domestica[4] and *Crotalaria retusa*[8] also modified the pH to 6 and 6 25 respectively. The release of leachates from *Ipomoea* pollen (present investigation) does not alter the pH further, after 30 min of incubation. This indicates that substances responsible for pH shift diffuse within the first 10 min and continued incubation (or release of substances from pollen tubes) do not significantly change the pH. This indicates that the substances responsible for pH change within the first 10 min of incubation originate from the pollen wall.

Our data in table I indicate that the rate of release of aminoacids and proteins are pH-dependent. The amount of material lost by the pollen is a function of pH of elution medium. The relation between pH of the medium and the release of proteins and aminoacids is not clear. The reverse is unlikely and does not seem to be the case, since the maximum release of proteins at pH 7 and aminoacids at pH 3 does not correspond with maximum pH shift at pH 4.

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TRACHEARY ELEMENTS IN *CERATOPTERIS THALICTROIDES* (L) BRONG

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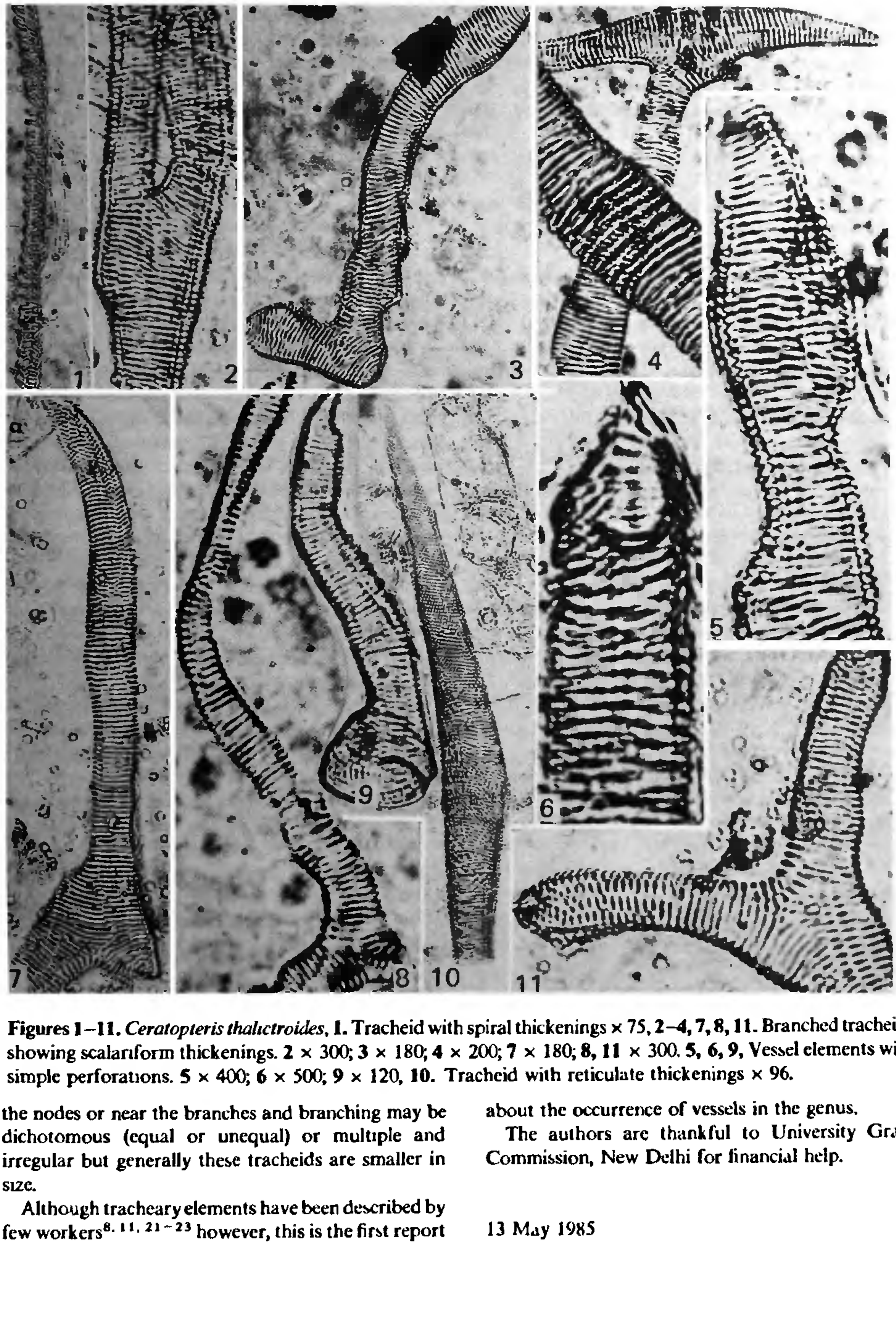
OCCURRENCE of the vessels in pteridophytes is uncommon, though in recent years, vessels have been described in a number of them *e.g. Selaginella*[1,2]; *Equisetum*[3,4]; *Helminthostachys zeylanica*[5]; *Pteridium aquilinium*[6–12]; *Pteridium esculentum*[11]; *Athyrium felix-femina*[12]; *Actiniopteris radiata*[13]; *Adiantum incisum*[14]; *Marsilea quadrifolia*[15–17] and *Regnellidium diphyllum*[18]. The present study describes vessels and branched tracheids for the first time in *Ceratopteris thalictroides*, a common water fern of Parkeriaceae. The vessels occur chiefly in the rhizomatous parts, and show either circular or elliptical perforations in their end walls and their lateral walls show scalariform, reticulate and spiral thickenings.

The plants of *C. thalictroides* were collected from Roxburgh Botanical Garden, Botany Department, University of Allahabad, Allahabad and from Garhwa lake (in Shankargarh), a locality nearly 50 km south west from Allahabad. Rhizomes, roots, stipes, rachis and leaves were macerated by the techniques of Jeffrey[19] and Ghouse and Sabir[20] and their tracheary elements were thereafter stained in safranin and were mounted in glycerine jelly. Some of the rhizome pieces were also sectioned and stained in safranin to confirm the occurrence of vessels in the respective parts.

The tracheary elements of the rhizomatous parts of *C. thalictroides* consist of tracheids and vessel elements. The tracheids are simple or branched showing variations in shape and size measuring, 225–800 μm long and 10–37 μm wide, having tapered end walls with scalariform, spiral and reticulate thickenings on the lateral walls. Some of the tracheary elements possess perforations at their end walls forming the vessel elements and perforation plate which measures, 143–300 μm long and 35–49 μm wide. The vessels are simple and unbranched having scalariform, spiral and reticulate thickenings in their lateral walls. The perforations are simple and oblique and generally at one end of the vessel element. It is usually terminal or subterminal in position. The perforations are oblique, circular or elliptical in form and vary from 38–50 μm $\times$ 24–30 μm in dimension (figures 1–11).

Branched tracheids also occur at the transitions of



Figures 1–11. *Ceratopteris thalictroides*, **1.** Tracheid with spiral thickenings × 75, **2–4, 7, 8, 11.** Branched tracheids showing scalariform thickenings. **2** × 300; **3** × 180; **4** × 200; **7** × 180; **8, 11** × 300. **5, 6, 9,** Vessel elements with simple perforations. **5** × 400; **6** × 500; **9** × 120, **10.** Tracheid with reticulate thickenings × 96.

the nodes or near the branches and branching may be dichotomous (equal or unequal) or multiple and irregular but generally these tracheids are smaller in size.

Although tracheary elements have been described by few workers[8, 11, 21–23] however, this is the first report about the occurrence of vessels in the genus.

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DEVELOPMENT OF VESICULAR-ARBUSCULAR MYCORRHIZAL FUNGI ON AN UPLAND RICE VARIETY

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VESICULAR-ARBUSCULAR (VA) mycorrhizal fungi are widespread in cultivated soils throughout the world[1]. Although the importance of these fungi, particularly in phosphorus uptake of plants by extending the absorptive area of root system has been well recognised[2], studies indicating the mycorrhizal formation in rice are very limited. From India the only report[3] is on the occurrence of *Endogone* sp in upland rice and also the infection of rice roots by *Glomus mosseae*[4]. In the present paper, we report the occurrence and development of mycorrhizas on an upland rice (*Oryza sativa* L) cultivar (MTU-17) under field conditions.

A farmer's field with an alluvial soil near Mangalagiri, 8 km from the University campus, was chosen for the study. The soil was planted to MTU-17, a popular upland rice cultivar, during the 1984 kharif season. During the preceding rabi season, black gram was grown in rice fallows. Five replicates of plant and rhizosphere soil samples were collected at random from the field, starting from 30 days after sowing up to harvest (90 days), at 15-day intervals. The roots were washed carefully, cut into one cm segments and stained following the technique of Phillips and Hayman[5]. From the pooled root segments, triplicate samples involving 20 bits in each were examined for the presence or absence of external and internal hyphae, arbuscules and vesicles or spores, both external and internal. The number of vesicles or spores was recorded. The resting spores were also extracted from 50 g rhizosphere soil by wet-sieving and decanting method[6].

In the initial stages, mycorrhizal infection was confined to finer lateral roots. Profuse external hyphae with one to many vesicles were commonly observed on the surface of the root (table 1). These hyphae were characteristically dimorphic and typically endogonaceous, with prominent angular projections. Hyphal penetration was mostly through epidermal cells forming a distinct appressorium. Occasionally, direct penetration through root hairs was also observed. The per cent of root segments colonized externally and internally also increased with increasing age of the plant. However, a slight decrease in per cent root colonization was evident at the harvest stage, due to the absence of infection in newly developing roots. Arbuscules appeared when the plants were 30 days old. Comb-like hyphae with radially oriented teeth were also noticed but less frequently. The most striking feature was the presence of arbuscules in all the samples throughout the period from that time. Vesicles were seen only after 40 days of plant growth and their number increased gradually up to 90 days. The formation of vesicles or spores internally was consistently much higher compared to that external to