

SPECIES OF *OPHIOGLOSSUM* IN INDIA : THEIR TAXONOMY AND PHYLOGENY

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ABSTRACT

The paper gives an account of the taxonomy of the genus *Ophioglossum* of which ten species are found in India. In doing so morphology of the leaf, stipules, spore and epidermal characters are taken into account and a key based on all characters is given to identify species. They are also summarised in a table. The question of confused taxonomy of species like *O. reticulatum*, *O. vulgatum* and *O. Aitchisoni* has been specifically discussed and the probable phylogeny of Indian species is schematically represented. The characters of stipules which were overlooked so far are given in detail.

INTRODUCTION

The family Ophioglossaceae is characterised by thick-walled sporangia borne on a spike subtended by leaf. Some of the recently discovered members of the Coenopteridaceae have also similar large, stalked, thick-walled sporangia; and this has aroused interest in the group afresh. The genus *Ophioglossum*, type genus of the family, represents a primitive type of fern, quite different from many others. It is of world wide occurrence comprising 30 species according to Claussen (1938). The genus has been validated by Linnaeus (1753) who had included it in his "*Species Plantarum*" (Ed. I, vol. 2, pp. 1062-64) using *Ophioglossum vulgatum* as the type. However, the genus had been known even before Linnaeus, having been described by two French brother botanists, Bauhins, Casper Bauhin (1620) who described three species of it in his "*Prodromus Theatri Botanicæ*" and J. Bauhin and Cherlero (1651) who described two more. Strangely enough Linnaeus (1753) besides describing four species of it, namely, *O. vulgatum*, *O. lusitanicum*, *O. reticulatum* and *O. palmatum*, also included a species of *Lygodium* and another of *Osmunda* under that generic name. They were, of course, removed from them later. Further workers on the taxonomy of the genus have been Presl (1845), Prantl (1883-84), Bitter (1900), etc. The family was monographed by Claussen (1938) and its various aspects have been described by many botanists. The present paper is mainly concerned with the phylogeny and taxonomy of this genus as it occurs in India. There are ten species of the genus in India, although earlier authors such as Clarke (1880), Beddome (1883), Hope (1903), Blatter and d'Almeida (1922), d'Almeida (1922), Chakravarti (1951), Balkrishnan, Thothathri and Henry (1960) have given each a different number.

In the present investigation the below mentioned ten species were collected and identified by me. Information concerning them in the Kew Herbarium was supplied to me by Mr. F. Ballard, Pteri-

dologist at the Kew Herbarium to whom my best thanks are due. It was supplemented with my own observations, during my two visits to that Herbarium in 1954 and 1959, and I have to thank the authorities of the Kew Herbarium for this help, especially Dr. Taylor and Dr. Hubbard. The material was collected at various places in India and the distribution patterns of the different species would be discussed elsewhere.*

The list of species is as follows:

1. *O. reticulatum* L. (Text fig. 1 and Pl. fig. 2).
2. *O. vulgatum* L. (Text figs. 2-4).
3. *O. japonicum* Prantl (Text figs. 5-6 and Pl. fig. 1).
4. *O. pedunculatum* Prantl *sensu non* Desv. (Text figs. 7-8 and Pl. figs. 4-5).
5. *O. nudicaule* L. (Text figs. 9-11 and Pl. fig. 8).
6. *O. lusitanicum* L. (Text figs. 12-15).
7. *O. fibrosum* Schum. (Text figs. 16-17 and Pl. figs. 6-7).
8. *O. gramineum* Willd. (Text fig. 18 and Pl. figs. 9-11).
9. *O. Aitchisoni* d'Alm. (Text figs. 19-20 and Pl. fig. 3).
10. *O. pendulum* L. (Text figs. 21-22).

OBSERVATIONS

There appears to be a good deal of controversy over the taxonomic status of some of these species and, therefore, it was thought worthwhile studying them as critically as possible with a view to distinguishing them from each other and tracing their phylogeny. Table I gives a summary of the broad morphological and anatomical characters in them.

* Some of these were discussed by the author for which see Mahabale (1938).

TABLE I

Species	Rhizome	Sterile lamina	Venation	Epidermal cells on the lower surface of the leaf and size in μ	Size of stomata in μ	Stomatal lie	Dermal appendages	Attachment of fertile spike	Size of spore in μ	No. of sporangia per spike	Leaf traces	Roots	Remarks
1. <i>O. lusitanicum</i>	Small, round, tuberous	Lineo-lanceolate, spatulate	No free vein-endings, areoles elongated	Elongated 159×28	60×45	Transverse or oblique	Hairy	Above the middle	42×42	8-16	Single	Monarch, diarch	Few stipites present on rhizome
2. <i>O. gramineum</i>	Small, erect	Linear	No free vein-ending, areoles elongated	Elongated 90×16	63×33	Parallel or irregular	Scaly	Below the middle	35×38	4-10	Single	Monarch	
3. <i>O. aitchisoni</i>	Erect, elongated	Lanceolate	Areoles large, elongated	Elongated 121×26	72×46	Transverse or oblique	Hairy	Above the middle on lamina	47	20-30	Double	Monarch, diarch, polyarch	Old stipites present on rhizome
4. <i>O. nudicaule</i>	Small, slightly tuberous	Linear to ovate	Free vein-endings in the marginal loops.	Elongated 78×25	58×34	Transverse or oblique	Scaly	Above the middle	$28-30$	3-8	Single	Monarch	
5. <i>O. vulgatum</i>	Erect, elongated cylindrical	Ovate, or ovate-oblong, hafted	Closely woven small meshes all over the leaf	Elongated 133×33	73×63	Parallel or irregular	Scaly	At the middle	$40-50$	15-20	Single	-do-	
6. <i>O. pedunculatum</i>	Erect, cylindrical at the base and tuberous at the top	Ovate to ovate orbicular	"Venatio anaxeti"	Elongated 79×27	59×40	Transverse or oblique	Scaly	Below or at the middle	$30-36$	14	Single	-do-	Few stipular scales present on rhizome
7. <i>O. japonicum</i>	Erect and cylindrical	Elliptical or elliptical oblong	"Venatio anaxeti", meshes elongated, irregular	Elongated 198×33	92×60	Parallel or irregular	Hairy	Above the middle	$32-40$	20-30	Double	Monarch, diarch	
8. <i>O. reticulatum</i>	Erect, cylindrical, cordate and tufted	Cordate	A dense net-work of broad, irregular meshes with many free vein-endings	Broad 86×61	62×46	Arch-like	Scaly	Above the middle	$40-42$	40-60	Double	Monarch, diarch	Leaf scars very prominent on rhizome
9. <i>O. fibrosum</i>	Large, round and distinctly tuberous	Ovate-lanceolate	A net work of broad, regular, polygonal meshes with variously branched veinlet	Broad 89×40	65×40	Transverse or oblique	Hairy	Above the middle	$30-37$	25	Double	Diarch, triarch	A rim for the insertion of leaves at the top of the rhizome, root fibrous
10. <i>O. pendulum</i>	Small and dorsiventral	Ribbon-like, strap-shaped or dichotomously divided	"Venatio marginariae"	Broad polygonal 112×86	$87-105 \times 56$	Parallel	Stiff scales with a few hairs	Far below the middle, very near the base of the sterile lamina	$40-50$		Multiple	Diarch, polyarch	Leaves pendulous; stomata have a ring of concentrically arranged cells around them

The following points emerge from the Table:

O. fibrosum has a distinct round corm-like rhizome, with its apex deep situated and hence it cannot be mixed up with any other species (Text figs. 16-17 and Pl. figs. 6, 7). The rhizome of *O. lusitanicum* is also round and tuberous, but it is not cormatous being rather erect (Text figs. 12-15).

The rhizome of *O. reticulatum*, *O. vulgatum* and *O. gramineum* is cylindrical and erect (Text figs. 1-4, 18 and Pl. figs. 2, 8). It is distinctly tubular at the base in *O. Aitchisoni* (Text figs. 19-20), *O. reticulatum* (Text fig. 1) and *O. nudicaule* (Text figs. 9-11). It becomes progressively enlarged towards the apex in *O. reticulatum* and *O. gramineum*. It is rather small, about 2 mm. broad and round in *O. nudicaule*. In epiphytic *O. pendulum* it is also small, 2-5 mm. broad, and stout; only a few roots arise from it (Text fig. 21). They are thick and very brittle. Thus on the basis of rhizome all these species can easily be distinguished as follows:—

- | | | | | |
|--|-----|-----|-----|--------------------------|
| A. Rhizome cormatous, roots fibrous, numerous | ... | ... | ... | <i>O. fibrosum</i> . |
| B. Rhizome round, roots not fibrous | ... | ... | ... | <i>O. lusitanicum</i> . |
| C. Rhizome cylindrical | | | | |
| Leaf cordate | ... | ... | ... | <i>O. reticulatum</i> . |
| Leaf ovate | ... | ... | ... | <i>O. vulgatum</i> . |
| Leaf lanceolate, mucronate | ... | ... | ... | <i>O. Aitchisoni</i> . |
| Leaves ovate or ovate lanceolate | ... | ... | ... | <i>O. japonicum</i> . |
| Leaves ovate oblong | ... | ... | ... | <i>O. pedunculatum</i> . |
| Rhizome small, roots thick and brittle, plants epiphytes | ... | ... | ... | <i>O. pendulum</i> . |
| Plants minute, leaf ovate or ovate oblong | ... | ... | ... | <i>O. nudicaule</i> . |
| Plants minute, leaves sickle-shaped | ... | ... | ... | <i>O. gramineum</i> . |

In order to distinguish the species further, epidermal characters of the leaf such as stomata, venation and stipules were studied.

It was found that the lie of the stomata in different species is different (Text figs. 23-34). Besides, the shape and arrangement of guard cells in *O. pendulum* are quite distinct from the rest of the species, in as much as, they are encircled by a ring of concentric cells as in *Helminthostachys* (Text figs. 31, 32). This character is not seen in any other species of *Ophioglossum* nor in *Botrychium*.

The genus *Ophioglossum* is easily distinguished from the rest of the members of the *Ophioglossaceae* or perhaps the *Marattiaceae*, with the exception of *Kaulfussia*, by its reticulate venation, which is furcate in all other genera of the *Eusporangiatae*. The degree of the reticulation however, differs in various species, as also the presence of midrib, areolae and vein-endings. Text figs. 35-47 illustrate them and an analytical key can be made on the basis of these characters. The presence or absence of free vein endings has been used by Prantl to distinguish the species of the subgenus *Euophioglossum* into two sections *Paraneura* and *Ptiloneura*. In the section *Paraneura* there are no free

vein endings, whereas in *Ptiloneura* they are always present. In *Ptiloneura* the leaf trace as a rule is double whereas in *Paraneura* it is single. In the sub-genus *Cheiroglossa* and *Ophioderma* it is multiple. No information is available about this character in the sub-genus *Rhizoglossum*.

On the basis of these *O. vulgatum*, *O. reticulatum*, *O. pedunculatum*, *O. fibrosum*, *O. japonicum* are distinguished from the rest by "*Venatio anaxeti*" (Text figs. 38-47). *O. Aitchisoni* also has similar veins, but they form two sets of meshes, large, thick nerves forming superficial areolae in which there is a close network of secondary veins (Text fig. 44). *O. pendulum* has very large vein and meshes. They are without vein-endings except at the distal margin of the leaf (Text fig. 35). In *O. lusitanicum* free veins occur only near the margin (Fig. 37). This type of venation is known as "*Venatio marginariae*".

Key to Indian species of *Ophioglossum* based on their venation.

- I. Midrib present
 - (a) Areoles elongated, irregular; free vein-endings divaricating, ascending or descending ... *O. japonicum*.
 - (b) Areoles broad, regular, often hexagonal; free vein endings dividing repeatedly in a scorpioid or dichopodial manner in the areoles ... *O. fibrosum*.
- II. Midrib absent
 - (c) Areoles elongated and regular
 - (i) Areoles completely filled with a dense net work of secondary areoles ... *O. Aitchisoni*.
 - (ii) Areoles not filled with a net work of secondary areoles and without free vein endings
 1. Submarginal commissure present ... *O. pendulum*.
 2. Submarginal commissure absent
 - No free vein-endings in the areoles but only the distal loops near the margins ... *O. gramineum*.
 - No free vein-endings in the areoles but a few club-shaped ends of veinlets at the margins ... *O. lusitanicum*.
 - Marginal loops closed but a few divaricating veinlets present in the marginal and submarginal areoles ... *O. nudicaule*.
 - (d) Areoles broad, irregular with "*Venatio anaxeti*"
 3. Free vein-endings spread all over the leaf ... *O. reticulatum*.
 4. Free vein-endings absent from the central core of elongated meshes constituting the median elevation on the back side of the leaf
 - Large veins at the base of the the lamina five ... *O. pedunculatum*.
 - Large veins at the base of the lamina eleven or more ... *O. vulgatum*.

There is always a certain amount of confusion in identification of *O. reticulatum* and *O. vulgatum* (Text figs. 1 and 2-4).^{*} These two species apart from

^{*}During my recent visit to many herbaria in U.S.S.R. I have examined hundreds of specimens of *O. vulgatum* and I have no doubt that it is quite a different species than *O. reticulatum*.

the shape of the leaf, cordate in *O. reticulatum* and ovate in *O. vulgatum*, differ in having a midvein running halfway in the leaf in *O. reticulatum* and right upto the apex in *O. vulgatum*. The stomatal lie also in them is different (Text figs. 29-30 & 33-34). But more distinct and reliable character is the shape of epidermal cells. In *O. reticulatum* the epidermal cells are broad and have corrugated walls (Text figs. 33-34) but not so in *O. vulgatum* which has elongated, slightly wavy walls (Text figs. 29-30).

O. Aitchisoni is sometimes called *O. capense* Prantl, as one of sheets in Calcutta herbarium bearing that name is from Prantl's collection from South Africa and is named as such. The question here, therefore, is one of nomenclature as per present International rules. The stipules (persistent sheaths) in *O. capense* however, are rather long and reddish compared to those in *O. Aitchisoni*. Perhaps they are two different varieties. But it would be risky to call them identical without examining some fresh African material of *O. capense* and comparing it with that of *O. Aitchisoni* from India (Text figs. 19-20). The leaf structure in the rest of the species is too distinct to be confounded.

Claussen (1938, pp. 143-152) in his monograph on the Ophioglossaceae first created a number of subspecies in *O. nudicaule*, but later he rightly felt that many of them are mere varieties, perhaps ecological variations, not worthy of any nomenclatorial distinction (*Loc. cit.*, p. 172). I agree with this view, as the plants of this species grow under very varied conditions all over the country from Himalayas to Annamallis and as such only they look different (Text figs. 9-11 and Pl. fig. 8).

Another very important character of *Ophioglossum* is stipules or the so-called persistent leaf sheaths. As this has escaped the attention of earlier workers, it may be given in detail here. Text figs. 48-60 illustrate the stipules in all the species studied. The leaf in *Ophioglossum* in young condition is encircled by cylindrical ochrea-like sheath (Fig. 48). Its margins are obliquely twisted and overlapping. They thus encircle within them the next successive young leaf as well as the rudiments of all subsequent leaves growing with it. This becomes very clear in a median L. S. of rhizome of *O. Aitchisoni* (Text fig. 48), in which one sees primordia of young leaves and stipules encircling each other near the growing point of rhizome. There is also some intercalary growth between stipule and the growing point of stem in some species. The sheath is open at the apex by a pore through which the leaf-tip, which is erect, and not circinate, comes out as in some species of *Pteris*, and the air outside reaches to the growing apex. As the leaf grows, the stipule matures and gets split into two parts which remains attached to the leaf base on the rhizome. These parts persist till the leaf dries and falls off, leaving brown coloured stipites (Text figs. 1, 4, 8, 19-20). Thus both the stipules as well as stipites are

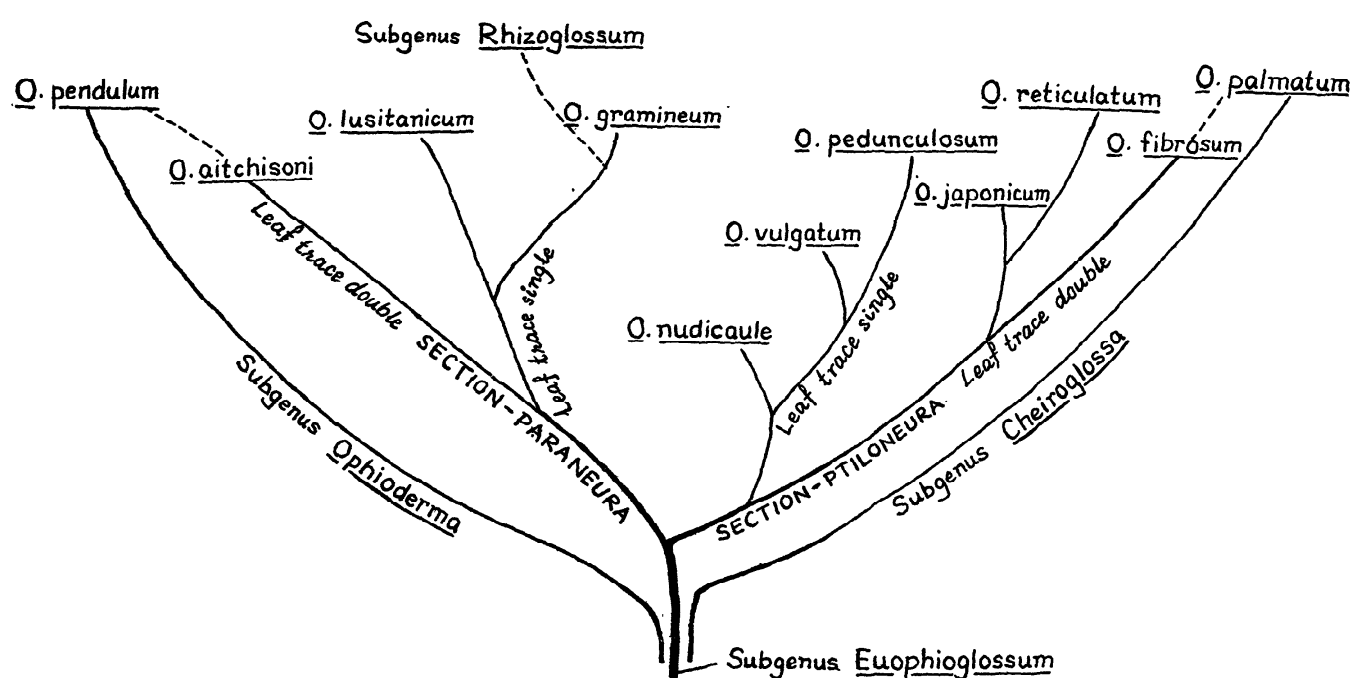
visible on old rhizome between the roots and root scars.

There are four types of stipules in *Ophioglossum*: (1) those that are distinctly scaly with thin-walled cells e.g. *O. pedunculatum* (Text fig. 55), (2) Scaly with thick-walled cells e.g. *O. gramineum* (Text figs. 56-57), (3) Those with a few glandular cells at the margin e.g. *O. nudicaule* (Text fig. 54), and (4) those that are distinctly hairy e.g. *O. fibrosum*, *O. japonicum*, *O. reticulatum*, *O. pendulum* and *O. Aitchisoni* (Text figs. 49, 53 and 58-60). On this basis, *O. reticulatum* having scaly stipules and short hairs, *O. gramineum* having thick stipules without hairs (Text figs. 56), *O. fibrosum* (Text figs. 49, 60), *O. lusitanicum* (Text fig. 58), *O. pendulum* (Fig. 59) and other species with distinctly hairy stipules (Text figs. 50, 51, 52, 53) can easily be recognised. Of these the stipules of *O. Aitchisoni* are highly characteristic (Text figs. 50, 51). In the two other related genera of *Ophioglossum*, *Botrychium* and *Helminthostachys*, they are mostly scaly except in *B. daucifolium* in which hairs are present. Stipules are also present in other members of the Marattiaceae e.g. green fleshy acrescent stipules of *Angiopteris* or *Marattia*. According to the usual belief, scaly stipules are advanced and hairy primitive. From this point of view there is a full range of stipules in the genus *Ophioglossum* from hairy to scaly which indicates that it may not be a primitive genus in the family.

The spores in different species are also characteristic and are shown in Text figs. 61-72. Their characters also can be used taxonomically; especially of *O. reticulatum*, *O. nudicaule*, *O. gramineum* and *O. pendulum* are highly significant. The spores in the last-named species have tri-radiate mark extended upto edge of the lower circular half of spore (Figs. 71, 72), as in some species of *Isoetes* like *I. lithophila*, *I. tenuissima* etc.

Anatomically the rhizome in *Ophioglossum* shows interesting transition from medullated protosteles at its base to schizostele in the adult stem; but the individual bundles do not seem to possess endodermis. Most of the plants in *O. reticulatum*, *O. Aitchisoni*, *O. nudicaule*, *O. vulgatum* or *O. pedunculatum* arise vegetatively from root buds (Text figs. 1, 3, 4, 7, 8, 10, 19, 20). The rhizome in such plants is tubular at the base and one sees a complete transition from protostele to schizostele in one and the same rhizome at different levels. The structure of rhizome in *O. fibrosum* is different. It is more like that in the corm of *Isoetes* in which leaf trace bundles lie scattered in storage parenchyma. Besides there is also slight periderm formation in *O. fibrosum*. Apparently there is no cauline stele in this species but only foliar, the leaf trace bundles joining one another to form a flat basket-like network of stele.

Another important anatomical character of the genus is leaf trace. It is single in *O. gramineum* and

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O. nudicaule, double in most of species growing terrestrially, and multiple in epiphytic *O. pendulum* having about 20 leaf trace bundles. On dissecting leaf traces, one clearly sees that the vascular traces going to spike arise from the primary furcations of the petiolar traces, the two adaxial branches of which enter the spike and two abaxial the lamina. This lends a strong support to the foliar nature of spike and to the telome concept of it.

The spike in *Ophioglossum* is unique structure. It is stalked and cylindrical at the base, but flattens out towards the apex, bearing bilaterally arranged alternate sporangia opening transversely. There is a median groove or a green band, somewhat like a midrib called middle *vitta*. It differs in different species. Stomata are present on both the surfaces of spike. It ends bluntly or in an apiculate manner, just like the sterile leaf. It is short and stout in *O. pendulum*. The shortest spike is found in *O. gramineum* in which it may bear as few as 2-3 sporangia. It is slender and long in *O. nudicaule*. In *O. gramineum*, *O. pendulum*, *O. Aitchisoni* it is more or less laterally attached to the leaf more towards one side; in others medially. In *O. Aitchisoni* and *O. pendulum* the point of attachment is far above the lamina (Text figs. 19-22). In the rest it is at the base of the lamina. In *O. gramineum* it is unevenly lateral (Text fig. 18). The spike in rare *O. Bergianum* is separate from the lamina from the base of the leaf and in *O. simplex* there is no sterile lamina at all.

Taking all these characters into account we might now try to trace the phylogeny of the Indian species.

It is customary to divide the genus *Ophioglossum* into four sub-genera: *Cheiroglossa*, *Ophioderma*, *Euophioglossum* and *Rhizoglossum*. The last sub-genus is represented by a single species found in the mountains of Cape of Good Hope in which the spike and leaf are separate *ab initio*, viz. in *O. Bergianum*. It is an extremely specialized sub-genus. The sub-genus *Cheiroglossa* is monotypic and grows in dense humid forests of Seychelles Island, Central and South America, Florida, West Indies, Brazil, Mexico, Annam (Indochina), etc.

Species belonging to sub-genus *Ophioderma* are also epiphytes growing in the forests of Lakhimpur in Assam, Barrawa Forests Reserve in Ceylon, Malaya, Fiji, Phillipines, Australia etc.

The leaf in *Cheiroglossa* is multilobed, 10-12 times and bears small 10-20 *Botrychium*-like spikes at the margin of the leaf. Each spike has a few sporangia on a short stalk. Obviously there is a tendency to form many but small spikes in this sub-genus. A some-what similar tendency is noticeable in *O. fibrosum*, the form and leaf characters of which tally with those of *O. palmatum* belonging to the sub-genus *Cheiroglossa*. Hence these two species are closely related to one another.

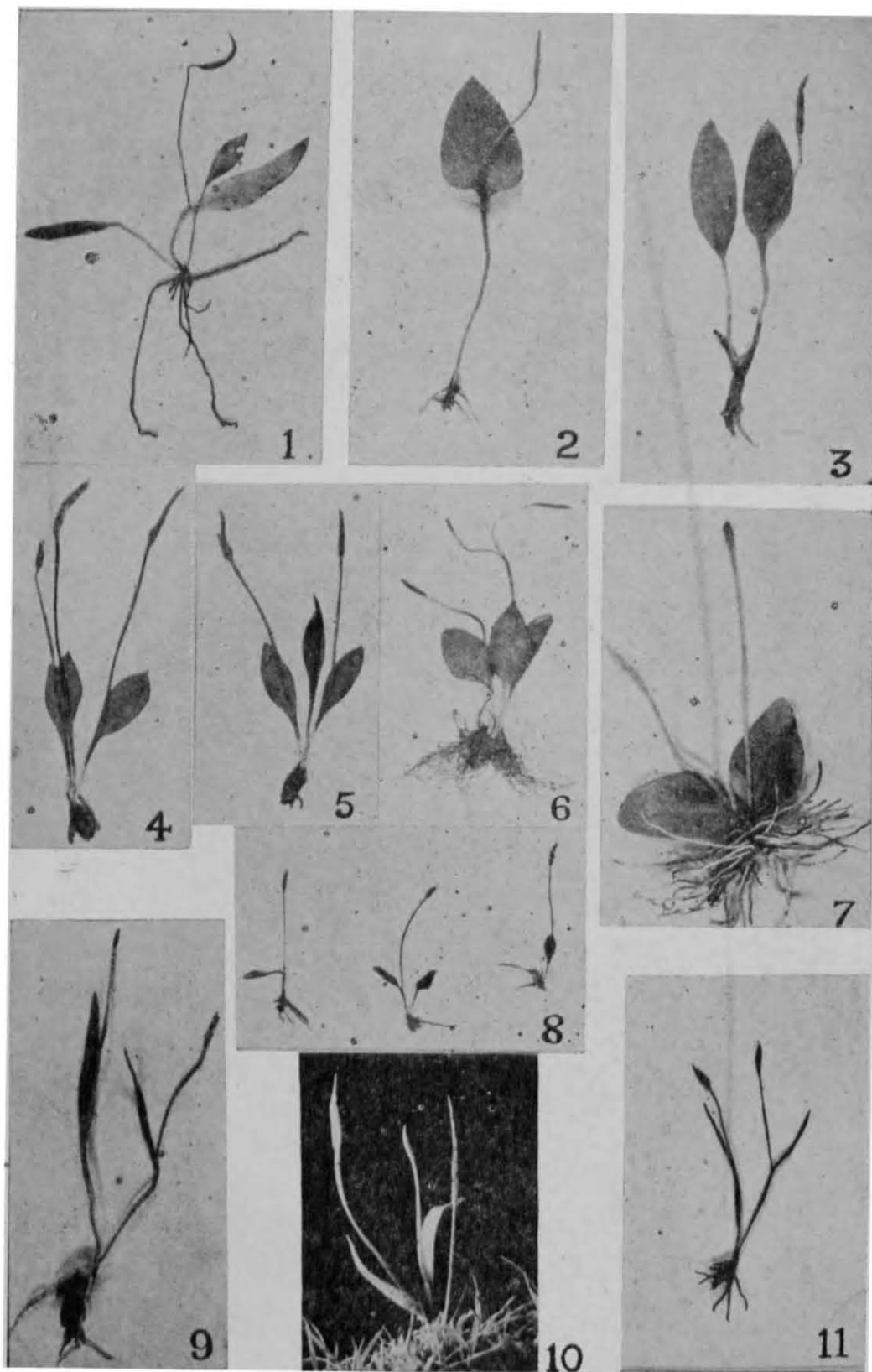
The genus *Euophioglossum* forms the central group of the genus represented by species like *O. vulgatum*, *O. reticulatum*, etc. They are all terrestrial and constitute the main line of evolution in the genus, the monotypic sub-genus *Rhizoglossum* being extremely isolated. The central group is related to (i) *O. pendulum* belonging to *Ophioderma* through *O. Aitchisoni* and *O. gramineum* and to (ii) sub-genus *Cheiroglossa* through *O. lusitanicum* and *O. fibrosum*. The spike in *Ophioderma* is stout, short-peduncled and bears numerous sporangia, 200 sometimes, on a spike attached to the leaf far above the base of the lamina. Their other characters also agree. At times in *O. pendulum* the lamina is bifurcated repeatedly and bears a huge single or multifarious spike. The sporangia in it are large and contain thousands of spores. The line of evolution from the central type *O. vulgatum* or *Euophioglossum* to *Ophioderma* therefore is indicated by species like *O. Aitchisoni*, and towards *Cheiroglossa* by *O. fibrosum* and *O. lusitanicum*.

It thus seems that the central position assigned to *Euophioglossum* to which most of the terrestrial species belong is fully justified. Two side lines arose from it: those in which spike tended to be stout and bore numerous sporangia and got associated with thick and fleshy leaf, as in other epiphytes belonging to Loranaceae, Gesneriaceae, etc. The *Ophioderma*; and the other in which the leaf became thin and multilobed; the sporangio-phores remained small and produced a few sporangia on each spike, the *Cheiroglossa*. Both these types are adapted to epiphytic existence, but in entirely different ways—one by forming a single large stout spike and leathery leaf, and the other by forming numerous tender small spikes with a few sporangia on a thin multilobed leaf. Diagram (p. 75) gives a schematic representation of the phylogeny of the Indian species studied. It excludes the sub-genus *Rhizoglossum* of which we have no plants. The sporangio-phore in it is separate from the tubular leaf from the very base of it. There is extreme reduction in the number of sporangia per spike, 2-3. The nearest Indian species approaching this sub-genus is *O. gramineum*. The genus on the whole, seems to be a highly specialized and not a primitive member of the *Ophioglossaceae*. There is little doubt that each genus of this family is an end product of a long series of forms not yet known to us, or the ones that have become extinct.

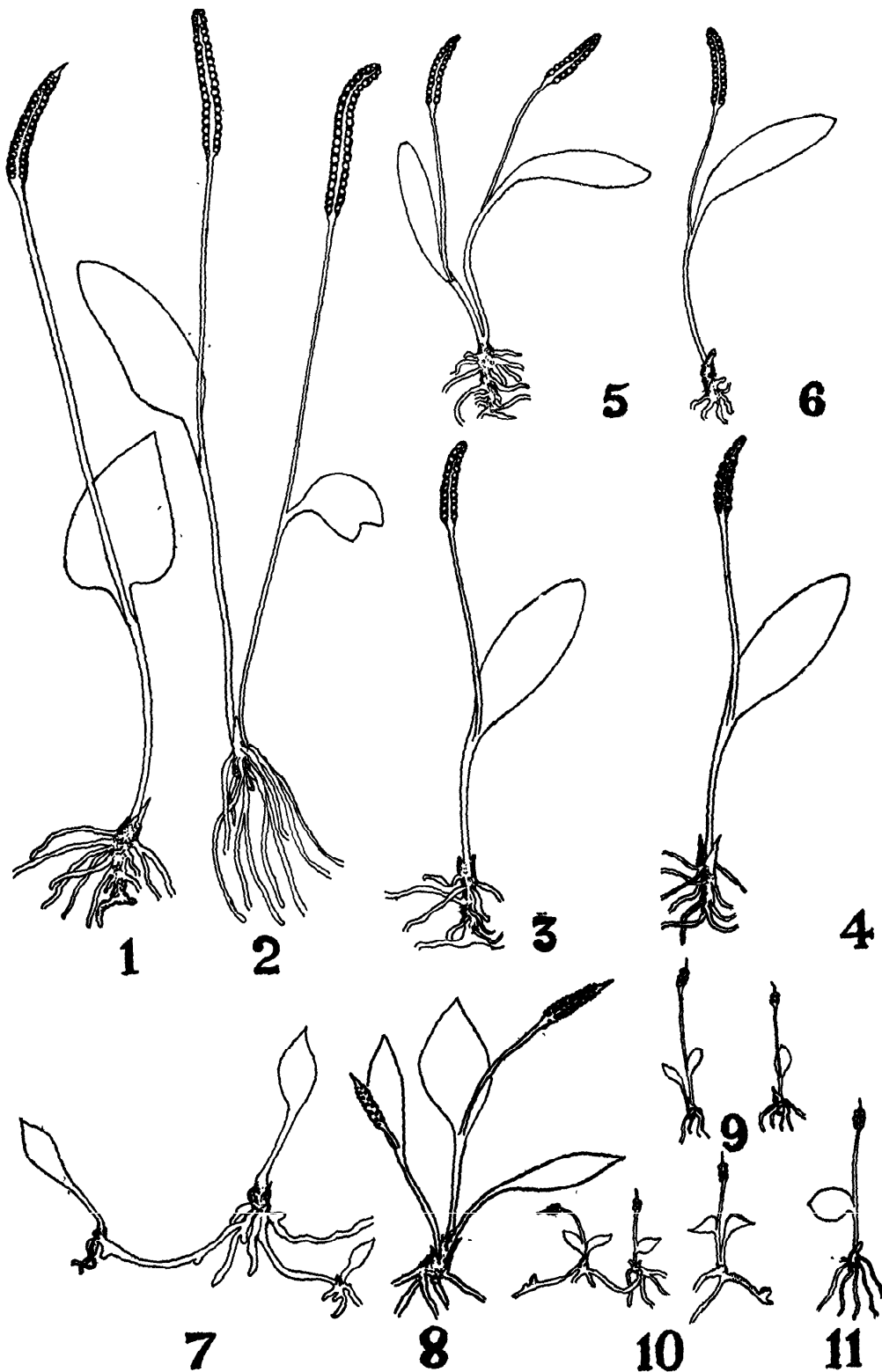
LITERATURE CITED

- BALKRISHNAN, N. P., K. THOTHATHRI AND A. N. HENRY. Some Indian *Ophioglossum*-Taxonomy and distribution. *Bull. bot. Surv. Ind.* 2 : 335-339, 1960.
- BEDDOME, R. H. *Hand Book of Ferns of British India* and "Supplement" to it (1892), 1893.
- BITTER, E. *Ophioglossaceae*—in Engler and Prantl, *Die Natürlichen Pflanzenfamilien*. Th. I. Abt. iv, 449-472, 1900.
- BLATTER, E. AND J. F. R. D'ALMEIDA. *Ferns of Bombay*. 1922.

- CHAKRAVARTI, H. L. Indian *Ophioglossum*. *Bull. Bot. Soc. Bengal*, 5 : 1-10, 1951.
- CLARKE, C. B. *A Review of ferns of Northern India*. 1880.
- CLAUSSEN, R. T. A Monograph of the Ophioglossaceae. *Mem. Torr. Bot. Club.*, 19(2), 1938.
- D'ALMEIDA, J. F. R. The Indian *Ophioglossums*. *J. Ind. Bot. Soc.* 3 : 58-65, 1922.
- HOPE, C. W. The ferns of Northern India. *Jour. Bom. nat. Hist. Soc.* 15 : 106-107, 1903.
- LINNAEUS, CARL. *Species Plantarum Universalis*. First edition, Second volume, p. 1062-1064, 1753.
- MAHABALE, T. S. Studies on the vascular cryptogams of the Bombay Presidency—Part II. Distribution of the Ophioglossaceae with notes on the ecology of the species, *J. Bombay Univ.* 6 : 104-117, 1938.
- PRESL, C. B. 'Supplementum Tentaminis Pteridographiae' *Abhandl. Bohm. Ges. d. wiss.*, V, serie iv : 301-320, (As cited by Bitter, 1900). 1845.

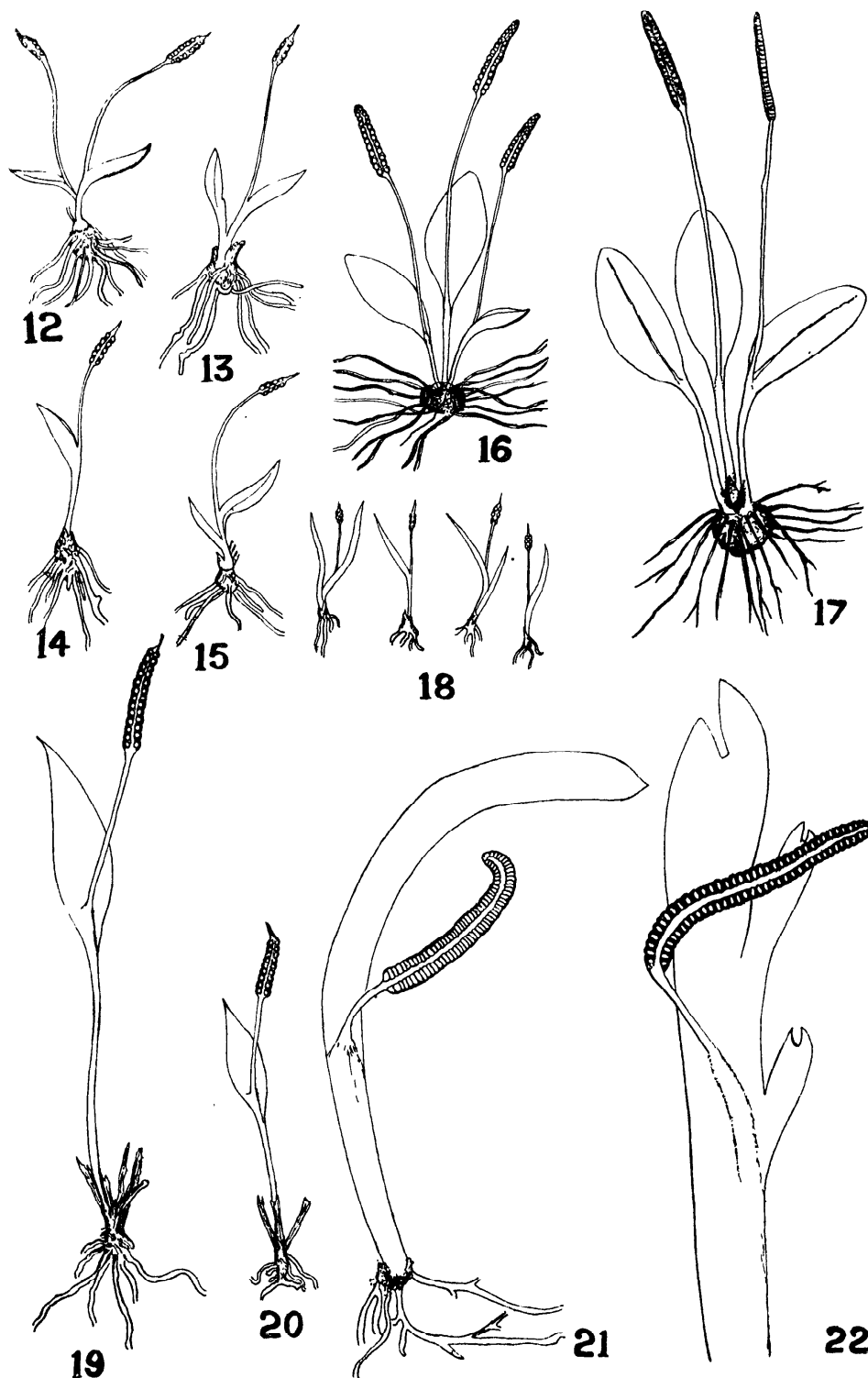


Pl. Figs. 1-11. Species of *Ophioglossum* in India. Fig. 1. *O. japonicum* Prantl. Fig. 2. *O. reticulatum* L. Fig. 3. *O. Aitchisoni* d'Alm. Figs. 4-5. *O. pedunculatum* Prantl. *sensu non* Desv. : Note bifurcated spike in fig. 5. Figs. 6-7. *O. fibrosum* Schum. : Note the cormatous rhizome, fibrous roots in this species and branched sporangiophore in Fig. 6. Fig. 8. *O. nudicaule* L. Figs. 9-11. *O. gramineum* Willd. (Figs. 1, 2, 3, 6, 7, 9 $\times 2/5$ N. S. ; Figs. 4, 5, 8, 10, 11 $\times 4/5$ N. S.).



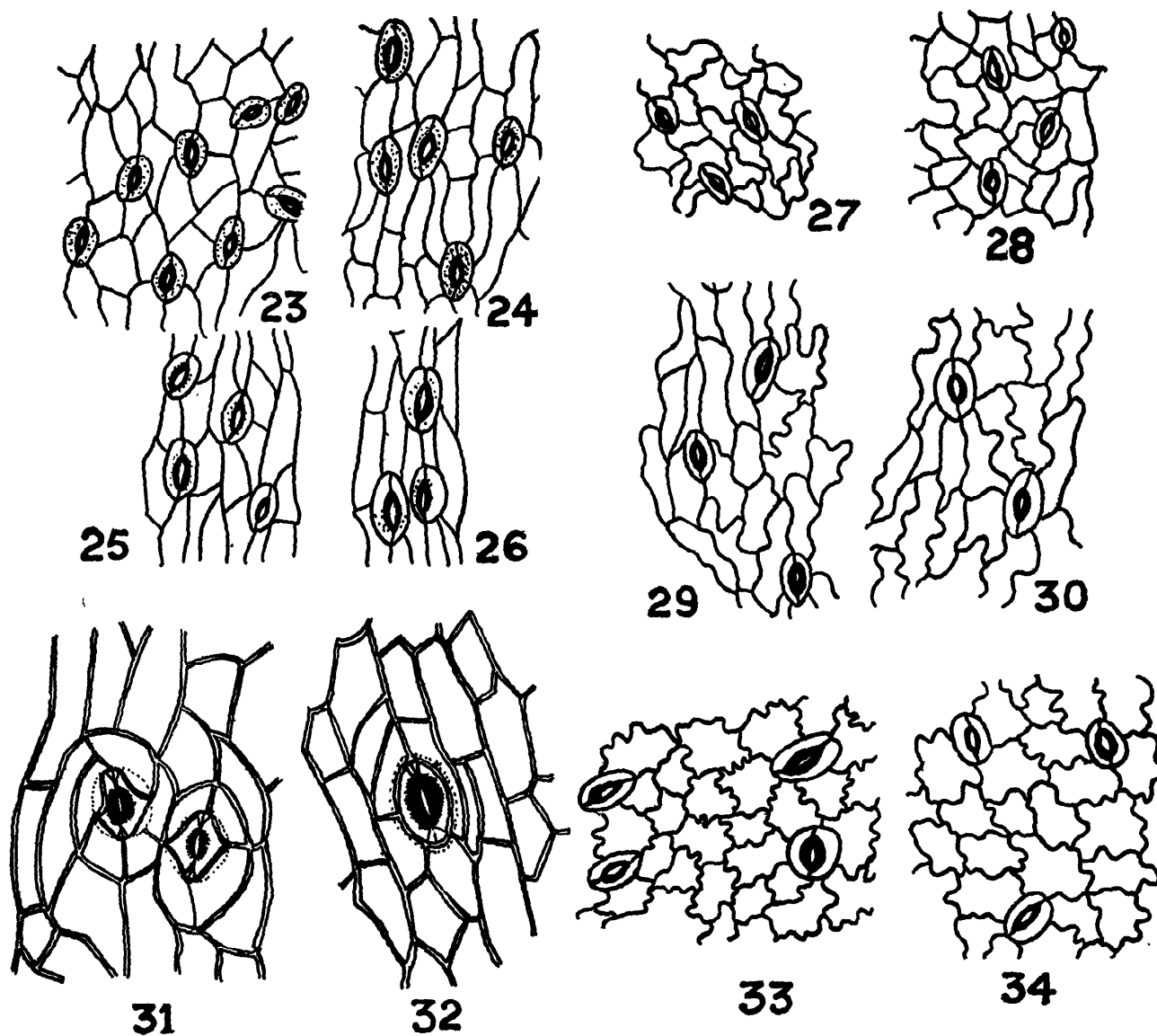
Figs. 1-11. Species of *Ophioglossum* in India.

Fig. 1. *O. reticulatum* L. $\times \frac{1}{4}$ N. S. Figs. 2-4. *O. vulgatum* L. $\times \frac{1}{4}$ N. S. Figs. 5-6. *O. japonicum* Prantl. $\times \frac{1}{4}$ N. S.
 Figs. 7-8. *O. pedunculatum* Prantl. *sensu non* Desv. : Note root-buds propagating plant vegetatively $\times \frac{1}{4}$ N. S.
 Figs. 9-11. *O. nudicaule* L. $\times \frac{1}{4}$ N. S.



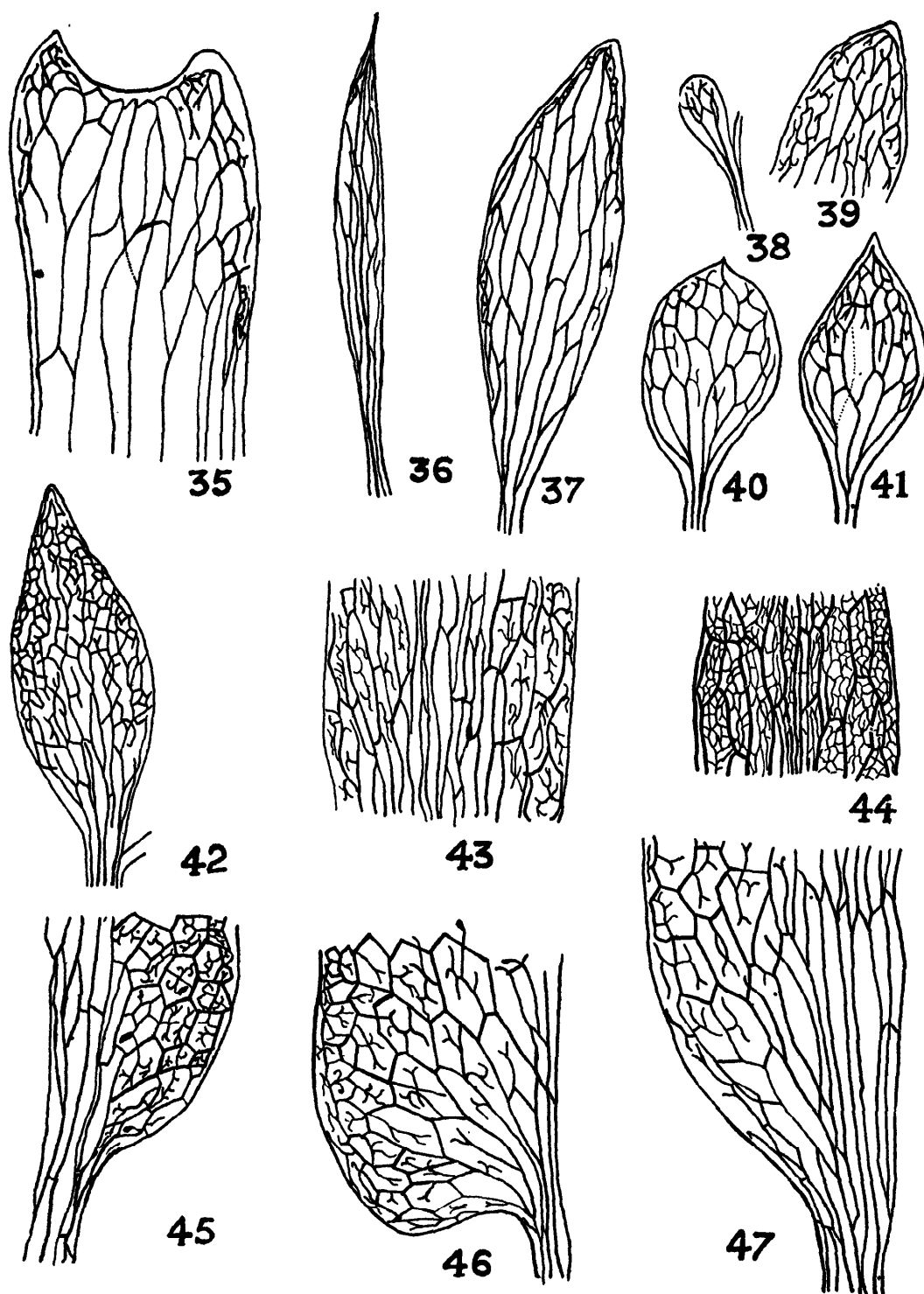
Figs. 12-22. Species of *Ophioglossum* in India.

Figs. 12-15. *O. lusitanicum* L. $\times \frac{1}{2}$ N. S. Figs. 16-17. *O. fibrosum* Schum. $\times \frac{1}{2}$ N. S. Fig. 18. *O. gramineum* Willd. $\times \frac{1}{2}$ N. S.
Figs. 19-20. *O. Aitchisoni* d'Alm. $\times \frac{1}{2}$ N. S. Figs. 21-22. *O. pendulum* L. : Note repeated dichotomy of the leaf $\times \frac{1}{2}$ N. S.



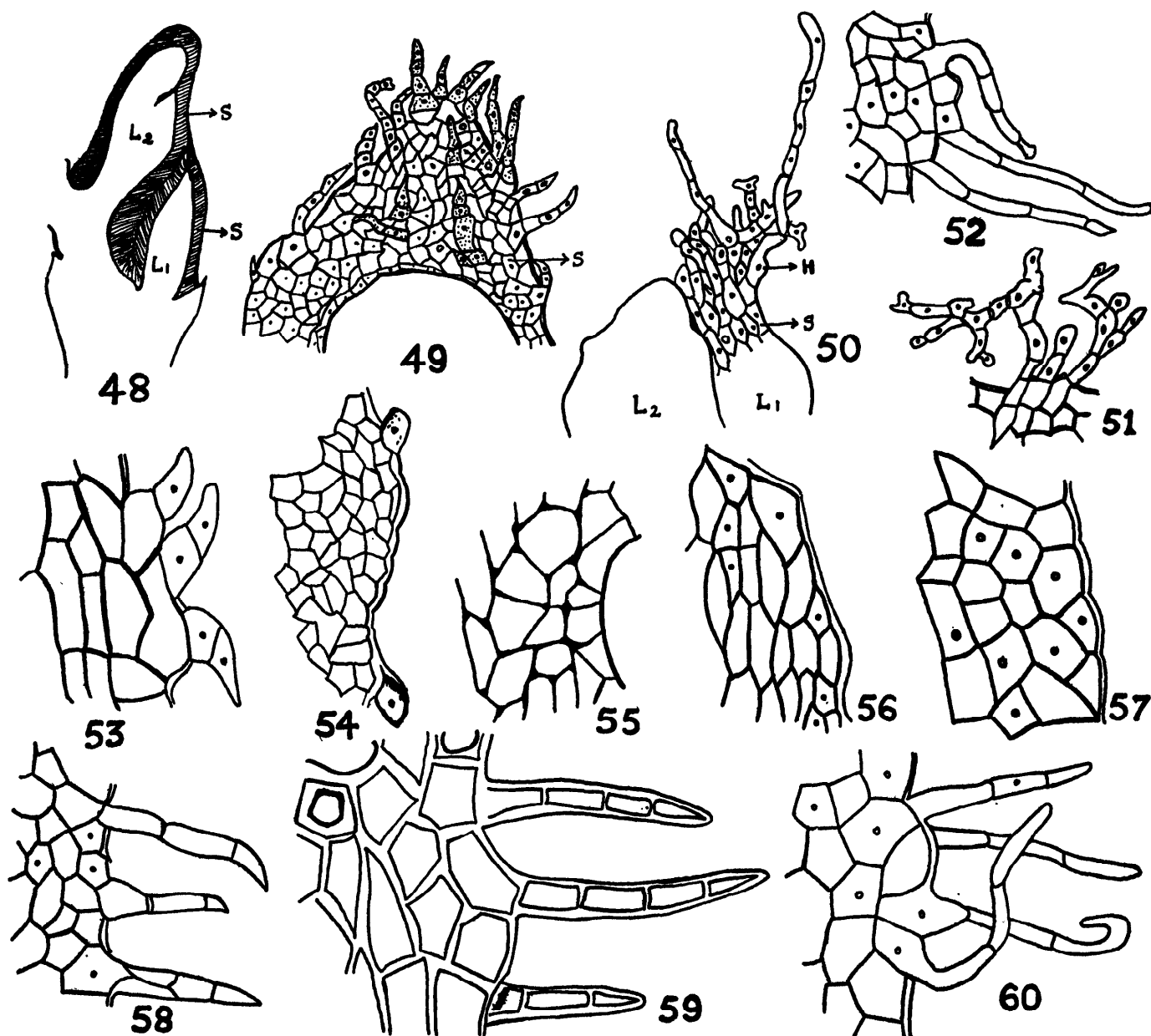
Figs. 23-34. Stomata and epidermis of leaf in Indian species of *Ophioglossum*.

Fig. 23. *O. Aitchisoni*. Upper epidermis of leaf $\times 60$. Fig. 24. The same, lower epidermis $\times 60$. Fig. 25. *O. gramineum*. Upper epidermis of leaf $\times 60$. Fig. 26. The same. Lower epidermis $\times 60$. Fig. 27. *O. pedunculatum*. Upper epidermis of leaf $\times 60$. Fig. 28. The same. Lower epidermis $\times 60$. Fig. 29. *O. vulgatum*. Upper epidermis $\times 60$. Fig. 30. The same. Lower epidermis $\times 60$. Fig. 31. *O. pendulum*. Upper epidermis of leaf $\times 60$. Fig. 32. The same. Lower epidermis $\times 60$. Fig. 33. *O. reticulatum*. Upper epidermis of leaf $\times 60$. Fig. 34. The same. Lower epidermis $\times 60$.



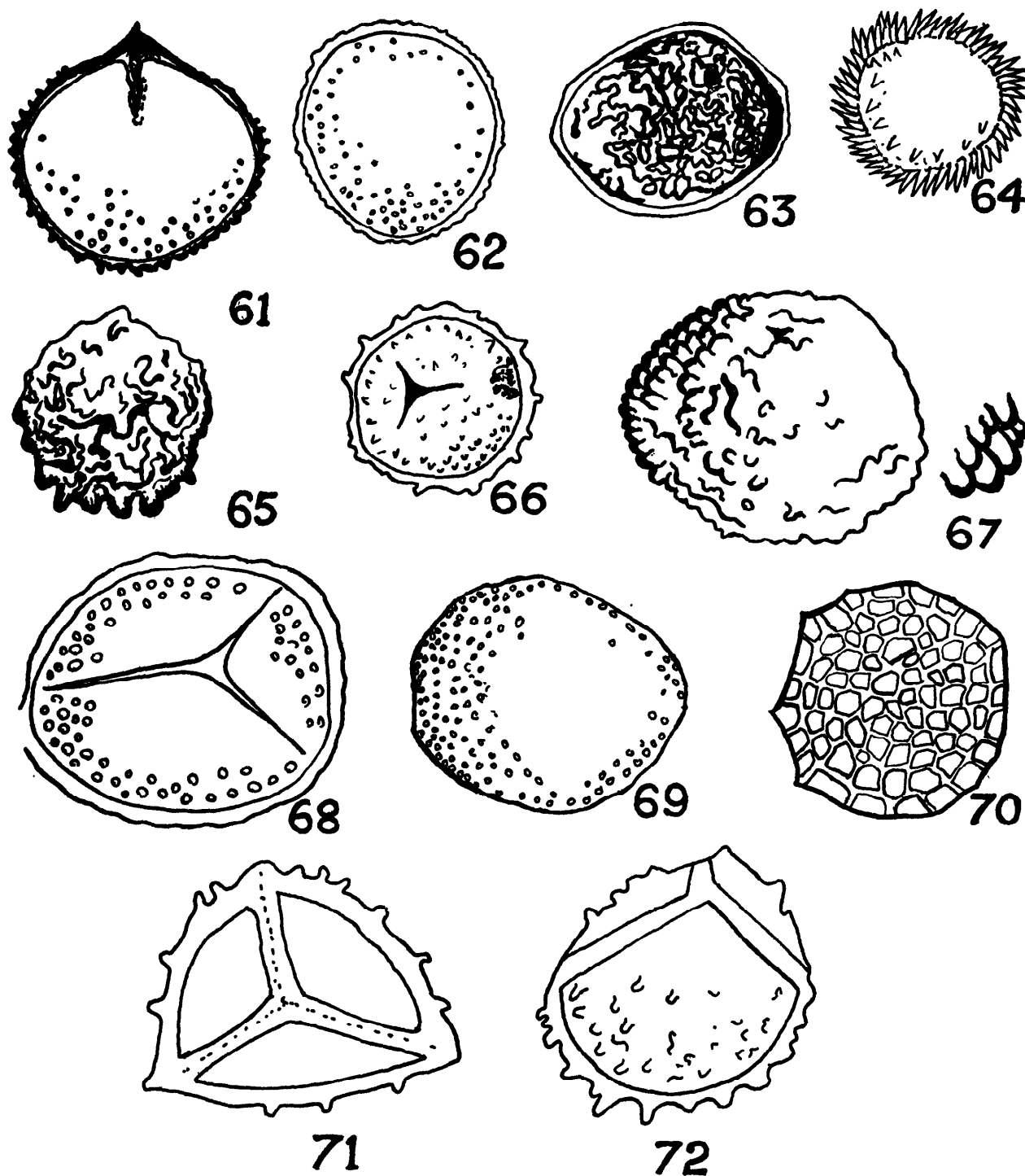
Figs. 35-47. Venation in different species of *Ophioglossum* in India.

Fig. 35. *O. pendulum*. Note the long areoles without free vein endings and a few free veins at the margin $\times 1.5$.
 Fig. 36. *O. gramineum*. Note enlarged vein meshes $\times 3.75$. Fig. 37. *O. lusitanicum*. Note enlarged meshes without free veins in the middle and a few free veins at the margin showing "Venatio marginariae" $\times 3.75$.
 Figs. 38-41. *O. nudicaule* $\times 3.75$. Fig. 38. Free vein-endings in an embryonic leaf. Figs. 39-41. Progressively older leaves with free vein-endings spreading from apex towards the midrib. Fig. 42. *O. pedunculatum* leaf showing "venatio anaxeti" $\times 2.25$. Fig. 43. *O. japonicum* leaf showing "venatio anaxeti" and elongated veins in the middle constituting midrib $\times 3.75$. Fig. 44. *O. Aitchisoni* leaf showing overlapping meshes of veins and free vein endings. Note large, elongated, swollen, hexagonal areolae $\times 3$. Fig. 45. *O. fibrosum*. Venation of leaf. Note regular hexagonal areolae with symmetrically bifurcated free vein-endings on both the sides in the free areolae. Note the enlarged meshes of the midrib $\times 3$. Fig. 46. *O. reticulatum* showing "venatio anaxeti" with polygonal areolae and asymmetrically divided free vein-endings. Note the midvein formed by elongated cells $\times 2.25$. Fig. 47. *O. vulgatum* showing elongated irregularly shaped areolae and free vein-endings. Note the thick midvein $\times 3.75$.



Figs. 48-60. Stipules in species of *Ophioglossum* in India.

- Fig. 48. L. S. of rhizome of *O. Aitchisoni* showing young leaves enclosed within the stipular sheaths $\times 6$.
 Fig. 49. *O. fibrosum*. Hood of stipular sheath $\times 40$. Fig. 50. *O. Aitchisoni*. Hood of the stipular sheath with a cluster of hairs (side view) $\times 40$. Fig. 51. The same: branched hairs on the stipule $\times 40$.
 Fig. 52. Stipules in *O. japonicum* $\times 40$. Fig. 53. Stipule in *O. reticulatum* $\times 40$. Fig. 54. Stipule in *O. nudicaule* $\times 40$. Fig. 55. Stipules in *O. pedunculatum* $\times 40$. Fig. 56. Stipule in *O. gramineum* $\times 40$. Fig. 57. Stipule in *O. vulgatum* $\times 40$. Fig. 58. Stipule in *O. lusitanicum* $\times 40$. Fig. 59. Stipule in *O. pendulum* $\times 40$. Fig. 60. Stipule in *O. fibrosum* $\times 40$.



Figs. 61-72. Spores in different species of *Ophioglossum* in India : $\times 675$.

Fig. 61. *O. vulgatum*. Fig. 62. *O. reticulatum*. Fig. 63. *O. japonicum*. Fig. 64. *O. pedunculatum*. Fig. 65. *O. nudicaule*. Fig. 66. *O. fibrosum*. Fig. 67. *O. lusitanicum*. Fig. 68-69. *O. Aitchisoni*. Fig. 70. *O. gramineum*. Fig. 71-72. *O. pendulum*.