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POLLEN MORPHOLOGY OF AQUATIC FLORA OF THE INDIAN BOTANIC GARDEN, HOWRAH, WEST BENGAL

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ABSTRACT

The paper presents pollen morphological study of the aquatic flora growing in the different pools and lakes of the Indian Botanic Garden, Shibpur, Howrah, West Bengal. In the present study 64 species, comprising 4 Pteridophytes, 23 Dicotyledons and 37 Monocotyledons have been described with special notes and/or remarks, if any. This study will be helpful for correct taxonomic identification of the aquatic plants as well as correlation of the lake sediments.

INTRODUCTION

The Indian Botanic Garden, Howrah was established in 1787 covering an area of 112 hectares on the West bank of the river Hooghly. Its unique landscape design initiated by Sir George King 1872 is considered to be one of the best in the botanic gardens of the world with the undulated land surface, artificial lakes and moats. Two century later now, this garden is a hidden treasure to the taxonomists and morphologists for studying hydrophytic vegetation on account of presence of several lakes and pools. Many plants of wide ecological groups from different parts of India and from other continents are being introduced from time to time in this garden for their taxonomical, and biosystematical interests. Some of these are being well suited in this climate and flowered.

Indian subcontinent is very rich with her fresh water aquatic flora for its tropical climatic condition and favourable edaphic factors which enable a very good place for studying the biology of the aquatic plants. At present this aspect is becoming a fascinating field of botanical research for better understanding of the adaptibility of the hydrophytes. In early days Arber (1920) made the most outstanding contribution to synthesise data on aquatic plants. Later on Biswas and Calder (1936, 1954) have described 171 species from 91 genera. Subramanyam (1962) described 117 taxa representing 32 families. In the last decade Deb (1976) made a very informative survey on the aquatic vascular plants of India and he recorded total 144 species from Pteridophytes, Monocotyledons and Dicotyledons with notes on distribution, endemism, indigenous and exotic elements. Mitra *et al.* (1971) published a list of aquatic and semiaquatic plants growing in the Indian Botanic Garden. They listed 94 species in total.

True hydrophytic habit is very much sensitive to temperature and water supply than the mesophytic one. Phenotypic plasticity is very common in aquatics when subjected to stress and create a taxonomic problem for the correct identification of the taxon (Backer 1951). The range of tolerance towards the habitat, sensitivity, physical and chemical properties of water and other factors are obviously reflecting on their pollen production, pollination, fertility and other reproductive factors. Sculthorpe (1967) made

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Out line map of the Indian Botanic Garden showing the details of the position of the lakes and division number a valuable contribution to the biology of the aquatic plants. Pollen morphological information on Indian aquatics are very meagre and mainly contributed by Raj and Saxena (1966) and Raj and Suryakanta (1973). They described only a few aquatic species common in Hyderabad. There are some stray pollen morphological descriptions of aquatic plant species published elsewhere in palynotaxonomical or phytomorphological studies by different authors like Erdtman (1952), Ram (1956), Maheshwari *et al.* (1956), Nair *et al.* (1963), Nair (1965), Sharma (1967), Mitra *et al.* (1982) and others.

The concept of aquatic plants may be subjected to various interpretations. Plants normally grow and develop the seedlings in water and have at least a part of their life cycle in water are treated as aquatic plants in the present study.

MATERIALS AND METHODS

Polliniferous materials of the aquatics were collected in different flowering seasons from the pools and lakes of the Indian Botanic Garden and sometimes from the culture pots of the Experimental Garden. Distribution of plants in different lakes have been abbreviated after the name of the plants. Fresh, mature, closed flower buds were selected. Pollen slides were prepared by Acetolysis method (Erdtman, 1960). Observations and measurements were based on the average of 25 readings of the pollen grains of each species. For palynological description the families have been arranged in accordance with the Bentham and Hooker (1862-1883) as modified in Kew Herbarium and Herbarium of the British Museum. Pollen morphological terminology of Erdtman (1952) and Faegri and Iversen (1964) has been followed.

Pollen grains, being three dimensional in some monocotyledons, the measurements are recorded as follows (Thanikaimoni, 1970).

L = the longest equatorial axis [measured equatorial and polar (distal and proximal) view of the pollen grains].

l = the short equatorial axis (measured in polar and lateral views).

P = the polar axis (measured in equatorial and lateral views).

Aperture—measure in distal polar view. The shape and measurements of the pollen grains are shown in Text Fig. I. Various pollen grains of the monocots are termed as convexo-convex, concavo-convex and plano-convex in the lateral views and spheroidal, ellipsoidal etc. in distal view following Erdtman (1952).

A map of the Indian Botanic Garden showing the details of the position of the lakes (*see* Map) is given which will be helpful for the future research on the correlation of the lake sediment deposits.

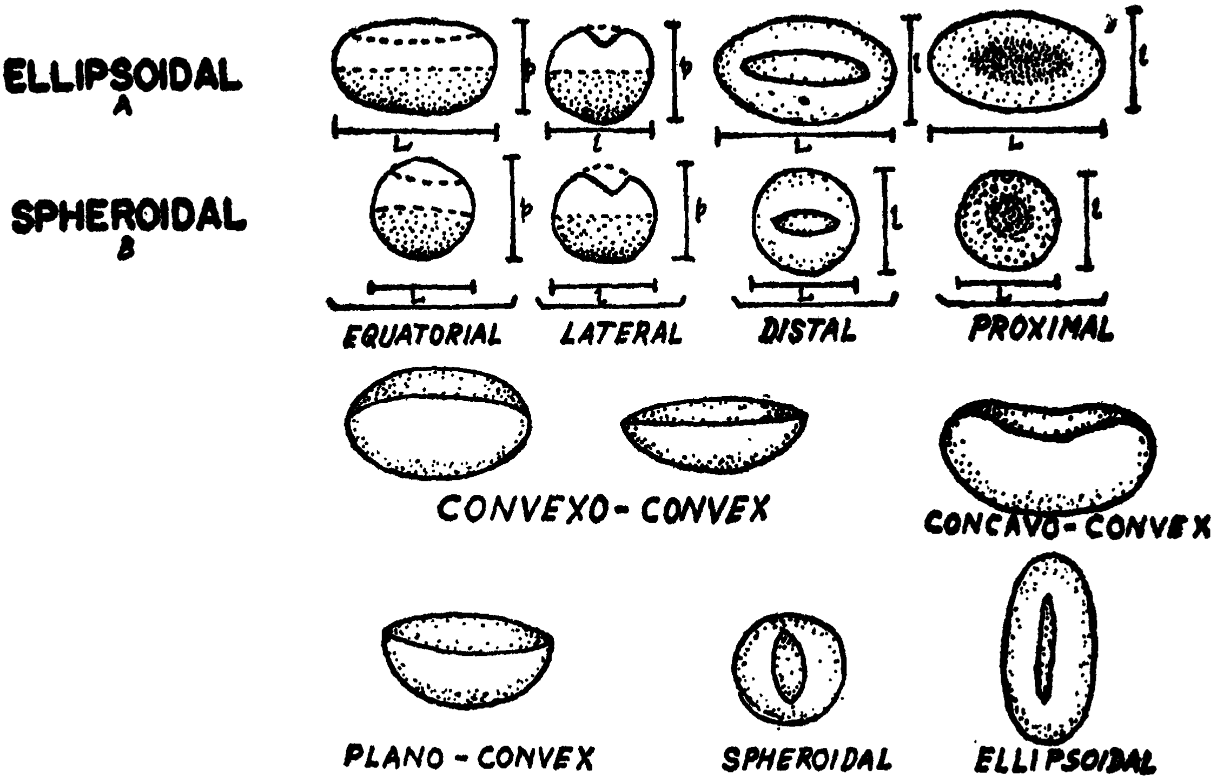
It should be mentioned here that besides the common water lilies and two giant water lilies (*Victoria*), the Indian Botanic Garden has to its credit a germplasm collection of 210 pot grown lilies belonging to 4 species and nearly 30 varieties including a number of hybrids. These have been excluded in the present study.

The names of the lakes abbreviated are as follows :—

DL—Diwan lake; I.G.—Introduction garden; JL—Janardan lake; KL—King lake; KUL—Kunstlar lake; L—Lake; LL—Lerum lake; LP—Lotus pool; PL—Prain lake; PC—Pot culture; SCL—Scortechini lake; SL—Shadir lake; Und. L—Unnamed lake (number given against Und. L.—denotes lake in that division of the Indian Botanic Garden).

OBSERVATIONS

Pollen grains of aquatic plants are normal monad type. Pteridophytic spores are mainly represented by the trilete tetrahedral or



Text Fig. 1 : Diagrammatic representation of the shape and measurements taken of the pollen grains [Based on Erdtman (1960) and Thanikaimani (1970)].

rounded triangular types. Monocotyledonous aquatics represent a broad spectrum of pollen morphoforms ranging from inaperturate, monoaperturate (monoporate or monosulcate) to pantoaperturate types. Biaperturate condition, though rare, is also recorded in some monocots. Dicotyledonous pollen grains are either triporate or tricolporate type except in the primitive family Nymphaeaceae. *Aeschynomene aspera* L. is very interesting having 3-colporate-diorate type of aperture condition, also reported earlier by Sharma (1968). Specific palynological description in details have been described below :

PTERIDOPHYTES

PARKERIACEAE

Ceratopteris thalictroides (Cl.) Brongn. Pl, JL.

Spores rounded-triangular, trilete, 2-4 costae arise from near the end of the trilete mark and pass on to distal surface, diameter 69 μ m, (range : 63-79 μ m). Exine $\pm$ 8 μ m thick, striate, homogenous. (Fig. 1, 2).

MARSILEACEAE

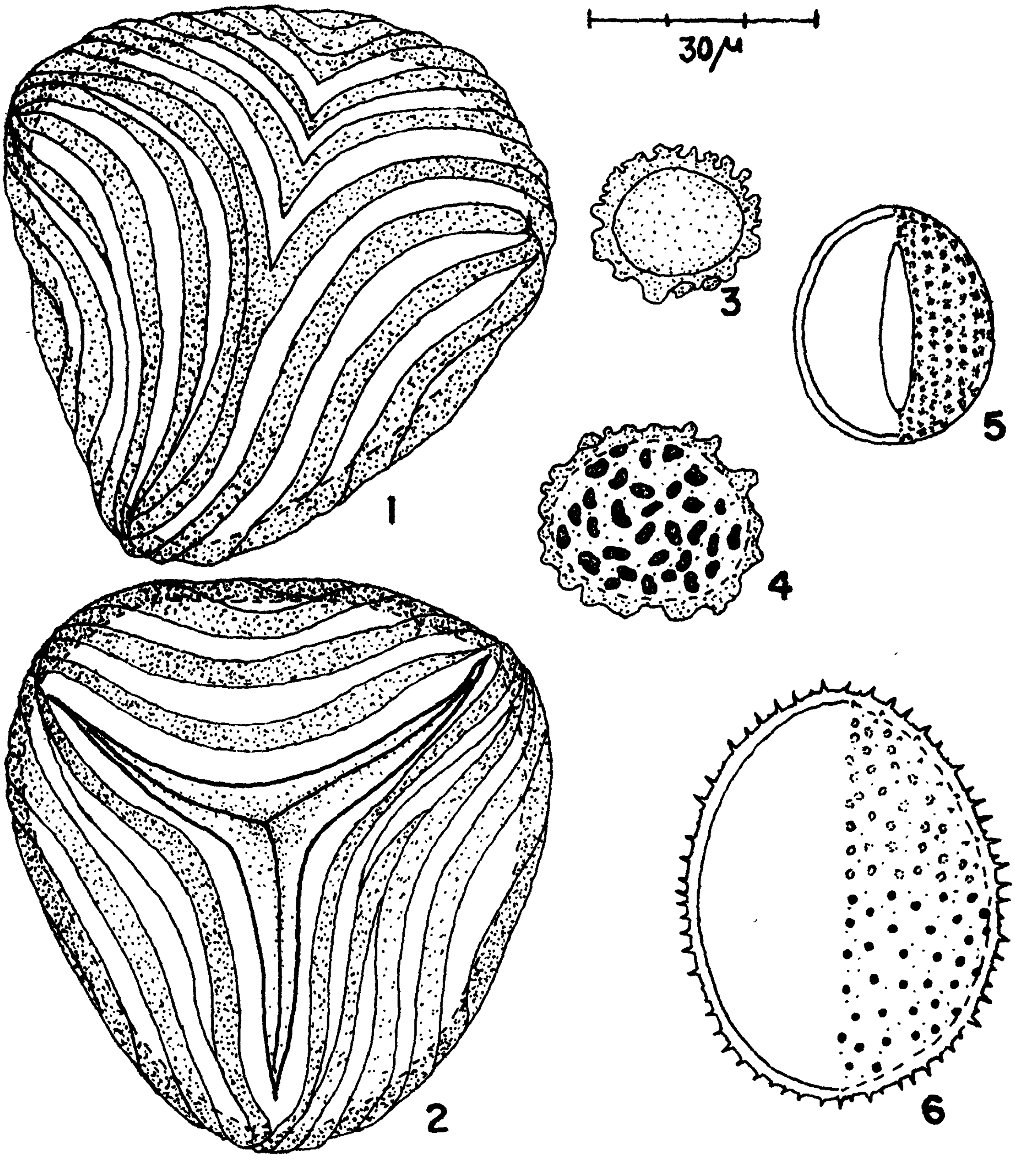
Marsilea quadrifolia (L.) Willd. Und. L 2, 3, 8, 13, 16, 18.

Spores trilete, tetrahedral, globose on maturity, diameter ranging from 43-76 μm, perisporate. Megaspores within gelatinous sheath and with a beak. Erine $\pm$ 7 μ m thick, homogenous. Spores borne within hard stony sporocarp.

SALVINIACEAE

Azolla pinnata R. Br. Und. L 13, 16, 11, 21, KL, PL, JL.

Microspores in groups of 8-12, called massulae, surrounded by spongy tissue with peripheral anchor shaped projections called glochidea. Individual spores trilete, rounded-triangular, with straight aperture-laesura.



Figs. 1-6 : 1. *Ceratopteris thalictroides* — Distal view showing striate exine ornamentation. 2. Proximal view showing trilete aperture and striate exine ornamentation. 3. *Azolla pinnata* — Microspore in optical section. 4. Same showing exine ornamentation. 5. *Pistia stratiotes* — showing faint aperture and faintly striated exine ornamentation. 6. *Ottelia alismoides* — showing spinulose exine ornamentation and LO pattern.

Diameter ranging from 18-28 μm. Exine $\pm$ 3μm thick, pitted. (Fig. 3, 4).

Salvinia auriculata Aubl. Und. L 8, 10, 12, 16, 18, 21, KL, PL.

Microsporangia and megasporangia are borne in different sporocarps. Microspores rounded-triangular, trilete, diameter ranging from 25-39 μm. Exine $\pm$ 6μ m thick, homogenous, psilate. Megaspores are very large, diam. 58-62 μ m.

DICOTYLEDONS

NYMPHAEACEAE

Euryale ferox Salisb. Und. L 20, 24, IG-PC.

Pollen grains 1-colpate, rarely 3-colpate, biconvex in lateral view, size 42 × 38 × 35 μm (range : 39-44 × 37-39 × 30-36 μm). Colpus extending upto poles, end rounded. Exine 1.5 μm thick, punctate reticulate. Sexine thinner than nexine.

Nelumbo nucifera Gaertn. KL, DL, LP.

Pollen grains 3-colpate, spheroidal, diameter 52 μm (range : 48-55 μm). Colpus slit like, faint, and rounded. Exine 7 μm thick, punctate reticulate, lumina 0.5-1 μm, irregular in shape. Sexine thinner than nexine.

Nymphaea nouchali Burm. f. Und. L 8, 19, 24, JL, DL.

Pollen grains 1-colpate, rarely inaperturate, spheroidal, diameter 37 μm (range : 34-39 μm). Colpus operculate, operculum provided with spinules. Exine very thin, 0.5 μm thick, spinulose. Sexine and nexine equally thick.

N. stellata Willd. IG-PC.

Pollen grains 1-colpate, rarely 2-colpate, spheroidal, equatorial diameter 31 μm (range : 25.5-35 μm). Colpus operculate. Exine thin, $\pm$ 0.5 μm thick, spinulose, some sparsely distributed warts also present. Nexine layer not distinguishable. (Fig. 13).

Victoria amazonica (Poepp.) Sow. Und. L 8, 16, SL.

Pollen grains 3-colpate, rarely 4-colpate, united in tetrahedral tetrads, 35 × 72.5 × 64 μm (range : 31-36.5 × 67.5-75 × 60.5-66 μm). Some free 3-colpate spheroidal pollen also observed. Diameter 61 μm. Exine $\pm$ 1.5 μm thick, spinulose or with small warts. Sexine and nexine equally thick.

V. cruzeana Orbigny, IG-PC, SL, Und. 16.

Pollen grains 3-colpate, rarely 4-colpate, free, spheroidal, diameter 42 μm (range : 36.5-47 μm). Exine thin, 0.75-1 μm thick, spinulose. Sexine and nexine equally thick.

FABACEAE

Aeschynomene aspera Linn. Und. L3.

Pollen grains 3-colporate, colpus extended from pole to pole, endoaperture two (diorate) per colpus, circular, prolate, 25 × 20 μm (range : 22-29 × 18-21 μm), contour elliptic oval (Mitra *et al.* l.c.). Exine 1.5 μm thick, reticulate, homobrochate. Sexine thicker than nexine.

A. indica Linn. Und. L3.

Pollen grains 3-colporate, prolate-prolate spheroidal, 19 × 17 μm (range : 17-21 × 14-19 μm), contour elliptic oval, colpus extending upto poles, endoaperture single, circular, diameter $\pm$ 6 μm. Exine 1 μm thick, reticulate, homobrochate. Sexine thicker than nexine.

MIMOSACEAE

Neptunia oleracea Lour. Und. L18, 12, KL.

Pollen grains 3-colporate, subprolate, 55.5 × 45 μm (range : 48-61 × 33-53 μm). Colpus long, tapering, endoaperture lalongate, 8 × 65 μm, sometimes circular, diameter $\pm$ 6 μm, granulated. Exine 4-4.5 μm thick, exine thinner towards aperture, striato-reticulate at mesocolpium, reticulate at poles. Sexine and nexine equally thick. (Fig. 7a-c).

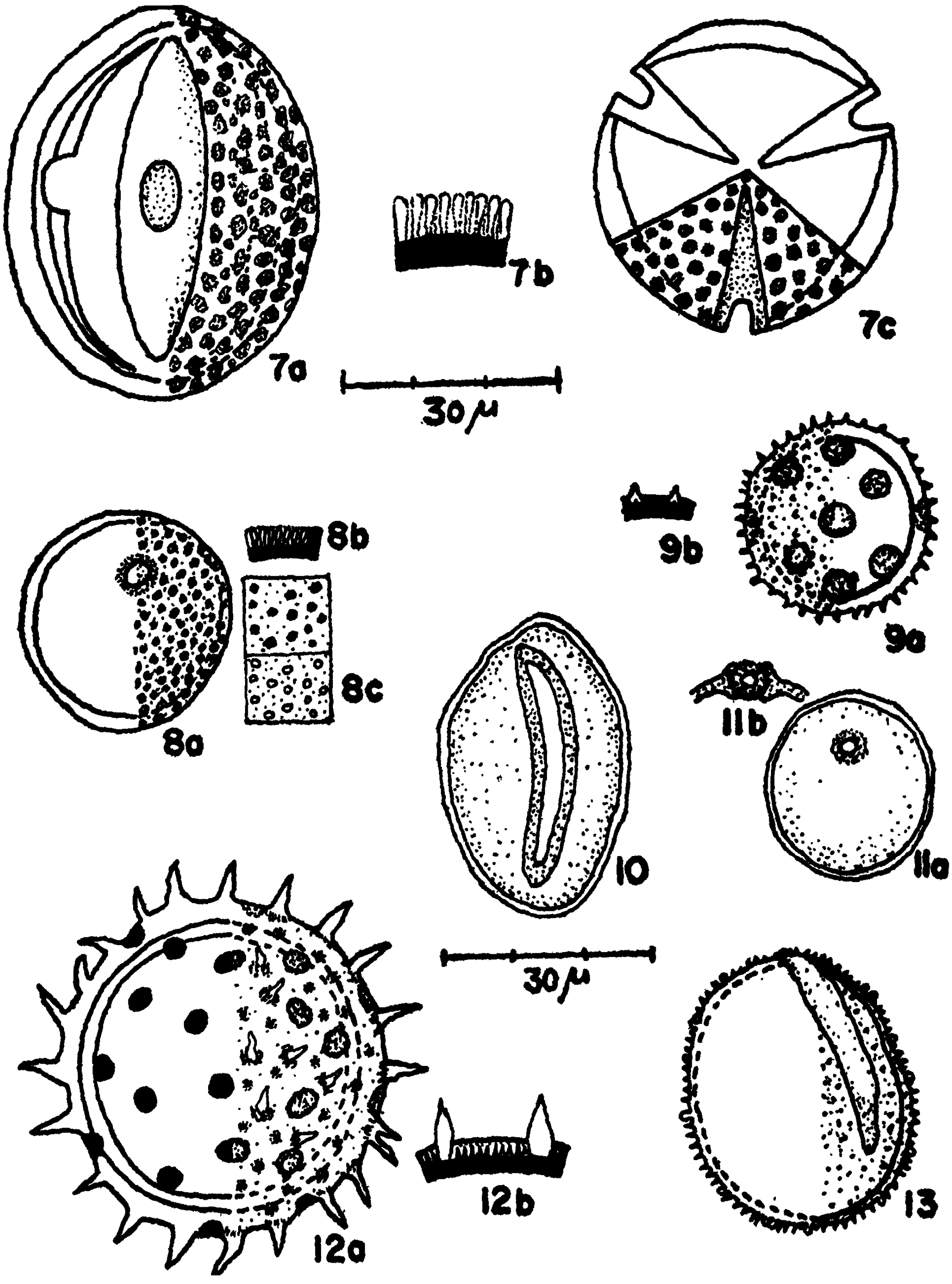
ONAGRACEAE

Ludwigia adscendens (Linn.) Hara Und. L16, KL.

Pollen grains 3-colporate, spheroidal, diameter 68 μm (range : 59.5-77 μm). Colpus long, slit like, ends pointed, endoaperture circular, $\pm$ 14 μm, margin irregular. Exine 3 μm thick, granulose. Sexine and nexine equally thick. Amb circular in polar view. Some dimorphic pollen grains with 4-colporate apertures and abnormal aperture positions were also observed.

L. perennis Linn. Und. L12, 24, PL.

Pollen morphology similar to *L. adscendens* (Linn.) Hara except pollen grain size comparatively smaller in this species, diameter 66.5 μm (range : 56-74 μm). Exine 2.5 μm thick. Dimorphic abnormal pollens



Figs. 7-13 : 7a. *Neptunia oleracea* Meridional view showing aperture and exine ornamentation. 7b. Exine stratification in optical section (diagrammatic). 7c. Polar view showing aperture and exine ornamentation. 8a. *Typha elephanta* — aperture and exine ornamentation. 8b. & 8c. Exine stratification and OL pattern (diagrammatic). 9a. *Tenagocharis latifolia* — distribution of aperture and exine ornamentation. 9b. Exine stratification (diagrammatic). 10. *Cyperus compressus* — aperture with margo and exine. 11a. *Paspalum scrobiculatum* — aperture and exine. 11b. Aperture in details (diagrammatic). 12a. *Ipomoea aquatica* — aperture distribution and exine ornamentation. 12b. Exine stratification (diagrammatic). 13. *Nymphaea stellata* — Aperture (slightly oblique) and exine ornamentation.

as observed in *L. adscendens* (Linn.) Hara are absent in this species.

TRAPACEAE

Trapa natans Linn. var. **bispinosa** (Roxb.) Makino Und. L16, IG-PC.

Pollen grains 3-colpate, oblate spheroidal, 76 × 83 μm (range : 71-77 × 79-84 μm). Exine 3.5 μm thick. Sexine thinner than nexine. Pollen grains provided with meridional crest.

GENTIANACEAE

Nymphoides cristatum (Roxb.) O. Kuntze Und. L3, 10, 18, KUL, SCL, JL.

Pollen grains 3-colpate, spheroidal, diameter 31 μm (range : 28-36 μm), parasyncolpate, each colpus bifurcated in the polar region and fused with neighbouring two colpi. Exine 2 μm thick, coarsely rugulate. Sexine thicker than nexine.

CONVOLVULACEAE

Ipomoea aquatica Forsk. Und. L 12, 13, 24.

Pollen grains pantoporate, spheroidal, diameter 75.5 μm (range : 70-77 μm), some giant pollen grains also observed, ± 105 μm in diameter. Pore circular, 7 μm, inter poral distance 3.5 μm. Exine ± 9 μm thick including spines, spines thin, pointed, ± 3.5 μm long, spines sometimes bifurcated, basal cushion present. Sexine thicker than nexine. (Fig. 12a-b).

LENTIBULARIACEAE

Utricularia stellaris Linn. f. var. **inflexa** Cl. Und. L28, IG-PC.

Pollen grains polycolporate, spheroidal, diameter 36 μm (range : 30-40.5 μm). Colpus long, slit like, extending upto poles, ± 18 in numbers, endoapertures synorate, form an equatorial girdle. Exine very thin, 0.5 μm to 0.8 μm thick, psilate. Sexine and nexine equally thick. Amb circular in polar view.

U. flexuosa Vahl, Und. L19, 20, IG-PC.

Pollen grains polycolporate, spheroidal, diameter 35.5 μm (range : 28.5-39 μm). Colpus long, slit like, ± 18 in numbers, synorate, as in *U. stellaris* Linn. f. var. *inflexa* Cl. Exine 0.75-1 μm thick, sexine and nexine equally thick.

ACANTHACEAE

Acanthus ilicifolius Linn. Und. L2.

Pollen grains 3-colpate, prolate, 52.5 × 31 μm (range : 49.5-55 × 27.5-32 μm). Colpus long, extending upto poles, tapering, colpus membrane granulated. Exine ± 4 μm thick, reticulate, homobrochate, retipilate at poles, sexine thinner than nexine.

Hygrophila difformis (Linn.) Bl. Und. L8, 18.

Pollen grains 3-colporate, prolate-spheroidal, 70.5 × 65 μm (range : 64-73 × 62.5-66.5 μm). Colpus long, slit like, tenuimarginate, endoaperture lalongate, equatorial margin indistinct. Exine 1.5-2 μm thick, reticulate, ornamentation finer towards aperture.

POLYGONACEAE

Polygonum barbatum Linn. Und. L3, 13, 20, 21.

Pollen grains pantoporate, spheroidal, diameter 49 μm (range : 46.5-51 μm). Pore circular, ± 7 μm, intruded. Exine 6 μm thick, reticulate, heterobrochate. Sexine thicker than nexine.

P. glabrum Willd. Und. L3, 8, 16, 18.

Pollen grains pantoporate, spheroidal, diameter 43 μm (range : 39-46 μm). Pore small, circular ± 5 μm. Exine 5.5 μm thick, reticulate, homobrochate. Sexine thicker than nexine.

P. orientale Linn. Und. L2, 5, 10, 13, 16, LL.

Pollen grains pantoporate, spheroidal, diameter 39.5 μm (range : 34.5-43 μm). Pore small, circular, ± 5 μm. Exine 5-5.3 μm thick, reticulate, homobrochate. Sexine thicker than nexine.

Rumex maritimus Linn. Und. L8, KL.

Pollen grains 3-colporate, oblate spheroidal, 26.5 × 31 μm (range : 24.5-28 × 28-33 μm). Colpus long, extending upto poles, slit like, endoaperture lalongate, 1.5 × 4.5 μm, sometimes circular. Exine 1.8-2 μm thick, granulose. Sexine thinner than nexine. Pollen grains circular in polar view.

CERATOPHYLLACEAE

Ceratophyllum demersum Linn. Und. L13, 21, 19, 21, KL, PL, JL.

Pollen grains inaperturate, spheroidal, diameter 38 μm. (range : 35.5-46 μm). Exine very thin, less than 1 μm, psilate/obscure. Sexine and nexine equally thick.

MONOCOTYLEDONS

HYDROCHARITACEAE

Blyxa auberti Rich. Und. L3, 21, SCL.

Pollen grains in tetrads, very rarely free. When tetrads, pollen grains are arranged in a bilateral manner. Aperture faint. Exine spinulose, spines ± 0.5 μm high. Sexine thicker than nexine.

Hydrilla verticillata (Linn.) Royle JL, KL, PL, KUL.

Pollen grains inaperturate, spheroidal, diameter 104 μm (range : 99-107 μm). Exine 1.5-1.8 μm thick, granulose. Sexine and nexine equally thick.

Ottelia alismoides (Linn.) Pers. LL, KL, JL.

Pollen grains inaperturate, sometimes with very faint sulcus, spheroidal, diameter 62 μm (range : 55-68 μm), sometimes prolate 59 × 56 μm. Sulcus when present faint, tenuimarginate, ends rounded. Exine spinulose, 2.5 μm thick, including spines, spinules ± 1.5 μm high, tips pointed. Sexine thicker than nexine. (Fig. 6).

Vallisneria spiralis Linn. Und. L2, 10, 13, 18, 19, 20.

Pollen grains inaperturate, sometimes with very faint sulcus, spheroidal, diameter 45.5 μm (range : 41-50.5 μm), rarely prolate, 49.5 × 38 μm (range : 43-52 × 34.5-44.5 μm). Sulcus when present margo sulcate. Exine 1-1.5 μm thick, areolate, areola 1-2 μm wide. Sexine thicker than nexine,

PONTEDERIACEAE

Eichhornia crassipes (Mart.) Solms. Und. L4, 5, LL.

Pollen grains 1-sulcate, rarely 2-sulcate, ellipsoidal, plano-convex, 51 × 24 × 18.4 μm (range : 43-61 × 18.5-32 × 16-19 μm), rarely spheroidal, diameter 41 μm (range : 36.5-46 μm). Sulcus tenuimarginate, margin wavy. Exine very thin, less than 0.5 μm thick, granulose. Sexine and nexine equally thick.

Monochoria hastata (Linn.) Solms. Und, L16, 18, 19, 24.

Pollen grains 1-sulcate, rarely 2-sulcate, ellipsoidal, plano-convex, 46.5 × 27 × 19 μm (range : 40.5-52 × 19-40 × 14-26 μm). Sulcus tenuimarginate, margin wavy. Exine 1.5 μm thick, granulose. Sexine thicker than nexine.

TYPHACEAE

Typha angustata Bory et Chaub. Und. L3, 4.

Pollen grains 1-porate, spheroidal, diameter 32 μm (range : 23-35.5 μm). Pore circular, 4.5 μm, operculate, margin faintly defined, uneven. Exine 2.5 μm thick, retipilate, thicker around pore, ± 3 μm thick, sexine thicker than nexine.

T. elephantina Roxb. Und. L24.

Pollen grains 1-porate, spheroidal, diameter 30 μm (range : 25-32 μm). Pore circular, diameter 4 μm, sometimes lalongate, 5.5 × 4.5 μm, margin clearly defined. Exine 2.5 μm thick, reticulate, retipilate towards the apertural area. Sexine and nexine equally thick. (Fig. 8a-c).

ARACEAE

Acorus calamus Linn. Und. L8.

Pollen grains 1-sulcate, ellipsoidal, plano-convex, 20.5 × 11.5 × 9.5 μm (range : 17-29 × 9-14.5 × 9-12 μm). Sulcus tenuimarginate. Exine very thin, ± 0.5 μm thick, spinulose, spinules less than 0.5 μm high. Sexine thicker than nexine.

Colocasia esculantum (Linn.) Schott. Und. L2, 8, 16, LL, DL.

Pollen grains inaperturate, spheroidal, diameter 20 μm (range : 16.5-21.5 μm). Exine spinulose, 1.5 μm thick including spinules, spinules 0.5 μm high. Sexine thicker than nexine.

Cryptocoryne ciliata Fisch. Und. L19, JL.

Pollen grains inaperturate, ellipsoidal, 72 × 24 μm (range : 59-78.5 × 19.5-29 μm). Exine 2.5-3 μm thick, psilate. Sexine and nexine indistinguishable.

Lasia aculeata Lour. Und. L24.

Pollen grains 1-sulcate, spheroidal, diameter 24 μm (range : 21-31 μm). Sulcus tapering, membrane granulose. Exine 1.2-1.5 μm thick, reticulate. Sexine and nexine equally thick.

Pistia stratiotes Linn. Und. L2, 5, 8, 16, 18.

Pollen grains inaperturate, very rarely 1-sulcate, spheroidal, diameter 44 μm (range : 40-47.5 μm), some comparatively small grains also present (range : 21-31 μm). Exine 1.5 μm thick, very faintly striate. Sexine thinner than nexine. (Fig. 5).

LEMNACEAE

Lemna minor Linn. Und. L8, 10, 12, 18, 24, SL, JL.

Pollen grains 1-sulcate, spheroidal, diameter 14 μm (range : 11-16.5 μm). Sulcus long, tapering, tenuimarginate. Exine very thin, $\pm$ 0.75 μm thick, spinulose, spinules minute, $\pm$ 0.25 μm high. Sexine thicker than nexine.

L. perpusilla Torr. Und. L10, 12, 14, JL.

Pollen morphology similar to *L. minor* Linn. except thicker exine (1.5 μm) and spinules $\pm$ 0.5 μm high.

Wolffia arrhiza (Linn.) Hork. ex Wimm. Und. L21.

Pollen grains inaperturate, sometimes faintly 1-sulcate, spheroidal, diameter 22 μm (range : 19.5-23.5 μm). Exine spinulose, 1 μm thick including spinules, spinules $\pm$ 0.5 μm high.

ALISMACEAE

Alisma plantago Linn. Und. L8.

Pollen grains pantoporate, spheroidal, diameter 29 μm (range : 25.5-32 μm). Pore circular, 4 μm. Exine 1.5 μm thick, thinner towards pore margins and coarsely granulose.

Sagittaria sagittifolia Linn. Und. L12.

Pollen grains pantoporate, spheroidal, diameter 23 μm (range : 19.5-26.5 μm). Pore circular, 4-5.5 μm with irregular margins, operculate, operculum provided with spinules. Exine spinulose, 1.5-2 μm thick including spinules. Spinules mixed type, 0.5-1 μm high. Sexine thicker than nexine.

LIMNOCHARITACEAE

Tenagocharis latifolia (D. Don) Buch.-Ham. Und. L13.

Pollen grains pantoporate, spheroidal, diameter 25.5 μm (range : 23-30 μm), sometimes ellipsoidal, 30.5 × 21 μm (range : 28-33.5 × 18-23.5 μm). Pore circular, tenuimarginate, operculate, operculum provided with spinules. Exine spinulose, 1.5 μm thick including spinules, spinules 0.75 μm high. In some ellipsoidal pollen grains exine is coarsely granulose. Sexine thicker than nexine. (Fig. 9 a-b).

APONOGETONACEAE

Aponogeton crispum Thunb. Und. L8, 10, 16, KL, KUL.

Pollen grains 1-sulcate, rarely trichotomosulcate, ellipsoidal, convexo-convex, 21.5 × 11 × 10.5 μm (range : 19.8-26 × 9-14.5 × 9-12 μm). Sulcus tapering, with margo. Exine 1 μm thick, reticulate, homobrochate, lumina circular. Sexine and nexine equally thick.

A. natans (Linn.) Engl. et Krause, KL, KUL.

Pollen grains 1-sulcate, ellipsoidal, convexo-convex, 19.75 × 11.5 × 9 μm (range : 18-22.5 × 9-13.5 × 8-11 μm), occasionally spheroidal, diameter 16.5 μm (range : 13.5-18.5 μm), some joint abnormal pollen also occur. Exine 1 μm thick, reticulate, heterobrochate, lumina heterogenous. Sexine and nexine equally thick.

POTAMOGETONACEAE

Potamogeton crispus Linn. KL, PL.

Pollen grains 1-sulcate, spheroidal, diameter 30 μm (range : 26.5-35.5 μm) or ellipsoidal, 31.5 × 19.5 μm (range : 27-37.5 × 12.5-23.5 μm). Sulcus tenuimarginate, margin irregular, exine 0.75 μm thick, reticulate. Sexine and nexine indistinguishable.

P. nodosus Poir Und. L8, 10.

Pollen grains 1-sulcate, spheroidal, diameter 23 μm (range : 18-29.5 μm), sometimes ellipsoidal and inaperturate abnormal pollen grains also observed. Sulcus tapering, margin irregular, tenuimarginate. Exine very thin, 0.5 μm thick, reticulate. Sexine and nexine indistinguishable.

CYPERACEAE

(Pollen grains of Cyperaceae in general is called Pseudomonad for its typical development).

Cyperus cephalotes Vahl LL.

Pollen grains 1-porate, spheroidal, diameter 25 μm (range : 23-26 μm). Pore circular, diameter 4-6 μm. Exine 1 μm thick, granulose. Sexine and nexine equally thick.

C. compressus Linn. LL, SCL.

Pollen grains 1-sulcate, ellipsoidal, convexo-convex, 36 × 22 × 22.5 μm (range : 33-45.5 × 15.5-31 × 17-24.5 μm), sometimes spheroidal, diameter 30.5 μm (range : 26-32.5 μm). Sulcus tapering, with margo. Exine 1.5 μm thick, granulose/obscure. Sexine thicker than nexine. (Fig. 10).

Fimbristylis complanata Linn. Und. L 24.

Pollen grains 1-sulcate, ellipsoidal, 28.5 × 18 μm (range : 21-31 × 14.5-19.5 μm). Sulcus tapering, margin irregular. Exine ± 1 μm thick, micro-reticulate. Lumina 0.5-0.75 μm. Sexine and nexine equally thick.

F. dichotoma (Linn.) Vahl Und. L24.

Pollen morphology similar to *F. complanata* Linn. except size, longest × shortest axes = 30 × 19.5 μm (range : 24.5-32 × 16.5-21 μm).

Mariscus sieberianus Nees Und. L16, PL.

Pollen grains panto-aperturate, spheroidal, diameter 22.5 μm (range : 19.5-25 μm). Apertures indistinct. Exine 1 μm thick, obscure/granulose. Sexine and nexine equally thick.

Scirpus articulatus Linn. Kl, Pl.

Pollen grains 1-sulcate, ellipsoidal, 36.5 × 23 μm (range : 29.5-39.5 μm × 18.5-26.5 μm). Sulcus faint, tenuimarginate. Exine 1.5 μm thick, microreticulate. Sexine and nexine equally thick.

POACEAE (GRAMINEAE)

Brachiaria mutica (Forsk.) Stapf. Und. L2, 3, 13, 21, LL, KL.

Pollen grains 1-porate, spheroidal, diameter 43.5 μm (range : 36.5-48 μm). Pore circular, with annulus 7-10 μm. Exine very thin, 0.5-0.75 μm thick, psilate. Sexine and nexine indistinguishable.

B. reptans (Linn.) Gard. et. C. E. Hubb. Und. L2, 10, 13, 18, 24, KL, JL.

Pollen characters similar to *B. Mutica* (Forsk.) Stapf. except pollen size 39.5 μm diameter (range : 35-45.5 μm) and pore diameter 4-7.5 μm with annulus.

Echinochloa colonum (Linn.) Link Und. L13, 16, 18, 24, DL, KUL.

Pollen grains 1-porate, spheroidal, diameter 45 μm (range : 40.5-51 μm). Pore circular, provided with annulus, operculate (operculum observed in fresh and unacetolysed pollen only), diameter 4 μm, 10-11 μm including annulus. Exine thin 0.5-0.75 μm thick, obscure. Sexine and nexine equally thick.

Panicum repens Linn. Und. L12, 24.

Pollen grains 1-porate, spheroidal, diameter 29.5 μm (range : 20-36.5 μm). Pore circular, diameter 4 μm, including annulus 7.5 μm. Exine thin, ± 0.5 μm thick, psilate. Sexine and nexine equally thick.

Paspalidium flavidum (Retz.) A. Camus Und. L12, 24.

Pollen grains 1-porate, spheroidal, diameter 43.5 μm (range : 38.5-47.5 μm). Pore circular, diameter 3.5 μm including annulus. Exine $\pm$ 0.5 μm thick, obscure. Sexine and nexine indistinguishable.

P. geminatum (Forsk.) Stapf. Und. L3, 10, 16.

Pollen morphology similar to *P. flavidum* (Retz.) A. camus except size, diameter 41 μm (range : 32.5-45.5 μm).

Paspalum scrobiculatum Linn. KL. PL.

Pollen grain 1-porate, spheroidal, diameter 31 μm (range : 25.5-34.5 μm), some larger pollen grains also observed having $\pm$ 42 μm diameter. Pore circular, diameter 4.2 μm, 9.5-10 μm including annulus. Exine very thin, 0.5 μm thick, pattern obscure or finely granulose. Sexine and nexine equally thick. (Fig. 11 a-b).

Setaria glauca (Linn.) Beauv. Und. L12, 16, 18, 21, KL, PL.

Pollen grain 1-porate, spheroidal, diameter 39.5 μm (range : 35-46 μm). Pore circular, diameter 3 μm, 8 μm including annulus. Exine thin, 0.5-0.75 μm thick, psilate. Sexine and nexine indistinguishable.

From the foregoing observations it is quite clear that pollen morphological variability, dimorphism and sometimes pollen abnormalities with infertile abortive pollens are common in aquatic angiosperms. It is evident that environmental stress sometimes cause lowering of pollen production per anther. In *Eichhornia crassipes* (Mart.) Solms., gradual drought lowers down the pollen production upto 40% of the normal aquatic condition. It has also been observed that presence of adequate humus in the lakes' sediments induce 30% more pollen production in *Eichhornia crassipes* (Mart.) Solms., and *Sagittaria sagittifolia* Linn. and gradual drought lowers down the fruit set ratio of *Eichhornia crassipes* (Mart.) Solms. *Ipomoea aquatica* Forsk. on the other hand shows 20%-30% higher pollen production rate per anther as well as higher flower primordia production in lakes with less humus deposits and direct sunlight fed water. *Victoria amazonica* (Poepp). Sowerby and *V. cruzeana* Orbigny—the giant glory lilly flower well in sunny lakes with abundant humus deposits. It shows about 63% fertile pollen production. Fruit set rate is seen to be higher when grown in culture pot and this is probably due to the interference of the aquatic insects and lake tortoise which might cause damage to the carpel heads and the ovules. It has also been observed that *Victoria amazonica* (Poepp.) Sowerby, grown in the lakes having abundant humus content and little bit acid soil-the flowers turn deep crimson within short time span than the plant grown in lakes having comparatively less humus content and less soil acidity. However, pollen production ratio and pollen fertility of this plant do not interfere for these edaphic and pH factors. It is evident from the above observation that the members of the family Cyperaceae and Poaceae (Gramineae) are very difficult to distinguish palynologically upto species level.

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Table 1 : Salient pollen/Spore morphological features of materials studied

Name of the family and species	Distribution in lakes of IBG	Shape	S I Z E: Diameter % mean µm	L. mean	l mean µm	p. mean	Polar axis length (P.) mean µm	Equatorial axis length (E) mean	EXINE: Thickness µm	EXINE: Orna	Aperture	Remarks
1	2	3	4	5			6		7	8	9	10
PTERIDOPHYTA												
PARKERIACEAE												
Ceratopteris thalictroides (Cl.) Brongn.	PL, JL		63-79 / 69						±8	Stri.	Trilete	Costae arise from near the end of the trilete mark. Exine homogeneous.
MARSILIACEAE												
Marsilea quadrifida (L.) Willd.	Und. L2, 3, 8, 13, 16, 18	Sph.	43-76 / 59.5	—	—				7	—	Trilete	Spores borne within hard stoney sporocarp.
SALVINIACEAE												
Azolla pinnata R. Br.	Und. L13, 16, 11, 21, KL, PL & JL		18-28	—	—				3	Psi.	Trilete	Spores in groups 8-12-celled massulae provided with glochide.
Salvinia auriculata Aubl.		Rounded triangular	25-39 & 58-62	—	—				6	Psi.	Trilete	Exine very thick, homogenous.
DICOTYLEDONS												
NYMPHAEACEAE												
Euryale ferox Salisb.	Und. L20, 24, IG-PC.	Ellip.	—	39-44 / 42	37-39 / 38	30-36 / 35	—	—	1.4	Punc.-ret.	1-colpate	Earely 3-colpate pollen grains also available.
Nelumbo nucifera Gaertn.	KL, DL, LP.	Sph.	48-55 / 52	—	—	—	—	—	7	Ret.	3-colpate	Colpus slit like, faint, end rounded.
Nymphaea nouchali Burm. f.	Und. L8, L9, 24, JL, & DL	Sph.	34-39 / 37	—	—	—	—	—	±0.5	Spinul.	1-colpate	Rarely inap. pollens also available.

Table 1 : Contd.

1	2	3	4	5		6			7	8	9	10
Nymphaea stellata Willd.	IG. PC.	Sph.	25.5-35 / 31	—	—	—	—	—	±0.5	Spinul.	1-colpate	Colpus operculate, some sparsely distributed warts also present.
Victoria amazonica Sowerby	Und, L8, 16, SL.	Sph.	59-63 / 61	—	—	—	—	—	1.5	Spinul.	3-colpate	Pollen grains usually in tetrads. Ex. sometimes with small warts.
V. cruzeana Orbigny	IG, SL, Und, 16,	Sph.	36.5-47 / 42	—	—	—	—		0.75-1	Spinul.	3-colpate	Rarely 4-colpate.
FABACEAE												
Aeschynomene aspera Linn.	Und. L3	Pro-Sph./ Pro	—	—	—	22-29 / 25	18-21 / 28		1.5	Ret.	3-colpor.	Colpus diorate.
A. indica Linn.	Und. L3	Pro-Sph./ Pro.	—	—	—	17-21 / 19	14-19 / 17		1	Ret.	3-colpor.	Colpus with single endoap.
MIMOSACEAE												
Neptunia oleracea Lour.	Und, L18, 12, KL.	Subpro.	—	—	—	48-61 / 55.5	33-53 / 45		4-4.5	Str.-ret.	3-colpor.	Endoap. granulated, Ex. Str. ret. at mesocolpium and ret. at poles.
ONAGRACEAE												
Ludwigia adscendens (Linn.) Hara	Und. L16, KL.	Sph.	59.5-77 / 68	—	—	—	—	—	3	Gr.	3-colpor.	Dimorphic pollens like 4-colporate with abnormal ap. position also available.
L. perennis Linn.	Und. L12, 24, PL.	Sph.	56-74 / 66.5	—	—	—	—	—	2.5	Gr.	3-colpr.	Dimorphic abnormal pollens absent.
TRAPACEAE												
Trapa natans Linn. var. *bispinosa* (Roxb.) Makino	Und. L16, IG-PC.	Ob-Sph.	—	—	—	71-77 / 76	79-84 / 83		3.5	Obs.	3-colpate	Pollen grains provided with meridional crests.
GENTIANACEAE												
Nymphoides cristatum (Roxb.) O. Kuntze	Und. L3, 10, 18, KUL, SCL, JL.	Sph.	28-36 / 31	—	—	—	—	—	2	Rug.	3-colpate	Parasyncolpate. In our Indian flora this genus goes under the name *Limnanthemum* Gmel. (1778) but this must make way for *Nymphoides* Hill. (1756) on account of priority.

Table I : Contd.

1	2	3	4	5	6	7	8	9	10
CONVOLVULACEAE									
Ipomoea aquatica Forsk.	Und. L12, 13, 24	Sph.	70-77	— — —	— —	±9	Echinate	Pantopo-rate	Some giant pollen of 105 μm dirm. observed. Some bifurcate spines with basal cushion also evident.
LENTIBULARIACEAE									
Utricularia flexuosa Vahl	Und. L. 19, 20, IG-Pc.	Sph.	28.5-39 35.5	— — —	— —	0.75-1	Psi.	Poly col-porate.	Endoap. fuse equatorially to form an equatorial girdle. Pollen grains cir. in pol. view.
U. stellaris Linn. f. var. *inflexa* Cl.	Und. L28, IG-Pc.	Sph.	30-40.5 36	— — —	— —	0.5-0.8	Psi.	Poly col-porate.	-dc-
ACANTHACEAE									
Acanthus ilicifolius Linn.	Und. L 2	Prolate	—	— — —	49.5-55 27.5-32 52.5 31	4	Ret.	3-colpate	Exine retipilate at poles. Sex thinner than nex.
Hygrophila difformis (Linn.) Bl.	Und. L8, 18	Pro-Sph.	—	— — —	64-73 62.5-56.5 70.5 65	1.5-2	Ret.	3-colpo. rate	Colpus slit like, tenuimarginate, Endoap. -lalongate. Exine ornamentation finer towards aperture.
POLYGONACEAE									
Polygonum barbatum Linn.	Und. L3, 13, 20, 21.	Sph.	46.5-51 49	— — —	— —	6	Ret.	Pantopo-rate cir. 7 μm.	Reticulation heterobrochate.
P. glabrum Willd.	Und. L3, 8, 16, 18.	Sph.	39-46 43	— — —	— —	5.5	Ret.	Pantopo-rate cir. 5 μm	Ret. homobrochate.
P. orientale Linn.		Sph.	34.5-43 39.5	— — —	— —	±5	Ret.	Panto-porate cir. 5 μm.	Reticulation homobrochate, pores sunken.
Rumex maritimus Linn.	Und. L8, KL	Ob. Sph.	—	— — —	24.5-28 28-33 26.5 31	1.8-2	Gr.	3-colporate.	Endoap., lalongate, rarely circular.

Table 1 : Contd.

1	2	3	4	5			6		7	8	9	10
CERATOPHYLLACEAE												
Ceratophyllum demersum Linn.	Und. L13, 21, 19, 21, KL, PL, JL.	Sph.	35.5-46 / 38	—	—	—	—	—	±1	Psi./obs.	Insp.	
MONOCOTYLEDONS												
HYDROCHARITACEAE												
Blyxa auberti Rich.	Und. L 3, 21, & SCL.	in tetrad	—	—	—	—	—	—	—	Spinul.	Indistinct.	Pollen very rarely free, tetrad bilateraly arranged.
Hydrilla verticillata (Linn.) Royle	JL, KL, PL, KUL.	Sph.	99-187 / 184	—	—	—	—	—	1.5-1.8	Gr.	Insp.	Sex. = Nex.
Ottelia alismoides (Linn.) Pers.	LL, KL, JL.	Sph.	55-68 / 62	—	—	—	—	—	2.5	Spinul.	Inap.	Sometimes very faint colpus present.
Vallisneria spiralis Linn.	Und. L2, 10, 13, 18, 19, 20.	Sph.	41-48.5 / 45.5	—	—	—	—	—	1-1.5	Areo.	Insp.	Sometimes very faint colpus seen.
PONTEDERIACEAE												
Eichhornia crassipes (Mart.) Solms.	Und. L4, 5, LL.	Ellip.	—	43-61 / 51	18.5-32 / 24	16-19 / 18.4	—	—	0.5	Gr.	1-sulcate	Pollen grains rarely sph., sulcus tenuimarginate, wavy.
Monochoria hastata (Linn.) Solms.	Und. L16, 18, 19, 24.	Ellip.	—	40.5-52 / 46.5	19-40 / 27	14-26 / 19	—	—	1.5	Gr.	1-sulcate	Rarely 2-Sulcate pollens available. Sexine thicker than Nexine.
TYPHACEAE												
Typha angustata Bory & Chaub.	Und. L3, 4	Sph.	23-35.5 / 32	—	—	—	—	—	2.5	Retipilate	1-porate. cir, 4.5 μm, operculate	Ex. thicker around the pore, ±3 μm, pore margin faintly defined. Sexine thicker than Nexine.
T. elephanta Roxb.	Und. L24.	Sph.	25-32 / 30	—	—	—	—	—	2.5	Ret.	1-porate	Ex. ornamentation retipilate towards the apertural area. Sex. = Nex.
ARACEAE												
Acorus calamus Linn.	Und. L 8	Ellip.	—	17-29 / 20.5	9-15.4 / 11.5	9-12 / 9.5	—	—	0.5	Obs.	1-sulcate	Aperture tenuimarginate.

Table 1 : Contd.

1	2	3	4	5		6			7	9	9	10
Colocasia esculantum (Linn.) Schott.	Und. L2, 8, 16, LL, DL.	Sph.	16.5-21.5 / 20	—	—	—	—	—	±0.5	Spinul.	Inap.	—
Cryptocoryne ciliata Fisch.	Und. L19, JL	Ellip.	—	59-78.5 / 72	19.5-29 / 24	—	—	—	2.5-3	Psi.	Inap.	Sex. and Nex. indistinguishable.
Lasia aculeata Lour.	Und. L24	Sph.	21-31 / 24	—	—	—	—	—	1.2-1.5	Ret.	1-sulcate	Sulcus tapering, membrane granulose.
Pistia stratiotes Linn.	Und. L2, 5, 8, 16, 18.	Sph.	40-47.5 / 44	—	—	—	—	—	1.5	faintly stri.	Inap.	Rarely 1-sulcate pollen also seen, some com paratively smaller pollen (21-31) μm also available.
LEMNACEAE												
Lemna minor Linn.	Und. L8, 10, 12, 18, 24, SL, JL.	Sph..	11-16.5 / 14	—	—	—	—	—	0.75	Spinul.	1-sulcate	Spinules minute, 0.25 μm high.
L. perpusilla Torn.	Und. L10, 12, 14, JL	Sph.	10-16 / 14.4	—	—	—	—	—	1.5	Spinul.	1-sulcate	Spinules comparatively longer than *L. minor* L. ±0.5 μm high.
Wolffia arrhiza (Linn.) Hork. ex Wimm.	Und. L21,	Sph.	19.5-23.5 / 22	—	—	—	—	—	1	Spinul.	Inap.	Sometimes faintly 1-colpate pollen grains seen.
ALISMATACEAE												
Alisma plantago Linn.	Und. L8	Sph.	25.5-32 / 29	—	—	—	—	—	1.5	gr.	Pantopor. cir. 4 μm.	Exine thinner towards pore margin.
Sagittaria sagittifolia Linn.	Und. L12	Sph.	19.5-26.5 / 23	—	—	—	—	—	1.5-2	Spinul.	Pantopor. cir. 4-5.5 μm	Pore margin irregular, operculate, operculum provided with spinules, sex, thicker than nex.
LIMNOCHARITACEAE												
Tenagocharis latifolia (D. Don) Buchen.	Und. L13	Sph.	23-30 / 25.5	—	—	—	—	—	1.5	Spinul.	Pantopor cir.	Pore operculate, some ellipsoidal pollen grains also available. Operculum provided with spinulose.

Table 1 : *Contd.*

1	2	3	4	5			6		7	8	9	10
APONOGETONACEAE												
Aponogeton crispum Thunb.	Und. L8, 10, 16, KL, KLL.	Ellip.	—	19.5-26 21.5	9-14.5 11	9-12 10.5	—	—	1	Ret.	1-sulcate	Margo aperturate, homobrochate.
A. natans (Linn.) Engl. et Krause	KL, KIL.	Ellip.	—	18-22.5 19.75	9-13.5 11.5	8-11 9	—	—	1	Ret.	1-sulcate	Heterobrochate.
POTAMOGETONACEAE												
Potamogeton crispus Linn.	KL & PL	Sph.	26.5-35.5 30	—	—	—	—	—	0.75	Ret.	1-sulcate	Some ellipsoidal pollen also seen, sulcus tenuimarginate, margin irregular, Sex. and Nex. indistinguishable.
P. nodosus Poir.	Und. L8, 10.	Sph.	18-29.5 23	—	—	—	—	—	0.5	Ret.	1-sulcate	Some ellipsoidal and inaperturate pollen grains also seen. Sulcus tapering, margin irregular, tenuimarginate, Sex. and Nex. indistinguishable.
CYPERACEAE												
Cyperus cephalotes Vahl	LL.	Sph.	23-26 25	—	—	—	—	—	1	gr.	1-porate, cir. 4-6 μm	Pollen grains of Cyperaceae in general is called pseudomonad for its typical development.
C. compressus Linn.	LL, SCL	Ellip./Sph.	26-32.5 30.5	—	—	—	—	—	1.5	gr./obs.	1-sulcate	—
Fimbristylis complanata Linn.	Und. L24.	Ellip.	—	21-31 28.5	14.5-19.5 18	—	—	—	1	Microret.	1-sulcate	Exine ornamentation very faint.
F. dichotoma (Linn.) Vahl	Und. L24	Ellip.	—	24.5-32 30	16.5-21 19.5	—	—	—	1	Microret.	1-sulcate	,,
Mariscus sieberanus Nees	Und. L16, PL	Sph.	19.5-25 22.5	—	—	—	—	—	1	gr./obs.	Panto-aperturate	Apertures indistinct.
Scirpus articulatus Linn.	KL & PL	Ellip.	—	29.5-39.5 36.5	18.5-25.5 23		—	—	1.5	Microret.	1-sulcate	Sulcus faint tenuimarginate.
POACEAE (GRAMINEAE)												
Brachiaria mutica (Forsk.) Stapf.	Und. L2, 3, 13, 21, LL, KL	Sph.	36.5-48 43.5	—	—	—	—	—	0.5-0.75	Psi.	1-porate, cir. 7-10 μm	Pores with annulus.

Table 1 : *Contd.*

1	2	3	4	5	6	7	8	9	10
Brachiaria reptans (Linn.) Gard. *et* C. E. Hubb.	Und. L2, 10, 13, 18, 24 KL, JL	Sph.	35-45.5 / 39.5	— — —	— —	0.5-0.75	Psi.	1-porate, 4-7.5 μm	Pores with annulus, other cha. same as *B. mutica*.
Echinochloa colonum (Linn.) Link.	Und. L13, 16, 18, 24, DL, KUL	Sph.	40.5-51 / 45	— — —	— —	0.5-0.75	obs.	1-porate, cir. 4 μm	Annulate, pore diam. 10-11 μm including annulus, operculate.
Panicum repens Linn.	Und. L12, 24	Sph.	20-36.5 / 29.5	— — —	— —	0.5	Psi.	1-porate, cir. 4μm	Pore annulate, diam. 7.5 μm including annulus.
Paspalidium flavidum (Retz.) A. camus	Und. L12, 24	Sph.	38.5-47.5 / 43.5	— — —	— —	0.5	obs.	1-porate cir. 3. 5 μm.	Pore annulate.
P. geminatum (Forsk.) Stapf.	Und. L3, 10, 16.	Sph.	32.5-45.5 / 41	— — —	— —	0.75	obs.	1-porate, cir. 3.5 μm	Pore annulate.
Paspalum scrobiculatum Linn.	KL & PL	Sph.	25.5-34.5 / 31	— — —	— —	0.5	f. gr./obs.	1-porate cir, 4.2μm	Pore annulate, 9.5-10 μm including annulus.
Setaria glauca (Linn.) Beauv.	Und. L12, 16, 18, 21, 16, 18, 21, KL & PL	Sph.	35-46 / 39.5	— — —	— —	0.5-0.75	Psi.	Pantoporate, cir. 3 μm	Pore annulate, 8 μm including annulus, Sex. Nex indistinguishable.

Abbreviations used :

Areo.—Areolate ; Cir.—Circular ; Colpr.—Colporate ; DL—Diwan Lake ; diam.—diameter ; Ellip—Elliptic ; Endo-ap.—Endoaperture ; Ex.—Exine ; f. gr.—finely granulose ; gr.—granulose, I. B. G. Indian Botanic Garden; I. G.—Introdu ction Garden ; Inap.—inaperturate ; J.L.—Janardan Lake ; K. L.—King Lake ; KUL.—Kunstlar Lake ; L.—Lake ; L. L. Lerum Lake ; L. P. Lotus pool ; Micro-ret. —Microreticulate ; Nex.—Nexine ; obs. Obscure ; Ob-sph.—oblate spheroidal ; Orna.—ornamentation ;Pantopor.—Panto porate ; P. L.—Prain Lake ; P.C.—Pot culture ; Pro.—Prolate ; pol : —polar ; pro-sph.—Prolate spheroidal ; Psi—Psilate ; Punc. ret. Punctate reticulate ; Ret.—Reticulate ; Rug.—Rugulose ; Sex.—Sexine ; SCL.—Scortechini Lake ; Sph.—Spheroidal ; S. L.—Shadir Lake ; Spinul.—Spinulose ; Str.—Striate ; Str.—ret.—Striatoreticulate ; Sub-pro.—Subprolate ; Und. L.—Unnamed lake (Number given against Und. L.—denotes lake in that division of the I.B.G.).

REFERENCES

ARBER, A. *Water plants* : A study of Aquatic Angiosperms. Cambridge Univ. Press. 1920.

BACKER, C. A. Pontederiaceae, In Van Steenis' *Flora Malesiana, Ser.* 1,4 : 255-261. 1951.

BENTHAM, G. AND J. D. HOOKER, *Genera Plantarum*. London. 1862-1883.

BISWAS, K. AND C. C. CALDER. *Handbook of common water and marsh plants of India and Burma*. ed. 1 & 2. With Bull. no. 24. New Delhi. Govt. of India Press. 1936. 1954.

DEB, D. B. A study on the aquatic vascular plants of India. *Bull. Bot. Soc. Bengal* 29 : 155-170. 1976.

ERDTMAN, G. *Pollen Morphology and Plant Taxonomy. Angiosperms*. Almquist & Wiksell, Stockholm. 1952.

—— Notes on the finer structure of some pollen grains. *Bot. Notiser*, 113(3) : 285-288. 1960.

FAEGRI, K. AND J. IVERSEN, *Text book of Pollen analysis*. Scandinavian University Books. Munksgard (2nd revised ed.). 1964.

MAHESHWARI, S. C. AND P. KHANNA. The embryology of *Arisaema wallichiana* Hook. f. and the systematic position of Araceae. *Phytomorphology* 6 : 379-388. 1956.

MITRA, K. AND M. S. MONDAL. Pollen morphology of exstipellate and stipellate Hedysareae (Leguminosae). *Proc. Ind. Natn. Sci. Acad.* B-48(6) : 755-769. 1982.

MITRA, S. N., R. B. GHOSH AND J. N. NASKAR. A census to the aquatic and semiaquatic vegetation of the Indian Botanic Garden, Howrah. *Bull. Bot. Soc. Bengal* 25 : 111-115. 1971.

NAIR, P. K. K. *Pollen grains of Western Himalayan Plants*. Asia Monographs, India 1(5) : VIII +1-102. 1965.

—— AND K. REHMAN. Pollen grains of Indian Plants-VI. *Bull. Nat. Bot. Gard. Lucknow* 83 : 1-16. 1963.

RAJ, B. AND M. R. SAXENA. Pollen morphology of aquatic angiosperms. *Pollen et spores* 8(1) : 49-55. 1966.

—— AND SURYAKANTA. Pollen morphology of aquatic angiosperms—II. *Palynological Bull.* 6(2) : 80-83. 1973.

RAM, M. Floral morphology and embryology of *Trapa bispinosa* Roxb. with a discussion on the systematic position of the genus. Phytomorphology 6 : 312-323. 1956.

SCULTHORPE, C. D. *Biology of aquatic vascular plants*. London. 1967.

SHARMA, B. D. Occurrence of 3-zonocolpate, diorate pollen in *Aeschynomene aspera* L. (Leguminosae) and the significance of pollen morphology in the toxonomy of the genus *Aeschynomene* Linn. *Bull. Bot. Surv. India* 10 : 369-373. 1968.

SHARMA, Mithilesh. Pollen morphology of Indian monocotyledons. *Journ. Palynology*, special vol. Lucknow. 1967.

SUBRAMANYAM, K. *Aquatic Angiosperms*. New Delhi. 1962.

THANIKAIMONI, G. LES *Palmiers* : Palynologie et systematique. Inst. Fr. Pondichery, *Trav. Sect. Sci. Tech.* 11 ; 1-286. 1970.