EMBRYOLOGY OF *GLINUS LOTOIDES* LINN.

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ABSTRACT

The quadrilocular anther has a 4-layered wall. The endothecium is fibrous. The uni-layered glandular tapetum consists of 2- to 3-nucleate, many nucleolate cells. The arrangement of microspores is tetrahedral or decussate. The pollen grains are spherical, tricolpate and 3-celled at the time of shedding. The ovule is ana-campylotropous, bitegminal and crassinucellar. There is a funicular obturator. The development of the embryo-sac follows the Polygonum type. The synergids are elongated with filiform apparatus. The egg is pear-shaped and the antipodals ephemeral. The endosperm is Nuclear. Embryogeny conforms to the Linum variation of Solanad type.

INTRODUCTION

Information on the embryology of the Molluginoidae of the Aizoaceae is meagre. Bhargava (1934) published the first account on the life-history of *Mollugo nudicaulis*. Later, Payne (1935) studied the flower and the development of seed in *Mollugo verticillata*. Joshi and Rao (1936) investigated the embryology of *Gisekia pharnaceoides*, a genus of doubtful systematic position. Raghavan and Srinivasan (1940) confirmed the haploid chromosome number in *Mollugo cerviana*. Recently Kshirsagar (1960) studied the embryology of *Polycarpaea corymbosa* and *Mollugo stricta* and Narayana and Lodha (1961) described in brief the development of the male and female gametophytes of *Glinus lotoides* respectively. Narayana and Lodha (1963) studied the embryology of *Orygia decumbens*, a monotypic Afro-Asian member of the Molluginoidae. In the present communication a detailed account of the embryology of *Glinus lotoides* is described.

MATERIAL AND METHODS

Flowers and fruits of all ages of *Glinus lotoides* were collected from Jodhpur and Ajmer and were fixed in formalin acetic alcohol. The material
was dehydrated and infiltrated with tertiary butyl alcohol series, embedded in paraffin and cut at a thickness of 6–12 microns. The sections were stained with safranin and fast green and Heidenhain’s haematoxylin with erythrosin as a counter stain; the latter combination of stains was found more satisfactory.

**Observations**

**Flower.**—Flowers are arranged in axillary clusters, monochlamydeous tetracylic and pentamerous. The tepals are free and quincuncial. The stamens are ten arranged in two whorls. The ovary is inferior pentacarpellary, syncarpous, pentalocular with two rows of ovules in each locule borne on axile placentation.

**Microsporangium, microsporogenesis and male gametophyte.**—A hypodermal archesporium differentiates at four corners of the anther and is two cells in breadth. It divides to form the outer primary parietal cells and inner sporogenous cells. The former by further development forms an anther wall of three layers besides the epidermis (Fig. 1) while the latter differentiate into microspore mother cells.

The epidermal cells are rectangular. The endothecial cells are larger than the epidermal cells and develop fibrous thickenings (Fig. 13). The single middle layer gets tangentially compressed and obliterated as the anther matures. The glandular tapetum is generally uni-layered. Occasionally, it is more than one cell thick at certain regions. The tapetal cells divide (Fig. 3), become two to three-nucleate and one to three-nucleolate (Fig. 4). Nuclear fusions (Fig. 5) result in a large polyploid nucleus with many chromatin bodies or chromocentres (Fig. 2). As the anther matures, numerous darkly staining bodies of dissimilar size called utisch granules border the tapetum (Fig. 13).

The microspore mother cells divide meiotically and the cytokinesis is of the simultaneous type (Figs. 6–9). The microspores are arranged either tetrahedrally or decussately (Figs. 10, 11), the tetrahedral arrangement being more frequent. The microspores are spherical with the wall differentiated into an outer thick exine and an inner thin intine. The exine is discontinuous at the region of germ pores (Fig. 12). The microspore nucleus divides to form a small ellipsoidal generative cell and a large vegetative cell (Fig. 13). The generative cell which is near the wall divides (Fig. 14) to form two male cells and the pollen grains are shed at the 3-celled stage.
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Ovule, megasporogenesis and female gametophyte.—The ovule appears as a papillate outgrowth on the placenta. The initials of the inner integument develop earlier than the outer, when the hypodermal archesporium in the nucellus (Fig. 15) divides forming a megaspore mother cell and a parietal cell (Fig. 16). Both the integuments grow simultaneously as the nucellus elongates and curves (Figs. 16, 17). The primordium of an aril differentiates at the base of the outer integument on the free side when the nucellus has just started curving (Fig. 16). The ovule becomes more than anatropous at the 2-nucleate stage of the embryo-sac (Fig. 18). The micropyle consists of only the endostome organised by the inner integument. The outer integument forms a collar around the endostome. The chalaza is not in line with the micropyle as in the anatropous condition. It is along one side with the lower region of the nucellus curved. The aril at this stage becomes distinct (Fig. 18). At the stage of mature embryo-sac the ovule becomes ana-campylotropous (Fig. 19) with a small space developed between the outer and the inner integuments along the free side at the chalazal region. The aril grows further enclosing the base of the ovule as a flap. The funiculus elongates more than the length of the ovule. Its epidermal cells on the adaxial side get enlarged, to form a glandular obturator.

The female archesporium is hypodermal (Fig. 15). Occasionally, as a result of the further development of two archesporial cells, two megaspore mother cells are formed (Fig. 20). However, only one of them functions (Fig. 17). The archesporial cell divides to form a primary parietal cell and a megaspore mother cell. The primary parietal cell undergoes vertical divisions to form a layer of one or more cells (Fig. 17). The megaspore mother cell elongates (Fig. 17) and divides meiotically to form a dyad at the first instance and a tetrad subsequently. The cells of the dyad may divide simultaneously (Fig. 23) or the lower may divide earlier than the upper (Fig. 21) or the upper may divide earlier than the lower and their products may degenerate earlier when still the lower dyad is under division (Fig. 22). A linear tetrad is finally formed and the chalazal megaspore functions while the others degenerate (Fig. 24). The nucleus of the functioning megaspore divides thrice to organize two-, four- and eight-nucleate embryo-sacs (Figs. 25–27). The development of the embryo-sac thus follows the Polygonum type (Maheshwari, 1950).

To begin with the cells of the egg apparatus are of the same size as the antipodals (Fig. 27). Later, they enlarge further both in length and breadth.
FIGS. 1-28
The synergids are elongated and show filiform apparatus. The egg is pear-shaped and median in position. The lower polar nucleus moves upward and fuses with the upper polar nucleus to form a secondary nucleus. In the mature embryo-sac the antipodals are similar in size or slightly reduces and...
their nuclei show signs of degeneration (Fig. 28). The embryo-sac is filled with plenty of starch grains.

**Fertilization.**—The entry of the pollen tube is porogamous. Double fertilisation is normal. The synergids disappear immediately after fertilization.

**Endosperm.**—The endosperm is Nuclear. The embryo-sac enlarges in length and breadth after fertilization. The primary endosperm nucleus moves away from the zygote (Fig. 29) before division. After early free nuclear divisions cytokinesis sets in from the micropylar end at the late globular stage and generally extends towards the chalazal end, thus completely filling the embryo-sac with endosperm cells surrounding the cordate-shaped embryo (Fig. 33).

**Embryo.**—The fertilized egg (Fig. 34) undergoes a brief period of rest. It divides after the first division of the endosperm nucleus (Fig. 31). The first division of the zygote is transverse forming a terminal cell ca and a basal cell cb (Fig. 35). Both ca and cb divide transversely to form a linear pro-embryo of four cells designated l, l', m and ci (Figs. 36–38). Tier ci divides transversely into cells n and n'. At this stage tier l undergoes a vertical division (Figs. 39, 40). This is followed by not only the division of m into d and f, but also the division of d into two more derivatives (Figs. 41–43). This is accompanied by one more vertical and a transverse division of the tier l (Figs. 42–43). Later, both the tiers l and l' undergo periclinal divisions to form the dermatogen (Fig. 44), while the inner lying cells divide further (Fig. 45) to form the periblem and plerome. The derivatives of d next to the l' function as the hypophysis. It divides both transversely and vertically to complete the dermatogen (Figs. 44, 45). In the mature embryo the plumule and the two cotyledons are derived from l and the hypocotyl by l'. The radicle is contributed partly by l' and partly by the derivatives of d. The mature embryo is curved with the two cotyledons appressed to each other.

**DISCUSSION**

Dark staining globular bodies of dissimilar size called Ubisch granules or bodies appear along the inner tangential wall of the glandular tapetal cells during the maturation of anther wall. The occurrence of such bodies has been reported by Tiagi (1951) in *Cuscuta hyalina* and *C. planiflora*, Johri and Tiagi (1952) in *Cuscuta reflexa*, and Narayana and Lodha (1963) in *Orygia decumbens*. Their presence is also reported in other plants (see
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Maheshwari, 1950). It is generally regarded that the Ubisch granules are produced by mitochondria in the tapetal cells; they are acetolysis resistant and have the same nature of sporopollenin and actively take part in exine formation of the microspores (see Heslop-Harrison, 1962).

In Glinus lotoides the pollen grains are 3-celled at the time of shedding as in Orygia decumbens (Narayana and Lodha, 1963). However, Bhargava (1934) and Joshi and Rao (1936) have reported 3-nucleate pollen in Mollugo nudicaulis and Gisekia pharnaceoides and Payne (1935) has observed them to be two-celled in Mollugo verticillata. Further, Bhargava (1934) and Kshirsagar (1960) have observed germination of pollen grains in situ in Mollugo nudicaulis and M. pentaphylla (M. stricta) respectively. No such germination of pollen grains has been observed in Glinus.

The ovule is ana-campylotropous in Glinus lotoides as in other members of the family (Bhargava, 1934; Joshi and Rao, 1936; Kshirsagar, 1960; and Narayana and Lodha, 1963). Further, Glinus has a funicular obturator. A similar type of obturator is reported by Kajale (1944, 1954) in members of the Phytolaccaceae. In Orygia the obturator is placental (Narayana and Lodha, 1963).

In Glinus lotoides the zygote does not have a long period of rest unlike the other members of the family. Its further development commences when the endosperm is 4-nucleate. The development of the embryo conforms to the Linum Variation, Solanad type (Johansen, 1950) or the ninth group of the second grand period in the system of embryonic classification by Souéges (1948, 1951). Among the other members of this family, a similar mode of embryo development is repeated for Trianthema monogyna, T. decandra, Sesuvium portulacastrum (see Johansen, 1950) and Orygia decumbens (Narayana and Lodha, 1963).

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EXPLANATION OF TEXT-FIGURES

Figs. 1-28 (ar. aril; ob., obturator). Fig. 1. Magnified view of the portion of microsporangium at microspore mother cell stage, × 540. Fig. 2. Tapetal cell with a large nucleus and many chromatin bodies, × 995. Fig. 3. Tapetal cell in division, × 995. Fig. 4. Binucleate tapetal cell with many nucleoli, × 995. Fig. 5. Tapetal cell with syntapetal nucleus, × 995. Figs. 6-9. Stages in the formation of microspore tetrads, × 995. Figs. 10-11. Decussate and tetrahedral tetrads, × 995. Fig. 12. Uninucleate microspore, × 995. Fig. 13. Magnified view of a portion of anther wall with a uninucleate pollen grain, × 540. Fig. 14. Pollen grain with dividing generative cell, × 995. Figs. 15-19. Stages in the
development of ana-campylotropous ovule, × 36. Fig. 20. L.s. nucellus showing primary parietal cells and two megaspore mother cells, × 540. Fig. 21. L.s. nucellus with upper undivided dyad and the lower dyad divided into two megaspores, × 540. Fig. 22. Upper dyad divided with megaspores degenerating, while lower dyad in division, × 540. Fig. 23. Dyads in division, × 540. Fig. 24. Linear tetrad, × 540. Fig. 25. 2-nucleate embryo-sac, × 540. Fig. 26. 4-nucleate embryo-sac, × 540. Fig. 27. Organised embryo-sac, × 540. Fig. 28. Mature embryo-sac, × 540.

Figs. 29–45. (emb., embryo; end., endosperm; pt., pollen tube; z., zygote). Fig. 29. Primary endosperm nucleus, × 866. Fig. 30. 2-nucleate endosperm, × 886. Fig. 31. 4-nucleate endosperm, × 886. Fig. 32. 8-nucleate endosperm, × 886. Fig. 33. Outline diagram of endosperm (cross-hatched), × 22. Figs. 34–45. Stages in the development of embryo, × 866.