EMBRYOLOGY OF *MOLLUGO PENTAPHYLLA* L.

G. N. V. FEBULAUS[1] and T. PULLAIAH[1]

(Manuscript received 26 March, 1990; revised version accepted 14 November, 1990)

Abstract: Anther is 4-sporangiate. Anther wall development is of the Monocotyledonous type. Anther tapetum is of the secretary type and its cells become 2-nucleate and polyploid. Cytokinesis is of the simultaneous type and pollen tetrads are tetrahedral, decussate and isobilateral. Pollen grains are 3-celled at shedding stage. The ovule is campylotropous, bitegmic and crassinucellate. Micropyle is formed by the inner integument. Megaspore tetrated is linear and embryo sac development is of the *Polygonum* type. Endosperm development is of the Nuclear type and embryo development follows Solanad type.

INTRODUCTION

A small family of 14 genera and 95 species, Molluginaceae are distributed primarily in the tropics and subtropics of both hemispheres. From the related Aizoaceae the Molluginaceae differ in having a scarcely (if at all) succulent habit, in possessing red pigments of the anthocyanin rather than betacyanin type, in lacking anomalous secondary growth in the stems and roots, in having floral parts few, usually free, hypogynous and cyclically arranged and in lacking a calyx tube (Boegle, 1970).

Embryological studies in this family are quite meagre. These were reviewed earlier by Davis (1966) and recently by Savina (1983). A perusal of the literature revealed that except for an abstract by Maheswari Devi and Girija (1981) detailed embryology of *Mollugo pentaphylla* L. has not been studied and hence the present investigation has been undertaken.

MATERIAL AND METHODS

The material has been collected in the Sri Krishnadevaraya University campus. Buds, flowers and fruits were collected at different stages of development and fixed in formalin-acetic acid-alcohol. Customary methods (Johansen, 1940) were employed for dehydration, clearing and embedding. Sections were cut at 7-9 μm thickness. The sections were stained with Delafield's haematoxylin and were mounted in Canada balsam.

OBSERVATIONS

Microsporangium, microsporogenisis and male gametophyte

Anther is tetrasporangiate (Fig. 1 A). Male archesporium is differentiated hypodermally at the four corners of the anther. The archesporium cuts off a primary parietal layer just below the epidermis and a primary sporongenous layer

(1) Department of Botany, Sri Krishnadevaraya University, Anantapur 515003, A.P., India.

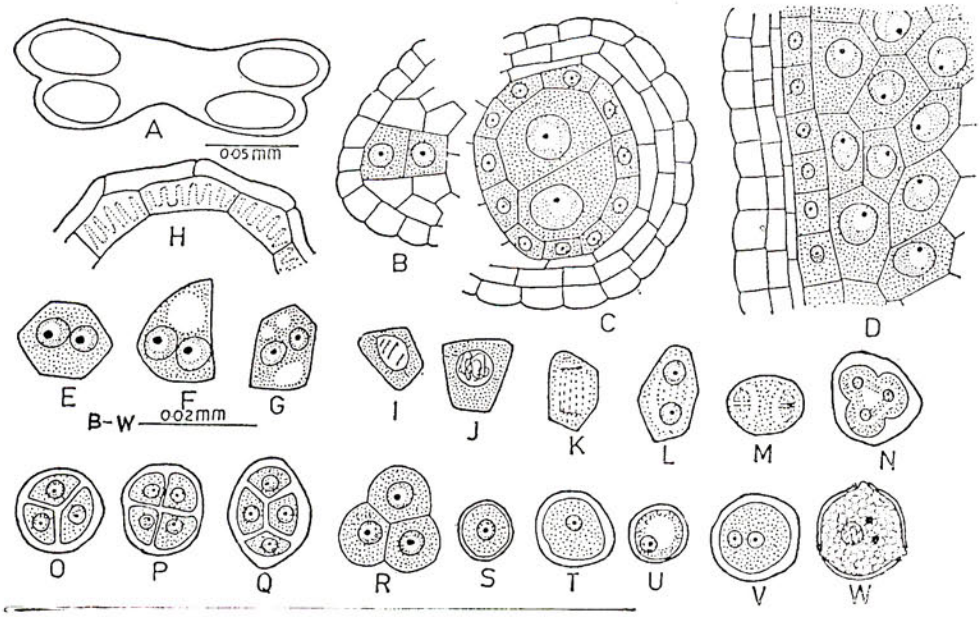

Fig. 1. A. Transverse section of anther; B. Transverse section of part of anther lobe showing sporogenous cell and parietal cell; C. Transverse section of anther lobe showing pollen mother cells and wall layers; D. Longitudinal section of part of anther lobe showing pollen mother cells and anther wall; E-G, I. Tapetal cells; H. Fibrous endothecium; J-N. Meiosis in pollen mother cells; O-R. Pollen tetrads. S-U. One-nucleate pollen grain; V. 2-celled pollen grain; W. Mature pollen grain.

towards the inner side (Fig. 1 B). The primary parietal layer divides by anticlinal and periclinal divisions into two layers. Of these outer layer forms endothecium. The inner divides again and forms middle layer and the tapetum (Fig. 1 C, D). This type of anther wall development according to Davis (1966) is known as Monocotyledonous type. The endothecium develops fibrous thickenings (Fig. 1 H). Anther tapetum is of the secretary type. The tapetal layer contains large uninucleate cells in begining but later on the tapetal nucleus divides to form 2 nuclei (Fig. 1 E-G). Polyploid nucleus is also observed in some tapetal cells (Fig. 1 I). The tapetal cells show vacuoles (Fig. 1 F, G). The middle layer gets crushed and degenerates.

The sporogenous cells divide to form 2-3 rows of pollen mother cells (Fig. 1 C, D). The pollen motherg cells undergo meiotic divisions and simultaneous cytokinesis result in the formation of microspore tetrads (Fig. 1 J-N). Microspore tetrads are arranged tetrahedrally, decussately and isobilaterally (Fig. 1 O-R). But tetrahedral tetrads are more frequent. The microspores after separation round off and increase in size and the usual exine and intine get differentiated (Fig. 1 S-U). The microscopore nucleus divides to form a large vegetative cell and small generative cell which later moves into the vegetative cell (Fig. 1 V). The generative cell gives rise to two male gametes. The vegetative nucleus starts disorganizing while still in the pollen grain. The pollen grains are triporate and are three-celled at the time of shedding (Fig. 1 W).

Ovule

The ovule appears as a papillate out growth on the placentum. The initials of the inner integument develop earlier than the outer, when the hypodermal archesporium in the nucellus divides forming a megaspore mother cell and parietal cell (Fig. 2A). Both the integuments grow, simultaneously as the nucellus elongates and the ovule curves (Fig. 2B). The ovule becomes anatropous at the organised embryo sac stage (Fig. 2C). After fertilization the embryo sac shows more curvature and the ovule becomes campylotropous (Fig. 2D). The micropyle consists of only the endostome organised by the inner integument. The outer integument forms a collar around the endostome. The ovule is bitegmic and crassinucellate. The two integuments are composed of 2 layers of cells each.

Megasporogenisis and female gametophyte

The female archesporium is hypodermal and consists of single cell. It undergoes a periclinal division resulting in a primary parietal cell and megaspore

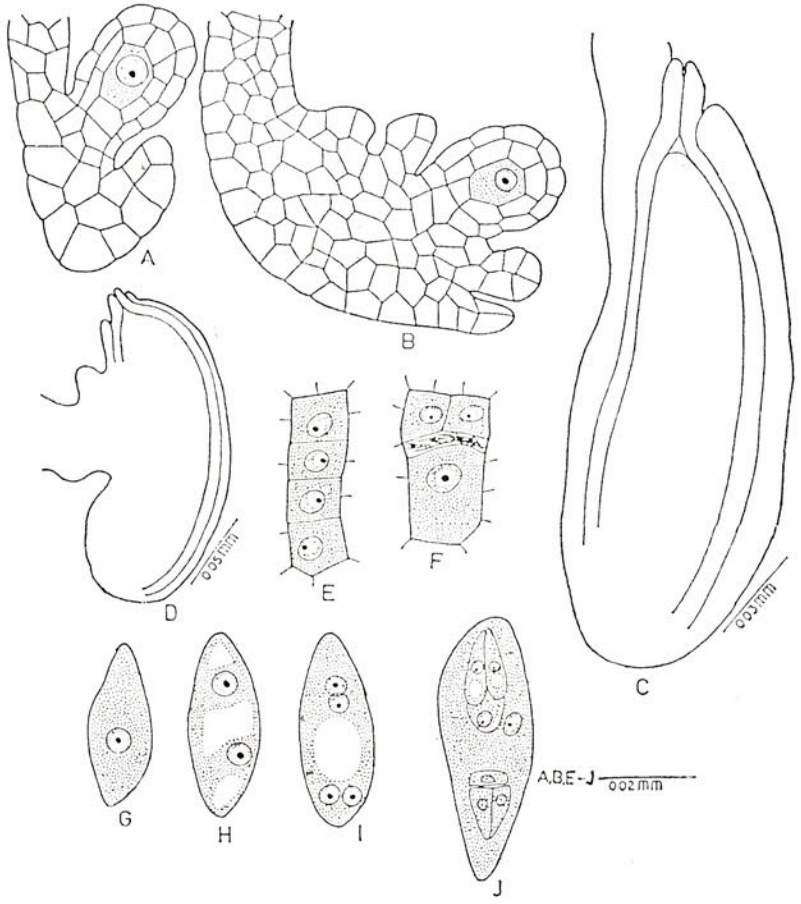

Fig. 2. A-D. Ovules at different stages of development; E. Linear megaspore tetrad; F. T-shaped tetrad; G-I. One, two and four nucleate embryo sacs respectively; J. organised embryo sac.

mother cell. Parietal cell undergo one more periclinal division and gives rise to two layers of parietal tissue (Fig. 2 A-B).

The megaspore mother cell enlarges and undergoes meiosis resulting in a linear tetrad of megaspores (Fig. 2 E). 'T'-shaped tetrads are also found rarely (Fig. 2 F). The chalazal megaspore is functional while the upper three degenerate.

The functional megaspore enlarges and undergoes three nuclear divisions resulting in an eight-nucleate, seven-celled embryo sac of Polygonum type (Fig. 2 G-J). The synergids are pear-shaped. The egg cell is flask-shaped structure with large vacuole towards the micropylar end and the nucleus embedded in the cytoplasm towards the chalazal end. The polar nuclei fuse near the egg apparatus. The antipodals are three in number and they are ephemeral. Their arrangement is similar to that of egg apparatus (Fig. 2 J).

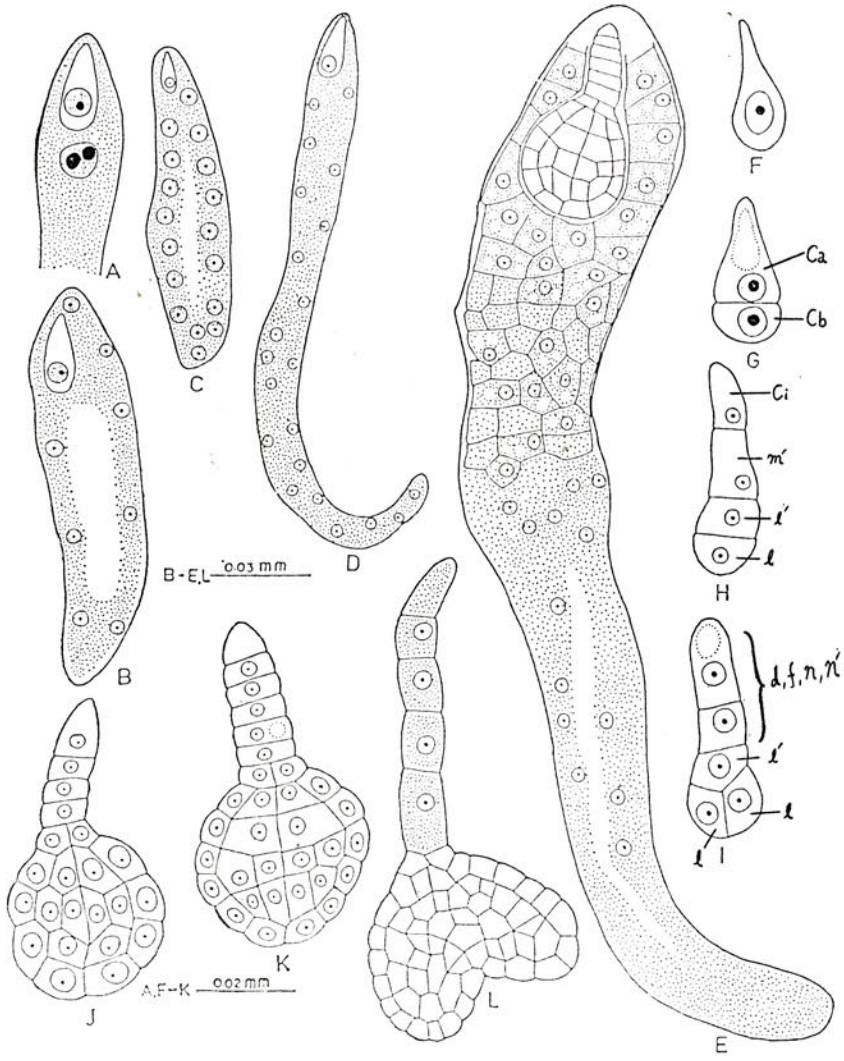

Fig. 3. A. Zygote and triple fusion nucleus; B-E. Stages in the development of Endosperm; F-L. Stages in the development of embryo.

Fertilization, endosperm and embryo

Fertilization is porogamous. Endosperm development is of Nuclear type. The primary endosperm nucleus divides earlier than the zygote. It undergoes free nuclear divisions and the nuclei are distributed in the periphery of the embryo sac (Fig. 3 A-D). The embryo sac continues to push its way down into the tissue of nucellus untill it reaches chalazal end of the seed and it curves. Wall formation in endosperm occurs at the glabular embryo stage. It proceeds from the micropylar end towards the chalazal end of the embryo sac (Fig. 3 E). It becomes completely cellular at the time of differentiation of the two cotyledons.

The zygote enlarges and the first division takes place in a transverse plane forming the terminal cell *ca* and the basal cell *cb* (Fig. 3 F, G). Both *ca* and *cb* undergoes another transverse divison resulting in the formation of linear proembryo of four cells (*l*, *l'*, *m* and *ci*) respecitively (Fig. 3 H). Subsequently *m*, *ci* divide transversely forming (*d*, *f*, *n*, *n'*). '*l*' divides vertically and 2nd vertical division in '*l*' takes place at right angles to the first resulting in a quadrant (Fig. 3 I). *l'* also undergoes 2 vertical divisions at right angles to each other resulting in four cells. A few more transverse and longitudinal divisions follow and the embryo becomes globular (Fig. 3 J, K). Periclinal division results in the demarcation of dermatogen, periblem and plerome initials. The cells of the suspensor are packed with food materials (Fig. 3 L).

As the terminal cell *ca* of the 2-celled proembryo and only one fourth of *cb* contributes to the embryo proper the development of embryo conforms to be Soland type of Johansen (1950). The tiers *f*, *n* and *n'* undergo transverse divisions and forms the suspensor of 6-8 cells.

DISCUSSION

The male archesporium is hypodermal and single layered in *Mollugo pentaphylla* (present study), however Narayana and Jain (1962) in *Limeum indicum* and Narayana and Lodha (1972) in *Glinus lotoides* reported 2-layerd male archesporium. Anther tapetal cells in *Mollugo pentaphylla* (present study) become 2-nucleate and some polyploid also. Narayana and Lodha (1963, 1972) reported that in *Orygia decumbens* and *Glinus lotoides* nuclear fusions result in large polyploid nucleus.

Ovules in the family Molluginaceae vary from anatropous to campylotropous. Bhargava (1934) described that ovules in *Mollugo nudicaulis* are anatrous but his diagrams reveal that the ovules are actually anacampylotropous. Anacampylotropous ovules have also been reported in *Glinus lotoides* and *Orygia decumbens* (Narayana and Lodha 1963, 1972). Payne (1935) reported that ovules in *Mollugo verticillata* are campylotropous. In *Mollugo pentaphylla* (Maheswari Devi and Girija 1981 and present study) ovules are anatropous in the begining but become campylotropous at a later stage. The ovules in all the members studied so far are bitegmic and crassinucellate.

Embryo development in *Mollugo pentaphylla* (present study) is of the Soland type and is in confirmity with that of Siva Rao (1975).

LITERATURE CITED

BOEGLE, A. L., 1970. The genera of Molluginaceae and Aizoaceae in the south-eastern United States. Journ. Arn. Arbor. **51**: 431-462.

BHARGAVA, H.R., 1934. Contribution to the morphology of *Mollugo nudicaulis*. Proc. Indian Acad. Sci. **1**: 271-278.
DAVIS, G.L., 1966. Systematic embryology of Angiosperms. Wiley Int. New York.
JOHANSEN, D.A., 1940. Plant Microtechnique. McGraw Hill, New York.
MAHESWARI DEVI, H. and A.R. GIRIJA, 1982. Development of gametophytes in *Mollugo pentaphylla*. Proc. 69th Indian Sci. cong. Part III. p. 90. Abstract.
NARAYANA, H.S. and K. JAIN, 1962. A contribution to the embryology of *Limeum indicum*. Lloydia **25**: 100-105.
NARAYANA, H.S. and B.C. LODHA, 1963. Embryology of *Orygia decumbens*. Phytomorphology **13**: 54-59.
NARAYANA, H.S. and B.C. LODHA, 1972. Embryology of *Glinus lotoides*. Indian Acad. Sci. B. **75**: 77-85.
PAYNE, N.A., 1935. The flower and seed of *Mollugo verticillata*. Bull. Univ. Kansas **36**: 5-25.
SAVINA, G.I., 1983. Molluginaceae. In M.S. Yakovlev (ed.) Comparitive embryology of Flowering plants. Nauka. Leningrad. p. 36-39.
SIVA RAO, B.S., 1975. Embryo development in five species of *Mollugo*. Curr. Sci. **44**: 712-713.

粟米草之胚胎學

G.N.V. FEBULAUS T. PULLAIAH

摘　　要

花藥具4花粉囊，花藥壁發育屬單子葉型(Mono cotyledonous type)。花藥營養層爲分泌型(secretary type)，細胞具有雙核且爲多倍體。細胞質分裂爲同步型 (simultaneous type)。四分體爲四面體，十字對生或等面排列。花粉粒在傳粉時期具3個細胞。胚珠彎生，具兩層珠被花粉，屬厚珠心型(coassinucellate type)。珠孔由內珠被形成。大孢子四分體爲線形排列(polygonum type)。胚囊發育爲蓼型，具無壁式胚乳，胚的發育則屬茄型 (solanad type)。