The development of the female gametophyte in Toddalia asiatica (Linn.) Lamk. (Syn. T. Aculeata Pers.)

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The present study reveals the mean features of pre-fertilisation stages in the ovule of the taxon under investigation. The origin of multiple embryo sacs in Toddalia asiatica may be due to the activity of the megaspores of linear tetrads. Polyembryony may be due to production of zygotic embryos from multiple gametophytes.

INTRODUCTION

The genus *Toddalia* Juss. belongs to the family Rutaceae of the order Geraniales (LAWRENCE, 1951) and Rutales (HUTCHINSON, 1959). In India the genus is represented by the only species *Toddalia aculeata* Pers., distributed from sub-tropical Himalaya extending from Kumaon to eastwards Bhutan and Assam «Khasia Hills» and in the peninsular India (HOOKER, 1875). The taxon is also reported to occur in Orissa (PRAIN, 1903).

Since review of literature on the embryology of Rutaceae by SOUÈGES (1926) and SCHNARF (1931), there have appeared several

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contributions of different taxa of the family (OSAWA, 1912; MAURITZON, 1935; BACCHI, 1943; BANERJI & PAL, 1958; DESAI, 1962 a, 1962 b). Recently, GHOSH (1969) has investigated the process of fertilisation, endosperm formation and embryogeny in *Ravenia spectabilis* Engl. Very recently, GHOSH (1974) has worked the embryological features of *Xanthoxylum oxyphyllum* Edgew. In spite of extensive embryological investigation in the Rutaceae, a few taxa of the same family still escape the eyes of morphologists The present investigation has been undertaken by the authors with a view to throwing some light on the embryological features of this unexplored taxon.

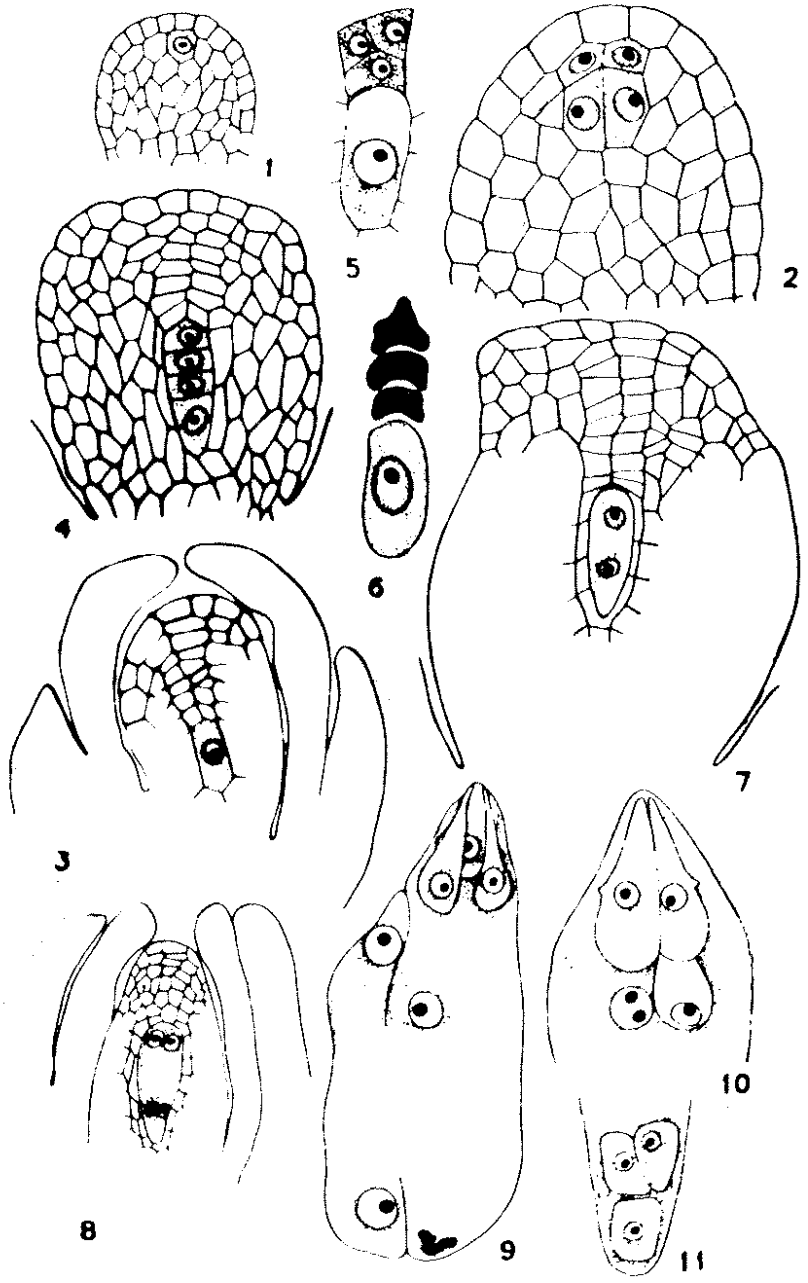
MATERIAL AND METHODS

The material for study was collected from the plants growing along saline ditches of villages near Digha, Dist. Midnapore and from Orissa in the year 1968. The flower buds were fixed in formalin-acetic-alcohol after passing through Carnoy's fluid for few seconds. The materials were dehydrated in alcohol, cleared in xylol and embedded in paraffin in the usual way. Sections were out 8-14 micron thick and stained in Heidenhain's iron-haematoxylin, sometimes with a counterstain of Fast Green.

OBSERVATIONS

Megasporogenesis

The archesporium is hypodermal and usually one-celled but rarely two-celled. It cuts off an auter parietal cell and a inner megaspore mother cell (figs. 1 & 2). The inner integument grows faster than the outer integument during development of megaspore mother cell. Finally, both the integuments contribute to the formation of micropyle. The megaspore mother cell becomes deep-seated on account of formation of massive nucellar tissue as a result of periclinal and anticlinal divisions of the parietal cell (fig. 3). A T-shaped or a linear tetrad of megaspores is formed following reduction divisions in the megaspore mother cell (figs. 4 & 5). Degeneration of the megaspores commences simultaneously which finally caps the functioning megaspore (fig. 6).



Toddalia asiatica (Linn.) Lamk. FIGS. 1-11: FIG. 1. L.s. of young ovule showing one-celled hypodermal archesporium, × 1100. — FIG. 2. Same showing two-celled archesporium with parietal cells, × 900. — FIG 3. L.s. mature ovule showing growth of interguments, deepseated megaspore mother cell, × 900. — FIG. 4. L.s. of ovule showing linear tetrad of megaspores, × 900; FIG. 5. T-shaped tetrad of megaspores, × 1400; FIG. 6. Showing degenerated micropylar megaspores and functional megaspore, × 1400. — FIGS. 7-8. Showing binucleate and tetranucleate stages of embryosac, × 800. — FIG. 9. Showing a mature embryo sac adpressed with a binucleate embryo sac indicating multiple embryo sacs, × 1400. — FIG. 10. A micropylar portion of embryo sac showing pear-shaped and hooked synergids without filiform apparatus, × 1400. — FIG. 11. A chalazal portion of embryo sac showing three antipodals, × 1400.

Female gametophyte

The functional megaspore undergoes three successive mitotic divisions resulting in the derivation of 2, — 4, — 8 nucleate gametophytes (figs. 7, 8, 9). Rarely, multiple embryo-sacs are noted in the mature ovule and the figure 9 represents a bi-nucleate embryo-sac adpressed to a mature embryo-sac. The mature 8-nucleate embryo-sac conforms to normal Polygonum type (MAHESHWARI, 1950). The synergids are hooked without filiform apparatus and pear-shaped. The egg is well protruded beyong the synergids abutting a fused polar nuclei. The three antipodals are almost equal in size and shape and ephemeral (figs. 9 & 11).

DISCUSSION

The present study reveals the features of pre-fertilisation stages in the ovule of the taxon under investigation. All the characters of megagametogenesis noted in the taxon bear similarities in respect of deepseated megaspore mother cell, T-shaped or linear tetrad, multiple embryo-sacs, ephemeral antipodals and 8-nucleate Polygonum type of embryo-sac (SCHNARF, 1931; MAURITZON, 1935 and others). The genus *Toddalia* shows the presence of a tow-celled ovular archesporium in addition to normal occurrence of one-celled archesporium as observed in *Pilocarpus. Skimmia* and *Thiphrasia* (MAURITZON, 1935), *Aegle* (JOHRI and AHUJA, 1957) and *Clausena lansium* and *Ravenia spectabilis* (GHOSH, 1973, 1974). The record of one megaspore mother cell and variable organisation of either a linear or a T-shaped tetrad of megaspores are noted in *Feronia limonia* (BANERJI and PAL, 1958) and *Ravenia spectabilis* (GHOSH, 1974). The occurrence of the pear-shaped and hooked synergids approaches the configuration except filiform apparatus in *Aegle* (JOHRI and AHUJA, 1957) and *Feronia* (BANERJI & PAL, 1958). The sequence of embryo-sac development in *Toddalia asiatica* corresponds to the «Polygonum» type (MAHESHWARI, 1950) as observed in most of the taxa of Rutaceae except a few rutaceous members, such as, *Xanthoxylum* which conforms to *Polygonum, Allium* or *Adoxa* types (MAURITZON, 1935) and *Glycosmis* which reveals the Onagrad type of embryo sac (DESAI, 1962).

The present investigation shows that the origin of multiple embryo sacs in *Toddalia asiatica* may be due to the activity of the megaspores of the same or different linear tetrads, as observed in *Citrus grandis* (BANERJI, 1954), *Feronia limonia* (BANERJI & PAL, 1958) and *Ravenia spectabilis* (GHOSH, 1974). The occurrence of multiple embryo sacs in the present taxon indicates the possibility of polyembryony due to production of zygotic embryos from multiple gametophytes as recorded in *Citrus aurantium* and *C. paradisii* (BACCHI, 1943).

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RESUMEN

En este estudio se intenta definir los principales de los estados previos a la fertilización encontrados en el óvulo del material que se investiga. El origen de los sacos múltiples embrionarios en Toddalia asiática puede ser debido a la actividad de las megasporas de las tétradas lineares iguales o diferentes. La poliembrionía puede ser debida a la producción de embriones a partir de gametofitos múltiples.

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