

STUDIES IN INDIAN ANTHOCEROTACEAE V. MORPHOTAXONOMY OF SOME INDIAN SPECIES OF *FOLIOCEROS* BHARADWAJ*

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ABSTRACT

Three species of *Folioceros* Bharadwaj have been described from India.

F. satpurensis (Sriv.) comb. nov. (Bharad. & Sriv.) is a dioecious plant with longish cavernous fronds. The involucre has cavities in two, superimposed layers. Its surface is smooth. Spores are baculate and without any distinct tetrad scar. Elaters have narrow lumen and the walls are thickened.

F. indicus sp. nov., is a monoecious plant with longish, cavernous fronds. The involucre has cavities in one layer and the surface is ridged. Spores are baculate and without any distinct tetrad scar. Elaters have narrow lumen and the walls are thickened.

F. physocladus (Schiffn. & Pande) comb. nov., is a dioecious plant with linear, pinnately lobed fronds. The involucre has cavities in one layer and the surface is lamellate. Spores are baculate and without any distinct tetrad scar. The elaters have narrow lumen and the walls are thickened.

The three species differ from each other and from those described earlier (BHARADWAJ, 1971) in quantitative characteristics such as the size of the spore, the number and size of the bacula along the equator of the spores, the length of elaters, the number of stomata per sq mm of capsule wall and the height of the stomata.

INTRODUCTION

In continuation of my earlier studies on Indian Anthocerotaceae (BHARADWAJ, 1950, 1952, 1958, 1960, 1965, 1971) the present paper includes morphotaxonomic description of three Indian species of *Folioceros* Bharad., viz., *F. satpurensis* (Sriv.) comb. nov. (Bharad. & Sriv.)*, *F. indicus* sp. nov., and *F. physocladus* (Schiffn. & Pande) comb. nov..

MATERIAL AND METHODS

Folioceros satpurensis (Sriv.) comb. nov. (Bharad. & Sriv.)—collected by S. K. Pande and K. P. Srivastava from Pansy Pool, Pachmarhi, M.P., in 1951, dry in packets and by D. C. Bharadwaj and K. P. Srivastava from Pansy Pool and near Chota Mahadeo at Pachmarhi, in 1958, fixed in form-acetic-alcohol and preserved in 70 per cent alcohol-glycerol as well as dry in packets (in author's personal collection).

F. indicus sp. nov.—collected by S. K. Pande and R. N. Misra from near Munsyari, W. Himalayas in dry condition (Lucknow University Hepaticae Herbarium No. 1598).

F. physocladus (Schiffn. & Pande) comb. nov.—collected by Decoly and Schaul, in 1898, (Levier's No. 656) from Ambutia, near Kurseong, Sikkim Himalayas (presented by Prof. V. Schiffner to Late Prof. S. K. Pande) in dry condition.

The usual method of study as described earlier for dry material, was followed. Spores were studied after, as well as without, acetolysis (ERDTMAN, 1933). It has been found that acetolysed spores increase in size by about 0.2 times from those mounted in dilute glycerol without any chemical treatment. The measurements given in this paper are

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from fresh preparations in glycerine jelly. The observations recorded here for various organs pertain to their similar location or state of maturity in different species, e.g., the fronds studied have been taken from well developed thalli, chloroplasts have been studied from dorsal cells of the lobes in the fronds, t. s. of involucre are from their middle region, spores have been measured in polar view from the mature ones only and the stomatal counts from the upper half of the capsule.

DESCRIPTION

Folioceros satpurensis (Sriv.) comb. nov. (Bharad. & Sriv.)

Syn. *Anthoceros satpurensis* Srivastava, 1960 (invalid vide I.C. Art. 36).

Diagnosis—Planta dioica, rupicola. *Frons* ad 2 cm longa, levis, cavernosa, furcata, anguste linearis, rami irregulariter incisolobati, lobis margine cellularum longarum, punctum crescens tuberiferum. *Involucra* cavernosa, cum cavibus in duobus ordinibus, levia. *Capsula* sparsa stomatifera. *Sporae* 36 μ , fulvae, minute baculosae, cicatrix tetradi non perspicua. *Elateres* 320 μ (280-350 μ) longi, septati, spadici anguste foramini. *Androecia* numerosa, on ramis propriis, polyandria (ad 40 in utroque alveolo). *Antheridia* corporum 180 μ (170-190 μ) longorum.

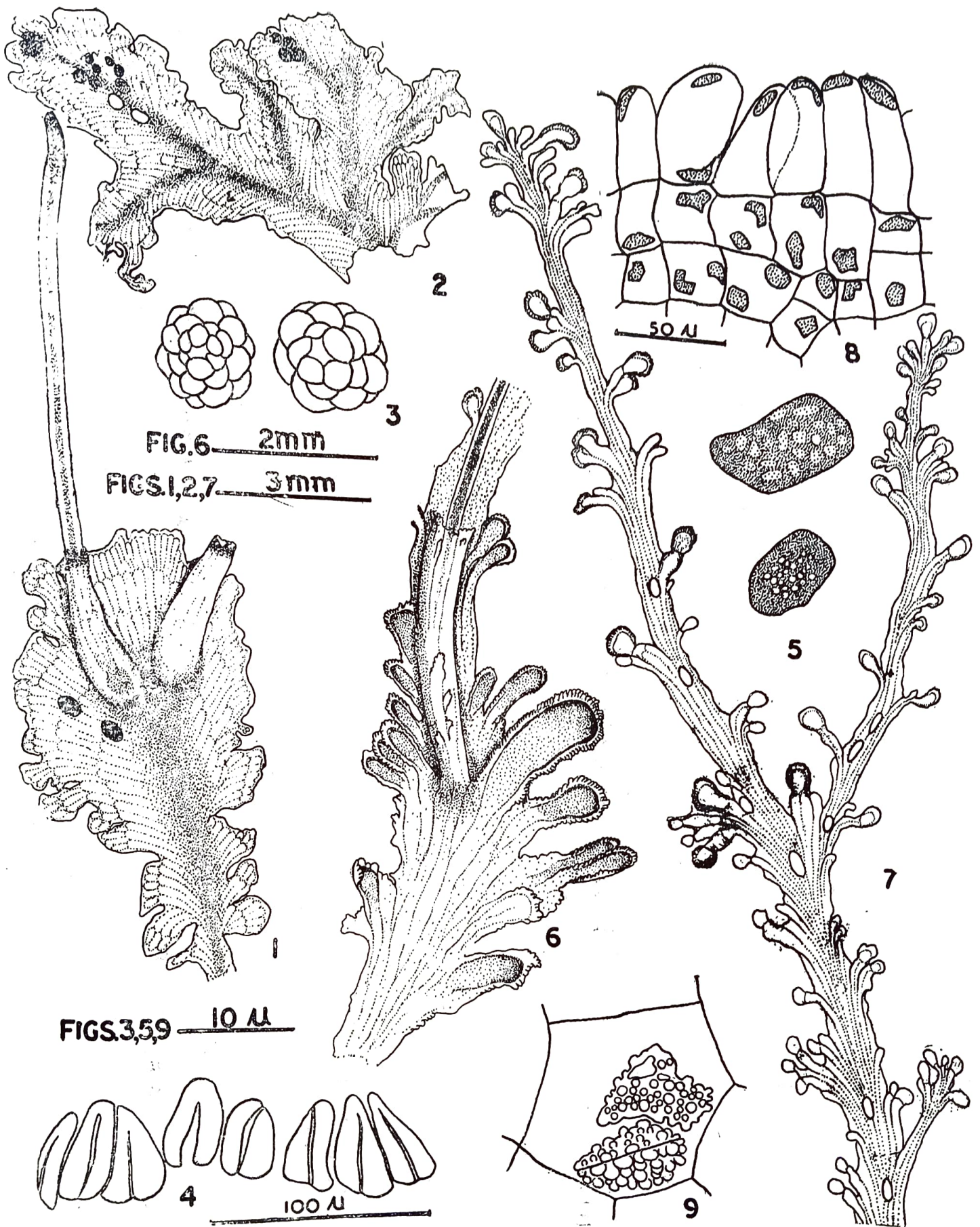
Type Repository—Author's personal collection, Lucknow.

Thallus—The plant is dioecious. Thalli form prostrate mats, mostly on rocks or finely gritty soil. The thallus is deeply divided into fronds which are much longer than broad. The male and female thalli occur usually in separate, pure patches, the fronds often overlapping and forming dense mats. No rosettes have been seen in nature. The fronds show irregularly pinnate lobing (Figs. 1, 2). Male thalli are easily distinguishable from the young female thalli by median, alternating rows of white pustular bodies, the androecia, on the surface. The female thallus has a perfectly smooth upper surface. The middle region of the fronds on the ventral side bears simple rhizoids.

In many of the male and female thalli, apical storage tubers have been seen. These are thick and dense, covering the area around the median notch at the apex of the frond. Young as well as older tubers have been seen. In some cases of the latter, young plants had already started to grow out.

Internally the thallus is cavernose due to mucilage containing schizogenous cavities. *Nostoc* colonies occur sparsely all over, lying nearer the ventral surfaces. The margin of the fronds is one cell thick, the cells being a little larger and with a convex outer wall (Pl. 1, Fig. 1). The chloroplast in these cells is rather small but in the dorsal surface cells the chloroplast is large. It is usually single and \pm circular. In dry material it has a lighter central region and denser marginal region (Pl. 1, Fig. 1). In fluid preserved material the chloroplasts appear spongy (Fig. 3). In both the cases there is no differentiation of the pyrenoid body.

Androecium—The androecia can be seen with naked eye as whitish specks against green background. They are usually located in the middle region of the thalli (Fig. 2). A larger part of the androecia is sunk within the thallus leaving the upper part as a raised hump above the surface. Every androecium opens upon maturity by an irregular, small pore. The surface cells of the hump are unequally raised giving a rough appearance. The number of antheridia produced in one androecium is fairly large. In some unopened chambers upto 20 antheridia in half mature to mature but undehisced stage of development were counted in a surface examination with the possibilities of an equal number of still younger antheridia lying underneath.



- 1-4. *Folioceros satpurensis* (Sriv.) comb. nov. (Bharad. & Sriv.) 1, Female frond, 2. Male frond, 3. Chloroplasts, 4. Cells of apical tier in the body of antheridium.
 5. *F. indicus* sp. nov. Chloroplasts.
 6-9. *F. physocladus* (Schiffn. & Pande) comb. nov. 6. Female frond, 7. Male frond, 8. Marginal cells of lobes, 9. Chloroplasts.

The antheridia are borne on a basal cushion indicating that the development of antheridium follows similar course as known for the species of *Anthoceros* and *Folioceros* (BHARADWAJ, 1958, 1960, 1965). The mature antheridium has a four cells thick stalk but it is only two cells high. The lower cells are more than two times the length of the upper cells. The body of the antheridium has a wall built up by four tiers of cells. The apical tier consists of eight groups of two cells each. Most of these groups of cells have an incomplete wall (Fig. 4). The antheridial body is roundly oblong. A mature body measures 180 μ (mean) in height with a range of 170 μ to 190 μ .

Involucre—Involucre is fully cavernous, the cavities being arranged in two, superimposed layers (Fig. 10). On the surface it is smooth.

Sporophyte—The columella is a bundle of 16 rows of cells. The capsule wall is five cells thick, the outermost being epidermis followed by four layers of loosely packed thin-walled large cells. All these cells usually have a single chloroplast each. The epidermis is sparsely stomatiferous, there being only 15 stomata per sq mm of the surface. The stomata are 56 μ (mean) long. The epidermis cells range in length from 105-260 μ (162 μ mean). The capsule is almost smooth, the two, opposed dehiscence grooves being shallow.

Spore—The spores are circular in polar view. Proximally the tetrad-mark is not visible. However, ridges of tetradic compression are seen in young spores. In this condition the spores have a pyramidal proximal face as visualized in an optical section. However, as the tetrads mature the proximal face in individual spores starts caving in, so that just before separation only the subequatorial fringe of the proximal face in one remains in loose contact with those of the others and the separated spores are saucer-shaped with a triangular part of the proximal spore wall caved in. Spore exine is ornamented with bacula of various shapes (Fig. 11). The proximal bacula are smaller but denser than those on the distal face of the spore (Pl. 1, Figs. 3, 4). Mature spores are light smoky in colour. The equatorial bacula are about 2 μ in height and 1.5 μ in width. Along the equator, on an average, 32 bacula have been counted in one focus. The distribution of bacula is irregular. Scattered inbetween the bacula are very small grana. The mature spores range in their equatorial diameter from 33 μ to 38 μ with a mean of 36 μ .

Elater—The elaters are narrow and long, brown in colour, the walls being thick surrounding a darker lumen of variable width (Fig. 12 ; Pl. 1, Fig. 2). Where the lumen is wide, especially near the transverse septa, the walls are less thick. The lumen is characterised by unevenness due to depressions or projections and sometimes the lumen is beaded in appearance. Two, three or four celled complete elaters, i.e., with both ends tapering, are equally prevalent. These are very fragile so that complete elaters are found only after considerable care, both in preparation and observation. Four celled elaters range in length from 280-350 μ with a mean of 320 μ and the two celled are on an average 200 μ long. The width of elaters ranges from 5.0 to 8.5 μ . The greatest width occurs at the joints.

***Folioceros indicus* sp. nov.**

Remarks—A taxonomic description of the plant referred here to *F. indicus* has been given earlier by PANDE and BHARADWAJ (1949) under the name *Aspiromitus harrisanus* St., from which it differs in the details of both, spore and elater.

Diagnosis—Planta monoica, terricola. *Frons* ad 2 cm longa, levis, cavernosa, longa furcata, furcis 5 mm latis, ligulatis, margine breviter inciso-lobulatis. *Involucra* superficies iniqua, cavernosa, cum cavibus in uno ordino. *Capsula* exigue stomatifera

Sporae 42 μ , fuscae, dense baculosae, cicatrix tetradi non perspicua. *Elateres* 310 μ (280-350 μ) longi, septati, spadici, angusta foramini. *Androecia* parva, sparsa, alveolis polyandris (ad 20 in utroque alveolo). *Antheridia* corporum 160 μ (150-170 μ) longorum.

Type Repository—Author's personal collection, Lucknow, India.

A fresh study of the plants reveals the following additional information :

Thallus—Margin of the fronds is narrowly segmented into many longish lobes arranged irregularly in a pinnate fashion. The lobes arise as small sessile spongy bodies (PANDE & BHARADWAJ 1949, p. 23, Fig. 5). In the surface cells of the thallus, the chloroplast is large, of irregular shape with a number of lighter areas and usually one chloroplast is present in the cells. No centralised pyrenoid body can be made out (PANDE & BHARADWAJ 1949, Pl. III, Fig. 2). Usually a number of lighter areas are seen in the chloroplast (Fig. 5). In extreme cases the body of the chloroplast is seen to consist of only a network.

Antheridium—Mature antheridia possess a body which is on an average 160 μ long, the range being 150 μ to 170 μ .

Involucre—The involucre is cavernous with cavities in one layer and the surface is ridged (Fig. 13).

Capsule—The columella is a bundle of 16 rows of cells. Capsule wall has the outermost layer of thick walled epidermal cells. Epidermis shows 10 stomata per sq mm of its surface area. The stomata are 72 μ (mean) long. The epidermal cells are 90-250 μ (162 μ mean) in length. The cortical region of the capsule wall has 4 layers of large, thin walled, loosely arranged cells. Each cortical cell contains a single chloroplast. The inner lining layer of the cortex consists of compacted, small cells. On the surface of the capsule, shallow dehiscence grooves are present.

Spore—The spores are circular in polar view (Pl. 1, Figs. 5-7). Proximally the tetrad mark is not visible and the exine is depressed in that region. Spore exine shows baculate ornamentation. Bacula are of various shapes (Fig. 14 ; Pl. 1, Fig. 5) as seen along the equator. These are 2.7 to 4 μ in height, about 2 μ in width at the base and on an average 45 in number along the equator in one focus. The proximal face has smaller and sparser bacula as compared to those on the distal face. The overall diameter of mature spores in polar view is 42 μ (mean ranging from 37 μ to 45 μ). Mature spores are blackish or smoky in colour.

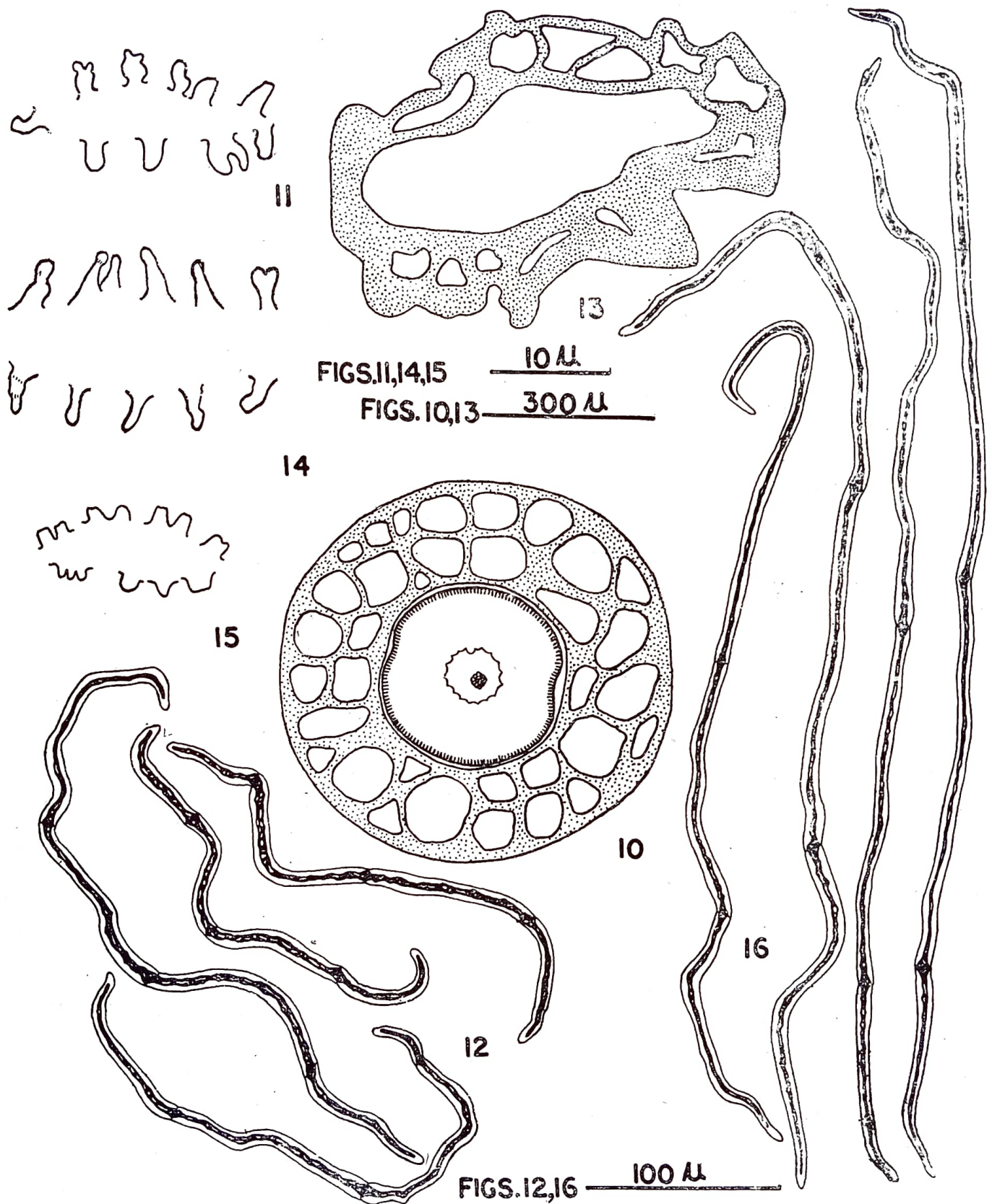
Elater—Two, three and four celled complete elaters are equally numerous. They are slender, long, brown in colour with thick walls enclosing a darker lumen of variable width which is wider nearer the transverse walls separating the contiguous elater cells. The floor of the lumen is uneven. Complete elaters, with their ends tapering, are 310 μ (mean) in length ranging from 280-350 μ if four celled and about 200 μ long if two celled. Four celled elaters are rather easily liable to break into two or more pieces. The width of the elaters ranges from 5.0—8.5 μ .

Folliceros physocladus (Schiffn. & Pande MS) comb. nov.

Syn. *Anthoceros physocladus* Schiffn. & Pande MS in Pande, 1960

Remarks—Although named by SCHIFFNER AND PANDE (1960) this species has not been scientifically diagnosed and described so far. The diagnosis and description given below are based upon the type material of *A. physocladus* studied by me.

Diagnosis—Planta dioica, corticola. *Frons* ad 4 cm longa et ad 5 mm lata, superficies lamellata, gross cavernosa, linearibus, pinnata, remote et alterne lobata, lobis linearibus



10-12. *F. satpurensis* (Sriv.) comb. nov. (Bharad & Sriv.) 10. T. S. of capsule through involucre, 11. Equatorial bacula in spore, 12. Elaters.

13-14. *F. indicus* sp. nov. 13. T. S. of involucre, 14. Equatorial bacula in spore.

15-16. *F. physocladus* (Schiffn. & Pande) comb. nov. 15. Equatorial bacula in spore, 16. Elaters.

anticis bullatis, margine cellarum longarum. *Involucra* cavernosa, lamellata. *Capsula* stomata numerosa. *Sporae* 31 μ , fulvae, baculose-conices, cicatrix tetradi non perspicua. *Elateres* 580 μ (530-630 μ) longi, septati, spadici anguste foramini. *Androecia* in ramis propriis, polyandria (ad 30 in utroque alveolo). *Antheridia* corporum 165 μ (155-170 μ) longorum.

Thallus—The plant is dioecious. Characteristically long and narrow fronds, overlapping with each other, build up dense mats. Each frond may be as long as 4 cm with the width only 2-5 mm (Figs. 6, 7 ; Pl. 1, Fig. 8). In the male thalli, the fronds bearing androecia in the median region, are slenderer as compared to the fronds in the female thalli bearing the sporogonia (Fig. 7). The surface of the fronds bears strap-shaped lamellae. The fronds appear pinnately lobed, the lobes being longish and apically swollen (Pl. 1, Figs. 8, 9). Each lobe is marginally characteristically bordered by one cell thick palisade of oblong cells (Fig. 8 ; Pl. 1, Fig. 9) with their outer walls strongly convex. Internally the fronds are copiously cavernous.

Each of the surface cells nearer the margin, usually has two chloroplast (Pl. 1, Fig. 10) but occasionally they may be three even. Chloroplast is ornamented with tubercles and is of various shapes but rarely circular (Fig. 9). No centralized group of pyrenoid bodies is apparent in them.

Androecia—Androecia occur sparsely along the median region of the fronds. They are sunken into the thallus with only a small part raised above as a mound. Each androecium develops a small, round and raised opening on maturity. The number of antheridia produced in each chamber could not be exactly ascertained, but they appeared to be about 30. Each antheridium has a stalk and a body wall composed of four superimposed tiers of cells. The average height of a mature, dehisced antheridial body is 165 μ , the range being 155-170 μ .

Involucre—The involucre is cavernous with cavities in one layer. A few lamellate outgrowths are borne on the surface.

Capsule—The epidermis is richly stomatiferous with 21 stomata per sq mm of the surface area. The stomata are 61 μ (mean) long. The epidermal cells are 100-300 μ (200 μ mean) in length.

Spore—The spores are almost circular in polar view (Pl. 1, Figs. 11, 12). Proximally the tetrad mark has never been seen. Spore exine is ornamented with variously shaped bacula (Fig. 15). Each baculum is up to 2 μ high and 1.5 μ wide. About 33 bacula have been counted on an average along the equator. The ornamentation on the proximal face is finer and sparser as compared to that on the distal face (Pl. 1, Figs. 11, 12). Mature spores are light brown in colour and are 31 μ (mean) in diameter in polar view, the range of variation being 27 μ to 33 μ .

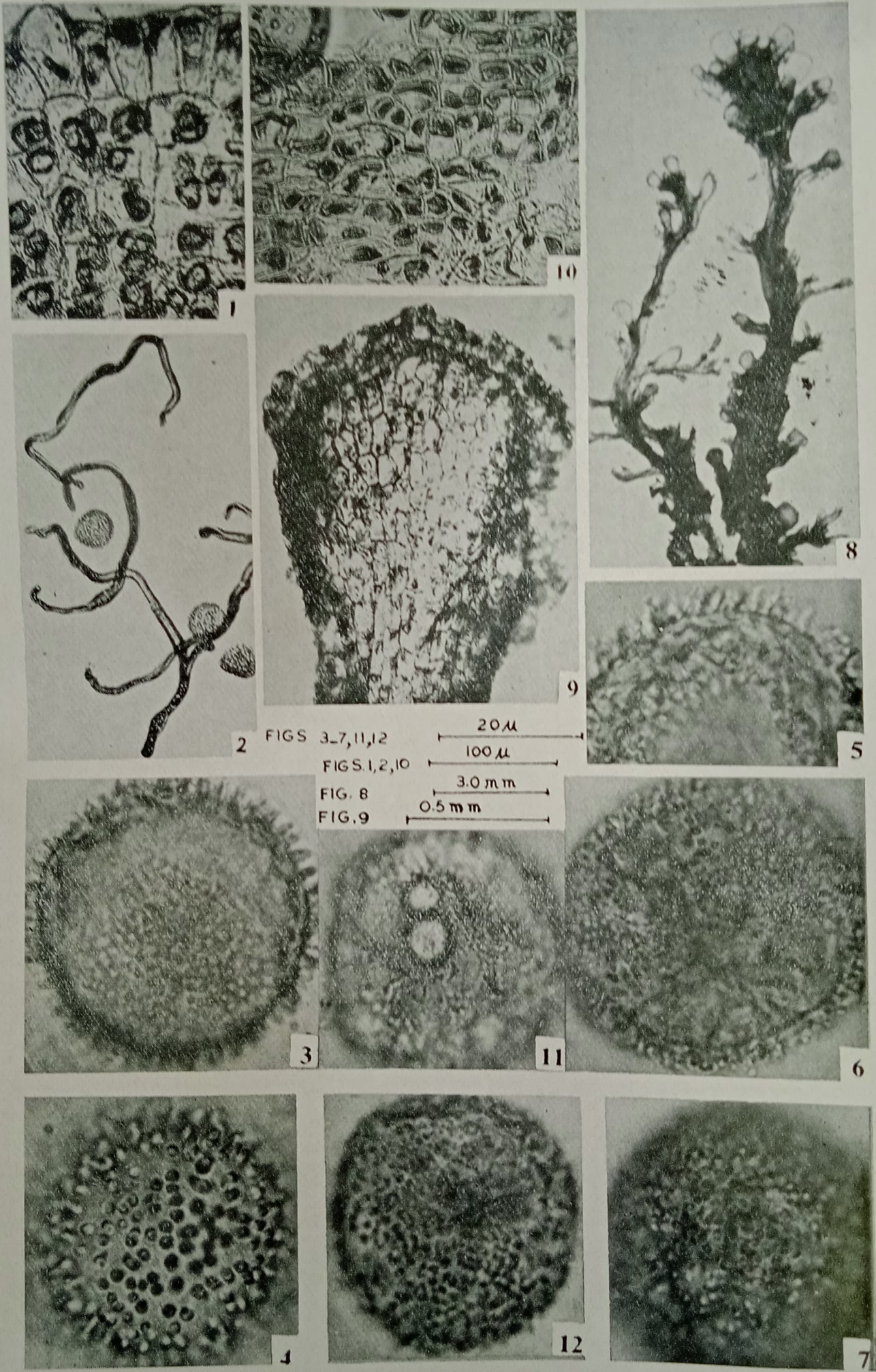
Elater—Normally the elaters are four celled (Fig. 16) with the ends tapering. Two or three celled elaters have not been seen by me so far. Each elater is slender and serpentine, light brown in colour with the wall in each cell substantially thickened enclosing darkish, narrow lumen (Fig. 16). The elaters are liable to break into two or three pieces but in gently prepared slides many complete elaters are usually found. A complete elater measures 580 μ (mean) varying in length from 530 μ to 630 μ . Elater width varies from 5.0-8.5 μ .

COMPARISONS

The essential characteristics of the three Indian species have been epitomized in Table 1 here on the same lines as done earlier (BHARADWAJ, 1972) to facilitate comparison

Table—1

Name of species	Sexuality	Thallus type	Antheridium		Spore (mature)		Elater size		Capsule Stomata per sq. mm. Length in μ (mean)	Special features				
			per chamber	Body height mean range	Diameter in μ mean range	Bacula size in μ (l \times b) biggest	Length in μ mean range	Width range						
<i>Spores baculate (laevigate)</i>														
<i>F. atpurensis</i>	Dioec.	longish	40	180	170-190	36	33-38	2.5 \times 1.75	320	280-350	5-8.5	15	56	apical storage tubers
<i>F. indicus</i>	Monoec.	longish	20	160	150-170	42	37-45	4 \times 2	310	280-350	5-8.5	10	72	marginal sub-sessile spongy bodies
<i>Spores baculate (dentate)</i>														
<i>F. physocladus</i>	Dioec.	pinnate	30	165	155-170	31	27-33	2 \times 1.5u	580	530-630	5-8.5	21	61	



with the species of *Folioceros* described so far. On the basis of spore ornamentation all the three Indian species have baculate spores. However, in two species the bacula are laevigate and only in *F. physocladus* the bacula are of dentate type.

Comparing the first two with their respective species group (BHARADWAJ, 1972—Table 1), *F. satpurensis* is distinct from *F. glandulosus* and *F. pinnilobus* in having bigger spores with smaller and narrower bacula, the number of stomata per sq mm is less as compared to *F. glandulosus* but the stoma are shorter in length as compared to *F. pinnilobus*. The apical storage tubers make *F. satpurensis* all the more distinguished. *F. indicus* has biggest spores. The bacula are long yet narrow and closer-set than all the other species. The stomatal distribution is sparser to that of *F. glandulosus* but the length of stoma is biggest as compared to all the other species. The sparse, sessile spongy bodies on the thallus margin are also individualistic. The species is monoecious which distinguishes it from *F. glandulosus* and *F. satpurensis*.

F. physocladus has remarkably linear pinnate fronds which are characteristic and are comparable with those of *F. incurvus* with which it agrees in being dioecious also. However, it differs from the latter in spore size and the bacula size besides by having much longer elaters. But the most striking difference between the two is copiously stomatiferous capsule wall in the former as against the total absence of stomata in the latter. As compared to the monoecious species of the group, the spores are smaller with slightly bigger bacula and much longer elaters besides the capsule wall being more stomatiferous.

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EXPLANATION OF PLATE 1

- 1-4. *Folioceros satpurensis* (Sriv.) comb. nov. (Bharad. & Sriv.). 1. Marginal cells and chloroplasts, 2. Elaters, 3. Acetolysed spore in proximal focus, 4. Same as 3 in distal focus.
- 5-7 *F. indicus* sp. nov. 5. Acetolysed spore, 6, 7. Non-acetolysed spore in proximal and distal focus respectively.
- 8-12 *F. physocladus* (Schiffn. & Pande) comb. nov. 8. Fronds, 9. Apical part of a lobe, 10. Chloroplasts, 11, 12. Acetolysed spores in proximal and distal views (with two air bubbles).