V. DISCUSSION AND CONCLUSION

The fruit is an interesting object of research as it is the end product of the intricate and complex reactions of pollination and fertilization. Plant anatomy has always served as a foundation on which the knowledge of plant kingdom has been built.

Since the essential parts of the fruit develop from ovary, the wall of the fertilized ovary develops into pericarp of the mature fruit. Hence the structure of ovary, young and developing fruits and mature fruits are discussed here.

1. OVARY

Convolvulaceae is one of the largest families of the plant kingdom with bicarpellary, syncarpous, superior and bilocular ovary with 2-4 ovules in Ipomoea obscura, 4 ovules in Merremia gangetica, M. hederacea but tetralocular with 4 ovules in Argyreia nervosa. The ovary wall is composed of unilayered outer and inner epidermis and inbetween a few layers of outer hypodermis (only in Argyreia nervosa) mesoderm and inner hypodermis. Its cells are parenchymatous in nature. Ovary wall of the same histological nature is reported earlier in Nicotiana tabacum, Hibiscus Sabdariffa (Dave et al, 1981, 1987). Cuter epidermis is covered with thin and wavy cuticle in Ipomoea obscura, Merremia hederacea and thin and smooth in Argyreia nervosa and Merremia gangetica.

Stomata are reported in the outer epidermis of the ovaries, except Argyreia nervosa and Merremia hederacea. All the investigated ovaries are devoid...
of any trichomes.

In all the four capsules investigated in detail for their development the mesoderm is homogenous and is traversed by two dorsal median and two ventral vascular bundles found in the ovary stage itself except in *Argyreia nervosa* and *Merremia gangetica*. In *M. gangetica* only two dorsal median bundles are distinct in the ovary stage, but two ventral vascular bundles are also found in further developing stage, thus they are differentiated only after anthesis. In the ovary of *Argyreia nervosa* only two dorsal median bundles are present. Here, dorsal median bundles show early differentiation and are prominent up to the stigmatic tip in all. The vascular supply of the ovary wall is through dorsal median bundles in the mesoderm of some carpels of Malvaceae (Rao, 1985). Laticifers with epithelial cells are found in *Argyreia nervosa*.

The gynoecium of this family receives 6 vascular strands. Two of these bundles constitute the dorsals of the carpels, while the remaining four bundles enter into the ventral or the marginal region of the carpels and furnish ovular traces either directly or after fusing with ovular traces and giving off two branches each for the ovules on either side. Obviously, therefore, these bundles have to be considered as ventral bundles of the carpels. Sphaeraphides are noticed in some cells of mesoderm in *L. obscura*.

The next zone beneath the mesoderm is inner hypodermis. The cells of this zone are compactly arranged in all the investigated ovaries. Anticlinal divisions are seen in some cells.

The innermost layer of the ovary wall is inner epidermis which is covered with thin and smooth cuticle in all.

Lateral walls of each carpel are called septae. At the extreme tip, septae are not seen. The ovule chamber remain beneath the terminal region.
Septum is broad at the base, becoming thinner towards the middle and again broad at the apex in L. obscura. Each septum is bounded by unilayered parenchymatous septal wall, which is incontinuation of inner epidermis of ovary wall except M. gangetica, where these septae are bounded by bilayered, parenchymatous septal wall. Placentae are found only at the base of ovary.

In the present investigation, the ovaries of Convolvulaceae show two different types of septa.

1. The carpel margins remain free in the centre i.e., not attached with axis in A. nervosa.
2. The carpel margins are completely fused in the centre i.e. attached with the axis in L. obscura, M. gangetica and M. hederacea.

At the base of bichambered ovaries investigated, the axial growth is found in between two ovules of each chamber, which reaches at the ovary wall and appears false four chambered. In texts and taxonomic books it is described that the placentation is axile in Convolvulaceae. But such a description cannot be supported on the basis of the vascular supply. Its anatomy is to be considered as somewhat similar to that of a parietal placentation (Govil, 1972).

Ahuja (1964) described parietal placentation in Hibiscus micranthus on the basis of the position of vascular bundles. Puri (1952) concluded on the basis of the study of Hibiscus that the axile placentation is evolved from parietal.

In the present investigation, two different types of placentations are observed. In the ovaries showing completely fused septa with axis (L. obscura, M. gangetica and M. hederacea), the placentation is axile. The ovary that shows unattached septa at the base, the placentation is parietal (A. nervosa). The parietal
placentation is earlier reported in Convolvulaceae in ovary of *Evolvulus alsinoides* by Tiagi and Gupta, (1963). The ovaries with unattached septa in *Andrographis alata*, *Ruellia prostrata* and *R. tuberosa* of Acanthaceae (Sabu, 1996), also show the parietal placentation.

2. **YOUNG AND DEVELOPING CAPSULES:**

The capsule development begins after the pollination and fertilization. The ovary wall differentiates into the capsule wall or the pericarp and the ovules into seeds. The developing pericarps of all the capsules investigated are light green to green in colour. After fertilization, the withered floral organs shed off but calyx remains persistent. During development, cell divisions, cell enlargement, cell elongation and differentiation occurs as also found in capsules of *Moringa oleifera*, *Datura innoxia* (Dave et al., 1974, 1980b), *Andrographis echioides*, *A. gangetica*, *Ruellia prostrata*, *R. tuberosa* (Sabu, 1996). In the investigated species, the thickness and striations of the cuticle increases. As development proceeds, outer layer of *A. nervosa*, *M. gangetica* and *M. hederacea* are sclerified in the form of beads as seen in surface view, which starts from young fruit stage.

The epicarp is unilayered parenchymatous in *L. obscura*; unilayered upto young fruit stage in *M. gangetica* and *M. hederacea* but during development it becomes bialayered due to periclinal divisions in the cells of outer layer. The outer layer is parenchymatous and inner layer gets thickened and may become lignified at maturity. Multilayered epicarp is found in *A. nervosa*, which develops from outer epidermis and outer hypodermis of ovary wall.

The cells of the epicarp of *A. nervosa* become thick except in outer epidermis. The thickening starts from young fruit stage and finally in last
The frequency of stomata decreases towards maturity. This may be because of the cell enlargement and elongation of the epicarpic cells and at the same time during development no more stomata are developed.

Endocarp develops from the inner hypodermis and inner epidermis of ovary wall in all the investigated species. Thickenings and lignifications proceed in the endocarp of L. obscura, M. gangetica and M. hederacea. Thickenings of cell walls of inner epidermis, septal epidermis, vacuolization of septal cells take place. Thickenings and lignification of cells of inner layer of septal epidermis proceeds in M. gangetica.

3. MATURE CAPSULE:

The wall of the fertilized ovary transforms during development into pericarp of mature fruit (Roth, 1977). In capsules, the pericarp usually develops into three distinct layers; an epicarp, mesocarp and endocarp. These three distinct zones of pericarp are reported earlier in other capsules also (Karawya et al., 1973; Dave et al. 1974; 1980b; 1987; Dave and Menon, 1986; Rao et al. 1987a,b; Kuriachen and Dave, 1989 b and Sabu, 1996).

Unilayered parenchymatous epicarp is investigated in Ipomoea obscura, L. hederifolia, L. nil, L. pestistidis, L. sinensis and Merremia tridentata. The unilayered epicarp is also reported in the capsules of Nicotiana rustica (Karawya et al., 1973); Moringa oleifera (Dave et al., 1974); Nicotiana tabacum (Dave et al. 1981); capsules of some solonaceae (Dave and Menon, 1986); Hibiscus sabdariffa (Dave et al 1987); Nyctanthes arbor-tristis and Olea (Kuriachen and Dave, 1989a,b); Cadaba fruticosa, Cleome gynandra, C. viscosa,
Impatiens balsamina, Liparis walkerae, Papaver sominiferum and Vanda testacea (Mercymol, 1994) and some capsules of Acanthaceae (Sabu, 1996). 1-2 layered homogenous parenchymatous epicarp is found in Ipomoea aquatica. Bilayered heterogeneous epicarps are investigated in Merremia gangetica and M. hederacea. Bilayered epicarp is also reported earlier in capsules of Argemone mexicana (Mercymol, 1994).

Multilayered heterogeneous epicarp is investigated as 4-5 layered in Argyreia nervosa and 6-8 layered in Ipomoea fistulosa. Multilayered epicarps are also reported in capsules of Datura innoxia (Dave et al., 1980b) and Schrebera swietenoides (Kuriachen and Dave, 1989b).

The outermost layer of epicarp i.e. outer epidermis in Argyreia nervosa, M. gangetica and M. hederacea is parenchymatous, however the inner layer of epicarp of M. gangetica, M. hederacea and inner 3-4 layers of Argyreia nervosa get lignified.

In Ipomoea fistulosa, 6-8 layered epicarp is differentiated into bilayered parenchymatous outer epidermis, next 2-3 layers are also parenchymatous but cells differ from outer epidermis, which are interspersed by a number of laticifers and rest 2-3 layers of cells become thick-walled and lignified. The lignified layers are the most conspicuous layers of the mature fruit wall in Convolvulaceae (Kaur and Singh, 1987).

The cutinized outer tangential walls of the epicarp are described in xerochastic capsules by Roth (1977). The occurrence of different types of cuticular sculptures in plants are described by various authors and different functions have been ascribed to sculpturing patterns of the cuticle by Kugler (1955), Martin and Juniper (1970), and Eller (1979). The functions ascribed to the surface thickenings are to reduce the ability to contaminate and control the temperature.
Here, all the investigated capsules of Convolvulaceae have thick and striated cuticle, while in *Argyreia nervosa* some places of fruit surface are covered with thick and smooth cuticle. These striations flow out (in two lateral groups) from the stomata i.e. at right angles to the pore, at long axes to the pore; they extend in all directions from the stomata and are found extending in all directions from the base of the trichome (*Ipomoea fistulosa* and *I. hederacea*). These striations are mostly linear while slightly wavy in some surfaces of *Argyreia nervosa* and corrugating are seen in terminal regions of *Ipomoea obscura*. In Convolvulaceae striated cuticles are reported earlier in their vegetative organs by Singh *et al.* (1974); Pant and Banerji (1965). Striated cuticles are also reported on fruit surfaces of Convolvulacea by Kaur and Singh (1987) and on five fruit surfaces of *Ipomoea* species by Sunita and Dave (1991).

The outer epidermis or outer epicarpic cells of all the capsules investigated are polygonal, isodiametric, sometimes elongated and irregularly arranged in surface view. The cell walls are thin, straight and arched in all except *Argyreia nervosa*, *Merremia gangetica*, *M. hederacea* and *M. tridentata*, while thin and sinuous in terminal regions of *Ipomoea obscura*. An interesting feature has been observed in the outer epidermis of the epicarp of *Argyreia nervosa*, *Merremia gangetica*, *M. hederacea*, *M. tridentata* and middle region of *Ipomoea fistulosa*, that is cell walls are sclerified as in the form of beads. It proceeds from young fruit stage in *Argyreia nervosa*, and from developing stages of above mentioned species of *Merremia*.

Epicarp ornamented with trichomes is only in *Ipomoea fistulosa* and *I. hederifolia*. These trichomes are unicellular, filiform smooth-walled with acute tips. In *Ipomoea hederifolia* they are found only in terminal and middle regions. The same type of trichomes are observed on basal, middle and rarely on
terminal regions of *Ipomoea fistulosa*, but their size is smaller than those of *I. hederifolia*. Trichomes are reported earlier in the vegetative organs of many members of Convolvulaceae, by Pant and Banerji (1965) and Singh *et al* (1974), Sunita and Dave (1991) fruit surface of *Ipomoea eriocarpa* and *I. hederifolia*. The rest of the capsules of Convolvulaceae investigated are found atrichomatus. The capsules of *Nicotiana rustica* (Karawya *et al.*, 1973); *Nicotiana tabacum* (Dave *et al.*, 1981); *Ipomoea obscura*, *I. sepia*, *I. sinensis* of Convolvulaceae (Sunita and Dave, 1991) *Barleria cristata*, *Ruellia tuberosa* and *Strobilanthes* (Sabu, 1996) are devoid of any trichomes.

According to Ramayya and Rao (1976), the probable function of trichomes is to reduce the water loss during summer and the tufted hairs help the organ in protection against insect attack. Roth (1977) stated that protective hairs which reduce transpiration occur especially in young fruits at the time when the outer walls are still delicate and not yet covered with a strong cuticle and waxy substances.

The stomata are observed on the surfaces of all the investigated capsules. In *Merremia hederacea* they are rare but if present only parcytic type. Seven types of stomata namely anomocytic, anisocytic, diacytic, hemiparacytic, laterocyclic, paracytic and staurocytic have been recorded here. Paracytic type of stomata is invariably found in all the species investigated and thus it seems to be dominant on fruit walls of Convolvulaceae. The anomocytic stomata are monocyclic surrounded by three to five epidermal cells in all; six epidermal cells are also observed in *Ipomoea obscura*. More than one cycle of subsidiary cells are also observed in *Ipomoea sinensis*. The anisocytic stomata are monocyclic and are surrounded by a ring of three subsidiary cells of which one is distinctly smaller than the remaining two. as in *Ipomoea fistulosa*, *I. hederifolia*, *I. nil*, *I. obscura*, *I. sepia*.
L sinensis and Merremia tridentata. The paracytic stomata are either monocyclic or partly or completely amphicyclic. The monocyclic paracytic stomata are flanked by two subsidiary cells parallel to the long axis of the guard cells. The subsidiary cells may be contiguous at both the ends as in Ipomoea hederifolia, L obscura, L pestigridis and L sinensis or non-contiguous at one end as in Ipomoea hederifolia, L obscura, L pestigridis and L sinensis or non-contiguous at both the ends as in all the species. The completely amphicyclic paracytic stomata are flanked by three subsidiary cells, two on one side and the third one on the other side of the guard cell as in Ipomoea sinensis. The completely amphicyclic stomata are flanked by four to five subsidiary cells, two on each side of the guard cell placed parallel to the pore as in Ipomoea sinensis. The subsidiary cells of amphicyclic stomata are usually semilunar, equal or unequal in size and contiguous or non-contiguous at one or two ends of the stomata. In paracytic stomata one subsidiary cell may be horse-shoe shaped as in Ipomoea nil and L obscura. Laterocyclic stomata are similar to paracytic stomata in which the two lateral subsidiary cells surrounded the guard cells completely as found in Ipomoea aquatica, L nil, L obscura and L sinensis. The diacytic stomata are also surrounded by two subsidiary cells but at right angles to the pore in Ipomoea obscura. The staurocytic stomata with four subsidiary cells oriented in a crossed position to the pore, depending on whether one arm of the cross is formed by the radial wall of the subsidiary cells or in line with the closure of the guard cells or at 45° to it as in Ipomoea aquatica and L obscura. The hemiparacytic stomata have only a single subsidiary cell placed parallel to the long axis of the pore. It may be longer or shorter than the guard cells found in Ipomoea aquatica, L hederifolia, L nil, L obscura, L sinensis and Argyreia nervosa. Sometimes stomata are found in groups in Ipomoea hederifolia. Three types of stomata viz. anomocytic, anisocytic and paracytic are reported.
earlier in the vegetative organs of Convolvulaceae by Metcalfe and Chalk (1950); an additional 4th transitional type by Pant and Banerji (1965); VanCotthem (1970) and Singh et al (1974) reported four types of stomata on leaf surfaces as anomocytic, anisocytic, paracytic and hemiparacytic; Inamdar (1969) reported laterocyclic; staurocytic, paracytic and rarely anisocytic type of stomata on foliar and floral organs of Ipomoea species; Patel et al (1982) observed six types of stomata in the vegetative and floral organs, including fruits of Ipomoea species i.e., paracytic, anomocytic, anisocytic, diacytic, tetracytic and staurocytic. Sunita and Dave (1991) reported the same seven types of stomata on the fruit walls of Ipomoea species. In paracytic stomata the occurrence of one horseshoe shaped subsidiary cell is also noted by Pant and Banerji (1965); Patel and Inamdar (1971) and Sunita and Dave (1991) in Convolvulaceae. Diacytic type of stomata are also reported on the epicarpic surface of Acanthacean capsules (Sabu, 1996).

The general abnormalities observed include stomata with a single guard cell and pore (Argyreia nervosa, Ipomoea obscura and I. sinensis); one guard cell smaller than other (Ipomoea obscura and Merremia tridentata); both the guard cells degenerated (Argyreia nervosa, Ipomoea obscura); contiguous stomata-juxtaposed; juxta-posed over-lapped, superimposed; superimposed displaced; at right angles to each other; obliquely placed and a common subsidiary cell between two stomata. One of the guard cells most reduced three guard cells degenerated from the contiguous stomata; all the guard cells degenerated in contiguous stomata; and one guard cell completely disappeared and rest 3 degenerated in a contiguous stomata as observed in Ipomoea obscura, Merremia tridentata and M. hederacea.

The mesocarp of the investigated capsules is thin-walled parenchymatous, loosely arranged and homogeneous while compactly arranged in
Ipomoea nil, I. pestigaridis and I. sinensis. The cells of the innermost layer of mesocarp are thick-walled parenchyma in Ipomoea sinensis. Homogeneous and parenchymatous mesocarps are reported, earlier in some other capsules also by Dave et al (1980b, 1981, 1987); Dave and Menon (1986); Mc Millan (1986); Rao et al (1987a); Kuriachen and Dave (1989b); Mercymol (1994) and Sabu (1996). Rhomboidal crystals are seen in some cells of mesocarp in Ipomoea pestigaridis and Merremia gangetica, and sphaeraphides in Ipomoea obscura and Merremia hederacea.

Vascular bundles of all the investigated species are conjoint, collateral and with endarch xylem. Roth (1977) states that “as the fruits derived mainly from carpels its vascularization reflects that of carpels.”

The capsules of convolvulaceae are bicarpellary (bicarpellary as well as tricarpellary in Ipomoea nil) in origin and thus two sets of dorsal, and two ventral bundles can be seen. According to Roth (1977), ventral bundles occur only in solid carpels with a ventral meristem and in the Convolvulaceae “ventral bundles” is the correct term for the vascular bundles situated at the end fused or free carpel margins. The vascular bundles of the middle region, which are running parallel to the longitudinal axis of the capsule but all these bundles of the middle region do not reach the extreme tip while but towards the terminal region they fuse and only two dorsal median bundles are found near the tip in Argyreia nervosa, Ipomoea hederifolia, I. nil, I. sinensis and Merremia tridentata. Two dorsal median bundles as well as two ventral vascular bundles reach at its tip in Ipomoea aquatica, I. fistulosa, I. obscura, I. pestigaridis, Merremia gangetica and M. hederacea. Lysigenous cavities are found in mesocarp of Ipomoea obscura, I. pestigaridis, I. sinensis and Merremia tridentata.
The presence of laticifers in the vegetative organs of Convolvulaceae members is a family character (Metcalfe and Chalk, 1950). The laticifers are internal secretory structures. Laticifers with epithelial cells are found in mesocarp of Argyreia nervosa, Ipomoea aquatica, I. hederifolia, I. nil, I. obscura, and Merremia tridentata. The laticifers are found to be more in the mesocarp of Argyreia nervosa than in other capsules investigated. Lateral vascular bundles are also found in mesocarp in all the investigated capsules.

The endocarp is multilayered in all the investigated fruits. It is multilayered parenchymatous in Argyreia nervosa and Ipomoea fistulosa. In the capsules of Datura innoxia (Dave et al, 1980b) and Halophila engelmanni (McCillan, 1986), the endocarp is multilayered and parenchymatous. Multilayered lignified as well as parenchymatous endocarp is observed in all the investigated capsules except Argyreia nervosa and Ipomoea fistulosa. Multilayered lignified endocarps are observed in Nicotiana tabacum (Dave et al, 1981), Datura metel (Anozie, 1987); Hibiscus sabdariffa (Dave et al, 1987); Nyctanthes arbor-tristis, Schrebera swietenioides and Olea dioica (Kuriachen and Dave, 1989b). The innermost layer of endocarp is thick-walled parenchymatous inner epidermis in all capsules studied but bilayered near septum in Merremia hederacea, M. gangetica. The inner epidermis is devoid of stomata and trichomes in all and it is protected by a layer of smooth cuticle which is thinner than that on the outer epicarp. According to Roth (1977) this is because the inner fruit surface has not to be protected against elevated transpiration.

The inner epidermis is incontinuation with septal wall and is reported in all the capsules. In Convolvulaceae a true septum separates the two locules which are formed by the fusion of the carpel margins of two carpels, except Argyreia nervosa. There it is bicarpellary and true four chambered and in I. nil it...
is bicarpellary as well as tricarpellary and forming 2-4 chambers. In all bichambered capsules a false septum develops which is the extension of axial tissues at its base forming false 4 chambered condition (only at the base of the capsule) and this axial growth gradually decreases towards the middle and finally disappears at the upper middle and terminal regions.

The septum is homogeneous and parenchymatous and bounded by unilayered septal wall except in *Merremia gangetica*; there it is bounded by bilayered wall in which outer is parenchymatous but inner is lignified. The septal cells are mostly polygonal, isodiametric, vacuolated and loosely arranged with intercellular spaces except in *Ipomoea nil* in which the cells are compactly arranged with less intercellular spaces. Each septum is traversed by its own vasculature except dorsal septae of *Argyreia nervosa*, where no vasculature is found. The same type of septa are reported in *Datura ninoxia, Nicotiana tabacum* (Dave et al. 1980b, 1981), *Asystasia dalzelliana, A. gangetica, Justicia glauca* and *J. uahlil* (Sabu, 1996). Where the septae are completely fused in the centre to form an axis, the capsules are with axile placentation as also reported earlier by Rao (1985) in some Malvaceae and in *Asystasia* and *Barleria* by Sabu (1996). In *Argyreia nervosa* the septae are unattached at its centre at the base and the placentation is parietal here. Placenta is found only at the base of all the investigated capsules. All the investigated capsules are dehiscent except *Argyreia nervosa*. The septum is attached with fruit wall in dehisced capsule up to maturity as in *Ipomoea aquatica, I. fistulosa* and *Merremia tridentata*, but the septum detaches from the fruit wall during maturity as noticed in *I. hederifolia, I. nil, I. obscura, I. pestignidis, I. sinensis, M. gangetica* and *M. hederacea*. This separation of the septum from the fruit wall starts from the developing stages of the capsule and completely detaches during dehiscence.
Central axis is found in all the capsules but in *Ipomoea nil* a central gap is also noticed. In *I. nil* increment in the circumference of fruit causes the outward pulling of septum. As a result a cleavage or gap is formed in the central column. In the extreme base, there is no such gap formation, but intercellular spaces are found among the parenchyma. The same type of central gap is reported earlier in the capsule of *Hibiscus sabdariffa* (Dave et al., 1986). The axis or central column is made up of thin or thick-walled parenchyma, loosely arranged with intercellular spaces. Axis reaches up to extreme tip of the capsule in *Ipomoea aquatica, I. fistulosa, I. sinensis,* and *Argyreia nervosa;* axis does not reach up to the extreme tip in *Ipomoea pestigridis, Merremia gangetica, M. hederacea* and *M. tridentata.* A hole is noticed at the tip in *Ipomoea hederifolia* and in *I. obscura.*

The fruit of *Argyreia nervosa* is described as berry by earlier workers and in taxonomic books. Lawrence (1951) described that “fruits are important in the classification, delimitation, and identification of seed plants because generally they provide characters very reliable in the characterization of genera and families.” According to him “berry is simple fruit, the product of a single pistil, fleshy throughout, texture homogeneous and indehiscent while capsule is a product of bicarpellate or multicarpellate ovary”. He described *Argyreia* as an indehiscent capsule. In the fleshy type of fruit the entire fruit wall or the external part of it differentiates into a parenchymatous tissue whose cells retain their protoplast in the mature fruit (Esau, 1965). According to her “an ovary wall maturing into the pericarp of a capsule may have but little increment in the number of cells as in *Tobacco,* or as in certain Lilies, numerous cell divisions may occur before the pericarp matures. The pericarps of capsules have both sclerenchymatous and parenchymatous tissues in variable distributions. “The pericarp of *Linum usitatissimum,* for example, has an exocarp of
highly lignified cells and a mesocarp and an endocarp of parenchymatous cells. Roth (1977) described that hypodermis may be transformed into fibres or sclereids in dry fruits. According to Dave et al (1981), Nicotiana tabacum is an indehiscent capsule, where texture is also heterogeneous as endocarp is lignified which develops from inner hypodermis.

I have observed that the fruit of Argyreia nervosa is not thoroughly fleshy type but is becoming dry later at maturity; a dry fruit is heterogeneous and a product of bicarpellary four chambered pistil with one seed in each of the four chambers. Its epicarp except its outer epidermal layer is highly lignified which are developed from outer hypodermis of ovary wall. The pericarp shows a total compression of the entire fruit at maturity and it helps in separation of sclerenchymatous and parenchymatous cells in the form of granular powder. Thus Argyreia nervosa is regarded as dry indehiscent capsule.

The bicarpellary dehiscent capsules of Convolvulaceae are valvular and open into 4 valves through the constricted (dehiscence) zones, but in Ipomoea nil capsule develops from bicarpellary and tricarpellary ovary where it opens by 4 and 3 valves respectively. In Ipomoea nil where it dehisces into 3 valves, the dehiscence is loculicidally septifragal. Fahn (1982) refers this zone as abscission tissue, which helps in the separation of the capsule valves. In all dehisent capsules the lignified layers of endocarp are discontinued at the dehiscence zones and are found filled with thick-walled parenchyma.

The capsule of Ipomoea obscura, I. pestigridis, I. sinensis and I. nil (only in bicarpellary bichambered and tetrachambered conditions) dehisces first into two equal halves through their dorsal median bundles or dorsal (dehiscence) zone as loculical and after that each carpel separates from each other through their ventral vascular bundle, or ventral (dehiscence) zone and finally to
form four valves. At the same time septum is also detached from the fruit wall. The rest of the capsules dehisce concurrently into four valves and septae detach.

The present study reveals that the anatomical structure of the pericarp, septa and placenta can explain very well the mechanism of dehiscence. When the fully matured fruit dries up, the thin-walled parenchyma cells of the epicarp and/or mesocarp act as the shrinking tissue. This shrinking causes a tension in the longitudinally arranged thick-walled parenchyma of epicarp and/or endocarp, and thus the separation occurs through the weak constricted zone of dehiscence. Simultaneously the parenchymatous septa shrinks and this shrinking helps to pull apart the pericarp valves. The shrinkage in placentae helps in the detachment and ejection of seeds from the capsule.

4. SIGNIFICANCE OF PERICARP ANATOMY IN TAXONOMY:

Roth (1977) commented that families in which the fruit structure is more or less uniform may be used for the establishment of a fruit taxonomy. The literature survey shows that several authors have used various anatomical characters of fruit for distinguishing the same genera or different genera of the same family.

Fahn and Zohary (1955) used the nature of hard layers in the pericarp for the classification of legume types. The "U" shaped thickening of the endocarp in the tribe Cynoglosseae is used by Bayer de Kraemer (1970) for distinguishing this group from Boraginaceae. Stant (1972) distinguished four species of Caesalpinia using the anatomical characters of pericarp. Dave (1986) and Dave and Menon (1986) considered various morphological features of the fruit like structure of epicarp, mesocarp, endocarp, placental outgrowths to distinguish different
genera and species of Solanaceae. The taxonomic value of the fruit walls of Capsicum
(cums (Dave, 1986); of family Solanaceae (Dave and Menon, 1986); of Trachyspermum species (Dave and Menon, 1989); of family Asclepiadaceae
(Kuriachen 1989; Kuriachen et al, 1992) and of family Acanthaceae (Sabu, 1996) is
described.

Eventhough the capsules of Convolvulaceae are showing more or less uniform pericarp structure, the variations in different characters like nature of epicarp, mesocarp, endocarp, septum, zone of dehiscence and the number of layers of cells in the pericarp etc. are found to be valuable for providing a taxonomic classification of genera and species and are presented here in the form of a key.

5. TAXANOMIC KEY TO THE INVESTIGATED CAPSULES OF
CONVOLVULACEAE

1. Fruit bicarpellary, tetrachambered, 1 seed in each chamber; placentation parietal; indehisent

.........Arqyrela nervosa

1. Fruit bicarpellary, bichambered, 1-2 seeds in each chamber; placentation axile; dehisces into 4 valves.

2.a Cell walls of outer epidermis of epicarp thin in surface view.

.............Ipomoea

2.b Cell walls of outer epidermis of epicarp is thick and is in the form of beaded seen in surface view.

.............Merremia
2.a. *Ipomoea*

A. Epicarp trichomatous
   A.a. Unilayered epicarp; trichomes unicellular, long-celled on the middle and terminal parts of the fruit.
       ..........\textit{L. hederifolia}
   A.b. Multilayered epicarp; trichomes unicellular, small on middle, basal and rarely terminal parts of the fruit.
       ..........\textit{L. fistulosa}

B. Epicarp atrichomatous
   B.a. Unilayered epicarp, mesocarp 3-5 layered loosely arranged parenchyma.
       ..........\textit{L. obscura}
   B.b. Epicarp unilayered; mesocarp 4-5 layered thin-walled compactly arranged parenchyma.
       ..........\textit{L. nil}
   B.c. Epicarp unilayered; mesocarp 2-3 layered thin-walled parenchyma with less or no intercellular spaces.
       ..........\textit{L. pestigridis}
   B.d. Epicarp unilayered, mesocarp 3-4 layered thin-walled compactly arranged parenchyma and the innermost layer of mesocarp slightly thick-walled.
       ..........\textit{L. sinensis}
   B.e. Epicarp 1-2 layered, mesocarp 6-8 layered thin-walled parenchyma with small or no intercellular spaces.
       ..........\textit{L. aquatica}
2.b. *Merremia*

A. Unilayered epicarp.

B. Bilayered epicarp and cells of inner layer lignified.
   B.a. Endocarp heterogeneous, outer endocarp sclerenchymatous, middle thick and compactly arranged, inner parenchymatous; unilayered parenchymatous septal wall.

B.b. Endocarp heterogeneous, outer endocarp sclerenchymatous, inner parenchymatous; bilayered septal wall, outer layer parenchymatous and inner layer lignified.

6. PHYLOGENY OF THE CAPSULE:

Pijl (1972) commented that in studies of plant evolution the fruit is mostly neglected. Evolution of fruit types is fundamentally based on the changes of gynoecium types and on distinct differentiation of fruit wall tissues (Roth, 1977). The elementary process leading to the development of different gynoecium types are mainly fusion, reduction and incurvation of carpels. In addition, the gynoecium undergoes polar differentiation in its longitudinal symmetry and can be divided into ovary, style and stigma. According to Radford (1986) the juvenile carpel forms possess three major vascular traces one dorsal bundle and two lateral bundles. But in Convolvulacean carpels more than three vascular traces are observed, which can be considered as an advanced character. The derived structural fea-
tures in carpellary evolution of Convolvulaceae are: 1) complete developmental fusion of the carpel margins resulting in a closed carpel; 2) differentiation of the carpel into ovary, style and stigma; 3) fusion of the vascular traces, particularly the margin bundles; 4) the placentation shows an advancement towards parietal from axile in Argyreia.

The carpels of convolvulaceae also show some primitive characters such as: 1) the axile placentation in Ipomoea and Merremia, 2) ovules are usually 2-4 in number; 3) ovary is superior.

According to Roth (1977), the occurrence of more mechanical tissue in the fruit wall is treated as a primitive form. She also stated that the dehiscent fruit forms are also regarded as the most primitive than the indehiscent ones and in this respect the dehiscent capsules of this work represent the most primitive type of fruits except of Argyreia. The syncarpous condition is often regarded as more primitive than the apocarpous one (Roth, 1977). But according to Goldberg (1986) the fruits other than the follicles are derived forms and he considered the loculicidal forms as the advanced type.

The presently investigated Convolvulaceous fruits fall under the category of capsules. The term 'Capsule' suggests that the pericarp should be dry and brittle and it opens to liberate the seeds at maturity. The capsules of Convolvulaceae have more or less a common fundamental structure. The bicarpellary capsule is divided into two locules by a true partition wall and opens into four valves through the weak zone of dehiscence. The ovules are borne on axis at the base. But the bicarpellary capsule of Argyreia nervosa is divided into
four locules by true partition walls and is indehiscent and the ovules are borne on
the septa at the base. Bicarpellary and Tricarpellary capsule is also investigated
in Ipomoea nil which opens by four and three valves respectively.

The study provided an excellent means for the comparison of
epicarpic, mesocarpic, endocarpic and septal tissues of different species of the
same family which help in the taxonomic distinction of true genus/species.