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A petrified fossil leaf of Hydrocharitaceae from Deccan Intertrappean exposures of central India

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ABSTRACT

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The paper deals with the anatomical description of a fossil leaf collected from the Deccan Basalt Intertrappean Sequence of Singhpur, Madhya Pradesh, India. However, petrified *Elodea* leaves showing mature and young condition are studied for anatomical details for the first time from this exposure. The anatomical details were studied by taking peel sections. The leaf is isobilateral with central midrib and lateral lamina. Mesophyll is undifferentiated and its cells are large and contain air cavity. Vascular bundle of midrib is collateral and closed.

The comparison is made with the recorded fossil leaves from the Deccan Intertrappean beds of India as well as living modern taxa, like Typhaceae, Pandanaceae, Sparganiaceae, Potamogetonaceae, Alismaceae and Hydrocharitaceae. The fossil leaf shows affinity to the family Hydrocharitaceae, specially with *Elodea* and named as *Elodeophyllum deccanii* gen. et sp. nov., the specific name after the Deccan trap. The finding indicates tropical conditions during the Deccan Intertrappean episode.

Key–words—*Elodeophyllum*, Deccan Intertrappean, Singhpur.

मध्य भारत के दक्कन अंतःट्रेपी अनावरणों से प्राप्त हाइड्रोकेरिटेसी की अश्मीभूत जीवाश्म पत्ती

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सारांश

शोध–पत्र सिंहपुर, मध्य प्रदेश, भारत के दक्कन बेसाल्ट अंतःट्रेपी अनुक्रम से संगृहीत जीवाश्म पत्ती के शारीरीय वर्णन से संबंधित है। इस अनावरण से पहली बार शारीरीय ब्यौरों हेतु परिपक्व एवं तरूण दशा दर्शा रहीं अश्मीभूत *इलोडिया* पत्तियॉं अध्ययन की गई हैं। छिलका खंडों को समाहित करते हुए शारीरीय ब्यौरे अध्ययन किए गए थे। पर्ण मध्यशिरा एवं पार्श्व पटल सहित समद्विपार्श्विक है। पर्णमध्योतक अविभेदी है तथा इसकी कोशिकाएं बड़ी व वायु गुहिका सन्निहित हैं। मध्यशिरा का वाहिका बंडल भिन्न शाखीय एवं बंद है।

भारत की दक्कन अंतःट्रेपी संस्तरों के साथ–साथ सजीव आधुनिक टैक्सा जैसे टायफेसी, पंडानेसी, स्पेरगेनिएसी, पोटामोगेटोनेसी, एलिसमेसी एवं हाइड्रोकेरिटेसी से अभिलिखित जीवाश्म पत्तियों से तुलना की गई है। जीवाश्म पत्ती विशेषतः *इलोडिया* से हाइड्रोकेरिटेसी कुटुंब से बंधुता दर्शाती है तथा *इलोडेफायल्लम डेक्कनयाई* वंश जाति नवम के रूप में नाम दिया गया, जो दक्कन पाश के उपरांत विशिष्ट नाम है। दक्कन अंतःट्रेपी घटना के दरम्यान खोज उष्णकटिबंधीय दशाएं इंगित करती है।

सूचक शब्द—*इलोडेफायल्लम*, दक्कन अंतःट्रेपी, सिंहपुर।

INTRODUCTION

THE fossil flora is very well known from the Deccan Intertrappean beds of India in the form of impression, petrification and fossilized fragment forms. A number of dicotyledonous and monocotyledonous roots, stems, leaves, flowers and fruits were studied as petrification by many workers reported from the Deccan Intertrappean sedimentary beds of central India. Mahabale and Udwadia (1960), Bonde *et al*. (2009) worked on monocot root, while Chitaley (1968), Kapgate (2005) worked on dicot root. Petrified leaves reported by Sheikh and Kolhe (1980), Mistri *et al.* (1995). The first petrified flower reported by Shukla (1944), later on Paradkar (1971), Chitaley and Patel (1973), Kapgate *et al.* (2006) worked on flower. The dicot fruit was described by Sahni (1943), Chitaley and Kate (1977), Mehrotra *et al.* (1983), Ambwani *et al.* (2004), Meshram (2013). Monocot fruit was reported by Bonde (1990), Kapgate *et al.* (2011). Majority of petrified stems are palms, assigned to the form genus *Palmoxylon*. Bonde (1995) described a large number of palm stems while dicot woods are reported by Bande (1973), Rashmi Srivastava (2010) from these beds.

The paper deals with the anatomical description of a fossil leaf collected from the Deccan Intertrappean sedimentary beds of the fossiliferous locality Singhpur, Madhya Pradesh, India (Lat. 19°58.141'N, Long. 78°40.838'E). Petrified leaves showing mature and young conditions are studied for anatomical details for the first time from this exposure.

The dicot leaves which could not be assigned to any of the modern families were described under the form genus *Phylites* (Rode, 1935) and *Dicotylophyllum* (Sheikh, 1980). A few leaf impressions such as *Smillaites* and *Flacourtiatites* (Nambudiri, 1970) assignable to modern taxa are reported from the Deccan Intertrappean beds. Petrified dicot leaves reported from these beds are *Deccanophyllum intertrappea* (Sheikh & Kolhe, 1980), *Dorsiventrophyllum chitaleyii* (Mistri *et al*., 1995); *Julianiophyllum sahnii* (Kapgate, 1999) and *Salicaceophyllum mohgaonsis* (Kapgate *et al*., 2008); *Marcgraviaceophyllum mohgaonse* (Kapgate & Paliwal, 2009), *Acanthophyllum shiblii* (Ramteke & Kapgate 2014); Monocot leaves, namely *Aerophyllites intertrappea* (Chitaley & Patil, 1970), *Thalassiophyllum mahabalei* (Kokate *et al*., 2010), *Hydrocharitaceophyllum patileii* (Narkhede & Nandeshwar, 2011), *Cariceophyllum singhpurii* (Dhabarde *et al*., 2012.), *Typhophyllites ganeshii* (Kokate *et al*., 2012.), *Potamogenatophyllites intertrappea* (Kokate *et al*., 2014) were reported from the Deccan Intertrappean exposures of central India.

MATERIAL AND METHODS

The present fossil specimen is a nicely preserved monocotyledonous and isobilateral leaf exposed in its transverse plane. The present fossil leaf was preserved in the silicified chert in the petrified form. After breaking the chert, single mature leaf, along with 10–12 small young leaves in a group was exposed in transverse section. The anatomical details were studied by etching the specimen with hydrofluoric acid and taking peel sections by applying peel technique.

DESCRIPTION

The present specimen is monocotyledonous and isobilateral leaf showing central midrib and lateral lamina (Pl. 1.1, 3). The lateral lamina is long and continuous on both the sides and forms laminar wings. It is up to 7.8 mm in width measuring 4.7 mm in left side and 3.1 mm in right side. The lamina is 0.1 to 0.5 mm thick. The lamina shows lateral veins with vascular bundles. The midrib region is 0.3 to 0.5. mm in thickness. (Pl. 1.4).

The anatomical detail of leaf is as follows:

Epidermis—The present leaf is covered on both the surfaces by single layered epidermis. The epidermis is well preserved and is made up of compactly arranged one celled thick large rectangular parenchymatous cells. Each cell is quite large and elongated, measuring 19–25 µm in size. The epidermis is without stomata and other out growths such as trichomes or hairs. Few air spaces are seen enclosed in lamina and midrib region (Pl. 1.7; Figs c, e). The epidermal cells shows some brown content and a few circular dots that may be the chlorophyll pigment (Pl. 1.6; Fig. 1 e). The epidermis is covered with waxy cuticular layer on both sides.

Mesophyll—In between epidermal layers a few mesophyll cells are present in mature leaf but are absent in small young leaves. Mesophyll tissue is undifferentiated (Pl. 1.5, 6; Fig. 1 e) and chlorophyllous. The cells of mesophyll are 15–20 µm in height. In a few air spaces are present measuring 9–12 µm in diameter.

PLATE 1

1. Group of young petrified leaves transversely exposed on a chert (15 x).
2. Transverse section of living *Elodea* leaves.
3. Transverse section of mature fossil leaf (15 x).
4. Magnified view of midrib showing bundle sheath, xylem and phloem (100 x).
5. Magnified view of lateral vein showing collateral vascular bundle (50 x).
6. Magnified view of lateral vein showing air cavity (100 x).
7. Lateral vein and cavities (50 x).

Bundle sheath–bs, xylem–xy, phloem–ph

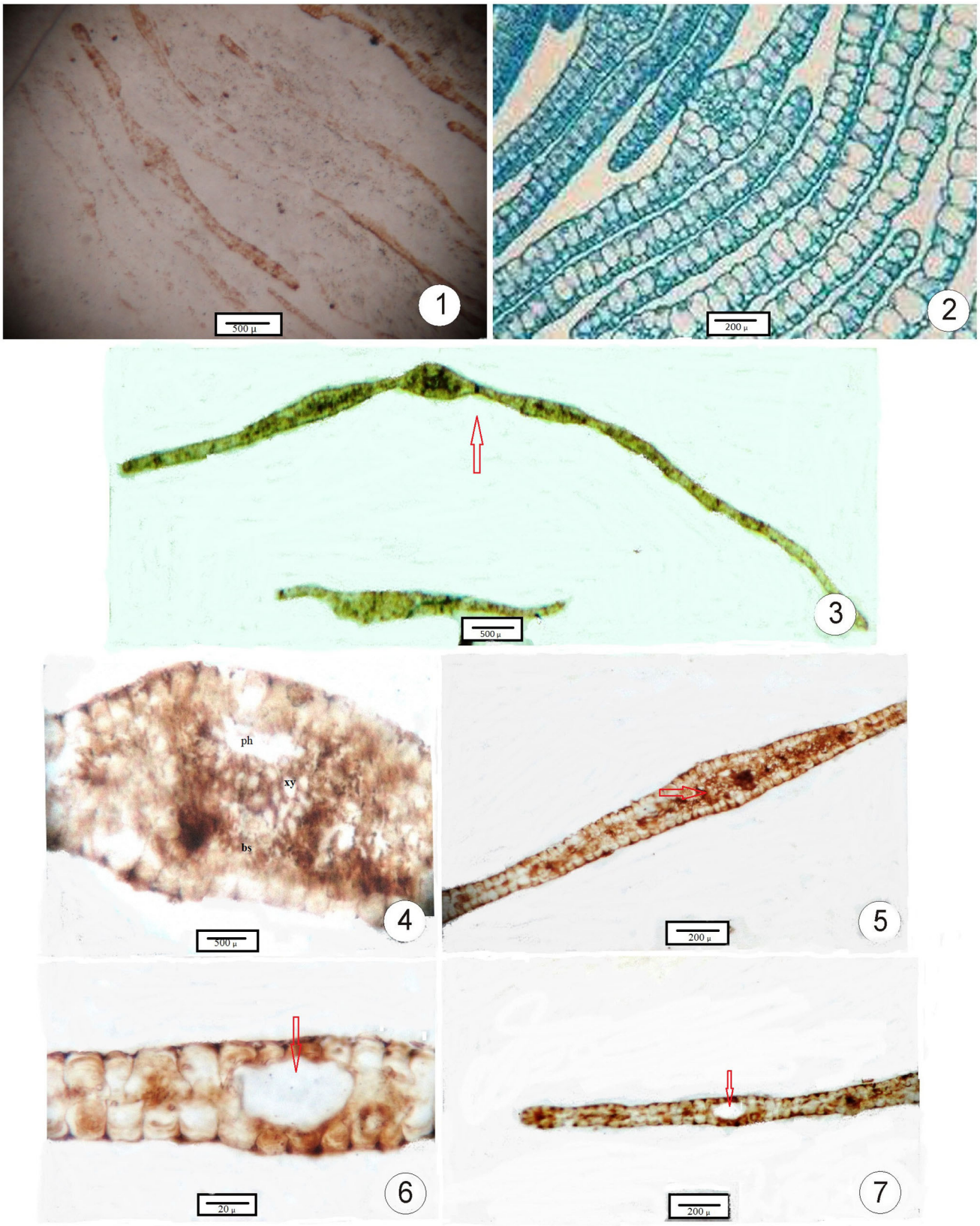

PLATE 1

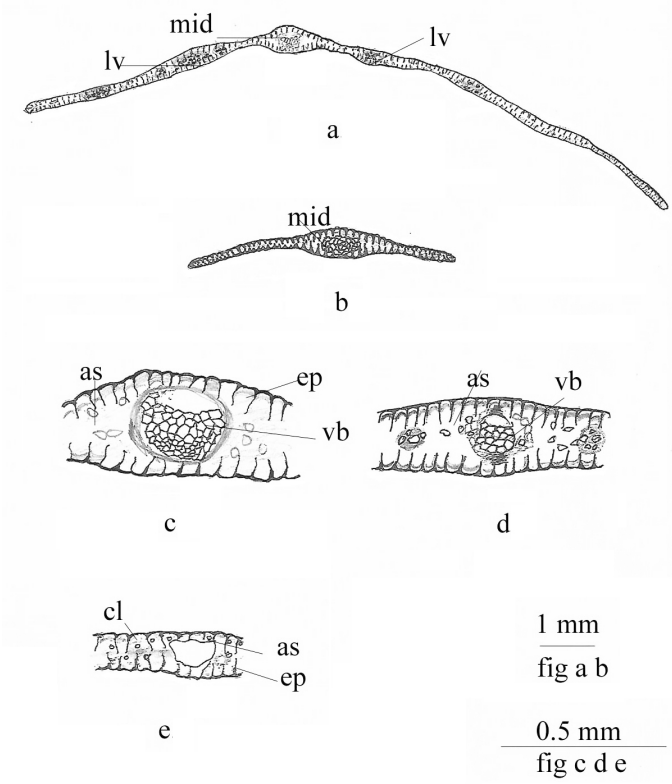

Fig 1—a. T.S. of mature leaf showing distinct midrib (mid) and lamina with lateral veins (lv) on both sides. b. T.S. of young leaf showing midrib. c. Midrib region of mature leaf showing vascular bundle (vb). d. Lateral vein showing vascular bundle and air spaces (as). e. Lamina of mature leaf showing waxy cuticle, epidermis (ep), air space (as) and chlorophyll content (cl).

Midrib—The midrib consists of bundle sheath, phloem, and xylem vessels (Pl. 1.4; Fig. 1c).

Vascular Bundles—Vascular bundle of midrib is large having vascular strand including xylem vessels arranged in radial rows measuring 0.8 × 1.9 mm in size. It is conjoint, collateral type (Fig. 1c). Numerous rectangular to hexangular xylem vessels measure 180–220 µm and are arranged in radial manner. They are differentiated into metaxylem and protoxylem. Metaxylem elements made up of rectangular xylem vessels are 3 to 5 celled and measure 80–90 µm in thickness. Protoxylem elements are in 1 to 2 layers and 55–65 µm thick. Phloem tissue is not preserved leaving the cavity. The complete vascular bundle enclosed by 40–55 µm thick fibrous sclerenchymatous bundle sheath.

Lateral lamina—Vascular bundles in lateral lamina are small, several on both sides. Each lateral lamina measures 0.18–0.25 mm in size (Pl. 1.5; Fig. 1d). Vascular bundles of veins are conjoint, collateral and endarch (Fig. 1d). A few cells of bundle sheath extension are preserved. Thus it shows that vascular bundles of lateral veins have sclerenchymatous bundle sheath extension. Veins are covered by bundle sheath.

DISCUSSION AND IDENTIFICATION

The fossil leaf has following diagnostic features:

- Epidermis is single layered without any outgrowths like hairs or trichomes.
- Stomata are absent.
- Waxy cuticle on both surfaces.
- Mesophyll is undifferentiated, chlorophyllous with a few air spaces.
- Mesophyll layer is absent in young leaves.
- Vascular bundle of midrib is single, large and having radially arranged vascular strand. Phloem tissue is not preserved leaving the cavity instead of phloem.
- It is conjoint and collateral; sclerenchymatous bundle sheath is present.
- Several lateral veins are on both the sides.

Comparison with the already known fossil leaves

The fossil leaf under consideration is isobilateral and therefore, belongs to monocots. *Aerophyllites intertrappea* (Chitaley & Patil, 1970) differs in having hypodermis, air chambers in mesophyll tissue forming continuous tube. *Thalassiophyllum mahabalei* (Kokate *et al*., 2010) differs in having air cavities in single series, regular segmentation of air cavities and hypodermal region with fibrous strands. *Hydrocharitaceophyllum patileii* (Narkhede & Nandeshwar, 2011) differs in having four large air cavities in the centre, vascular bundle in the centre of the septa of air cavities. *Cariceophyllum singhpurii* (Dhabarde *et al.,* 2012) has air cavities in mesophyll tissue, but differs from present fossil leaf in having 18 vascular bundles, amphistomatous and large mesophyll cells in the middle. *Typhophyllites ganeshi* (Kokate *et al*., 2012) differs in having air cavities in mesophyll. *Potamogenatophyllites intertrappea* (Kokate *et al*., 2014) shows similarity in having undifferentiated mesophyll but differs from the present fossil in possessing cavities in single row and vascular bundle only in partition wall.

Comparison with modern taxa

The fossil leaf is compared with the modern leaves of monocotyledonous families, namely Typhaceae, Pandanaceae, Sparganiaceae, Araceae, Alismataceae, Aponogetonaceae, Potamogetonaceae and Hydrocharitaceae (Metcalfe & Chalk, 1950). The leaves of these families resemble the present fossil in having general characters of a hydrophytic leaf, such as presence of air cavities, undifferentiated mesophyll and waxy cuticle, but differ in various ways. The family Typhaceae possesses a prominent system of aerochymatous channels which are compartmentalized by 1–3 layered thick diaphragm interspersed with large intercellular spaces. Stomata are paracytic. Epidermis contains myriophyllin cells filled with tannin. Family Pandanaceae differs in having papilla and

stomata. Family Sparganiaceae widely differs in presence of paracytic stomata. The mucilage cells (with raphides) of the mesophyll contain calcium oxalate crystals, minor leaf veins are without phloem transfer cells and vessels end–walls are scalariform. Family Araceae comprises of uniseriate epidermis and collateral vascular bundles but widely differs in presence of stomata in abaxial surface, mesophyll consisting of chlorenchyma and vascular bundles completely surrounded by sclerenchyma. In addition in the midrib and petiole, they are surrounded by parenchyma cells rich in starch. Moreover, idioblasts containing phenolic compounds and calcium oxalate crystals are also found. Leaves of the family Alismataceae consist of nonglandular trichomes in the midrib, crystals are frequent in the mesophyll and paracytic stomata on leaf surface and hydropoten are present. Hydropoten, articulated laticifer and crystals are present in leaves of the family Aponogetonaceae. Potamogetonaceae differs in having large air cavities, presence of vascular bundles present on both sides of lacuna and chlorenchymatous tissue in epidermal region. The palisade tissue is not seen in this family. Hydrocharitaceae resembles the most in having undifferentiated mesophyll, waxy cuticle, single layered epidermis, air cavities in epidermis and mesophyll layer and chlorophyll pigments. Moreover, vascular bundle of midrib is radially arranged, single, large, conjoint, collateral and sclerenchymatous bundle sheath present. Phloem tissue is not preserved but is marked by the cavity. Several lateral veins are present on both the sides, while lateral vascular bundles are conjoint and collateral.

The present specimen is compared with the genus of family Hydrocharitaceae. *Thalassia* differs in having uniseriate hypodermis, three to five longitudinal air–canals between consecutive vascular girders, each air–canal delimited by one cell thick longitudinal partitions. *Hydrilla* differs in having transfer cell, serrations on the leaf edge, spines on the midrib. *Lagarosiphon* differs in having 3 veins with visible midvein, minutely toothed leaf margin.

It is evident from the above comparison that the fossil leaf resembles in many characters to the family Hydrocharitaceae, especially with *Elodea* hence, the present fossil leaf is kept under the family Hydrocharitaceae and named as *Elodeophyllum deccanii* gen. et sp. nov. The specific name after the Deccan trap.

Palaeoecological significance

Presence of air spaces in epidermis and mesophyll indicates aquatic habitat, while waxy cuticle on both surfaces shows submerged nature of plant. Ecologically, the family is found throughout the world in a variety of habitats, but is mainly tropical in nature.

Holotype—VDN/Ang. Leaf/Deposited in Department of Botany, Institute of Science, Nagpur.

Horizon—Deccan Intertrappean beds.

Locality—Singhpur, Madhya Pradesh, India.

Age—Uppermost Cretaceous (Maastrichtian).

Diagnosis

Elodeophyllum gen. nov.

A monocotyledonous isobilateral leaf with single layered epidermis without stomata and any outgrowth, chlorophyllous with a few air spaces. Mesophyll undifferentiated in palisade and spongy parenchyma, several lateral veins at both the sides of leaf, lateral vein vascular bundles conjoint and collateral and presence of air cavities.

Elodeophyllum deccanii gen. et sp. nov.

A leaf measuring 7.8 mm in length, lateral lamina on right side 3.1 mm and on left side 4.7 in length and 0.1–0.5 mm thick. Midrib ranges is 0.3 to 0.5. mm in size. Epidermis of single layered elongated cells, waxy cuticle on both surfaces. Mesophyll undifferentiated, measuring 15–20 μm in height. Median vascular bundle well preserved, lateral vascular bundle conjoint and collateral. In mesophyll, air spaces present measuring 9–12 μm. Stomata absent. Metaxylem elements measuring 80–90 μm and protoxylem 55–65 μm in size.

Systematic Position

ANGIOSPERMS

MONOCOTYLEDONS

ALISMATALES

HYDROCHARITACEAE

Elodeophyllum gen. nov.

Elodeophyllum deccanii gen. et sp. nov.

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