To be able to identify an organism is a major step towards the research into any aspect of that organism.

PAGE

NUMBERING

AS ORIGINAL

DEDICATED TO:

MRS SONIA DONALDSON

AND

THE STAFF AND STUDENTS

OF RAYMONT HALL

PAST, PRESENT AND FUTURE

A TAXONOMIC REVISION OF THE SPECIES OF

SELAGINELLA BEAUV. SUBGENUS

STACHYGYNANDRUM (BEAUV.) BAK.

FROM WEST AFRICA AND MADAGASCAR

BY

NATHANIEL QUANSAH

[BSc. (HONS.), DIP. ED., MSc.]

JULY 1986

A THESIS SUBMITTED TO THE UNIVERSITY OF LONDON

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

LIFE SCIENCES DEPARTMENT

GOLDSMITHS' COLLEGE

LONDON SE14 6NW

ABSTRACT

A taxonomic revision of the species of the genus *Selaginella* Beauv. has been undertaken. The study was concentrated on the species of the subgenus *Stachygynandrum* (Beauv.) Bak. found in West Africa and Madagascar.

On the basis of the examination of the morphological features - vegetative and reproductive - a total of 29 species have been recognized to be present in West Africa and Madagascar. Twenty species occur in West Africa, 11 species are found in Madagascar while two species are common to both areas. All the 29 species have been described, illustrated and keys for their identification given. A new species - *S. serrato-squarrosa* Quansah - from West Africa has been identified.

A proposed scheme of classification for the genus *Selaginella* is given. In this scheme, the genus is divided into two subgenera - *Selaginella* Bak. and *Stachygynandrum* - while subgenus *Stachygynandrum* is subdivided into two sections - *Homostachys* (Bak.) Quansah and *Heterostachys* (Bak.) Quansah.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

CHAPTER ONE

INTRODUCTION

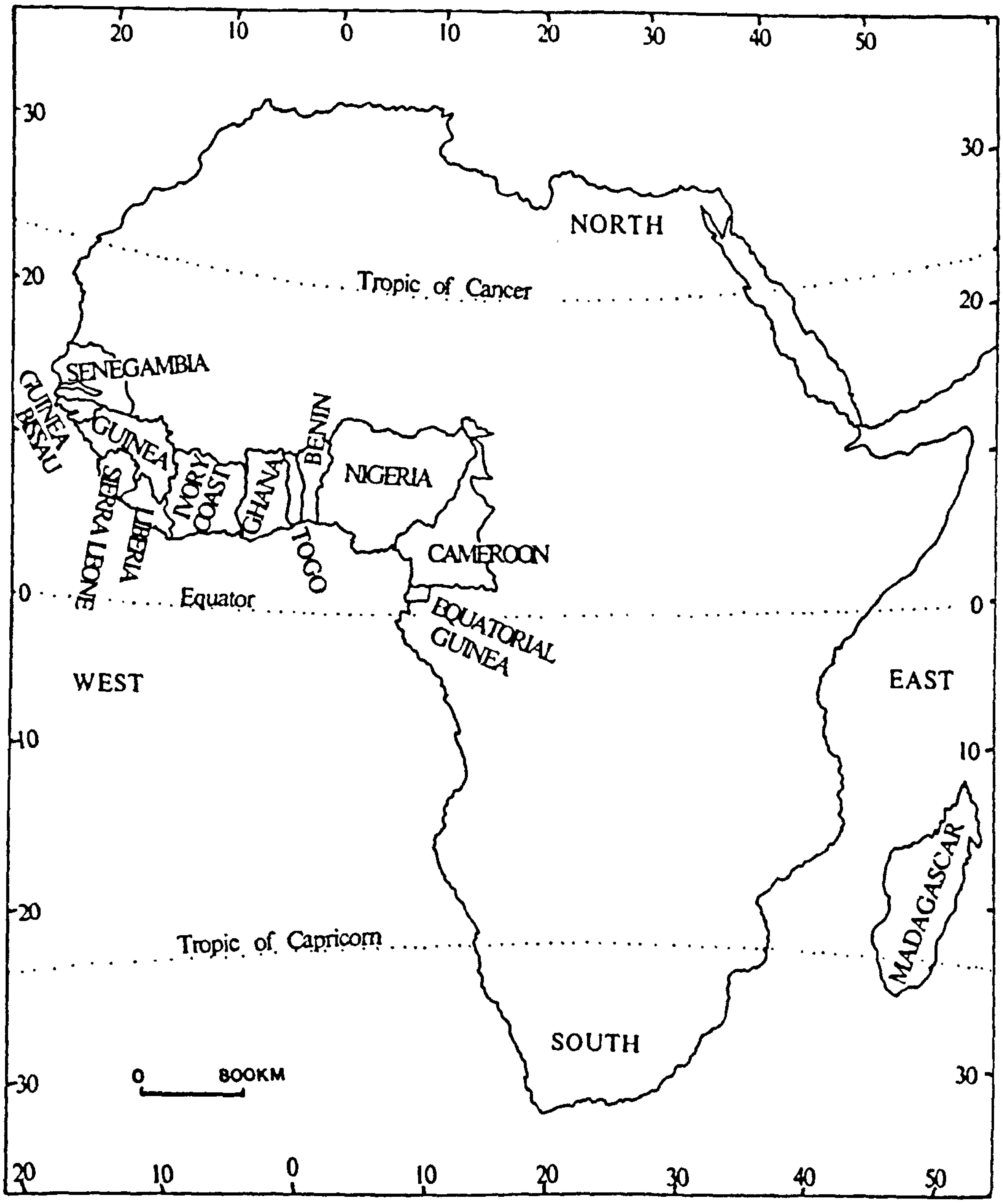


Fig. 1: Map of Africa showing area covered in this study.

TABLE 1 : Distribution of species of the genus Selaginella subgenus Stachygynandrum in the countries of West Africa and Madagascar

Species	Countries												
	Senegambia	Guinea-Bissau	Guinea	Sierra Leone	Liberia	Ivory Coast	Ghana	Togo	Benin	Nigeria	Cameroon	Equatorial-Guinea	Madagascar
S. versicolor Spring	●		●	●	●	●	●	●		●	●	●	
S. vogelii Spring			●	●	●	●	●		●	●	●	●	●
S. kraussiana (Kunze) A.Br.				●							●	●	
S. cathedrifolia Spring		●	●	●	●	●	●	●		●	●	●	
S. myosurus (Sw.) Alston	●		●	●	●	●	●	●		●	●	●	
S. buchholzii Hieron.				●		●	●	●		●	●		
S. soyauxii Hieron.			●	●	●	●			●		●	●	
S. blepharophylla Alston			●		●	●	●			●	●		
S. zechii Hieron.			●				●	●		●			
S. protensa Alston						●							
S. tenerrima A.Br. ex Kuhn			●	●						●	●		
S. kalbreyeri Bak.			●	●	●	●	●	●		●	●	●	
S. leoneensis Hieron.			●	●	●	●				●	●		
S. molleri Hieron.					●					●	●	●	
S. molliceps Spring			●		●	●	●	●		●	●	●	
S. subcordata A.Br. ex Kuhn			●	●	●	●	●						
S. squarrosa Bak.			●								●		
S. serrato-squarrosa Quansah											●		
S. goudotana Spring							●			●	●	●	●
S. thomensis Alston				●							●	●	
S. fissidentoides (Hook. & Grev.) Spr.													●
S. pervillei Spring													●
S. digitata Spring													●
S. helicoclada Alston													●
S. pectinata Spring													●
S. lyallii (Hook. & Grev.) Spr.													●
S. hildebrandtii A. Br. ex Kuhn													●
S. perpusilla Bak.													●
S. unilateralis Spring													●

INTRODUCTION

The genus Selaginella Beauv., comprised of about 700 species world-wide, divides naturally into two subgenera - Selaginella Bak. and Stachygynandrum (Beauv.) Bak. - on the basis of isophyllous (similar-) and anisophyllous (dissimilar-) leaves.

Subgenus Selaginella containing species with isophyllous leaves is made up of about 50 species (Tryon & Tryon, 1981) and Tryon (1955) has thoroughly treated this subgenus.

Subgenus Stachygynandrum containing the species with anisophyllous leaves is made up of over 600 species (Tryon & Tryon, 1981). Most work done in this subgenus has been on the New World species (eg Alston 1955, Alston et al., 1981). Works done on the Old World (African) species, eg Exell (1944), Jermy in Schelpe (1970), Bizzarri (1975, 1981 and 1983), have been restricted to specific regions or calling attention to new species discovered in an area and these have not dealt specifically with subgenus Stachygynandrum. Also these various works have been centred around other parts of Africa but not West Africa and Madagascar. Alston (1932, 1959) who gave the first comprehensive accounts of the genus Selaginella in Madagascar and West Africa, listed 13 species from Madagascar and 20 species from West Africa. Eleven of the Madagascan and 19 of the West African species belong to the subgenus Stachygynandrum while the remaining two from Madagascar and one from West Africa belong to the subgenus Selaginella. Not much work has been done since Alston (1932, 1959) on Madagascan and West African Selaginella except by Benl (1978) on species from Fernando Po. This current study is therefore concentrated on Madagascar and West Africa (fig. 1) and is an attempt to reassess taxonomically, the subgenus Stachygynandrum, examining as many characters as possible and thus help to contribute to our knowledge of subgenus Stachygynandrum in these areas to fall in line with the other parts of Africa. This will then form the basis for a revision and update of the Old World (African) species in future. A summary of the distribution of the species of the subgenus Stachygynandrum within the countries of the area covered in this study is given in Table 1.

This study recognises 21 species from West Africa (including the 20 species recognized by Alston, 1959, and one new species). Twenty of these species belong to the subgenus Stachygynandrum while the remaining one belongs to the subgenus Selaginella. Thirteen species are recognized from Madagascar; this excludes one of the 13 species recognized by Alston (1932) and includes another species, also found in West Africa but, not reported for Madagascar. Of the 13 species from Madagascar, 11 belong to the subgenus Stachygynandrum while the other two belong to the subgenus Selaginella.

CHAPTER TWO

SYSTEMATICS

SYSTEMATICS

The genus Selaginella is recognized by most pteridologists as the only living genus of the family Selaginellaceae Milde. Other genera also put in the Selaginellaceae are the fossils, Selaginellites Zeiller, Mittagia Lignier, Porostrobus Nathorst and Barsostrobus Fairon-Demaret (Thomas & Brack-Hanes, 1984). Rothmaler (1944) however, recognized three distinct genera of Selaginellaceae, viz. Selaginella, Lycopodioides Boehmer and Didiclis Beauv. These genera have not been accepted by later authors (eg Bizzarri, 1975; Tryon and Tryon, 1981).

Earlier classifications (eg Willdenow, 1810; and Sprengel, 1827) had placed Selaginella within the genus Lycopodium until Spring (1850) presented the major monograph of the genus Selaginella, as it is presently known. There have been four other major treatments of the genus since Spring's work. These are works by Braun (1865), Baker (1883, 1887), Hieronymus (1901), and Walton and Alston (1938). See Table 2 for a summary of these classifications.

The early monographers, Spring (1850), Braun (1865) and Baker (1883, 1887), used plant habit as a criterion for major divisions within the genus. Hieronymus (1901) was an exception as, though he used growth characters in establishing two subgenera, he made extensive use of the stelar pattern in his taxonomic treatment. Walton and Alston (1938), Panigrahi & Dixit (1968), Crabbe and Jermy (1976) and Alston et al. (1981) have also made use of plant habit as a diagnostic feature in their recent works.

These treatments of the genus by the above authors have differed in the number of subgeneric groups accepted. Spring (1850) and Hieronymus (1901) divided the genus into two subgenera

- Homoeophyllum containing taxa with isophyllous leaves and Heterophyllum containing taxa with anisophyllous leaves. Braun (1865) named the same groups Homotropae and Dichotropae respectively while Baker (1883, 1887) and Walton and Alston (1938) recogniszed four subgenera - Selaginella (=Euselaginella), Stachygynandrum, Homostachys and Heterostachys (Table 2). As can be seen from Table 2, subgenus Selaginella of Baker (1883, 1887) and Euselaginella of Walton and Alston (1938) correspond to Homoeophyllum of Spring (1850) and Hieronymus (1901) and Homotropae of Braun (1865) whereas their other three subgenera (Stachygynandrum, Homostachys and Heterostachys) together correspond to subgenus Heterophyllum of Spring (1850) and Hieronymus (1901) and Dichotropae of Braun (1865). Thus, in the systems of Baker (1883, 1887) and Walton and Alston (1938), subgenus Selaginella (=Euselaginella) is separated from the other three subgenera on the basis of isophyllous leaves. Subgenera Stachygynandrum, Homostachys, and Heterostachys all are anisophyllous. These three subgenera are distinguished from each other mainly on the basis of strobilus morphology.

Recent workers, including Jermy, Jones and Colden (1967), Crabbe and Jermy (1973), Alston et al. (1981), and Tryon and Tryon (1981) recognize two subgenera - Selaginella and Stachygynandrum - in the genus.

From the present study, and from a preliminary review of sporophyll structure of some 100 South American species (Quansah and Thomas, 1985), I see no justification of upholding four subgenera in the genus. I recognize two subgenera - Selaginella containing species with isophyllous leaves and Stachygynandrum containing species with anisophyllous leaves. These two subgenera are retained from Baker's (1883, 1887) classification. The other two subgenera Homostachys and Heterostachys, recognized by Baker (1883, 1887) and Walton and Alston (1938) have been absorbed into subgenus Stachygynandrum. These two subgenera - Homostachys and Heterostachys - were erected by Baker (1883, 1887) and adopted by Walton and Alston (1938) on the basis of strobilus morphology only alongside Stachygynandrum, and since in other characters, eg habit and leaf characters, the two exhibit the same features as species of subgenus Stachygynandrum, I see no justification of upholding their subgeneric status. I have however, given them the status of Sections under subgenus Stachygynandrum on the basis of strobilus (sporophyll) morphism. Section Homostachys includes all species with uniform (monomorphic) sporophylls while Section Heterostachys includes all species with dimorphic sporophylls.

The proposed classification of the species of the genus Selaginella is as follows:

Subgenus 1. Selaginella Bak. Vegetative leaves isophyllous; sporophylls monomorphous.

Subgenus 2. Stachygynandrum (Beauv.) Bak. Vegetative leaves anisophyllous; sporophylls monomorphous or dimorphous.

Section 1. Homostachys (Bak.) Quansah Sporophylls monomorphous.

Section 2. Heterostachys (Bak.) Quansah Sporophylls dimorphous.

The proposed classification above is the classification adapted in this study and is given in Table 2 alongside the previous ones of Spring (1850), Braun (1865), Baker (1883, 1887), Hieronymus (1901), and Walton and Alston (1938).

TABLE 2: MAJOR CLASSIFICATION SCHEMES FOR THE GENUS SELAGINELLA
(including a new proposed classification by the author)

Spring (1850)	Braun (1865)	Baker (1883, 1887)	Hieronymus (1901)	Walton & Alston (1938)	Quansah (1986)
Sect. 1. Homoeophyllae	Sect. I. Homotropae	Subgenus 1. Selaginella	Subgenus 1. Homoeophyllum	Subgenus 1. Euselaginella	Subgenus 1. Selaginella
	A. Polystichae		Sect. I. Cylindrostachyae		
	B. Tetrastichae		Sect. II. Tetragonostachyae		
Sect. 2. Heterophyllae	Sect. II. Dichotropae	Subgenus 2. Stachygynandrum	Subgenus 2. Heterophyllum	Subgenus 2. Stachygynandrum	Subgenus 2. Stachygynandrum
1. Tetragonostachyae	A. Tetragonostachyae		Sect. I. Pleiomacrosporangiatae		Sect. 1. Homostachys
2. Platystachyae	B. Platystachyae		Sect. II. Oligomacrosporangiatae		Sect. 2. Heterostachys
		Subgenus 3. Homostachys		Subgenus 3. Homostachys	
		Subgenus 4. Heterostachys		Subgenus 4. Heterostachys	

CHAPTER THREE

MATERIALS AND METHODS

MATERIALS AND METHODS

Material studied included living plants I collected in the wild in West Africa (WA) and Madagascar (M) and identified using the keys in Alston (1959 and 1932) respectively. The bulk of material studied however, came from specimens obtained from the herbaria at the British Museum (Natural History) (BM) and the Royal Botanic Gardens, Kew (K), in England; the herbaria at the Parc Tsimbazaza, Antananarivo, Madagascar (TAN), Botanical Museum, Berlin-Dahlem (BD), Department et Jardin Botanique L'Université, Liege, Belgium (LG), Museum National d'Histoire Naturelle, Paris (P) and from private collections of Dr A. Fay of New York.

Initial observations of all specimens (WA and M) were made with binocular microscopes in the herbaria at BM, K and TAN. The specimens examined in this study are listed at the end of the descriptions of each species.

Samples of whole plants and/or plant parts including leaves and strobili (sporophylls, sporangia and spores) were frequently removed as needed from sheets for detail examinations in the laboratory of Goldsmiths' College Life Sciences Department.

The procedure used and described below was modified from the methods used by Mital (1969) and Thomas (1971). For epidermal studies, whole plants or branches with leaves and strobili, leaves and sporophylls were soaked in 70% ethanol overnight and warmed (material in 70% alcohol) in boiling water for a minimum of 10 minutes. The material was cleared in 10% sodium hydroxide (NaOH) solution for a minimum of 24 hours (this clearing stage was made faster by putting the material in NaOH solution in oven at 40^{o}C, overnight) and then rinsed in water three times for 5 minutes each and transfered to 70% ethanol for 5 minutes. The material was stained in 2% Safranin in 70% ethanol for a minimum of 20 minutes and dehydrated in 70% ethanol (10 minutes), 95% ethanol (15 minutes), 100% ethanol (20 minutes), 1:1 100% ethanol - histosol (15 minutes), and histosol (10 minutes) [times given are minimum times]. The material was finally mounted in D.P.X. mountant on 76 x 38 mm or 76 x 26 mm slides and covered with 64 x 35 mm or 50 x 24 mm coverslips, respectively. More D.P.X. mountant was added where necessary and the slides were placed on a drying box for a week and then stored. The prepared slides have been put in the herbarium sheets and deposited at the various herbaria.

The method made it possible for both the upper and lower epidermises of leaves and sporophylls to be observed at different foci of the microscope. Stomatal distribution on leaves and sporophylls were also observed and stomatal indices calculated. Where the prepared material included strobili, the sporangial arrangement of the strobili was examined.

Illustrations of epidermal cells were made using the drawing tube attached to a Zeiss Photomicroscope III or photographed under a x40 objective and 1.25 optivar using the same microscope on an Ilford FP4 film. Diagrams of whole leaves and sporophylls were also drawn from the prepared material (it was easier to observe the sclerotic cells when present) using the drawing tube.

At most five strobili were removed from fertile specimens and treated (in the same way as above for epidermal studies) for sporangial arrangement in the various species. The procedure (which is also modified from Horner and Arnott, 1963) made it easy for the distribution of both mega - and microsporangia to be observed. Staining the strobili with 2% Safranin enhanced sporangia observation even though Horner and Arnott (1963) implied that they did not stain the strobili after they found that initial staining with Safranin O made the sporangial details obscured. The sporangial arrangement was examined also in the untreated strobili which were still attached to plants on herbarium sheets since it was possible to do that without destroying the strobili.

Ligule measurements and observations for shape and basal trichomes were made mainly from cleared leaves and sporophylls with the ligule intact, using a calibrated eye piece graticule under a x2.5 objective and 1.25 optivar on a Zeiss Photomicroscope III. Diagrams were made using the drawing tube. Some observations for shape and basal trichomes were also made from material kept in 70% ethanol.

Megaspores and microspores were mounted in glycerine solution and examined for the presence of an equatorial ring and flange in the mega - and microspores respectively. Measurements of the spores were also made from these temporary preparations under a x40 objective and a x10 ocular using a calibrated Swift light microscope (No. 7955673). Spore size proportion (inequality of spore sizes) per megasporangium was examined in the cleared strobili containing megasporangia with spores and the percentage occurrence calculated. Increase or decrease in megaspore number from the normal four megaspores per megasporangium was also observed in the cleared material.

In addition to the light microscope studies, specimens were further examined with the scanning electron microscope (SEM). Samples of spores, leaves and sporophylls with ligules intact were mounted in a drop of water on standard aluminium stubs which had pieces of FP4 films stuck on (in reverse manner) and left to dry for one hour in a dessicator or on aluminium stubs bearing double-sided sellotape. The prepared stubs were coated with gold at 1.2KV using a Polaron E5000 Sputter Coater. Specimens were viewed initially on an ISI-SUPER IIIA instrument equipped with a Pentax MX camera and an Ilford FP4 film, but later a JEOL JSM-35C instrument was used. This was equipped with a Mamiya camera and an Ilford FP4 Safety Film. Both instruments are at Goldsmiths' College, Life Sciences Department Electron Microscope Suite.

CHAPTER FOUR

MORPHOLOGY AND STRUCTURE OF *SELAGINELLA* SUBGENUS *STACHYGYNANDRUM*

MORPHOLOGY AND STRUCTURE OF SELAGINELLA SUBGENUS STACHYGYNANDRUM

(i) PLANT HABIT

In habit, the species may be prostrate and creeping, eg S. cathedrifolia and S. fissidentoides (Plate 27), suberect to erect, eg S. blepharophylla and S. goudotana (Plate 25), or climbing, eg S. myosurus (Plate 12). Where branching occurs in the plant, whether from the basal or upper part of the stem, also contributes to the general appearance of the plant. The erect forms may be caulescent (branched at the upper part of plant) eg S. pectinata, S. vogelii and S. lyallii (Plate 32) or branched from the base of the stem eg S. molliceps. Even though branching occurs in all the species, some may be simple (unbranched) as seen in eg S. subcordata and S. tenerrima.

Branching patterns may vary within species but generally two main forms are recognised - a pseudopinnate form, in which an apparent main axis is recognizable, composed of a series of the more robust member from each dichotomy (eg S. myosurus and S. leoneensis) and a fan-shaped or flabellate form, composed of a series of dichotomies in which no apparent unidirectional main branch axis is recognised (eg S. pectinata, S. vogelii). Species may exhibit both patterns especially the species showing prostrate growth habit.

(ii) STEM

The stem may be articulated or not. The articulations are seen as shiny bulging areas just below the points of bifurcation where branching occurs in the living plant but are better seen in the dried material as a sunken ring or a dark zone.

S. kraussiana is the only species found to possess stem articulations in this study, no other species (West African and Madagascan) possesses this character.

The stem and branches may be pubescent or glabrous. All species from West Africa (WA) and Madagascar (M) have glabrous stems and branches with the exception of S. vogelii (WA & M) and S. pervillei (M) which are pubescent at their dorsal sides.

Stem colour is variable within species. It may be pale green, greyish-dark brown, pale yellowish-brown, pinkish, straw-coloured, purplish or reddish-brown. Species often show more than one stem colour eg S. molleri may have greenish or straw-coloured stems.

Stem anatomy has not been looked at, in detail, in this study. However, observations at cleared plants reveal that the stelar pattern may change with the order of branching, eg S. squarrosa seems to possess a single stele in the main stem axis and more than one in the branches. It has been observed also that S. myosurus (cleared material) has different types of stele for the main axis and for the branches and nodes.

(iii) RHIZOPHORE

The rhizophore, a positively geotropic, elongate organ possessing no root cap, arises at the points of dichotomy where branching occurs in the plant. It may be positioned at the dorsal side, ventral side or in the axil of the stem of the suberect and prostrate species. The rhizophores may be distributed throughout the whole plant (the creeping, prostrate and climbing species), found at the basal quarter or basal third of the plant (suberect to erect forms) or restricted only to the very base of the plant (erect species).

(iv) LEAF

The leaves are anisophyllous and are arranged in four rows along the branches in all the species. On the upper plane are two rows of smaller leaves occupying a relatively median position, which are known as the median leaves. The lower plane is occupied by two rows of larger and more laterally placed leaves - the lateral leaves. The axillary leaves (which can be regarded as modified lateral leaves) are found at all the points of dichotomy in the branch-system. A fourth leaf type - the stem leaves - are uniform (isomorphous) leaves that may be present on the main stems of the plant and may or may not look like either the lateral or median leaves. Generally, the leaves decrease in size with each branching, becoming smaller on the last branches.

The following leaf characters have been examined for the species in this study: (i) shape, (ii) margin, (iii) apex, (iv) base, (v) distribution and position of stomata, (vi) papillae and sclerotic cells on epidermis, (vii) number of veins present in the leaf, (viii) nature of epidermises (whether same or different for the upper (ventral) and lower (dorsal) surfaces, (ix) colour, and (x) size.

Generally, axillary leaves are symmetrical while lateral and median leaves are asymmetrical. The leaves may have one of the following shapes (fig. 2A): lanceolate, ovate, elliptic, oblong, falcate, deltate, obovate, oblanceolate, or a combination of two types eg ovate-oblong. The margins (fig. 2B) may be entire, denticulate, serrate, serrulate, aculeate, ciliate or a

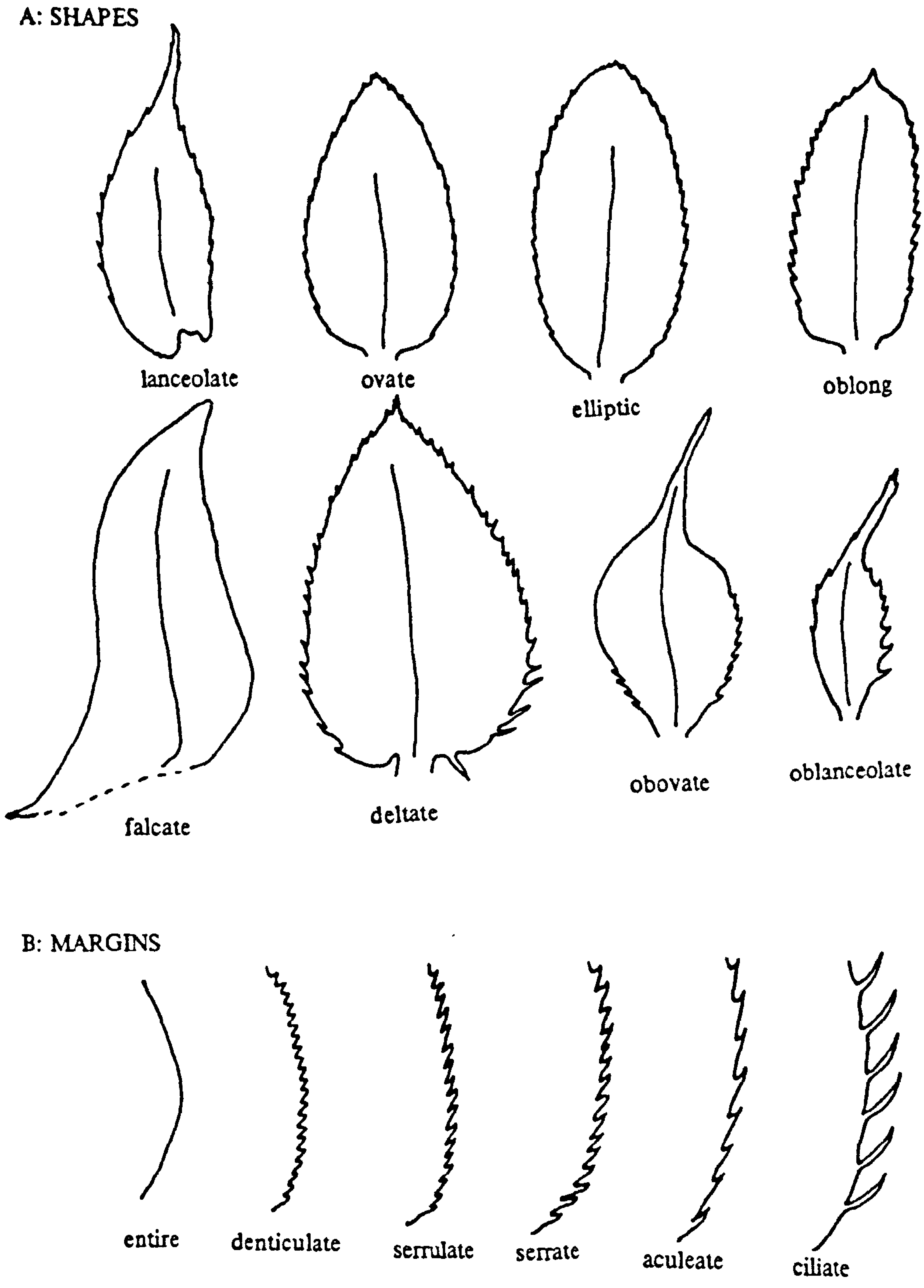


Fig. 2: Shapes and margins of leaves of Selaginella subgenus Stachygynandrum from West Africa and Madagascar.

combination of these eg ciliate-serrate. Leaf apices (fig. 3A) are generally uniform within species though some variation may occur as one moves from the basal part of the plant to the apical part. The apex may be acute, apiculate, mucronate (mucronulate), acuminate or subobtuse for the lateral, axillary and stem leaves. Only the acuminate type is seen in the median leaf. In addition to the acuminate type, the apex of the median leaf may be aristate, cuspidate or caudate. The leaf base (fig. 3B) may be one of the following - obtuse, cuneate, cordate, subcordate, truncate, attenuate or oblique or a combination of two eg cordate-truncate. All types of leaves (lateral, median, axillary and stem-leaves) show the above types of bases. The median leaf may possess, in addition to the above types, an auriculate or subsaggitate leaf base.

The leaves may be amphistomatous or hypostomatous, that is, the stomata may be distributed on both the upper (ligular) and lower (aligular) surfaces eg S. goudotana or only on the lower (aligular) surface eg S. molleri. The stomata may be found only at the midvein region either in rows eg S. kalbreyeri or scattered eg S. blepharophylla, at the margin(s) eg S. cathedrifolia or scattered on the whole lamina surface eg S. vogelii.

Papillae may or may not be present on the leaf. When present, the papillae are seen near the margins and/or at the apex of the leaves. The sclerotic cells, seen as shiny (silvery) areas on the lamina, are better seen in cleared and stained leaves. They are present in bands and/or patches on the aligular surface of the leaf lamina (fig. 9).

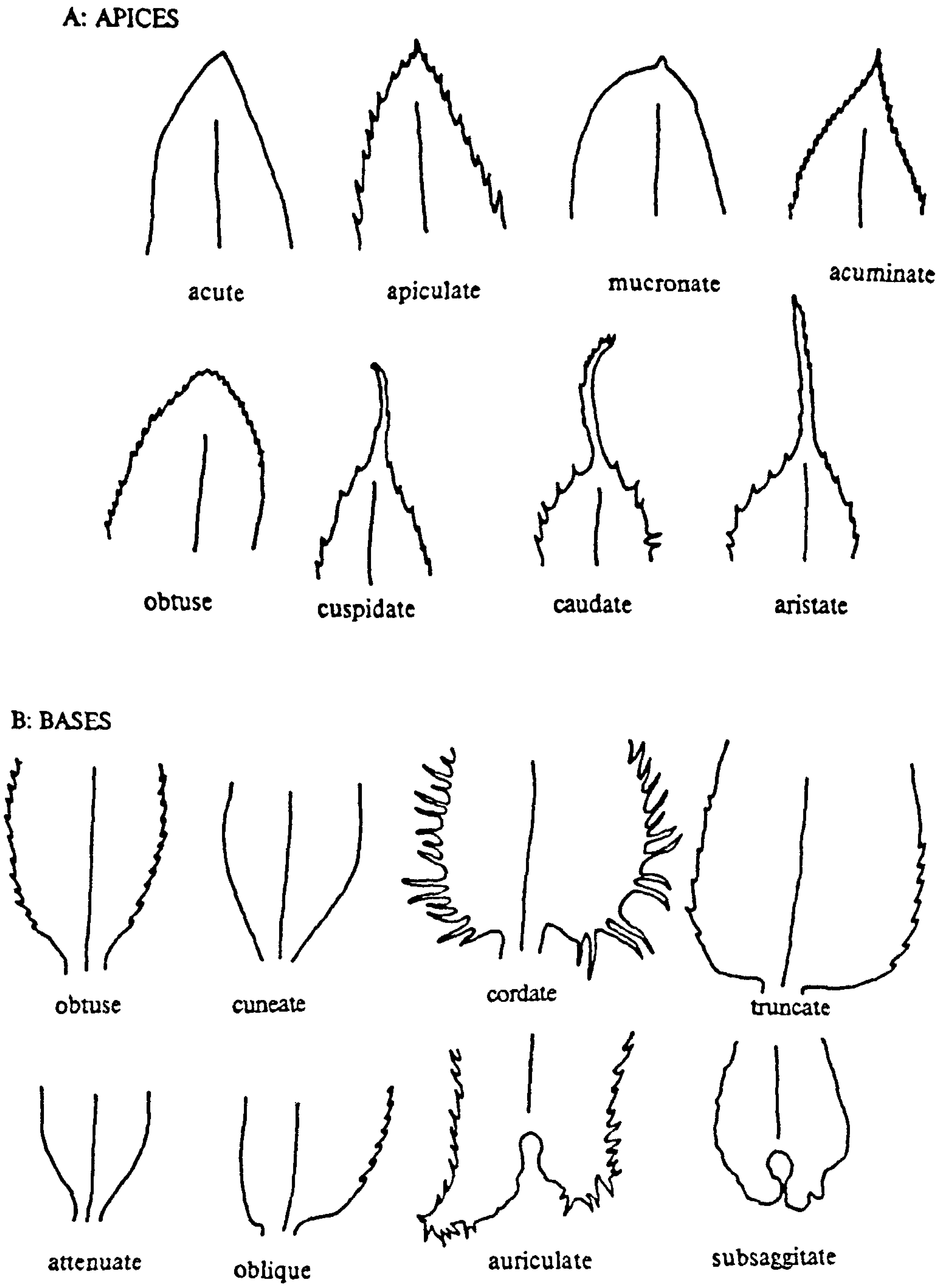


Fig. 3: Apices and bases of leaves of Selaginella subgenus Stachygynandrum from West Africa and Madagascar.

The leaves are generally, single-veined, however, some species may have more than one vein as seen in S. lyallii, S. myosurus and S. pectinata which possess leaves that have three veins. The veins, better seen in cleared and stained material, run more or less parallel to each other in the middle of the lamina.

The epidermises (figs. 4-6) of the leaves may be similar on both the ligular and aligular surfaces (eg S. kraussiana) or different (eg S. subcordata). The ligular surface epidermal cells of the lateral and axillary leaves are isodiametric, occasionally polygonal while the aligular surface is comprised of elongate cells. The cell wall may be straight, sinous or undulating or a combination of these in form. The median leaf has the opposite of what pertains for the lateral and axillary leaves. The ligular surface epidermis is made up of elongate cells while the aligular surface is comprised of isodiametric, occasionally polygonal cells. The cell wall has forms similar to those of the lateral and axillary leaves - straight, sinous or undulating.

The colour of the leaves appears to be affected by the environment (eg light) and may be dark green, coppery green to blue-green in the shade or pale green to yellowish green in the open.

Considerable variation is encountered within species in terms of leaf size (Tables 3 & 4). The sizes of leaves are different;they are generally larger at the basal part of the plant than at the apical part.

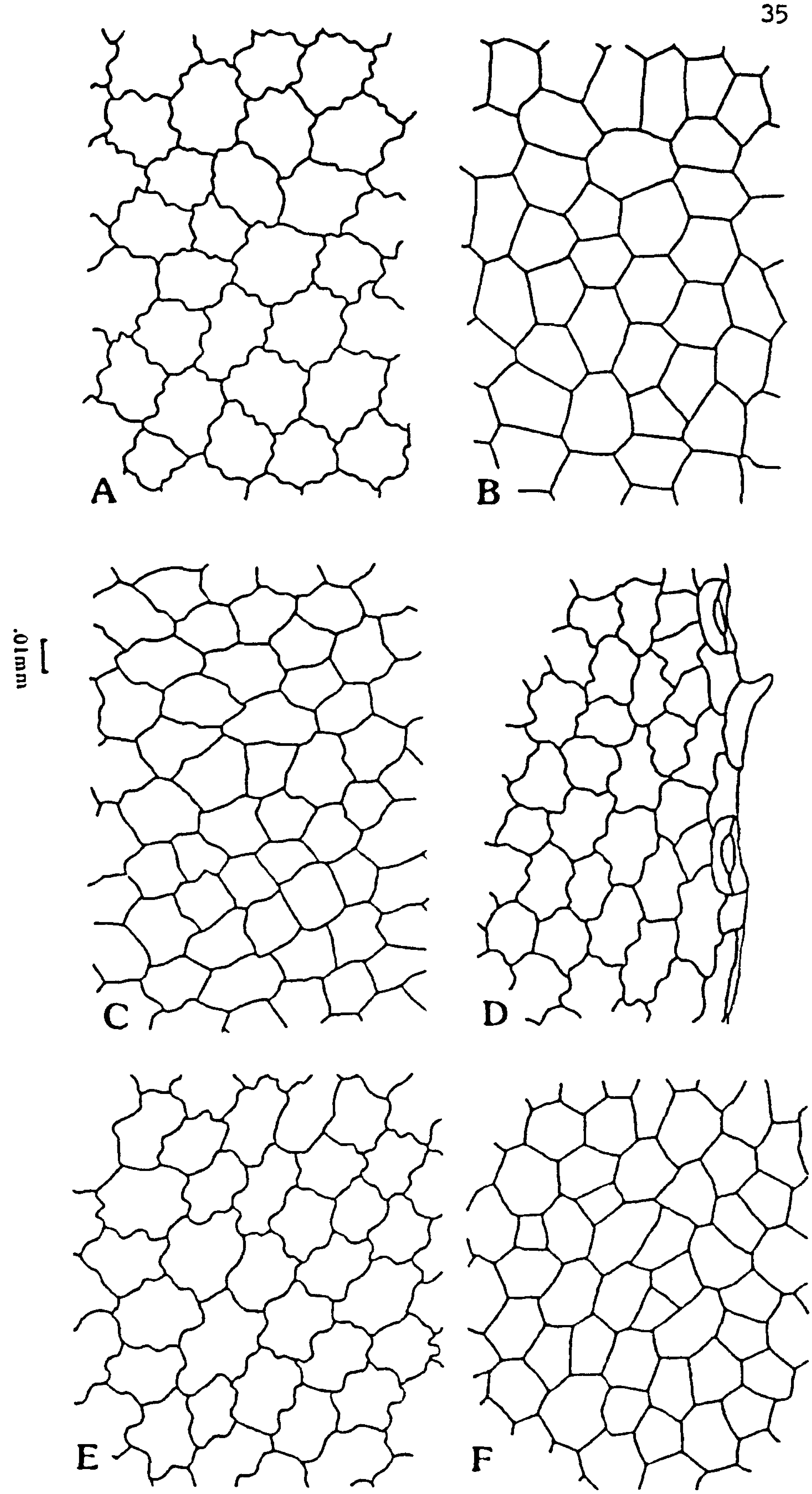


Fig. 4A: Ligular surface epidermal cells of leaves of Selaginella subgenus Stachygynandrum: A. S. molliceps (Exell 500, BM); B. S. zechii (Box 3506, BM); c. S. soyauxii (Soyaux 419, BD); D. S. goudotana (Quansah Q1088, BM); E. S. perpusilla (Wakefield s.n., BM); F. S. unilateralis (Bâthie 8320, BM). A, B, C = lateral leaves; D, E, F = Axillary leaves.

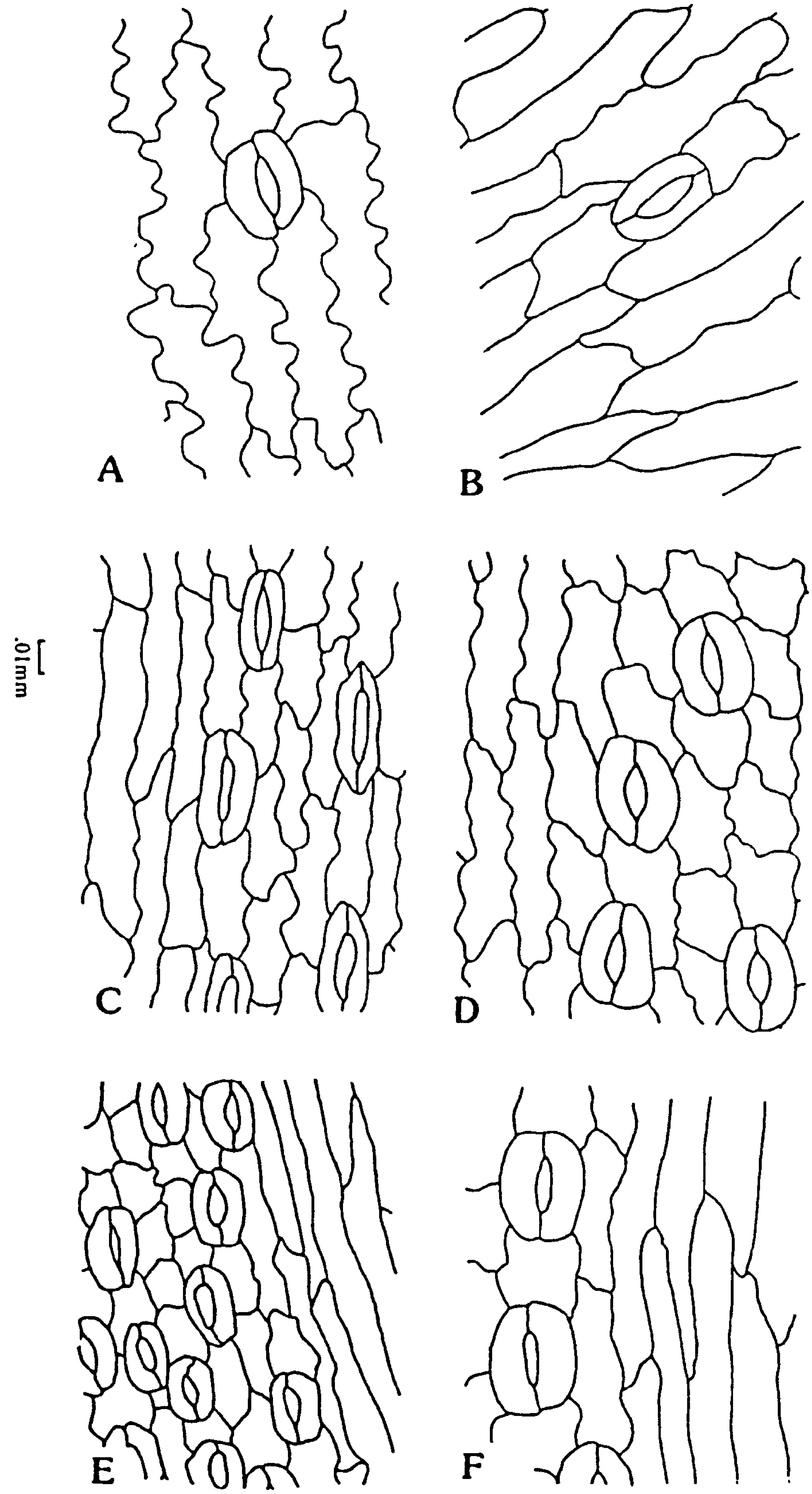


Fig. 4B: Aligular surface epidermal cells of axillary leaves of Selaginella subgenus Stachygynandrum: A. S. subcordata (Deighton 3087B, BM); B. S. buchholzii (Buchholz s.n., BD); C. S. molliceps (Exell 500, BM); D. S. squarrosa (Mann 1407, K); E. S. kalbreyeri (Kalbreyer 164, BM); F. S. thomensis (Exell 423, BM).

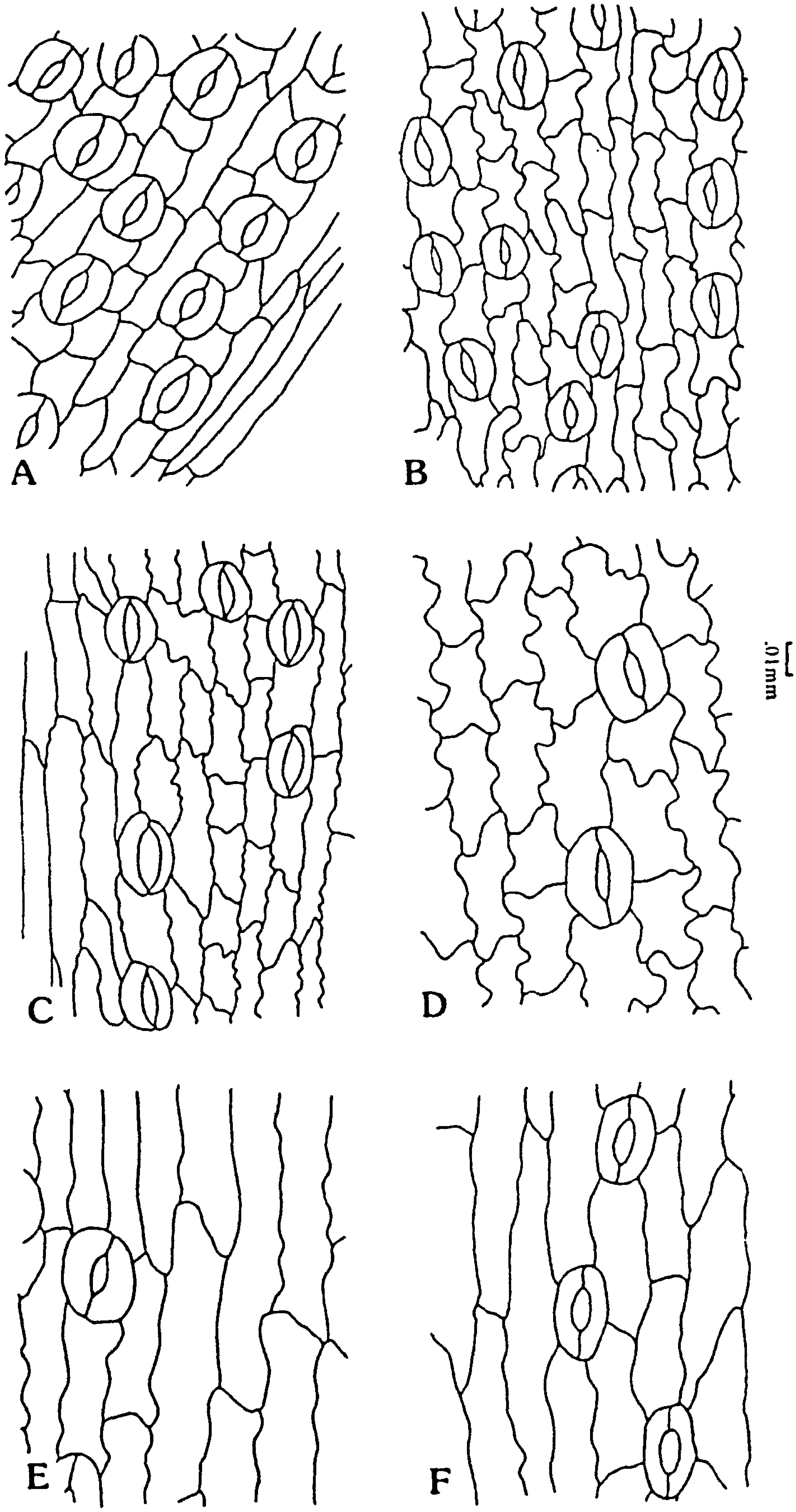


Fig. 4C: Aligular surface epidermal cells of lateral leaves of *Selaginella* subgenus *Stachygynandrum*: A. *S. helicoclada* (Bâthie 947, BM); B. *S. myosurus* (Gossweiler 7029, BM); C. *S. cathedrifolia* (Adams 1335, BM); D. *S. vogelii* (Box 3589, BM); E. *S. kraussiana* (Brenan 4385, BM); F. *S. versicolor* (Hossain GC 40003, BM).

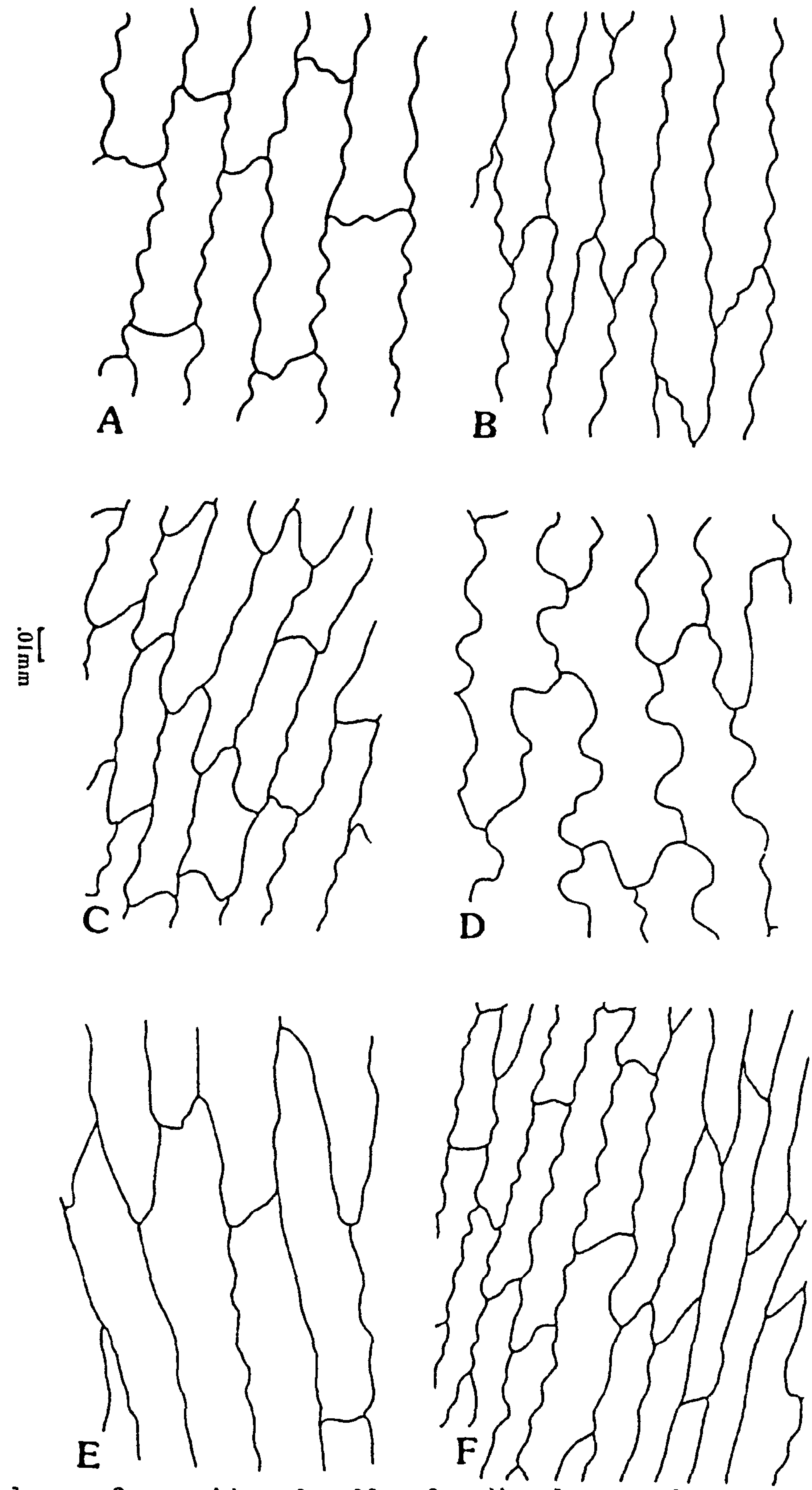


Fig. 5A: Ligular surface epidermal cells of median leaves of *Selaginella* subgenus *Stachygynandrum*: A. *S. squarrosa* (Mann 1407, K); B. *S. serrato-squarrosa* (Nickles 102, P); C. *S. soyauxii* (Soyaux 419, BD); D. *S. kraussiana* (Brenan 4385, BM); E. *S. versicolor* (Hossain GC 40003, BM); F. *S. unilateralis* (Bâthie 8320, BM).

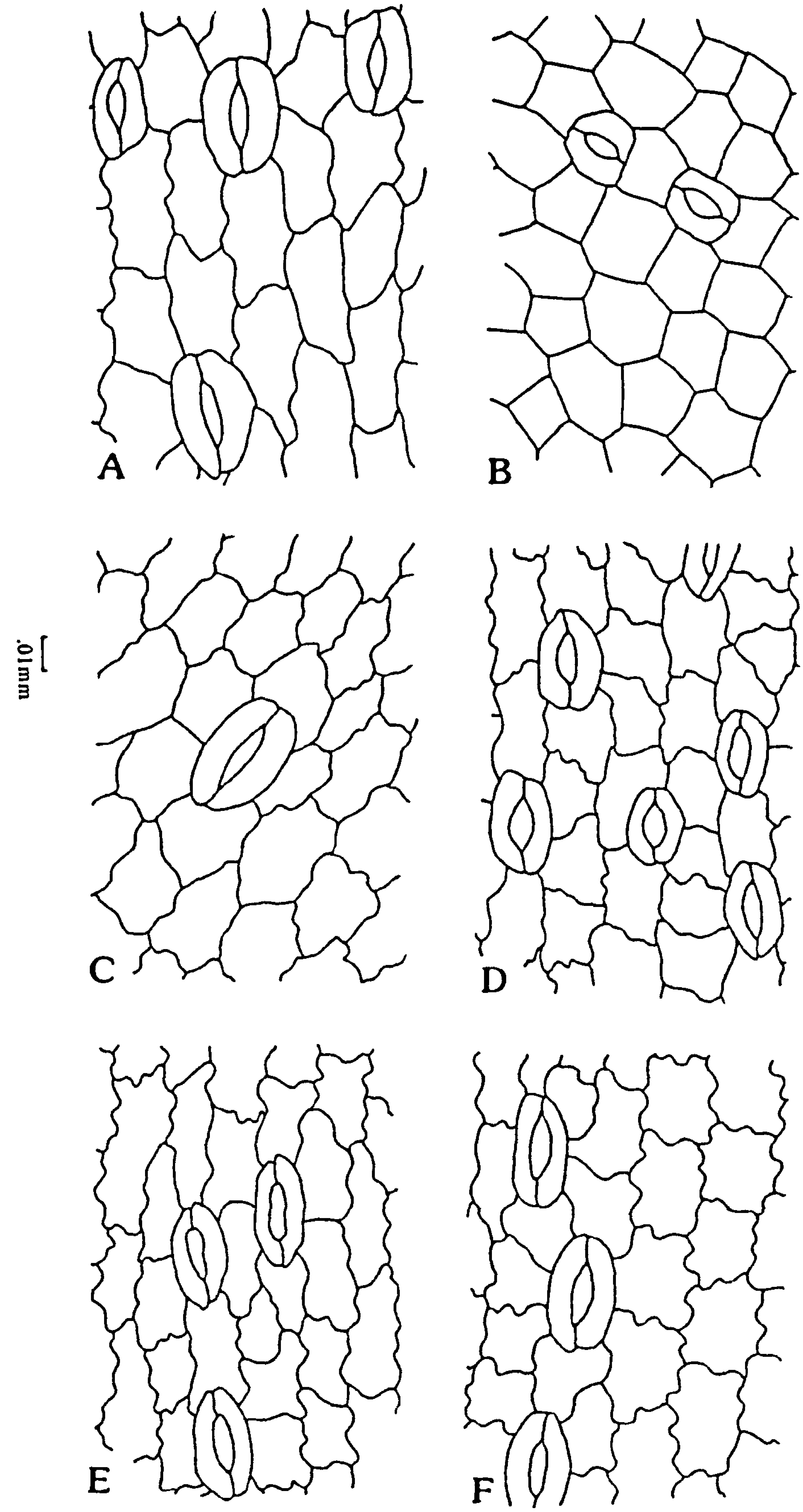


Fig. 5B: Aligular surface epidermal cells of median leaves of <u>Selaginella</u> subgenus <u>Stachygynandrum</u>: A. <u>S.</u> <u>leoneensis</u> (Harley F161, BM); B. <u>S.</u> <u>buchholzii</u> (Buchholz s.n., BD); C. <u>S.</u> <u>protensa</u> (Portères s.n., P.); D. <u>S.</u> <u>kalbreyeri</u> (Kalbreyer 164, BM); E. <u>S.</u> <u>molliceps</u> (Exell 500, BM); F. <u>S.</u> <u>squarrosa</u> (Mann 1407, K).

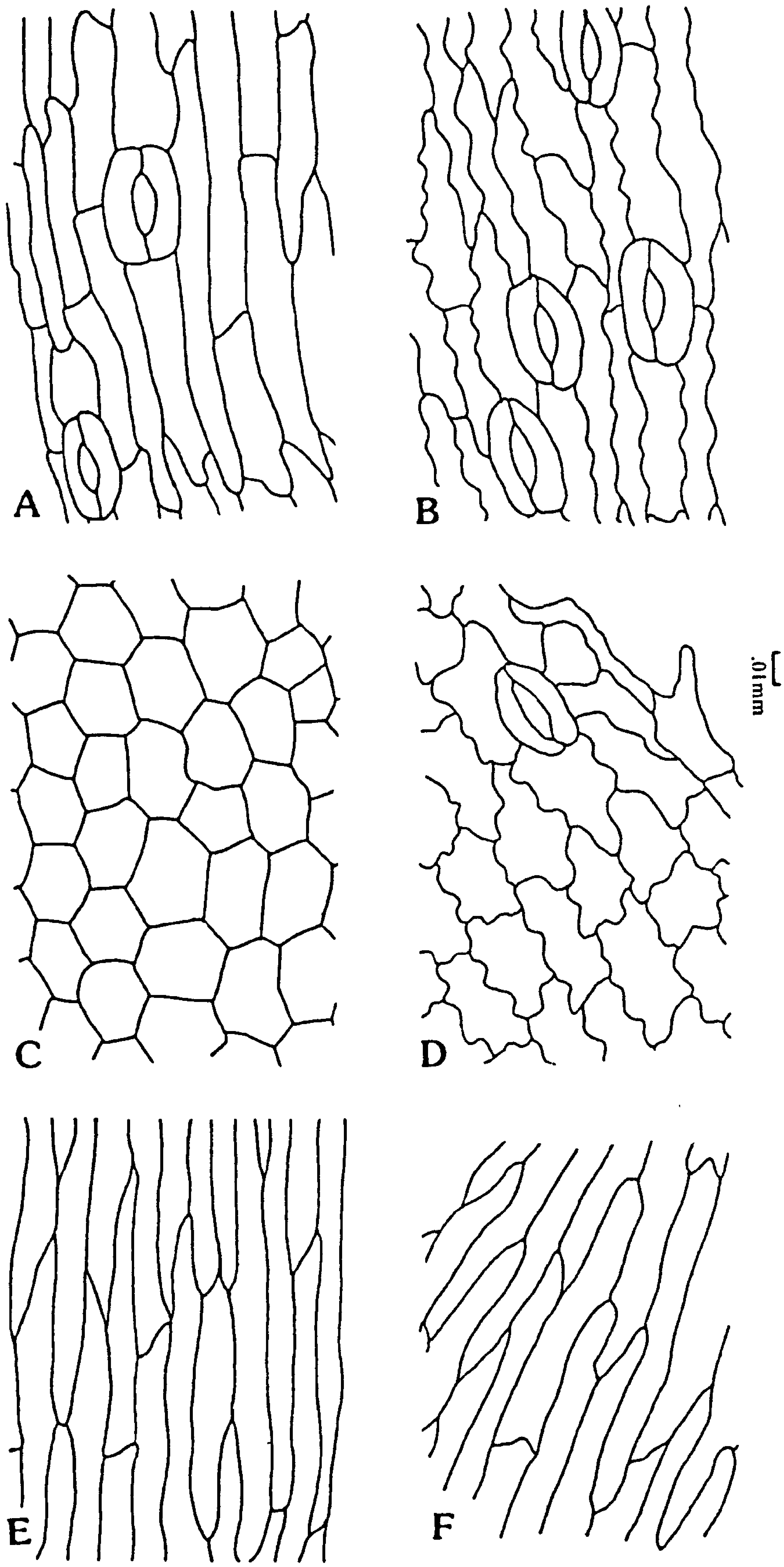


Fig. 6A: Epidermal cells of sporophylls of Selaginella subgenus Stachygynandrum: A. S. thomensis (Exell 423, BM); B. S. leoneensis (Harley F161, BM); C. S. squarrosa (Mann 1407, K) ; D. S. subcordata (Deighton 3087B, BM); E. S. hildebrandtii (Bâthie 8224, BM); F. S. protensa (Portères s.n., P). A-D = ventral sporophylls; A-B = ligular surface, C-D = aligular surface; E-F = dorsal sporophylls.

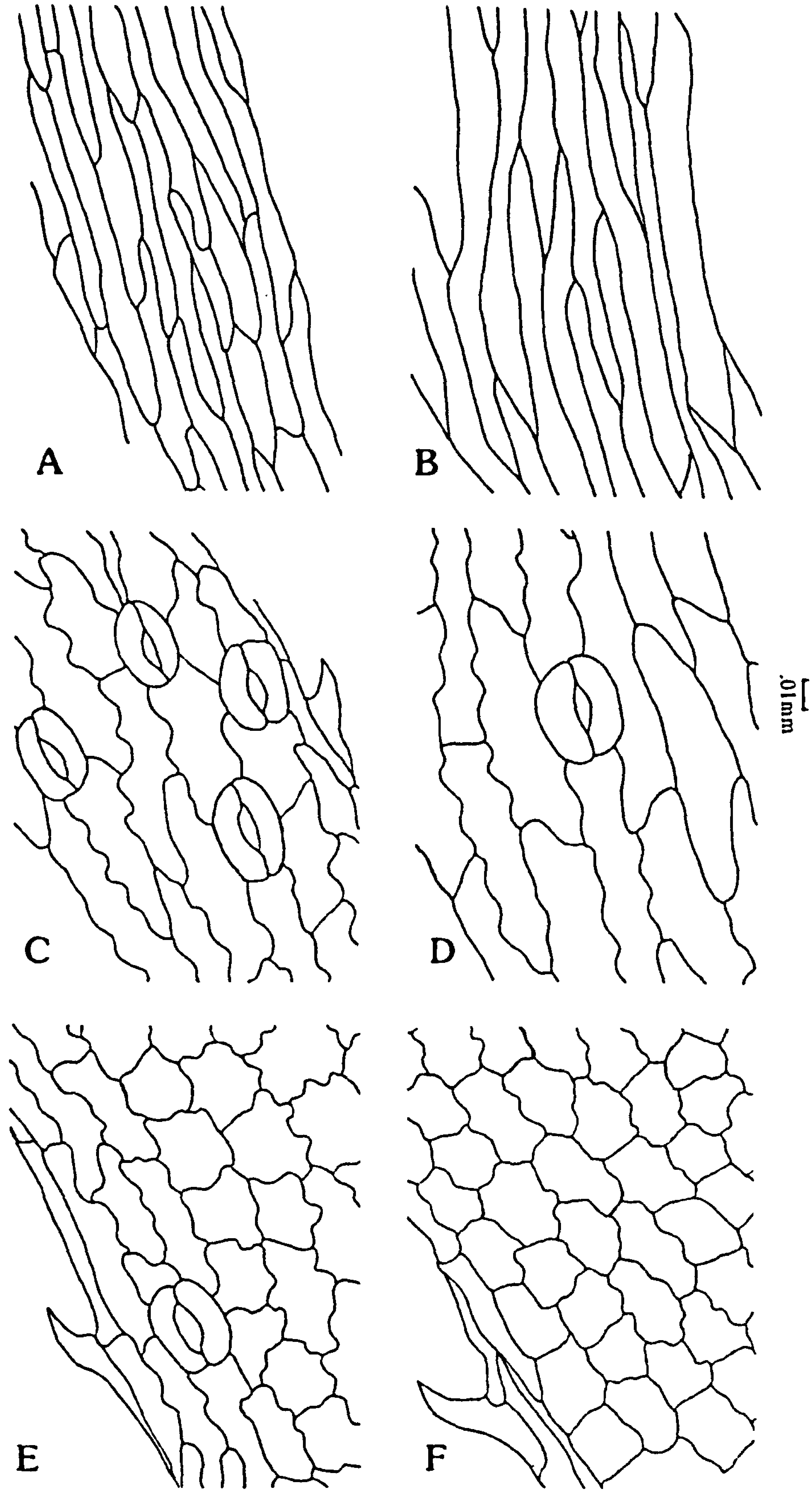


Fig. 6B: Epidermal cells of sporophylls of Selaginella subgenus Stachygynandrum: A. S. lyallii (Quansah Q409030, BM); B. S. unilateralis (Bâthie 8320, BM); C. S. goudotana (Quansah Q1088, BM); D. S. hildebrandtii (Bâthie 8224, BM); E. S. goudotana (Quansah Q1088, BM); F. S. hildebrandtii (Bâthie 8224, BM). B = dorsal sporophyll; C-F = ventral sporophylls; C-D = ligular surface; E-F = aligular surface.

Table 3A : Leaf measurements of species of West African *Selaginella* subgenus *Stachygynandrum* (based on 25 replicates per leaf type per species)*

SPECIES	LATERAL LEAVES		MEDIAN LEAVES		AXILLARY LEAVES	
	Length (L) Range (mm)	Width (W) Range (mm)	Length (L) Range (mm)	Width (W) Range (mm)	Length (L) Range (mm)	Width (W) Range (mm)
S. versicolor	2.50-5.00	1.00-3.00	2.10-2.5	1.00-1.80	2.40-4.70	1.00-3.20
S. vogelii	2.40-3.50	1.00-1.50	0.80-1.20	0.20-0.70	1.90-3.00	0.80-1.60
S. kraussiana	2.40-4.00	1.20-1.80	2.10-2.80	0.60-1.00	2.40-3.80	1.00-2.00
S. cathedrifolia	1.50-2.20	0.90-1.50	0.60-1.10	0.30-0.60	1.50-2.20	0.80-1.60
S. myosurus	2.50-4.00	1.00-2.00	0.70-2.20	0.30-0.80	2.40-3.80	1.30-2.30
S. buchholzii	1.70-2.30	0.80-1.30	0.70-1.50	0.40-0.80	1.50-2.00	0.80-1.20
S. soyauxii	2.20-4.50	1.00-2.00	1.50-2.50	0.60-1.50	1.90-4.00	0.90-2.20
S. blepharophylla	1.60-4.00	1.00-2.20	1.40-2.50	0.50-1.30	1.50-3.80	1.10-2.40
S. zechii	2.20-2.60	0.80-1.50	1.20-1.60	0.30-0.60	2.10-2.50	0.90-1.40
S. protensa	2.00-3.80	0.80-1.90	1.60-2.30	0.50-0.80	2.00-3.60	1.00-2.00
S. tenerrima	1.90-2.30	0.80-1.00	0.40-1.00	0.20-0.50	1.50-2.00	0.70-1.10
S. kalbreyeri	2.50-3.50	0.90-1.50	0.70-1.70	0.30-1.30	2.50-3.30	1.00-1.50
S. leoneensis	2.00-2.80	0.70-1.30	1.00-1.40	0.30-0.50	1.80-2.60	1.10-1.40
S. molleri	1.60-2.80	0.70-1.20	0.90-2.00	0.30-0.80	1.40-2.70	0.60-1.40
S. molliceps	2.00-3.00	1.00-1.30	0.70-1.70	0.30-0.70	2.40-2.80	1.10-1.50
S. subcordata	2.00-2.50	0.90-1.30	0.90-1.30	0.30-0.60	1.90-2.50	1.10-1.50
S. squarrosa	3.20-5.10	1.20-1.70	3.10-4.20	0.90-1.20	2.70-4.80	1.10-1.80
S. serrato-squarrosa	3.30-5.30	1.10-1.60	3.20-4.50	0.80-1.10	3.00-5.00	1.20-1.80
S. goudotana	1.90-3.00	1.10-2.00	0.80-1.70	0.40-1.00	1.80-2.80	1.10-2.10
S. thomensis	1.60-3.00	0.80-1.50	1.00-1.30	0.40-0.70	1.50-2.80	1.00-1.60

* See Table 3B for average values

TABLE 3B: Leaf measurements of species of West African Selaginella subgenus Stachygynandrum (Based on 25 replicates per leaf type per species)

SPECIES	LATERAL LEAVES			MEDIAN LEAVES			AXILLARY LEAVES		
	Length (L) $\bar{x} \pm \delta$ (mm)	Width (W) $\bar{x} \pm \delta$(mm)	L/W $\bar{x}$	Length (L) $\bar{x} \pm \delta$ (mm)	Width (W) $\bar{x} \pm \delta$(mm)	L/W $\bar{x}$	Length (L) $\bar{x} \pm \delta$ (mm)	Width (W) $\bar{x} \pm \delta$(mm)	L/W $\bar{x}$
S. versicolor	4.80 ± 0.16	2.74 ± 0.22	1.76	2.36 ± 0.11	1.61 ± 0.14	1.47	4.61 ± 0.10	3.09 ± 0.10	1.50
S. vogelii	3.31 ± 0.18	1.33 ± 0.16	2.51	0.92 ± 0.09	0.33 ± 0.06	2.88	2.89 ± 0.10	1.44 ± 0.12	2.02
S. kraussiana	3.76 ± 0.19	1.66 ± 0.13	2.27	2.65 ± 0.13	0.84 ± 0.14	3.26	3.66 ± 0.13	1.88 ± 0.10	1.95
S. cathedrifolia	1.83 ± 0.14	1.23 ± 0.20	1.51	0.71 ± 0.09	0.36 ± 0.05	2.02	1.77 ± 0.18	1.42 ± 0.18	1.26
S. myosurus	3.76 ± 0.20	1.79 ± 0.17	2.12	0.90 ± 0.09	0.45 ± 0.07	2.05	3.70 ± 0.10	2.20 ± 0.12	1.68
S. buchholzii	2.03 ± 0.19	1.07 ± 0.18	1.93	0.91 ± 0.10	0.59 ± 0.11	1.59	1.88 ± 0.12	1.02 ± 0.14	1.88
S. soyauxii	4.26 ± 0.18	1.80 ± 0.17	2.38	2.34 ± 0.13	1.34 ± 0.14	1.76	3.85 ± 0.13	2.04 ± 0.14	1.90
S. blepharophylla	3.70 ± 0.30	1.84 ± 0.25	2.03	2.14 ± 0.30	1.06 ± 0.19	2.05	3.45 ± 0.29	2.14 ± 0.20	1.62
S. zechii	2.45 ± 0.13	1.03 ± 0.09	2.40	1.42 ± 0.08	0.48 ± 0.10	3.11	2.35 ± 0.13	1.12 ± 0.08	2.10
S. protensa	3.64 ± 0.12	1.69 ± 0.14	2.17	1.83 ± 0.13	0.70 ± 0.11	2.68	3.49 ± 0.12	1.78 ± 0.14	1.97
S. tenerrima	2.12 ± 0.16	0.93 ± 0.07	2.29	0.52 ± 0.08	0.27 ± 0.05	1.98	1.91 ± 0.08	1.01 ± 0.09	1.47
S. kalbreyeri	3.29 ± 0.17	1.26 ± 0.19	2.65	0.89 ± 0.11	0.36 ± 0.05	2.47	3.12 ± 0.15	1.19 ± 0.18	2.68
S. leoneensis	2.64 ± 0.14	1.19 ± 0.12	2.22	1.25 ± 0.15	0.41 ± 0.08	3.11	2.48 ± 0.11	1.28 ± 0.11	1.95
S. molleri	2.60 ± 0.15	1.14 ± 0.07	2.30	1.08 ± 0.10	0.41 ± 0.08	2.73	2.53 ± 0.11	1.31 ± 0.10	1.95
S. molliceps	2.83 ± 0.14	1.20 ± 0.10	2.37	0.88 ± 0.10	0.42 ± 0.08	2.14	2.68 ± 0.12	1.40 ± 0.08	1.91
S. subcordata	2.28 ± 0.18	1.16 ± 0.13	1.98	1.14 ± 0.13	0.48 ± 0.09	2.43	2.14 ± 0.13	1.30 ± 0.14	1.66
S. squarrosa	4.87 ± 0.16	1.51 ± 0.18	3.27	4.04 ± 0.13	1.05 ± 0.10	3.87	4.68 ± 0.12	1.66 ± 0.11	2.83
S. serrato-squarrosa	5.10 ± 0.18	1.40 ± 0.16	3.69	4.33 ± 0.15	1.01 ± 0.10	4.33	4.85 ± 0.14	1.63 ± 0.13	2.98
S. goudotana	2.62 ± 0.32	1.58 ± 0.31	1.69	1.25 ± 0.18	0.80 ± 0.21	1.61	2.32 ± 0.38	1.75 ± 0.26	1.33
S. thomensis	2.82 ± 0.14	1.37 ± 0.11	1.43	1.17 ± 0.11	0.56 ± 0.11	2.13	2.68 ± 0.10	1.50 ± 0.09	1.79

Table 4A : Leaf measurements of species of Madagascan <u>Selaginella</u> subgenus <u>Stachygynandrum</u> based on 25 replicates per leaf type per species)*

SPECIES	LATERAL LEAVES Length (L) Range (mm)	Width (W) Range (mm)	MEDIAN LEAVES Length (L) Range (mm)	Width (W) Range (mm)	AXILLARY LEAVES Length (L) Range (mm)	Width (W) Range (mm)
S. fissidentoides	1.70-2.60	0.58-0.94	1.25-2.10	0.48-0.98	1.17-1.70	0.42-0.68
S. vogelii	2.40-3.50	1.00-1.50	0.80-1.20	0.20-0.70	1.90-3.00	0.80-1.60
S. pervillei	1.60-2.50	0.68-1.10	1.13-1.60	0.42-0.54	1.20-1.70	0.40-0.56
S. digitata	0.54-0.76	0.45-0.54	0.45-0.56	0.36-0.44	0.54-0.76	0.45-0.54
S. helicoclada	0.76-0.80	0.50-0.76	0.56-0.64	0.44-0.54	0.76-0.80	0.50-0.76
S. pectinata	3.84-5.83	1.60-3.25	1.39-2.00	0.36-0.60	2.20-5.10	0.87-2.94
S. lyallii	2.06-4.32	0.92-2.18	1.25-2.40	0.33-0.74	1.58-4.02	0.60-2.16
S. hildebrandtii	2.00-2.91	0.92-1.90	0.86-1.60	0.29-0.47	2.00-2.77	0.83-1.22
S. goudotana	1.90-3.00	1.10-2.00	0.80-1.70	0.40-1.00	1.80-2.80	1.10-2.10
S. perpusilla	1.42-2.31	0.65-1.32	0.97-1.44	0.57-0.76	1.25-2.03	0.60-1.19
S. unilateralis	1.80-3.20	0.56-1.48	1.33-1.80	0.42-0.7	1.68-2.83	0.94-1.40

* See Table 4B for average values

TABLE 4B: Leaf measurements of species of Madagascan *Selaginella* subgenus *Stachygynandrum* (based on 25 replicates per leaf type per species)

SPECIES	LATERAL LEAVES Length (L) $\bar{x} \pm \delta$ (mm)	Width (W) $\bar{x} \pm \delta$ (mm)	L/W $\bar{x}$	MEDIAN LEAVES Length (L) $\bar{x} \pm \delta$ (mm)	Width (W) $\bar{x} \pm \delta$ (mm)	L/W $\bar{x}$	AXILLARY LEAVES Length (L) $\bar{x} \pm \delta$ (mm)	Width (W) $\bar{x} \pm \delta$ (mm)	L/W $\bar{x}$
S. fissidentoides	2.26 ± 0.38	0.77 ± 0.14	2.92	1.61 ± 0.34	0.64 ± 0.20	2.57	1.42 ± 0.22	0.53 ± 0.11	2.70
S. vogelii	3.31 ± 0.18	1.33 ± 0.16	2.51	0.92 ± 0.09	0.33 ± 0.06	2.88	2.89 ± 0.10	1.44 ± 0.12	2.02
S. pervillei	2.19 ± 0.38	0.95 ± 0.19	2.32	1.42 ± 0.18	0.49 ± 0.05	2.92	1.47 ± 0.18	0.53 ± 0.05	2.95
S. digitata	0.63 ± 0.09	0.49 ± 0.04	1.34	0.51 ± 0.04	0.41 ± 0.04	1.24	0.63 ± 0.09	0.49 ± 0.04	1.34
S. helicoclada	0.77 ± 0.03	0.67 ± 0.12	1.17	0.60 ± 0.03	0.52 ± 0.07	1.28	0.77 ± 0.03	0.67 ± 0.12	1.28
S. pectinata	5.14 ± 0.60	2.39 ± 0.55	2.20	1.60 ± 0.27	0.48 ± 0.08	3.39	3.47 ± 1.18	1.71 ± 0.89	2.22
S. lyallii	3.41 ± 0.92	1.69 ± 0.55	2.06	1.72 ± 0.46	0.52 ± 0.17	3.31	2.78 ± 1.05	1.41 ± 0.63	2.05
S. hildebrandtii	2.48 ± 0.36	1.27 ± 0.36	2.03	1.32 ± 0.26	0.38 ± 0.07	3.56	2.39 ± 0.31	1.02 ± 0.16	2.36
S. goudotana	2.62 ± 0.32	1.58 ± 0.31	1.69	1.25 ± 0.18	0.80 ± 0.21	1.61	2.32 ± 0.38	1.75 ± 0.26	1.33
S. perpusilla	1.90 ± 0.39	1.00 ± 0.29	1.92	1.21 ± 0.17	0.66 ± 0.07	1.84	1.67 ± 0.30	0.87 ± 0.24	1.96
S. unilateralis	2.66 ± 0.54	1.25 ± 0.39	2.28	1.55 ± 0.18	0.56 ± 0.11	2.84	2.43 ± 0.36	1.33 ± 0.10	1.84

(v) LIGULE

The ligule, a small membranous structure, is situated at the base on the adaxial surface of leaves and sporophylls. Even though it is pleomorphic, its shape is identical on all the leaves (lateral, median and axillary) and sporophylls (dorsal and ventral) and is consistent for all the species. The shape (fig. 7) may be one of the following: clavate, femurate, lingulate, flabelliform, rectangular, pedate, obclavate or obturbinate. The ligule may have trichomes at their bases, as seen in the ligules of the lateral leaves of S. versicolor (Plate 1), but in general, no trichome is present at their bases. The length of the ligule is variable within species and appears to be affected by the age and size of the leaf or sporophyll.

(vi) STROBILUS

The strobilus is terminal on branches and/or branchlets. There are two basic types of strobilus depending on the form (morphism) of the sporophylls. The strobilus may be either tetragonous or bilateral. The tetragonous strobilus (Plate 8) has monomorphic or subuniform sporophylls (eg S. fissidentoides) while the bilateral type (Plate 18) has dimorphic sporophylls (eg S. buchholzii). The relation of the dimorphic sporophylls, in the bilateral strobilus, to the vegetative median and lateral leaves as regards plane position has resulted in two forms of bilateral strobilus:- resupinate and non-resupinate. In the resupinate form (Plate 18), the smaller dorsal sporophylls are in the same plane as the larger lateral vegetative leaves while the larger ventral sporophylls are in the same plane as the

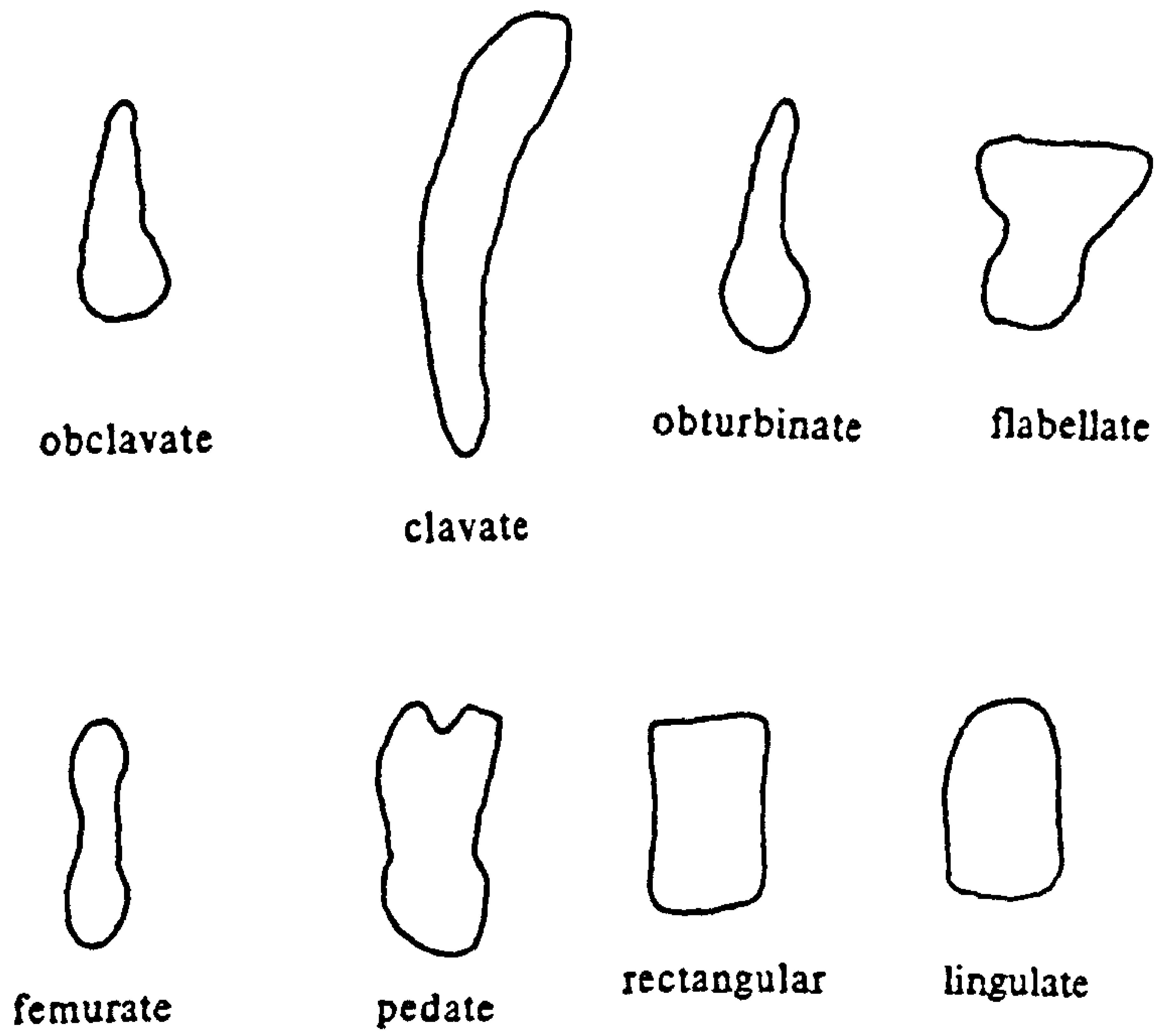
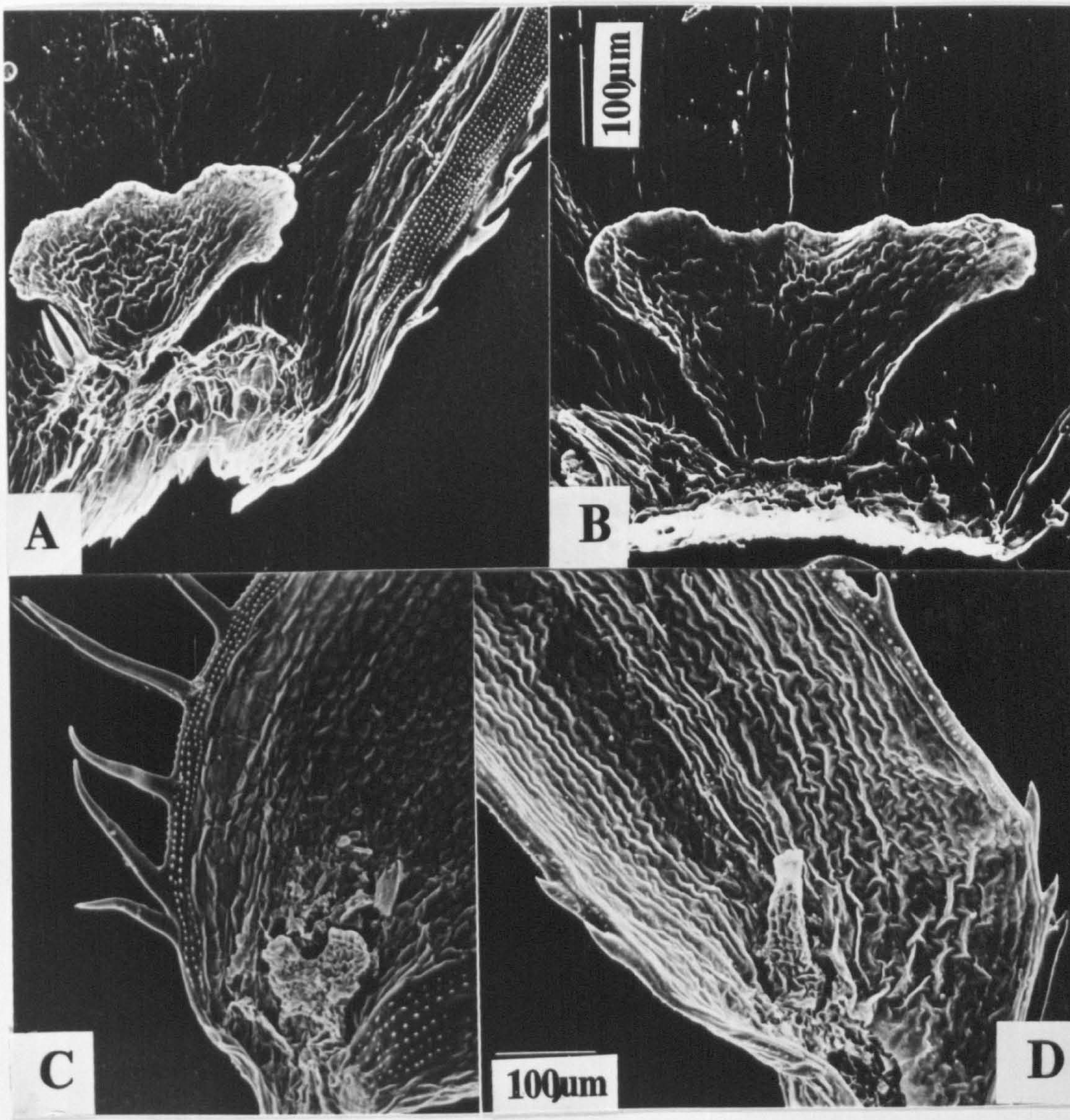


Fig. 7: Ligule shapes of species of Selaginella subgenus Stachygynandrum from West Africa and Madagascar.

PLATE 1

(see opposite page)

Ligules of some species of *Selaginella* subgenus *Stachygynandrum*: A-B. *S. versicolor* (note trichomes at the base of ligule of A; A = lateral leaf; B = axillary leaf. Both from Hossain GC 40003). C. *S. cathedrifolia*, Adams 1335. D. *S. myosurus*, Johnston s.n.


100µm
A
B
C
100µm
D

smaller median vegetative leaves (eg S. leoneensis). The non-resupinate form has the smaller sporophylls in the same plane as the smaller median vegetative leaves and the larger sporophylls in the same plane as the larger lateral vegetative leaves. None of the species from WA and M exhibits this form of strobilus, however, I have seen specimens of S. pallidissima Spring, from Java, which show the non-resupinate form of strobilus. Two growth patterns are encountered in the strobili of the subgenus - the determinate and intermittent growth patterns. In the determinate pattern (Plate 8), growth of the strobilus is finite and terminates the growth of the shoot. In the intermittent pattern (Plate 21) growth of the strobilus does not terminate the growth of the shoot. The strobilus reverts, at the apex, to a vegetative shoot which may or may not revert again to form a strobilus. All the species looked at in this study exhibit the determinate growth pattern, which is regarded as the normal pattern. Two species from WA (S. molleri and S. versicolor) have specimens that show, in addition to the determinate pattern, the intermittent growth pattern.

The length of the strobilus varies within species and appears to be affected by the age of the plant.

(a) Sporophylls

Two types of sporophylls - megasporophyll and microsporophyll - are seen in the species of Selaginella. These sporophylls may be uniform (subuniform) or dimorphous in the strobili of the species of the subgenus. The uniform sporophylls result in a tetragonous strobilus while the dimorphic sporophylls result in a bilateral strobilus (resupinate or non-resupinate).

The shape of the uniform sporophylls of the tetragonous strobilus and the dorsal sporophylls of the bilateral resupinate strobilus may be ovate (subovate), lanceolate, or trullate (subtrullate). The ventral sporophylls of the bilateral resupinate strobilus may have one of the following shapes: oblong, elliptic, lanceolate-elliptic, ovate-oblong, ovate-deltate, ovate-lanceolate or subpanduriform-ovate. The margins of the sporophylls may be entire (subentire), denticulate, serrulate, serrate, aculeate, or ciliate or a combination of these eg serrate-serrulate.

The apices of the sporophylls of the tetragonous strobilus and the dorsal sporophylls of the bilateral resupinate strobilus may be acuminate, cuspidate or aristate while the ventral sporophylls of the bilateral resupinate strobilus may have apices which are acute, apiculate, acuminate, cuspidate, or subretuse.

The bases of all the sporophylls may be obtuse, cuneate, truncate, subcordate, subauriculate, oblique or a combination of two of these eg obtuse-truncate. The sporophylls may be amphistomatous or hypostomatous.

The sporophylls of the species possessing tetragonous strobili have isomorphic epidermises with the ligular and aligular surfaces having elongate cells with straight, sinuous or undulating walls. The dorsal sporophylls of the species with bilateral resupinate strobili also have the epidermises of both the ligular and aligular surfaces being similar. The cells are elongate with straight or sinous walls. The epidermises of the ligular and aligular surfaces of the ventral sporophylls are different. The ligular surface epidermis is made up of elongate cells while the aligular surface epidermis has isodiametric, occasionally polygonal cells. The cell walls are similar for both surfaces; they may be straight, sinous or undulating.

The ventral sporophylls of the bilateral resupinate strobilus have sporophyll-pteryx, a vertical/oblique projection, on their adaxial surfaces. The sporophyll-pteryx appears to be the result of a fold of the outer half of the sporophyll onto itself and the fusion of laminal tissue on the adaxial surface. There are two forms of sporophyll-pteryx depending on the extent of folding and fusion - complete (eg S. hildebrandtii) and partial (eg S. kalbreyeri). The margin of the sporophyll-pteryx is the same as the margin of the unfolded side of the sporophyll. The cells of the sporophyll-pteryx are elongate with straight and/or sinous walls. The function of the sporophyll-pteryx is not known but it appears to be of a protective nature, protecting the sporangium where it occurs. The ventral sporophylls of both the tetragonous and bilateral strobili may be sterile in some species.

(b) Sporangia and Sporangial Distribution Pattern

Two types of sporangia - mega and microsporangia - are seen in Selaginella and both sporangia are short-stalked and borne in the axils of sporophylls.

The megasporangium is unilocular and four-lobed and may have one of the following shapes - ovoid, deltoid, ovoid-triangular or obovoid. - Generally, the megasporangium contains four megaspores (which gives it the four-lobed appearance). The sizes of the four megaspores are generally the same in each megasporangium of all the species. Inequality of spore sizes however, occur in the megasporangia of some species (see Tables 5 A & B). Three kinds of spore size inequality are observed. These are: 3 large: 1 small; 2 large: 2 small and 1 large: 3 small spores per megasporangium. There may be cases of an increase or a decrease in the number of megaspores per megasporangium. One case of an increase in the number of spores in a megasporangium of a specimen of S. cathedrifolia was seen in this study; there were eight spores in the megasporangium. Also observed, were two cases of a decrease in the number of spores per megasporangium; one case each, in S. kraussiana and S. fissidentoides, a single megaspore was observed in each megasporangium. The microsporangium is also unilocular but not lobed. It may have one of the following shapes - ellipsoid, ovoid, oblong, reniform or roundish. The shapes are consistent for each species. The number of spores in the microsporangium is large and indefinite for all the species.

Examination of the sporangium wall has shown that the inner basal wall of the microsporangium may have annuloid-like cells, as shown in S. kraussiana, or not, as in the rest of the species.

The distribution of the sporangia (mega and micro) in the strobili shows some pattern in the species. The sporangial distribution pattern found in the strobili of the species of the subgenus is basically, a dorsal side of megasporangia and a ventral side of microsporangia. This basic pattern may be modified to one of the eight major types and five variations (fig. 8), observed in this study. The sporangial distribution pattern is consistent for each species even though some species may exhibit more than one type and/or variation. A description of the types and variations of the sporangial distribution patterns is given in Table 6 .

Table 5A :Spore size proportions of the four megaspores per megasporangium of the West African species of *Selaginella* subgenus *Stachygynandrum*

Species	Number of megasporangia examined	Spore size proportion (%) All 4 spores same size	3 Large: 1 small	2 Large: 2 small	1 Large: 3 small
S. versicolor	240	100	-	-	-
S. vogelii	210	81.4	-	18.6	-
S. kraussiana	20	30	-	45	25
S. cathedrifolia	260	80.8	5	14.2	-
S. myosurus	130	70	19.2	10.8	-
S. buchholzii	180	91.1	8.9	-	-
S. soyauxii	50	86	6	8	-
S. blepharophylla	120	100	-	-	-
S. zechii	150	96.7	3.3	-	-
S. protensa	15	100	-	-	-
S. tenerrima	80	100	-	-	-
S. kalbreyeri	70	100	-	-	-
S. leoneensis	90	86.7	-	13.3	-
S. molleri	96	100	-	-	-
S. molliceps	125	88.8	11.2	-	-
S. subcordata	85	89.4	10.6	-	-
S. squarrosa	16	100	-	-	-
S. serrato-squarrosa	10	100	-	-	-
S. goudotana	105	80	20	-	-
S. thomensis	140	100	-	-	-

TABLE 5B : Spore size proportions of the four megaspores per megasporangium of the Madagascan species of *Selaginella* subgenus *Stachygynandrum*

Species	Number of megasporangia examined	Spore size proportion (%)			
		All 4 spores Same Size	3 Large: 1 Small	2 Large: 2 Small	1 Large: 3 Small
S. fissidentoides	30	83.3	-	3.3	13.3
S. vogelii	210	81.4	-	18.6	-
S. pervillei	65	76.9	20	3.1	-
*S. digitata**	-	-	-	-	-
S. helicoclada	15	100	-	-	-
S. pectinata	185	54.1	41.1	4.9	-
S. lyallii	96	85.4	12.5	2.1	-
S. hildebrandtii	75	93.3	6.7	-	-
S. goudotana	105	80	20	-	-
S. perpusilla	10	80	20	-	-
S. unilateralis	10	70	10	20	-

* = sporangia not seen

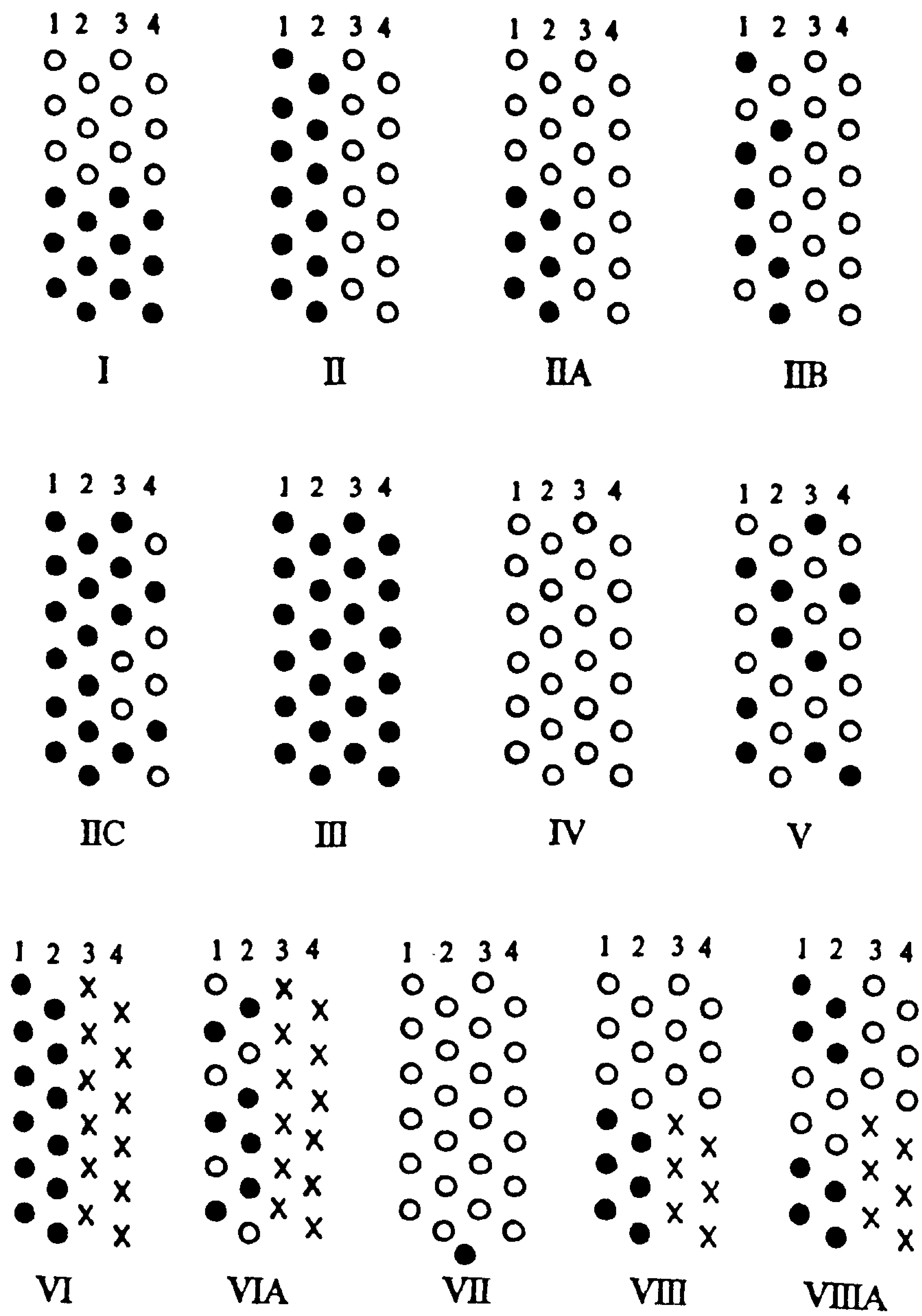


Fig. 8 : Schematic representations of sporangial distribution patterns that occur in strobili of Selaginella .

KEY: ● = megasporangia, O = microsporangia, X = sterile sporophylls,
rows 1 and 2 represent dorsal side of strobili
rows 3 and 4 represent ventral side of strobili
Roman numerals (I - VIII) refer to the Types of sporangial pattern described in Table 6.

TABLE 6 : Description of the Types of sporangial distribution patterns that occur in strobili of Selaginella subgenus Stachygynandrum from West Africa and Madagascar (see fig. 8 for schematic representations).

TYPE		DESCRIPTION
I		Strobili with a basal megasporangiate zone and an apical microsporangiate zone (eg S. vogelii; S. pervillei).
II		Strobili with the dorsal side wholly megasporangiate and the ventral side wholly microsporangiate (eg S. molliceps).
		Three variations occur in this type of distribution: A, B and C.
	A	Strobili with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate (eg S. goudotana).
	B	Strobili with the dorsal side containing both mega and microsporangia in random pattern and the ventral side wholly microsporangiate (eg S. squarrosa).
	C	Strobili with the dorsal side wholly megasporangiate and the ventral side containing both mega- and micro-sporangia (eg S. molleri). This variation may have

Table 6 (continued)

	one row of the ventral side containing entirely one type of sporangium and the other row both sporangia.
III	Strobili wholly megasporangiate (eg *S. thomensis*; *S. perpusilla*).
IV	Strobili wholly microsporangiate (eg *S. leoneensis*; *S. versicolor*).
V	Strobili with no particular pattern of sporangial distribution (eg *S. soyauxii*). This type may predominantly be either megaporangiate or microsporangiate.
VI	Strobili with the dorsal side wholly megasporangiate and the ventral sporophylls sterile (eg *S. protensa*; *S. pectinata*). This type appears to be a modification of either Type II without the ventral microsporangia or Type III with no ventral megasporangia.
	One variation occurs in this type of distribution: A.
	A Strobili with the dorsal side containing both mega- and microsporangia and the ventral sporophylls sterile (eg *S. subcordata*). This variation appears to be a modification of Type IIB without the ventral microsporangia. One row of the dorsal side may contain entirely one type of sporangium and the other

Table 6 (continued)

	row both sporangia.
VII	Strobili with a single basal megasporangium, the rest of the cone being microsporangiate (eg *S. myosurus*; *S. lyallii*).
VIII	Strobili with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side with a basal zone of sterile sporophylls and an apical microsporangiate zone (eg *S. pectinata*). This type appears to be a modification of either Type I or Type IIA without the basal microsporangiate zone of the ventral side.
	One variation occurs in this type of distribution: A.
	A Strobili with the dorsal side having the basal and apical thirds megasporangiate and the middle third microsporangiate and the ventral side with a basal zone of sterile sporophylls and an apical microsporangiate zone (eg *S. pectinata*).

(c) Spore

Two types of spores - megaspores and microspores - are produced by species of the genus Selaginella. Both types of spore are trilete and have more or less similar shapes. The shape may be tetrahedral, subtriangular, globose or subglobose. Megaspores are larger in size than the microspores and are even observable with the naked eye. The size of the megaspores ranges from 44 µm in *S. helicoclada* to 1100 µm in *S. kraussiana* while microspore size ranges from 13 µm in *S. versicolor* to 42 µm in *S. myosurus*, in this study. The range of size overlaps between species (Tables 7A & B). Generally, the megaspores and microspores have different ornamentation in the same species. Megaspore ornamentation (Plates 2-4) may be psilate, granulose, scabrate, verrucate, baculate, rugulose, reticulate, striate or cristate-reticulate. Microspores generally have one of the following ornamentations (Plates 5-7) - granulose, papillate, scabrate, foveolate, verrucate, clavate, echinate or a combination of these eg scabrate-verrucate. The ornamentation of the spores is consistent for each species.

Some species may have a distinct equatorial ring (Plate 2) on the megaspore eg *S. cathedrifolia* and *S. versicolor*; in other species, eg *S. kraussiana*, the equatorial ring may or may not be distinct while other species lack the equatorial ring eg *S. zechii*.

The microspore of some species eg *S. myosurus*, may have the outer layer extended to form an equatorial flange (Plate 6) around it while, in others eg *S. leoneensis*, the flange is absent.

TABLE 7A: Spore characters observed in species of *Selaginella* subgenus *Stachygynandrum* of West Africa

SPECIES	MEGASPORE Shape	Ornamentation	Equatorial ring (+ or -)	Size (µm)	MICROSPORE Shape	Ornamentation	Equatorial flange (+ or -)	Size (µm)
S. versicolor	subglobose	loosely reticulate	+	240-($\bar{M}$300)-330	globose	baculate-verrucate	-	13-($\bar{M}$19)-28
S. vogelii	tetrahedral-subtriangular	baculate	-	210-($\bar{M}$285)-328	globose	verrucate-echinate	-	25-($\bar{M}$30)-40
S. kraussiana	globose	cristate-reticulate	±	400-($\bar{M}$800)-1100	subglobose	echinate	-	25-($\bar{M}$32)-36
S. cathedrifolia	globose (subglobose)	rugulose	+	200-($\bar{M}$240)-298	tetrahedral-subtriangular	scabrate-echinate	-	19-($\bar{M}$25)-30
S. myosurus	globose	solidly striate-reticulate	-	696-($\bar{M}$810)-945	globose	verrucate (psilate)	+	24-($\bar{M}$33)-42
S. buchholzii	globose	finely granulose (psilate)	-	228-($\bar{M}$257)-300	subglobose	baculate-clavate	-	20-($\bar{M}$24)-32
S. soyauxii	globose	psilate	-	383-($\bar{M}$400)-430	subglobose	verrucate-echinate	-	34-($\bar{M}$38)-41
S. blepharophylla	tetrahedral-subtriangular	loosely reticulate	-	198-($\bar{M}$225)-240	globose	finely granulose	-	27-($\bar{M}$30)-35
S. zechii	subglobose	granulose (minutely rugulose)	-	160-($\bar{M}$180)-215	tetrahedral-subtriangular	finely granulose	-	20-($\bar{M}$23)-26
S. protensa	globose	finely rugulose-reticulate	-	210-($\bar{M}$254)-276	-	-	-	-
S. tenerrima	subglobose	compactly reticulate	-	160-($\bar{M}$195)-230	subglobose	scabrate	-	25-($\bar{M}$35)-38
S. kalbreyeri	globose	verrucate-scabrate	-	190-($\bar{M}$230)-280	subglobose	verrucate	-	20-($\bar{M}$24)-32
S. leoneensis	subglobose	reticulate	-	190-($\bar{M}$220)-236	subglobose	granulose-papillate	-	25-($\bar{M}$29)-34
S. molleri	globose	reticulate	-	225-($\bar{M}$237)-280	tetrahedral-subtriangular	scabrate-verrucate	-	29-($\bar{M}$36)-40
S. molliceps	subglobose	reticulate	-	185-($\bar{M}$240)-275	tetrahedral-subtriangular	scabrate	-	24-($\bar{M}$28)-30
S. subcordata	subglobose	rugulose	-	200-($\bar{M}$230)-255	subglobose	verrucate-clavate	-	30-($\bar{M}$38)-42
S. squarrosa	subglobose	reticulate-rugulose	-	190-($\bar{M}$205)-245	tetrahedral-subtriangular	scabrate	-	20-($\bar{M}$24)-26

S. serrato-squarrosa	subglobose	rugulose	-	210-($\bar{M}$220)-255	tetrahedral-subtriangular	foveolate (granulose)	-	15-($\bar{M}$19)-28
S. goudotana	tetrahedral-subtriangular	scabrate-verrucate	-	225-($\bar{M}$260)-305	subglobose	verrucate-echinate	-	25-($\bar{M}$35)-40
S. thomensis	subglobose	compactly reticulate	-	220-($\bar{M}$230)-245	subglobose	verrucate	-	20-($\bar{M}$26)-30

TABLE 7B : Spore characters observed in species of Selaginella subgenus Stachygynandrum of Madagascar

SPECIES	MEGASPORE Shape	Ornamentation	Size (µm)	MICROSPORE Shape	Ornamentation	Size (µm)
S. fissidentoides	globose	scabrate	453-($\bar{M}$489)-540	subglobose	rugulose	42-($\bar{M}$46)-52
S. vogelii	tetrahedral-subtriangular	baculate	210-($\bar{M}$285)-328	globose	verrucate-echinate	25-($\bar{M}$30)-40
S. pervillei	subglobose	scabrate-verrucate	221-($\bar{M}$252)-300	subglobose	verrucate-echinate	24-($\bar{M}$28)-33
S. digitata*	-	-	-	-	-	-
S. helicoclada	globose	coarsely granulose (scabrate)	44-($\bar{M}$57)-70	globose	granulose	16-($\bar{M}$20)-25
S. pectinata	globose	reticulate	721-($\bar{M}$809)-875	subglobose	rugulose-granulose	23-($\bar{M}$26)-29
S. lyallii	globose	reticulate	575-($\bar{M}$745)-900	subglobose	verrucate-granulose	27-($\bar{M}$30)-34
S. hildebrandtii	subglobose	reticulate	215-($\bar{M}$221)-246	subglobose	scabrate-granulose	25-($\bar{M}$28)-32
S. goudotana	tetrahedral-subtriangular	scabrate-verrucate	225-($\bar{M}$260)-305	subglobose	verrucate-echinate	25-($\bar{M}$35)-40
S. perpusilla	globose	reticulate	231-($\bar{M}$264)-291	subglobose	baculate	23-($\bar{M}$27)-33
S. unilateralis	subglobose	rugulose-reticulate	198-($\bar{M}$214)-236	subglobose	scabrate	19-($\bar{M}$21)-24

PLATE 2

(see opposite page)

Megaspores of Selaginella subgenus Stachygynandrum: A-B. S. versicolor; A. Proximal surface (r = equatorial ring); B. Distal surface. Both from Hossain GC 40003. C. S. tenerrima (Welwitsch 45). D. S. molliceps (Exell 500). E. S. blepharophylla (Harley F156). F. S. leoneensis (Brown & Brown 79). G. S. serrato-squarrosa (Nickles 102). H-I. S. cathedrifolia; H. Side-view; I. Proximal surface (r = equatorial ring). Both from Guinea 188. J. S. thomensis (Exell 423). K. S. myosurus (Gossweiler 7029).

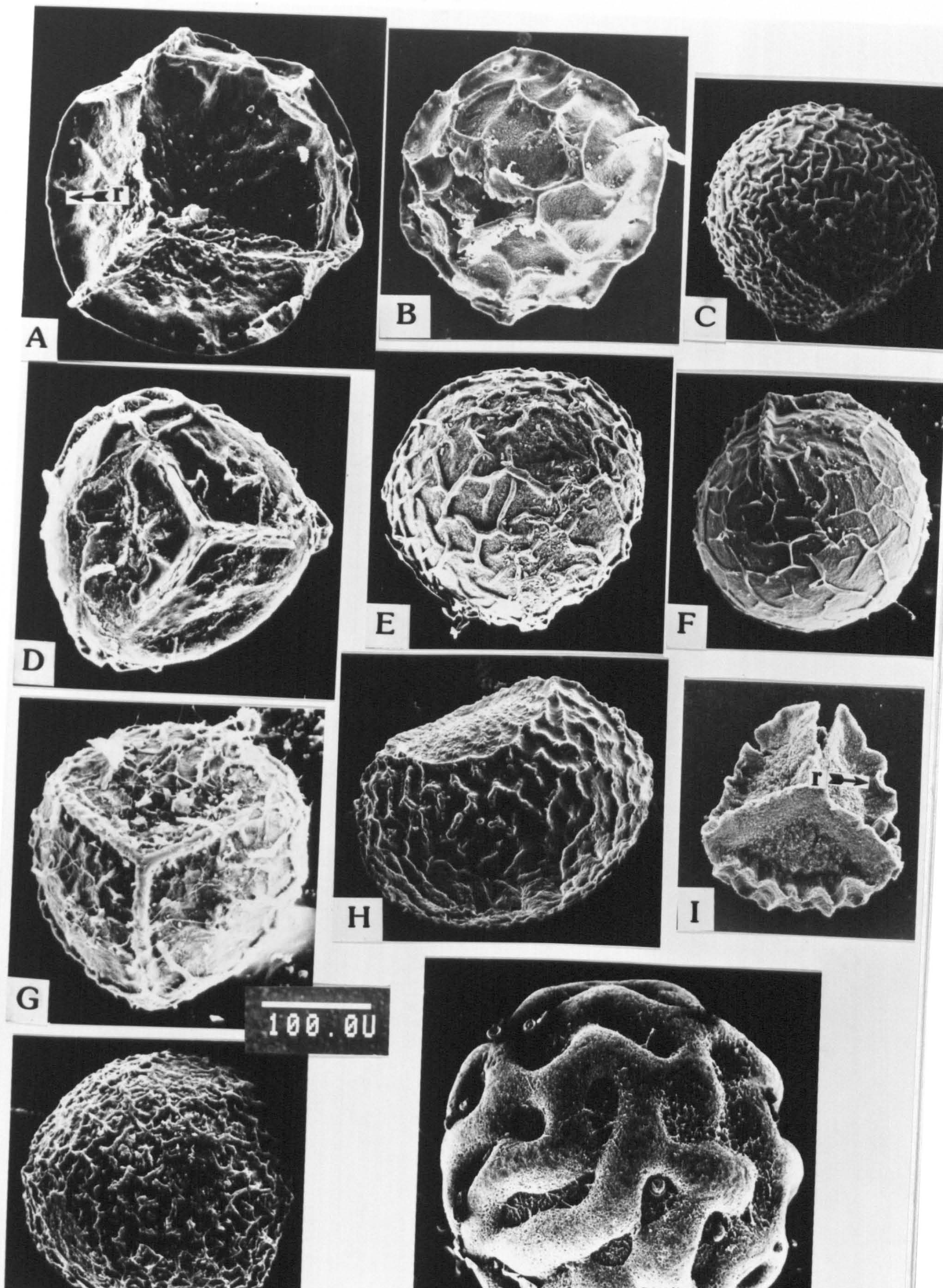

A
r
B
C
D
E
F
G
H
I
r
100.0U
J
K
100.0U

PLATE 3

(see opposite page)

Megaspores of _Selaginella_ subgenus _Stachygynandrum_: A-B. _S._ _vogelii_; A. Proximal surface; B. Close-up. Both from Box 3589. C. _S._ _kraussinana_ (Rosevear 37). D. _S._ _kalbreyeri_ (Abbayes 341). E. _S._ _buchholzii_ (Buchholz s.n.). F. _S._ _molleri_ (Moller 79pp). G. _S._ _zechii_ (Box 3506). H. _S._ _subcordata_ (Deighton 3087B). I. _S._ _goudotana_ (Quartin-Dillon 9.). J. _S._ _soyauxii_ (Soyaux 419). K. _S._ _protensa_ (Portères s.n.). L. _S._ _squarrosa_ (Mann 1407).

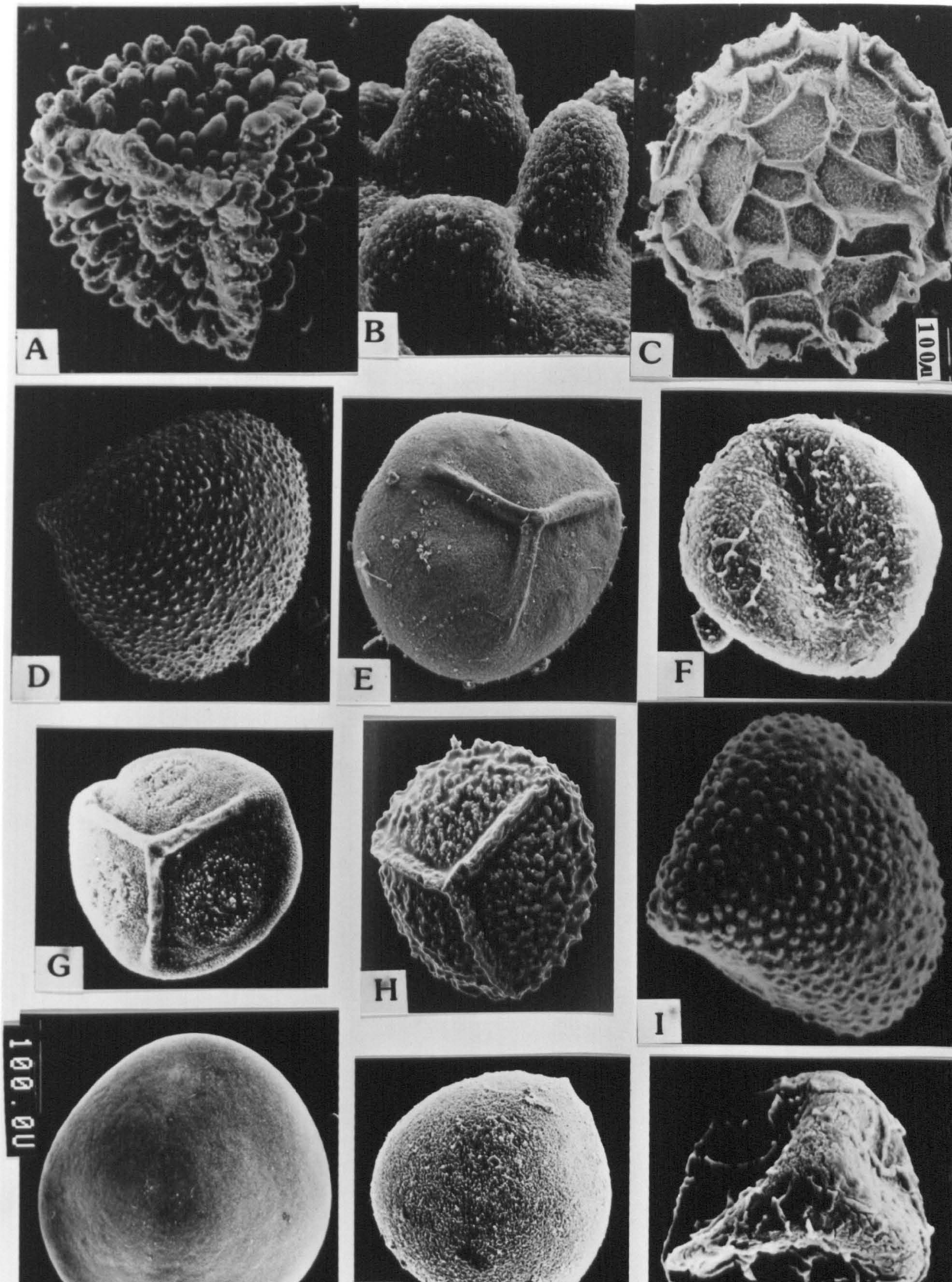

A
B
C
100µ
D
E
F
G
H
I
100.0U
J
K
L
100.0U

PLATE 4

(see opposite page)

Megaspores of *Selaginella* subgenus *Stachygynandrum*:
A. *S.* *unilateralis* (Bâthie 8320). B. *S.* *perpusilla* (Wakefield s.n.). C. *S.* *hildebrandtii* (Bathie 8224). D. *S.* *lyallii* (Quansah Q409030). E. *S.* *pectinata* (Quansah Q30826). F. *S.* *pervillei* (Baron 6691; m = microspore). G. *S.* *helicoclada* (Bâthie 947). H. *S.* *fissidentoides* (Quansah Q50909).

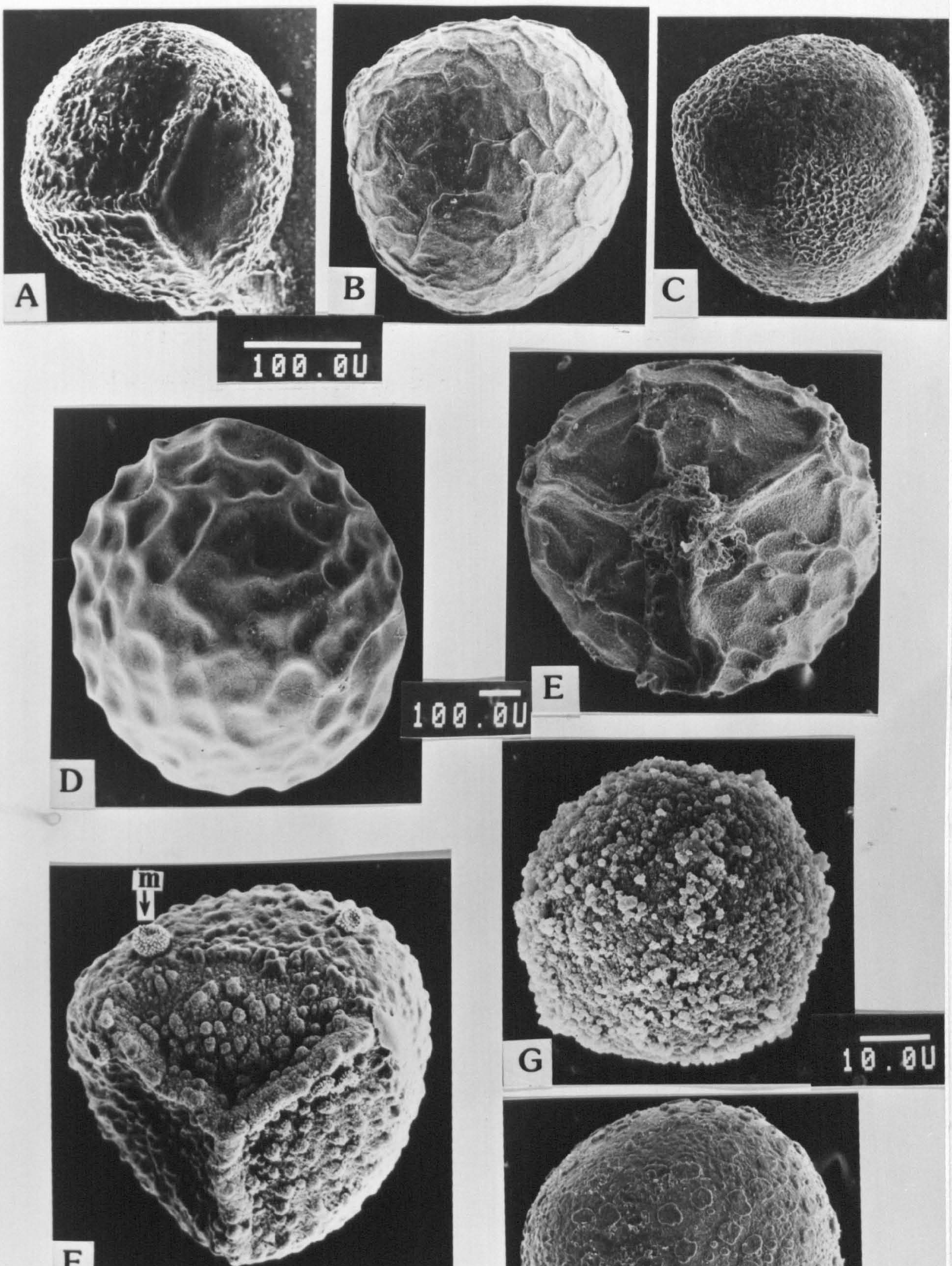

A
B
C
100.0U
D
E
100.0U
F
m
G
10.0U
H
100.0U

PLATE 5

(see opposite page)

Microspores of *Selaginella* subgenus *Stachygynandrum*: A. *S. vogelii* (Box 3589). B. *S. kraussiana* (Rosevear 37). C. *S. kalbreyeri* (Abbayes 341). D. *S. buchholzii* (Buchholz s.n.). E. *S. goudotana* (Quartin-Dillon 9.). F. *S. molliceps* (Exell 500). G. *S. cathedrifolia* (Guinea 188). H. *S. subcordata* (Deighton 3087B). I. *S. versicolor* (Hossain GC 40003).

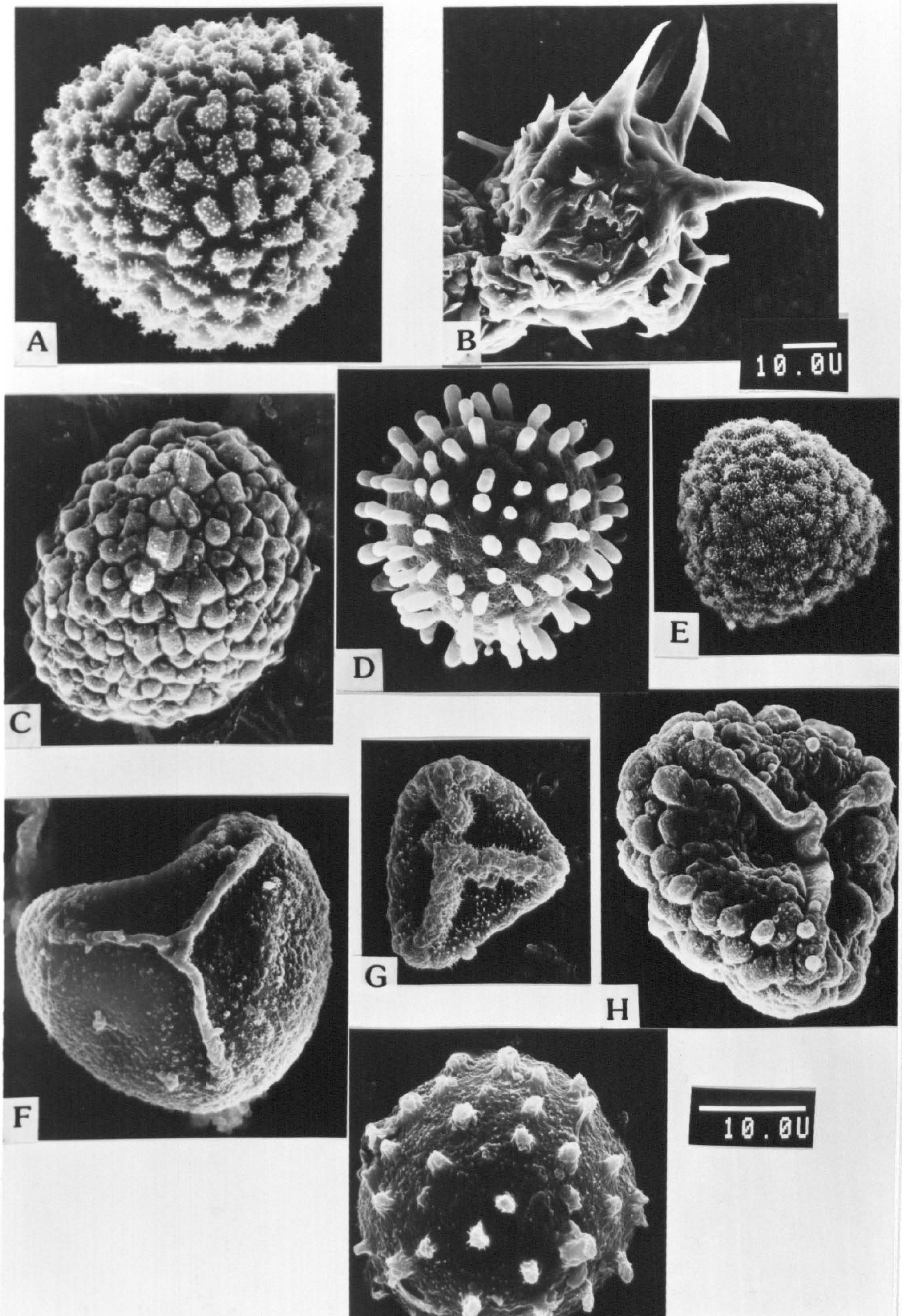

A
B
10.0U
C
D
E
F
G
H
I
10.0U

PLATE 6

(see opposite page)

Microspores of Selaginella subgenus Stachygynandrum: A-B. S. soyauxii; A. Distal surface; B. Close-up. Both from Soyaux 419. C. S. thomensis (Exell 423). D. S. serrato-squarrosa (Nickles 102). E-F. S. myosurus; E. Proximal surface; F. Distal surface (f = equatorial flange). Both from Gossweiler 7029. G. S. leoneensis (Brown & Brown 79). H. S. blepharophylla (Harley F156). I. S. tenerrima (Welwitsch 45). J. S. molleri (Moller 79pp).

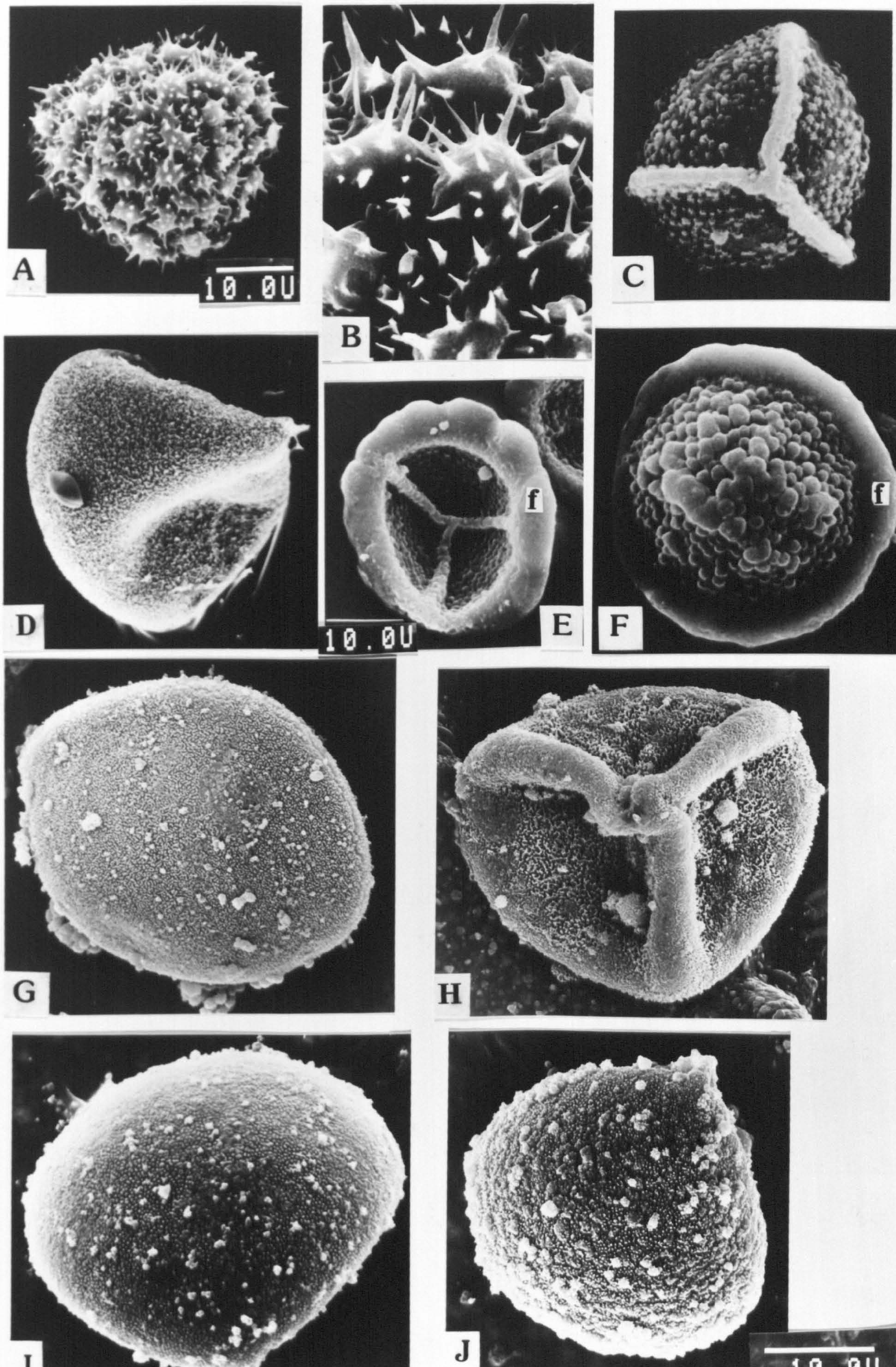
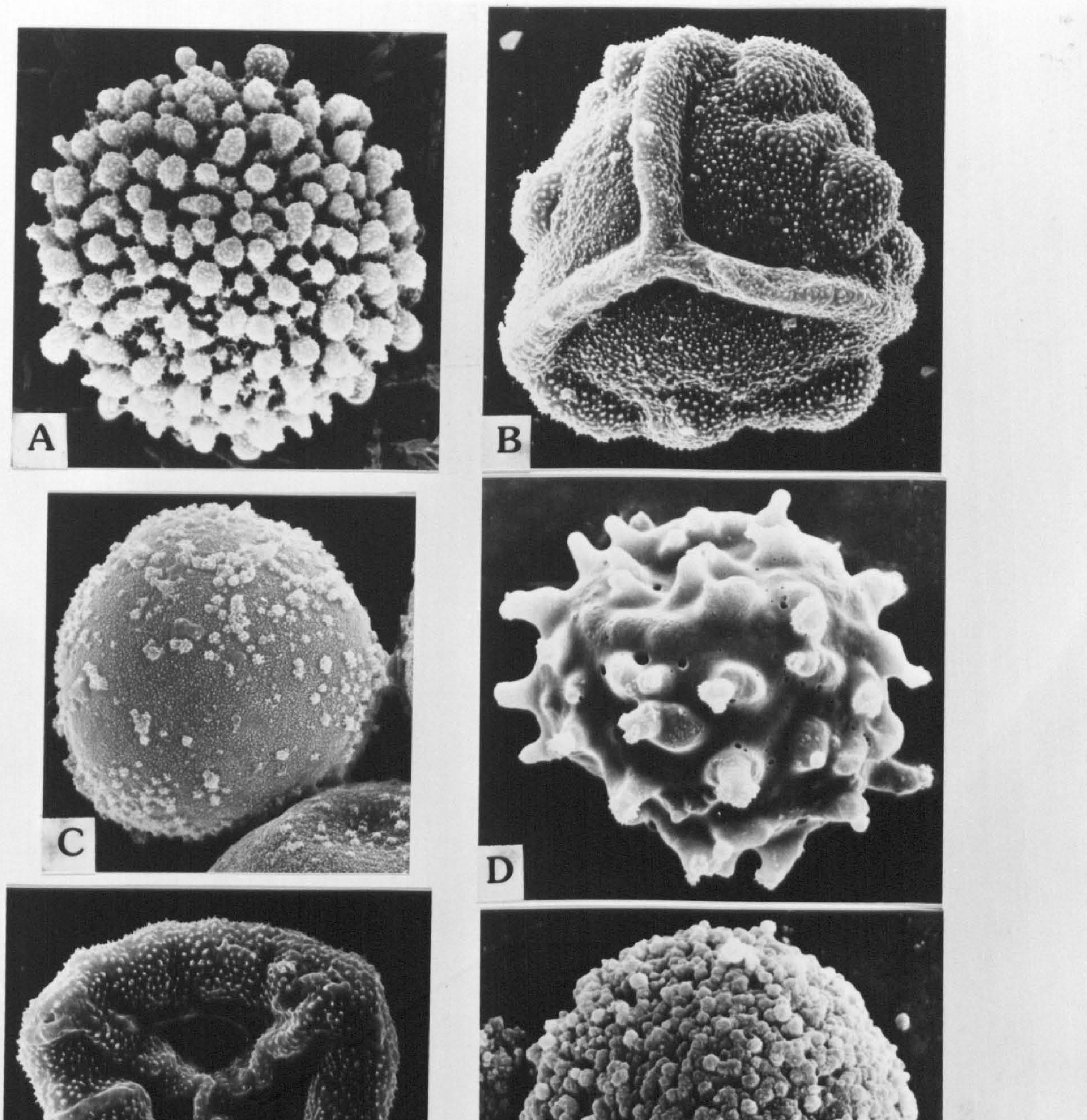

A
10.0U
B
C
D
f
E
10.0U
f
F
G
H
I
J
10.0U

PLATE 7

(see opposite page)

Microspores of Selaginella subgenus Stachygynandrum: A. S. pervillei (Baron 6691). B. S. lyallii (Quansah Q409030). C. S. unilateralis (Bâthie 8320). D. S. perpusilla (Wakefield s.n.). E. S. hildebrandtii (Bâthie 8224). F. S. helicoclada (Bâthie 947). G. S. pectinata (Quansah Q30826). H. S. fissidentoides (Quansah Q50909).


A
B
C
D
E
F
10.0U
G
10.0U
H
10.0U

Spore colour, in both megaspores and microspores, is variable within species and appears to be dependent on the degree of maturation. Megaspores may be cream, whitish-cream, yellowish to light-brown in colour while microspores may be brick-red, reddish-brown, cream or yellowish-brown in colour.

CHAPTER FIVE

CYTOLOGY

CYTOLOGY

Cytological studies of species of the genus Selaginella were not undertaken primarily, due to lack of fresh and living material at the early stages of the current study. The cytological account below therefore, is a summary of information taken from the literature on Selaginella.

Very little work has been done on the cytology of the genus Selaginella, compared to other groups of pteridophytes. Cytologists have carried out their investigations in the genus, using sporangia (for meiotic) and true root tips and rhizophores (for somatic) chromosome counts. This genus has been found to possess extremely small spore mother cells which makes cytological studies very difficult (Graustein, 1930; Manton, 1950); the chromosomes vary from very small to minute, are erratic in their staining responses and in their reaction to pretreatment reagents (Jermy, Jones & Colden, 1967).

The earliest account of chromosome counts of Selaginella is the one of Denke (1902) who reported the numbers in S. emmeliana van Geert (= pallescens (Presl) Spring) and S. serpens (Derv.) Spring as $2n = 16$ ($n = 8$). Heitz (1926) later reported on the numbers in other species including S. vogelii ($2n = 16$). Manton (1950) also reported on the numbers of three species, S. denticulata (L.) Link, S. helvetica (L.) Spring and S. spinulosa A. Br. (= selaginoides (L.) Link) as $2n = 18$. Löve & Löve (1961) also found the same number ($2n = 18$) in S. selaginoides. Even though Manton's work has been regarded as the first absolute reliable counts for the family (Manton, 1950), the major cytological works of the genus Selaginella in recent years, have been those of Kuriachan (1963) who worked on eight

Indian species including S. crassipes Spring (n = 9) and S. braunii Bak. (n = 10, 2n = 20) and Jones & Colden in Jermy, Jones & Colden (1967) who studied plants in cultivation at Kew, of over 50 species from New Guinea, Borneo, Malaya, Brazil, Trinidad, Puerto Rico, Australia, New England and Africa. Fabbri (1965) has also given a list of chromosome numbers of 14 species of the genus (including the eight species studied by Kuriachan, 1963). Borgen (1975), Loyal (1976) and Kornaś and Jankun (1983) have also added to the list of species of Selaginella which have their chromosomes counted by reporting on some species from Macaronesia, North-Western Himalayas and Africa, respectively.

The studies of the above authors have revealed the presence of five basic chromosome numbers - x = 7, x = 8, x = 9, x = 10 and x = 12 - in the genus. The basic number x = 7 contains only one species, S. schlechteri Hieron. (2n = 14) from New Guinea, while the basic number x = 8 has four species including S. molliceps (2n = 16) from an unknown locality in Africa (Jermy, Jones & Colden, 1967). Majority of the species studied by the various investigators have the x = 9 and x = 10 basic chromosome numbers. The basic number x = 12 contains a single species, S. chrysocaulos (Hook. & Grev.) Spring (2n = 24) (Loyal, 1976). Polyploids have been reported as occuring in the species with x = 9 and x = 10 basic numbers. Kuriachan (1963) reported a tetraploid, an unidentified Indian species, with n = 18 and 2n = 36 and Jones and Colden (in Jermy et al. 1967) reported three triploids including S. vogelii with 2n = 27 and one tetraploid, S. longiciliata Hieron. with 2n = 36. Kornaś & Jankun (1983) have also reported one triploid, S. tenerrima with 2n = 30.

Jermy et al. (1967) reported that species in each of the major basic number groups showed a pattern of growth and maturation in their aerial and subaerial branch systems. The species with x = 10 basic number have a finite growth in the lateral systems which results in cones being formed simultaneously at the tips of the branchlets while the species with x = 9 basic chromosome number have cones haphazardly produced and branch systems which can continue to grow at intervals throughout the season. In the species with x = 8, the pattern of coning is not uniform; some species have infinite growth of the main branches (eg S. molliceps). Others have haphazard growth, like those with x = 9 basic number, and unusual lateral cones. Still others show similar growth form like the only species with x = 7 basic number, which appears to have an infinite apical growth, each major branch system maturing and coning before the next begins to expand.

Kuriachan (1963) and Jermy, Jones & Colden (1967) pointed out that x = 10 precedes x = 9 and that evolution of these basic numbers have been from the higher to the lower. Loyal (1976) also pointed out that the presence of basic numbers x = 8 and x = 12 suggests that x = 4 was probably one of the original basic numbers in the genus.

Only six species from West Africa and Madagascar have been cytologically studied. These species, studied by Jones and Colden (in Jermy et al., 1967) and Kornaś & Jankun (1983), fall into three of the five basic chromosome number groups; x = 8, x = 9 and x = 10. The species are: S. molliceps (2n = 16), S. lyallii (2n = 18), S. vogelii (2n = 27), S. kraussiana (2n = 20), and S. myosurus (2n = 18 - 20), studied by Jones and Colden and S. tenerrima (2n = 30), studied by Kornaś & Jankun (1983). S. vogelii is a triploid of the basic number x = 9 and S. tenerrima is a triploid of the basic number x = 10. The other four species are diploids. The growth patterns of these six species, as observed in this study, fit in with the patterns of the known chromosome numbers as mentioned above.

The Selaginellaceae, it can be said, remains a family which has not undergone the spectacular chromosome increase shown by many of the ferns (Jermy, Jones & Colden, 1967).

CHAPTER SIX

USEFULNESS OF CHARACTER STATES AND POSSIBLE CLASSIFICATION

USEFULNESS OF CHARACTER STATES AND POSSIBLE CLASSIFICATION

A number of characters have been examined in this study, some seem important, others less so in the taxonomy of the species of the subgenus Stachygynandrum. In this chapter, a discussion of the usefulness of these characters in the possible classification of the species of the subgenus is described.

(i) PLANT HABIT

The use of plant habit as a criterion for divisions within the genus dates from the early work of Spring in 1850. Recent workers including Panigrahi & Dixit (1968), Crabbe & Jermy (1976) and Alston et al. (1981) still make use of this character. In this study, plant habit has been found to be useful in delimiting species within the subgenus Stachygynandrum. Although a distinct appearance of the branch-system may occur consistently and allow rapid recognition of some species (Wong, 1982) the extent of variation within and between species is such that branch-system is not considered as a strict diagnostic feature in this study.

(ii) STEM

Stem articulation is regarded as a useful taxonomic feature, in this study, since its presence in some species eg S. kraussiana and not in others enables the various species to be delimited. Braun (1865) and Somers (1978) have reported on the importance of this character in the Articulatae series. The function of the articulations, if any, is unknown (Alston et al., 1981) although it appears to be a means whereby the plant propagates vegetatively since Hieronymus (1901) suggested that strong winds, animals or the weight of the plants themselves could break the plants at these points and Somers (1978) has observed specimens broken in this way.

The presence of trichomes on the stems and branches of some species eg S. vogelii (from WA and M) and S. pervillei (from M) distinguishes these species from others that possess glabrous stems and branches. Alston (1932, 1959) has also observed this feature (presence of trichomes) in these species from WA and M and used it in the species identificaiton. The presence or absence of trichomes on the stems and branches is a consistent character in the species in which it occurs and is therefore taxonomically useful.

Stem colour has been used for taxonomic purposes by some authors eg Alston (1959). In this study however, stem colour has been found to be inconsistent within species and therefore without any taxonomic significance. For example, the stem of S. vogelii recognised by most authors as having a pink colour, also exhibits the pale green and straw colours seen in other species. Stem colour appears to be dependent on the age of the plant and also the environment eg light.

Hieronymus (1901) made use of stem anatomy and stelar characters to delimit sections within the genus. Other workers have also looked at the stem anatomy of the species of the genus (Harvey-Gibson, 1894; Bower, 1935; Zamora, 1958; DeVol, 1967; Mickel & Hellwig, 1969; and Ogura, 1972). The studies of these workers have resulted in the following types of steles - simple protostele, two steles (which in prostrate species are flattened in the plane parallel to the substrate), compound plectosteles of several plate meristeles (which vary from being flat in cross-section, to U-shaped or a closed circle), and a T- and X- shaped 'actinosteles'- been described for the genus (Zamora, 1958; Mickel & Hellwig, 1969). Even though detailed anatomical work of the stem has not been undertaken in this study, observations of cleared materials have shown that the stelar patterns may be different for the main axis and for the branches and nodes. This observation is in agreement with the findings of Nozeran & Espagnac (1975) who reported that the main axis of S. myosurus has a monostele with an accessory bundle that may sometimes be fused with the monostele while the lateral branches have a simple monostele. Bierhorst (1971) has also pointed out that variations can occur in the stelar pattern of species depending on the position and width of stems. It thus, appears that the anatomy of the stem though useful must be used with some care and that one should define the part of the stem (whether main stem, basal or apical portion, branch or node) being looked at.

(iii) RHIZOPHORE

The taxonomic significance of the position of rhizophore in the species of the genus has been reported by Sodiro (1893) and Alston (1952, 1955). Somers (1978) also found the ventral positioning of the rhizophores in the Articulatae series of the genus very characteristic. In this study, the position of the rhizophores has been found to be consistent for the species. The distribution of the rhizophores on the plant has also been found to be consistent for the species. The position and distribution of the rhizophores on the stem are regarded as diagnostic and have been used, in this study, to delimit species.

(iv) LEAF

The anisophylly of the vegetative leaves of the Stachygynandrum species distinguishes this subgenus from the other subgenus, Selaginella, which has species with isophyllous leaves. Some workers, including Spring (1850) and Alston et al. (1981) have divided the genus into two on the basis of leaf form, those with uniform (isophyllous) leaves and those with different (anisophyllous) leaves. This study agrees with the basic division of the genus into two on the basis of leaf form.

The vegetative leaves-lateral, median, axillary and occasionally the main stem leaves - are the most easily observable part of the plant and offer the most characters for distinguishing between various species within the subgenus. Even though the shapes of the leaves are consistent for the various species, it is not easy to distinguish between species using leaf shapes especially the shapes of lateral leaves, due to morphological intergredation. The shape of the median leaf and occasionally the axillary leaf however, enables one to distinguish between species easily.

The presence or absence of outgrowths on the margins of the leaves is useful when looking at the species of the subgenus. Species show consistent leaf margin characters even though the different leaf types (lateral, median, axillary and stem leaves) may show different margin characters. The lateral and axillary leaves often show different margin features from those of the median leaf. Where the leaves have ciliate margins, the cilia often show varying lengths. It is possible however, to delimit species on the basis of cilia length by defining range limits for the cilia length and providing adjectives accordingly. Thus, in this study, species have been grouped into various categories as long ciliate (having cilia equal to or more than 0.26 mm long), ciliate (with cilia length of 0.18-0.25 mm), and short ciliate (with cilia length of 0.11-0.17mm).

The apex of the median leaf affords a character which enables the species to be delimited easily. It is also possible to distinguish some species from others using the apices of the lateral and axillary leaves even though these seem not to be diagnostic for the species due to slight variations that occur within the species as one moves from the basal to the apical part of the plant.

Leaf bases may be different for each leaf type within species but are consistent for the species and are useful in distinguishing between various species.

The distribution of stomata is consistent for each leaf type and for the species. Species can therefore be grouped into eg those having amphistomatous lateral leaves and hypostomatous median leaves and those with all leaves being amphistomatous or hypostomatous. The position of the stomata on the leaves (whether scattered all over lamina, only at the margins or concentrated on the midvein in rows or not) is also a feature that is useful in the delimitation of species within the subgenus. Harvey-Gibson (1897), Mital (1969) and Buck & Lucansky (1976) have observed and reported on the taxonomic importance of stomatal distribution in the genus.

The presence of papillae has been observed on the epidermises of S. martensii (Dengler, 1980). This character has been observed on the epidermises of some species eg S. cathedrifolia and S. versicolor however, it is not consistent for the species in which it occurs; it is therefore regarded as not diagnostic. Sclerotic cells, which may be present in bands and/or patches on the lamina of some species may or may not be diagnostic. They are consistent in some species eg S.

versicolor and inconsistent in others eg S. kalbreyeri. Mukherjee & Sen (1981) have reported on the importance of sclerotic cells and fibres in Indian species of Selaginella. The sclerotic cells are so prominent in S. versicolor that Alston (1959) and Benl (1978) have called them false nerves (veins) in this species.

The leaves of Selaginella have been morphologically termed microphylls (eg Foster & Gifford, 1974; Stewart, 1983) to indicate their fundamental difference from the leaves (megaphylls) of ferns and seed plants on the presence of a single unbranched vascular strand that arises from the vascular cylinder of the stem without leaving a leaf gap. According to Wagner et al. (1982), a microphyll has a single unbranched vein running more or less medially through the blade; a megaphyll has a complex branching venation pattern. In this study, the term microphyll has not been used since no anatomical work has been undertaken and evolutionary relationships have not been considered. Three-veined leaves have been observed in three species (S. myosurus, S. pectinata and S. lyallii). The presence of the three-veined leaves makes it easier to distinguish these species from the others which have single-veined leaves. The three veins in these leaves though unbranched, however, shows that using the term microphyll for all leaves of Selaginella is not wholly satisfactory. Furthermore, branched veins have been observed to be characteristic of S. adunca A.Br. ex Hieron. (Mukherjee & Sen, 1981; Wagner et al., 1982) and 'S. schaffneri Hieron. has a venation pattern as complex as that of certain ferns and gymnosperms' (Wagner et al., 1982). The number of veins present in the leaves of the species is regarded as diagnostic.

Mital (1969) has reported on the importance of the epidermal cells in species of Indian Selaginella. In this study, the nature of the epidermal cells (whether similar or different) on both the ligular and aligular surfaces of the leaves has been found to be consistent for the species. This character is thus, regarded as diagnostic, for one can differentiate between species with similar epidermal cells and species with dissimilar epidermal cells on both the ligular and aligular surfaces. Krishnan (1975) observed the possession of similar cells in both the upper and lower epidermises of some species of Indian Selaginella. The aligular surface epidermal cells of the lateral and axillary leaves have been found to be identical to the ligular surface epidermal cells of the median leaf while the ligular surface epidermal cells of the lateral and axillary leaves are similar to the epidermal cells of the aligular surface of the median leaf. Hsü (1937) has observed the identical nature of the epidermises of the abaxial surface of the lateral leaf and the adaxial surface of the median leaf. The identical nature of the opposite surfaces epidermal cells is consistent and diagnostic for the species.

Benl (1978), Alston et al. (1981) and Wong (1982) have made mention of the characteristic colours of leaves of species of Selaginella. Leaf colour has been found to be inconsistent in the species studied and is not taxonomically important. It appears that leaf colour is affected by the environment, especially light intensity, for species eg S. fissidentoides, may be dark green to coppery green in the shade and pale green to yellowish green in the open. Thus, where the plant grows seems to influence the leaf colour.

The size of the leaf appears to be affected by the age of the plant and varies within species. Leaf size is therefore not consistent enough to be of much taxonomic value.

(v) LIGULE

Most studies conducted on the ligule have been developmental, anatomical and/or histological (Harvey-Gibson, 1896; Horner & Beltz, 1970; Sigee, 1974; and Horner et al., 1974). Even though the ligule is pleomorphic, its shape is consistent for the species and is therefore regarded as taxonomically important in the delimitation of the species. Generally, species have no trichomes at the bases of their ligules. The presence of unicellular acicular trichomes at the bases of some species eg S. versicolor, makes it easy to distinguish between the species. This character is regarded as diagnostic. Ligule length is not taxonomically important due to its variation within species. It appears to be affected by the age and size of the leaf or sporophyll.

(vi) STROBILUS

The type of strobilus - tetragonous or bilateral - and the form of the bilateral strobilus (resupinate or non-resupinate) are consistent for the species and are regarded as taxonomically useful, in this study. This is in agreement with the taxonomic value placed on these characters by earlier workers including Spring (1850), Baker (1883, 1884, 1885, 1887) and Walton & Alston (1938). Walton & Alston (1938) however, described a loose or lax strobilus to be a feature of their subgenus Homostachys. The loose strobilus has been found to be the result of sporangia dehiscence, occuring in all species whether they exhibit tetragonous or bilateral strobili. Loose strobilus is therefore a character of no taxonomic significance.

The growth patterns - determinate and intermittent - seen in the strobili of the species of the subgenus have also been reported by Bower (1901), Mitchell (1910), Sykes & Stiles (1910), Tryon (1955) and Dahlen (1982) in the genus Selaginella. The determinate pattern is regarded as the normal growth pattern since it occurs in all the species. The growth patterns may appear to be diagnostic, however, they are not because they occur in species with tetragonous strobili as well as those with bilateral resupinate strobili. Also both growth patterns may be seen in a single plant.

The length of the strobilus is variable within species and appears to depend on the age of the plant. It is therefore of no taxonomic importance in the subgenus.

a) Sporophylls

The form of the sporophylls [uniform (monomorphous) or different (dimorphous)] determines the type of strobilus (tetragonous or bilateral). Species have been separated on the basis of the form of the sporophylls into those with monomorphic sporophylls and those with dimorphic sporophylls by many authors including Spring (1850), Hieronymus (1901) and Alston et al. (1981). This study agrees with the taxonomic value placed on the form of the sporophylls. The shapes, margins, apices and bases of the sporophylls are as consistent for the species as the vegetative leaves and are useful in delimiting the species. The nature of the epidermal cells of the sporophylls of species with tetragonous strobili and the ventral sporophylls of the species with bilateral resupinate strobili has been found to be consistent for the species and is of taxonomic importance in the subgenus. The epidermal cells of the dorsal sporophylls of the species with bilateral resuinate strobili, though consistent for the species, are not diagnostic for any species. All the species within the subgenus with the bilateral resupinate strobili have dorsal sporophylls with epidermal cells that are elongate with straight and/or sinous walls.

The presence of sporophyll-pteryx on the adaxial surface of sporophylls has been reported to be of taxonomic value in Selaginella (Quansah & Thomas, 1985). The sporophyll-pteryx is seen only in the ventral sporophylls of the species with the bilateral resupinate strobilus. Sykes & Stiles (1910) have reported on sporophylls which are folded adaxially so as to enclose the sporangia in their axils and Mukhopadhay & Sen (1981) have also reported on the presence of a laminal flap on the sporophylls and bracts in Selaginella. The folds and laminal flaps are the same as the sporophyll-pteryx. This study confirms the taxonomic importance of the sporophyll-pteryx in the subgenus. The margin of the sporophyll-pteryx is consistent for the species and has been found to be diagnostic.

Sterility of the ventral sporophylls is characteristic of some species eg S. protensa and makes it easy to distinguish those species from others which do not possess sterile sporophylls.

b) Sporangia and Sporangial Distribution Pattern

The sporangium may or may not afford any important taxonomic features. Of the two sporangia, it is the microsporangium that appears to have some features that are taxonomically important. The inner basal wall of the microsporangium may possess annuloid-like cells, as seen in S. kraussiana, and this character is diagnostic for this species since no other species, in this study, possesses the annuloid-like cells. The presence of these annuloid-like cells has been observed by Mitchell (1910) and Somers (1978) has also reported on the diagnostic nature of them in the Series Articulatae. The shape of the microsporangia is consistent for each species and is a character which is useful in distinguishing between species. The shape of the megasporangia appears to be affected by the number of megaspores present in the megasporangia and the sizes of the spores in them. These characters (number of spores and their sizes) vary within species and result in the variation encountered in the shape of the megasporangia. Increase or decrease in the number of megaspores in the megasporangia seen in this study, has been reported by Mitchell (1910) and Duerden (1929) in some species of Selaginella including S. vogelii (12 spores), S. involvens (8 spores) and S. willdenowii (1-42 spores). The increase or decrease in spore number, from the normal four spores, is not consistent and unique for any species and is therefore regarded as not diagnostic. Similarly, the inequality of spore sizes per megasporangium is not taxonomically important because of its inconsistency within species.

The sporangial distribution pattern in the strobilus has been shown to be of taxonomic value by the work of Horner & Arnott (1963). Other workers, Hieronymus (1900), Mitchell (1910), Duthie (1923), Tryon (1955), Hellwig (1969) and Fraile & Riba (1981) have also shown the taxonomic importance of this character. In this study, the sporangial distribution pattern has been found to be consistent for species and has been used in the delimitation of species in the subgenus. This study, therefore, agrees with the taxonomic value placed on this character by the earlier workers.

c) Spores

Different aspects of Selaginella spore morphology have been studied by various workers using the light microscope, SEM, and transmission electron microscope (eg Fitting, 1900; Nayar & Lata, 1965; Stainer, 1967; Kempf, 1970; Tryon & Lugardon, 1978; and Minaki, 1984). Both megaspore and microspore morphology have been shown to be of taxonomic importance by the works of Tryon (1949), Knox (1950) and Hellwig (1969).

Some of the spore characters examined in this study appear to be taxonomically important while others seem less so. Spore shape, which is more or less similar in all species, is not useful in distinguishing between species. Even though some species have characteristically large spores (both mega - and micro-), size differences within species and also the overlap in the range of spore size between species make it difficult to use spore size as a criterion in the delimitation of species. Knox (1950) and Nayar & Lata (1965) however, have made use of spore size in their treatments of the species of the genus.

The ornamentation (surface sculpture) of the spores is consistent and characteristic for the species. It is thus regarded as a diagnostic character in agreement with the findings of other authors (eg Tryon, 1949; Minaki, 1984) who regarded spore ornamentation as taxonomically important. Attention, however, is drawn to the fact that the method and equipment (light microscope or SEM) used in the examination of the spores should be made known. This is because the use of SEM may show finer details at higher magnifications, even though both techniques can give same results at lower magnifications.

The presence of a distinct equatorial ring on the megaspores of some species and not others enables different species to be distinguished from each other. A corresponding feature, the equatorial flange, is also seen in the microspores of some species and these characters (the equatorial ring and flange) are diagnostic for the species in the subgenus.

Hellwig (1969) has made an extensive use of spore colour in his work on the Selaginella of Mexico and Central America. In this study, however, spore colour (both megaspore and microspore) has been found to be variable within species. It appears to be dependent on the degree of maturation. Spore colour, is thus, seen as being of little or no taxonomic significance for the species of the subgenus.

Most of the characters regarded as diagnostic, in this study, it must be mentioned, are not sufficient enough on their own to define species. Few species possess distinctive single characters; most species are distinguished by a combinaton of characters. Even though species must be defined by a combination of characters rather than distinctive ones, a set of specific characters for each species does not exist by itself but only in relation to other species. A set of characters may distinguish a species from its close allies, whereas, additional ones, or another set, may distinguish it from less closely related species. Tryon (1955) has also made this observation in his treatment of the subgenus Selaginella.

Although the vegetative leaves provide the most useful part of the plant for taxonomic purposes, one cannot overlook the importance of the reproductive part (strobilus). When a plant is fertile, there is hardly any room for doubt as to which group the plant belongs. Thus, in the taxonomy of the species of the subgenus Stachygynandrum, the vegetative and reproductive parts of the plants should be taken into consideration since both provide the basis for a good system of classification for the genus Selaginella.

CHAPTER SEVEN

KEY AND DESCRIPTIONS OF WEST AFRICAN SPECIES OF *SELAGINELLA* SUBGENUS *STACHYGYNANDRUM*

Key to species of West African Selaginella subgenus Stachygynandrum

Sporophylls monomorphous (uniform) - - Section Homostachys (1-5)
Sporophylls dimorphous - - - - - - - Section Heterostachys (6-20)

1. Strobili tetragonous, not resupinate; ventral sporophylls with no sporophyll-pteryx on the adaxial surface - - - - 2

2. Stems erect; rhizophores restricted to the very base of plant - 3

3. Stems sobiliferous, glabrous; lateral and axillary leaves with sclerotic cells forming two broad bands running alongside midvein on lamina, serrate; median leaves aristate (aristae up to same length as lamina); ligules flabelliform (ligules of lateral leaves with 2-4 unicellular acicular trichomes at their bases); strobili with Types II, IIA (IIB and IV) sporangial distribution patterns; megaspores with distinct equatorial ring, proximal surfaces granulose-rugulose, distal surfaces loosely reticulate; microspores baculate-verrucate - - - - - - - - - - - - - versicolor (1)

3. Stems not soboliferous, pubescent at dorsal side; lateral and axillary leaves with no sclerotic cells on lamina, entire (subentire); median leaves caudate; ligules obturbinate with no trichomes at their bases; strobili with Types I (IIB and IV) sporangial distribution patterns; megaspores with no equatorial ring, both proximal and distal surfaces baculate; microspores verrucate-echinate - vogelii (3)

2. Stems prostrate or climbing, rhizophores distributed more or less on the whole plant - - - - - - - - - - - - - - - - - 4

4. Stems articulated; rhizophores positioned at the ventral side of stem at where branching occurs; median leaves elliptic-lanceolate, serrulate-denticulate, acuminate; ligules broadly femurate; megaspores cristate-reticulate; microspores echinate - - - - - - - - - - - - <u>kraussiana</u> (3)

4. Stems not articulated; rhizophores not positioned at the ventral side of stem at where branching occurs; median leaves not elliptic-lanceolate, not serrulate-denticulate, cuspidate; ligules not femurate; megaspores not cristate-reticulate; microspores not echinate - - - - - - - - - - 5

5. Leaves single-veined, epidermises of ligular and aligular surfaces different; lateral and median leaves amphistomatous; lateral and axillary leaves long ciliate-serrate; median leaves short ciliate-serrate; ligules flabelliform ± bifid (or femurate); strobili with Types II, IIB and IV sporangial distribution patterns; megaspores with distinct equatorial ring, proximal surfaces granulose, distal surfaces rugulose; microspores with no equatorial flange, scabrate-echinate - - - - - - - <u>cathedrifolia</u> (4)

5. Leaves three-veined, epidermises of ligular and aligular surfaces similar; lateral and median leaves hypostomatous; lateral and axillary leaves serrate; median leaves serrate-serrulate; ligules obturbinate; strobili with Type VII

sporangial distribution pattern; megaspores with no equatorial ring, both proximal and distal surfaces solidly striate-reticulate; microspores with equatorial flange, verrucate - myosurus (5)

1. Strobili bilateral, resupinate; ventral sporophylls with sporophyll-pteryx on the adaxial surface - - - - - - - 6

6. Stems prostrate or prostrate-ascendent; rhizophores distributed more or less on the whole plant - - - - - - 7

7. Lateral and axillary leaves ciliate at basal half; median leaves deltate, cuspidate; dorsal sporophylls deltate/ovate, long ciliate-serrate, not keeled; ligules obclavate or femurate; strobili with Types IIC and III sporangial distribution patterns; megaspores finely granulose-psilate; microspores baculate-clavate - buchholzii (6)

7. Lateral and axillary leaves entire at basal half; median leaves obovate, caudate; dorsal sporophylls elliptic-ovate, serrate-subentire, ± keeled; ligules pedate; strobili with Types IIB and V sporangial distribution patterns; megaspores psilate; microspores verrucate-echinate - - soyauxii (7)

6. Stems erect or suberect; rhizophores restricted to the basal 1/4 or basal 1/3 of plant - - - - - - - - - - - - - - 8

8. Lateral and axillary leaves long ciliate-serrate - 9

9. Axillary leaves amphistomatous; median leaves lanceolate, long ciliate-serrate, cuspidate; strobili with Types II and IIC sporangial distribution patterns; megaspores loosely reticulate - - - - - <u>blepharophylla</u> (8)

9. Axillary leaves hypostomatous; median leaves weakly oblanceolate, ciliate-serrate, aristate (aristae up to same length as lamina); strobili with Types IIC and III sporangial distribution patterns; megaspores granulose to minutely rugulose - - - - - - - - - - - - - - - <u>zechii</u> (9)

8. Lateral and axillary leaves not long ciliate-serrate - 10

10. Lateral and axillary leaves with sclerotic cells forming patches and bands on lamina; dorsal sporophylls short ciliate-aculeate, cuspidate - - - - - - - - - - 11

11. Lateral leaves ovate-elliptic, short ciliate-serrate, acuminate; median leaves ovate-lanceolate, aristate (aristae up to same length as lamina); ligules obturbinate; strobili with Type VI sporangial distribution pattern; ventral sporophylls sterile; megaspores finely rugulose-reticulate - - - - - - - - - - - - - - - - <u>protensa</u> (10)

11. Lateral leaves ovate-oblong, serrate-subentire, acute to apiculate; median leaves deltate, cuspidate; ligules obclavate, ± curved apex; strobili with Types IIC and III sporangial distribution patterns; ventral sporophylls fertile; megaspores compactly reticulate - <u>tenerrima</u> (11)

10. Lateral and axillary leaves with no sclerotic cells on lamina; dorsal sporophylls not short ciliate-aculeate, not cuspidate - 12

12. Stems pendent, arching and rooting at tips; lateral and axillary leaves long ciliate-serrate; lateral leaves deltate-ovate; axillary leaves deltate; median leaves long ciliate-serrate; ligules pedate, ± bifid; ventral sporophylls with partial sporophyll-pteryx on adaxial surfaces; megaspores verrucate-scabrate - -kalbreyeri (12)

12. Stems not pendent, not arching, not rooting at tips; lateral and axillary leaves not long ciliate-serrate; lateral leaves not deltate-ovate; axillary leaves ovate; median leaves not long ciliate-serrate; ligules obclavate; ventral sporophylls with complete sporophyll-pteryx on adaxial surfaces; megaspores loosely reticulate or rugulose- 13

13. Lateral and axillary leaves short ciliate; dorsal sporophylls cuspidate - - - - - - - - - - - - - - 14

14. Median leaves oblanceolate, aristate (aristae up to 3/4 the length of lamina); ventral sporophylls aculeate-denticulate, apiculate; dorsal sporophylls ciliate; strobili with determinate growth form and Types IIB and IV sporangial distribution patterns; megaspores reticulate; microspores finely granulose-papillate - leoneensis (13)

14. Median leaves elliptic-ovate, aristate (aristae up to same length as lamina); ventral sporophylls short ciliate-serrate, acute to acuminate; dorsal sporophylls short ciliate; strobili with intermittent and determinate growth forms and Type IIC sporangial distribution pattern; megaspores rugulose; microspores scabrate-verrucate - molleri (14)

13. Lateral and axillary leaves ciliate-serrate; dorsal sporophylls aristate or cuspidate - - - - - - - - - 15

15. Median leaves ciliate-serrate - - - - - - 6

16. Lateral leaves elliptic-oblong to ovate-oblong, subobtuse to mucronulate; dorsal sporophylls lanceolate, ciliate; ventral sporophylls fertile, lanceolate-elliptic, subretuse to acute-apiculate, oblique; strobili with Types II, IIC, III and IV sporangial distribution patterns; megaspores reticulate; microspores scabrate - molliceps (15)

16. Lateral leaves subdeltate, acuminate; dorsal sporophylls ovate, long ciliate; ventral sporophylls sterile, oblong-elliptic, acuminate, obtuse; strobili with Types VI and VIA sporangial distribution patterns; megaspores rugulose; microspores verrucate-clavate - - - - - - - - - - - subcordata (16)

15. Median leaves not ciliate-serrate - - - - - - 17

17. Median leaves long aristate - - - - - - -18

18. Lateral and axillary leaves entire, acute to mucronulate; aristae of median leaves up to 1.5 times as long as lamina; ligules broadly clavate; ventral sporophylls entire; dorsal sporophylls ovate, subentire-serrate; strobili with Type IIB sporangial distribution pattern; megaspores reticulate-rugulose; microspores scabrate - - - - - - - - - - - squarrosa (17)

18. Lateral and axillary leaves serrate-subentire, acute; aristae of median leaves more than 1.5 times the length of lamina; ligules elongate pedate ± bifid; ventral sporophylls aculeate-entire; dorsal sporophylls lanceolate, serrate; strobili with Types IIB and IV sporangial distribution patterns; megaspores rugulose; microspores coarsely granulose - - serrato-squarrosa (18)

17. Median leaves not long aristate - - - - 19

19. Stems soboliferous; lateral, median and axillary leaves amphistomatous; lateral leaves serrate-denticulate, acute to apiculate; median leaves aristate (aristae up to 1/2 the length of lamina), subcordate to cordate; ligules obclavate; dorsal sporophylls ovate-lanceolate, short ciliate to serrate,

cuspidate; strobili with Types IIA and IIB sporangial distribution patterns; megaspores scabrate-verrucate - - - - - - goudotana (19)

19. Stems not soboliferous; lateral, median and axillary leaves hypostomatous; lateral leaves serrate, subobtuse to acute; median leaves cuspidate, oblique; ligules obturbinate; dorsal sporophylls subtriangular to weakly deltate, serrate-serrulate, acuminate; strobili with Types IIC and III sporangial distribution patterns; megaspores reticulate - - - - - - - - - - thomensis (20)

1. S. versicolor Spring in Bull. Acad. Brux. 10:143 no. 57 (1843); Baker F. Allies no. 195 (1887); Alston, J. Bot. 72 (Suppl.): 11 (1934), Mém. Soc. Linn. Normandie Bot. 1: 81 (1938), Mém. I. F. A. N. 50: 34-35 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959); Knox, Trans. Edinb. Bot. Soc. 35: 281 (1950); Alston & Abbayes, Bull. Inst. Fr. d'Afr. Noire, 13: 85 (1951); Adams & Alston, Bull. Brit. Mus. (Nat. Hist.) Bot. 1: 184 (1955). Plate 8; fig. 9.

TYPE: SENEGAMBIA. Les ravins chez les Landoumas, Heudolot s.n. (LG, isolectotype).

Nomenclature

SYNONYM: S. nitens Bak. in J. Bot. 23: 48 (1885), F. Allies 99 (1887).

TYPE: CAMEROON, Kalbreyer 158 (K).

Description

Plants erect or arching, soboliferous; branch systems 1-3 pseudopinnate and/or flabellate with dichotomies; rhizophores restricted to the very base of the plant.

Leaves anisophyllous on branches, simple monomorphic on main stem, single-veined; stomata 19-29x13-18 µm; ligules up to 0.39 mm long, flabelliform (2-4 unicellular acicular cilia at the bases of the ligules of lateral leaves only). Lateral leaves asymmetrical, ovate-oblong, up to 5.0x3.0 mm, base oblique, apex acute, margins serrate-sub-entire; ligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed near the margins, stomatal index (SI) 2-($\bar{M}$2)-3; aligular surface epidermis with elongate, sinous cells on lamina and more elongate, less sinous to straight-sided cells on the midvein, with sclerotic cells forming broad bands on lamina running alongside the midvein, stomata randomly distributed on the lamina and the midvein, SI 8-($\bar{M}$9)-10. Median leaves asymmetrical, weakly obovate, up to 2.5x1.8 mm, base obliquely auriculate, apex aristate (aristae up to same length as lamina), margins denticulate-serrate; ligular surface epidermis with elongate, slightly sinous to straight-sided cells, without stomata; aligular surface epidermis with isodiametric, sinous cells, stomata randomly distributed on lamina, SI 2-($\bar{M}$2)-3. Axillary leaves symmetrical, ovate, up to 4.7x3.2 mm, base sub-attenuate, apex acute, margins of basal half serrate, apical half entire (subentire); ligular surface epidermis with isodiametric, sinous cells, stomata evenly distributed on lamina, SI 7-($\bar{M}$7)-8; aligular surface epidermis with elongate, occasionally isodiametric, sinous to straight-sided cells, with sclerotic cells forming two broad bands on lamina running alongside the midvein, stomata randomly distributed on lamina, SI 10-($\bar{M}$10)-12.

Strobili tetragonous, at apices of branchlets, with both determinate and intermittent growth patterns, up to 30 mm long, with four sporangial arrangements: (i) cone wholly microsporangiate; (ii) with dorsal side wholly megasporangiate and ventral side wholly microsporangiate; (iii) with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate; and (iv) with dorsal side containing basal megasporangia and apical microsporangia and ventral side wholly microsporangiate. Sporophylls uniform, keeled, occasionally with sclerotic cells present in bands on lamina, ovate-lanceolate, up to 3.2x2.1 mm, base obtuse, apex long cuspidate to aristate (aristae up to 4/5 the length of lamina), margins serrate; both ligular and aligular surface epidermises with elongate, slightly sinous to straight-sided cells, stomata evenly distributed on lamina of aligular surface epidermis only, SI 7-($\bar{M}$8)-9. Megasporangia triangular-ovoid, with similar-sized spores; megaspores 240-($\bar{M}$300)-330 µm in equatorial diameter, with distinct equatorial ring, trilete, subglobose, proximal surfaces granulose-rugulose, distal surfaces loosely reticulate. Microsporangia ellipsoid; microspores 13-($\bar{M}$19)-28 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces baculate-verrucate.

Ecological notes: On wet rocks near waterfalls, on grounds and rocks in shady moist forest, also on stream banks in plantations, sometimes (but rarely) epiphytic on tree trunks; sea level to 1700 m altitude.

Specimen examined

SENEGAMBIA. Coast of Tamara: Serrand s.n. (K); Ravins chez les Landoumas, Heudelot s.n. (isolectotype, LG).

GUINEA. Fouta-Djallon: Dintin (cercle de Mamou), 700 m Abbayes 876 (BM); Dalabe: Pitha Ravine, Kola, Schnell 7339 (BM, K).

SIERRA LEONE. Baiima: Deighton 3047 (BM, K); Freetown, Lewis s.n. (BM); Makump: Old Mission House, Deighton 1382 (BM); Colony Peninsula: York Pass, 400 m, Deighton 3327 (BM, K); l.c., Deighton 3328 (BM, K); l.c., Deighton 3329 (BM, K); l.c., Bridge on Waterloo-York path, 300 m, Melville & Hooker 468a (K); Picket Hill, 600 m, Jones 325 (BM); l.c., 700m, Jones 326 (BM); Loma Mt., Jaeger 2032, 951 (K); l.c., 1300 m, Jaeger 1844 (K); Gberia Fotombu, Small 418 (K); Between Kanya and Gendema (Bumpe), Deighton 6128 (K); Koya, on Bafodia road, 900 m, Haswell 66, 77 (K); Sini-Koro, Jaeger 1865 (K); Jau (Tunkia), Deighton 5223 (K); Gberia, Timbako, Small 318 (K); Between Mattru and Gbangbama, Deighton 2340 (K); Gola Forest, Deighton 459 (K); Giewahun, Deighton 460 (K); Kasewe Hills Reserve, 150 m, Fay 1082 (NY);

l.c., 80 m, Fay 1066 (NY); No locality, Deighton 1382 (K).

LIBERIA. Bobei Village: base of Bili Mt., Winne 163 (BM); Kitoma, Harley F160 (BM); l.c., Harley F162 (BM); Mt. Bili, Barker 1168 (K); l.c., Harley F197 (BM, K); l.c., Harley F107 (BM, K); Sanniquellie: Ganta, Harley F22 (BM); l.c., Harley F23 (BM, K); Ganta Mission Hill, Harley F231 (BM, K); Webo: Diebla, Baldwin Jr. 6287 (BM); Vonjama: Wohmen, Baldwin Jr. 10098 (BM, K); Bolahun: Ndange, Earthy 21 (BM); Mt Bele road, 500 m, Adames 613 (K); LAMCO Headquarters Camp, 550 m, Adames 623 (K).

IVORY COAST. Man: Bepleu, Mt. Tonkoui, 400 m, Abbayes 294 (BM); l.c., 1050 m, Abbayes 224 (BM); l.c., Abbayes 225 (BM); l.c., 110 m, Abbayes 577 (BM); Tai and Guiglo, Abbayes 2061 (BM).

GHANA. Kibi: Puso Puso Ravine, 400 m, Adams 89 (BM); l.c., Adams 72 (BM); l.c., 500 m, Box 3257 (BM); l.c., Adams 409 (K); l.c., Bigger 414 (K); Begoro: Akrum Waterfall, 500 m, Box 2949 (BM); l.c., Bigger 2489 (K); S. Scarp F. R., Bigger 2481 (K); Bunso, Thompson s.n. (BM); Achimota, Foote 48 (BM); Mampong Scarp: Ninting Hill, 500 m, Box 2904 (BM); Asiakwa, 300-400 m, Adams 191 (BM); Mpraeso Scarp, Hall 2639 (BM); l.c., Hall 0140 (K); Atewa Range F.R., 800 m, Hossain GC40003 (BM, K); l.c., 500 m, Bigger 2409 (K); l.c., 700 m, Bigger 2509 (K); l.c., Enti & Bowling GC37416 (K); Obomen: S. Scarp F. R., Obeng-Darko 5090 (K); Winneba, 60 m, Vigne 2915 (K); Kibi-Akim, Johnson 248, 259 (K).

TOGO. Tomegbe: Badou, Mathey & Scholz 279 (K).

NIGERIA. Calabar: mile 58, Calabar-Mamfe road, Baldwin Jr. 13765 (BM); l.c., mile 54, Baldwin Jr. 13759 (BM); Ogoja: Ikom, Obokum, Keay FHI 28283 (BM); Aboabam, Keay FHI 28231 (BM); Oyo: Busogboro, Ibadan North F. R., Keay FHI 25358 (BM); Ile Ife, University of Ife Campus, Hall 15 (K); Jamaa: Dogon Kurmi, Mutch & Latilo FHI 19949 (BM); l.c., Sanga River F. R., Keay FHI 22254

(BM); l.c., 300 m, Killick 40 (K); l.c., near Jagindi, Hepper 1035 (K); Ondo: Akure, Idanre, 200 m, Savory UCI 38 (BM); l.c., Richards 3823 (BM, K); l.c., Keay FHI 22670 (BM); l.c., Brenan 3852 (K); l.c., Keay FHI 25498 (BM); Benin: Ehor and Ibekwe areas, c 100 m, Fairbairn 19 (BM); Bamenda: Bafut, Savory UCI (BM); Wum Escarpment, 900 m, Savory UCI 351 (BM); Ibadan: Gambari F.R., Onochie FHI 34991 (K); l.c., Onochie; FHI 35318 (K); Gwari: N.A. Gawu Hills, Onochie FHI 35915 (K); Okelife, 400 m, Onochie FHI 34347 (K); Abuja Emirate: Gurara Falls, Tuley 1672 (K); Kagoro-Jemaa Road F. R., Tuley 1781 (K); Ilesha: Erin-Ijesha, Gbile & Daramola FHI 67596 (K).

CAMEROON. Mupanga, c 1000-1100 m, Kalbreyer 152 (BM); Kumba: mile 52 on Victoria-Kumba road, Brenan 4068 (BM, K); l.c., bank of river Kumba from the Barombi Crater Lake, 350 m, Leeuwenberg 6878 (K); Mamfe, c 250 m, Rosevear s.n. (BM); mile 40 on Mamfe-Bamenda road, Baldwin Jr. 13819 (BM); Buea, 1000 m, Rosevear 38 (BM); l.c., Rosevear 40 (BM); l.c., Tryon & Tryon 6531 (K); l.c., Gregory 90 (K); Urwaldgebiet: Station Johann-Albrechtshöhe, Staudt 515 (BM, K); l.c., Staudt 468 (K); Liho: bank of Ntotse river, Dunlap 256 (K); No localities: Grenss 578 (BM), Kalbreyer 158 (K).

EQUATORIAL GUINEA. Fernando Po: Moka, c 1400 m, Melville 462 (BM); l.c., Exell 794 (BM); l.c., Ureka, c 200 m, on cocoa trees, Thorold TF 33 (BM); No locality, Mann 149 (K).

Also seen:

ZAIRE. near Kamuhene river, 950 m, Osmaston 2243 (BM);

SUDAN. Aloma Plateau: Yei, Kajiko river, c 1200 m, Macleay. 475 (BM).

UGANDA. Budongo, Eggeling 2107 (BM).

PLATE 8A

(see opposite page)

Specimen of *S. versicolor*: Adams 191 (BM).

FLORA OF GOLD COAST

Botanical Name: Selaginella versicolor Spring

Vernacular Name:

Locality: near Asiakwa.

Altitude: 1000'

Date: 30.3.1950

Habitat: dry stream bed.

Notes: in fruit.

Collector C.D.Adams

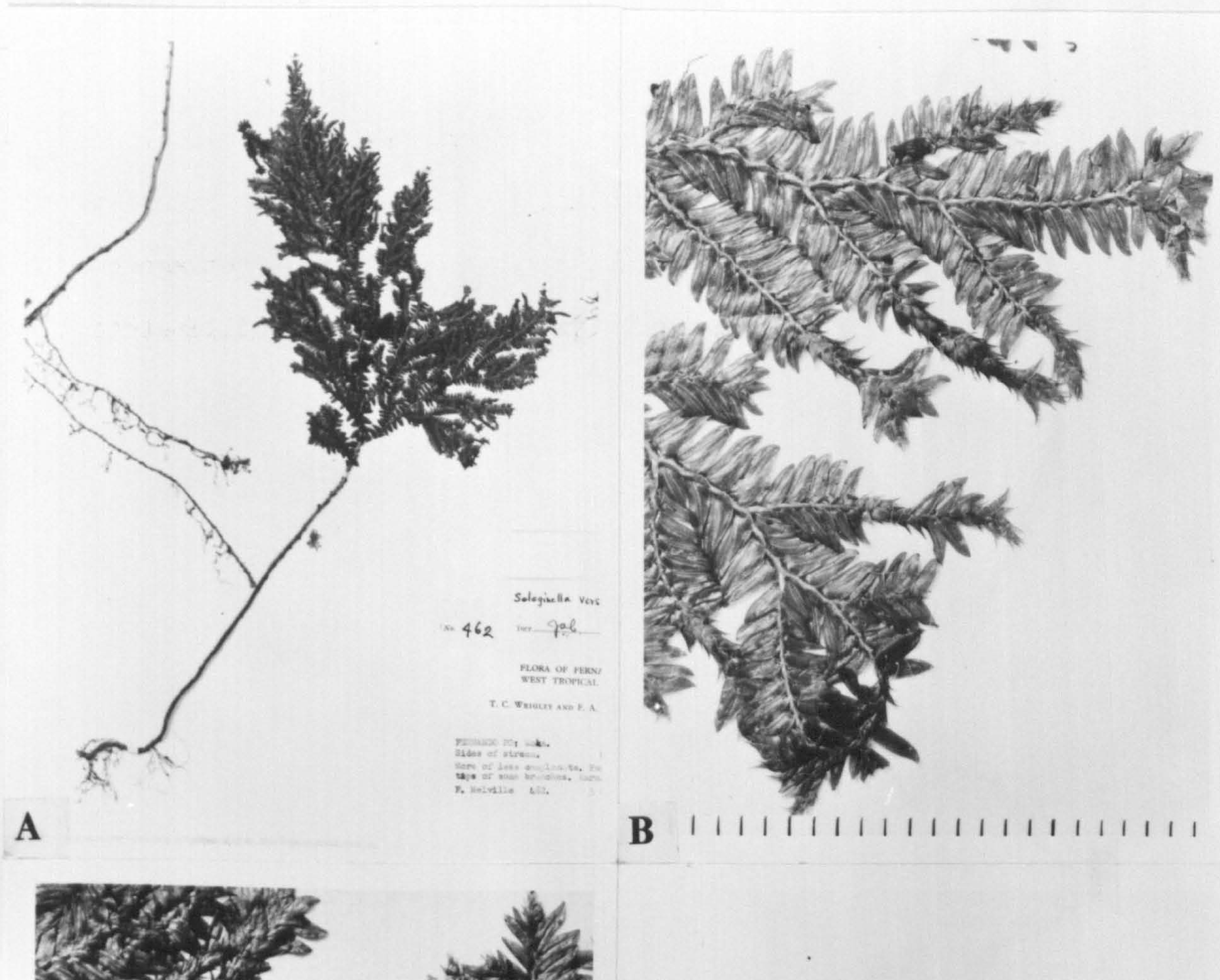
No. 191

Seen for Revised
Edition of F.W.T.A.

PLATE 8B

(see opposite page)

A-D. _S. versicolor_; A. Whole specimen. B-C. Close-ups showing intermittent growth patterns in tetragonous strobili. D. Close-up showing determinate growth pattern in tetragonous strobili. All from Melville 462 (BM). Scale in millimetres.


Selaginella vers
No. 462
FLORA OF FERN
WEST TROPICAL
T. C. WRIGLEY AND F. A.
Sides of stream.
F. Melville
A
B
C
D

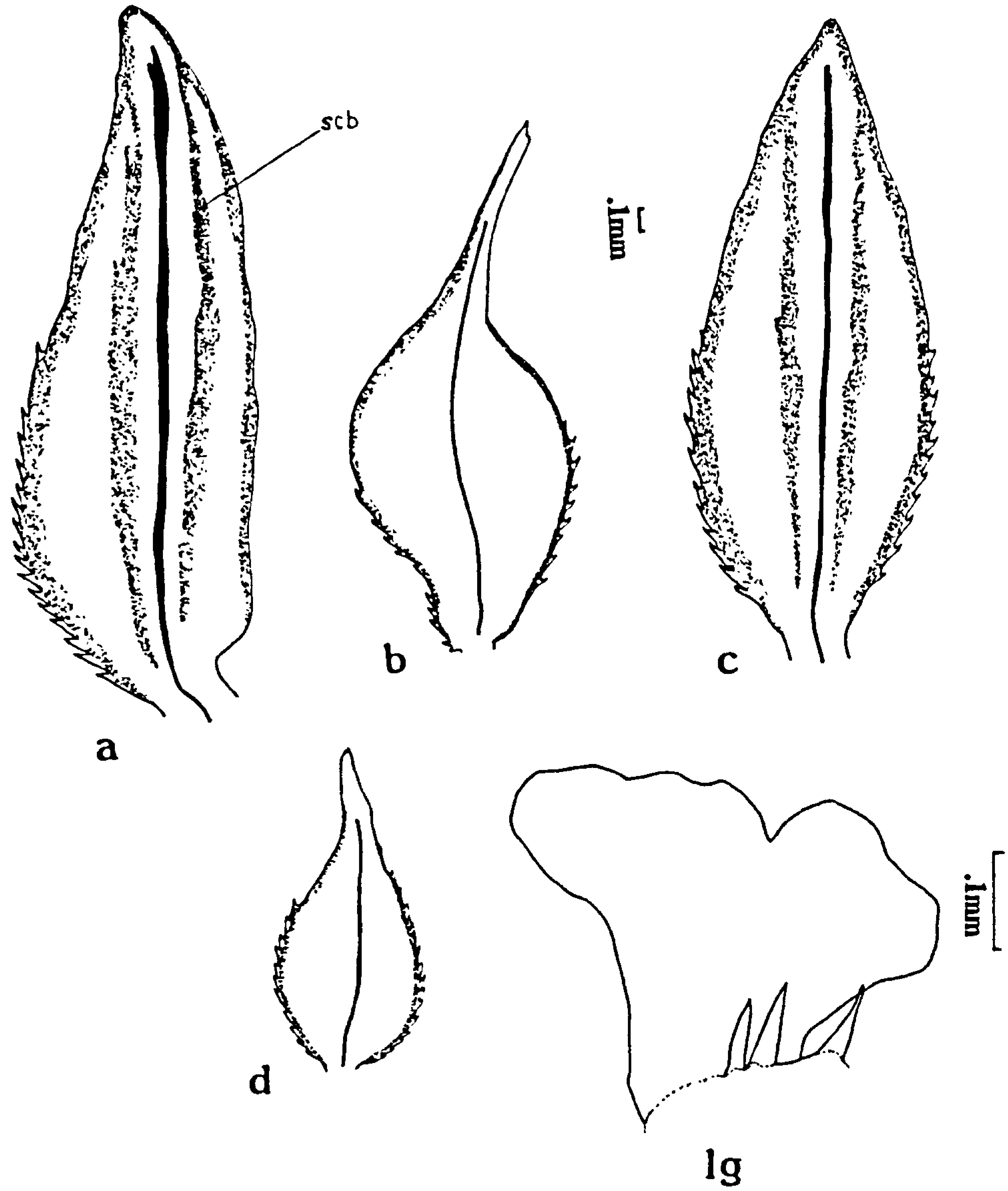


Fig. 9: S. versicolor: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Hossain GC40003. (scb = sclerotic cells forming bands on lamina).

Geographical distribution: Senegambia, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea [Fernando PO (FP)], Gabon, Congo, Zaire, Angola, Malawi, Uganda, Sudan - A tropical African element.

Taxonomic notes: S. versicolor is distinguished from all other West African species by the presence of the two broad sclerotic cells forming bands on the lamina of the lateral and axillary leaves, the 2-4 acicular hairs at the bases of the ligules of the lateral leaves and the soboles.

2. S. vogelii Spring, Monogr. Fam. Lycopod. 2: 170 (1849), Mem. Acad. Belg. 24: 170 (1850); Hook. Sec. Cent. Ferns t. 86 (1861, 1864); Baker F. Allies 100 no. 250 (1887); Knox, Trans. Edinb. Bot. Soc. 35: 272 (1950); Alston, Mém. Soc. Linn. Normandie Bot. 1:80 (1938), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959); Alston & Abbayes, Bull. Inst. Fr. d'Afr. Noire, 13: 85 (1951); Adams & Alston, Bull. Brit. Mus. (Nat. Hist.) Bot. 1: 184 (1955). Plate 9; fig. 10.

TYPE: EQUATORIAL GUINEA. Fernando Po, Vogel s.n. (K, holotype).

Nomenclature

SYNONYM: S. africana A. Br. (1857) Index Sem. Berol.

S. dichrous Hort., ex A. Br. 1857.

S. dinklageana Sadeb. in Jahrb. Hamb. Wiss. Anst. 14, Suppl. 16 (1897).

Description

Plants erect, stout from a creeping rhizome; branch-systems 3-4 pseudopinnate, flabellate with few dichotomies, pubescent at dorsal side; rhizophores restricted to the very base of the plant.

Leaves anisophyllous on branches, simple monomorphic on main stem, single-veined; stomata 24-31 x 20-23 μm; ligules up to 0.25 mm long, obturbinate. Lateral leaves asymmetrical, lanceolate-oblong, up to 3.5x1.5 mm, base oblique, apex acute, margins entire to sub-entire; ligular surface epidermis with isodiametric, undulating to sinous cells, without stomata; aligular surface epidermis with elongate, undulating, sinous cells, stomata randomly distributed on lamina, SI 12-($\bar{M}$13)-14. Median leaves asymmetrical, sub-obovate, up to 1.2x0.7 mm, base oblique (decurrent), apex caudate, margins entire-subentire (distantly serrate); ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed on lamina and towards the margins, SI 3-($\bar{M}$4)-4. Axillary leaves symmetrical, obovate to oblanceolate, up to 3.0x1.6 mm, base sub-attenuate, apex acute, margins entire (sub-entire); ligular surface epidermis with isodiametric, sinous to undulating cells, stomata randomly distributed on the lamina, SI 7-($\bar{M}$8)-9; aligular surface epidermis with elongate, undulating, sinous cells, stomata randomly distributed on the lamina, SI 11-($\bar{M}$11)-13.

Strobili tetragonous, at apices of branchlets, up to 10 mm long, with three sporangial arrangements: (i) cone wholly microsporangiate; (ii) with basal megasporangiate zone and apical microsporangiate zone; (iii) with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate. Sporophylls uniform (subuniform) keeled, broadly ovate to widely trullate, up to 1.5x0.8 mm, base obtuse to sub-auriculate, apex cuspidate, margins sub-entire (distantly serrate); both ligular and aligular surfaces epidermis with elongate, undulating, sinous cells, stomata sparsely distributed on lamina of aligular surface epidermis only, SI 5-($\bar{M}$6)-7. Megasporangia deltoid, with 81.4% similar-sized and 18.6% 2 Large: 2 Small (-L:-S) spores; megaspores 210-($\bar{M}$285)-328 µm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces baculate. Microsporangia ellipsoid; microspores 25-($\bar{M}$30)-40 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces verrucate-echinate.

<u>Ecological notes</u>: On rocks or ground in wet forest especially near water; sea level to 1800 m altitude.

<u>Specimens examined</u>

GUINEA. Nzo: Schnell 583 (BM); l.c., Abbayes 598 (BM); Kakoulima: Nickles s.n. (K).

SIERRA LEONE. N. Kono: Tingi Mts., 600 m, Morton & Gledhill SL 1985 (K); l.c., Fisher 89 (K); Yifin, foot of Loma Mt., Morton & Gledhill SL1136 (K); Gola North: Garua, Bakshi 38 (K); l.c., Forest Block III, Small 532 (K); Jau (Tunkia), Deighton 5222 (K); Benikoro, 300 m, Thomas 2948 (K); Giewahun, Deighton 457 (K); Kofiu Mt., Scott-Elliot 4614 (K); Maraka, Morton & Jarr SL1297 (K).

LIBERIA. Kitoma, Harley F160a (BM, K); Bobei, Harley F232 (BM, K); Ganta, Harley F22, F22A (K); Webo: Mnanulu, Baldwin Jr. 6059 (BM, K); Sanniquellie: Sakimpa, foot of Bilimu, Harley F115 (BM, K); Sinoe Basin, Whyte s.n. (K); Gangi, Linder 850 (K); Boporo: Zuie, Baldwin Jr. 12090 (BM).

IVORY COAST. Tai, Guiglo, Abbayes 2060 (BM); Niapidou: 64 km N of Sassandra, Leeuwenberg 2429 (K).

GHANA. Nfuom: Kakum F.R., c 200 m, Box 2861 (BM); Kibi: Puso Puso Ravine, c 300-500 m, Box 3258 (BM); Fanti-Nyankumasi, Box 2073 (BM); Potroasi, Adams 165 (BM); Banka, Ashanti, Irvine 480 (K); Akim: Kibi Hills, Johnston 264 (K); Akwapim Hills, Johnston 380 (K); Akropong Mts., Brown 332 (K); Kwadjo Nkwanta to Sikamang, Kitson 1246 (K); Tarkwa: Neung F. R., Agona, Cudjoe 18 (K); Konongo, Akpabla 254 (K); Anyinam, Obeng & Dade MDA 4 (K).

NIGERIA. Calabar, Robb s.n. (BM); l.c., Abak, Jackson's Land, Maggs 151 (BM, K); mile 54, Calabar-Mamfe road, Baldwin Jr. 13760 (BM); Kwa Falls, Richards 3995 (BM, K); l.c., Richards 3991 (BM, K); Benin: Ehor and Ibekwe, c 100 m, Fairbairn 16 (BM); Sonkwala: Ijua, 900 m, Savory & Keay FHI 25028 (BM); Okomu F.R., Compartment 53, Richards 3857 (BM, K); l.c., Compartment 56, Brenan 3635 (BM, K); Nsuka, Chaloner 15/1 (K); Boje: Aboabam, Jones & Onochie 18628 (BM, K); Ogoja: Abbot Village, Jones 1474 (BM); Oban, Richards 5144 (BM); Osomba Village, Onyeachusin & Latilo FHI 48194 (K); Owenna: Akue F.R., Onochie FHI 34218 (K).

CAMEROON. Buea, c 1000 m, Tryon & Tryon 6484 (K); Man Spring, Mt. Cameroon, Hambler 162 (BM); l.c., c 1000 m, Fraser 31 (BM); l.c., 1200 m, Migeod 12 (BM, K); l.c., 300 m, Dunlap 239 (K); l.c., Dunlap 132 (K); l.c., Maitland 838 (K); Victoria, Brenan 4384 (BM, K); Between Victoria and Kumba, Hutchinson & Metcalfe

PLATE 9

(see opposite page)

Specimen of *S. vormlii*: Box 2073 (BM).


12 APR 1940
FLORA OF GOLD COAST
Botanical Name: Selaginella Vogelii Spring
Vernacular Name:
Locality: 3 m. W. of Fanti Nyankumasi, Central Prov.
Altitude: c. 300 ft.
Date: 6 Jan 1940
Habitat: In small societies by side of track in the Evergreen Forest
Notes: Young plants have a beautiful iridescent "peacock-blue" sheen
Collector: Harold E. Box
No. 2073
Seen for Revised
Edition of F.W.T.A.

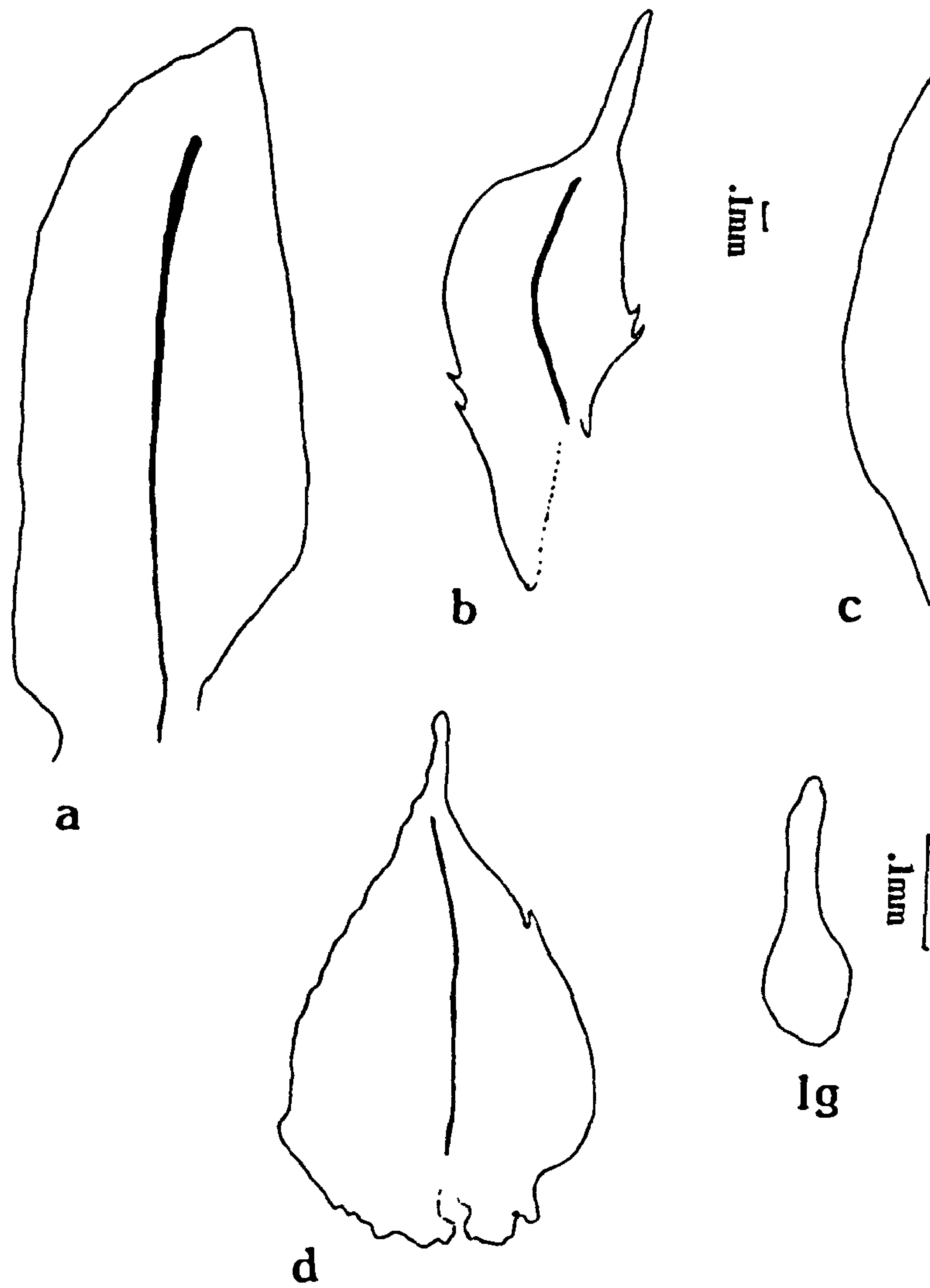


Fig. 10: S. vogelii: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Box 3589.

140 (K); Kumba: Lake Barombi, 350 m, Leeuwenberg 6852 (K); l.c., Box 3598 (BM); Urwaldgebiet: Bipinde, Zenker 903 (BM); l.c., Zenker 4454 (BM); Barombi Station, Preuss 279 (BM); Yaounde Station, 800 m, Zenker & Staudt 35 (BM); l.c., Zenker & Staudt 179 (BM); l.c., Zenker & Staudt 190 (BM); Mapanga, c 700-1300 m, Kalbreyer 150 (BM); Mamfe-Assam forest, 300 m, Gregory 253 (K).

EQUATORIAL GUINEA. Fernando Po: Mt. Balea, Guinea 359 (BM); l.c., Mann 149 (BM, K); No localities: Barter 1044, 1398 (K); Mann 1406 (K); Vogel s.n. (K).

MADAGASCAR. Nossi Bé, Lam & Meeuse 6088 (K); Be Kilus Mts., Last s.n. (BM); Antsiatsia, forêt d'Anjahana, SE Ambilobe, Cremers 2690 (TAN).

Geographical distribution: Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Benin, Nigeria, Cameroon, Equatorial Guinea (FP), Gabon, Congo, Zaire, Angola, Tanzania, Kenya, Zambia, Madagascar.

Taxonomic notes: S. vogelii is distinguished from all the other West African and Madagascan species by its pubescent stems and branches and from S. pervillei from Madagascar by its entire leaf margins.

3. S. kraussiana (Kunze) A.Br., Ind. Sem. Hort. Berol. 1859, append. 1860 22; Baker F. Allies 65 (1887); Sim F. S. A. 335 t. 182, Fig. 1 (1915); Alston, J. Bot. 77: 223 (1939), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959); Knox, Trans. Edinb. Bot. Soc. 35: 291 (1950). Plate 10; fig. 11.

TYPE: SOUTH AFRICA. Zitzikamma District, Kraus Marks s.n. (BD, holotype).

Nomenclature

SYNONYM: Lycopodium kraussianum Kunze in Linnaea 18: 114 (1844) TYPE as above.

S. azorica Bak. (1883).

Description

Plants prostrate, branched from the base, stems articulate; branch system flabellate and/or 2-4 pseudopinnate; rhizophores arising at the ventral side of primary branches and distributed more or less throughout the plant.

Leaves anisophyllous, single-veined; stomata 23-31x16-23 µm, ligules up to 0.35 mm long, femurate. Lateral leaves asymmetrical, ovate-elliptic, up to 4.0x1.8 mm, base obtuse, apex acute, margins serrate-serrulate; ligular surface epidermis with elongate, undulating, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, undulating, sinous cells at the midvein region and elongate, straight-sided cells towards the margins, stomata sparsely distributed on the margins and the apex and concentrated along the midvein in 3-5 rows, SI 18-($\bar{M}$20)-21. Median leaves asymmetrical, broadly elliptic-lanceolate, up to 2.8x1.0 mm, base oblique, apex acuminate, margins serrulate-denticulate; ligular surface epidermis with elongate, undulating, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with undulating, sinous cells at the midvein region and elongate, straight-sided cells towards the margins, stomata sparsely distributed on the margins and the apex and concentrated along the midvein in 2-4 rows, SI 13-($\bar{M}$14)-15. Axillary leaves symmetrical, oblong-elliptic, up to 3.8x2.0 mm, base obtuse, apex acute, margins serrate-serrulate; ligular surface epidermis with elongate, undulating, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, undulating, sinous cells at the midvein region and elongate, straight-sided cells towards the margins, stomata sparsely distributed on the margins and the apex and concentrated along the midvein in 3-6 rows, SI 20-($\bar{M}$22)-23.

Strobili tetragonous, at apices of branches and/or branchlets, up to 4 mm long, with one sporangial arrangement: with a single megasporangium at the base, rest of cone being microsporangiate. Sporophylls uniform (sub-uniform), lanceolate-sub-trullate, up to 2.7x0.8 mm, base cuneate, apex acuminate, margins serrate-serrulate-denticulate; both ligular and aligular surfaces epidermis with elongate, undulating, weakly sinous cells, stomata concentrated along the midvein in 1-3 rows, at the aligular surface only, SI 14-($\bar{M}$16)-17. Megasporangia triangular-ovoid to obovoid, with 30% similar-sized, 45% 2L: 2S, and 25% 1L: 3S spores; megaspores 400-($\bar{M}$800)-1100 µm in equatorial diameter, occasionally with distinct equatorial ring, trilete, globose, both proximal and distal surfaces cristate-reticulate. Microsporangia oblong to ellipsoid, with annuloid-like cells at the inner basal central surface; microspores 25-($\bar{M}$32)-36 µm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces echinate.

Ecological notes: Frequent on moist sunny or shaded ground beside paths in lowland and montane rain forests; 600-2140 m altitude.

Specimens examined

CAMEROON. Buea: c 1000 m, Rosevear 41 (BM); l.c., Rosevear 37 (BM); l.c., 1200 m, Migeod 23 (BM, K); l.c., Hambler 224 (BM); l.c., Victoria, Brenan 4385 (BM, K); Cameroon Mt, 1500-1800 m, Box 3609 (BM); Ubile: Victoria, Mann's Spring, 950 m, Richards 4358 (BM, K); Batibo, 1200 m, Brunt 1061 (K); No locality, Mann 383 (K).

EQUATORIAL GUINEA. Fernando Po: Ascencion al Pico Serrano, Guinea 2018 (BM); l.c., Ilache waterfall, 1200 m, Adams 1080 (BM).

SOUTH AFRICA. Zitzikamma Dist., Kraus Marks s.n. (holotype? BD) Port Natal, Gueinzius 307 (isotype BD).

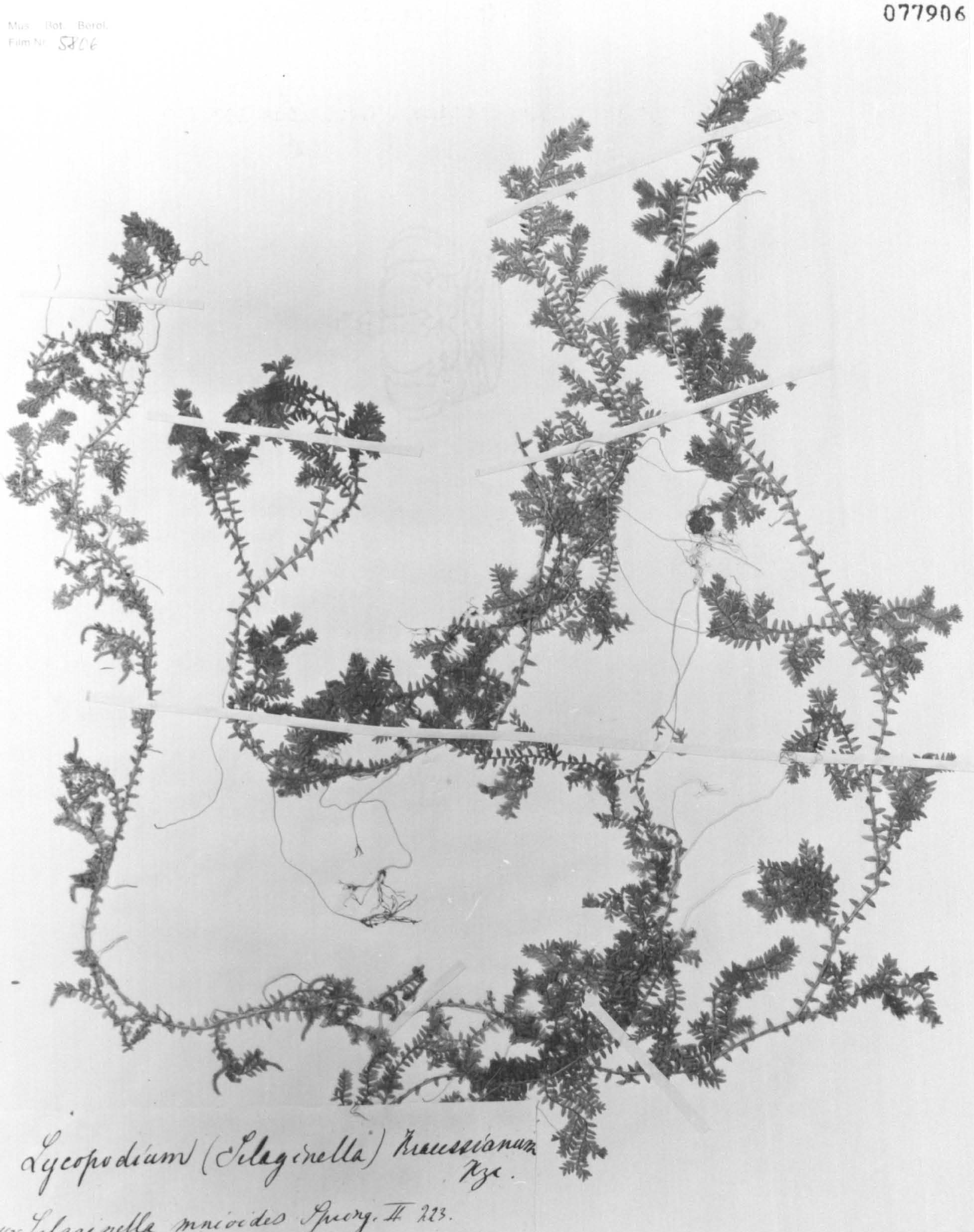
Geographical distribution: Sierra Leone, Cameroon, Equatorial Guinea (FP), Congo, Zaire, Rep. S. Africa, Mozambique, Zimbabwe, Malawi, Tanzania, Kenya, Rwanda, Burundi, Uganda, Ethiopia, Sudan, Canary Islands, Madeira, Azores-Tropical Africa, naturalized in Europe and America.

Taxonomic notes: S. kraussiana is distinguished from all the other West African species by its articulated stems, ventral-positioned rhizophores, and the annuloid-like cells of the microsporangia.

PLATE 10

(see opposite page)

S. kraussiana: Lectotype specimen, Gueinzius 307 (BD).



Lycopodium (Selaginella) Kraussianum Kze.

163 Selaginella mnioides Spreng. II 223.

Port. Natal.
leg. Gueinzius. n. 307

Lycopod. (Selaginella) Kraussianum. Kze.
Natalia. In rupib. sylvat.

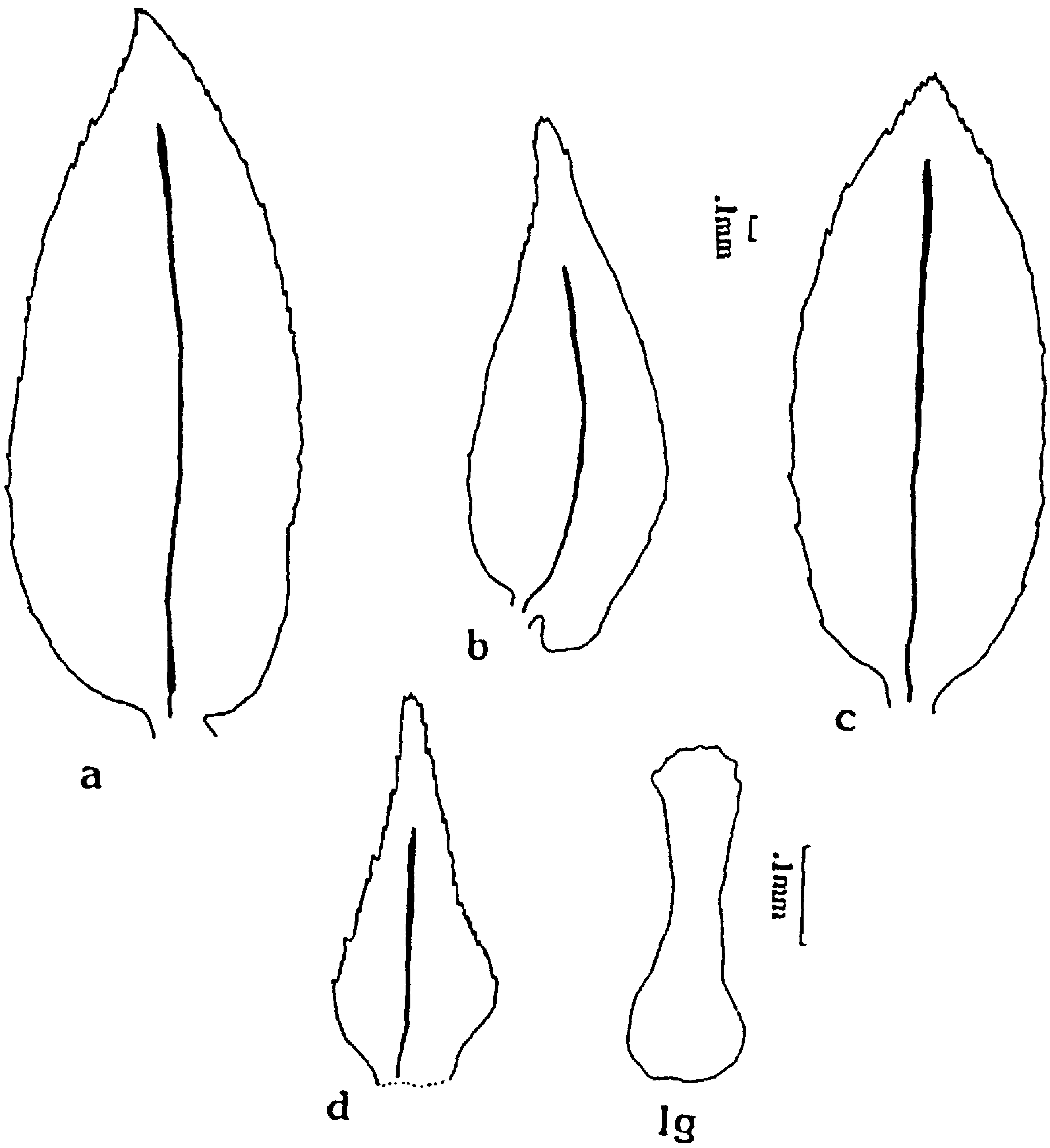


Fig. 11: S. kraussiana: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Brenan 4385.

4. S. cathedrifolia Spring in Mem. Acad. Belg. 24: 112 (1850); Baker, J. Bot. 21: 82 (1883), F. Allies 40 no. 24 (1887); Alston, J. Bot. 72 (Suppl. 2): 10 (1934), Cat. Vasc. Pl. S. Tomé 96 (1944), Mém. I.F.A.N. 50: 36-37 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959); Knox, Trans. Edinb. Bot. Soc. 35: 161 (1950); Alston & Abbayes, Bull. Inst. Fr. d'Afr. Noire, 13: 83 (1951); Adams & Alston, Bull. Brit. Mus. (Nat. Hist.) Bot. 1: 183 (1955). Plate 11; fig. 12.

TYPE: PRINCIPE. Curror 58 (K, holotype; P, isotype).

Nomenclature

SYNONYM: S. zenkeri Hieron. ex Bonap., Notes Pteridol. 7: 253 (1911) n.n.

Description

Plants prostrate, branched from the base; branch system 1-3 pseudopinnate; rhizophores arising at the dorsal side and/or the axils of primary branches and distributed more or less throughout the plant.

Leaves anisophyllous, single-veined, with sclerotic cells forming patches and/or bands on aligular surface epidermis; stomata 20-33 x 15-23 µm; ligules up to 0.19 mm long, flabelliform, occasionally bifid or weakly femurate. Lateral leaves asymmetrical, ovate-oblong, up to 2.2x1.5 mm, base obtuse, apex acuminate to apiculate, margins long-ciliate-serrate (cilia up to 0.46 mm long) at basal half, apical half serrate-denticulate; ligular surface epidermis with isodiametric, sinous cells on lamina and isodiametric, polygonal, straight-sided cells towards the margins, stomata sparsely distributed near the margins, SI 2-($\bar{M}$3)-3; aligular surface epidermis with elongate, straight-sided cells on lamina and less elongate, sinous cells at the midvein region, stomata concentrated along midvein (not in rows), SI 12-($\bar{M}$13)-14. Median leaves asymmetrical, ovate, up to 1.1 x 0.6 mm, base obtuse, apex cuspidate, margins short-ciliate-serrate (cilia up to 0.13 mm long); ligular surface epidermis with elongate, sinous cells, stomata randomly distributed near margins, SI 9-($\bar{M}$10)-10; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed along midvein, SI 5-($\bar{M}$6)-7. Axillary leaves symmetrical, broadly lanceolate to narrowly ovate, up to 2.2x1.6 mm, base obtuse, apex acuminate, margins long-ciliate (cilia up to 0.50 mm long) at basal half, apical half serrate-serrulate; ligular surface epidermis with isodiametric, sinous cells, stomata occasionally present near margins, SI 4-($\bar{M}$5)-5; aligular surface epidermis with elongate, sinous cells, stomata concentrated along midvein (not in bands), SI 7-($\bar{M}$7)-8.

Strobili tetragonous, at apices of branches and/or branchlets, up to 15 mm long, with three sporangial arrangements: (i) with dorsal side wholly megasporangiate and ventral side wholly microsporangiate; (ii) with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate; and (iii) cone wholly microsporangiate. Sporophylls uniform, keeled, ovate-lanceolate, up to 1.2x0.5 mm, base obtuse, apex cuspidate, margins serrate-serrulate; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata sparsely distributed along the midvein, at aligular surface epidermis only, SI 4-($\bar{M}$6)-7. Megasporangia ovoid-triangular, with 80.8% similar-sized, 14.2% 2L: 2S and 5% 3L: 1S spores; megaspores 200-($\bar{M}$240)-298 µm in equatorial diameter, with distinct equatorial ring, trilete, sub-globose to globose, proximal surfaces granulose, distal surfaces rugulose. Microsporangia oblong-ellipsoid; microspores

19-(M25)-30 μm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces compactly scabrate-echinate.

Ecological notes: On rocks and stones on the banks or in stream in wet forests; up to 1500 m altitude.

Specimens examined

GUINEA-BISSAU. Mafenebu: Guinea 187 (BM); l.c., Guinea 188 (BM); Guinayong: Guinea 100 (BM).

GUINEA. Ziama: Schnell 2664 (BM); Gouee to Nzo: Abbayes 619 (BM).

SIERRA LEONE. Bong County: Kpatawee Waterfall, 250 m, Fay 1250, 1261 (NY); Kasewe F.R., 250 m, Fay 1200, 1278 (NY); Gorama Mende Chiefdom, East Province, 40 m, NNE of Bo, Fay 1287 (NY); Njala, bank near river Taia, Fay 1058, 1077 (NY); l.c., Deighton 646 (BM, K); l.c., (Kori), Jones 418 (K); Kambi Hills: Waanjee river, Bakshi 57 (K); Neaboi, Small 892 (K); Between Gorahun and Bobobu, Deighton 3649 (K); Kenema, Deighton 5224 (K); l.c., Deighton 5225 (K); Lalehun (Gaura), Bakshi 194 (K); Bagroo river, Mann 911 (K).

LIBERIA. Sanniequellie: Ganta, Harley F19 (BM); Kitoma, Harley F154 (BM, K); Jaurazon: Sinoe Co., Baldwin Jr. 11452 (BM, K); Webo: Mnanulu, Baldwin Jr. 6025 (BM, K); l.c., Duo, Baldwin Jr. 11339 (BM, K); Gbaringa: Pallilah, Baldwin Jr. 13129 (BM); l.c., NE of Suacoco, Daniel 417 (BM); l.c., Barker 1389 (K); Mt. Bili, Barker LL71 (K); LAMCO Headquarters Camp, 550 m, Adames 479 (K); Between Waimu and Bagoleta, c 32 km N of Kakata, Wilde 3871 (K); Moala, Linder 1378 (K).

IVORY COAST. Glike, Schnell 1631 (BM); Gouee, Abbayes 601 (BM); l.c., Abbayes 2138 (BM); Taï-Tabou, Hana river bank, Wilde 3529 (K); Tai flou Forest near Danane, Schnell 6325 (K).

GHANA. Axim, Ahenlezo, Cudjoe 76 (BM); Tarkwa, Ankobra river, Johnson 987, 988, 989 (K); Dompim, Neung F. R., Enti FE1320 (K); Sekondi, Fishlock 21 (K); Nadum, bank of river Offin, Fishlock 45 (K); No locality: Fishlock s.n. (K).

NIGERIA. Calabar: Oban, Richards 5146 (BM); Kwa Falls, c 60 m, Maggs 156 (BM, K); l.c., Richards 3994 (BM, K); Calabar-Mamfe road, Baldwin Jr. 1377 (BM); l.c., Baldwin Jr. 13764 (BM); Old Calabar, Thomson 119 (K).

CAMEROON. Urwaldgebiet: Bipinde, Zenker 3095 (BM); l.c., Zenker 1328 (BM); l.c., Zenker 102 (BM); l.c., Zenker 4057 (BM); Lolodorf, Staudt 24 (BM); l.c., Staudt 45 (BM); Bertoua, Nickles 122 (BM); Munanya road, W. of Mamfe, Adams 1335 (BM, K); Lomie, 600 m, Price & Evans 64, 196, 229 (K).

Also seen

PRINCIPE. Pico Papagaio, c 600 m, Exell 687 (BM); Infante D. Henrique, c 300 m, Exell 629 (BM); Prince Island, Curror 58 (K).

ZAIRE. Luebo-Kasai, Achten 367A (BM); Gumbari, Hant Uele, Seret 484 (BM).

Geographical distribution: Guinea-Bissau, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea [Rio Muni (RM), FP], Principe, Gabon, Congo, Zaire, Angola.

Taxonomic notes: This species is easily recognized by its long ciliate lateral and axillary leaves combined with the prostrate habit.

PLATE 11

(see opposite page)

Specimen of *S. cathedrifolia*: Adams 1335 (BM).

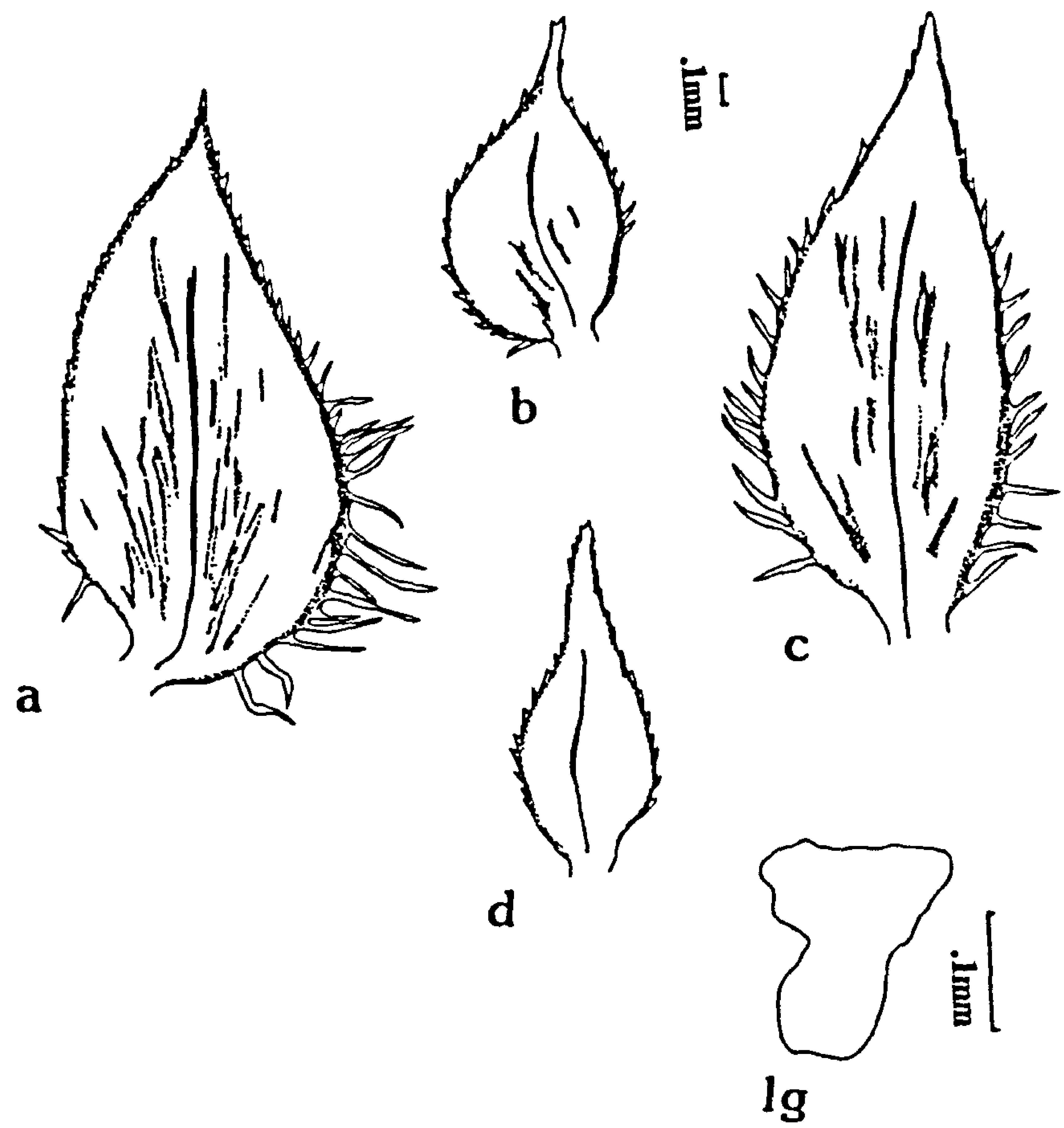


Fig. 12: S. cathedrifolia: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Adams 1335.

5. S. myosurus (Sw.) Alston in J. Bot. 72: 64 no. 6 (1932), Mém. Soc. Linn. Normandie Bot. 1: 81 (1938), Mém. I.F.A.N. 50: 29-30 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959); Alston & Abbayes, Bull. I.F.A.N. 13: 84 (1951); Adams & Alston, Bull. Brit. Mus. (Nat. Hist.) Bot. 1 (6): 184 (1955). Plate 12; fig. 13.
TYPE: SIERRA LEONE. Afzelius s.n. (BM, holotype).

Nomenclature

SYNONYM: Lycopodium myosurus Sw. in Schrad. J. Bot. 1800, t.2: 118 (1891). TYPE: SIERRA LEONE. Afzelius s.n. (BM).

Stachygynandrum scandens (Beauv.) Spring-Kuhn Fil. Afr. 102 (1+3); Baker F. Allies 93 (1887), E. & P. Pflanzenfam, 1, 4: 70 fig. 407, Engl. Pflanzenw. Afr. 2: 79, t. 78 (1908); Knox, in Trans. Edinb. Bot. Soc. 35: 254, fig. 93 a & b (1950).
TYPE: SIERRA LEONE. Beauvois s.n. (BM).

Description

Plants twinning, climbing up to 3 m; branch-system 2-3 pseudopinnate; rhizophores arising at the dorsal side and/or axils of primary branches and distributed more or less throughout the plant.

Leaves anisophyllous, three veined; stomata 22-30x18-20 µm; ligules up to 0.28 mm long, obturbinate. Primary stem leaves sub-symmetrical, ovate to weakly elliptic, up to 3.5 x 1.2 mm, base auriculate, apex acuminate, margins serrate-double-serrate; ligular surface epidermis with slightly elongate, undulating, sinous cells, without stomata; aligular surface epidermis with slightly elongate, undulating, weakly sinous cells, stomata concentrated along the midvein in 2-4 rows, SI 11-($\bar{M}$12)-13.

Lateral leaves asymmetrical, ovate-elliptic to oblong, up to 4.0x2.0 mm, base obtuse, apex acuminate, margins serrate-serrulate; ligular surface epidermis with slightly elongate, undulating, weakly sinous cells, without stomata; aligular surface epidermis with slightly elongate, undulating, weakly sinuous cells, stomata concentrated along the midvein in 3-7 rows, SI 19-($\bar{M}$20)-21. Median leaves asymmetrical, lanceolate, up to 2.2x0.8 mm, base weakly auriculate, apex cuspidate, margins serrate-serrulate; ligular surface epidermis with slightly elongate, sinous cells, without stomata; aligular surface epidermis with slightly elongate, sinous cells, stomata concentrated along the midvein in 2-4 rows, SI 11-($\bar{M}$11)-12. Axillary leaves symmetrical, ovate, up to 3.8x2.3 mm, base obtuse, apex acuminate, margins serrate-serrulate; ligular surface epidermis with slightly elongate, undulating, weakly sinous cells, stomata concentrated along the midvein in 2-6 rows, SI 7-($\bar{M}$8)-9; aligular surface epidermis with slightly elongate, undulating, weakly sinous cells, stomata concentrated along the midvein in 3-8 rows, SI 14-($\bar{M}$14)-15.

Strobili tetragonus, at apices of branchlets, up to 40 mm long, with one sporangial arrangement: with a single megasporangium at the base, the rest of cone being microsporangiate. Sporophylls uniform (sub-uniform), sub-ovate-trullate, up to 2.1x1.0 mm, base obtuse, apex cuspidate, margins serrate-serrulate; both ligular and aligular surfaces epidermis with elongate, undulating, weakly sinous cells, stomata concentrated along the midvein, at the aligular surface only, in 2-5 rows, SI 9-($\bar{M}$10)-10. Megasporangia ovoid-triangular, with 70% similar-sized, 19.2% 2L: 2S, and 10.8% 1L:3S spores; megaspores 696-($\bar{M}$810)-941 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces solidly striate-reticulate. Microsporangia weakly reniform; microspores 24-(M33)-42 µm in equatorial diameter, with equatorial flange, trilete, globose, both proximal and distal surfaces verrucate with psilate flanges.

Ecological notes: Prefers sunny sites on road banks, at forest margins, along paths in plantations and secondary woodland; a lowland element, up to 1200 m altitude.

Specimens examined

SENEGAMBIA. No locality, Heudelot 790 (K); Desvaux 37 (K).

GUINEA. Conakry: Maclaud s.n. (K); Rio Benito: Guinea 967 (BM); Nzo: Schnell s.n. (K).

SIERRA LEONE. Freetown: Welwitsch 2 (BM); l.c., Nicol Brook, 250 m, Johnston s.n. (BM); l.c., Johnston 29, 31 (K); l.c., Dalziel 982 (BM, K); Colony, Warm Water river, 50 m, Melville & Hooker 610 (K); l.c., No 2 river, 8 m, Melville & Hooker 503 (K); Guma, 220 m, Hepper & Pyne 2510 (K); Picket Hill, c 700 m, Jones 355 (BM); Sugar Loaf Mt., c 500 m, Jones 349 (BM); l.c., c 600 m, Melville 73 (K); Bule Town, Melville & Hooker 367 (K); l.c., S of Kortright House, Melville & Hooker 13 (K); Njala, Deighton 2084 (BM, K); l.c., (Kori), Pyne 1 (K); l.c., 150 m, Fay 1059, 1075 (NY); Dambaye, Kenema, Small 61 (K); Nongowa, Bakshi 19 (K); Peninsula, Leicester Peak, Morton & Gledhill SL244 (K); Koinaduga, 1.5 km E of Bafodia, 400 m, Haswell 92 (K); Between Mansonia and Perankoro, E of Mt. Loma, Jaeger 1736 (K); Makumf, 100 m, Thomas 901 (K); Kafoko, 200 m, Thomas 2117 (K); Bun Kolo (Idolo), 150 m, Thomas 1840 (K); Yonibana, 100 m, Thomas 5060 (K); Gola North (Garua), Bakshi 35 (K); Bendugu (Sengbe), Bakshi 13 (K). Matotoka, c 100 m, Thomas 1347 (K); Potoru (Bari), Jones

371 (K); Pejuhun (Panga-Kabonde), Jackson 2 (K); Makeni (Bombali Sebora), Jones 408 (K); Sherbro Island, Hunter s.n. (BM); Heddle's Farm, Scott-Elliot 3920 (K); No localities: Afzelius s.n. (BM); Beauvois s.n. (BM); Morson s.n. (K); Barter s.n. (K); Marmo 303 (K); Thomas 8668 (K).

LIBERIA. Ganta, Harley 17 (BM); l.c., Harley F37 (BM, K); Gbarnga, Linder 446 (K); l.c., NE of Suacoco, Daniel 402 (BM, K); Bolahun, Earthy 17 pp (BM); Webo: Nyaake, Baldwin Jr. 6216 (BM); Boporo, Zuie, Baldwin Jr. 12091 (BM); Monrovia: Firestone Plantations, Dukwai river, Cooper 42 (BM, K); Montserrado Co., Baldwin Jr. 13012 (BM); Port Marshall, c 10m, Kundsen 6 (BM); Nimba Mts., LAMCO compound, 700 m, Leeuwenberg & Voorhoeve 4620 (K); l.c., Bos 2451 (K); Jachere, 450 m, Adam 20671 (K); Mt. Bele road, 500 m, Adames 482 (K); Between Waimu and Bagoleta, 32 km N of Kakata, Leeuwenberg & Voorhoeve 3863 (K); Sinoe Co., Eggeling L4 (K); Grand Cape Mount Co., Jabrocca (near Fisherman's Lake), Baldwin Jr. 10855 (K); No locality: 600 m, Adam 20754 (K).

IVORY COAST. Mt. Tonkoui, SW of Man, 1180 m, Leeuwenberg 2951 (K); l.c., 1100 m, Abbayes 553 (BM); Mossou, road to Eloka, Abbayes 476 (BM); l.c., Porteres 1556 (K); National Park of Barco, c 5 km NE of Abidjan, Wilde 923 (K); Dabou, N of Lopou, Leeuwenberg 2321 (K); l.c., 16 km W of Dabou, Boughey GC 18886 (K); 1.5 km S of Tai off road to Tabou, Boughey GC 14964 (K); E of Issia, Boughey GC 14690 (K).

GHANA. Dixcove, Box 2074 (BM); Dunkwa, Cape Coast-Praso road, c 60 m, Box 2062 (BM); Tarkwa, Vigne 4125 (K); l.c., Subiri F. R., Andoh FH 5234 (K); Brawile, near Axim, Cudjoe 6 (K); Axim, Akpabla 105 (K); l.c., Chipp 415 (K); Aburi Hills, Obeng MDA18 (K); Essiama, WR, Fishlock 87 (K); l.c., Fishlock III (K); Atwabo, Fishlock 44 (K); Vane, Volta Region, 600 m, Bigger 2486 (K); Brenasi, Akim, Irvine 552 (K); Amedzofe Hill, Anti GC 42418

(K); Kumasi, Cummins s.n. (K).

TOGO. Klouto, 12 km NW of Palime, Hiekpo & Schultze-Motel 42 (K); Tomegbe, Badou, 720 m, Mathey & Scholz 284 (K).

NIGERIA. Benin: Sapoba, by Jamieson river, Richards 3897 (BM, K); Iyekorhiomwon, Emwiogbon FHI 45337 (K); l.c., Lowe 1950 (K); l.c., Meikle 529 (K); Oweri: Mbieri, Richards 3960 (K); l.c., Richards 3966 (BM); l.c., Naze road to Aba, Richards 5136 (BM); Calabar, Kalbreyer 47 (BM); l.c., Robb s.n. (BM); l.c., on Atimbo road, Onyeachusim & Latilo FHI 48161 (K); Kwa Falls, Lowe 2639 (K); Enugu: Onitsha, Joa valley, Jones 1076 (BM); Ajalli, c 200 m, Maggs 142 (BM, K); l.c., Mamu River F. R., Keay FHI 22299 (BM); Awka river, Awbibia valley, Jones FHI 4543 (K); Pitwood Plantation, on bank of Ekulu stream, Olorunfemi FHI 34194 (K); Port Harcourt, New Calabar river, Delta area, Fraser 25 (BM); l.c., by creek near Golf Course, Stubbings 54 (K); Eket, Talbot & Talbot s.n. (BM); Usonibge F.R., Urhuehue, Keay & Onochie FHI 19669 (K); Umuatia, A. J. C. 242 (K); No localities: Barter 44, 2086 (K); Kennedy 2701 (K).

CAMEROON. Douala, c 30 m, Exell 746 (BM); Yaounde station, Zenker & Staudt 186 (BM); Mamfe, 300 m, Gregory 244 (K); Urwaldgebiet, Lolodorf, Staudt 265 (BM); Bibundi, Schlechter 12414 (BM); No localities: Braun 7 (BM); Preuss 398 (BM).

EQUATORIAL GUINEA. Fernando Po, Mann 1860 (BM); l.c., Mann 150 (K); Musola, Senicio Agronomico, Guinea 989 (BM).

Also seen

ANGOLA. Nzala, S of Belinze-Moriombe, Gossweiller 7029 (BM).

ZAIRE. Kinshasa: Kintusi, 100 km S of Kisantu, Callens 3892 (BM); Kwango: Kibunda (Mwala), Callens 3996 (BM); Yangambi, Lovis 14632 (BM).

PLATE 12

(see opposite page)

S. myosurus: Type specimen, Johnston s.n. (BM).


Name, Selaginella scandens, Spr.
(fide J. G. Baker)
Habitat, Shady wooded banks at stream side about 800 feet above sea level.
Station, Nicol Brook, near Freetown, Sierra Leone, Africa.
Date, 18th November 1882.
Collector, Henry Halero Johnston
Remark, Young plants. Common.
Name, Selaginella scandens, Spr.
(fide J. G. Baker)
Habitat, Damp shady wooded ground at stream side about 800 feet above sea level.
Station, Source of Nicol Brook near Freetown, Sierra Leone, Africa.
Date, 20th November 1882.
Collector, Henry Halero Johnston
Remark, Stem twining left to right round other plants, or creeping on the ground.
Selaginella myosurus (Sw.) Alston
March '53 Det. A. H. G. Alston
Seen for Revised Edition of F.W.T.A.

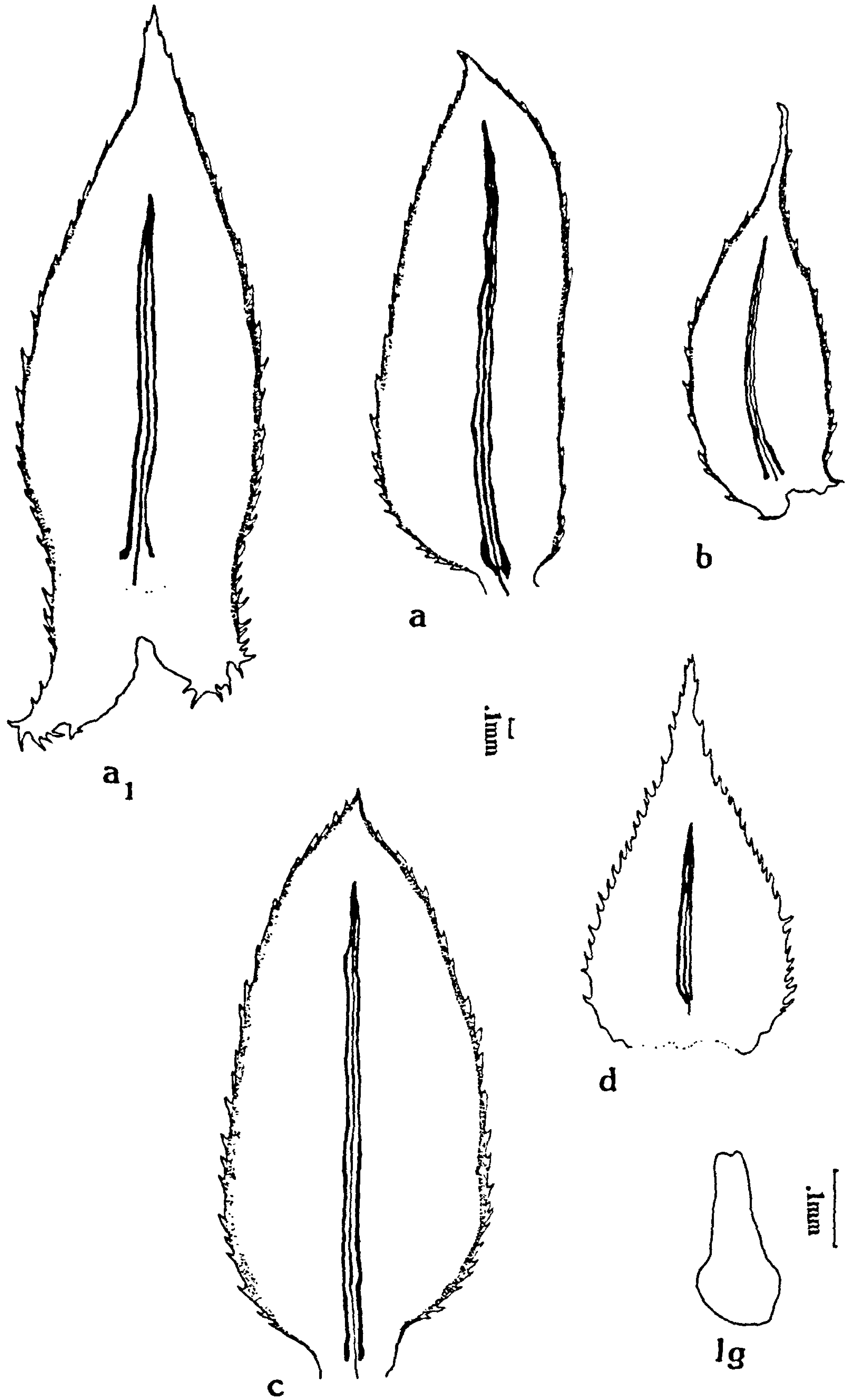


Fig. 13: S. myosurus: a_1. stem leaf; a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Gossweiler 7029.

Geographical distribution: Senegambia, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea (RM, FP), Gabon, Congo, Zaire, Angola, Kenya.

Taxonomic notes: This species is recognized by its twinning, climbing habit and the three-veined leaves.

6. S. buchholzii Hieron in E. & P. Pflanzenfam. 1, 4: 696 no. 272 (1901), Hedwigia 43: 51 no. 56 (1904); Alston & Abbayes, Bull. I.F.A.N. 13: 83 (1951); Adams & Alston, Bull. Brit. Mus. (Nat. Hist.) Bot. 1: 183 (1955); Alston, Mém. I.F.A.N. 50: 39 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959).
Plate 13; fig. 14.
TYPE: CAMEROON. Jansoki, by river Quaqua, Buchholz s.n. (BD, holotype; P, isotype).

Description

Plants suberect or shortly prostrate, main stem branched at the base; branch-system 1-3 pseudopinnate; rhizophores arising at the axils and/or dorsal side of the primary branches and distributed more or less throughout the plant.

Leaves anisophyllous, single-veined, with sclerotic cells occasionally present forming patches on lamina at aligular surface epidermis; stomata 19-33x18-21 µm; ligules up to 0.23 mm long, obclavate or weakly femurate. Lateral leaves asymmetrical, ovate-oblong to ovate-elliptic, up to 2.3x1.3 mm; base obtuse, apex acuminate to weakly mucronate, margins of basal half ciliate-denticulate (cilia up to 0.22 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, weakly sinous to straight-sided cells, stomata evenly distributed on lamina, SI 17-($\bar{M}$19)-20. Median leaves sub-symmetrical, weakly deltate, up to 1.5x0.8 mm, base cordate, apex cuspidate, margins serrate-denticulate; ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, polygonal straight-sided cells, stomata sparsely distributed on lamina, SI 8-($\bar{M}$8)-9. Axillary leaves symmetrical, ovate, up to 2.0x1.2 mm base obtuse, apex apiculate to acuminate, margins of basal half ciliate (cilia up to 0.22 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, weakly sinous to straight-sided cells, stomata evenly distributed on lamina, SI 21-($\bar{M}$22)-23.

Strobili bilateral, resupinate, at apices of branches, up to 10 mm long, with two sporangial arrangements : (i) cone wholly megasporangiate; (ii) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous, with sclerotic cells forming patches on lamina at aligular surface epidermis. Ventral sporophylls ovate-sub-panduriform, up to 2.1x1.1 mm, base oblique (subcordate-obtuse), apex acuminate, margins aculeate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina at side with sporophyll-pteryx, SI 18-($\bar{M}$19)-20; aligular surface epidermis, with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed on lamina, SI 4-($\bar{M}$5)-5; sporophyll-pteryx with ciliate margin (cilia up to 0.23 mm long), with elongate, sinous cells, stomata (1-2) present on the outer side. Dorsal sporophylls trullate to deltate, up to 1.7x1.0 mm, base obtuse to subcordate, apex shortly cuspidate to long acuminate, margins long-ciliate-serrate (cilia up to 0.31 mm long); both ligular and aligular surfaces epidermis with elongate, sinous cells, stomata sparsely distributed on lamina and midvein at aligular surface epidermis only, SI 6-($\bar{M}$7)-7. Megasporangia deltoid, with 91.1% similar-sized and 8.9% 3L:1S spores; megaspores 228-($\bar{M}$257)-300 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces finely granulose to psilate. Microsporangia ellipsoid; microspores 20-($\bar{M}$24)-32 µm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces baculate-clavate.

Ecological notes: Among stones on river banks, under bushes or in dry exposed positions; near sea level up to 1000 m altitude.

Specimens examined

SIERRA LEONE. Musaia: Dembelia, Small 271 (BM, K); Loma Mts., Morton SL 2613 (K); Koyema: Tingi Hills, Morton & Gledhill SL3212 (K); Morea Junction to Fintonia, Morton & Gledhill SL580 (K).

IVORY COAST. Vavoua: Cercle de Daloa, Abbayes 167 (BM).

GHANA. Ankaful: near Cape Coast, Hall 2360 (K); Elmina: Hall 1522 (K); Accra: Achimota, Foote 156 (BM); l.c., Milne-Redhead 5135 (BM); Ejura Scarp: Adams & Akpabla 4525 (BM); Kpandu: Kpeme, c 250 m, Adams 1813 (BM); Anloga: Hall 3403 (BM); Nakpanduri: Hall CC 511 (BM); Banda: Hall 2096 (K).

PLATE 13A

(see opposite page)

S. buchholzii: Type specimens, Buchholz s.n. (BD).

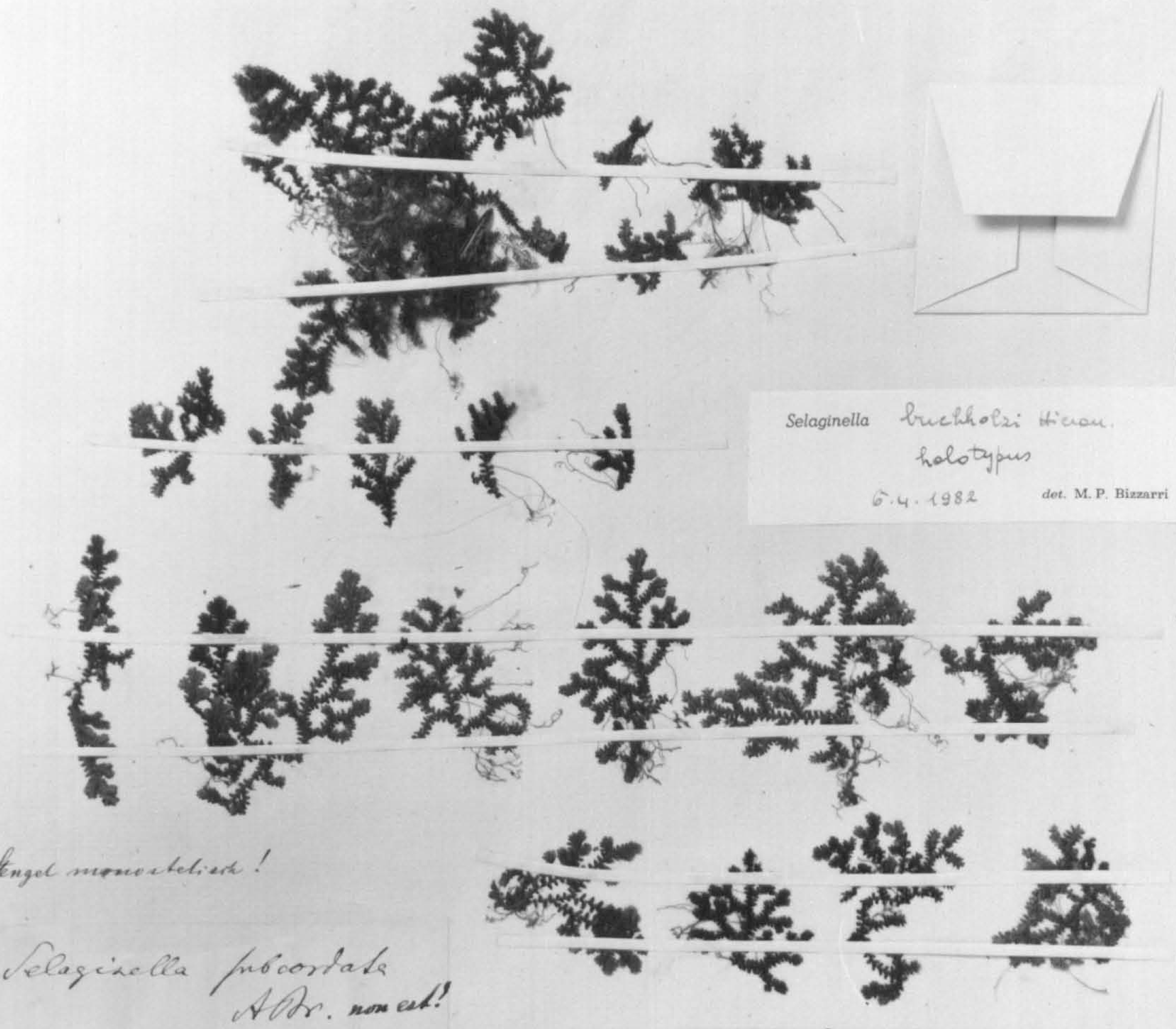
Herbarium A. Braun

Selaginella
subcordata
A.Braun

Auf trockenem lehmigen Boden bei dem Dorfe Jenssöki am Quaqua December 1874.
Buchholz.

Kleine Selaginella subcordata A.Br.
gesammelt auf trockenem lehmigen Boden
bei dem Dorfe Jenssöki (am Quaqua)
Mitte December 74.
leg. Buchholz.

Mikrosporen orangefarben mit stäbchenförm. Höckern an der abgerundeten Seite.



Selaginella buchholzi Hieron.
holotypus
6.4.1982 det. M. P. Bizzarri

Stengel monostelisch!

Selaginella subcordata
A.Br. non est!

Winzige Selaginella, welche wie ich glaube ich noch früher nicht bemerkt habe?
Jenssöki am Quaqua Dec. 74
auf lehmigen Boden im Dorfe und sonst [illegible]
Africa occid. [illegible] [illegible] 1. Buchholz

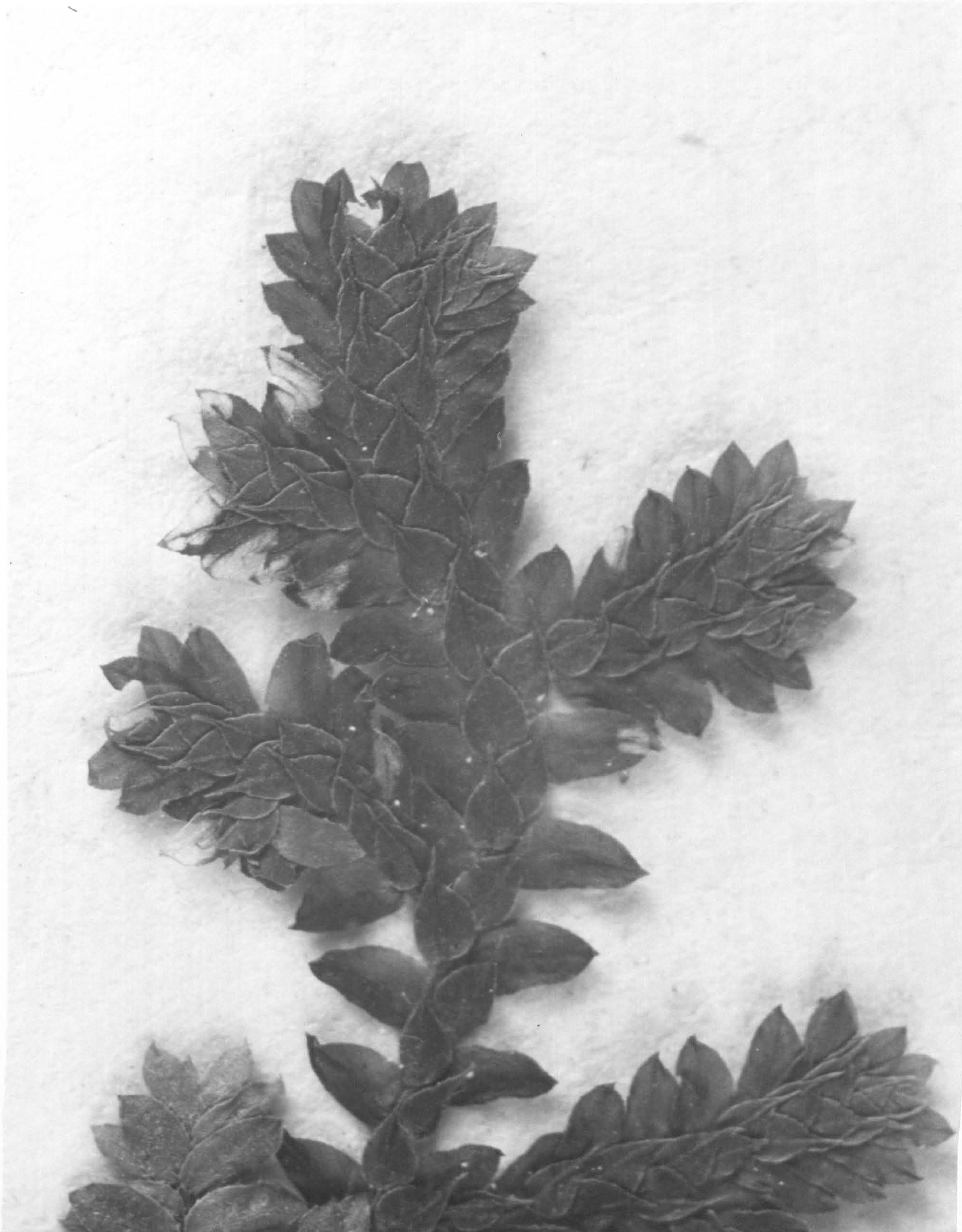
steht der S. proniflora (Lam.) Bak. sehr nahe!

Selaginella Buchholzii
Hieron.
von S. subcordata Al.Br. verschieden!
det. G. Hieronymus.

PLATE 13B

(see opposite page)

S. buchholzii: Close-up of Type specimen showing vegetative leaves.



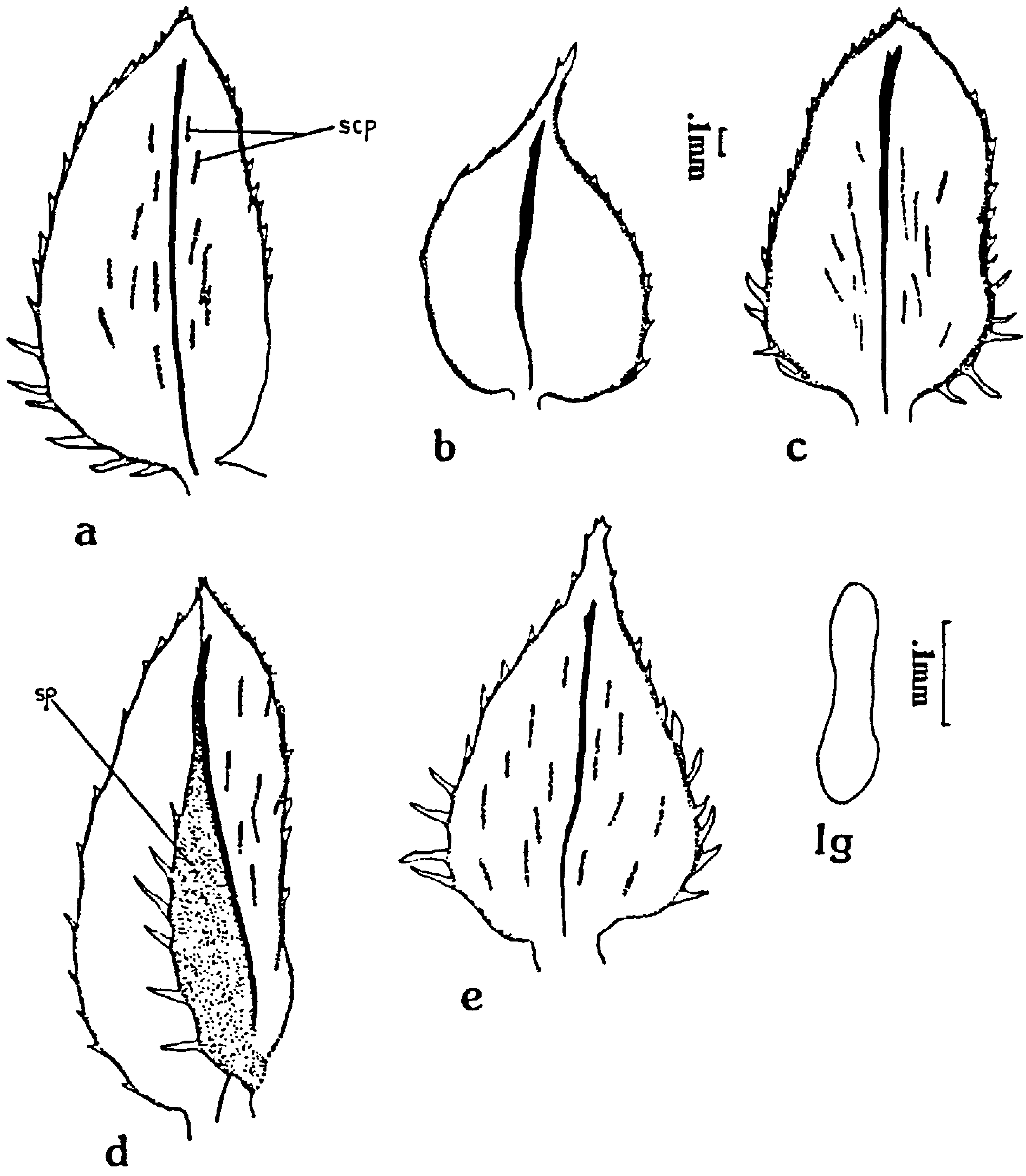


Fig. 14: S. buchholzii: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Adams 1813. (sp = sporophyll-pteryx; scp = sclerotic cells forming patches on lamina).

TOGO. Sokode: Schroder s.n. (K).

NIGERIA. Onitsha: Agulu, Keay FHI 25288 (BM); Ondo: Orosun, Idanre Hills, Keay 25422 (BM); Enugu: Baldwin, Jr. 13795 (BM); Ibadan: Oyo Road, Meikle 1003 (BM, K); Abeokuta: Olokemeji, Charter FHI 31294 (K).

CAMEROON. Jansoki: S.E. Douala, Buchholz s.n. (K)

Also seen:

ZAIRE. Mayombe: Les Bandal, Nickles 118 (BM); Thysville: Vanderyst 4459 (BM); Kisantu: Moyen Congo, Vanderyst 11550 (BM).

Geographical distribution: Sierra Leone, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Gabon, Zaire.

Taxonomic notes: This species is closely allied to the Madagascan *S. perpusilla* from which it is distinguished by its ciliate leaves and psilate megaspores.

7. *S. soyauxii* Hieron. in E. & P. Pflanzenfam. 1, 4: 697 no. 305 (1901), Hedwigia 43: 57 (1904); Alston, Mém. Soc. Linn. Normandie Bot. 1: 81 (1938), Bol. Real. Soc. Esp. Nat. Hist. 49: 199 (1951), Mém. I.F.A.N. 50:37 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 14; fig. 15.

TYPE: GABON. Munda: Sibange-Farm, Soyaux 419 (K, holotype; BD, isotype).

Description

Plants prostrate-ascendent; branch system 2-3 pseudopinnate;

rhizophores arising at the axils and/or dorsal side of primary branches and distributed more or less throughout the plant.

Leaves anisophyllous, single-veined; stomata 31-36x19-26 μm; ligules up to 0.28 mm long, pedate occasionally bifid. Lateral leaves asymmetrical, elliptic-oblong to ovate-oblong, up to 4.5x2.0 mm, base oblique, apex acute to acuminate, margins of basal half entire, apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina and along the midvein, SI 13-($\bar{M}$15)-16. Median leaves asymmetrical, obovate, up to 2.5x1.5mm, base sub-cuneate to obtuse, apex caudate, margins entire (sub-entire); ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, polygonal, weakly sinous to straight-sided cells, stomata randomly distributed along the midvein, lamina and margins, SI 8-($\bar{M}$9)-9. Axillary leaves symmetrical, oblanceolate, up to 4.0x2.2 mm, base attenuate, apex acute, margins of basal half entire (sub-entire), apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina, SI 16-($\bar{M}$19)-20.

Strobili bilateral, resupinate, at apices of branchlets, up to 8.5 mm long, with two sporangial arrangements: (i) with no particular pattern; (ii) with dorsal side containing both megasporangia and microsporangia randomly arrranged and ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls oblong-ovate, up to 3.0x1.5 mm, base oblique to sub-obtuse, apex acuminate, margins entire-aculeate with complete sporophyll-pteryx on the adaxial surface; ligular surface epidermis with elongate, weakly sinous cells, stomata sparsely distributed on lamina, SI 6-($\bar{M}$7)-8; aligular surface epidermis with isodiametric, weakly sinous to straight-sided cells, stomata sparsely distributed on lamina, SI 3-($\bar{M}$4)-4; sporophyll-pteryx with serrate-sub-entire margin, with elongate, weakly sinous cells, stomata occasionally present on the outer side. Dorsal sporophylls elliptic-ovate, keeled up to 2.1x1.1 mm, base sub-obtuse, apex cuspidate to long acuminate, margins serrate-sub-entire; both ligular and aligular surfaces epidermis with elongate, weakly sinous cells, stomata sparsely distributed on lamina at aligular surface epidermis only, SI 2-($\bar{M}$3)-4. Megasporangia deltoid, with 86% similar-sized, 8% 2L: 2S, and 6% 3L:1S spores; megaspores 383-($\bar{M}$400)-430 µm in equatorial diameter, trilete, globose to sub-globose, both proximal and distal surfaces psilate. Microsporangia reniform; microspore 34-($\bar{M}$38)-41 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces echinate on verrucate perispore (verrucate-echinate).

Ecological notes: Prefers moist and shady sites (rocks and banks) in forests, mostly in lower montane zones, from 200 to 1200 m altitude.

Specimen examined

SIERRA LEONE. Between Mattru and Gbangbama, Deighton 2341 (K); Kenema: Saama Village, Scurlock 15 (K); Denkali: Loma Mts., Jaeger 255 (K); Jau (Tunkia), Deighton 5221 (K); Giewahun, Deighton 458 (K); Kasewe F. R., 150 m, Fay 1090 (NY); l.c., Morton SL 1481 (K).

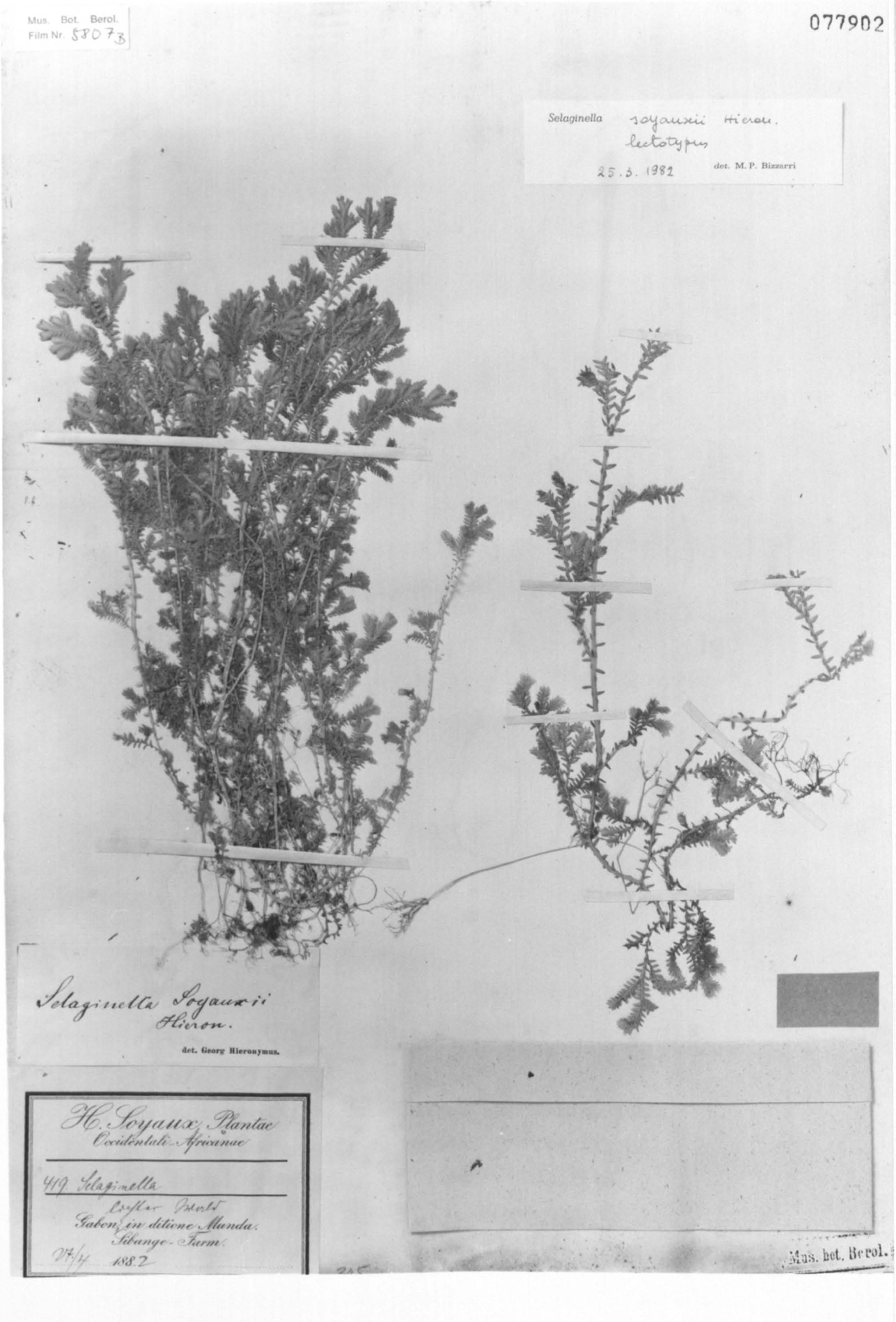
LIBERIA. Bilimu: Harley 2098 (BM); Bolahun: Earthy 17 pp (BM); l.c., Earthy Misc I (BM).

IVORY COAST. Danane: Schnell (BM); Man: Mt. Tonkoui, 1050 m,

PLATE 14

(see opposite page)

S. soyauxii: Lectotype specimen, Soyaux 419 (BD).


Mus. Bot. Berol.
Film Nr. 58073
077902
Selaginella soyauxii Hieron.
lectotypus
25.3.1982
det. M. P. Bizzarri
Selaginella Soyauxii Hieron.
det. Georg Hieronymus.
H. Soyaux Plantae Occidentali-Africanae
419. Selaginella
Gabon, in ditione Munda.
Sibange-Farm.
1882
Mus. bot. Berol.

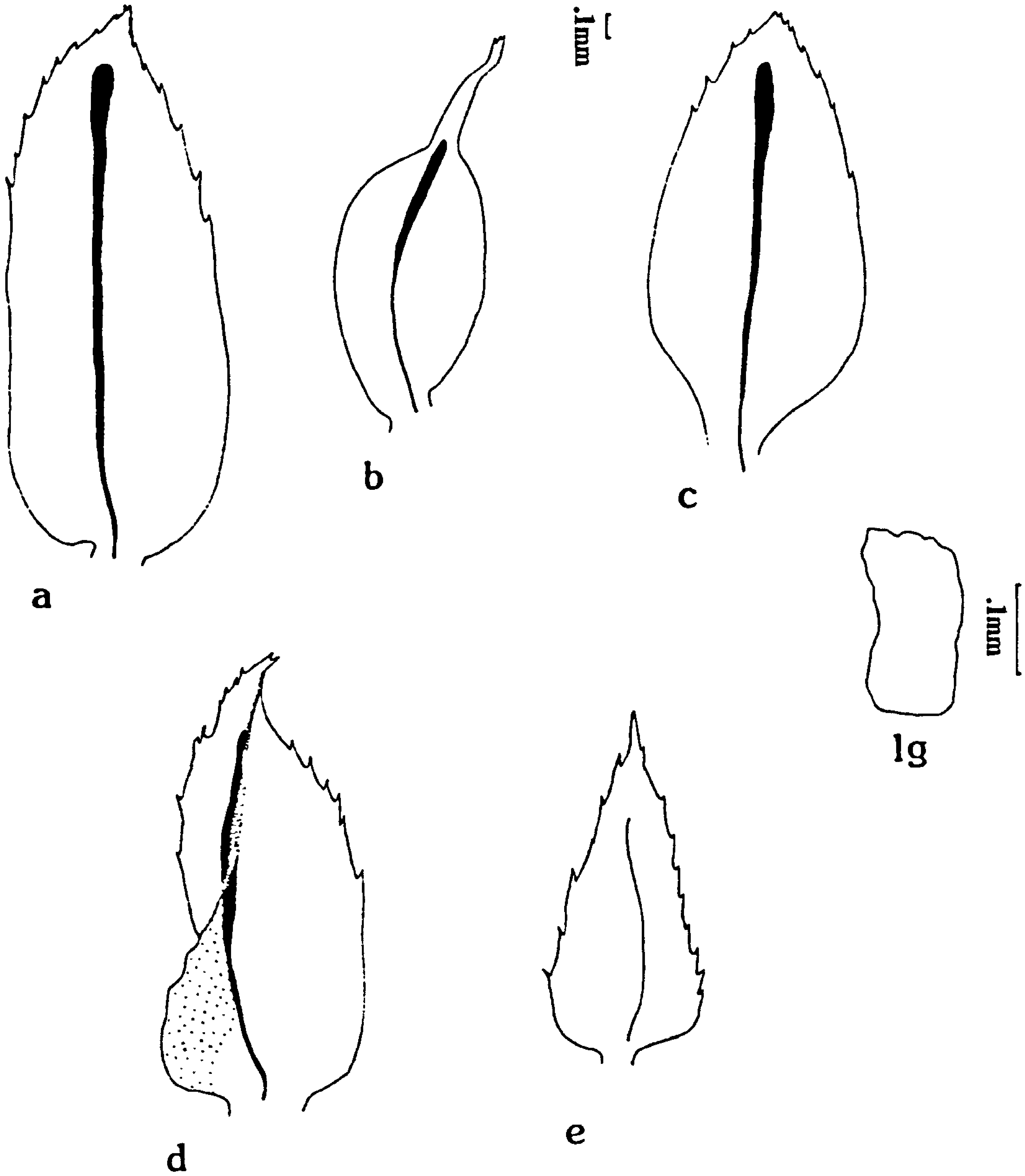


Fig. 15: S. soyauxii: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Soyaux 419.

Abbayes 230 (BM).

CAMEROON. Bamenda: Bafut, Savory UCI 295 (BM); Mopenja: c 800 m, Kalbreyer 102 (BM); Buea: c 950 m, Rosevear Cam 37/37 (BM); l.c., c 900 m, Migeod 6 (BM); Signal Hill, 1000 m, Tryon & Tryon 6471 (K); Forestry Plantation, 1100 m, Tryon & Tryon s.n. (K); Cameroon Mt., 1000 m, Dunlap 143 (K).

EQUATORIAL GUINEA. Fernando Po: Iladyi, c 1180 m, Benl & Benl FP 129 (K); Musola: Sewicio Agronomico, Guinea 1313 (BM).

Also seen

GABON. Munda: Sibange Farm, Soyaux 419 (holotype, K; BD).

Geographical distribution: Guinea, Sierra Leone, Liberia, Ivory Coast, Benin, Cameroon, Equatorial Guinea (Fernando Po), Gabon, Congo, Zaire, Uganda - Tropical regions in Africa.

Taxonomic notes: S. soyauxii is distinguished from other species by its obovate median leaves and pedate ligules.

8. S. blepharophylla Alston in Mém I.F.A.N. 50: 40 t. 6, ff. 9-15 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 15; fig. 16.

TYPE: LIBERIA. Kitoma, clay bank by roadside, 18 Sept. 1949, Harley F156 (BM, holotype).

Description

Plants erect or suberect; main stem branched in the lower quarter; branch-systems 3-4 pseudopinnate; rhizophores arising at the axils of primary branches.

Leaves anisophyllous, single-veined; stomata 28-34x18-26 µm;

ligules up to 0.35 mm long, elongate, obclavate. Lateral leaves asymmetrical, ovate-deltate, up to 4.0x2.2 mm, base oblique, apex acute, margins of basal half subentire-long ciliate (cilia up to 0.32 mm long), apical half distantly serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate sinous cells, with sclerotic cells forming patches and/or bands on lamina, stomata distributed sparsely on margins but more concentrated on the midvein, SI 21-($\bar{M}$23)-23. Median leaves asymmetrical, broadly lanceolate, up to 2.5x1.3 mm, base obtuse, apex cuspidate, margins long-ciliate-serrate (cilia up to 0.36 mm long); ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata concentrated along the midvein and/or margins, SI 7-($\bar{M}$8)-9. Axillary leaves symmetrical to sub-symmetrical, ovate, up to 3.8x2.4 mm, base obtuse to shortly truncate, apex acute to weakly acuminate, margins of basal half long-ciliate (cilia up to 0.45 mm long), apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, with stomata concentrated on margins, SI 11-($\bar{M}$12)-13; aligular surface epidermis with elongate, sinous cells, with sclerotic cells forming patches and/or bands on lamina, stomata concentrated on midvein and/or occasionally on lamina, SI 18-($\bar{M}$19)-20.

Strobili bilateral, resupinate, at the apices of branchlets, up to 10 mm long, with two sporangial arrangements: (i) with dorsal side wholly megasporangiate and the ventral side wholly microsporangiate; (ii) with dorsal side wholly megasporangiate and the ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls ovate-sub-deltate to ovate-oblong, up to

3.6x1.7 mm, base oblique (truncate-obtuse), apex broadly acute, margins short-ciliate-serrate (cilia up to 0.16 mm long), with a complete sporophyll-pteryx on the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata scattered on lamina, SI 8-($\bar{M}$9)-9; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed on lamina and margins, SI 5-($\bar{M}$6)-6; sporophyll-pteryx with ciliate margin (cilia up to 0.18 mm long), with elongate, sinous to straight-sided cells. Dorsal sporophylls lanceolate to sub-ovate, up to 2.2x1.0mm, base sub-obtuse to oblique, apex cuspidate, margins ciliate (cilia up to 0.24 mm long); ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on lamina and elongate, sinous cells on the midvein, stomata sparsely distributed on midvein, SI 9-($\bar{M}$10)-11.
Megasporangia ovoid-triangular, with similar-sized spores; megaspores 198-($\bar{M}$225)-240 µm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces loosely reticulate. Microsporangia ovoid-ellipsoid; microspores 27-(M30)-35 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces finely granulose.

Ecological notes: On wet rocks near streams and wet roadside clay banks in secondary forest; up to 800 m altitude.

Specimens examined

LIBERIA. Kitoma: Harley F156 (BM, holotype); Sanniquellie: Baldwin, Jr. 13132 (BM); Bilimu, Harley F196 (BM); Bong-Range: between Waimu and Bagoleta, 32 km N of Kakata, Wilde 3862 (K); Mt. Bele road, 500 m, Adames 612 (K); Ganta, Harley F19 (K); Webo: Diebla, Baldwin Jr. 6288 (K).

PLATE 15

(see opposite page)

S. blepharophylla: Type specimen, Harley F156 (BM).

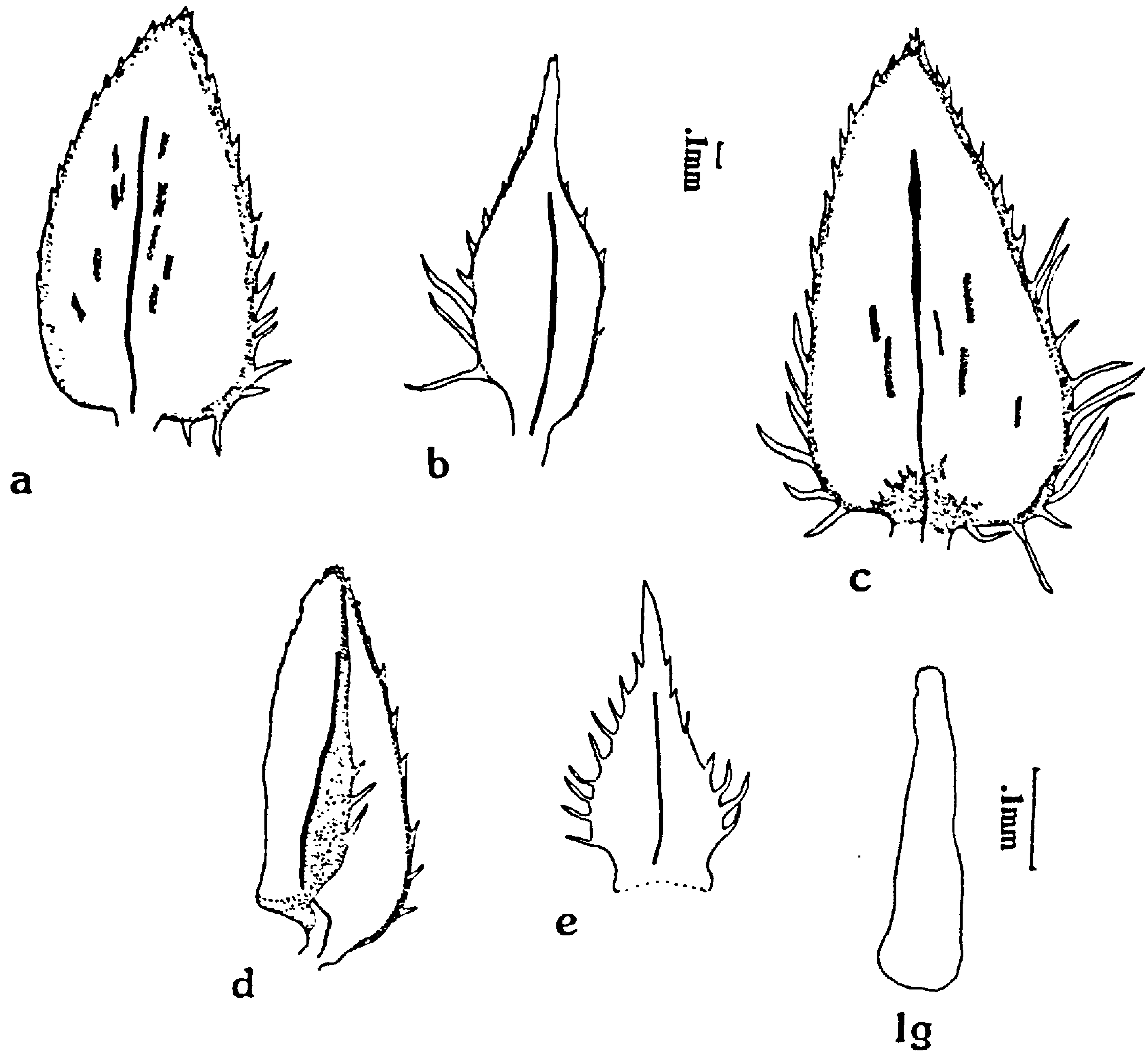


Fig. 16: S. blepharophylla: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Harley F156.

IVORY COAST. Tai, 3 ml South, Boughey (14) 856 (K).

GHANA. Axim: Ankobra river, Avonle stream, Cudjoe 116 (BM); Atewa Mt., 800 m, Bigger 2425 (K); Prestea: Ampeam F.R., Cudjoe 36 (K).

NIGERIA. Plateau Province, William Camp, Hall 627 (K).

CAMEROON. Urwaldgebiet: Johann - Albrechtshohe Station, Staudt 452 (K).

Geographical distribution: Guinea, Liberia, Ivory Coast, Ghana, Nigeria, Cameroon.

Taxonomic notes: This species is distinguished from other species by its long ciliate leaves and from S. zechii by its reticulate megaspores.

9. S. zechii Hieron. in E. & P. Pflanzenfam. 1, 4: 697 no. 298 (1901), Hedwigia 43: 54 no. 59 (1904); Alston, Mém. I.F.A.N. 50: 42-43 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 16; fig. 17.

TYPE: TOGO. Kete Kratschi, Zech 388 (BD, holotype).

Description

Plants erect or sub-erect, main stem branched at the base; branch-system 1-3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal quarter of the plant.

Leaves anisophyllous, single-veined; stomata 33-38x19-23 µm; ligules up to 0.29 mm long, obclavate. Lateral leaves asymmetrical, ovate-oblong to deltate, up to 2.6x1.5 mm, base sub-obtuse to oblique, apex acute to sub-obtuse, margins of basal half long-ciliate-subentire (cilia up to 0.32 mm long), apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, occasionally isodiametric, sinous to straight-sided cells, with sclerotic cells forming patches on lamina, stomata randomly distributed on lamina, midvein and margins, SI 13-($\bar{M}$15)-16. Median leaves asymmetrical, sub-oblanceolate, up to 1.6x0.6 mm, base obtuse, apex aristate (aristae up to same length as lamina), margins ciliate-serrate (cilia up to 0.20 mm long); ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, sinous to straight-sided cells, stomata concentrated along the midvein, SI 4-($\bar{M}$5)-5. Axillary leaves symmetrical, ovate-deltate, up to 2.5x1.4 mm, base weakly obtuse to subcordate, apex acute to apiculate, margins long-ciliate-serrate (cilia up to 0.36 mm long); ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, occasionally isodiametric, sinous to straight-sided cells, with sclerotic cells forming patches on lamina, stomata randomly distributed on lamina, midvein and margins, SI 12-($\bar{M}$13)-14.

Strobili bilateral, resupinate, at apices of branchlets, up to 12 mm long, with two sporangial arrangements: (i) cone wholly megasporangiate; (ii) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls oblong-ovate, up to 2.1x0.9 mm, base obtuse, apex apiculate, margins of basal half short-ciliate-sub-entire (cilia up to 0.16 mm long), apical half distantly serrate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina at side with sporophyll-pteryx, SI 14-($\bar{M}$15)-16; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed on lamina and margins, SI 3-($\bar{M}$4)-5; sporophyll-pteryx with ciliate margin (cilia up to 0.18 mm long), with elongate, sinous cells, stomata occasionally present on the outer side. Dorsal sporophylls lanceolate, up to 1.7x0.6 mm, base obtuse, apex cuspidate to aristate (aristae up to two-thirds the length of lamina); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata sparsely distributed along midvein at aligular surface epidermis only, SI 2-($\bar{M}$2)-3. Megasporangia ovoid to deltoid, with 96.7% similar-sized and 3.3% 3L:1S spores; megaspores 160-($\bar{M}$180)-215 µm in equatorial diameter, trilete, sub-globose, proximal surface occasionally with 3 scars (one scar in each area defined by triradiate marks), both proximal and distal surfaces granulose to minutely rugulose Microsporangia ellipsoid to roundish; microspores 20-($\bar{M}$23)-26 µm in widest area, trilete, tetrahedral-subtriangular, both proximal and distal surfaces finely granulose.

Ecological notes: On wet rocks and moist lateritic banks in forest; up to 1160 m altitude.

Specimens examined

GUINEA. Boule Col.: Macenta, Schnell 125 (BM).

GHANA. Kibi, c 350 m, Box 3506 (BM).

TOGO. Kete Kratschi, Zech 388 (Type, BD).

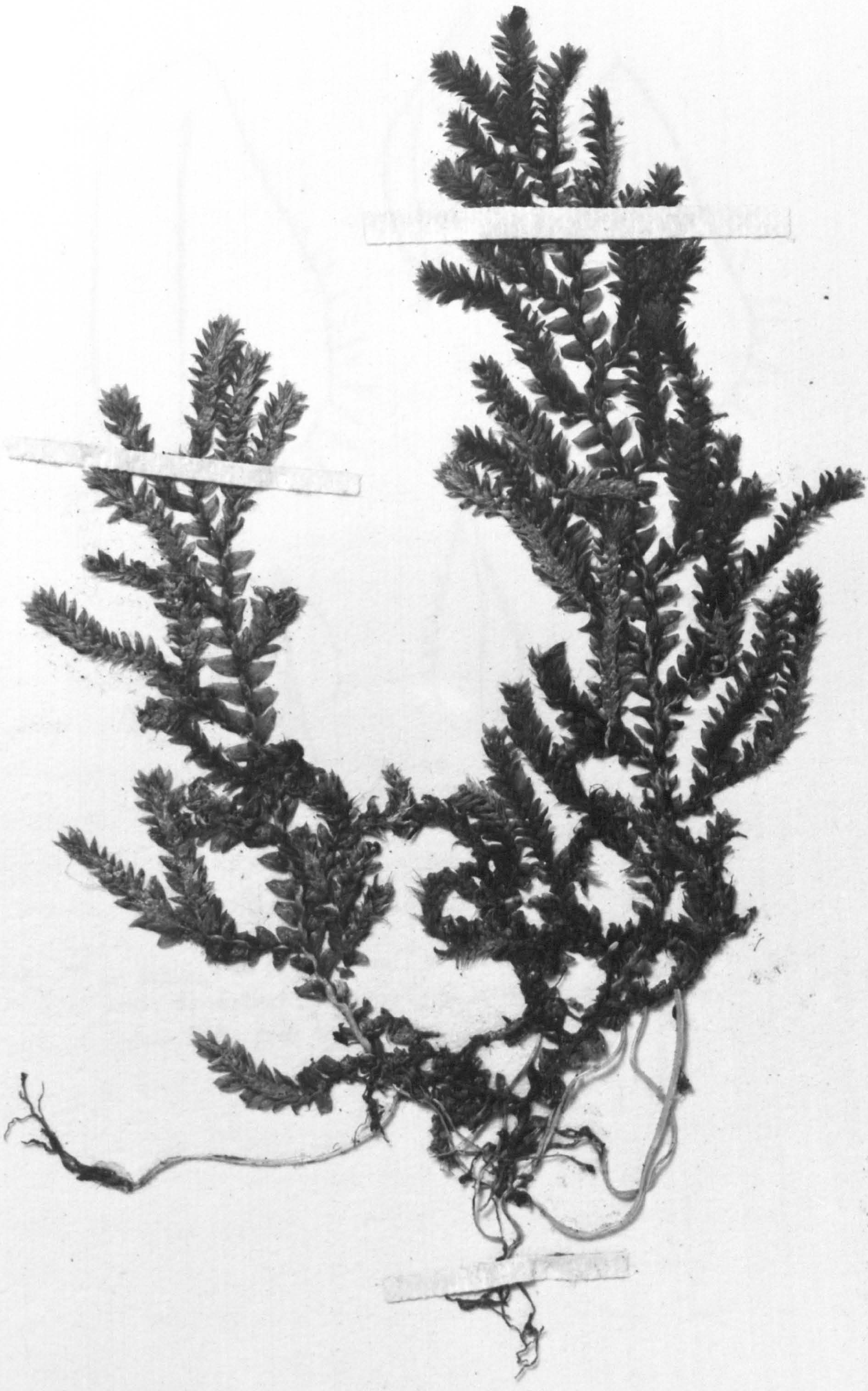
NIGERIA. Silang above Gurum, 1160 m, Hepper 1333 (K).

Geographical distribution: Guinea, Ghana, Togo, Nigeria.

PLATE 16

(see opposite page)

Specimen of *S. zechii*: Box 3506 (BM).



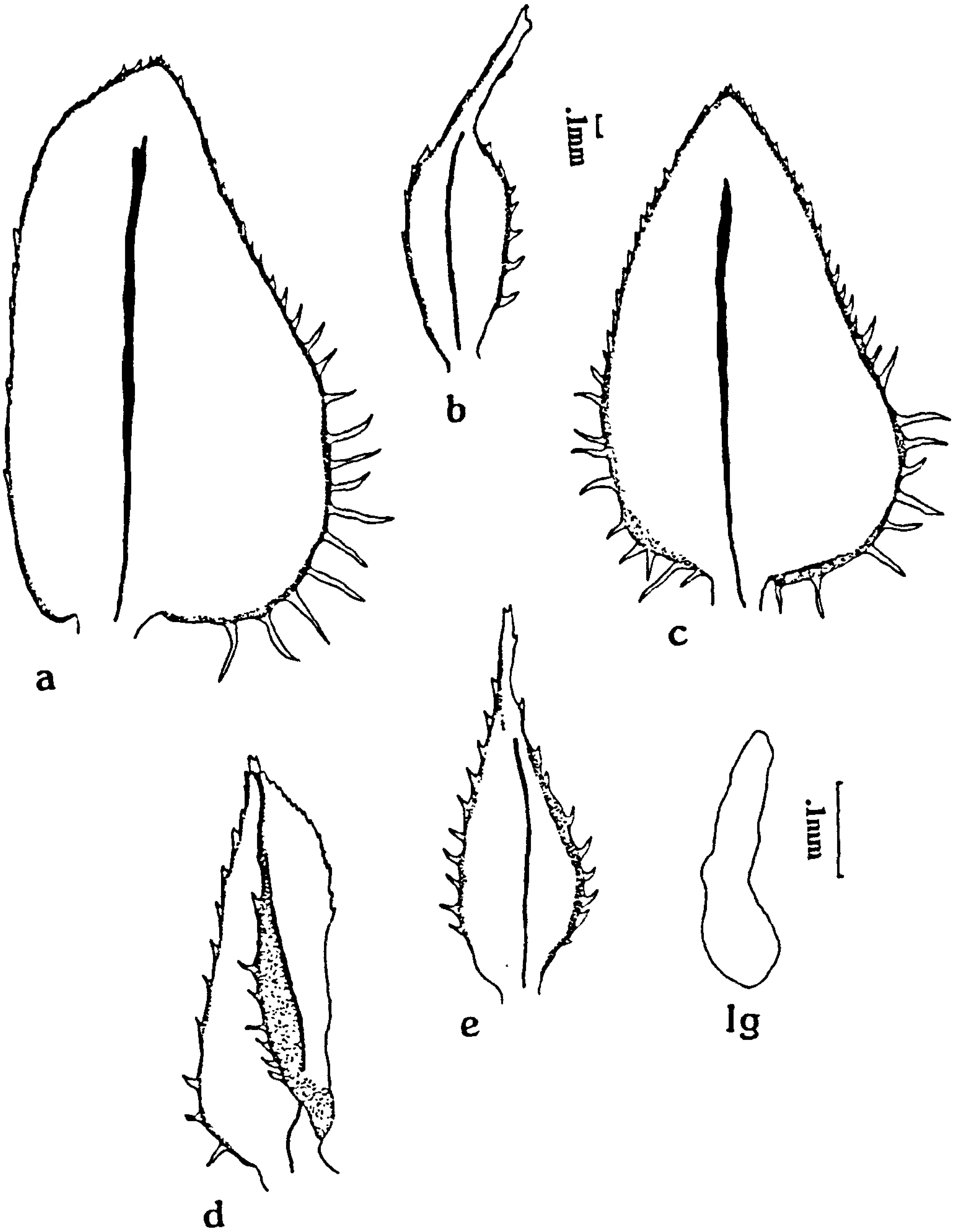


Fig. 17: S. zechii: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Box 3506.

Taxonomic notes: This species is recognized by its long ciliate leaves and the suboblanceolate median leaves.

10. S. protensa Alston in Mém. I.F.A.N. 50: 41 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 17; fig. 18. TYPE: IVORY COAST. Nimba N., 1575 m, Portères s.n. (P, holotype).

Description

Plants erect or suberect; branch-system 1-3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal quarter of plant.

Leaves anisophyllous, single-veined; stomata 38-41x20-23 µm; ligules up to 0.35 mm long, obturbinate. Lateral leaves asymmetrical, ovate-elliptic to deltate-oblong, up to 3.8x1.9 mm, base obtuse, apex acuminate, margins of basal half short-ciliate-sub-entire (cilia up to 0.12 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous cells at midvein region and elongate, sinous to straight-sided cells on lamina, with sclerotic cells forming patches and bands on lamina, stomata randomly distributed on lamina but concentrated along midvein, SI 5-($\bar{M}$7)-10. Median leaves asymmetrical, ovate-lanceolate, up to 2.3x0.8 mm, base obtuse, apex aristate (aristae up to same length as lamina), margins short-ciliate-distantly-serrate (cilia up to 0.12 mm long); ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, sinous cells, stomata randomly distributed along midvein to the base of aristae, SI 4-($\bar{M}$6)-7. Axillary leaves symmetrical, elliptic to ovate, up to 3.6x2.0 mm, base obtuse, apex acuminate, margins of basal third short-ciliate (cilia up to 0.14 mm long), apical two-thirds serrate; ligular surface epidermis with isodiametric, polygonal, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous cells, with sclerotic cells forming patches and bands on lamina, stomata randomly distributed on lamina, SI 12-($\bar{M}$14)-14.

Strobili bilateral, resupinate, at apices of branchlets, up to 6 mm long, with one sporangial arrangement: with dorsal side wholly megasporangiate and ventral sporophylls sterile. Sporophylls dimorphous. Ventral sporophylls ovate-lanceolate, up to 3.2x1.2mm, base obtuse, apex cuspidate to long acuminate, margins of basal half short-ciliate-sub-entire (cilia up to 0.13 mm long), apical half aculeate-serrate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata sparsely distributed on lamina and margins, SI 3-($\bar{M}$4)-4; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed on lamina, SI 3-($\bar{M}$4)-4; sporophyll-pteryx with aculeate to short-ciliate margin (cilia up to 0.14 mm long), with elongate, sinous cells. Dorsal sporophylls lanceolate, up to 1.8x0.6 mm, base obtuse, apex cuspidate, margins aculeate-short-ciliate (cilia up to 0.12 mm long); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed along midvein at aligular surface epidermis only, SI 6-($\bar{M}$8)-9. Megasporangia deltoid, with similar-sized spores; megaspores 210-(M254)-276 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces finely reticulate-rugulose. No microsporangia and microspores seen.

PLATE 17

(see opposite page)

S. protensa: Type specimen, Portères (P).

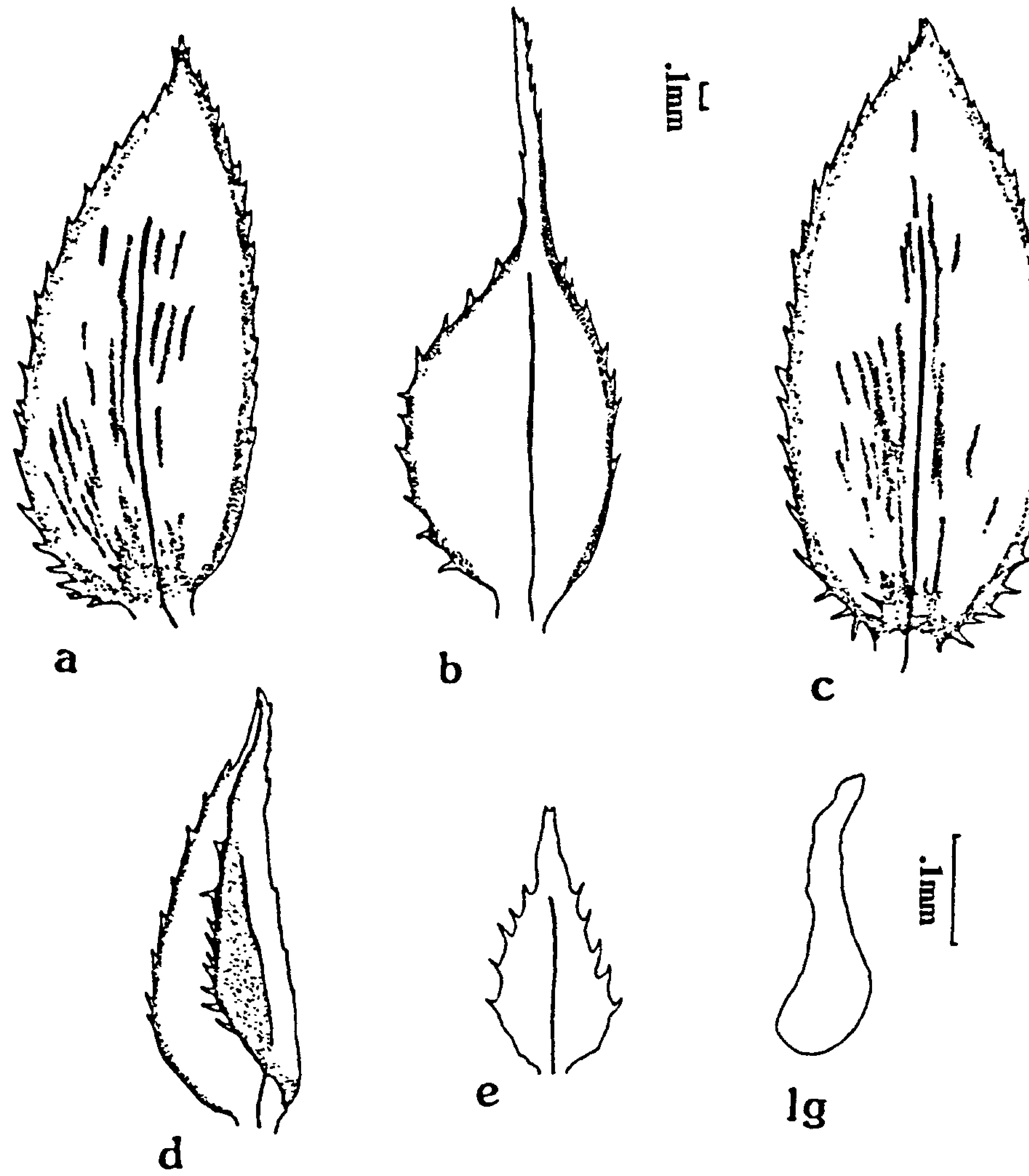


Fig. 18: S. protensa: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Portères s.n.

Ecological notes: On rocky grounds, up to 1575 m altitude.

Specimens examined

IVORY COAST. Nimba N: Zongue ravin, 1575 m, Portères s.n. (holotype, P; part of type, BM).

Geographical distribution: Ivory Coast.

Taxonomic notes: This species is recognized by its short ciliate margins and sterile ventral sporophylls.

11. *S. tenerrima* A.Br. ex Kuhn, Fil. Afr. 193 (1868); Baker, F. Allies 119 no. 320 (1887); Alston, Mém. I.F.A.N. 50: 41-42 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 18; fig. 19.

TYPE: ANGOLA. Golingo Alto, 1856, Welwitsch 45 (BM, holotype; BD, isotype).

Description

Plants erect or sub-erect, tufted; main stem branched at base; branch-system 1-3 pseudopinnate; rhizophores arising at axils of primary branches and restricted to basal quarter of plant. Plants sometimes unbranched.

Leaves anisophyllous, single-veined; stomata 26-35x19-25 µm; ligules up to 0.17 mm long, obclavate, occasionally with a curved tip. Lateral leaves asymmetrical, ovate-oblong, up to 2.3x1.0mm, base oblique (subcordate-obtuse), apex acute to apiculate, margins of basal half serrate-sub-entire, apical half serrate; ligular surface epidermis with isodiametric, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous to straight-sided cells, with sclerotic cells forming patches and bands on lamina, stomata evenly distributed on lamina and margins, SI 18-($\bar{M}$19)-20. Median leaves asymmetrical, narrowly deltate, up to 1.0x0.5 mm, base oblique (subcordate-truncate), apex cuspidate, margins serrate-aculeate; ligular surface epidermis with elongate, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata concentrated along midvein, SI 2-($\bar{M}$3)-4. Axillary leaves symmetrical, ovate-elliptic, up to 2.0x1.1 mm, base obtuse, apex mucronulate to acute, margins serrate-serrulate; ligular surface epidermis with isodiametric, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous to straight-sided cells, with sclerotic cells forming patches and bands on lamina, stomata evenly distributed on lamina and margins, SI 13-($\bar{M}$14)-15.

Strobili bilateral, resupinate, at apices of branches and/or branchlets, up to 5 mm long, with two sporangial arrangements : (i) cone wholly megasporangiate; (ii) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls sub-panduriform-elliptic, up to 1.9x0.7 mm, base obtuse, apex acuminate, margins serrate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina and margin, SI 9-($\bar{M}$10)-10; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed on margins, SI 1-($\bar{M}$1)-2; sporophyll-pteryx with aculeate-serrate margin, with elongate, sinous to straight-sided cells, with stomata (1-3) present at the outer side. Dorsal sporophylls ovate-lanceolate, up to 1.2x0.5 mm, base obtuse, apex cuspidate, margins short-ciliate-aculeate (cilia up to 0.12 mm long); both ligular and aligular surfaces epidermis with elongate, weakly sinous to straight-sided cells, stomata sparsely distributed along the midvein at the apical half of the aligular surface epidermis only, SI 3-($\bar{M}$3)-4. Megasporangia deltoid, with similar-sized spores; megaspores 160-($\bar{M}$195)-230 µm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces compactly reticulate. Microsporangia ellipsoid; microspores 30-($\bar{M}$35)-38 µm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces compactly scabrate.

Ecological notes: Wet shaded rocks, bare soils, around the bases of boulders in holes in soil, often associated with tiny bryophytes eg *Fissidens* spp. (Kornaś, 1983); from near sea level, c 750 m to 1200 m altitude.

Specimens examined

SIERRA LEONE. Kono: Tingi Mt., Morton & Gledhill SL 3151 (K).
NIGERIA. Shabe Rock, Hambler 1018 (BM); Ogoja: Ikom, Obokum, Keay FHI 28281 (BM); Jos Plateau: Naraguta F. R., Lawlor & Hall FHI 46545 (K).
CAMEROON. Bamenda: Bafut, Bafut-Wum Road, Metchen Falls, Savory UCI 313 (BM).

Also seen

ANGOLA. Golingo Alto: Serrado Alto, Welwitsch 45 (holotype, BM; BD) Lunda: Xa-Sengne, 1200 m, Exell & Mendoça 402 (BM).
ZAIRE. Kabanga: E'ville, Homblie 194 (BM).

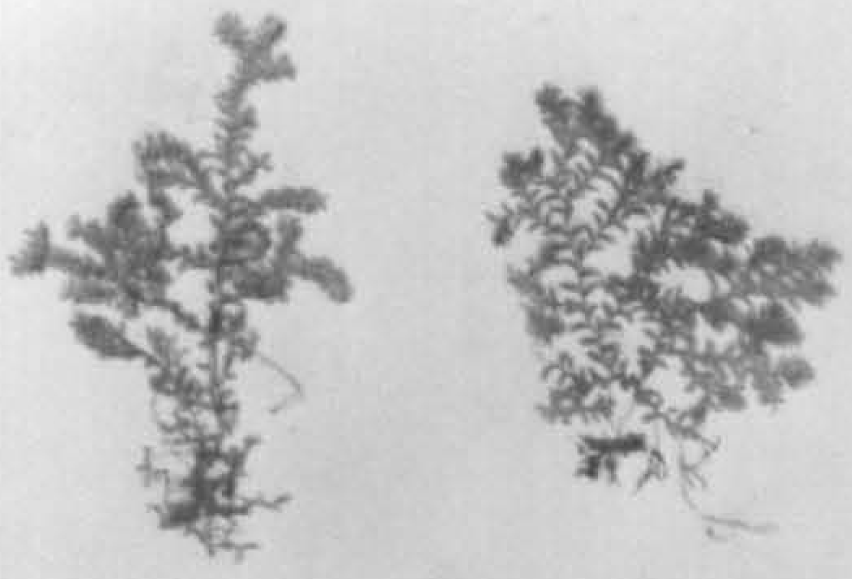
Geographical distribution: Guinea, Sierra Leone, Nigeria,

PLATE 18A

(see opposite page)

S. tenerrima: Type specimen, Welwitsch 45 (BD).

n. 45



WELW. ITER ANGOLENSE.

(Reg. II. 1,000—2,400 p. alt.) (Distr. GOLUNGO ALTO.)

No. 45. Selaginella tenerrima A.Br.

Habit. rarior ad rivulos in Sylvis primitiv. edit. de Serra de alta Queta
c.fr. Apr. 1856 leg. Dr. Welwitsch.

Typus!

Selaginella
tenerrima
mihi

Stengel monostelisch!

No. 45.
Selaginella tenerrima A.Br.

Golungo alto, rarior ad rivulos in silvis primitiv. edit. de Serra de Alta Queta
1000–2400 alt. Apr. 1856

leg. Dr. Welwitsch

Makrosporen schwefelgelb fast glatt.
Mikrosporen mennigroth glatt.

Selaginella tenerrima A.Br. ex Kuhn
holotypus
26.8.1983 det. M.P. Bizzarri

PLATE 18B

(see opposite page)

A-B. S. tenerrima: Close-ups of Type specimen showing bilateral resupinate strobili. A. ventral surface; B. dorsal surface. Scale in millimetres.


A
B

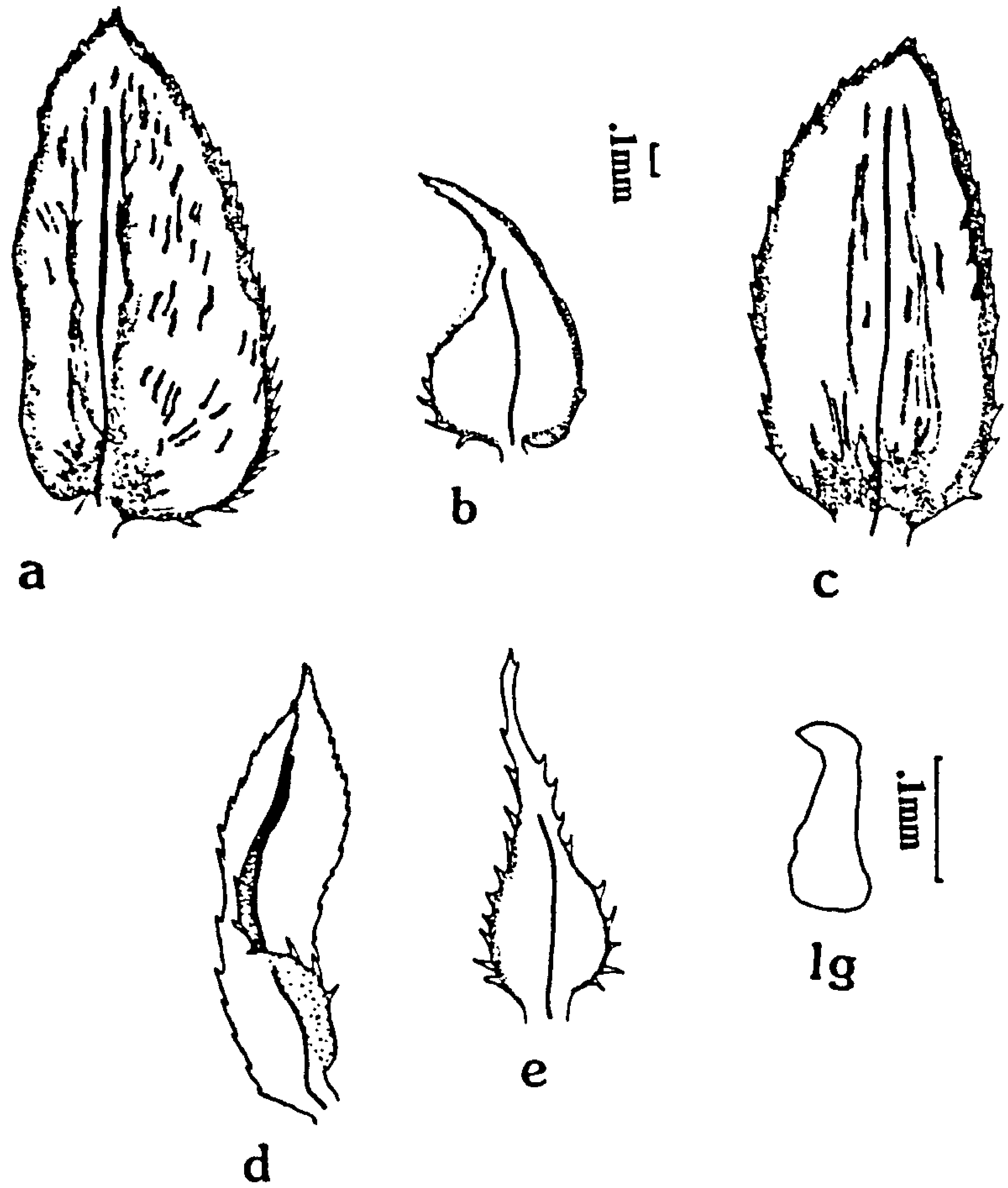


Fig. 19: S. tenerrima: a. lateral leaf; b. median leaf;
c. axillary leaf; d. ventral sporophyll;
e. dorsal sporophyll; lg. ligule. All from
Welwitsch 45.

Cameroon, Central African Republic, Zaire, Gabon, Angola, Zambia, Mozambique-Tropical regions of Africa.

Taxonomic notes: This species is recognized by its deltate, cuspidate median leaves, occasionally unbranched nature and compactly reticulate megaspores.

12. S. kalbreyeri Bak. in J. Bot. 22: 276 no. 157 (1884), F. Allies 77 no. 169 (1887); Alston & Abbayes, Bull. I.F.A.N. 13: 83 (1951); Alston, Mém. I.F.A.N. 50: 36 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 19; fig.20.
TYPE: CAMEROON. Likombé: 2 April, 1877, Kalbreyer 164 (BM, holotype).

Description

Plants erect, arching, pendent; branch-system 2-4 pseudopinnate and/or flabellate; rhizophores arising at the axils of primary branches and restricted to the basal quarter of plant or at tips of prolonged and pendent branches.

Leaves anisophyllous, single-veined; stomata 20-31x13-19μm; ligules up to 0.24 mm long, pedate, occasionally bifid. Lateral leaves asymmetrical, deltate-ovate, up to 3.5x1.5 mm, base oblique (subcordate-truncate), apex broadly acute to sub-obtuse, margins of basal half long-ciliate-serrate (cilia up to 0.45 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on lamina and less elongate, weakly sinous cells at the midvein region, with sclerotic cells occasionally present on lamina, stomata concentrated along midvein in 2-4 rows, SI 18-

($\bar{M}$18)-19. Median leaves asymmetrical, broadly deltate-ovate to subreniform, up to 1.7x1.3 mm, base cordate to weakly auriculate, apex caudate to aristate (aristae up to same length as lamina), margins long-ciliate-serrate (cilia up to 0.56 mm long); ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with isodiametric, sinous cells, stomata evenly distributed on lamina, SI 12-($\bar{M}$14)-14. Axillary leaves symmetrical, deltate, up to 3.3x1.5 mm, base cordate, apex acute, margins long-ciliate-serrate (cilia up to 0.40 mm long); ligular surface epidermis with isodiametric, sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on lamina and less elongate, weakly sinous cells at the midvein region, stomata concentrated along the midvein in 2-5 rows, SI 19-($\bar{M}$21)-21.

Strobili bilateral, resupinate, at apices of branchlets, up to 4.5 mm long, with one sporangial arrangement: with dorsal side containing a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls ovate-lanceolate, up to 1.8x0.9 mm, base obtuse, apex acuminate, margins aculeate-serrate, with a partial sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, slightly sinous cells, stomata sparsely distributed on lamina and midvein, SI 5-($\bar{M}$6)-7; aligular surface epidermis with isodiametric, sinous to straight-sided cells, stomata sparsely distributed on lamina, SI 2-($\bar{M}$2)-3; sporophyll-pteryx with serrate (aculeate) margin, with elongate, slightly sinous cells, stomata (1-3) present on the outer side. Dorsal sporophylls ovate, up to 1.1x0.6 mm, base obtuse to sub-truncate, apex cuspidate, margins serrate-serrulate; both ligular and aligular surfaces epidermis with elongate, sinous to straight-sided cells, stomata sparsely distributed along the midvein at aligular surface epidermis, SI 1-($\bar{M}$2)-2. Megasporangia ovoid-triangular, with similar-sized spores; megaspores 190-($\bar{M}$230)-280 μm in equatorial diameter, trilete, globose, both proximal and distal surfaces scabrate-verrucate. Microsporangia broadly oblong to ovoid; microspores 20-($\bar{M}$24)-32 μm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces verrucate.

Ecological notes: On wet rocks and banks of water-courses in more or less shaded districts in montane woodlands; up to 1450 m altitude.

Specimens examined

GUINEA. Dubreka: Mt. Kakoulima, 950 m, Abbayes 341 (BM); Wassif, Schnell 6672 (BM).

SIERRA LEONE. Loma Mt., Jaeger 234, 184 (K); l.c., Denkali, Jaeger 952 (K); l.c., above Yifin, Morton & Gledhill SL 1131 (K) l.c., Morton SL 2765 (K).

LIBERIA. Sanniquellie, Bahn, Harley F123 (BM); l.c., Baldwin Jr. 13133 (BM); Nimba Mt. near LAMCO, 1000 m, Leeuwenberg & Voorhoeve 4782 (K).

IVORY COAST. Man: Mt. Tonkoui, 1100 m, Abbayes 570 (BM); l.c., Abbayes 573 (BM); l.c., Cremers 40302 (K); Beoumi: Seguela, Abbayes 517 (BM).

GHANA. Adaklu, c 400 m, Hall & Seku GC 37012 (BM); l.c., 600 m, Hall GC43386 (K); Lake Bosomtwe, Irvine 5127 (K).

NIGERIA. Ondo: Akure, Idanre, Jones 3806 (BM).

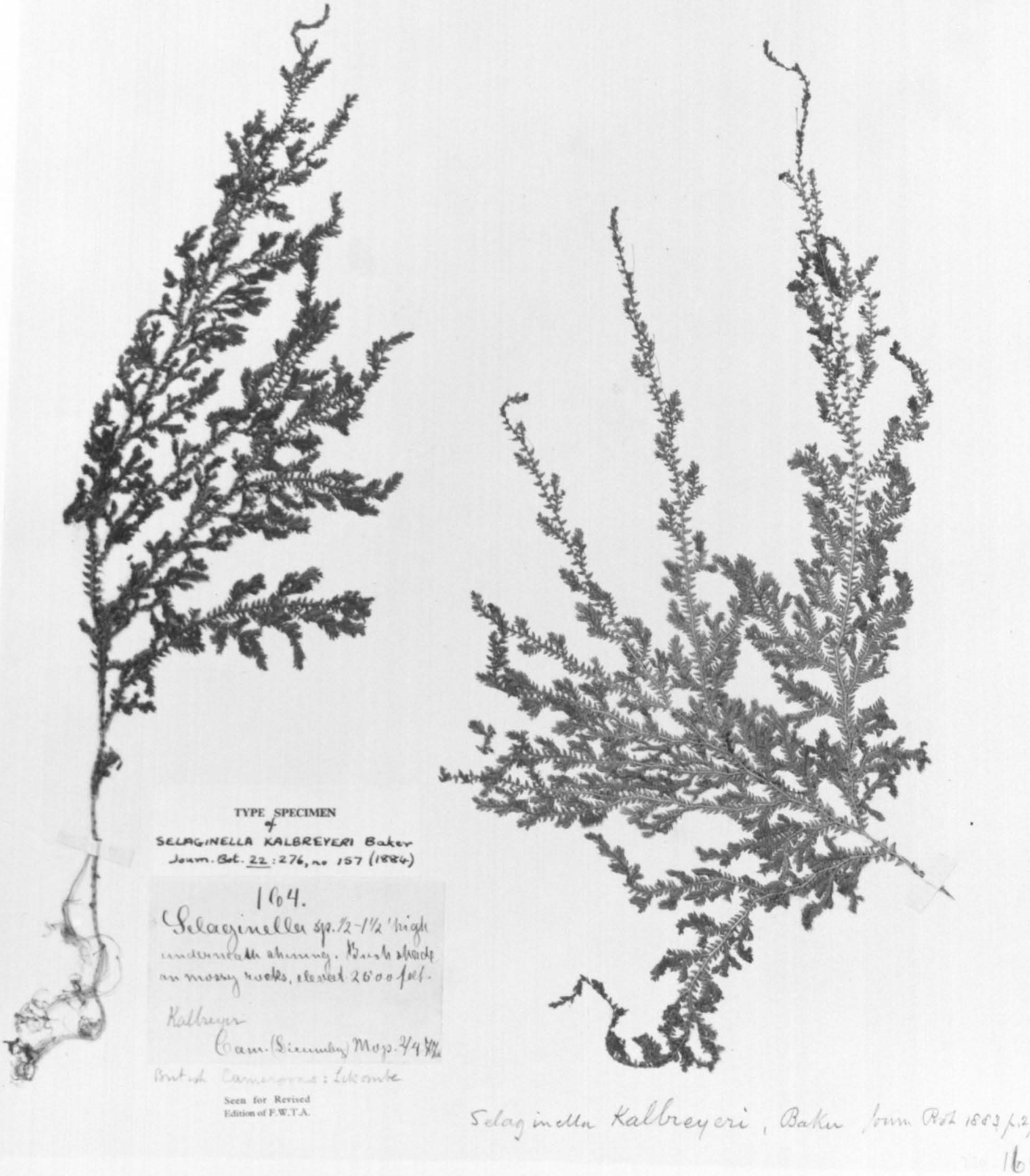
CAMEROON. Likombe, c 800m, Kalbreyer 164 (BM); Buea Forestry Plantation, Tryon & Tryon 6483 (K).

EQUATORIAL GUINEA. Fernando Po: Rio Iladyi, 1180-1190 m, Benl &

PLATE 19

(see opposite page)

S. kalbreyeri: Type specimen, Kalbreyer 164 (BM).


TYPE SPECIMEN
of
SELAGINELLA KALBREYERI Baker
Journ. Bot. 22: 276, no 157 (1884)
164.
Kalbreyer
Seen for Revised
Edition of F.W.T.A.
Selaginella Kalbreyeri, Baker
16

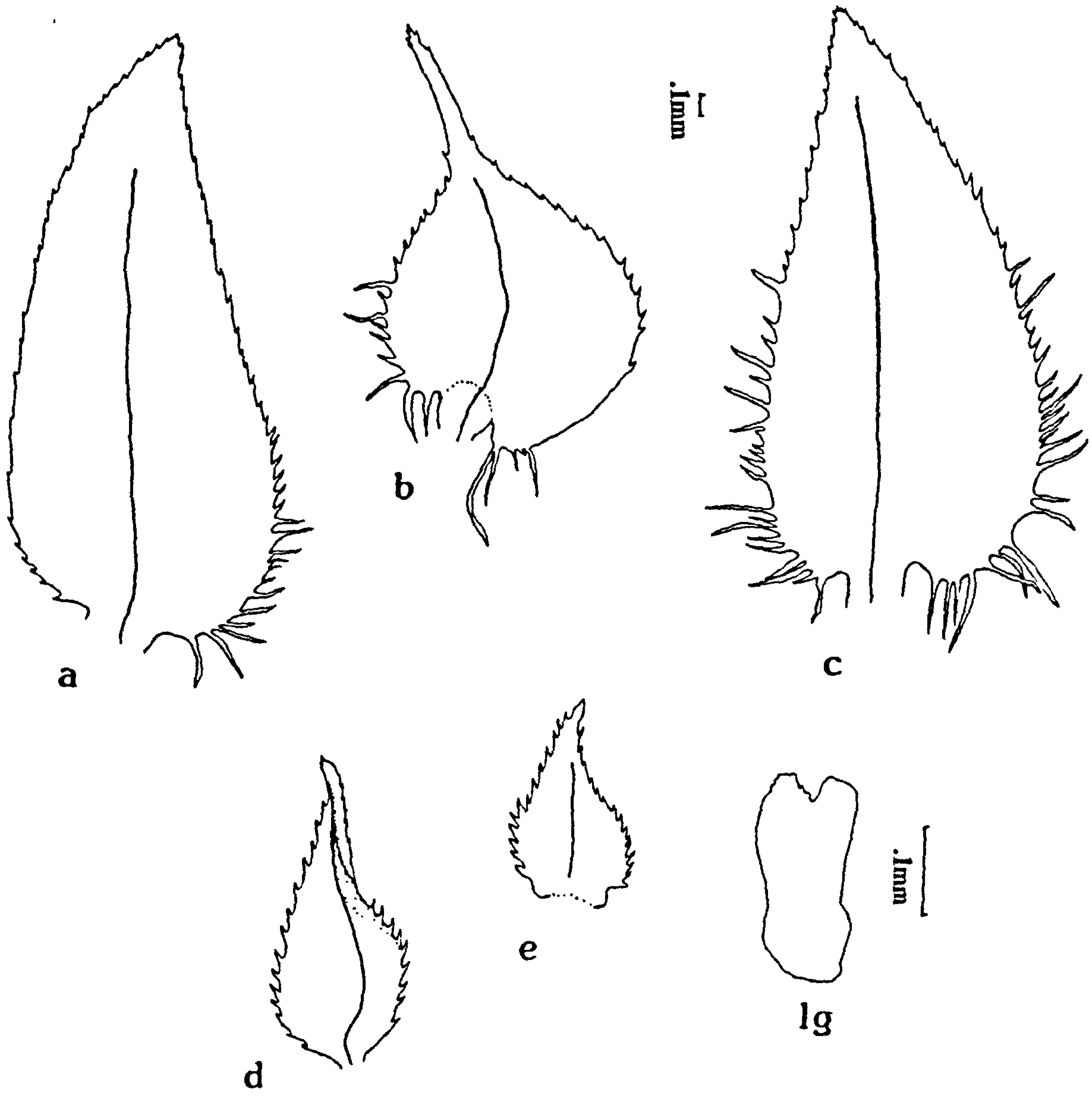


Fig. 20: S. kalbreyeri: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Abbayes 341.

Benl 172 (K).

Geographical distribution: Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea (FP), Gabon, Congo, Zaire, Uganda, Ethiopia.

Taxonomic notes: *S. kalbreyeri* is recognized by its pendent, arching stems; long ciliate leaf margins, and the partial sporophyll-pteryx.

13. *S. leoneensis* Hieron. in E. & P. Pflanzenfam. 1, 4: 697 (1901), Hedwigia 43: 54 no. 58 (1904); Knox, Trans. Edin. Bot. Soc. 35: 257 (1950); Alston, Mém. I.F.A.N. 50: 43 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 20; fig.21. TYPE: SIERRA LEONE. Freetown, Brown & Brown 79 (BD, holotype; K, P, isotypes).

Description

Plants erect or suberect, main stem branched at the base; branch systems 3-5 pseudopinnate; rhizophores arising at the axils of the primary branches and restricted to the basal third of the plant.

Leaves anisophyllous, single-veined; stomata 30-36x15-24 µm; ligules up to 0.24 mm long, obclavate. Lateral leaves asymmetrical, elliptic-oblong, up to 2.8x1.3 mm, base oblique, apex acute to weakly mucronulate, margins of basal half short ciliate-serrate (-sub-entire) (cilia up to 0.15 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, occasionally isodiametric, sinous cells, stomata randomly distributed on lamina, SI 14-($\bar{M}$16)-17. Median leaves asymmetrical, lanceolate, up to 1.4x0.5 mm, base obtuse to weakly attenuate, apex aristate (aristae up to 3/4 the length of lamina), margins distantly serrate; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed on lamina, SI 1-($\bar{M}$2)-3. Axillary leaves symmetrical, ovate, up to 2.6x1.4 mm, base obtuse, apex broadly acute to sub-obtuse, margins short ciliate-serrate (cilia up to 0.12 mm long); ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, occasionally isodiametric, sinous cells, stomata randomly distributed on lamina and margins, SI 13-($\bar{M}$15)-16.

Strobili bilateral, resupinate, at apices of branchlets, up to 10 mm long, with two sporangial arrangements: (i) cone wholly microsporangiate; (ii) with the dorsal side containing both megasporangia and microsporangia randomly arranged and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls ovate-sub-panduriform, up to 1.9x0.9 mm, base oblique (obtuse-truncate), apex apiculate, margins aculeate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina, SI 7-($\bar{M}$9)-10; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed on lamina and margins, SI 1-($\bar{M}$2)-2; sporophyll-pteryx with ciliate margin (cilia up to 0.18 mm long), with elongate, sinous cells, without stomata. Dorsal sporophylls narrowly ovate, up to 1.2x0.4 mm, base weakly obtuse, apex cuspidate, margins ciliate (cilia up to 0.20 mm long); both ligular and aligular surfaces epidermis with elongate, weakly sinous to straight-sided cells, occasionally, stomata sparsely distributed at the apical half on the midvein of the aligular surface epidermis only, SI 2-($\bar{M}$3)-3. Megasporangia ovoid-triangular, with 86.7% similar-sized and 13.3% 2L:2S spores; megaspores 190-($\bar{M}$220)-236 µm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces reticulate. Microsporangia ellipsoid; microspores 25-(M29)-34 µm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces granulose-papillate.

Ecological notes: On rocks, stones, or ground along paths through forests; also on shaded wet banks in forest; up to 1000 m altitude.

Specimens examined

SIERRA LEONE. Colony Peninsula: York Pass, 350 m, Deighton 3330 (BM, K); l.c., 300 m, Deighton 3331 (BM, K); l.c., Deighton 3326 (BM, K); Colony: Sugar Loaf Mt., c 300 m, Jones 346 (BM); l.c., Jones 347 (BM); Picket Hill, 700 m, Jones 324 (BM); Loma Mt., Morton SL 2764 (K); Bridge on Waterloo-York path, 950 m, Melville & Hooker 4686 (K); Freetown, Brown & Brown 79 (holotype BD; isotype K); Njala: Taia River bank, 150 m, Fay 1050 (NY); No localities: Lane-Poole 436 (K), Hart s.n. (K).

LIBERIA. Kitoma: Harley F161 (BM); Bilimu: Harley 2099 (BM); l.c., Harley F108 (K); Vonjama: Wohmen, Baldwin, Jr. 10068 (K).

IVORY COAST. Teke, 40 km N. d'Abidjan, Abbayes 295 (BM); l.c., Abbayes 296 (BM); Yapo, 45 km N. d'Abidjan, Abbayes 258 (BM);

PLATE 20

(see opposite page)

S. leoneensis: Type specimens, Brown & Brown 79 (BD).

FROM
THE UNITED STATES NATIONAL HERBARIUM
UNITED STATES ECLIPSE EXPEDITION TO WESTERN AFRICA

Free Town, Sierra Leone, Africa.
W. H. BROWN, } Collectors. No. 79. Nov. 19. 1889
A. H. BROWN, }

Stengel monostelisch!

unterscheidet sich von S. Preussii Hieron. durch etwas herablaufende Unterblätter, durch spitzere dorsale Brakteen, noch längeren [illegible] verschiedene ventrale und das Fehlen von Ausläufern.
det. G. Hieronymus.

Makrosporen schwefelgelb, glatt
Mikrosporen mennig roth, glatt.

FROM
THE UNITED STATES NATIONAL HERBARIUM
UNITED STATES ECLIPSE EXPEDITION TO WESTERN AFRICA

Free Town, Sierra Leone, Africa.
H. BROWN, } Collectors. No. 79. Nov. 19. 1889
H. BROWN, }

Selaginella leoneensis
Hieron. n. sp.
det. G. Hieronymus.

843

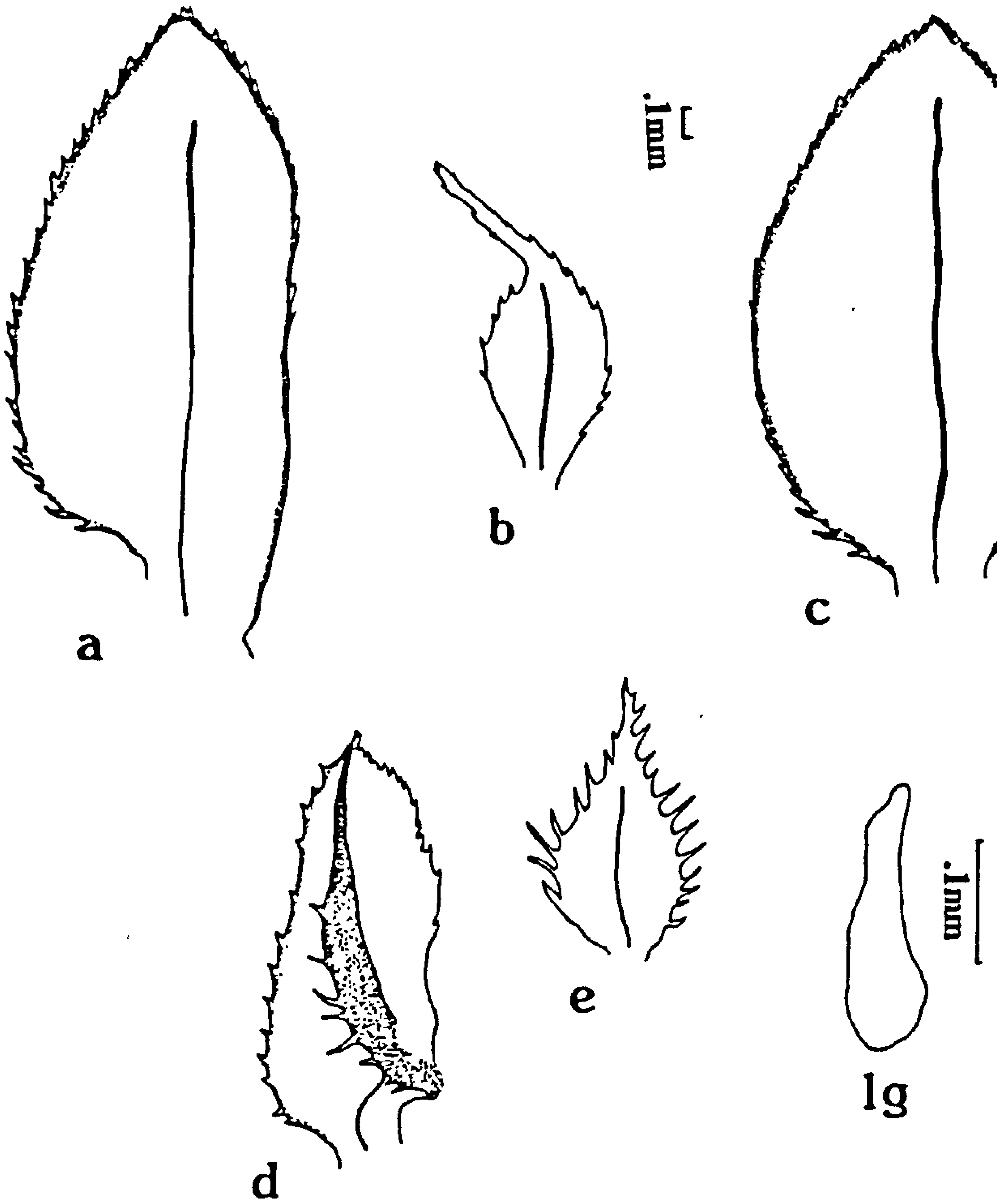


Fig. 21: S. leoneensis: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Harley F161.

Memba, 45 km N. d'Abidjan, Abbayes 293 (BM).

NIGERIA. Abakaliki, Baldwin Jr. 13811 (BM); Obudu: Sonkwala, Balinge-Ikwette path, Savory & Keay FHI 25157 (BM); Ondo: Akure, Idanre, c 300 m, Savory UCI 41 (BM); l.c., Richards 3805 (BM); l.c., Brenan 3852 (BM); l.c., Keay FHI 22669 (BM); l.c., Keay FHI 25497 (BM); l.c., Keay FHI 25499 (BM); l.c., Jones 3824 (K); Oyo: Ile Ife, University of Ife Campus, Hall 16 (K).

CAMEROON. Bamenda: Bafut, Savory UCI 294 (BM); l.c., mile 44 from Mamfe, c 450 m, Keay FHI 28546 (BM).

Geographical distribution: Guinea, Sierra Leone, Liberia, Ivory Coast, Nigeria, Cameroon.

Taxonomic notes: This species is recognized by its widely spaced lateral leaves combined with the short ciliate lateral and axillary leaves and ciliate dorsal sporophylls.

14. *S. molleri* Hieron. in E. & P. Pflanzenfam. 1, 4: 697 (1901), Hedwigia 43: 52 no. 57 (1904); Alston, in Exell, Cat. Vasc. Pl. S. Tomé 97 (1944), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 21; fig. 22.

TYPE: SÂO TOMÉ. Bom Successo, 1250 m, Moller 79 pp (BM, holotype; K, isotype).

Description

Plants erect or suberect, main stem branched at the base; branch-system 1-2 pseudopinnate; rhizophores arising at the axils of the primary branches and restricted to the basal third of the plant.

Leaves anisophyllous, single-veined; stomata 31-35x15-23 μm; ligules up to 0.27 mm long, obclavate. Lateral leaves asymmetrical, ovate-elliptic, up to 2.8x1.2 mm, base obtuse, apex acute, margins short-ciliate-serrate (cilia up to 0.13 mm long); ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous, occasionally isodiametric cells, with sclerotic cells forming patches and bands on lamina, stomata, more or less, evenly distributed on lamina, also on margins, SI 17-($\bar{M}$18)-19. Median leaves asymmetrical, elliptic-ovate to broadly lanceolate, up to 2.0x0.8 mm, base oblique (obtuse-cuneate), apex aristate (aristae 2/3 to same length as lamina), margins short-ciliate (cilia up to 0.14 mm long); ligular surface epidermis with elongate, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with isodiametric, straight-sided cells, stomata evenly distributed on lamina, also on arista, SI 8-($\bar{M}$9)-9. Axillary leaves symmetrical, ovate, up to 2.6x1.4 mm, base obtuse, apex acute to apiculate, margins of basal half short-ciliate (cilia up to 0.13 mm long), apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous to straight-sided cells, stomata, more or less evenly distributed on lamina, also on margins, SI 15-($\bar{M}$17)-19.

Strobili bilateral, resupinate, at apices of branches and/or branchlets, with both determinate and intermittent growth patterns, with one sporangial arrangement: cone with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls oblong-ovate, up to 2.0x1.0 mm, base oblique, apex acute to acuminate, margins short-ciliate-double serrate (cilia up to 0.12 mm long), with complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous, occasionally straight-sided cells, stomata randomly distributed on lamina and margins, SI 11-($\bar{M}$13)-14; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata randomly distributed on lamina, SI 8-($\bar{M}$9)-9; sporophyll-pteryx with short-ciliate margin (cilia up to 0.11 mm long), with elongate, sinous to straight-sided cells, without stomata. Dorsal sporophylls trullate to ovate, up to 1.5x0.8 mm, base subcordate, apex cuspidate, margins short-ciliate (cilia up to 0.12 mm long); both ligular and aligular surfaces epidermis with elongate, weakly sinous to straight-sided cells, stomata sparsely distributed along the midvein at the apical half of the aligular surface epidermis only, SI 2-($\bar{M}$3)-3. Megasporangia deltoid, with similar-sized spores; megaspores 225-($\bar{M}$237)-280 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces rugulose. Microsporangia oblong-ellipsoid; microspores 29-($\bar{M}$36)-40 µm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces scabrate-verrucate.

Ecological notes: On mossy rocks, under bushes, on banks in forest and near waterfalls, rarely as an 'epiphyte' on tree ferns and other trees; up to 1300 m altitude.

PLATE 21A

(see opposite page)

Specimen of *S. molleri*: Exell 180 (BM).

PLATE 21B

(see opposite page)

A-B. Specimen of *S. molleri*; A. Part of specimen; B. Close-up showing intermittent growth pattern in a bilateral resupinate strobilus. Both from Exell 180 (BM). Scale in millimetres.


A
B

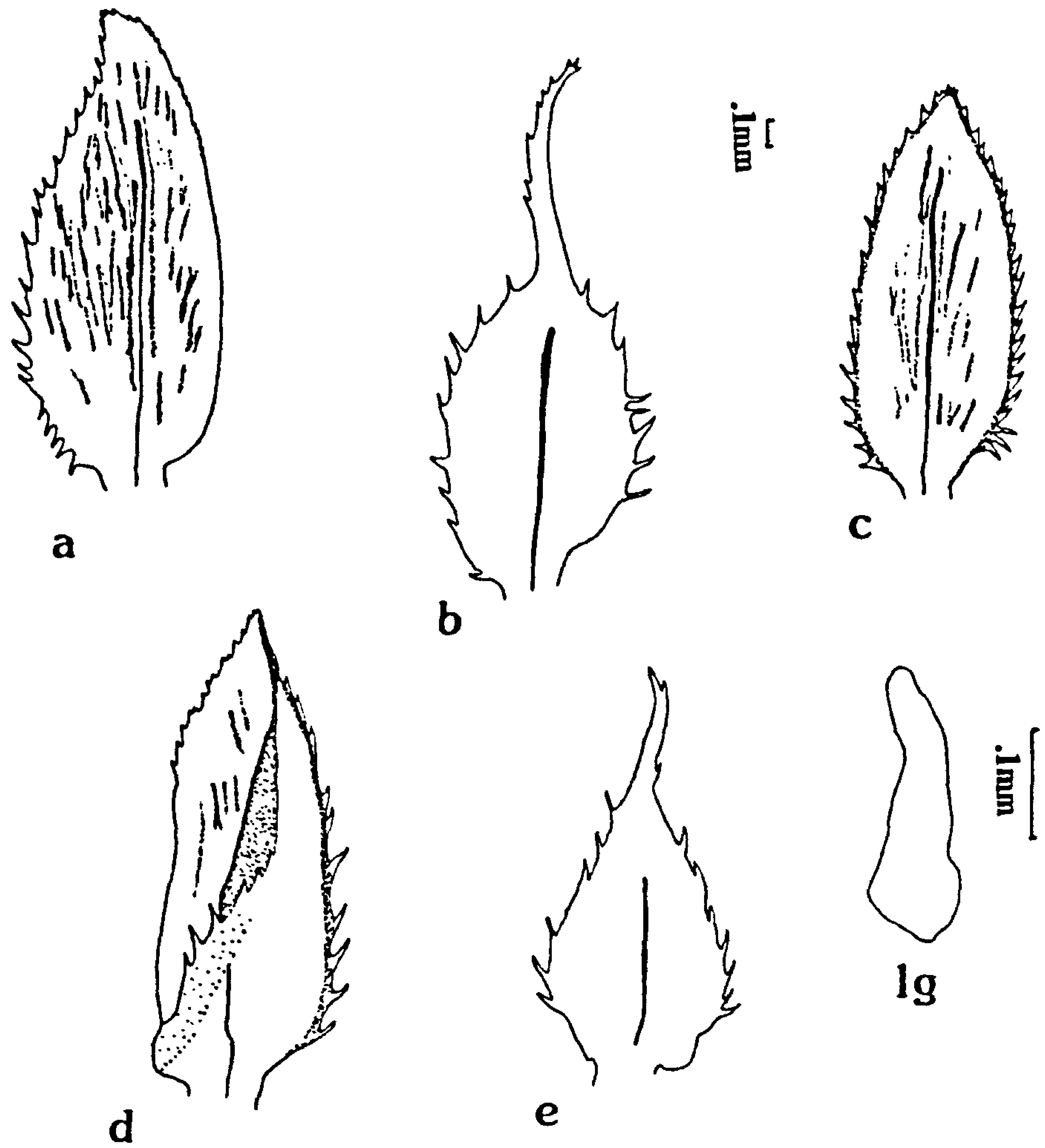


Fig. 22: S. molleri: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Moller 79pp.

Specimens examined

NIGERIA. Ondo: Orosun, Idanre Hills, c 900 m, Keay FHI 25522 (BM), l.c., Keay FHI 25516 (BM); l.c., Richards 3785 (K); Between William Camp and Marhai, near Farun Rua, Hall 645 (K); Panshanu F.R., 900 m, Drew 244 (K); l.c., foothill leading to Ziem Peak, 950 m, Lawlor & Hall 433 (K); Sardanna: Mambilla Plateau; Chapman 100 (K).

CAMEROON. Nyasoso, 800 m, Thorold 17 (K).

EQUATORIAL GUINEA. Fernando Po: Lago Biao, c 1300 m, Melville 662 (BM, K).

Also seen

SAO TOME. Bom Successo, 1250 m, Moller 79 pp (holotype, BM; isotype, K); Macambrara: Vanhulst, c 1100-1300 m, Exell 180 (BM); Santa Maria, mule track between Jamar and Santa Maria, c 1300 m, Exell 261 (BM).

Geographical distribution: Liberia, Nigeria, Cameroon, Equatorial Guinea (FP), Sâo Tomé.

Taxonomic notes: S. molleri is distinguished from S. thomensis by its short ciliate leaves, median leaves with aristate apices and occasional intermittent strobili growth pattern.

15. S. molliceps Spring in Mem. Acad. Belg. 24: 257 (1850); Baker, F. Allies 120 no 325 (1887); Sim F.S.A. 2nd Ed: 339, t. 183 (1915); Alston, J. Bot. 72 (Suppl. 2): 11 (1934), Mém. Soc. Linn.

Normandie Bot. 1: 81 (1938), in Exell, Cat. Vasc. Pl. S. Tomé, 97 (1944); Alston & Abbayes, Bull. I.F.A.N. 13: 84 (1951); Adams & Alston, Bull. Brit. Mus (Nat. Hist.) Bot. 1: 183 (1955); Alston, Mém. I.F.A.N. 50: 43-44 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 22; fig. 23.

TYPE: PRINCIPE. Afrique Occidentale, (herb. Hooker), Curror s.n. (K).

Nomenclature

SYNONYM: S. rubricaulis Hort. (1859)

TYPE: ANGOLA. Golingo Alto. c 800 m, Welwitsch 46, 47 (K, holotype; BM, isotype).

Description

Plants suberect to erect; branching from the base, branch-systems 2-3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant.

Leaves anisophyllous, single-veined; stomata 30-39x13-18 µm; ligules up to 0.38 mm long, elongate obclavate. Lateral leaves asymmetrical, ovate-oblong to elliptic-oblong, up to 3.0x1.3 mm, base oblique, apex subobtuse to weakly mucronulate, margins ciliate-serrate (cilia up to 0.25 mm long); ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, sinous cells, with sclerotic cells forming patches on lamina, stomata concentrated along the midvein in 1-2 rows and scattered on the margins, SI 10-($\bar{M}$13)-14. Median leaves asymmetrical, lanceolate, up to 1.7x0.7 mm, base obtuse (attenuate), apex cuspidate to aristate (aristae up to 1/3 the length of lamina), margins ciliate-distantly serrate (cilia up to 0.23 mm long); ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, sinous cells, stomata concentrated along the midvein in 1-2 rows and scattered on the margins and on the basal third of arista, SI 3-($\bar{M}$4)-5. Axillary leaves symmetrical, elliptic-ovate, up to 2.8x1.5 mm, base obtuse, apex broadly acute to subobtuse, margins ciliate at the basal half (cilia up to 0.23 mm long) and serrate at the apical half; ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, sinous cells, with sclerotic cells forming patches on lamina, stomata concentrated along the midvein in 1-3 rows and scattered on the margins, SI 14-($\bar{M}$15)-16.

Strobili bilateral, resupinate, at apices of branches and/or branchlets, up to 15 mm long, with four sporangial arrangements: (i) cone wholly megasporangiate; (ii) with dorsal side wholly megasporangiate and ventral side wholly microsporangiate; (iii) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged; (iv) cone wholly microsporangiate. Sporohylls dimorphous. Ventral sporophylls lanceolate-elliptic, up to 2.1x1.0 mm, base oblique, apex subretuse or acute-apiculate, margins short ciliate-serrate (cilia up to 0.13 mm long) to aculeate-subentire, with complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata randomly distributed on the lamina of the 'folded' side, SI 6-($\bar{M}$7)-9; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed along the margins, SI 1-($\bar{M}$2)-3; sporophyll-pteryx with short ciliate-serrate margin (cilia up to 0.14 mm long), with elongate, sinous cells and stomata sparsely distributed (1-2) at the outer side. Dorsal sporohylls lanceolate, up to 1.2x0.4 mm, base obtuse, apex cuspidate to aristate (aristae up to 2/3 the length of lamina), margins ciliate (cilia up 0.20 mm long); ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous cells at the midvein region and elongate, straight-sided cells at the lamina region, stomata more or less evenly distributed along the midvein in 1-2 rows, SI 2-($\bar{M}$3)-3. Megasporangia deltoid, with 88.8% similar-sized and 11.2% 3L: 1S spores; megaspores 185-($\bar{M}$240)-275 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces reticulate. Microsporangia ellipsoid; microspores 24-($\bar{M}$28)-33 µm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces compactly scabrate.

Ecological notes: Usually growing on laterite banks of water courses in shady forest and on boulders. Also found along paths and roads; primarily reported from rain forests below 1000 m altitude, occasionally found at 2000 m.

Specimens examined

GUINEA. Dintinn: Fouta-Djallon, 750 m, Abbayes 867 (BM); Damane to Nzo Road, Gouee Bridge, 400 m, Abbayes 600 (BM).

LIBERIA. Webo: Diebla, Baldwin Jr. 6288 (BM); Tappita, Baldwin Jr. 9103 (BM).

IVORY COAST. Teke forest, Abbayes 296 (BM).

GHANA. Aburi, c 500 m, Thompson 1898 (BM); Nfuom: Kakum F.R., c 200 m, Box 2919 (BM); l.c., Box 2862 (BM); l.c., c 100 m, Box 2915 (BM); l.c., Box 2935 (BM); l.c., Box 2855 (BM); Potroasi, Adams 183 (BM); Kibi: Puso Puso ravine, c 400 - 500 m, Box 3256 (BM); Foso: Foso-Juaso F. R., c 150 m, Box 2487 (BM); l.c., Spholes 251 (BM); Akim: Kibi Hills, Johnson 506 (K); Dominasi: Dominasi Bridge on River Ankobra, Hall 2679 (BM); Awiebo, Hall 3389 (BM); No localities: Irvine 3537 (BM); Forte 49 (BM).

TOGO. Fomana, c 300 m, Box 2912 (BM).

NIGERIA. Benin: Ehor and Ibekwe, c 100 m, Fiarbairn 8 (BM); Bamenda: Bafut-Wum Road, Metchen Falls, Savory UCI 313 (BM); Calabar: Kwa Falls, Richards 4005 (BM); Ikom: Ogoja, Aboabam, Keay FHI 28232 (BM); Mambilla Plateau, Chapman 2697 (K).

CAMEROON. Urwaldgebiet: Bipinde, Zenker 4104 (BM); Kumba: Banga, S. Bakundu F.R., Richards 4028 (BM, K); Man of War Bay, Schlechter 12392 (BM); Barombi: Barombi Station, Preuss 305 (BM); Yaounde: Yaounde Station, c 800 m, Zenker & Staudt 176 (BM); Bertoua to Yaounde, Nickles 123 (BM); Mt. Bamboutos, c 2000 m, Nickles 48 (BM); No locality: Zenker 1846 (BM).

EQUATORIAL GUINEA. Fernando Po: Ureka, c 150 m, Thorold TF 33A (BM); Monte Balea, Guinea 495 (BM); l.c., Guinea 511 (BM); Biao, c 2000 m, Melville 468 (BM); 'Fishtown', c 50 m, Benl & Benl FP 259 (BM); No locality: Barter 1399, 2041 (K).

PLATE 22

(see opposite page)

S. molliceps: Type specimen, Welwitsch 47 (BM).

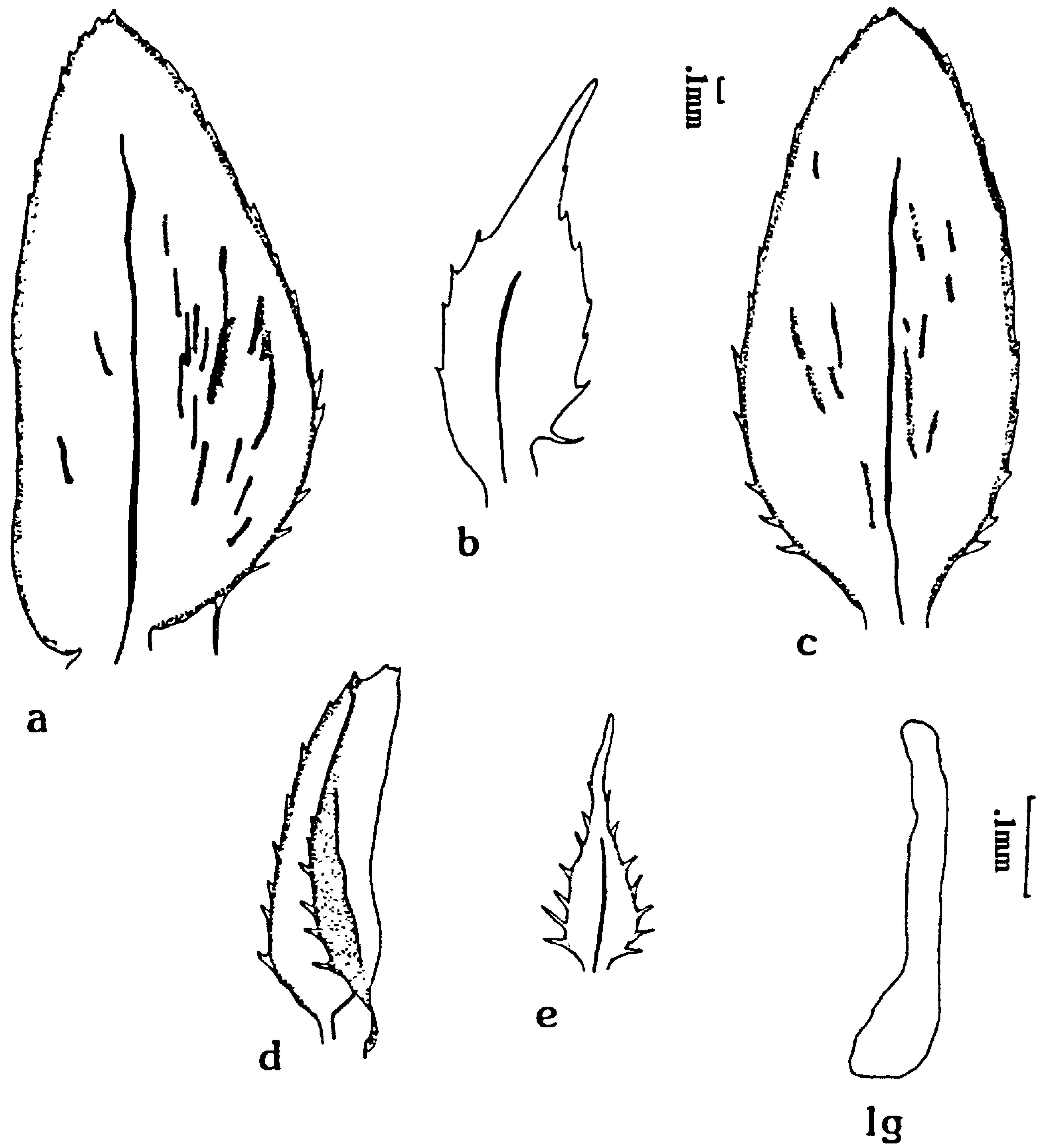


Fig. 23: S. molliceps: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Exell 500.

Also seen

ANGOLA. Golingo Alto, c 800 m, Welwitsch 46, 47 (BM, K; Type of S. rubricaulis Hort.).

PRINCIPE. Pico de Papagaio, c 900 m, Welwitsch II (BM, K); Ôque Pipi, c 300 m, Exell 500 (BM).

Geographical distribution: Guinea, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea (RM, FP); São Tomé, Principe, Gabon, Congo, Zaire, Angola.

Taxonomic notes: This species is closely allied to S. hildebrandtii from Madagascar from which it is distinguished by its ciliate leaf margins. It is recognized in West Africa by its subretuse ventral sporophylls.

16. S. subcordata A. Br. ex Kuhn Fil. Afr. 193 (1868); Baker F. Allies 119 no. 321 (1887); Knox, Trans. Edinb. Bot. Soc. 35: 268 (1950); Alston & Abbayes, Bull. I.F.A.N. 38: 84 (1951); Alston, Mém. I.F.A.N. 50: 40-41 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 23 ; fig. 24.

TYPE: SIERRA LEONE. Freetown, Sept. 1853, Welwitsch 3 (BM, holotype).

Description

Plants erect or sub-erect, main stem branched from the base, branch-systems 1-3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant. Plants may be simple (unbranched).

Leaves anisophyllous, single-veined; stomata 26-30x10-24 µm; ligules up to 0.24 mm long, narrowly sub-obclavate. Lateral leaves asymmetrical, weakly deltate, up to 2.5x1.3 mm, base cordate-subcordate, apex acuminate, margins of basal half ciliate-serrate (cilia up 0.22 mm long), apical half serrate; ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, sinous to undulating cells, stomata randomly distributed along the midvein and margins, SI 11-($\bar{M}$11)-12. Median leaves asymmetrical, ovate-lanceolate, keeled, up to 1.3x0.6 mm, base sub-obtuse, apex aristate (aristae up to 2/3 the length of lamina), margins short-ciliate-serrate (cilia up to 0.15 mm long); ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed on lamina, SI 3-($\bar{M}$3)-4. Axillary leaves symmetrical, ovate to weakly deltate, up to 2.5x1.5 mm, base cordate, apex apiculate, margins of basal third ciliate (cilia up to 0.24 mm long), apical two-thirds serrate-serrulate; ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, sinous to undulating cells, stomata randomly distributed on lamina and margins, SI 10-($\bar{M}$10)-12.

Strobili bilateral, resupinate, at apices of branchlets, up to 4.3 mm long, with two sporangial arrangements: (i) with dorsal side wholly megasporangiate and ventral side with sterile sporophylls, (ii) with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side with sterile sporohylls. Sporophylls dimorphous. Ventral sporophylls oblong-elliptic, up to 2.2x1.1 mm, base obtuse, apex acuminate, margins of basal quarter ciliate (cilia up to 0.25 mm long), apical 3/4 aculeate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina, SI 8-($\bar{M}$8)-9; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed on and/or towards the margins, SI 4-($\bar{M}$4)-5; sporophyll-pteryx with ciliate-serrate margin (cilia up to 0.24 mm long), with elongate, sinous to straight-sided cells, without stomata. Dorsal sporophylls ovate, up to 1.6x0.7 mm, base obtuse, apex cuspidate, margins long-ciliate (cilia up to 0.35 mm long); both ligular and aligular surfaces epidermis with elongate, sinous to straight-sided cells, stomata sparsely distributed along midvein at the apical third of the aligular surface epidermis only, SI 6-($\bar{M}$6)-7. Megasporangia ovoid-triangular, with 89.4% similar-sized and 10.6% 3L:1S spores; megaspores 200-($\bar{M}$230)-255 µm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces rugulose. Microsporangia roundish; microspores 30-($\bar{M}$38)-42 µm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces verrucate-clavate.

Ecological notes: On ground, on rocks in shade in both savannah and fringing forest; sea level to 1300 m altitude.

Specimens examined

GUINEA. Dalabo: Schnell 7011 (BM, K); l.c., Fouta-Djallon, Abbayes 814 (BM); Gouee: Abbayes 599 (BM); Mt Kakoulima: Schnell 7538 (BM).

SIERRA LEONE. Freetown: Welwitsch 3 (holotype, BM; isotype, K); l.c., Lewis s.n. (BM); Mano: Njala, Deighton 3087A, 3087B (BM); Colony Peninsula: York, Deighton 3292 (BM, K); Kanga: 500 m, Thomas 2971 (K); Waterloo: Melville & Hooker 266 (K); Hill Station: Deighton 528 (K); Loma Mt., Morton SL2761 (K); l.c., Jaeger 231, 1578, 2033 (K); Musaia: Agric. Station, c 400 m, Sellar B15 (BM).

LIBERIA. Boporo: Tawata, Baldwin, Jr. 10348 (BM, K); Sanniquellie: Sacampa Village, Winne 77 (BM); Jamesville: Harley F209 (BM).

IVORY COAST. Man: Mt. Tonkoui, 1050 m, Abbayes 231 (BM); Seguela, Ake Assi 6671 (K).

GHANA. Damongo: Hall 831 (BM).

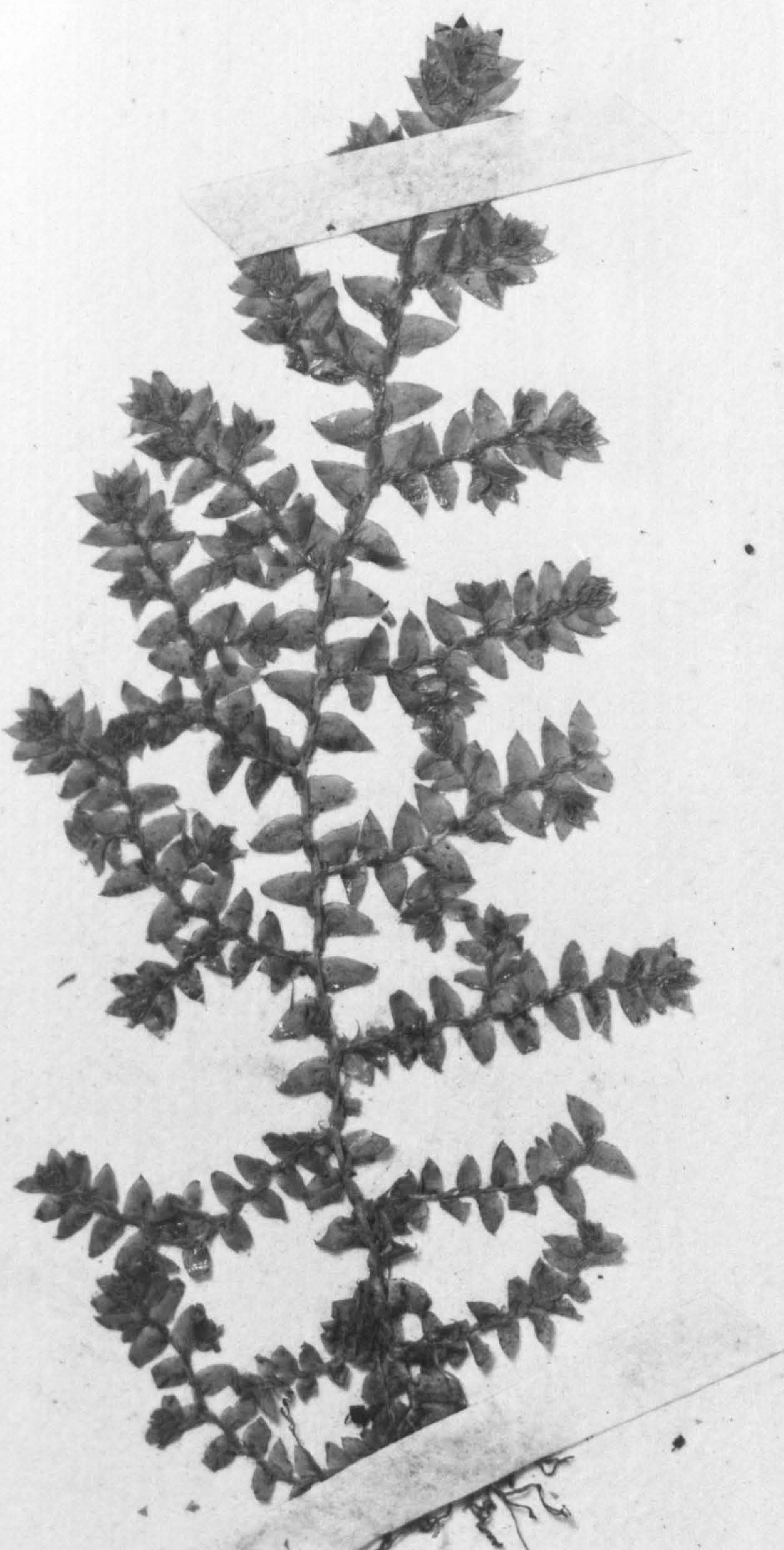
Geographical distribution: Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Congo.

Taxonomic notes: S. subcordata is recognized by its keeled median leaves; lateral leaves with acuminate apices, dorsal sporophylls with long ciliate margins and sterile ventral sporophylls.

PLATE 23

(see opposite page)

S. subcordata: Type specimen, Welwitsch 3 (BM).



3\. Sierra Leone

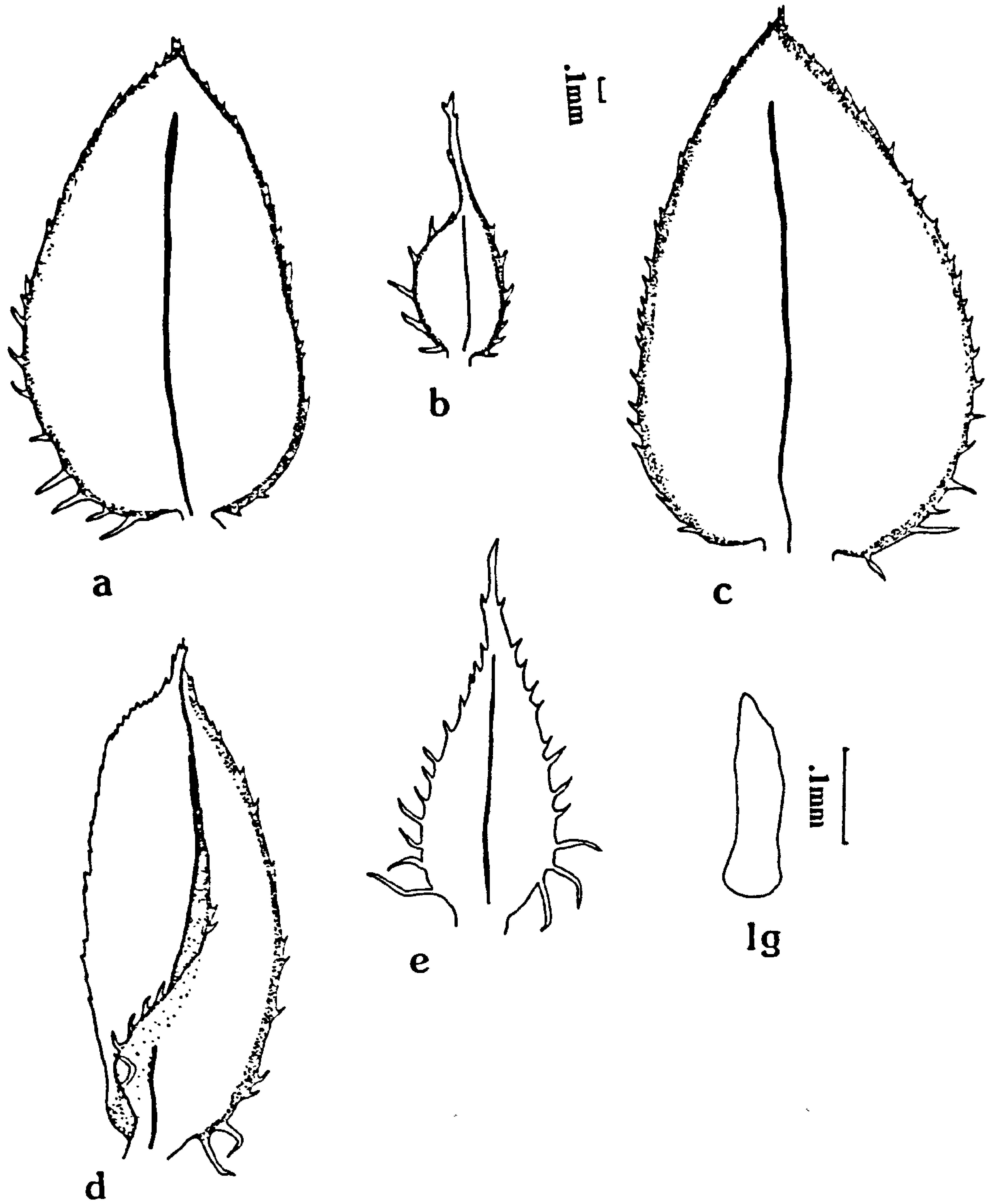


Fig. 24: S. subcordata: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Deighton 3087B.

17. S. squarrosa Bak. in J. Bot. 23: 180 no. 276 (1885), F. Allies 113 no. 298 (1887); Alston, Mém. I.F.A.N. 50: 38 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed. (Suppl.): 14-17 (1959). Fig. 25
TYPE: CAMEROON. Cameroon Mt., 1000 m, Mann 1407 (K, holotype).

Description

Plants erect, ascendent; branch system 2-4 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant.

Leaves anisophyllous, single-veined; stomata 30-35x20-25 µm; ligules up to 0.46 mm long, broadly clavate. Lateral leaves asymmetrical, deltate-sub-oblong, up to 5.1x1.7 mm, base sub-obtuse to oblique, apex acute to weakly mucronulate, margins entire (sub-entire); ligular surface epidermis with isodiametric, polygonal, sinous to straight-sided cells, stomata randomly distributed on the margin of the sub-oblong side, SI 8-($\bar{M}$9)-10; aligular surface epidermis with elongate, sinous cells with sclerotic cells forming patches on lamina, stomata, more or less, evenly distributed along the midvein, SI 14-($\bar{M}$15)-16. Median leaves asymmetrical, ovate, up to 4.2x1.2 mm, base obtuse, apex aristate (aristae up to 1.5 times as long as lamina), margins entire; ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, sinous cells, stomata concentrated along the midvein at the apical half of the leaf (not on arista), SI 4-($\bar{M}$5)-6. Axillary leaves symmetrical, narrowly ovate, up to 4.8x1.8 mm, base obtuse, apex acute to weakly mucronulate, margins entire; ligular surface epidermis with isodiametric, polygonal, sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous cells, with sclerotic cells forming patches on lamina, stomata evenly distributed on lamina and along the midvein, SI 11-($\bar{M}$12)-13.

Strobili bilateral, resupinate, at apices of branchlets, up to 6 mm long, with one sporangial arrangement: cone with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls sub-panduriform-deltate, up to 2.2x1.0 mm, base oblique, apex acute, margins entire, with a complete sporophyll-pteryx at adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina of the 'folded' side, SI 13-($\bar{M}$14)-15; aligular surface epidermis with isodiametric, sinous cells, occasionally with sclerotic cells forming patches on lamina, stomata sparsely distributed on margin of the 'folded' side, SI 1-($\bar{M}$1)-2; sporophyll-pteryx with entire margin, with elongate, straight-sided cells, without stomata. Dorsal sporophylls ovate, up to 1.6x0.9 mm, base obtuse, apex cuspidate, margins serrate-sub-entire (serrate at middle-third region); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata sparsely distributed along midvein at aligular surface epidermis only, SI 1-($\bar{M}$2)-2. Megasporangia ovoid, with similar-sized spores; megaspores 190-($\bar{M}$205)-245 μm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces reticulate-rugulose. Microsporangia ellipsoid; microspores 20-($\bar{M}$24)-26 μm in widest area, trilete, sub-triangular-tetrahedral, both proximal and distal surfaces scabrate.

Ecological notes: On wet forest floor, up to 1400 m altitude.

Specimens examined

CAMEROON. Cameroon Mt., 1000 m, Mann 1407 (holotype, K).

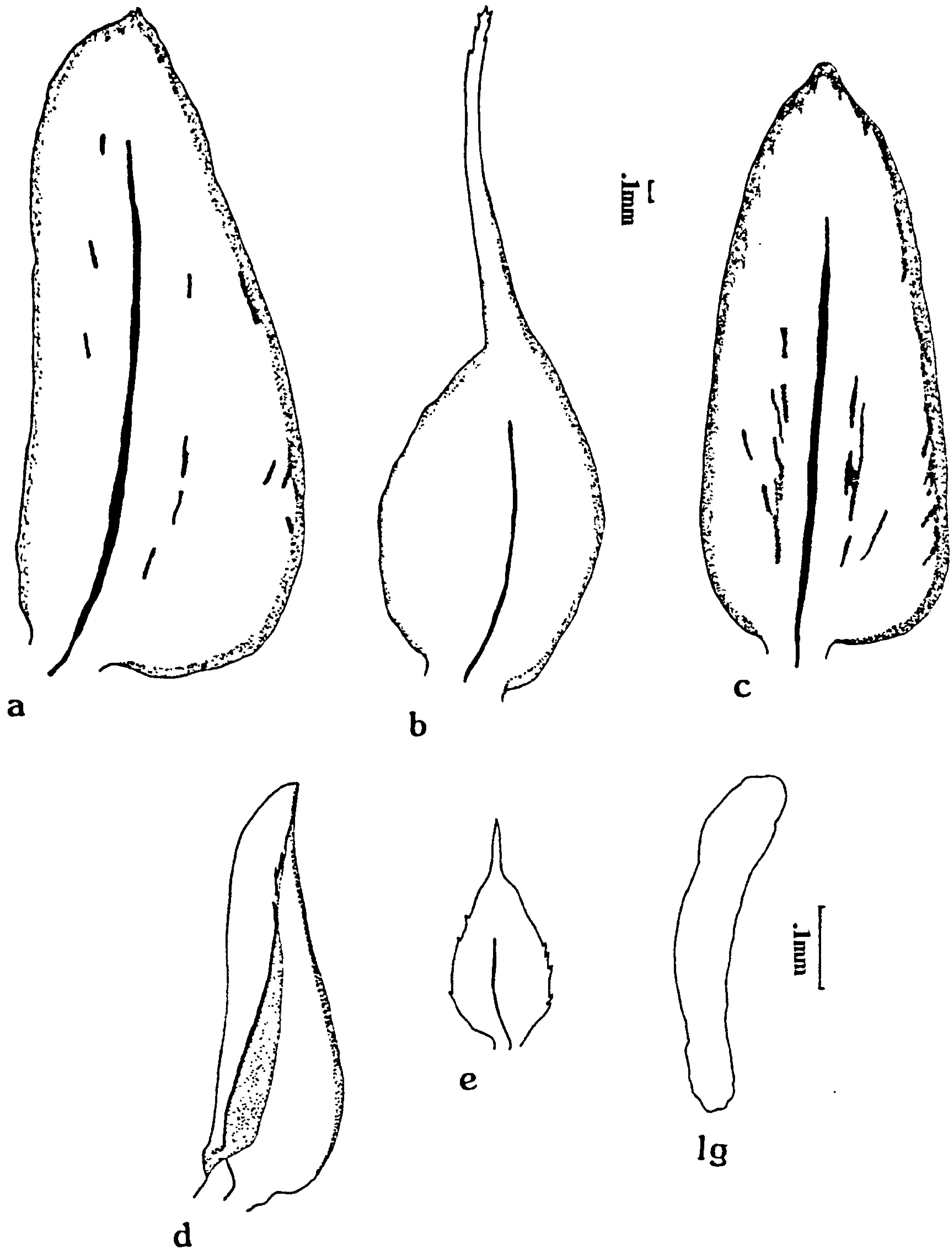


Fig. 25: S. squarrosa: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Mann 1407.

Geographical distribution: Guinea, Cameroon.

Taxonomic notes: S. squarrosa is closely allied to S. serrato - squarrosa from which it is distinguished by its entire-margined leaves.

18. S. serrato-squarrosa N. Quansah sp. nov. Plate 24; fig. 26.
TYPE: CAMEROON. Edea, Nickles 102 (P, holotype).

Description

Plants erect or sub-erect; branch-system 3-5 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal quarter of the plant.

Leaves anisophyllous, single-veined; stomata 31-38x20-26 µm; ligules up to 0.45 mm long, elongate pedate, occasionally bifid. Lateral leaves asymmetrical, sub-subulate to ovate-oblong, up to 5.3x1.6 mm, base sub-attenuate to oblique, apex acute, margins of basal third serrate-entire, apical two-thirds entire-subentire; ligular surface epidermis with isodiametric, sinous cells, stomata randomly distributed near and on the margins of the entire side, SI 8-($\bar{M}$9)-9; aligular surface epidermis with elongate, sinous cells, with sclerotic cells forming patches and/or bands on lamina, stomata more or less evenly distributed on lamina, SI 14-($\bar{M}$16)-16. Median leaves asymmetrical, lanceolate, up to 4.5x1.1 mm, base oblique (obtuse-cuneate), apex long-aristate (aristae up to 2 times the length of lamina), margins serrate; ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epidermis with isodiametric, sinous cells, stomata randomly distributed on lamina and basal third of arista, SI 7-($\bar{M}$8)-8. Axillary leaves symmetrical, ovate to narrowly deltate, up to 5.0x1.8 mm, base truncate to weakly subcordate, apex acute, margins of basal half serrate, apical half entire; ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, sinous cells, stomata evenly distributed on lamina, SI 16-($\bar{M}$18)-18.

Strobili bilateral, resupinate, at apices of branchlets, up to 5 mm long, with two sporangial arrangements: (i) cone wholly microsporangiate; (ii) with dorsal side containing both megasporangia and microsporangia randomly arranged and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls subpanduriform-ovate, up to 2.4x1.0 mm, base obtuse, apex acute, margins serrate-entire to aculeate-entire, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata randomly distributed on lamina and margins, SI 8-($\bar{M}$10)-11; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed on lamina, SI 2-($\bar{M}$2)-3; sporophyll-pteryx with serrate margin, with elongate, straight-sided cells, with stomata (1-3) distributed on the outer side. Dorsal sporophylls lanceolate, up to 1.2x0.6 mm, base obutse, apex cuspidate to aristate (aristae up to same length as lamina), margins serrate; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed on the lamina at the aligular surface epidermis only, SI 2-($\bar{M}$3)-4. Megasporangia ovoid-triangular, with similar-sized spores; megaspores 210-($\bar{M}$220)-255 μm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces rugulose. Microsporangia ellipsoid to roundish; microspores 15-($\bar{M}$19)-28 μm in widest area, trilete, sub-triangular, both proximal and distal surface granulose to foveolate.

PLATE 24

(see opposite page)

S. serrato-squarrosa: Type specimen, Nickles 102 (P).


Selaginella ~~squarrosa~~ Bak.
March 1955 Det. A. H. G. Alston.
nº 102
HERB. INST. FR. AFRIQUE NOIRE
Selaginella ~~Mannii~~
Forêt humide
Logbatjeck, région d'Edea (Cameroun).
28 avril 1948.
Reçu le
HERB. MUS. PARIS.
Holotype
S. serrato-squarrosa Quansah
Reçu le
HERB. MUS. PARIS
PRÊT Nº
17/86
PHANEROGAMIE

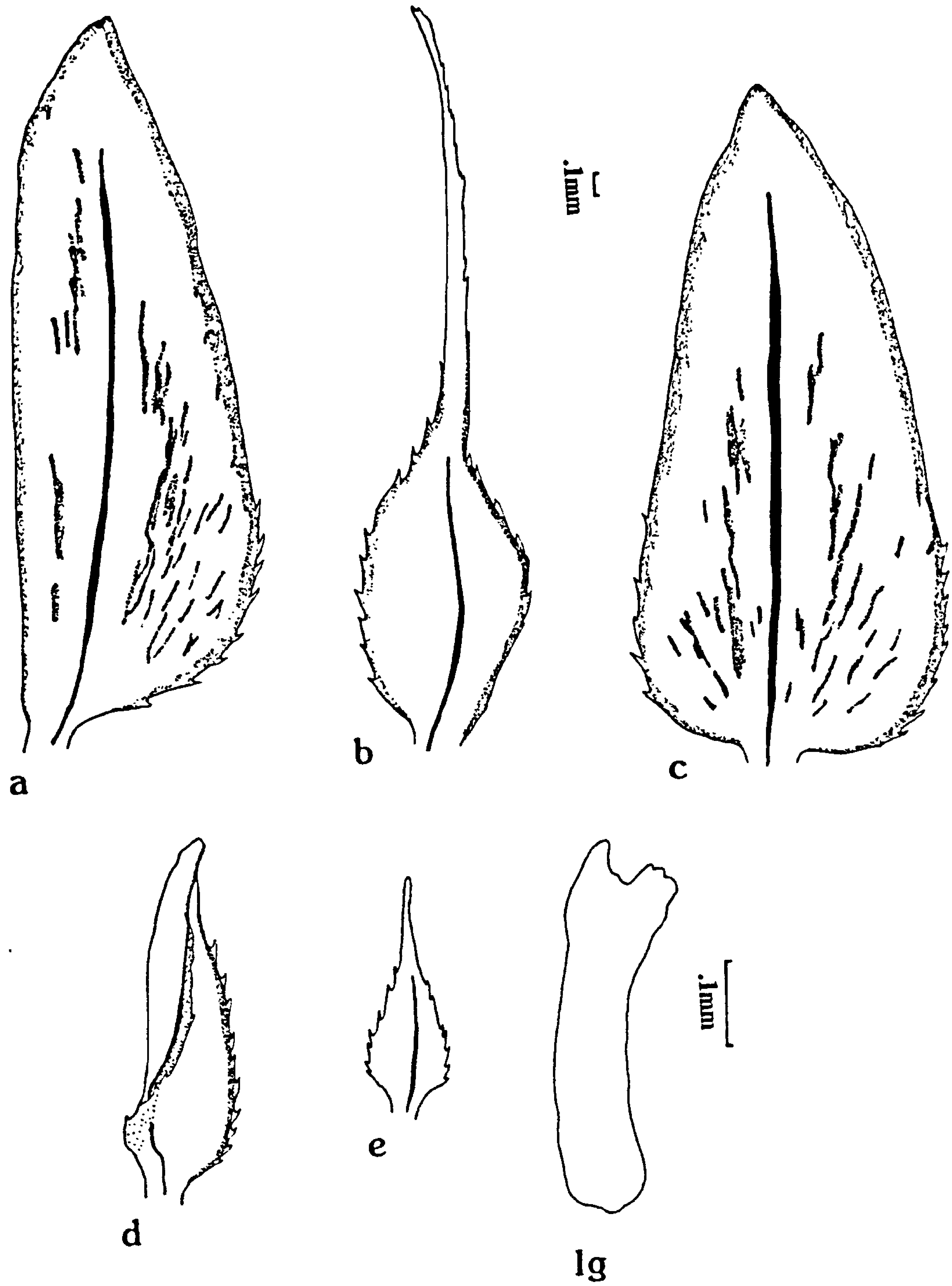


Fig. 26: S. serrato-squarrosa: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Nickles 102.

Ecological notes: On wet forest floor; up to 1500 m altitude

Specimens examined

CAMEROON. Edea, Nickles 102 (P, holotype).

GABON. Nkan: NE Mela, Mont de Cristal, Halle & Villiers 4788 (K).

Geographical distribution: Cameroon, Gabon.

Taxonomic notes: This species is closely allied to S. squarrosa from which it is distinguished by its serrate-margined leaves and very long aristate median leaves.

19. S. goudotana Spring, Bull. Acad. Brux. 10 (1): 140 (1843); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932); Bizzarri, Webbia 29(2): 580-592 (1975; including var. goudotana and var. abyssinica). Plate 25; fig.27
TYPE: MADAGASCAR. Antananarivo, Goudot s.n. (holotype G; isotype, BD).

Nomenclature

SYNONYM: S. madagascariensis Bak., J. Bot. 18: 372 (1880)
TYPE: MADAGASCAR. Antananarivo, 3/77, Gilpin s.n. (lectotype, K)
S. melleri Bak. J. Bot. 18: 372 (1880)
TYPE: MADAGASCAR. Mbatomanga, Aug. 6., 1892, Meller s.n. (lectotype, K).
S. magnusii Hieron. in Engler & Prantl, Nat. Pflanzenfam. 1, 4: 686 (1901).
TYPE: MADAGASCAR. Ost-Imerina: Urwld von Andragoloaka, Nov. 1880, Hildebrandt 3782 (lectotype, BD.; Type numbers in BM, K).

S. abyssinica Spring in Mem. Acad. Belg. 24: 99 (1850); Baker F. Allies 84: no 194 (1887); Knox, Trans. Bot. Soc. Edinb. 35: 263 (1950); Alston, Mém. I.F.A.N. 50: 37-38 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959).

TYPE: ETHIOPIA. Abyssinia, Sholoda, Quartin-Dillon 9 (lectotype LG).

S. preusii Hieron. in E. & P. Pflanzenfam. 1, 4: 686 no 16 (1901)

TYPE: CAMEROON. Buea, Preuss s.n. (isotype, K; lectotype, BD; Preuss 978).

S. goetzii Hieron. in Engler Bot. Jahrb. Syst. 30: 265 (1901)

TYPE: CAMEROON. Ukinga-Berge: Kingika-Berg. Schattigen Erdriss., 2600 m, 25 Mai 1899, Goetzee 941 (holotype BD; isotype, K).

S. whytei Hieron. in E. & P. Pflanzenfam. 1, 4: 697 (1901)

TYPE: N. NYASALAND. Whyte s.n. (holotype, BD; isotype, K).

S. bueensis Hieron. Hedwigia 43: 20 (1904)

TYPE: CAMEROON. Buea, Preuss 1079 (holotype, BD; isotype, K).

Description

Plants erect to ascending (occasionally trailing), soboliferous, branching from the base, branch-system 2-4 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant.

Leaves anisophyllous, single-veined; stomata 22-31 x 18-24 µm; ligules up to 0.23 mm long, obclavate. Lateral leaves asymmetrical, narrowly ovate to oblong (ovate-oblong), up to 3.0 x 2.0 mm, base oblique (obtuse-subcuneate), apex acute to apiculate, margins serrate-denticulate; ligular surface epidermis with isodiametric, sinous cells, stomata randomly distributed at and/or near the margins, SI 16-($\bar{M}$16)-17; aligular surface epidermis with elongate, sinous cells, occasionally with sclerotic cells forming bands and patches on lamina, stomata concentrated along the midvein in 2-5 rows, SI 19-($\bar{M}$20)-21. Median leaves asymmetrical, lanceolate to narrowly sub-deltate, up to 1.7 x 1.0 mm, base subcordate to weakly cordate, apex aristate (aristae up to half the length of lamina), margins serrate; ligular surface epidermis with elongate, sinous to straight-sided cells, stomata sparsely distributed at the margins, SI 4-($\bar{M}$4)-5; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed along the midvein in a single row, SI 5-($\bar{M}$5)-6. Axillary leaves symmetrical, elliptic to narrowly ovate, up to 2.8 x 2.1 mm, base weakly obtuse to cuneate, apex acute to apiculate, margins short ciliate-serrate-denticulate (cilia up to 0.15 mm long); ligular surface epidermis with isodiametric, sinous cells, stomata randomly distributed at and/or near the margins, SI 13-($\bar{M}$13)-14; aligular surface epidermis with elongate, sinous cells, occasionally with sclerotic cells forming bands and patches on lamina, stomata concentrated along the midvein in 2-5 rows, SI 18- ($\bar{M}$19)-20.

Strobili bilateral, resupinate, at apices of branchlets, up to 4.5 mm long, with two sporangial arrangements: (i) cone with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate; (ii) with the dorsal side containing both megasporangia and microsporangia randomly arranged and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls elliptic-lanceolate (-subpanduriform), up to 2.0x1.0 mm, base obtuse, apex acute to apiculate, margins aculeate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata sparsely distributed on the lamina, SI 5-($\bar{M}$6)-7; aligular surface epidermis with isodiametric, straight-sided cells, stomata sparsely distributed on lamina, SI 3-($\bar{M}$3)-4; sporophyll-pteryx with serrate-serrulate margin, with elongate, sinous cells, without stomata. Dorsal sporophylls ovate-lanceolate, up to 1.1 x 0.8 mm, base obtuse to broadly cuneate, apex cuspidate, margins short ciliate-serrate (cilia up to 0.16 mm long); both ligular and aligular surfaces epidermis with elongate, sinous to straight-sided cells, stomata randomly distributed on the lamina at the aligular surface epidermis only, SI 7-($\bar{M}$9)-9. Megasporangia deltoid, with 80% similar-sized and 20% 2L:2S spores; megaspores 225-($\bar{M}$260)-305 µm in widest area, trilete, subglobose to tetrahedral-subtriangular, both proximal and distal surfaces compactly scabrate-verrucate. Microsporangia ellipsoid to roundish; microspores 25-($\bar{M}$35)-40 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces verrucate-echinate.

Ecological notes: In evergreen forest on wet rocks near streams and water falls, as well as open well grazed pasture of higher ground; from 700 m to 2600 m altitude.

Specimens examined

NIGERIA. Bamenda: Bafut, Bafut-Wum Road, c 900m, Savory UCI 308 (BM); Ondo: Akure, Idanre, Orosun Peak, 850 m, Richards 3785a (K).

CAMEROON. Buea: Preuss s.n. (Type of S. preusii Hieron., K); l.c., Preuss s.n. (isotype of S. bueensis Hieron., K); Cameroon Mt.: Road to VHF Radio Station, 2000 m, Tryon & Tryon 6519 (K); Deulash, Kingika-Berge, Goetze 941 (isotype of S. goetzei

Hieron., K).

EQUATORIAL GUINEA. Fernando Po: Moka, Mioko heights, c 2000m, Adams 1104 (BM, K); l.c., Basakato, c1000m, Adams 1006 (BM); l.c., Ilache waterfall, c 1200m, Adams 1067 (BM); l.c., Peak of Clarence, Mann 667 (K); l.c., 'Heathland' near Biao, Wrigley & Melville 469 (K).

MADAGASCAR. Ost-Imerina: Urwld von Andragoloaka, Hildebrandt 3782 (BM, K, BD, lectotype of S. magnusii); Analamaitso, Bemarivo, Bâthie 8267 (BM); Ankaratra Mts., Scott-Elliot 1966 (BM,K); Antananarivo, Pool 2201 (K); l.c., Gilpin s.n. (K; lectotype of S. madagascariensis); Tampoketsa, Bemarido, Bâthie 8341 (BM); Mbatomanga, Meller s.n. (K; lectotype of S. melleri); Antsirabe, Bâthie 8331 (BM); Manonjeba, Bâthie 8290 (BM); Perinet, 25 km E of Moramanga, 880 m, Abbayes 2589 (BM); Anosibe, 93 km S of Moramanga, 750 m, Abbayes 2759 (BM); Mandraka, 1330 m, Abbayes 2609 (BM); Tanala, Kitching s.n. (K); Andramgodonka, Parker s.n. (K); Lalandro, N of Ihosy, 800-1000 m, Mabberley 886 (K); Manakambahiny-Est, Andromangabe, Zahamena Nature Reserve, 700-950 m, Quansah Q0188 (TAN, BM); l.c., Quansah Q1088 (TAN, BM); l.c., Quansah Q10814 (TAN, BM); Andramasino, Descoings 3080 (TAN); Anjavidilava-ouest-Andringitra, c 1600 m, Guillaumet 3807 (TAN).

Geographical distribution: Ghana, Nigeria, Cameroon, Equatorial Guinea (Rio Muni, Fernando Po), Congo, Zaire, Angola, Rep. S. Africa, Mozambique, Zimbabwe, Zambia, Tanzania, Kenya, Burundi, Uganda, Somalia, Ethiopia, Sudan, Madagascar-African tropics.

Taxonomic notes: This species is distinguished from all other West African and Madagascan species with dimorphic sporophylls by its soboles.

PLATE 25

(see opposite page)

Specimen of _S. goudotana_: Quansah 01088 (BM).

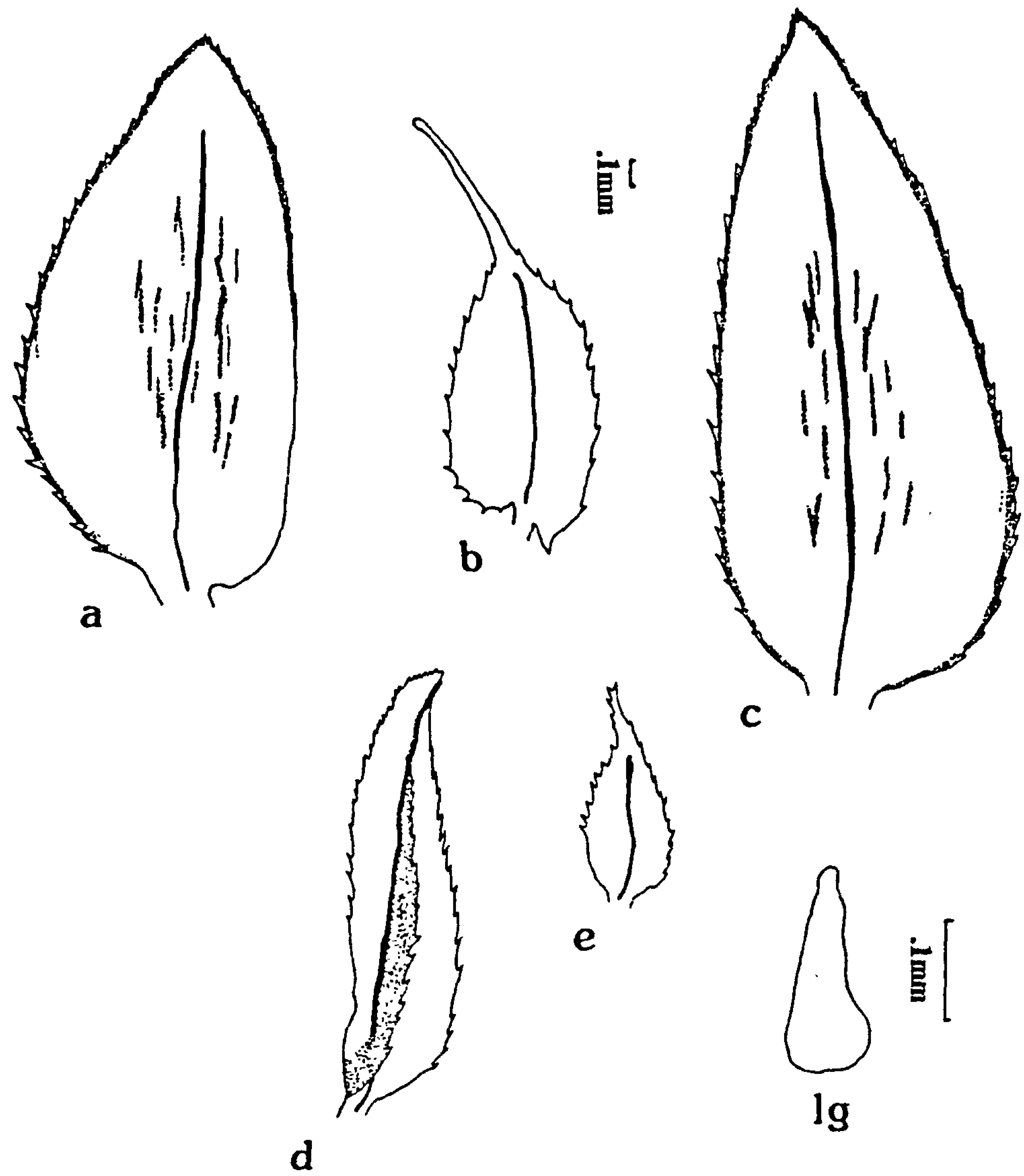


Fig. 27: S. goudotana: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Quartin-Dillon 9.

20. S. thomensis Alston in Exell, Cat. Vasc. Pl. S. Tomé: 97, t. 3 (1944), Mém. I.F.A.N. 50: 44 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959). Plate 26; fig. 28.

TYPE: São Tomé. Vanhulst (Macambrara), 1000-1300 m, Exell 423 (BM, holotype).

Description

Plants erect or suberect from a very small creeping base; branch systems 2-4 pseudopinnate; rhizophores arising at the axils and/or dorsal side of primary branches and restricted to the basal third of the plant.

Leaves anisophyllous, single-veined; stomata 20-33x17-26 µm; ligules up to 0.25 mm long, obturbinate. Lateral leaves asymmetrical, ovate-elliptic to ovate-subovate, up to 3.0x1.5 mm, base oblique (obtuse-sub-truncate), apex sub-obtuse to broadly acute, margins serrate-subentire; ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on the lamina, less elongate, occasionally isodiametric, sinous cells on midvein, with sclerotic cells forming patches and bands on lamina, stomata randomly distributed on lamina, margins but concentrated along the midvein, SI 12-($\bar{M}$13)-14. Median leaves asymmetrical, oblanceolate, up to 1.3x0.7 mm, base oblique, apex cuspidate, margins serrate-aculeate; ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with isodiametric, weakly sinous to straight-sided cells, stomata concentrated along the midvein, SI 6-($\bar{M}$6)-7. Axillary leaves symmetrical, ovate, up to 2.8x1.6 mm, base obtuse, apex sub-obtuse to broadly acute, margins serrate; ligular surface epidermis with isodiametric, weakly sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on lamina, less elongate, occasionally isodiametric, weakly sinous cells on midvein, with sclerotic cells forming patches and bands on lamina, stomata, more or less, evenly distributed on lamina, also on margins, SI 14-($\bar{M}$15)-15.

Strobili bilateral, resupinate, at apices of branchlets, up to 5 mm long, with two sporangial arrangements: (i) cone wholly megasporangiate; (ii) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls elliptic to elliptic-oblong, up to 2.1x1.1mm, base obtuse, apex acute, margins sub-entire-aculeate to serrate-subentire, with complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, straight-sided cells, stomata randomly distributed on lamina, SI 11-($\bar{M}$13)-14; aligular surface epidermis with isodiametric, weakly sinous to straight-sided cells, stomata sparsely distributed on lamina, SI 3-($\bar{M}$3)-4; sporophyll-pteryx with serrate margin, with elongate, straight-sided cells, without stomata. Dorsal sporophylls subtriangular to weakly deltate, up to 1.3x0.9 mm, base truncate, apex acuminate, margins serrate-serrulate; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed on lamina at aligular surface epidermis only, SI 9-($\bar{M}$10)-10. Megasporangia ovoid-triangular to deltoid, with similar-sized spores; megaspores 220-($\bar{M}$230)-245 μm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces compactly reticulate. Microsporangia ellipsoid to spheroid; microspores 20-($\bar{M}$26)-30 μm in equatorial diameter, trilete, sub-globose, both proximal and distal surfaces verrucate.

Ecological notes: On wet rocks in streams, also on steep rocky banks in forest; up to 2000 m altitude.

Specimens examined

SIERRA LEONE. York, Adames 205 (BM, K).

NIGERIA. Calabar: Kwa Falls, Richards 4005 (BM, K).

CAMEROON. Bamenda: Mile 43 Mamfe-Bamenda Road, Richards 5278 (BM); N'dian: Kameruna, Dusen Comm 1895 (BM).

Also seen

SÂO TOMÉ. Vanhulst: Macambrara, 1100-1300 m, Exell 423 (holotype, BM).

Geographical distribution: Sierra Leone, Nigeria, Cameroon, Gabon, Sâo Tomé.

Taxonomic notes: S. thomensis is closely allied to S. molleri from which it is distinguished by its serrate-margined leaves and cuspidate median leaves (S. molleri has leaves with short ciliate margins and median leaves with aristate apices).

PLATE 26

(see opposite page)

S. thomensis: Type specimen, Exell 423 (BM).


sporophylla
ciliolata
vix aristata

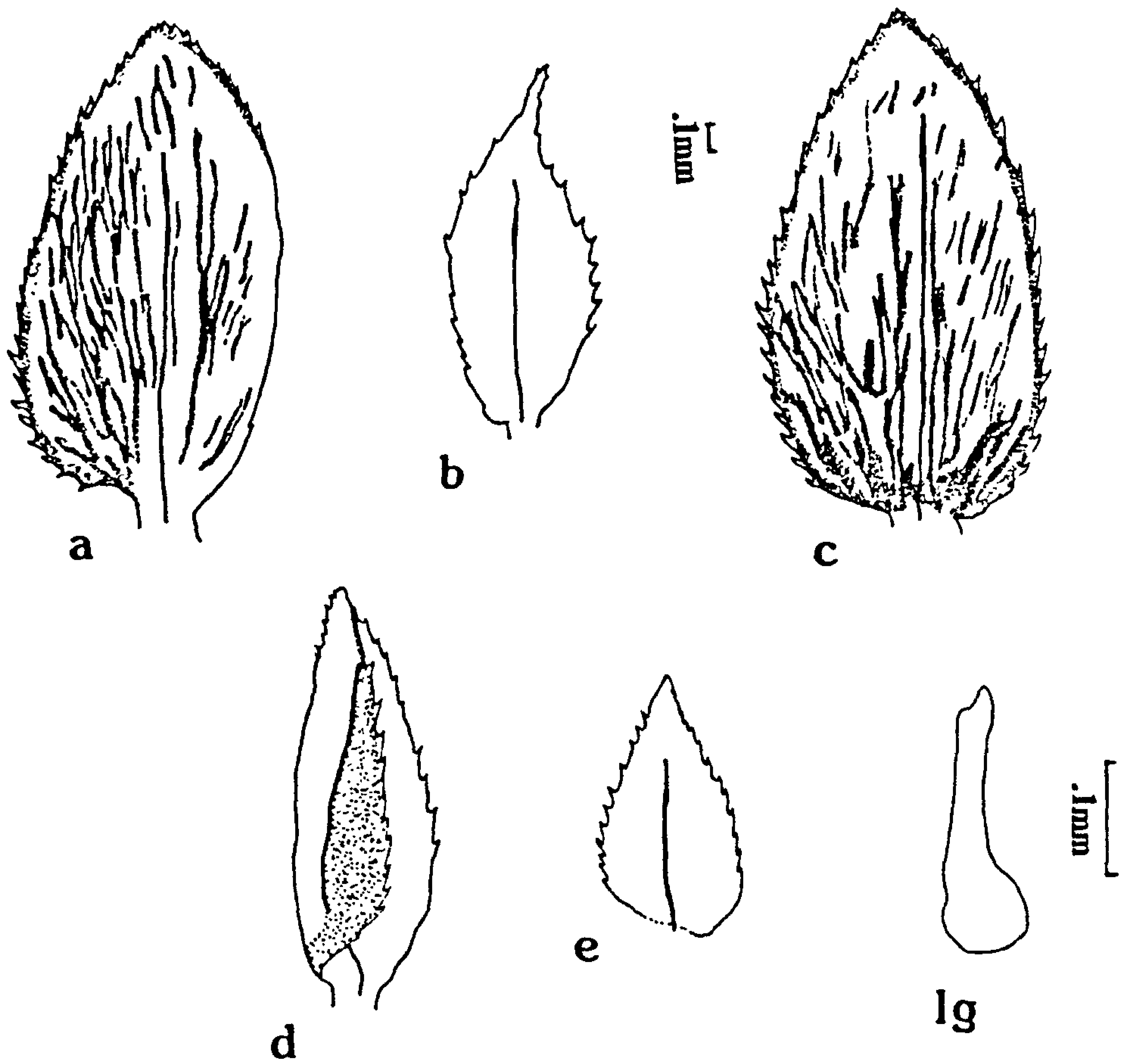


Fig. 28: S. thomensis: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Exell 423.

Key to Species of Madagascan *Selaginella* subgenus *Stachygynandrum*

Sporophylls monomorphous - - - - - Section *Homostachys* (1-7)

Sporophylls dimorphous - - - - Section *Heterostachys* (8-11)

1. Strobili tetragonous, not resupinate, ventral sporophylls with no sporophyll-pteryx on the adaxial surface - - - - - 2
   2. Stems prostrate-ascendent, rhizophores distributed more or less on the whole plant, positioned at the dorsal side of stem, median leaves subauriculate, ligules flabellate - - - - - - - - - - - - - - *fissidentoides* (1)
   2. Stems erect, rhizophores distributed at the very base of plant, not positioned at the dorsal side of stem, median leaves not subauriculate, ligules not flabellate - - -3
      3. Stems and branches pubescent at the dorsal side, strobili with Type I sporangial distribution pattern - 4
         4. Leaves entire (subentire), ligules obturbinate, strobili with Types IIB and IV sporangial distribution patterns, megaspores baculate- *vogelii* (2)
         4. Leaves short ciliate-serrate, ligules lingulate, strobili with Type IIA sporangial distribution pattern, megaspores scabrate-verrucate- *pervillei* (3)
      3. Stems and branches glabrous, strobili not with Type I sporangial distribution pattern - - - - - - - - 5

5. Branches curling up when dried, leaves single-veined, epidermis of ligular and aligular surfaces similar- -6

    6. Median leaves entire - - - - - - - <u>digitata</u> (4)

    6. Median leaves serrate - - - - - <u>helicoclada</u> (5)

5. Branches not curling up when dried, leaves three-veined, epidermises of ligular and aligular surfaces different - 7

    7. Lateral leaves falcate, entire, broadly acute (subobtuse); median leaves linear-lanceolate; strobili with Types IIA, IV, VI, VIII and VIIIA sporangial distribution patterns- -<u>pectinata</u> (6)

    7. Lateral leaves ovate-oblong, subentire (irregularly wavy), acuminate; median leaves lanceolate; strobili with Type VII sporangial distribution pattern - - - - - - - - <u>lyallii</u> (7)

1. Strobili bilateral, resupinate, ventral sporophylls with sporophyll-pteryx on the adaxial surface - - - - - - - - 8

    8. Median leaves aristate, dorsal sporophylls short ciliate-serrate - 9

        9. Stems not soboliferous, leaves hypostomatous, strobili with Types II, IIC and III sporangial distribution patterns, megaspores reticulate, microspores scabrate-granulose- - -<u>hildebrandtii</u> (8)

        9. Stems soboliferous, leaves amphistomatous, strobili with Types IIA and IIB sporangial distribution patterns, megaspores scabrate-verrucate, microspores verrucate-echinate - - - - - - - - - - <u>goudotana</u> (9)

    8. Median leaves cuspidate, dorsal sporophylls long ciliate - 10

10. Lateral and axillary leaves short ciliate-serrate (denticulate), acuminate; median leaves deltate, cordate; strobili with Types IIC and III sporangial distribution patterns, megaspores reticulate, microspores baculate - - - - - - - - - perpusilla (10)

10. Lateral and axillary leaves ciliate-serrate, acute; median leaves lanceolate, obtuse; strobili with Types I, IIA and IV sporangial distribution patterns, megaspores rugulose-reticulate, microspores scabrate - - - - - - - - unilateralis (11)

1. S. fissidentoides (Hook. & Grev.) Spring, Bull. Acad. Brux. 10: 142 (1843); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932). Plate 27; fig. 29.

TYPE: MADAGASCAR. S. loco, Lyall 287 (holotype, K).

Nomenclature

SYNONYM: Lycopodium fissidentoides Hook. & Grev. in Hook., Bot. Misc. 2: 395 (1831).

TYPE: As above.

Description

Plants prostrate-ascendent, branch systems flabellate with dichotomies; rhizophores arising at the dorsal sides of primary branches and distributed more or less throughout the whole plant.

Leaves anisophyllous, single-veined; stomata 20-31x15-20 μm; ligules up to 0.22 mm long, flabellate. Lateral leaves asymmetrical, ovate-oblong, up to 2.6x0.9 mm, base obtuse, apex obtuse, margins serrate-subentire; ligular surface epidermis with elongate, sinous, occasionally undulating cells, without stomata; aligular surface epidermis with elongate, sinous to undulating cells, with sclerotic cells forming patches and bands on lamina, stomata concentrated on the midvein, SI 17-($\bar{M}$18)-20. Median leaves asymmetrical, lanceolate, up to 2.1x0.68 mm, base subauriculate, apex cuspidate (long acuminate), margins serrate; ligular surface epidermis with elongate, sinous to undulating cells, without stomata; aligular surface epidermis with elongate, sinous, occasionally undulating cells, stomata concentrated on the midvein, SI 13-($\bar{M}$15)-16. Axillary leaves symmetrical, elliptic, up to 1.7x0.8 mm, base obtuse, apex obtuse, margins serrate-denticulate; ligular surface epidermis with elongate, sinous, occasionally undulating cells, without stomata; aligular surface epidermis with elongate, sinous, undulating cells, with sclerotic cells forming patches and bands on lamina, stomata concentrated on the midvein, SI 14-($\bar{M}$16)-18.

Strobili tetragonous, at apices of branchlets, up to 15 mm long, with one sporangial arrangement: with a single megasporangium at the base, the rest of cone being microsporangiate. Sporophylls uniform, ovate, up to 1.7x1.0 mm, base obtuse, apex long acuminate, margins serrate; both ligular and aligular surfaces epidermis with elongate, sinous to undulating cells, stomata concentrated on the midvein at the aligular surface only, SI 7-($\bar{M}$8)-9. Megasporangia triangular-ovoid, with 83.3% similar-sized, 3.3% 2L:2S and 13.3% 1L:3S spores; megaspores 453-($\bar{M}$489)-540 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces scabrate. Microsporangia reniform; microspores 42-($\bar{M}$46)-52 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces rugulose.

Ecological notes: On ground, rocks (boulders) in stream and along banks of streams and rivers in forest; up to 900 m altitude.

Specimens examined

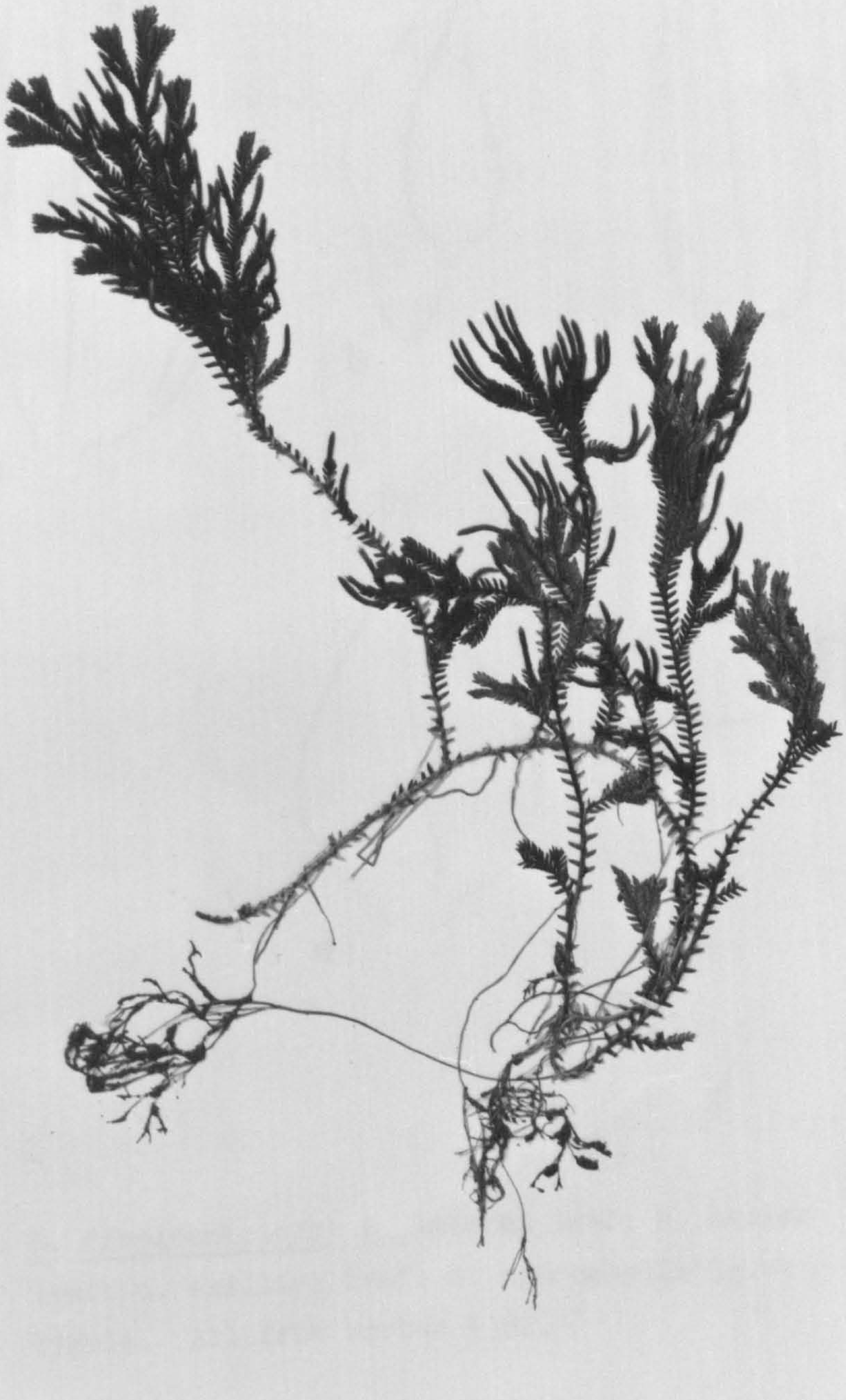
MADAGASCAR. Nossi Bé, Hildebrandt 3166 (BM, K); Ambodilara, Warbur 5382 (BM); Ambalamena, Bâthie 8281 (BM); Vatovary, 250 m, Bâthie 8260 (BM); Andakambararata, Palm & Afzelius s.n. (BM); Massif de l'Andohahelo, 500 m, Abbayes 3207 (BM); Antananarivo, Meller s.n. (K); l.c., Warbur s.n. (K); Perinet (Est Moramanga), Cremers 3014 (TAN); Manakambahiny-Est, Zahamena F.R., c 800 m, Quansah Q108011 (TAN, BM); l.c., Quansah Q50910 (TAN, BM); l.c., Quansah Q10815 (TAN, BM); No localities, Guillot 378 (BM), Thompson 151 (BM).

Geographical distribution: Madagascar, Comoros.

PLATE 27

(see opposite page)

Specimen of *S. fissidentoides*: Quansah 050909 (BM).



Herbarium Musei Britannici
MADAGASCAR

Selaginella fissidentoides (Hook et Grev) Spr.

Ambatondrazaka District: Manakambahiny Est,
Zahamena Nature Reserve.
Lower montane rainforest, 700–950m alt.

Forming a dense covering of forest floor

Nathaniel Quansah No. Q 50909 9. 9.

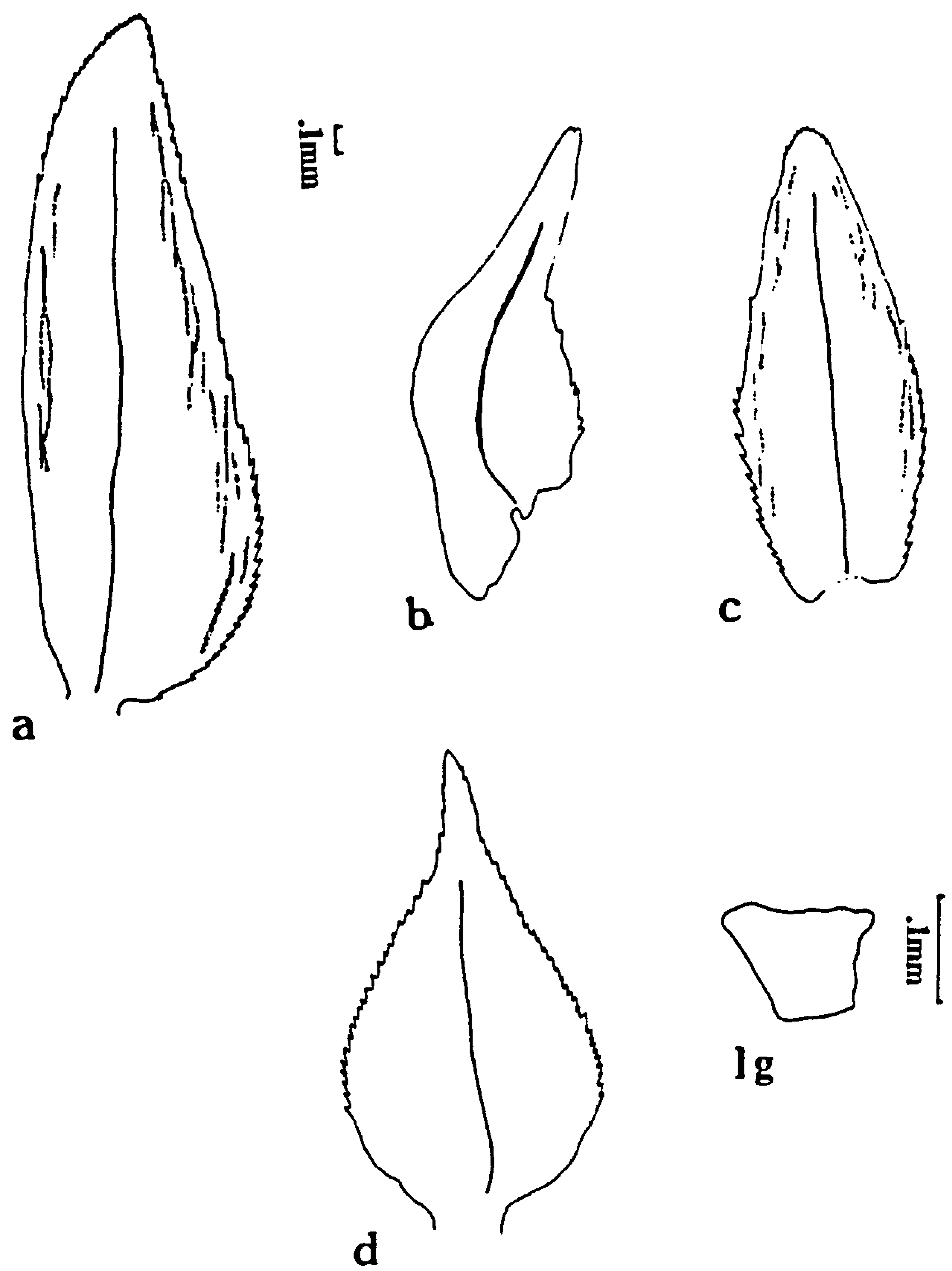


Fig. 29: S. fissidentoides: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Warbur 5382.

Taxonomic notes: This is the only species that shows the prostrate-ascendent habit and dichotomous branching in Madagascar.

2. S. vogelii Spring, Monogr. Fam. Lycopod. 2: 170 (1849), Mem. Acad. Belg. 24: 170 (1850); Hook. Sec. Cent. Ferns t. 86 (1861, 1864); Baker F. Allies 100 no. 250 (1887); Knox, Trans. Edinb. Bot. Soc. 35: 272 (1950); Alston, Mém. Soc. Linn. Normandie Bot. 1: 80 (1932), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959); Alston & Abbayes, Bull. Inst. Fr. d'Afr. Noire, 13: 85 (1951); Adams & Alston, Bull. Brit. Mus. (Nat. Hist.) Bot. 1: 184 (1955). Plate 9; fig. 10.

TYPE: EQUATORIAL GUINEA. Fernando Po, Vogel s.n. (K, holotype).

Nomenclature

SYNONYM: S. africana A. Br. (1857) Index Sem. Berol.

S. dichrous Hort., ex A. Br. 1857.

S. dinklageana Sadeb. in Jahrb. Hamb. Wiss. Anst. 14, Suppl. 16 (1897).

Description

Plants erect, stout from a creeping rhizome; branch-systems 3-4 pseudopinnate and/or flabellate with few dichotomies, pubescent at dorsal side; rhizophores restricted to the very base of the plant.

Leaves anisophyllous on branches, simple monomorphic on main stem, single-veined; stomata 24-31x20-23 µm; ligules up to 0.25 mm long, obturbinate. Lateral leaves asymmetrical, lanceolate-oblong, up to 3.5x1.5 mm, base oblique, apex acute, margins entire to sub-entire; ligular surface epidermis with isodiametric, undulating to sinous cells, without stomata;

aligular surface epidermis with elongate, undulating, sinous cells, stomata randomly distributed on lamina, SI 12-($\bar{M}$13)-14. Median leaves asymmetrical, sub-obovate, up to 1.2x0.7 mm, base oblique (decurrent), apex caudate, margins entire-subentire (distantly serrate); ligular surface epidermis with elongate, sinous cells, without stomata; aligular surface epiderrmis with isodiametric, sinous cells, stomata sparsely distributed on lamina and towards the margins, SI 3-($\bar{M}$4)-4. Axillary leaves symmetrical, obovate to oblanceolate, up to 3.0x1.6 mm, base sub-attenuate, apex acute, margins entire (sub-entire); ligular surface epidermis with isodiametric, sinous to undulating cells, stomata randomly distributed on the lamina, SI 7-($\bar{M}$8)-9; aligular surface epidermis with elongate, undulating, sinous cells, stomata randomly distributed on the lamina, SI 11-($\bar{M}$11)-13.

Strobili tetragonus, at apices of branchlets, up to 10 mm long, with three sporangial arrangements: (i) cone wholly microsporangiate; (ii) with basal megasporangiate zone and apical microsporangiate zone; (iii) with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate. Sporophylls uniform (subuniform) keeled, broadly ovate to widely trullate, up to 1.5x0.8 mm, base obtuse to sub-auriculate, apex cuspidate, margins sub-entire (distantly serrate); both ligular and aligular surfaces epidermis with elongate, undulating, sinous cells, stomata sparsely distributed on lamina of aligular surface epidermis only, SI 5-($\bar{M}$6)-7. Megasporangia deltoid, with 81.4% similar-sized and 18.6% 2 L: 2 S spores; megaspores 210-($\bar{M}$285)-328 μm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces baculate. Microsporangia ellipsoid; microspores 25-($\bar{M}$30)-40 μm in equatorial diameter, trilete, globose, both proximal and distal surfaces verrucate-echinate.

Ecological notes: On rocks or ground in wet forest especially near water; sea level to 1800 m altitude.

Specimens examined

GUINEA. Nzo: Schnell 583 (BM); l.c., Abbayes 598 (BM); Kakoulima: Nickles s.n. (K).

SIERRA LEONE. N. Kono: Tingi Mts., 600 m, Morton & Gledhill SL 1985 (K); l.c., Fisher 89 (K); Yifin, foot of Loma Mt., Morton & Gledhill SL 1136 (K); Gola North: Garua, Bakshi 38 (K); l.c., Forest Block III, Small 532 (K); Jau (Tunkia), Deighton 5222 (K); Benikoro, 300 m, Thomas 2948 (K); Giewahun, Deighton 457 (K); Kofiu Mt., Scott-Elliot 4614 (K); Maraka, Morton & Jarr SL1297 (K).

LIBERIA. Kitoma, Harley F160a (BM K); Bobei, Harley F232 (BM, K); Ganta, Harley F22, F22A (K); Webo: Mnanulu, Baldwin Jr. 6059 (BM, K); Sanniquellie: Sakimpa, foot of Bilimu, Harley F115 (BM, K); Sinoe Basin, Whyte s.n. (K); Gangi, Linder 850 (K); Boporo: Zuie, Baldwin Jr. 12090 (BM).

IVORY COAST. Tai, Guiglo, Abbayes 2060 (BM); Niapidou: 64 km N of Sassandra, Leeuwenberg 2429 (K).

GHANA. Nfuom: Kakum F.R., c 200 m, Box 2861 (BM); Kibi: Puso Puso Ravine, c 300-500 m, Box 3258 (BM); Fanti-Nyankumasi, Box 2073 (BM); Potroasi, Adams 165 (BM); Banka, Ashanti, Irvine 480 (K); Akim: Kibi Hills, Johnston 264 (K); Akwapim Hills, Johnston 380 (K); Akropong Mts., Brown 332 (K); Kwadjo Nkwanta to Sikamang, Kitson 1246 (K); Tarkwa: Neung F.R., Agona, Cudjoe 18 (K); Konongo, Akpabla 254 (K); Anyinam, Obeng & Dade MDA 4 (K).

NIGERIA. Calabar, Robb s.n. (BM); l.c., Abak, Jackson's Land, Maggs 151 (BM, K); mile 54, Calabar-Mamfe road, Baldwin Jr. 13760 (BM); Kwa Falls, Richards 3995 (BM, K); l.c., Richards 3991 (BM, K); Benin: Ehor and Ibekwe, c 100 m, Fairbairn 16 (BM); Sonkwala: Ijua, 900 m, Savory & Keay FHI 25028 (BM); Okomu F.R., Compartment 53, Richards 3857 (BM, K); l.c., Compartment 56, Brenan 3635 (BM, K); Nsuka, Chaloner 15/1 (K); Boje: Aboabam, Jones & Onochie 18628 (BM, K); Ogoja: Abbot Village, Jones 1474 (BM); Oban, Richards 5144 (BM); Osomba Village, Onyeachusin & Latilo FHI 48194 (K); Owenna: Akure F.R., Onochie FHI 34218 (K).

CAMEROON. Buea, c 1000 m, Tryon & Tryon 6484 (K); Man Spring, Mt. Cameroon, Hambler 162 (BM); l.c., c 1000 m, Fraser 31 (BM); l.c., 1200 m, Migeod 12 (BM, K); l.c., 300 m, Dunlap 239 (K); l.c., Dunlap 132 (K); l.c., Maitland 838 (K); Victoria, Brenan 4384 (BM, K); Between Victoria and Kumba, Hutchinson & Metcalfe 140 (K); Kumba: Lake Barombi, 350 m, Leeuwenberg 6852 (K); l.c., Box 3598 (BM); Urwaldgebiet: Bipinde, Zenker 903 (BM); l.c., Zenker 4454 (BM); Barombi Station, Preuss 279 (BM); Yaounde Station, 800 m, Zenker & Staudt 35 (BM); l.c., Zenker & Staudt 179 (BM); l.c., Zenker & Staudt 190 (BM); Mapanga, c 700-1300 m, Kalbreyer 150 (BM); Mamfe-Assam forest, 300 m, Gregory 253 (K).

EQUATORIAL GUINEA. Fernando Po: Mt. Balea, Guinea 359 (BM); l.c., Mann 149 (BM, K); No localities: Barter 1044; 1398 (K); Mann 1406 (K); Vogel s.n. (K).

MADAGASCAR. Nossi Bé, Lam & Meeuse 6088 (K); Be Kilus Mts., Last s.n. (BM); Antsiatsia, forêt d'Anjahana, SE Ambilobe, Cremers 2690 (TAN).

Geographical distribution: Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Benin, Nigeria, Cameroon, Equatorial Guinea (FP), Gabon, Congo, Zaire, Angola, Tanzania, Kenya, Zambia, Madagascar.

Taxonomic notes: *S. vogelii* is distinguished from all the other West African and Madagascan species by its pubescent stems and branches and from *S. pervillei* from Madagascar (which also has pubescent stems and branches) by its entire leaf margins (*S. pervillei* has short ciliate-serrate leaves).

3. S. pervillei Spring, Mem. Acad. Belg. 24: 169 (1850); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932). Plate 28; fig. 30.

TYPE: MADAGASCAR. Nossi Bé, Pervillé s.n. (holotype, K).

Description

Plants erect, branch systems flabellate and/or 2-4 pseudopinnate, pubescent at dorsal side; rhizophores restricted to the very base of the plant.

Leaves anisophyllous on branches, simple monomorphic on main stem, single-veined; stomata 19-30x15-25 µm; ligules up to 0.20 mm long, lingulate (obturbinate). Lateral leaves asymmetrical, ovate-oblong, up to 2.5x1.1 mm, base obtuse, apex acute, margins short ciliate-serrate (cilia up to 0.16 mm long); ligular surface epidermis with isodiametric, sinous to undulating cells, without stomata; aligular surface epidermis with elongate, sinous to undulating cells, stomata randomly distributed on lamina, SI 18-($\bar{M}$22)-24. Median leaves asymmetrical, elliptic to subobovate, up to 1.6x0.5 mm, base obtuse, apex aristate (aristae up to 2/3 the length of lamina) to caudate, margins short ciliate (cilia up to 0.15 mm long); ligular surface epidermis with elongate, sinous to undulating cells, without stomata; aligular surface epidermis with isodiametric, sinous to undulating cells, stomata randomly distributed on lamina, SI 20-($\bar{M}$23)-28. Axillary leaves symmetrical, elliptic to obovate, up to 1.7x0.6 mm, base obtuse, apex acute, margins ciliate-serrate (cilia up to 0.19 mm long); ligular surface epidermis with isodiametric, sinous to undulating cells, without stomata; aligular surface epidermis with elongate, sinous to undulating cells, stomata randomly distributed on the lamina, SI 15-($\bar{M}$19)-24.

Strobili tetragonous, at apices of branchlets, up to 15 mm long with two sporangial arrangements: (i) with basal megasporangiate zone and apical microsporangiate zone; (ii) with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate. Sporophylls uniform, ovate, up to 1.2x0.6 mm, base obtuse, apex aristate (aristae up to 2/3 the length of lamina), margins short ciliate-serrate (cilia up to 0.12 mm long); both ligular and aligular surfaces epidermis with elongate, sinous to undulating cells, stomata randomly distributed on lamina of aligular surface epidermis only, SI 10-(M̄11)-13. Megasporangia ovoid-triangular (deltoid), with 76.9% similar-sized, 20% 3L:1S and 3.1% 2L:2S spores; megaspores 221-(M̄252)-300 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces scabrate-verrucate. Microsporangia ellipsoid; microspores 24-(M̄28)-33 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces verrucate-echinate.

Ecological notes: On ground and rocks near streams and rivers in forest, up to 1200 m altitude.

Specimens examined

MADAGASCAR. Ambohitsi Mts., Hildebrandt 3385c (BM, K); Nossi Bé, Pervillé s.n. (holotype, K); l.c., Hildebrandt 2935 (K); Ambatosoratra, Cremers? 3394 (TAN); Forêt d'Antsoy, Cremers 2538 (TAN); No locality, Baron 6691 (BM); Be Kilus Mts., Last s.n. (BM).

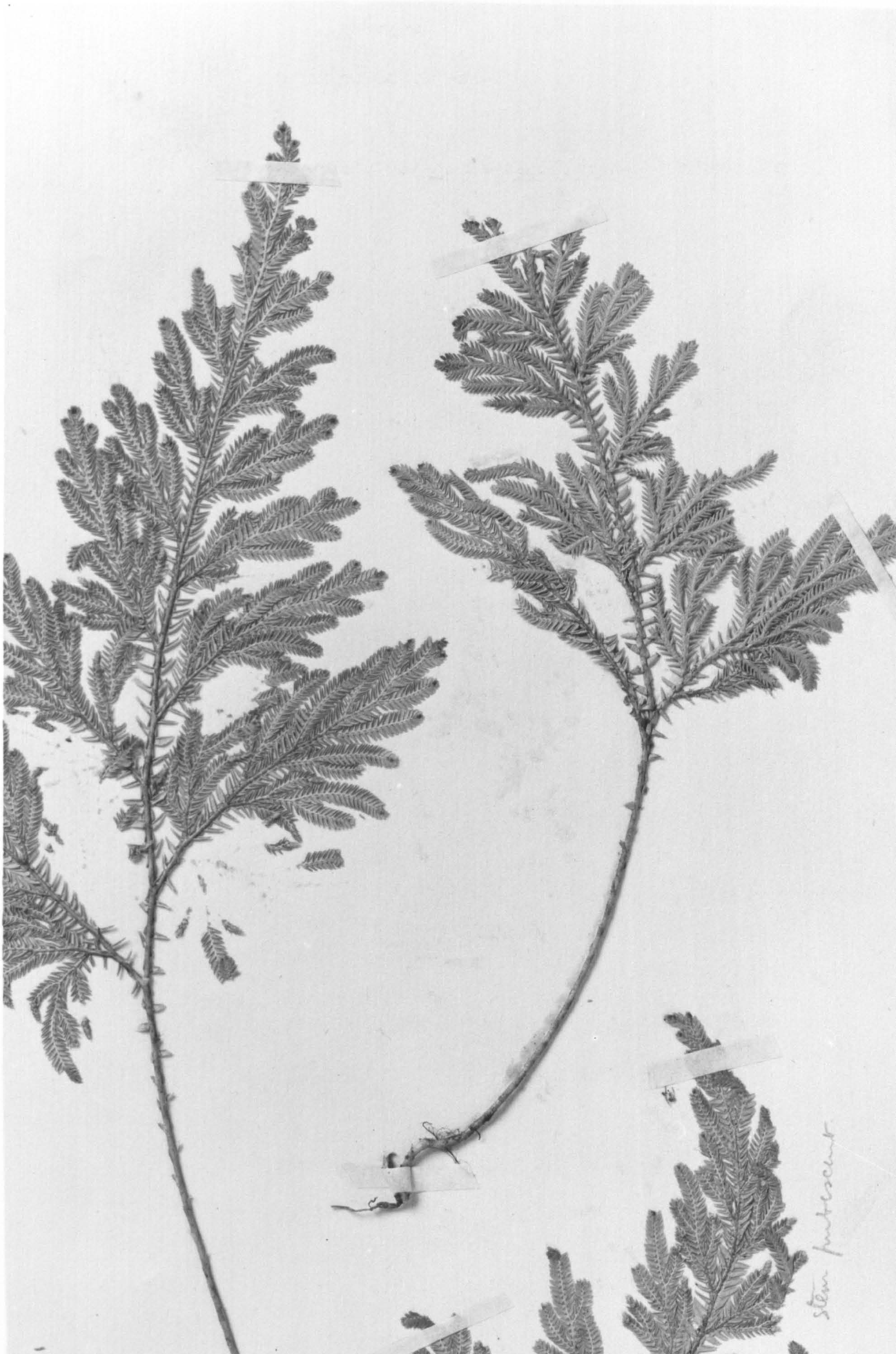
Geographical distribution: Madagascar

Taxonomic notes: This species is endemic to Madagascar and is distinguished from all other Madagascan species by its pubescent stem and branches and from *S. vogelii* by its short ciliate-

PLATE 28

(see opposite page)

Specimen of _S._ _pervillei_: Baron 6691 (BM).


stem pubescent

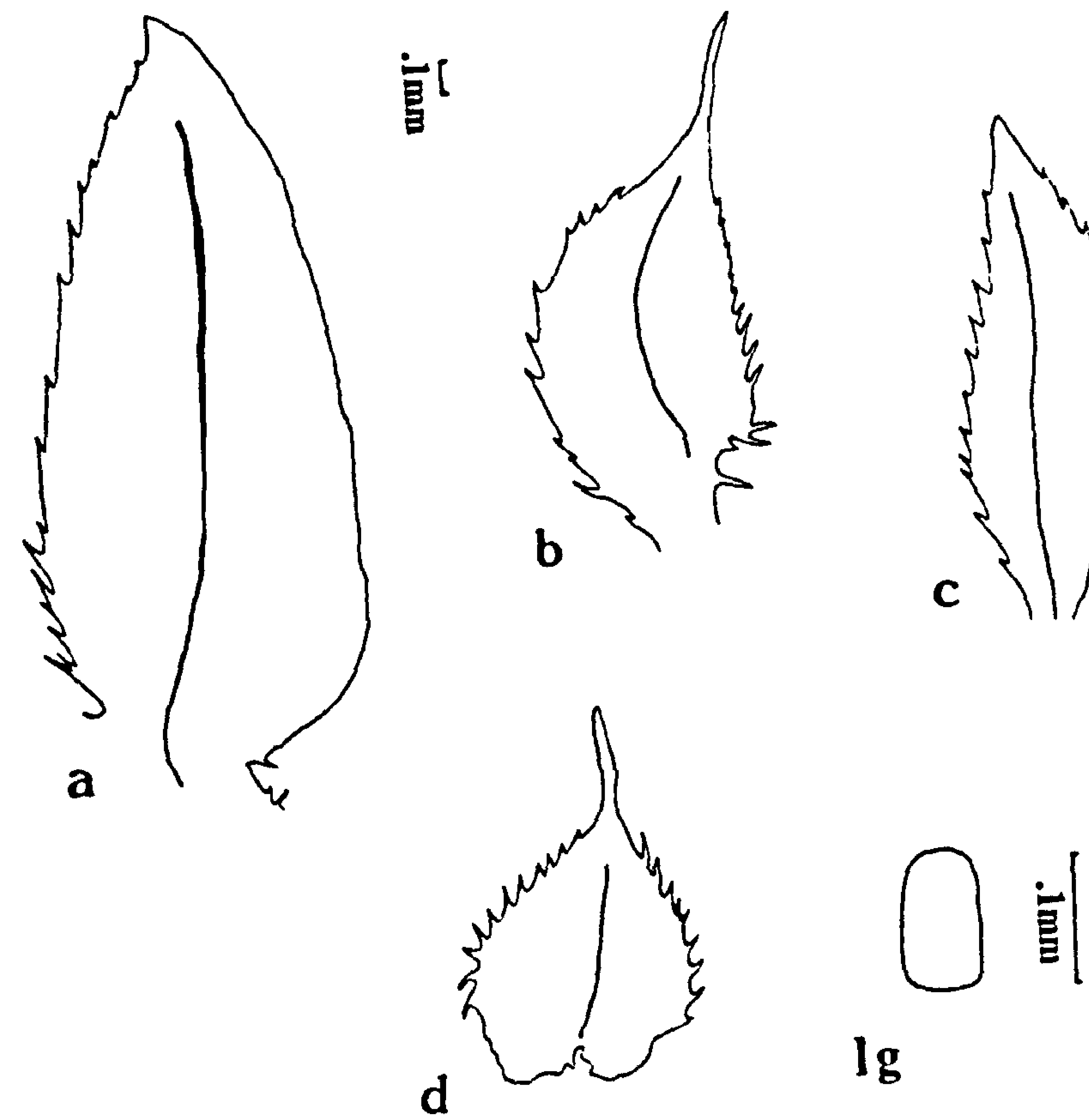


Fig. 30: S. pervillei: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Baron 6691.

serrate leaves [S. vogelii has entire (subentire) leaves].

4. S. digitata Spring, Monogr. 2, Mem. Acad. Belg. 24: 75 (1850); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932). Plate 29; fig. 31.

TYPE: MADAGASCAR. Ambongo, Pervillé 608 (holotype, K; BM).

Description

Plants erect; branch system flabellate; rhizophores restricted to the very base of plant.

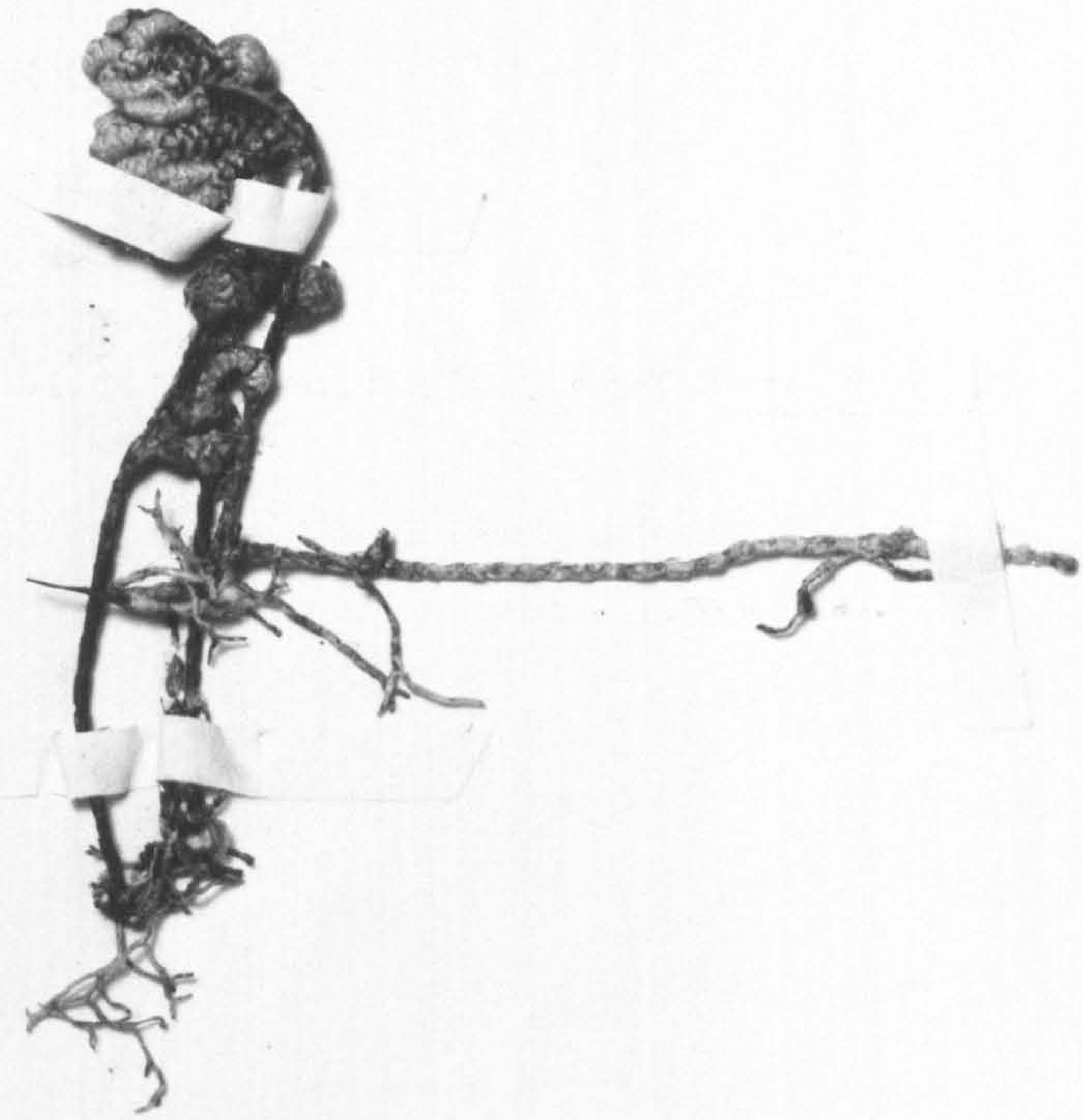
Leaves anisophyllous on branches, scaly on main stem, single-veined; stomata 15-25x13-15 µm; ligules up to 0.10 mm long, rectangular. Lateral leaves asymmetrical elliptic-oblong (-ovate), up to 0.8x0.5 mm, base obtuse, apex obtuse (rounded), margins entire (subentire); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, with sclerotic cells forming bands on lamina, stomata randomly distributed on lamina at aligular surface epidermis only, SI 28-($\bar{M}$29)-31. Median leaves asymmetrical, elliptic, up to 0.6x0.4 mm, base obtuse, apex mucronulate, margins entire; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, with sclerotic cells forming bands on lamina, stomata randomly distributed on lamina at aligular surface only, SI 26-($\bar{M}$27)-29. Axillary leaves symmetrical, elliptic-ovate, up to 0.8x0.5 mm, base obtuse, apex obtuse, margins entire; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, with sclerotic cells forming bands on lamina, stomata randomly distributed on lamina at aligular surface epidermis only, SI 28-($\bar{M}$29)-31.

Strobili not seen.

PLATE 29

(see opposite page)

S. digitata: Type collection, Pervillé 608 (BM).



Type ~~Specimen~~ Collection of
Selaginella digitata Spring

Selaginella digitata Spring

Ambongo, Madagascar, 1841

Coll. ~~& Comm.~~ Pervillé 608

Brought from Hb. Kew. Sept. 1930.

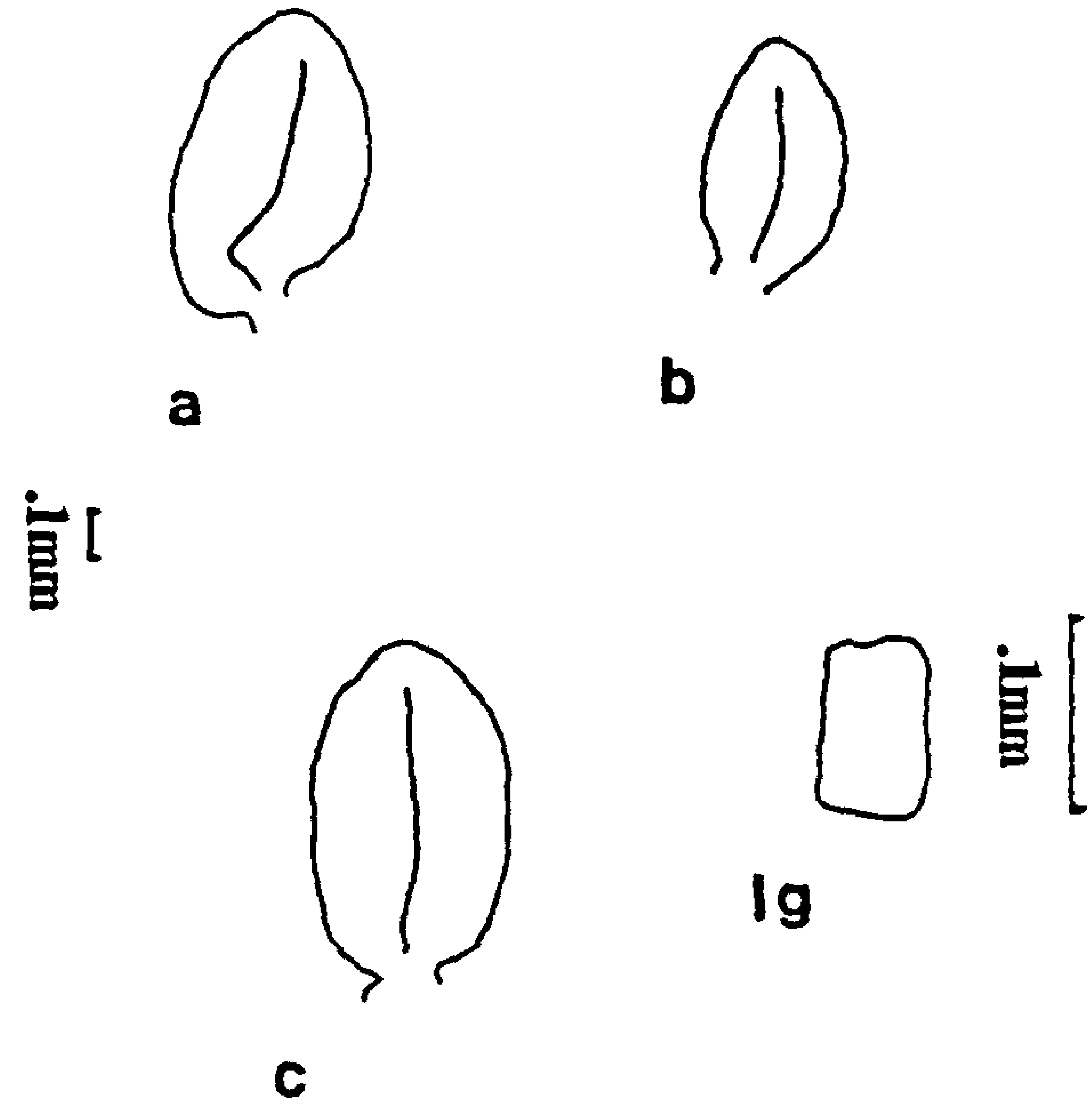


Fig. 31: S. digitata: a. lateral leaf; b. median leaf; c. axillary leaf; lg. ligule. All from Pervillé 608.

Ecological notes: Xerophyte, on ground and rocks; up to 1000 m altitude.

Specimens examined

MADAGASCAR. Ambongo, Pervillé 608 (holotype, K; BM); Ifotaka, Lam & Meeuse 5431a (K).

Geographical distribution: Madagascar.

Taxonomic notes: *S. digitata* is endemic to Madagascar and resembles *S. helicoclada* in habit. It is distinguished from *S. helicoclada* by its entire leaves (*S. helicoclada* has serrate leaves).

5. *S. helicoclada* Alston in Perrier Cat. 71 (1932); in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932). Plate 30; fig. 32.
TYPE: MADAGASCAR. Vallée d'Ihosy, 850-1000 m, Humbert & Swingle 4915 (holotype, BM).

Description

Plants erect; branch system flabellate; rhizophores restricted to the very base of plant.

Leaves anisophyllous on branches, scaly on main stem, single-veined; stomata 20-35x13-18 μm; ligules up to 0.12 mm long, lingulate (rectangular). Lateral leaves asymmetrical, elliptic-oblong (-ovate), up to 0.9x0.8 mm, base obtuse, apex obtuse (rounded), margins serrate; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, with sclerotic cells forming bands on lamina, stomata randomly distributed on lamina at aligular surface epidermis only, SI 28-($\bar{M}$30)-32. Median leaves asymmetrical, elliptic, up to 0.6x0.5 mm, base obtuse, apex mucronulate, margins serrate; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, with sclerotic cells forming bands on lamina, stomata randomly distributed on lamina at aligular surface epidermis only, SI 27-($\bar{M}$29)-30. Axillary leaves symmetrical, elliptic-ovate, up to 0.9x0.8 mm, base obtuse, apex obtuse, margins serrate; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, with sclerotic cells forming bands on lamina, stomata randomly distributed on lamina at aligular surface epidermis only, SI 28-($\bar{M}$30)-32.

Strobili tetragonous, at apices of branchlets, up to 5 mm long, with one sporangial arrangement: with no particular pattern. Sporophylls uniform, ovate (elliptic), up to 0.8x0.6 mm, base obtuse (subtruncate), apex mucronulate, margins irregularly dentate, both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed on lamina at aligular surface epidermis only, SI 20-($\bar{M}$22)-24. Megasporangia deltoid, with similar-sized spores; megaspores 44-($\bar{M}$57)-70 μm in equatorial diameter, trilete, globose, both proximal and distal surfaces coarsely granulose (scabrate). Microsporangia ellipsoid; microspores 16-($\bar{M}$20)-25 μm in equatorial diameter, trilete, globose, both proximal and distal surfaces granulose.

Ecological notes: On ground and rocks in dry environments, up to 1000 m altitude.

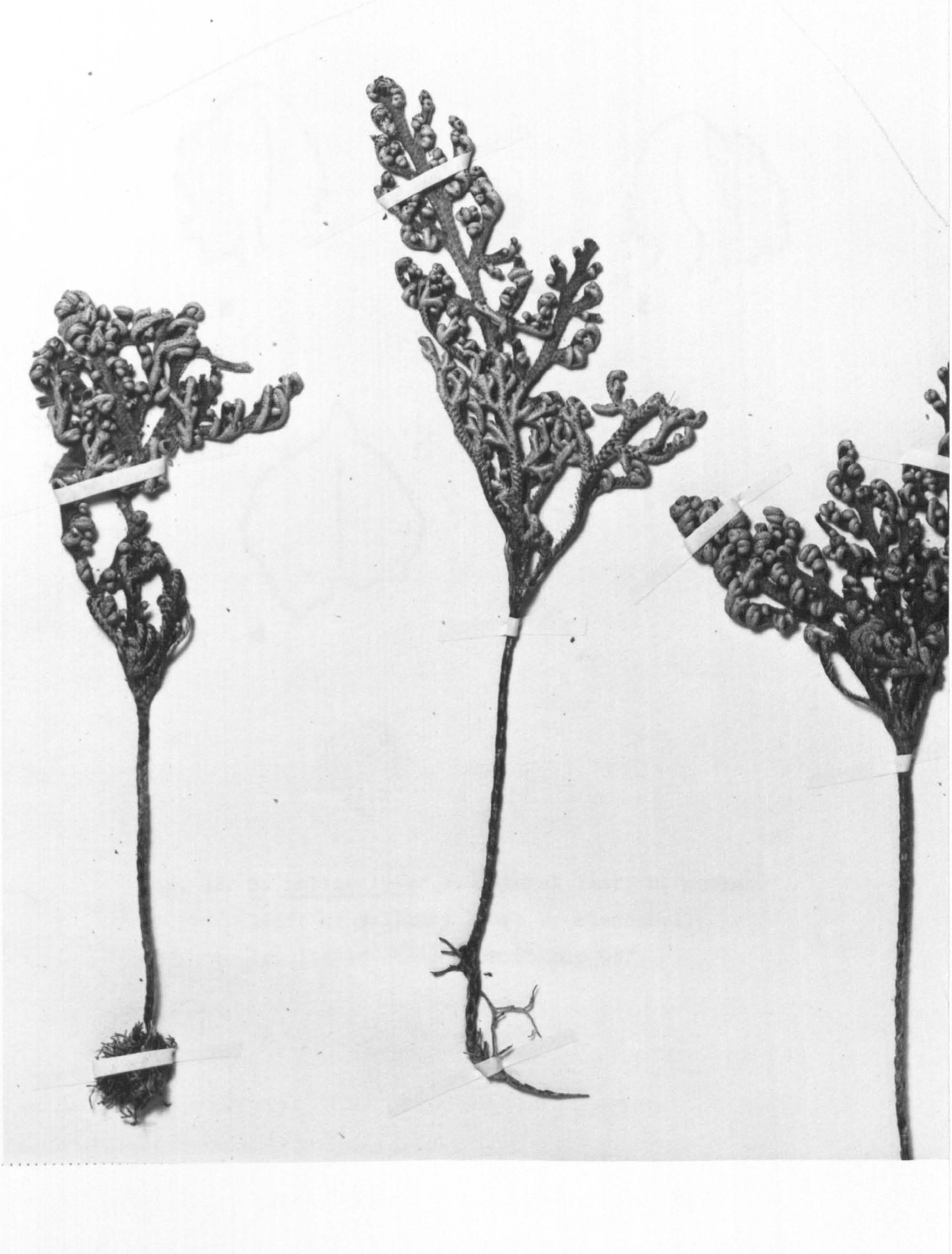
Specimens examined

MADAGASCAR. Vallée d'Ihosy, 850-1000 m, Humbert & Swingle 4915 (holotype, BM); Betsiboka, Marataitra, Bâthie 947 (paratype, BM); Beilonolo, c 30 km E of Ihosy, 800-1000 m, Mabberley 914 (K); Sud d'Ambalavo, Cremers 2295 (TAN); Rewarala, Cremers 3689 (TAN).

PLATE 30

(see opposite page)

S. helicoclada: Type specimen, Bâthie 947 (BM).



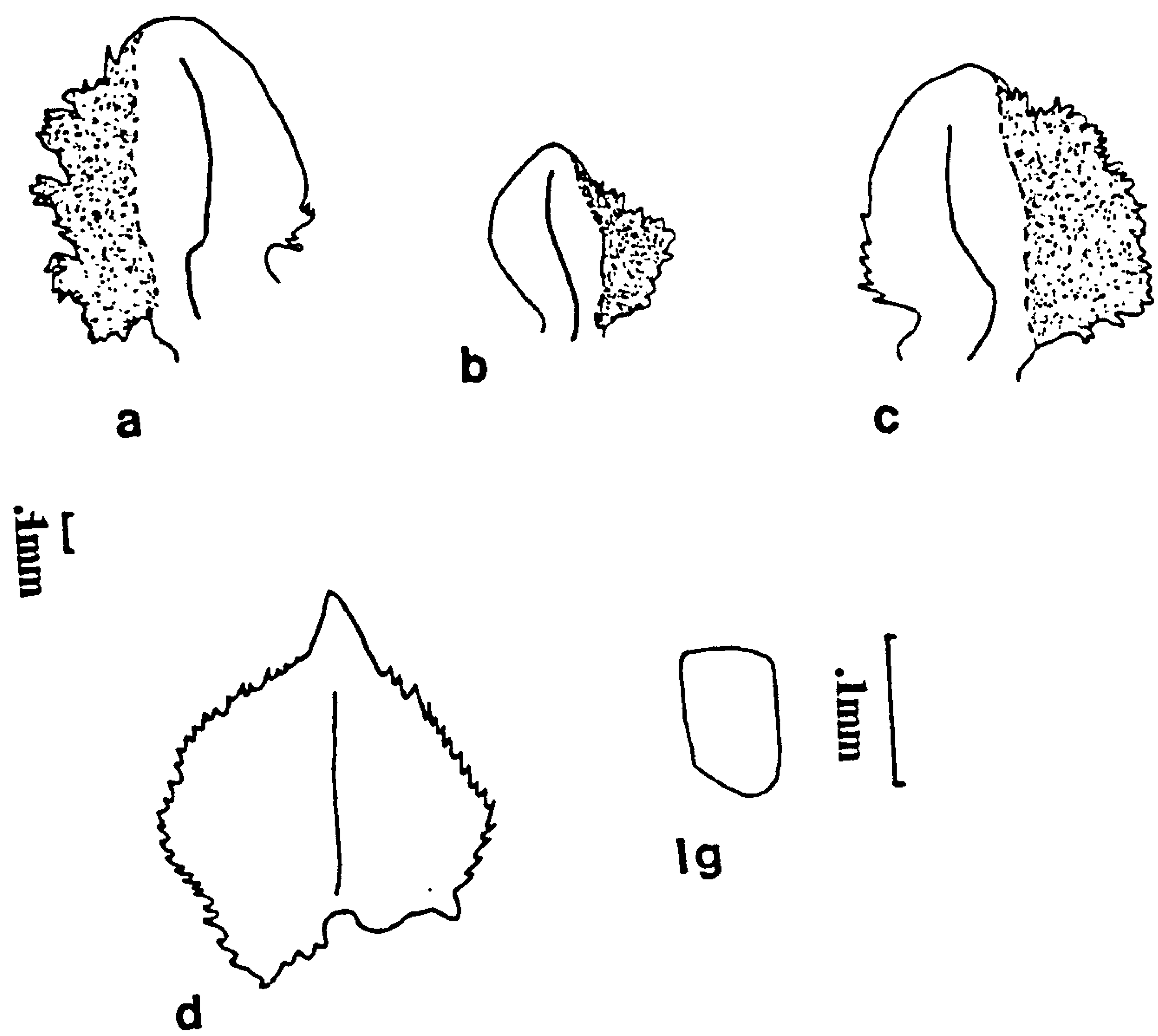


Fig. 32: S. helicoclada: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Bâthie 947.

Geographical distribution: Madagascar.

Taxonomic notes: This species is endemic to Madagascar. It is closely allied to S. digitata, from which it may be distinguished by its large size and serrate-margined leaves.

6. S. pectinata Spring, Bull. Acad. Brux. 10: 146 (1843), Mon. II: 166 (1850); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932). Plate 31; fig. 33.

TYPE: MADAGASCAR. S. loco, Commerson, Herb. Willd. 19400 (cotype, BM).

Nomenclature

SYNONYM: Lycopodium pectinatum Willd. sp. 5: 44 [1840, (non Lam. 1791)]. Type as above.

L. laevigatum Lam., Enc. 3: 652 [1791, (non Willd. 1840].

Selaginella laevigata Bak., Gard. Chron. 1867: 785, 1109 [1867, (non Spring 1840)].

S. laevigata brachystachys Hieron. in E. & P., Nat. Pfl. 1 (4): 707 (1901).

Stachygynandrum laevigatum (Lamk.) Beauv., Brongn., Hist. Veg. Foss. II. t. 5 f. 1. (1837).

Description

Plants erect, pendent; branch systems flabellate and/or 2-3 pseudopinnate; rhizophores restricted to the very base of plant.

Leaves anisophyllous on branches, simple, monomorphic on main stem, three-veined; stomata 25-30x15-20 µm; ligules up to 0.51 mm long, lingulate. Lateral leaves asymmetrical, falcate, up to 5.8x3.3 mm, base oblique, apex broadly acute (subobtuse), margins entire; ligular surface epidermis with elongate, occasionally sinous, straight-sided cells, without stomata; aligular surface epidermis with elongate sinous to occasionally undulating cells, stomata concentrated on the midveins, SI 20-($\bar{M}$22)-24. Median leaves subsymmetrical, linear-lanceolate, up to 2.0x0.6 mm, base cuneate to decurrent, apex broadly acute (subobtuse), margins entire; ligular surface epidermis with elongate sinous to occasionally undulating cells, without stomata; aligular surface epidermis with elongate, occasionally sinous, undulating cells, stomata concentrated on the midveins, SI 14-($\bar{M}$16)-17. Axillary leaves symmetrical, ovate, up to 5.1x2.9 mm, base obtuse, apex obtuse, margins entire; ligular surface epidermis with elongate, undulating to occasionally sinous and/or straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided to occasionally sinous cells, stomata concentrated on the midveins, SI 19-($\bar{M}$20)-21.

Strobili tetragonous, at apices of branchlets, up to 40 mm long, with five sporangial arrangements: (i) with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate; (ii) cone wholly microsporangiate; (iii) with the dorsal side wholly megasporangiate and the ventral sporophylls sterile; (iv) with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side with a basal zone of sterile sporophylls and an apical microsporangiate zone; and (v) with the dorsal side having the basal and apical thirds megasporangiate and the middle third microsporangiate and the ventral side with a basal zone of sterile sporophylls and an apical microsporangiate zone. Sporophylls uniform, broadly ovate to trullate, up to 3.7x2.2 mm, base obtuse to subsaggitate, apex acute, margins wavy, both ligular and aligular surfaces epidermis with elongate, straight-sided to occasionally sinous cells, stomata concentrated on the midvein at the aligular surface epidermis only, SI 13-(M̄15)-17. Megasporangia deltoid, with 54.1% similar-sized, 41.1% 3L: 1S, and 4.9% 2L: 2S spores; megaspores 721-(M̄809)-875 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces reticulate. Microsporangia reniform; microspores 23-(M̄26)-29 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces rugulose-granulose.

Ecological notes: On forest floor on ground at the slopes; 250 m to 1000 m altitude.

Specimens examined

MADAGASCAR. Befotaka, Farafangana, Decary 4760 (BM); Ambongo, near Andronomavo, Bâthie 1518 (BM); Etanetana, S. of Andohahelo, 250 m, Abbayes 3205 (BM); Perinet (Analamazaotra Forest), 25 km E. of Moramanga, 900 m, Abbayes 2584 (BM); l.c., Mabberley 808 (K); 16 km W. of Perinet, Lorence 2002 (K); Nossi Bé, Hildebrandt 3302e (BM); Be Kilus Mts., Last s.n. (BM); Ankafana, Deans Cowan s.n. (BM); Imeri, Deans Cowan s.n. (BM); Central Plateau, Hodgkin & Stansfield 17 (BM); Toamasina (Tamatave), Warbur s.n. (K); N. W. Madagascar, Baron 5077, 5633 (K); Antananarivo, Pool 4/76 (K); Ambohimitombo Forest, Forsyth Major 609 (K); Tsiroavomandidy, Morat 3379 (TAN); Mt. Ankazobe, Bosser 12.823 (TAN); Fort Dauphin, Bosser 14.403 (TAN); Tamatave, c 850-900 m, Mabberley 808 (TAN); Manakambahiny-Est, Zahamena F.R., c 800-950 m, Quansah Q30825 (TAN, BM); l.c., Quansah Q28017 (TAN, BM); l.c., Quansah Q4090020 (TAN, BM); No locality, Thompson s.n. (BM).

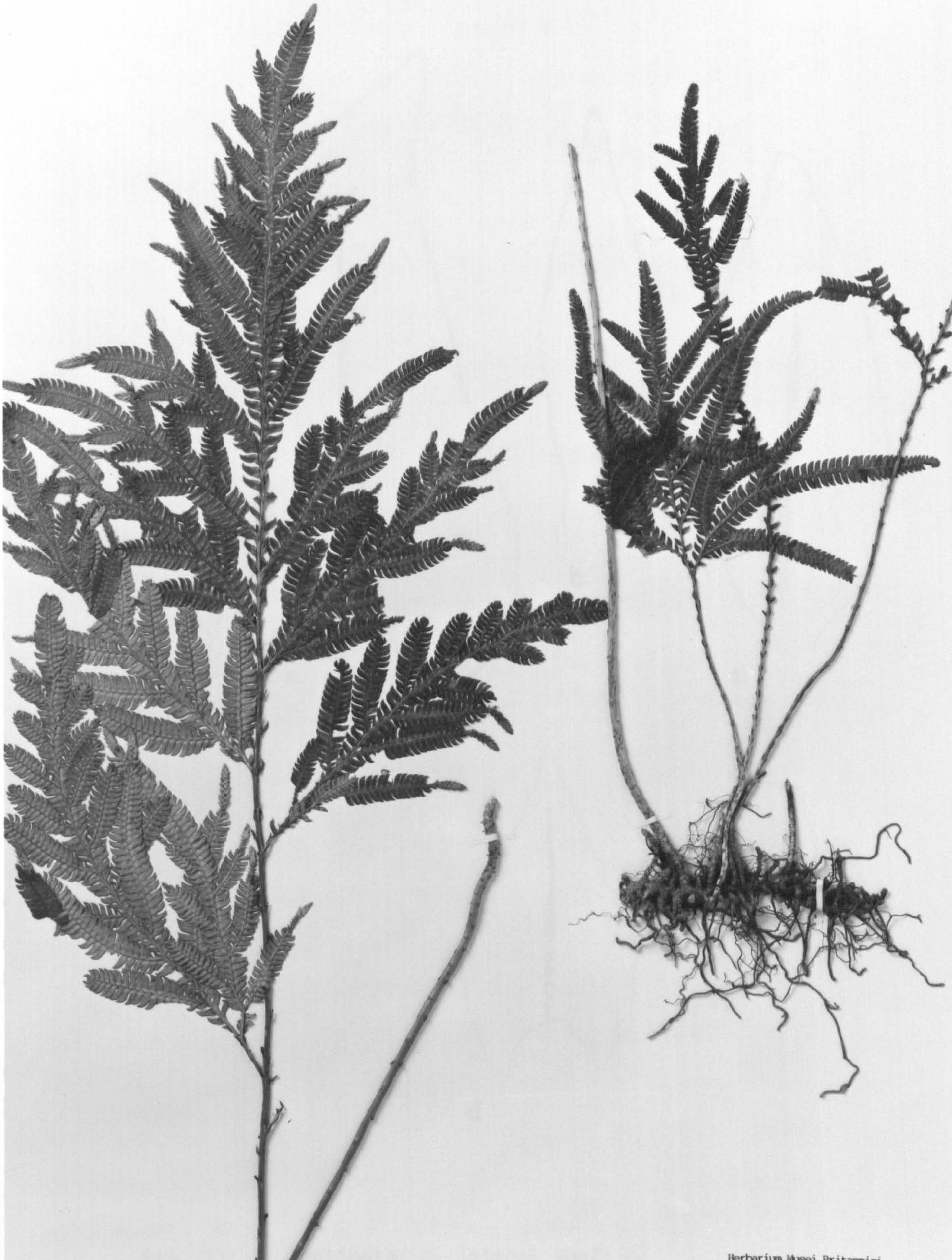
Geographical distribution: Madagascar.

Taxonomic notes: S. pectinata is endemic to Madagascar. It is closely allied to S. lyallii (also an endemic to Madagascar) from

PLATE 31

(see opposite page)

Specimen of S. pectinata: Quansah Q30826 (BM).



Herbarium Musei Britannici
MADAGASCAR

Selaginella pectinata Spring

Ambatondrazaka District: Manakambahiny Est,
Zahamena Nature Reserve.
Lower montane rainforest, 700-950m alt.

By trail on forest floor

Nathaniel Quansah No. Q30826 26.8.85

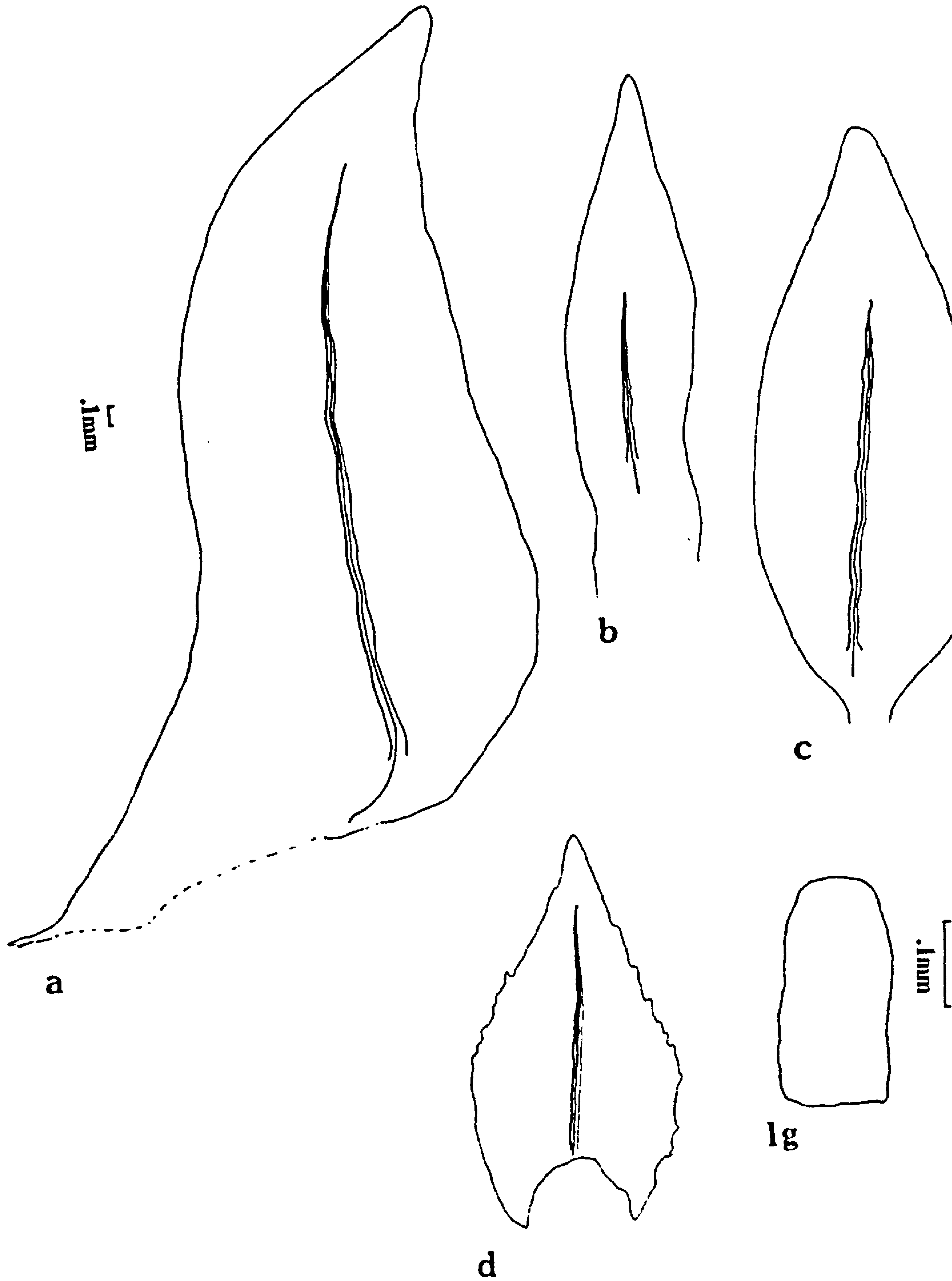


Fig. 33: S. pectinata: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Quansah Q30826.

which it is distinguished by its falcate lateral leaves, linear-lanceolate median leaves and broadly acute to obtuse leaf apices. S. pectinata is also distinguished from S. lyallii by having five types of sporangial distribution patterns (S. lyallii has only one type of sporangial arrangement).

7. S. lyallii (Hook & Grev.) Spring in Bull. Acad. Brux. 10: 146 (1843); Hieron. in E. & P., Nat. Pfl. 1 (4) Fig. 408 (1901); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932). Plate 32; fig. 34.

TYPE: MADAGASCAR. S. loco, Lyall 265 (holotype, K).

Nomenclature

SYNONYM: Lycopodium lyallii Hook. Grev. in Hook., Bot. Mus. 2: 387 (1831). Type as above.

Selaginella laevigata var. lyallii Bak., J. Bot. 23: 116 (1885).

Description

Plants erect from a robust creeping rhizome; branch systems flabellate and/or 3-4 pseudopinnate; rhizophores restricted to the very base of plant.

Leaves anisophyllous on branches, simple, monomorphic on main stem, three-veined; stomata 20-30x13-23 μm; ligules up to 0.36 mm long, rectangular (lingulate). Lateral leaves asymmetrical, ovate-oblong, up to 4.3x2.2 mm, base oblique (obtuse-subcuneate; decurrent), apex acuminate, margins subentire (irregularly wavy); ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with elongate, undulating, occasionally sinous to straight-sided cells, stomata concentrated on the midveins, SI 18-($\bar{M}$20)-21. Median leaves subsymmetrical, lanceolate, up to 2.4x0.7 mm, base cuneate, apex long acuminate, margins entire; ligular surface epidermis with elongate, undulating, occasionally sinous to straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided to occasionally sinous cells, stomata concentrated on the midveins, SI 13-($\bar{M}$14)-16. Axillary leaves symmetrical, elliptic, up to 4.0x2.2 mm, base obtuse, apex acuminate, margins subentire (wavy); ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with elongate, undulating, occasionally sinous to straight-sided cells, stomata concentrated on the midveins, SI 17-($\bar{M}$18)-19.

Strobili tetragonus, at apices of branchlets, up to 15 mm long, with one sporangial arrangement: with a single basal megasporangium, the rest of cone being microsporangiate. Sporophylls uniform, ovate, up to 3.5x2.2 mm, base obtuse, apex subobtuse to acuminate, margins irregularly wavy; both ligular and aligular surfaces epidermis with elongate, straight-sided, occasionally sinous to undulating cells, stomata concentrated on the midveins at the aligular surface epidermis only, SI 14-($\bar{M}$15)-17. Megasporangia ovoid-triangular (deltoid), with 85.4% similar-sized, 12.5% 3L: 1S, and 2.1% 2L: 2S spores; megaspores 575-($\bar{M}$745)-900 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces reticulate. Microsporangia subreniform; microspores 27-($\bar{M}$30)-34 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces verrucate-granulose.

Ecological notes: On forest floor on ground at the slopes; 700 m to 1000 m altitude.

PLATE 32

(see opposite page)

Specimen of *S. lyallii*: Quansah Q409030 (BM).

Herbarium Musei Britannici
MADAGASCAR

Selaginella lyallii (Hook. et Grev.) Spring

Ambatondrazaka District: Manakambahiny Est,
Zahamena Nature Reserve.
Lower montane rainforest, 700-950m alt.

By path on forest floor

Nathaniel Quansah No. Q409030   3·9·85

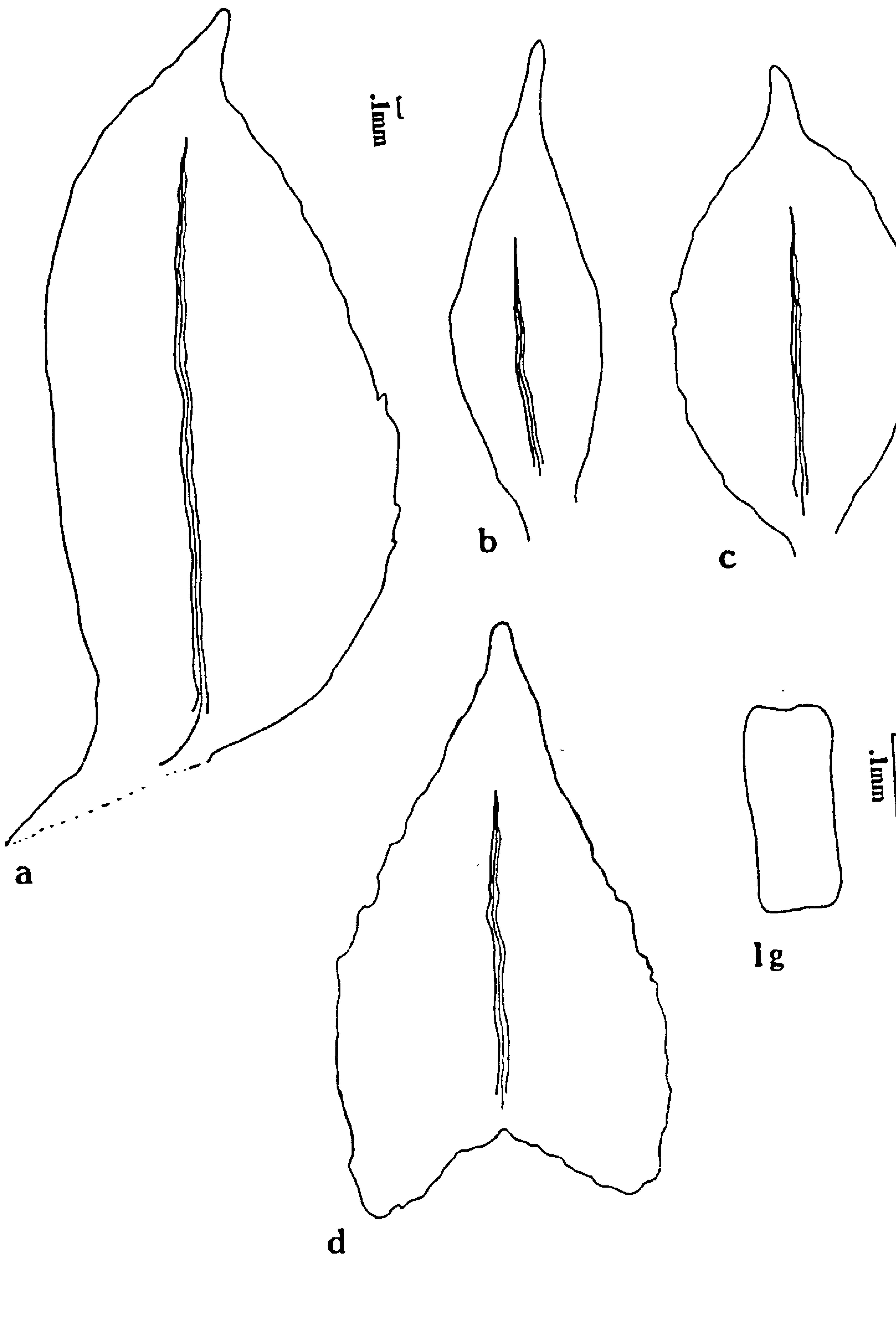


Fig. 34: S. lyallii: a. lateral leaf; b. median leaf; c. axillary leaf; d. sporophyll; lg. ligule. All from Quansah Q409030.

Specimens examined

MADAGASCAR. Central Plateau, Hodgkin & Stansfield 12 (BM, K); Imerina, Deans Cowan s.n. (BM); Irohimauritra Forest, Forsyth Major 134 (BM, K); Perinet, 25 km E of Moramanga, 920 m, Abbayes 2493 (BM); Soanierana, Lam & Meeuse 5946 (K); Tamatave, 850-900 m, Mabberley 807 (TAN); Mandraka, 7.5 km S. Tananarive, Cremers 1301 (TAN); Vohitrarivo, Bosser 3980 (TAN); Lentu-Est, route Moramanga, Bosser 6537 (TAN); Manakambahiny-Est, Zahamena F.R., c 800-950 m, Quansah Q2816 (TAN, BM); l.c., Quansah Q40902 (TAN, BM); l.c., Quansah Q409030 (TAN, BM).

Geographical distribution: Madagascar.

Taxonomic notes: S. lyallii is endemic to Madagascar. It is closely allied to S. pectinata from which it is distinguished by its ovate-oblong lateral leaves, lanceolate median leaves and acuminate leaf apices. S. lyallii is also distinguished from S. pectinata by the presence of a single sporangial distribution pattern [a single basal megasporangium, the rest of the cone being microsporangiate; (S. pectinata has five sporangial arrangements in its strobili)].

8. S. hildebrandtii A. Br. ex Kuhn in V. Decken's Reise 3(3) Bot. 71 [1879 (nomen)]; Hieron. in E. & P., Nat. Pfl. 1(4): 697 (1901); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932). Plate 33; fig. 35.

TYPE: COMOROS. Johanna, Hildebrandt 1807, 1807b (holotype, BM, K).

Description

Plants suberect to erect, branched from base, branch system 2-3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant.

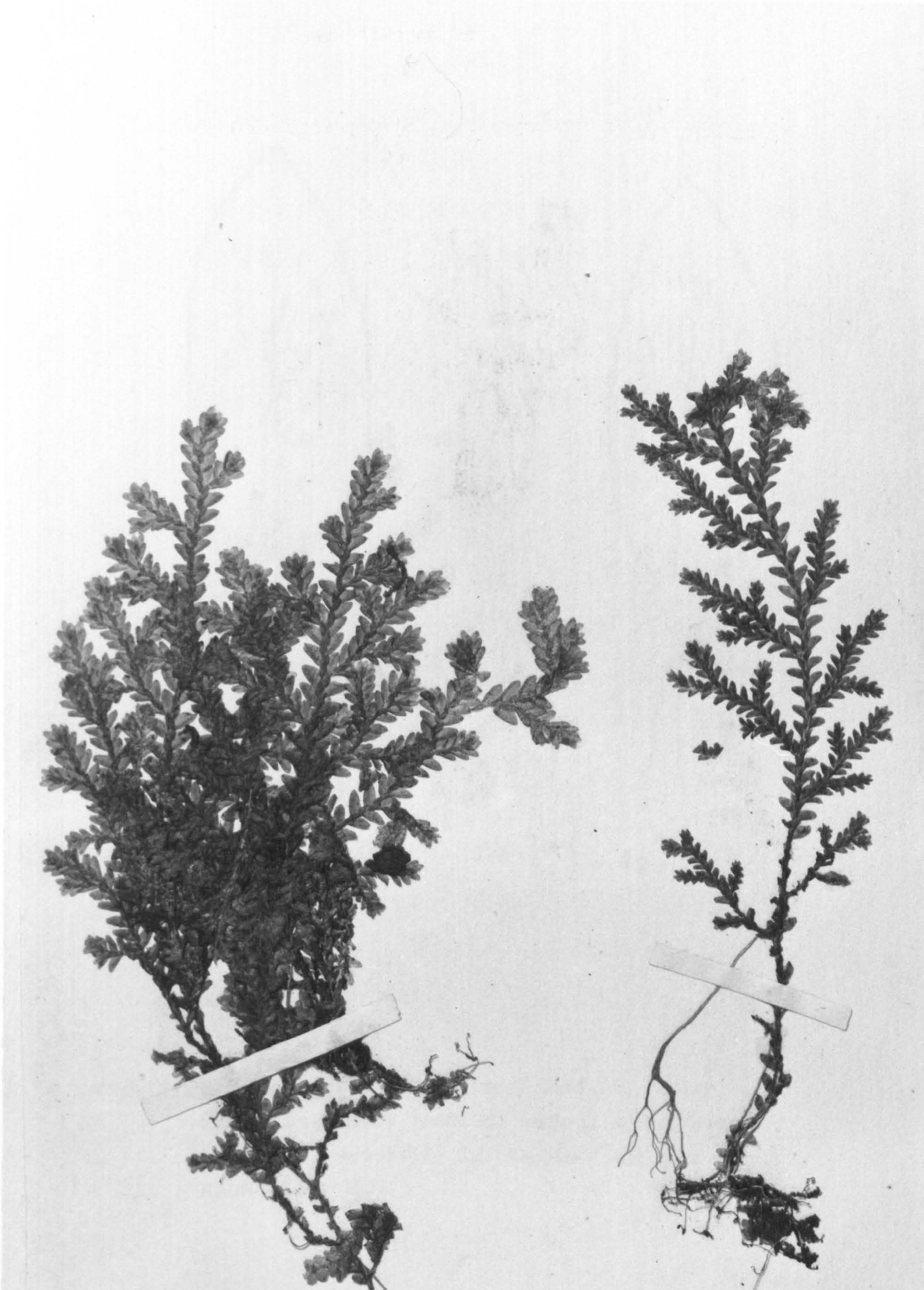
Leaves anisophyllous, single-veined; stomata 25-38x18-26 µm; ligules up to 0.35 mm long, obclavate. Lateral leaves asymmetrical, elliptic-ovate, up to 2.9x1.9 mm, base obtuse, apex broadly acute to apiculate, margins short ciliate-serrate-denticulate (cilia up to 0.15 mm long); ligular surface epidermis with isodiametric, sinous to occasionally straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous to occasionally straight-sided cells, with sclerotic cells forming patches on lamina, stomata randomly distributed on lamina, SI 10-($\bar{M}$11)-12. Median leaves asymmetrical, lanceolate, up to 1.6x0.5 mm, base obtuse, apex aristate (aristae up to 2/3 the length of lamina), margins serrate; ligular surface epidermis with elongate, sinous to occasionally straight-sided cells, without stomata; aligular surface epidermis with isodiametric, sinous to occasionally straight-sided cells, stomata randomly distributed on the lamina and at or near the margins, SI 3-($\bar{M}$4)-5. Axillary leaves symmetrical, ovate to elliptic, up to 2.8x1.2 mm, base obtuse, apex broadly acute to subobtuse, margins short ciliate-serrate (cilia up to 0.16 mm long); ligular surface epidermis with isodiametric, sinous to occasionally straight-sided cells, without stomata; aligular surface epidermis with elongate, sinous to occasionally straight-sided cells, with sclerotic cells forming patches on lamina, stomata randomly distributed on lamina, SI 8-($\bar{M}$10)-12.

Strobili bilateral, resupinate, at apices of branchlets, up to 10 mm long, with three sporangial arrangements: (i) with the dorsal side wholly megasporangiate and the ventral side wholly microsporangiate; (ii) with the dorsal side wholly megasporangiate and the ventral side containing both megasporangia and microsporangia; and (iii) cone wholly megasporangiate. Sporophylls dimorphous. Ventral sporophylls ovate-subpanduriform, up to 1.6x0.5 mm, base oblique (cuneate-subcordate), apex acuminate (occasionally subretuse), margins serrate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous to occasionally straight-sided cells, with sclerotic cells occasionally present forming patches on lamina, stomata randomly distributed on lamina, SI 9-($\bar{M}$10)-12; aligular surface epidermis with isodiametric, straight-sided to occasionally sinous cells, stomata randomly distributed at the margins, SI 2-($\bar{M}$2)-3; sporophyll-pteryx with aculeate-serrate margin, with elongate, sinous to straight-sided cells, without stomata. Dorsal sporophylls lanceolate, up to 1.1x0.4 mm, base obtuse, apex cuspidate, margins short ciliate (cilia up to 0.14 mm long); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed on the midvein at the aligular surface epidermis only, SI 4-($\bar{M}$5)-8. Megasporangia ovoid-triangular, with 93.3% similar-sized, and 6.3% 3L: 1S spores; megaspores 215-($\bar{M}$221)-246 μm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces reticulate. Microsporangia ellipsoid; microspores 25-($\bar{M}$28)-32 μm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces scabrate-granulose.

PLATE 33

(see opposite page)

_S_. _hildebrandtii_: Type specimen, Hildebrandt 1807 (BM).



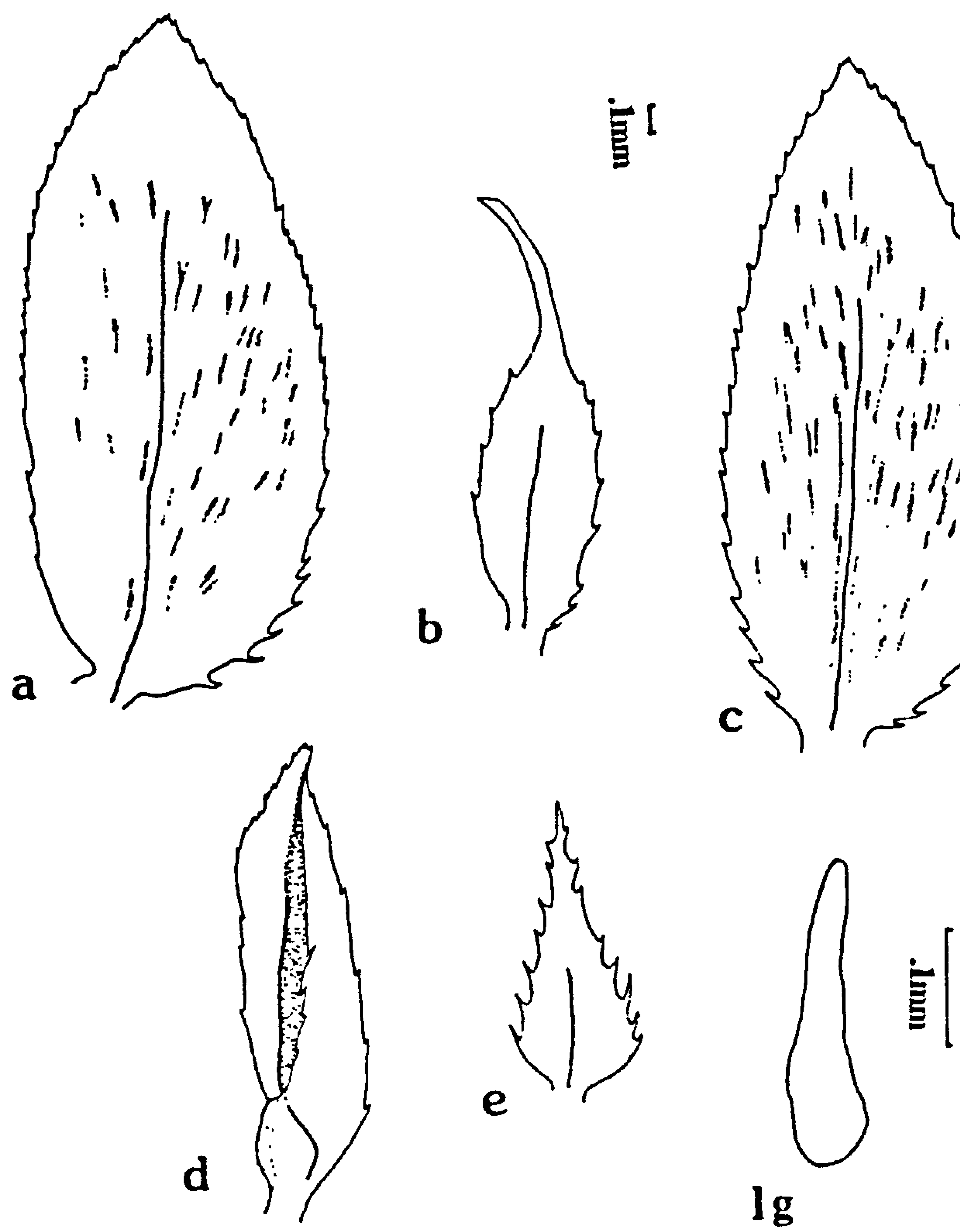


Fig. 35: S. hildebrandtii: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Hildebrandt 1807.

Ecological notes: On ground, along banks of streams and rivers in forest; up to 1000 m altitude.

Specimens examined

MADAGASCAR. Manonjeba, 300 m, Bâthie 8258 (BM); Manongarivo, Bâthie 8274 (BM); Vallée de Marofatatra, foot of Mt. Bekolosy, Bâthie 8291 bis (BM); La Mandraka, Guillaument 4278 (TAN).

Also seen

COMOROS. Johanna, Hildebrandt 1807, 1807b (holotype, BM, K); l.c., Humbolt 1522 (BM); l.c., Patterson 17014 (BM).

Geographical distribution: Madagascar, Comoros.

Taxonomic notes: S. hildebrandtii is closely allied to S. molliceps of West Africa from which it is distinguished by the short ciliate leaf margins (S. molliceps has ciliate leaf margins).

9. S. goudotana Spring, Bull. Acad. Brux. 10 (i): 140 (1843); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932); Bizzarri, Webbia 29(2): 580-592 (1975; including var. goudotana and var. abyssinica). Plate 25; fig. 27.

TYPE: MADAGASCAR. Antananarivo, Goudot s.n. (holotype G; isotype, BD).

Nomenclature

SYNONYM: S. madagascariensis Bak. J. Bot. 18: 372 (1880)

TYPE: MADAGASCAR. Mbatomanga, Aug. 6., 1862, Meller s.n. (lectotype, K).

S. magnusii Hieron. in Engler & Prantl, Nat. Pflanzenfam. 1, 4: 686 (1901).

TYPE: MADAGASCAR. Ost:-Imerina: Urwld von Andragoloaka, Nov. 1880, Hildebrandt 3782 (lectotype, BD); Type numbers in BM, K).

S. abyssinica Spring in Mem. Acad. Belg. 24: 99 (1850); Baker F. Allies 84: no 194 (1887); Knox, Trans. Bot. Soc. Edinb. 35: 263 (1950); Alston, Mém. I.F.A.N. 50: 37-38 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959).

TYPE: ETHIOPIA. Abyssinia, Sholoda, Quartin-Dillon 9 (lectotype LG).

S. preusii Hieron. in E. & P. Pflanzenfam. 1, 4: 686 no 161 (1901).

TYPE: CAMEROON. Buea, Preuss s.n. (isotype, K; lectotype, BD; Preuss 978).

S. goetzii Hieron. in Engler Bot. Jahrb. Syst. 30: 265 (1901).

TYPE: CAMEROON. Ukinga-Berge: Kingika-Berg, Schattigen Erdriss., 2600 m, 25 Mai 1899, Goetze 941 (holotype BD; isotype, K).

S. whytei Hieron. in E. & P. Pflanzenfam. 1, 4: 697 (1901).

TYPE: N. NYASALAND. Whyte s.n. (holotype, BD; isotype, K).

S. bueensis Hieron. Hedwigia 43: 20 (1904).

TYPE: CAMEROON. Buea, Preuss 1079 (holotype, BD; isotype, K).

Description

Plants erect to ascending (occasionally trailing), soboliferous, branching from the base, branch-system 2-4 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant.

Leaves anisophyllous, single-veined; stomata 22-31x18-24 µm, ligules up to 0.23 mm long, obclavate. Lateral leaves asymmetrical, narrowly ovate to oblong (ovate-oblong), up to 3.0x2.0 mm, base oblique (obtuse-subcuneate), apex acute to apiculate, margins serrate-denticulate; ligular surface epidermis with isodiametric, sinous cells, stomata randomly distributed at and/or near the margins, SI 16-($\bar{M}$16)-17; aligular surface epidermis with elongate, sinous cells, occasionally with sclerotic cells forming bands and patches on lamina, stomata concentrated along the midvein in 2-5 rows, SI 19-($\bar{M}$20)-21. Median leaves asymmetrical, lanceolate to narrowly sub-deltate, up to 1.7x1.0 mm, base subcordate to weakly cordate, apex aristate (aristae up to half the length of lamina) margins serrate; ligular surface epidermis with elongate, sinous to straight-sided cells, stomata sparsely distributed at the margins, SI 4-($\bar{M}$4)-5; aligular surface epidermis with isodiametric, sinous cells, stomata sparsely distributed along the midvein in a single row, SI 5-($\bar{M}$5)-6. Axillary leaves symmetrical, elliptic to narrowly ovate, up to 2.8x2.1 mm, base weakly obtuse to cuneate, apex acute to apiculate, margins short ciliate-serrate-denticulate (cilia up to 0.15 mm long); ligular surface epidermis with isodiametric, sinous cells, stomata randomly distributed at and/or near the margins, SI 13-($\bar{M}$13)-14; aligular surface epidermis with elongate, sinous cells, occasionally with sclerotic cells forming bands and patches on lamina, stomata concentrated along the midvein in 2-5 rows, SI 18-($\bar{M}$19)-20.

Strobili bilateral, resupinate, at apices of branchlets, up to 4.5 mm long, with two sporangial arrangements: (i) cone with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate; (ii) with the dorsal side containing both megasporangia and microsporangia randomly arranged and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls elliptic-lanceolate (-subpanduriform), up to 2.0x1.0 mm, base obtuse, apex acute to apiculate, margins aculeate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous cells, stomata sparsely distributed on the lamina, SI 5-($\bar{M}$6)-7; aligular surface epidermis with isodiametric, straight-sided cells, spomata sparsely distributed on lamina, SI 3-(M3)-4; sporophyll-pteryx with serrate-serrulate margin, with elongate, sinous cells, without stomata. Dorsal sporophylls ovate-lanceolate, up to 1.1x0.8 mm, base obtuse to broadly cuneate, apex cuspidate, margins short ciliate-serrate; both ligular and aligular surfaces epidermis with elongate, sinous to straight-sided cells, stomata randomly distributed on the lamina at the aligular surface epidermis only, SI 7-($\bar{M}$9)-9. Megasporangia deltoid, with 80% similar-sized and 20% 2L: 2S spores; megaspores 225-($\bar{M}$260)-305 μm in widest area, trilete, subglobose to tetrahedral-subtriangular, both proximal and distal surfaces compactly scabrate-verrucate. Microsporangia ellipsoid to roundish; microspores 25-($\bar{M}$35)-40 μm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces verrucate-echinate.

Ecological notes: In evergreen forest on wet rocks near streams and waterfalls, as well as open well grazed pasture of higher ground; from 700 m to 2600 m altitude.

Specimens examined

NIGERIA. Bamenda: Bafut, Bafut-Wum Road, c 900 m, Savory UCI 308 (BM); Ondo: Akure, Idanre, Orosun Peak, 850 m, Richards 3785a (K).

CAMEROON. Buea; Preuss s.n. (Type of S. preusii Hieron., K); l.c., Preuss s.n. (isotype of S. bueensis Hieron., K); Cameroon Mt.: Road to VHF Radio Station, 2000 m, Tryon & Tryon 6519 (K); Deulash, Kingika-Berge, Goetze 941 (isotype of S. goetzei Hieron., K).

EQUATORIAL GUINEA. Fernando Po: Moka, Mioko heights, c 2000 m, Adams 1104 (BM, K); l.c., Basakato, c 1000 m, Adams 1006 (BM); l.c., Ilache waterfall, c 1200 m, Adams 1067 (BM); l.c., Peak of Clarence, Mann 667 (K); l.c., 'Heathland' near Biao, Wrigley & Melville 468 (K).

MADAGASCAR. Ost-Imerina: Urwld von Andragoloaka, Hildebrandt 3782 (BM, K; BD, lectotype of S. magnusii); Analamaitso, Bemarivo, Bâthie 8267 (BM); Ankaratra Mts., Scott-Elliot 1966 (BM, K); Antananarivo, Pool 2201 (K); l.c., Gilpin s.n. (K; lectotype of S. madagascariensis); Tampoketsa, Bemarido, Bâthie 8341 (BM); Mbatomanga, Meller s.n. (K; lectotype of S. melleri); Antsirabe, Bâthie 8331 (BM); Manonjeba, Bâthie 8290 (BM); Perinet, 25 km E of Moramanga, 880 m, Abbayes 2589 (BM); Anosibe 93 km S of Moramanga, 750 m, Abbayes 2759 (BM); Mandraka, 1330 m, Abbayes 2609 (BM); Tanala, Kitching s.n. (K); Andramgodonka, Parker s.n. (K); Lalandro, N of Ihosy, 800-1000 m, Mabberley 886 (K); Manakambahiny-Est, Andromangabe, Zahamena Nature Reserve, 700-950 m, Quansah Q0188 (TAN, BM); l.c., Quansah Q1088 (TAN, BM); l.c., Quansah Q10814 (TAN, BM); Andramasino, Descoings 3080 (TAN); Anjavidilava-ouest-Andringitra, c 1600 m, Guillaumet 3807 (TAN).

Geographical distribution: Ghana, Nigeria, Cameroon, Equatorial Guinea (Rio Muni, Fernando Po), Congo, Zaire, Angola, Rep. S. Africa, Mozambique, Zimbabwe, Zambia, Tanzania, Kenya, Burundi, Uganda, Somalia, Ethiopia, Sudan, Madagascar - African tropics.

Taxonomic notes: This species is distinguished from all other species from Madagascar and West Africa with dimorphic sporophylls by its soboles.

10. S. perpusilla Baker, J. Bot. 23: 292 (1885), F. Allies no. 119 (1887); Alston, in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932). Plate 34; fig. 36.
TYPE: REP. S. AFRICA. Nyika Plateau, Wakefield s.n. (holotype, BM).

Description

Plants suberect to erect, branched from the base, branch system 1-3 pseudopinnate; rhizophores arising at the axils, occasionally at the dorsal side of primary branches and distributed more or less throughout the plant.

Leaves anisophyllous, single-veined; stomata 18-28x15-25 µm; ligules up to 0.21 mm long, obclavate. Lateral leaves asymmetrical, ovate-oblong to ovate-elliptic, up to 2.3x1.3 mm, base obtuse, apex acuminate, margins short ciliate-serrate-denticulate (cilia up to 0.16 mm long); ligular surface epidermis with isodiametric, sinous cells, without stomata; aligular surface epidermis with elongate, sinous to undulating cells, with sclerotic cells forming patches on lamina, stomata randomly distributed on lamina and at the margins, SI 17-($\bar{M}$18)-19. Median leaves subsymmetrical, deltate, up to 1.4x0.8 mm, base cordate, apex cuspidate, margins serrate-denticulate; ligular surface epidermis with elongate, sinous to undulating cells, occasionally with sclerotic cells forming patches on lamina, without stomata; aligular surface epidermis with isodiametric, sinous to occasionally straight-sided cells, stomata randomly distributed on lamina, SI 7-(M̄7)-8. Axillary leaves symmetrical, ovate, up to 2.0x1.2 mm, base obtuse, apex acuminate (apiculate), margins short ciliate-serrate (cilia up to 0.16 mm long); ligular surface epidermis with isodiametric, straight-sided to occasionally sinous cells, without stomata; aligular surface epidermis with elongate, straight-sided to occasionally sinous cells, with sclerotic cells forming patches on lamina, stomata randomly distributed on lamina, SI 16-(M̄18)-19.

Strobili bilateral, resupinate, at apices of branches and/or branchlets, up to 10 mm long, with two sporangial arrangements: (i) with the dorsal side wholly megasporangiate and the ventral side containing both megasporangia and microsporangia; (ii) cone wholly megasporangiate. Sporophylls dimorphous. Ventral sporophylls ovate-subpanduriform, up to 2.2x1.6 mm, base subcuneate to oblique, apex long acuminate, margins aculeate-serrate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinous to undulating cells, with sclerotic cells occasionally present forming patches on lamina, stomata, more or less, evenly distributed on lamina, SI 17-(M̄18)-19; aligular surface epidermis with isodiametric, sinous to occasionally straight-sided cells, stomata sparsely distributed on lamina, SI 4-(M̄4)-5; sporophyll-pteryx with aculeate-serrate margin, with elongate, straight-sided to occasionally sinous cells, without stomata. Dorsal

PLATE 34

(see opposite page)

S. perpusilla: Type specimen, Wakefield s.n. (BM).

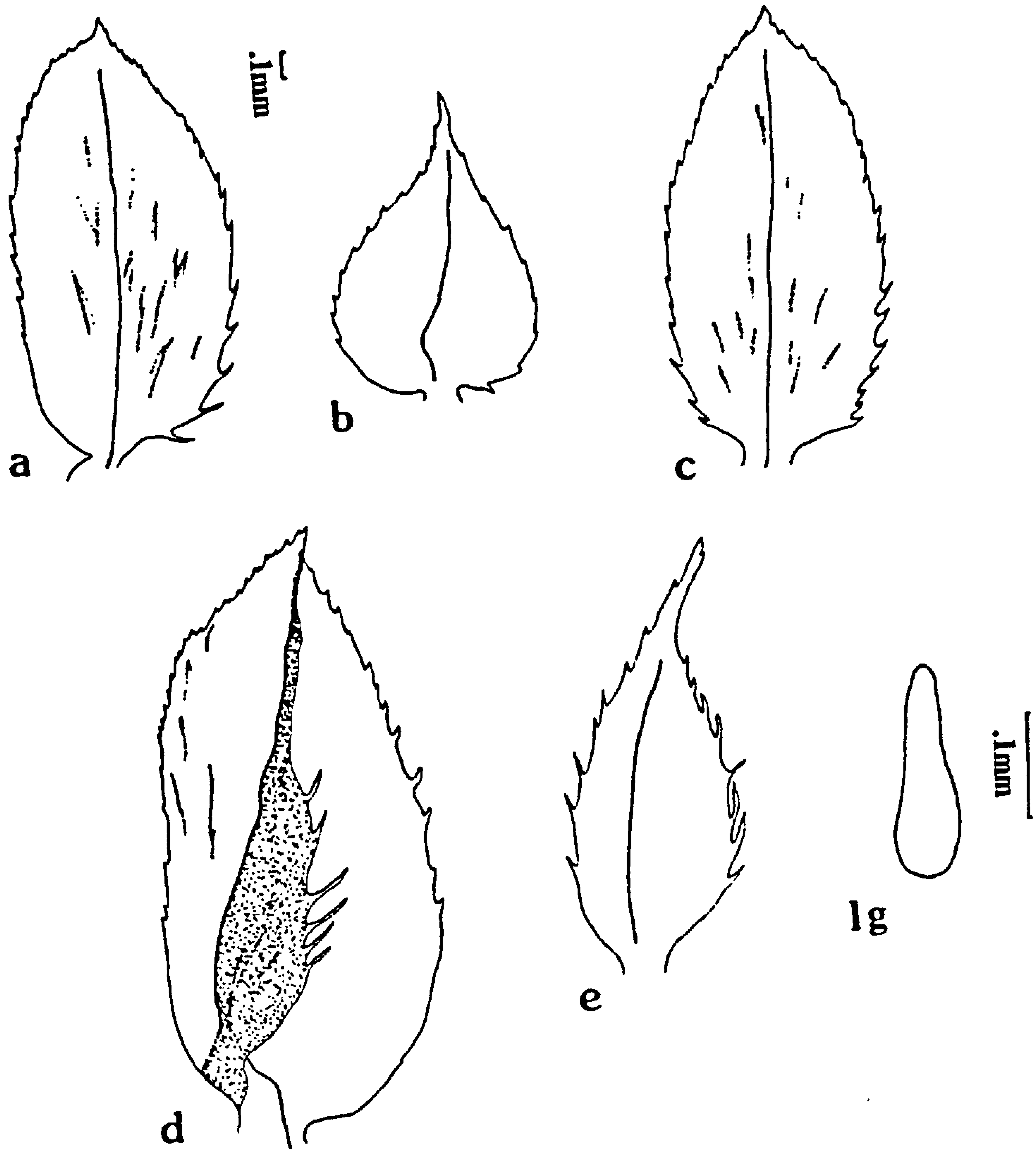


Fig. 36: S. perpusilla: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll; lg. ligule. All from Wakefield s.n.

sporophylls lanceolate, up to 1.7x0.8 mm, base obtuse, apex cuspidate, margins long ciliate-serrate (cilia up to 0.28 mm long); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed on lamina at aligular surface epidermis only, SI 5-($\bar{M}$6)-7. Megasporangia deltoid, with 80% similar-sized, and 20% 3L:1S spores; megaspores 231-($\bar{M}$264)-291 µm in equatorial diameter, trilete, globose, both proximal and distal surfaces reticulate. Microsporangia ellipsoid; microspores 23-($\bar{M}$27)-33 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces baculate.

Ecological notes: On banks, under bushes or in dry exposed positions or among stones, up to 1000 m altitude.

Specimens examined

MADAGASCAR. Berasotra: Bâthie 181 (BM); Cap. St. André: Bâthie 1735 (BM); Ambongo: Andranomado, Bâthie 8342 (BM).

Also seen

SOUTH AFRICA. Nyika Plateau, Wakefield s.n. (holotype, BM).

Geographical distribution: Congo, S. Africa, Madagascar.

Taxonomic notes: This species is closely allied to the West African S. buchholzii from which it is distinguished by its short-ciliate-serrate leaves and reticulate megaspores.

11. S. unilateralis Spring, Bull. Acad. Brux. 10: 232 (1843); Alston

in Christensen, Dansk Bot. Ark. Bd. 7: 193-200 (1932).

Plate 35; fig. 37.

TYPE: MADAGASCAR. Bernier s.n. (?K).

Description

Plants suberect to erect, branched from the base; branch system 2-3 pseudopinnate; rhizophores arising at the axils of primary branches, restricted to the basal third of plant.

Leaves anisophyllous, single-veined, stomata 25-34x15-25 μm; ligules not seen. Lateral leaves asymmetrical, ovate-elliptic, up to 3.2x1.5 mm, base obtuse, apex acute, margins ciliate-serrate (cilia up to 0.23 mm long); ligular surface epidermis with isodiametric, straight-sided to occasionally sinous cells, without stomata; aligular surface epidermis with elongate, straight-sided to occasionally sinous cells, with sclerotic cells forming bands on lamina, stomata randomly distributed on the midvein and at the margins, SI 16-($\bar{M}$18)-19. Median leaves asymmetrical, lanceolate, up to 1.8x0.7 mm, base obtuse, apex cuspidate, margins short ciliate-serrate (cilia up to 0.15 mm long); ligular surface epidermis with elongate, straight-sided to occasionally sinous cells, without stomata; aligular surface epidermis with isodiametric, straight-sided to occasionally sinous cells, stomata sparsely distributed on the midvein, SI 3-($\bar{M}$4)-5. Axillary leaves symmetrical, ovate, up to 2.8x1.4 mm, base obtuse, apex acute, margins ciliate-serrate (cilia up to 0.24 mm long); ligular surface epidermis with isodiametric, straight-sided to occasionally sinous cells, without stomata; aligular surface epidermis with elongate, straight-sided to occasionally sinous cells, with sclerotic cells forming bands and patches on lamina, stomata randomly distributed on midvein and at the margins, SI 18-(M̄22)-25.

Strobili bilateral, resupinate, at apices of branchlets, up to 8.5 mm long, with three sporangial arrangements: (i) with a basal megasporangiate zone and an apical microsporangiate zone; (ii) with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate; and (iii) cone wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls ovate-subpanduriform, up to 1.2x0.4 mm, base oblique (cuneate-obtuse), apex acuminate (apiculate), margins ciliate-serrate (cilia up to 0.22 mm long), with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, straight-sided to occasionally sinous cells, with sclerotic cells occasionally present forming patches on lamina, stomata randomly distributed on lamina and at margins, SI 7-(M̄9)-11; aligular surface epidermis with isodiametric sinous to undulating cells, stomata randomly distributed on lamina and at margins, SI 4-(M̄5)-7, sporophyll-pteryx with ciliate-serrate margin (cilia up to 0.23 mm long), with elongate, straight-sided cells, without stomata. Dorsal sporophylls lanceolate, up to 0.9x0.4 mm, base obtuse, apex cuspidate to short aristate (aristae up to 1/3 the length of lamina), margins ciliate (cilia up to 0.22 mm long); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed on the midvein at the aligular surface epidermis, SI 4-(M̄5)-7. Megasporangia ovoid-triangular, with 70% similar-sized, 10% 3L: 1S, and 20% 2L:2S spores; megaspores 198-(M̄214)-236 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces rugulose-reticulate. Microsporangia ellipsoid; microspores 19-(M̄21)-24 µm in equatorial diameter, trilete, subglobose, both proximal and distal surfaces scabrate.

Ecological notes: Lower montane forest species, up to 500 m altitude.

Specimens examined

MADAGASCAR. Bidi Anodi, 200 m, Bâthie 8320 (BM); Antananarivo, Warbur s.n. (K); Soamierana, 350 m, Lam & Meeuse 5925 (K); Tang-Ansuky, Thompson s.n. (BM).

Geographical distribution: Madagascar.

Taxonomic notes: This species is endemic to Madagascar and is distinguished from all other Madagascan species by its ciliate-margined leaves.

PLATE 35

(see opposite page)

Specimen of *S. unilateralis*: Bathie 8320 (BM).

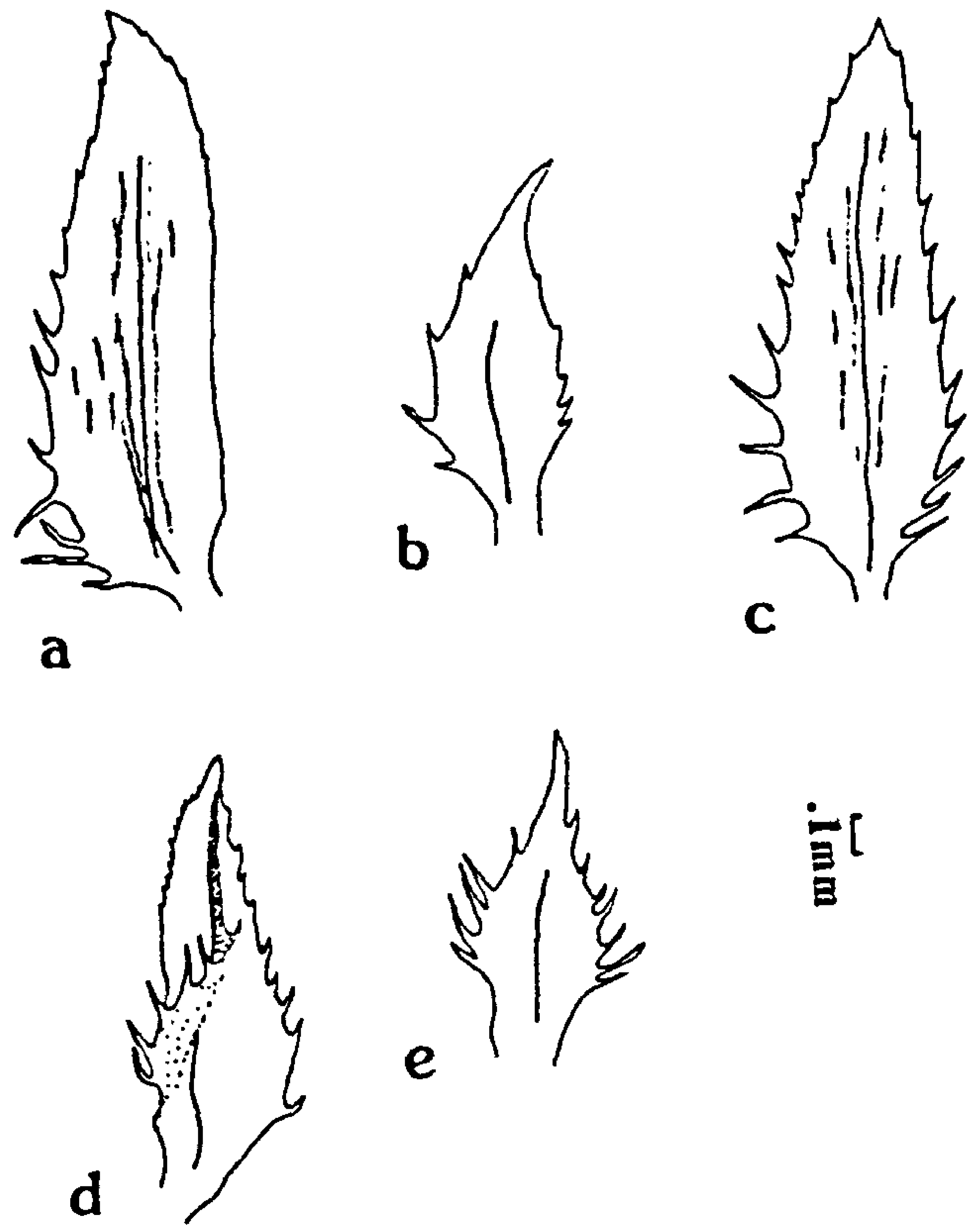


Fig. 37: S. unilateralis: a. lateral leaf; b. median leaf; c. axillary leaf; d. ventral sporophyll; e. dorsal sporophyll. All from Bâthie 8320.

CHAPTER NINE

RELATIONSHIPS OF THE *SELAGINELLA* FLORAS OF WEST AFRICA AND MADAGASCAR

RELATIONSHIPS OF THE SELAGINELLA FLORAS OF WEST AFRICA AND MADAGASCAR

The vegetation of the Earth as we know it today is the result of a long process of evolutionary development under the influence of environmental factors, both past and present. The positions of the continents relative to each other and to the poles have repeatedly changed during the course of time so that the floristic development in the various parts of the Earth has followed divergent routes (Walter, 1973).

Evidence presented by many authors (eg Wilson, 1966; Seyfert & Sirkin, 1973) indicates that there were displacements between the continents during the Pre-Cambrian and the Palaeozoic. Palaeomagnetic, structural and geochronological data suggest that five separate continents existed during the Proterozoic Era (Seyfert & Sirkin, 1973). These are designated as Ancestral North America, Ancestral Europe, Gondwanaland, Ancestral Siberia, and Ancestral China. Gondwanaland consisted of Africa, South America, Antarctica, Australia, most of the Middle East and India, and segments of southern Europe, the Southern United States, Mexico and Central America.

During the palaeozoic, a super continent of Pangea was formed by the joining of the ancestral continents. According to Darlington (1965), the vegetation of the world was strongly zoned in the late Palaeozoic and the zonation was evidently correlated with climate. Pangea was gradually torn apart during the Mesozoic. Palaeomagnetic and structural data presented by Seyfert & Sirkin (1973) indicate, again, that the breakup of Pangea occurred in several stages: the initial stage began during the Late Triassic with the separation of North America and

Gondwanaland. The breakup of Gondwanaland probably began in the Late Jurassic, when South America and a plate that included Antarctica and Australia separated from a plate that included India and Africa. The separation of North America, Greenland and Europe probably began during the Jurassic. By the early Tertiary, the continents had achieved their present outlines, but the Atlantic and Indian Oceans had not yet reached their present widths (Seyfert & Sirkin, 1973).

Various authors, including McElhinny, 1970; Smith & Hallam, 1970 and Tarling, 1971, have given different reconstructions of Gondwanaland for end-Palaeozoic time. In the reconstruction by Smith & Hallam (1970), Madagascar occupies the embayment in the coastline of East Africa, part of Antarctica the embayment near southern Mozambique, and the Indian Ocean does not exist. Smith & Hallam (1970) have given geological evidence for this reconstruction and also shown, partly from igneous rocks along coastal eastern Africa, that Antarctica broke away from Africa in the Upper Triassic - Lower Cretaceous interval whereas Madagascar did not break away until the Upper Cretaceous.

Sowerbutts (1970) has also reported that the extensive series of rift faults, known collectively as the East African rift system, results from three separate periods of rifting, and that these periods were associated with the fragmentation of Gondwanaland. According to Sowerbutts (1970), the first period occurred in the Triassic-Jurassic associated with the breakup of Antarctica and Africa, the second in the Cretaceous associated with the breakup of Madagascar and Africa, and the third began in the mid- Cainozoic associated with the breakup of Arabia and Africa. The latter is still in progress.

Africa is a rigid and ancient Pre-Cambrian shield. The essential features of the structure and present morphology are the consequences of Recent, Tertiary and Quaternary movements in the sense that epeirogenic movements and erosion are of the considerable importance in the recent epochs. One should, however, remember that some fundamental features such as the Rift Valleys and other large troughs are of Cretaceous age and that the direction of certain plate movements date back to the Pre-Cambrian. Dixey (1960) and Paulian (1984) have reported on the similarity between the main groups of the Pre-Cambrian of Madagascar and Africa [the Mozambique belt (East Africa) and South Africa].

Major prehistoric environmental changes ('palaeoecological events'), like the splitting of a supercontinent or the advent of an ice age, tend to affect large areas simultaneously, so that many species come to have greater or lesser coincidence in their distributions (Collinson, 1977).

Profound climatic change occurred with the onset of widespread continental glaciation around two million years ago (Collinson, 1977). Since that time, repeated cycles of glaciation have devastated the floras of the world, extinguishing many species, stimulating the evolution of adaptations in many others, disrupting or modifying the geographic range of the majority.

In the Tropics, Quaternary climates seem to have alternated between rainy periods (pluvials) and drier spells (interpluvials). The former had the effect of destroying large areas of level erosion surfaces inherited from Pliocene times, so that new varied mosaics of different soils were created. In the latter periods, areas covered by the wet tropical forests were reduced, often to isolated regions. In West Africa, for example, the tropical forest trees in the drier interpluvials seem to have been confined to only three refuges in Liberia, western Ghana and the Cameroons. The resulting impoverishment of the flora of this region and the evolution of new plant types are still evident today (Collinson, 1977).

In a study on the vascular plants of West Africa, Morton (1972) has reported that West Africa has a flora of some 7,500 species. Within the montane flora of West Africa, 47% of the species are confined to West Africa - that is are West African endemics; 53% are species which occur outside West Africa, mainly on the mountains of East and Central Africa.

Madagascar, the fourth largest island in the world, is situated in the Indian Ocean about 400 km off the coast of Mozambique, East Africa. It has been separated from the continent of Africa for some 100 million years (Sowerbutts, 1970; Tarling & Tarling, 1971; Smith et al., 1971; Paulian, 1984). This separation has meant that the islands flora, and indeed fauna, has developed in comparative isolation from the mainland forms, resulting in the regions' unique organisms.

In his studies on the pteridophytes of Madagascar, Christensen (1932) reported that 'the African Continent is poorer in ferns than Tropical America and Asia which partly is due to the less favourable edaphic and climatic factors that prevail in the immense areas of savannahs, steppes and deserts, but even the big equatorial primaeval forest covering the plains of the Congo basin is poor in fern species; only the mountainous regions of Tropical West Africa (The Cameroons and other mountains) and of the lake-district in eastern Belgian Congo (Ruwenzori, etc.) and East Africa ((Kilimanjaro, Kenya) rival Madagascar in the number of species'. Christensen (1932) went on to indicate how rich

Madagascar was in endemic species. He also showed that besides a not surprising element of species also found on the African continent, Madagascar was characterized by the occurrence of a considerable number of Indian and Malayan and a smaller number of American species. Other workers, including Guillaumet (1984) have also reported on the extensive endemism and the uniqueness of the Madagascan flora, with 12,000 species of flowering plants, of which 85% are confined to Madagascar.

According to Richards (1973) the depauperate nature of the African forest viz-a-viz those of other tropical areas may be seen to be possibly related to the extinctions caused in arid phases, during the Quaternary, which were perhaps more severe in Africa than elsewhere in the tropics.

Even though the pteridophyte flora found in Madagascar has developed in isolation, some species are found on the African continent while others show very close relationships to the species on mainland Africa.

The closeness of relationships of species from Madagascar to those from West Africa is seen in the genus Selaginella subgenus Stachygynandrum. There are about 66 species of Selaginella in Africa and Madagascar. Thirty-four of these are found in West Africa and Madagascar. Of the 34 species, three belong to subgenus Selaginella and 31 belong to subgenus Stachygynandrum. Two of the 31 species recorded for West Africa and Madagascar are common to both areas. Analysis of the species of subgenus Stachygynandrum in West Africa and Madagascar, indicates that 38% of them belong to the section Homostachys while 62% belong to the section Heterostachys. Of the species belonging to the section Homostachys, 1% is common to both areas while 6% of the Heterostachys are common to both areas.

Species found in West Africa

There are 20 species of subgenus Stachygynandrum in West Africa, 25% of which belong to the section Homostachys and 75% to the section Heterostachys. Of these 20 species, 35% are endemics; 55% are species which also occur outside West Africa, mainly in Central and East Africa but not Madagascar, while 10% also occur in Madagascar. The species in West Africa show a gap in their distribution in Benin. Most of them are found in the countries east and west of Benin but not in Benin itself. Senegambia and Guinea-Bissau also lack most of the species. The absence of Selaginella in these countries, especially Senegambia and Guinea-Bissau (only two species are found in Senegambia and only one in Guinea-Bissau) may be attributed to lack of collectors in these areas. This is because, prior to this work, the number of species recorded by Alston (1959) for some of the countries has been very few. However, recent collections by botanists and others travelling around West Africa have resulted in an increase in the number of countries known to be sites for Selaginella species. For example, S. blepharophylla has been reported by Alston (1959) as occuring only in three countries (Guinea, Liberia and Ivory Coast) but recent collections have shown that this species is also present in Ghana, Nigeria and Cameroon. Also, no species had been reported from Guinea-Bissau before but examination of recent collections at the BM reveal that S. cathedrifolia is present in this country. S. cathedrifolia is now recorded in ten West African countries where - as Alston (1959) reported it to be present in only seven of them.

The absence of most of the species in Benin [(Dahomey), only two species occur in Benin] may be due to the presence of the 'Dahomey-Gap' which is a zone of forest-savannah mosaic between the two rain forest areas of West Africa. This gap has been explained by Aubreville (1949) as being related to the fact that the coast of West Africa runs in a WSW-ENE direction at that point. As a result of this direction, the wind makes an acute angle with the coast and little moisture is brought ashore. Thus, the area is a dry patch in a moist zone.

An alternative explanation centres around geological evidence which seems to show that Benin is an area where a dislocation of a mega-craton [which covered the northern half of the African continent (including West Africa)] occurred. Choubert et al. (1971) have reported that there is a zone of more recent formations, such as, the mountains of Togo (Atakora-Akwapim) which separate the stable craton of West Africa from the Ahaggar-Dahomey rejuvenated mobile zone. This, according to Choubert et al. (1971) shows that the dislocation of the mega-craton occurred well before 600-500 million years ago when the rejuvenation occurred. This explanation may account for the presence of the 'Dahomey-Gap' and the resulting lack of Selaginella and indeed, other plant species (Flenley, 1979) in Benin.

Most of the species belonging to the 55% which occur outside West Africa spread to the east (Ethiopia, Somalia and Mozambique) and/or south (South Africa) through the central part (Congo, Zaire) of the continent.

Morton (1972), dealing with montane angiosperm species in West Africa reported that, given climate change, distances would be greatly reduced making it possible for the upland areas lying between the main mountain systems to support montane communities and become stepping stones for the spread of the montane flora. Morton (1972) again reported that, a lowering of vegetation belts by about 650-1000 m in the area separating the Cameroon system and the mountains of East and Central Africa would have a similar effect and a series of short hops would be all that was necessary to get the present montane flora across the continent.

In West Africa many upland areas exist between the main mountain systems, eg Idanre in Nigeria, Atewa and Banda Hills and Gambaga Scarp in Ghana, the Gbenge and Kuru Hills in Sierra Leone. According to Morton (1972), most of these upland areas already hold a small and presumably relict montane floras, indicating that they have functioned as such stepping stones for migration under former climates which were more favourable to the species. A corridor of high land connects the mountains of East and Central Africa with the Cameroon system, and out of this, smaller peaks rise which would have formed the links in a chain of montane communities across the continent.

The spread of the West African species of Selaginella across the continent to the east might have occurred in a similar fashion as the angiosperms; the species using the many upland areas existing between the main mountain system as stepping stones.

Species found in Madagascar

There are eleven species of subgenus Stachygynandrum in Madagascar. Out of these, 64% belong to the section Homostachys and 36% belong to the section Heterostachys. 55% of the species found in Madagascar are endemics; while the remaining 45% are not. Of the species that also occur outside Madagascar, 18% are found only in the nearby Comoros, 9% occur in Central and South Africa but not in West Africa while 18% occur in West and East Africa.

In his comprehensive work on the Pteridophyta of Madagascar, Christensen (1932) reported that about 50% of all Pteridophyta found in Madagascar were endemics while the other 50% were non-endemics. He also showed that the fern-flora of Madagascar exhibited the closest affinity to the flora of the Mascarene islands and of continental Africa. Of all non-endemic species 28% occur also in the Mascarenes and about 70% in continental Africa. Some of the species that showed affinities to those in the Mascarenes and continental Africa also occur in the Indian and Malayan regions and in Tropical America.

This current study has shown that apart from one of the endemics (S. unilateralis), which may be regarded as an isolated endemic, and S. fissidentoides, which extends to the Comoros, the rest of the species (both endemics and non-endemics), which occur in Madagascar, have near relatives on the continent - S. digitata and S. helicoclada are closely related to S. imbricata (Forssk.) Spring found in East Africa, in habit. [Alston (1932) included S. imbricata in his treatment of Madagascan Selaginella. I have not seen a single specimen of this species throughout this study; I have therefore not included S. imbricata in the species found in and described for Madagascar]. S. pervillei is allied to S. vogelii which occurs in both West Africa and Madagascar. These two species are erect, have pubescent stems and branches and possess same types of sporangial distribution patterns. S. pervillei is distinguished from S. vogelii by its short ciliate-serrate leaves, S. vogelii has entire (subentire leaves) and occasionally pinkish stems. S. lyallii and S. pectinata are probably related to S. myosurus from West Africa by the possession of three-veined leaves. S. lyallii also possesses the same type of sporangial distribution pattern as S. myosurus. S. lyallii and S. pectinata are, however, erect species while S. myosurus is a climber and twiner. S. hildebrandtii, which extends to the Comoros, is closely related to S. molliceps found in West Africa. These two species share a number of characters in common, including the shapes of leaves, habit, sporangial distribution patterns etc. S. hildebrandtii has serrate-serrulate, occasionally short ciliate, leaf margins while S. molliceps has ciliate-serrate leaf margins. S. perpusilla found in Madagascar occurs also in South Africa and the Congo and is closely allied to S. buchholzii from West Africa. The two species are small and have comparatively large strobili in relation to the general size of the plant. They have ciliate dorsal sporophylls and possess same types of sporangial distribution patterns. They are distinguished from each other by the presence of ciliate-serrate leaves, psilate megaspores and baculate-clavate microspores in S. buchholzii while S. perpusilla possesses short ciliate-serrate-serrulate leaves, reticulate megaspores and baculate microspores.

Are the areas in West Africa (and other parts of Africa) where the species of Selaginella occur, the distributional limits of these species or do they occur in Madagascar? Do the species from Madagascar occur on the continent? The answers to these questions may be fully known when the whole continent and Madagascar are better explored. This study, however, reveals close relations between some species from West Africa (and other parts of the continent) and Madagascar (even the endemic species) while other species do occur in both areas.

The distribution of any terrestrial organism is determined partly by distribution of land and partly by climate (Darlington, 1965). If land plants and animals can occur only on the land that they can reach, and only where climate is suitable, then it seems probable that the presence of Selaginella species in West Africa and Madagascar (and indeed, all the other parts of the world) is the result of an existence of a pre-drift landmass, a supercontinent and/or the closeness of the current continents in the past before these continents drifted away from each other.

Continental drift has been used to explain the occurrence of same species of fossil and living plants and animals and closely related ones on the different continents now separated by deep oceans (Bramwell, 1972; Hallam, 1972; Moore, 1973; Seyfert & Sirkin, 1973).

Selaginellites, a genus of the Carboniferous and later periods, includes some older species that have been placed in Selaginella. Tryon (1971) has reported that Selaginella species can migrate readily on continental areas, but probably due to heterospory, are poorly represented on isolated islands. Thus, the early Selaginellas could have migrated on the existing continents before they (the continents) drifted to their present positions.

Livingstone (1975) assessing the late Quaternary climatic change in Africa reported that, 'the present equatorial biota represents a lag concentrate of species that were able to persist through much drier and cooler condition than those of today'; and that 'it might be better to consider the surviving equatorial species as a selected set of the Tertiary biota, the organisms that were able to tolerate the cool, dry ice ages as well as the hot and humid condition of the past.'

Species of the genus *Selaginella* could well be said to be one of the selected species that were able to survive the conditions of the past and still occur in the conditions of the present.

This study, having shown the close relations existing between the *Selaginella* species of West Africa and Madagascar, also agrees with the findings of Christensen (1932) and Guillaumet (1984) that the flora of Madagascar is unique and rich in endemic species even though one cannot say with certainty that the *Selaginella* species regarded as endemics are real endemics just because they have not been found elsewhere. Further explorations may reveal that even the 'endemics' from Madagascar do occur in the West African forests (and other parts of the continent) and that the species from West Africa may also occur in Madagascar as shown in the case of *S. goudotana* and *S. vogelii*.

CONCLUSION

CONCLUSION

This study has shown that the species of the genus Selaginella subgenus Stachygynandrum from West Africa and Madagascar are closely allied to each other. Twenty-nine species are found in these areas. Twenty of these occur in West Africa, eleven are found in Madagascar while two species are common to both areas.

Over fifty characters have been examined in the study. Most of these characters, though regarded as diagnostic, are not sufficient enough on their own to define species. Few species possess distinctive single characters; most species are distinguished by a combination of characters rather than distinctive ones. A set of specific characters for each species does not exist by itself but only in relation to other species. A set of characters may distinguish a species from its close allies, whereas, additional ones, or another set, may distinguish it from less closely related species.

Although the vegetative leaves provide the most useful part of the plant for taxonomic purposes, one cannot overlook the importance of the reproductive part (strobilus). Thus, in the taxonomy of the species of the subgenus Stachygynandrum, both the vegetative and reproductive parts of the plants should be taken into consideration since both provide the basis for a good system of classification.

The genus Selaginella divides naturally into two on the basis of vegetative leaf form - subgenus Selaginella which has species with uniform leaves and subgenus Stachygynandrum which has species with different leaves. Subgenus Stachygynandrum also divides naturally into two on the basis of the type of strobilus and sporophyll form - the section Homostachys which comprises of species with tetragonous strobili and uniform sporophylls and the section Heterostachys which has species with bilateral strobili and different (dimorphic) sporophylls. These basic divisions of the genus and subgenus should be maintained.

Continental drift may be used to explain the occurrence of Selaginella species in West Africa and Madagascar (and indeed, all the other parts of the world) which are now separated by deep oceans. The spread of the West African species across the continent of Africa might have occurred in the past; the species using the many upland areas existing between the main mountain systems as "stepping stones".

Further explorations of the continent and Madagascar are needed to give better understanding (knowledge) of the distribution of the species of Selaginella subgenus Stachygynandrum in these areas. These explorations may reveal that more species are common to both areas other than the two found in this study or that most of the species are true endemics in the areas in which they occur.

CHAPTER TEN

GLOSSARY

GLOSSARY

The terminology used throughout this study has been taken from many sources including Reitsma (1970), Erdtman (1972), Gary et al. (1972), Hickey (1973), Stearn (1973), Radford et al. (1974), Moore and Webb (1983), and Mcleod and Hanks (1985).

I however, want to draw attention to the misuse of two terms - ventral and dorsal - in the literature of the studies of the genus Selaginella. Some authors eg, Alston (1932), Hsü (1937), Alston et al. (1981), Dahlen (1982), and Bilderback (1984, 1984), have confused the use of these terms in that, they have referred to the dorsal side as the upper or front part instead of the lower or back part, and the ventral side as the lower or back part instead of the upper or front part. For example, Bilderback (1984, 1984) referred to the leaves of 'the two upper or dorsal rows being decidedly smaller than those of the two lateral rows' and also 'the ventral portion of the stem never bears leaves', when he was actually referring to the ventral median leaves in the first instance and the dorsal side of the stem in the second case. These terms have been used in this study in the way they have been used by Stearn (1973) and Mcleod and Hanks (1985) thus, ventral refers to the upper or front part and dorsal refers to the lower or back side of the plant or plant part; eg the ventral surface is the upper or ligular surface and the dorsal surface is the lower or aligular surface of a leaf of a species of Selaginella.

ABBREVIATIONS - comp.: compound words; eg: for example; Gk: Greek; ie: that is, pl: plural.

Abaxial:	refers to the side of a leaf or other lateral organ that faces away from the axis, ie, the under surface of a leaf.
Aculeate:	armed with prickles or prickle-like structures.
Acuminate:	having a tapering point or acumen, the sides of the apex being somewhat concave.
Acute:	pertaining to a leaf, sharply pointed without being drawn out, the sides being straight or somewhat convex forming an angle of less than 90^{o}.
Adaxial:	refers to the side of a leaf or other lateral organ that faces towards the axis, ie, the upper surface of a leaf.
Aligular:	side facing away from the surface having the ligule.
Amphistomatous:	pertaining to a leaf, bearing stomata on both the adaxial and abaxial surfaces.
Auriculate:	equipped with auricles.
Axillary (leaf):	pertaining to the axil; (leaf borne in the axil of branches).

Anisophyllous: without equal or similar type of leaves (with different leaves).

Baculate: spore with pillar-like processes, always longer than broad and higher than 1 um. The process is a baculum (pl. bacula).

Bifid: deeply cleft into two.

Ciliate: with trichomes protruding, from margins (leaves) or body (spores).

Clavate: club-shaped; with processes higher than broad, with swollen heads that are slightly tapering towards the base. The process is a clava (pl. clavae).

Conical: round and tapering to a point; having figure of a true cone.

Cordate: leaf base embayed in a sinus whose sides are straight or convex.

Craton: a part of the Earth's crust which has attained stability, and which has been little deformed for a prolonged period.

Crested: having an elevated line or ridge on the surface that is irregular and often toothed.

Cristate:	crested.
Cuneate:	triangular; wedge-shaped.
Cuspidate:	tipped with a sharp, rigid point or cusp following a sharply-concave constriction.
Dentate:	toothed, particularly with sharp, spreading teeth or indentations that point outwards at right angles to midrib or midvein.
Denticulate:	finely dentate.
Determinate:	finite; the growth of plant parts the size of which is limited by cessation of meristematic activity during the year.
Diastrophism:	a general term for all movement of the crust produced by Earth forces, including the formation of ocean basins, continents, plateaus, and mountain ranges, etc.
Distal surface:	surface of spore that faces in opposite of the centre of the tetrad during meiosis.

Dorsal:	refers to the back, lower or outer side of an organ. In plants, the dorsal surface is that which is turned away from the main axis; eg, the dorsal surface of a leaf is its undersurface or lower surface.
Echinate:	with external spine-like processes, always higher than 1 um. The process is echina (pl. echinae).
Elliptic; (Elliptical):	shaped like an ellipse; with widest axis at midpoint of structure and with margins symmetrically curved.
Entire:	margin forming a smooth line or arc without noticeable projections or indentations.
Epeirogeny (Epeirogenic):	a form of diastrophism which has produced the larger features of the continents and oceans, eg., plateaus and basins. Epeirogenic movements are primarily vertical, either upward or downward.
Femurate:	shaped like the thigh-bone (femur).
Flabellate; Flabelliform:	fan-shaped, in the form of a broad wedge.

Glabrous:	devoid of trichomes.
Globose:	nearly spherical.
Granulose:	consisting of grains; covered with grains, or looking as if so.
Habit:	The general appearance of a plant, eg, climbing, erect etc.
Hetero-(in Gk. comp.):	different, other.
Heteromorphous (Heteromorphic):	existing in two or more forms.
Holotype:	nomenclatural type of a species designated by the author of the species.
Homo-(in Gk. comp):	like, of the same kind.
Hypostomatous:	bearing stomata on the abaxial surface only.
Indeterminate:	continued growth of plant parts, not limited by a cessation of meristematic activity.
Intermittent:	a renewal and cessation of meristematic activity which produces clusters of stems and/or leaves along an axis.

Iso-(in Gk. comp.):	equal, like.
Isophyllous:	with equal or similar type of leaves.
Lanceolate:	narrow and tapering towards each end, with the greatest width roughly one-third of the way from base to tip.
Lateral:	located on or developing from the side (lateral leaf: leaf located on the side of a stem).
Lectotype:	the nomenclatural type of species, being a specimen from original material from which the species was described, and for which the author failed to designate a holotype (or the holotype has been lost or destroyed).
Ligulate:	provided with a ligule.
Ligule:	a minute organ which arises internally from the adaxial base of the leaf or sporophyll.
Lingulate:	tongue-shaped, plano-convex in cross section.
Lumen:	space between muri (pl. lumina).

Median leaf:	leaf borne on the upper plane of the stem or branch.
Megasporangium:	a sporangium in which megaspores are produced.
Megaspore:	the first cell of the female gametophyte generation in heterosporous plants; it is the larger of the two kinds of spores produced by these plants.
Megasporophyll:	the organ, commonly a leaf or modified leaf, which bears megasporangia.
Microsporangium:	sporangium in which microspores are produced.
Microspore:	the first cell of the male gametophyte generation in heterosporous plants; it is the smaller of the two kinds of spores produced by these plants.
Microsporophyll:	the organ, commonly a leaf or modified leaf, which bears microsporangia.
Mono-(in Gk. comp.):	one.
Mucronate:	possessing a short narrow point or mucro (a sharp, and abrupt tip or point).

Mucronulate:	diminutive of mucronate.
Murus:	structural elements (ridges) separating lumina in reticulate spores (pl. muri).
Obclavate:	inversely clavate.
Obconic:	inversely conical.
Oblong:	a shape in which the widest portion constitutes a zone through the middle of the long axis, the margins being parallel or nearly so within this zone.
Obovate:	inversely ovate.
Obturbinate:	inversely turbinate.
Ovate:	a shape with the axis of the greatest width below the middle, the margins being symmetrically curved.
Panduriform:	fiddle-shaped; obovate with sinous or indentation on each side near base and with two small basal lobes.
Papillose:	covered with minute tubercles.
Pedate:	foot-like.

Proximal surface: surface of spore that faces towards the centre of the tetrad during meiosis. It is the surface with the trilete mark.

Psilate: with no visible external features; smooth.

Resupinate: reversed, inverted by twisting of stalk.

Reticulate: spore provided with a network formed by muri and lumina.

Rugulose: spore provided with an irregular pattern of lumina and muri.

Scabrate: provided with elements of different shape, smaller than 1 um. The element is scabra (pl. scabrae).

Serrate: saw-toothed; teeth sharp and ascending, but cut 1/16 - 1/8 distance to midrib or midvein.

Serrulate: diminutive of serrate.

Sinuate (sinous): shallowly and smoothly indented, wavy in a horizontal plane, without distinctive teeth or lobes.

Sobole: a sprouting shoot or runner which arises shortly above the base of a stem and spreads over the surface of the ground. It normally has reduced leaves and wide interspaces. By rooting (or bearing bulbils) at the apex, it propagates the species asexually.

Soboliferous: bearing soboles.

Sporophyll-pteryx: a vertical/oblique projection on the adaxial surface of the ventral sporophyll of a bilateral resupinate strobilus.

Stachys (in Gk. comp.): relating to a spike.

Striate: provided with a regular pattern of approximately parallel lumina and muri.

Trullate: with widest axis below middle and with straight margins; ovate but margins straight and angled below middle; trowel-shaped.

Turbinate: top-shaped, obconic.

Undulate: shallowly and smoothly indented, wavy in a vertical plane.

Ventral: refers to the upper or inner side of an organ. In plants, the ventral surface is that which is facing the main axis; the ventral surface of a leaf is its upper or inner surface.

Verrucate: with wart-like processes always broader than high and always higher than 1 um. The process is verruca (pl. verrucae).

CHAPTER ELEVEN

APPENDIX

I. TABLE OF CHARACTERS EXAMINED IN THIS STUDY

TABLE 8 : Morphological charaters examined in the taxonomic revision of the species of <u>Selaginella</u> subgenus <u>Stachygynandrum</u> of West Africa and Madagascar

CHARACTER	OBSERVATION
STEM	
Habit	prostrate, twining, climbing, ascendent, suberect, erect
Branch-system	pseudopinnate, flabellate
Articulation	+ or -
Pubescence	+ or -
Soboles	+ or -
RHIZOPHORE	
Distribution on plant	very base, basal 1/4, basal 1/3, throughout the plant
Position on stem	ventral, dorsal, axil
LEAF	
Morphism	anisophyllous
Number of veins	1, 3
Shape	lanceolate, ovate, elliptic, oblong, falcate, deltate, obovate, oblanceolate or a combination of these, eg ovate-oblong
Margin	entire, denticulate, serrate, serrulate, aculeate, ciliate or a combination of these, eg serrate-denticulate

Base	obtuse, cuneate, cordate, subcordate, truncate, attenuate, auriculate, subsaggitate, oblique
Apex	acute, apiculate, mucronate (mucronulate), acuminate, obtuse (subobtuse), cuspidate, caudate, aristate
Colour	dark-green, coppery-green, blue-green, pale-green, yellowish-green
Size	variable, up to 5.83x3.25 mm
Stomata	
distribution	hypostomatous, amphistomatous
position	lamina, midvein, margin
size	variable, up to 41x26 um
stomatal index	variable, up to 32
Sclerotic cells	+ or -; in bands or patches
Papillae	+ or -
Epidermal cells	similar or different at the ligular and aligular surface
shape	isodiametric, polygonal, elongate
form	straight-sided, sinous, undulating
LIGULE	
Shape	clavate, obclavate, femurate, lingulate, flabelliform (flabellate), rectangular, pedate, obturbinate
Basal trichomes	+ or -
Length	variable, up to 0.51 mm
STROBILUS	
Position	terminal on branches and/or branchlets

Type	tetragonous, bilateral
Form	resupinate, non-resupinate
Growth pattern	determinate, intermittent
Length	variable, up to 40 mm
Sporophylls	
Type	microsporophyll, megasporophyll
Morphism	monomorphous, dimorphous
Number of veins	1, 3
Shape	ovate, subovate, lanceolate, trullate (subtrullate) oblong, elliptic, subpanduriform or a combination of these, eg subpanduriform-ovate
Margin	entire (subentire), denticulate, serrulate, serrate, aculeate, ciliate or a combination of these, eg serrate-aculeate
Base	obtuse, cuneate, truncate, subcordate, subauriculate, oblique
Apex	acute, subretuse, apiculate, acuminate, cuspidate, aristate
Size	variable, up to 4.5x1.7 mm
Stomata	
distribution	hypostomatous, amphistomatous
position	lamina, midvein, margin
size	variable, up to 41x26 µm
stomatal index	variable, up to 24
Sclerotic cells	+ or -; in bands or patches
Epidermal cells	similar or different at ligular and aligular surfaces
shape	isodiametric, polygonal, elongate

form	straight-sided, sinous
Sporangia	
Type	microsporangium, megasporangium
Shape	
megasporangium	ovoid, obovoid, ovoid-triangular, deltoid
microsporangium	ellipsoid, ovoid, oblong, reniform, roundish
Spore	
Type	microspore, megaspore
Colour	cream, whitish-cream, yellowish to light-brown (megaspores); brick-red, reddish-brown to yellowish-brown, cream (microspores)
Triradiate mark	+
Shape	tetrahedral, subtriangular, globose, subglobose
Size	variable, up to 1100 μm (megaspore); up to 42 μm (microspore)
Ornamentation	psilate, granulose, scabrate, verrucate, baculate, rugulose, striate, reticulate, cristate-reticulate (megasore); granulose, papillate, scabrate, verrucate, foveolate, clavate, echinate (microspore)
Equatorial ring	+ or - (megaspore)
Equatorial flange	+ or - (microspore)

II. TABLES OF OTHER RESULTS

TABLE 9A: Comparison of basic leaf characters in species of Selaginella subgenus Stachygynandrum of West Africa

SPECIES	LATERAL LEAVES Shape	Base	Margin	Apex	MEDIAN LEAVES Shape	Base	Margin	Apex
S. versicolor	ovate-oblong	oblique	serrate-sub-entire	acute	weakly obovate	obliquely weakly auriculate	denticulate-serrate. (subentire)	aristate
S. vogelii	lanceolate-oblong	oblique	entire (subentire)	acute	subobovate	oblique, (decurrent)	entire (subentire)	caudate
S. kraussiana	ovate-elliptic	obtuse	serrate-serrulate	acute	broadly elliptic-lanceolate	oblique	serrulate-denticulate	acuminate
S. cathedrifolia	ovate-oblong	obtuse	long ciliate-serrate	acuminate, apiculate	ovate	obtuse	short ciliate-serrate	cuspidate
S. myosurus	ovate-elliptic, oblong	obtuse	serrate-serrulate	acuminate	lanceolate	weakly auriculate	serrate-serrulate	cuspidate
S. buchholzii	ovate-oblong, ovate-elliptic	obtuse	ciliate-denticulate-serrate	acuminate, weakly mucronate	deltate	cordate	serrate-denticulate	cuspidate
S. soyauxii	elliptic-oblong, ovate-oblong	oblique	entire-serrate	acute, acuminate	obovate	subcuneate, obtuse	entire (subentire)	caudate
S. blepharophylla	ovate-deltate	oblique	long ciliate-subentire/ distantly serrate	acute	broadly lanceolate	obtuse	long ciliate-serrate	cuspidate
S. zechii	ovate-oblong, deltate	oblique, subobtuse	long ciliate-subentire-serrate	acute, subobtuse	subobianceolate	obtuse	ciliate-serrate	aristate
S. protensa	ovate-elliptic, deltate-oblong	obtuse	short ciliate-subentire-serrate-serrulate	acuminate	ovate-lanceolate	obtuse	short ciliate-distantly serrate	aristate
S. tenerrima	ovate-oblong	oblique (subcordate-obtuse)	serrate-subentire	acute, apiculate	deltate	oblique (subcordate-truncate)	serrate-aculeate	cuspidate
S. kalbreyeri	deltate-ovate	oblique (subcordate-truncate)	long ciliate-serrate	broadly acute (subobtuse)	broadly deltate-ovate, subreniform	cordate, weakly auriculate	long ciliate-serrate	caudate, aristate
S. [illegible]	elliptic-oblong	oblique	short ciliate-serrate-serrulate	acute, weakly mucronulate	lanceolate	obtuse, weakly attenuate	distantly serrate	aristate
S. mulleri	ovate-elliptic	obtuse	short ciliate-serrate	acute	elliptic-ovate, broadly lanceolate	oblique (obtuse-cuneate)	short ciliate	aristate
S. molliceps	ovate-oblong, elliptic-oblong	oblique	ciliate-serrate	subobtuse, weakly mucronulate	lanceolate	attenuate, obtuse	ciliate-distantly serrate	cuspidate, aristate

TABLE 9A continued

SPECIES	LATERAL LEAVES Shape	Base	Margin	Apex	MEDIAN LEAVES Shape	Base	Margin	Apex
S. subcordata	deltate	cordate, subcordate	ciliate-serrate	acuminate	ovate-lanceolate	subobtuse	short ciliate-serrate	aristate
S. squarrosa	deltate suboblong,	oblique, subobtuse	entire (subentire)	acute, weakly mucronulate	ovate	obtuse	entire	aristate
S. serrato-squarrosa	sub-subulate, ovate-oblong	oblique, subattenuate	serrate-entire	acute	lanceolate	oblique (obtuse-cuneate)	serrate	aristate
S. goudotana	ovate-oblong	oblique (obtuse-subcuneate)	serrate-denticulate	acute-apiculate	lanceolate-narrowly sub-deltate	subcordate, cordate	serrate	aristate
S. thomensis	ovate-elliptic, ovate-subobovate	oblique (obtuse-sub truncate)	serrate-subentire	subobtuse, acute	oblanceolate	oblique	aculeate-distantly serrate	cuspidate

TABLE 9A continued

SPECIES	AXILLARY LEAVES Shape	Base	Margin	Apex
S. versicolor	ovate	subattenuate	serrate-entire (subentire)	acute
S. vogelii	obovate, oblanceolate	subattenuate	entire (subentire)	acute
S. kraussiana	oblong-elliptic	obtuse	serrate-serrulate	acute
S. cathedrifolia	broadly lanceolate, narrowly ovate	obtuse	long ciliate-serrate	acuminate
S. myosurus	ovate	obtuse	serrate-serrulate	acuminate
S. buchholzii	ovate	obtuse	ciliate-serrate-serrulate	apiculate, acuminate
S. soyauxii	oblanceolate	attenuate	entire-serrate	acute
S. blepharophylla	ovate	obtuse, shortly truncate	long ciliate-serrate	acute, weakly acuminate
S. zechii	ovate-deltate	weakly obtuse, subcordate	long ciliate-serrate	apiculate, acute
S. protensa	elliptic, ovate	obtuse	short ciliate-serrate	acuminate
S. tenerrima	ovate-elliptic	weakly obtuse,	serrate-serrulate	mucronulate, acute
S. kalbreyeri	broadly deltate	cordate	long ciliate serrate	acute
S. laurentensis	ovate	obtuse	short ciliate-serrate	broadly acute, subobtuse
S. molleri	ovate	obtuse	short ciliate-serrate	acute, apiculate
S. mollicepa	elliptic-ovate	obtuse	ciliate-serrate	broadly acute, subobtuse

SPECIES	AXILLARY LEAVES Shape	Base	Margin	Apex
S. subcordata	ovate, weakly deltate	cordate	ciliate-serrate-serrulate	apiculate
S. squarrosa	narrowly ovate	obtuse	entire	acute, weakly mucronulate
S. serrato-squarrosa	ovate, narrowly deltate	truncate, subcordate	serrate-entire	acute
S. goudotana	elliptic, narrowly ovate	cuneate, weakly obtuse	short ciliate-serrate-denticulate	acute, apiculate
S. thomensis	ovate	obtuse	serrate	subobtuse, broadly acute

TABLE 9B: Comparison of basic leaf characters in species of *Selaginella* subgenus *Stachygynandrum* of Madagascar

	LATERAL LEAVES				MEDIAN LEAVES			
SPECIES	Shape	Base	Margin	Apex	Shape	Base	Margin	Apex
S. fissidentoides	ovate-oblong	obtuse	serrate-subentire	obtuse	lanceolate	subauriculate	serrate	cuspidate (long acuminate)
S. vogelii	lanceolate-oblong	oblique (obtuse-sub cuneate)	entire (subentire)	acute	subobovate	oblique, (decurrent)	entire (subentire)	caudate
S. pervillei	ovate-oblong	obtuse	short ciliate-serrate	acute	elliptic, subobovate	obtuse	serrate	aristate (caudate)
S. digitata	elliptic-oblong (ovate)	obtuse	entire	rounded, obtuse	elliptic	obtuse	entire	mucronulate
S. helicoclada	elliptic-oblong (ovate)	obtuse	serrate	rounded, obtuse	elliptic	obtuse	serrate	mucronulate
S. pectinata	falcate	oblique	entire	broadly acute (subobtuse)	linear-lanceolate	decurrent, cuneate	entire	broadly acute (sub obtuse)
S. lyallii	ovate-oblong	oblique (obtuse-sub cuneate) (decurrent)	subentire (irregularly wavy)	acuminate	lanceolate	cuneate	entire	long acuminate
S. hildebrandtii	elliptic-ovate	obtuse	short ciliate-serrate-denticulate	broadly acute, apiculate	lanceolate	obtuse	serrate	aristate
S. goudotana	ovate-oblong	oblique (obtuse-subcuneate)	serrate-denticulate	acute-apiculate	lanceolate subdeltate	subcordate, cordate	serrate	aristate
S. perpusilla	ovate-oblong, ovate-elliptic	obtuse	short ciliate-denticulate-serrate	acuminate	deltate	cordate	serrate-denticulate	cuspidate
S. unilateralis	ovate-elliptic	obtuse	ciliate-serrate	acute	lanceolate	obtuse	short ciliate-serrate	cuspidate

TABLE 9B continued

	AXILLARY LEAVES Shape	Base	Margin	Apex
S. fissidentoides	elliptic	obtuse	serrate-denticulate	obtuse
S. vogelii	obovate oblanceolate	subattenuate	entire (subentire)	acute
S. pervillei	elliptic	obtuse	short ciliate-serrate	acute
S. digitata	elliptic-ovate	obtuse	entire	obtuse
S. helicoclada	elliptic-ovate	obtuse	serrate	obtuse
S. pectinata	ovate	obtuse	entire	obtuse
S. lyallii	elliptic	obtuse	subentire (wavy)	acuminate
S. hildebrandtii	ovate, elliptic	obtuse	short ciliate-serrate	broadly acute, subobtuse
S. goudotana	elliptic, narrowly ovate	cuneate weakly obtuse	short ciliate-serrate-denticulate	acute, apiculate
S. perpusilla	ovate	obtuse	short ciliate-serrate	acuminate, apiculate
S. unilateralis	narrowly ovate	obtuse	ciliate	acute

TABLE 10A: Distribution of epidermal cell types in lateral leaves of species of West African *Selaginella* subgenus *Stachygynandrum*

SPECIES	LIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinuous cells	undulating cells	straight cells	sclerotic cells	ABLIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinuous cells	undulating cells	straight cells	sclerotic cells
S. versicolor	m	+	-	+	-	-	-	l	-	+	s	-	+	b
S. vogelii	-	+	-	+	+	-	-	l	-	+	+	+	-	-
S. kraussiana	-	-	+	+	+	+	-	v,m	-	+	+	+	+	-
S. cathedrifolia	m	+	-	+	-	+	-	v	-	+	+	-	+	b,p
S. myosurus	-	-	+	+	+	-	-	v	-	+	+	+	-	-
S. buchholzii	-	+	-	-	-	+	-	l	-	+	+	-	+	p
S. soyauxii	-	+	-	-	-	+	-	l,v	-	+	+	-	-	-
S. blepharophylla	-	+	-	-	-	+	-	l,v,m	-	+	+	-	-	b,p
S. zechii	-	+	-	-	-	+	-	l,v,m	+	+	+	-	+	p
S. protensa	-	+	-	+	-	+	-	l,v	-	+	+	-	+	b,p
S. tenerrima	-	+	-	-	-	+	-	l,m	-	+	+	-	+	b,p
S. kalbreyeri	-	+	-	+	-	+	-	v	-	+	+	-	+	-
S. leonensis	-	+	-	+	-	-	-	l	s	+	+	-	-	-
S. mollери	-	+	-	-	-	+	-	l,m	-	+	+	-	+	b,p
S. molliceps	-	+	-	+	-	-	-	v,m	-	+	+	-	-	p
S. subcordata	-	+	-	+	-	-	-	v,m	-	+	+	s	-	-
S. squarrosa	m	+	-	+	-	+	-	v	-	+	+	-	-	p
S. serrato-squarrosa *		+	-	+	-	-	-	l	-	+	+	-	-	b,p
S. gradstana	m	+	-	+	-	-	-	v	-	+	+	-	-	b,p
S. thomensis	-	+	-	+	-	-	-	l,v,m	s	+	+	-	+	p

Key: Symbols indicate the location of cell types as follows:
+ = present
- = absent
s = occasionally present
l = present on lamina
m = present near midrib or at the margins
v = present along the midvein
p = present in patches
b = present in bands

TABLE 108: Distribution of epidermal cell types in median leaves of species of West African Selaginella subgenus Stachygynandrum

SPECIES	LIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinuous cells	undulating cells	straight cells	sclerotic cells	ALIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinuous cells	undulating cells	straight cells	sclerotic cells
S. versicolor	-	-	+	±	-	±	-	l	+	-	+	-	-	-
S. vogelii	-	-	+	+	-	-	-	l,m	+	-	+	-	-	-
S. kraussiana	-	-	+	+	+	+	-	v,m	-	+	+	+	+	-
S. cathedrifolia	m	-	+	+	-	-	p	v	+	-	+	-	-	-
S. myosurus	-	-	±	+	-	-	-	v	-	±	+	-	-	-
S. buchholzii	-	-	+	+	-	-	p	l	+	-	-	-	+	-
S. soyauxii	-	-	+	+	-	-	-	l,v,m	+	-	±	-	+	-
S. blepharophylla	-	-	+	+	-	-	-	v,m	+	-	-	-	+	-
S. zechii	-	-	+	+	-	-	-	v	+	-	+	-	+	-
S. protensa	-	-	+	+	-	-	-	v	+	-	+	-	-	-
S. tenerrima	-	-	+	±	-	+	-	v	+	-	-	-	+	-
S. kalbreyeri	-	-	+	-	-	+	-	l	+	-	+	-	-	-
S. leonensis	-	-	+	+	-	-	-	l	+	-	+	-	-	-
S. molleri	-	-	+	+	-	+	-	l,a	±	±	-	-	+	-
S. mollicepa	-	-	+	+	-	-	-	l,m,a	+	-	+	-	-	-
S. subcordata	-	-	+	+	-	-	-	l	+	-	+	-	-	-
S. squarrosa	-	-	+	+	-	-	-	v	+	-	+	-	-	-
S. serrato-squarrosa	-	-	+	+	-	-	-	l,a	+	-	+	-	-	-
S. gnabiana	m	-	+	+	-	+	-	v	+	-	+	-	-	-
S. thomensis	-	-	+	-	-	+	-	l,v,m	+	-	+	-	-	-

Key: Symbols indicate the location of cell types as follows:

+ = present
- = absent
± = occasionally present

l = present on lamina
m = present near midrib or at the margins

v = present along the midvein
p = present in patches
a = present on the arista

TABLE 10C: Distribution of epidermal cell types in axillary leaves of species of West African Selaginella subgenus Stachygynandrum

SPECIES	LIGULAR SURFACE stomata	LIGULAR SURFACE isodiametric cells	LIGULAR SURFACE elongate cells	LIGULAR SURFACE sinuous cells	LIGULAR SURFACE undulating cells	LIGULAR SURFACE straight cells	LIGULAR SURFACE sclerotic cells	ALIGULAR SURFACE stomata	ALIGULAR SURFACE isodiametric cells	ALIGULAR SURFACE elongate cells	ALIGULAR SURFACE sinuous cells	ALIGULAR SURFACE undulating cells	ALIGULAR SURFACE straight cells	ALIGULAR SURFACE sclerotic cells
S. versicolor	l	+	-	+	-	+	-	l	±	±	+	-	±	b
S. vogelii	l	+	-	+	+	-	-	l	-	+	+	+	-	-
S. kraussiana	-	-	+	±	+	±	-	v,m	-	+	±	+	+	-
S. cathedrifolia	m	+	-	+	-	-	-	v	-	+	+	-	-	p,b
S. myosurus	v	-	+	±	+	-	-	v	-	+	±	+	-	-
S. buchholzii	-	+	-	-	-	+	-	l	-	+	±	-	+	p
S. soyauxii	-	+	-	-	-	+	-	l	-	+	+	-	-	-
S. blepharophylla	m	+	-	-	-	+	-	l,v	-	+	+	-	-	p,b
S. zechii	-	+	-	-	-	+	-	l,v,m	±	+	±	-	+	p
S. protensa	-	+	-	±	-	+	-	l	-	+	+	-	-	p,b
S. tenerrima	-	+	-	±	-	+	-	l,m	-	+	+	-	+	p,b
S. kalbreyeri	-	+	-	+	-	+	-	v	-	+	±	-	+	-
S. leoneensis	-	+	-	+	-	-	-	l,m	±	+	+	-	-	-
S. molleri	-	+	-	-	-	+	-	l,m	-	+	+	-	+	p,b
S. molliceps	-	+	-	+	-	-	-	v,m	-	+	+	-	-	p
S. subcordata	-	+	-	+	-	-	-	l,m	-	+	+	±	-	-
S. squarrosa	-	+	-	+	-	±	-	l,v	-	+	+	-	-	p,b
S. serrato-squarrosa	-	+	-	+	-	-	-	l	-	+	+	-	-	p,b
S. goudotana	m	+	-	+	-	-	-	v	-	+	+	-	-	p
S. thomensis	-	+	-	+	-	±	-	l,m	±	+	±	-	+	p,b

Key: Symbols indicate the location of cell types as follows:

+ = present	l = present on lamina	v = present along the midvein
- = absent	m = present near and/ or at the margin	p = present in patches
± = occasionally present		b = present in bands

TABLE 11A: Distribution of epidermal cell types in lateral leaves of species of Madagascan <u>Selaginella</u> subgenus <u>Stachygynandrum</u> :

	LIGULAR SURFACE							ALIGULAR SURFACE						
SPECIES	stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells	stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells
S. fissidentoides	-	-	+	+	±	-	-	v	-	+	+	+	-	b,p
S. vogelii	-	+	-	+	+	-	-	l	-	+	+	+	-	-
S. pervillei	-	+	-	+	+	-	-	l	-	+	+	+	-	-
S. digitata	-	-	+	-	-	+	-	l	-	+	-	-	+	b
S. helicoclada	-	-	+	-	-	+	-	l	-	+	-	-	+	b
S. pectinata	-	-	+	±	-	+	-	v	-	+	+	±	-	-
S. lyallii	-	-	+	-	-	+	-	v	-	+	±	+	±	-
S. hildebrandtii	-	+	-	+	-	±	-	l	-	+	+	-	±	p
S. goudotana	m	+	-	+	-	-	-	v	-	+	+	-	-	b,p
S. perpusilla	-	+	-	+	-	-	-	l,v	-	+	+	+	-	p
S. unilateralis	-	+	-	±	-	+	-	v,m	-	+	±	-	+	b

Key: Symbols indicate the location of cell types as follows:

+ = present m = present near and/or at the margin
- = absent v = present along the midvein
± = occasionally present p = present in patches
l = present on lamina b = present in bands

TABLE 11B : Distribution of epidermal cell types in median leaves of species of Madagascan Selaginella subgenus Stachygynandrum

SPECIES	LIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells	ALIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells
S. fissidentoides	-	-	+	+	+	-	-	v	-	+	+	±	-	-
S. vogelii	-	-	+	+	-	-	-	l,m	+	-	+	-	-	-
S. pervillei	-	-	+	+	+	-	-	l	+	-	+	+	-	-
S. digitata	-	-	+	-	-	+	-	l	-	+	-	-	+	+b
S. helicoclada	-	-	+	-	-	+	-	l	-	+	-	-	+	+b
S. pectinata	-	-	+	+	±	-	-	v	-	+	±	-	+	-
S. lyallii	-	-	+	±	+	±	-	v	-	+	±	-	+	-
S. hildebrandtii	-	-	+	+	-	±	-	l,m	+	-	+	-	±	-
S. goudotana	m	-	+	+	-	+	-	v	+	-	+	-	-	-
S. perpusilla	-	-	+	+	+	-	p	l	+	-	+	-	±	-
S. unilateralis	-	-	+	±	-	+	-	v	+	-	±	-	+	-

Key: Symbols indicate the location of cell types as follows:

+ = present m = present near and/or at the margin
- = absent v = present along the midvein
± = occasionally present p = present in patches
l = present on lamina b = present in bands

TABLE 11C: Distribution of epidermal cell types in axillary leaves of species of Madagascan *Selaginella* subgenus *Stachygynandrum*

SPECIES	LIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells	ALIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells
S. fissidentoides	-	-	+	+	±	-	-	v	-	+	+	+	-	b,p
S. vogelii	l	+	-	+	+	-	-	l	-	+	+	+	-	-
S. pervillei	-	+	-	+	+	-	-	l	-	+	+	+	-	-
S. digitata	-	-	+	-	-	+	-	l	-	+	-	-	+	b
S. helicoclada	-	-	+	-	-	+	-	l	-	+	-	-	+	b
S. pectinata	-	-	+	±	+	±	-	v	-	+	±	-	+	-
S. lyallii	-	-	+	-	-	+	-	v	-	+	±	+	±	-
S. hildebrandtii	-	+	-	+	-	±	-	l	-	+	+	-	±	p
S. goudotana	m	+	-	+	-	-	-	v	-	+	+	-	-	p
S. perpusilla	-	+	-	-	-	+	-	l	-	+	±	-	+	p
S. unilateralis	-	+	-	±	-	+	-	v,m	-	+	±	-	+	b,p

Key: Symbols indicate the location of cell types as follows:
+ = present m = present near and/or at the margin
- = absent v = present along the midvein
± = occasionally present p = present in patches
l = present on lamina b = present in bands

TABLE 12A: Stomatal index values for the leaves of species of _Selaginella_ subgenus _Stachygynandrum_ of West Africa (Based on 25 leaves per leaf type per species; values to the nearest whole number)

SPECIES	LEAF TYPE: LATERAL		MEDIAN		AXILLARY	
	Ligular Surface $\bar{x}$ (range)±δ	Aligular Surface $\bar{x}$ (range)±δ	Ligular Surface $\bar{x}$ (range)±δ	Aligular Surface $\bar{x}$ (range)±δ	Ligular Surface $\bar{x}$ (range)±δ	Aligular Surface $\bar{x}$ (range)±δ
S. _versicolor_	2(2-3)±0.3	9(8-10)±0.8	-	2(2-3)±0.4	7(7-8)±0.8	10(10-12)±0.5
S. _vogelii_	-	13(12-14)±0.4	-	4(3-4)±0.5	8(7-9)±0.7	11(11-13)±0.7
S. _kraussiana_	-	20(18-21)±0.9	-	14(13-15)±0.6	-	22(20-23)±1.1
S. _cathedrifolia_	3(2-3)±0.5	13(12-14)±0.7	10(9-10)±0.5	6(5-7)±1.3	5(4-5)±0.4	7(7-8)±0.6
S. _myosurus_	-	20(19-20)±0.5	-	11(11-12)±0.5	8(7-9)±0.6	14(14-15)±0.5
S. _buchholzii_	-	19(17-20)±0.8	-	8(8-9)±0.2	-	22(21-23)±0.9
S. _soyauxii_	-	15(13-16)±0.9	-	9(8-9)±0.5	-	19(16-20)±1.3
S. _blepharophylla_	-	23(21-23)±0.8	-	8(7-9)±0.6	12(11-13)±0.6	19(18-20)±2.2
S. _zechii_	-	15(13-16)±1.2	-	5(4-5)±0.7	-	13(12-14)±0.8
S. _protensa_	-	7(5-10)±2.4	-	6(4-7)±0.6	-	14(12-14)±1.1
S. _tenerrima_	-	19(18-20)±0.9	-	3(2-4)±0.3	-	14(13-15)±0.5
S. _kalbreyeri_	-	18(18-19)±0.4	-	14(12-14)±0.5	-	21(19-21)±0.8
S. _leoneensis_	-	16(14-17)±1.2	-	2(1-3)±0.5	-	15(13-16)±0.6
S. _molleri_	-	18(17-19)±0.5	-	9(8-9)±0.6	-	17(15-19)±1.1
S. _molliceps_	-	13(10-14)±1.3	-	4(3-5)±0.7	-	15(14-16)±0.7
S. _subcordata_	-	11(11-12)±0.6	-	3(3-4)±0.1	-	10(10-12)±0.9
S. _squarrosa_	9(8-10)±0.6	15(14-16)±0.5	-	5(4-6)±0.4	-	12(11-13)±0.6
S. _serrato-squarrosa_	9(8-9)±0.2	16(14-16)±0.7	-	8(7-8)±0.3	-	18(16-18)±0.6
S. _goudotana_	16(16-17)±0.4	20(19-21)±0.5	4(4-5) 0.4	5(5-6)±0.2	13(13-14)±0.5	19(18-20)±0.5
S. _thomensis_	-	13(12-14)±0.3	-	6(6-7)±0.4	-	15(14-15)±0.5

TABLE 12B: Stomatal index values for the leaves of species of Selaginella subgenus Stachygynandrum of Madagascar (based on 25 leaves per leaf type per species; values to the nearest whole number)

SPECIES	LEAF TYPE: LATERAL Ligular surface $\bar{x}$ (range) ± δ	LATERAL Aligular surface $\bar{x}$ (range) ± δ	MEDIAN Ligular surface $\bar{x}$ (range) ± δ	MEDIAN Aligular surface $\bar{x}$ (range) ± δ	AXILLARY Ligular surface $\bar{x}$ (range) ± δ	AXILLARY Aligular surface $\bar{x}$ (range) ± δ
S. fissidentoides	-	18(17-20) ± 0.9	-	15(13-16) ± 1.1	-	16(14-18) ± 1.7
S. vogelii	-	13(12-14) ± 0.4	-	4(3-4) ± 0.5	8(7-9) ± 0.7	11(11-13) ± 0.7
S. pervillei	-	22(18-24) ± 1.9	-	23(20-28) ± 2.6	-	19(15-24) ± 2.9
S. digitata	-	29(28-31) ± 1.2	-	27(26-29) ± 1.3	-	29(28-31) ± 1.2
S. helicoclada	-	30(28-32) ± 1.9	-	29(27-30) ± 1.5	-	30(28-32) ± 1.9
S. pectinata	-	22(20-24) ± 1.7	-	16(14-17) ± 1.0	-	20(19-21) ± 1.0
S. lyallii	-	20(18-21) ± 1.1	-	14(13-16) ± 1.2	-	18(17-19) ± 1.1
S. hildebrandtii	-	11(10-12) ± 0.9	-	4(3-5) ± 0.	-	10(8-12) ± 1.5
S. goudotana	16(16-17) ± 0.4	20(19-21) ± 0.5	4(4-5) ± 0.4	5(5-6) ± 0.2	13(13-14) ± 0.5	19(18-20) ± 0.5
S. perpusilla	-	18(17-19) ± 0.9	-	7(7-8) ± 0.6	-	18(16-19) ± 1.3
S. unilateralis	-	18(16-19) ± 1.0	-	4(3-5) ± 0.6	-	22(18-25) ± 2.2

Table 13A: Ligule characters observed in species of West African *Selaginella* subgenus *Stachygynandrum*

Species	Shape(s)	Character Basal cilia (+ or -)	Maximum length (mm)
S. versicolor	flabelliform	+ (2-4; lateral leaves only)	0.39
S. vogelii	obturbinate	-	0.25
S. kraussiana	broadly femurate	-	0.35
S. cathedrifolia	flabelliform ± bifid; weakly femurate	-	0.19
S. myosurus	obturbinate	-	0.28
S. buchholzii	obclavate; femurate	-	0.23
S. soyauxii	shortly pedate ± bifid	-	0.28
S. blepharophylla	elongate obclavate	-	0.35
S. zechii	obclavate	-	0.29
S. protensa	obturbinate	-	0.35
S. tenerrima	obclavate ± curved tip	-	0.17
S. kalbreyeri	pedate ± bifid	-	0.24
S. leoneensis	obclavate	-	0.24
S. molleri	obclavate	-	0.27
S. molliceps	elongate obclavate	-	0.38
S. subcordata	narrowly subobclavate	-	0.24
S. squarrosa	broadly clavate	-	0.46
S. serrato-squarrosa	elongate pedate ± bifid	-	0.45
S. goudotana	obclavate	-	0.23
S. thomensis	obturbinate	-	0.25

Key: + = present
- = absent
± = occasionally present

TABLE 13B: Ligule characters observed in species of Madagascan *Selaginella* subgenus *Stachygynandrum*

Species	Shape(s)	Characters Basal cilia	Maximum length (mm)
S. fissidentoides	flabellate	-	0.22
S. vogelii	obturbinate	-	0.25
S. pervillei	lingulate	-	0.20
S. digitata	rectangular	-	0.10
S. helicoclada	lingulate (rectangular)	-	0.12
S. pectinata	lingulate	-	0.51
S. lyallii	rectangular (lingulate)	-	0.36
S. hildebrandtii	obclavate	-	0.35
S. goudotana	obclavate	-	0.23
S. perpusilla	obclavate	-	0.21
*S. unilateralis**			

Key: - = absent
* = ligule not seen

TABLE 14A: Strobilus characters observed in species of West African Selaginella subgenus Stachygynandrum

Species	Type	Form	Growth Pattern	Type of sporangial distribution pattern	Maximum Length (mm)
S. versicolor	tetragonous	not resupinate	intermittent and determinate	II, IIA, IIB, IV	30
S. vogelii	tetragonous	not resupinate	determinate	I, IIB, IV	10
S. kraussiana	tetragonous	not resupinate	determinate	VII	4
S. cathedrifolia	tetragonous	not resupinate	determinate	II, IIB, IV	15
S. myosurus	tetragonous	not resupinate	determinate	VII	40
S. buchholzii	bilateral	resupinate	determinate	IIC, III	10
S. soyauxii	bilateral	resupinate	determinate	IIB, V	8.5
S. blepharophylla	bilateral	resupinate	determinate	II, IIC	10
S. zechii	bilateral	resupinate	determinate	IIC, III	12
S. protensa	bilateral	resupinate	determinate	VI	6
S. tenerrima	bilateral	resupinate	determinate	IIC, III	5
S. kalbreyeri	bilateral	resupinate	determinate	IIA	4.5
S. leoneensis	bilateral	resupinate	determinate	IIB, IV	10
S. molleri	bilateral	resupinate	intermittent and determinate	IIC	5
S. molliceps	bilateral	resupinate	determinate	II, IIC, III, IV	15
S. subcordata	bilateral	resupinate	determinate	VI, VIA	4.3
S. squarrosa	bilateral	resupinate	determinate	IIB	6
S. serrato-squarrosa	bilateral	resupinate	determinate	IIB, IV	5
S. goudotana	bilateral	resupinate	determinate	IIA, IIB	4.5
S. thomensis	bilateral	resupinate	determinate	IIC, III	5

TABLE 14B: Strobilus characters observed in species of Madagascan Selaginella subgenus Stachygynandrum

Species	Type	Form	Growth Pattern	Type of sporangial distribution pattern	Maximum length (mm)
S. fissidentoides	tetragonous	not resupinate	determinate	VII	15
S. vogelii	tetragonous	not resupinate	determinate	I, IIB, IV	10
S. pervillei	tetragonous	not resupinate	determinate	I, IIA	15
S. digitata*					
S. helicoclada	tetragonous	not resupinate	determinate	V	5
S. pectinata	tetragonous	not resupinate	determinate	IIA, IV, VI, VIII, VIIIA	40
S. lyallii	tetragonous	not resupinate	determinate	VII	15
S. hildebrandtii	bilateral	resupinate	determinate	II, IIC, III	10
S. goudotana	bilateral	resupinate	determinate	IIA, IIB	4.5
S. perpusilla	bilateral	resupinate	determinate	IIC, III	10
S. unilateralis	bilateral	resupinate	determinate	I, IIA, IV	8.5

* Strobilus not seen

TABLE 15A: Comparison of basic sporophyll characters in species of Selaginella subgenus Stachygynandrum of West Africa

SPECIES	VENTRAL SPOROPHYLL Shape	Base	Margin	Apex	sporophyll-pteryx	DORSAL SPOROPHYLL Shape	Base	Margin	Apex
S. versicolor*	ovate-lanceolate	obtuse	serrate	long cuspidate, aristate	-				
S. vogelii*	widely trullate broadly ovate	subauriculate, obtuse	subentire (distantly serrate)	cuspidate	-				
S. kraussiana*	lanceolate, subtrullate	cuneate	serrate-denticulate	acuminate	-				
S. cathedrifolia*	ovate-lanceolate	obtuse	serrate-serrulate	cuspidate	-				
S. myosurus*	subovate trullate	obtuse	serrate-serrulate	cuspidate	-				
S. buchholzii	ovate-sub panduriform	oblique (subcordate-obtuse)	aculeate-denticulate	acuminate	+ c	trullate, deltate	subcordate, obtuse	long ciliate-serrate	shortly cuspidate long acuminate
S. soyauxii	subpandurate-oblong, oblong-ovate	oblique	entire-aculeate	acuminate	+ c	elliptic-ovate, elliptic-deltate	subobtuse	serrate-sub entire	cuspidate, long acuminate
S. blepharophylla	ovate-elliptic ovate-oblong	oblique	short ciliate-serrate	broadly acute, apiculate	+ c	lanceolate, subovate	subobtuse, oblique	ciliate	cuspidate
S. zechii	oblong-ovate	obtuse	short ciliate-subentire-serrate-denticulate	apiculate	+ c	lanceolate	obtuse	ciliate	aristate, cuspidate
S. protensa	ovate-lanceolate	obtuse	short ciliate-serrate	cuspidate, long acuminate	+ c	lanceolate	obtuse	short ciliate	cuspidate
S. tenerrima	subpanduri-form-elliptic	obtuse	serrate-denticulate	acuminate	+ c	ovate-lanceolate	obtuse	short ciliate-aculeate	cuspidate
S. kalbreyeri	ovate-lanceolate	obtuse	aculeate-serrate	acuminate	+ p	ovate	subtruncate, obtuse	serrate, serrulate	cuspidate
S. leonensis	ovate, subpanduriform	oblique (obtuse-truncate)	aculeate-denticulate	apiculate	+ c	narrowly ovate	weakly obtuse	ciliate	cuspidate
S. molleri	oblong-ovate	oblique	short ciliate-double serrate	acuminate	+ c	ovate	subcordate	short ciliate	cuspidate

Table 15A continued

SPECIES	VENTRAL SPOROPHYLL Shape	Base	Margin	Apex	Sporophyll-pteryx	DORSAL SPOROPHYLL Shape	Base	Margin	Apex
S. molliceps	lanceolate-elliptic	oblique	aculeate-sub entire	retuse acute-apiculate	+ c	lanceolate	obtuse	ciliate	aristate, cuspidate
S. subcordata	oblong-elliptic	obtuse	aculeate-denticulate	acuminate	+ c	ovate	obtuse	long ciliate	cuspidate
S. squarrosa	subpanduriform - deltate	oblique	entire	acute,	+ c	ovate	obtuse	serrate-aculeate-entire	cuspidate
S. serrato-squarrosa	subpanduriform-ovate	obtuse	serrate-entire, aculeate-entire	acute	+ c	lanceolate	obtuse	serrate	cuspidate, aristate
S. goudotana	subpanduriform, lanceolate-elliptic	obtuse	aculeate-denticulate	acute, apiculate	+ c	ovate-lanceolate	obtuse, broadly cuneate	short-ciliate-serrate	cuspidate
S. thomensis	weakly subulate elliptic-oblong	obtuse	subentire-aculeate	acute	+ c	subtriangular	truncate	serrate-serrulate	acuminate

Key:

* = species with uniform sporophylls
+ c = present; complete
+ p = present; partial
\- = absent

TABLE 158: Comparison of basic sporophyll characters in species of _Selaginella_ subgenus _Stachygynandrum_ of Madagascar

SPECIES	VENTRAL SPOROPHYLL Shape	Base	Margin	Apex	Sporophyll-pteryx	DORSAL SPOROPHYLL Shape	Base	Margin	Apex
_S. fissidentoides_*	broadly ovate	obtuse	serrate acuminate	long acuminate	-				
_S. vogelii_*	broadly ovate, widely trullate	obtuse, subauriculate	subentire (distantly serrate)	cuspidate	-				
_S. pervillei_*	ovate	obtuse	short ciliate-serrate	aristate	-				
S. digitata**					-				
_S. helicoclada_*	ovate (elliptic)	subtruncate (obtuse)	irregularly dentate	mucronulate	-				
_S. pectinata_*	broadly ovate (trullate)	obtuse (subsaggitate)	wavy	acute	-				
_S. lyallii_*	ovate	obtuse	wavy (irregular)	subobtuse, acuminate	-				
S. hildebrandtii	ovate-subpanduriform	oblique (cuneate-subcordate)	serrate-denticulate	acuminate	+c	lanceolate	obtuse	short ciliate	cuspidate
S. goudotana	lanceolate-elliptic, subpanduriform	obtuse	aculeate-denticulate	acute, apiculate	+c	ovate-lanceolate	obtuse, broadly cuneate	short ciliate-serrate	cuspidate
S. perpusilla	ovate-subpanduriform	subcuneate (oblique)	aculeate-serrate	long acuminate	+c	lanceolate	obtuse	long ciliate-serrate	cuspidate
S. unilateralis	ovate-subpanduriform	oblique (cuneate-obtuse)	ciliate-serrate	acuminate, apiculate	+c	lanceolate	obtuse	long ciliate	short aristate, cuspidate

Key: * = species with uniform sporophylls; +c = present; complete
- = absent ; ** = strobilus not seen

TABLE 16A: Distribution of epidermal cell types in ventral sporophylls of species of West African <u>Selaginella</u> subgenus <u>Stachygynandrum</u>

SPECIES	LIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells	ALIGULAR SURFACE stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells
<u>S. versicolor</u>*	-	-	+	+	-	+	±b	l	-	+	+	-	+	b
<u>S. vogelii</u>*	-	-	+	+	+	-	-	l	-	+	+	+	-	-
<u>S. kraussiana</u>*	-	-	+	±	+	-	-	v	-	+	±	+	-	-
<u>S. cathedrifolia</u>*	-	-	+	-	-	+	-	v	-	+	-	-	+	-
<u>S. myosurus</u>*	-	-	+	±	+	-	-	v	-	+	±	+	-	-
<u>S. buchholzii</u>	l	-	+	+	-	-	±p	l	+	-	-	-	+	-
<u>S. soyauxii</u>	l	-	+	+	-	-	-	l	+	-	±	-	+	-
<u>S. blepharophylla</u>	l	-	+	+	-	-	-	l,m	+	-	-	-	+	-
<u>S. zechii</u>	l	-	+	+	-	-	-	l,m	+	-	-	-	+	-
<u>S. protensa</u>	l,m	-	+	+	-	-	p	l	+	-	+	-	-	-
<u>S. tenerrima</u>	l,m	-	+	+	-	-	-	m	+	-	-	-	+	-
<u>S. kalbreyeri</u>	l,v	-	+	+	-	-	-	l	+	-	+	-	+	-
<u>S. leoneensis</u>	l	-	+	+	-	-	-	l,m	+	-	+	-	-	-
<u>S. molleri</u>	l,m	-	+	+	-	±	-	l	+	-	-	-	+	-
<u>S. molliceps</u>	l	-	+	+	-	-	-	m	+	-	-	-	+	-
<u>S. subcordata</u>	l	+	+	+	-	-	-	m	+	-	+	-	-	-
<u>S. squarrosa</u>	l	-	+	+	-	-	-	m	+	-	+	-	-	-
<u>S. serrato-squarrosa</u>	l,m	-	+	+	-	-	p	l	+	-	+	-	-	-
<u>S. goudotana</u>	l	-	+	+	-	-	-	l	+	-	-	-	+	-
<u>S. thomensis</u>	l	-	+	-	-	+	p,b	l,m	+	-	±	-	+	-

Key: Symbols indicate the location of cell types as follows:

+ = present
- = absent
± = occasionally present
l = present on lamina
m = present near and/ or at the margin
v = present along the midvein
p = present in patches
b = present in bands
* = species with uniform sporophylls

TABLE 16B: Distribution of epidermal cell types in dorsal sporophylls of species of West African *Selaginella* subgenus *Stachygynandrum* :

SPECIES	LIGULAR SURFACE elongate cells	sinous cells	straight cells	sclerotic cells	ALIGULAR SURFACE stomata	elongate cells	sinous cells	straight cells	sclerotic cells
*S. versicolor**	-	-	-	-	-	-	-	-	-
*S. vogelii**	-	-	-	-	-	-	-	-	-
*S. kraussiana**	-	-	-	-	-	-	-	-	-
*S. cathedrifolia**	-	-	-	-	-	-	-	-	-
*S. myosurus**	-	-	-	-	-	-	-	-	-
S. buchholzii	+	+	-	±p	l	+	+	-	±p
S. soyauxii	+	-	+	-	l	+	±	+	-
S. blepharophylla	+	-	+	-	v	+	+	+	-
S. zechii	+	-	+	-	v	+	-	+	-
S. protensa	+	-	+	-	v	+	-	+	p
S. tenerrima	+	±	+	±p	v	+	±	+	±p
S. kalbreyeri	+	+	+	-	v	+	+	+	-
S. leonensis	+	±	+	-	±v	+	±	+	-
S. molleri	+	±	+	-	v	+	±	+	-
S. molliceps	+	-	+	-	v	+	+	+	-
S. subcordata	+	+	+	-	v	+	+	+	-
S. squarrosa	+	-	+	-	v	+	-	+	-
S. serrato-squarrosa	+	-	+	-	l	+	-	+	-
S. goudotana	+	+	+	-	l	+	+	+	-
S. thomensis	+	-	+	-	l	+	-	+	-

Key: Symbols indicate the location of cell types as follows:
+ = present — v = present along the midvein
- = absent — p = present in patches
± = occasionally present — * = species with uniform sporophylls; see Ventral sporophyll (Table 16A)
l = present on lamina

TABLE 17A: Distribution of epidermal cell types in ventral sporophylls of species of Madagascan _Selaginella_ subgenus _Stachygynandrum_

	LIGULAR SURFACE							ALIGULAR SURFACE						
SPECIES	stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells	stomata	isodiametric cells	elongate cells	sinous cells	undulating cells	straight cells	sclerotic cells
_S. fissidentoides_*	-	-	+	+	+	-	-	v	-	+	+	+	-	±p,b
_S. vogelii_*	-	-	+	+	+	-	-	l	-	+	+	+	-	-
_S. pervillei_*	-	-	+	+	+	-	-	l	-	+	+	+	-	-
S. digitata**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
_S. helicoclada_*	-	-	+	-	-	+	-	l	±	+	-	-	+	-
_S. pectinata_*	-	-	+	±	-	+	-	v	-	+	±	-	+	-
_S. lyallii_*	-	-	+	±	±	+	-	v	-	+	±	±	+	-
S. hildebrandtii	l	-	+	+	-	±	±p	m	+	-	±	-	+	-
S. goudotana	l	-	+	+	-	-	-	l	+	-	-	-	+	-
S. perpusilla	l	-	+	+	+	-	±p	l	+	-	+	-	±	-
S. unilateralis	l,m	-	+	±	-	+	±p	l,m	+	-	+	+	-	-

Key: Symbols indicate the location of cell types as follows:
+ = present
- = absent
± = occasionally present
l = present on lamina
* = species with uniform sporophylls
m = present near and/or at the margin
v = present along the midvein
p = present in patches
b = present in bands
** = strobilus not seen

TABLE 17B: Distribution of epidermal cell types in dorsal sporophylls of species of Madagascan _Selaginella_ subgenus _Stachygynandrum_

SPECIES	LIGULAR SURFACE elongate cells	sinous cells	straight cells	sclerotic cells	ALIGULAR SURFACE stomata cells	elongate cells	sinous cells	straight cells	sclerotic
_S. fissidentoides_*	-	-	-	-	-	-	-	-	-
_S. vogelii_*	-	-	-	-	-	-	-	-	-
_S. pervillei_*	-	-	-	-	-	-	-	-	-
S. digitata**	-	-	-	-	-	-	-	-	-
_S. helicoclada_*	-	-	-	-	-	-	-	-	-
_S. pectinata_*	-	-	-	-	-	-	-	-	-
_S. lyallii_*	-	-	-	-	-	-	-	-	-
S. hildebrandtii	+	-	+	-	v	+	-	+	-
S. goudotana	+	+	+	-	1	+	+	+	-
S. perpusilla	+	+	-	-	1	+	+	-	-
S. unilateralis	+	-	+	-	v	+	-	+	-

Key: Symbols indicate the location of cell types as follows:
+ = present
- = absent
1 = present on lamina
v = present along the midvein
* = species with uniform sporophylls; see ventral sporophyll (Table 17A)
** = strobilus not seen

TABLE 18A: Stomatal index values for the sporophylls of species of *Selaginella* Subgenus *Stachygynandrum* of West Africa (based on 25 sporophylls per sporophyll type per species; values to the nearest whole number)

SPECIES	SPOROPHYLL TYPE: VENTRAL SPOROPHYLL Ligular Surface $\bar{x}$(range) ± δ	VENTRAL SPOROPHYLL Aligular Surface $\bar{x}$(range) ± δ	DORSAL SPOROPHYLL Ligular Surface $\bar{x}$(range) ± δ	DORSAL SPOROPHYLL Aligular Surface $\bar{x}$(range) ± δ
S. versicolor*	-	8 (7 - 9) ± 0.5	-	-
S. vogelii*	-	6 (5 - 7) ± 0.5	-	-
S. kraussiana*	-	16 (14 - 17) ± 0.7	-	-
S. cathedrifolia*	-	6 (4 - 7) ± 1.3	-	-
S. myosurus*	-	10 (9 - 10) ± 0.5	-	-
S. buchholzii	19 (18 - 20) ± 0.9	5 (4 - 5) ± 0.1	-	7 (6 - 7) ± 0.3
S. soyauxii	7 (6 - 8) ± 0.6	4 (3 - 4) ± 0.4	-	3 (2 - 4) ± 0.5
S. blepharophylla	9 (8 - 9) ± 0.5	6 (5 - 6) ± 0.4	-	10 (9 - 11) ± 0.7
S. zechii	15 (14 - 16) ± 0.6	4 (3 - 5) ± 0.4	-	2 (2 - 3) ± 0.2
S. protensa	4 (3 - 4) ± 0.2	4 (3 - 5) ± 0.8	-	8 (6 - 9) ± 1.1
S. tenerrima	10 (9 - 10) ± 0.3	1 (1 - 2) ± 0.5	-	3 (3 - 4) ± 0.2
S. kalbreyeri	6 (5 - 7) ± 0.5	2 (2 - 3) ± 0.4	-	2 (1 - 2) ± 0.5
S. leoneensis	9 (7 - 10) ± 0.9	2 (1 - 2) ± 0.4	-	3 (2 - 3) ± 0.1
S. molleri	13 (11 - 14) ± 1.0	9 (8 - 9) ± 0.2	-	3 (2 - 3) ± 0.2
S. molliceps	7 (6 - 9) ± 0.8	2 (1 - 3) ± 0.5	-	3 (2 - 3) ± 0.1
S. subcordata	8 (8 - 9) ± 0.4	4 (4 - 5) ± 0.2	-	6 (6 - 7) ± 0.3
S. squarrosa	14 (13 - 15) ± 0.8	1 (1 - 2) ± 0.5	-	2 (1 - 2) ± 0.1
S. serrato-squarrosa	10 (8 - 11) ± 1.1	2 (2 - 3) ± 0.4	-	3 (2 - 4) ± 0.8
S. goudotana	6 (5 - 7) ± 0.7	3 (3 - 4) ± 0.2	-	9 (7 - 9) ± 0.6
S. thomensis	13 (11 - 14) ± 1.1	3 (3 - 4) ± 0.6	-	10 (9 - 10) ± 0.4

Key: * = species with uniform sporophylls

TABLE 18B: Stomatal index values for the sporophylls of species of Selaginella subgenus Stachygynandrum of Madagascar (based on 25 sporophylls per sporophyll type per species; values to the nearest whole number)

SPECIES	SPOROPHYLL TYPE: VENTRAL SPOROPHYLL Ligular Surface $\bar{x}$ (range) ± δ	VENTRAL SPOROPHYLL Aligular Surface $\bar{x}$ (range) ± δ	DORSAL SPOROPHYLL Ligular Surface $\bar{x}$ (range) ± δ	DORSAL SPOROPHYLL Aligular Surface $\bar{x}$ (range) ± δ
S. fissidentoides*	-	8(7-9) ± 0.9	-	-
S. vogelii*	-	6(5-7) ± 0.5	-	-
S. pervillei*	-	11(10-13) ± 0.7	-	-
S. digitata**	-	-	-	-
S. helicoclada*	-	22(20-24) ± 1.5	-	-
S. pectinata*	-	15(13-17) ± 1.4	-	-
S. lyallii*	-	15(14-17) ± 1.0	-	-
S. hildebrandtii	10(9-12) ± 0.9	2(2-3) ± 0.8	-	5(4-8) ± 1.4
S. goudotana	6(5-7) ± 0.7	3(3-4) ± 0.2	-	9(7-9) ± 0.6
S. perpusilla	18(17-19) ± 0.8	4(4-5) ± 0.3	-	6(5-7) ± 0.7
S. unilateralis	9(7-11) ± 1.2	5(4-7) ± 1.0	-	5(4-7) ± 1.0

Key : * = species with uniform sporophylls
** = strobilus not seen

III. ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

Dr B A Thomas, Head of Botany Department, National Museum of Wales, Cardiff (NMW) and Mr A C Jermy, Botany Department, British Museum (Nat. Hist.) (BM) suggested to me, in the early part of 1983, that I consider researching into the Selaginella of Africa. At that time, I was a visiting student at Goldsmiths' College. After a careful consideration, I agreed to their suggestion and started examining the species of Selaginella found in West Africa, even though I knew very little about Selaginella as a group. This has resulted in this Ph.D. work and I have not regretted agreeing to do this work after they suggested it. My most sincere debt of gratitude goes to them: to Dr B A Thomas, also, for supervising this work from the start (when he was at Goldsmiths' College) and continuing to give me many useful suggestions to the end, even when he left Goldsmiths' College to NMW; and to Mr A C Jermy, also, for the numerous useful suggestions he offered as he read through the manuscripts.

My grateful thanks are due to Dr R A Spicer, Life Sciences Department, Goldsmiths' College, who agreed to take and took over the supervision of this work when Dr B A Thomas left Goldsmiths' College to NMW.

I wish to thank all the members of staff of the Life Sciences Department, Goldsmiths' College, for their help given in the many diverse ways and in particular the technical help of the following - Dr M Ann Smith and Mrs V Blackburn (on the SEM) and Mrs Gladys Murley (for Green House assistance).

I appreciate the assistance given to me by Miss Heike Hettler, a student of the Life Sciences Department, Goldsmiths' College, in the translation of the German literature that I had to deal with.

I am grateful to Miss A M Paul and Miss J M Camus of the BM, for encouragement, Dr B Croxwall and Mr P Edwards of the Royal Botanic Gardens, Kew, Dr A Fay of New York, and the Keepers of the Herbaria at BD, LG, P, and TAN for the provision of herbarium materials.

So many people have contributed, in one way or the other, in making this work become possible. I cannot mention all their names individually; I am, however, very grateful to all, both far and near, for their interest, encouragement and help.

This work has been made possible by the award of the Ghana Government Scholarship to me. I would like to acknowledge this financial support and also the support received from Goldsmiths' College, The Botanical Research Fund, and other sponsors, in making it possible for me to go to Madagascar in 1985 to do part of my research there.

Finally, I wish to thank Miss Elizabeth Roome, the secretary of the Life Sciences Department, Goldsmiths' College, for typing this work.

JULY 1986 NATHANIEL QUANSAH

BIBLIOGRAPHY

BIBLIOGRAPHY

ADAMS, C. D. & ALSTON, A. H. G., 1955. A list of the Gold Coast Pteridophyta. Bull. Brit. Mus. (Nat. Hist.) Bot. 1:144-185.

ALSTON, A. H. G., 1932. Selaginellaceae. In C. Christensen, The Pteridophyta of Madagascar. Dansk Bot. Ark. 7: 193-200 + 3 plates.

ALSTON, A. H. G., 1952. A revision of West Indian species of Selaginella. Bull. Brit. Mus. (Nat. Hist) Bot. 1: 25-47.

ALSTON, A. H. G., 1955. The heterophyllous Selaginellae of Continental North America. Bull. Brit. Mus. (Nat. Hist.) Bot. 1:219-274.

ALSTON, A. H. G., 1957. Famille des Selaginellaceae. In M. L. Tardieu-Blot & A. H. G. Alston, Les pteridophytes d'Afrique intertropicale Française. Mém. Inst. fr. Afr. Noire 50: 26-44.

ALSTON, A. H. G., 1959. The ferns and fern-allies of West Tropical Africa. Suppl. to the 2nd ed. of the Flora of West Africa. VIII + 89 pp. Crown Agents for Overseas Government and Administrations, London.

ALSTON, A. H. G., JERMY, A. C. & RANKIN, J. M., 1981. The genus Selaginella in Tropical South America. Bull. Brit. Mus. (Nat. Hist.) Bot. 9:223-330.

AUBREVILLE, A., 1949. Climats, Forêt et désertification de l'Afrique tropicale, Société d'Editions Géographiques, Martimes et Coloniales, Paris.

BAKER, J. G., 1883. A synopsis of the genus Selaginella. Jour. Bot. London 21: 1-5, 42-46, 80-84, 97-100, 141-145, 210-213, 240-244, 332-336.

BAKER, J. G., 1884. A synopsis of the genus Selaginella. Jour. Bot. London 22: 23-26, 86-90, 110-113, 243-247, 275-278, 295-300, 373-377.

BAKER, J. G., 1885. A synopsis of the genus Selaginella. Jour. Bot. London 23: 19-25, 45-48, 116-122, 154-157, 176-180, 248-252, 292-302.

BAKER, J. G., 1887. Handbook of Fern-Allies. A synopsis of the genera and species of the natural orders of Equisetaceae, Lycopodiaceae, Selaginellaceae, Rhizocapeae. London 159 pp.

BENL, G., 1978. The Pteridophyta of Fernando Po (Contributions to a Flora of the Island) I: Lycopodiaceae, Selaginellaceae, Psilotaceae, Schizaeaceae, Gleicheniaceae, Osmundaceae, Cyatheaceae. Acta Botanica Barcinonensia 31:1-31.

BIERHORST, D. W., 1971. Morphology of Vascular Plants. Macmillan, New York.

BILDERBACK, D. E., 1984. Phototropism of Selaginella. The differential response to light. Amer. J. Bot. 71 (10): 1323-1329.

BILDERBACK, D. E., 1984. Phototropism of Selaginella. The role of the small dorsal leaves and auxin. Amer. J. Bot. 71 (10): 1330-1337.

BIZZARRI, M. P., 1975. Adumbratio Florae Aethiopicae - 27. Selaginellaceae. Webbia 29: 545-593.

BIZZARRI, M. P., 1981. Two new species of Selaginella (Pteridophyta) from Tropical Africa. Bull. Jard. Bot. Nat. Belg. 51: 219-224.

BIZZARRI, M. P., 1983. Two new species of Selaginella (Selaginellaceae) from Zaire. Bull. Jard. Bot. Nat. Belg. 53: 171-176.

BORGEN, L., 1975. Chromosome numbers of vascular plants from Macaronesia. Norw. J. Bot. 22: 71-76.

BOWER, F. O., 1901. Imperfect sporangia in certain Pteridophyta-are they vestigial? Ann. Bot. 15.

BOWER, F. O., 1935. Primitive Land Plants. Macmillan, London.

BRAMWELL, D., 1972. Endemism in the Flora of the Canary Islands. In Valentine (ed.), Taxonomy, phytogeography and evolution. Academic Press, London & New York, pp 141-159.

BRAUN, A., 1857. Index Seminum Horti Botanici. Berol Append. p. 11-23.

BRAUN, A., 1865. Selaginellae in J. Triana et J. E. Planchon: Prodromus Florae Novo-Granatensis. Ann. Sci. Nat. Bot. V, 3: 270-305.

BUCK, W. R. & LUCANSKY, T. W., 1976. An anatomical and morphological comparison of _Selaginella apoda_ and _Selaginella ludoviciana_. Bull. Torrey Bot. Club 103:9-16.

CHOUBERT, G., FAURE-MURET, A., & TURNER, D. C., 1971. 'Mobile' eastern zone with rejuvenated basement. In UNESCO, Tectonics of Africa. Imprimerie Atar, Geneva, pp 211-264.

CHRISTENSEN, C., 1932. The Pteridophyta of Madagascar. Dansk Bot. Ark. 7: 1-253.

COLLINSON, A. S., 1977. Introduction to World Vegetation. George Allen & Unwin., London.

CRABBE, J. A. & JERMY, A. C., 1973. Seven new species of _Selaginella_ from Tropical South America. Am. Fern J. 63: 135-144.

CRABBE, J. A. & JERMY, A. C., 1976. Six new species of _Selginella_ from Tropical South America. Fern Gaz. 11: 255-262.

DAHLEN, M. A., 1982. A taxonomic reassessment of the Hong Kong fern allies with special reference to _Selaginella_ Beauv. Ph.D. thesis, Univ. Hong Kong (unpubl.).

DARLINGTON, P. J. Jr., 1965. Biogeography of the Southern End of the World: Distribution and history of far-southern life and land, with an assessment of continental drift. Harv. Univ. Press, Cambridge, Mass.

DENGLER, N. G., 1980. The histological basis of leaf dimorphism in Selaginella martensii. Can. J. Bot. 58: 1225-1234.

DENKE, P., 1902. Sporentwicklung bei Selaginella. Beih. bot. Zbl. 12: 182-199.

DEVOL, C. E., 1967. Selaginella stem anatomy additional notes on Taiwan species. Taiwania 13:13-14.

DIXEY, F., 1960. The geology and geomorphology of Madagascar. Q. J. Geol. Soc. Lond. no. 463 vol. 116 pt. 3, p 255-268.

DUERDEN, H., 1929. Variations in megaspore numbers in Selaginella. Ann. Bot. 43: 451-457.

DUTHIE, A. V., 1923. Studies in the morphology of Selaginella pumila Spring. Part I - The vegetative organs of the sporophyte. Trans. Roy. Soc. South Africa, X: 201-212.

ERDTMAN, G., 1972. Pollen and Spore Morphology/Plant Taxonomy, Vol. 2. New York: Hafner Publ. Co., Inc. (Selaginella. pp 90-94).

EXELL, A. W., 1944. Catologue of the Vascular Plants of S. Tome (with Principe and Annobon). London.

FABBRI, F., 1965. Secondo supplemento alle tavole cromosomiche delle pteridophyta di Alberto Chiaguri. Caryologia 18: 675-731.

FITTING, H., 1900. Bau und Entwickelungsgeschichte der Makrosporen von Isoëtes und Selaginella und ihre Bedeutung für die Kenntniss des Wachsthums pflanzlicher Zellmembranen. Botanische Zeitung 58: 107-156.

FLENLEY, J. R., 1979. The Equatorial Rain Forest: a geological history. Butterworths, London.

FOSTER, A. S. & GIFFORD, E. M. Jr., 1974. Comparative Morphology of Vascular Plants. Freeman, San Francisco, p. 39.

FOULETIER, B., 1969. Variabilité morphologique chez Selaginella kraussiana A. Br. Mem. Soc. Bot. Fr. 1969: 163-177.

FRAILE, E. & RIBA, R., 1981. Distribucion esporangial en estrobilos de especies de Selaginella. Bol. Soc. Bot. Mexico. 41: 33-40.

GARY, M., McAFEE, R., Jr. & WOLF, C. L., 1972. Glossary of Geology. Am. Geol. Inst., Washington, D. C.

GRAUSTEIN, J. E., 1930. Evidences of hybridism in Selaginella. Bot. Gaz. 90: 46-74.

GUILLAUMET, J-L., 1984. The Vegetation: An Extraordinary Diversity. In A. Jolly et al. (Eds), Madagascar. Pergamon Press, Oxford.

HALLAM, A., 1972. Continental drift and the fossil record. Scient. Am. 227: 56-70.

HARVEY-GIBSON, R. J., 1894. Contributions towards a knowledge of the anatomy of the genus Selaginella, Spr. Part I - The stem. Ann. Bot. 8: 133-206.

HARVEY-GIBSON, R. J., 1896. Contributions towards a knowledge of the anatomy of the genus Selaginella, Spr. Part II - The ligule. Ann. Bot. 10: 77-88 + plates.

HARVEY-GIBSON, R. J., 1897. Contributions towards a knowledge of the anatomy of the genus Selaginella, Spr. Part III - The leaf. Ann. Bot. 11: 123-155.

HEITZ, E., 1926. Der Nachweis der Chromosomen. Z. Bot. 18: 625-681.

HELLWIG, R. L., 1969. Spores of the heterophyllous Selaginellae of Mexico and Central America. Ann. Missouri Bot. Gard. 56: 444-464.

HICKEY, L. J., 1973. Classification of the architecture of dicotyledonous leaves. Amer. J. Bot. 60: 17-33.

HIERONYMUS, G., 1900. Selaginellarum species novae, I. Species novae e sectione Homeophyllarum Spring (Homotroparum Al. Br., subgeneris Euselaginellae Warb.) subsectione Rupestrium. Hedwigia 39: 290-320.

HIERONYMUS, G., 1901. Selaginellaceae. In Engler and Prantl, Nat. Pfl.-fam. 1(4): 621-715. Leipzig.

HIERONYMUS, G. ex R. BONAPARTE, 1915. Notes Pteridologiques 1: 136-141.

HORNER, H. T. Jr. & ARNOTT, H. J., 1963. Sporangial arrangement in North American species of Selaginella. Bot. Gaz. 124: 371-383.

HORNER, H. T. Jr. & BELTZ, C. K., 1970. Cellular differentiation of heterospory in Selaginella. Protoplasma 71: 335-341.

HORNER, H. T. Jr., BELTZ, C. K., JAGELS, R. & BOUDREAU, R. E., 1975. Ligule development and fine structure in two heterophyllous species of Selaginella. Can. J. Bot. 53: 127-143.

HSÜ, J., 1937. Anatomy, development and life history of Selaginella sinensis. I. Anatomy and development of the shoot. Bull. Chin. Bot. Soc. 3: 75-95.

JERMY, A. C., 1970. In Schelpe, E. A. C. L. E. Flora Zambesiaca, Pteridophyta. Exell and Launert (Ed.). Crown Agents for Oversea Government's and Administration, London.

JERMY, A. C., JONES, K., & COLDEN, C., 1967. Cytomorphological variation in Selaginella. Jour. Linn. Soc. Bot. 60: 147-158.

KEMPF, E. K., 1970. Elektronemikroskopie der sporodermis von megasporen der gattung Selaginella (Pteridophyta). Rev. Palaeobot. Palynol. 10: 99-116.

KNOX, E. M., 1950. The spores of Lycopodium, Phylloglossum Selaginella and Isoetes and their value in the study of microfossils of Palaeozoic age. Trans. Bot. Soc. Edin. 35: 207-357 + 19 plates.

KORNAŚ, J & JANKUN, A., 1983. Annual habit and apomixis as drought adaptations in Selaginella tenerrima. Bothalia 14, 3 & 4: 647-651.

KRISHNAN, J., 1975. Physiological leaf anatomy of Selaginella. B.Sc. thesis, University of Malaya, Kuala Lumpur (unpubl.)

KURIACHAN, P. I., 1963. Cytology of the genus Selaginella. Cytologia 28: 376-380.

LIVINGSTONE, D. A., 1975. Late Quaternary climatic change in Africa. Ann. Rev. Ecol. System. 6: 332-341.

LÖVE, A. & LÖVE, D., 1961. Some chromosome numbers of Icelandic ferns and fern allies. Am. Fern J. 51: 127-128.

LOYAL, D. S., 1976. Chromosome counts in northwestern Himalayan species of Selaginella-I. Proc. Indian Sci. Congr. Assoc. 63: 127-128.

MANTON, I., 1950. Problems of cytology and evolution in the Pteridophyta. Cambridge.

McELHINNY, M. W., 1970. Formation of the Indian Ocean. Nature 228: 977-979.

McLEOD, W. T. & HANKS, P., 1985. The New Collins Concise Dictionary of the English Language. Guild Publ., London.

MICKEL, J. T. & HELLWIG, R. L., 1969. Actino-plectostely, a complex new stelar pattern in Selaginella Am. Fern J. 59: 123-134.

MINAKI, M., 1984. Macrospore morphology and taxonomy of Selaginella (Selaginellaceae). Pollen Spores, 26 (3-4): 421-480.

MITAL, P. L., 1969. Epidermal studies in the genus Selaginella Beauv. Bull. Bot. Surv. India 11: 150-160.

MITCHELL, G., 1910. Contributions towards a knowledge of the anatomy of the genus Selaginella, Spr.-Part V. The strobilus. Ann. Bot. 24: 19-33.

MOORE, H. E., 1973. Palms in the Tropical Forest Ecosystems of Africa and South America. In Meggers et al. (Eds.), Tropical Forest Ecosystems of Africa and South America: a comparative review. Smithsonian Inst. Press, Washington, pp 63-88.

MOORE, P. D. & WEBB, J. A., 1983. An illustrated guide to pollen analysis. Hodder and Stoughton Ltd. London.

MORTON, J. K., 1972. Phytogeography of the West African mountains. In Valentine (ed.), Taxonomy, Phytogeography and evolution. Academic Press, London & New York: pp 221-236.

MUKHERJEE, R. N. & SEN, U., 1981. A forked vein and foliar fibres in Selaginella. Fern Gaz. 12: 175-177.

MUKHOPADHAY, R. & SEN, U., 1981. The occurrence of a laminal flap in Selaginella. Fern Gaz. 12: 180-181.

NAYAR, B. K. & LATA, P., 1965. Spore morphology of some African fern-allies. Pollen Spores 7: 313-318.

NOZERAN, R. & ESPAGNAC, H., 1975. Quelques enseignments tirés de l'analyse de l'anatomie de Selaginella myosurus (Sw.) Alston. Ann. Sci. Nat. Bot. Biol. Veg. 16: 309-318.

OGURA, Y., 1972. Comparative anatomy of vegetative organs of the Pteridophytes. Encyclopedia of Plant Anatomy VII (3). Berlin: Gebruder Borntraeger. 502 pp. (Selaginellales, pp 191-202).

PANIGRAHI, G. & DIXIT, R. D., 1968. Studies in the systematics of Indian Selaginella. I. Proc. Nat. Inst. Sci. India 34, B (4): 191-209.

PAULIAN, R., 1984. Madagascar: A Micro-Continent between Africa and Asia. In A. Jolly et al. (Eds.), Madagascar. Pergamon Press, Oxford.

PICHI SERMOLLI, R.E.G., 1982. A further contribution to the nomenclature of the families of Pteridophyta. Webbia 35 (2): 223-237.

QUANSAH, N. & THOMAS, B. A., 1985. 'Sporophyll-pteryx' in African and American Selaginella. Fern Gaz. 13 (1): 49-52.

RADFORD, A. E., DICKISON, W. C., MASSEY, J. R. & Bell, C. R., 1974. Vascular Plant Systematics. Harper & Row Publ. New York.

REED, C. F., 1965. Index Selaginellarum. Memoiras da Sociedade Broteriana 18. Coimbra. 287 pp.

REITSMA, T., 1970. Suggestions towards unification of descriptive terminology of angiosperm pollen grains. Rev. Palaeobotan. Palynol. 10: 39-60.

RICHARDS, P. W., 1973. Africa, the 'Odd Man Out'. In Meggers et al. (Eds.), Tropical Forest Ecosystems in Africa and south America: a comparative review. Smithsonian Inst. Press, Washington, pp 21-26.

ROTHMALER, W., 1944. Pteridophyten-Studien, 1. Fedde Repert. 54: 55-82.

SEYFERT, C. K. & SIRKIN, L. A., 1973. Earth History and Plate Tectonics: An Introduction to Historical Geology. Harper & Row Publ., New York.

SIGEE, D. C., 1974. Structure and function in the ligule of Selaginella kraussiana. Protoplasma 79: 359-375.

SIM, T. R., 1915. Ferns of South Africa containing Descriptions and figures of the Fern and Fern Allies of South Africa. 2nd Ed. 384 pp and 186 plates; Cambridge Univ. Press.

SMITH, A. G. & HALLAM, A., 1970. The Fit of the Southern Continents. Nature 225: 139-144.

SMITH, A. G., HURLEY, A. M. & BRIDEN, J. C., 1981. Phanerozoic paleocontinental world maps. Cambridge Univ. Press, Cambridge.

SODIRO, P. A. (1893). Cryptogamae vasculares quitenses, adjectis speciebus in aliis privinciis ditionis Ecuadorensis hactemus detectis. Quito. (Selaginella, pp 588-625).

SOMERS, P. Jr., 1978. A systematic survey of the Articulatae Series of the genus Selaginella and monographic treatment of the S. sulcata group (sensu str.). Ph.D. dissertation, University of Tennessee, Knoxville (unpublished).

SOWERBUTTS, W. T. C., 1972. Rifting in Eastern Africa and the Fragmentation of Gondwanaland. Nature 235: 435-437.

SPRENGEL, K., 1827. In C. Linnaei: Systema Vegetabilium 4 (1): 12-22 (Lycopodium).

SPRING, A. F., 1843. Enumeratio Lycopodinearum. Bull Acad. Roy. Sci. Brux. 10 (2-3): 225-235.

SPRING, A. F., 1850. Monographie Famille des Lycopodiacees, Seconde partie. Mem. Acad. Sci. Belg. 24: 1-358.

STAINIER, F., 1967. Morphological study of the walls of the mega- and micro-spores of Selaginella myosurus (Sw.) Alston. Rev. Palaeonbotan. Palynol. 3 (1-4): 47-50.

STEWART, W. N., 1983. Palaeobotany and the evolution of plants. Cambridge Univ. Press, Cambridge.

SYKES, M. G. & STILES, W., 1910. The cones of the genus

Selaginella. Ann. Bot. 24: 523-536.

TARLING, D. H., 1971. Gondwanaland, Palaeomagnetism and Continental Drift. Nature 229: 17-21.

TARLING, D. H. & TARLING, M. P., 1971. Continental Drift. A Study of the Earth's Moving Surface. Bell& Sons Ltd., London.

THOMAS, B. A., 1971. A 3-D Approach to Teaching Plant Morphology. J. Biol. Ed. 5: 71-75.

THOMAS, B. A. & BRACK-HANES, S. D., 1984. A new approach to Family groupings in the Lycophytes. Taxon 33 (2): 247-255.

TRYON, A. F., 1949. Spores of the genus Selaginella in North America, north of Mexico. Ann. Missouri Bot. Gard. 36: 413-431.

TRYON, A. F. & LUGARDON, B., 1978. Wall structure and mineral content in Selaginella spores. Pollen Spores 20: 315-340.

TRYON, R. M. Jr., 1955. Selaginella rupestris and its allies. Ann. Missouri Bot. Gard. 42: 1-99.

TRYON, R. M. Jr., 1971. The process of evolutionary migration in species of Selaginella. Brittonia 23: 89-100.

TRYON, R. M. Jr. & TRYON, A. F., 1981. Ferns and Allied plants. With special reference to Tropical America.

Selaginellaceae; Springer-Verlag. New York. 813-825.

WAGNER, W. H. Jr., BEITEL, J. M. & WAGNER, F. S., 1982. Complex venation patterns in the leaves of Selaginella: Megaphyll-like leaves in Lycophytes. Science 218: 793-794.

WALTER, H., 1973. Vegetation of the Earth: In relation to climate and the eco-physiological conditions (Translated from the 2nd German Edition by Joy Wieser.). Springer-Verlag, New York.

WALTON, J. & ALSTON, A. H. G., 1938. Lycopodiinae. In F. Verdoorne (Ed.), Manual of Pteridology: 500-506. Den Haag.

WILLDENOW, K. L., 1810. Linne: Species Plantarum, 4th ed., 5: 10-55. Berolini.

WILSON, J. T., 1966. Did the Atlantic close and then re-open? Nature 211: 676-681.

WONG, K. M., 1983. Critical observations on Peninsular Malaysian Selaginella. Gard. Bull. 35: 107-135.

ZAMORA, P. M., 1958. Anatomy of the protoxylem elements of several Selaginella species. Philippine Jour. Sci. 87: 93-114.