

Chapter – I

General account on
Commelinaceae



Spiderworts, the members of family Commelinaceae, are widely distributed throughout the world, however, in spite of their vegetative propagation species are sparsely distributed and many of them are endemic. The three major centers of taxonomic diversity of Commelinaceae are: Tropical Africa; Mexico and Northern Central America; and the Indian subcontinent. In the family only six genera (*Aneilema*, *Buforrestia*, *Commelina*, *Floscopa*, *Murdannia* and *Pollia*) have indigenous species in both the New World and the Old World (Faden, 1978).

Family Commelinaceae comprises about 41 genera and 650 species distributed mostly in the tropical and warm temperate regions of the world (Faden, 2000). According to Faden (1998a) Peninsular India and the foothills of Himalayas to Thailand and Southwestern China is major center of diversity for Commelinaceae. It is represented in India with 14 genera and 85 species (Karthikeyan and Jain, 1989).

The noteworthy majority of Commelinaceae are perennials, including almost all the species that occur in the forests. Perennials of nonforested habitats typically persist during the dry season as leaf or stem succulents or by means of underground storage organs, with rhizomes, root tubers or rarely bulbs. Annuals are common in some genera such as *Commelina*, *Murdannia*, and *Cyanotis*. Climbers are uncommon and are restricted to forests. They occur in tropical America, Africa and Asia. The only African climber *Palisota thollonii*, which has been recorded to 15m in length, and is probably the longest/ tallest species in the family. Other genera with climbers include *Dichorisandra* (tropical America) and *Porandra* and the three genera of subtribe *Streptoliriinae* (Asia). Some African species of *Aneilema* and *Commelina* are sometimes described as scandent because they scramble through other vegetation. *Tripogandra grandiflora* of Mexico and Central America seems to scramble similarly.

Epiphytes are rare in the family. Both the species of the neotropical genus *Cochilostema* grow as bromeliad like tank-epiphyte that hold rainwater. *Cochilostema velutinum* also grow as a creeping epiphyte. In Commelinaceae,

only other species that is regularly epiphyte is *Belosynapsis vivipara* of peninsular India.

Commelinaceae shows great diversity in their habits. It is sometimes difficult to determine whether a plant is an annual or a perennial. As used here, annuals are monocarpic plants that, under natural conditions, live less than a year.

The shoots of Commelinaceae species is vary from monomorphic to strongly dimorphic. In the monomorphic types there is no differentiation into vegetative and reproductive shoots.

The basic inflorescence type in Commelinaceae is terminal, pedunculate thyse with an intermediate central axis to which are attached several – many, determinate, stipitate, cymose branches (cincinni) that may be alternate, sub-opposite, or sub-verticillate in attachment.

Evolutionary trends in the inflorescence largely have been in the direction of reduction or loss of some parts or axes (Brenan, 1966). However, while the cincinnus bracts have become caducous, reducing number of stamens and staminodes, adaptation and many things other proves the family Commelinaceae are under evolutionary flux.

Cincinnus or group of cincinni usually subtended by a foliaceous bract is basic inflorescence type of genus *Cyanotis*, while leaf opposite, composed of 1 to 2 cincinni enclosed in folded sheath is characteristic of genus *Commelina*. Persistent, pedicel-opposed bracteoles are present in all taxa of Commelinaceae.

The flower in Commelinaceae shows greater variation than any other organ. This variation is both *biologically important* reflecting differences in breeding systems, including pollination mechanisms, and *taxonomically useful*, providing approximately as many characters as all the other organs combined.

Floral dimorphism is common in the family Commelinaceae. In most cases the two flower types, bisexual and male are differing by the partial or complete abortion of the gynoecium as in *Commelina* and many *Aneilema* species. According to Faden (1991) other differences may include length of pedicel

(*Commelina*), length and curvature of staminal filament (*Aneilema* and *Palisota*), orientation of anther (*Aneilema*) and anther-sac dehiscence (*Palisota*). Enantiostyly in *Murdannia* is another form of floral dimorphism in the family, as is the occurrence of cleistogamous as well as chasmogamous flowers in species of *Commelina*. Heterostyly has been reported erroneously in *Aneilema* (Ornduff, 1974 and Faden, 1991).

Individual flowers are usually brightly colored and conspicuous to potential pollinators, even in autogamous species. When the flowers are small, the inflorescence and/ or associated bracts may attract pollinators. The most extreme case occurs in some populations of *Coleotrype madagascariensis* in which the uppermost leaves on the flowering shoot may be bright pink, like bracts of *Poinsettia* in Euphorbiaceae. Floral scents are uncommon but, when present, they may be strong, as in *Callisia fragrans* and *Cochilostema*. In *Palisota*, floral odor varies from species to species and may be biologically and taxonomically significant (Faden, 1992).

The flowers are all bisexual or there may be bisexual and male, or rarely bisexual and female, or bisexual, male and female. These kinds, when different, are produced in the same inflorescence, sometimes in specific sequence. Bisexual and functionally male flowers of the same plant generally differ solely by the abortion of gynoecium in male flowers, but other differences may include pedicel length, stamens or staminode number, or length and curvature of some of the staminal filaments. Cleistogamous flowers are produced by some species of *Commelina*.

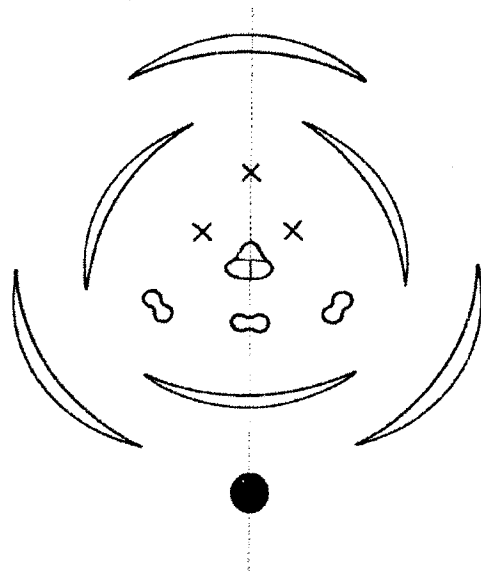
In Commelinaceae flowers are pedicellate, pentacyclic and trimerous. They are zygomorphic in tribe Commelineae and actinomorphic in tribe Tradescantieae (**Fig. 1 and Plate-I**). The basic structure of flower in tribe Commelineae consists of three free sepaloïd sepals; three free petaloïd petals; three staminodes (one antesepalous, two antepetalous), some time one absent, borne on one side of the flower; three stamens (two antesepalous, one antepetalous) borne on the other side

and a fundamentally trilocular ovary, in which one locule is frequently abortive. In tribe Tradescantieae flower comprises of three free sepaloid; three free or united petaloid petals; six fertile stamens and trilocular ovary with all fertile ovules.

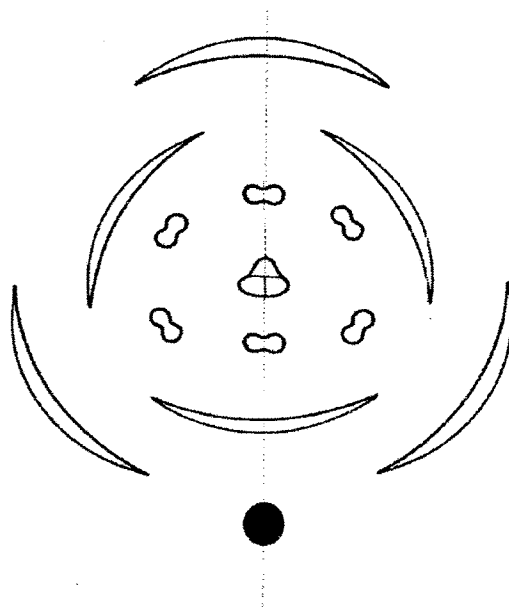
In Commelinaceae the flowers are generally unscented and remain open for a few daylight hours at the end of which they fade. Fading includes deliquescence of the corolla. The presence of perfect pistillate and/ or staminate flowers and the type or types of flowers usually species specific. Flowers vary in size from 4 to 40 mm wide.

Pedicel in Commelinaceae is varying in length, thickness, colour, pubescence, curvature, and persistence. Pedicel length usually increases measurably in fruits. Sepals are three, free or connate, ovate to obovate, usually subequal and sepaloid, occasionally petaloid, glabrous or puberulous or rarely glandular hairy. Petals are three, ovate to obovate; cordate to subcordate in shape with entire to crenulate margins. Range in colour from white to lilac, lavender, or sky blue to blue, or yellow to orange, or flesh. Stamens 6, all fertile or some staminodial or lacking; filament glabrous or bearded.

The position and length of the stamens may affect the species of insects that visit the flower and the place of deposition of pollen on the insect, as in *Aneilema*. The reciprocal position of the lower fertile stamen in male flowers and of the gynoecium in bisexual flowers in *Palisota* enhances pollen transfer (Faden, 1998b). Mirror-image symmetry of the stamens and style, or enantiostyly occurs in many species of *Murdannia*. Floral hairs are common in some genera. They may be present on any of the floral parts; it is primarily on the staminal filaments that are related to pollination. Filament hairs may attract pollinators when they are brightly colored, provide footholds for insects, retain shed or dropped pollen grains within the flower, and enhance the efficiency with which pollen can be collected (Faden 1992). The insect pollinated Commelinaceae usually offer pollen as a food reward. Moniliform hairs on the filaments are believed to delude insects to scraping them as if gathering pollen (Vogel, 1978).



Floral diagram for representing tribe Commelineae



Floral diagram representing tribe Tradescantieae

(The solid circle represents the cincinnus axis and the dotted line the plane of symmetry)

Fig. 1

Floral Diagram for Tribe Commelineae and Tradescantieae

In Commelinaceae, anthers are four-celled and longitudinally dehiscent, basifixed, or dorsifixed, or versatile. The anthers vary accordingly in each taxon, in their relative degree of development, shape, size, form of the connective, color, attachment, orientation, and pollen colour.

The pollen grains in Commelinaceae vary in color from white to yellow or orange. Commonly the pollen of the medial anther differs in hue from that of the lateral anthers. They are monosulcate and ellipsoid to bean-shaped or sometimes irregularly spherical.

Pollen is the only reward for pollinators. Often staminodes, yellow hairs, or dimorphic stamens deceptively attract insects away from the main source of pollen in the flower. Dimorphic pollen occurs in individual flowers of *Palisota*, *Tripogandra*, *Aneilema* and *Tinantia* species (Lee, 1961; Handlos, 1975; Simpson *et al.*, 1986; Faden, 1998b and 1991). Self incompatibility has been found in some *Tradescantiinae*, which would make them obligate outcrossers (Owens and Kimmins, 1981). *Callisia fragrans* is probably anemophilous.

The gynoecium consists of a basically trilocular ovary and a simple, terminal style and stigma. The ovary may be sessile or stipitate, but the distinction between these conditions is seldom clear-cut. Stigmas vary from very small to slightly capitate, penicillate, triangular, or slightly 3 lobed. Stigma types in the family have been surveyed by Owens and Kimmins (*loc. cit.*).

In Commelinaceae capsules are sessile or stipitate, dry usually dehiscent, bi- or trilocular, usually lustrous and grey to brown in colour.

Seeds are variable in shape, flattish to ovoid or angular often truncate at one end and rounded at the other; embryo small and in a special chamber, usually outlined on the surface by a circular, depressed area with a central nipple; hilum- a distinct narrow line on a flattish side; endosperm starchy. Seeds are small and hard, with a punctiform to linear hilum and dorsal to lateral (rarely terminal) cap-like callosity, the operculum (called embryotega or embryostega), which covers the embryo. The testa is derived from both the integuments (Grootjen and Bouman

1981a; Chikkannaiah and Hemaraddi, 1979). An aril is present on the seeds of *Amischotolype*, *Dichorisandra* and *Porandra*. The seeds of *Aetheolirion* are winged.

Information of seed dispersal in Commelinaceae is almost all conjectural or anecdotal. Most Commelinaceae seeds have no specialized means of dispersal. The berries of *Palisota* and berrylike fruits of *Pollia*, a few species of *Commelina*, and *Tradescantia zanonoa* are probably endozoochrous. The sticky fruits of *Rhopalephora* are likely to be dispersed externally on birds and mammals. Ants have been observed carrying seeds of *Commelina erecta* (Faden, unpubl.). The winged seeds of *Anthiolirion* are probably wind-assisted in their descent. Dispersal by water and/ or in mud on animal feet is likely for species of *Commelina*, *Murdannia*, *Cyanotis*, and *Floscopa* that grow in or beside water. Dimorphic seeds or propagules with presumably different means of dispersal are frequent in *Commelina* and *Aneilema* (Faden, 1991).

Basic chromosome number ranges from $x = 4$ to $x = 29$ with $x = 6 - 16$ being most frequent. Chromosome size is very diverse; it is commonly characteristic for a genus. In general, the tradescantioid genera have much larger chromosomes than the commelinoid genera. *Cartonema* has very small chromosomes.

Aneuploidy within genera is common at the diploid level. It is apparently infrequent in polyploids. Aneuploid series of four or more basic numbers occur in *Aneilema*, *Commelina*, *Cymbispatha*, *Murdannia* and *Tinantia* (Faden and Suda, 1980). Within this series the evolutionary direction has been towards reduction in basic number and increase in chromosome size. Symmetric karyotypes may be either primitive or advanced, according to the genus.

A good amount of embryological work has been done on the members of Commelinaceae. The family has received attention of early embryologists like Strasburger and Guignard. Earliest contribution is of Solms-Laubach (1878) who studied the embryo development in *Tinantia* and *Heterochia*, noted that embryo is

nonsuspensoric, the shoot apex is originated from the terminal hairs of proembryo, and it later pushed to the lateral side by strong growth of single cotyledons. Following him, Strasburger (1915) described *Polygonum* type of embryosac development in *Tinantia virginica*., however, reported *Scilla* type of embryosac in certain *Tradescantia* and *Commelina stricta*. The details of development of tapetal periplasmodium in microsporogenesis have been noted by earlier workers like Tischler (1915). Schnarf (1931) has reviewed the literature on the embryology of this family. After publication of Schnarf's book "Verocichende Embryology der Angiospermen" number of articles has appeared dealing with the embryology of several members of family Commelinaceae.

For indulgent phylogeny, pollination biology, evolution and embryology, family Commelinaceae has been studied exclusively by Saarela, *et al.* (2008); Evans, *et al.* (2003); Evans, *et al.* (2000); Givnish, *et al.* (1999); Chikkannaih (1962, 1963 and 1964); Maheshwari and Baldev (1958); Parks (1935); Strasburger (1915); Guignard (1882); Solms-Laubach (1878).

The family is of little economic importance. Species of a number of genera are commonly cultivated as ornamentals in the out door and indoor gardens. Some species are eaten (mostly by domesticated animals, sometimes by man); some are used locally as medicines or in rites. Two forms of *Tradescantia* are reputed to be useful indicators of low levels of radiation (Grossman, 1979).

Systematic Position:

The family Commelinaceae is very natural and mostly very well defined. Its characters and relationship with other families belonging to Farinosae have been fully discussed by Hamann (1961, 1962 and 1963). Bruckner (1926) classified the family in two subfamilies- Tradescantieae with actinomorphic and Commelineae with zygomorphic flowers. Tradescantieae is further divided into 'Declinatae' and 'Inclinatae' determined by floral buds being bent away and towards the axis respectively. The genera *Murdannia* Royle are separated from

Aneilema R. Br. on the basis of floral symmetry (Bruckner, 1926). According to him *Aneilema* in the restricted sense belongs to sub family Commelineae, whereas *Murdannia* to Tradescantieae. Woodson (1942) also recognized two tribes in Commelinaceae viz. Tradescantieae and Commelineae; the former has paired sessile scorpid cymes which appear as two sided units superficially, whereas in the later ultimate branches of inflorescence of individual scorpid cymes appear one sided. Supposedly he rejected the idea of sorting out *Murdannia* from *Aneilema* and kept them in his tribe Commelineae.

Bentham and Hooker (1883) put the Family Commelinaceae in the series 'Coronariae' along with the families Roxburghiaceae, Liliaceae, Pontederiaceae, Philydraceae, Xyridaceae, Mayaceae and Rapataceae. Engler (1895 and 1897) placed the family in order 'Farinosae' under sub-order 'Commelinae' consisting single family Commelinaceae. Order Farinosae of Engler and Prantle (1915) also includes Flagellariaceae, Restionaceae, Centrolepidaceae, Mayaceae, Xyridaceae, Eriocaulaceae and Philydraceae; and is characterized by copious mealy endosperm. Bessey (1915) placed the family in his order 'Liliales', which include Liliaceae and Najadaceae, along with many families of Farinosae of Engler. According to Hutchinson (1934) his order Commelinales including Commelinaceae, Mayaceae, Flagellariaceae and Cartonemataceae to be a basic terrestrial stock of his Calyciflorae, from which has evolved his order Zingiberales. The seeds of the members of Commelinales are characterized by having an 'embryotega', a special development of micropyle (Hutchinson, *loc. cit.*).

The predominant trend, which begun by Meisner (1842), was to divide the family into two major groups. His tribe Tradescantieae had 6 fertile stamens while tribe Commelineae had a reduced number of fertile stamens. Hasskarl (1870) used Meisner's classification, as did Clarke (1881), who also separated out a small, third tribe, Pollicae for genera with berries or berrylike fruits.

Bruckner (1926 and 1930) raised the two major divisions of the family to subfamily rank and distinguished them on the basis of floral symmetry- subfamily 'Tradescantieae' (flowers actinomorphic) and subfamily 'Commelineae' (flowers zygomorphic). Subfamily Tradescantieae was divided into tribes Hexandreae (6 fertile stamens) and Triandreae (3 fertile stamens). Subfamily Commelineae was split into tribes Declinatae (buds bent downward, the posterior stamens less developed and usually sterile) and Inclinatae (buds curved inward, the 3 anterior stamens less developed and usually sterile).

Woodson (1942) and Rohweder (1956), focusing on the American genera, returned to 2 tribes, Commelineae and Tradescantieae, but defined them on the basis of inflorescence rather than floral characters.

Pichon (1946) was the first worker to completely break away from the tradition of dividing the family into 2 major components. He recognized 10 tribes- Tradescantieae, Callisieae, Anthericopsidae, Commelineae, Geogenantheae, Cochliostemateae, Pseudoparideae, Zebrineae, Cyanoteae and Dichorisandreae, on the basis of morphological characters. He further separated the genus *Cartonema* into its own family Cartonemataceae, based in part, on anatomical grounds.

Brenan (1966) recognized 15 informal 'groups', using a combination of morphological characters. He predicted that not all of his groups would prove to be of equal taxonomic rank.

The history of the subdivision of the Commelinaceae was summarized by Faden and Hunt (1991) (briefly previewed by Faden, 1985), accepted 2 subfamilies- subfamily Cartonematoideae (tribes Cartonemeae and Triceratelleae) and subfamily Commelinoideae (tribes Tradescantieae with 25 genera and 285 species and Commelineae with 13 genera and 348 species). Within the tribe Tradescantieae, 7 subtribes were accepted- Palisotinae, Dichorisandrinae, Thysantheminae, Streptoliriinae, Cyarotinae, Coleotrypinae and Tradescantiinae.

This classification employed anatomical, palynological and morphological characters, but it did not include a cladistic analysis.

Evans (1995) studied the cladistic relationships among the genera of Commelinaceae using morphological characters and sequence data from the chloroplast gene *rbcL*. He also made a combined analysis of the two data sets. *Cartonema* was found to be basal in the family. Tribe Commelineae was shown to be monophyletic, as were subtribes Cynotinae, Coleotrypinae and Thyrsantheminae were polyphyletic, and tribe Dichorisandrinae was polyphyletic in some analyses and monophyletic in others. With the inclusion of the genus *Elasis* from subtribe Thyrsantheminae and subtribe Tradescantiinae was monophyletic (Evans *et al.*, 2000). The positions of the subtribes Streptoliriinae and Palisotinae are varied. Subtribe Palisotinae with the sole genus *Palisota* sometimes emerging as the sister group to the entire family except *Cartonema*.

Modern ideas about the affinities and relationships of the Commelinaceae vary greatly, depending upon the kinds of data employed. Using characters other than DNA sequence data, the family is generally combined with Mayaceae, Xyridaceae, Rapataceae, and sometimes Eriocaulaceae as the order Commelinales (Dahlgren and Clifford, 1982). The most comprehensive such analysis, using 101 morphological, anatomical, embryological and phytochemical characters and all of the families of Dahlgren *et al.* (1985), yielded an order Commelinaceae comprising the same five families of Stevenson and Loconte (1995).

In contrast to the above, analyses using DNA sequence data for the plastid gene *rbcL*. Chase *et al.* (1995); Duvall *et al.* (1993) placed the Pontederiaceae, Philydraceae and Haemodoraceae as the families closest to Commelinaceae. Combining morphological characters and *rbcL* sequence data produced results identical with or very similar to the *rbcL* phylogenies alone (Chase *et al.*, 1995) showing the Pontederiaceae as the sister group to the Commelinaceae.