Taxonomy and Pollen Morphology of the Genus *Ruppia* L. (Ruppiaceae) in India with Special Reference to Systematic Position

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The genus *Ruppia* L. is a cosmopolitan genus distributed in the temperate and tropical regions of the world. The genus as a rule is abundant in a habitat of brackish water in coastal areas with some exceptional reports of occurrence in fresh water conditions from South America, New Zealand and India. Taxonomically *Ruppia* L. has been treated variously from time to time. Most of the workers consider only a single species whereas others recognize 2-7 species. In India it is represented by a single species with a subspecies. The present paper deals with morphology, phytogeography, pollen morphology, pollination biology and chromosome number, etc. towards better understanding of the systematic position and taxonomic circumscription of the taxon.

Key-words - *Ruppia*, Morphology, Taxonomy.

INTRODUCTION

THE genus *Ruppia* L. is an annual or perennial submerged herb of shallow brackish water near sea coasts, saline inland water and sometimes fresh water in temperate and tropical regions of the world. Plants have also been collected from about 4000m in the Andes (Heywood, 1978). The genus attains the interest of botanists for the controversial taxonomy as some workers recognize only one species while others regard 2-7 species. In India it is represented by a single species with a subspecies. The genus has often been placed in the family Potamogetonaceae. The present authors prefer to keep it under a distinct family Ruppiaceae. The plant is a source of food for water fowls, occasionally consumed by fishes and also offers them protection from predators.

MATERIALS AND METHODS

Herbarium specimens for the present study were examined from CAL & MH. Fresh materials collected from the fields have been deposited in CAL and introduced in Indian Botanic Garden germplasm collection unit. Pollen slides have been prepared and deposited in the sporotheck, Palynology Laboratory, Central National Herbarium, Howrah.

Review of Literature : The genus *Ruppia* L. was described by Linnaeaus (1753) in his *Species Plantarum*, considering *Ruppia maritima* as the type species, based on a material from Europe. Since then it has been studied by various workers from different view points. A literature survey reveals that important taxonomical and morphological works have been contributed by Graves (1908), Hutchinson (1934, 1973), Mc Cann (1945), Setchell (1946), Mason (1967), Gamerro (1968), Cronquist (1968, 1981, 1988), Takhtajan (1969, 1980, 1987), Aston (1973), Davis and Tomlinson (1974), Thorne (1976, 1983), Brock (1982a, 1982b), Jacobs and Brock (1982), Dahlgren *et al.* (1985), Talavera and Garcia –Murillo (1987). Being an aquatic species of varied ecological habitat it has attracted the attention of ecologists like Verhoeven (1979), Richardson (1980), Brock (1981), Vollebergh and Congdon (1986). Important contributions have been made in the fields of floral biology, floral anatomy and pollination biology by Singh (1965), Posluzy and Sattler (1974), Cook (1988), Haynes (1988), Cox and Knox (1989). Cytological information so far available have been mainly contributed by Reese (1962, 1963), Van Vierssen *et al.* (1981), Marchioni-Ortu (1982), Snoeijs and Van der Ster (1983) and Talavera *et al.* (1993). Pollen morphological informations are mainly contributed by Erdtman (1952), Heusser (1971).

TAXONOMY

Ruppia L., *Sp. Pl.*, 127. 1753; *Gen. Pl.* ed 5.61. 1754; Hook. f., *Fl. Brit. India*, **6**: 568. 1893: Aschers, *et* Graebn. *in Engl. Pflanzenr.* 4.2:142. 1907; Karthikeyan *et al., Fl. Ind. Enum. (Monoc.)* : 285. 1989.

Type species : *Ruppia maritima* L.

Herbs monoecious, rhizomatous, glabrous. Roots fibrous. Leaves alternate, opposite or whorled, linear or filiform, base sheathing, 1-nerved, green. Inflorescence 2- flowered spike, terminal, peduncle elongate or short, spirally coiled or not. Flowers inconspicuous, bisexual, ebracteate. Perianth absent. Stamens 2, opposite, anthers sessile, dithecous, tetrasporangiate, extrorse, connective expanded. Carpels (2-) 4 (-8), distinct, sessile or subsessile, elongated after effective fertilization to form long stipitate fruit, stigma ventro-apical, ovule solitary. Fruits ovoid, symmetrical or asymmetrical drupelets, long stipitate. Seeds pendulous, without endosperm.

Ruppia maritima L. A. Habit, B. Inflorescence concealed within leaf sheath, C. Inflorescence, D. Stamen, E. Carpel, F. Fruits, G. A Single Fruit.

Ruppia maritima L. *Sp. Pl.* 127. 1753; Fischer in Gamble, *Fl. Pres. Madr.*: 1600. 1931 (**3**: 1116. 1957, Repr. ed.); Mc Cann in *J. Bombay nat. Hist. Soc.* 45: 396. 1945; Santapau, *Pl. Sauras.*: 837. 1953; Subramanyam, *Aquat. Angio.*: *96*. 1962; Bole *et* Pathak, *Fl Sauras.* **3**:334. 1988; Bhargavan *in* Henry *Fl. Tamil Nadu*, **3**: 61. 1989. *Ruppia rostellata* Koch. *in* Reichb. *Ic. Crit.* **2**: 66. 1824; Hook. f., *Fl. Brit. India*, **6**: 568. 1893; Prain, *Beng. Pl.* **2**: 1124. 1903 (2: 846. 1963, Repr. ed.); Cooke, *Fl. Bomb Pres.*, **3**: 351. 1958 (Repr. ed.); Hanies, *Bot. Bih. Or.* **3**: 890. 1961 (Repr. ed.).

Herbs monoecious, glabrous, rhizomatous. Roots fibrous. Stem slender, horizontal or erect, internodes upto 3.4 cm. Leaves alternate or whorled, linear, apex acute, with sheathing base and without ligule, 81x0.5 mm, entire, 1-nerved. Inflorescence 2-flowered spike, 2 mm, concealed in the sheath of uppermost vegetative leaf; peduncle not spirally coiled, 3-4 mm, base reddish, recurved in fruit. Perianth absent. Stamens 2, opposite, sessile, anthers 0.5 mm, bilocular, loculi reniform, connective expanded. Carpels 3-4, 0.5 mm; stigma obovate, subsessile. Fruit ovoid, almost symmetrical, 2-3x 1-1.5 mm, stipe 0.7-1.2 cm, endocarp beak 0.5 mm. Seed dark brown.

Key to subspecies

Peduncle not coiled.....ssp. ***maritima***

Peduncle coiled.....ssp. ***spiralis***

ssp. ***maritima.***

Type : Herb. LINN 1085

Fl. & Fr. : Throughout the year.

Distrib. : West Bengal, Orissa, Tamil Nadu, Maharashtra, Gujarat. It has been introduced in National Botanical Research Institute, Lucknow, Uttar Pradesh.

Specimens examined : WEST BENGAL : Lower Bengal, Calcutta, Kurz, s.n. (CAL); Calcutta, Kurz, s.n., May 1868 (CAL); Sunderbans, Mondal & Guha - 210, 26.03. 1998. (CAL). ANDHRA PRADESH: Podauppalam, Kakinanda, East Godavari Distt., Ravikumar & Ganesan, Coll. No. 88828,

11.09. 1988 (MH). TAMIL NADU : Tuticorin, Anonymous, Coll. No. 1215, 1839 (MH). MAHARASHTRA : Tendana, Anonymous, Coll. No. 53177 (CAL); Concan, Stockes. s.n. (CAL); near Mumbai,Anonymous, s.n. ((CAL); Savantvadi, Dalzels, s.n. 03. 04. 1900 (CAL).

Note : Setchell (1946) suggested that the specimen of *Ruppia maritima* (2 specimens) in the Linnaeaen herbarium might have been obtained after Linnaeaus had described *Ruppia*. Setchell indicated that Linnaeaus had based his concept on plate 35 in Micheli (1729), and that the same is the type. Jacobs and Brock (1982), consider plate 35 of Micheli, Nova Plantarum Genera.....72 (1729) as Lectotype of *Ruppia maritima*.

ssp. ***spiralis*** L .ex Dumort., *Fl. Belg.*: 164. 1827; Fischer *in* Gamble *Fl. Pres. Madr.*: 1600. 1931 (**3**: 1116. 1957, Repr. ed.); Karthikeyan *et al.*, *Fl. Ind. Enum.* (*Monoc.*): 285. 1989.

Leaves, whorled or alternate, linear, apex acute. Flowers minute bisexual, ebracteate, peduncle coiled. Stamens 2, anthers sessile. Carpels 4, sessile, long stipitate in fruit, stigma sessile, obovate. Fruits ovoid.

Distrib. : Tamil Nadu.

Note. : The present authors on personal examination of the herbarium specimen in CAL and MH did not find any specimen belonging to ssp. *spiralis* L. ex Dumort., nor they could collect any from the field.

PHYTOGEOGRAPHY

Cosmopolitan genus *Ruppia* L. is distributed in South Africa, Madagascar, Comoro Islands, Mauritius, Pakistan, India, China, Taiwan, Malay Peninsula, Japan, New Caledonia, Australia, Europe, North America, Central America, South America, Hawaiian Islands, West Indies including Bermuda.

In India it is found in the coastal areas of West Bengal, Orissa, Tamil Nadu, Maharashtra and Gujarat. It has been recorded in fresh water conditions from Uttar Pradesh (Lucknow) and West Bengal (Mondal & Guha, 1998).

POLLEN MORPHOLOGY AND POLLINATION BIOLOGY

Ruppia maritima L. : Pollen grains heteropolar, bilateral convexo-concave, faintly arcuate, 3-tenuate, longest axis range: 70-75 µm (35x72x30 µm), exine reticulate, thin towards convex pole, thicker in the non-tenuate area, sexine thicker than nexine in non-tenuate portion (*Material* : Mondal & Guha -210, Sunderbans, 26.03.1998).

In *Ruppia maritima* L. ssp. *maritima* the pollination takes place under water, where after peduncle elongation, the anthers dehisce under water, the released pollen grains are trapped in air bubbles which remain adhered to the inflorescence for quite sometime, ascertaining self pollination (Verhoeven, 1979). This ensures ample seed set. But sometimes in shallow waters the inflorescence is raised at the water surface, where the pollen grains are trapped in the air bubble, which when break release the pollen. The liberated pollen grains float and on coming in contact with a stigma effects cross fertilization. *Ruppia maritima* L. ssp. *maritima*, thus exhibits a case of both ephydrophily and hyphydrophily.

Ruppia maritima ssp. *spiralis* L. ex Dumort. represents a case of ephydrophily, where pollination takes place at the water surface. Here the released pollen grains are trapped in air bubble, which break free from the inflorescence and rise to the water surface. The air bubble breaks and the liberated pollen float on account of air trapped in the reticulations of the exine. On coming in contact with a stigma at water surface cross pollination occurs (Haynes, 1988).

The functional morphology of the gynoecium suggests that the funnel-like arrangement of the carpels direct pollen grains—which remain aggregated facilitated by their boomerang like morphology— to the stigmatic regions. The bouyancy of the carpellary outgrowth is due to the presence of stomates and underlying spongy tissue (Lacroix & Kemp 1997).

CHROMOSOME NUMBER

Chromosome number reports so far available reveal that the basic chromosome number of *Ruppia* L. is x=10 (also some reports of x=8). Diploid

Table 1 : Pollination Systems in *Potamogeton L.* (few species), *Ruppia* L. and *Zannichellia* L.

Taxon	Habitat	Sexual reproduction	Sexual condition	Pollination type
Potamogeton nodosus Poir	Fresh water	Common	Monoecious	Anemophilous
P. natans L.	Fresh water	Common	Monoecious	Anemophilous
P. crispus L.	Fresh water	Common	Monoecious	Anemophilous
Ruppia maritima.ssp *spiralis* L. ex Dumort.	Brackish water	Common	Monoecious	Ephydrophilous
R. maritima L. ssp *maritima.*	Brackish water/Fresh water	Common	Monoecious	Hyphydrophilous
Zannichellia palustris L.	Brackish water/Fresh water	Common	Monoecious	Hyphydrophilous

populations have been reported from cold regions of northern Europe and Canada, whereas tertraploid specimens have been reported mainly from warm and temperate areas of the Mediterranean region and Japan (Talavera *et al.*, 1993). Hexaploid as well as triploid specimen have been reported from Germany and South Australia respectively (Reese, 1962; Snoeijs & Van der Ster, 1983). *Ruppia maritima* L. has a pair of larger chromosomes, which have a satellite on the longer arm. The tetraploids have two pairs of large chromosomes, whereas hexaploids have three pairs (Reese, 1963).

SYSTEMATIC CONSIDERATIONS AND CONCLUSION

The systematic position of *Ruppia* L. has been a matter of controversy both at the specific and familial level among the taxonomists. Since the genus is closely related to *Potamogeton* L. many workers have included it under the family Potamogetonaceae. Ascherson and Graebner (1907) included *Ruppia* L. within the tribe Potamogetoneae. Hutchinson (1934, 1973) erected a distinct family Ruppiaceae on the basis of its habitat, terminal spikes, absence of perianth and long stipitate fruiting carpels with pendulous seeds. This has been supported by Cronquist (1968, 1981, 1988) Takhtajan (1969, 1980, 1987), Aston (1973), Cook *et al.*, (1974) and Stebbins (1974). But some authors like Thorne (1976, 1983), Dahlgren (1980), Jacobs and Brock (1982) have questioned about the distinction between the Ruppiaceae and Potamogetonaceae. Goldberg (1989) considers *Ruppia* L.under Potamogetonaceae.

Regarding floral anatomy, the triangular outgrowth of the stamen connective in *Ruppia* L. has been considered as homologous with the perianth segment of *Potamogeton* L. by Singh (1965). Foliar anatomy of *Potamogeton* L. and *Ruppia* L. reveal that the leaf of both the genus receives three traces. Singh (*l.c.*) prefers to keep *Potamogeton* L., *Ruppia* L. and *Zannichellia* L. together rather than splitting them, though *Zannichellia* L. seems to be more allied to Cymodoceaceae.

The basic chromosome number of *Ruppia* L. is x =10. Some populations are diploids, others tetraploid in tetraploid populations the large chromosomes are not identical-one pair metacentric and the other submetacentric, thus showing karyotypic asymmetry (Talavera *et al.*, 1993). Triploid and hexaploid specimens have also been reported (Reese, 1962, Snoeijs & Van der Ster, 1983). In *Zannichellia* L. the basic chromosome number is x=6, though some aberrant materials with 2n=36 (*Z. palustris* L.) have also been recorded (Van Viersen & Van Wijk, 1982)-diploids, tetraploids and hexaploids have also been found. *Potamogeton* L. have predominantly the basic chromosomes number of x =13, though 8, 10, 14 and 15 have also been recorded-the chromosomes are very short with gradation in karyotype and constrictions being usually median. A high degree of polyploidy characterises majority of this genus (Sharma & Chatterjee, 1967). Thus on the basis of karyological characters-*Rupia* L. have relatively asymmetric and low number of chromosomes, whereas *Potamogeton* L. have comparatively symmetric and high chromosome number suggesting an advanced degree of development.

Palynologically *Ruppia* L. is quite distinct from *Potamogeton* L. and *Zannichellia* L. The pollen of *Ruppia* L. are tri-tenuate, *Potamogeton* L. 1-colpate

or inaperturate and those of *Zannichellia* L. inaperturate. Pollen morphologically species of *Potamongeton* L. shows relatively derived type of morphoforms and *Ruppia* L. stands between the *Potamogeton* L. and *Zannichellia* L.

The pollination biology of *Ruppia* L. shows a transition between *Potamogeton* L. - a wind pollinated genus (with some exceptions like *P. filiformis* Pers., *P. pectinatus* L., etc. pollinated under water) and *Zannichellia* L. which exhibits totally submerged pollination (*Potamogeton* L.—*Ruppia* L.—*Zannichellia* L.) (Table-1).

The species recorded from Australia (*Ruppia tuberosa* Davis & Tomlinson) throws some light on the relationship between *Ruppia* L. and *Potamogeton* L. This species has swollen shoots rich in starch at the end of nearly all axes recalling the turions of *Potamogeton* L. Davis and Tomlinson (1974) support the inclusion of the two genera, *Ruppia* L. and *Potamogeton* L. in the same family.

Though the similarity between *Ruppia* L. and *Potamogeton* L. is apparent from floral anatomy, pollination biology and vegetative morphology to some extent, the difference between the two seem to be quite sufficient to maintain Ruppiaceae as a distinct family, rather than retaining *Ruppia* L. under Potamogetonaceae especially when the pollen grains are also distinctly different from Potamogetonaceae (Table -2).

The genus *Ruppia* L. has been treated variously by the taxonomists from time to time. Some consider a single species with subspecies and varieties whereas others recognize 2-7 species.

The Linnaeaen concept was that *Ruppia* L. is a single species with a form with spiral peduncle. Setchell (1946) recognizes two valid species and according to him various species, subspecies, varieties, proles and forms are just reversible expressions of form and size. He emphasized on the ecotype variation. Mason (1967) considered shape of leaf tip, leaf sheath, shape of pollen sac, shape and size of fruit, podogyne length as specific characters, and stressed that length of the peduncle has no diagnostic value for the species where pollination is affected on the water surface because it depends on the depth of the water.

Pollen resembling *Ruppia* L. has been recorded from Paleocene of Texas by Elsik (1968), but without description. The photomicrograph of the fossil pollen shows a general resemblance but of much smaller size and columellate structure being not visible (Mueller 1981).

Present authors during the course of revisionary work of the group Helobieae dealing with the genus *Ruppia* L. have come to the conclusion that the habit of the plant varies greatly depending on the environment, but some characters are of taxonomic value like creeping habit with short stems and long leaves, 2-

Table 2 : Comparative salient features of *Ruppia* L. , *Potamogeton* L. and *Zannichellia* L.

Characters	*Ruppia* L.	*Potamogeton* L.	*Zannichellia* L.
Habitat	Fresh to brackish water	Fresh to saline water	Fresh or brackish water, salt marshes, lagoons.
Sheath	Leaf sheat free without ligule	Stipular sheath & free leaf sheath with ligule	Leaf sheath with ligule
Inflorescence	Axillary or terminal spike	Axillary or terminal spike	Axillary cyme
Flowers	2	More than 2	1 male & 4 female
Perianth	Absent	Present	Absent in male flower, cupular in female flower.
Stamen	2	4	1-3
Carpel	2-8	4	1-9
Fruiting carpels	Stipitate	Sessile	Stipitate
Pollen	Tri-tenuate	1-colpate & inaperturate	Inaperturate
Chromosome numbers	x = 10	x = 8, 10, 13, 14, 15, especially 13	x = 6

flowered spike, absence of perianth, number of stamens, fruiting carpels, leaf sheath and pollen grains.

Considering all the foregoing discussions on morphological, biosystematical and palynological data and correlation of characters from other branches of botany, present authors support the erection of a distinct family Ruppiaceae for the genus *Ruppia* L. rather than retaining it under Potamogetonaceae.

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REFERENCES

Aston, H.I. 1973. *Aquatic Plants of Australia*. Melbourne Univ. Press. Melbourne, 368 pp.

Brock, M.A. 1981. The ecology of halophytes in the south east of South Australia. *Hydrobiologia*, **81**: 23-32.

Brock, M.A. 1982a. Biology of the salinity tolerant genus *Ruppia* L. in saline lakes of South Australia. I. Morphological variation within and between species and ecophysiology. A*quat. Bot.*, **13**: 219-248.

Brock, M.A. 1982b. Biology of the salinity tolerant genus *Ruppia* L. in saline lakes of South Australia. I. Population ecology and reproductive biology. *Aquat. Bot.*, **13**: 249-268.

Cook, C.D.K. 1988. Wind pollination in aquatic angiosperms. *Ann. Missouri. Bot. Gard.* **75**: 768-777.

Cook, C.D. K., Gut, B.J., Rix, E. M., Schneller, J. & Seitz, M. 1974. *Water Plants of the World.* Junk, The Hague.

Cox, P.A. & Knox, R.B. 1989. Two dimensional pollination in hydrophilous plants: Convergent evolution in the genera *Halodule, Halophilia, Ruppia, Lepilaena. Am. J. Bot.*, **76**: 164-175.

Cronquist, A. 1968. *The Evolution and Classification of Flowering Plants.* Thomas Nelson & Sons, London.

Cronquist, A. 1981. *An integrated System of Classification of Flowering Plants.* Columbia Univ. Press.

Cronquist, A. 1988. *The Evolution and Classification of Flowering Plants.* 2nd Edn.

Dahlgren, R.M.T. 1980. A revised system of classification of the angiosperms. *Bot. J. Linn. Soc.*, **80**:91-124.

Dahlgren, R.M.T., Clifford, H.T. & Yeo, P.F.1985. *The Families of the Monocotyledons : Structure, Evolution & Taxonomy.* Berlin, Heidelberg, New York & Tokyo.

Davis, J.S. & Tomlinson, P.B. 1974. A new species of *Ruppia* L. in high salinity in Western Australia. *J. Arnold. Arbor.*, **55**: 59-66.

Elsik, WC. 1968. Palynology of a Paleocene Rockdale lignite, Milam County, Texas. II. Morphology and Taxonomy. *Pollen Spores* **10**: 599-664.

Erdtman, G. 1952. *Pollen Morphology and Plant Taxanomy (Angiosperms).* Waltham Mass., U.S.A.

Gamerro, J.C. 1968. Observations sobre la biologia floral morfologia de la Potamogetonacea *Ruppia cirrhosa* (Petag.) Grande (= *R. spiralis* L. ex Dum.). *Darwiniana*, **14**: 575-608. (not seen in original).

Goldberg, A. 1989. Classification, Evolution and Phylogeny of the families of Monocotyledons, *Smithsonian Contributions to Botany*, 71.

Graves, A.H. 1908. The morphology of *Ruppia maritima* L., *Trans, Conn. Acad. Arts Sci.*, **14**: 55-170.

Haynes, RR 1988. Reproductive biology of selected aquatic plants. *Ann. Missouri Bot. Gard.*, **75**: 805-810.

Heusser, C.J. 1971. Pollen and spores of Chile. Univ. Arizona press. Teusen.

Heywood, V.H., Moore, D.M., Richardson, I.B.K. & Stearn, W.T. (Eds.) 1978. *Flowering Plants of the World.* New York.

Hutchinson, J. 1934. *The Families of Flowering Plants.* II. Monocotyledons. Clarendon Press, Oxford, 1st Edn.

Hutchinson, J. 1973. *The Families of Flowering Plants.* ed. 3. Oxford Univ. Press, London.

Jacobs, S.W.S. & Brock, M.A., 1982. A revision of the genus *Ruppia* L. (Potamogetonaceae) in Australia. *Aquat. Bot.*, **14**: 325-337.

Lacroix, C.R. & Kemp, J.R. 1997. Development morphology of the androecium & gynoecium in *Ruppia maritima* L.: considerations for pollination . *Aquat. Bot.*, **59**:3-4, 253-262.

Marchioni-Ortu, A. 1982. Numeri chromosomici per la Flora Italiana: 873-876. *Inf. Bot. Ital.*, **14**: 234-237. (Not seen in original).

Mason, R. 1967. The species of *Ruppia* L. In New Zealand, *N.Z.J. Bot.*, **5**(4): 519-531.

Mc Cann., C. 1945. Notes on the genus *Ruppia* (Ruppiaceae). *J. Bombay nat. Hist, Soc.*, **45**: 396-402.

Mondal M.S. & Ratna Guha, 1998. The Dutch-Grass-A noteworthy plant species from wetlands of West Bengal with interesting floral biology, *ENVIS*, **5**:4-5 (Botanical Survey of India).

Mueller J 1981. Fossil pollen record of extant Angiosperms. *Bot. Rev.* **47 (1)** : 1-40

Posluzy, U. & Sattler, R. 1974. Floral development of *Ruppia maritima* L. var. *maritima*. *Can.J. Bot.*, **52**: 1607-1612.

Reese, G. 1962. Zur intragenerischen Taxonomie der Gattung *Ruppia* L. Ein cytosystematischer. *Beitrag. Z. Bot.* (Stuttgart), **50**: 237-264. (not seen in original).

Reese, G. 1963. Über die deutschen *Ruppia* L. und *Zannichellia* L. Kategorien und ihre Verbreitung in Schleswig-Nolstein, **34**: 44-70. (not seen in original).

Richardson, F.D. 1980. Ecology of *Ruppia maritima* L. in New Hampshire (U.S.A.) tidal marshes. *Rhodora*, **82**: 403-439.

Setchell, W.A. 1946. The genus *Ruppia* L., *Proc. Calif. Acad. Sci.*, **25**:469-478.

Sharma, M. 1967. Pollen morphology of Indian monocotyledons *J. Palynology* (Special Vol.) Lucknow : 46.

Sharma, A. & Chatterjee J. 1967. Cytotaxonomy of Helobieae with

special reference to the mode of Evolution, *Cytologia*, **32**: 286-307.

Singh, V. 1965. Morphological and anatomical studies in Helobieae. *Bot. Gaz.*, **126** (2): 137-144.

Snoeijs, P.J.M. & Van der Ster, H.E. 1983. Some notes on the cytotaxonomy of two *Ruppia* L. species in South Australia. *Aquat. Bot.*, **16**: 297-302.

Stebbins, G.L. 1974. *Flowering Plants, Evolution above the species level*. Cambridge, Massachusetts. (not seen in original).

Takhtajan, A. 1969. *Flowering Plants: Origin and Dispersal*. Edinburgh, Scotland.

Takhtajan, A. 1980. Outline of the classification of Flowering Plants (Magnoliophyta). *Bot. Rev.* **46**(3): 225-359.

Takhtajan, A. 1987. *Systema Magnoliophytorum*. Leningard [In Russian].

Talavera, S. & Garcia-Murillo, P. 1987. *Ruppia* L. In: B. Valdes, S. Talavera & E.F. Galiano (Eds.). *Flora Vascular de Andalucia Occidental*. **3**. Ketres. Barcelona: 194-195.

Talavera, S., Garcia-Murillo, P. & Herrera, J. 1993. Chromosome numbers and a new model for karyotype evolution in *Ruppia* L. (Ruppiaceae). *Aquat. Bot.*, **45**: 1-13.

Thorne, R.F. 1976. A phylogenetic classification of the Angiosperms. *Evol. Biol.* **9**: 35-106.

Thorne, R.F. 1983. Proposed New Realignments in the Angiosperms. *Nord. J. Bot.*, **3**: 85-117.

Van Vierssen, W., & Van Wijk, R.J. 1982. On the Identity & Autoecology of *Zannichellia peltata* Bertol. in Western Europe. *Aquat. Bot.* **13**: 367-383.

Van Vierssen, W., Van Wijk, R.J. & Van der Zee, J.R. 1981. Some additional notes on the cytotaxonomy of *Ruppia* taxa in Western Europe. *Aquat. Bot.*, **11**: 297-301.

Verhoeven, J.T.A. 1979. The ecology of *Ruppia* L. dominated communities in Western Europe. I. Distribution of *Ruppia* representatives in relation to their autecology. *Aquat. Bot.*, **6**: 197-267.

Vollebergh, P.J. & Congdon, R.A. 1986. Germination and growth of *Ruppia polycarpa* and *Lepilaena cylindrocarpa* in ephemeral salt marsh pools, Westernport Bay, Victoria. *Aquat. Bot.*, **26**: 165-196.

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