Studies of Teratology in Heliotropium curassavicum L.

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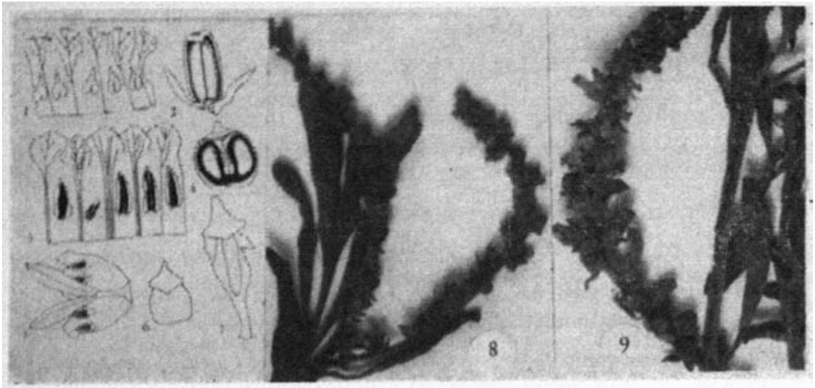
With the advancement of developmental physiology in the last twenty-five years the study of abnormalities in plants has been tried for the understanding of the developmental processes, their correlation with genetic interpretations, biochemistry (hormones and proteins) and environmental factors, more especially photoperiodism. Nevertheless, the usefulness of such abnormalities has long been demonstrated in the studies of morphogenesis. Magnus (1882) pointed out the sympodial nature of the inflorescence of the Boraginaceae in a fasciated inflorescence of the *Myosotis alpestris* which he interpreted as monopodial. Examples of phyllody, where all parts of the floral organs transform into leaves as in *Rosa indica,* have been used as supporting evidence for the theory of Wolf (1774) and Goethe (1790) on the nature of floral organs. On the other hand, from the point of view of taxonomy the knowledge of such deviations from the normal type is highly desirable in minimizing taxonomic confusion. Tumors and galls have been very intensively studied in pathological researches, especially for the cure of cancer.

A few scattered plants of *H. curassavicum* L. were found at the Pakistan Air Force Officers resident quarters, Drighroad, Karachi. This species is very common throughout the Karachi area on saline soils, and the particular population under observation was growing at the side of an overground waste-water way.

Description of Normal Plant: Perennial, fleshy, more or less glaucous, diffuse, the branches 1.5-4.5 dcms. long; leaves oblanceolate, linear or spatulate, entire, inconspicuously veined, 2-5 cms. long, 3-6 mms. wide, obtuse narrowed into petioles, subsessile or sessile; scorpioid spikes, dense, ebracteate, flowers in two rows; calyx 5, fused at the base, segments acute, persistent; corolla 5, white, gamopetalous; stamens 5, epipetalous, alternating with petals, filaments very small, more or less inconspicuous, anthers acuminate, attached at the middle of the corolla tube; gynoecium bicarpellary, four ovules developing into 4 nutlets, stigma umbrella shaped, sessile; fruit globose (Fig. 8).

Abnormal Plants: The size and vegetative parts of abnormal plants were found to be the same both anatomically and morphologically. However, phyllody was observed in the flowers. The position of the origin of the flowers on the inflorescence did not change. The changes observed were restricted to aberrant structure in each member of the floral whorl.

Calyx: The normal calyx in cross section shows 3 vascular strands which are close to the ventral epidermis. The chlorenchymatous tissue is only present beneath the dorsal epidermis. The cells are not elongated and look like any other mesophyll cell rather than the elongated palisade type in the leaf.



Legend to the Figs. 1-9.

1. Normal corolla showing venation pattern and stamens. 5X.
2. Longitudinal section of abnormal ovary. 3X.
3. Corolla of abnormal flower showing changed vein pattern and enlarged stamens. 5X.
4. Longitudinal section of normal ovary. 4X.
5. Abnormal flower showing prominent filaments and gynoecium completely changed into two leaves. 3X.
6. Normal ovary. 5X.
7. Abnormal ovary showing out-growths. 7X.
8. A normal flowering shoot. 1.5X.
9. An abnormal shoot. 1.5X.

A modified calyx shows numerous veins which are centrally located. The chlorenchyma develops on both the dorsal and ventral sides and the cells elongate more or less like palisade cells. These changes are closely correlated with the changing appearance of the calyx which was first observed to become larger, changing towards polysepaly and finally taking the shape of a leaf. Anatomical characters also showed a transitional development in the same direction.

Corolla: Each of the five petals of the gamopetalous corolla is supplied by a single vein (Fig. 1). The most conspicuous change observed here was the formation of numerous veins in each petal (Fig. 3). In less modified forms the corolla tube elongates while in others there is a trend towards polypetaly. The development of palisade beneath both epidermal layers results in the formation of a complete leafy structure.

Stamens: Two types of modifications were observed in the stamens. One (quite rare) consisted of the formation of a highly reduced staminode and in the other, the anthers were highly enlarged and were partially green rather than being yellow. Both the types were observed on the same flowers (Fig. 3). In other flowers the stamens were completely transformed into leaves. In certain cases conspicous filaments were observed (Fig. 5).

Carpels: The carpels seemed to be more sensitive to aberrant change than the rest of the floral organs. Carpels were observed on one branch only. This branch was situated at the base of the plant, and seemed to be older than the rest of the branches. However, the terminal flowers of this branch were completely sterile. The first few carpels from the basal side of this branch were more or less globose and resembled a normal carpel (Figs. 4 & 6), and the ones between the normal and sterile types were elongated. A transverse section of one of the elongated types showed two developing and two abortive ovules. Longitudinal section (Fig. 2), however, revealed elongation of the ovules correlated with the elongation of the pericarp. In some types some overgrowth on these carpels was observed (Fig. 7) whose developmental nature could not be explained. On completely modified flowers two leaves (Fig. 5) were observed instead of carpels. It is interesting to note that the gynoecium in this case is bicarpellary and tetralocular, each locule with one ovule. At maturity each ovule forms a nutlet. Our interpretation in this observation fits very nicely with the theory of the bicarpellary origin of this flower which was demonstrated by the appearance of two floral leaves instead of four nutlets.

The causes of plant abnormalities are manifold, but the most common cause known to date has been described as microorganisms, i.e., a virus, bacteria or other fungi. Hence, Bos (1957) has proposed the name pathological-morphology rather than teratology. In our observations not all the abnormalities may be an outcome of infection by microorganisms as found in infections of *Albugo, Sinapsis orvensis* (Chadefaud, 1956) including artificial induction on various plants by *Agrobacterium tumefaciens* (Bene, 1957), or the virus infection which leads to the formation of abnormal fruits in *Lycopersicon esculentum* (Cutter, 1955). There have been various reports indicating that abnormalities resulted from causes other than microorganisms. Vanterpool (1957) found deformed inflorescenses in a tomato plant which he suspected are due to mutation. Resende (1956) found teratological abrnormalities of *Aloe* inflorescences after back crossing certain hybrids. He believed these to be genetic in nature. Sinnot (1960) has pointed out that little but descriptive work has been done on these plants and more intensive work will indicate various other factors which result in growth abnormalities. Under these condtions it does not seem very logical to change the term teratology into pathological-morphology restricting the scope and coverage of the field. It is felt that teratology is more commonly used and encompasses all the aspects of abnormalities regardless of their cause. It will be more useful for those who are interested in the basic biochemical or morphogenetical approach.

In this material it is presumed that none of these processes described above are involved. As already described, this material was found growing by the sides of an overground, waste waterway. Since these places are sprayed with insecticides for the control of mosquitoes it is very likely that these abnormalities are an outcome of a toxic substance, probably DDT, which disturbed the normal metabolism necessary for the production of flowers.

At present it is not at all clear whether flower formation is the result of a specific hormone or a number of hormones (Hamner and Bonner, 1939) or whether there is some other influence involved. As a matter of fact, regardless of the type of substance which is responsible for the initiation and development of the flower, a toxic substance may very well hinder and disturb the chain of reactions inside a plant in the same way as a microorganism or a genetic factor would affect the developing tissues of the organs. Such a morphogenetic effect of a toxic substance on plants is very nicely demonstrated by the use of 2,4-D. (Holt, 1955). Presence of normal carpels at the base, elongated ones at the middle and apical ones completely transformed into two well defined leaves in the same inflorescence, seems to be a very interesting teratological condition. Thus transitional changes from the carpels to two leaves could be studied with all the intermediate stages. This gives sufficient proof of the bicarpellate nature of this plant. Similar transitions of calyx, corolla and androecium are also found. However, effects on the reproductive structures of the flowers are more severe than on the calyx and corolla. Is it because calyx and corolla are closer to the leaves than stamens and carpels? It seems that whatever condition might have induced the abnormality also affected the plant when some of the fruits were already mature. The partially mature fruits showed an abnormal growth, while the flowers without a pistil seemed to have developed after induction took place (fig. 9).

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