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Distribution and pollen characters of selected aquatic angiosperms of Pondicherry region, South India

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ABSTRACT

The distribution of selected hydrophytes and their pollen morphology was carried out in six water bodies of Puducherry outskirts during the years 2006-07. Fifteen angiosperm species belonging to fifteen genera and fifteen families were identified (*Aeschynomene indica*, *Aponogeton natans*, *Eichhornia crassipes*, *Ipomoea aquatica*, *Limnophila polystachia* , *Ludwigia adscendens*, *Nelumbo nucifera*, *Neptunia oleracea*, *Nymphaea pubescens*, *Nymphoides hydrophylla*, *Ottelia alismoides*, *Persicaria pulchra*, *Pistia stratiotes*, *Scirpus articulatus*, *Typha angustata).* Many of the species observed were found in all the places studied. The mean number of pollen production per anther ranged from 847 to 41416. The pollen grains are mostly apolar or isopolar rarely heteropolar. The shape is commonly spheroidal or oblate-spheroidal rarely boat shaped (*Nymphaea pubescens*) and sub-prolate (*Nelumbo nucifera*). In *Typha angustata* the pollen grains are found in tetrads. Similarly exine sculpturing is also extremely varied ranging from reticulate to regulate. Apertures are mostly colpate or porate. The present study for the first time documents the diversity and pollen morphology of selected species in water bodies of the coastal environs.

Introduction

Wetland ecosystem is an important environment for aquatic, semi-aquatic and moisture loving floral and faunal associations. Aquatic floral species act as bio-filter, as they intake large amount of organic as well as inorganic nutrients from eutrophic water bodies/nutrient enriched pollutant through various dynamic processes, like water cycle, nutrient cycle and food chain, therefore known as kidney of the landscape or biological super market of the areas where the soil saturated with water are crucial incubators known for high species diversity [1-2]. Several angiosperms and ferns are established well solely in the aquatic habitats like ponds, lakes, puddles, reservoirs, streams, channels etc. as flora, while fresh water fishes, amphibians, crustaceans and reptiles are the important fauna and this ecosystem needs to be conserved for sustainable development [3-4].

Due to increasing anthropogenic pressures such as increasing human population, urbanization, industrialization and inadequate sanitation the water bodies are becoming dumping sites of waste materials, fragmented and degrade very fast ultimately increase the alien species and further reduction in native macrophytic diversity of aquatic ecosystem [4]. The removal of even a single aquatic plant species from these communities can unbalance the ecosystem and cause valuable genetic resources to disappear. Many species are endangered due to unscrupulous collection of the plants from the wild. So it is necessary to explore the vegetation of a unique, deteriorating habitat periodically to understand the impact of environment on vegetation.

Most of the aquatic plants have anatomical, morphological, reproductive and physiological peculiarities. The morphology of the pollen is an important tool for the identification of species of aquatic angiosperms. The analysis of pollen can reveal the identity of the plants, from where they originated, since each group of pollen has its own characteristics and shape. Pollen grains under certain conditions are virtually indestructible, thus paving the way for the survival of man and animals through drought, famine, wars, earthquakes or whatever terrible mishap may befall many unfortunate people on this earth. A methodical investigation of pollen grains will, slowly but surely, reveal changes that have taken place in the plant and animal world since the ice age, like the unfolding of ancient history before our eyes. The exine layer endowed with all the patterning attributes remarkable to pollen, may be specific to family, tribe, genus or even species. It is possible to relate pollen fossils preserved in geological deposits to living plant pollens, providing valuable clues on the history of plant life in past geological eras [5]. It also provides information about the vegetation of a particular area and the climatic changes that have occurred [6]. Palynologists depend upon matching unknown fossils with present day reference pollens, making the important assumption that there have been no evolutionary changes in exine structure [7]. Changes in vegetation can be related to what is now known of the history of continental geography.

However, literature dealing with the pollen morphology of aquatic flowering plants is rather scarce. The present study explores the distribution and pollen morphology of selected hydrophytes from six water bodies in and around Puducherry for the first time.

Materials and Methods

Study site

Pondicherry is a Union Territory bounded by the Bay of Bengal on the east and by the Cuddalore and Vizhupuram district of Tamilnadu on all other sides. It lies between 11°46'-12°3' N and 79°36'-79°53' E. The total area covered by this region is *ca.* 290 square kilometers of which *ca*. 25832-hectares

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of lands are used for cultivation. The climate is dry except during the Northeast/retreating monsoon. The average annual rainfall was recorded 1282 millimeter with 54 mean rainy days during the year 2006-'07. The temperature extends between 20˚C and 38˚C January and May respectively (Figure 1.). The relative humidity of the atmosphere ranged from 75-90 percent. There are about 80 water bodies existing in and around Puducherry amidst rich diversity of flora and fauna.

Periodical survey were made on six water bodies of Pondicherry and its outskirts (Bahour, Ousteri, Puthurai, Thuthipet, Veerampattinam and Velrampet), in two years period. Fifteen angiosperm species were chosen for this study (Table1.). The specimens collected were identified with the help of regional floras [8-9] and photographs illustrated (Plates 1-5).

Pollen Productivity

Pollen production per anther was estimated using Haemocytometer method [10]. Mature flower buds were collected just before opening. Anther was crushed in one milliliter (ml) distilled water; 0.1ml of residue was poured on the sterile glass slide by using micropipette spread evenly using sterile scups and covered 22 mm (number zero) sterile cover glass. Pollen counts were done with the help of haemocytometer in the light microscope. The counting was repeated for 25 times and the mean values were presented.

Pollen morphology

Pollen morphological features were scrutinized under stage micrometer and expressed in micrometer (μm) (Table 2). Pollen size, shape, sculpture, aperture were taken into account in the optical section of meridinal view (Equatorial view) of pollen grains prepared by using Wodehouse method [11]. The Mean and Standard Deviation (SD) of each pollen grain were calculated. The size measurement of the pollen grains was considered excluding sculptural elements such as spines, verrucate etc.

Results and Discussion

Fifteen angiosperm species belonging to fifteen genera and fifteen families were identified from six water bodies of Puducherry and its surroundings in the present study. The taxonomy and pollen morphology of species identified were described below

1. *Aeschynomene indica* L.

Sub-shrub; leaves odd pinnate, alternate/opposite, leaflets 30-35 pairs, oblong, stipules setaceous; raceme; peduncle and pedicle present; calyx tube hispid, bi-lipped; corolla yellow, standard petal orbicular; Stamens 5+5, anthers uniform. Occurs in low-lying, marshy areas and banks of lakes. Flowering throughout the year (peak during January-March).

2. *Aponogeton natans* (L.) Engl. & K. Krause

Aquatic or marsh herb, rhizome tuberous; leaves submerged or floating, base sheathing, lateral nerves parallel, cross nerves prominent; spike, spathe caducous; flowers bisexual; tepals 2, persistent, violetish; stamens 6. Distributed in the plains, especially by the coast in ponds. Flowering from May to June.

3. *Eichhornia crassipes* (Mart.) Solms- Laub.

Free floating and rooting at nodes to the mud; stolon slender; leaves erect or floating, ovate, rotund, cordate rarely lanceolate; petioles usually turbinately swollen to form floats, up to 10 inches long; flowers simple, irregular, rarely paniculate, sub-spicate racemes from the sheath of the leaf; perianth tube greenish, sub erect, lobes 3+3, upper one lilac, with a blue bordered yellow median blotch, lower ones gradually smaller; stamens 3+3, sub-equal. A serious pest in all waterways and lakes. Flowering from January-April.

4. *Ipomoea aquatica* Forsskal

Syn: *Ipomoea reptans* Poiret

Profusely branched aquatic creeper rooting at nodes, branchlets semi-succulent, usually floating; leaves lanceolate to hastate; flowers single or in cymes; calyx lobes sub-equal; petals five, corolla pink, funnel shaped; stamens 5, unequal, villose at base. Occurs commonly in the plains, especially by the coast, stagnant ponds, irrigation canals, river banks. Flowering from November to March, opening after 9 am.

5. *Limnophila polystachia* Benth.

Gregarious, prostrate, partly submerged herb; profusely branched forming dense mats; leaves sessile, ternate, linear-lanceolate, laciniate below, 3-nerved, serrulate, capillaceo-multifid; flowers in decussate pairs, bracteoles linear; calyx lobes 5, equal; corolla tubular, lobes 5, unequal, pink/ white; Stamens 4, didynamous. It is found to be common towards the coast, in still water with extensive clumps. Flowering from November to April.

6. *Ludwigia adscendens* (L.) H. Hara

***Syn: Jussieua repens* L.**

Floating, profusely branched herb, with spongy, cream, fusiform, mucronate, aerophores; leaves alternate, oblong-elliptic, glabrous; flowers 4 cm across; calyx lobes 5, deltoid; petals 5, cream with a yellow blotch inside, obovate; stamens 10. Occurs in the plains from the coast, perennial ponds and marshy places. Flowering throughout the year.

7. *Nelumbo nucifera* Gaertn.

Syn: *Nelumbium speciosum* Willd.

A gregarious, stoloniferous, floating herb; leaves usually floating, sometimes erect, rotund, flat, somewhat hollowed, waxy, glaucous beneath, entire, petiole stout and long; flowers erect or cernuous, as long as petiole; sepals 4 or 5, greenish/white, adnate to torus; petals many, rose, gradually diminishing in size and transforming into stamens; Stamens numerous, appendaged, inserted above petals, anthers long. Found very often in ponds. Flowering throughout the year.

8. *Neptunia oleracea* Lour.

Floating, profusely branched, gregarious herb with white spongy floats on the internodes; leaves alternate, bipinnate, pinnae 2-3 pairs, leaflets 10-14 pairs; floral-head solitary, oblong; pedunculate; flower pentamerous, polygamous, bisexual apically, male in the middle and sterile ones at the base; calyx tube 5-lobed; petals yellow, oblanceolate, clavate; stamens 10, free, anthers gland tipped. Common in still waters. Flowering from December-February.

9. *Nymphaea pubescens* Willd.

Stoloniferous aquatic herbs; leaves peltate, usually floating, flat, deeply cordate at base, nerves radiating and bifurcating at periphery, glabrous waxy, green above, purple below, entire or dentate; flowers solitary, actinomorphic, bisexual; sepals four; petals many, rose, arising from base of torus; receptacle copular; stamens numerous, often basally united to the petals, filaments appendaged. Common in stagnant water bodies. Flowering throughout the year.

10. *Nymphoides hydrophylla* (Lour.) Kuntze

Syn. *Limnanthemum indicum* (L) Griseb

Perennial, aquatic, rhizomatous herbs; stems petiole like, succulent; leaves on the proximal node of the stem, floating, peltate, orbicular-reniform, palminerved; flowers in umbellate fascicles, bracteate, pentamerous; calyx lobes 5, shortly connate, persistent; corolla sub-rotate, lobes 5, white with yellow centers, disc glands 5, nectariferous; stamens 5, filaments filiform. Occurs in ponds and slow-flowing rivers. Flowering throughout the year.

11. *Ottelia alismoides* (L.) Pers.

A flacid, submerged, fresh water herb; root stock ovoid, vertical; leaves radical, submerged and floating, submerged ones oblong, floating ones broadly ovate-suborbicular or cordate; flowers bisexual, solitary, sessile in a tubular, long peduncled spathe; sepals 3, oblong- lanceolate, persistant; petals 3, white with yellow spots, oblong-ovate; stamens 9-15 in 3-5 whorls, often unequal, anthers erect. Distributed from the coast to the plain in stagnant clear waters. Flowering throughout the year.

12. *Persicaria pulchra* (Blume) Sajak

Syn. *Polygonum tomentosum* Willd.

Gregarious, erect herb rooting at nodes; leaves lanceolate or linearly obovate, silky tomentose; ocreae tubular, 2-3 cm, ciliate, getting torn with age; panicles terminal; flowers actinomorphic bisexual, bracts ochreate, bracteoles 2-5, hyaline, pedicel jointed; perianth pinkish; Stamens 5.

Occur on the banks of stagnant pools, lakes, and low lying marshes. Flowering from December-February.

13. *Pistia stratiotes* L.

A small, free floating, gregarious, stoloniferous herb; roots of tufted fibres; leaves sessile in a close spiral forming a rosette structure, ovate-cuneate, densely pubescent on both surfaces, spathe small, short peduncle, opening into an ovate, concave limb; spadix adnate to the tube of spathe below and free above; male flowers represented by 4-6 sessile anthers in a synandrium found beneath the apex of spadix, neuters in a ring below male; female flowers solitary perianth nil. Occurring profusely in still waters of tanks. Flowering throughout the year.

14. *Scirpus articulatus* L.

Rhizomatous perennials, sometimes stoloniferous; stem tufted, transversely septate, spongy; Leaves reduced to sheathing scales. Inflorescence pseudo-lateral, capitate; spikelets usually 60 cm in a cluster, ovoid or oblong; glumes broadly ovate; stamens 3. Gregarious in marshy places. Flowering throughout the year.

15. *Typha angustata* Bory and Chaub.

Aquatic or Marsh herbs with perennial, creeping, rhizomatous; rhizome clothed with distichous scales; rachis terete; leaves distichous linear, erect, sheathing below, up to 8 feet long; flowers monoecious, minute, in terminal superposed dense cylindric spikes, the upper spike male, the lower of female flowers often intermixed with slender clavate bracts, sterile female flowers or simple or branched hairs; perianth absent; stamens 3, filaments connate, tip of connective thickened; anther 4-celled, erect, basifixed. Gregarious weed of marsh habitats. Flowering throughout the year.

Pollen analysis

The pollen productions per anther and per flower of fifteen species were presented in Table 2. The mean number of pollen production per anther was maximum in *Nymphaea pubescens* (41416) and minimum in *Ottelia alismoides* (847). The mean number of pollen per flower was maximum in *Nelumbo nucifera* (5630700) and minimum in *Scirpus articulatus* (4425). Of the fifteen species studied the largest pollen was recorded in *Ipomoea aquatica* (81.795 µm) and the smallest in *Typha angustata* (23.31 µm). The pollen grains are mostly apolar or isopolar rarely heteropolar. The shape is commonly spheroidal or oblate-spheroidal rarely boat shaped as in *Nymphaea pubescens* and sub-prolate as in *Nelumbo nucifera*. However in *Typha angustata* the pollen grains are found in tetrads. Similarly exine sculpturing is also extremely varied ranging from reticulate to regulate. Apertures are mostly colpate or porate (Table 2 and Plates 1-5).

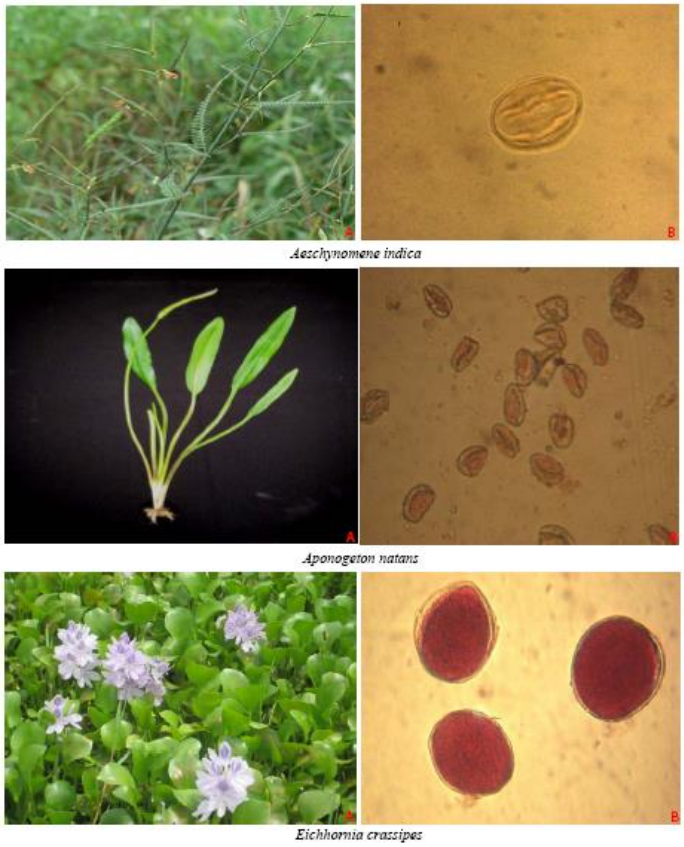

Plate 1. Habit (A) and Pollen (B) of hydrophytes

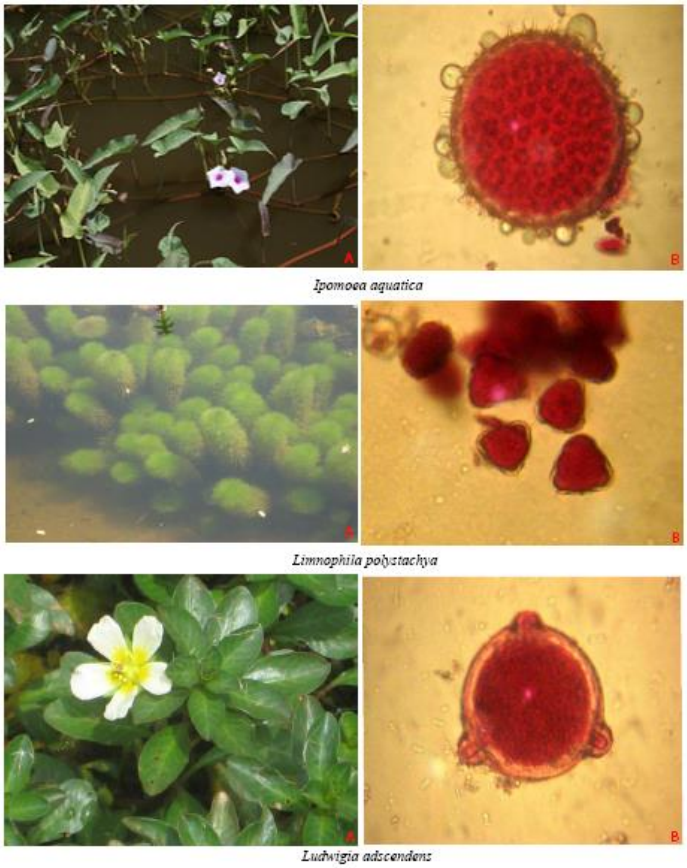

Plate 2. Habit (A) and Pollen (B) of hydrophytes

Aquatic plants are an extremely heterogeneous assemblage of species belonging to various families that survive in similar habitats but evolved from fundamentally different evolutionary pathways. They are unique in their diversity and vulnerable like all other tropical rain-forest ecosystems. They also exhibit great diversity in their pollen characters such as shape, size, aperture,

polarity and tectum type [12]. The morphology of the pollen is an important tool for the identification of species of aquatic angiosperms. Further the pollen profile of a particular area reflects the pattern of vegetation of the area under investigation. So it is essential to make a record of aquatic angiosperms periodically.

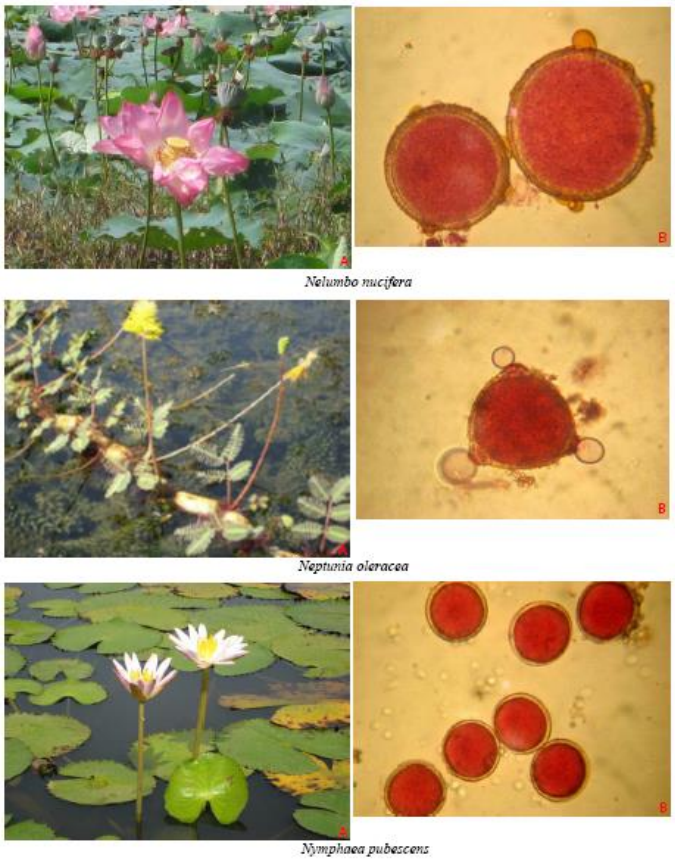

Plate 3. Habit (A) and Pollen (B) of hydrophytes

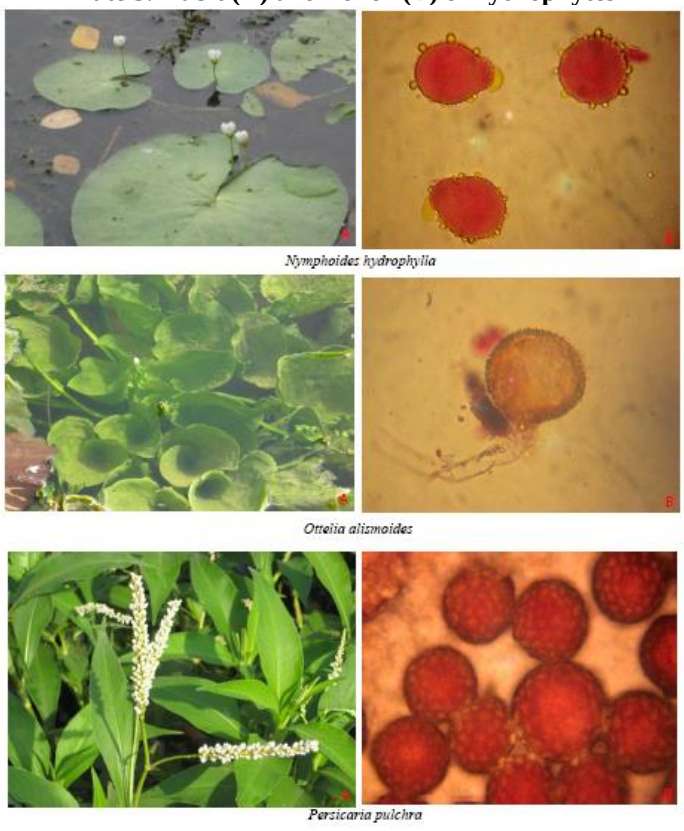

Plate 4. Habit (A) and Pollen (B) of hydrophytes

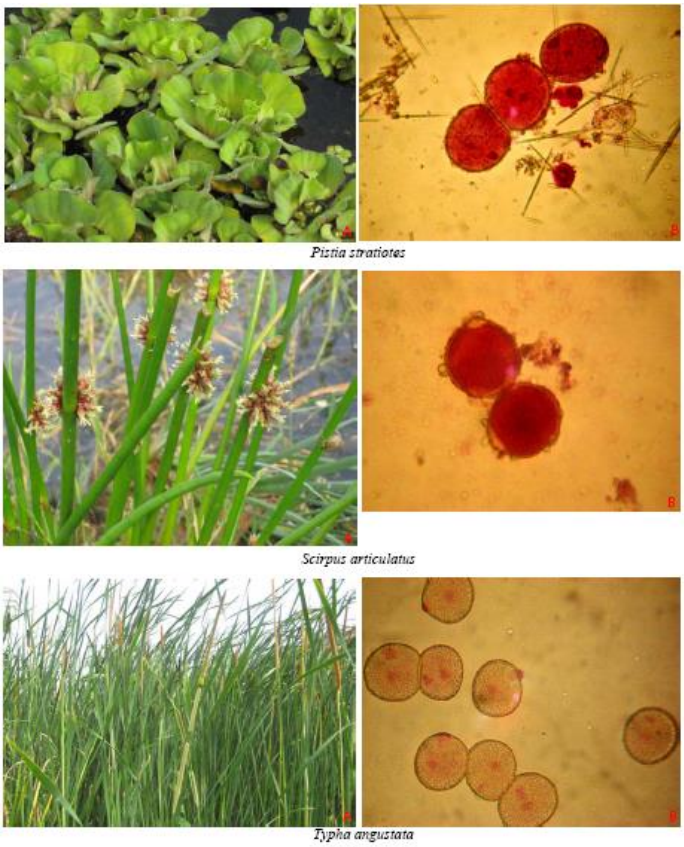

Plate 5. Habit (A) and Pollen (B) of hydrophytes

According to [13-14] the aquatic angiosperms include about 79 families and 380 genera. [15] listed out 117 aquatic angiosperms in India. Later [16] has published the aquatic and wetland flora of India. [17] have documented 45 hydrophytes from five ephemeral lakes of Chennai suburb and highlighted the wealth of aquatic plants. Fifteen angiosperm species belonging to fifteen genera and fifteen families were identified in the present study. Many of the species observed were found in all the places studied. *Limnophila polystachia* was found in one place only (Thuthipet). Most of the species studied were found throughout the year. Ousteri was found to be the richest lake in aquatic angiosperms. Most of the species occur in gregarious masses especially those which produce pollen grains in large number. Thus the present study for the first time documents the diversity and pollen morphology of selected species in water bodies of the coastal environs.

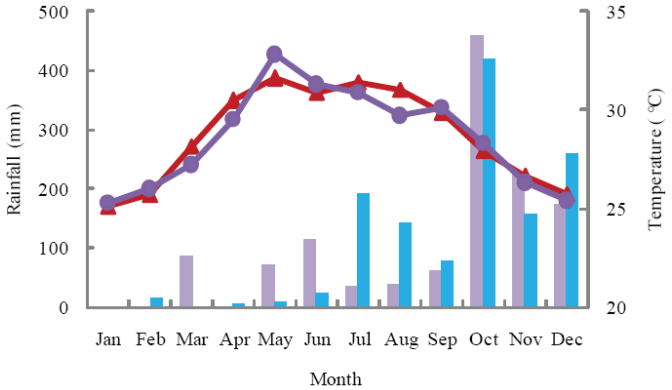

Figure 1. Pattern of rainfall and temperature during the study period

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Table 1. Distribution of selected hydrophytes in the study sites

Binomial	Family	Study sites					
		Bahour	Ousteri	Setharapattu	Thuthipet	Velrampet	Puthurai
Aeschynomene indica *L.*	*Fabaceae*	+	+	+	-	-	-
Aponogeton natans (L.) Engl. & K. Krause	Aponogetonaceae	+	+	+	+	+	+
Eichhornia crassipes (Mart.) Solms- Laub.	*Pontederiaceae*	++	+	++	+	+	++
Ipomoea aquatica Forsskal	*Convolvulaceae*	+	++	++	++	++	+
Limnophila polystachia *Benth.*	*Scrophulariaceae*	-	-	-	++	-	-
Ludwigia adscendens (L.) H. Hara	Onagraceae	+	+	+	+	+	-
Nelumbo nucifera Gaertn.	Nelumbonaceae	++	+++	+++	++	++	++
Neptunia oleracea Lour.	Mimosaceae	++	+++	++	-	-	-
Nymphaea pubescens Willd.	Nymphaeaceae	+++	+++	+++	++	++	++
Nymphoides hydrophylla (Lour.) Kuntze	Menyanthaceae	++	++	+	+	+	+
Ottelia alismoides (L.) Pers.	Hydrocharitaceae	+	+	+	++	+	+
Persicaria pulchra (Blume) Sajak	Polygonaceae	++	++	++	+	++	-
Pistia stratiotes L.	Araceae	++	+	+	++	+	+
Scirpus articulatus L.	Cyperaceae	+	++	+	-	+	-
Typha angustata Bory and Chaub.	Typhaceae	++	+++	++	+	++	++

Note: +++ = abundant; ++ = common; + = rare; - = absent

Table 2. Pollen traits of selected Hydrophytes

Species	Pollen/anther	Anthers/ Flower	Pollen/ Flower	Pollen size (µm)	Pollen shape
Aeschynomene indica	6272	10	62720	22.454 ± 0.847	Isopolar, Spheroidal
Aponogeton natans	1525	6	9150	L=23.602 ± 1.037 B=13.406 ± 0.625	Heteropolar, Ellipsoid
Eichhornia crassipes	6787	6	40722	L=69.525 ± 1.732 B=40.500 ± 1.975	Heteropolar, Oblong
Ipomoea aquatica	6018	5	30090	81.795 ± 2.620	Isopolar, Spheroidal
Limnophila polystachia	5391	4	21564	18.862 ± 0.652	Heteropolar, Triangular
Ludwigia adscendens	4375	10	43750	71.437 ± 2.351	Spheroidal, Echinate
Nelumbo nucifera.	20550	274	5630700	63.881 ± 2.375	Isopolar, Spheroidal
Neptunia oleracea	1633	10	16330	64.537 ± 1.971	Isopolar, Spheroidal
Nymphaea pubescens	41416	79	3271864	36.063 ± 2.320	Heteropolar,Boat haped
Nymphoides hydrophylla	5133	5	15665	27.018 ± 0.713	Heteropolar, Oblate
Ottelia alismoides	847	9	7623	60.795 ± 1.975	Isopolar, Spheroidal
Persicaria pulchra	1023	8	8184	46.327 ± 0.965	Apolar, Spheroidal
Pistia stratiotes	1116	6	6696	L=35.831 ± 1.832 B=31.687 ± 1.226	Heteropolar, Ellipsoidal
Scirpus articulatus	1475	3	4425	34.582 ± 1.087	Heteropolar, Triangular in equatorial view, circular in polar view
Typha angustata	13800	3	41400	23.310 ± 0.653	Apolar, Spheroidal

Note: Values are mean ± Standard error; L= Length B= Breadth

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