

A CONSPECTUS OF THE FAMILIES PODOSTEMACEAE AND TRISTICHACEAE*

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ABSTRACT

Recent literature is reviewed and additional evidences presented to support Willis who had split Podostemaceae into two families, Podostemaceae *sensu stricto* and Tristichaceae. In view of the available embryological and anatomical evidences it is suggested that further studies should precede attempts to trace the ancestry of these families to Crassulaceae or Saxifragaceae. Keys and distribution data for the genera of Tristichaceae and Indian Podostemaceae are given.

INTRODUCTION

Podostemaceae and Tristichaceae are two remarkable families of dicotyledons distributed in the tropics and subtropics of the world. Most of the members resemble algae or bryophytes in habit and grow exclusively in fresh water rapids and cataracts. Vegetative organs show considerable complexity. Seeds on germination produce a short-lived primary axis from the base of which buds out green thalloid organs. These are considered to be morphologically equivalent to adventitious roots and may be filamentous, ribbon-like or flattened, creeping and lichen-like or attached to the rocks and with or without free floating branches. From this thallus secondary shoots arise which remain vegetative till the water level subsides and exposes them. When exposed the secondary shoots become floriferous. After shedding the seeds, the plants die unless there is an early rise in water.

Sprague (1933) has discussed the question of the correct spelling of Podostemaceae. He has shown that it should be Podostemaceae and not Podostemonaceae. Moreover the former spelling has been conserved according to the International Code of Botanical Nomenclature, 1966.

Willis (1915) has shown that Podostemaceae *sensu lato* contained many plants which are not in reality very closely related even when the most aberrant of them—*Hydrostachys*—is removed and placed in a separate family Hydrostachyaceae. According to him, the two great divisions which make up Podostemaceae were perhaps more widely separated one from the other than the divisions in any other family of the flowering plants. Presenting very convincing arguments, he separated the perianth bearing members as a distinct family called Tristi-

chaceae with *Tristicha* Thours, as the type. In fact he was only repeating what Bongard had done in 1835 except that Bongard used the illegitimate name Philocrenaceae based on *Philocrena*—a synonym of *Tristicha*. After removing *Tristicha* and related genera Willis redefined Podostemaceae to include the remaining genera.

Engler (1930, p. 27) did not accept the views of Willis on the basis of embryological similarities. He argues: "da auch bei *Lawia* (W. Magnus) und *Tristicha* (Cario) der gleiche Bau der Samenanlage mit einem Pseudoembryosack und einem über das innere Integument hinaustretenden Kopfende des Embryosackes wahr genommen wird, wie bei den P. der *Marathreae*, *Mourereae* (untersucht von Went) und *Eupodostemoneae* (W. Magnus)" van Royen (1951, p. 11), who made a detailed study of the Podostemaceae of the New World has also hesitated to accept the views of Willis. He writes: "Although the argumentation of Willis is convincing, he led too much emphasis on the differences and underrated the value of the points of resemblance between the two groups. The latter are to be found in the embryology, the structure of the pollen grains and the anatomy". Recent embryological and palynological studies, however, lend support to the segregation of *Tristicha* and related genera into a separate family.

EMBRYOLOGY

Podostemaceae and Tristichaceae, no doubt, share many embryological features (Mukkada, 1962 and 1964; Chopra and Mukkada, 1966; Subramanyam, 1962a). The anthers are ditheous, the anther wall is four layered and the tapetum is of the secretory type. Division of pollen mother cells is of the

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successive type in Podostemaceae and simultaneous in Tristichaceae. The ovules are anatropous, tenuinucellar and bitegminal, but only the outer forms the micropyle. Both the integuments differentiate simultaneously in Tristichaceae while in Podostemaceae the inner integument is initiated only after the outer one has covered the nucellus. Both Tristichaceae and Podostemaceae (except *Dicraeia*) possess a reduced Allium type of embryo sac. Although basically bisporic in development the tetra-nucleate embryo sac of *Dicraeia* with the peculiar egg apparatus with a single synergid and egg, the absence of polar nuclei and the presence of two or occasionally one antipodal cell(s) shows a rare combination of characters not found in any other angiosperm, not even in any other member of the Podostemaceae. It is unique in having sister cells as the egg and synergid and having no micropylar quartet. It further differs from the reduced Allium type in that the functional dyad nucleus undergoes only 2 divisions against three in the latter. This new type of embryo sac was named *Dicraeia* type by Palm (1915) and Mukkada (1964). There is no double fertilization, one male gamete fertilizes the egg while the other remains in the pollen tube. A pseudoembryo sac is formed before embryogeny in all the members of Tristichaceae and Podostemaceae so far studied. The embryo occupies the entire pseudoembryo sac. There is no endosperm development. The basal cell of the suspensor enlarges prominently, becomes coenocytic and develops haustorial processes into the integuments.

PALYNOLOGY

Erdtman (1952) reported 3-colporoidate (*Weddellina*) and forate monads (*Tristicha*) in Tristichaceae and 3-colpate as well as nonaperturate monads and dyads in Podostemaceae. Nair (1965) reported 3-zonocolpate dyads in four more members of Podostemaceae. Bezuidenhout (1964) studied the pollen of several African genera and confirmed the findings of earlier workers. He reported forate monads in Tristichaceae (*Tristicha*) and small 3-colpate monads or dyads and zonate dyads in Podostemaceae. Chopra and Mukkada (1966) reported monads in a member of Tristichaceae (*Indotristicha*). Our own studies on the remaining genus of Tristichaceae (*Terniola*) have proved that dyads are totally absent in Tristichaceae; *Terniola zeylanica* has 3-colporoidate monads (Pate I, fig. 1). Two more species of *Dicraeia* studied by us show 3-colpate dyads (Plate

I, fig. 2). Bezuidenhout (*l.c.*) visualizes 3 evolutionary trends:

- (1) Tricolpate monads—tricolpate dyads.
- (2) Nonacolpate monad—(Hexacolpate derivative with six furrows)—Zonate monad—Zonate dyad.
- (3) Nonacolpate monad—forate monad.

ANATOMY

Engler (1930) and Metcalfe and Chalk (1950) have summarized our knowledge of the anatomy of Podostemaceae and Tristichaceae. The thalloid root is compressed dorsiventrally, the ventral surface being flat and the dorsal convex. Its fundamental root nature is indicated by a somewhat abnormal root cap. A root of this kind contains, as in *Mniopsis saldanhana* Warm., a central vascular system including 2 xylem groups, the latter reportedly containing a few vessels. According to Engler (*l.c.*) the xylem may be completely absent and the vascular strand consisting exclusively of phloem will be supported by collenchyma, especially on the dorsal side. The remainder of the root consists of large, amyloiferous cells. In *Hydrobryum japonicum* (Imamura, 1929) the vascular system is in the form of a net work in the root, and the cortical cells contain starch. The thalloid root in most cases is attached to the substratum by means of elongated hair-like cells of the ventral epidermis. In some genera, like *Dicraeia*, in addition to the flattened creeping type of root there are free-floating ribbon-like roots as well.

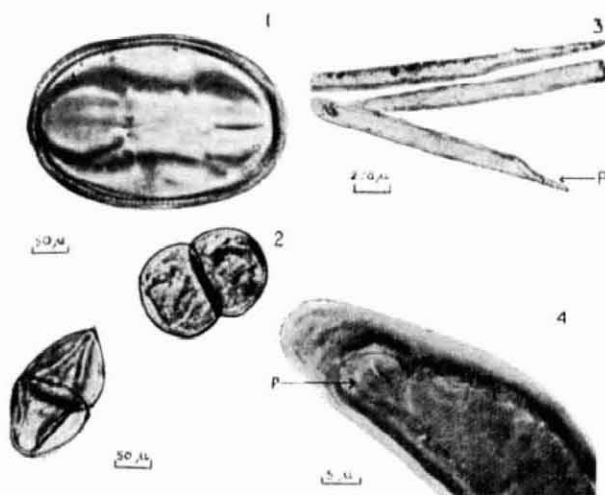


Plate 1 : Figs. 1-4: 1. Pollen of *Terniola zeylanica* (Gardn.) Tul. 2. Pollen of *Dicraeia stylosa* Wt. 3. Perforated tracheary elements of *Willisia selaginoides* (Bedd.) Warm. 4. Magnified view of the perforation. P—Perforation plate.

The roots bear in many species organs which are described as shoots and leaves, though it is often difficult to distinguish between these various morphological categories. Steude (1935) reported in the floating stems of *Mourera aspera* (Bong.) Tul., a central cylinder containing a number of vascular bundles. The annular and spiral elements of the xylem collapse and give rise to large air canals. Sieve tubes were not observed but a thin-walled tissue of narrow elements around the 'vessels' might be mistaken for phloem. Numerous scattered bundles devoid of air canals and including partly developed vessels occur embedded in the cortical tissues of the same species. According to Engler (1930) a cauline bundle accompanied by leaf traces occur in two species of *Apinagia*. A form of secondary thickening through tangential cell divisions has been reported by Mathieson (1908) in *Weddellina squamulosa* Tul. Secretory elements occur in several genera like *Weddellina*, *Podostemum*, *Mourera*, *Marathrum* and *Oenone*. Leucoplasts are stated to be common in the leaves of Podostemaceae but absent in Tristichaceae. Silicious bodies are secreted in large numbers in many species, especially in the peripheral tissues and they are supposed to enable the plants to withstand mechanical damage and periods of dessication.

Even though there occur in the literature terms like "Vessels" and "Gefässe" in the descriptions of the vascular tissues, it is doubtful whether they are true vessels and not merely tracheids. Hammond (1937, p. 23) made a detailed study of *Podostemum ceratophyllum* Michx. and stated categorically: "Nowhere in the material studied have true vessels been found." Eames (1961) and Sculthorpe (1967) also report that vessels are absent in Podostemaceae. Our studies on *Dicraeia stylosa* and *Indotristicha ramosissima* failed to reveal the presence of true vessels. Materials of the latter contain prosenchymatous elements with internal partitions, resembling the septate fibres of many dicotyledons. Materials of *Willisia selaginoides* however, revealed several tracheary elements with perforations. The individual elements resemble fibre-tracheids and have tapering ends with oblique perforation plates with one or more perforations (Plate I, figs. 3 & 4).

GEOGRAPHICAL DISTRIBUTION

At present there are about 200 species in about 45 genera distributed in the tropics and subtropics

of the world. *Podostemum ceratophyllum* and some species of *Inversodicraea* and *Hydrobryum* are the only ones that reach temperate zones. Most of the Podostemaceae are found in the Americas—about 140 spp. There are about 40 species in Africa, about 20 in Asia and one in Australia. A remarkable range of distribution is shown by the genus *Podostemum*. Its species are found in the first place in North and Central America and in the West Indian Islands and secondly in Southern Brazil, Uruguay and Paraguay. The last named area is contiguous with the area in Africa, which on its other side passes into the area in Asia.

ORIGIN AND EVOLUTION

Willis (1915, 1926) had dealt with the origin and evolution of Podostemaceae and Tristichaceae in some detail. According to him ancestors of these two families were dicotyledons growing on the edges of rapids. These plants sent out roots that crept along the stones of the falls. Along the roots adventitious shoots would have been formed. Then a single large fundamental mutation would have sufficed to produce a plant that was able to stick to the rock and this would have been the first Podostemaceae and Tristichaceae. Subsequent mutations of smaller magnitude must have produced our present day members of these two families. Willis bases his assumption that the ancestors must have been land plants on the structure exhibited by extant members of these families; the flowers and fruits are more obviously of the "Land" type, the seedlings show no adaptation to water life, no large intercellular spaces are present and no aquatic ancestors are known as would have been expected as living conditions could not have changed very much and competition was so little even between themselves. van Royen (1951) points out that if we accept the assumption that the ancestors were altogether exterminated, it is, as Willis himself points out, difficult to explain why no trace has been found in the fossil flora.*

*This is not quite true. van Royen (1961) reports finding among the papers of Warming in Copenhagen a report by an unknown author of 3 fossil Podostemaceae in a work called "Index generum plantarum fossilium". There are two other reports: one by Szafer [in Acta Soc. Bot. Polon. 21(4): 747-769, 1962]—a fossil Podostemaceae from Europe—about which van Royen (1954, p. 216) remarks: "As I have not seen the material it is at present impossible to judge the value of the discovery though it seems highly improbable that Podostemaceae ever lived in Europe". Another report by Weyland (1937) escaped van Royen's attention. Engler (1964) describes it—*Podostemanopsis tertiaria* from the Oligocene of Rhine—as "ein Pflanzengeographisch bedeutsamer Fund".

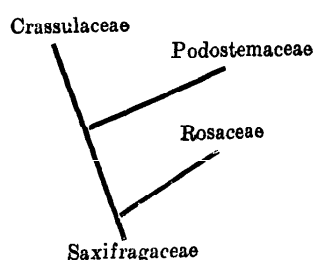
According to him the only way out of the difficulty would be to assume that they arose from land plants like the Crassulaceae or the Saxifragaceae by means of a single fundamental mutation as suggested by Willis. Maheshwari (1945, p. 31) has also concluded on the basis of embryological features that it is "almost certain that the Podostemaceae are much reduced apetalous derivatives of the Crassulaceae". Subramanyam (1962a) while agreeing with this view, pointed out some striking differences in embryological characters—reduced Allium type of embryo sac, absence of endosperm etc.—and suggested that they are probably derivative characters due to the special mode of life of these plants. The occurrence of perforated vascular elements in *Willisia selaginoides* (Bedd.) Warm., opens up the possibility of checking the affinities of this family. At present we are not in a position to state categorically that these perforated elements are true vessels and not merely perforated tracheids similar to those reported in some conifers (Bannan, 1958; Jane, 1956). However, assuming for the time being that they are true vessel members, what significance can be attributed to their presence in Podostemaceae? Extensive studies on the tracheary elements of vascular plants during the last fifty years have clearly shown unidirectional trends of specialization in vessels. It has been established that vessel members with simple porous perforation plates are advanced forms derived from vessel members having scalariform perforation plates and that this is a trend of evolution that is definitely irreversible. As Swamy (1958, p. 11) pointed out, though anatomical data "cannot be made use for pronouncing positive assertions in taxonomic procedure... the information is of great help in drawing valid negations". According to available data (Metcalf and Chalk, 1950) vessels in Crassulaceae and Saxifragaceae are provided with simple porous perforations. As already mentioned, vessel members of *Willisia* not uncommonly show several perforations. Hence it does not appear to be logical to trace the ancestry of Podostemaceae or Tristichaceae to Crassulaceae or Saxifragaceae. Since there is no other group of plants among our present day angiosperms from which these two families could have evolved, the question of their origin will have to remain a riddle until further palaeobotanical, embryological, cytological and palynological investigations could bring to light some new information.

Discussing evolution within Podostemaceae and Tristichaceae, Willis (1949) remarks that the extraordinary features found in these two families could not have arisen in response to any need for adaptation to different conditions, for there are no different conditions to which to be adapted. Evolution, according to him, proceeded by definite single divergent mutations that can cover at one stroke the differences between one species, genus, or family and the next, and is more or less completely independent of natural selection. An individual not up to the standard of its birth place would be eliminated while any showing definite improvement would be preserved. Probably most mutations simply produce structurally divergent, but adaptationally indifferent alterations, the local adaptation of the new species being a more or less functional and compulsory affair. Arber (1920) while agreeing with Willis in his contention that natural selection could scarcely have played a part in the origin of Podostemaceae does not rule out its role as one of the various factors to which adaptation may be due. She argues (p. 332): "The view may well be taken that the lack of adaptation which Willis finds so striking, is actually in part *attributable* to the absence of competition and hence the elimination of natural selection. From this point of view, the Podostemaceae furnishes evidence—negative but forcible—for the importance of natural selection in the development of adaptation, since here we have a case of the absence of natural selection correlated with the absence of special adaptations. Among the Podostemads, presumably, all variations—good, bad, or indifferent—have had an equal chance of perpetuation, provided they did not interfere with those general features which gave the group its special capacity for growth in the rapidly running water, which is so inimical to most forms of plant life".

TAXONOMIC POSITION

Bentham and Hooker (1880) placed the family in a separate series called Multiovulatae Aquaticae in his Monochlamydeae. His Podostemaceae included Tristichaceae and Hydrostachyaceae as well. Though Engler recognised in his 7th edition of the Syllabus (1912) (*cf.* Willis, p. xx, 1966), the three families Podostemaceae, Tristichaceae and Hydrostachyaceae and placed them in a suborder Podostemineae in the order Rosales along with other suborders Saxifragineae and Rosineae, later he changed

his view and sunk Tristichaceae into Podostemaceae (Engler, 1930). Hutchinson (1959) united Hydrostachyaceae and Podostemaceae (including Tristichaceae) in the order Podostemales which he brought in close relation to the Saxifragales. van Royen (1951) suggests that Podostemaceae and Crassulaceae form the final stages of three diverging lines starting from the Saxifragaceae, the Crassulaceae and Podostemaceae forming one line at first and parting later on. He considers Podostemaceae sufficiently distinct to form a separate order Podostemales.



In the 12th edition of Engler's Syllabus (Revised by Melchior, 1964), Hydrostachyaceae and Podostemaceae (into which has been sunk Tristichaceae—probably on the basis of the arguments presented by van Royen, 1951) are treated in separate orders Hydrostachyales and Podostemales of the Archichlamydeae. Takhtajan (1966) treats Podostemaceae as the only family of Podostemales under the suborder Rosidae of Magnoliatae. He does not recognise Tristichaceae as a separate family. He removes the Hydrostachyaceae to the order Scrophulariales of the suborder Asteridae. In our opinion Melchior's treatment appears to be satisfactory if Tristichaceae is reinstated as a distinct family of Podostemales. The major differences between Tristichaceae and Podostemaceae are tabled below:

Character	Tristichaceae	Podostemaceae
1. Branching	Simple	In the "axil" of a lower stipule.
2. Leaves	Simple, moss-like, exstipulate	Complex compound leaves, stipulate; rarely exstipulate and simple. When exstipulate and simple, sheathing bases and peculiar modes of branching present.
3. Secondary shoots	Simple or slightly thalloid with leaves on the upper side as well as on the margins.	Complex with leaves only on the margins.

Character	Tristichaceae	Podostemaceae
4. Spathes	Absent	Present
5. Perianth	Present	Absent
6. Stamens	Few (1-3) except in <i>Weddellina</i> (5-25). Staminodes absent.	Many to few. When few, anthropodium mostly present. Staminodes present.
7. Pollen	Exclusively monads. Forate or tricolporoidate. Quadruplication simultaneous.	Mostly dyads, rarely monads. Tricolpate or zonate. Forate grains not reported. Quadruplication successive.
8. Ovules	Bitegmic. Both integuments differentiate simultaneously.	Bitegmic. The inner integument is initiated only after the outer one has covered the nucellus.
9. Leucoplasts	Present in the leaves	Absent in the leaves.

Tristichaceae Willis in J. Linn. Soc. 43: 51, 1915 (for a detailed treatment of the genera of this family, see Engler, 1930; van Royen, 1951, 1953, 1954, 1959 and Subramanyam, 1962b).

Herbs with numerous large secondary shoots from the creeping roots—rarely the primary root flattened into a creeping thallus—bearing delicate, minute, simple, exstipulate leaves. Flowers bisexual, fully hypogynous, small, inconspicuous, regular or slightly irregular by the absence of one or two stamens, monochlamydeous with 3-5 free or united perianth members. Stamens as many as or rarely 4-5 times as many or reduced to 2 or 1, usually alternate with the perianth; anthers bilocular, introrse; pollen granular, tricolporoidate or forate. Ovary of 2-3 carpels, 2-3 locular with thick central placenta, delicate septa and several anatropous ovules; stigma usually sessile, as many as carpels. Capsule stalked and generally conspicuously ribbed; seeds many, exalbuminous, mucilaginous when wet.

Type genus: Tristicha Thouars.

KEY TO THE GENERA

1. Perianth-lobes 5, stamens 5-25 ... *Weddellina*
1. Perianth-lobes 3, stamens 3-1 :
 2. Stamen 1, ovary 2-celled, roots creeping, shoots not thalloid, profusely branched out ... *Tristicha*
 2. Stamens 3, ovary 3-celled :
 3. Roots thread-like, creeping, long, slender, often branched, free-floating; shoots with linear scattered leaves ... *Indotristicha*
 3. Roots thalloid, frondose, closely attached to rocks; shoots with 2 kinds of linear leaves densely conferted at the tip of the shoots ... *Terniola*

This unique family containing four monotypic genera shows an interesting pattern in their distribution. *Weddellina* Tul., with *W. squamulosa* Tul., is the only genus of Tristichaceae which shows some signs of affinity to the Podostemaceae in some features like numerous stamens and bicarpellary ovary. It is confined to British Guiana, Suriname, Colombia and Northern Brazil. *Indotristicha ramosissima* (Wt.) van Royen, the type and only species of *Indotristicha* van Royen was formerly assigned to *Dalzellia*, *Terniola* and *Tristicha*. It is endemic to the Western Ghats of India. *Terniola zeylanica* (Gardn.) Tul., the type of the monotypic genus *Terniola* Tul., was formerly treated as belong-

ing to *Tristicha* and *Lawia*. It occurs in Ceylon and in the Western Ghats of India. *Tristicha* Thours. is the only genus which has a wider distribution embracing the two continents of America and Africa. The only species of this genus *T. trifaria* (Bory ex Willd.) Spreng. occurs in Mexico, Honduras, Nicaragua, Guatemala, El Salvador, Costa Rica, Panama, Colombia, Cuba, Venezuela, British Guiana, Brazil, Uruguay and Argentina in America and Sudan, Uganda, Senegal, Cameroon, South Africa and Angola in Africa and Madagascar and the Mascarene Islands. It does not occur in Asia (Map).

TRISTICHACEAE - DISTRIBUTION



Map showing distribution of Tristichaceae

Podostemaceae L. C. Richard ex C. A. Agardh. Aphor. 125, 1822 (Podostemaceae) *nom. fam. cons.* (For a detailed account of the genera of this family, see Engler, 1930; van Royen, 1951, 1953, 1954, 1959 and Subramanyam, 1962b).

Herbs with creeping roots of great variety of form bearing secondary shoots also of great diversity of form. Leaves usually large, stipulate, much

branched and complicated, the branches arising under special lower stipules. Flowers bisexual, fully hypogynous, small or fairly large, inconspicuous or brightly coloured, regular, slightly irregular or highly zygomorphic, achlamydeous, enclosed before anthesis in a closed spathe springing from the base of the stalk, and opening at the tip or along the upper side. Stamens many to 1, in one

or more whorls, free or united in one or more groups, regular or only on the lower side of the flower, usually with as many staminodes; pollen tricolpate monads or tricolpate, zonocolpate or zonate dyads. Ovary superior, ellipsoid, of two carpels, 2-1-locular, symmetrical or zygomorphic (often highly so) with thick central placenta and many to few (10-2) anatropous ovules; stigmas usually as many as carpels. Capsule stalked or sessile, ribbed or smooth, dehiscent or indehiscent with equal or unequal valves; seeds many to few, exalbuminous with straight embryo; testa mucilaginous when wet.

*Type genus: *Podostemum* A. Michaux.

KEY TO THE INDIAN GENERA

- | | |
|---|----------------------|
| 1. Fruit 2-4-seeded, indehiscent; stamen 1 | <i>Farmeria</i> |
| 1. Fruit many-seeded, dehiscent; stamens 2,
rarely 1: | |
| 2. Capsule not oblique, chambers of ovary large, capsule wall mostly remains after dehiscence: | |
| 3. Capsule smooth with a slight rib in the centre of each valve; leafy shoot thread-shaped, flowers terminal on prominent shoots bearing triquetrous and decussate scaly leaves ... | <i>Willisia</i> |
| 3. Capsule ribbed prominently; floriferous shoots not prominent and without decussate scale leaves: | |
| 4. Stigma thread-like or narrow or thin oval-shaped, inclined; spathe tubular beyond the opening; roots filiform, covering the stones and sending accessory floating roots ... | <i>Dicraeia</i> |
| 4. Stigma broad, flat, keel-shaped, shredded at the margin; spathe boat-shaped; roots crustaceous, flattened, creeping and lichen-like without free floating branches ... | <i>Hydrobryum</i> |
| 2. Capsule oblique, unequal chambered or with unequal valves from which the smaller one falls off and the bigger one remains: | |
| 5. Capsule smooth, pollen in monads: | |
| 6. Flowers sessile, stigma long, linear ... | <i>Hydrobryopsis</i> |
| 6. Flowers pedicellate, stigma acicular-shaped ... | <i>Griffithella</i> |
| 5. Capsule ribbed, pollen in dyads: | |
| 7. Root crustaceous, rarely ribbon-like ... | <i>Zeylanidium</i> |
| 7. Root filiform ... | <i>Podostemum</i> |

**Podo* (Gk.)—foot; *stemum* (Gk.)—stem or crown: from the nature of the stem which is in the form of a foot.

Among the eight genera, three are monotypic and endemic to the Western Ghats of India. They are: *Griffithella* (Tul.) Warm. [*G. hookeriana* (Tul.) Warm.], *Hydrobryopsis* Engl. [*H. sessilis* (Willis) Engl.] and *Willisia* Warm. [*W. selaginoides* (Bedd.) Warm. ex Willis]. *Hydrobryopsis hookeriana* (Tul.) Warm., has been reported from Eastern Ghats (near Vizakapatnam) also. Of the remaining genera *Farmeria* Willis has 2 species: one in Ceylon [*F. metzgeroides* (Trimen) Willis] and another in the Western Ghats of India near Tirunelveli (*F. indica* Willis). *Hydrobryum* Engl. has 2 species: *H. griffithii* (Wall. ex Griffith) Tul. distributed over Nepal (Himalayas), Sikkim, N. Assam, Khasia, Manipur, N. Thailand and Tonkin. A second species *H. japonicum* Imamura occurs in the Kyvshu Island of Japan. Similarly *Zeylanidium* (Tul.) Engl., has 2 species: *Z. olivaceum* (Gardn.) Engl., with several highly variable forms [into which perhaps should be sunk *Z. johnsonii* (Wt.) Engl.] occurring in Ceylon and Western Ghats of India and *Z. lichenoides* (Kurz) Engl., distributed over Ceylon, India, Burma and Thailand. *Dicraeia* Thou. with 12 species has a wider distribution: from Tropical and South Africa through Madagascar to Ceylon and India. In India, seven species occur: *D. elongata* Tul. in Kerala, *D. dichotoma* (Gardn.) Tul. in the Western Ghats of Madras and Kerala, *D. stylosa* Wt. in the Western Ghats of Mysore, Madras and Kerala, *D. minor* Wedd. in the Khasia Hills of Assam, *D. wallichii* (R. Br.) Tul. in Assam and Burma, *D. filifolia* Ram. et Joseph in Kerala and Orissa, and *D. agharkarii* Nandi in Khasia Hills of Assam. *Podostemum* Michx., with over 17 species is the most widely distributed genus of this family. Its species occur in S. and S. E. parts of N. America, in West Indian Islands, Central America, S. and S. W. parts of Brazil, Uruguay, Paraguay, Argentina, Tropical Africa, Ceylon and India. In India, *P. subulatum* Gardn. is found in the Western Ghats at Anamalai Hills of Madras State and *P. barberi* Willis in the hills of South Canara at Bel-tangudi in the Western Ghats and in the Bastar district of Madhya Pradesh.

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REFERENCES

- ARBER, A. *Water Plants*. Cambridge, 1920.
- BANNAN, M. W. An occurrence of perforated tracheids in *Thuja occidentalis* L. *New Phytol.* 57 : 132-134, 1958.
- BENTHAM, G. AND J. D. HOOKER. *Genera Plantarum*. London, 1862-1883.
- BEZUIDENHOUT, A. The Pollen of the African Podostemaceae. *Pollen et Spores* 6 : 467-478, 1964.
- *BONGARD, H. G. Genera Lacis reviso. *Zap. imp. Akad. Nank.* Ser. 6, tome 3, part 2 : 73-83, tab. 1-6, 1835.
- CHOPRA, R. N. AND A. J. MUKKADA. Gametogenesis and Pseudoembryosac in *Indotrística ramosissima* (Wt.) van Royen. *Phytomorphology* 16 : 182-188, 1966.
- EAMES, A. J. *Morphology of Angiosperms*. New York, 1960.
- ENGLER, A. Podostemonaceae: In Engler and Prantl, *Die natürlichen Pflanzenfamilien* 18a : 1-68, 1930.
- *Syllabus der Pflanzenfamilien*. Revised by Melchior. 12th Ed. Berlin, 1964.
- ERDTMAN, G. *Pollen morphology and plant taxonomy*. Stockholm, 1952.
- JANE, F. W. Perforated vertical tracheids in *Sequoia sempervirens* Endl. *New Phytol.* 55 : 367-368, 1956.
- HAMMOND, B. L. Development of *Podostemon ceratophyllum*. *Bull. Torrey bot. Club* 64 : 17-36, 1937.
- HUTCHINSON, J. *Families of Flowering Plants*. Vol. 1. London, 1959.
- *IMAMURA, S. J. Über *Hydrobryum japonicum* Imamura, eine neue Podostemonaceae in Japan. *Bot. Mag. Tokyo* 43 : 332-339, 1929.
- MAHESHWARI, P. The place of Angiosperm Embryology in research and teaching. *J. Indian bot. Soc.* 24 : 25-41, 1945.
- *MATHIESON, Fr. J. Beiträge zur Kenntnis der Podostemonaceae. *Bibl. Bot. Stuttgart* 68 : 1-55, 1908.
- METCALFE, C. R. AND L. CHALK. *Anatomy of the Dicotyledons*. Vol. 2. Oxford, 1950.
- MUKKADA, A. J. Some observations on the embryology of *Dicraeia stylosa* Wt. *Plant Embryology : A Symposium* 139-145, New Delhi, 1962.
- An addition to the bisporic embryo sacs—the *Dicraeia* type. *New Phytol.* 63 : 289-292, 1964.
- NAIR, P. K. K. Pollen morphology of Indian Podostemaceae. *Curr. Sci.* 34 : 381-382, 1965.
- *PALM, B. *Studien über Konstruktions typen und Entwicklungswege des Embryosackes der Angiospermen*. Diss. Stockholm, 1915.
- *STEUDE, H. Beiträge zur Morphologie und Anatomie von *Mourea aspera*. *Beih. bot. Zbl.* 53 : 627-650, 1935.
- SCULTHORPE, C. D. *The Biology of Aquatic Vascular Plants*. London, 1967.
- SPRAGUE, T. A. Podostemaceae or Podostemonaceae. *Kew Bull.* 1933 : 46, 1933.
- SUBRAMANYAM, K. Embryology in relation to systematic botany with particular reference to Crassulaceae. *Plant Embryology—A Symposium* 94-112, New Delhi, 1962a.
- *Aquatic Angiosperms*. CSIR Monograph No. 2, New Delhi, 1962b.
- SWAMY, B. G. L. Wood anatomy and Taxonomy. *Mem. Indian bot. Soc.* 1 : 10-14, 1958.
- TAKHTAJAN, A. *Systema et Phylogenia Magnoliophytorum*. Moskwa, 1966.
- VAN ROYEN, P. The Podostemaceae of the New World I. *Meded. bot. Mus. Rijksuniv. Utrecht* 107 : 1-151, 1951.
- The Podostemaceae of the New World II. *Acta bot. Neerland.* 2 : 1-122, 1953.
- The Podostemaceae of the New World III. *Ibid.* 3 : 215-263, 1954.
- Nomenclatural notes on the genera *Dalzellia*, *Lawia*, *Mnianthus* and *Terniola* (Podostemaceae). *Ibid.* 8 : 473-476, 1959.
- *WEYLAND, H. Beiträge zur Kenntnis der rheinischen tertiar flora II. *Palaeontographica* Abt. B. 83 : 67-122, 1937.
- WILLIS, J. C. A new natural family of flowering plants. Tristichaceae. *J. Linn. Soc. London* 43 : 49-54, 1914.
- The origin of Tristichaceae and Podostemaceae. *Ann. bot. London* 29 : 299-306, 1915.
- The evolution of Tristichaceae and Podostemaceae. *Ibid.* 40 : 349-367, 1926.
- The Birth and spread of Plants. *Boissiera* 8 : 1-561, 1949.
- *A Dictionary of Flowering Plants and Ferns*. Revised by Airy Shaw. Cambridge, 1966.

*Not seen in original.