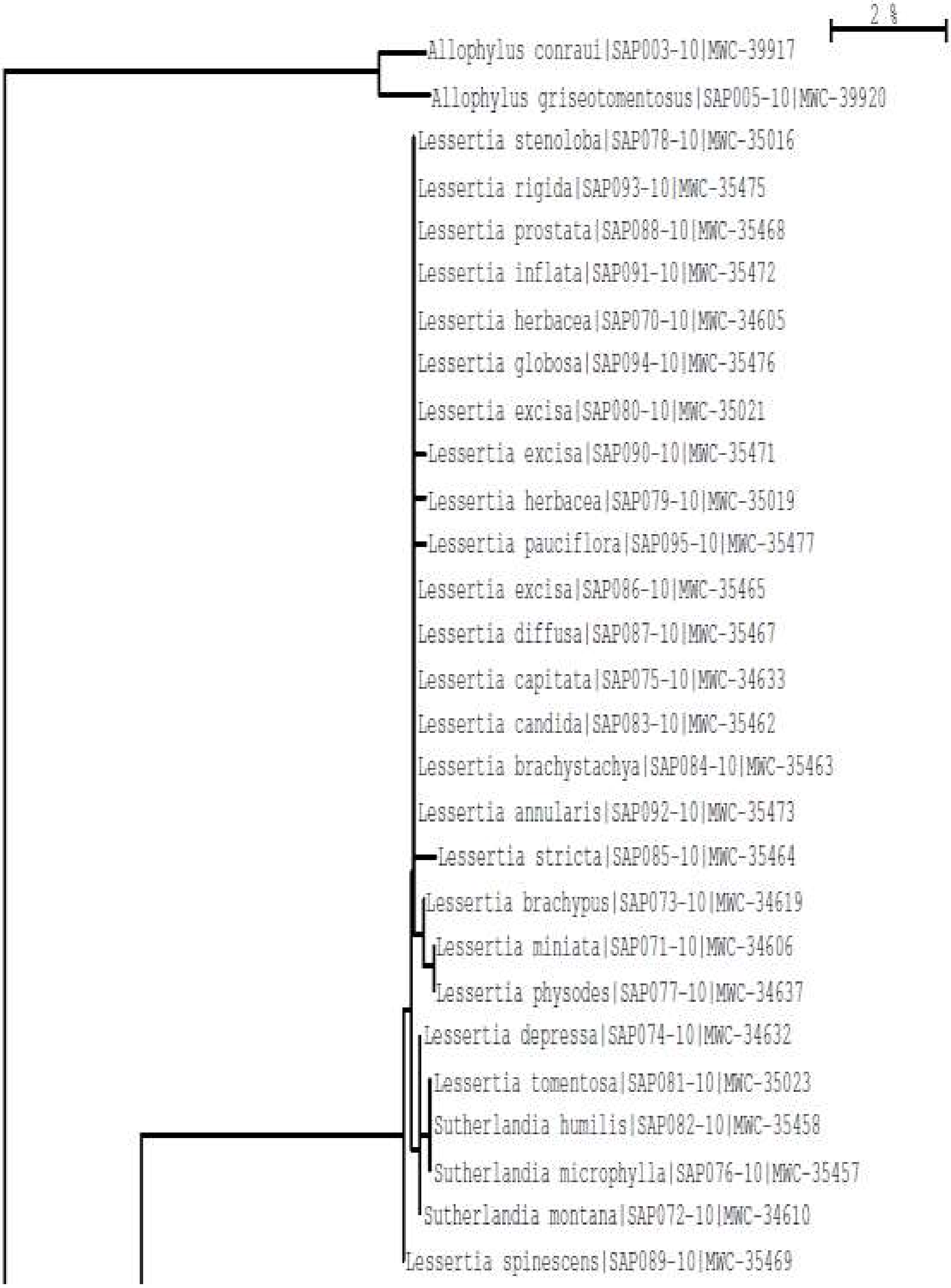


Figure 4.4.12: Phylogenetic relationship within Sapindaceae based on rbcL barcode sequence data

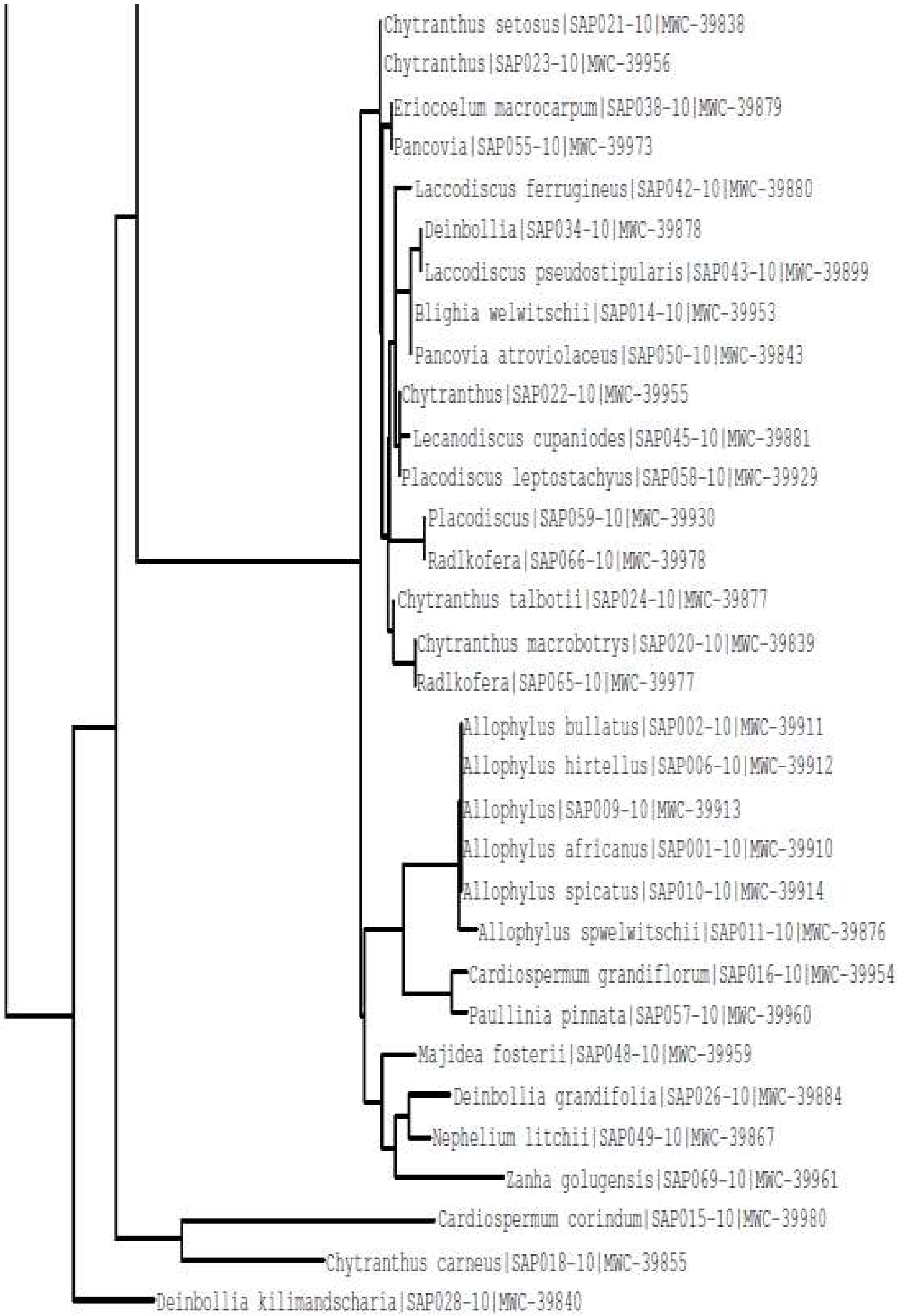


Figure 4.4.12: Phylogenetic relationship within Sapindaceae based on rbcL barcode sequence data (cont'd).

CHAPTER FIVE

5.0 DISCUSSION

Africa's biodiversity is one of the richest in the world but also one of the most threatened by human activities (such as population growth, over-exploitation, logging) and climatic change (desertification, global warming). International institutions such as the International Convention on Biological Diversity (CBD) and the United Nations Millennium Development Goals (MDG), have been set up to tackle the loss of biodiversity, while recognizing that sustainable development and poverty reduction cannot be achieved without the preservation and sensible use of biodiversity. They have also set up measurable targets including the reduction of the rate of loss of biodiversity by 2010.

While biodiversity is disappearing alarmingly fast, there have also been fantastic technological developments that can help reverse biodiversity loss – but the problem is that these novel technologies are not easily accessible by countries rich in biodiversity but constrained in resources. Although members of the family Sapindaceae have been recorded to be widely distributed in Africa, their occurrence is being threatened by high rate of deforestation and agricultural practices leading to loss of forest and threatened status of the family as recorded in the IUCN R.L. (2008). However, our sampling revealed that there are twenty eight (28) genera and a hundred and six (106) species in West Africa in contrast to the twenty four (22) genera recorded by Burkhill (2000). The other six genera include *Aphania, Atalaya, Ganophyllum, Haplocoelum, Laccodiscus* and *Litchi.*

Members of the family were largely found in the lowland forest region with a few taxa located in the highland and mountains (*Allophylus bullatus, Schleichera trijuga, Sapindus saponaria*). In West Africa, the most species rich regions are Nigeria, western Cameroon and Ghana with forty seven (47), forty five (45) and twenty five (25) taxa respectively. Endemism and number of taxa shared are highest between Nigeria and Ghana with nine (9) species endemic to the mountains and the coast respectively.

Species distribution modelling with climatological data analysis using nineteen (19) standard environmental variables from the WorldClim database revealed that the species distribution is most affected by the minimum temperature of the coldest month (bio 6) with a variable contribution of 35.4%. This is followed by precipitation of coldest quarter (bio 19) and precipitation of the wettest month (bio 13) with 16.9% and 14.9% contribution respectively. These results support the location of Sapindaceae mostly in the tropics rather than the temperate region. Also, from the AUC curve generated, it can be concluded that this present model is more reliable as it predicts the species distribution better than a typical random model as shown in figure 4.2.3. This makes it useful for future projections.

Members of the family can be largely grouped into trees (*Aporrhiza, Atalaya, Blighia, Chytranthus, Deinbollia, Dodonaea, Eriocoelum, Ganophyllum, Lecaniodiscus, Lepisanthes, Litchi, Lychnodiscus, Majidea, Melicoccus, Nephelium, Placodiscus, Radlkofera, Sapindus, Schleichera* and *Zanha*), shrubs (*Allophylus, Glenniea, Haplocoelum, Harpullia, Laccodiscus* and *Pancovia*) and climbers (*Cardiospermum and Paullinia*). They possess compound paripinnate or trifoliate leaves with exception to *Dodonaea* and the leaf surface could either be papery and glossy, glabruos or pubescent. Petiole is usually bulbous and short with tendrils in the climbing forms. Flowers are usually in form of raceme or cyme while fruits are in form of berry, drupe or capsule (3 or 5 lobed). These observations are consistent with earlier description of the family given by Heywood (1978) and Singh (2004). However, several cases of synonyms were observed and some of which are as follows:

- *Crossonephelis africanus* (Radlk.) Leenhouts*, Melanodiscus africanus* Radlk. and *Glenniea africanus* Radlk. are all the same species and the accepted name is *Glenniea africanus* Radlk.
- *Cardiospermum halicacabum* L. and *Cardiospermum corindum* L. are both same species and the accepted name is *Cardiospermum halicacabum* L.
- *Chytranthus cauliflorus* (Hutch. and Dalzi.) Wickens and *Laccodiscus cauliflorus* Hutch. and Dalzi. are synonyms and the accepted name is *Laccodiscus cauliflorus* Hutch. and Dalzi.
- *Chytranthus bracteosus* Radlk. and *Chytranthus verecundus* N. Halle and ke Assi. are synonyms and the accepted name is *Chytranthus bracteosus* Radlk.
- *Nephelium litchi* L. and *Litchi chinensis* Sonn. are synonyms and the accepted name is *Litchi chinensis* Sonn.
- *Aphania senegalensis* (Juss.) Radlk. and *Lepisanthes senegalensis* Blume are synonyms and the accepted name is *Lepisanthes senegalensis* Blume.

Also, a case of misidentification of taxa was recorded with *Laccodiscus* species (sample ID: MWC 39962). DNA analysis of the sample revealed that it is more closely related to members of family Anacardiaceae (see figures 4.4.5b, 4.4.8, and 4.4.9) however, the correct identification is yet to be confirmed.

The vegetative and reproductive morphology of Sapindaceae shows similarities and differences among the various genera constituting the family as shown in figure 4.1.1. The results obtained from the pair-wise similarity analysis support most of the taxonomic groups arrived at by orthodox methods. A common feature in the phenogram is the clear separation of the family into two major clades equivalent to the two subfamilies recognized within the family Sapindaceae i.e. Sapindoideae and Dodonaeoideae. However, within the Sapindoideae genera were separated first based on the type of leaves they bear then by the type of fruits produced. Hence *Allophylus, Cardiospermum and Paullinia* were grouped in the same clade and separated from all the other genera in the subfamily Sapindoideae due to their imparipinnate leaf type. Furthermore, *Allophylus* was separated from the other two genera due to its non-climbing habit while *Allophylus spicatus, Allophylus hirtellus* and *Allophylus schweinfurthii* were delimited from all the other *Allophylus* species due to the presence of hairs on their leaves.

Members of the Sapindaceae bearing paripinnate leaves were delimited using reproductive morphology especially the fruits thereby forming two major sub-clades i.e. one consisting of capsule bearing genera (including *Aporrhiza, Blighia, Chytranthus, Eriocoelum, Laccodiscus, Lychnodiscus* and *Pancovia*) and the other comprising berry or drupe bearing genera (including *Atalaya, Deinbollia, Glenniea, Harpullia, Haplocoelum, Lecaniodiscus, Lepisanthes, Litchi, Melicoccus, Nephelium, Placodiscus, Radlkofera, Sapindus* and *Schleichera*). Although *Zanha* has been recorded in several literatures as a member of the subfamily Dodonaeoideae (see Figure 4.4.7), it was suggested in this analysis that it is more loosely related to *Radlkofera* than other members of the subfamily Dodonaeoideae based on ITS and matK sequence data as well as combined plastid and nuclear sequence data, (see figures 4.4.4, 4.4.6 and 4.4.10).

Anatomical characterization of the family Sapindaceae using light and scanning electron microscopy revealed that the surface features consist of hairs, ridges, papillae and stomata. Members bear stomata on the abaxial surface only i.e. they are hypostomatic and this is consistent with the report of Metcalfe and Chalk (1979); exceptions are however recorded in *Dodonaea viscosa* and *Sapindus saponaria* both of which are amphistomatic in nature. Trichomes were also recorded in the family most of which are either found superficially or adpressed to the leaf surface. They are either simple unicellular, glandular, non-glandular or stellate on form; this is consistent with observations made by Pole (2010). Anticlinal wall pattern ranges from straight to wavy form with polygonal, rectangular or irregular shape. Stomata are mostly anomocytic or paracytic some of which are covered by papillae or possess striations. In addition, wax granules are found widely distributed on the leaf especially on the adaxial surface.

Taxa sampling within Sapindaceae was difficult especially as DNA was extracted from herbarium materials. Though the herbarium materials were readily available, the problem was how they were preserved and what kinds of chemicals were present in the samples. The method of plant collection and duration of drying the material is important for the survival of the DNA (Savolainen *et al.,* 1995). Some of the materials were oven dried and the old material had been exposed to pesticides, these could have degraded the quality of DNA. Due to the degraded DNA in some of the samples, not all the regions could be amplified thus; the individual data matrices do not contain identical sets of taxa. Nevertheless, DNA was successfully extracted from a hundred and nineteen (119) samples and 48% of the samples had an absorbance ratio of 1.40 – 2.0. Also, ninety (90) taxa were amplified, but more than twenty (20) taxa failed to produce sequence data. Sequences were aligned manually and each insertion/deletion was characterised by assigning gaps.

In addition to being a challenging family at the taxonomic level, the amplification of molecular markers in Sapindaceae s.l. is made difficult by several mutations occurring in flanking regions of widely used plastid and nuclear regions such as matK (Harrington *et al.,* 2005) and ITS (Edwards and Gadek, 2001). Those mutations complicate the compilation of multilocus data sets without missing data. In spite of all these technical drawbacks, the phylogeny of the family Sapindaceae was assessed.

Although there has been recent interest in the taxonomy and classification of the family Sapindaceae, there is still need to study its phylogeny. In previous studies, Sapindaceae was considered as the sister-group of Xanthoceraceae in the order Sapindales (Buerki *et al.,* 2009). The report presented in this work is probably the first record of phylogenetic study on African Sapindaceae especially those represented in the West African region. In this present study, the relationship among the genera of Sapindaceae occurring in Africa in relation to other result on the Sapindaceae and other related families like Simaroubaceae, Anacardiaceae, Aceraceae, Hippocastanaceae and Xanthoceraceae was investigated.

The phylogenetic analysis was based on a combination of one nuclear (ITS region; ITS1, 5.8S, ITS2) and four plastid (coding matK and rbcL; non-coding trnL intron and intergenic spacer trnL-trnF) markers. This is because coding plastid regions have proven to be useful in addressing phylogenetic relationships at higher taxonomic levels (e.g. Clayton, 2007; Muellner *et al.,* 2006, 2007; Harrington *et al.,* 2005), whereas non-coding regions (introns and intergenic spacers) were shown to be more useful at lower taxonomic ranks (Baldwin, 1992; Soltis and Soltis, 1998b).

This study supports previous studies by Harrington *et al.* (2005) and Buerki *et al.* (2009) on a broadly defined Sapindaceae including the family Aceraceae and Hippocastanaceae with 66% bp in the combined gene analysis (Figure 4.4.10) and 92% bp in the single gene analysis using trnL data (Figure 4.4.5b). Also there is little difference between the report of Buerki *et al.* (2009) and the result of this study in that though there is some support for "Xanthoceratoideae" being the first lineage to diverge within the broadly defined Sapindaceae assemblage (Figure 4.4.6a); *Xanthoceras* was not sister to the rest of the family in single gene analyses, being somewhat embedded. However, exception to this was recorded in the matK gene analysis where *Xanthoceras* was found to be sister to all other Sapindaceae.

While Sapindaceae occurs as a monophyletic family, paraphyly is observed at subfamilial level and this supports previous reports given by Harrington *et al.* (2005) and Buerki *et al.* (2009). In this study, *Dodonaea, Glenniea, Haplocoelum, Lepisanthes, Litchi, Majidea, Melicoccus, Nephelium, Paullinia, Sapindus, Schleichera* and *Zanha* are recognized as monophyletic while *Allophylus, Blighia, Cardiospermum, Chytranthus, Deinbollia, Eriocoelum, Harpullia, Laccodiscus, Lecaniodiscus,* *Pancovia, Placodiscus,* and *Radlkofera* as currently recognized, are para/polyphyletic. Sequence information from the matK gene produced an angiosperm tree that is considerably more robust than any previous single gene tree (Figure 4.4.6a-b). Congruence is high between our matK tree and those based on multiple genes representing one, two, or all three genomes while the least resolution was achieved with ITS gene (Figure 4.4.4a-b).

Although matK sequences provide good resolution within many angiosperm orders, combined analyses of matK and other rapidly evolving DNA regions with available multigene data sets have strong potential to enhance resolution and internal support in deep level angiosperm phylogenetics and provide additional insights into angiosperm evolution (Hilu *et al.,* 2003). This is confirmed in the present study (Figure 4.4.10).

Combined phylogenetic analyses based on trnL intron, trnL-F spacer, ITS and matK gene sequences provide strong support for the monophyly of the family when *Xanthoceras sorbifolia*, Aceraceae and Hippocastanaceae are included (although relationships among subfamilies are still weakly supported). However, in all the analyses, taxa with no sequence data were grouped with the out-group taxa. Also, one of the out-group taxa from the family Anacardiaceae – *Sorindea* species was observed as being somewhat embedded within the Sapindaceae suggesting close relationship with *Laccodiscus* species with 56% bp.

Maximizing taxa and markers representation to provide a reliable phylogenetic hypothesis inferred from nuclear and plastid genomes is required to propose a new classification for family Sapindaceae. While the inclusion of missing data was widely recognized as a major drawback in phylogenetic analyses during the early 90s (e.g.

Huelsenbeck, 1991; Wiens and Reeder, 1995), recent simulations (Wiens, 1998a, 2003, 2006) and empirical analyses (Bapteste *et al*., 2002; Driskell *et al.,* 2004; Phillipe *et al*., 2004) have shown that taxa comprising high levels of missing data could be accurately placed in phylogenies. Moreover, adding incomplete taxa to a phylogenetic analysis was even shown to improve the accuracy of a given topology, e.g. by subdividing misleading long branches (Wiens, 2005).

The present analyses resolved four clades within the family Sapindaceae: Sapindoideae, Dodonaeoideae, (57% bp) Hippocastanoideae (66% bp) (including Aceraceae) and a monotypic Xanthoceroideae. *Xanthoceras* is sister to the rest of the family while Hippocastanoideae is sister to subfamily Sapindoideae and Dodonaeoideae. A high degree of paraphyly and polyphyly were also highlighted at subfamilial and tribal level, especially in Sapindaceae s.s. (subfamilies Dodonaeoideae and Sapindoideae).

Within the subfamily Sapindoideae, twelve (12) tribes were recognised i.e. Cupaniaeae (94% bp), Thouinieae (85% bp), Paullinieae (97% bp), Melicoccaeae (78% bp), Lepisantheae (100% bp), Sapindeae, Nephelieae (84% bp), Schleichereae (100% bp), Koelreuterieae (100% bp), the *Blomia* group, *Delavaya* group and *Macphersonia* group (98% bp) while Dodonaeoideae consists three tribes namely: Dodonaeae (82% bp), Harpullieae (51%) and Doratoxyleae (76% bp).

CHAPTER SIX

6.0 SUMMARY OF FINDINGS

- The family Sapindaceae comprises twenty eight (28) genera and a hundred and six (106) species widely distributed in Africa. Members possess compound leaves which are either paripinnate, imparipinnate or trifoliate, flowers are in spirits and fruits are either in form berry, drupe or capsule (usually trilobed) and usually possess white or orange aril.
- Most of the plants in the family are found in lowland rainforest. Some however, are restricted to the mountains. The most species rich regions are Nigeria (47 taxa), Cameroon (45 taxa) and Ghana (25 taxa). Southern highlands of Nigeria have the highest number of species followed by western river banks of Ghana. Taxa shared are highest between Nigeria and Ghana. Endemism is highest in the western regions of Nigeria and Ghana with 9 species endemic to the mountains and coasts.
- The species distribution for the African Sapindaceae is most affected by the minimum temperature of the coldest month (35.4%) followed by precipitation of the coldest quarter (16.9%) and least affected by minimum temperature of driest quarter (0.2%) and precipitation of the driest month (0.3%). Also, it was observed that some of the species earlier recorded in some of the reserves were no longer found largely due to the high rate of deforestation and agricultural activities observed in the reserves.

- Genomic DNA samples from all the collected samples have been deposited in the DNA Bank at the Royal Botanic gardens Kew. Of all the samples, only sixty (60) taxa were amplified. Sixty-nine (69) DNA barcodes were generated for the family Sapindaceae based on matK and rbcL sequence data and deposited at the Barcode of Life database (BOLD) website for public use. In addition, a total of two hundred and four (204) gene sequences were generated and deposited at the Genbank.
- Phylogenetic analysis based on combined trnL intron, trnL spacer, ITS and matK sequences provides strong support for the monophyly of the family when *Xanthoceras sorbifolia*, Aceraceae and Hippocastanaceae are included (although relationships among subfamilies are still weakly supported). The family can be subdivided into four (4) subfamilies: Sapindoideae, Dodonaeoideae, (57% bp) Hippocastanoideae (66% bp) (including Aceraceae) and a monotypic Xanthoceroideae. *Xanthoceras* is sister to the rest of the family while Hippocastanoideae is sister to subfamily Sapindoideae and Dodonaeoideae. A high degree of paraphyly and polyphyly is also highlighted at subfamilial and tribal level, especially in subfamilies Dodonaeoideae and Sapindoideae. Within the subfamily Sapindoideae, twelve (12) tribes were recognised: Cupaniaeae (94% bp), Thouinieae (85% bp), Paullinieae (97% bp), Melicoccaeae (78% bp), Lepisantheae (100% bp), Sapindeae, Nephelieae (84% bp), Schleichereae, Koelreuterieae (100% bp), the *Blomia* group, *Delavaya* group and *Macphersonia* group (98% bp) while Dodonaeoideae consists three tribes namely: Dodonaeae (82% bp), Harpullieae (51%) and Doratoxyleae (76% bp).

6.1 Contributions to Knowledge

This research has been able to contribute to knowledge in taxonomic research through the following means:

1. Production of probably the first report on the position of African Sapindaceae using molecular data – a major contribution to Plant Systematics.
2. Provision of species database of the Sapindaceae in Africa with emphasis on variation patterns (a major contribution to global biodiversity information system).
3. Production of genomic DNA samples which were deposited at the DNA Bank of the Royal Botanic Gardens Kew, London – a major contribution to the conservation of plant genetic materials.
4. Production of 69 DNA barcodes and 204 DNA sequence data for Sapindaceae – a major contribution to the TREEBOL Africa and Genbank.
5. Elucidation of the contribution of environmental variables on the species distribution of family Sapindaceae in Africa.

SYSTEMATIC DESCRIPTION

Family: SAPINDACEAE Juss.

Sapindaceae Juss. nom. cons. Gen. Pl.: 246. (1789).

Type Genus: *Sapindus* L.

Description:

Trees or shrubs (or woody vines with tendrils in *Cardiospermum* and *Paullinia*), rarely herbaceous climbers. Indumentums is usually of simple hairs, often glandular on young parts, buds, and inflorescences. Leaves alternate, usually estipulate; leaf blade pinnate or digitate, mostly compound, a few simple (*Dodonaea* and *Pappea*); leaflets alternate or sub-opposite, entire or dentate to serrate. Inflorescence is a terminal or axillary thyrse. Flowers are usually unisexual, actinomorphic or zygomorphic, usually small. Sepals are 4 or 5(or 6), equal or unequal, free or connate at base. Petals are 4 or 5(or 6), sometimes absent, free, imbricate, usually clawed, often with scales or hair-tufted basal appendages. Fruit, a capsule, berry or drupe, or consisting of 2 or 3 samaras, often 1-seeded and 1-loculed by abortion. Seeds 1 (or 2 or more) per locule; testa black or brown, hard, often with a conspicuous fleshy aril.

Key to Genera:

A tropical family comprising trees, shrubs or climbers with simple, imparipinnate or paripinnate leaves and fruits in form of drupe, berry or capsule.

1a. Leaves imparipinnate, simple, biternate or trifoliate... 2

2a. Tree or Shrub, tendril absent... 3

3a. Leaves simple, fruit dehiscent capsule... *Dodonaea*

3b. Leaves trifoliate, fruit indehiscent berry...................................... *Allophylus*

2b. Climbing plant, tendril present.. 4

4a. Woody, leaves imparipinnate, margin dentate, fruit not inflated...... *Paullinia*

4b. Herbaceous, leaves biternate, margin serrate, fruit inflated... *Cardiospermum*

1b. Leaves paripinnate, leaflets 3–10 pairs.. 5

5a. Fruit dehiscent, ovary 2 or 3 lobed.. 6

6a. Inflorescence cymose, not less than 10 cm long.. 7

7a. shrub, leaf elliptic 8-12 cm long.. *Laccodiscus*

7b. Small tree, leaf oblong 10-25 cm long............................... *Lychnodiscus*

6b. Inflorescence raceme, less than 10 cm long... 8

8a. Fruit 2-lobed, leaf not more than 15 cm long.......................... *Aporrhiza*

8b. Fruit 3-lobed, leaf up to 30 cm long.. 9

9a. Inflorescence up to 20 cm long, seed without aril................ *Pancovia*

9b. Inflorescence less than 20 cm long, seed with orange aril............... 10

10a. Leaflets 5 pairs, base acute.. *Blighia*

10b. Leaflets more than 5 pairs, base cuneate....................... *Eriocoelum*

5b. Fruit indehiscent, ovary 1-3 lobed.. 11

11a. Tree, seeds without aril... 12

12a. Petiole less than 5 cm long, ovary 3-lobed.. 13

13a. Leaf apex cuspidate, leaflets less than 30 cm, stamen 7-15........*Chytranthus*

13b. Leaf apex acuminate, leaflets less than 45 cm, stamen 8............ *Placodiscus*

12b. Petiole up to 10 cm long, ovary 1-lobed.. 14

14a. Fruit berry, 3-8 cm in diameter.. 15

15a. Leaf venation pinnate, petiole pubescent........................ *Lecaniodiscus*

15b. Leaf venation reticulate, petiole glabrous.. 16

16a. Leaflet less than 12 cm long, blade up to 34 cm................ *Sapindus*

16b. Leaflets more than 12 cm long, blade up to 42 cm.......... *Schleichera*

14b. Fruit drupe, up to 10cm in diameter... 17

17a. Leaflets 3-9 pairs, inflorescence raceme... 18

18a. Leaves oblong, leaflets 5-9 pairs, seed 1........................... *Deinbollia*

18b. Leaves obovate, leaflets 4 pairs, seed 2........................... *Radlkofera*

17b. Leaflets 5 pairs, inflorescence cyme.. 19

19a. Leaves oblong, inflorescence 10-25 cm long, seed 1............... *Zanha*

19b. Leaves obovate, inflorescence 8-15 cm long, seed 2....... *Lepisanthes*

11b. Shrub or tree, seeds with aril.. 20

20a. Shrub, fruit 2-lobed... 21

21a. Leaflets 3 pairs, more than 7 cm long... *Glenniea*

21b. Leaflets 10 pairs, less than 7 cm long... 22

22a. Inflorescence 10 cm long, leaflets up to 5 cm long.................. *Harpullia*

22b. Inflorescence 10-15 cm long, leaflets less than 3 cm long... *Haplocoelum*

20b. Tree, fruit 1-3 lobed.. 23

23a. Fruit bladder-like, 3-lobed, inflorescence cyme............................ *Majidea*

23b. Fruit drupe, 1-2 lobed, inflorescence raceme... 24

24a. Leaflets 3-7 cm wide, seed with white aril... 25

25a. Fruit 3-6 cm long, seed 3... *Litchi*

25b. Fruit 5-10 cm long, seed 1.. *Nephelium*

24b. Leaflets 2-6 cm wide, seed with orange aril... 26

26a. Leaflets elliptic, 8-12 cm long...................................... *Ganophyllum*

26b. Leaflets oblong, 4-8 cm long... 27

27a. Petiole glabrous, seed 1, inflorescence up to 15 cm............. *Atalaya*

27b. Petiole sessile, seed 2, inflorescence less than 10 cm.... *Melicoccus*

Sub Family I: SAPINDOIDEAE Burnett

Sapindoideae Burnett Outl. Bot.: 889. (1835).

Type Genus: *Sapindus* L.

Description:

They grow as trees, shrubs or vines. The leaves are spirally arranged or opposite on the branches. The flowers are four-or fivefold. Carpels are usually three (two to six) with a single ovule.

Tribe I: Thouinieae Blume emend. Radlk.

Thouinieae Blume emend. Radlk. Rumphia 3: 186. (1847).

Type: *Thouinia trifoliolata* Poit. Antilles Ann. Mus. Paris: 72. (1804).

1. **Genus:** *Allophylus* L.

Allophylus L. Sp. Pl. 1: 348. (1753).

Type Species: *Allophylus zeylanicus* L. Sp. pl. 1: 348. (1753).

Description:

Shrubs, rarely trees [rarely woody climbers], monoecious or dioecious. Leaves 3-foliolate, usually minutely glandular and serrate, often associated with tufts of hairs in the axils of the main nerves beneath. Inflorescences axillary, racemose or compound racemose. Flowers unisexual, usually male and female in the same inflorescence. Sepals 4, the 2 outer are larger, petals 4, each with a hairy scale, green, white or yellow. Fruit parted into 2 or 3 schizocarps, often only 1 developed, berrylike, subglobose or obovoid. Seeds ellipsoidal to globose, black, without arillode.

1. *Allophylus abyssinicus* (Hochst.) Radlk. Nat. Pflanzenfam. 3(5): 313 (1895).

Syn.: *Schmidelia abyssinica* Hochst. Flora 26: 80 (1843).

Description:

Medium-sized to large tree 6-25 m, or shrub c. 1.2 m tall, monoecious; trunk 0.5-1 m, sometimes fluted; wood hard, white, brittle; bark smooth, grey(-green); side shoots sometimes arising from the trunk. Leaves spirally arranged 3-foliolate; leaflets elliptic, sometimes terminal leaflet shorter than lateral leaflets but often more or less similar in size, up to 14 cm long, 6 cm wide, thinly textured, hair-tuft domatia conspicuous in the axils of the veins below; margin irregularly toothed. Flowers in 1-2 branched catkin-like inflorescences up to 8 cm long, finely velvety. Fruit berry, 8 mm long, 6 mm wide, obovoid or spherical.

Habitat: (sub) montane evergreen rain forest, *Albizzia*-Croton forest, forest edges; mixed *Podocarpus latifolius* forest; riverine forest; often persisting after forest clearing; dry or moist forest (remnants); 650-4000 m alt.

Flowering time: November - March

Distribution: From Ethiopia and the DRC to Malawi and Zimbabwe.

2. *Allophylus africanus* P. Beauv. Fl. Oware 2: 54, t. 107. (1818).

Description:

Shrub or small tree. Leaves trifoliate; leaflets obovate, variously hairy; margin dentate, serrate or almost entire. Inflorescences axillary often branched, spike-like. Flowers small, creamy-white. Fruit fleshy, nearly spherical, red or black when ripe.

Habitat: In riverine thickets, open woodland and forest edges, often associated with termite mounds.

Flowering time: December - March

Distribution: Throughout Tropical Africa extending to the Eastern Cape, South Africa

2.1*Allophylus africanus* P. Beauv. var. *africanus*

Syn.: *Allophylus schweinfurthii* Gilg. Bot. Jahrb. Syst. 24: 286. (1897).

Allophylus subcoriaceus Bak. J. Linn. Soc. Bot. 37: 136. (1905).

Description:

Shrub or tree (2–)4.5–10 m tall, with heavy spreading crown; bark black or grey to reddish, smooth or rough. Leaves trifoliate, typically glabrous but hairy in variety, when glabrous dark and shiny above; leaflets narrowly elliptic to elliptic, 2–14.5 cm long, 1–7 cm wide, rounded to acuminate at the apex, attenuate to cuneate at the base, irregularly dentate, petiole (1–)2–7.5 cm long. Inflorescences 4.5–15 cm long, unbranched or usually with 1–6 branches, usually pubescent; cymules subsessile. Flowers white, greenish white or yellowish green, scented; outer sepals broadly elliptic, 1 mm long and wide; petal spathulate, 1 mm long, 0.5 mm wide. Fruit ellipsoid, 5–7 mm long, 4–4.5 mm wide, very sparsely hairy. Seed ellipsoidal, 5.5–6 mm long, 4.5 mm wide.

Habitat: Secondary forests and riverine forests.

Distribution: Cameroon.

2.2Allophylus africanus var. *griseotomentosus* Gilg. Verdc. Fl. Trop. E. Africa, Sapind. 82. (1998).

Syn.: *Allophylus griseotomentosus* Gilg. Bot. Jahrb. Syst. 24: 290. (1897).

Description:

Leaflets sparsely to densely grey pubescent beneath and often with hairy domatia in axils of main nerves and some veins.

Habitat: 200–1800 m alt.

Distribution: Burundi, Tanzania and Uganda

3. Allophylus bullatus Radlk. Bayer. Akad. Wiss. 38: 223. (1908).

Description:

Small tree 10-18 m; young branchlets yellowish-grey, 5-6 mm; leaves 3-foliolate, bullate, sparsely perbulous beneath except for conspicuous tufts of hairs in the axils of veins as well as along midrib, obovate, cuneate at the base.

Habitat: subtropical or tropical moist montane, forest; forest with *Albizzia gummifera*; 500-2500 m alt.

Distribution: Found in Cameroon, Nigeria and Sao Tome and Principe.

4. *Allophylus chaunostachys* Gilg. Bot. Jahrb. Syst. 30: 349. (1901).

Syn.: *Allophylus didymanaeus* Radlk. Bayer. Akad. Wiss. 38: 219. (1908).

Description:

Shrub or small tree, branchlets with conspicuous pale lenticels. Leaves trifoliate; leaflets elliptic, up to 16 cm long, central leaflet longer than lateral ones, glossy dark green above, paler below, thinly leathery, hairless except for hair tuft domatia in the axils of the veins below; margin with shallow spaced teeth to sub-entire. Flowers are in mostly unbranched racemes, whitish and 10-24 cm long. Fruit almost round, fleshy, 6 mm in diameter, red when ripe.

Habitat: Occurring in the understorey of sub-montane forest.

Flowering time: March - May

Distribution: Eastern DRC, Tanzania, Malawi, Mozambique, Zambia, Zimbabwe and Mpumalanga, South Africa.

5. *Allophylus cobbe* (L.) Raeusch. Corner, Gard. Bull. Straits Settlem. 10: 41. (1939).

Syn.: *Rhus cobbe* L. Sp. pl. 1: 267. (1753).

Allophylus cobbe (L.) Raeush. Nomencl. Bot.: 108. (1797).

Allophylus cobbe (L.) Blume Rumphius: 3. (1847).

Allophylus cobbe Blume Rumphia 3: 131. (1849).

Description:

Mostly a shrub, more rarely a tree up to 25 m. *Leaves* mostly 3-foliolate, l*eaflets* elliptic or oblong, more rarely lanceolate, laterals often ovate and oblique, terminal sometimes obovate, 2.5-35 cm long, 1.5-22 cm wide, nearly membranous to fleshy, base cuneate to rounded, often slightly decurrent, in the terminal leaflet; apex tapering acuminate; margin entire or serrate, crenate, or dentate, midrib hardly prominent to keeled above, prominent beneath. *Inflorescences* axillary, solitary or rarely 2 in one axil, simple to thyrsoid, up to 40 cm long, glabrous to densely pubescent. *Fruits* mostly with only l mericarp developed, globular to obovoid and narrowed at the base, 4.5-12.5 mm long, 3.5-8 mm wide, smooth to slightly wrinkled, red (black to brown when dry), somewhat fleshy and almost glabrous when ripe.

Habitat: Under ever wet as well as under seasonal conditions; on sandy beaches and coastal rocks, in brackish as well as freshwater swamps, in open places, shrubberies, and along and in secondary as well as primary forests of all kinds, as well on limestone outcrops as on granitic boulders;

from sea level up to 1500(-2000) m altitude.

Flowering time: Jan.-Dec.

Distribution: Pantropical, S Africa, Madagascar, and S.E Asia slightly penetrating into the subtropics; throughout Malesia.

6. *Allophylus conraui* Gilg ex Radlk. Bayer. Akad. Wiss. 38: 221. (1908).

Description:

Shrub, 0.8-1.5 m tall, not spiny; stems leaves and inflorescence with whitish hairs 3 mm long; leaves membranous, 3-foliolate; leaflets sub-equal, oblanceolate, sessile, toothed, 9-13 cm long, 3.5-5 cm wide.

Habitat: Ever green forest; 200-1100 m alt. (cf. below under *A. ujori.*)

Distribution: in Cameroon

7. *Allophylus ferrugineus* Taub. var. *ferrugineus* Die Pflanzenwelt Ost-Afrikas C: 249. (1895).

Syn.: *Allophylus macrobotrys* Gilg. Bot. Jahrb. Syst. 24: 288. (1897).

Allophylus welwitschii Gilg. Bot. Jahrb. Syst. 24: 287. (1897).

Description:

Tree or shrub or sometimes a climber or creeper 0.9–9 m long or tall, monoecious; bark grey, brown or reddish, smooth; slash white; young branchlets pubescent. Leaves trifoliate; petiole (1–)2–10 cm long; leaflets drying bright green, elliptic, ovate-oblong, rhomboid, obovate or oblanceolate, (2.5–)6–22 cm long, (0.9–)2.5–11 cm wide, acute to acuminate at the apex, attenuate to cuneate at the base, the laterals very asymmetric, regularly toothed or serrate, glabrous, pubescent, ferruginous hairy or velvety. Cymules 1–6-flowered, the stalks 1.5–5 mm long, usually well-spaced; pedicels 1.5–3(–5) mm long, minutely puberulous. Flowers green, white, greenish white or yellow; outer sepals elliptic, 1–1.5 mm long, 1 mm wide, 1.5–2 mm in diameter; petals spathulate, 2 mm long, 1 mm. wide. Fruit orange to scarlet, often of 2–3 mericarps, each ellipsoid, obovoid or globose, 5–8 mm. long., 4–6.5 mm. wide, or 7.5 mm. in diameter, at first sparsely hairy, glabrescent.

Habitat: Lowland, medium altitude and montane forest and bushlands. Sometimes in termite mounds in woodlands.

Distribution: West tropical Africa, Sudan

8. *Allophylus grandifolius* (Bak.) Radlk. Math.-Phys. Cl. Bayer. Akad. Wiss. 20: 313. (1890).

Syn.: *Schmidelia grandifolia* Bak. Fl. Trop. Afr. 1: 421. (1868).

Description:

Tree or shrub 3-4(-12) m tall; branchlets strong, woody, sparingly puberulous or glabrous, smooth, ash-coloured; leaves 3-foliolate, shiny reddish above, mat and sparingly puberulous beneath.

Habitat: Forest, farm bush; primary forest; forest gallery; low altitudes.

Distribution: Cameroon

9. *Allophylus hirtellus* (Hook. f.) Radlk. Sitzungsber. Math.-Phys. Cl. Bayer. Akad. Wiss. 20: 312. (1890).

Syn.: *Schmidelia hirtella* Hook f. Niger Fl.: 248. (1849).

Description:

Tree, up to 1.5 m, leaves unifoliolate. Flowers white, unisexual or polygamous, on short axillary inflorescence. Fruits about 1 cm long, red when mature.

Habitat: Forest; 1-600 m alt.

Distribution: South-east Nigeria to Western Cameroon

10. *Allophylus megaphyllus* Hutch. & Dalz. Fl. W. Trop. Afr. 1: 500. (1928).

Description:

Shrub, little-branched, branchlets pubescent, 2-4 m tall; twigs coarsely pubescent; leaves simple, large, oblong-lanceolate, with short densely pubescent petiole (1-4 cm long), 18-45 cm long, 7-15 cm broad; flowers white in dense simple inflorescences 3-8 cm long.

Habitat: In undergrowth of high forest, occasional; 1-400 m alt.

Distribution: SE Nigeria to Western Cameroon

11. *Allophylus nigericus* Bak. J. Bot. 57: 158 (1919).

Description:

Shrub 1-2 m tall; (young) branchlets and leaves (both sides) densely spreading setose; leaves simple, oblong-lanceolate, 9-22 cm long, 4-10 cm wide; flowers white; inflorescences simple, 1.5-3 cm long; fruit unknown.

Habitat: Forest

Distribution: Southeast Nigeria to Western Cameroon

12. *Allophylus rubifolius* Engl. Abh. Preuss. Akad. Wiss. 2: 292. (1892).

Syn.: *Allophylus rubifolius* (Hochst. ex A. Rich.) Engl.

Allophylus alnifolius (Baker) Radlk. Die Nat. Pflanzenfam. 3(5): 313. (1895).

Schmidelia rubifolia Hochst. ex A. Rich. Tent. Fl. Abyss. 1: 103. (1847).

Description:

Shrub or small tree. Leaves trifoliate; leaflets obovate to elliptic, 3-9 cm long, glossy green above, paler below; domatia conspicuous in the axils of lateral veins below; margins irregularly crenate-dentate. Inflorescences axillary in branched or unbranched, catkin-like racemes. Flowers small cream or yellowish-green. Fruit fleshy, ovoid to near-spherical, orange-red to black when ripe.

Habitat: Riverine thickets, woodland.

Flowering time: November – March

Distribution: Congo, Mozambique, Zimbabwe, Madagascar and North-east Tropical Africa

13. *Allophylus spicatus* Radlk. Nat. Pflanzenfam. 3(5): 312. (1895).

Description:

Shrub 3-4 m tall; young branchlets with fine, spreading ferruginous silky hairs, later glabrescent; leaves 3-foliolate, terminal leaflet largest, elliptic-obovate, leaflets and petioles spreading long-hairy. Inflorescences pendulous; calyx green, petals white; ripe fruits red.

Habitat: Forest; forest gallery; degraded forest; savannah, in rocky sites and along streams; on granitic rocks; rocky riversides; shrub; rare in the forest zone; 300-600 m alt.

Distribution: West tropical Africa

14. *Allophylus sp*

Description:

Shrub 4 m, leaves trifoliate, glabrous, obovate with serrate margin, acuminate apex and cuneate base.

Habitat: Rain forest

Distribution: Cameroon

15. *Allophylus talbotii* Bak. J. Bot. 57: 186. (1919).

Description:

Liane 10 m long; twigs reddish, slightly lenticellate; leaves 3-foliolate; leaflets papery, glabrous, entire, 8-12 cm long, 3-6 cm wide, drying silvery brown; flowers white in branched slender panicles with a few scattered hairs, longer than leaves.

Habitat: Evergreen or moister forests; higher alt. (850 m, Liberia, Mt Nimba).

Distribution: West tropical Africa.

16. *Allophylus zenkeri* Gilg. ex Radlk. Bayer. Akad. Wiss. 38: 224. (1908).

Description:

Shrub 2-3 m tall, or tree 5-20 m, or liane; branches pubescent; leaves 3-foliolate, petiole hairy, 3-5 cm long; leaflets reddish above, light brown beneath, 12-18 cm long, 5-6 cm wide, glabrous except for midribs and nerves on both surfaces.

Habitat: Forest

Distribution: Cameroon

Tribe II: Paullinieae Kunth ex DC.

Paullinieae Kunth ex DC. Prodr. 1: 601. (1824).

Type: *Paullinia* L.

2. **Genus:** *Cardiospermum L.*

Cardiospermum L. Sp. Pl. 1: 366. (1753).

Type Species: *Cardiospermum halicacabum* L.

Description:

Annual or perennial climbing herbs, stems ridged, stipules small. Leaves alternate, compound (2-ternate to apparently pinnate). Inflorescence axillary, at the apex of a relatively long peduncle, with a pair of coiled tendrils just below. Flowers zygomorphic, bracts minute, sepals 4; lateral small, the other 2 larger; petals 4, stamens 8, ovary 3-locular. Fruit an inflated membranous capsule. Seed black with a white, ovate to reniform (sometimes heart-shaped) hilum.

Worldwide: 14 spp., mainly tropical America, but with 3 spp. widespread in the tropics.

17. *Cardiospermum corindum* L. Sp. Pl. 1: 526. (1753).

Syn.: *Cardiospermum pubescens* Lagasca. Gen. Sp. Pl. 14. (1816).

Cardiospermum molle Kunth. H.B.K. Nov. Gen. Sp. 5: 104. (1821).

Cardiospermum canescens Wall. Pl. Asiat. Par. 1: 14. (1830).

Cardiospermum alatum Bremek. & Oberm. Ann. Transvaal Mus. 16: 422. (1935).

Description:

Annual herbaceous climber. Leaves pinnate to biternate; leaflets up to 4 cm long, 2 cm wide, lowest pair ternate, bright green above, grey-green below, finely velvety; margin scalloped to lobed. Flowers white to creamy yellow, 4-6 mm long, in axillary branched many-flowered heads; peduncle 6 cm long, with paired coiled tendrils below the flowers. Fruit a membranous, inflated capsule, 2-3.5 cm long, 3-angled. Seed 5 mm in diameter with a kidney-shape.

Habitat: riverine fringes and dry deciduous woodland and scrub.

Distribution: Widespread in tropical and subtropical regions but in our area confined mainly to the Limpopo, Runde-Save and Upper Zambezi river valleys.

18. *Cardiospermum grandiflorum* Sw. Prodr.: 64. (1788).

Syn.: *Cardiospermum barbicule* Baker D. Oliver, Fl. trop. Afr. 1: 418. (1868).

Cardiospermum hirsutum Willd. Sp. pl. 2(1): 467. (1799).

Description:

Perennial climber. Stems with bristly hairs, sometimes slightly woody; tendrils present. Leaves compound; leaflets with serrate margins. Flowers in many-flowered axillary heads, white with a yellowish centre, fragrant. Fruit a membranous, inflated capsule, green, drying to brown. Seeds round and black with an oblong to heart-shaped spot (hilum). It was introduced as a garden ornamental and has only recently become widely naturalised, particularly in and around Harare.

Habitat: urban areas but also near the margins of forest and riverine fringes.

Distribution: Tropical Africa

19. *Cardiospermum halicacabum* L. Sp. Pl. 1: 366. (1753).

Syn.: *Cardiospermum halicacabum* L. var. halicacabum

Cardiospermum microcarpum Kunth. Nov. Gen. et Sp. 5: 1.104. (1820).

Cardiospermum halicacabum var. microcarpum (Kunth) Blume. Rumphia. 3: 185. (1847).

Description:

Annual climber. Stems with minutely puberulous, sometimes slightly woody; tendrils present. Leaves biternate, essentially 3-foliolate with each part divided again into 3 leaflets; leaflets with coarse serrate teeth. Flowers in axillary heads, usually 3-flowered by abortion, white with a yellowish centre. Fruit a membranous, inflated capsule, green, drying to brown, more than 2 cm long. Seeds round and black with a broadly heart-shaped or kidney-shaped spot.

Habitat: Mainly in riverine fringes, up to 1300 m.

Distribution: Pantropical

3. **Genus:** *Paullinia* L.

Paullinia L. Sp. Pl. 1: 366. (1753).

Type Species: *Paullinia pinnata* L.

Description:

Woody climbers. Stipules present. Leaves imparipinnate. Inflorescence raceme-like with 2 coiled tendrils from the peduncle apex. Flowers unisexual, slightly zygomorphic, sepals 5, petals 4, stamens 8, ovary 5-locular. Fruit a tardily dehiscent, trigonous or narrowly winged, woody capsule. Seed with arillode.

Worldwide: 150-200 spp. all apart from *P. pinnata*, confined to tropical America.

20. *Paullinia pinnata* L. Sp. Pl. 1: 366. (1753).

    Syn.: *Paullinia pendulifolia* Rusby Mem. New York Bot. Gard. 7: 291. (1927).

    Paullinia angusta N.E. Br Trans. & Proc. Bot. Soc. Edinburgh 20: 49. (1894).

    Paullinia hostmannii Steud. Flora 27: 725. (1844).

    Description:

    Liane or climbing shrub. Leaves imparipinnate with winged rachis. Inflorescences axillary on long stalks, bearing paired coiled tendrils. Flowers white. Fruit 2.5 cm long, obconical, 3-lobed at the apex, red when ripe.

    Habit: In evergreen and mixed forest.

    Flowering time: December – January

Distribution: Widespread in tropical America, tropical Africa and Madagascar.

Tribe III: Sapindeae Kunth ex DC.

Sapindeae Kunth ex DC. Prodr. 1: 607. (1824).

Type: *Sapindus* L.

4. **Genus:** *Atalaya* Blume

Atalaya Blume Rumphia 3: 186. (1849.)

Type Species: *Atalaya salicifolia* (DC.) Blume

Description:

Small trees or shrubs, monoecious. *Leaves* paripinnate (towards the inflorescence sometimes ternate to 1-foliolate), stipules absent; petiole and rachis often partly marginate to sometimes winged. *Leaflets* entire; petiolules short to very short, swollen. *Inflorescences* terminal and sometimes in the upper leaf-axils, paniculate. *Sepals* 5, free, imbricate, outer 2 smaller, p*etals* 5, imbricate, (sub)equal, slightly longer than the calyx, clawed, outside variably pilose, inside above the claw provided with a small, long-hairy scale. F*ruits* 3-winged, breaking up to samara with a dorsal, straight, curved or oblique wing, s*eeds* without aril.

Worldwide: 12 species: 9 in north and east Australia, 1 in southeast New Guinea; 2 species in South Africa.

21. *Atalaya capensis* R.A. Dyer S. African J. Sci. 34: 216. (1937).

Description:

Perennial tree 1.5 - 13 m, leaves paripinnately compound, leaflets oblong, entire, apex acuminate, base cuneate, 4-8 cm long, 2-6 cm wide, alternate and glabrous. Inflorescence raceme, white, 5-15 cm long. Fruit indehiscent drupe, ellipsoidal with black seed.

Habit: Alt 155 - 425 m.

Distribution: South Africa and south eastern Guinea. Tropical and subtropical regions with a periodically dry climate; light forests.

5. **Genus:** *Deinbollia* Schumach. & Thonn.

Deinbollia Schumach. & Thonn. Danske Vinensk Selsk. Skift. 4: 16. (1827).

Type Species: *Deinbollia pinnata* (Poir.) Schum. & Thonn.

Description:

Dioecious trees or shrubs. Leaves paripinnate; leaflets in 2-11 pairs. Inflorescence a terminal or axillary thyrse. Flowers actinomorphic, sepals 5, free or almost so, petals present, well-developed, 5, ciliate, with a deeply 2-lobed scale at the base. Stamens 12-30. Ovary (2)3(5)-locular; each loculus 1-ovulate. Fruits of (2)3(5) cocci, sub-spherical, indehiscent, seed 1 per coccus.

Worldwide: 40 species in warm regions of Africa and Madagascar.

22. *Deinbollia angustifolius* D.W. Thomas Ann. Missouri Bot. Gard. 73(1): 219 (1986).

Description:

Much branched shrub to 1 m tall; leaves with 1 pair of leaflets linear-lanceolate, 10-30 cm long, 0.8-2.2 cm wide; panicles sparsely pubescent, to 12 cm long; fruits 1.5 cm.

Habit: Exposed rocky river banks; rheophyte.

Distribution: Cameroon

23. *Deinbollia grandifolia* Hook. f. Niger Fl.: 249. (1849).

Description:

Shrub or single-stemmed tree, straight, 1.5-4-8(-15) m tall; trunk to 30 cm; bark ash-grey, scaly, resinous, with pungent smell; branchlets often zigzag, reddish with white lenticels; l eaves in terminal whorls, 0.7-1 m long.

Habit: Deciduous forest, in understorey; forest with *Triplochiton scleroxylon*; riverine forest; up to 700 m alt.

Distribution: West tropical Africa and Cameroon

24. *Deinbollia insignis* Hook. f. Niger Fl.: 250. (1849).

Description:

Tree 3.5-8 m, palm-shaped; leaves 60-100 cm long (petiole 20 cm); leaflets in 6-8 pairs, oblong-elliptic, acuminate, the uppermost the largest (45 cm long, 16 cm wide); inflorescence terminal, paniculate or simple, pubescent, 10-35 (-70) cm long.

Habit: lowland rain forest

Distribution: Nigeria and Cameroon

25. *Deinbollia kilimandscharia* Taub. Pflanzenw. Ost-Afrikas C: 250. (1895).

    Syn.: *Deinbollia kilimandscharia* Taub. var. *kilimandscharia*

    Description:

    Tree 1.2-8-12 m, or shrub; trunk unbranched; branchlets and leaves sub-glabrous to dark brownish pubescent; leaves in terminal rosette, 20-80 cm long (petiole 5-30 cm); petiole and rachis mottled brown or green and straw-coloured when dry.

    Habit: Evergreen moist or dry forest, *Podocarpus-Ocotea* forest, gorge and riverine forests, primary upland *Aningeria-Olea* forest, lowland *Aningeria altissima-Chlorophora-Celtis* forest; downward extensions of upland rainforest; 600-2600 m alt.

    Distribution: East tropical Africa

26. *Deinbollia maxima* Gilg Mem. Soc. Linn. Normand. xxvi. II. 73 (1924).

    Description:

    Tree 4-6 m or shrub 1-3 m tall, branched; branchlets striate, inconspicuously lenticellate-punctate, glabrous, 1.2 cm; bark greyish-brown; leaves 50-65 cm long (petiole 10-22 cm).

    Habit: Forest; 1-400 m alt.

    Distribution: Upper and Lower Guinea, in Sierra Leone, Nigeria, Cameroon and Gabon.

27. *Deinbollia mezilii* D.W.Thomas & D.J.Harris Kew Bull. 54(4): 954 (1999).

Description:

Tree to 1.5 m, unbranched; stem terete terminating in a cluster of leaves; bark pale grey, smooth, shining; leaf petiole stout, triangular, thickened at base and apex 1 cm long.

Habit: Sub montane rain forest

Distribution: Cameroon

28. *Deinbollia molluscula* Radlk. Wiss. Erg. Deut. Zentr.-Afr. Exped. (1907-1908). Bot. 2: 477. (1912).

Description:

Shrub or tree 1-5 m tall; densely lenticellate, slightly grey-downy or glabrous; leaves 15-30 cm long with petiole 8-10 cm.

Habit: Sub montane rain forest

Distribution: Cameroon

29. *Deinbollia pinnata* (Poir.) Schum. & Thonn. Danske Vinensk Selsk. Skift. 4: 16. (1827).

Syn.: *Ornitrophe pinnata* Poir. Encycl. 8: 266. (1808).

Description:

Erect shrub or tree 0.3-5 m tall; twigs 5 mm, densely lenticellate, slightly grey-downy or glabrous; leaves 20-30 cm long (petiole 8-10 cm).

Habit: Coastal grass savannah; sandy laterite soils; forest, especially secondary forest, savannah/forest edges and gaps in forest; old farms; teak plantations; weedy; 400-1300(-1818) m alt.

Distribution: Cameroon

30. *Deinbollia pycnophylla* Gilg ex Radlk. Engl. Pflanzenreich, Sapindac. 683 (1932).

Description:

Tree 8-12 m, branched, palm-shaped; branches 1 cm, sparsely hairy, soon glabrescent; bark ash-grey; leaves 55-80 cm long (petiole 10-15 cm).

Habit: Primary forest; 400 m alt.

Distribution: Cameroon

31. *Deinbollia pynaertii* De Wild. Ann. Mus. Congo Belge, Bot. sér. 5, 3[1]: 111. (1909).

Syn.: *Deinbollia pynaertii* De Wild. var. *pynaertii*

Description:

Shrub or tree, unbranched, palm-shaped, 3-4 m tall; stem 10-12 cm; leaves 60-70 cm long (petiole 10-20 cm), rachis sub-velutinous or glabrous; leaflets in 6-11 pairs, oblong, glabrous, 8-35 cm long, 4-15 cm wide, very variable even on the same plant.

Habit: Plateau and swampy forest, on islands (muddy soil); 400 m alt.

Distribution: DR Congo.

32. *Deinbollia* sp

<u>Description:</u>

Shrub 4-6 m tall. Leaf compound paripinnate, 6-8 leaflets, elliptic to oblanceolate, microphylls entire, herbaceous with winged rachis.

<u>Habit:</u> Lowland rain forest

<u>Distribution:</u> Cameroon

33. *Deinbollia voltensis* Hutch. Check-Lists For Trees & Shrubs Brit. Empire No. 3: 126. (1937), anglice.

<u>Description:</u>

Shrub 0.6 m, leaf paripinnately compound, 4-6 leaflets, elliptic to oblanceolate, microphylls entire, herbaceous with winged rachis.

<u>Habit:</u> Seasonally flooded grassland, gallery forest.

<u>Distribution:</u> Upper guinea, Ghana.

6. **Genus:** *Sapindus* L.

Sapindus L. nom. cons. Gen. Pl. 1: 359. (1737).

Type Species: *Sapindus saponaria* L.

<u>Description:</u>

Trees, rarely shrubs, monoecious. Leaves paripinnate, rarely simple, alternate, estipulate; leaflets entire, opposite or alternate. Thyrses large, many branched, terminal or fascicled at branchlet apices. Flowers unisexual, actinomorphic or zygomorphic, sepals 5 or sometimes 4, imbricate, outer 2 smaller, petals 5, clawed, with 2 earlike scales at base or margin thickened adaxially. Fruits trilobed.

34. *Sapindus saponaria* L. nom. cons. Sp. Pl. 1: 367. (1753).

Syn.: *Sapindus inaequalis* DC. Prodr. 1: 608. (1824.)

Sapindus saponaria L. f. *inaequalis* (DC.) Radlk. Publ. Field Columbian Mus., Bot. Ser., 1(4): 402. (1898).

Sapindus divaricatus Cambess. A. F. C. P. de Saint-Hilaire, Fl. Bras. merid. 1: 300. (1828).

Sapindus indicus Poir. Encycl. 6: 667. (1805). "*indica*"

Description:

Tree 8-18(-20) m, monoecious; crown rounded; bark yellowish brown, rough and corrugated on trunk, flaking off in large flakes to reveal brown patches, but smooth on branches. Leaves with petiole 25-45 cm or longer, axis slightly flat, glabrous; leaflets 5-8 pairs, usually sub-opposite; petiole 5 mm; blades 7-15 cm long, 2-5 cm wide, thinly papery, base cuneate, apex acute or shortly acuminate. Inflorescence terminal, conical, flowers actinomorphic, small, sepals ovate or oblong-ovate, larger ones 2 mm. Petals 5, lanceolate, 2.5 mm.

Habit: Boreal forest, coniferous forests, cultivated areas, deciduous woods and forests, desert, desert scrub, disturbed sites, fence rows, fields, forest edges, forests, gardens, grasslands, hammocks, hardwood forests, mature forests, meadows, open forests, pasture, pine forests, plantations, rain forest, shrubby vegetation, thickets, tropical forest and tundra grassland.

Distribution: Widely cultivated in tropical Africa.

35. *Sapindus trifoliatus* L. Sp. Pl. 367. (1753).

Syn.: *Sapindus laurifolius* Vahl Symb. Bot. 3: 54. (1794).

Description:

Tree to 18 m; bole 1.5 m in girth; branchlets purplish brown; leaves 15-25(-35) cm long; leaflets in (1-)3(-4) pairs, elliptic-oblong to obovate, 10-20 cm long, 5-11 cm wide; panicles 6-15 cm long.

Habit: Rain forest, shrubby vegetation, thickets, tropical forest

Distribution: Widely cultivated in tropical Africa.

Tribe IV: Lepisantheae Radlk.

Lepisantheae Radlk. Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 8: 269. (1878).

Type: *Lepisanthes* Blume.

7. **Genus:** *Chytranthus* Hook. f.

Chytranthus Hook. f. Gen. Pl. 1(1): 403. (1862).

Type Species: *Chytranthus mannii* Hook f.

Description:

Shrub or tree. Leaves compound paripinnate, pubescent or glabrescent, hairy on the petioles, rhachides, petiolules and midrib. Leaflets oblong to elliptic, apex acuminate, base cuneate. Inflorescence raceme. Stamen 7-9.

36. *Chytranthus angustifolius* Exell. J. Bot. 66, Suppl. 1: 86 (1928).

Syn.: *Chytranthus bracteosus* Radlk. Engl. Pflanzenreich, Sapindac: 787 (1932).

Description:

Tree (or shrub) with simple fleshy trunk 3-8 m tall, 5 cm; leaves 45-90 cm long with 8-12 pairs of leaflets hairy or velvety to touch, shiny beneath, middle ones the largest, acuminate to drip-tipped, narrow, (9-16-) 20 cm long, (3-) 4-5 cm wide.

Habitat: Forest; shady humid forests; 50-700 m alt.

Distribution: Angola

37. *Chytranthus atroviolaceus* Bak. ex Hutch. & Dalz. Fl. W. Trop. Afr. ed. 1(1): 504. (1928).

Syn.: *Chytranthus brunneo-tomentosus* Gilg ex Radlk. Veg. Erde 3: II. (1921)

Description:

Shrub or slender tree, unbranched, 0.8-5-18 m; trunk (2-)15 cm; small axillary buds conspicuously hirsute; leaves 0.5-1.2 m long, in terminal clusters, with 3-6 pairs of leaflets, elliptic, 15-40 cm long, 7-15 cm wide, the largest pairs at apex, hairy or glabrous.

Habitat: (Evergreen) forest; in understorey of high forest; moist and periodically flooded forest, on grey clay loams; forest margins; 1-1300 m alt.

Distribution: Cameroon, Nigeria.

38. *Chytranthus carneus* Radlk. Wiss. Erg. Deut. Zentr.-Afr. Exped. (1907-1908).

Syn.: *Chytranthus villiger* Radlk. Engl. Pflanzenreich, Sapindac: 794. (1932).

Chytranthus welwitschii Exell J. Bot. 66(Suppl. 1): 85. (1928).

Description:

Tree (or shrub) monoecious, palm-like, rarely branched, 3-10 m tall; stem 10-15 cm, hairy when young, with 2 deep groves below the basal thickening of the petioles; leaves 0.6-1.2 m long, with 4-12 pairs of leaflets, the outermost largest.

Habitat: Various types of forests, in understorey; evergreen forest; riverine forest; 1-700 m alt.

Distribution: Cameroon

39. *Chytranthus cauliflorus* (Hutch. & Dalz.) Wickens. Kew. Bull. 23: 345. (1969).

Syn.: *Laccodiscus cauliflorus* Hutch. & Dalz. Fl. W. Trop. Afr. 1: 500. (1928).

Chytranthus mangenotii N. Halle & Ake Assi. Adansonia. ser 2(2): 295 tab. 1. (1962).

Description:

Unbranched shrub or tree 2-8 m tall; branchlets, leaf-rachis, lower surface of leaflets and inflorescence densely orange-brown long-hairy; trunk 2-8 cm; leaves 0.5-1 m long, with 3-7(-11) pairs of leaflets.

Habitat: Evergreen forest in understorey; in small stands in primary rain-forest; 500-586 m alt.

Distribution: Gabon

40. *Chytranthus gilleti* De Wild. Ann. Mus. Congo Belge. Bot., Ser. 5 1: 284 (1906).

Description:

Tree, unbranched, 2-8(-10) m; leaves 35-70 cm long, with (3-) 4-6 (-7) pairs of leaflets; petiole, rachis and nerves of leaflets densely tomentose.

Habitat: Forest with *Gilbertiodendron dewevrei*; terra firma mixed-species forest; in understorey; gallery forest; 480-950 m alt.

Distribution: Cameroon and west tropical Africa.

41. *Chytranthus macrobotrys* (Gilg) Exell & Mendonca., Carrisso, Consp. Fl. Angol. 2: 84 (1954)

Syn.: *Glossolepis macrobotrys* Gilg Bot. Jahrb. Syst. 24: 299. (1897).

Description:

Tree, palm-shaped, with 1 or 2 short branches, (1.5-) 2-11 m tall, or often a straggling shrub, sparingly branched, arching over the ground; leaves 50-80 cm long (petiole 16-25 cm), glabrous, with (2-)3-6 pairs of leaflets.

Habit: Closed forest in wet situations, in understorey; primary riverine forest, swamp forest; also in drier forest, mountainous forest; forest with *Gilbertiodendron dewevrei* and with mixed species; 1-950 m alt.

Distribution: Ghana, Nigeria, Cameroon

42. *Chytranthus setosus* Radlk. Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 20: 232 (1890).

Description:

Tree 1.5-6 m, palm-shaped, or shrub 2.5-4 m tall, dioecious; trunk slender, 1.5-10 cm; young branchlets grooved; all parts whitish tomentose.

Habit: Terra firma forest; evergreen forests; shady woods; forest gallery and on islands; secondary forests; 200-400 m alt.

Distribution: West tropical Africa, Cameroon, Congo

43. *Chytranthus* sp 1

Description:

Tree, leaves paripinnately compound, leaflets oblong, entire, apex cuspidate, base cuneate, 19-45 cm long, 10-20 cm wide. Inflorescence raceme, up to 10 cm long. Fruits capsule, 3-lobed, 5-10 cm in diameter.

Habit: Sub-montane forest

Distribution: Cameroon

44. *Chytranthus* sp 2

Description:

Tree, leaves paripinnately compound, leaflets oblong, entire, apex cuspidate, base cuneate, 8-15 cm long, 3-7 cm wide. Inflorescence receme, up to 10 cm long. Fruits capsule, 3-lobed, 10-15 cm in diameter.

Habit: Sub-montane forest

Distribution: Cameroon

45. Chytranthus talbotii (Bak.) Keay Bull. Jar. Bot. Etat. 26: 194. (1956).

Syn.: *Glossolepis talbotii* Baker f. Cat. Talbot 's Nigerian. Pl.: 20. (1913).

Description:

Shrub or tree, palm-shaped, sparingly branched, 3-10 m tall; trunk 8 cm; leaves 0.4-1 m long (0.2-0.4 m petiole length), with 7-14 pairs of leaflets all of similar size, long-acuminate at apex, glabrous, shining above.

Habit: Rain-forest near the coast; forest with *Terminalia;* swamps in wetter forests; 1-770 m alt.

Distribution: Upper and Lower Guinea, from Ivory Coast to Cameroon.

8. **Genus:** *Glenniea* Hook. f.

Glenniea Hook. f. Gen. Pl. 1: 404 (1862).

Syn.: *Crossonephelis* Baill. Adansonia 11: 245. (1874).

Description:

Small trees or shrubs, monoecious or dioecious. *Leaves* spirally arranged or partly decussate, unifoliolate or paripinnate. *Leaflets* opposite to alternate, ovate, beneath smooth, glabrous or variably hairy; base symmetrical or slightly oblique; margin entire; veins and veinlets finely reticulate. *Inflorescences* terminal and usually in the upper leaf-axils, thyrsoid or paniculate with few spreading branches. *Flowers* actinomorphic, unisexual, s*epals* 4 or 5, connate at base, petals absent. *Fruits* variable, indehiscent with a thick pericarp and membranous to thin-crustaceous endocarp, wings absent. *Seeds* with a thin-crustaceous testa, closely adhering to the endocarp, no arillode.

Worldwide: 8 species, 3 of which in tropical Africa, 1 in Madagascar, 1 in Sri Lanka, and 3 in Malesia.

46. *Glenniea africanus* (Radlk.) Leenh. Blumea 22(3): 412. (1975).

Syn.: *Crossonephelis africanus* (Radlk.) Leenh. Blumea 21: 95. (1973).

Cnemidiscus thorelii Pierre Fl. forest. Cochinch. 4(fasc. 20): t. 320a. (1895).

Nephelium thorelii (Pierre) Lecomte Fl. Indo-Chine 1:1052. (1912).

Melanodiscus africanus Radlk. Ind. Gen. Phan. 75. (1887).

Description:

Small to medium-sized tree, spreading, dioecious, 5-7-15-20 m tall, or shrub. Leaves alternate, paripinnate with 2-3 pairs of elliptic leaflets 17 cm long, 7 cm wide, more or less thinly textured, mostly hairless. Flowers pink and yellowish, 4 mm in diameter, in axillary spike-like inflorescences, together appearing as a terminal head up to 20 cm long, unisexual on different trees. Fruit a sub-spherical berry, up to 2.5 cm long, 2-lobed, velvety, orange to golden-brown. Seed ellipsoid, flattened, without an aril.

Habit: In woodland and forest, often in rocky places. Closed forest, wet evergreen forest, riparian forest, bush land, lowland rain-forest with *Chrysophyllum albidum*, *Cola gigantea, Erythrophleum suaveolens, Alstonia, Parinari excelsa, Milicia excelsa;* wooded ravines.

Flowering time: September – April.

Distribution: DRC, Kenya, Tanzania, Malawi, Mozambique and Zimbabwe.

9. **Genus:** *Lepisanthes* Blume

Lepisanthes Blume Bijdr. Fl. Ned. Ind. 237: (1825).

Description:

Trees or shrubs, monoecious. Leaves usually paripinnate, alternate, estipulate, usually petiolate; leaflets 2 to several pairs, opposite or alternate, usually entire. Flowers unisexual, actinomorphic or zygomorphic, sepals 5, leathery, concave, imbricate, outer 2 smaller, orbicular, inner ones usually broadly ovate or elliptic, petals 4 or 5, often spoon-shaped, longer than sepals, base clawed, apex with adaxial scale. Fruit ellipsoidal, 2- or 3-loculed; pericarp leathery or slightly fleshy, both sides or only abaxially hairy, rarely glabrous on both sides. Seeds ellipsoidal, bilaterally slightly flat.

Worldwide: About 24 species in tropical Africa, South and South-east Asia, North-west Australia, Madagascar.

47. *Lepisanthes senegalensis* (Juss. ex Poir.) Leenh. Blumea 17: 85. (1969).

Syn.: *Sapindus senegalensis* Juss. ex Poir. Encyclopédie Méthodique, Botanique 6: 666. (1805).

Aphania senegalensis (Juss. ex Poir.) Radlk. Sapind. Holl.-Ind. 21: 69. (1877); Act. Congr. int. Bot., Amsterdam 70-133, 216-254, (1877).

Manongarivea perrieri Choux Compt. Rend. Hebd. Séances Acad. Sci. 182: 713. (1926).

Lepisanthes perrierri (Choux) Buerki, Callm. & Lowry Adansonia, série 3, 31(2): 304. (2009.)

Description:

Tree, evergreen, monoecious, 6-25 m, or shrub 6-9 m tall, rarely liane; crown dense, spreading; habit of *Mangifera indica*; bole short, to 11 m high, dbh to 50-75 cm, 1.6 m in girth; bark smooth, grey to brown, bark-slash strong-scented.

Habitat: Evergreen forest, often in moist places, rain-forest, gallery forest; forest with *Khaya grandifolia, Cola gigantea*; stream sides in wooded depressions; fringing forest and moist gorges in savannah regions; secondary forests; 0-1900 m alt.

Distribution: West tropical Africa

10. **Genus**: *Pancovia* Willd.

Pancovia Willd. Sp. Pl. 2: 280-285. (1799).

Type Species: *Pancovia bijuga* Willd.

Description:

Trees or shrubs. Leaves paripinnate. Inflorescence usually a raceme-like thyrse. Flowers unisexual, zygomorphic, sepals 4-5, unequal, connate to form a campanulate calyx, petals 3-4, unguiculate. Fruit indehiscent, fleshy, seed flattened.

Worldwide: 12 species in tropical Africa.

48. *Pancovia atroviolaceus*

Description:

Small tree, leaves paripinnately compound, leaflets papery, glossy, glabrous, 10-20 cm long, 2-5 cm wide, elliptic, entire, alternate, venation reticulate, apex acuminate, base cuneate, petiole pubescent, 2-4 cm in diameter. Flowers 10-18 cm long, racemose, whitish green, petal 5, sepal 5. Fruits capsule, 3-lobed, dehiscent, orange to red. Seed black, globose, 2 cm in diameter.

Habit: Sub montane forest.

Distribution: Cameroon

49. *Pancovia bijuga* Willd. Sp. Pl. 2: 285. (1799).

Description:

Tree, much-branched, 4-6-10 m tall, or shrub 2.5-3 m high, low-branching, young branchlets at first angular, striate, with very short brown hairs, becoming almost glabrous. Inflorescence raceme, 5-10 cm long, petals 4, sepals 4.

Habit: In dry areas, on the northern border of the forest zone along streams, gallery forest; forest, fringing forest; on laterite.

Distribution: Tropical Africa

50. *Pancovia floribunda* Pellegrin. Bull. Mus. Natl. Hist. Nat. xxviii. 313. (1922).

Description:

Tree 4 m tall; trunk 35 cm; leaflets in 4-5(-6) pairs, the uppermost largest, 8-20 cm long, 4-6 cm wide, acumen 1 cm long; flowers yellow-white, pedicel 2-6 mm long, in slender (1 mm, simple or little branched) inflorescences 10-15 cm long.

Habit: Forest, 50-500 m alt.

Distribution: Cameroon

51. *Pancovia harmsiana* Gilg. Bot. Jahrb. 24: 302. (1897).

Description:

Tree 5-18-20 m; bole to 25 cm; young branchlets glabrescent; young leaves whitish to light violet, drooping; petiole 4-18 cm long, swollen at base, glabrous.

Habit: Terra firma forest, plateau forest; riverine or swampy forests; high forest in understorey; 100-450 m alt. (Gabon).

Distribution: Cameroon

52. *Pancovia laurentii* (De Wild.) Gilg ex De Wild. Études Fl. Bas- Moyen-Congo 3: 112. (1909).

Syn.: *Chytranthus laurentii* De Wild. Miss. Laur: 146. (1905).

Pancovia lujai De Wild. Bull. Jard. Bot. Etat Bruxelles 4: 372. (1914).

Pancovia angustifolia Radlk. Engl. Pflanzenreich. *Sapindaceae*: 807. (1933).

Description:

Tree 20-25 m, dioecious; bole to 10 m high, 45 cm; young plants palm-like; leaves in rosettes at apex of branches, petiole thickened at base; leaflets in 7-10-12 pairs, the outermost largest, 15-23 cm long, 4.5-6 cm wide, glandular beneath.

Habit: Primary terra firma plateau forest; riverine forest.

Distribution: Cameroon

53. *Pancovia sessiliflora* Hutch. & Dalz. Fl. W. Trop. Afr. ed. 1(1): 504. (1928).

Description:

Small shrub, often trailing, monoecious; young branchlets glabrous; leaf petiole 1.5-6.5 cm long, rachis 0.5-1.2 cm; leaflets in (1-)2 pairs (simple leaves on lower/shaded parts of shoots), thin-textured, glabrous, venation reticulate, 4.5-17 cm long, 1.5-6 cm wide.

Habit: Rain-forest.

Distribution: Tropical Africa, Nigeria, Cameroon.

54. *Pancovia* sp 1

Description:

Tree 5 m high, leaves compound paripinnate. Leaflets 7-8 pairs, papery and glossy, elliptic, entire, 10-20 cm long, 3-5 cm wide, apex acuminate, base cuneate. Flower racemose, creamy white, petal 4, sepals 4, inflorescence 10-18 cm long. Fruits capsule, trilobed, 5-10 cm in diameter, Seed globose, black, 2 cm in diameter.

Habit: Evergreen rain-forest, sub montane forest.

Distribution: Cameroon

55. *Pancovia* sp 2

Description:

Small tree, leaves compound paripinnate. Leaflets 10-12 pairs, papery and glossy, elliptic, entire, 10-25 cm long, 3-5 cm wide, apex acuminate, base cuneate. Flower racemose, creamy white, petal 4, sepals 4, inflorescence 10-18 cm long. Fruits capsule, trilobed, 5-8 cm in diameter, Seed globose, black, 2 cm in diameter.

Habit: Evergreen rain-forest, sub montane forest.

Distribution: Cameroon

56. *Pancovia* sp 3

Description:

Shrub, leaves compound paripinnate. Leaflets 12-16 pairs, papery and glossy, elliptic, entire, 8-20 cm long, 3-5 cm wide, apex acuminate, base cuneate. Flower racemose, creamy white, petal 4, sepals 4, inflorescence 10-18 cm long. Fruits capsule, trilobed, 5-8 cm in diameter, Seed globose, black, 2 cm in diameter.

Habit: Evergreen rain-forest, sub montane forest.

Distribution: Cameroon

57. *Pancovia turbinata* Radlk. Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 8: 270. (1878).

Syn.: *Pancovia pedicellaris* Radlk. & Gilg. Bot. Jahrb. 26: 302. (1897).

Description:

Shrub or small tree 1-3.5 m tall (P turbinata, in W Africa) or tree to 15(-25) m (*P. pedicellaris*), monoecious, with dense crown and trunk to 30 cm, much-branched, fluted or gnarled; bark (red-)brown, thin, smooth, horizontally striated.

Habit: Evergreen rain-forest, in understorey; riverine forest, primary forest with *Celtis,* also dry forest on coastal sand; low alt. to 1500 m.

Distribution: Tropical Africa.

11. **Genus:** *Placodiscus* Radlk.

Placodiscus Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 8: 332. (1878).

Type Species: *Placodiscus turbinatus* Radlk.

Description:

Tree 5-12 m; glandular hairs present; leaves 30-40 cm long, petiole 2-11 cm, rachis 5-16 cm, drying pale green; leaflets in 4 pairs, oblong-elliptic, 15-21 cm long, 3-7 cm wide, hairy beneath, acuminate at apex (1-1.5 cm long), petiolules 3-5 mm long.

58. *Placodiscus angustifolius* Radlk. Engl. Pflanzenreich, Sapindac.: 813 (1932)

Syn.: *Placodiscus cuneatus* Radlk. ex Engl. Engl. Pflanzenw. Afr. 3(11): 277. (1921).

Description:

Tree 6-15-18 m; branches angular; leaf petiole 5 cm long, rachis 50-70 cm; leaflets in 7-12 pairs, linear, 11-22(-30) cm long, 2-4(-6) cm wide, the uppermost pair largest, tip acuminate (1 cm); flowers white, in 40-50 cm long inflorescences borne on large branches.

Habit: Forest; 200-300 m alt.

Distribution: East tropical Africa.

59. *Placodiscus attenuatus* J.B. Hall Adansonia, sér. 2 20(3): 290 (1980)

Description:

Tree to 3-5(-15) m tall; bole cylindrical; bark smooth; twigs glabrous, rounded; terminal bud covered by reddish indumentum (like *P. boya*).

Habit: Forest, on rocky hills and stream sides; also moist semi-deciduous and moist evergreen forest.

Distribution: Ivory Coast, tropical Africa.

60. *Placodiscus bacoensis* Aubrév. & Pellegr. Fl. Forest. Cote d 'Ivoire. 2: 200. (1936).

Description:

Tree to 16 m tall; bole cylindrical, unbranched, to 30 cm, 1.2 m in girth; slash orange-brown, gritty, hot-tasting; branches 5 cm, glabrous.

Habit: Moist evergreen forest.

Distribution: Ivory Coast.

61. *Placodiscus boya* Aubreville & Pellegrin. Fl. For. Côte d'Ivoire 2: 200. (1936).

Description:

Tree 20 m tall; trunk low-branching, twisted, 0.5 m, fluted; bark rough, very hard, flaky with greenish-orange patches; young branchlets flattened; young axil buds very hairy; crown dense, spreading.

Habit: Closed forest; dry forest; evergreen- and semi-deciduous forests; in understorey; very common in places, sometimes dominant; 350-586 m alt.

Distribution: West tropical Africa, Cameroon, Gabon.

62. *Placodiscus bracteosus* J.B. Hall Adansonia sér. 2, 20(3): 289. (1980).

Description:

Tree much-branched, or erect shrub 5-7 m tall; branchlets 8 mm, glabrescent; leaf petiole 5-8(-12) cm long, rachis (10-)15-22 cm.

Habit: Semi-deciduous forest, dry forest, in rocky wet places, especially stream sides.

Distribution: Nigeria, Ghana, Ivory Coast.

63. *Placodiscus caudatus* Pierre ex Radlk. Mem. Soc. Linn. Normandie 26(2): 70. (1924).

Syn.: *Placodiscus riparius* Keay Bull. Jard. Bot. Etat Bruxelles 26: 194. (1956).

Description:

Shrub 1-3 m tall; branchlets, leaf petiole and rachis minutely puberulous; leaf petiole 8-9 cm long, rachis 25 cm; leaflets in 3-4 pairs, drying dark brown, lamina oblong-lanceolate, 12-15 cm long, 7-8 cm wide, minutely puberulous on midrib.

Habit: Forest; 50 m alt.

Distribution: Gabon

64. *Placodiscus glandulosus* Radlk. Engl. Pflanzenw. Afr. 3(11): 277. (1921).

Description:

Tree or shrub 4-8(-15) m with few branches; branchlets glabrous; leaves crowded at apex of branches, drying reddish brown.

Habit: Forest, in understorey; 1-300 m alt.

Distribution: Tropical Africa, Nigeria, Cameroon, Gabon, Equitorial Guinea.

65. *Placodiscus leptostachys* Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 9: 606. (1879).

Description:

Tree 7 m tall; leaf petiole 6-8 cm long, rachis 35 cm; leaflets in 2-5 pairs; flower pedicel 5 mm long; inflorescences 25-25 cm long.

Habit: Forest; 600-800 m alt.

Distribution: Nigeria, Cameroon and Gabon.

66. *Placodiscus oblongifolius* J.B. Hall Adansonia sér. 2, 20(3): 291. (1980).

Description:

Tree 7 m; trunk 8 cm; little branched; leaves in tufts at tips of branches; young leaves bright red; leaf axis 30-75 cm long whereof petiole 1/3; leaflets in 5-7(-9) pairs, oblong, 15-25 cm long, 4-6 cm wide, abruptly acuminate at apex.

Habit: Evergreen (moist) forest.

Distribution: West tropical Africa.

67. *Placodiscus opacus* Radlk. Engl. Pflanzenreich. *Sapindaceae*: 814. (1932).

Syn.: *Placodiscus letestui* Pellegrin. Bull. Soc. Bot. France 102: 229. (1955).

Description:

Shrub or tree 3-6 m tall branched; branches angular, 7 mm; branchlets glabrescent, without glands; leaf petiole 4-10 cm long, rachis 15-30 cm.

Habit: Riverine forest, forest; 225-770 m alt. (Gabon).

Distribution: Nigeria, East tropical Africa.

68. *Placodiscus pseudostipularis* Radlk. Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 20: 242. (1890).

Description:

Shrub or tree to 15 m tall; trunk to 20 cm; branches glabrous; bark rough, bumby, black-green; leaves sessile, rachis 1-12 cm long; leaflets in 2 pairs, shiny, glabrous.

Habit: Closed forest, rain-forest, commonly in understorey.

Distribution: West tropical Africa.

69. *Placodiscus* sp 1

Description:

Tree, leaves compound paripinnate, alternate, oblong, entire, papery, glossy, apex acuminate, base cuneate, leaflets 5-15 cm long, 3-5 cm wide. Flower creamy white, inflorescence raceme, up to 20 cm long, petals 5, sepals 5. Fruit drupaceous, 4-8 cm in diameter, indehiscent, trilobed. Seed globose and black, 2 cm in diameter.

Habitat: Lowland rain forest

Distribution: Cameroon

70. *Placodiscus* sp 2

Description:

Tree, leaves compound paripinnate, alternate, oblong, entire, papery, glossy, apex acuminate, base cuneate, leaflets 10-28 cm long, 4-8 cm wide. Flower creamy white, inflorescence raceme, 15-20 cm in diameter, petals 5, sepals 5. Fruit drupaceous, indehiscent, trilobed, 3-8 cm. Seed globose and black.

Habitat: Lowland rain forest

Distribution: Nigeria

71. *Placodiscus pynaertii* De Wild. Bull. Jard. Bot. Etat Bruxelles 4: 371. (1914).

Description:

Tree 5-10 m, or shrub, much-branched; trunk to 20 cm; branches finely striate, 4 mm; leaf petiole 6-8 cm long, rachis 10-12 cm, glabrous; leaflets in 2-4 pairs, glabrous, elliptic-oblong, 6-13-20 cm long, 4-8 cm wide, petioles 5-7 mm, margins wavy.

Habit: Riverbanks in forest, swamp forest, on islands in rivers, often also in water.

Distribution: Central Africa Republic, Congo Democratic Republic.

72. *Placodiscus turbinatus* Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 7: 332. 1878.

Description:

Tree 5-12 m; glandular hairs present; leaves 30-40 cm long, petiole 2-11 cm, rachis 5-16 cm, drying pale green; leaflets in 4 pairs, oblong-elliptic, 15-21 cm long, 3-7 cm wide, hairy beneath, acuminate at apex (1-1.5 cm long), petiolules 3-5 mm long.

Habit: Forest.

Distribution: Nigeria and Cameroon.

12. **Genus:** *Radlkofera* Gilg

Radlkofera Gilg Bot. Jahrb. Syst. 24: 300. (1897).

Type Species: *Radlkofera calodendron* Gilg.

73. *Radlkofera calodendron* Gilg. Engl. & Prantl. Nat. Pflanzenfam. Nachtr. *Sapindaceae* 1: 228. (1897); Bot. Jahrb. Syst. 24: 300 (1897).

Description:

Tree, palm-like, usually unbranched, monoecious, 4-15 m tall; trunk 20 cm, sometimes divided near the base; leaves tufted at apex, 1-2 m long, 40-50 cm wide, petiole 25-30(-50) cm long, 1.5 cm, brownish velvety like the rachis.

Habitat: Humid shady forests, forest with *Terminalia*, mountain rain-forest; 200-800 m alt.

Distribution: Tropical Africa

74. *Radlkofera* sp 1

Description:

Tree, leaves compound paripinnate, alternate, obovate, entire, papery, glossy, apex acuminate, base cuneate, leaflets 18-43 cm long, 6-10 cm wide. Flower creamy white, inflorescence raceme up to 10-15 cm long. Fruit drupaceous, indehiscent, ellipsoidal, 6-10 cm in diameter, petals 5, sepals 5. Seed globose and black.

Habitat: Lowland rain forest

Distribution: Nigeria

75. *Radlkofera* sp 2

Description:

Tree, leaves compound paripinnate, alternate, obovate, entire, papery, glossy, apex acuminate, base cuneate, leaflets 20-38 cm long, 5-12 cm wide. Flower creamy white, inflorescence raceme, 15-20 cm, petals 5, sepals 5. Fruit drupaceous, indehiscent, ellipsoidal 15-20 cm in diameter. Seed globose and black.

Habitat: Lowland rain forest

Distribution: Nigeria

76. *Radlkofera* sp 3

Description:

Tree, leaves compound paripinnate, alternate, obovate, entire, papery, glossy, apex acuminate, base cuneate, leaflets 22-35 cm long, 8-12 cm wide,. Flower creamy white, inflorescence raceme up to 10-25 cm, sepals 5, petals 5. Fruit drupaceous, indehiscent, ellipsoidal 6-10 cm in diameter. Seed globose and black.

Habitat: Lowland rain forest

Distribution: Cameroon.

Tribe V: Melicocceae

Type: *Melicocca* L. Sp. Pl., ed. 2(1): 495. (1762).

13. **Genus:** *Melicoccus* P. Browne.

Melicoccus P. Browne., Civ. Nat. Hist. Jamaica: 210. (1756).

Type Species: *Melicoccus bijugatus* Jacq.

Description:

Evergreen trees 30 m tall, leaves pinnate, alternate, leaflets 4 or 6, opposite (no terminal leaflet). Fruits drupaceous.

77. *Melicoccus bijugatus* Jacq. Enum. Syst. Pl. 19. (1760).

Syn.: *Melicocca bijuga* L. Sp. Pl., ed. 2, 495. (1762). nom. illeg.

Melicoccus bijugatus Jacq. f. *alatus* Kitan. Fitologiya 11: 48. (1979).

Description:

Tree, 10–25 m (33–82 ft) tall. Leaves alternate, 8–5 cm long, pinnate with two or four opposite leaflets (no terminal leaflet). Leaflets usually 4 to 14 cm long (sometimes as much as 20 cm) and 2.2 to 5 cm wide (occasionally up to 7 cm). Fruits green, ovoid, seed ovoid with a fleshy tan-coloured edible seed coat. Flowers in panicles at the tips of branches, greenish-white, unisexual, either with male and female inflorescences on the same tree, or on separate trees.

Habit: Forest

Distribution: Native to tropical America but cultivated in tropical Africa.

Tribe VI: Nephelieae Radlk.

Type: *Nephelium* L.

14. **Genus:** *Litchi* Sonn.

Litchi Sonn. Voy. Indes Orient. 3: 255. (1782).

Type Species: *Litchi sinensis* Sonn.

Description:

Evergreen Tree dense, monoecious, round-topped, slow-growing, 9-30 m high. Leaves, 12.5-20 cm long, paripinnate, leaflets 4-8 pairs, alternate, elliptic-oblong to lanceolate, abruptly pointed, leathery, smooth, glossy, dark-green on the upper surface and grayish-green beneath, 5-7.5 cm long. Flowers in terminal clusters, unisexual, actinomorphic, greenish-white to yellowish, 75 cm long. Fruits, in loose, pendent clusters of 2-30, deeply parted into 2 or 3 schizocarps, usually strawberry-red, sometimes rose, pinkish or amber, and some types tinged with green; 2.5 cm wide, 4 cm long; skin thin, leathery, rough or minutely warty, flexible and easily peeled when fresh. Seed 20 mm long, hard, with a shiny, dark-brown coat.

Worldwide: One species: Southeast Asia; widely cultivated in subtropical regions.

78. *Litchi chinensis* Sonn. Voy. Indes Orient. 3: 255. (1782).

Syn.: *Scytalia* chinensis (Sonnerat) Gaertner.

Litchi sinensis Sonn. Voy. Indes Orient. 2: 230. (1782).

Nephelium litchi Cambess. Mém. Mus. Hist. Nat. 18: 30. (1829).

Litchi litchi (Lour.) Britton Fl. Bermuda: 226. (1918).

Description:

Evergreen tree less than 10 m tall, sometimes more than 15 m. Bark grey-black, branches brownish-red. Leaves with petiole 10-25 cm or longer, leaflets in 2-4 pairs, 7-8 mm, margin entire, apex cuspidate or shortly caudate-acuminate. Flowers terminal, white, yellow, or green; inflorescence panicle, 10 to 40 cm. Fruits usually dark red to fresh red when mature, 5 cm long, 4 cm wide, round, to ovoid, to heart-shaped. Seed thoroughly covered by fleshy arillode, 1-3.3 cm long and 0.6-1.2 cm wide.

Habit: Forest edges.

Distribution: Madagascar.

15. **Genus:** *Nephelium* L.

Nephelium L. Syst. Nat., ed. 12. 2: 623. (1767); alt. publ.: Mant. Pl. 18: 125. (1767).

Type Species: *Nephelium lappaceum* L.

Description:

Evergreen trees, rarely shrubs, monoecious or dioecious, 12–20 m. Leaves paripinnately compound, alternate, petiolate, 10–30 cm long, with 3-11 leaflets, each 5–15 cm wide, 3-10 cm broad, with an entire margin. Flowers unisexual, actinomorphic, small, 2.5–5 mm, apetalous, discoidal, borne in erect terminal panicles 15–30 cm wide, calyx cupular, 5- or 6-lobed; sepals small, valvate or imbricate, often opening early. Fruits drupe deeply parted into 2 or 3 schizocarps, round to oval, 3–6 cm (8 cm) tall and 3-4 cm broad with a leathery skin. Seed glossy brown, 1–1.3 cm.

Worldwide: About 22 species: Southeast Asia; three species (one endemic, one introduced) in China.

79. *Nephelium lappaceum* L. Mant. Pl. 1: 125. (1767).

Syn.: *Dimocarpus crinita* Lour.

Description:

Tree 10-27 m; twigs hairy; leaves simple or of 1-5(-7) leaflets 5-30 cm long, 2.5-11 cm wide; inflorescences lax; fruit variable in colour: crimson, purple, greenish, yellowish, orange, 6-8 cm long covered with soft fleshy spine-like appendages to 2 cm long.

Habit: Grown for its edible fruits.

Distribution: Native to Thailand, Malaysia

Tribe VII: Schleichereae Radlk.

Schleichereae Radlk. Ind. Gen.: 76. (1887).

Type: *Schleichera* Willd.

16. **Genus:** *Haplocoelum* Radlk.

Haplocoelum Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 8: 336. (1878).

Type Species: *Haplocoelum inopleum* Radlk.

Description:

Dioecious trees or shrubs. Leaves paripinnate. Inflorescence short, raceme-like. Flowers unisexual, actinomorphic, apetalous, sepals 5-6. Fruit indehiscent, 1-seeded by abortion. Seed with an arillode nearly covering the seed.

Worldwide: 7 spp. in tropical Africa and Madagascar.

80. *Haplocoelum gallaense* (Engler) Radlk. Nat. Pflanzenfam., ed. 1, Nachtr. 3: 204. (1907).

Syn.: Pistaciopsis gallaense Engl. Bot. Jahrb. 32: 125. (1902); 34: 156. (1904).

Description:

Shrub or tree 2.7-10(-18) m tall; bark smooth, grey, flaking in patches; leaflets in 4-7(-8) pairs, 0.8-3.2 cm long, 0.7-1.6 cm wide.

Habit: Dry Juniperus forest; *Acacia-Commiphora* and *Combretum-Terminalia* woodland and bush land; grassland with *Combretum*, dry thicket, particularly on rocky outcrops and hollows, rocky mountains with quartzite sand and pebbles; 650-2000 m alt.

Distribution: Uganda-S Sudan-Kenya- N Tanzania-Rwanda-Cameroon-Central Africa Republic, Ethiopia.

17. **Genus:** *Lecaniodiscus* Planch. ex Benth. Niger Fl.: 250. (1849).

Type Species: *Lecaniodiscus cupanioides* Planch.

Description:

Tree (2-)10-12(-30) m, sometimes shrub 1.5-3 m tall, dioecious; bole to 15 m high, 10-50 cm, often with many adventitious shoots near base; crown spreading; young branchlets with dense orange soft curly hairs.

81. *Lecaniodiscus cupanioides* Planch. Niger Fl.: 251. (1849).

Description:

Tree (2-)10-12(-30) m, sometimes shrub 1.5-3 m tall, dioecious.

Habit: Road sides, forest edges.

Distribution: Throughout tropical Africa

82. *Lecaniodiscus punctatus* J.B. Hall. Bull. Jard. Bot. Natl. Belg. 50(1-2): 262. (1980).

Description:

Tree 20-25 m, monoecious; crown dense; bole to 50 cm, low-branching, with many adventitious shoots near base; bark reddish brown, thin; leaf petiole and rachis 10-15 cm long each; leaflets in 3-5 pairs, glabrous.

Habit: Forest, in understorey.

Distribution: Nigeria, Ghana.

18. Genus: *Schleichera* Willd.

Schleichera Willd. Sp. Pl., ed. 4(2): 892, 1096. (1806).

Syn.: *Koon* Gaertn.

Type Species: *Schleichera trijuga* Willd

Description:

Trees dioecious. *Leaves* paripinnate, 2-4-jugate; rachis not winged; no pseudo-stipules, l*eaflets* sub-opposite (to alternate), margin entire. *Inflorescences* in the defoliated part of the branchlets above the leaf-scars, sometimes axillary, f*lowers* sometimes male and female flowers present in the same inflorescence, *sepals* 4 or 5 (or 6), p*etals* absent. *Fruit* a hard-crustaceous, dry berry, l- (or 2) celled, not winged, either smooth or with patent, simple or branched, strong thorns, glabrous. *Seeds* completely enveloped by a thin-papery arillode, often adhering to the endocarp when dried.

83. *Schleichera trijuga* Willd. Sp. Pl. 4: 1096. (1806).

Syn.: *Schleichera oleosa* (Lour.) Oken Allg. Naturgesch. 3(2): 1341. (1841).

Description:

Large deciduous trees, up to 20 m tall. Leaves compound paripinnate, alternate, glabrous, petiole up to 0.3 cm long, glabrous, leaflets 2-3 pairs, 4-26 cm long, 1.8-9 cm wide, variable in shape, oblanceolate, obovate to elliptic-oblong, base cuneate, margin entire. Inflorescences axillary panicles. Fruit dupe, 1.5cm long, 1 cm wide, ellipsoid, seeds 1-2 enclosed in aril.

Habit: Along margin of evergreen forests, semi-evergreen and deciduous forests up to 1000 m.

Distribution: Oceania and Southeast Asia.

Tribe VIII: Cupanieae Reich. Consp. Reg. Veg.: 200. (1828).

Type: *Cupania* L. Gen. Pl. (1737).

19. **Genus:** *Aporrhiza* Radlk.

Aporrhiza Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 8: 338. (1878).

Type species*:* *Aporrhiza paniculata* Radlk.

Description:

Tree 4.5–22 m tall; bark smooth, grey; young parts and fruits with a short, velvety, reddish or grey-green pubescence. Petiole 1–9 cm long, woody; rachis 10–36 cm long; leaflets in 3–5 pairs, sub-opposite; petiolules fleshy, sparsely pilose; blade oblong-elliptic or elliptic, the terminal pair largest, 9–25 cm long, 5–9 cm wide, the other pairs progressively smaller, shortly and bluntly acuminate, the base acute. Inflorescence-axes 20–50 cm long; branches 2–16 cm long. Calyx-lobes green, 2 mm long, petals yellow or white, equalling the sepals, ovate, ciliate. Seed black, 1.3 cm long, 5 mm wide, covered by an orange aril.

84. *Aporrhiza nitida* Gilg. Engl. Pflanzenwelt. Afr. 3 (2): 280. (1921).

Synonym of: *Aporrhiza paniculata* Radlk. Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München viii. 339. (1878).

Description:

Medium sized tree. Leaves alternate, paripinnate, with 2-4 pairs of oblong-elliptic leaflets, up to 18 cm long, 7 cm wide, somewhat leathery, hairless above, velvety below, particularly on the main veins, up to 36 cm long, 16 cm wide, oblong-elliptic or elliptic; margin entire. Flowers small, unisexual in the same inflorescence, creamy-white, in large terminal branched heads, up to 40 cm long and 20 cm wide. Fruit a flattened capsule 2 cm long, 2.5 cm wide, with a distinct rim, velvety, splitting with the valves curling backwards. Seeds 1.3 cm long, brownish-black, with a red aril.

Habitat: Riverine and swamp forest.

Flowering time: October

Distribution: DRC (Katanga), Tanzania, Malawi, Mozambique, Zambia, Zimbabwe.

85. *Aporrhiza talbotii* Bak. Catal. Pl. Talbot: 20. (1913).

Description:

Tree 7-10 m, monoecious; branchlets brownish pubescent; leaves 30-40 cm long, with 4-7(-8) pairs of leaflets, the terminal one largest; leaflets shiny above, matt and glabrous or pubescent beneath.

Habitat: Forest; 25-500 m alt.

Distribution: East and West tropical Africa.

86. *Aporrhiza urophylla* Gilg. Bot. Jahrb 24: 305. (1897).

Description:

Straggly tree 5-15-20 m, monoecious; bole to 40 cm, often tortuous; bark smooth, ash-grey; slash red or orange-brown, not scented; young branchlets deeply striate to grooved. Leaflets opposite or alternate with slender petiolules and 8 pairs of laterals; rachis and petiolules reddish velvety.

Habitat: Evergreen forest and transitional (to semi-deciduous) forest; high forest in under-storey; riverbanks and on sandy soil near swamps; coastal forest; 1-1000 m alt.

Distribution: Throughout West tropical Africa, Cameroon and Gabon.

20. **Genus:** *Laccodiscus* Radlk.

Laccodiscus Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 9: 477, 496, 535. (1879).

Type Species: *Laccodiscus ferrugineus* (Bak.) Radlk.

Description:

Slender tree or shrub, up to 20 ft high, densely clothed with brown hairs, fruits bright red when ripe, seeds with a bright orange aril.

87. *Laccodiscus ferrugineus* (Bak.) Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 9: 477. (1879).

Syn.: *Cupania ferruginea* Bak. Oliv. FTA: 425. (1868).

Description:

Shrub, erect, 2-3 m tall, or scandent 5-6 m, or tree 6-7 m, all parts densely clothed with brown hairs 1-2 mm long; monoecious; leaf petiole 6-15 cm long; leaflets in 3-5 pairs, oblong, acuminate, dentate in upper half, 7-22 (-30) cm long and 4-10 cm wide.

Habit: Rain-forests; forest with *Lophira alata, Saccoglottis gabonensis,* gallery forest, forest gaps, 1-1800 m alt.

Distribution: Nigeria, Cameroon, Equitorial Guinea, Gabon.

88. *Laccodiscus pseudostipularis* Radlk. Engl. Pflanzenwelt. Afr. 3 (2): 280. (1921).

Description:

Tree (3-) 6-10 (-20-27) m, monoecious; bole to 20 m high, 10-40 cm; branchlets and panicles yellowish tomentellous.

Habit: Dry and swampy or riverine rain-forests; forest with *Cynometra alexandri*; 420-1400 m alt.

Distribution: East tropical Africa.

21. **Genus:** *Lychnodiscus* Radlk.

Lychnodiscus Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 8: 271. (1878).

Type Species: *Lychnodiscus reticulatus* Radlk.

Description:

Slender, small to medium-sized tree up to 20 m tall; bark smooth, greyish white; twigs soft short-hairy. Leaves alternate, paripinnately compound with 6–7 pairs of leaflets; stipules absent; petiole up to 10 cm long, rachis grooved, up to 60 cm long; petiolules 3–6 mm long; leaflets opposite to alternate, oblong-elliptical to ovate-oblong, 11–15 cm long, 3–5 cm wide, acuminate at apex, margins usually toothed, pinnately veined with 10–16(–22) pairs of lateral veins. Inflorescence an axillary or terminal panicle up to 45 cm long, brown hairy. Flowers unisexual, regular, 5-merous; pedicel 4–6 mm long; sepals 2.5 mm long, fused at base; petals free, funnel-shaped, 3–3.5 mm long, whitish, with a reflexed hairy scale just below the apex; stamens 10–13. Fruit a 3-lobed ellipsoid to ovoid capsule up to 2 cm long, hairy, red when ripe, dehiscent, (1–) 3-seeded. Seeds 3-angled, up to 18 mm long, covered by a waxy, red aril.

Worldwide: comprises of 7 species and is confined to tropical Africa.

89. *Lychnodiscus brevibracteatus* R. Fouilloy. Fl. Cameroun 16: 166. (1973).

Syn.: *L. reticulatus* Radlk. var. b*revibracteatus* Pellegrin. Bull. Soc. Bot. France, Mem. 102: 61. (1955). *nom. nud.*

Description:

Shrubby tree 3 m tall or tree with sinuous trunk 50 cm; bark dark green, grey or purplish, with small irregular scales and orange under bark.

Habit: Forest.

Distribution: Cameroon and Gabon.

90. *Lychnodiscus danaensis* Aubreville & Pellegrin. Fl. Forest. Côte d'Ivoire 2: 184. (1936).

Description:

Shrub or tree to 16 m tall; bole with petiole scars, 60 cm in girth; young parts rusty hairy; leaflets in 4-6 pairs, often entire, elongate-obovate.

Habit: Closed forest, semi-deciduous forest, in understorey.

Distribution: West tropical Africa, Congo DRC.

91. *Lychnodiscus grandifolius* Radlk. Nat. Pflanzenfam. ed. 1, Nachtr. 3: 206. (1907).

Description:

Tree 6-10 m; stems stout, densely pubescent; leaves to 1.2 m long, petiole shortly brown tomentellous, glabrescent; leaflets in 5-6 pairs, elliptic, 20-42 cm long, 10-18 cm wide, glabrous, leathery, glossy, with few nerves, often entire.

Habit: Primary forest, forest on shores and swamps; 1-200, 1700-1950 m alt.

Distribution: Nigeria and Cameroon.

92. *Lychnodiscus reticulatus* Radlk. Sitzungsber. Bayer. Akad. Wiss. Munchen 8: 333. (1878)

Description:

Tree 10-15 m; crown spreading; bark thin, rough, sometimes slightly spiny; slash orange, brittle; branchlets ribbed, puberulous, drooping; leaf rachis slightly winged.

Habit: Moist forest, in understorey.

Distribution: West tropical Africa.

22. **Genus:** *Eriocoelum* Hook. f.

Eriocoelum Hook. f. Gen. Pl. 1 (1): 400. (1862).

Type Species: *Eriocoelum paniculatum* Bak.

Description:

Tree 6-10 or 20-25 m; bole 20-30 cm; branchlets rusty spreading hirsute; leaves with 3-6 pairs of leaflets, the lowermost stipule-like, cordate, 3 cm, the others obovate, 4-16 cm long and 3.5-5.5 cm wide.

93. *Eriocoelum kertstingii* Gilg ex Engler. Sitzungsber. Bayer. Akad. Wiss. Munchen 38: 817. (1908).

    Description:

    Tree 3-6-15-20 m, spreading; crown round, dense, branches often drooping; bole crooked, 30 cm, 1.6 m in girth; bark dark green; slash red with fine white streaks; branchlets with yellow curly hairs.

    Habit: Stream banks in closed gallery forest in high rainfall savannah; relic deciduous forest on stream sides; evergreen moist forest; waterlogged soils of dry and upland areas; banana plantation; 10-1000 m alt.

    Distribution: Tropical Africa.

94. *Eriocoelum microspermum* Radlk. ex De Wild. Ann. Mus. Congo Belge, Bot. sér. 5, 2(3): 296. (1908).

    Description:

Tree 25-30-35 m, or shrub 4 m tall; bole to 13 m high, 60-80 cm; young branchlets rusty pulverulent.

Habit: Riverine and coastal forest, islands in streams, swampy gallery forest, swamps, moist forest or seasonally flooded; 700-1400 m. alt.

Distribution: Cameroon and throughout east tropical Africa.

95. *Eriocoelum macrocarpum* Gilg ex Radlk. Engl. Pflanzenreich, *Sapindaceae:* 1155. (1933).

Description:

Tree 4-20-30-35 m, monoecious; bole straight, cylindrical, to 20 m high, 40-60 cm; branchlets rusty puberulous; bark grey, smooth.

Habit: Forest, also coastal; abundant on savannah edges; 1-1400 m alt.

Distribution: Nigeria, Cameroon, Equatorial Guinea and Gabon.

96. *Eriocoelum oblongum* Keay Bull. Jard. Bot. Etat Bruxelles 26: 200. 1956.

Description:

Tree to 25 m; branchlets densely golden-brown hairy, bark greyish or brown; slash dark red; leaves with 3-4(-5) pairs of leaflets.

Habit: Rain-forest, along rivers; 13-250 m alt.

Distribution: Nigeria, Cameroon and Gabon.

97. *Eriocoelum pungens* Radlk. ex Engl. Ann. Mus. Congo Belge, Bot. sér. 5, 2(3): 296. (1908).

Syn.: *Eriocoelum pungens* Radlk. ex Engl. var. *pungens*

Description:

Tree up to 11 m tall or spreading shrub, stilt-rooted; trunk to 1.5 m in girth; twigs and leaves with scattered stiff, bristly hairs; branchlets rusty-hairy; leaves red when young; leaf rachis short (10 cm).

Habit: Evergreen forest, often in moist places, riversides, swamps, in understorey, persisting in cocoa plantations.

Distribution: West tropical Africa.

98. Eriocoelum racemosum Bak. Fl. Trop. Afr. 1: 427. (1868).

Syn.: *E. pendulum* Stapf. Journ. Lin. Soc. 38: 91. (1905)

Description:

Tree, spreading, 9-15 m tall or shrub; trunk 45 cm in girth, with low buttresses; branches and leaf rachis with long soft spreading rusty hairs; leaves red when young.

Habit: Evergreen closed forest, in wet places, riversides, in understorey; 100-125 m alt.

Distribution: West tropical Africa and Gabon.

23. **Genus:** *Blighia* Koenig

Blighia Koenig Ann. Bot. 2: 571 tab 16, 17 (1806).

Syn.: *Phialodiscus* Radlk., Sitzungsber. Bayer. Akad. Wiss. Munchen 9: 479, 497, 539, 655 (1879); 20: 263, 291 (1890).

Type Species: *Blighia sapida* Koenig.

Description:

Shrubs or trees, leaves paripinnate with 2-5 leaflets. Inflorescence an axillary raceme-like thyrse, flowers actinomorphic, sepals 5, connate, petals present, well-developed, not or scarcely exceeding the sepals, 5, pouch-like. Fruit a 3-lobed, 3-winged dehiscent capsule. Seed with a fleshy arillode enclosing the base.

Distribution: 4 species in tropical Africa.

99. *Blighia sapida* Koenig. Ann. Bot. 2: 571. (1806).

Syn.: *Cupania edulis* Schum. & Thonn. Danske Vidensk. Selsk. Skrift 3: 210. (1828)

Cupania sapida Voigt Hort. suburb. Calcutt. 94. (1845).

Description:

Tree, evergreen 6-25 m; crown round, heavy, or umbrella-shaped; bole long, fluted at base, or often short and crooked, 0.5-1.2 m , 2.5 m in girth; bark smooth, grey; young branchlets yellow-tomentose, striate, glabrescent and whitish.

Habitat: Moist or drier forest areas and forest outliers and patches in savannah regions; dry places in forest areas; forest re-growth; gallery forest; low alt.

Distribution: Throughout tropical Africa.

100. *Blighia unijugata* Bak. FTA 1: 427. (1868).

Syn.: *Phialodiscus unijugatus* (Baker) Radlk. (1879).

Phialodiscus plurijugatus Radlk. l.c (1890).

Phialodiscus verschuerenii De Wild., l.c.: 361. (1914).

Phialodiscus laurentii De Wild., Ann. Mus. Congo ser. 5, 3: 114 (1909)

Description:

Shrub or small tree. Leaves paripinnate, up to 30 cm with 2-3 pairs of leaflets; leaflets ovate to elliptic, end pair largest, up to 15 cm, glossy dark green above, hairless, apex tapering into a drip tip; margin entire, often wavy. Flowers unisexual, usually on different trees, white, sweetly scented. Fruit in clusters, 3-lobed, somewhat pear-shaped, with ridge-like wings, bright pink to red, splitting with the valves curling backwards.

Habitat: riverine thickets, open woodland and evergreen forest, often associated with termite mounds.

Flowering time: Sep- Oct

Distribution: Widespread in tropical Africa southwards to Zimbabwe, Mozambique, just entering coastal KwaZulu-Natal, South Africa.

101. *Blighia welwitschii* (Hiern) Radlk. Engl. Pflanzenreich, *Sapindaceae:* 1146. (1933).

Syn.: *Phialodiscus welwitschii* Hiern, Cat. Pl. Welw: 171. (1896).

Blighia wildemaniana Gilg ex De Wild., Ann. Mus. Congo Belge, ser. 5, 2: 296. (1908).

Blighia laurentii De Wild., l.c. 3: 113. (1909).

Blighia mildbraedii Radlk. Deutsch. Zentr. Afr. Exped. 1907-08. 2: 481. (1912).

Phialodiscus mortehanii De Wild., Bull. Jard. Bot. Etat Bruxelles 4: 361. (1914).

Blighia kamerunensis Radlk. Engl. Pflanzenreich, *Sapindaceae:* 1145. (1933).

Phialodiscus bacoensis Aubr. & Pellegrin. Bull. Soc. Bot. France 85: 291. (1938).

Description:

Tree, deciduous, 20-50 m; bole straight, cylindrical, somewhat fluted at base, to 20 m high, 0.8-1 m; bark grey with small reticulate fissures, or thin and smooth, hard, flaking; slash orange and brownish mottled.

Habit: Closed forest; forest with Leguminosae and Sapotaceae; evergreen wet forest; secondary forests; 1-1150 m alt.

Distribution: Tropical Africa.

Sub Family II: DODONAEOIDEAE

Dodonaeoideae

Type Genus: *Dodonaea* L.

Tribe I: Harpullieae Radlk. Ind. Gen.: 81 (1887).

Type: *Harpullia* Roxb.

24. **Genus:** *Majidea* J. Kirk ex Oliv.

Majidea J. Kirk ex Oliv. Hook. Ic. Pl. 11: 78 (1871).

Syn.: *Harpullia* Roxb., subgen. *Majidea* (Kirk) Radlk. Sap. Holl. Ind.: 53 (1877-78); Sitzungsber. Bayer. Akad. Wiss. Munchen 8: 273 (1878); 20: 279 (1890)

Anoumabia Chev., Bull. Soc. Bot. France 58: Mem.: 148 (1912).

Type Species: *Majidea zanguebarica* Kirk.

Description:

Tree, 2-22-25 m; bark rough or smooth, whitish, slash cream orange; young branchlets pale-mid-brown, lenticels conspicuous; leaflets (5-7 pairs) 3-6 cm long, glabrous, shining, drooping when young; flowers pink or red.

102.*Majidea fosterii* (Sprague) Radlk. Bot. Jahrb. Syst. 56: 255 (1920).

Syn.: *Harpullia fosterii* Sprague. Kew. Bull.:434 (1908).

Description:

Tree, 10-15-35(-40) m, monoecious, deciduous; bole straight, sometimes buttressed, clean to 10 m height, 0.6-1 m, 1.5-2 m in girth; crown spreading; bark greyish(-brown) or yellowish, thin, smooth, slightly flaking, slash smelling of toothpaste.

Habit: Semi-deciduous forest; closed high forest; terra firma forest; forest clearings, managed forest; c. 1000-1200 m alt.

Distribution: Tropical Africa.

25. **Genus:** *Harpullia* Roxb.

Harpullia Roxb. Fl. Ind. 2: 441. (1824).

Type Species: *Harpullia pendula* Planch. ex F.Muell.

Description:

Shrubs to medium-sized trees, dioecious. *Leaves* paripinnate, 1-9-jugate, without pseudostipules; (petiole and rachis winged). *Leaflets* alternate (or opposite), not papillate beneath; margin entire. *Inflorescences* axillary, terminal. *Flowers* unisexual, actinomorphic, s*epals* 5, free, imbricate, petals 5, longer than the sepals. *Fruits* capsules, 2- or 3-lobed, the lobes erect to spreading, inflated, round. *Seeds* with a thin-crustaceous testa; arillode, covering half the seed and without appendages; hilum covering less than 1/6 of the seed.

103. *Harpullia zanguebarica* (Oliv.) Radlk. Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 20: 279. (1890).

Description:

Small tree up to 5 m. Leaves compound, pinnate, leaflets up to 10 pairs. Flowers in dense clusters, small, green. Fruits spherical with 3 lobes, 3 cm long; splits open, interior bright red with 3 spherical, velvety blue-black seeds.

Habit: Forest, 0-300 m alt.

Distribution: Madagascar, East tropical Africa.

Tribe II: Dodonaeeae Kunth Nov. Gen. Sp. 5: 100 (1821).

Type: *Dodonaea* L.

26. **Genus:** *Dodonaea* L.

Dodonaea L. Gen., ed. 1. Append. *Octandriae:* 341 (1737).

Syn.: *Dodonaea* Mill. Gard. Dict. Abr. (ed. 4) no. 1: (1754).

Type Species: *Dodonaea viscosa* (L.) Jacq.

Description:

Usually dioecious trees or shrubs. Leaves simple. Inflorescence a raceme-like or paniculate thyrse. Flowers actinomorphic, unisexual or (rarely) bisexual. Sepals 3-7, sometimes slightly connate. Petals 0. Stamens 5-8. Ovary 2-4(-5)-locular; loculi 2-ovulate. Fruit a 2-6-locular capsule, winged. Seed without an arillode.

Worldwide: 50 spp. mainly in Australia; a few pantropical and one in Madagascar.

104. *Dodonaea viscosa* (L.) Jacq. Enum. Pl. Carib: 19. (1760).

Syn.: *Dodonaea burmanniana* D C. Prodr. 1: 616. (1824).

Dodonaea dioica Roxb. Hort. Beng.: 28. (1814); Fl. Ind.: 324. (1832).

Ptelea viscosa L. Sp. Pl. 118. 1753.

Accepted names: *Dodonaea* Mill. Gard. Dict. Abr. ed. 4, vol 1. (1754).

Dodonaea viscosa (L.) Jacq. Enumeratio Systematica Plantarum, quas in insulis Caribaeis 19. (1760). (Enum. Syst. Pl.)

Dodonaea viscosa Jacq. Enumeratio Systematica Plantarum, quas in insulis Caribaeis 19. (1760). (Enum. Syst. Pl.)

Dodonaea viscosa Sm.

Dodonaea viscosa Mart. Flora 22(1, Beibl.): 57 (1839); Cf. Schlecht. in Linnaea, 18: (1844) 35(err. typ. 51).

Description:

Shrub or small tree. Leaves simple, yellowish-green, glabrous, resinous; lamina narrowly elliptic; apex acute or acuminate; base decurrent into the petiole. Inflorescences terminal, flowers greenish-yellow, often turning reddish later, stamens 6, style 4-6 mm long, fruits with 2-3 papery wings.

Habitat: At the margins of evergreen forest and in riverine and grassland scrub.

Flowering time: March - September

Distribution: Pantropical

Tribe III: Doratoxyleae Radlk.

Doratoxyleae Radlk. Ind. Gen.: 81 (1887).

Type Genus: *Doratoxylon* Thou.

27. **Genus:** *Ganophyllum* Blume

Ganophyllum Blume Mus. Bot. 1: 230. (1850).

Type Species: *Ganophyllum falcatum* Blume. Museum Botanicum Lugduno-Batavum: 1 (1850).

<u>Description:</u>

Tall trees, possibly monoecious. Leaves paripinnate, leaflets alternate to rarely opposite, herbaceous; base slightly to strongly oblique; margin entire. Inflorescences axillary thyrses. Flowers unisexual, actinomorphic, sepals 4-6, petals absent. Fruit a sessile drupe, not winged, smooth, outside and inside glabrous, with 1 or 2 locules. Seeds 1 per locule, arillode absent.

<u>Worldwide:</u> Two species, one in West and Central Africa, the other from the Andamans and Nicobars to Northeast Australia and the Solomon Islands, throughout Malesia.

105. *Ganophyllum giganteum* (Chev.) Hauman., Fl. Congo Belge 9: 363 (1960).

Syn.: *Pseudospondias giganteum* Chev., Veg. Ut. Afr. Trop. Fr. 9: 151. (1917).

Ganophyllum africanum Mildbr., Not. Bot. Gart. Mus. Berlin 8: 708. (1924).

Description:

Tree 25-40 m, deciduous, dioecious; bole cylindrical, buttressed, bole free to 10-25 m height, 0.8-1.2 m; bark red-brown, flaking off in irregular patches; leaves shiny, resinous; leaflets 10-24, alternate, 10-16 cm long, 3-4 cm wide, acuminate.

Habit: Terra firma and gallery forest, semi-deciduous plateau forest; primary and managed rain-forests; 200-700 m alt.

Distribution: East tropical Africa.

28. **Genus:** *Zanha* Hiern.

Zanha Hiern. Cat. Afr. Pl. Welw. 1: 128. (1896).

Type Species: *Zanha golugensis* Hiern

Description:

Dioecious trees. Leaves paripinnate, but often appearing imparipinnate; Inflorescence a short paniculate thyrse. Sepals 4-6. Petals absent. Stamens (3-) 4-7. Ovary 2-locular; loculi with 2 ovules. Fruit 1-seeded by abortion, drupaceous, indehiscent. Seed 1; aril absent.

Worldwide: 3 spp: 2 in tropical Africa and one in Madagascar.

106. Zanha golugensis Hiern Cat. Afr. Pl. 1: 128. (1896).

Syn.: *Talisiopsis oliviformis* Radlk. Nat. Pflanzenfam., ed. 1, Nachtr. 3: 208. (1907).

<u>Description:</u>

Tree up to 18 m or rarely shrub 2-3 m tall, monoecious, deciduous. Leaves 1-pinnate; leaflets in 3-7 pairs, sub-sessile, elliptic-oblong, glabrous when mature; apex obtuse and often acuminate; margin crenate, shallowly dentate or entire; base cuneate. Inflorescence congested sub-spherical thyrse, 1.5-2 cm in diameter, sepals 2-2.5 mm, petals absent. Fruit up to 2 cm long, 1.5 cm wide, yellow or pink, ellipsoid or nearly spherical and glabrous.

<u>Habit:</u> Deciduous woodland, often with *Combretum, Brachystegia;* (semi) evergreen lowland forest; termite mounds, transitional rain-forest; forest gallery; fringing forest, riparian forest in savannah (mainly so in W Africa); 300-1700 m alt.

<u>Flowering time:</u> September - October

<u>Distribution:</u> Widespread in tropical Africa.

REFERENCES

Acevedo-Rodríguez, P. (1993a). A revision of *Lophostigma* (Sapindaceae). *Systematic Botany* **18**: 379–388.

Acevedo-Rodríguez, P. (1993b). Systematics of *Serjania* (Sapindaceae). I. A Revision of *Serjania* Sect. *Platycoccus*. *Memoirs of the New York Botanical Garden* **67:** 1-93.

Acevedo-Rodríguez, P. (2003). Melicocceae (Sapindaceae): *Melicoccus* and *Talisia. Flora Neotropica Monogr*. **87**: 1-179.

Adema, F., Leenhouts, P.W. and van Welzen, P.C. (1994). Sapindaceae. *Flora Malesiana* **11** (I): 419-768.

Ahmad, K.J (1976). Epidermal studies in some species of *Hygrophila and Dyschoriste* (Acanthaceae). *Journal of Indian Botanical Society* **55:** 41-52.

Akhil, B and Subhan, C.N. (1997). Foliar epidermal characters in twelve species of *Cinnamomum* Schaeffer (Lauraceae) from North-eastern India. *Phytomorphology,* **47(2):** 127-134

Angiosperm Phylogeny Group (APG II) (2003). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnean Society* **141:** 399-436.

Angiosperm Phylogeny Group (APG III) (2009). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society* **161**: 105-121.

Ayodele, A.E. (2000). *Systematic studies in the family Polygonaceae.* Unpublished Ph.D. Thesis submitted to the University of Lagos, Nigeria. 239pp.

Baldwin, B.G., (1992). Phylogenetic utility of the internal transcribed spacers of nuclear ribosomal DNA in plants: an example from the Compositae. *Molecular Phylogenetics and Evolution* **1**: 3-16.

Bapteste, E., Brinkmann, H., Lee, J.A., Moore, D.V., Sensen, C.W., Gordon, P., Durufle, L., Gaasterland, T., Lopez, P., Müller, M. and Philippe, H. (2002). The analysis of 100 genes supports the grouping of three highly divergent amoebae: Dictyostelium, Entamoeba, and Mastigamoeba. *Proceedings of the National Academy of Science USA* **99:** 1414-1419.

Bentham, G. and Hooker J.D. (1862). *Genera Plantarum: Ad Exemplaria Imprimis In Herbarius Kewensibus Servata.* Voluminis Primi, Pars 1. Black A, Hookerian Herbarium, Kew, London. 454pp.

Bentham, G. and Hooker J.D. (1867). *Genera Plantarum: Ad Exemplaria Imprimis In Herbarius Kewensibus Servata.* Voluminis Primi, Pars 3. Reeve & Co, Convent Garden, London. 1040pp.

Bhandari, J.B. and Mukhopadhyay, R. (1997). Morphological and Anatomical studies on *Antrophyum callifolium* BL. *Phytomorphology* **47(2):** 155-160.

Buerki, S., Forest, F., Acevedo-Rodríguez, P., Callmander, M.W., Nylander, J.A.A., Harrington, M., Sanmartín, I., Küpfer, P., and Alvarez, N. (2009). Plastid and nuclear DNA markers reveal intricate relationships at subfamilial and tribal levels in the soapberry family (Sapindaceae). *Molecular Phylogenetics and Evolution* **51**: 238-258.

Buerki, S., Phillipson, P.B., Lowry II, P.P. and Callmander, M.W. (2010). Molecular phylogenetics and morphological evidence support recognition of *Gereaua,* a new endemic genus of Sapindaceae from Madagascar. *Systematic Botany* **35**: 172-180.

Burkhill, H.M. (2000). *The Useful Plants of West Tropical Africa*. Volume 5, Edition 2. Royal Botanic Gardens Kew, London. 686pp.

Cambessedes, A. (1828). *Myrtus grumixama* Vell. *Fl. Flumin*. **5**: 2163

Capuron, R. (1969). Révision des Sapindacées de Madagascar et des Comores. Mém. *Mus. Natl. Hist. Nat. B Bot.* **19**: 1-189.

Chapman, K. R. (1984). Lychee - *Litchi chinensis* Sonn. In: Page, P. E. (Ed). *Tropical Tree Fruits for Australia.* Queensland Department of Primary Industries, Brisbane. Pp 179-191.

Chase, M.W. and Hills, H.H. (1991). Silica-gel – an ideal material for field preservation of leaf samples for DNA studies. *Taxon* **40:** 215-220.

Claugher, D. (1990). Scanning Electron Microscopy in Taxonomy and Functional Morphology. *The Systematics Association* **41:** 69-94.

Clayton, J.W. (2007). Molecular phylogeny of the tree-of-heaven family (Simaroubaceae) based on chloroplast and nuclear markers. *International Journal of Plant Science* **168:** 1325–1339.

Coetzee, J.A. and Muller, J. (1984). The phytogeographic significance of some extinct Gondwana pollen types from the Tertiary of the south-western Cape (South Africa). *Ann. Missouri Bot. Gard.* **71:** 1088-1099.

Cronquist, A. (1988). *The Evolution and Classification of Flowering Plants*. Second edition. New York Botanic Gardens, New York. 555pp.

Cutler, D.F. and Sheahan, M.C. (1993). Contribution of vegetative anatomy to the systematics of the Zygophyllaceae R.Br. *Botanical Journal of the Linnaean Society* **113:** 227-262.

Dahlgren, G. (1989). An updated system of classification. *Botanical Journal of the Linnaean Society* **100**: 197-203.

Davies, F.G. (1997). A new genus *Haplocoelopsis* (Sapindaceae) from East and Central Africa. *Kew Bull*. **52:** 719–723.

Davis, P.H. and Heywood, V.H. (1963). *Principles of Angiosperm Taxonomy.* Oliver and Boyd Ltd, Edinburgh. 556pp.

DeMers, John and Norma, Benghiat. (1998). *The Food of Jamaica: Authentic Recipes from the Jewel of the Caribbean.* 1st edition. Periplus Editions, Boston, MA. 132pp.

Dilcher, D.L. (1974). Approaches to the Identification of Angiosperm Leaf Remains. *Botanical Revisions* **40:** 1-157.

Doyle, J.J. and Doyle, J.L. (1987). A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochem. Bull. Bot. Soc. Amer.* **19**: 11-15.

Doyle, J.J. and Doyle, J.L. (1990). Isolation of plant DNA from fresh tissue. *Focus* **12:** 13-15

Driskell, A.C., Ané, C., Burleigh, J.G., McMahon, M.M., O'Meara, B.C., Sanderson, M.J. (2004). Prospects for building the Tree of Life from large sequence databases. *Science* **306**: 1172-1174.

Edwards, K.J. and Gadek, P.A. (2001). Evolution and biogeography of *Alectryon* (Sapindaceae). *Molecular Phylogenetics and Evolution* **20**: 14-26.

Felsenstein, J. (1985). Confidence limits on phylogenetic: an approach using the bootstrap. *Evolution* **39**: 783-791.

Ferrucci, M.S. (1998). *Flora fanerogamica Argentina*: *Sapindaceae* **52:** 1–165.

Forest, F., Drouin, J.N., Charest, R., Brouillet, L. and Bruneau, A. (2001). A morphological phylogenetic analysis of *Aesculus* L. and *Billia* Peyr. (Sapindaceae) *Can. J. Bot*. **79**(2): 154-169

Fortenelle, G.B., Costa, C.G. and Machado, R.D. (1994). Foliar anatomy and micromorphology of eleven species of *Eugenia* L. (Myrtaceae). *Botanical Journal of the Linnaean Society* **115:** 111-133.

Gadek, P.A., Fernando, E.S., Quinn, C.J., Hoot, S.B., Terrazas, T., Sheahan, M.C., Chase, M.W. (1996). Sapindales: molecular delimitation and infraordinal groups. *American Journal of Botany* **83:** 802-811.

Ghosh, A. and Bansal, M (2003). "A glossary of DNA structures from A to Z". *Acta Crystallogr D Biol Crystallogr* **59** (Pt 4): 620-626.

Harrington, M.G. and Gadek, P.A. (2009). *A species well travelled – the Dodonaea viscosa (Sapindaceae) complex based on phylogenetic analyses of nuclear ribosomal ITS and ETSf sequences. Journal of Biogeography,* **36**(12): 2313-2323.

Harrington, M.G., Edwards, K.J., Johnson, S.A., Chase, M.W., Gadek, P.A. (2005). Phylogenetic inference in Sapindaceae sensu lato using plastid matK and rbcL DNA sequences. *Systematic Botany* **30**: 366–382.

Heywood, V.H. (1978). *Flowering Plants of the World*. Oxford University Press, London. 335pp.

Hickey, L.F. (1973). Classification of the Architecture of Dicotyledonous Leaves. *American Journal of Botany* **60:** 17-33.

Hilu, K.W., Borsch, T., Muller, K., Soltis, D.E., Soltis, P.S., Savolainen, V., Chase, M., Powell, M., Alice, L.A., Evans, R., Sauquet, H., Neinhuis, C., Slotta, T.A., Rohwer, J.G., Campbell, C.S. and Chatrou, L. (2003). Angiosperm phylogeny based on matK sequence information. *American Journal of Botany* **90:** 1758 – 1776.

Huelsenbeck, J.P. (1991). When are fossils better than extant taxa in phylogenetic analysis? *Systematic Zoology* **40**: 458–469.

Hutchinson, J. and Daziel, J.M. (1958). *Flora of West Tropical Africa.* Volume 1, Part 2. Crown Agents for Oversea Government and Administrations, Millbank, London. 828pp.

Inamdar, J.A. and Gangadhara, M. (1997). Studies on the trichomes of some euphorbiaceae. *Feddes Repertorium.* **88:** 103-111.

Johansen, D.A. (1940). *Plant Microtechniques.* Mc Graw Hill, New York. 53pp.

Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F. and Donoghue, M. J. (2007). *Plant Systematics: A Phylogenetic Approach.* 3rd edition. Sinauer Associates, Sunderland, MA. 565pp.

Judd, W.S., Sanders, R.W. and Donoghue, M.J. (1994). Angiosperm family pairs: preliminary phylogenetic analyses. *Harvard Papers in Botany* **5**: 1–51.

Jussieu, A.L. (1789). *Genera Plantarum Secundum Ordines Naturales Disposita, Juxia Methodum in Horto Regio Parisiensi Exaratam, Anno 1774.* Herissant and Barrois, Paris. 453pp.

Kadiri, A.B. (2003). Foliar epidermal morphology of the medicinal genus *Momordica* Linn. (Cucurbitaceae) in Nigeria. *Nigeria Journal of Science* **37(1):** 25-33.

Kadiri, A.B. and Ayodele, A.E. (2003). Comparative leaf micromorphological characters of the Nigerian species *Rauvolfia* Linn. (Apocynaceae). *Bioscience Research Communications* **15(6):** 35-41.

Keay, R.W.J., Onochie, C.F.A., and Stanfield, D.P. (1964). *Nigerian Trees.* Volume II Department of Forest Research, Ibadan. 495pp.

Khatijah, H.H. and Zaharina, M.S. (1998). Comparative leaf anatomical studies on some *Sterculia* species L. (Sterculiaceae). *Botanical Journal of the Linnaean society.***127:** 159-174.

Khatijah, H.H., Bkhtiar, A.W. and Che, P.T. (1996). Comparative leaf anatomical studies of some *Mallotus* species Lour. (Euphorbiaceae). *Botanical Journal of the Linnaean society* **122:** 137-153.

Klaassen, R. (1999). Wood anatomy of the Sapindaceae. *International Association of Wood Anatomists Journal* **2** (suppl.): 1–214.

Kotresha, K. and Seetharam, N.Y. (1995). Epidermal studies in some species of *Bauhinia* L. (Caesalpinoideae). *Phytomorphology* **45(1-2):** 127-137.

Kotresha, K. and Seetharam, N.Y. (2000). Epidermal micromorphology of some *Cassia* L. (Caesalpiniaceae). *Phytomorphology* **50(3-4):** 229-237.

Leenhouts, P. W. (1978). Systematic notes on the Sapindaceae-Nephelieae. *Blumea* **24:** 395-403.

Leenhouts, P. W. (1986). A taxonomic revision of *Nephelium* (Sapindaceae). *Blumea* **31:** 373-436.

Metcalfe, C.R. and Chalk, L. (1957). *Anatomy of Dicotyledons*. Volume 1 Clarendon Press, Oxford. 725pp.

Metcalfe, C.R. and Chalk, L. (1979). *Anatomy of Dicotyledons.* (2nd edition) Volume 1. Oxford University Press, Oxford. 276pp.

Müller, J. and Leenhouts, P.W. (1976). A general survey of pollen types in Sapindaceae in relation to taxonomy. In: Ferguson, I.K. and Müller, J. (Eds.) *The Evolutionary Significance of the Exine.* Academic Press, London. Pp. 407–445.

Muellner, A.N., Savolainen, V., Samuel, R. and Chase, M.W. (2006). The mahogany family ‘‘out-of-Africa”: divergence time estimation, global biogeographic patterns inferred from plastid rbcL DNA sequences, extant, and fossil distribution of diversity. *Molecular Phylogenetics and Evolution* **40:** 236–250.

Muellner, A.N., Vassiliades, D.D. and Renner, S.S. (2007). Placing Biebersteiniaceae, a herbaceous clade of Sapindales, in a temporal and geographic context. *Plant Systematics and Evolution* **266**: 233–252.

Odugbemi, T. and Akinsulire, O. (2006). Medicinal plants according to Family names. In: Odugbemi, T. (Ed.) *Outlines and Pictures of Medicinal Plants from Nigeria.* University of Lagos Press, Akoka, Yaba, Nigeria. Pp 117-161.

Ogundipe, O.T. and Akinrinlade, O.O. (1998). Epidermal micromorphology of some species of *Albizzia* Durazz (Mimosaceae). *Phytomorphology* **48:** 217-323.

Ogundipe, O.T. and Chase, M.W. (2009). Phylogenetic Analyses of Amaranthaceae Based on matK DNA Sequence Data with Emphasis on West African Species. *Turkish Journal of Botany* **33:** 153-161.

Ogundipe, O.T. and Daramola, S.O. (1998). Epidermal studies in some *Solanum* (Solanaceae). *Biol. Soc. Brot. Ser. 4*, **69:** 101-112.

Ogundipe, O.T. and Olatunji, O.A. (1991). The leaf anatomy of *Cochlospermum* Kunth (Cochlospermaceae) in West Africa. *Feddes Rereptorium* **102(3-4):** 183-187.

Ogundipe, O.T., Ajayi, G.O. and Adeyemi, T.O. (2009). Phytoanatomical and Antimicrobial Studies on *Gomphrena Celosioides* Mart. (Amaranthaceae). *Hamdard Medicus* **51(3):** 146-156.

Olowokudejo, J.D. (1980). *Systematic studies in the genus Biscutella L.* Unpublished Ph.D. Thesis submitted to the University of Reading, England. 421pp.

Olowokudejo, J.D. (1993). Comparative epidermal morphology of West African species of *Jatropha* L. (Euphorbiaceae). *Botanical Journal of the Linnaean Society* **111:** 139-154.

Olowokudejo, J.D. and Ayodele, A.E. (1997). Systematic importance of leaf and epidermal characters in West African species of family Myrtaceae. *Biol. Soc. Brot. Ser*, **2(68):** 35-72.

Olowokudejo, J.D. and Nyananyo, B.L. (1986). Taxonomic studies in the genus *Talinum* (Portulacaceae) in Nigeria. *Willdenowia* **15:** 455-463.

Olowokudejo, J.D. and Obi-osang, T.E. (1993). Taxonomic significance of epidermal morphology in Nigerian Rhizophoraceae. *Acta. Bot. Neerl.* **26:** 225-230.

Olowokudejo, J.D. and Pereira-Sheteolu, O. (1988). The taxonomic value of epidermal characters in the genus *Ocimum* (Lamiaceae). *Phytopmorphology* **38(2-3):** 147-158.

Phillipe, H., Snell, E.A., Bapteste, E., Lopez, P., Holland, P.W.H. and Casane, D. (2004). Phylogenomics of eukaryotes: impact of missing data on large alignments. *Mol. Biol. Evol.* **21:** 1740–1752.

Phillips, S.J. and Dudik, M. (2008). **Modelling of species distributions with Maxent: new extensions and a comprehensive evaluation.** *Ecography*, **31**: 161-175.

Pole, M. (2010). Cuticle morphology of Australasian Sapindaceae. *Botanical Journal of the Linnean Society*, **164:** 264–292

Powell, M., van der Bank, M., Maurin, O and Savolainen, V. (2009). *DNA Barcoding: A Practical Guide.* University of Johannesburg, South Africa. 23pp.

Radford, A.E., Dickson, W.C., Massey, J.R. and Bell, C.R. (1974). *Vascular Plant Systematics.* Harper and Row Publishers, New York. 891pp.

Radlkofer, L. (1890). Ueber die Gliederung der Familie der Sapindaceen. *Sitzungsberichte der Königl. Bayerischen Akademie der Wissenschaften zu München* **20:** 105–379.

Radlkofer, L. (1933). Sapindaceae. In: Engler, A. (Ed.) *Das Pflanzenreich: Regni Vegetabilis Conspectus (IV) 165 (Heft 98ah)*. Leipzig, Verlag von Wilhelm, Engelmann. Pp 983-1002.

Rehder, A. (1935). *Handeliodendron*, a new genus of the Sapindaceae. *Journal of the Arnold Arboretum* 1**6:** 65–67.

Rejdali, M. (1991). Systematic Botany and Plant Population Biology. *Systematic Botany* **1:** 284-316.

Renner, S.S., Schaefer, H. and Kocyan, A. (2007). Phylogenetics of *Cucumis* (Cucurbitaceae): Cucumber (*C. sativus*) belongs in an Asian/Australian clade far from melon (*C. melo*). *BMC Evolutionary Biology* **7**: 58.

Rohlf, F.J. (1993). NTSYS-pc. *Numerical taxonomy and multivariate analysis,* Version 2.02j. Applied Biostatistics, New York.

Ronquist, F., van der Mark, P and Huelsenbeck, J.P. (2009). Bayesian phylogenetic analysis using MR BAYES. In: Philippe, L., Marco, S. and Anne-Mieke, V. (Eds.) *The Phylogenetic Handbook: A practical approach to phylogenetic Analysis and Hypothesis Testing.* 2nd edition. Cambridge University Press, London. Pp 210-266.

Sasikala, K. and Narayanan, R. (1998). Numerical evaluation of trichome characters in certain members of Asteraceae. *Phytomorphology* **48 (1):** 67-81.

Savolainen, V., Chase, M.W., Hoot, S.B., Morton, C.M., Soltis, D.E., Bayer, C., Fay, M.F., De Bruijn, A.Y., Sullivan, S. and Qui, Y.L. (2000a). Phylogenetics of flowering plants based upon a combined analysis of plastid atpB and rbcL gene sequences. *Systematic Biology* **49**: 306–362.

Savolainen, V., Fay, M.F., Albach, D.C., Backlund, M., Van der Bank, M., Cameron, K.M., Johnson, S.A., Lledo´, L., Pintaud, J.C., Powell, M., Sheanan, M.C., Soltis, D.E., Soltis, P.S., Weston, P., Whitten, W.M., Wurdack, K.J. and Chase, M.W. (2000b). Phylogeny of the eudicots: A nearly complete familial analysis of the rbcL gene sequences. *Kew Bulletin* **55**: 257–309.

Seelanan, T., Schnabel, A. and Wendel, J.F. (1997). Congruence and consensus in the cotton tribe (Malvaceae). *Systematic Botany* **22:** 259-290.

Singh, G. (2004). Plant Systematics: An Integrated Approach. Science Publishers, New Hampshire, Enfield. 561pp.

Sneath, P.H.A. and Sokal, R.R. (1973). *Numerical Taxonomy.* W.H. Freeman, San Francisco. 573pp.

Soltis, D.E. and Soltis, P.S. (1998a). Introduction to molecular systematics. In: Soltis D E, Soltis P.S & Doyle, J.J. (Eds), *Molecular Systematics of Plants II: DNA Sequencing*. Kluwer Boston, Massachusetts, USA. Pp. 188–210.

Soltis, D.E. and Soltis, P.S. (1998b). Choosing an approach and appropriate gene for phylogenetic analysis. In: Soltis, D.E., Soltis, P.S. and Doyle, J.J. (Eds.), *Molecular Systematics of Plants II: DNA Sequencing.* Kluwer Boston, Massachusetts, USA. Pp. 1–42.

Stace, C.A. (1965). Cultural studies as an aid to Plant taxonomy. *Bull. Br. Mus. Nat. Hist. Bot.* **4:** 3-78.

Stoeckle, M., Waggoner, P. and Ausubel, J. (2005). Barcoding Life Illustrated: Goals, Rationale and Results. *Consortium for the Barcode of Life Leaflet* **3:** 1-2.

Stuessy, T.F. (1990). *Plant Taxonomy: The Systematic Evaluation of Comparative Data.* Columbia University Press, New York. 514pp.

Sun, Y., Skinner, D.Z., Liang, G.H. and Hulbert, S.H. (1994). Phylogenetic Analysis of *Sorghum* and Related Taxa Using Internal Transcribed Spacers of Nuclear Ribosomal DNA. *Theoretical and Applied Genetics* **89:** 26-32.

Swofford, D.L. and Sullivan, J. (2009). Phylogeny inference based on Parsimony and other methods using PAUP*. In: Philippe, L., Marco, S. and Anne-Mieke, V. (Eds.) *The Phylogenetic Handbook: A practical approach to phylogenetic Analysis and Hypothesis Testing.* 2nd edition, Cambridge University Press, UK. Pp 267-312.

Taberlet, P., Gielly, L., Pautou, G. and Bouvet, J. (1991). Universal Primers for Amplification of 3 Noncoding Regions of Chloroplast DNA. *Plant Molecular Biology* **17:** 1105-1109.

Takhtajan, A. (1987). *Systema Magnoliophytorum.* Soviet Sciences Press, Leningrad, Russia. 437pp.

Thomas, D.W. and Harris, D.J. (1999). New Sapindaceae from Cameroon and Nigeria. *Kew Bull.* **54**: 951–957.

Thorne, R.F. (2000). The classification and geography of the flowering plants: dicotyledons of the class Angiospermae. *Botanical Reviews* **66**: 441–647.

Thorne, R.F. (2007). An update classification of the class Magnoliopsida (‘‘Angiospermae”). *Botanical Reviews* **73:** 67–182.

Ugborogbo, R.E., Ng, N.Q., Thottapilly, G. and Hahn, S.K. (1993). The relevance of stomatal frequency, type and size in the delimitation of three complex species of *Dioscorea* L. (Dioscoreaceae). *Feddes Repertorium.* **104(7-8)**: 485-496.

Umadevi, I. and Daniel, M. (1991). Chemosystematics of the Sapindaceae. *Feddes Repertorium* **102**: 607–612.

Verma, S. and Eckstein, F. (1998). "Modified oligonucleotides: synthesis and strategy for users". *Annu. Rev. Biochem.* **67**: 99–134.

Watson J.D. and Crick F.H.C. (1953). "A Structure for Deoxyribose Nucleic Acid" *Nature* **171** (4356): 737–738.

Watson, L. and Dallwitz, M.J. (2008). *The families of flowering plants: descriptions, illustrations, identification and information retrieval; including synonyms, morphology, anatomy , physiology, phytochemistry, cytology, classification, pathogens, world and local distribution and references. The grass Genera of the World.* Retrieved 2009-08-19.

White, T.J., Bruns, T., Lee, S. and Taylor, J. (1990). Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis, M., Gelfand, D., Sninsky, J. and White, Y. (Eds.) *PCR protocols: a guide to methods and applications.* Academic Press, San Diego. Pp 315-322.

Wiens, J.J. (1998a). Does adding characters with missing data increase or decrease phylogenetic accuracy? *Systematic Biology* **47**: 625–640.

Wiens, J.J. (1998b). Combining data sets with different phylogenetic histories. *Systematic Botany* **47:** 568-58

Wiens, J.J. (2003). Missing data, incomplete taxa, and phylogenetic accuracy. *Systematic Biology* **52**: 528–538.

Wiens, J.J. (2005). Can incomplete taxa rescue phylogenetic analyses from long-branch attraction? *Systematic Biology* **54**: 731–742.

Wiens, J.J. (2006). Missing data and the design of phylogenetic analyses. *Journal of Biomedical Information* **39:** 34–42.

Wiens, J.J. and Reeder, T.W. (1995). Combining data sets with different numbers of taxa for phylogenetic analysis. *Systematic Biology* **44:** 548–558.

Wilkinson, H.P. (1983). Leaf Anatomy of *Gluta* (L.) Ding Hon. (Anacardiaceae). *Botanical Journal of the Linnaean Society* **86:** 375-403.

Wilkinson, H.P. (1989). Leaf Anatomy of *the Menispermaceae tribe Tiliacoreae Miers. Botanical Journal of the Linnaean Society* **99:** 125-174.

Xia, N. and Gadek, P.A. (2007). Sapindaceae. *Flora of China* **12**: 1–6.

Yakovchuk, P., Protozanova, E. and Frank-Kamenetskii, M.D. (2006). "Base-stacking and base-pairing contributions into thermal stability of the DNA double helix". *Nucleic Acids Res.* **34** (2): 564–74.

Yeap, C. K. (1987). The Sapindaceous fruits and nuts. *Yearbook of the West Australian Nut and Tree Crops Association* **12:** 16-33.

APPENDICES

Appendix 1: Operational Definition of Terms

Bootstrapping: This is a statistical method for estimating the sampling distribution of an estimator by sampling with replacement from the original sample, most often with the purpose of deriving robust estimates of standard errors and confidence intervals of a population parameter like a mean, median, proportion, odds ratio, correlation coefficient or regression coefficient.

Exon: An exon is a nucleic acid sequence that is represented in the mature form of an RNA molecule either after portions of a precursor RNA (introns) has been removed by cis-splicing or when two or more precursor RNA molecules have been ligated by trans-splicing.

Family: This is the smallest major category most frequently encountered in taxonomic studies. It consists of one or more genera closely related to each other and the type of a family is the genus.

Genus: This is a collective taxonomic unit containing a number of similar or related species i.e. a category of one or more species with common phylogenetic origin.

Heuristic Search: This designates a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality.

Appendix 1 (cont'd)

Intron: An intron is a DNA region within a gene that is not translated into protein.

Jackknifing: It is used to estimate the bias and standard error (variance) of a statistic, when a random sample of observations is used to calculate it i.e. estimating the precision of sample statistics (medians, variances, percentiles) by using subsets of available data

MAXENT: Maximum Entropy is the least biased-estimate possible on the given information.

Maximum Parsimony: Maximum parsimony is a character-based method that infers a phylogenetic tree by minimizing the total number of evolutionary steps required to explain a given set of data, or in other words by minimizing the total tree length.

Molecular Phylogenetics: This is the use of the structure of molecules to gain information on an organism's evolutionary relationships.

Parsimony: Parsimony implies that simpler hypotheses are preferable to more complicated ones

SEVAG: 24 chloroform : 1 ethyl alcohol

Tribe: A rank in the taxonomic hierarchy between family and genus; when used together with subfamily, tribe is the less inclusive taxon and it is characterized by the suffix –eae.

Appendix 2: Abbreviations and Acronyms

%: Percentage

µl: Microlitres

alt: Altitude

AUC: Area under the receiver operating curve

bp: Bootstrap percentages

CCDB: Canadian Centre for DNA Barcoding

cm: Centimeters

cm^2: Centimetres square

cont'd: Continued

DMSO: Dimethyl sulfoxide

DNA: Deoxyribonucleic acid is a nucleic acid that contains the genetic instructions used in the development and functioning of all known living organisms (with the exception of RNA viruses).

ft: feet

g: Grams

h: Hours

ITS: Internal Transcribed spacer is found in the nucleus.

IUCN: International Union for Conservation of Nature - engaging the private sector to help conserve the integrity and diversity of nature and ensure that any use of natural resources is equitable and ecologically sustainable.

kb: Kilobyte

L: Litres

M: Molar

Appendix 2 (cont'd)

matK: Maturase K gene is found in the large single copy region of the chloroplast genome.

Milli Amp: Milli amperes

min: Minutes

ml: Millilitre

mm: Millimetre

mM: Milli-molar

mm^2: Millimetres square

^{o} C: Degrees Celsius

PCR: Polymerase Chain Reaction is the enzymatic synthesis of multiple copies of a specific DNA sequence in a cyclical manner.

rbcL: Ribulose 1,5-bisphosphate carboxylase large subunit gene of the photosynthetic enzyme rubisco (a carbon fixation enzyme of about 1428 base pairs in size), is found in the chloroplast.

rpm: Rate per minutes

s.l.: Sensu lato (in the widest sense)

s.s.: Sensu strict (in the strict sense)

s: Seconds

trnC: Transfer RNA gene for tRNA (Cys) is found in the chloroplast.

trnF: Transfer RNA gene for tRNA (Phe) is found in the chloroplast.

trnL: Transfer RNA gene for tRNA (Leu)1 is found in the chloroplast.

V: Volts

Appendix 3: Sites Visited for Plant Collection

SITES	COUNTRY	SPECIFIC LOCATION	COORDINATES
Forest Reserves	Cameroon	Bakingili Forest Reserve, Limbe	N04^{O} 04’ 29.5’’ E009^{O} 02’ 35.1’’
		Bali Ngemba Forest Reserve, Bali	N05^{O} 50’ 28.3’’ E10^{O} 04’ 41.1’’
		Bimbia/Mabeta Forest Reserve, Limbe	N03^{O} 57’ 51.1’’ E009^{O} 15’ 09.3’’
		Buea/Likombe Mountain, Buea	N04^{O} 06’ 53.3’’ E009^{O} 10’ 08.7’’
	Ghana	Achimota Community Forest	N05^{O} 37’ 38.0’’ W000^{O} 12’ 49.0’’
	Togo	Lome forest reserve	N06^{O} 08’ 16.0’’ E001^{O} 12’ 45.0’’
	Nigeria	Aponmu Forest Reserve, Ondo	N07^{O} 14’ 14.0’’ E005^{O} 03’ 19.8’’
		Edondon Community forest, Obubra, Cross river.	N05^{O} 52’ 38.0’’ E008^{O} 25’ 49.0’’
		Awi Forest Reserve, Cross river	N05^{O} 15’ 30.0’’ E008^{O} 22’ 34.9’’
		Cross river national Park, Erokut Station, Calabar.	N05^{O} 21’ 86.4’’ E008^{O} 26’ 06.2’’
		Idanre Hills Forest Reserve, Ondo	N07^{O} 06’ 13.8’’ E005^{O} 06’ 05.4’’
		Olokemeji Forest Reserve, Ibadan	N07^{O} 25’ 54.0’’ E003^{O} 31’ 29.7’’
		Owena Forest Reserve, Ondo	N07^{O} 12’ 03.7’’ E005^{O} 01’ 44.4’’
		Sakponba Forest Reserve, Benin	N06^{O} 15’ 11.0’’ E005^{O} 42’ 47.0’’

Appendix 3 (cont'd)

SITES	COUNTRY	SPECIFIC LOCATION	COORDINATES
Botanic Gardens	Cameroon	Limbe Botanic Gardens, Limbe	N04^{O} 00' 57.6'' E009^{O} 13' 27.0''
	Ghana	Aburi Botanic Gardens, Kumasi	N06^{O} 40' 35.0'' W001^{O} 37' 54.9''
		University of Ghana Botanic Garden, Legon	N05^{O} 39' 28.0'' W000^{O} 11' 09.0''
	Nigeria	Ahmadu Bello University Botanic Garden, Zaria	N11^{O} 04' 02.0'' E007^{O} 42' 01.0''
		University of Lagos Botanic Garden, Akoka, Lagos	N06^{O} 31' 03..0'' E003^{O} 23' 07.0''
Herbarium	Cameroon	Limbe Botanic Gardens Herbarium, Limbe	N04^{O} 00' 57.6'' E009^{O} 13' 27.0''
		National Herbarium of Cameroon, Yaoundé (HNC)	N3^{o} 52' E 11^{o} 31'
		Savannah Botanic Gardens Herbarium (SABOGA), Bamenda	N6^{o} 05' E10^{o} 06'
	Ghana	University of Ghana Herbarium, Legon (UGH)	N05^{O} 39' 28.0'' W000^{O}11' 09.0''
	Madagascar	National Herbarium, Antananarivo	S18^{O} 56' E047^{O} 31'
	Nigeria	Ahmadu Bello University	N11^{o} 04' E 7^{o} 42'

		Herbarium, Zaria (ABU)	
		Bayero University Herbarium, Kano (BUH)	N11º 58’51’’ E 8 º 28’57’’
		Forestry Herbarium Ibadan (FHI)	N07º 31’ 08.6’’ E003º 42’ 03.4’’
		University of Benin Herbarium	N16º 20.022’ E 5 º 36.009’
		University of Ibadan Herbarium (UIH)	N7º 23’47’’ E 3 º 55’00’’
		University of Lagos Herbarium (LUH)	N06º 30.934’ E003 º 23.978’
	United Kingdom	Museum of Natural History Herbarium (NHM), Kensington.	N51º 29’46’’ W 0 º 10’35’’
		Royal Botanic Gardens Kew Herbarium (RBG), Richmond	N51º 28’28.8’’ W 0 º 17’43.68’’
Other Sites	Cameroon	Douala River, Douala	N04º 03’ 28.5’’ E009º 41’ 27.0’’
	Madagascar	Tana Town, Antananarivo	S18º 56’ E047º 31’
	Nigeria	Forestry Research Institute of Nigeria, Ibadan	N07º 31’ 08.6’’ E003º 42’ 03.4’’
		Oshodi Express Way, Lagos	N06º 32’ 24.0’’ E003º 20’ 06.0’’

Appendix 4: Sources of Materials used for the Study

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
1.	*Allophylus abyssinicus*		16-Jan-64		Trinderet forest	FHI 20336	ATO 038	MWC 39915
2.	*Allophylus africanus*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 1194	ATO 001	MWC 39910
3.	*Allophylus bullatus*	Adeyemi, T.O	22-Sep-09	Cameroon	Buea Mountain	LUH1185	ATO 002	MWC 39911
4.	*Allophylus cobbe*	Bos, J.J	19-Dec-69	Cameroon	Buea Mountain	FHI 103688	ATO 039	MWC 39916
5.	*Allophylus conraui*	Chapman,	12-Feb-72	Nigeria	Mambilla Plateau	FHI 78107	ATO 040	MWC 39917
6.	*Allophylus didymanaeus*					FHI 75205	ATO 041	MWC 39918
7.	*Allophylus grandifolius*	Letouzey, R.	26-Aug-83	Cameroon	Muyuka	HNC 50596	ATO 042	MWC 39919
8.	*Allophylus griseotomentosus*			Cameroon		FHI	ATO 043	MWC 39920
9.	*Allophylus hirtellus*	Adeyemi, T.O	17-Sep-09	Cameroon	Bakingili forest	LUH 1190	ATO 003	MWC 39912

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
10.	*Allophylus macrobotrys*	Reekmans,	04-Jan-79	Cameroon	Limbe Botanic Gardens	FHI 95067	ATO 044	MWC 39921
11.	*Allophylus megaphyllus*	Thomas, D.W.	24-Nov-86	Cameroon	Ndian	HNC 64379	ATO 045	MWC 39922
12.	*Allophylus nigericus*	Olorunfemi, J	27-Jun-79	Nigeria	Calabar	FHI 92242	ATO 046	MWC 39923
13.	*Allophylus rubifolius*	Reekmans,	24-Nov-86	Cameroon	Ndian falls	FHI 98646	ATO 047	MWC 39924
14.	*Allophylus schweinfurthii*	Bos, J.J	7-Oct-68	Cameroon	Kribi	HNC 30321	ATO 050	MWC 39925
15.	*Allophylus sp*	Adeyemi, T.O	17-Sep-09	Cameroon	Bakingili forest	LUH 3441	ATO 004	MWC 39913
16.	*Allophylus spicatus*	Adeyemi, T.O	08-Jul-08	Nigeria	Olokemeji Forest Res.	LUH 3442	ATO 005	MWC 39914
17.	*Allophylus subcoriaceus*	Elias Endengle	25-Jul-60	Cameroon	Yaoundé	SFRK 19156	ATO 051	MWC 39926
18.	*Allophylus talbotii*	Letouzey, R	25-Jul-60	Cameroon	Yaoundé	SFRK 28391	ATO 052	MWC 39927

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
19.	*Allophylus welwitschii*	Adeyemi, T.O	17-Sep-09	Cameroon	Bakingili forest	LUH 1192	ATO 006	MWC 39876
20.	*Allophylus zenkeri*	Letouzey, R	14-Apr-62	Cameroon	Batouri	SFRK 6261	ATO 053	MWC 39928
21.	*Aporrhiza nitida*	Emwiogbon	21-Jan-79	Nigeria	Sakponba	FHI 63061	ATO 054	MWC 39947
22.	*Aporrhiza talbotii*	Amshoff, G	11-May-78	Nigeria	Cross river	FHI 87370	ATO 056	MWC 39948
23.	*Aporrhiza urophylla*	Alexandria, C.P.	29-Dec-65	Sierra Leone		FHI 6969	ATO 057	MWC 39949
24.	*Atalaya capensis*	Ohaeri, A.O	Jan-37	South Africa	Pretoria	GCH 8980	ATO 058	MWC 39950
25.	*Blighia sapida*	Adeyemi, T.O	14-Feb-10	Nigeria	Oshodi Expressway	LUH 1196	ATO 007	MWC 39951
26.	*Blighia unijugata*	Adeyemi, T.O	13-Dec-09	Nigeria	Sakponba Forest Res.	LUH 3443	ATO 008	MWC 39952

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
27.	*Blighia welwitschii*	Adeyemi, T.O	17-Sep-09	Cameroon	Bakingili forest	LUH 1192	ATO 009	MWC 39953
28.	*Cardiospermum corindium*	Daramola, B.O				FHI	ATO 049	MWC 39980
29.	*Cardiospermum grandiflorum*	Adeyemi, T.O	14-Dec-09	Nigeria	Owena Community For.	LUH 1196	ATO 010	MWC 39954
30.	*Cardiospermum halicacabum*	Ohaeri, A.O. 947	29-May-75	Nigeria	Dumbi community	ABU 947	ATO 059	MWC 39853
31.	*Chytranthus angustifolius*	Gentry, A.L	20-Jul-81	Gabon	Makoku	FHI 102936	ATO 060	MWC 39837
32.	*Chytranthus atroviolaceus*	Hall, J.B	28-Mar-72	Ghana	Kade	GCH 43435	ATO 061	MWC 39854

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
33.	*Chytranthus bracteosus*	Hall, J.B. & A. Assi	14-Aug-75	Ivory coast	Zaque	GCH 45416	ATO 062	MWC 39841
34.	*Chytranthus brunneo-tomensosus*	Edwin Ujor	28-Jun-51	Cameroon	Bamenda	GCH	ATO 063	MWC 39957
35.	*Chytranthus carneus*	Abbiw & Hall, J.B.	26-Sep-76	Ghana	Bia National park	GCH 4650	ATO 064	MWC 39855
36.	*Chytranthus cauliflorus*	Abbiw & Hall, J.B.	05-Jan-74	Ghana		GCH 44715	ATO 079	MWC 39836
37.	*Chytranthus gilleti*	Mbamba, Ekitike	23-Aug-82	Cameroon	Mbalam	HNC 48253	ATO 066	MWC 39883
38.	*Chytranthus macrobotrys*	Adeyemi, T.O	19-Sep-09	Cameroon	Limbe Botanic Gardens	LUH 1187	ATO 011	MWC 39839
39.	*Chytranthus setosus*	Adeyemi, T.O	17-Sep-09	Cameroon	Bakingili forest	LUH 3444	ATO 012	MWC 39838
40.	*Chytranthus sp1*	Adeyemi, T.O	17-Sep-09	Cameroon	Bakingili forest	LUH 3445	ATO 014	MWC 39955

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
41.	*Chytranthus sp2*	Adeyemi, T.O	17-Sep-09	Cameroon	Bakingili forest	LUH 3446	ATO 015	MWC 39956
42.	*Chytranthus talbotii*	Adeyemi, T.O	14-Dec-09	Nigeria	Aponmu Forest Reserve	LUH 3447	ATO 013	MWC 39877
43.	*Chytranthus villger*	Enti, A.A & Hall, J.B.	01-Dec-68	Ghana	Atewa	GCH 38921	ATO 067	MWC 39856
44.	*Chytranthus welwitschii*	Letouzey, R.	13-May-59	Cameroon	Batouri	FHI 20385	ATO 068	-
45.	*Deinbollia angustifolius*	Gentry A.L	20-Jul-81	Gabon	Makoku	FHI 84378	ATO 070	MWC 39857
46.	*Deinbollia grandifolia*	Hall, J.B.	09-Jun-79	Ghana	Bakwai	GCH 47068	ATO 071	MWC 39884
47.	*Deinbollia insignis*	Ariwaodo, J.O & Odewo, T.K.	18-Mar-86	Nigeria	Obudu	FHI 102216	ATO 072	MWC 39858
48.	*Deinbollia kilimandscharia*	De WILDE, J.J & De WILDE, B.E.	17-Aug-65	Ethiopia		GCH 7781	ATO 073	MWC 39840

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
49.	*Deinbollia maxima*	Thomas, D.W & Mcleod, H.L.	03-Jan-86	Cameroon	Bakossi mountain	HNC 56603	ATO 074	MWC 39885
50.	*Deinbollia mezilii*	De WILDE, J.J	24-Jun-75	Cameroon	Kribi	GCH 44613	ATO 075	MWC 39859
51.	*Deinbollia molluscula*	Abbiw & Hall	05-Nov-73	Ghana	Bonsa	GCH 45939	ATO 076	MWC 39886
52.	*Deinbollia pinnata*	Odewo, T.K.	17-Apr-89	Nigeria	Ondo	FHI 103697	ATO 077	MWC 39887
53.	*Deinbollia pycnophylla*	Letouzey, R.	30-Apr-62	Cameroon	Batouri	GCH 6226	ATO 078	MWC 39888
54.	*Deinbollia pynaerti*	Letouzey, R.	30-Apr-62	Cameroon	Batouri	GCH	ATO 068	MWC 39945
55.	*Deinbollia sp*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 3448	ATO 016	MWC 39878
56.	*Deinbollia voltensis*	Hall, J.B.	15-Jul-70	Ghana	Kpondai	GCH 40483	ATO 065	MWC 39890
57.	*Dodonaea viscosa*	Adeyemi, T.O	02-Jun-09	Nigeria	ABU, Zaria	LUH	ATO 037	MWC 39860

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
58.	*Eriocoelum kertstingii*	Ibhanesebhor	13-Nov-75	Nigeria	Mambilla Plateau	FHI 177683	ATO 080	MWC 39891
59.	*Eriocoelum macrocarpum*	Adeyemi, T.O	16-Sep-09	Cameroon	Limbe Botanic Gardens	LUH 1195	ATO 017	MWC 39892
60.	*Eriocoelum microspermum*			Cameroon	Limbe Botanic Gardens	FHI	ATO 069	MWC 39879
61.	*Eriocoelum oblongum*	Onyechuson	28-Mar-64	Nigeria	Calabar	FHI 154222	ATO 082	MWC 39893
62.	*Eriocoelum pungens*	De WILDE, J.J	29-Sep-63	Ivory coast	Abidjan	GCH 53159	ATO 083	MWC 39894
63.	*Eriocoelum racemosum*	Enti, A.A	Sep-59	Ghana	Benso	GCH 7306	ATO 084	MWC 39895
64.	*Ganophyllum giganteum*	Letouzey, R	2-Jul-63	Cameroon	Youkadouma	HNC 7361	ATO 087	MWC 39897
65.	*Glenniea africanus*	Adeyemi, T.O	14-Dec-09	Nigeria	Aponmu Forest Reserve	LUH 3449	ATO 020	MWC 39882

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
66.	*Haplocoelum gallaense*	Letouzey, R	20-Jul-86	Cameroon		HNC 59423	ATO 088	MWC 39861
67.	*Harpullia zanguebarica*			Cameroon	Victoria	FHI 9291	ATO 086	MWC 39896
68.	*Laccodiscus cauliflorus*	Villiers, J.F	05-Jan-74	Ghana		GCH	ATO 079	MWC 39898
69.	*Laccodiscus ferrugineus*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 1183	ATO 018	MWC 39880
70.	*Laccodiscus pseudostipularis*	Florey, J.J.	Nov-72	Cameroon	Mamfe	FHI 39252	ATO 085	MWC 39899
71.	*Laccodiscus sp*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 3450	ATO 048	MWC 39962
72.	*Lecaniodiscus cupanioides*	Adeyemi, T.O	13-Dec-09	Nigeria	Eruwa Express Road	LUH 3451	ATO 019	MWC 39881
73.	*Lecaniodiscus punctatus*	Hall, J.B.	25-Nov-77	Ghana	Kibi-Akwadum	GCH 46960	ATO 089	MWC 39862

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
74.	*Lepisanthes senegalensis*	Ohaeri, A.O.	13-Sep-88	Nigeria	Imo	ABU 2619	ATO 081	MWC 39852
75.	*Litchi chinensis*	Adeyemi, T.O	30-Apr-10	Madagascar	Antananarivo	LUH 3452	ATO 036	MWC 39867
76.	*Lychnodiscus brevibracteatus*	Letouzey, R	6-Jul-72	Cameroon	Yaoundé	SFRK 28388	ATO 090	MWC 39900
77.	*Lychnodiscus danaensis*	Enti, A.A	02-Mar-73	Ghana	Asukese	FHI 79666	ATO 091	MWC 39863
78.	*Lychnodiscus grandifolius*	Bos, J.J	15-Dec-69	Cameroon	Kribi	HNC 31755	ATO 092	MWC 39864
79.	*Lychnodiscus reticulatus*	Ariwaodo, J.O	18-May-77	Nigeria	Obubra	FHI 88761	ATO 093	MWC 39865
80.	*Majidea fosterii*	Adeyemi, T.O	16-Sep-09	Cameroon	Limbe Botanic Gardens	LUH 1718	ATO 025	MWC 39959
81.	*Melicoccus bijugatus*	Ogu	13-Apr-60	Cameroon	Victoria	FHI 52431	ATO 094	MWC 39901

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
82.	*Nephelium lappaceum*	Hall, J.B	14-Jul-76	Ghana	Kade	GCH 46110	ATO 095	MWC 39866
83.	*Pancovia atroviolaceus*	Adeyemi, T.O	17-Sep-09	Cameroon	Bakingili forest	LUH 1182	ATO 021	MWC 39843
84.	*Pancovia bijuga*	Jullick, R	06-May-77	Nigeria	Lagos	FHI 56562	ATO 096	MWC 39902
85.	*Pancovia floribunda*	Adeyemi, T.O	28-Mar-09	Nigeria	Calabar	LUH 12061	ATO 118	MWC 39909
86.	*Pancovia harmsiana*	Letouzey, R	20-Jan-60	Cameroon	Bertoua	SFRK 2926	ATO 097	MWC 39903
87.	*Pancovia laurentii*	Letouzey, R	21-Feb-62	Cameroon	Mesamena	SFRK 6223	ATO 098	MWC 39904
88.	*Pancovia pedicellaris*	Letouzey, R	6-Mar-60	Cameroon	Bertoua	SFRK 3819	ATO 099	MWC 39842
89.	*Pancovia sessiliflora*	Letouzey, R	16-Oct-73	Nigeria	Cross river	SFRK 72404	ATO 100	MWC 39906
90.	*Pancovia sp1*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 1188	ATO 022	MWC 39972

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
91.	*Pancovia sp2*	Adeyemi, T.O	10-Sep-09	Cameroon	Bimbia forest reserve	LUH 1186	ATO 023	MWC 39973
92.	*Pancovia sp3*	Adeyemi, T.O	22-Sep-09	Cameroon	Buea	LUH 3453	ATO 024	MWC 39974
93.	*Pancovia turbinata*	Abbiw & Hall, J.B.	12-Aug-75	Ivory coast	Marone	GCH 45363	ATO 101	MWC 39907
94.	*Paullinia pinnata*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 1193	ATO 026	MWC 39960
95.	*Placodiscus attenuatus*	Hall, J.B	2-Mar-75	Ivorycoast	Kissi	GCH 47087	ATO 102	MWC 39932
96.	*Placodiscus bacoensis*	Hall, J.B and Abbiw	6-Apr-76	Ghana	Yakossi	GCH 3193	ATO 103	MWC 39933
97.	*Placodiscus boya*	Letouzey, R	08-Feb-71	Cameroon	Yokadouma	SFRK 23551	ATO 104	MWC 39934
98.	*Placodiscus bracteosus*	Vigne, G	Jan-30	Ghana	Ashanti	GCH 2694	ATO 105	MWC 39935
99.	*Placodiscus caudatus*	Binuyo, A	12-May-59	Nigeria	Cross river	FHI 41293	ATO 106	MWC 39936

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
100.	*Placodiscus cuneatus*	-	21-Nov-63	Cameroon	Yaoundé	HNC	ATO 107	MWC 39937
101.	*Placodiscus glandulosus*	Letouzey, R	8-Jan-72	Cameroon	Ndikinimiki	SFRK 28397	ATO 108	MWC 39938
102.	*Placodiscus leptostachys*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 3454	ATO 027	MWC 39929
103.	*Placodiscus letestui*	Latilo, A and Oguntayo	28-Feb-73	Nigeria	Cross river	FHI 67759	ATO 109	MWC 39939
104.	*Placodiscus oblongifolius*	Leewenberg, A.J.	23-Feb-59	Ivory coast	Beberi	GCH 2796	ATO 110	MWC 39940
105.	*Placodiscus opacus*	Latilo, M.G.	16-May-52	Nigeria	Calabar	FHI 30970	ATO 111	MWC 39908
106.	*Placodiscus pseudostipularis*	Hall, J.B and Abbiw	20-Aug-75	Ivory coast	Beberi	GCH 45568	ATO 112	MWC 39941
107.	*Placodiscus pynaertii*	Abbiw & Hall, J.B.	14-Sep-46	Congo	Congo	FHI 15475	ATO 113	MWC 39942

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
108.	*Placodiscus riparius*	Deighton, J.C.	17-Sep-51	Sierra Leone	Njala	FHI 39473	ATO 114	MWC 39943
109.	*Placodiscus sp1*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 3455	ATO 028	MWC 39930
110.	*Placodiscus sp2*	Adeyemi, T.O	14-Dec-09	Nigeria	Aponmu Forest Reserve	LUH 3456	ATO 029	MWC 39931
111.	*Placodiscus turbinatus*	Odewo, T.K	3-Apr-88	Cameroon	Korup	FHI 10543	ATO 116	MWC 39946
112.	*Radlkofera calodendron*	Adeyemi, T.O	19-Sep-09	Cameroon	Bimbia forest reserve	LUH 3457	ATO 030	MWC 39975
113.	*Radlkofera sp1*	Adeyemi, T.O	14-Dec-09	Nigeria	Aponmu Forest Reserve	LUH 3458	ATO 031	MWC 39976
114.	*Radlkofera sp2*	Adeyemi, T.O	14-Dec-09	Nigeria	Owena Forest	LUH 3459	ATO 032	MWC 39977
115.	*Radlkofera sp3*	Adeyemi, T.O	22-Sep-09	Cameroon	Buea Mountain	LUH 3460	ATO 033	MWC 39978
116.	*Sapindus saponaria*	Adeyemi, T.O	16-Sep-09	Cameroon	Limbe Botanic Gardens	LUH 3461	ATO 034	MWC 39958

Appendix 4 (cont'd)

S/No	Species	Collectors	Collection Date	Country	Exact Site	Voucher location	Collection Number	DNA Bank Number
117.	*Sapindus trifoliatus*	Daramola, B.O.	31-Aug-68	Nigeria	Abeokuta	FHI 61564	ATO 117	MWC 39905
118.	*Schleichera trijuga*	De WILDE, J.J	14-Mar-34	Cameroon	Limbe Botanic Gardens	FHI 12061	ATO 115	MWC 39979
119.	*Zanha golugensis*	Adeyemi, T.O	08-Jul-08	Nigeria	FRIN, Ibadan	LUH 3462	ATO 035	MWC 39961

Appendix 5.1: Qualitative Morphological Characterization

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
1.	*Allophylus abyssinicus*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
2.	*Allophylus africanus*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	Red	ellips oidal	oval	black	orange	L
3.	*Allophylus bullatus*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	Red	ellips oidal	globose	black	orange	L
4.	*Allophylus cobbe*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
5.	*Allophylus conraui*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
6.	*Allophylus didymanaeus*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
7.	*Allophylus grandifolius*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
8.	*Allophylus griseotomentosu s*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
9.	*Allophylus hirtellus*	s	c.imp	pub	obovate	ser	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	pub
10.	*Allophylus macrobotrys*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
11.	*Allophylus megaphyllus*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
12.	*Allophylus nigericus*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
13.	*Allophylus rubifolius*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
14.	*Allophylus schweinfurthii*	s	c.imp	pub	obovate	ser	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
15.	*Allophylus sp*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
16.	*Allophylus spicatus*	s	c.imp	pub	obovate	ser	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	pub
17.	*Allophylus subcoriaceus*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
18.	*Allophylus talbotii*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
19.	*Allophylus welwitschii*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
20.	*Allophylus zenkeri*	s	c.imp	p.l.g	obovate	ser	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	orange	ellips oidal	globose	black	orange	L
21.	*Aporrhiza nitida*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	Red	flat2l obed	oval	black	yellow	L
22.	*Aporrhiza talbotii*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	Red	flat2l obed	oval	black	yellow	L
23.	*Aporrhiza urophylla*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	capsule	dehis	Red	flat2l obed	oval	black	yellow	pub
24.	*Atalaya capensis*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	orange	L
25.	*Blighia sapida*	t	c.par	p.l.g	oblong	ent	acuminate	acute	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	Red	Trilo bed	globose	black	orange	pub
26.	*Blighia unijugata*	t	c.par	p.l.g	oblong	ent	acuminate	acute	pin	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	Trilo bed	globose	black	orange	L
27.	*Blighia welwitschii*	t	c.par	p.l.g	oblong	ent	acuminate	acute	pin	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	Trilo bed	globose	black	orange	L
28.	*Cardiospermum corindium*	c	c.imp	p.l.g	obovate	den	acuminate	cuneate	pin	alt	pub	c.w	cyme	white	green	inflated	indehis	green	Ovoi d	globose	black	absent	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
29.	*Cardiospermum grandiflorum*	c	c.imp	pub	obovate	den	acuminate	cuneate	pin	alt	pub	c.w	cyme	white	green	inflated	indehis	green	ovoi d	globose	black	absent	pub
30.	*Cardiospermum halicacabum*	c	c.imp	p.l.g	obovate	den	acuminate	cuneate	pin	alt	pub	c.w	cyme	white	green	inflated	indehis	green	ovoi d	globose	black	absent	L
31.	*Chytranthus angustifolius*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	purple	green	capsule	indehis	green	flat3l obed	globose	black	absent	L
32.	*Chytranthus atroviolaceus*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	purple	green	capsule	indehis	brown	flat3l obed	globose	black	absent	pub
33.	*Chytranthus bracteosus*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	glab	c.w	raceme	purple	green	capsule	indehis	orange	flat5l obed	globose	black	absent	pub
34.	*Chytranthus brunneo-tomensosus*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	purple	green	capsule	indehis	green	flat3l obed	globose	black	absent	L
35.	*Chytranthus carneus*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	white	green	capsule	indehis	orange	flat3l obed	globose	black	absent	L
36.	*Chytranthus cauliflorus*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	purple	green	capsule	indehis	yellow	flat3l obed	globose	black	absent	pub
37.	*Chytranthus gilleti*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	purple	green	capsule	indehis	yellow	flat3l obed	globose	black	absent	pub

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
38.	*Chytranthus macrobotrys*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	white	green	capsule	indehis	yellow	flat3l obed	globose	black	absent	L
39.	*Chytranthus setosus*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	purple	green	capsule	indehis	yellow	flat3l obed	globose	brow n	absent	pub
40.	*Chytranthus sp*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	purple	green	capsule	indehis	yellow	flat3l obed	globose	black	absent	L
41.	*Chytranthus sp*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	purple	green	capsule	indehis	yellow	flat3l obed	globose	black	absent	L
42.	*Chytranthus talbotii*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	white	green	capsule	indehis	yellow	flat3l obed	globose	black	absent	L
43.	*Chytranthus villger*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	white	green	capsule	indehis	yellow	flat3l obed	globose	black	absent	pub
44.	*Chytranthus welwitschii*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	white	green	capsule	indehis	Red	flat3l obed	globose	b	absent	pub
45.	*Deinbollia angustifolius*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
46.	*Deinbollia grandifolia*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
47.	*Deinbollia insignis*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
48.	*Deinbollia kilimandscharia*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
49.	*Deinbollia maxima*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
50.	*Deinbollia mezilii*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
51.	*Deinbollia molluscula*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
52.	*Deinbollia pinnata*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	yellow	green	drupe	indehis	green	flat	globose	black	absent	pub
53.	*Deinbollia pycnophylla*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
54.	*Deinbollia pynaerti*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
55.	*Deinbollia sp*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L
56.	*Deinbollia voltensis*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	absent	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
57.	*Dodonaea viscosa*	t	simple	p.l.g	oblanceolate	ent	acuminate	cuneate	pin	alt	glab	pink	panicle	white	green	capsule	dehis	orange	flat	globose	black	orange	L
58.	*Eriocoelum kertstingii*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	yellow	trilobed	globose	black	orange	pub
59.	*Eriocoelum macrocarpum*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	yellow	trilobed	globose	black	orange	pub
60.	*Eriocoelum microspermum*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	yellow	trilobed	globose	black	orange	pub
61.	*Eriocoelum oblongum*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	yellow	trilobed	globose	black	orange	pub
62.	*Eriocoelum pungens*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	yellow	trilobed	globose	black	orange	pub
63.	*Eriocoelum racemosum*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	capsule	dehis	yellow	trilobed	globose	black	orange	pub
64.	*Ganophyllum giganteum*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	drupe	indehis	yellow	ellipsoidal	globose	black	orange	pub
65.	*Glenniea africanus*	s	c.par	p.l.g	obovate	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	drupe	indehis	yellow	ellipsoidal	globose	black	orange	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
66.	*Haplocoelum gallaense*	s	c.par	p.l.g	elliptic	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	orange	L
67.	*Harpullia zanguebarica*	s	c.par	p.l.g	elliptic	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	drupe	indehis	orange	ellips oidal	globose	black	orange	L
68.	*Laccodiscus cauliflorus*	s	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	cyme	white	green	capsule	dehis	Red	trilob ed	globose	black	orange	L
69.	*Laccodiscus ferrugineus*	s	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	cyme	white	green	capsule	dehis	Red	trilob ed	globose	black	yellow	L
70.	*Laccodiscus pseudostipularis*	s	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	cyme	white	green	capsule	dehis	Red	trilob ed	globose	black	yellow	L
71.	*Laccodiscus sp*	s	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	cyme	white	green	capsule	dehis	Red	trilob ed	globose	black	orange	L
72.	*Lecaniodiscus cupanioides*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	pub	c.w	raceme	white	green	berry	indehis	Red	ellips oidal	globose	black	absent	L
73.	*Lecaniodiscus punctatus*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	berry	indehis	Red	ellips oidal	globose	black	absent	L
74.	*Lepisanthes senegalensis*	t	c.par	p.l.g	obovate	ent	acuminate	cuneate	ret	alt	glab	c.w	cyme	white	green	drupe	indehis	Red	ellips oidal	globose	black	absent	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
75.	*Litchi chinensis*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellipsoidal	globose	black	white	L
76.	*Lychnodiscus brevibracteatus*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	pin	alt	glab	c.w	cyme	white	green	capsule	dehis	Red	trilobed	globose	black	orange	L
77.	*Lychnodiscus danaensis*	t	c.par	p.l.g	elliptic	ser	acuminate	cuneate	pin	alt	pub	c.w	cyme	white	green	capsule	dehis	Red	trilobed	globose	black	orange	pub
78.	*Lychnodiscus grandifolius*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	pin	alt	glab	c.w	cyme	white	green	capsule	dehis	Red	trilobed	globose	black	orange	L
79.	*Lychnodiscus reticulatus*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	pin	alt	glab	c.w	cyme	white	green	capsule	dehis	Red	trilobed	globose	black	orange	L
80.	*Majidea fosterii*	t	c.imp	p.l.g	oblong	ent	acuminate	acute	ret	alt	sess	c.w	cyme	white	green	inflated	indehis	Red	trilobed	globose	black	red	L
81.	*Melicoccus bijugatus*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	pin	alt	sess	c.w	raceme	white	green	drupe	indehis	orange	ellipsoidal	globose	black	orange	L
82.	*Nephelium lappaceum*	t	c.imp	p.l.g	obovate	ent	acuminate	cuneate	pin	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellipsoidal	globose	black	white	L
83.	*Pancovia atroviolaceus*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilobed	globose	black	absent	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
84.	*Pancovia bijuga*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L
85.	*Pancovia floribunda*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L
86.	*Pancovia harmsiana*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L
87.	*Pancovia laurentii*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L
88.	*Pancovia pedicellaris*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L
89.	*Pancovia sessiliflora*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	Red	trilob ed	globose	black	absent	L
90.	*Pancovia sp*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L
91.	*Pancovia sp*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L
92.	*Pancovia sp*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
93.	*Pancovia turbinata*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	absent	L
94.	*Paullinia pinnata*	c	c.imp	p.l.g	obovate	den	acuminate	cuneate	pin	alt	sess	c.w	raceme	white	green	capsule	dehis	orange	trilob ed	globose	black	orange	L
95.	*Placodiscus attenuatus*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
96.	*Placodiscus bacoensis*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	pub	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
97.	*Placodiscus boya*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
98.	*Placodiscus bracteosus*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
99.	*Placodiscus caudatus*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
100.	*Placodiscus cuneatus*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
101.	*Placodiscus glandulosus*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	pink	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
102.	*Placodiscus leptostachys*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
103.	*Placodiscus letestui*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
104.	*Placodiscus oblongifolius*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
105.	*Placodiscus opacus*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
106.	*Placodiscus pseudostipularis*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
107.	*Placodiscus pynaertii*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
108.	*Placodiscus riparius*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
109.	*Placodiscus sp*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
110.	*Placodiscus sp*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	trilob ed	globose	black	absent	L
111.	*Placodiscus turbinatus*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	glab	c.w	raceme	purple	pink	drupe	indehis	orange	trilob ed	globose	black	absent	L

S/ No	Species	Habit	Leaf Type	L. surface	L. Shape	L. Margin	L. Apex	L. Base	L. venation	L. arrangement	Petiole	Flower colour	inflorescence	Petal Colour	Sepal Colour	Fruit Type	Fruit type	F. Colour	F. Shape	Seed Shape	S. Colour	Aril Colour	Stem Surface
112.	*Radlkofera calodendron*	t	c.par	p.l.g	obovate	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellipsoidal	globose	black	absent	pub
113.	*Radlkofera sp*	t	c.par	p.l.g	obovate	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellipsoidal	globose	black	absent	L
114.	*Radlkofera sp*	t	c.par	p.l.g	obovate	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellipsoidal	globose	black	absent	L
115.	*Radlkofera sp*	t	c.par	p.l.g	obovate	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	drupe	indehis	orange	ellipsoidal	globose	black	absent	L
116.	*Sapindus saponaria*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	berry	indehis	green	ellipsoidal	globose	black	absent	pub
117.	*Sapindus trifoliatus*	t	c.par	p.l.g	oblong	ent	cuspidate	cuneate	ret	alt	glab	c.w	raceme	white	green	berry	indehis	Red	ellipsoidal	globose	black	absent	L
118.	*Schleichera trijuga*	t	c.par	p.l.g	elliptic	ent	acuminate	cuneate	ret	alt	glab	c.w	raceme	white	green	berry	indehis	green	ellipsoidal	globose	black	absent	L
119.	*Zanha golugensis*	t	c.par	p.l.g	oblong	ent	acuminate	cuneate	ret	alt	glab	c.w	cyme	white	green	drupe	indehis	orange	ellipsoidal	globose	black	absent	L

Key: c = climber, t = tree, s = shrub, c.imp = compound imparipinnate, c.par = compound paripinnate, p.l.g = papery, leathery and glossy; ent = entire, ser = serrate, den = dentate, pub = pubescent, glab = glabrous, pin = pinnate, ret = reticulate, alt = alternate, c.w = creamy white, dehis = dehiscent, indehis = indehiscent, L = lignified

Appendix 5.2: Quantitative Morphological Characterization

S/No	Genus	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
1.	*Allophylus abyssinicus*	3-9	20-26	2-4	3	3-7	3-10	1.00	1	2-4	5	5	3.00
2.	*Allophylus africanus*	2-14	6-33	2-6	3	3-11	10-20	1.00	1	2-5	5	5	3.00
3.	*Allophylus bullatus*	6-11	14-32	3-9	3	3-7	7-15	1.00	1	2-3	5	5	3.00
4.	*Allophylus cobbe*	7-11	18-35	3-8	3	2-8	5-10	1.00	1	2-6	5	5	3.00
5.	*Allophylus conraui*	9-11	20-32	4-8	3	4-10	4-15	1.00	1	2-6	5	5	3.00
6.	*Allophylus didymanaeus*	10-11	17-35	4-8	3	12-20	4-15	1.00	1	2-6	5	5	3.00
7.	*Allophylus grandifolius*	10-25	18-30	3-7	3	13-23	5-15	1.00	1	2-6	5	5	2.00
8.	*Allophylus griseotomentosus*	8-40	20-30	3-7	3	3-5	5-15	1.00	1	2-6	5	5	2.00
9.	*Allophylus hirtellus*	10-26	12-47	4-10	3	3-7	5-15	1.00	1	2-6	5	5	2.00
10.	*Allophylus macrobotrys*	4-12	11-15	3-7	3	2-6	5-15	1.00	1	2-6	5	5	2.00
11.	*Allophylus megaphyllus*	17-30	20-40	7-11	3	2-6	5-15	1.00	1	2-6	5	5	2.00
12.	*Allophylus nigericus*	10-22	22-43	3-11	3	2-4	5-15	1.00	1	2-6	5	5	2.00
13.	*Allophylus rubifolius*	3-11	10-18	3-7	3	2-4	5-15	1.00	1	2-6	5	5	2.00

S/No	Genus	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
14.	*Allophylus schweinfurthii*	9-18	9-20	3-7	3	3-10	5-15	1.00	1	4-8	5	5	2.00
15.	*Allophylus sp*	4-12	13-35	3-11	3	4-10	5-15	1.00	1	4-8	5	5	2.00
16.	*Allophylus spicatus*	5-15	10-25	3-11	3	3-11	5-15	1.00	1	4-8	5	5	2.00
17.	*Allophylus subcoriaceus*	6-14	10-22	5-11	3	2-10	5-15	1.00	1	4-8	5	5	2.00
18.	*Allophylus talbotii*	7-15	9-21	5-11	3	3-9	4-8	1.00	1	4-8	5	5	2.00
19.	*Allophylus welwitschii*	7-15	12-28	5-9	3	3-9	5-15	1.00	1	4-8	5	5	2.00
20.	*Allophylus zenkeri*	6-14	10-28	7-11	3	10-15	5-15	1.00	1	4-8	5	5	2.00
21.	*Aporrhiza nitida*	6-12	15-35	4-10	12	1-5	5-15	1.00	2	4-8	5	5	2.00
22.	*Aporrhiza talbotii*	8-15	20-40	4-8	14	4-16	5-15	1.00	2	4-8	5	5	2.00
23.	*Aporrhiza urophylla*	7-10	20-40	3-7	10	3-7	5-15	1.00	2	3-7	5	5	2.00
24.	*Atalaya capensis*	4-8	7-11	2-6	6	3-7	5-15	1.00	3	4-8	5	5	2.00
25.	*Blighia sapida*	3-15	20-32	3-7	10	3-7	5-15	3.00	3	5-15	5	5	2.00
26.	*Blighia unijugata*	7-20	17-35	2-8	10	3-7	5-15	3.00	3	5-15	5	5	2.00
27.	*Blighia welwitschii*	15-24	20-40	4-10	6	3-7	5-15	3.00	3	3-10	5	5	2.00

S/No	Genus	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
28.	*Cardiospermum corindium*	2-6	4-10	1-3	3	1-5	5-15	2.00	3	3-10	5	5	1.00
29.	*Cardiospermum grandiflorum*	1-5	2-8	1-3	3	1-5	5-15	2.00	3	3-10	5	5	1.00
30.	*Cardiospermum halicacabum*	2-6	4-10	1-3	3	1-5	5-15	2.00	3	3-10	5	5	1.00
31.	*Chytranthus angustifolius*	7-25	20-48	6-15	20	1-5	7-15	2.00	2	5-14	5	5	2.00
32.	*Chytranthus atroviolaceus*	19-45	35-85	10-20	14	2-5	5-10	2.00	2	3-7	5	5	2.00
33.	*Chytranthus bracteosus*	8-26	15-54	3-5	20	2-5	5-10	2.00	2	6-8	5	5	2.00
34.	*Chytranthus brunneo-tomensosus*	19-45	35-85	10-20	14	2-5	5-10	2.00	2	3-7	5	5	2.00
35.	*Chytranthus carneus*	20-30	30-60	3-7	16	2-5	7-10	2.00	2	3-5	5	5	2.00
36.	*Chytranthus cauliflorus*	8-20	20-38	3-7	10	3-5	10-15	2.00	2	3-5	5	5	2.00
37.	*Chytranthus gilleti*	8-15	20-44	4-8	10	3-5	10-15	2.00	2	5-15	5	5	2.00
38.	*Chytranthus macrobotrys*	8-38	20-62	4-15	16	3-5	10-30	2.00	2	5-15	5	5	2.00
39.	*Chytranthus setosus*	9-30	14-60	5-10	8	3-5	4-10	2.00	2	7-14	5	5	2.00
40.	*Chytranthus sp*	19-45	35-85	10-20	10	3-5	10-15	2.00	2	5-15	5	5	2.00
41.	*Chytranthus sp*	8-15	20-44	4-8	10	3-5	10-15	2.00	2	5-15	5	5	2.00

S/No	Genus	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
42.	*Chytranthus talbotii*	9-25	18-60	3-7	20	3-5	15-25	2.00	2	5-15	5	5	2.00
43.	*Chytranthus villger*	8-20	15-38	3-6	8	3-5	10-20	2.00	2	5-15	5	5	2.00
44.	*Chytranthus welwitschii*	13-27	28-60	5-7	8	3-5	10-15	2.00	2	5-10	5	5	2.00
45.	*Deinbollia angustifolius*	10-15	25-35	1-2	10	5-10	4-10	2.00	1	3-6	5	5	2.00
46.	*Deinbollia grandifolia*	14-28	28-60	6-15	14	8-15	7-30	2.00	1	3-6	5	5	2.00
47.	*Deinbollia insignis*	10-15	25-35	3-5	10	10-15	15-35	2.00	1	2-3	5	5	2.00
48.	*Deinbollia kilimandscharia*	8-16	20-40	6-8	10-12	8-15	20-40	2.00	1	3-5	5	5	2.00
49.	*Deinbollia maxima*	15-21	25-40	3-8	6	5-15	16-30	2.00	1	2-3	5	5	2.00
50.	*Deinbollia mezilii*	30-40	60-65	3-5	10	10-15	10-20	2.00	1	3-5	5	5	2.00
51.	*Deinbollia molluscula*	14-28	28-60	3-5	18	10-15	10-20	2.00	1	3-5	5	5	
52.	*Deinbollia pinnata*	3-24	10-60	3-9	14	15-20	8-30	2.00	1	3-5	5	5	1.0
53.	*Deinbollia pycnophylla*	8-15	26-50	3-5	14	15-20	15-25	2.00	1	3-5	5	5	1.0
54.	*Deinbollia pynaerti*	14-28	28-60	3-5	10	10-15	5-10	2.00	1	3-5	5	5	1.0
55.	*Deinbollia sp*	15-24	30-60	5-9	10	9-16	8-20	2.00	1	3-4	5	5	1.00

S/No	Genus	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
56.	*Deinbollia voltensis*	5-12	12-18	2-5	6	3-5	15-20	2.00	1	3-5	5	5	2.00
57.	*Dodonaea viscosa*	2-12	8-25	3-5	-	2-3	3-7	1.00	3	3-7	5	5	3.00
58.	*Eriocoelum kertstingii*	2-20	6-60	3-9	10	2-4	4-10	4.00	3	8-10	5	5	2.00
59.	*Eriocoelum macrocarpum*	4-25	10-60	3-10	20	2-4	5-10	3.00	3	5-15	5	5	2.00
60.	*Eriocoelum microspermum*	12-30	30-55	3-8		2-4	5-10	3.00	3	5-12	5	5	1.00
61.	*Eriocoelum oblongum*	7-16	18-40	3-6	16	2-4	10-12	3.00	3	5-15	5	5	1.00
62.	*Eriocoelum pungens*	2-25	5-58	1-11	10	2-4	5-10	3.00	3	6-12	5	5	1.00
63.	*Eriocoelum racemosum*	7-16	15-35	3-8	16	2-4	10-15	3.00	3	3-8	5	5	1.00
64.	*Ganophyllum giganteum*	8-12	18-25	3-5	10	10-15	10-15	3.00	3	4-10	5	5	2.00
65.	*Glenniea africanus*	7-26	18-50	3-10	6	2-4	10-15	4.00	2	6-8	5	5	1.00
66.	*Haplocoelum gallaense*	1-3	5-7	0.5-1	20	1-2	10	2.00	2	3-5	5	5	1.00
67.	*Harpullia zanguebarica*	2-5	5-15	0.5-1	20	1-2	10-15	2.00	2	3-5	5	5	1.00
68.	*Laccodiscus cauliflorus*	8-12	18-25	3-5	10	10-15	10-15	3.00	3	4-10	5	5	2.00
69.	*Laccodiscus ferrugineus*	17-25	25-40	3-6	14	3-5	20-30	2.00	3	3-8	5	5	1.00

S/No	Genus	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
70.	*Laccodiscus pseudostipularis*	7-16	16-36	3-7	14	3-7	8-20	2.00	3	3-8	5	5	1.00
71.	*Laccodiscus sp*	8-12	18-25	3-5	10	3-5	10-15	3.00	3	3-7	5	5	2.00
72.	*Lecaniodiscus cupanioides*	4-15	6-28	3-7	16	3-10	5-25	1.00	1	1-3	5	5	1.00
73.	*Lecaniodiscus punctatus*	15-25	40-56	6-8	10	3-7	5-10	1.00	2	1-3	5	5	1.00
74.	*Lepisanthes senegalensis*	8-24	22-46	3-8	10	3-6	8-15	1.00	2	2-3	5	5	2.00
75.	*Litchi chinensis*	8-18	18-45	3-7	10	3-5	10-15	3.00	3	3-6	5	5	2.00
76.	*Lychnodiscus brevibracteatus*	10-18	25-40	3-6	10	3-6	10-15	1.00	3	3-6	5	5	2.00
77.	*Lychnodiscus danaensis*	11-25	30-60	5-11	10	2-5	5-10	1.00	3	3-6	5	5	2.00
78.	*Lychnodiscus grandifolius*	10-30	22-65	4-7	10	3-5	18-35	1.00	3	3-5	5	5	2.00
79.	*Lychnodiscus reticulatus*	8-15	18-46	3-7	10	1-3	7-20	1.00	3	3-8	5	5	2.00
80.	*Majidea fosterii*	5-10	10-22	2-5	19	2-5	5-10	2.00	2	6-10	0	5	2.00
81.	*Melicoccus bijugatus*	4-8	12-20	2-4	20	3-4	5-10	2.00	2	5-8	5	5	2.00
82.	*Nephelium lappaceum*	6-13	13-32	3-7	16	2-4	6-15	2.00	1	5-10	5	5	2.00
83.	*Pancovia atroviolaceus*	10-20	12-50	3-5	16	2-4	10-18	2.00	3	5-8	5	5	2.00

S/No	**Genus**	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
84.	*Pancovia bijuga*	4-12	10-30	3-5	10	2-4	5-10	2.00	3	3-5	4	4	2.00
85.	*Pancovia floribunda*	10-20	12-50	3-5	10	2-4	10-18	2.00	3	5-8	4	4	2.00
86.	*Pancovia harmsiana*	10-20	12-50	3-5	8	2-4	10-15	2.00	3	5-8	4	4	2.00
87.	*Pancovia laurentii*	25-30	55-60	5-6	16	2-4	10-20	2.00	3	5-8	4	4	1.00
88.	*Pancovia pedicellaris*	10-15	18-25	3-4	8	3-7	5-15	2.00	3	5-8	0	5	1.00
89.	*Pancovia sessiliflora*	10-28	25-50	2-7	20	2-5	10-15	2.00	3	5-10	4	4	2.00
90.	*Pancovia sp*	10-20	12-50	3-5	16	2-5	10-18	2.00	3	5-8	4	4	2.00
91.	*Pancovia sp*	10-25	20-45	3-5	10	2-5	10-18	2.00	3	5-8	4	4	2.00
92.	*Pancovia sp*	8-20	15-50	3-5	16	2-5	10-18	2.00	3	5-8	4	4	2.00
93.	*Pancovia turbinata*	8-25	22-60	3-9	20	4-7	5-10	2.00	3	5-8	5	5	2.00
94.	*Paullinia pinnata*	5-16	8-34	3-6	5	3-7	5-10	2.00	3	3-6	5	5	2.00
95.	*Placodiscus attenuatus*	8-15	20-32	6-8	10	3-5	10-15	2.00	3	3-6	5	5	2.00
96.	*Placodiscus bacoensis*	20-30	30-70	3-8	10	3-5	10-15	2.00	3	3-8	5	5	2.00
97.	*Placodiscus boya*	7-20	12-40	3-8	8	3-7	5-10	2.00	3	3-7	5	5	2.00

S/No	**Genus**	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
98.	*Placodiscus bracteosus*	10-25	30-60	5-8	10	3-5	12-30	2.00	3	3-6	5	5	2.00
99.	*Placodiscus caudatus*	15-18	35-40	3-6	10	3-5	15-20	2.00	3	4-8	5	5	2.00
100.	*Placodiscus cuneatus*	8-18	22-40	3-8	12	10-15	20-30	2.00	3	4-8	5	5	2.00
101.	*Placodiscus glandulosus*	10-25	28-65	3-9	10	3-10	15-25	2.00	3	3-5	5	5	2.00
102.	*Placodiscus leptostachys*	10-30	18-62	4-10	10	3-4	18-25	2.00	3	5-8	5	5	2.00
103.	*Placodiscus letestui*	15-22	30-60	5-10	4	3-10	15-28	2.00	3	3-6	5	5	2.00
104.	*Placodiscus oblongifolius*	30-45	32-70	4-6	10	3-4	15-30	2.00	3	3-5	5	5	2.00
105.	*Placodiscus opacus*	10-18	20-40	5-8	10	3-7	15-20	2.00	3	3-8	5	5	2.00
106.	*Placodiscus pseudostipularis*	3-15	10-35	3-6	6	3-6	10-18	2.00	3	3-8	5	5	2.00
107.	*Placodiscus pynaertii*	30-45	32-70	4-6	10	3-4	15-30	2.00	3	3-5	5	5	2.00
108.	*Placodiscus riparius*	7-12	20-26	3-4	6	3-5	5-15	2.00	3	4-8	5	5	2.00
109.	*Placodiscus sp*	5-15	10-25	3-5	6	3-6	10-20	2.00	3	3-8	5	5	2.00
110.	*Placodiscus sp*	10-28	22-50	4-8	10	3-7	15-20	2.00	3	3-8	5	5	2.00
111.	*Placodiscus turbinatus*	6-30	24-58	3-8	16	3-7	12-25	2.00	3	3-5	6	2	2.00

S/No	**Genus**	Leaf Length (cm)	Leaf Blade Length (cm)	Leaf Width (cm)	No. of Leaflets	Petiole Length (cm)	Inflorescence length (cm)	Seed Size (cm)	No of Seeds	Fruit size (cm)	No of petals	No of sepals	Stem girth (cm)
112.	*Radlkofera calodendron*	22-36	60-96	8-12	8	2-5	5-12	2.00	2	6-10	5	5	2.00
113.	*Radlkofera sp*	18-43	35-90	6-10	8	2-5	10-15	2.00	2	6-10	5	5	2.00
114.	*Radlkofera sp*	20-38	38-96	5-12	8	2-5	15-20	2.00	2	6-10	5	5	2.00
115.	*Radlkofera sp*	22-35	60-94	8-12	8	2-5	10-25	2.00	2	6-10	5	5	2.00
116.	*Sapindus saponaria*	5-12	10-25	3-7	6	4-6	10-15	2.00	1	6-8	5	5	1.00
117.	*Sapindus trifoliatus*	7-24	30-42	4-9	6	3-6	5-12	2.00	1	5-9	5	2	1.00
118.	*Schleichera trijuga*	6-12	18-34	6-12	6	3-5	12-15	2.00	1	3-8	5	5	1.00
119.	*Zanha golugensis*	3-12	10-28	2-5	10	3-5	10-25	2.00	1	4-6	5	5	1.00

Appendix 6: Pair - wise Analysis Data (Morphology) for NTSYS.

1	**119**	**22**																				
Allophylus abyssinicus	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus africanus	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus bullatus	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus cobbe	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus conraui	1	0	1	2	2	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus didymanaeus	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus grandifolius	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus griseotomentosus	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus hirtellus	1	0	0	2	2	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus macrobotrys	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus megaphyllus	1	0	1	2	2	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus nigericus	1	0	1	2	2	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus rubifolius	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus schweinfurthii	1	0	0	2	2	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus sp	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus spicatus	1	0	0	2	2	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus subcoriaceus	1	0	1	2	2	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus talbotii	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus welwitschii	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Allophylus zenkeri	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1

Appendix 6 (cont'd)

Aporrhiza nitida	2	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	2	0	1	1	0	1
Aporrhiza talbotii	2	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	2	0	1	1	0	1
Aporrhiza urophylla	2	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	2	0	1	1	0	0
Atalaya capensis	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	0	1
Blighia sapida	2	1	1	1	1	1	0	1	1	0	1	1	1	1	0	0	2	2	1	1	0	0
Blighia unijugata	2	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	2	2	1	1	0	1
Blighia welwitschii	2	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	2	2	1	1	0	1
Cardiospermum corindium	3	0	1	2	0	1	1	1	1	0	1	0	1	1	3	1	2	1	1	1	1	1
Cardiospermum grandiflorum	3	0	0	2	0	1	1	1	1	0	1	0	1	1	3	1	2	1	1	1	1	0
Cardiospermum halicacabum	3	0	1	2	0	1	1	1	1	0	1	0	1	1	3	1	2	1	1	1	1	1
Chytranthus angustifolius	2	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	2	2	1	1	1	1
Chytranthus atroviolaceus	2	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	2	2	1	1	1	0
Chytranthus bracteosus	2	1	1	1	1	0	1	0	1	1	1	1	0	1	0	0	2	3	1	1	1	0
Chytranthus brunneo-tomensosus	2	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	2	2	1	1	1	1
Chytranthus carneus	2	1	1	1	1	0	1	0	1	0	1	1	1	1	0	0	2	2	1	1	1	1
Chytranthus cauliflorus	2	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	2	2	1	1	1	0
Chytranthus gilleti	2	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	2	2	1	1	1	0
Chytranthus macrobotrys	2	1	1	1	1	0	1	0	1	0	1	1	1	1	0	0	2	2	1	1	1	1
Chytranthus setosus	2	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	2	2	1	1	1	0

Appendix 6 (cont'd)

Chytranthus sp	2	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	2	2	1	1	1	1
Chytranthus sp	2	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	2	2	1	1	1	1
Chytranthus talbotii	2	1	1	1	1	0	1	0	1	0	1	1	1	1	0	0	2	2	1	1	1	1
Chytranthus villger	2	1	1	1	1	0	1	0	1	0	1	1	1	1	0	0	2	2	1	1	1	0
Chytranthus welwitschii	2	1	1	1	1	0	1	0	1	0	1	1	1	1	0	0	2	2	1	1	1	0
Deinbollia angustifolius	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia grandifolia	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia insignis	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia kilimandscharia	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia maxima	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia mezilii	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia molluscula	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia pinnata	2	1	1	1	1	1	1	1	1	0	1	1	2	1	2	1	2	4	1	1	1	0
Deinbollia pycnophylla	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia pynaerti	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia sp	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Deinbollia voltensis	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Dodonaea viscosa	2	1	1	3	1	1	1	1	1	1	0	2	1	1	0	0	2	4	1	1	0	1
Eriocoelum kertstingii	2	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	2	2	1	1	0	0
Eriocoelum macrocarpum	2	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	2	2	1	1	0	0

Appendix 6 (cont'd)

Eriocoelum microspermum	2	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	2	2	1	1	0	0
Eriocoelum oblongum	2	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	2	2	1	1	0	0
Eriocoelum pungens	2	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	2	2	1	1	0	0
Eriocoelum racemosum	2	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	2	2	1	1	0	0
Ganophyllum giganteum	2	1	1	0	1	1	1	1	1	0	1	1	1	1	2	1	2	1	1	1	0	0
Glenniea africanus	1	1	1	2	1	1	1	1	1	0	1	1	1	1	2	1	2	1	1	1	0	1
Haplocoelum gallaense	1	1	1	0	1	1	1	1	1	0	1	1	1	1	2	1	2	1	1	1	0	1
Harpullia zanguebarica	1	1	1	0	1	1	1	1	1	0	1	1	1	1	2	1	2	1	1	1	0	1
Laccodiscus cauliflorus	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	0	2	2	1	1	0	1
Laccodiscus ferrugineus	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	0	2	2	1	1	0	1
Laccodiscus pseudostipularis	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	2	2	1	1	0	1
Laccodiscus sp	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	2	2	1	1	0	1
Lecaniodiscus cupanioides	2	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	1	1	1	1
Lecaniodiscus punctatus	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Lepisanthes senegalensis	2	1	1	2	1	1	1	0	1	1	1	0	1	1	2	1	2	1	1	1	1	1
Litchi chinensis	2	1	1	0	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	2	1
Lychnodiscus brevibracteatus	2	1	1	0	1	1	1	1	1	1	1	0	1	1	0	0	2	2	1	1	0	1
Lychnodiscus danaensis	2	1	1	0	1	1	1	1	1	1	1	0	1	1	0	0	2	2	1	1	0	0
Lychnodiscus grandifolius	2	1	1	0	1	1	1	1	1	1	1	0	1	1	0	0	2	2	1	1	0	1

Appendix 6 (cont'd)

Lychnodiscus reticulatus	2	1	1	0	1	2	1	1	1	1	1	0	1	1	0	0	2	2	1	1	0	1
Majidea fosterii	2	0	1	1	1	1	0	0	1	2	1	0	1	1	3	1	2	2	1	1	0	1
Melicoccus bijugatus	2	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	2	1	1	1	0	1
Nephelium lappaceum	2	0	1	2	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	2	1
Pancovia atroviolaceus	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia bijuga	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia floribunda	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia harmsiana	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia laurentii	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia pedicellaris	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia sessiliflora	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia sp	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia sp	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia sp	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Pancovia turbinata	2	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	2	2	1	1	1	1
Paullinia pinnata	3	0	1	2	0	1	1	1	1	2	1	1	1	1	0	0	2	2	1	1	0	1
Placodiscus attenuatus	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus bacoensis	2	1	1	1	1	1	1	0	1	0	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus boya	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus bracteosus	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus caudatus	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1

Appendix 6 (cont'd)

Placodiscus cuneatus	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus glandulosus	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus leptostachys	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus letestui	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus oblongifolius	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus opacus	2	1	1	1	1	1	1	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus pseudostipularis	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus pynaertii	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus riparius	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus sp	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus sp	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1	1	1
Placodiscus turbinatus	2	1	1	1	1	0	1	0	1	1	1	1	0	3	2	1	2	2	1	1	1	1
Radlkofera calodendron	2	1	1	2	1	1	1	0	1	1	1	1	1	1	2	1	2	1	1	1	1	0
Radlkofera sp	2	1	1	2	1	1	1	0	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Radlkofera sp	2	1	1	2	1	1	1	0	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Radlkofera sp	2	1	1	2	1	1	1	0	1	1	1	1	1	1	2	1	2	1	1	1	1	1
Sapindus saponaria	2	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	2	1	1	1	1	0
Sapindus trifoliatus	2	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Schleichera trijuga	2	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Zanha golugensis	2	1	1	1	1	1	1	0	1	1	1	0	1	1	2	1	2	1	1	1	1	1

Appendix 7: List of Characters, Character States and Codes used in Numerical Analysis

Characters	**Character States and Code**
Habit	1. Climber 2. Shrub 3. Tree
Stem Characters	
Stem girth in cm	Actual mean value for each taxon
Stem surface	1. Lignified 2. Pubescent
Leaf Characters	
Leaf apex	1. Acuminate 2. Acute
Leaf arrangement	1. Alternate 2. Sub-opposite
Leaf base	1. Acute 2. Cuneate
Leaf blade length	Actual mean value
Leaf length	Actual mean value
Leaf margin	1. Entire 2. Dentate 3. Serrate
Leaf surface	1. Papery/Leathery/Glossy 2. Pubescent
Leaf type	1. Compound imparipinnate 2. Compound paripinnate 3. Simple
Leaf veination	1. Pinnate 2. Reticulate
Leaf width	Actual mean value
No. of Leaflets	Actual mean value

Appendix 7 (cont'd)

Characters	**Character States and Code**
Overall leaf shape	1. Elliptic 2. Oblong 3. Obovate
Petiole length	Actual mean value
Petiole surface	1. Glabrous 2. Pubescent
Inflorescence Characters	
Inflorescence length	Actual mean value
Inflorescence type	1. Cyme 2. Raceme
Fruit Characters	
Fruit size in cm	Actual mean value
Fruit type	1. Berry 2. Capsule 3. Drupe 4. Inflated 5. Dehiscent 6. Indehiscent
Fruit shape	1. Ellipsoidal 2. Ovoid 3. Flat/trilobed
No. of seeds	Actual mean value
Seed shape	1. Globose 2. Oval
Seed size	Actual mean value

Appendix 8: Sample Prediction Data for Maxent Model

X	Y	Test or train	Raw prediction	Cumulative prediction	Logistic prediction
4.867	8.883	train	0.002595	76.37941	0.762132
4.617	9.433	train	0.003142	80.58048	0.795095
3.95	11.367	train	6.32E-04	38.83137	0.438136
3.083	10.4	train	0.001065	52.87043	0.568026
3	10.033	train	0.001314	58.32626	0.618677
5.083	9.7	train	0.001776	66.87571	0.686861
2.717	9.867	train	0.001144	54.33371	0.585458
4.917	8.833	train	0.001472	60.9346	0.64506
6.25	5	train	0.002181	73.27385	0.72919
6.383	9.367	train	0.001879	68.87773	0.698858
4.833	9.017	train	0.00347	84.91852	0.810769
3.817	11.467	train	6.39E-04	39.20232	0.441167
4.3	9.1	train	0.001425	60.25291	0.637666
14.817	3.017	train	1.17E-04	10.00963	0.126142
4.7	8.95	train	0.002668	77.43223	0.767142
6.176	5.893	train	0.001949	70.33247	0.706483
7.201	5.029	train	0.003799	86.75497	0.824297
5.05	8.8	train	9.50E-04	49.53057	0.539787
2.867	9.983	train	0.001643	64.23886	0.669835
4.867	9.467	train	0.003466	84.57154	0.810593
5.267	9.183	train	0.004169	87.97299	0.837351

Appendix 8 (cont'd)

X	Y	Test or train	Raw prediction	Cumulative prediction	Logistic prediction
5.283	9.083	train	0.002016	70.93406	0.713397
2.833	11.15	train	1.53E-04	13.11642	0.158497
-7.316	4.9	train	0.001596	63.44776	0.663423
-0.2	5.65	train	4.15E-04	29.98265	0.338736
-0.9	6.78	train	1.77E-04	15.03619	0.17904
-0.99	7.72	train	2.07E-04	17.32219	0.203701
-2.4	5.2	train	0.001253	56.51764	0.60745
-2.85	6.617	train	3.28E-04	25.14248	0.28854
-8.9	8.533	train	6.11E-04	38.12639	0.429965
-8.933	7.533	train	4.62E-04	32.09277	0.363167
-8.573	8.139	train	5.10E-04	34.04223	0.386396
2.7799	16.42	train	0.003197	81.53624	0.797906
2.1099	14.06	train	2.75E-04	21.59617	0.253291
2.63	15.38	train	0.001036	51.69802	0.561208
3	15.47	train	9.29E-04	49.28229	0.534169
1.6617	13.2812	train	1.34E-04	11.41681	0.141697
0.25	11.67	train	0.00207	71.34372	0.718796
1.62	10.07	train	0.002596	76.63894	0.762247
2.98	16.22	train	0.003038	80.26617	0.78952
0.17	12.5399	train	3.00E-04	23.14027	0.270112
2.7	16.12	train	0.003531	85.62149	0.813442

Appendix 8 (cont'd)

X	Y	Test or train	Raw prediction	Cumulative prediction	Logistic prediction
4.83	9.68	train	0.001341	58.85997	0.623502
4.73	9.48	train	0.003463	84.22473	0.810479
4.0199	9.17	train	0.001503	61.65816	0.649782
1.1299	10.22	train	0.002272	74.17233	0.737248
0.4199	11.5	train	0.002546	75.86207	0.758678
1.34	9.51	train	0.001822	68.03554	0.69229
1.65	10.2899	train	0.001334	58.59218	0.622202
1.43	10.21	train	0.002657	77.16538	0.766409
1.76	10.27	train	0.002087	71.55246	0.720486
2.33	16.18	train	0.003906	87.14566	0.828271
2.35	16.15	train	0.003786	86.37511	0.823791
2.37	16.17	train	0.003292	82.5172	0.802572
2.65	17.17	train	1.03E-04	8.739581	0.112492
5.93	8.92	train	0.002158	72.62147	0.727095
5	9.17	train	0.003395	83.22769	0.807413
0.22	10.92	train	0.00237	74.87521	0.745331
0.4	11.88	train	4.24E-04	30.63014	0.34367
6.23	9.32	train	0.001743	66.26109	0.68272
2.5	10.58	train	0.001196	55.03722	0.596261
1.58	11.52	train	0.001947	70.13749	0.706198
4.95	9.53	train	0.003443	83.53278	0.809575

Appendix 8 (cont'd)

X	Y	Test or train	Raw prediction	Cumulative prediction	Logistic prediction
5.1	8.85	train	0.003172	80.89757	0.796597
6.22	9.47	train	0.001904	69.17226	0.701627
1.85	13.97	train	2.19E-04	18.11794	0.212786
0.7699	13.05	train	9.61E-05	8.225549	0.106123
0.67	11.83	train	0.001833	68.35485	0.693597
10.033	5.067	train	0.00272	77.97343	0.770593
8.883	4.867	train	0.006745	94.15583	0.892809
9.433	4.617	train	0.008155	97.12801	0.909668
3.05	8.333	train	2.39E-04	19.70019	0.227957
10.033	3	train	0.00375	86.20071	0.82241
9.867	2.717	train	0.002606	76.89959	0.76294
8.833	4.917	train	0.008626	97.99062	0.914173
0.15	5.683	train	3.70E-04	27.53325	0.313712
9.017	4.833	train	0.009699	98.96048	0.922935
11.467	3.817	train	0.001758	66.45687	0.684655
9.1	4.3	train	0.005227	92.27989	0.865849
8.95	4.7	train	0.002743	78.24769	0.77204
5.838	6.125	train	0.001918	69.36403	0.703113
5.893	6.176	train	0.001411	60.11021	0.635398
8.451	5.374	train	0.003497	85.26838	0.811973
8.8	5.05	train	0.004939	90.25272	0.859135

Appendix 8 (cont'd)

X	Y	Test or train	Raw prediction	Cumulative prediction	Logistic prediction
9.983	2.867	train	0.005366	92.81649	0.868871
11.117	3.567	train	0.002118	71.76433	0.723382
9.183	5.267	train	0.00502	91.25167	0.86108
9.083	5.283	train	0.005055	91.75713	0.861906
9.75	4.917	Train	0.004104	87.55609	0.835199
11.15	2.833	Train	0.002899	79.36955	0.781655
16.42	2.7799	Train	9.63E-04	49.743	0.543097
14.06	2.1099	Train	1.72E-04	14.6796	0.17491
15.38	2.63	Train	9.94E-04	50.31093	0.551083
13.2812	1.6617	Train	7.68E-04	43.60025	0.486835
11.67	0.25	Train	3.71E-04	27.55872	0.314211
10.07	1.62	Train	0.004447	88.84127	0.845959
16.22	2.98	Train	8.51E-04	47.20339	0.512415
12.5399	0.17	Train	6.46E-04	39.51031	0.443574
16.12	2.7	Train	9.53E-04	49.5797	0.540557
9.68	4.83	Train	0.004496	89.29088	0.847382
9.33	4.6	Train	0.010395	99.99999	0.927725
9.48	4.73	Train	0.006968	94.85267	0.895882
9.17	4.0199	Train	0.002342	74.63821	0.743037
-3.6	6.5	Train	3.85E-04	28.21746	0.322369
11.5	0.4199	Train	2.74E-04	21.50628	0.252608

Appendix 8 (cont'd)

X	Y	Test or train	Raw prediction	Cumulative prediction	Logistic prediction
9.51	1.34	Train	0.001345	58.91166	0.624103
10.2899	1.65	Train	0.002982	79.96242	0.786446
10.27	1.76	Train	0.00497	90.74973	0.859892
16.18	2.33	Train	8.01E-04	44.87804	0.497216
16.15	2.35	Train	0.001063	52.78386	0.567696
16.17	2.37	Train	7.38E-04	42.51902	0.476691
9.17	5	Train	0.007378	96.31247	0.901098
10.92	0.22	Train	5.08E-04	33.87541	0.385471
11.88	0.4	Train	4.24E-04	30.64073	0.343838
9.91	1.88	Train	0.00199	70.53146	0.710759
9.32	6.23	Train	6.96E-04	41.50522	0.462288
9.83	0	Train	8.41E-04	46.79959	0.509336
10.58	2.5	Train	0.004679	89.7588	0.852457
8.85	5.1	Train	0.006648	93.48132	0.891412
9.47	6.22	Train	0.001305	58.00773	0.617149
12.03	0.5	Train	5.11E-04	34.06782	0.386689
13.97	1.85	Train	1.90E-04	16.05499	0.189726
13.05	0.7699	Train	7.63E-04	43.31862	0.485167
3.567	11.117	Test	1.61E-04	13.92413	0.166111
6.125	5.838	Test	0.002346	74.67201	0.743367
5.067	10.033	Test	7.99E-04	44.76611	0.496661

Appendix 8 (cont'd)

X	Y	Test or train	Raw prediction	Cumulative prediction	Logistic prediction
5	6.25	Test	6.68E-04	40.67991	0.451971
9.367	6.383	Test	6.58E-04	40.13617	0.448299
0.5	12.03	Test	3.65E-04	27.24949	0.310587
4.917	9.75	Test	0.001357	59.09911	0.626269
9.467	4.867	Test	0.004235	88.39651	0.839473
8.92	5.93	Test	0.001756	66.43434	0.684434
10.21	1.43	Test	0.003376	83.10495	0.80653
9.7	5.083	Test	0.001022	51.42363	0.558011
11.52	1.58	Test	0.001494	61.36578	0.648534
1.88	9.91	Test	0.001821	67.8578	0.692218
3.017	14.817	Test	2.02E-04	16.96666	0.199743
9.53	4.95	Test	0.003686	85.88631	0.819865
0	9.83	Test	0.001554	62.90571	0.657383
5.029	7.201	Test	3.84E-04	28.12025	0.321478
3	8	Test	1.55E-04	13.32612	0.160752
10.4	3.083	Test	0.002352	74.72451	0.743877
10.22	1.1299	Test	0.002205	73.51397	0.73134
15.47	3	Test	9.70E-04	49.92603	0.54508
5.374	8.451	Test	1.89E-04	16.03191	0.189379
11.367	3.95	Test	0.00115	54.39348	0.586805
-3.1	6.083	Test	7.38E-04	42.53504	0.476906

Appendix 8 (cont'd)

X	Y	Test or train	Raw prediction	Cumulative prediction	Logistic prediction
4.6	9.33	Test	0.003292	82.49978	0.802563
17.17	2.65	Test	1.20E-04	10.25002	0.129493
-8.212	7.604	Test	6.12E-04	38.15246	0.43039
-7.788	6.174	Test	2.91E-04	22.52435	0.26436
-2.617	5.533	Test	3.63E-04	27.18695	0.309767
11.83	0.67	Test	4.20E-04	30.42565	0.341261

Appendix 9: Spectrophotometric Quantification of DNA Samples

S/No	SPECIES	SPECTROPHOTOMETRIC READINGS				
		CONC ng/µl	**A_{230}**	**A_{260}**	**A_{280}**	**$A_{260/A280}$**
1.	*Allophylus abyssinicus*	1487	0.671	0.522	0.311	1.68
2.	*Allophylus africanus*	1638	0.53	0.575	0.361	1.59
3.	*Allophylus bullatus*	2261	0.796	0.793	0.475	1.67
4.	*Allophylus cobbe*	103	0.048	0.036	0.03	1.21
5.	*Allophylus conraui*	410	0.168	0.144	0.128	1.12
6.	*Allophylus didymanaeus*	433	0.111	0.152	0.092	1.65
7.	*Allophylus grandifolius*	351	0.122	0.123	0.08	1.53
8.	*Allophylus griseotomentosus*	206	0.104	0.072	0.064	1.13
9.	*Allophylus hirtellus*	723	0.323	0.254	0.152	1.67
10.	*Allophylus macrobotrys*	1895	0.681	0.665	0.463	1.44
11.	*Allophylus megaphyllus*	1975	0.63	0.693	0.702	0.99
12.	*Allophylus nigericus*	1824	0.957	0.64	0.477	1.34
13.	*Allophylus rubifolius*	209	0.081	0.073	0.052	1.42
14.	*Allophylus schweinfurthii*	1499	0.429	0.526	0.321	1.64
15.	*Allophylus sp*	1118	0.426	0.392	0.318	1.24
16.	*Allophylus spicatus*	1472	0.609	0.516	0.341	1.51
17.	*Allophylus subcoriaceus*	616	0.29	0.216	0.202	1.07
18.	*Allophylus talbotii*	1090	0.54	0.383	0.229	1.67
19.	*Allophylus welwitschii*	1321	0.433	0.463	0.273	1.7
20.	*Allophylus zenkeri*	449	0.363	0.158	0.092	1.71
21.	*Aporrhiza nitida*	738	0.344	0.259	0.223	1.16
22.	*Aporrhiza talbotii*	1026	0.403	0.36	0.327	1.1

Appendix 9 (cont'd)

S/No	SPECIES	CONC ng/µl	A_{230}	A_{260}	A_{280}	$A_{260/A280}$
23.	*Aporrhiza urophylla*	3215	1.246	1.128	0.99	1.14
24.	*Atalaya capensis*	871	0.366	0.306	0.194	1.57
25.	*Blighia sapida*	4469	1.818	1.568	1.513	1.04
26.	*Blighia unijugata*	1335	0.551	0.468	0.348	1.34
27.	*Blighia welwitschii*	316	0.226	0.111	0.06	1.84
28.	*Cardiospermum corindium*	1083	0.416	0.38	0.291	1.31
29.	*Cardiospermum grandiflorum*	3474	1.167	1.21	0.848	1.44
30.	*Cardiospermum halicacabum*	25.7	0.006	0.008	0.005	1.76
31.	*Chytranthus angustifolius*	20	0.006	0.008	0.005	1.76
32.	*Chytranthus atroviolaceus*	89.9	0.415	0.407	0.385	1.06
33.	*Chytranthus bracteosus*	19.4	0.02	0.015	0.014	1.07
34.	*Chytranthus brunneo-tomensosus*	308	0.197	0.108	0.077	1.4
35.	*Chytranthus carneus*	58	0.025	0.035	0.02	1.75
36.	*Chytranthus cauliflorus*	26	0.015	0.014	0.012	1.34
37.	*Chytranthus gilleti*	427	0.152	0.15	0.11	1.36
38.	*Chytranthus macrobotrys*	46.6	0.032	0.031	0.025	1.55
39.	*Chytranthus setosus*	50	0.018	0.022	0.015	1.56
40.	*Chytranthus sp*	195	0.069	0.068	0.045	1.53
41.	*Chytranthus sp*	2198	0.601	0.771	0.45	1.71
42.	*Chytranthus talbotii*	472	0.396	0.166	0.083	1.99
43.	*Chytranthus villger*	28	0.045	0.082	0.05	1.64
44.	*Chytranthus welwitschii*	LOST				
45.	*Deinbollia angustifolius*	27	0.02	0.024	0.02	1.64

Appendix 9 (cont'd)

S/No	SPECIES	CONC ng/µl	A_{230}	A_{260}	A_{280}	A_{260}/A_{280}
46.	*Deinbollia grandifolia*	2485	0.894	0.872	0.51	1.71
47.	*Deinbollia insignis*	26	0.025	0.049	0.03	1.63
48.	*Deinbollia kilimandscharia*	30.8	0.025	0.024	0.02	1.64
49.	*Deinbollia maxima*	294	0.129	0.103	0.076	1.36
50.	*Deinbollia mezilii*	5316	1.022	1.865	2.116	0.88
51.	*Deinbollia molluscula*	1003	0.363	0.352	0.245	1.44
52.	*Deinbollia pinnata*	2615	1.063	0.917	0.712	1.29
53.	*Deinbollia pycnophylla*	1909	0.701	0.67	0.389	1.72
54.	*Deinbollia pynaerti*	419	0.165	0.147	0.103	1.43
55.	*Deinbollia sp*	91	0.042	0.032	0.023	1.37
56.	*Deinbollia voltensis*	2027	0.595	0.711	0.409	1.74
57.	*Dodonaea viscosa*	990	0.731	0.347	0.209	1.66
58.	*Eriocoelum kertstingii*	451	0.187	0.158	0.127	1.24
59.	*Eriocoelum macrocarpum*	1828	1.139	0.642	0.449	1.43
60.	*Eriocoelum microspermum*	812	0.471	0.285	0.243	1.17
61.	*Eriocoelum oblongum*	1257	0.512	0.441	0.363	1.21
62.	*Eriocoelum pungens*	115	0.07	0.04	0.033	1.22
63.	*Eriocoelum racemosum*	1675	0.675	0.588	0.501	1.17
64.	*Ganophyllum giganteum*	226	0.106	0.079	0.07	1.14
65.	*Glenniea africanus*	5172	1.541	1.815	1.585	1.14
66.	*Haplocoelum gallaense*	531	0.191	0.186	0.12	1.55
67.	*Harpullia zanguebarica*	1985	0.578	0.697	0.655	1.06
68.	*Laccodiscus cauliflorus*	408	0.145	0.143	0.126	1.14

Appendix 9 (cont'd)

S/No	SPECIES	CONC ng/µl	A_{230}	A_{260}	A_{280}	A_{260}/A_{280}
69.	*Laccodiscus ferrugineus*	601	0.229	0.211	0.133	1.58
70.	*Laccodiscus pseudostipularis*	128	0.052	0.045	0.037	1.21
71.	*Laccodiscus sp*	4634	2.03	1.626	1.391	1.17
72.	*Lecaniodiscus cupanioides*	2705	0.686	0.949	0.925	1.03
73.	*Lecaniodiscus punctatus*	3325	1.363	1.167	1.24	0.94
74.	*Lepisanthes senegalensis*	56.7	0.018	0.022	0.015	1.56
75.	*Litchi chinensis*	45.5	0.034	0.026	0.018	2.01
76.	*Lychnodiscus brevibracteatus*	5316	1.022	1.865	2.116	0.88
77.	*Lychnodiscus danaensis*	3360	0.881	1.179	1.193	0.99
78.	*Lychnodiscus grandifolius*	2982	1.131	0.406	0.707	1.48
79.	*Lychnodiscus reticulatus*	1505	0.473	0.528	0.446	1.18
80.	*Majidea fosterii*	1162	0.215	0.408	0.219	1.86
81.	*Melicoccus bijugatus*	990	0.731	0.347	0.209	1.66
82.	*Nephelium lappaceum*	1159	0.415	0.407	0.385	1.06
83.	*Pancovia atroviolaceus*	70.2	0.02	0.031	0.022	1.55
84.	*Pancovia bijuga*	531	0.191	0.186	0.12	1.55
85.	*Pancovia floribunda*	546	0.202	0.192	0.142	1.35
86.	*Pancovia harmsiana*	3325	1.363	1.167	1.24	0.94
87.	*Pancovia laurentii*	3360	0.881	1.179	1.193	0.99
88.	*Pancovia pedicellaris*	29	1.022	1.865	2.116	0.88
89.	*Pancovia sessiliflora*	1505	0.473	0.528	0.446	1.18
90.	*Pancovia sp*	886	0.704	0.311	0.176	1.76
91.	*Pancovia sp*	3716	1.777	1.304	0.888	1.47

Appendix 9 (cont'd)

S/No	SPECIES	CONC ng/µl	A_{230}	A_{260}	A_{280}	A_{260}/A_{280}
92.	*Pancovia sp*	785	0.236	0.275	0.2	1.38
93.	*Pancovia turbinata*	1159	0.415	0.407	0.385	1.06
94.	*Paullinia pinnata*	472	0.157	0.166	0.112	1.48
95.	*Placodiscus attenuatus*	2091	1.017	0.734	0.603	1.22
96.	*Placodiscus bacoensis*	487	0.391	0.171	0.121	1.41
97.	*Placodiscus boya*	1370	0.855	0.481	0.392	1.23
98.	*Placodiscus bracteosus*	652	0.206	0.229	0.263	0.87
99.	*Placodiscus caudatus*	1755	1.104	0.616	0.507	1.21
100.	*Placodiscus cuneatus*	484	0.179	0.17	0.164	1.03
101.	*Placodiscus glandulosus*	1762	0.872	0.618	0.516	1.2
102.	*Placodiscus leptostachys*	642	0.241	0.225	0.142	1.59
103.	*Placodiscus letestui*	649	0.417	0.228	0.171	1.33
104.	*Placodiscus oblongifolius*	631	0.693	0.221	0.117	1.89
105.	*Placodiscus opacus*	1504	0.364	0.528	0.484	1.09
106.	*Placodiscus pseudostipularis*	457	0.186	0.16	0.141	1.13
107.	*Placodiscus pynaertii*	701	0.295	0.246	0.269	0.92
108.	*Placodiscus riparius*	520	0.198	0.182	0.166	1.1
109.	*Placodiscus sp1*	1033	0.647	0.362	0.244	1.48
110.	*Placodiscus sp2*	1339	0.453	0.47	0.389	1.21
111.	*Placodiscus turbinatus*	478	0.356	0.168	0.131	1.28
112.	*Radlkofera calodendron*	886	0.285	0.311	0.204	1.52
113.	*Radlkofera sp1*	2066	1.098	0.725	0.54	1.34
114.	*Radlkofera sp2*	2016	0.757	0.707	0.499	1.42
115.	*Radlkofera sp3*	1055	0.38	0.37	0.236	1.57
116.	*Sapindus saponaria*	6169	1.917	2.164	2.033	1.06
117.	*Sapindus trifoliatus*	2982	1.131	0.406	0.707	1.48
118.	*Schleichera trijuga*	2341	0.905	0.822	0.626	1.31
119.	*Zanha golugensis*	1211	0.408	0.425	0.257	1.65

Appendix 10: Voucher information and GenBank accession number of taxa used in the phylogenetic analysis of family Sapindaceae s.l. (including out-groups).

Voucher information and GenBank accession numbers for taxa used in the phylogenetic analysis of family Sapindaceae s.l. (including outgroups). *Abbreviations:* ANH, Andong National University, South Korea; BBG, Bogor Botanic Garden, India, living collections; CSIRO, CSIRO Arboretum, Australia; G, Conservatoire et Jardin Botanique de la ville de Genève, Switzerland; JCT, James Cook University of Northern Queensland, Australia; K, Royal Botanic Gardens, Kew, UK; NEU, Neuchâtel, Switzerland; MO, Missouri Botanical Garden, USA; P, Muséum d'Histoire Naturelle, France; RBG, Royal Botanic Gardens, Kew, UK, living collections; US, Smithsonian Institution, USA; Z, University of Zürich, Switzerland.

Genera	Species	Author	Voucher	Herbarium	Country	GenBank Accession Nos.							
						ITS	matK	rpoB	trnD-trnT	trnK-matK	trnL	trnL-F	trnS-trnG
Ingroup													
Acer	*erianthum*	Schwer.	*Chase 19983*	K	China	EU720501	-	EU720843	EU720980	-	EU721271	EU721459	-
Acer	*saccharum*	Marshall	*Chase 106*	K	Cult. source, Orange Co.	EU720502	-	EU720844	-	-	EU721272	EU721460	-
Aesculus	*indica*	(Wall. ex Cambess.) Hook.	*Chase 19987*	K	India	EU827392	-	EU720845	EU720981	-	EU721273	EU721461	-
Alectryon	*connatus*	Radlk.	*Chase 2047*	K	Australia	EU720415	EU720577	EU720732	EU720928	EU721025	EU721169	EU721357	EU721534
Amesiodendron	*chinensis*	(Merr.) Hu	*Yuan s.n.*	NEU	China	EU720403	-	EU720718	EU720917	-	EU721155	EU721344	EU721525
Arfeuillea	*arborescens*	Pierre	*Chase 2122*	K	Bogor, BG	EU720461	EU720629	EU720793	EU720962	EU721067	EU721229	EU721417	-
Arytera	*littoralis*	Blume	*Yuan s.n.*	NEU	China	EU720405	EU720566	EU720720	EU720919	EU721018	EU721157	EU721346	EU721527
Arytera	*littoralis*	Blume	*Chase 2123*	K	Bogor, BG	EU720462	EU720630	EU720794	EU720963	EU721068	EU721230	EU721418	-
Atalaya	*alata*	(Sim) H. Forbes	*Edwards KE228*	JCT	South Africa	EU720425	EU720593	EU720748	EU720939	EU721036	EU721184	EU721372	EU721543
Atalaya	*capense*	R.A. Dyer	*Edwards KE 509*	JCT	South Africa	EU720429	-	EU720752	-	-	EU721188	EU721376	-
Athyana	*weinmanniifolia*	(Griseb.) Radlk.	*Pennington 17581*	MO	Peru	EU720487	EU720649	EU720824	EU720975	EU721086	EU721257	EU721445	EU721576
Averrhoidium	*dallyi*	Acev.-Rodr. & Ferrucci	*Weckerle 06/03/18-1/1*	Z	Peru	EU720495	-	EU720836	-	-	EU721268	EU721456	-
Beguea	*apetala*	Capuron	*Baerki 149*	NEU	Madagascar	EU720491	EU720652	EU720828	EU720978	EU721089	EU721261	EU721448	-
Beguea	*apetala*	Capuron	*Vary 40*	MO	Madagascar	EU720512	EU720663	EU720856	-	EU721100	EU721281	EU721469	-
Blighia	*sapida*	K.D. Koenig	*Edwards KE86*	JCT	West Africa	EU720416	EU720578	EU720733	EU720929	EU721026	EU721170	EU721358	EU721535
Blomia	*prisca*	(Standl.) Lundell	*Acevedo 12242*	US	Mexico, Yucatan	EU720444	EU720611	EU720772	-	EU721050	EU721208	EU721396	-
Bridgesia	*incisifolia*	Bertero ex Cambess.	*Killip & Pisano 39778*	K	Chile	EU720476	EU720645	EU720811	EU720973	EU721082	EU721247	EU721435	-
Cardiospermum	sp.		*Yuan s.n.*	NEU	China	EU720399	-	EU720713	EU720912	-	EU721150	EU721339	-
Chytranthus	*carneus*	Radlk.	*Chase 2868*	RBG	-	EU720477	EU720646	EU720812	EU720974	EU721083	EU721248	EU721436	EU721575
Conchopetalum	*brachysepalum*	Capuron	*Rabarimanarivo 8*	MO	Madagascar	EU720530	EU720680	EU720877	-	EU721117	EU721299	EU721487	EU721586
Cubilia	*cubili*	(Blanco) Adelb.	*Chase 2125*	K	Bogor, BG	EU720463	EU720631	EU720795	EU720964	EU721069	EU721231	EU721419	EU721567
Cupania	*dentata*	DC.	*Acevedo 12243*	US	Mexico, Yucatan	EU720523	EU720670	EU720867	EU720988	EU721107	EU721289	EU721477	EU721581
Cupania	*hirsuta*	Radlk.	*Acevedo 1101*	US	French Guiana	EU720521	EU720668	EU720865	-	EU721105	EU721287	EU721475	-
Cupania	*rubiginosa*	(Poir.) Radlk.	*Mori 8868*	MO	French Guiana	EU720481	-	EU720817	-	-	EU721251	EU721439	-
Cupania	*scrobiculata*	Rich.	*Acevedo 11100*	US	French Guiana	EU720524	EU720671	EU720868	EU720989	EU721108	EU721290	EU721478	-
Cupaniopsis	*anacardioides*	Radlk.	*Chase 217*	K	Australia	EU720438	EU720605	EU720763	EU720946	EU721045	EU721199	EU721387	EU721552
Cupaniopsis	*flagelliformis*	(Bailey) Radlk.	*Edwards KE42*	JCT	Australia	EU720432	EU720598	EU720755	EU720942	-	EU721191	EU721379	EU721547
Cupaniopsis	*fruticosa*	Radlk.	*Munzinger 564*	MO	New Caledonia	EU720533	-	EU720881	-	EU721119	EU721302	EU721490	-
Cupaniopsis	sp.		*Munzinger 730*	MO	New Caledonia	EU720532	-	EU720880	EU720996	-	EU721301	EU721489	EU721587
Cupaniopsis	sp.		*Munzinger 1103*	MO	New Caledonia	EU720507	EU720660	EU720851	-	EU721097	EU721278	EU721466	-
Deinbollia	*borbonica*	Scheff.	*Edwards KE197*	JCT	Tanzania	EU720412	EU720574	EU720729	-	-	EU721166	EU721354	EU721532
Deinbollia	*macrocarpa*	Capuron	*H. Razafindraibe 118*	MO	Madagascar	EU720535	EU720683	EU720883	-	EU721121	EU721304	EU721492	EU721589
Deinbollia	*macrocarpa*	Capuron	*Baerki 144*	NEU	Madagascar	EU720503	EU720656	EU720847	-	EU721093	EU721275	EU721463	-
Deinbollia	*oblongifolia*	(E. Mey. ex Arn.) Radlk.	*Edwards KE233*	JCT	South Africa	EU720427	EU720595	EU720750	-	-	EU721186	EU721374	EU721545
Deinbollia	*pervillei*	(Blume) Radlk.	*Phillipson 5919*	MO	Madagascar	EU720395	EU720560	EU720708	-	EU721012	EU721145	EU721334	-
Deinbollia	*pervillei*	(Blume) Radlk.	*Callmander 688*	MO	Madagascar	EU720514	-	EU720858	-	-	EU721283	EU721471	-

(continued on next page)

Appendix (continued)

Genera	Species	Author	Voucher	Herbarium	Country	GenBank Accession No.							
						ITS	matK	rpoB	trnD-trnT	trnK-matK	trnL	trnL-F	trnS-trnG
Delavaya	yunnanensis	Franch.	Forrest 20682	MO	China, Yunnan	EU720484	–	EU720821	–	–	EU721254	EU721442	–
Diatenopteryx	sorbifolia	Radlk.	Zardini 43371	MO	Paraguay	EU720534	EU720682	EU720882	–	EU721120	EU721303	EU721491	EU721588
Dictyoneura	obtusa	Blume	Edwards KE142	JCT	Australia	EU720428	–	EU720751	–	–	EU721187	EU721375	–
Dimocarpus	australianus	Leenh.	Edwards KE34	JCT	Australia	EU720433	–	EU720757	–	–	EU721193	EU721381	–
Diploglottis	campbellii	Cheel	Chase 2048	K	Australian, BG	EU720457	EU720624	EU720788	EU720960	EU721062	EU721224	EU721412	–
Diplopeltis	huegelii	Endl.	Chase 2192	K	Australia	EU720473	EU720642	EU720807	EU720971	EU721079	EU721243	EU721431	–
Dipteronia	sinensis	Oliv.	Chase 502	RBG	–	EU720445	EU720612	EU720774	–	–	EU721210	EU721398	–
Dodonaea	madagascariensis	Radlk.	Bockberger G8028	NEU	Madagascar	EU720518		EU720862	EU720984	–	EU721284	EU721472	–
Dodonaea	viscosa	Jacq.	Razafitsalama 956	MO	Madagascar	EU720519	EU720666	EU720863	EU720985	EU721108	EU721285	EU721473	–
Dodonaea	viscosa	Jacq.	Merello 1077	MO	Peru	EU720536	EU720684	EU720884	EU720997	EU721122	EU721305	EU721493	–
Dodonaea	viscosa	Jacq.	Yuan s.n.	NEU	China	EU720406	EU720567	EU720721	EU720920	EU721019	EU721158	EU721347	–
Doratoxylon	chouxii	Capuron	Labat JNL3543	P	Madagascar	EU720394	EU720559	EU720707	EU720908	EU721001	EU721144	EU721333	–
Doratoxylon	chouxii	Capuron	Callmander 679	MO	Madagascar	EU720513	EU720664	EU720857	–	EU721101	EU721282	EU721470	–
Elattostachys	apetala	Radlk.	Munzinger 692	MO	New Caledonia	EU720537	EU720685	EU720885	EU720998	EU721123	EU721306	EU721494	EU721590
Elattostachys	apetala	Radlk.	McPherson 18784	MO	New Caledonia	EU720538	EU720686	EU720886	EU720999	EU721124	EU721307	EU721495	EU721591
Elattostachys	microcarpa	S.T. Reynolds	Edwards KE58	JCT	Australia	EU720409	EU720571	EU720726	–	–	EU721163	EU721351	–
Elattostachys	nervosa	(F. Muell.) Radlk.	Chase 2022	K	Australian, BG	EU720455	EU720622	EU720786	EU720959	EU721060	EU721222	EU721410	EU721563
Elattostachys	sp.		Lowry 5650A	MO	New Caledonia	EU720529	EU720679	EU720876	EU720994	EU721116	EU721298	EU721486	EU721585
Eriocoelum	kerstingii	Gilg ex Engl.	Merello 1586	MO	Ghana	EU720539	EU720687	EU720887	EU721000	EU721125	EU721308	EU721496	EU721592
Eriocoelum	microspermum	Radlk.	Bradley 1025	MO	Gabon	EU720540	EU720688	EU720888	EU721001	EU721126	EU721309	EU721497	EU721593
Euphorianthus	longifolius	Radlk.	Chase 2126	K	Bogor, BG	EU720464	–	EU720796	–	–	EU721232	EU721420	–
Eurycorymbus	cavaleriei	(H. Lév.) Rehder & Hand.-Mazz.	Yuan s.n.	NEU	China	EU720404	EU720565	EU720719	EU720918	EU721017	EU721156	EU721345	EU721526
Filicium	decipiens	(Wight & Arn.) Thwaites	Chase 2128	K	Bogor, BG	EU720466	EU720633	EU720798	–	–	EU721234	EU721422	–
Filicium	longifolium	(H. Perrier) Capuron	Rabenantoandro 1113	MO	Madagascar	EU720541	–	EU720889	–	–	EU721310	EU721498	–
Filicium	thouarsianum	(A. DC.) Capuron	Antilahimena 5021	MO	Madagascar	EU720493	–	EU720832	–	–	EU721265	EU721453	–
Ganophyllum	falcatum	Blume	Chase 2129	K	Bogor, BG	EU720467	EU720634	EU720799	–	EU721071	EU721235	EU721423	–
Glenniea	pervillei	(Baill.) Leenh.	Andriamihajarivo 1053	MO	Madagascar	EU720490	EU720651	EU720827	EU720977	EU721088	EU721260	EU721448	–
Gongrodiscus	bilocularis	H.Turner	Munzinger 749	MO	New Caledonia	EU720542	EU720689	EU720890	–	EU721127	EU721311	EU721499	–
Guioa	glauca	Radlk.	McPherson 18230	MO	New Caledonia	EU720545	EU720692	EU720893	–	EU721130	EU721315	EU721503	–
Guioa	microsepala	Radlk.	Munzinger 744	MO	New Caledonia	EU720546	EU720693	EU720894	–	EU721131	EU721316	EU721504	EU721596
Guioa	semiglauca	(F. Muell.) Radlk.	Chase 2058	K	Australian, BG	EU720458	EU720625	EU720789	–	EU721063	EU721225	EU721413	–
Guioa	villosa	Radlk.	McPherson 18040	MO	New Caledonia	EU720544	EU720691	EU720892	EU721003	EU721129	EU721314	EU721502	EU721595
Guioa	sp.		Munzinger 945	MO	New Caledonia	EU720505	EU720658	EU720849	–	EU721095	EU721277	EU721465	–
Haplocoelopsis	africana	F.G. Davies	Edwards KE276	JCT	Tanzania	EU720441	EU720608	EU720767	EU720940	–	EU721203	EU721391	EU721555
Haplocoelum	foliolosum	(Hiern) Bullock	Friis 1894	MO	Ethiopia	EU720479	–	EU720815	–	–	EU721250	EU721438	–
Haplocoelum	foliolosum subsp. foliolosum	(Hiern) Bullock	Edwards KE195	JCT	Tanzania	EU720410	EU720572	EU720727	EU720924	–	EU721164	EU721352	EU721530
Haplocoelum	perrieri	Capuron	Rakotomalaza 1165	MO	Madagascar	EU720396	–	EU720709	EU720909	–	EU721146	EU721335	EU721519
Harpullia	arborea	(Blanco) Radlk.	Chase 1353	K	Bogor, BG	EU720448	–	EU720779	–	–	EU721215	EU721403	–
Jagera	javanica	(Blume) Blume ex Kalkman	Chase 2130	K	Bogor, BG	EU720468	EU720635	EU720800	–	EU721072	EU721236	EU721424	EU721569
Jagera	javanica subsp. australiana	Leenh.	Edwards KE178	JCT	Australia	EU720442	–	EU720769	–	–	EU721205	EU721393	EU721556
Koelreuteria	paniculata	Laxm.	Harder 5668	MO	Vietnam	EU720548	EU720695	EU720896	–	EU721133	EU721318	EU721506	–
Koelreuteria	paniculata	Laxm.	Yuan CN2006-3	NEU	China	EU720397	EU720561	EU720710	–	EU721003	EU721147	EU721336	EU721520

Koelreuteria	sp.		Harder 5724	MO	Vietnam	EU720547	EU720694	EU720895	EU721004	EU721132	EU721317	EU721505	-
Laccodiscus	klaineanus	Pierre ex Engl.	Walters 1269	MO	Gabon	EU720549	EU720696	EU720897	-	EU721134	EU721319	EU721507	-
Lecaniodiscus	fraxinifolius	Baker	Edwards KE194	JCT	Tanzania	EU720418	EU720580	EU720735	EU720931	EU721028	EU721172	EU721360	EU721536
Lepiderema	hirsuta	S.T. Reynolds	Edwards KE36	JCT	Australia	EU720435	EU720601	EU720759	-	EU721041	EU721195	EU721383	EU721549
Lepiderema	pulchella	Radlk.	Chase 2020	K	Australian, BG	EU720454	-	EU720785	EU720958	-	EU721221	EU721409	-
Lepidopetalum	fructoglabrum	Welzen	Edwards KE139	JCT	Australia	EU720408	-	EU720724	EU720922	-	EU721161	EU721349	EU721528
Lepisanthes	alata	(Blume) Leenh.	Chase 1355	K	Bogor, BG	EU720450	EU720618	EU720781	-	EU721056	EU721217	EU721405	-
Lepisanthes	ferruginea	(Radlk.) Leenh.	Chase 1354	K	Bogor, BG	EU720449	EU720617	EU720780	-	EU721055	EU721216	EU721404	-
Lepisanthes	rubiginosa	(Roxb.) Leenh.	Chase 1350	K	Bogor, BG	EU720446	EU720614	EU720776	EU720952	EU721052	EU721212	EU721400	EU721558
Lepisanthes	senegalensis	(Poir.) Leenh.	Callmander 627	MO	Madagascar	EU720492	EU720654	EU720830	EU720979	EU721091	EU721263	EU721451	EU721577
Litchi	chinensis	Sonn.	Yuan s.n.	NEU	China	EU720400	EU720564	EU720715	EU720914	EU721016	EU721152	EU721341	EU721522
Llagunoa	mollis	Kunth	Jaramillo&Mejía 3199	MO	Colombia	EU720482	-	EU720818	-	-	EU721252	EU721440	-
Llagunoa	nitida	Ruiz & Pav.	Pennington 17552	MO	Peru	EU720486	-	EU720823	-	-	EU721256	EU721444	-
Loxodiscus	coriaceus	Hook. f.	Bradford 1136	MO	New Caledonia	EU720488	-	EU720825	-	-	EU721258	EU721446	-
Macphersonia	chapelieri	(Baill.) Capuron	Buerki 138	NEU	Madagascar	EU720459	EU720627	EU720791	EU720961	EU721065	EU721227	EU721415	EU721566
Macphersonia	gracilis	O. Hoffm.	Rabenantoandro 1061	MO	Madagascar	EU720550	EU720697	EU720898	EU721005	EU721135	EU721320	EU721508	EU721597
Majidea	zanguebarica	Kirk ex Oliv.	TH275	MO	Madagascar	EU720552	-	EU720900	EU721006	-	EU721322	EU721510	-
Matayba	apetala	Radlk.	Acevedo 11920	US	Jamaica	EU720526	EU720674	EU720871	-	EU721111	EU721293	EU721481	EU721583
Matayba	cf. opaca	Radlk.	Acevedo 11118	US	French Guiana	EU720522	EU720669	EU720866	EU720987	EU721106	EU721288	EU721476	EU721580
Matayba	domingensis	(DC.) Radlk.	Taylor 11839	MO	Caribbean	EU720551	EU720698	EU720899	-	EU721136	EU721321	EU721509	EU721598
Matayba	elaeagnoides	Radlk.	Zardini 43278	MO	Paraguay	EU720553	EU720699	EU720901	-	EU721137	EU721323	EU721511	-
Matayba	guianensis	Aubl.	Acevedo 12342	US	French Guiana	EU720527	EU720675	EU720872	-	EU721112	EU721294	EU721482	-
Matayba	laevigata	Radlk.	Acevedo 12357	US	French Guiana	EU720528	EU720676	EU720873	EU720992	EU721113	EU721295	EU721483	-
Melicoccus	bijugatus	Jacq.	Acevedo s.n.	US	Puerto Rico	EU927391	EU720610	EU720771	-	EU721049	EU721207	EU721395	-
Melicoccus	lepidopetalus	Radlk.	Acevedo 11128	US	Bolivia	EU720443	-	EU720770	-	-	EU721206	EU721394	-
Mischarytera	sp.	-	Edwards KE159	JCT	Australia	EU720417	EU720579	EU720734	EU720930	EU721027	EU721171	EU721359	-
Mischocarpus	exangulatus	(F. Muell.) Radlk.	Edwards KE30	JCT	Australia	EU720434	EU720600	EU720758	EU720943	EU721040	EU721194	EU721382	-
Mischocarpus	grandissimus	Radlk.	Edwards KE37	JCT	Australia	EU720437	EU720604	EU720762	EU720945	EU721044	EU721198	EU721386	EU721551
Mischocarpus	pentapetalus	(Rox.) Radlk.	Chase 2133	K	Bogor, BG	EU720470	EU720637	EU720802	EU720966	EU721074	EU721238	EU721426	EU721571
Mischocarpus	pyriformis	(F. Muell.) Radlk.	Chase 2059	K	Australian, BG	EU720460	EU720628	EU720792	-	EU721066	EU721228	EU721416	-
Molinaea	petiolaris	Radlk.	Rabenantoandro 1448	MO	Madagascar	EU720554	EU720700	EU720902	EU721007	EU721138	EU721324	EU721512	-
Molinaea	sp. nov.		Antilahimena 4301	MO	Madagascar	EU720510	EU720662	EU720854	EU720983	EU721099	EU721280	EU721468	EU721578
Neotina	coursii	Capuron	H. Razafindraibe 119	MO	Madagascar	EU720543	EU720690	EU720891	EU721002	EU721128	EU721313	EU721501	EU721594
Nephelium	lappaceum (=N. chryseum)	L.	Yuan s.n.	NEU	China	EU720401	-	EU720716	EU720915	-	EU721153	EU721342	EU721523
Pancovia	golungensis	(Hiern) Exell & Mendonça	Edwards KE231	JCT	Tanzania	EU720411	EU720573	EU720728	EU720925	EU721022	EU721165	EU721353	EU721531
Pappea	capensis	Eckl. & Zeyh.	Edwards KE232	JCT	South Africa	EU720424	EU720592	EU720747	EU720938	EU721035	EU721183	EU721371	EU721542
Paranephelium	macrophyllum	King	Chase 1356	K	Bogor, BG	EU720451	EU720619	EU720782	EU720955	EU721057	EU721218	EU721406	-
Paranephelium	xestophyllum	Miq.	Edwards KE500	JCT	Asia	EU720420	EU720582	EU720737	-	EU721029	EU721174	EU721362	-
Paullinia	pinnata	L.	Edwards KE199	JCT	Tanzania	EU720413	EU720575	EU720730	EU720926	EU721023	EU721167	EU721355	-
Paullinia	subaurriculata	Radlk.	Meckerle 00/03/19-1/7	Z	Peru	EU720494	-	EU720833	-	-	EU721266	EU721454	-
Plagioscyphus	aff. louvelii	Danguy & Choux	Lowry 6034	MO	Madagascar	EU720555	EU720701	EU720903	EU721008	EU721139	EU721325	EU721513	EU721599
Plagioscyphus	unijugatus	Capuron	Buerki 145	NEU	Madagascar	EU720475	EU720644	EU720809	EU720972	EU721081	EU721245	EU721433	EU721574
Podonephelium	homei	Radlk.	Pillon 156	MO	New Caledonia	EU720489	EU720650	EU720826	EU720976	EU721087	EU721259	EU721447	-
Pometia	pinnata	J.R. Forst. & G. Forst.	Chase 2135	K	Bogor, BG	EU720471	EU720638	EU720803	EU720967	EU721075	EU721239	EU721427	EU721572
Pometia	pinnata	J.R. Forst. & G. Forst.	Yuan s.n.	NEU	China	EU720402	-	EU720717	EU720916	-	EU721154	EU721343	EU721524
Pseudima	sp.		McPherson 15867	MO	Panama	EU720556	EU720702	EU720904	EU721009	EU721140	EU721326	EU721514	EU721600
Rhysotoechia	mortoniana	(F. Muell.) Radlk.	Edwards KE117	JCT	Australia	EU720414	EU720576	EU720731	EU720927	EU721024	EU721168	EU721356	EU721533
Sapindus	oligophyllus (=Aphania oligophylla)	Merr. & Chun	Yuan s.n.	NEU	China	EU720407	EU720568	EU720722	EU720921	EU721020	EU721159	EU721159	-
Sarcopteryx	martyana	(F. Muell.) Radlk.	Irvine IRV1810	CSIRO	Australia	EU720426	EU720594	EU720749	EU720940	EU721037	EU721185	EU721373	EU721544
Sarcopteryx	reticulata	S.T. Reynolds	Gray BG1137	CSIRO	Australia	EU720421	EU720587	EU720741	-	EU721033	EU721178	EU721366	EU721539

Genera	Species	Author	Voucher	Herbarium	Country	GenBank Accession Nos.							
						ITS	matK	rpoB	trnD-trnT	trnK-matK	trnL	trnL-F	trnS-trnG
Sarcopteryx	sp.	-	Edwards KE49	JCT	Australia	EU720439	EU720607	EU720765	EU720946	EU721047	EU721201	EU721389	EU721554
Sarcotoechia	serrata	S.T. Reynolds	Edwards KE31	JCT	Australia	EU720436	EU720603	EU720761	EU720944	EU721043	EU721197	EU721385	EU721550
Sarcotoechia	villosa	S.T. Reynolds	Edwards KE102	JCT	Australia	EU720419	EU720581	EU720736	-	-	EU721173	EU721361	-
Schleichera	oleosa	(Lour.) Oken	Chase 2137	K	Bogor, BG	EU720423	EU720591	EU720746	EU720937	-	EU721182	EU721370	EU721541
Serjania	altissima	(Poepp.) Radlk.	Weckerle 08/07/02-1/4	Z	Peru	EU720498	-	EU720840	-	-	EU721269	EU721457	-
Serjania	communis	Cambess.	Chase 2138	K	Bogor, BG	EU720472	EU720640	EU720805	EU720969	EU721077	EU721241	EU721429	-
Serjania	glabrata	Kunth	Merello 1058	MO	Peru	EU720557	EU720703	EU720905	EU721010	EU721141	EU721327	EU721515	-
Storthocalyx	sp.		Munzinger 960	MO	New Caledonia	EU720504	EU720657	EU720848	-	EU721094	EU721276	EU721464	-
Synima	macrophylla	S.T. Reynolds	Edwards KE19	JCT	Australia	EU720430	EU720596	EU720753	EU720941	-	EU721189	EU721377	EU721546
Talisia	angustifolia	Radlk.	Zardini 43668	MO	Paraguay	EU720558	EU720705	EU720907	-	EU721142	EU721328	EU721516	-
Talisia	nervosa	Radlk.	Pennington 628	MO	-	EU720474	EU720643	EU720808	-	EU721080	EU721244	EU721432	-
Talisia	obovata	A.C. Sm.	R.Lombello 13	MO	Brazil	EU720485	EU720648	EU720822	-	EU721085	EU721255	EU721443	-
Thouinia	acuminata	S. Watson	Liston 633-2	MO	Mexico, Jalisco	EU720478	EU720647	EU720814	-	EU721084	EU721249	EU721437	-
Tina	isaloensis	Drake	Ranirison PR827	G	Madagascar	EU720520	EU720667	EU720864	EU720986	EU721104	EU721286	EU721474	EU721579
Tina	striata	Radlk.	Vary 45	MO	Madagascar	EU720509	EU720661	EU720853	-	EU721098	EU721279	EU721467	-
Tinopsis	apiculata	Radlk.	Buerki 131	NEU	Madagascar	EU720422	EU720589	EU720744	EU720936	EU721034	EU721180	EU721368	EU721540
Toechima	erythrocarpum	(F. Muell.) Radlk.	Edwards KE20	JCT	Australia	EU720431	EU720597	EU720754	-	EU721038	EU721190	EU721378	-
Toechima	plurinerve	Radlk.	Chase 1357	K	Bogor, BG	EU720452	EU720620	EU720783	EU720956	EU721058	EU721219	EU721407	EU721561
Toechima	tenax	(Cunn. ex Benth.) Radlk.	Chase 2046	K	Australian, BG	EU720456	EU720623	EU720787	-	EU721061	EU721223	EU721411	EU721564
Toechima	tenax	(Cunn. ex Benth.) Radlk.	Chase 2132	K	Bogor, BG	EU720469	EU720636	EU720801	EU720965	EU721073	EU721237	EU721425	EU721570
Tristiropsis	acutangula	Radlk.	Chase 1358	K	Bogor, BG	EU720453	EU720621	EU720784	EU720957	EU721059	EU721220	EU721408	EU721562
Urvillea	ulmacea	Kunth	Weckerle 08/07/05-1/1	Z	Peru	EU720499	EU720655	EU720841	-	EU721092	EU721270	EU721458	-
Vouarana	guianensis	Aubl.	Lucas 109	MO	French Guiana	EU720525	EU720673	EU720870	EU720991	EU721110	EU721292	EU721480	EU721582
Xanthoceras	sorbifolium	Bunge	Yuan CN2006	NEU	China	EU720398	EU720562	EU720711	EU720910	EU721014	EU721148	EU721337	-
Outgroup													
Sorindeia	sp.		Buerki 137	NEU	Madagascar	-	-	EU720831	-	-	EU721264	EU721452	-
Harrisonia	abyssinica	Oliv.	Edwards KE510	JCT	Tanzania	EU720440	-	EU720766	-	-	EU721202	EU721390	-