T. PULLAIAH* & D. SARADA*: **Embryology of *Boerhavia erecta* L. (Nyctaginaceae)**

T. プライア*・D. サラダ*: *Boerhavia erecta* L. (オシロイバナ科) の胚学的研究

Nyctaginaceae is a small family of approximately 30 genera and 250-300 species. Embryological investigations in the family are scanty and these have been reviewed by Davis (1966) and recently by Anisimova (1983). Although the genus *Boerhavia* comprises 40 species, embryology of this genus is studied only in two species. Maheshwari (1929) studied the embryology of *B. diffusa* while Bhargava (1932) studied *B. repanda*. Kajale (1936, 1937) gave an account of embryo and seed development in *B. diffusa* and *B. repanda*. Embryology of *B. erecta* L. has not been investigated earlier and hence the present investigation has been undertaken.

Material and methods The material for the present investigation was collected from the Tamilnadu Agricultural University campus, Coimbatore by T. Pullaiah. Flowers and fruits at different stages of development were fixed in formalin-acetic-alcohol (F. A. A). Usual methods of dehydration, infiltration and embedding were followed. Serial longitudinal and transverse sections were cut at a thickness of 2-5 μm and were stained in Delafield's haematoxylin.

Observations Microsporangium, microsporogenesis and male gametophyte. Anther is tetrasporangiate (Fig. 1A). The young anther is at first a homogenous mass of meristematic cells surrounded by epidermis. When the anther becomes lobed, a single row of archesporial cells get differentiated in each anther lobe. In longitudinal section the archesporial cells are two-celled (Fig. 1B). Thus there are only eight archesporial cells per anther.

The archesporial cells divide periclinally forming primary parietal cells and primary sporogenous cells (Fig. 1C). The cells of the primary parietal layer divide periclinally to form two layers (Fig. 1D). The outer layer functions as endothecium while the one adjacent to the spore mother cells divides once more periclinally (Fig. 1E) forming the middle layer and tapetum (Fig. 1F, G). This

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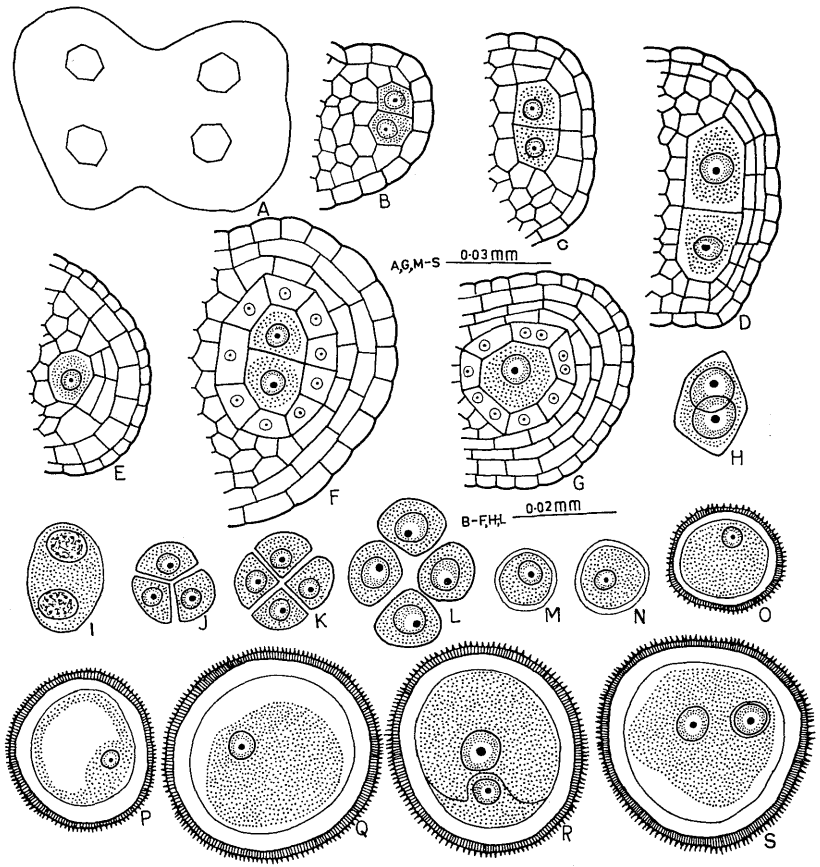

Fig. 1. *Boerhavia erecta*. A. Transverse section of tetrasporangiate anther. B. Longitudinal section of anther lobe showing archesporium. C–G. Anther wall development (B–D, F. longitudinal sections; E.G. transverse sections). H. Tapetal cell. I. Microspore dyad. J–L. Microspore tetrads. M–S. Stages in the development of pollen grain.

type of anther wall development according to Davis (1966) is known as Monocotyledonous type.

The epidermis persists in the mature anther as flattened layer. The hypodermal layer develops fibrous thickenings forming fibrous endothecium. The middle layer divides periclinally forming two layers. Anther tapetum is of the Glandular type. Its cells become two-nucleate during later stages (Fig. 1H).

The sporogenous cells function directly as pollen mother cells without any increase in the number. The pollen mother cells undergo meiotic division (Fig. 1I) resulting in pollen tetrads (Fig. 1J-L). Quadripartition of the microspores is by furrowing. Isobilateral pollen tetrads are more common but tetrahedral tetrads are also met with occasionally.

The microspores soon after separation from the tetrads enlarge in size considerably (Fig. 1M-Q). The nucleus in the pollen grain divides and two unequal cells are formed (Fig. 1R). The smaller cell is the generative cell which during later stage gets pinched off into the pollen grain. Pollen grain at the shedding is 2-celled (Fig. 1S). The exine is thick with minute projections while the intine is thin.

Ovary and ovule. The ovary is superior and unilocular with a single basal ovule which is unitegmic and crassinucellate. The ovule arises as a papillate outgrowth from the base of the ovary. Due to divisions on only one side of the ovule it gets curved and becomes anatropous (Fig. 2A, B). The ovule remains in the anatropous condition even at about 2-celled embryo stage. But later on the nucellus grows backwards and gets curved so that the ovule becomes campylotropous (Fig. 2C). The single integument is 3-6-layered in thickness.

Megasporogenesis and female gametophyte. Female archesporium is hypodermal and single-celled. It undergoes periclinal division forming a parietal cell towards the surface and a megaspore mother cell towards inside. The parietal cell undergoes periclinal and anticlinal divisions forming a massive parietal tissues. The deep seated megaspore mother cell (Fig. 2D) undergoes meiosis resulting in a linear tetrad of megaspores (Fig. 2E). The chalazal megaspore is functional while the micropylar three megaspores degenerate.

The functional megaspore elongates and enlarges and its nucleus which is centrally located undergoes mitosis to produce binucleate cell. The nuclei separate and move to the ends of the cell and undergo division to form a 4-nucleate embryo sac (Fig. 2F). A large central vacuole is present at this 4-nucleate embryo sac stage. The nuclei divide once again to produce eight nuclei which organize into 3-celled egg apparatus and 3 antipodal cells while remaining two fuse in the centre forming secondary nucleus (Fig. 2G). This type of embryo sac development is known as monosporic *Polygonum* type.

The egg is vacuolate at the upper side, the cytoplasm being aggregated

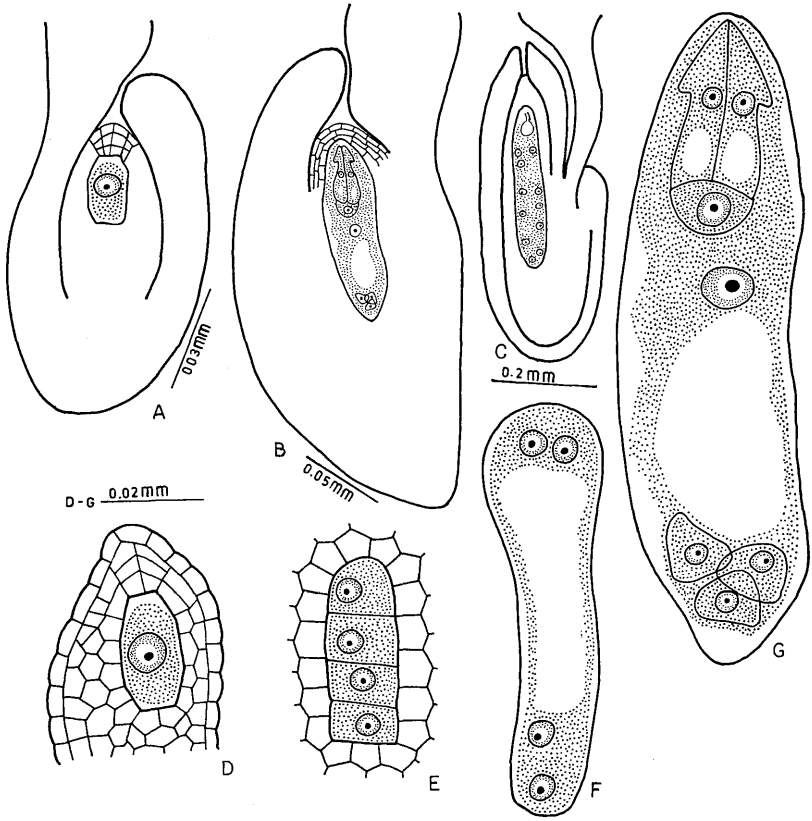

Fig. 2. *Boerhavia erecta*. A-C. Stages in the development of the ovule. D. Megaspore mother cell. E. Megaspore tetrad. F. 4-nucleate embryo sac. G. Organised embryo sac.

round the nucleus at the lower end. The synergids are pyriform in shape and are hooked. The nucleus lies towards the upper end of the synergid and at the lower side a vacuole is present. Secondary nucleus lies near the egg apparatus. Antipodals are three in number and are persistent up to the globular stage of embryo.

Fertilization, endosperm and embryo. Fertilization is porogamous. The primary endosperm nucleus divides earlier than the zygote forming two nuclei which are scattered in the thin layer of cytoplasm around the periphery of the

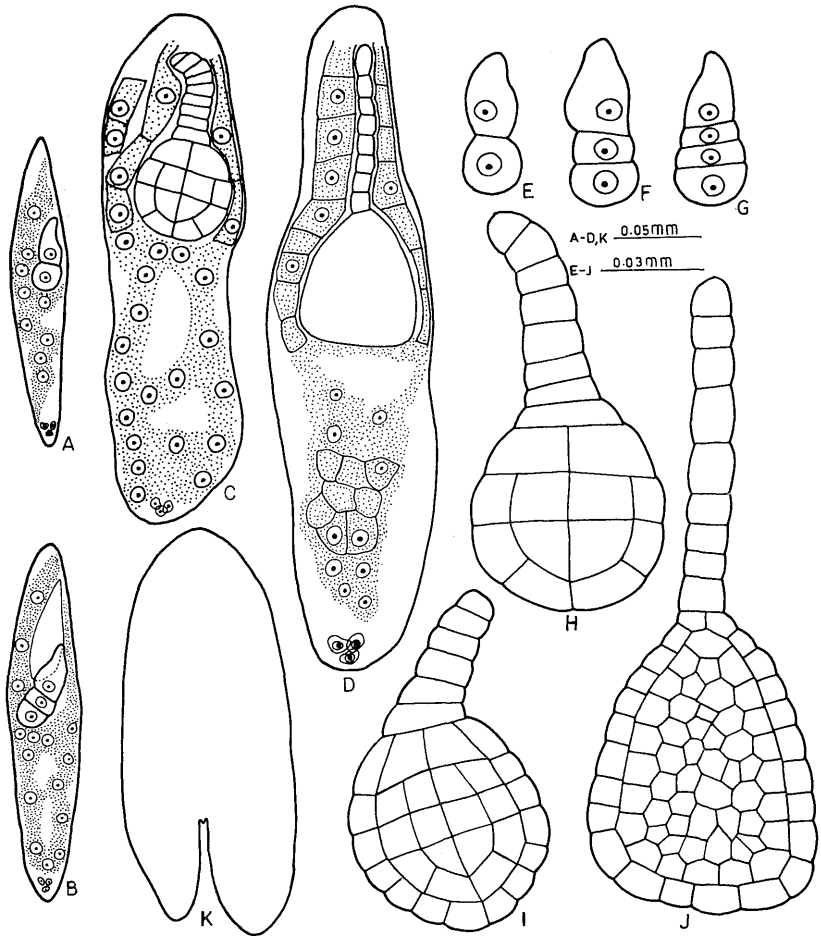

Fig. 3. *Boerhavia erecta*. A-C. Stages in the development of endosperm. E-K. Stages in the development of embryo.

greatly enlarged embryo sac (Fig. 3A, B). Cellularization starts at the 4-celled embryo stage and it is confined only to the micropylar region around the embryo (Fig. 3C, D), while the chalazal portion remains free nuclear.

The first division in the zygote is by a transverse wall and leads to differentiation of an apical cell *ca* and a basal cell *cb* (Fig. 3E). The next division

takes place in the basal cell and is again transverse resulting in *m* and *ci*. Thus a filamentaous proembryo of three cells is formed (Fig. 3F). Another transverse division occurs in the cell *ci* resulting in *n* and *n'* and the proembryo becomes four-celled (Fig. 3G).

The terminal cell *ca* undergoes two vertical divisions at right angles to each other forming quadrants *q*. This tier undergoes transverse division resulting in two tiers *l* and *l'*.

The destination of the tiers are as follows: The tier *l* gives rise to cotyledons and plumule, *l'* forms upper part of hypocotyl, *m* gives rise to the lower part of hypocotyl and major part of root, *n* forms root apex and root cap and *n'* develops into a suspensor which is 8-12 cells in length (Fig. 3H-K). This type of embryo development is known as the Asterad type according to Johansen (1950). A suspensor is formed and no epiphysis is differentiated which is characteristic of the *Polygonum* variation of Asterad type.

Discussion Male archesporium in *Boerhavia erecta* (present study) consists of only two cells which are in a single row. Similar situation has earlier been reported in *B. diffusa* by Maheshwari (1929) while Bhargava (1932) reported that in *B. repanda* male archesporium consists of a single row of 3-4 cells. Anther wall development in all the centrospermous families so far investigated is of the Monocotyledonous type. Anther tapetum in *B. erecta* is of the Glandular type which is the case with other members of the family Nyctaginaceae.

The ovule in the family Nyctaginaceae is quite variable. Woodcock (1929) describes single campylotropous ovule as occuring in both *Mirabilis jalapa* and *Thelygonium cynocrambe*. Maheshwari (1929) reports that there is a single basal anatropous ovule in *Boerhavia diffusa*. Bhargave (1932) also reported anatropous ovules in *B. ropanda*. But Kajale (1937) reported that the ovule in *B. diffusa* and *B. repanda* shows a distinct bend pointing towards campylotropy. He says, "The figures of Maheshwari and Bhargava also show this clearly". According to Cooper (1932) the ovule of *Bougainvillea glabra* is intermediate between campylotropous and anatropous condition. Anacampylotropous ovules have also been reported in *Pisonia aculeata* (Venkateswarlu 1947) and *Oxybaphus nyctagineus* (Rocen 1927, Cooper 1949) while campylotropous ovules have been recorded in *Oxybaphus viscosus, O. micranthus* (Rocen 1927), *Mirabilis multiflora, M. longiflora* and *Abronia umbellata* (Rocen 1927). In

Boerhavia erecta (present study) ovule is campylotropous.

The ovule is unitegmic in *Boerhavia diffusa* (Maneshwari 1929), *B. repanda* (Bhargava 1932), *B. erecta* (present study), *Abronia umbellata* (Rocen 1927) and *Mirabilis jalapa* (Rocen 1927, Woodcock 1929). It is bitegmic in *Bougainvillea glabra, B. spectabilis* (Cooper 1931, 1932), *Oxybaphus nyctagineus, O. viscosus, O. micranthus, Mirabilis multiflora, M. longiflora* (Rocen 1927) and *Pisonia aculeata* (Venkateswarlu 1947).

Embryo sac development in the family Nyctaginaceae is of the monosporic Polygonum type. Such a type has been reported in *Boerhavia diffusa* (Maheshwari 1929), *Mirabilis jalapa, Oxybaphus nyctagineus, O. viscosus, O. micranthus, Mirabilis multiflora, M. longiflora, Abronia umbellata* (Rocen 1927), *Pisonia aculeata* (Venkateswarlu 1947) and *Boerhavia erecta* (present study).

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ナハカノコソウ属 *Boerhavia erecta* の花粉，胚嚢，胚乳，胚の初期発生を調べた。花粉の始原組織は2細胞である。花粉母細胞の形成は単子葉型である。タペタム形成は glandular 型である。花粉の四分子分裂は多くは isobilateral であるが，ときに tetrahedral のものも見られた。花粉は2細胞になって放出される。胚珠は受精時は倒生であるが，その後しだいに湾生となる。胚珠は1枚の珠皮と多層の珠心の中に胚嚢がある。胚嚢形成は普通型，胚乳形成は多核型である。

□「清瀬の自然フィールドガイド」編集委員会：**清瀬の自然フィールドガイド 春** 212pp. 1986. 清瀬市，東京．¥1,500. 最近地方自治体が独自の自然案内や図鑑を出版するようになった。市町村の文化活動がこういう面にも向けられるようになったのは結構なことである。本書もそのひとつで，山崎敬氏の監修になる植物の部は128頁にわたり，もっとも多くの部分を占める。内容は原色写真に簡単な解説をつけたもので，雑木林，道端などといくつかの生育地別にわけてある。動物では昆虫と鳥が同様に解説されている。こういう図鑑の生命はなんといっても写真のきれいさにあるが，この点では十分満足のゆくものである。　（金井弘夫）

□日外アソシエーツ：**日本件名図書目録⑨　動・植物関係77/84** 598pp. 1985. 日外アソシエーツ，東京．¥19,000. 1977年から1984年6月までに日本国内で刊行された動植物関係図書19,000点を，動植物名および関連項目名から検出できるようにしたもので，典拠は JAPAN/MARC, NIPPON MARK, 日本全国書誌週刊版，同索引，出版年鑑である。9-38頁に項目名が50音順に並べられ，出現頁が示されている。職業別電話帳と同じと考えればよい。たとえば日本(植物)では，ほぼ県別に仕分けされて315点が並んでいる。いくつもの検索項目をもつ文献はそれぞれの項目見出しの下に重複して採録されている，たとえば宮城県の植物関係文献は日本(植物—宮城県)と宮城県(植物)の両方の見出しの下に見いだされ，検索者の手間を省くようにされている。和文の単行本のみで，雑誌収載論文や英文図書は採録されていないようで，Hara *et al.* (ed.) : OZEGAHARA (1982) は見当たらない。最近 VAN や CAPTEN の公開で，データベース検索はオンラインで行なうのが常識のような風潮があるが，検索はこのようなハードコピーのほうがずっとやりやすい。研究機関のみならず，少しでも専門的な仕事をする者には必要な資料となるだろう。　（金井弘夫）