STUDIES IN THE ORDER CENTROSPERMALES

III. Vascular Anatomy of the Flower of Some Species of the Family Ficoidaceae*

BY H. P. SHARMA
(National Botanic Gardens, Lucknow)

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INTRODUCTION

Family Ficoidaceae comprises a large number of genera occurring mostly as weeds in the tropical and subtropical regions. While anatomy of the vegetative parts, cytology and embryology of this family has received considerable attention of botanists from time to time, vascular anatomy of the node, the inflorescence and the flower have not been attempted so far. The present communication is a step towards filling this gap.

MATERIAL AND METHODS

The present account is based on six species, viz., Sesuvium portulacastrum Linn., Trianthema pentandra Linn., T. decandra Linn., T. portulacastrum Juss, T. crystallina Vahl and Galenia secunda Sond. Material of Sesuvium portulacastrum was collected from herbarium sheets of the Botany Department, Meerut College; that of Trianthema decandra was received from the Superintendent, Government Gardens, Bangalore, and that of Galenia secunda was lent by the Herbarium of the National Botanic Gardens, Lucknow. Material of the remaining species was collected locally and preserved in F.A.A. Serial microtome sections of 8–12 μ thickness were cut and stained with both crystal violet-erythrosin and safranin-fast green combinations. With the herbarium material, however, the better combination gave better results.

OBSERVATIONS

Sesuvium portulacastrum is a diffuse procumbent or prostrate herb with solitary axillary flowers. The perianth is five-lobed and the tepals are ovate-

* A major part of this work was carried out at the School of Plant Morphology, Meerut College, Meerut.
lanceolate and cuspidate. There are 15–40 free stamens and a tricarpellary
gynœceum with two rows of ovules on an axile placenta. In the upper region
of the ovary the placentæ withdraw from the centre and continue to bear
ovules for some distance. As a result, the ovary becomes one-chambered
at this level.

The pedicel is supplied by a hollow vascular cylinder which breaks up
into eight or nine bundles as the receptacle is approached (Fig. 1). These
bundles diverge outward as perianth supply leaving minor vascular elements
towards the centre (Figs. 2 and 3, p). Repeated divisions in the perianth
traces, as they are diverging outward, result in numerous branches for each
tepal (Figs. 4–7).

As already pointed out, departure of the perianth supply leaves minor
vascular elements towards the centre (Figs. 2 and 3). These reorganise
into a tri-radiate vascular ring from the angles of which 9–10 stamen cords
arise without causing any gaps in the ring (Figs. 4 and 5, s). These divide
into two to three branches each. The resulting branches expand sideways
and each enters one stamen (Figs. 6 and 7, s).

Departure of the stamen cords leaves a tri-radiate vascular ring in the
centre (Fig. 4). The angles of this ring break up into a dorsal and 4 lateral
bundles for each carpel (Figs. 5 and 6, d and l). All these traverse upward,
and show some branchings before disappearing in the sub-stylar region
(Figs. 7–9). Only the dorsals pass into the respective styles (Fig. 9, d).

The remaining stelar tissue reorganises in the centre and gives out ovular
strands at successive levels (Fig. 7, D). Each of these strands soon separates
into two traces for a pair of ovules arising at one level. Below the level where
the septic withdraw from the centre, the central placental strand breaks up
into three bundles which come to occur in the angles of the separated septic.
These bundles continue to give out ovular traces as usual even after the sepa-
ration of septic (Fig. 8). The roof of the ovary is sometimes ridged inwards
at the dorsal radius. As a result of this each locule appears to be divided
into two at this level.

*Trianthema pentandra.*—The flower, in this species, has a short pedicel
and five green tepals that are produced into a dorsal spine. The dorsal
epidermal cells on the midribs of these possess mammillate cells with much
thickened outer walls. The andrœcium consists of five stamens alternating
with the tepals. Three stamens have also been observed by the author as
an abnormality. The cells of the dorsal epidermis are conical. There are
two carpels in the gynœceum, the top of which is disk-shaped. Two completely
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Figs. 1–21
free styles arise from the centre of this disk. The ovary is bilocular and its wall is 3–4-layered in the lower portion with large water storage cells similar to those on the tepals. The disk is many-layered and has thick-walled conical cells on the outer side. Each carpel contains two ovules arising at the same level from an axile placenta but arranged one above the other. The stylar canal lies in the common septum and, nearly halfway down the locule, is bifurcated into two, each part continuous with the respective locule. At the time of dehiscence, the carpel disk breaks away from the lower portion into two component parts, each of which takes away the upper seed enclosed within a constricted cavity.

The vascular supply of the pedicel is in the form of a hollow cylinder from which some eight or nine traces diverge out for the perianth (Fig. 10, p). They are variously distributed between the five tepals. Fusion between traces of the same and different tepals is quite common and sometimes even one of the stamen traces may also get adnated with one of the tepal cords. There is profuse branching in all these traces and before they enter the tepals the entire perianth supply is arranged in the form of a pentagon (in transverse section) each arm of which forms the supply of one tepal (Figs. 12–21).

Alternating with tepals there are five stamens whose traces arise independently from the parent stele (Figs. 11–13, s). Sometimes, however, one of the stamen traces may arise adnate with a tepal cord from which it soon separates as a branch on the inner side.

The remaining vascular tissue first organises into a ring which in a cross-section assumes a dumble-shaped appearance higher up (Fig. 13). Almost immediately the dumble breaks into two carpel dorsals at diametrically opposite points (Figs. 14 and 15, d). The resulting two arcs contract and leave a lateral trace on either side of each carpel dorsal (Figs. 14-16, l). A little higher up each arc again leaves one big bundle on either end of the common septum (Fig. 15, l). Thus at this level there will be one dorsal for each carpel with two bundles on its either side, the nearer one being smaller than the one farther away (Fig. 17). All these bundles form the carpellary wall supply. The laterals and the secondary marginal bundles start branching soon after their demarcation and show anastomosis in the upper regions of the carpel wall (Figs. 18–20). Carpel dorsals do not usually show branching but occasionally one of them breaks up into two bundles in the upper regions, which again unite as the dorsal passes into the style (Fig. 20).

After the departure of carpellary wall traces, the two arcs of the dumble come closer and fuse by their middle portions in the centre of the common
septum in such a way that they give the appearance of two 'C' joined back to back (Fig. 16, x). Soon, however, the two arms of each 'C' separate away and form the corresponding ovular trace (Figs. 17–19, D). Sometimes the 'C' may get closed to form a large solid bundle before the ovular traces originate. Departure of the ovular supply leaves a little "residual" tissue in the centre, which fades almost immediately.

*Trianthema decandra.*—The plants are very similar to those of *T. pentandra* in their floral organisation. The only difference is in the number of stamens which are generally 10–15 (up to 17 in our material) arranged in two whorls. The inner whorl consists of 5 stamens alternating with tepals while the number of stamens in the outer whorl is variable. It is usually 10 of which 5 are opposite and the rest alternate with the tepals. In some cases, one or two of the alternating set of stamens arise in pairs instead of being arranged singly, thus accounting for the excess stamens. The filaments are all fused with the perianth tube at the base. There are two carpels in this species as in *T. pentandra*. The ovary is bilocular with two ovules in each locule and is topped by a disk similar to that of *T. pentandra*.

The pedicel of a flower consists of a hollow cylinder of vascular tissue as in *T. pentandra*. This breaks up into 9–11 bundles which expand leaving feeble vascular elements towards the inner side (Figs. 22 and 23, p). These peripherally migrating bundles divide almost immediately and form a pentagon of unequal bundles (Figs. 24–29). Each arm of this pentagon forms one tepal supply (Figs. 30–32). The exact number of bundles entering a tepal is variable and indeterminable due to repeated divisions in the migrating tepal bundles, as already stated. At the apex of the tepals they all show frequent anastomosis and a single large amphicribral bundle passes into the dorsal spine while the rest fade away in the expanded part (Figs. 34–36).

Departure of the tepal supply leaves a number of feeble vascular elements near the centre. These reorganise into a pentagon and give out 5–6 stamen cords (Figs. 24 and 25, s). These cords expand sideways and divide so as to give ten traces, five of which are opposite and five alternating with the tepals (Figs. 26 and 27, s). The latter again give out one bundle each on their inner sides (Figs. 28–30). Thus at this level there are five bundles in the inner whorl and ten in the outer. Each trace supplies the corresponding stamen. Sometimes there are 17 stamens in a flower. In such a case there are five stamen traces in the inner whorl and twelve in the outer (Figs. 30–32), in the latter whorl five bundles opposite the tepals are present as usual. Similarly, three of the alternitepalous bundles are also normal. The remain-
ing two alternate tepalous positions are, however, occupied by paired bundles (Figs. 31 and 32).

The remaining stelar tissue rearranges itself into a hollow cylinder as in \textit{T. pentandra} and gives out carpel bundles in exactly the same manner (Figs. 26 and 27, d). In this species, however, the central stele gives out two laterals (instead of one in \textit{T. pentandra}) on either side of the dorsal bundle besides the usual secondary marginals. All these show frequent divisions in the carpellary wall (Figs. 28–32). In the disk-shaped roof of the ovary these show frequent anastomosis and only a single bundle passes into the respective style (Fig. 33). The carpel dorsal bundles have not been seen to divide in this species.

\textit{Trianthema portulacastrum}.—The plant, as usual, is a prostrate much-branched herb with branches slightly pubescent along the median line. It has petiolate unequal leaves arising in pairs at each node at slightly different levels. The petioles are sheathing to form a cup-like depression.

The solitary flowers are arranged alternately right and left on subsequent nodes and are borne within the petiolar cups with which are also fused two lateral bracteoles. The five tepals of the flower are united into a perianth cup and are dorsally produced into spines at the tip as usual. The semi-inferior monocarpellary ovary is situated within this cup. There are 10–20 petalous stamens in this species. The filaments are triangular in cross-sections and have conical cells in their dorsal epidermis. The single carpel is apparently laterally oriented in so far as the ventral suture is in line with the two ‘bracteoles’. It has a single locule with ovules arising in two rows from a marginal placenta. This placenta arises a little above the base of the ovary, gradually protrudes into the locule and ends abruptly before reaching the top of the ovary. The two uppermost ovules are borne almost vertically upward. A massive disk tops the ovary. It is biconcave and its sides are produced into horns. The wall of the disk is many-celled while the lower portion of the ovary wall is only 3–4-celled. The outer epidermal cells of the disk are conical in shape. At the time of dehiscence the disk breaks away taking the two topmost seeds along with it.

The main stem has a ring of vascular bundles with slightly thick-walled pericycle on the outside. A little higher up this ring breaks up into individual bundles and so does the pericycle. Below the region of the flower the stele breaks into two unequal arcs for axillary vegetative branches. Simultaneously with this, some branches from the laterally situated stelar bundles migrate inward with a slight downward incline (Figs. 38–40). These organise into...
a hollow cylinder and provide the necessary floral traces. The inward migra-
tion of the stelar bundles on the placental side takes place at a slightly higher level. All these bundles divide repeatedly and anastomose forming a plexus which gives off vascular traces to the various organs of the flower. While the flower supply is still moving in, two bract bundles differentiate and diverge out for their respective destination (Figs. 40–44, b). A little higher up or almost at the same level some seven tepal cords get separated from the vascular plexus of the flower. They divide a little higher up and ultimately the tepals receive three branches each (Figs. 41–48, p). Further divisions are frequent in the tepals higher up. In the upper region the tepals end in dorsal spines which receive a large amplicribral bundle. The lateral branches anastomose and end in the flattened portion as shown in T. decandra.

After the passing out of the perianth traces a varying number of indepen-
dent cords separate from the central vascular tissue (Figs. 41–45, s). These divide to give about 20 branches for as many stamens, each branch passing into one stamen where it continues undivided (Figs. 46–48).

The remaining vascular tissue gives 7–9 carpellary wall traces (Figs. 44 and 45, w). All these traverse the ovary wall and anastomose in the carpellary disk to form a ring near the periphery (Fig. 47). A large number of blindly ending branches arise from this vascular ring and enter the respective horns of the disk (Fig. 48). The carpel dorsal, however, alone enters the single style (Fig. 48).

Besides the wall bundles just mentioned, there is a large hollow cylinder on the placental side (Figs. 37 and 45, x). A little distance up the locule this cylinder gives out two more bundles to the carpellary wall (Fig. 45). In the upper region the placental bundle gets completely ‘used up’ in supplying the ovules arising in pairs at successive levels (Fig. 46).

Trianthema crystallina.—The plants in this species are spreading with glabrous or minutely papillose branches. Leaves are opposite, much smaller and have very short petioles. There is slight difference in the level of attachment of the two leaves.

One or sometimes two flowers are present in between two vegetative branches which in turn end in similar flowers. Tepals are united at the base to form a persistent perianth tube. There are no hairs on the dorsal side of the tepals. The androecium consists of five alternipetalous stamens. These are united with the perianth tube at the base. The epidermal cells of the filaments are like those of T. portulacastrum. There is a monocarpellary gynæceum and the placenta is oriented almost, though not exactly, at right
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Figs. 37-54
angles to the plane of vegetative branching. The top of the ovary is saucer-shaped without any lateral horns. Placentation is marginal.

The vascular supply of the pedicel consists of a ring of bundles, which give off one bract trace on either side (Figs. 49–52, b). Slightly higher up eight or nine traces diverge out for the five tepals. These divide repeatedly and provide a varying number of traces to the five tepals (Figs. 49–54, p).

The remaining stelar tissue organises itself into a pentagon from the angles of which arise five stamen traces for as many stamens (Figs. 50 and 51, s). A little higher up, the parent stele breaks up into a small carpel, dorsal and a very big amphicribral placental cord (Figs. 52 and 53, x). This cord divides into two amphicribral branches. These bundles supply the two ovular traces one after another (Fig. 54). Even after providing the ovular supply the daughter bundles continue up in the carpel wall where they branch repeatedly and show fusions with the dorsal bundle as it passes into the single style.

Galenia secunda.—The plants are, as usual, diffusely spreading herbs with sub-opposite leaves and single flowers sunken between the leaf petioles and the opposite branch. There are five tepals, 10–11 epitepalous stamens some of which may occasionally become flattened staminodes. The gynaeceum is semi-inferior and consists of three carpels.

From the hollow vascular cylinder traversing the stem, a single leaf trace arises somewhat laterally. A little higher up the central stele breaks up into three parts (Fig. 55). The median one of these organises itself into a hollow vascular cylinder and forms the supply of the solitary flower. From this stele about 11–13 vascular cords diverge outward (Figs. 56 and 57, p). All, or nearly all of these, are either tepal-stamen or tepal-carpel cords. Sometimes one or two of these may be purely carpel or stamen cords. The tepals are basically three trace organs but the various dorsals and marginals are haphazardly fused and show divisions before entering the tepals. Some of the tepal dorsals arise conjoint with traces of the inner organs while the others arise along with the marginals.

The stamen cords number five to six and usually arise conjoint with the tepal traces at alternitepalous radii (Figs. 59–61, s). Sometimes, however, they may arise fused with the respective tepal dorsals. Independently arising stamen cords are also met with. Each of these cords divides into two and one of the daughter branches again divides into two. Thus, in all, about eleven stamen traces are formed (Figs. 61 and 62). The first of these traces forms the supply of an inner stamen while the latter branches form traces of two outer stamens.
The carpellary wall supply also arises conjoint with the tepal cords occurring on septal radii. But sometimes one or two of these, occurring opposite the tepals, may arise independently from the axial stele (Fig. 59, w). In all, ten carpellary wall cords—5 dorsals and 5 median laterals—are formed. All these cords expand sideways forming vascular arcs extending up to the carpellary dorsal region (Figs. 60 and 61). As the carpel wall separates these arcs disappear leaving only five large bundles towards the outer side of the septa (Figs. 61-63, w). In the ovary roof they show profuse branching, of which one passes into each style and disappears below the stigma region.

Whatever vascular tissue is left in the centre reorganises into a hollow cylinder. This contracts near the base of the locule (Figs. 59 and 60). A
little higher up it breaks up into five bundles which supply the ovules in the respective locules (Fig. 63).

**DISCUSSION**

*The Perianth.*—The different species studied show a progressive adnation between the perianth and the stamen. Whereas in the allied family Molluginaceae the tepals are free, in the Ficoidaceae they are not only united among themselves but they even get fused with the bases of the stamens to form a perianth stamen tube. In *Sesuvium portulacastrum*, *Trianthema decandra*, and *T. crystallina* the vascular traces of the two whorls remain separate. In *T. pentandra* also traces of the two whorls usually remain separate. Sometimes, however, one of the stamen traces may arise adnate with the tepal supply. In *T. portulacastrum*, where the flowers are sunk in petiolar cup, there is a greater degree of condensation in the stele so that the perianth and the stamen traces differentiate at almost the same level. In *Galenia secunda* there is still greater condensation and the vascular traces of the stamens and the tepals arise as common cords.

*The Androecium.*—The number of stamens in the genera studied varies from 5 (sometimes 3) to 40. In *Sesuvium portulacastrum* there are up to 40 stamens with their traces arising fused in 9–10 cords at three points from the central stele. In *Trianthema portulacastrum* there are up to 20 stamens getting their supply as 9–10 cords. In *T. decandra* there are 10–15 stamens (17 in our material) with 5 in an inner alternitepalous whorl and the remaining outer to these. The stamen traces in this species too show cohesion and arise as 5 cords (sometimes 6) alternating with the tepals. Thus, in this species stamen traces of the outer and inner whorls arise fused together. In *Galenia secunda* with 10–11 stamens, their traces arise as 5–6 cords adnate with the tepal traces. One stamen cord may occasionally arise independently too. In the remaining species there are only 5 stamens with their traces arising independently from the central stele. From this it appears that the simple condition for the family is the presence of a large number of stamens arranged in more than one whorl. From this, modifications have arisen through cohesion subsequently leading to adnation of the perianth and stamen traces. Along with this, individual members have also been lost as a result of condensation leading ultimately to an inferior ovary. A higher number of stamens in Ficoidaceae is often supposed to have arisen as a result of dedoublement (see Hutchinson, 1959; Rendle, 1959; Lawrence, 1951). The present studies, however, show that a lesser number of stamens is a derived condition.

* This excludes *mesembryanthemums* which will be considered elsewhere.
The Gynceceum.—The number of carpels varies from three in Sesuvium portulacastrum and Galenia secunda to two in Trianthema pentandra and T. decandra and one each in T. portulacastrum and T. crystallina. In all the species studied the carpellary wall is supplied by five or more bundles. In T. portulacastrum, two bundles separate from the placental cylinder nearly one-fourth way up the locule and traverse the ovary wall. These bundles are, therefore, secondary marginals. In T. crystallina two bundles continue up beyond the placental region. In view of the close resemblance between the two species these bundles also appear to be secondary marginals. Thus, whereas in Molluginaceae the carpel wall is supplied by a dorsal and two secondary marginals alone, in Ficoidaeae, besides these traces, there are found some laterals as well. This condition is more advanced.

The placental supply in some of the species studied is interesting and significant in so far as it throws some light on the carpellary reduction tendencies within the family. It will be remembered that the placentation is axile in Sesuvium portulacastrum, Galenia secunda, Trianthema decandra and T. pentandra and marginal in the other two species of Trianthema. The placental supply in all the species, however, is in the form of a hollow vascular cylinder which leaves a little residual vascular tissue in Trianthema pentandra. While such a cylinder is quite normal for the multicarpellary gynaecia, it is rather unusual for monocarpellary ones. In T. crystallina there is a large solid cylinder in the placental region. It divides below the ovular attachment and continues as two prominent cords which probably represent the carpellary marginals with 'residual' stelar tissue incorporated alongwith. The separation of the secondary marginals above the level of the locule in T. portulacastrum as also the presence of a 'residual' tissue in T. pentandra clearly shows that this placental cylinder is stelar in nature. The persistence of stelar tissue almost up to the top of the ovary in the monocarpellary species cannot but mean that originally the genus possessed a multicarpellary ovary and the present monocarpellary condition has been brought about by a phylogenetic suppression of the additional carpels. The presence of a hollow vascular cylinder as also an axile placentation in Molluginaceae (Sharma, 1961) further supports such an inference. The 'marginal' placentation has generally been believed to be the simplest condition and the axile type derived from it (see Puri, 1952). From their placental supply, however, it is clear that the 'marginal' placentation in Trianthema portulacastrum and T. crystallina has actually resulted from the suppression of additional placentae in an originally axile placentation. This confirms Puri's suspicion about the marginal placentation being primitive as well as a derived condition (dotted line in Puri, 1952).
Beside the modification of the vascular plan, the placenta shows a tendency towards reduction in its extent. In *Sesuvium portulacastrum* (cf. *Molluginaceae*, Sharma, 1961) the placenta bears a large number of ovules. In *Trianthema portulacastrum* there are 6–8 ovules of which the two uppermost ones arise much below the top of the locule. In *T. decandra* and *T. pentandra*, the lower portion of placenta remains sterile and each has two ovules arising from its middle. In *T. crystallina* also there are only two ovules in the ovary.

**Affinities.**—As is well known, there are two opinions about the splitting of the single family *Aizoaceae* into *Molluginaceae* and *Ficoidaceae* advocated by Hutchinson (1959) (see Rendle, 1959; Lawrence, 1951; Gundersen, 1950). From the present studies it can be said that while there are undoubtedly some points of basic similarity between the two families there are some characters which are markedly distinctive. Some of the embryological and cytological differences have already been pointed out by Joshi and Rao (1936) and Raghavan and Srinivasan (1940). Origin of all tepal traces at the same level; multi-traced condition of tepals at the level of their separation (in *Molluginaceae* they are three-traced); fusion of adjacent stamen traces (in *Molluginaceae* there is more of adnation); multi-traced carpellary wall (three-traced in *Molluginaceae*); lesser number of ovules as compared to *Molluginaceae* and lastly, non separation of carpel marginals from the 'residual' axial tissue are some additional points brought out here. It, thus, appears that even though the two families are closely related, they probably represent two independent evolutionary lines. Further, origin of tepal traces at the same level, fusion of tepals to form a tube, epipetal, epigyny (*Galenia secunda*), division in the tepal traces as also in the carpel dorsals giving rise to a large number of laterals, loss of carpels leading to monomery are some of the points which show that *Ficoidaceae* is a more advanced family than *Molluginaceae*.

**Summary**

Vascular anatomy of the flower of six species of the *Ficoidaceae* has been studied.

In *Trianthema pentandra* and *T. crystallina* five stamen traces arise independently from the receptacular stele. In the former species, however, sometimes one of the stamen traces may also arise fused with the respective tepal cord.

In *Sesuvium portulacastrum*, *Trianthema decandra* and *T. portulacastrum* there is considerable cohesion in the stamen traces of the various whorls. In *Galenia secunda* along with cohesion the stamen traces also show adnation
with the respective tepal cords. The belief that the larger number of stamens in some of the Ficoidaceae has arisen as a result of dedoublement in a fewer number of stamen primordia is not supported by the present studies. On the contrary, it appears that the fewer number of stamens is a derived condition.

In *Trianthema portulacastrum* the ovary is sunken in the petiolar cup and the condition is perigynous; in *Galenia secunda* the ovary is semi-inferior while in the rest it is superior with tepals and stamens separating near the top of the ovary.

In all other species excepting *Galenia secunda*, each carpel wall is supplied by more than three traces. In the latter species there is, instead, a vascular arc.

In *Trianthema pentandra* and *T. decandra* the secondary marginals separate from the receptacular stele below the differentiation of the locule. In *T. portulacastrum* they separate a little above the base of the locule.

In tri- and bi-carpellary gynæcia there is a hollow vascular cylinder in the central column, which, sometimes, leaves a little residual tissue above the level of the ovular supply. A similar vascular cylinder is present in the placental region in *T. portulacastrum* as well.

In *T. crystallina* two prominent cords continue up from the vascular tissue in the placental region even above the level of the ovules. These cords probably represent the carpellary marginals still incorporating some 'residual' axial tissue.

It has been concluded that the monomerous condition in some of the *Trianthema* species is probably due to suppression of additional carpels in an originally multi-carpellary gynæceum.

In species with tri- and bi-carpellary gynæcia the placentation is axile. The 'marginal' condition found in *T. portulacastrum* and *T. crystallina* has probably resulted from the suppression of additional placentæ in an originally axile placentation.

It has been concluded that the 'marginal' placentation is not always the most primitive condition. In certain cases it may also be the derived type.

Despite its undoubted resemblances with the Molluginaceae, Ficoidaceae differs from the previous family in having multi-traced tepals, multi-traced carpellary wall, lesser number of ovules and non-separation of the carpellary marginals from the 'residual' vascular tissue.

Family Ficoidaceae is more advanced than the Molluginaceae in showing fusion of tepals to form a tube, having tepal traces arising at the same level,
division of tepal traces within the receptacular cortex, division of carpellary wall traces before leaving the receptacle, epipetalal, peri- and epigynous carpel and placental reduction.

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REFERENCES

Gundersen, A. ...
Hutchinson, J. ...
Joshi, A. C. and Rao, V. R. ...
Lawrence, G. H. M. ...
Puri, V. ...
Raghavan, T. S. and Srinivasan, V. R. ...
Rendle, A. B. ...
Sharma, H. P. ...

"The embryology of Gisekia pharnaceoides Linn."
"Placentation in Angiosperms,"
"Studies in the Indian Aizoacem,"
"Morphological studies in the order Centrospermales. II. Vascular anatomy of the flower of certain species of the Molluginaceae,"
*Jour. Indian bot. Soc. (in Press)*.

EXPLANATION OF FIGURES

**Figs. 1-21.** Figs. 1-9. Serial transections of the flower of *Sesuvium portulacastrum* from base upward. Figs. 1-3. Perianth traces (p) arising. Fig. 4. Stamen traces (s) arising. Figs. 5 and 6. Carpellary dorsals (d) and lateral traces (l) arising. Fig. 7. Showing origin of ovular traces. Fig. 8. Septa separated at the centre. Fig. 9. Carpel dorsals (d) passing into the style. Figs. 10-21. Serial transections of flowering branch of *Trianthema pentandra* from base upward. Fig. 10. Floral supply (centre) giving out perianth traces (p) (vascular cylinders towards the upper and lower ends in this and subsequent figures belong to the side branches). Figs. 11-12. Stamen traces demarcating. Fig. 13. Five stamen traces distinguishable. Perianth traces dividing. Figs. 14-15. Carpellary wall supply (d and l) demarcating. Fig. 16. Placental supply reorganising, carpel dorsals (d) and laterals (l) completely demarcated. Figs. 17-19. Ovular supply arising. Fig. 20. Carpellary roof showing division of wall bundles and inward migration of dorsal bundles. Fig. 21. Showing the stigma region.

**Figs. 22-36.** Serial transections of the flower of *Trianthema decandra* from base upward. Fig. 22. Vascular supply in the pedicel expanding. Fig. 23. Perianth supply (P) arising. Figs. 24 and 25. Stamen cords (s) arising. Fig. 26. Stamen cords dividing and central vascular tissue forming a hollow cylinder. Fig. 27. Carpellary dorsals (d) fully demarcated, lateral
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Figs. 37-54. Figs. 37-48. Trianthema portulacastrum. Fig. 37. Longitudinal section of the flower showing a hollow vascular cylinder in the placental region (semi-diagrammatic). Figs. 38-47. Serial transections of the flower from base upward. Figs. 38 and 39. Showing organisation of floral supply in the centre. Fig. 40. One of the bract traces (b) arising in the lateral plane. Figs. 41-43. Central cylinder giving out perianth (p) and stamen (s) traces. Fig. 44. Carpellary wall traces getting demarcated. Fig. 45. Placental supply (x) demarcated. Fig. 46. Ovary wall separated from the perianth tube; placental supply (x) getting "used up". Fig. 47. Carpellary wall bundles forming a hollow vascular ring within the carpellary disk. Fig. 48. Carpel dorsal passing into the style. Figs. 49-54. Serial transections of the flower of Trianthema crystallina from base upward. Fig. 49. Perianth supply (p) arising; one of the bracts already demarcated while the vascular trace of the other (L) diverging out. Fig. 50. Perianth traces (p) complete. Stamen traces (s) arising. Fig. 51. Five stamen traces (s) arising. Figs. 52 and 53. Carpellary dorsal (d) already cut; large amphi-ribral bundle (x) present in the placental region. Fig. 54. Placental cord (x) broken into two bundles each giving out an ovular trace.

Figs. 55-63. Serial transections of the flower of Galenia secunda from base upward. Fig. 55. Floral supply demarcated in the centre: the hollow vascular cylinders on either side are for branches and the bundle towards the upper side is the leaf trace. Figs. 56-57. Perianth cords (p) arising. Fig. 58. Stamen and carpellary wall traces separating on the inner side of perianth cords. Figs. 59-60. Carpellary wall bundles (w) expanding and getting connected. Fig. 61. Stamen cords (s) already separated preparing to divide along the dotted lines; carpellary wall separating from the perianth tube. Fig. 62. Stamen traces separated (connections shown by continuous lines are daughter bundles). Fig. 63. Ovular traces diverging (note single bundles in the carpel wall on the septal radii).