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Podostemaceae, An Enigmatic Family

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Abstract

The Podostemaceae are of great morphological and embryological interests because of their great biodiversity in a particular habitat. Kapil (1970b) reported Podostemaceae as an "embryological family" because of several remarkable features such as (a) diverse pattern of female gametophyte development; (b) lack of antipodal cells; (c) absence of double fertilization and endosperm; (d) presence of pseudo embryosac; (e) lack of plumule and radicle in mature embryo, etc. These characters not only make the Podostemads markedly distinct from other angiosperms, but also biologically interesting and evolutionarily enigmatic.

Keywords:Podostemaceae, *Hydrobryum griffithii* (Wall. ex Griff.) Tul., *Podostemon subulatus* Gard., *Polypleurum wallichii* (R. Br. ex Griff.) Warm., Riverweeds, North East India.

Introduction:

Podostemaceae Rich. Ex C. Agardh, the only representative of an order Podostemales, consists of aquatic angiosperms that typically grow on rocks in cascades, waterfalls and rapids where there are great fluctuations in the river water levels. The members of Podostemaceae have a plant body (thallus) resembling that of

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Bryophyta or Phaeophyceae (Algae). Podostemaceae is the largest family of strictly aquatic angiosperm with 49 genera and 270 species (Philbrick & Novello, 1998); About 11 genera and 42 species are reported in India, (Hooker, 1885; Cook, 1996; Mohan Ram & Anita Seghal, 2001; Mathew, 2003);

The members of the family are commonly called river-weeds with very peculiar vegetative form; revealing many unique morphological, anatomical and ecological features and stands clearly apart from all other angiospermous family. Podostemaceae are remarkable because of the ecological condition under which they grow; attached tenaciously by unique holdfast to rocks in the swift currents of river rapids and waterfalls. They grow firmly attached to rocks and stones by means of adhesive holdfast or haptera that secretes mucilage. The vegetative plants grow submerged during the rainy season; in contrast, the floral biology of riverweeds is essentially terrestrial; flowering occurs when the plants are exposed as the water level recedes, followed by flowering and setting fruit, dehydrating and eventually dying (Philbrick 1984).

Owing to their unusual morphology, anatomy and ecology, riverweeds have long fascinated biologists (e.g., Willis 1902; Schnell 1963; Nagendran et al., 1977). The unique combination of characters presented by this family is unparalleled among the angiosperms, leading to the recent resurgence of worldwide interest.The present paper presents the biodiversity of three species from Meghalaya, viz. *Hydrobryum griffithii* (Wall. ex Griff.) Tul., *Podostemon subulatus* Gard. and *Polypleurum wallichii* (R. Br. ex Griff.)Warm., with illustrations for easy identification and of great phytogeographical interests.

Materials and Methods:

1. The following species of Podostemaceae viz. *Hydrobryum griffithii* (Wall. ex Griff.) Tul., *Podostemon subulatus* Gard.

and *Polypleurum wallichii* (R. Br. ex Griff.)Warm., were collected from Janiaw and Umtienger in Meghalaya state of North East India, (Location 25°. 02' to 26°. 07' N latitude and 89°. 49' to 92°.50' Elongitude) with an elevation of about 2040mabove MSL .

2. Formalin acetic-alcohol and Carnoy's fluid were used as the primary fixative. The materials were prepared for microtomy by the usual methods of dehydration in the Tertiary butyl alcohol series followed by impregnation with paraffin wax.

3. A rotary microtome was used to produce 7-10 μm thick sections that were stained with safranin-fastgreen, erythrosine, Haematoxylin, Toluidine blue, Methyl green pyroninr- G.

4. Photomicrographs were taken by using Nikon E600 and Leitz Wetzlar Germany (Type 307-083. 103) fluorescence microscope. External surfaces of the plant body, androecia and gynoecia were studied morphologically by using Joel (JSM-6360) scanning electron microscope (SEM).

Boidiversity of Podostemaceae Members:

The members of Podostemaceae, popularly known as "river-weeds" are markedly specialized and diverse in their habits that are adapted to extreme habitats such as river-rapids and waterfalls. The members have unique morphological, anatomical and ecological features and stands clearly apart from all other angiospermous families. The biodiversity within this family is remarkable, resembling that of Algae and Bryophytes.

1. *Hydrobryum griffithii*

The plants are annuals, aquatics, growing on rocky surfaces in tropical streams, closely appressed to substrate and spreading over stones, more or less ovoid to circular outline. Frond coriaceous, green, lobed, patches about 10-15 cm wide, sending

up buds clothed at the base with distichously scale-like imbricate leaves, enlarged at the base, tips caduceus. Leaves filiform- linear, greenish, scattered in groups of 2-3 on the upper surface of the thallus, up to 12 mm long. Flowers sub-sessile, zygomorphic, pedicellate, pedicels 2-6 mm long, remaining within the spathe.

Fig. 1: Thallus with vegetative phase

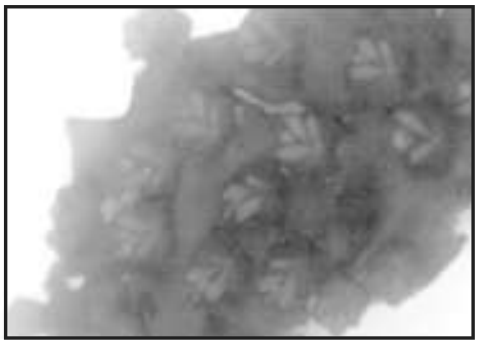


Fig.2: Habitat with flowers

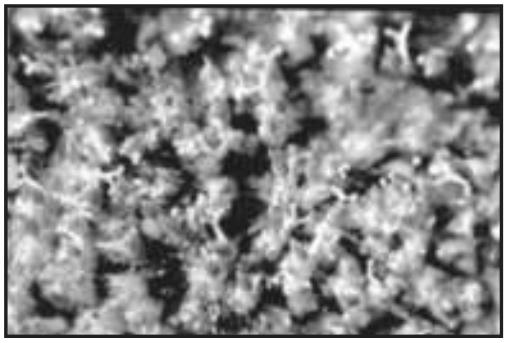


Fig.3: An enlarged view of bisexual flower

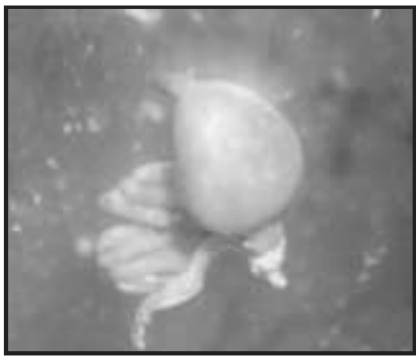
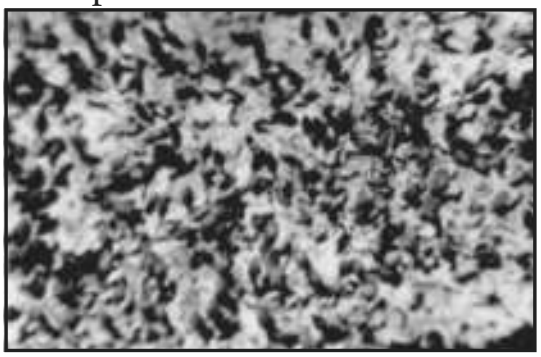


Fig.4: Fruiting stage with capsules and dried thallus



Stamens 2, borne on an andropodium, as long as the ovary, anther lobes golden yellowish, staminodes 2; Ovary subtriangular, green; stigma bifid, entire, wedge-shaped, brownish. Fruit capsule, isolobous, distinctly 12-ribbed. Seeds minute, numerous, elliptical-patelliform, surface granular.

2. *Podostemum subulatus*

Plants haptophyte, submerged minute herbs in rapid mountain streams, creeping and attached to rocks; thallus

filiform, thread or ribbon like, frond lobulate, elongate, branched; buds on the edges of the lobes continuous with the veins; secondary shoots ascending. Leaves slender, subulate, very dense, obscuring the thallus when viewed from above. Flowers axillary, zygomorphic, naked, enclosed by tubular or funnel shaped spathe.

Fig,1: Habitat

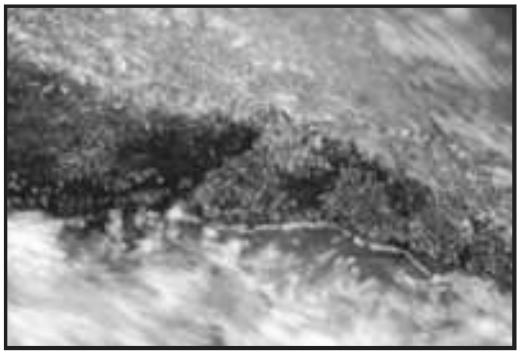
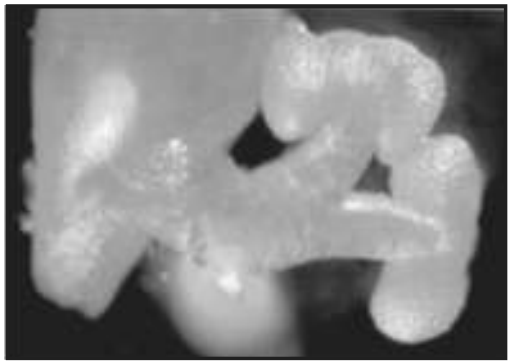


Fig.2: Thallus with reproductive phase

Fig.3: An enlarged view of bisexual flower

Fig.4: Bi-forked filament with stamens



Stamens 2, with two transparent staminodes on either side of fertile stamen. Ovary ellipsoid, 2-locular, green, stigma bifid. Fruit capsule, unequally lobed, 8-10 ribbed, pedicellate, capsule valves rounded, persistent, incurved; seeds numerous, oval, minute.

3. *Polypleurum wallichii*

The plant body is a green or brownish flat, bilaterally symmetrical, fucoid thallus with wavy margins. It is fleshy, often branching exogenously and generally free drifting in the flowing water. It is attached at the base by a stout holdfast. Thallus various, usually free-floating with marginal ultimately 1-flowered secondary shoot.

Fig.1: Habitat

Fig.2: Thallus with filiform leaves

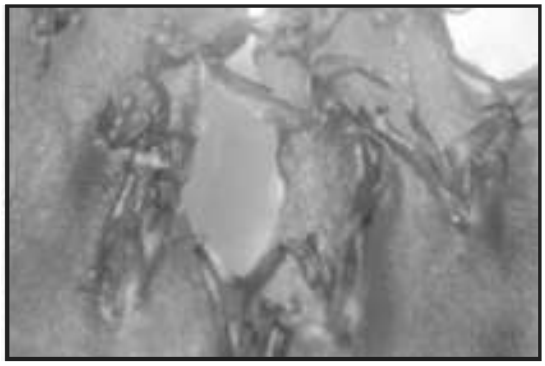


Fig.3: Root system

Fig. 4: Plant with flowers

Flowers zygomorphic, bisexual and hypogynous. Young flower bud is enclosed by a thin transparent membranous, sac-like spathe, staminal filament is forked, and each fork bearing four loculed anthers, light brown in colour. Ovary sessile, bicarpellary, syncarpous and elliptic, green with brown longitudinal ridges ; smooth when young, ripening into capsule,

8-ribbed; stigmas subulate, dark brown in colour. Fruit a capsule, isolobous.

Fig. 5: An enlarged bisexual flower

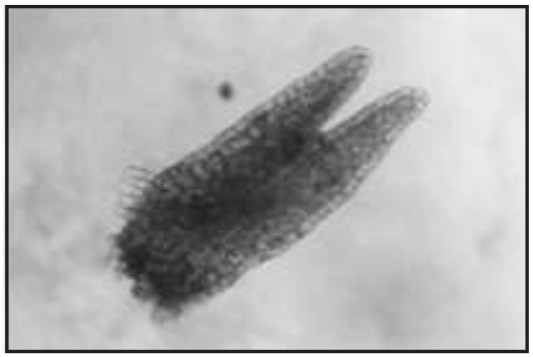


Fig. 6: Seed germination

Fig.7: Seedling with rhizoids

Conclusion

The Two species *Hydrobryum griffithii* (Wall. ex Griff.) Tul., and *Podostemum subulatus* Gard. have been rediscovered and re-described after Hooker (1885), from Meghalaya that too after a long gap of 118 years.These species are belonging to the group Podostemoideae, which are highly specialized and occupy narrow aquatic ecological niches The Voucher specimens along with *Polypleurum wallichii* (R. Br. ex Griff.)Warm., have been deposited in the Eastern Circle, BSI, Shillong, India.

The plants grow in rapidly flowing rivers and streams. Plants are well adapted for the mechanical stress imposed by these harsh environments. The present study indicates that the Podostemaceae life cycles are linked to the hydrological cycle of their habitats i.e. the high and low water periods. The population undergo an annual cycle of colonization, establishment of a canopy of mature plant, and die back when the water level drops. Podostemaceae donot produce asexual propagules of dispersal that they depend upon seeds for extending to new locations. However, the plants rely on clonal growth for maintenance of local populations. Till date, the previous workers mostly confined their studies on female gametophytes only, because of its remarkable reduced nature. The present study, apart from the megasporogenesis and embryogenesis, deals with the details of another development and microspore formation in all the three members.

Discussion

Nowadays, the aquatic biodiversity especially riverweed is important to conserve but they are not always treated with the respect they deserved (Cook, 1996). Riverweed habitats are under increasing pressures from reduced water quality and altering of water flow patterns (dam building). Increasing impacts on tropical rivers are leading to loss of riverweed habitat, extirpation of populations and extinction of species. The members are subjected to wide range of anthropogenic disturbances. Predictions regarding global warming may also adversely affect Podostemads as they occur in seasonally pulsating rivers (Grimm 1993, Philbrick 1997). As the plants are confined to the tropics, the light and temperature conditions are practically uniform. They are, however, subject to changes during the monsoons caused by the level and turbidity of the water. It is observed that flowers are produced even when the plants are submerged; perhaps, the

clarity of the water and the intensity of light are more important factors. Among the three plants studied, there seems to be a certain degree of variation in the individual requirements of physiological maturity before flowering takes place, even in the same locality and under identical conditions.

Yet, from evolutionary perspective the family is enigmatic. Issues ranging from where the origin of the ancestral roots lie within terrestrial groups, to the ecological and biological factors that have resulted in its remarkable radiation into extreme aquatic environments, remain unexplored. In fact Podostemaceae may provide valuable means for testing components of the paradigm for slow evolutionary rates and thus small taxonomic sizes that pervades aquatic angiosperms (Arber 1920).

Sculpthore (1967) remarked that *"There is surely no stranger and more provocative family of angiosperm than the Podostemaceae".* The unique combination of characters presented by this family is unparalleled among the angiosperms, leading to the recent resurgence of worldwide interest.An extreme view has been taken by Cusset and Cusset (1988b,c), who proposed the Podostemopsida as a class of angiosperms equivalent in rank to monocotyledons and dicotyledons. A special volume of aquatic Botany (1997, vol 57) has been brought out on the Podostemaceae highlighting the current state of the knowledge and scope for future work. The biodiversity of Podostemaceae, thus offer challenging problems to the morphologists, the anatomists, the embryologists, the ecologists, and the physiologists through the problems associated with various aspects of their biology.

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