

# FERTILE BRACTS AND SCALES OF GLOSSOPTERIS FRUCTIFICATIONS FROM THE LOWER GONDWANA OF INDIA

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## ABSTRACT

Detached fertile scales and bracts of *Glossopteris* reproductive organs are described here. *Eretmonia emarginata* comb. nov., incorporating *Steveocarpus emarginatus* Surange, has been created. A new species of *Glossotheca*, *G. immanis* has also been described. The detached scales are referred to *Glossopteris* fructifications: *Eretmonia*, *Glossotheca*, *Lidgettonia*, *Partha*, *Denkania*, *Dictyopteridium*, *Plumsteadioctrobos* and *Venustostrobos*.

## INTRODUCTION

THE association of scale leaves with *Glossopteris* was known for a long time, but their relationship was not understood until Surange and Chandra (1973, 1974) in a series of papers demonstrated that the different types of reproductive organs were borne on such scale leaves. Earlier, Feistmantel (1880-81, 1882) named some detached scales from different localities of Indian Lower Gondwana as *Squamae*. Their occurrence was also noted by several authors such as Zeiller (1902), Arber (1905), Seward and Sahni (1920), Pant (1958) and others. Seward and Sahni (1920) distinguished two types of scale leaves and named them as *Squama forma integerrima* and *Squama forma lacerata*. The latter has now been described by Maithy (1965) as *Palmatophyllites* Seward & Sahni (1920) regarded *Squama forma integerrima* as a convex scale leaf, suggesting that it may have acted like a protecting bract. They also suspected that Feistmantel's *Squamae* may be the detached bracts or cupules from seed bearing shoots. Pant (1958) on the other hand, suggested that his specimens of scale leaves may be ordinary protective scales of a vegetative bud of *Glossopteris* and that there is no reason to regard them as reproductive organs.

In our studies so far we have found that all scale leaves, whether attached or detached, have a definite shape, size and venation pattern and are distinct from the

vegetative leaves of *Glossopteris*. Furthermore, they are the fertile bracts or scales, which are directly associated with the male or female reproductive organs of *Glossopteris*. When found preserved in detached condition, they can be easily assigned to their respective genera established for the reproductive organs of *Glossopteris*. In this paper detached scales found in the material from Handappa have been described under the genera to which they belong.

## DESCRIPTION

Detached scale leaves or bracts of almost all the reproductive organs described by Surange and Shaila Chandra (1973, 1974), Shaila Chandra and Surange (1976) and other authors have been found in Handappa material. The reproductive organs are *Eretmonia*, *Glossotheca*, *Partha*, *Denkania*, *Lidgettonia*, *Dictyopteridium*, *Plumsteadioctrobos* and *Venustostrobos*. The first two genera are sporangia bearing organs and the rest are the seed bearing organs.

### Genus—*Eretmonia*

So far four species of *Eretmonia* have been described from India. They are *E. utkalensis*, *E. hinjridaensis*, *E. karanpurensis* and *E. ovoides*. They have distinct types of scale leaves (Text-fig. 1D, E, F; Pl. 1, figs. 1, 6). *E. ovoides* has an ovate lamina, *E. utkalensis* has a rhomboid lamina and *E. hinjridaensis* has a spatulate lamina. A new species, *E. emarginata*, which is described below, has a lanceolate lamina. All the scale leaves are stalked on which sporangia are borne, but in detached condition the stalks are generally not preserved. It appears that the scale lamina gets detached from the top of the stalk when the sporangia are shed off.

The venation pattern of scale leaves is almost the same in all species of *Eretmonia*. There is no midrib but a number of separate bundles from the stalk enter the base of the lamina (Text-fig. 1; figs. E, H). The central bundles run straight upwards and divide only in the apical region. One or two veins may run into the acute apex without dividing. The side veins fan out towards the margin dividing and joining to form meshes. The outermost bundles supply the basal region of the lamina.

*Eretmonia* scales are thick and tough organs. Detached *Eretmonia* scales may be preserved from the abaxial or adaxial side. In some species abaxial side shows a concavity (Pl. 2, fig. 8) in the basal region, on which sometimes sporangia were found sticking. In young condition the sporangial heads must have found protection in the concavity of the scale lamina.

Pl. 1, fig. 6 and Text-fig. 1D illustrate detached scales leaves of *Eretmonia ovoides*, preserved without a stalk. The ovate shape and acute apex is quite marked. The scale lamina is somewhat large in size. Sometimes the long apex appears like a pointed long thorn. About half a dozen strong vascular bundles in the middle run straight upwards giving an appearance of a broad midrib. Other veins also arise from the base, arch out towards the margin, dichotomising and anastomosing. The outermost bundles arch out sharply so that they supply the basal region of the lamina. The meshes are broad and the entire venation looks like a leaf venation. Some specimens show basal depression in the lamina as in other species of *Eretmonia*.

*Eretmonia emarginata* comb. nov.

1957 — *Stereocarpus emarginatus* Surange.

Pl. 2, figs. 10, 11 and Text-fig. 1G, H illustrate the scale leaves ascribed to this species. Such scales without stalks were earlier described by Surange (1957) as seeds under the name *Stereocarpus emarginatus*.

The scale leaf has a strong stalk (Pl. 2, figs. 10, 11; Text-fig. 1H). The scale lamina is lanceolate, or appears convex and almond shaped. Its size varies. The apex is long, drawn out and acute. The lamina is thick and sometimes shows strong convexity.

A few median veins run straight upwards, branching only in the apical region. The side veins arch out in the basal and middle region, dichotomise and anastomose, forming broad meshes. The meshes in the basal region is markedly broader than those in *Eretmonia utkalensis*.

*Eretmonia emarginata* comb. nov.

*Diagnosis* — Lanceolate or almond shaped fertile scale with broad, strong stalk; 2-4 central veins run straight upwards and divide only in apical region, side veins arch out towards margin, branching and fusing, basal meshes broad.

*Holotype* — B.S.I.P. no. 35287.

*Locality* — Raniganj Coalfield.

*Horizon* — Raniganj Stage.

*Eretmonia emarginata* differs from other species of *Eretmonia* in its shape, thick convex lamina, long drawn out apex and broad meshes in the basal region.

#### Genus — *Glossotheca*

*Glossotheca* is another sporangia bearing organ of *Glossopteris*. It differs from *Eretmonia* in bearing four pairs of sporangial heads as against one in *Eretmonia*. Two species of *Glossotheca* have been described so far, viz., *Glossotheca utkalensis* and *Glossotheca orissiana*. A third new species possessing a distinct type of scale leaf is described below.

*Glossotheca immanis* sp. nov.

*Diagnosis* — Fertile scale leaf, large in size with broad stalk; shape of lamina oblong to oblanceolate, median veins strong, divide in apical region, side veins dichotomise several times, unite and form meshes; four pairs of sporangial heads borne in the middle region, spaced at a fair distance from one another.

*Holotype* — B.S.I.P. no. 35288.

*Locality* — Raniganj Coalfield.

*Horizon* — Raniganj Stage.

In Pl. 1, fig. 2 and Text-fig. 1A, the fertile scale of this species is largest in size as compared to other two known species, viz., *Glossotheca utkalensis* and *Glossotheca orissiana* (see Text-fig. 1B, C). It is fairly



broad, oblong to oblanceolate in shape with acute apex. Strong prominent veins in the middle of the lamina occupy a fairly broad portion, forming a strong pseudo-midrib. The side veins form a good network. The meshes are short and comparatively broad. Pl. 1, fig. 5 shows a detached scale of this species.

Four pairs of sporangial heads are seen on the specimen (Pl. 1, fig. 2; Text-fig. 3). The two sporangial groups of the lowermost pair is seen at the base of the scale stalk, one head lying on its right and the other on the left. The right side sporangial head shows a strong peduncle originating from the middle of the midrib region. We presume that the peduncle must have repeatedly branched by dichotomy, each ultimate branch bearing one sporangium each as in other species of *Glossotheca*. One sporangial head of the second pair is seen on the scale lamina, while the other head is lying on the right side. The third and fourth pair are lying below the scale lamina and show only the depressions, or elevations on the lamina indicating the position of the sporangial heads. From the size of the sporangial heads, it appears that the sporangia on the lowermost head matured first and those on the uppermost head matured last.

The sporangia in external appearance look similar to those described for other species of *Glossotheca*. They are elliptical—oval and both ends bluntly rounded. Sporangial surface is marked by longitudinal lines.

*Comparison* — *Glossotheca immanis* is largest in size among the three species of *Glossotheca* known so far. The shape of the fertile scale leaves is quite distinct in all the three species (Text-fig. 1A, B, C).

*Glossotheca orissiana* has a small, rhomboid scale leaf with not a very long stalk (Text-fig. 1B). *Glossotheca utkalensis* has an orbicular, short lamina and a very long stalk. Obviously these three are distinct species of *Glossotheca* and must have been borne on different plants and produced different types of spores.

#### SEED BEARING SCALE LEAVES

Fertile scales which bore seeds and the protective bracts in the axil of which multi-ovulate heads are borne, are also found preserved in detached condition. Pl. 1, figs. 3, 7, 8 and Text-fig. 2 illustrate these scale leaves. They are quite distinct from one another and can easily be identified with the genera established for the female reproductive organs of *Glossopteris*.

Text-fig. 2A, B, C, D and Pl. 1, figs. 3, 7, 8 illustrate the detached scales of *Lidgettonia*, *Partha* and *Denkania*. *Lidgettonia* has a large scale leaf with a stout stalk (Text-fig. 2A). The middle veins are strong and appear like a midrib. The secondary veins also form strong meshes. The lamina is rhomboidal and broad in the apical region. It has its own characteristic shape and size. The two species of *Partha* (Text-fig. 2B, C) have smaller scale leaves which are distinct in shape. *Partha indica* has rhomboidal lamina and a long and a comparatively narrow stalk. *Partha spatulata* has a spatulate lamina and a short stalk. *Denkania indica* (Text-fig. 2D) has a shape like a *Glossopteris* leaf and a short stalk.

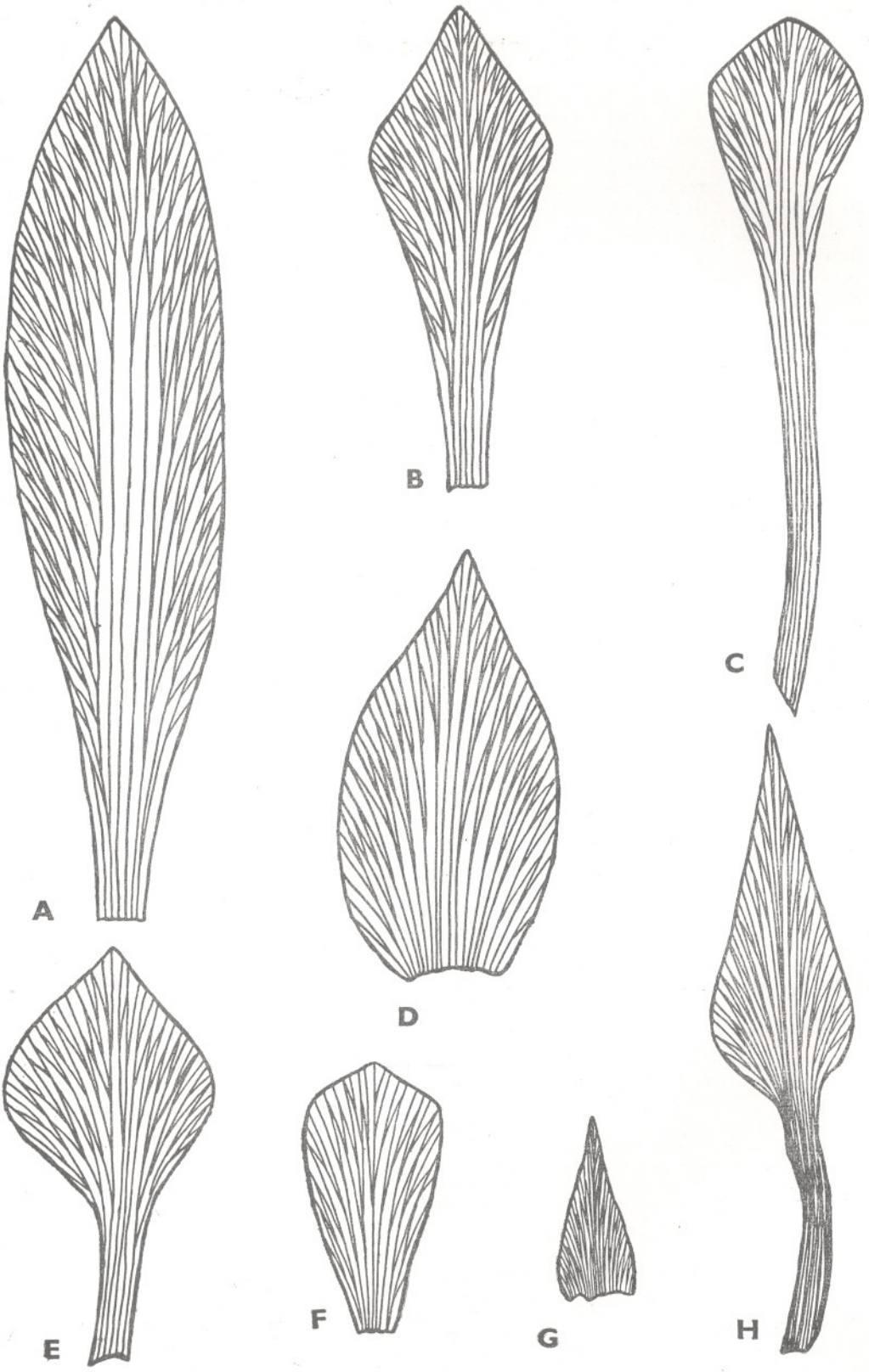
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TEXT-FIG. 1 — Detached scale leaves of sporangia bearing male reproductive organs. Note the different shapes and sizes. The venation is more or less on the same pattern in all the scale leaves. A, *Glossotheca immanis* sp. nov.; B, *Glossotheca orissiana*; C, *Glossotheca utkalensis*; D, *Eretmonia ovoides*; E, *Eretmonia utkalensis*; F, *Eretmonia hinjridaensis*; G, *Eretmonia emarginata* without stalk; H, *Eretmonia emarginata* with stalk. All figures  $\times 2$ .

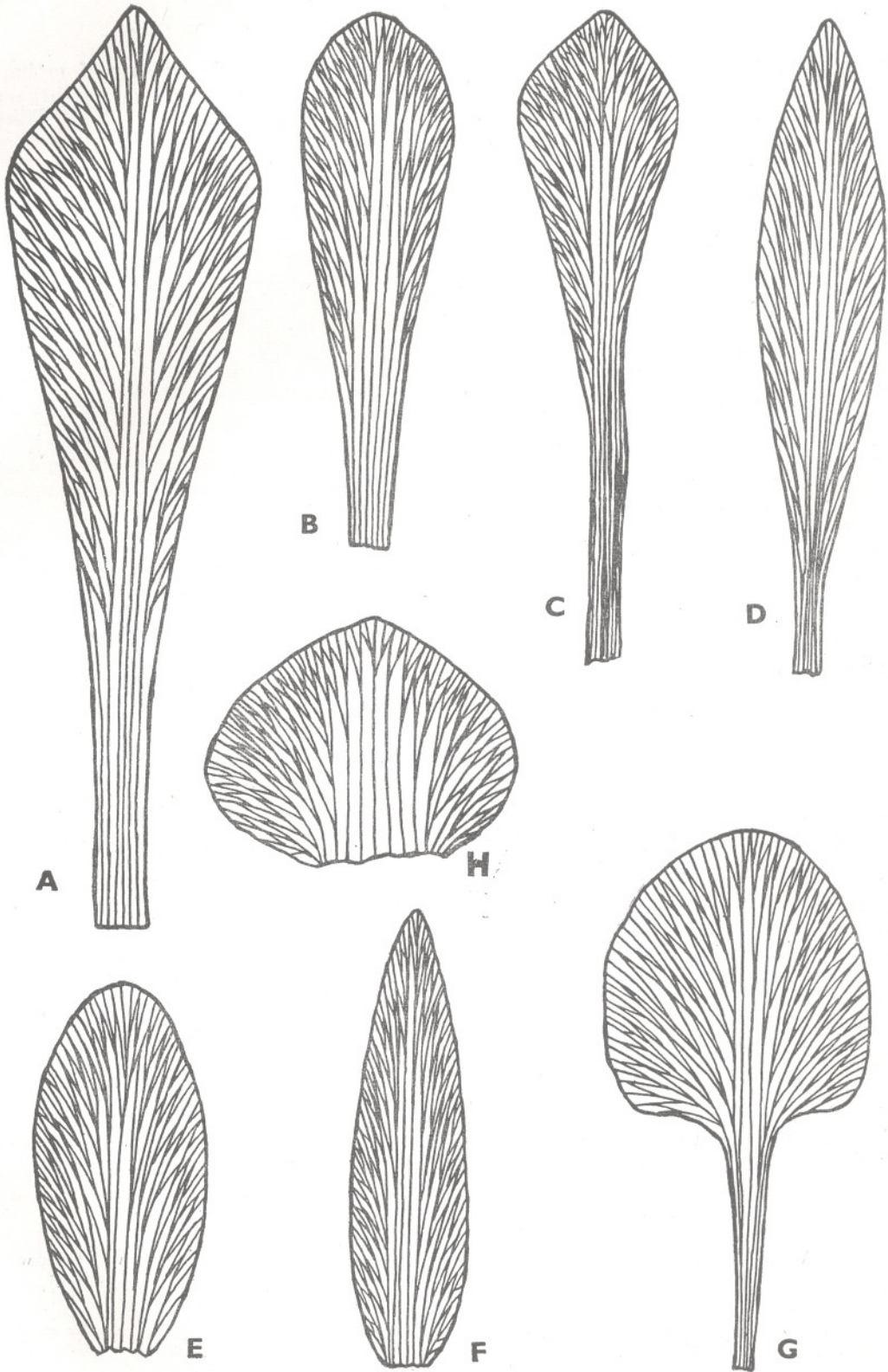
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TEXT-FIG. 2 — Detached scale leaves of female reproductive organs. Note the different shapes. A, *Lidgettonia mucronata*; B, *Partha spatulata*; C, *Partha indica*; D, *Denkania indica*; E, *Plumsteadios-trobus pretiosus*; F, *Dictyopteridium feistmanteli*; G, *Venustostrobus*; H, *Venustostrobus*. All figures  $\times 2$ .



TEXT-FIG. 1





TEXT-FIG. 2

The detached bracts of the multiovulate reproductive organs are shown in Text-fig. 2E, F, G, H and Pl. 1, figs. 7, 8. They are distinct even in detached condition and could be assigned to the known female reproductive organs of *Glossopteris*. The protective bract of *Dictyopteridium* (Text-fig. 2F) is long and narrowly elliptical in shape with acute apex. The stalk has never been found preserved. Generally it goes with the seed bearing receptacle. The protective bract of *Plumsteadia*, of which only one species is known, is ovate (Text-fig. 2E) with rounded apex. The bracts of the *Scutum* type fructifications, which have been put under a new genus, *Venustostrobos* (Shaila Chandra & Surange, in press) are quite thick structures with orbicular or fan-shaped lamina (Pl. 1, figs. 7, 8). It is preserved with or without its stalk (Text-fig. 2G, H). Each species of the reproductive organ has its own characteristic type of protective bract. The veins are strong and the secondary veins form short, broad meshes. The middle veins are strong and prominent. The bract appears thicker in the middle region and thinner at the margin.

### DISCUSSION

Although the scale leaves are of common occurrence in the *Glossopteris* flora, their exact function was not known so far. Feistmantel placed them under a general name, *Squamae*. Seward and Sahni (1921) however, suspected that they are the bracts or cupules from seed bearing shoots. Recently a number of reproductive organs have been described by us and all of them were borne on such scale leaves or were associated with them. It is, therefore, evident that they are the fertile scales or bracts, connected with the reproductive organs of *Glossopteris*.

Three types of scales or bracts (Text-figs. 1, 2) can be recognized. Two of them, *Eretmonia* and *Glossotheca* bore sporangia, and thus were connected with the male reproductive organs. The scale leaves of

*Lidgettonia*, *Partha*, *Denkania* and perhaps *Palmatophyllites* are seed bearing organs. The scale leaves of *Dictyopteridium*, *Plumsteadia* and *Venustostrobos* act as protective bracts for the naked ovule bearing receptacle which is borne in its axil. Text-figs. 1 and 2 illustrate all the scale leaves and bracts found in detached condition and they are easily assignable to the reproductive organs of *Glossopteris*. It can be observed that every scale leaf has its own distinct shape, size and details of venation and so, if found detached could be referred to the reproductive organ which it bore. It means that each scale leaf could be placed under the genus of a particular *Glossopteris* reproductive organ. The scale leaves thus, when found preserved in a particular rock formation, could become dependable index fossils for that horizon.

The venation of *Glossopteris* leaves and those of the scale leaves is distinct, although the secondary veins form a network in both. Therefore, a vegetative leaf of *Glossopteris* and that of a scale leaf, apart from difference in their size, could be easily separated by their venation. There is no midrib in the scale leaf, but generally a few strong veins (their number and behaviour differ in different scales) run straight upwards in the middle and dissolve into secondary veins only in the apical region. All the bundles from the stalk (which may or may not be preserved in detached condition) enter the base of the scale lamina, the outermost spread out in the basal region and the central bundles run upwards in the middle region as mentioned earlier. The branching and fusing of the secondary veins is peculiar to each species.

The fact that the fertile scale leaves and fertile bracts are found well-preserved in detached condition shows that they are tough organs and that when seeds or sporangia are shed off, they themselves get detached from the parent plants and fall down. The plant then gets ready to bear a new crop of reproductive organs.

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## EXPLANATION OF PLATES

## PLATE 1

1. Holotype specimen of *Eretmonia emarginata* sp. nov. B.S.I.P. specimen no. 35287.  $\times 2$ .
2. Holotype specimen of *Glossotheca immanis* sp. nov. sporangial groups are lying below the scale leaf. Three pairs are clearly visible. The fourth is lying in the middle of the scale lamina. B.S.I.P. specimen no. 35288.  $\times Ca 3$ .
3. Detached scale of *Partha spatulata*. B.S.I.P. specimen no. 35289.  $\times Ca 2$ .

4. Detached scale of *Denkania indica*. B.S.I.P. specimen no. 35290.  $\times 2$ .
5. Detached scale of *Glossotheca immanis* sp. nov. B.S.I.P. specimen no. 35291.  $\times Ca 1.5$ .
6. Detached scale leaf of *Eretmonia ovooides*. B.S.I.P. specimen no. 35292.  $\times 2.5$ .
7. Detached scale leaf of *Venustostrobos*. B.S.I.P. specimen no. 35293.  $\times 3$ .
8. Detached scale leaf of *Venustostrobos*. B.S.I.P. specimen no. 35294.  $\times 1.5$ .