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Morphology of the flower and fruit of *Hydrocera triflora* Wight and Arn. emend Venkat. and Dutt—an elucidation

D RAMADEVI and L L NARAYANA
Department of Botany, Kakatiya University, Warangal 506 009, India

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Abstract. The details on the floral morphology and development of fruit and seed in *Hydrocera triflora* that escaped the attention of earlier investigators have been highlighted. The flower in *Hydrocera* is interpreted as primitive over *Impatiens*. Though *Hydrocera* resembles *Impatiens* closely, it possesses certain distinctive features on the basis of which it is suggested that *Hydrocera* be treated as a tribe, Hydrocereae or as a sub-family, Hydroceroideae under the family, Balsaminaceae.

Keywords. *Hydrocera triflora*; morphology; flower; fruit.

1. Introduction

The monotypic *Hydrocera* and *Impatiens* with about 900 species (Grey-Wilson 1980) constitute the family Balsaminaceae. Three other genera, viz., *Impatientella* Peer., *Petalonema* Peter non Correns and *Semeiocardium* Zoll. were earlier included in the family. Grey-Wilson (1980), however, considers these 3 genera as congeneric with *Impatiens*. While *Hydrocera* is restricted to Indomalayan region, the species of *Impatiens* are distributed in tropical and sub-tropical regions of the old world and also occur in temperate regions of north America, Europe and Asia.

The embryology and floral anatomy of *Hydrocera* and a few species of *Impatiens* have been studied (Venkateswarlu and Lakshminarayana 1957; Narayana 1963, 1965, 1974). More recently, Grey-Wilson (1980) made certain observations on the floral morphology of *Hydrocera* and discussed its affinities with *Impatiens*. His observations on perianth and androecium broadly agree with those of Venkateswarlu and Dutt (1961) and Narayana (1974) while those on fruit and seed are at variance with the earlier reports of Venkateswarlu and Lakshminarayana (1957) and Venkateswarlu and Dutt (1961). The present study was therefore undertaken to critically examine the differences in the observations of Grey-Wilson (1980) and others (Venkateswarlu and Lakshminarayana 1957; Venkateswarlu and Dutt 1961; Narayana 1974) and to give a correct account of the details of development of fruit wall and seed coat that escaped the attention of the earlier investigators.

2. Materials and methods

Flowers and fruits of different stages of development were collected at Sarpavaram, a place near Kakinada, Andhra Pradesh and were fixed in FAA. The material was processed and embedded in paraffin wax following conventional methods. Sections were cut at a thickness of 10–14 μm and were stained using crystal violet and erythrosin combination.

3. Results

The hypogynous bracteate flower of *Hydrocera* is tetracyclic, pentamerous and zygomorphic owing to the development of a spur on the posterior sepal. The perianth parts are free and their traces also arise independently from the main stele. The stamens exhibit union by filaments just below the anthers which surround the top of the ovary as reported earlier by Narayana (1974).

The gynoecium is 5-carpellary, syncarpous, 5-locular and the placentation is axile (figure 1). The 3 ovules in each loculus are suspended from a 3-lobed placenta (figure 4). Though the gynoecium is predominantly 5-carpellary and 5-locular, 6-carpellary gynoecia with as many locules (figure 2) and 6-carpellary with only 5 locules have also been encountered for the first time (figure 3). In transections of the 6-carpellary and 5-locular ovary, one of the locules showed 6 ovules and another only two (figure 3) because of one ovule which is located at a different level did not come into view. Of the 3 ovules in each locules, one is dorsal and the other two are lateral (figures 1, 2). The ovules abut against one another by their inner surfaces and are free from the wall of the loculus (figure 5). In the regions of contact the epidermal layers of the abutting ovules are distinct (figure 6).

At this stage the ovary wall shows the outer and inner epidermal layers and 8–9 layers of intervening cells which are thin walled with prominent intercellular spaces (figure 7). The cells of the inner epidermal layer and the subepidermal layer are tangentially elongated (figure 7). The layer of cells below the outer epidermis and some of the intervening cells show accumulation of dark staining contents (figure 7).

After fertilization the gynoecium develops into the fruit. The number of layers in the pericarp remain the same but the cells enlarge considerably and the intercellular spaces become larger (figure 8). The walls of some of the parenchyamatous cells of

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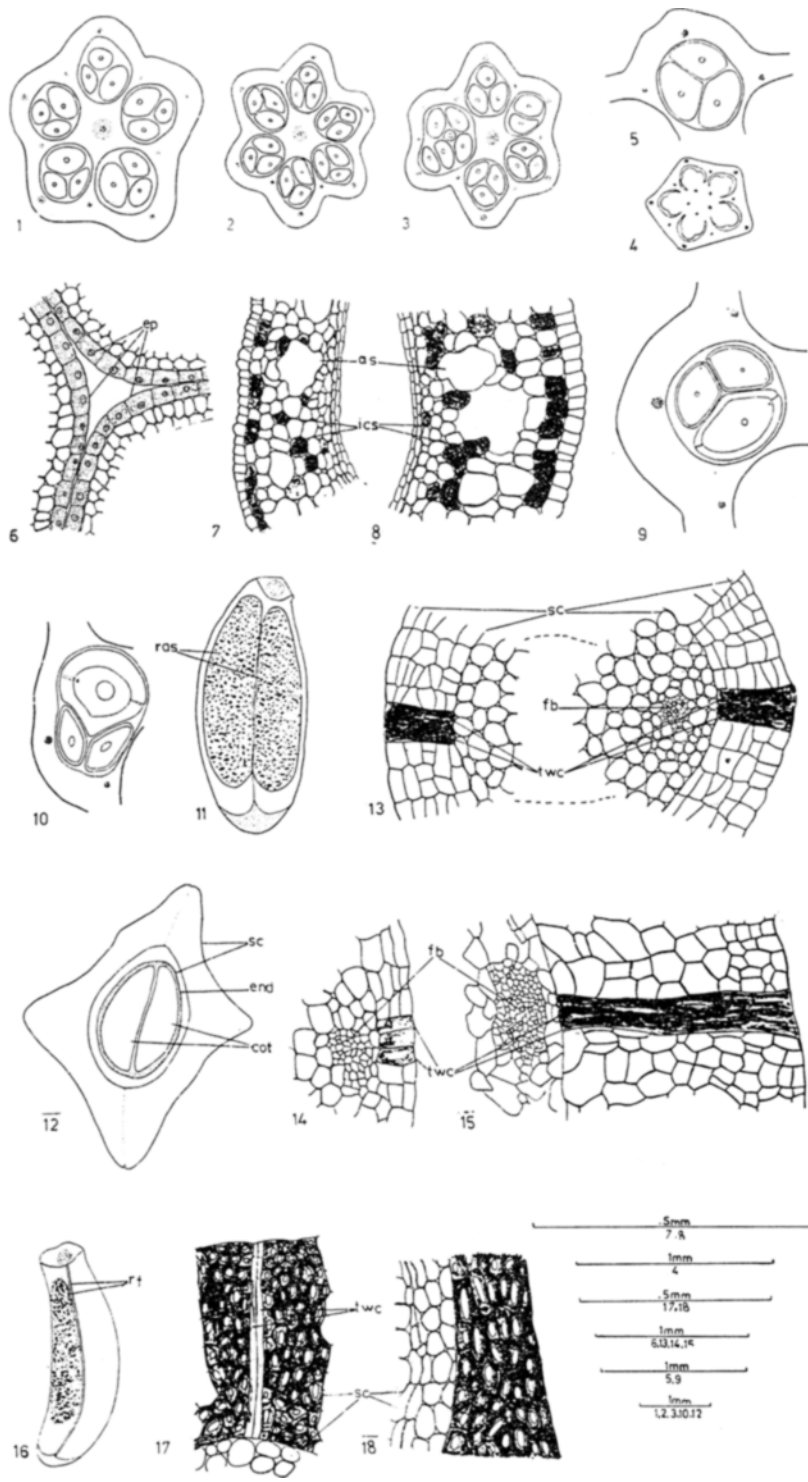
Figures 1–18. *H. triflora.* **1.** TS 5-carpellary, 5-locular ovary with 3 ovules in each loculus. **2.** TS 6-carpellary, 6-locular ovary with 3 ovules in each loculus. **3.** TS 6-carpellary, 5-locular ovary with 6 ovules in one loculus and 2 in another and 3 in each of the other 3 loculi. **4.** TS ovary showing 3-lobed placenta and ventral bundles opposite the loculi. **5.** TS ovary-one locule enlarged showing 3 abutting ovules. **6.** Same as in figure 5 showing intact epidermal layers of the abutting ovules. **7.** TS ovary wall. **8.** TS fruit wall. Note large air spaces and intercellular spaces. **9.** TS locule of young fruit enlarged. Note enlarging seed. **10.** Same as in figure 9 at an advanced stage. **11.** Mature seed showing the adpressed remnants of abortive seeds on the inner side. **12.** TS mature seed showing seed coat, a thin layer of endosperm and cotyledons. **13.** TS part of young seed showing development of seed coat from epidermal cells of the outer integument. Note enlarging epidermal cells opposite the funicular vascular bundle and on the antiraphe side. **14.** TS part of abortive seed on the raphe side. Note limited number of cells of the seed coat and the thin walled cells opposite the funicular vascular bundle. **15.** TS part of the developing seed on the raphe side showing thick walled cells of seed coat and elongating thin walled cells opposite the funicular vascular bundle. **16.** Side view of the mature seed showing the ridges and furrow in the seed coat and remnants of the degenerating seed appressed to it. **17.** TS mature seed coat in the region of the ridge on the antiraphe side. Note elongated thin walled cells in the seed coat. **18.** TS mature seed coat in the region between the ridges.

(ep, Epidermal layers of abutting ovules; as, air space; ics, intercellular space; ras, remnants of abortive seeds; sc, seed coat; twc, thin walled cells, fb, funicular vascular bundle; rf, ridges and furrows).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Figures 1–18.

the pericarp break down leading to the formation of large air cavities which help the ripe fruits float on water (figure 8). The cells of the ovary wall in no stage of the development of the fruit show any special alignment of the cells so common in dehiscent fruits. Thus, the anatomy of the fruit wall does not give a clue to its dehiscent nature.

All the 3 ovules develop normally till the mature embryo sac stage and for a limited time after fertilization but subsequently two of them, the one towards the dorsal side and one of the two lateral ovules, abort (figures 9, 10). The other lateral ovule alone develops into the seed (figures 9, 10). The remnants of the abortive seeds persist and remain adpressed to the mature seed on its inner side (figure 11).

The mature seed is prominently 4-angled, along the raphe and antiraphe sides and at right angles to them (figure 12). The seed coat is derived from the outer epidermis of the outer integument. These epidermal cells undergo repeated periclinal divisions cutting off cells to the outerside (figure 13). In the abortive seeds also the epidermal cells divide periclinally and the derivatives which remain only 2–4 layered, remain thin walled (figure 14). In the fertile seeds 2–4 epidermal cells opposite the funicular vascular bundle and on the antiraphe side do not divide periclinally but remain thin walled and elongate keeping pace with the divisions in the surrounding cells (figures 13, 15). This feature is also observed in the abortive seeds (figure 14).

A critical examination of the surface of the mature seed revealed two ridges and a furrow along each of the raphe and antiraphe sides. The former corresponds to the margins of the seed coat and the latter to the region of the elongated thin walled cells of the seed coat (figure 16).

The seed coat is 10–13 cells thick in the region of the ridges (figure 17) while in the other regions it is 7–9 cells thick (figure 18).

As the seed develops the embryo sac enlarges and encroaches upon the thin walled cells of the fused integuments leaving only a few layers of cells in the mature seed. Below these layers of cells a layer of endosperm cells persists in the mature seed (figure 12).

4. Discussion

In the basic 5-merous and 4-cyclic floral plan *Hydrocera* resembles *Impatiens* (Narayana 1974; Venkateswarlu and Dutt 1961; Rama Devi and Narayana 1989) but differs from *Impatiens* in the freedom of perianth parts and independent origin of their traces and can be reckoned as more primitive than *Impatiens*.

According to Grey-Wilson (1980), the anterolateral sepals in *Impatiens* have disappeared during the evolution of the flower. They are, however, inconspicuous in most species but conspicuous in *I. hongkongensis*, *I. tinctoria* and *I. quadrisepala* (Grey-Wilson 1980). There is thus a gradual tendency towards suppression of the anterolateral sepals. The reported loss of anterolateral sepals is due to adnation between the anterior petal and anterolateral sepals resulting in the formation of a compound structure on the anterior side. The origin and branching of the trace that supplies the composite structure supports this contention (Narayana 1974; Rama Devi and Narayana 1989).

All the petals are free in *Hydrocera* whereas in *Impatiens* 4 of the 5 petals unite to form two lateral pairs and the fifth one is incorporated into the anteriorly situated

composite perianth part (Grey-Wilson 1980; Narayana 1974; Rama Devi and Narayana 1989). *Hydrocera* and *Impatiens* resemble each other in their androecial character.

The observations of Grey-Wilson (1980) on the ovary and fruit of *Hydrocera* are at variance with those of the earlier investigators (Venkateswarlu and Lakshminarayana 1957; Venkateswarlu and Dutt 1961) and of the present authors. In the 5-carpellary, 5-locular ovary, *Hydrocera* resembles *Impatiens*. However, in having the 5-traced carpels and only 3 ovules being suspended from a common 3-lobed placenta, *Hydrocera* differs from *Impatiens* in which the carpels are 3-traced and the number of ovules varies from few to many in each locules (Narayana 1974; present study). Therefore the statement of Cronquist (1981) that the locules are uniovulate in *Hydrocera* appears to be incorrect. However, 6-carpellary ovaries with 6 or 5 locules have been observed in some flowers of *Hydrocera* for the first time. In the latter situation one locule showed 6 ovules suggesting the fusion of two loculi of the adjacent carpels. It may thus be inferred that the 5-carpellary condition in *Hydrocera* may have been derived from a multicarpellary ancestry.

Grey-Wilson's (1980) report that each loculus in *Hydrocera* has 3 closely adhering compartments of which only one bears the ovule the others remain empty, is certainly incorrect. The present study and earlier reports clearly show that each loculus in *Hydrocera* has 3 ovules, of which only one matures into a seed. However, the remnants of the abortive seeds persist and lie appressed to the mature seed on the inner side.

The fruit of *Impatiens* is a capsule while in *Hydrocera* it has been variously described as a drupe (Bentham and Hooker 1862–1893), a 5-seeded stone (Dunn 1967), a capsular berry (Venkateswarlu and Dutt 1961), a 5-seeded indehiscent berry (Grey-Wilson 1980), a fleshy pseudoberry with a pentagonal outline (Grey-Wilson 1980) and a pentagonal, berry-like drupe with the stone separating into five 1-seeded pyrenes (Cronquist 1981).

The present critical study on the development and structure of the fruit wall and seed coat in *Hydrocera* casts a doubt as to the correctness of the reports of earlier investigators (Venkateswarlu and Dutt 1961; Grey-Wilson 1980). The observations of Grey-Wilson (1980) that the common wall surrounding the 3 compartments of each carpel 'becomes part of the endocarp which is embedded in the soft tissues of the surrounding mesocarp' are contrary to facts. The present study clearly shows that the fruit wall does not at any stage differentiate into the epicarp, mesocarp and endocarp. The thick walled cells of the seed coat of the maturing seed and the few layers of the cells of the seed coat of the abortive seeds become closely appressed to the loculus giving a false impression of endocarp. Therefore, the description of the fruit as a drupe by Venkateswarlu and Lakshminarayana (1957) and a berry like drupe by Cronquist (1981) is untenable.

The statement of Grey-Wilson (1980) that each seed in *Hydrocera* is associated with two air sacs derived from the empty compartments of a loculus is also erroneous. The present study and observations of Venkateswarlu and Lakshminarayana (1957) and Venkateswarlu and Dutt (1961) clearly show that what have been mistakenly interpreted as 'air sacs' are nothing but the remnants of the persisting abortive seeds adpressed to the mature seeds.

The observations of the present authors on the dispersal of fruits in *Hydrocera* are at variance with those of Grey-Wilson (1980) according to whom the ripe fruits

are heavy and hence sink after they fall into the water. After the decay of the soft tissues of the fruit wall the endocarp separates into 5 units each consisting of a thick walled seed coat and two hollow compartments which function as air sacs (Grey-Wilson 1980). The observations of the authors clearly show that the ripe fruits fall into the water and float on the surface of water and are thus dispersed by water currents but do not sink due to the weight of the fruit as reported by Grey-Wilson (1980). The intercellular spaces and the large air spaces that develop due to the dissolution of the walls of some of the parenchymatous cells of the pericarp lend buoyancy for the fruit to float on water. As the water in the puddles dries up the fruits settle at the bottom and lie there till the next season. By then the pericarp decays and the 5 stony seeds which are set free, then germinate in the next season. The statement of Cronquist (1981) that the endocarp (stone) separates into five 1-seeded pyrenes is untenable because the pericarp does not show any differentiation of endocarp. The stony seeds are separated from one another by the septa and separate from one another after the disintegration of the fruit wall and not due to breaking up of the endocarp as reported by Cronquist (1981).

Any characteristic alignment of the cells in the fruit wall generally met with in the dehiscent type of fruits, is absent in *Hydrocera* and this clearly rules out the dehiscent nature of the fruit. In the absence of any external and anatomical evidence for the dehiscence, the fruit in *Hydrocera* can be described as a berry with 5 stony seeds.

The seed coat in *Hydrocera* is formed entirely from the cells formed by the periclinal divisions in the cells of the outer epidermis of the outer integument. However, a few layers of thin walled cells of the inner integument and a layer of endosperm cells also persist (Venkateswarlu and Lakshminarayana 1957; present study). In *Impatiens* the seed coat is formed by the outer epidermis of the outer integument and a few layers below it (Narayana 1965). Grey-Wilson (1980) reported many types of 'processes' on the testa of *Impatiens* species examined by him and attributed functions of anchorage, uptake of water and protection against desiccation.

Another noteworthy feature which escaped the attention of earlier investigators is the discontinuities in the seed coat along the region external to the funicular vascular bundle and the corresponding opposite side, formed by the elongation of 2–4 epidermal cells instead of their division as in the adjacent cells. These discontinuities appear as furrows between two ridges corresponding to the margins of the seed coat along the raphe and antiraphe sides. These furrows may be concerned in the diffusion of water necessary for the germination of the seed.

From the above discussion it is obvious that the genus *Hydrocera* though resembling *Impatiens* in essential floral morphological characters, differs from it in the semiaquatic habitat, 3-flowered inflorescence, absence of connation between the perianth parts and their traces, 5–6 carpellary ovary, 5-traced carpels, 3 ovules per locule suspended from a 3-lobed placenta, indehiscent fruit (berry with 5 stony seeds) and the seed coat of thick walled cells derived from the outer epidermis of the outer integument. In view of these significant differences between *Hydrocera* and *Impatiens* it is tentatively suggested that *Hydrocera* perhaps deserves to be treated either as a sub-family, Hydroceroideae or as a tribe Hydrocereae, under the family Balsaminaceae.

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References

Bentham G and Hooker J D 1862–1893 Geraniaceae; *Genera Plantarum* **1** 269–278 (London: Reeve and Co.)

Cronquist A 1981 *An integrated system of classification of flowering plants* (New York: Columbia University Press)

Dunn S T 1967 *Flora of presidency of Madras* (Calcutta: Botanical Survey of India)

Grey-Wilson C 1980 Studies in Balsaminaceae: V *Hydrocera triflora* its floral morphology and relationship with *Impatiens*; *Kew Bull.* **35** 213–219

Narayana L L 1963 Contributions to the embryology at Balsaminaceae I; *J. Indian Bot. Soc.* **42** 102–109

Narayana L L 1965 Contributions to the embryology of Balsaminaceae II; *J. Jpn. Bot.* **40** 104–116

Narayana L L 1974 A contribution to the floral anatomy of Balsaminaceae; *J. Jpn. Bot.* **49** 315–320

Rama Devi D and Narayana L L 1989 *Floral anatomy of Balsaminaceae* (S S Bir Commemoration Volume) (in press)

Venkateswarlu J and Dutt B S M 1961 Amended description of *Hydrocera triflora* Wt. and Arn.; *J. Bombay Nat. Hist. Soc.* **58** 545–547

Venkateswarlu J and Lakshminarayana L 1957 A contribution to the embryology of *Hydrocera triflora* Wt. and Arn; *Phytomorphology* **7** 194–203