An interesting observation on the mycorrhizal symbiosis in the insectivorous plant, *Drosera peltata* Sm., in Meghalaya, North-East India

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Abstract

The work deals with new observations of a mycorrhizal symbiotic association in the corms and subterranean lateral foliar organs of *Drosera peltata* Sm. North-East, India. The fungal species is *Suillus luteus*, an indigenous common mycobiont in this region. This mycobiont enhances the efficiency of mineral uptake, particularly phosphorous. Calcofluor fluorochrome does not fluoresce at the subepidermal region of the corm, due to a mycorrhizal hartig net. This is an additional report of mycorrhizal symbiosis in the carnivorous plant *Drosera peltata* after Fuchs & Haselwandter (2004) in *Drosera intermedia.*

Introduction

In angiosperms about 645 species have evolved a carnivorous habit to capture prey (Rice 2006, pers. comm.), secreting digestive enzymes, reabsorbing the digested products and benefiting from the supplementary nutrition to the usual nutrition of plants (Fahn 1979; Heslop-Harrison 1976b). The carnivorous habit is most important in supplementing nitrogen supply (Heslop-Harrison 1976a). However, the experiments conducted by Pringsheim & Pringsheim (1962, 1967) and Harder (1963) on *Utricularia*, and Harder & Zemlin (1967, 1968) on *Pinguicula* showed that carnivory may contribute to the supply of other mineral elements.

The association of fungi with roots or underground plant organs is the chief organ of nutrient uptake by many land plants (Smith & Read 1994). Harley & Smith (1983) reported that 118 angiosperm genera in 35 families and 10 gymnosperm genera have mycorrhizal associations. Recent research work of Fuchs & Haselwandter (2004) showed the occurrence of vesicular arbuscular mycorrhiza in *Drosera intermedia*, Hayne an endangered carnivorous plant in Salzburg, Austria. There is some evidence of mycorrhizal association in the roots of *Nepenthes* (Moran, in Clarke, 2001). During the course of study on the developmental aspects of secretory glands in the carnivorous plants of Meghalaya, the authors came across an interesting observation of the mycorrhizal symbiosis in *Drosera peltata*. The underground organs of *Drosera peltata* consist of a corm, vertical shoot, and numerous lateral foliar organs produced exogenously, that while appear rootlike, lack a root cap and true root hairs. Goebel (1923) described them as "dubious roots."

Drosera peltata is a seasonal perennial plant that commences above-ground growth in the month of July and completes its life cycle at the end of October. Globally, *Drosera peltata* occurs throughout much of southeast Asia, Australia, and New Zealand. *Drosera peltata* grows in certain areas of Meghalaya such as Jarain, Sohrarim and Mawsynram where the soil has a low nutrient content. During the dry, hot winter these plants survive as underground corms. The corms and poorly developed lateral foliar organs are sheathed by a mycorrhizal mantle. *Drosera peltata* perennates by these corms, which are filled with abundant starch grains.

Materials and Methods

The corms and lateral foliar organs of *Drosera peltata* were fixed in FAA and sections were taken 8-10 mm thickness after dehydration and paraffinization. The sections were stained with

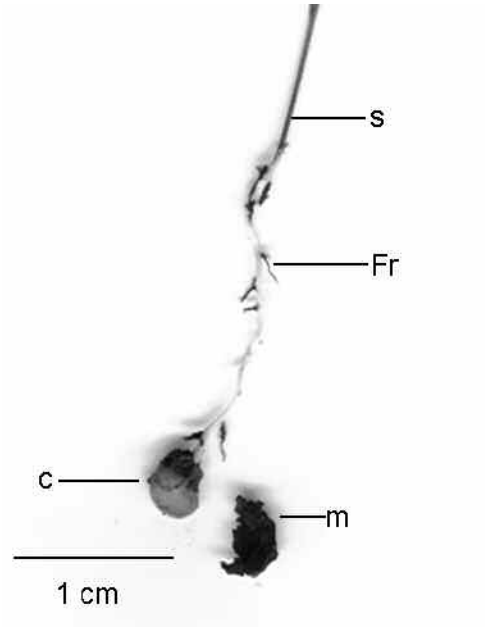

Figure 1: An enlarged portion of the *Drosera peltata* root system showing the corm (c) with detached mycorrhizal mantle (m), dark lateral foliar "roots" (Fr) covered with mycorrhiza and the main stem (s). Scale bar = 1 cm.

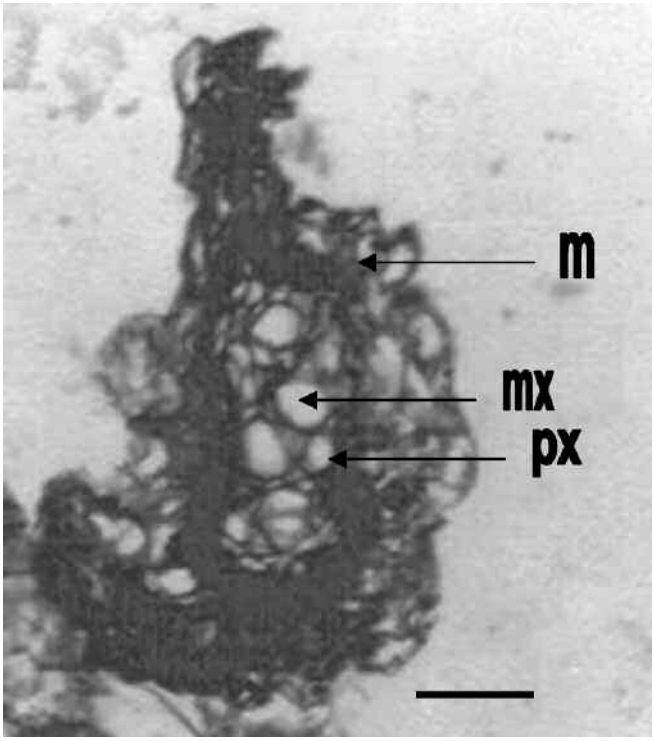

Figure 2: Transverse section of a lateral foliar "root" showing mantle (m), the disorganised vasculature of the protoxylem (px) and metaxylem (mx). Scale bar = 60μm.

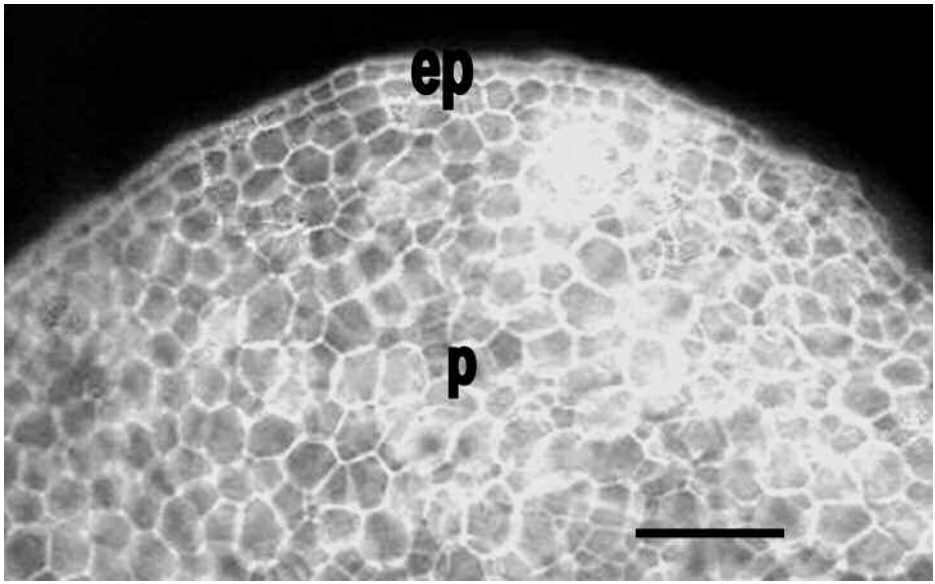

Figure 3: Fluorescence micrograph of transverse section of *Drosera peltata* corm illustrating the difference between the non-mycorrhizal and mycorrhizal zones. The hartig net is absent below the epidermis. Note the fluorescing epidermal (ep) and peridermal (p) layers. Scale bar = 240 μm.

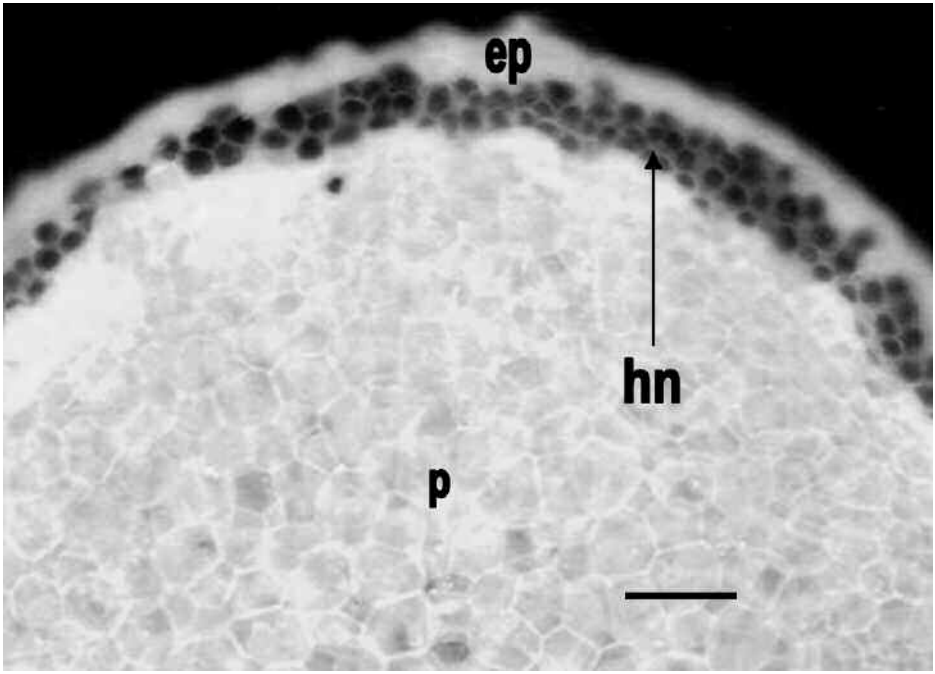

Figure 4: Fluorescence micrograph of transverse section of *Drosera peltata* corm showing the mycorrhizal zone. Note the subepidermal location of the mycobiont *Suillius luteus* and the the absence of fluoresence in the mycorrhizal zone due to the presence of hartig net (hn), and the fluorescing epidermal (ep) and peridermal (p) layers. Scale bar = 240 μm.

Aniline blue and Cotton blue (Johansen 1940; O'Brien & McCully 1981). Mycorrhizal spores were extracted from the 50 g of soil surrounding the corm. This extraction was performed using the sieving method (Daniels & Skipper 1982; Brundrett *et al*. 1996) and centrifugation using a 60% sucrose gradient. Spores were extracted from the supernatant by pipette and mounted in polyvinyl alcohol-lacto-glycerol (PVLG) without staining. The spores were observed under Nikon E 600 microscope. The spores are smooth, hyaline, broadly ellipsoid to sub-globose, ochraceous or buff coloured, and measured 3-4x4-7 µm. Identification of the fungus as *Suillus luteus* was based on spore wall structure and followed published descriptions (Schenck & Perez 1990). Moreover, *Drosera peltata* grows in the understory of *Pinus kesiya* Royle ex Gorden, which is also associated with *Suillus luteus*. Fluorescence microphotographs were taken by using Leitz Biomed Fluorescence microscope. Phosphatase activity was measured using the method described in Dodd *et al*. (1987). The mantle portion of mycorrhiza was removed and washed with double distilled water. The total phosphorus content in the root and corm was estimated after an acid wet oxidation in $HNO_3 + H_2SO_4 + HClO_4$; analyses were performed for phosphorus as suggested by Allen (1974). Translocation percent of phosphorus to the shoot was calculated as described by Theodorou & Bowen (1993): %P (translocated)=100% × shoot P (mg)/total P (mg).

Result and discussion

In *Drosera peltata the* "root" system (i.e. the lateral foliar organs described in the Introduction) is frail, weak and thin. The lateral "roots" are 5-10mm in length and 1-2 mm in diameter completely covered by dark colored mycorrhizal sheath. In transverse section the "roots" have an outer most epidermis in which the cells are radially stretched. The epidermal layer does not produce any root hairs. The cortex consists of 1-2 layers of isodiametric cells with starch grains. The xylem of the "roots" is either di- or tri-arch. The corm is devoid of any lateral true roots. In addition to the modified "lateral roots", at the junction of the corm and the main stem arise small horizontal shoots that during the growing season can form the new shoot, or during the end of the season or winter can produce the resting corm (Adlassnig *et al.* 2005; Slack 2000). In transverse section, the Hartig net is 3-5 cells thick in the peripheral portion of the corms. This region does not fluoresce with Calcofluor.

The primary mycobiont was identified as being *Suillus luteus.* Phosphatase activity (375.0±29.50 µg P- nitrophenol g^{-1} dry $wt.^{-1}h$) in the underground organs was greater in plants associated with the mycobiont than in plants without the mycorrhizal association (190.0±12.40 µg P-nitrophenol g^{-1} dry $wt.^{-1}h$). Similarly, phosphorus content of the shoot and corm was greater in mycobiont-associated plants (86.0±6.75 µm/gm) than in plants without mycorrhizal associations (45.0±1.90 µm/gm). Translocation efficiency of phosphorus (52%) from soil to the shoot by plants was higher in *Suillus luteus* infected plants. Plants without *Suillus luteus* had lower translocation efficiency (39%). The results depict that mycorrhizal infection and production was better in plants associated with *Suillus luteus* as compared to plants without the symbiont.

Drosera peltata frequently grows with grasses and other vegetation, and as such the soil is likely have enhanced amounts of organic material. Mycorrhizal fungi can degrade these composts and make them available to the associated plants (Schisler & Linderman 1989).

The improved phosphorus uptake in mycorrhizal associated plants, as we observed in *Drosera* peltata is supported by other authors (Stribley *et al*. 1980; Lodge *et al*. 1994; Robinson 1994). Higher nutrient uptake by mycorrhizal plants is due to improved hyphal growth and improved exploitation of the soil volume by *S. luteus*. Higher phosphate uptake by plants is correlated to higher rate of phosphatase activity in mycorrhizal than non- mycorrhizal ones (Tarafdar & Marschner 1994).

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