

# THE PROTHALLUS OF *POLYSTICHUM*

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Received May 13, 1968

(Communicated by Dr. T. N. Khoshoo, F.A.Sc.)

## INTRODUCTION

*Polystichum* is a terrestrial leptosporangiate fern genus, commonly regarded by pteridologists as of dryopteridoid affinity (Ching, 1940; Christensen, 1938; Copeland, 1947; Holttum, 1947). Little information is available in literature regarding its detailed morphology even though it is a large genus (c. 175 spp.) of world-wide distribution. The prothalli of this genus are practically unknown. The following account deals with the development and morphology of the prothalli of 9 species, viz., *Polystichum acanthophyllum* (Franch) Christ, *P. aculeatum* (L.) Roth., *P. angulare* Pr., *P. auriculatum* (Linn.) Pr., *P. bibristatum* Moore, *P. brownii* (Spenn.) Fee, *P. lentum* (Don) Moore, *P. lonchitis* (L.) Roth. and *P. squarrosum* (Don) Fee. The study is based on laboratory cultures raised on sterile Knop's agar plates maintained at  $24 \pm 2^\circ$  C. and c. 600 ft.-c. light intensity (Nayar, 1962). Spores were collected in the field from forests of Eastern India, except those of *P. angulare* and *P. brownii* which were supplied by the American Fern Society's exchange department.

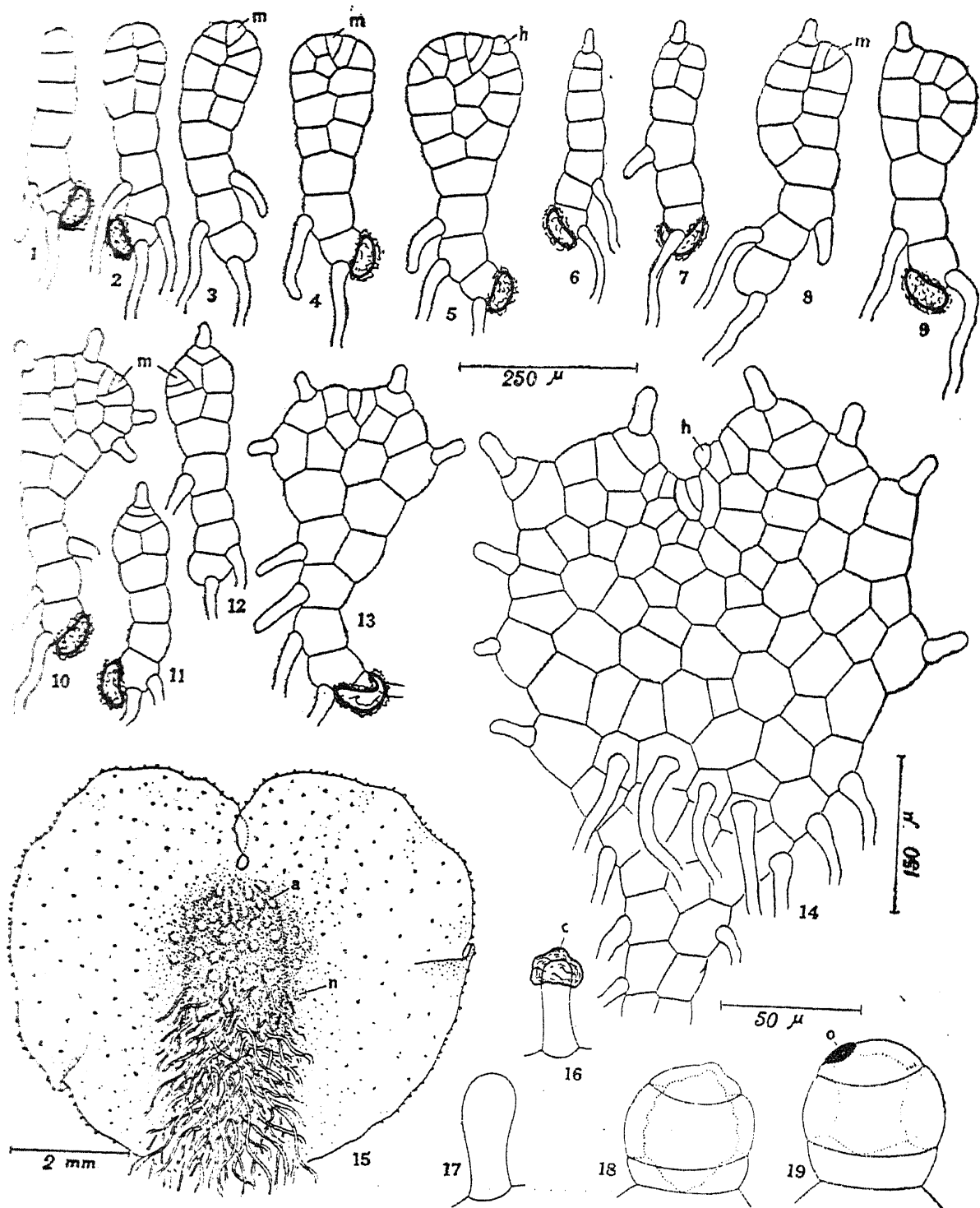
## PROTHALLIAL DEVELOPMENT

The spores (Nayar and Devi, 1964; Devi, 1966) are of the bilateral type provided with a distinctively wrinkled loose perine, and contain several light green plastids (for details see Nayar and Devi, 1964). On sowing they germinate readily in about a week and grow into uniseriate, slender, densely chlorophyllous germ filaments bearing a few basal, non-chlorophyllous, hyaline rhizoids. In about one week after spore germination the germ filament becomes 5-8 cells long (Fig. 1) and begins to develop into a prothallial plate. Commonly, the terminal cell and one or two cells behind it divide longitudinally (Fig. 2) to initiate plate formation. Establishment of an obconical apical meristematic cell may occur directly afterwards by an oblique division in one of the daughter cells of the terminal cell (Figs. 3, 4). Sometimes, an apical cell is differentiated only after

the prothallial plate becomes three or four cells broad. The posterior region of the germ filament (2-4 cells) generally remains uniseriate, slender and cylindrical; in *P. squarrosum* and *P. lonchitis* these cells may also sometimes divide longitudinally once. Unicellular, capped, papillate hairs may be developed by the young prothalli soon after an apical cell is formed or as in *P. brownii* and *P. squarrosum* the young thalli may remain naked for quite long (Fig. 5). Nearly 75% of the germ filaments of *P. aculeatum* and *P. angulare* and nearly 20% of the germ filaments of *P. auriculatum*, *P. biaristatum* and *P. lentum*, produce a unicellular papillate hair crowning its terminal cell before the development of a prothallial plate is initiated (Fig. 6). Soon after producing a hair the terminal cell expands unilaterally and undergoes a longitudinal division (Fig. 7) in such a way that the hair crowns one of the daughter cells. Commonly an obconical meristematic cell is then established by a wall formed oblique to the longitudinal wall in the sister cell of the hair-bearing cell (Fig. 8). However, the establishment of a meristematic cell is delayed in some cases and then an expanded non-meristic lobe is formed by the repeated division of this cell as in *P. auriculatum* (Fig. 9). Several marginal hairs may be developed by such prothallial plates before a meristematic cell is differentiated in one of the marginal cells at the apex of the expanded lobe (Fig. 10). In a few germ filaments (nearly 15% under cultural conditions), particularly of *P. aculeatum* and *P. lentum*, the terminal cell (rarely also the penultimate cell) exhibits marked retardation of growth when the germ filaments are 5-8 cells long. Soon a terminal hair is produced crowning the quiescent terminal cell. In such cases the cell next to the quiescent apex of the germ filament divides longitudinally (Fig. 11) initiating plate formation. One of the daughter cells thus formed expands more markedly than the other and, by two oblique divisions, delimits a meristematic cell laterally (Fig. 12). Soon a spatulate prothallial plate is formed by the activity of the meristematic cell and the quiescent anterior region of the germ filament is pushed away to one side. Very infrequently this type of development is noticed also in *P. auriculatum* and *P. biaristatum*.

#### MATURE PROTHALLUS

The young prothalli of *Polystichum* become cordate (Figs. 13, 14), generally in *c.* 8 weeks after spore germination. The meristematic cell is then replaced by a pluricellular meristem in the usual way. Marginal papillate hairs are produced profusely. In *P. brownii* and *P. squarrosum* in which the young thalli are naked, hair formation is usually initiated as the thalli become cordate. In *c.* 3 months from spore germination the prothalli of



FIGS. 1-19

*Polystichum* become full grown. The [mature prothallus (Fig. 15) is of the cordate type, possessing a thick midrib and spread-out wings. Papillate hairs (Fig. 16) of the common aspidiaceous type (Stokey, 1951, 1960; Nayar, 1960 *a, b*; Nayar and Kaur, 1963, 1964; Nayar and Chandra, 1963,

1965) occur profusely both on the surfaces and margin. In addition, unicellular club-shaped hairs (Fig. 17), slightly larger than the papillate hairs and devoid of any extracellular secretion are found on the anterior margin.

Sex organs are restricted to the midrib region of the prothallus and are of the common leptosporangiate type. The archegonial neck is curved away from the apex of the prothallus and the neck canal cell is binucleate at maturity. The antheridium is hemispherical to oblong-hemispherical in shape. The basal cell is short and nearly funnel-like. The cap cell is discoid but may often be rather beaked (Fig. 18) in mature antheridia on account of a terminal or subterminal inconspicuous bulge. During antheridial dehiscence a circular pore-like opening (Fig. 19-*o*) is developed by the rupture of the cap cell at this bulged region. The spermatozoids, as they escape through this pore, finally tear the cap cell apart. Antheridia with divided cap cells are frequent.

#### SUMMARY

In the 9 spp. of *Polystichum* studied, a uniseriate germ filament is produced on spore germination. The anterior cells of the germ filament develop into a prothallial plate commonly before or sometimes after the terminal cell develops a papillate hair. A meristematic cell is differentiated early during plate formation, commonly in one of the daughter cells of the terminal cell or rarely (when the terminal cell is quiescent and hair-bearing as in *P. aculeatum* and *P. lentum*) of the penultimate cell. Young thalli become cordate in *c.* 8 weeks from spore germination and fully grown in *c.* 3 months. The mature prothallus is profusely hairy and cordate with a thick midrib and spread-out wings. Hairs are of the capped, unicellular, papillate type; a few club-shaped, unicellular hairs devoid of terminal caps are found in addition on the anterior margin. Sex organs are of the usual leptosporangiate type. The antheridium dehisces by a pore-like opening formed in the cap cell.

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## EXPLANATION OF FIGURES

FIGS. 1-19. Fig. 1. Germ filament of *Polystichum brownii*, one-week-old. Fig. 2. Initiation of plate formation in *P. squarrosum*. Figs. 3 and 4. Young prothalli of *P. brownii* (Fig. 3) and *P. squarrosum* (Fig. 4) showing early establishment of a meristematic cell. Fig. 5. Young prothallus of *P. squarrosum* showing initiation of hair formation. Fig. 6. Germ filament of *P. angulare* (one-week-old) showing development of a terminal hair. Fig. 7. Germ filament of *P. biaristatum* showing initiation of plate formation by division of the terminal cell after producing a hair. Fig. 8. Young prothallus of *P. lentum* showing meristematic cell. Fig. 9. Young non-meristic prothallus of *P. auriculatum*. Fig. 10. Young prothallus of *P. angulare* showing the establishment of a meristematic cell at the apex of the lateral lobe. Fig. 11. Germ filament of *P. lentum* showing retarded growth in the anterior region and the initiation of prothallial plate by a longitudinal division in an intercalary cell. Fig. 12. Formation of a meristematic cell in a thallus which developed like that shown in Fig. 11. Fig. 13. Young spatulate prothallus of *P. aculeatum*. Fig. 14. Young cordate prothallus of *P. aculeatum*. Fig. 15. Mature prothallus of *P. lentum*. Figs. 16 and 17. Marginal hairs of secretory (Fig. 16) and non-secretory (Fig. 17) type. Fig. 18. Mature antheridium of *P. aculeatum*. Fig. 19. Antheridium of same showing pore-like opening in the cap cell.

(a—archegonium; c—cap-like extracellular secretion; h—hair initial; m—meristematic cell; n—antheridium; o—pore-like opening in the cap cell.)