

POLLEN MORPHOLOGY OF NYMPHAEACEAE (S.L.)

G. V. S. MURTHY

Botanical Survey of India, Howrah

ABSTRACT

Eleven taxa of the Nymphaeaceae (s.l.) belonging to five genera viz., BRASENIA, EURYALE, NYMPHAEA, NELUMBO and VICTORIA were examined for the present study. NELUMBO pollen is quite distinct from other genera of Nymphaeaceae in having 3-zonocolpate apertures and reticulate exine. In VICTORIA pollen are shed as permanent tetrads, while in BRASENIA, EURYALE and NYMPHAEA pollen are produced as monads. The pollen grains are 1-(2)-aperturate, zoni or zonasulculate and hetero-or iso-polar. Exine surface is spinate, tuberculate, verrucate, granulate or psilate. The application of pollen characters within the family is discussed.

Key words : Nymphaeaceae, monad, tetrad, colpate, zonasulculate.

INTRODUCTION

The family Nymphaeaceae (s.l.) have five genera and about eleven species in India (Mitra, 1993). The plants are fresh water herbs with perennial, erect or horizontal rhizomes. The genera BRASENIA, EURYALE, NYMPHAEA and NELUMBO occur in wild while VICTORIA is a novelty and confined to gardens. Bentham and Hooker (1862) included all these genera under one family Nymphaeaceae, while others segregated them into different families as Nymphaeaceae (s.s.), Cabombaceae, Barclayaceae, Nelumbonaceae etc., (Cronquist, 1981; Hutchinson, 1969; Takhtajan, 1980).

It is generally considered that Nymphaeaceae is one of the primitive families of the angiosperms and this view is supported by pollen morphology (Erdtman, 1952; Ueno, 1962; and Walker, 1974 a & b). Pollen grains in Nymphaeaceae are bilaterally symmetrical and generally have a single aperture, except NELUMBO. The nature of aperture of NYMPHAEA

pollen was interpreted variously by earlier workers. Erdtman (1952), Walker (1974a) and Chanda and Ghosh (1979) interpreted the aperture as a single narrow colpus that encircles the grain and situated at distal and end of the pollen and referred to it as zonisulculate. While Fageri and Iversen (1975) and Jones and Clarke (1981) considered it as a single large pore centered on one pole and covered by an operculum and described it as monoporate. In this study the encircling aperture is described as "zonasulculate" following Walker (1974a): which may be located at the equator (zonizonasulculate) or at the distal pole (anazonasulculate).

The purpose of this paper is to present a Palynological account of Indian Nymphaeaceae (s.l.) as examined with SEM and its taxonomical significance.

MATERIALS AND METHODS

Polliniferous materials from herbarium specimens were collected from CAL and MH.

Fresh pollen from the plants growing in the Indian Botanic Garden (IBG), Howrah were also collected for palynological preparation.

For the light microscopic investigation the pollen were acetolysed and mounted in glycerine-jelly. Observations were made with Olympus microscope using oil immersion objective ($\times 100$) and $15 \times$ eyepieces. Pollen slides were deposited at the Palynology

Laboratory, Central National Herbarium (CAL), Howrah. For SEM study the alcohol dried pollen were placed on stubs, coated with gold and examined with a Philips SEM 515.

The taxa are presented in alphabetical sequence within the subfamilies of Bentham and Hooker (*l.c.*). The voucher numbers and pollen slide accession numbers (PS) are cited after pollen description of each species.

OBSERVATIONS

KEY TO THE GENERA

- | | |
|---|----------------------|
| 1a. Pollen 3-zonocolpate; exine reticulate | NELUMBO |
| 1b. Pollen 1-2-aperturate; exine not reticulate | ...2 |
| 2a. Pollen in permanent tetrads | ...VICTORIA |
| 2b. Pollen not in tetrads | ...3 |
| 3a. Exine collumellate | ...BRASENIA |
| 3b. Exine not columellate | ...4 |
| 4a. Exine spinulate | ...EURYALE, NYMPHAEA |
| 4b. Exine psilate/baculate/gemmate | ...NYMPHAEA |

I. CABOMBEAE

Brasenia schreberi J.F. Gmel. (Fig. 1)
(= *B. peltata* Pursh)

Pollen 1-aperturate, zonizonasulculate; isopolar. Pollen grain $18 \times 30 \mu\text{m}$ in eq. view. Exine scabrate; sexine slightly thicker than nexine, columellate; columellae circular in outline. Pollen similar to *Nymphaea nouchali* type.

R. L. Mitra 1475 CAL PS. 4141.

II. NYMPHAEAE

Euryale ferox Salisb.

Pollen 1-2-colpate or zonosulculate, colpi at distal pole, colpus $20 \times 6 \mu\text{m}$, margin irregular. Pollen grain $26 \times 48 \times 39 \mu\text{m}$ in 2-colpate pollen, $31-40 \times 40 \mu\text{m}$ in zonosulculate pollen. Exine spinulate, spinules about $1 \mu\text{m}$, conical; exine $1-1.5 \mu\text{m}$ thick, sexine thicker than nexine, collumellae obscure.

G.V.S. Murthy, fresh IBG, PS 3389.

Nymphaea alba Linn. (Fig.2).

Pollen 1-aperturate, anazonasulculate, membrane scabrate. Pollen grain $35-42 \times 30-40 \mu\text{m}$ in polar view, amb circular. Heteropolar.

Exine surface gemmate, gemmae up to 3 μ m, intergemmae area scabrate. Operculum scabrate or verrucate. Exine 1 μ m thick, stratification obscure, columellae absent, sexine elements variable in shape, tectate.

G.V.S. Murthy, fresh IBG, PS 3385.

***Nymphaea candida* C. Presl.**

(= *N. alba* var. *cachmeriana* H. f. & T.)

Pollen 1-aperturate, anazonasulculate. Pollen grain 42-47 $\times$ 28 μ m in polar view, amb circular. Heteropolar. Exine surface baculate and gemmate, bacula cylindrical up to 3 μ m, ends rounded, gemmae 2 μ m. Operculum psilate. Exine 1 μ m thick, stratification obscure, tectate.

T.A. Rao 9489 CAL, PS 707.

***N. nouchali* Burm. f. (Fig. 3 & 4).**

(= *N. stellata* Willd.)

Pollen 1-aperturate, zonizonasulculate furrow 3 μ m wide, membrane psilate to foveolate. Pollen grain 25 - 26 $\times$ 32 - 42 μ m in eq. view, amb circular. Isopolar. Exine psilate (LM), rugulate in SEM; 1 μ m thick, tectate.

Panigrahi 13473 CAL, PS 1059; *K. Thoathathi* 9600 CAL, PS 724.

***N. pubescens* Willd. (Fig. 5).**

[= *N. lotus* var. *pubescens* (Willd.) H. f. & T.]

Pollen 1-aperturate, anazonasulculate. membrane scabrate. Pollen grain 20 - 22 $\times$ 28 μ m in eq. view, amb circular. Heteropolar. Operculum psilate, flat to convex with shallow depression. Exine granulate; 1 μ m thick, columellae obscure, tectate.

M. Chandrabose 45126 MH, PS 3283; *G.V.S. Murthy* fresh IBG, PS 3383.

***N. rubra* Roxb. (Fig. 6).**

Pollen 1-aperturate, anazonasulculate. Pollen grain 42 $\times$ 35 μ m in polar view. Heteropolar. Exine psilate-granulate, 2 μ m thick, tectate. Operculum scabrate.

Panigrahi 11805 CAL, PS, 705; *G.V.S. Murthy* fresh IBG, PS 3384.

***N. tetragona* Georgi (Fig. 7).**

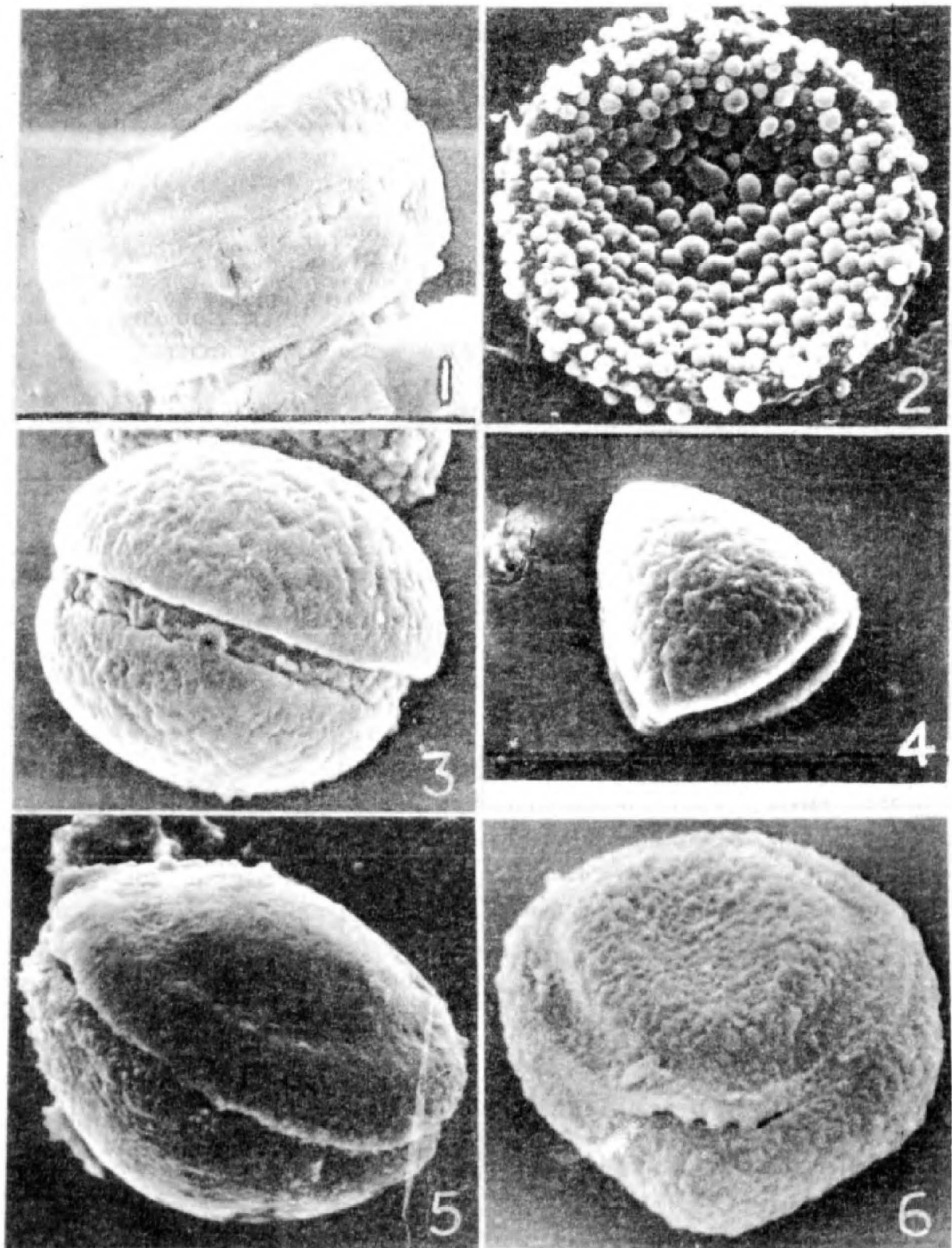
(= *N. pygmaea* Ait.).

Pollen 1-aperturate, zonizonasulculate. Pollen grain 20 - 22 $\times$ 30 - 32 μ m in eq. view. Isopolar, convex at both poles. Exine psilate-scabrate (LM), tuberculate (SEM).

R.L. Mitra 1476 CAL, PS 4140.

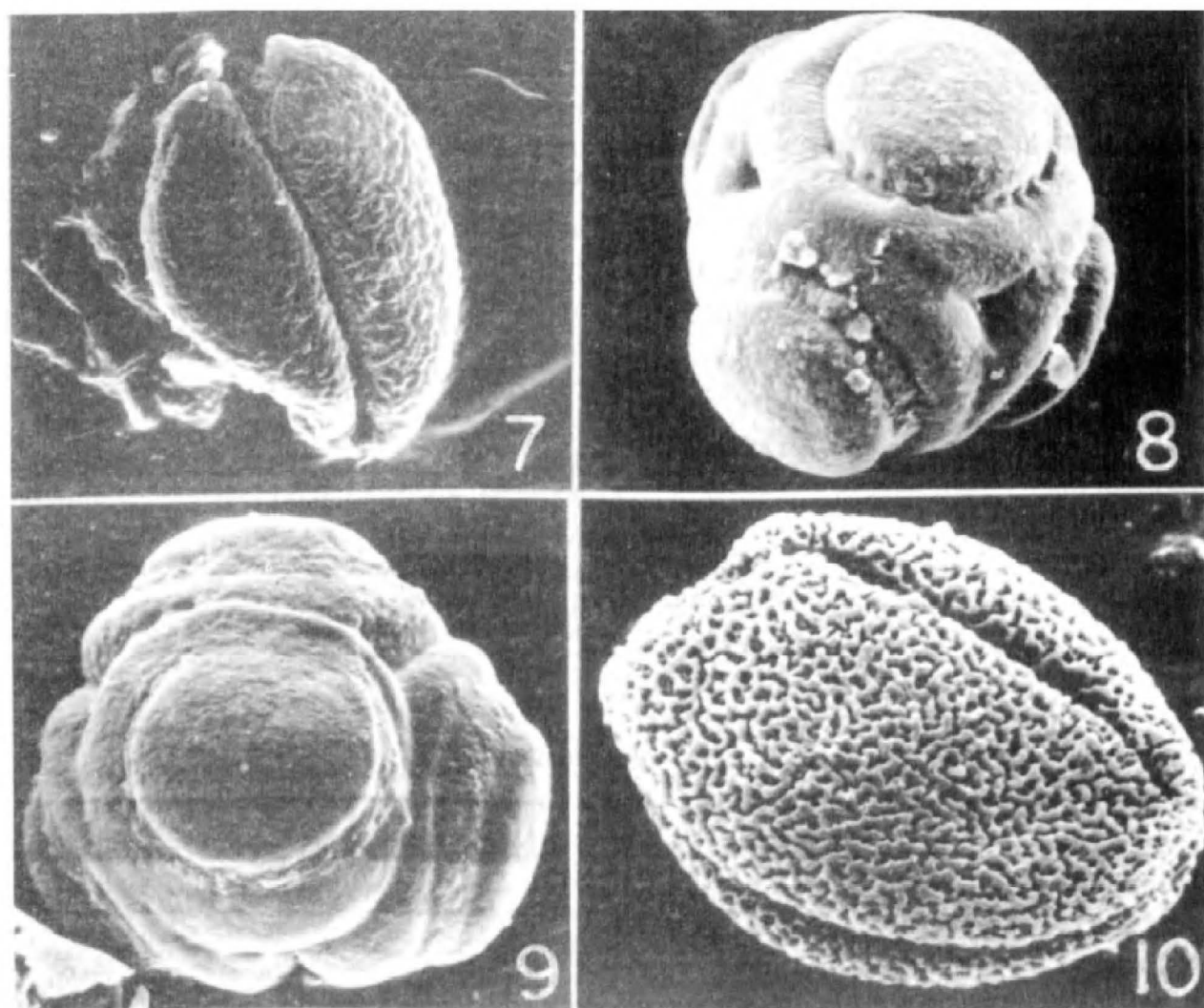
KEY TO NYMPHAEA SPECIES

- | | |
|--------------------------------|---|
| 1a. Aperture zonizonasulculate | ... <i>N. nouchali</i>
... <i>N. tetragona</i> |
| 1b. Aperture anazonasulculate | ...2 |
| 2a. Exine gemmate/baculate | ... <i>N. alba</i>
... <i>N. candida</i> |
| 2b. Exine psilate-granulate | ... <i>N. pubescens</i>
... <i>N. rubra</i> |



EXPLANATION OF FIGURES

1. *Brasenia schreberi*, equatorial view with zonizonasulcate aperture, $\times 1900$. 2. *Nymphaea alba*, polar view, exine gemmate, $\times 2200$. 3. and 4. *N. nouchali*; 3. zonizonasulcate pollen in hydrated state. $\times 2900$; 4. pollen in dry state, $\times 1400$. 5. *N. pubescens*, equatorial view, operculum psilate, $\times 2100$. 6. *N. rubra*, anazonasulcate with verrucate operculum. $\times 2500$.



EXPLANATION OF FIGURES

7. *N. tetragona*, zonizonasulcate with tuberculate exine, 1400.
8. *Victoria amazonica*, tetrahedral tetrad showing anazonasulculus. $\times 800$.
9. *V. cruziana*, tetrad with psilate exine and operculum, $\times 800$.
10. *Nelumbo nucifera*, equatorial view with colpi and reticulate exine, 1200.

Victoria amazonica (Poepp.) Sowerby (Fig. 8).
(=*V. regia* Lindl.)

Pollen in permanent tetrahedral tetrads; tetrad size $30 \times 32 \mu\text{m}$. Aperture anazonasulcate, membrane scabrate, operculum diam. $25 \mu\text{m}$. Exine psilate(LM), $1 \mu\text{m}$ thick; sexine slightly thicker than nexine, tectate. Operculum psilate.

Intine $2 \mu\text{m}$ thick in unacetolysed pollen.

G.V.S. Murthy fresh IBG, PS 3410.

V. cruziana Orbigny (Fig. 9).

Pollen similar to *V. amazonica*, as permanent tetrahedral tetrads.

G.V.S. Murthy fresh IBG, PS 3411.

III. NELUMBIEAE

Nelumbo nucifera Gaertn. (Fig. 10).

Pollen 3-zonocolpate; colpi $60 \times 2 \mu\text{m}$. Pollen grains $74 \times 53 \mu\text{m}$ ($63 - 74 \times 52 \times 68 \mu\text{m}$). **Prolate**. Exine reticulate, heterobrochate, muri curved, lumina rugulate; exine $3 \mu\text{m}$ thick, sexine thicker than nexine, simple columellate.

M. Chandrabose 45247 MH, PS 3282;
G.V.S. Murthy fresh IBG, PS 3251.

DISCUSSION

The pollen are variable in the family Nymphaeaceae (*s.l.*) with regard to number of apertures, aperture type, polarity, exine sculpture and structure. The pollen of VICTORIA are produced as permanent tetrahedral tetrads, whereas in BRASENIA, EURYALE, NYMPHAEA and NELUMBO they occur as monads.

Aperture : The number of apertures range from one to three. The ring like, encircling aperture position in BRASENIA, EURYALE, NYMPHAEA and VICTORIA varies from being around the distal pole (anazonasulculate) to the equator (zonizonasulculate) (Erdtman, 1952 and Walker, 1974a). Intermediate stages in the evolution of these zonasulculate aperture types may be observed in the pollen of the genus NYMPHAEA. Pollen of *N. candida* is considered to possess the most primitive aperture condition in the genus (Walker, 1974a). They are heteropolar in nature. The advanced aperture type within the genus seems to be that with isopolar pollen, which has an equatorially located zonasulculus as in *N. nouchali* and *N. tetragona* (Figs. 3 & 7). The operculum which occurs in the pollen of some species of NYMPHAEA appears to have originated from anasulcate pollen (Walker, 1974a). The interpretation of nonequatorial aperture in the

Nymphaeaceae as distal may actually be observed in the permanent tetrads of VICTORIA (Fig. 8) and in young stages of pollen development in NYMPHAEA (Ueno, 1962). The NELUMBO pollen is characterised by the advanced typical dicotyledenous 3-zonocolpate type (Fig. 10). The pollen of VICTORIA species are always anazonasulculate and remain as permanent tetrads (Fig. 8 & 9) and not 3 or 4-colpate as observed by Mondal (1989).

Polarity and symmetry : The pollen of the NELUMBO are isopolar and radially symmetrical. NYMPHAEA and BRASENIA have both heteropolar and isopolar and bilateral pollen. The pollen of Euryale are bilateral and isopolar. The pollen in VICTORIA are tetrahedral tetrads.

Shape and size : The shape expressed by mean P/E ratio varied from oblate spheroidal to spheroidal. The dry pollen of NYMPHAEA, EURYALE and BRASENIA are folded along the equatorial line and appear either circular or triangular in polar view (Fig. 4). In hydrated state they become spherical along the equatorial line (Fig. 3). The NELUMBO pollen are spheroidal to prolate. The grains are smaller in *Brasenia schreberi* $18 \times 30 \mu\text{m}$ while larger in *Nelumbo nucifera* $74 \times 53 \mu\text{m}$. The pollen of EURYALE, NYMPHAEA and VICTORIA are in between $26 - 40 \mu\text{m}$.

Exine sculpture and structure : The exine surface is variously sculptured. The exine surface is psilate in *Nymphaea nouchali* and *N. pubescens*, granulate in *N. rubra*, *N. tetragona*, BRASENIA and VICTORIA, gemmate and baculate in *N. alba* and *N. candida*, while spinate in *Euryale ferox*. The genus NELUMBO alone has reticulate exine. The operculum in *N. alba*, *N. candida*, *N. pubescens*, *N. rubra* and VICTORIA is psilate to scabrate and differs

from general exine sculpture. The exine of *Euryale ferox* appear as reticulate under LM (Nair, 1965; Mondal, 1989), but it is spinulose in SEM (Walker, 1974b; Ueno, 1962). The exines of *Nymphaea nouchali* and *VICTORIA* are not spinulose or warty as recorded by Mondal (1989).

The exine thickness is more or less 1 μ m in all the species except *Nelumbo nucifera* where it is 3 μ m. The general exine structure is nexine and sexine; the sexine consists of a tectum and a granular or homogenous layer below it. The *NELUMBO* and *BRASENIA* pollen have distinct columellae layer below the tectum and differ from others in exine structure (Ueno, 1962; Walker, 1974b; Clarke and Jones, 1981).

Pollen morphology and taxonomy : According to Hutchinson (1969) Cabombaceae is more closely allied to Ranunculaceae than to Nymphaeaceae (s.s.). This is however, not corroborated by the pollen morphology. Taxonomically the Cabombaceae is recognised as being closely related to the Nymphaeaceae and is sometimes included in that family (Bentham and Hooker, 1862). As in the species of NYMPHAEA the pollen of BRASENIA are bilaterally symmetrical with a zonaulculate aperture, but differs from Nymphaeaceae (s.s.) in having well developed columellae below the tectum. Considering all facts palynological evidence supports segregation of Cabombaceae as Cabombaceae and Nelumbieae as Nelumbonaceae and to retain the rest in Nymphaeaceae (s.s.) (Erdtman, 1952; Ueno, 1962; Walker, 1974a & b and Jones and Clarke, 1981).

Walker (1974b) has reported that Nymphaeaceae (s.s.) pollen have no distinct

columellae, instead show a granular layer between the nexine and tectum as in gymnospermous pollen. Walker argues that this feature is an indication of phylogenetically primitiveness of the family.

The pollen grains of Nymphaeaceae are very distinct from that of Berberidaceae, Ceratophyllaceae and Ranunculaceae. The NYMPHAEA type of pollen grains are encountered in another ranalian family Eupomatiaceae (Walker, 1974a).

ACKNOWLEDGEMENTS

Thanks are due to Mr. R.L. Mitra, Scientist SE, Botanical Survey of India for his valuable suggestions and for providing some materials for this study.

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