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A Synthetic Discipline of the Genus *Ipomoea* L. (Convolvulaceae): A review

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Introduction:

The genus *Ipomoea* comprises the largest number of species within the family Convolvulaceae. Throughout the world *Ipomoea* is usually estimated to contain 500 species are found throughout tropical and subtropical region of the world. The species of *Ipomoea* have been used as food plants, medicines, and ornamental plants and in religious ritual.

Key Words: Genus, *Ipomoea*, Convolvulaceae

Anatomy:

The mature stomata on leaves, sepals and petals are mostly paracytic rarely anisocytic in *Ipomoea obscura* and *Ipomoea triloba*, whereas on the integument and disc they are anomocytic. The ontogeny of paracytic and anisocytic stomata confirms to the syndetocheilic or mesogenous type, while that of the anomocytic type is haplocheilic or perigenous (Inamdar,1969). The leaf anatomy of *Ipomoea cynanchifolia* shows broad cuticles with epicuticulars trails, stomates present on both upper and lower epidermis, the mesophyll is of the dorsiventral type. Calcium oxalate crystals were encountered in the petiole. The pattern of venation is brachidodromous and vein networks are not quite dense (Macedo, 1975). The stem of *Ipomoea batatas* is characterized by the possession of a ring of bicollateral, leaf trace bundles. Laticifers occur in the pith. The xylem groups become united by the activity of the inter fascicular cambium. Anomalous growth takes place as a result of the activity of accessory cambia, which develop in the primary cortex, the secondary phloem and the phelloderm residual. Parenchyma of the pith and xylem undergoes hyperplasia to produce a callus tissue which lines the cavity made by the larvae.

(Duncan, 1973). The primary root in *Ipomoea batatas* is tetrarch to hexarch. The early secondary growth is normal in fibrous as well as would be fleshy roots. But in the later stages of development the root that is destined to become fleshy shows more of secondary xylem parenchyma. The tuberization is caused by the activation of xylem parenchyma cells and the cambium cells. The xylem parenchyma cells form a number of meristematic strips which add more and more parenchymatous cells. Mature tubers of *Ipomoea batata* when sown in moist, soil develop certain buds which grow into new plants. The development of these buds is acropetal and they are arranged in definite rows corresponding to the protoxylem groups inside the tuber. The early ontogeny and anatomy of the tuber reveals that it is a part of the root which due to localized activity and for functional adaptation has become swollen (Govil, 1971).

Apical summit organization and leaf histogenesis of *Ipomoea batatas*, *Ipomoea purpurea* and *Ipomoea pes-caprae* shows tunica in two layered except *Ipomoea quamoclit* in which it is three or four layered zones of tunica and corpous initials, flank meristem and rib meristem are well marked. Initiation of the leaf starts with periclinal divisions in cells of the second and third layers of the tunica. In cases where the tunica layers are more than two, the corpous cells contribute a little towards leaf buttress formation. Apical and sub-apical cells differentiate early in ontogeny. (Govil, 1972). In the genus *Ipomoea*, stomata are mostly paracytic, while anisocytic, anomocytic and brachyparacytic are less frequent. All the taxa show more than one stomatal type excepting *Ipomoea horsfalliae* and *Ipomoea nil* which possess exclusively paracytic. Presence of dominant as well as co-dominant stomatal types is taxonomically an important trait. Stomatal abnormalities like contiguous stomata, degenerated stomata, arrested stomata and stomata with a single guard cell are also encountered in *Ipomoea* (Leela, 1994). In the petiolar anatomy of *Ipomoea clarkei* shows secretary cavities. Likewise, the latex cells in the ground tissue are found only in *Ipomoea illustris* and *Ipomoea triloba*. (Tayade, 2008). The characters described in leaf architecture of *Ipomoea* are found to be taxonomically significant, such as venation pattern, thickness of the primary vein, number of primary veins, primary veins basal or suprabasal, number of secondary, ultimate marginal venation, formation of the areole with tertiaries, quaternaries or quinternaries and type of tracheoids (ShanmukhaRao, 1990).The striations form concentric rings around stomata in *Ipomoea obscura* and *Ipomoea maxima*, whereas they appear to radiate from stomata in *Ipomoea quinquefolia*. Stomata are typically sunken on both surfaces in *Ipomoea muricata* and on upper only in Ipomoea maxima. Stomata are relatively big in *Ipomoea quinquefolia* and *Ipomoea staphylina*. Stomatal aperture is quite narrow in *Ipomoea obscura* and *Ipomoea pes-tigridis* but relatively wide in *Ipomoea quinquefolia* and *Ipomoea staphylina*.(Srivastava, 1983) The development of stomata on the foliar and floral organs of *Ipomoea obscura* and *Ipomoea triloba* show mature stomata on leaves, sepals and petals are mostly paracytic, rarely anisocytic, whereas on the integument and disc they are anomocytic. The ontogeny of paracytic and anisocytic stomata conforms to the syndetochelic or mesogenous type, while that of the anomocytic type is haplochelic or perigenous (Inamdar, 1968).

Biochemistry:

The morphological and biochemical analyses complemented each other. According to the phyletic tree, *Ipomoea aquatic*, appeared to be most primitive, giving rise to *Ipomoea fistulosa* and *Ipomoea pes-carpae* in one direction, and *Ipomoea triloba* in another through gradual reduction of the cleft. From, *Ipomoea triloba,* changes occurred in one direction as reflected in a gradual lengthening of the apical cleft and angle of divergence and in another through gradual reduction of both (Das, 1997). The genus *Ipomoea* represents a chemically hetero-genus assemblage of individuals and is characterized by an abundance of primitive features such as the presence of proanthocyanins and the predominance of flavonols. Flavonols are more widespread than flavones in *Ipomoea*. Proanthocyanins are located in *Ipomoea cairica, Ipomoea sinensis and Ipomoea triloba*. Naphthoquinones are found to co-occur with flavonols in *Ipomoea aquatic* and *Ipomoea pes-caprae* (Nair *et al*, 1986). *Ipomoea* genus has components like ergoline, indolizidine, alkaloids, nortropane alkaloids, flavonoids, glycolipids, lidnin and tri-terpenes. These compounds are reported foe their psychotropic, uterotonic, haemostatic properties. *Ipomoea pes-tigridis* extract is capable of inhibiting non-inflammatory reactions as well as inflammatory pain (Selvam *et al*, 2015). The species of the genus *Ipomoea*, as well as, of the Convolvulaceae family have the property of phytotoxicity. Due to their content of ergot type alkaloids, several species of *Ipomoea* are used as hallucinogenics. Some species of Ipomoea showed antimicrobial, analgesic, spamolitic, spasmogenic, hypotensive, psychotomimetic and anticancer activities. The most common use of the roots of Ipomoea species is to treat constipation (Meira *et al*, 2012).

Morphology:

The structure of petiolar nectarines in the genus *Ipomoea* ranges from simple beds of superficial nectar secreting trichomes to slightly recessed basin nectarines to crypt nectarines, which are structurally the most complex extrafloral nectarines. Petiolar nectaries are present in all sub genera, but all crypt nectarines occur in the same section species with extra floral nectaris tend to be annual (Kathleen, 1979). Keeler, K.H and R.B.Kaul (1979) discussed, the structure of petiolar nectarines in the genus Ipomoea, which ranges from simple beds of superficial nectar-secreting trichomes, to slightly recessed “basin nectaries”, to “crypt nectarines”, which are structurally the most complex extra-floral nectarines known. Petiolar nectarines are present in all subgenera, but all crypt nectarines occur in the same section (*Eriospermum*). Species with extra-floral nectarines tend to be perennial; species lacking extra-floral nectarines tend to be annual. There is no relationship between temperate or tropical habitat and presence of nectarines.

Embryology:

The ovule in *Ipomoea sinuate*, *Ipomoea carnea* and *Ipomoea purpurea* is anatropous, unitegmic and crassinucellar. The micropyle is long and narrow. The obturator develops from the placenta and covers the micropyle. The vascular supply is present in the integument. Development of the female gametophyte follows the polygonum type. The mature seed coat consists of thick-walled epidermal cells and hairs followed by a single-layered hypodermis and two to many-layered, anticlinally elongated, thick-walled inner hypodermal layers of common origin (Kaur, *et al* 1970). An interpretation of the gynoecium at various stages of development is proposed in Convolvulaceae-*Ipomoeae* within an ontogenetical frame work that includes changes in fruit structure allowing a classification of ovaries at anthesis. In *Ipomoea*, all subgenera, which probably differ in pollination syndromes, exhibit an evolutionary acceleration in the formation of fruit features, linked with a weedy annual habit (Derion, 1999). In *Ipomoea pes-tigridis* two ovules are noted with two embryo sacs in each and two fully developed embryos with an aborted 3-celled embryo are noted. In Ipomoea aquatic the synergids and the egg are extremely large in size and much vacuolated. By the entrance of pollen tube one synergid is destroyed but the other persists for some time. The seed coat consists of epidermis and hypodermis and two or three layers of thick-walled palisade sclerenchyma cells, but in the micropylar region 5 layers of radially stretched cells are present. There are only about 10 layers of parenchymatous cells and others are consumed by the embryo (Jos, 1963). *Ipomoea* has varied testa topography and reveals four patterns. The common pattern is simple reticulate in *Ipomoea eriocarpa, Ipomoea hederifolia, Ipomoea nil, Ipomoea obscura, Ipomoea pes-tigridis* and *tuberose* whereas regulate in *Ipomoea purpurea,* lophate in *Ipomoea pes-carpae* and *papillose* in *Ipomoea quamoclit* patterns show restricted occurrence. However, it is interesting to find that seeds of *Ipomoea* reveal a uniform pattern of testa topography on the entire seed surface (Shanmukha Rao, 1993). Generally, large seeds are associated with perennials, especially woody plants. These seeds and plants are considered to be primitive on the basis of seed character *Ipomoea fistulosa*, *Ipomoea pes-carpae* and *Ipomoea aquatica* appeared to be more primitive. The conspicuous colours such as orange in *Ipomoea chryseide s*haves diagnostic value. (Das *et al*, 1995). Kaur (1969) observe embryology and seed structure of *Ipomoea quamoclit*. The ovule is anatropous, unitegminal and crassinucellar, funicular vascular supply extends up to the micropyle on the dorsal side of the ovule. The megaspore tetrad is linear and development of embryo sac follows the polygonum type. Endosperm development is of the nuclear type enucleated cytoplasmic endosperm nodules are formed near the pro-embryo. The pollen tube persists up to globular proembryo stage. The seed coat is formed of epidermis, a hypodermis and 1-2 layers of palisade-like sub-hypodermal cells. The embryo is large and somewhat folded. Govil (1971), recorded seed coat development and its structure of *Ipomoea carnea, I. cairica, I. sepiaria, I. sindica, I. purpurea* and *Ipomoea quamoclit*. The seed in all the species are characterized by the presence of a "pad" like structure present in between the funiculus and the micropyle. This pad develops from the epidermal cells of that region. The epidermal cells divide to form four to five layers of parenchymatous cells. The outer three or four layers form the compact parenchyma of the pad while the innermost layer forms the radially elongated long palisade like sclerenchyma. The subepidermal cells are also radially elongated in this region. Yana, K.L. and P.S.Rao (1993),

observe embryology of *Ipomoea macrantha*, *Ipomoea hederifolia* and *Ipomoea pes-carpae*, anther wall development is of the Dicotyledonous type and at maturity consists of the endothecium, 1-2 middle layers and a secretory tapetum. Tapetum is also formed from the connective. Microspore mother cell undergoes simultaneous divisions and produce tetrahedral and decussate microspore tetrad. Pollen grains are spheroidal, achinate, polyporate and are mostly 2-celled at anthesis. Rarely 3-celled grains occur in *Ipomoea macrantha*. Antipodals are ephemeral. Fertilization is porogamous. Syngamy and triple fusion occurs almost simultaneously. Endosperm is nuclear. Embryo development is of the sherardia variation of the Solanad type. Suspensor is large and haustorial.

Palynology:

Jayeola, A.A. and O.R Oladunjoye (2012), described length of style and filament of *Ipomoea* species, highest length in styles is recorded in *Ipomoea hrderifolia* (37.0-38.5 mm) while the minimum is recorded in *Ipomoea vagans* (16.5-19.0 mm). Pollen grains are found tobe radially symmetrical; circular in outline, sculpture is echinate, circular aperture, pores equidistantly distributed, oblate, speriodal and oblate-spheriodal. Largest pollen size is recorded in Ipomoea aquatic (60.2-62.5 μm), suggesting a less derived position whereas the minimum size (30.7-31.4 μm) is observed in *Ipomoea hederifolia*. The maximum spine length is recorded in *Ipomoea involcurata* (8.3-9.6 μm) and minimum is recorded in *Ipomoea hederifolia* (3.3-4.0 μm). Rajkumar, A.V, A.V. Tidke and G.V.Patil (2011), have been examined Light and Scanning Electron Micropscope of pollen morphology of *Ipomoea fistulosa*, *Ipomoea palmate*, *Ipomoea quamoclit* and *Ipomoea triloba*. Pollen grains are usually pantoporate, radially symmetrical, circular in outline, tectumechinate, circular aperture between the spine, suboblate-oblate spheriodal or spheroidal. Among the four species of *Ipomoea* maximum pollen size (97.39-100.86 μm) across is found in *Ipomoea quamoclit* whereas, minimum pollen size (59.17-65.75 μm) across is noted in *Ipomoea palmata*. The maximum spine length (8-14 μm) is recorded in *Ipomoea palmate*, while it was minimum (4.99-7.33 μm) in *Ipomoea triloba*. Considering pore size all four species of *Ipomoea* showed close similarities with minor differences. Sculpturing pattern is found to be uniform in all four species of *Ipomoea.*

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