# DEVELOPMENT OF FEMALE GAMETOPHYTE IN SOME SCROPHULARIACEAE

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## Abstract

Development of female gametophyte has been worked out in 10 species of the family Scrophulariaceae. Ovules are unitegmic, tenuinucellate and anatropous in all except in *Collinsia heterophylla* where they become amphitropous. Development of the female gametophyte conforms the *Polygonum*-type.

## Introduction

Embryological literature in the family Scrophulariaceae has been reviewed a few times (see Davis, 1966 ; Tiagi & Varghese, 1970). Beside these reviews, a few papers have also appeared (Singh & Taneja, 1968; Taneja, 1970; Vijayaraghavan & Ratnaparkhi, 1972 ; Kapoor *et al.*, 1975 ; Bhatnagar & Kallarakal, 1979 ; Chandra *et al.*, 1980). The present account deals with the development of female gametophyte in 10 species belonging to six tribes, namely, *Verbasum phlomoides* Linn. (Verbaceae), *Angelonia angustifolia* Benth. (Hemimerideae), *Antirrhinum orontium* var. *indicum* Chav., *A. orontium* var. *parviflorum* D.c.f., *Linaria bipartita* Willd. (Antirrhineae), *Collinsia heterophylla* R. Grah., *Russelia equisetiformis* Schlecht. and *R. sarmentosa* Jacq. (Cheloneae), *Mimulus luteus* Linn., *Lindenbergia indica* (Linn.) Kuntze (Gratioleae) and *Veronica anagallis acquatica* Linn (Digitaleae).

## Material and methods

Floral buds and flowers of all the taxa studied were collected at different stages of growth from the gardens of the National Botanical Research Institute, Lucknow and fixed in formalin-acetic acid-alcohol (FAA) and later stored in 70 per cent ethanol. Usual methods of dehydration, infiltration and embedding in paraffin wax were followed. Serial microtome sections cut between 8-10 $\mu m$ thickness were stained with safranin-fast green combination.

## Observations

*Ovary and ovules*—The gynoecium is bicarpellary and the ovary is syncarpous, bilocular and superior with indefinite number of ovules attached to the swollen axile placenta (Text-fig. 1A). The ovular primordia arise as small, erect, mound-shaped protuberances and, as they grow, they bend on one side (Text-fig. 1 B,C). The ovules finally become anatropous in most cases (Text-fig. 1D). Being large in number, all the ovules do not get sufficient space in the ovary to become completely inverted and many of them, therefore, remain half inverted or somewhat obliquely placed on the placenta.

The initial of the single integument arises nearly at the lower level of the archesporial cell and ultimately surrounds the nucellus leaving a narrow micropyle by the time megaspore tetrad stage is reached (Text-fig. 1 D). In *Angelonia angustifolia* the embryo sac is embedded deep in the ovule and the micropyle is fairly long and narrow (Text-fig. 1 E). The

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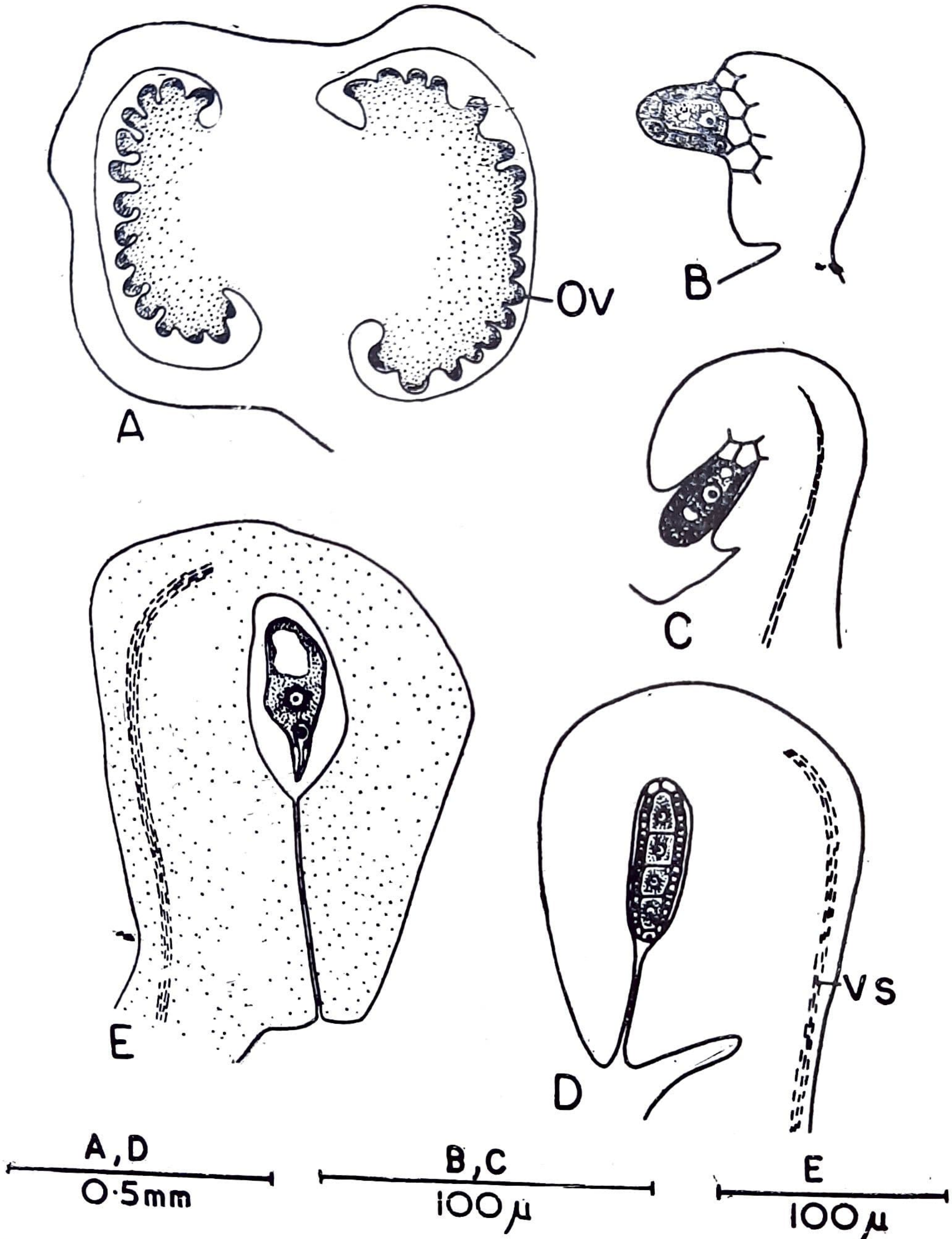
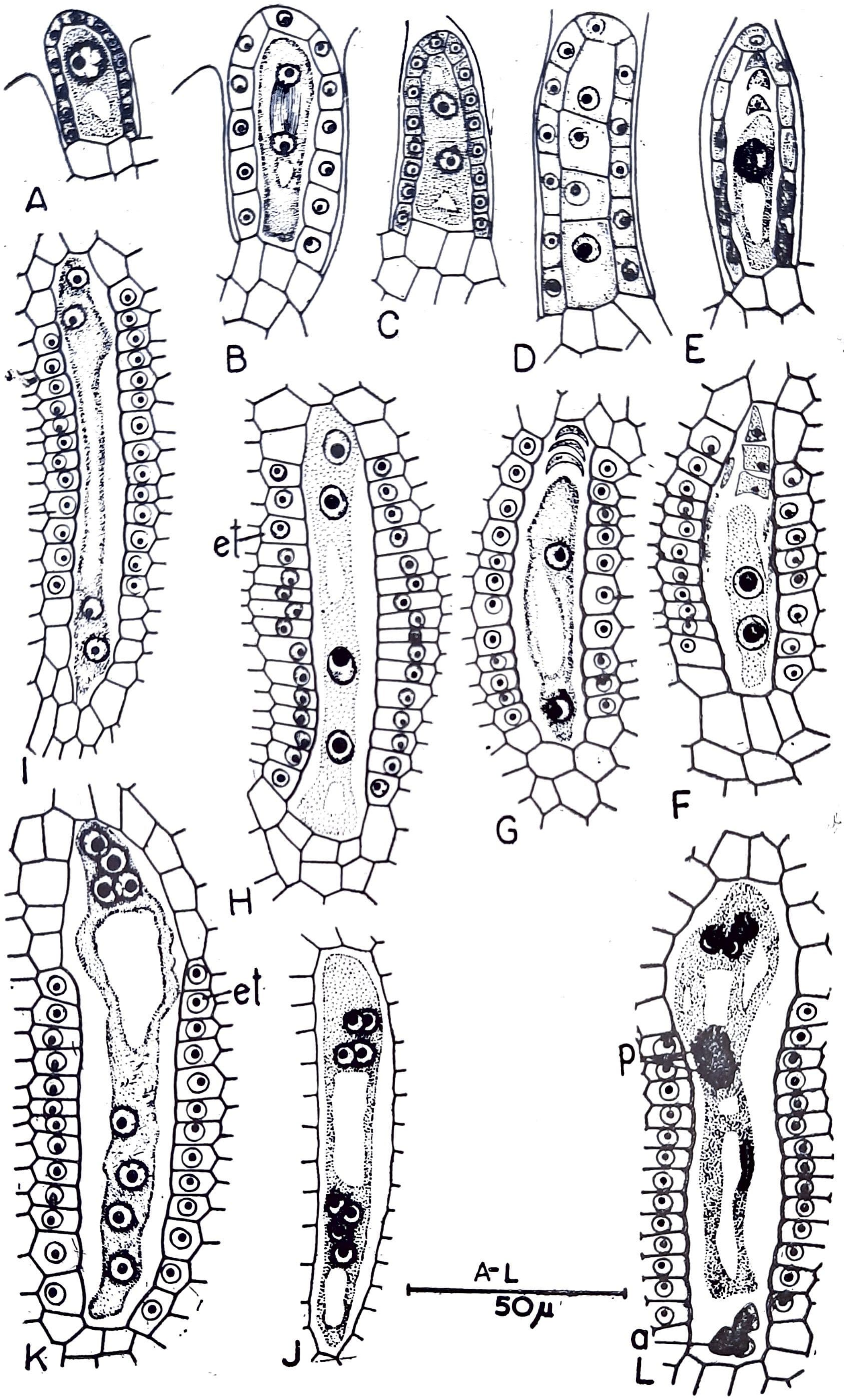
vascular supply of the ovule extends through the funicle up to chalaza and is procambial in nature in pre-fertilization stages.

A small group of cells at the chalazal end of the embryo sac become conspicuous due to their rich cytoplasmic contents. In *V. phlomoides*, *R. equesetiformis* and *M. luteus*, this pad is quite distinct up to organised embryo sac stage but after fertilization the cells gradually degenerate long before the seed matures.

*Megasporogenesis and megagametogenesis*—A single archesporial cell differentiates in the hypodermis of each ovular primordium and functions directly as the megaspore mother cells (Text-fig. 2A) and undergoes meiosis to form first a dyad and then a tetrad of megaspores (Text-fig. 2 B, C, D). The megaspore towards the chalazal end of the tetrad functions while the other three degenerate (Text-fig.2E). The functional megaspore undergoes three

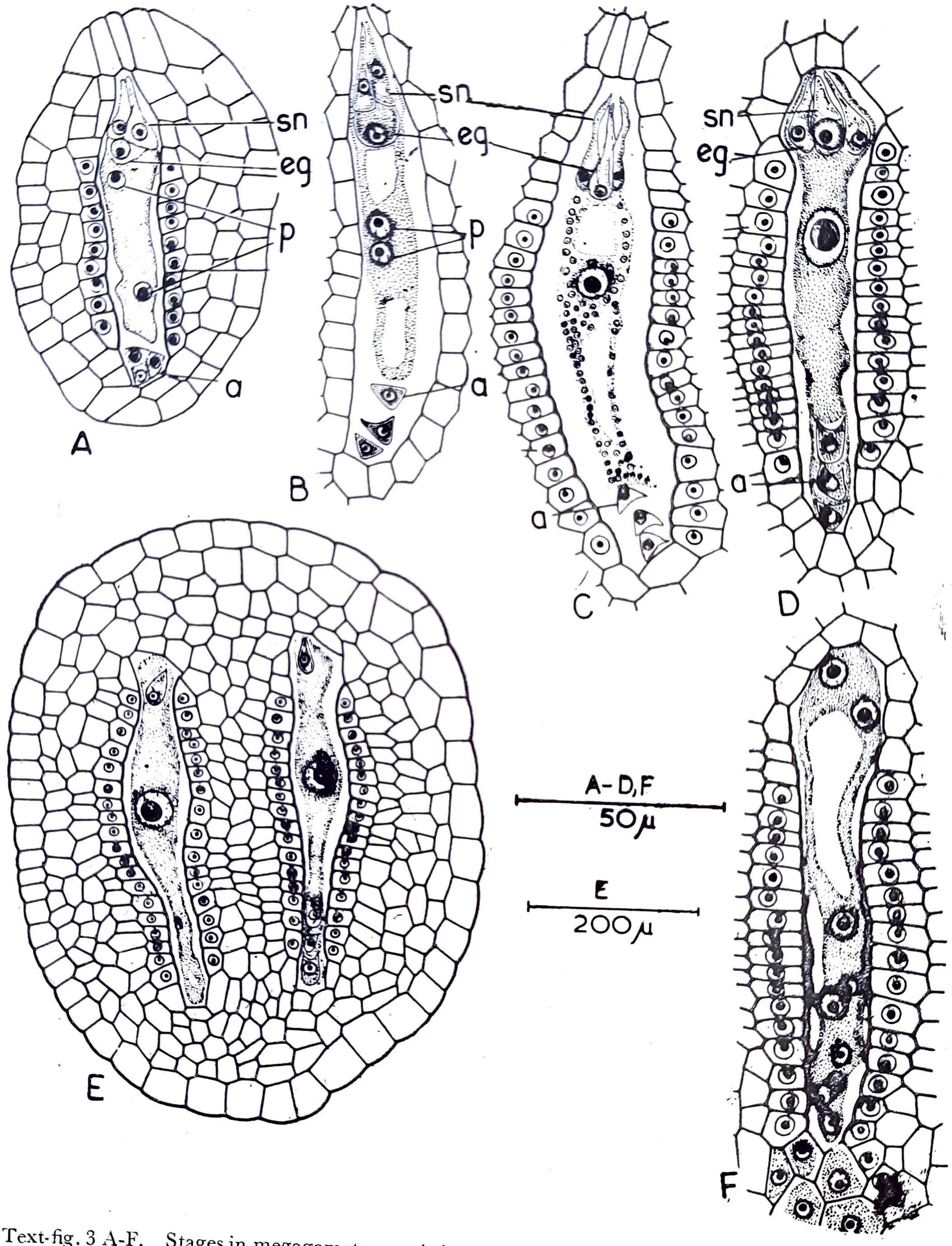



Text-fig. 1 A-E. Stages in ovule development in some Scrophulariaceae. **A,** T.s young ovary showing swollen axile placenta ad ovule primordium in *Verbascum phlomoides*; **B, C, D,** Stages of ovule development in *Verbascum phlomoides*; **E,** L. S. ovule in *Angelonia angustifolia*. (OV, ovule primordium; VS, vascular supply)




Text-fig. 2 A-L. Stages of megasporogenesis and megagametogenesis in some Scrophulariaceae. **A,** *Lindenbergia indica;* **B, F, H,** *Mimulus luteus;* **C,** *Russelia equisetiformis;* **D,** *Collinsia heterophylla*, **E, L,** *Verbasacum phlomoides;* **G. I.,** *Antirrhinum orontium* var. *indicum;* **J.** *Angelonia angustifolia;* **K,** *Mimulus luteus.* (a, antipodals; et, endothelium; p, polars).

mitotic divisions unaccompanied by wall-formation resulting in two, four and ultimately eight-nucleate female gametophyte (Text-fig. 2 F-K). The antipodals in most cases are the first to organise into cells (Text-fig. 2L). The fully organised female gametophyte is seven-celled and the two polars get fused to form the secondary nucleus (Tesg-fig. 3 A-D)




Text-fig. 3 A-F. Stages in megagametogenesis in some Scrophulariaceae. **A,** *Vernoica anagallis-aquatica*; **B,** *Russelia equisetiformis*; **C,** *Antirrhinum orontium* var. *indicum*; **D, E, F,** *Mimulus luteus*. (a, antipodals; eg, egg; p, polars; sn, synergids).

The egg apparatus comprises two elongated synergids and an egg. The antipodals are ephemeral and are not discernible after fertilization, but in *Mimulus luteus*, occasionally, they persist for sometime after fertilization (Text-fig. 3E). Besides the pattern of development described above, in a few embryo sacs of this taxon unequal sized nuclei were seen (Text-fig. 3F). The smaller nuclei were generally present in the chalazal region. It is very likely that these nuclei might have migrated in the embryo sac from the degenerating ovular cells at the chalazal end but their exact mode of origin has not been seen. Same feature is reported in *Hedychium gardnerianum* (Madge, 1934) and *Pandanus* (Fagerlind, 1940). Concomitant with the development of female gametophyte, the nucellar epidermis starts degenerating and by the time two-nucleate embryo sac stage is reached, it is represented only by its remnants (Text-fig. 2F).

The endothelium is differentiated at the megaspore tetrad stage and is well-marked by the time female gametophyte reaches two-nucleate stage (Text-fig. 2 F, G). There is no differentiation of a distinct endothelium in *Angelonia angustifolia*, *Russelia equisetiformis* and *R. sarmentosa*. Srinivasan (1940) also reports absence of endothelium in *Angelonia grandiflora*. The endothelium does not keep pace with the developing embryo sac with the result that it does not surround the embryo sac in the region of the egg apparatus. (Text-figs. 2L ; 3 A-E).

In a few ovules of *Mimulus luteus* two embryo sacs separated apart by a mass of parenchymatous tissue have been seen (Text-fig. 3E). These embryo sacs are surrounded by separate endothelial layer.

## Discussion

Ovules are basically anatropous, unitegmic and tenuinucellate but they may also be hemianatropous are campylotropous. In *Collinsia heterophylla* they are anatropous at the megaspore mother cell stage but become amphitropous during post fertilization stages (present study). Arekal (1963) reports hemianatropous ovules in *Euphrasia arctica* and Tiagi (1965) describes the condition to be campylotropous in *Melampyrum numerosum* and *M. arvense*. In *Torenia fournieri* the form of the ovules ranges from anatropy to compylotropy (Guilford & Fisk, 1952).

During the present study only one archesporial cell is found to differentiate in the hypodermal layer of the nucellus and subsequently functioning as the megaspore mother cell. More than one archesporial cell is found in *Angelonia grandiflora* (Srinivasan, 1940), *Gerardia pedicularia* (Arekal, 1964) and *Nemesia strumosa* (Singh & Taneja, 1968). Development of the female gametophyte conforms to the Polygonum type. According to Crete (1958), the development of the female gametophyte in *Collinsia bicolour* (-*C. heterophylla*) involves more than one megaspore, but he is uncertain about the precise origin. During the present investigation the development is found to be clearly monosporic in the same species.

The antipodal cells are three in number and are ephemeral except occasionally in *Mimulus luteus* (present study). Persistence of antipodal cells after fertilization for some time is reported in *Mimulus ringens* (Arekal, 1965) and *Alectra parasitica* var. *chitrakutensis* (Chandra *et al.*, 1980).

The two polars generally fuse before fertilization to form secondary nucleus. Arekal (1963) reports that in *Melampyrum lineare* there is no fusion of polars and the micropylar polar fuses with the male gamete to form the primary endosperm nucleus while the small chalazal polar degenerates.

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