



Review of Literature

REVIEW OF LITERATURE

The Alismatidae traditionally referred to as Helobiae are one of the most interesting taxon of monocotyledons which have retained some very primitive characters on one hand and are specialized in several characters on other hand. Among the monocotyledons, Helobiae have been generally accepted as the most primitive group because of the polymery of the flowers, which have little or no fusion. Within Magnoliidae the aquatic order Nymphaeales presents the closest approach to the Alismatidae (Cronquist 1981). Alismatidae is one of the most interesting taxon of Monocotyledons from several points of views, such as primitive monocots, origin and evolution of monocots and their relationship with dicots. Therefore the group has attracted an attention of several workers in past. The literature dealing with Helobiae is extensive and scattered. It is impossible to reviews the entire literature on the group in such M.phil dissertation and therefore only important works on Helobiae in general and Alismataceae and Aponogetonaceae in particular are reviewed.

There is an extensive work on Helobiae and summaries of such works already exist in several excellent publications (Arber, 1920, 1925; Salisbury, 1926; Solereder and Meyer, 1933; Cheadle 1942; Pichon, 1946; Uhl, 1947; Rao, 1953; Harada, 1956; Eames, 1961; Sawami and Parameswaran 1963; Sharma and Chatterjee, 1967; Davis, 1966; Wilder, 1975; Ly thi Ba and Guignard, 1979; Takhtajan 1969; Dalhgren, 1980; Cronquist, 1981; and Tomlinson, 1982). An excellent account of morphological and anatomical research on Helobiae

upto year 1981 is summerised by Tomlinson (1982) in his book, "Anatomy of the monocotyledons VII - Helobiae (Alismatales)."

It will be unjustice, if I fail to mention the names of some important workers who have contributed much to Helobiae for better understanding of the group. They have published series of articles on various aspects such as palynology (Argue, Argue & Mayer), morpohology and taxanomy (Bruggen, Hartong, Miki, St.John) morphology and anatomy (Sigh, Stant, Tomlinson, Charlton, Cuttler, Meyer) floral anatomy (Kaul), floral development (Posluszny and Sattler, Sattler) emoryology (Johri, Laxshmanan, Lutige, Swamy, Swamy et al.) and Cytology (Harada, Sharma and Chatterjee) Majority of them have contributed more than 10 Research papers on Helobiae.

The early survey of Schenk (1886 a, b) are classical and established the major constructional feature of aquatic plants. Arber (1920) in her " **Water Plants A Study of Aquatic Angiosperms** " surveys the older morphological and anatomical literature and the book is in dispensable even to the modern student. More recent literature especially related to ecology and biology of herbaceous aquatic plants has been summarized by Sculthorpe (1967) in " **The Biology of Aquatic Vascular plants** ". similarly taxonomic overview of fresh- water aquatic plants has been done by C.D.K. Cook and collabotars (1974) in " **Water Plants of the World - a Manual for the Identification of the general fresh-water Macrophytes** ".

An early work on Helobiae primarily of systematic orientation

is of Richard (1815) which influenced the latter works such as those of Buchenau (1857, 1882) leading up to treatments in Engler's *Das Pflanzenreich* (Buchenau, 1903 a,c). Although these works primarily systematic orientation also took into the consideration vegetative anatomy and developmental morphology. Caspary (1858) is known for his treatment of the Hydrocharitaceae while Bornet (1964) is remembered for his beautifully illustrated monographs on **Cymodocea nodosa** (Cymodoceaceae) and Prillieux (1864) for similar work on **Althenia** (Zannichelliaceae). Series of papers by Camille Sauvageau (1887-1884) on the group are excellent in description and illustration. Systematic survey of Ascherson and Gurke (1889) and Ascherson and Graebner (1907) incorporates many morphological and anatomical data. Magnus (1870) work on **Najas** is of outstanding standard. Solereder and Meyer made extensive surveys of the systematic anatomy of Hydrocharitaceae and Alismataceae and provided a summary of existing anatomical information for a number of helobian families in " **Systematische Anatomie der Monokotyledonen** " (Solereder & Meyer, 1933). This work on the Alismataceae was continued further by Mayer (1943). Raunkiaer (1903) made extensive comparative studies of the Helobiae and provided the way in which anatomical informations could be applied to the systematics of the difficult genus **Potamogeton**. Hagstrom (1916); Ogden (1943) continued similar studies in Helobiae. Miki (1937) made many new taxa known to science, complete with anatomical descriptions and contributed to the discussion of interpretation of floral morphology.

More recently Charlton (1968) has made an extensive morphological investigation of Alismataceae using the information on the

basis for experimental study. Survey of floral vasculature in Helobiae have been provided by Singh (1966). Studies on floral organogenesis by Sattler and his associates have important phylogenetic implications. The work of Kaul (1967) has also phylogenetic implications. The taxonomic work of the sea-grasses by den Hartong (1970 a) includes much morphological information and this work has been extended by Phillips and McRoy (1980). Serbanescu - Jitariu (1964) has investigated the extent to which syncarpy occurs in Helobiae. Pollen morphology has been studied in relation to hydrophily. Experimental morphology (Charlton, 1979 a & b) has reflected the ease with which aquatic plants can be cultured clonally and manipulated axenically. The accounts by Chrysler (1907) and Monoyer (1927) of the vascular system of the Helobiae contain little developmental information. Sattler's work has revealed the significance of developmental study in interpreting floral morphology. The work of Wilder (1975) on vegetative morphology is complimentary to work on reproductive morphology.

Helobiae have been classified in various ways (Bentham and Hooker, 1883; Engler, 1904; Hutchinson, 1959; Eckardt, 1964; Takhtajan, 1969, Dahlgren, 1980, Cronquist, 1981 and Tomlinson, (1982). however, if we ignore rank and deal with taxonomic units, the disparity between the systems is seen to be slight. Helobiae is accepted as a natural order which is considered to be monophyletic in origin. However, it is not possible to arrange them in a linear sequence which reflects phyletic trends in view of the marked adaptive radiation that they exhibit.

Most authors claim to detect lines of reduction within the order. This has been done for vegetative architecture (Wilder, 1975). Vascular systems (Chrysler, 1907; Monoyer, 1927), floral Morphology (Uhl, 1947; Posluszny and Sattler, 1976) embryo structure (Yamashita, 1976). Other authors have been content to represent the diversity as a good example of adaptive radiation (Sattler and Singh, 1978). A completely opposite view is taken by Burger (1978) who hypothesizes a trend of elaboration from *Lilaea* like ancestors.

The classical view is that the monocotyledons are derived from primitive aquatic dicotyledons, best represented by Nymphaeales, and that certain members of the Helobiae, especially Alismatales are progenitors of the whole of the monocotyledons. This view has been accepted by many taxonomists such as Cronquist (1968), Eckardt (1964), Hatchinson (1953), Takhtajan (1966) and Dahlgren (1980). However, accumulated evidences suggest that Helobiae is scarcely on main line of evolution and represent a specialized side branch of monocots which has retained some very primitive characters. Major work on cytology of Helobiae include that of Harada (1955) and Sharma and Chatterjee (1967) ^{this} work on the group also supports the view that Helobiae is a specialized group.

ALISMATACEAE :

Many botanist consider the Alismataceae to be among the most primitive of extant monocot families. (Takhtajan, 1967, 1969; Cronquist, 1968). Current taxonomic treatments list 13 genera and about 70 species in the family. Pichon (1946) has distributed 13 genera into 7 subtribes largely on the basis of gynoecial characters.

Argue (1976) made SEM and TEM studies of pollen grains of 12 genera and 56 species of Alismataceae with special reference to taxonomy of the taxon. On the basis of pollen and gynoecial morphology and base chromosome number he has given the generic alignment in the family. It is summarized in following table.

TABLE No. 1

Level of gynoecial development	Subtribe	Pollen subtype		
			2b (x = 11)	
		2a (x = 7,8)	Spinules mostly medium to short	Spinules mostly long
3.	Machaerocarpaceae	Machaerocarpus (x = ?)		
	Damasoniinae	Damasonium (x = 7)		
2.	Wisneriinae		Wiesneria (x = ?)	
	Luroniinae	Luronium (a) (x = 7?) (2n = 42)		
	Alismatinae	Alisma (a) (x = 7)	Caldesia (x = 11)	Limnophyton (x = 11)
1.	Burnatiinae		Burnatia (x = ?)	
	Sagittariinae	Baldellia (7 = 7,8)	Echinodorus (x = 11)	Sagittaria (x = 11) Lophotocarpus (x = 11)

Several workers have contributed towards the resolution of assorted morphological, anatomical problems in this taxonomically difficult family (Stant, 1964; Stebbins, 1974; Hutchinson, 1959; Cronquist, 1968; Hendricks 1959; Bjorkquist 1967; 1968; Argue 1971 a; 1971 b, 1973, 1974, 1976). Significant literature on morphology and anatomy includes that of Arber (1918 b, 1919, 1920, 1921, 1922 b, 1925 a & 1925 b), Bjorkquist (1967, 1968), Bloedel and Hirsch (1979), Buchenau (1857, 1882, 1889, 1903a), Carter (1960), Charlton (1968, 1973, 1974, 1976, 1979 a, b), Charlton and Ahmed (1973a b), Costantin (1885 c, 1886 c), Dibbem (1903), Duval Jouve (1873 b), Eber (1934), Eichler (1875), Fassett (1955), Francois (1908), Gegard (1881), Gibson (1905), Gluck (1905), Goebel (1896), Govindarajalu (1967), Von Guttenberg & Jakuszt 1957, Den Hartong (1957), Hutchinson (1959), Jadin (1888), Kaul (1967 a, 1976 a, b, 1978, 1979), Klinge (1880), Kristen (1969), Kroemer (1903), Laessle (1953), le Blan (1912), Lee and Hsin-Ying (1958), Leins and Stadler (1973), Lieu (1979 b, c), Lyr and Streitberg (1955), Maheshwari (1962), Meyer (1915, 1943), Messeri (1925), Metcalf (1963), Meyer (1932 a, b, c, d, 1934; 1935 a, b, c, d, e, f,), Paliwal and Lavania (1978), Raunkiaer (1875-1899), Salisburg (1926), Sattler and Singh (1978), Schenck (1886b), Severin (1932), Singh (1966 a), Singh & Sattler (1972, 1973, 1977 a), Stant (1964), Tarnavski and Nedek (1973), Van Tieghem and Douliot (1888), Wilder (1975), Wooten (1971).

Alismataceae occupies an important place in the interpretation of the evolutionary hierarchy of the flowering plants. This is because the family has been thought to represent a primitive group of monocotyledons because of apocarpy and presumed spiral arrangement

of floral parts and derived from a Ranalean dicotyledons, either through Nymphaeales (Takhtajan, 1966) or in particular from the family Ranunculaceae (Hutchinson, 1959). Hutchinson saw **Ranalisma** as a genus sharing features with both the Ranunculaceae and Alismataceae. However, Maheshwari (1962) pointed out the numerous difference between Alismataceae and Ranunculaceae. Recent extensive morphological and anatomical study (Stant, 1964; Stebbins, 1974; Hutchinson, 1959; Cronquist, 1968; Hendricks, 1957; Bjaruquist, 1967, 1968) renders these classical interpretations still more untenable. Detailed studies on vegetative organisation (Charlton 1968, 1973; Charlton and Ahmed 1973 a, Wilder, 1975), floral development (Sattler & Singh 1978), vegetative anatomy (Metcalf 1963; Meyer 1932 a; Stant 1964) does not support derivation of Alismataceae from Ranunculaceae. The only reasonable conclusion is that the Alismataceae are a derived and highly specialized group which provide no useful evidence for the phylogeny of the monocotyledons or for evolutionary relationships between dicotyledons and monocotyledons (Tomlinson, 1982).

The flowers in Alismataceae are usually bisexual or have become unisexual by abortion. Plants are monoecious, polygamous or rarely dioecious. Wooten (1971) and Kaul (1979) noted that the sex ratios remain constant in monoecious and dioecious populations of **Sagittaria** species. The basically trimerous flowers have a biseriate perianth. Carpels are usually free or rarely connate at base. The carpel & stamen number is definite or becomes numerous by secondary proliferation. The ovules are usually solitary but sometimes they are more. The fruit is usually indehiscent achene.

Seeds are non endospermic. The germination of seed is epigeal and the radicle is suppressed (Kaul 1978). Anatomically the family is characterised by abundant squamules, absence of hairs, paracytic stomata and presence of secretory canals. The form of plant is usually determined by environment (Charlton, 1968; Charlton and Ahmed 1973 b).

Branching patterns of an occurrence of vegetative and reproductive meristems is studied extensively by Lieu (1979 b,c), Charlton (1973, 1968) and Charlton and Ahmed (1973 b). Extensive study on leaf blade by Meyer (1935, a - e) have shown that leaves are usually dorsiventrally but submerged leaves are more or less isobilateral. Hairs are usually absent but leaves are conspicuously pubescent in *Limnophyton angolense* (Carter, 1960) and *Sagittaria lancifolia* var. *pubescens*. Meyer (1934) recorded unicellular hairs on petiole of *Lophotocarpus guayanensis*, Stant (1964) observed unicellular or multicellular branched trichomes on lower surface of *Echinodorus macrophyllus*. Hydrotropes is recorded in many genera of Alismaceae (Mayer, 1915) which consists of an irregular aggregate of flattened epidermal cells with special contents. Stomata are usually paracytic. In *Baldellia* they are tetracytic. Sunken stomata are reported in *Burnatia enneandra* (Meyer 1932 b). The palisade is 2-3 layered made of vertically elongated cells, however, armed palisade is recorded in some members (Meyer 1932 a - 1935 e). Although laticifers are absent in root of majority of genera, however, they are reported in *Limnophyton* and *Wiesneria* (Tomlinson, 1982). Laticiferous canals are considered to be a diagnostic feature of the family by most

authors (Bechnau, 1903; Meyer 1932 - 1935 f; Stant 1967) and are present in aerial parts of all the taxa. Presence of crystals in lamina, petiole and root have been recorded in many taxa (Stant, 1967; Meyer, 1932 a - 1935 f). Crystals are either rhomboidal or rod-shaped styloids. Tannin cells are observed in leaf lamina of **Wiesneria** of **Luronium** and roots of **Luronium** (Tomlinson 1982). Starch is common storage food found in almost all organs of the plant (Stant, 1964). Vessels are recorded only in roots. All the vascular tissue is reduced due to its very habit. The construction of inflorescence in family is peculiar and worked out by Charlton (1968, 1973), Charlton and Ahmed (1973 a,b), Lieu (1979 b,c). The flowers of family basically trimerous is shown by studies of Singh (1978), Sattler and Singh (1972,1973,1971) and Sattler and Singh (1978). Sattler and Singh (1978) concluded that there is no evidence for the spiral generation of floral parts in the Alismatales. Studies of Singh (1966 a) have revealed that the floral vasculature shows a number of common features in various genera of Alismataceae. Kaul (1973 a) showed range of carpel vasculature in various members and found that most elaborate vasculature occurs in **Dansonium polyspermum** which has several ovules in each carpel. Flower vasculature in different members have been studied by Kaul (1967 a, 1976 a) Singh and Sattler (1972,1977), Charlton and Ahmed (1973 a).

Notable contributions to palynology of Alismataceae are those of Argue (1971 a, 1971 b, 1973, 1974, 1976), Erdtman (1952), Thanikaimoni (1972, 1973) and Sharma (1967). The pollen of this family has been studied in detail with light, scanning and transmission electron microscopy (Argue, 1972, 1974, 1976; Hesse, 1980;

Pant and Reumer, 1981). Argue recognises two pollen groups in this family based on pore number and pollen amb. He further divided type 2 into sub type **a** and **b** based on pollen granula number, presence or absence of coarse mid interporal structural bands, spinule character and pore on pentagonal or hexagonal area. Relationship between level of gynoecium development, base number and pollen morphology with reference to Pichon (1946) classification has been discussed by Argue (1976).

Chromosome numbers and Karyomorphology of some Alismataceous members have been worked out by different authors from various centers of research (Maude, 1940; Love and Love, 1942, 1944; Castro and Wagner, 1950, Erlandson, 1946, Harada, 1955, Sharma and Mukherjee, 1955; Sheriff and Nagaraj, 1966, Sharma and Chatterjee, 1967). These studies have revealed that absolute symmetrical karyotype is absent in any of the Alismataceae member, however, in genus **Alisma** considerable amount of symmetry in comparatively long chromosomes is observed (Harada, 1955). It is admitted on cytological grounds that Alismataceae is highly advanced taxa evolving in divergent directions (Sharma and Chatterjee, 1967). In Alismataceae, basic chromosome number ranges from 5 to 13 (Darlington and Wylie, 1955). Such a great diversity in basic numbers indicates that polyploidy and aneuploidy have played a major role in the evolution of members. Studies of Sharma and Chatterjee (1967) revealed that in all the genera investigated by them viz. **Limnophyton**, **Stydrocharis**, **Butomus**, **Tenagocharis**, **Sagittaria** and **Limnocharis**, one pair of chromosomes is distinctly longer than the rest. This pair with

median primary constriction is so conspicuous that it may be regarded as a marker chromosome for all these genera (Sharma and Chatterjee, 1967).

The embryology of Alismataceae have drawn the attention of many botanists which is reviewed by Davis (1966). The significant works include those of Nitzschke (1914); Tischler (1915); Stenar (1925 b); Dahlgren (1927 d, 1928 a, 1934 a); Claussen (1927); Lemesle (1929 b), Johri (1933, 1934 a,b, 1935 b, c, e, 1936 a), Murthy (1933 a,b, 1935 b) Maheshwari and Singh (1943), Nagl (1962), Kudryashov and Sauich (1963); Swamy and Parameswaran (1962 b) have surveyed the literature on Helobial endosperm. Embryological studies have revealed that the anther development is of monocot type, tapetum is of amoeboid type, pollens are 3-celled when shed, ovules are anatropous, bitgmic and pseudocrassinucellate, embryo-sac is bisporium allium type, endosperm development is of Helobial type and embryogenes is of caryophyllad type. Nayar and Sworupanandan (1978) studied morphology of fruit and mechanism of seed dispersal of *Limnocharis flava* and concluded that effective reproductory mechanism make the species potentially dangerous weed.

APONOGETONACEAE :

Family Aponogetonaceae is a small family represented by the genus *Aponogeton* L., consisting of about 45 species (Bruggen, 1990) distributed over Africa (17 sp), Madagascar (11 sp), Tropical Asia (12 sp), Papua - New Guinea (2 sp) and Australia (4 sp). The family is especially well developed in tropical Africa and Madagascar. the significant literature on morphology and vegetative

anatomy of Aponogetonaceae include that of Afzelius (1920), Arber; (1921, 1922 b), Van Bruggen (1968,1969,1970,1973,1982,1985,1987); Chrysler (1907), Costantin (1886 b), Czaja (1930), Drawert (1938), Dutailly (1875), Duval -Jouive (1873 b), Eber (1934), Eichler (1875), Engler; (1887,1889 a), Gibson (1905), Gluck (1924), Guillarmod and Marais (1972), Hutchinson (1959), Kaul (1976 b), Krause and Engler (1906), Lagertheim (1913), Mayer (1915); Von Minden (1899), Obermeyer (1966 a), Paliwal (1976), Planchon (1844), Riede (1920), Sane (1940), Saunders (1929), Sculthorpe (1967), Sergueeff (1907), Shah (1972), Singh (1965 c), Singh and Sattler (1977 b), Solerender and Meyer (1933), Van Tieghem (1870 - 1), Van Tieghem and Doulit (1888), Uhl (1947), Verdoorn(1922), Yamashita (1976 b), Lye (1986,1989), Pneva (1988), and Zhilin (1974).

So far the chromosome number for only few species of **Aponogeton** are known such as **A.distachyas** $n=8$ (Surgueeff, 1907), $2n=16$ (Sussenguth, 1921), $n= 12$ & $2n=24$ (Harada, 1955), **A.fenestralis** $n=8$ (Sargueeff, 1907), **A.natans** $2n=72$ (Sharma & Chatterjee 1967) **A.satarensis** ^{$2n=26$} (Yadav et. al. 1989) and **A.decaryi** $2n=66$ (Observed by auther himself). chromosomes in species of **Aponogeton** are very short and with the gradation in the karyotype and the constrictions being mostly median in position. The chromosome size and presence of high number of chromosomes in some species suggests an advanced degree of development and closely graded size of the chromosomes suggest the symmetrical nature of karyotype.

The pollen of **Aponogeton echinatus** Roxb. has been studied by using scanning and transmission electron microscopy (Zavada, 1983).

These studies have revealed that pollens of family Aponogetonaceae are monosulcate, foreolate and pollen wall structure is tectate collumellate.

Many of the species of **Aponogeton** are very localized in distribution (Van Bruggen, 1968,1969,1970,1973,1982,1985,1987,1990), (Sculthorpe, 1967). Leaf arrangement was described by Engler (1889 a) for **A.distachyos** correcting earlier accounts of Planchon (1844) and Dutailly (1875). Riede (1920) made extended observation on leaf arrangement. The leaves are usually in opposite pairs. Sergueeff (1907) noted that leaves of same pair succeed each other almost immediately but interval between successive leaves of different pairs is much longer. Further contributions to the leaf morphology have been made by Riede (1920). Arber (1922 b), Czaja (1930) and Solereder and Mayer (1933). Mayer (1915) observed hydrotropes in all the species of **Aponogeton** studied by him.

Contribution to anatomy of Aponogetonaceae is made by various workers viz. leaf (Arber 1921, 1922 b, Czaja 1930, Dutailly 1875, Gluck 1924, Kaul 1976 a & b, Lagerheim 1913, Mayer 1915, Miden 1899, Paliwal 1976, Riede 1920, Sergueeff 1907, Singh 1965 c, Solereder & Meyer 1933), root (Van Tieghem 1870-1, Van Tieghem and Douliot 1888), rhizome (Chrysler 1907), floral development (Singh 1965 c, Singh and Sattler 1977 b) seed development (Afzelius 1920) and for all parts (Duval-Jouve 1873 b, Riede 1920, Sergueeff 1907, Solereder & Meyer 1933).

Embryological work on Aponogetonaceae include that of

Schnaraf (1931), Stenar (1925), Suessenguth (1919), Tischler (1915), Clausen (1927), Afzelius (1920), Sergueeff (1907), Sane (1940), Shah (1970, 1972) and Yamashita (1976 b). Above embryological studies has revealed that the anther development is of monocot type, tapetum of amoeboid type, pollens shed in 3-celled conditions, ovules bitegmic crassinucellate and anatropous, polygonum type of female gamatophyte development, endosperm of helobial type.

Aponogetonaceae is closely related to Helobian families. Engler suggested its affinity to Araceae and indeed there are many common characters shared by these two families. Therefore Singh and Sattler (1977 b) compared floral development of **Acorus** (Araceae) with that of **Aponogeton** and found striking resemblances between the two genera. These studies also revealed that there are strong resemblance between **Aponogeton** and **Scheuchzeria** as suggested by Uhl on the basis of carpel vasculature. These observations are further supported by detailed investigations of floral anatomy by Singh (1965 c).

Aponogeton Satarensis is newly described species from India (Raghvan et. al. 1982). It is an interesting only dioecious species with forked inflorescence from Asia and shows affinities with African species named **A. decaryi**. To determine the affinities between these species, studies on them is in progress in our laboratory. It has been revealed that **A. satarensis** has $2n=26$ ($n=13$) chromosome number (Yadav et.al. 1989). The chromosomes are meta-centric and Karyotype is symmetrical.