

DEVELOPMENT OF MALE GAMETOPHYTE IN SOME SCROPHULARIACEAE*

SAROJ CHANDRA

National Botanical Research Institute, Rana Pratap Marg, Lucknow 226 001, India

Abstract

Development of male gametophyte has been investigated in 10 species of Scrophulariaceae. Development of anther-wall follows the dicotyledonous type and it consists of a layer each of epidermis, endothecium, middle layer and tapetum of glandular type. Pollen grains dehisce at bicelled stage and have three germ pores.

Introduction

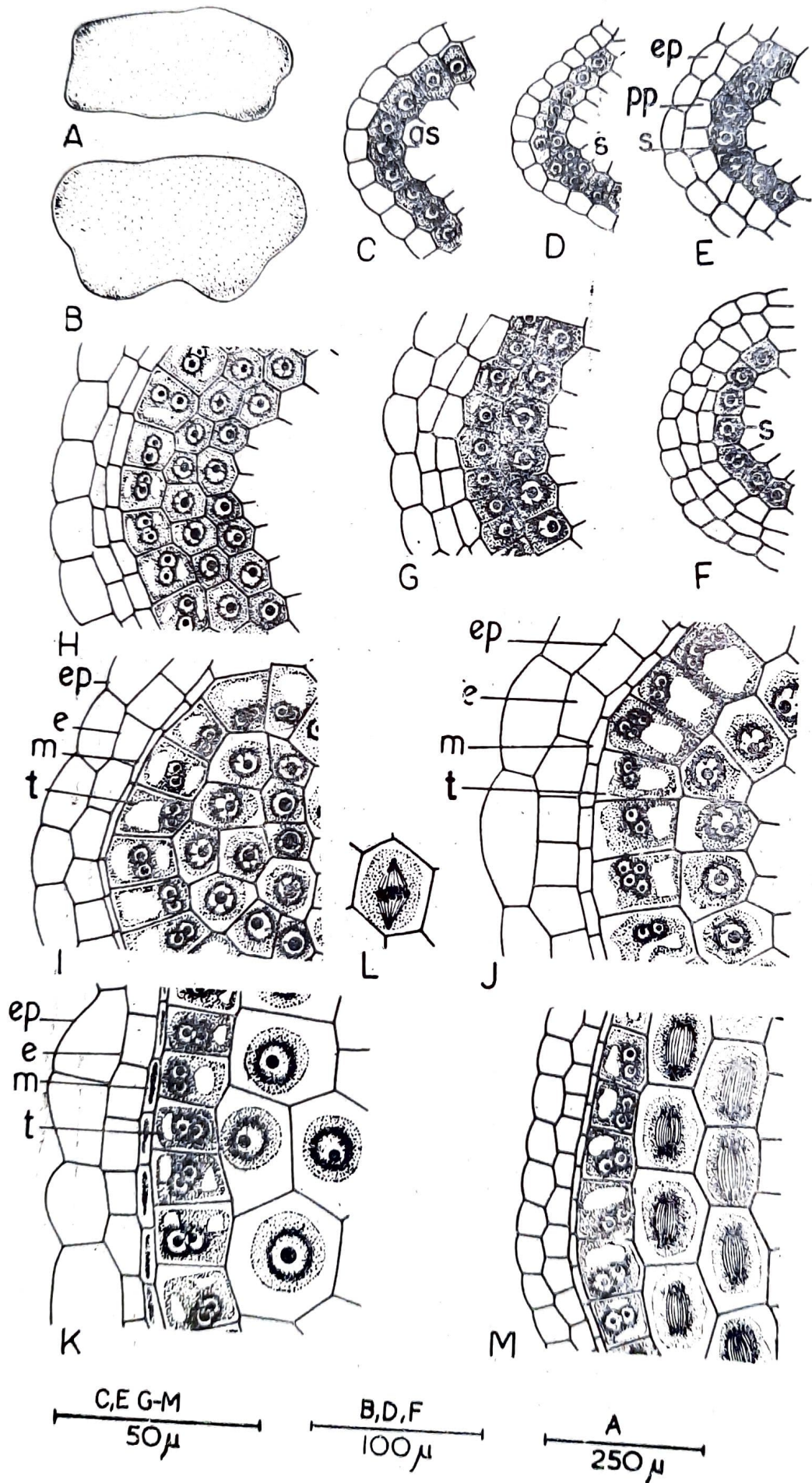
Embryological investigations in the family Scrophulariaceae have been reviewed by Davis (1966) and Tiagi and Varghese (1970). The present communication describes in detail development of male gametophyte in 10 species belonging to six tribes namely, *Verbascum phlomoides* Linn. (Verbaceae), *Angelonia angustifolia* Benth. (Hemimerideae), *Antirrhinum orontium* var. *indicum* Chav., *A. orontium* var. *parviflorum* D.c.f., *Linaria bipartita* Willd. (Antirrhineae), *Collinsia heterophylla* R. Garh., *Russelia euqisetiformis* Schlecht. and Cham., *R. sermentosa* Jacq. (Cheloneae), *Mimulus luteus* Linn., *Lindenbergia indica* (Linn.) Kuntze (Gratiroleae) and *Veronica angallis aquatica* Linn. (Digitaleae).

Material and method

Buds and flowers of all the taxa were collected at different stages of growth from the garden of the National Botanical Research Institute 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 μ m thickness were stained with safranin-fast green combination.

Observations

Anther wall, microsporogenesis and microgametogenesis—Young anthers in cross-section are nearly oval in outline which soon become more or less rectangular (Text-fig. 1A) and thereafter each anther shows differentiation of four lobes (Text-fig. 1B). At this stage a number of cells in the hypodermal region become distinguishable in each lobe and constitute the male archesporial tissue (Text-fig. 1C). Periclinal division ensues in these cells to form the primary parietal and the primary sporogenous layer on outer and inner sides, respectively (Text-fig. 1 D, E). The cells of the former divide again in periclinal plane resulting in two layers (Text-fig. 1 F). The cells of the inner layer function as the tapetum while those of the outer layer undergo further periclinal division to give rise to the endothecium on the outer side and a single middle layer on the inner (Text-fig. 1 G). Development of the anther wall in all these species follows the Dicotyledonous type (Davis,



Text-fig. 1

1966). Cells of the endothecium in later stages show fibrous thickenings which are well developed at the time of anther dehiscence (Text-fig. 2 I, J, K, L).

The cells of the middle layer elongate considerably in tangential plane and begin to degenerate as the microspore mother cells prepare for meiosis (Text-fig. 1 I, J, K); they finally disappear as the microspores separate from the tetrads. The tapetal cells enlarge, show vacuolation and become binucleate (Text-fig. 1 H, I, J, K, M). In *Russelia equisetiformis* the tapetal cells may remain either binucleate or may become tetranucleate (Text-figs. 1 J; 2 B). The tapetum is of glandular type and is completely absorbed by the time mature pollen grains are formed (Text-fig. 2, K, L). The cells of the epidermis show cytoplasmic content even at the mature pollen grain stage and are elongated in tangential plane but in *Russelia sarmentosa* they show radial elongation too (Text-fig. 2 J.) They remain intact and do not rupture at this stage (Text-fig. 2 I-L).

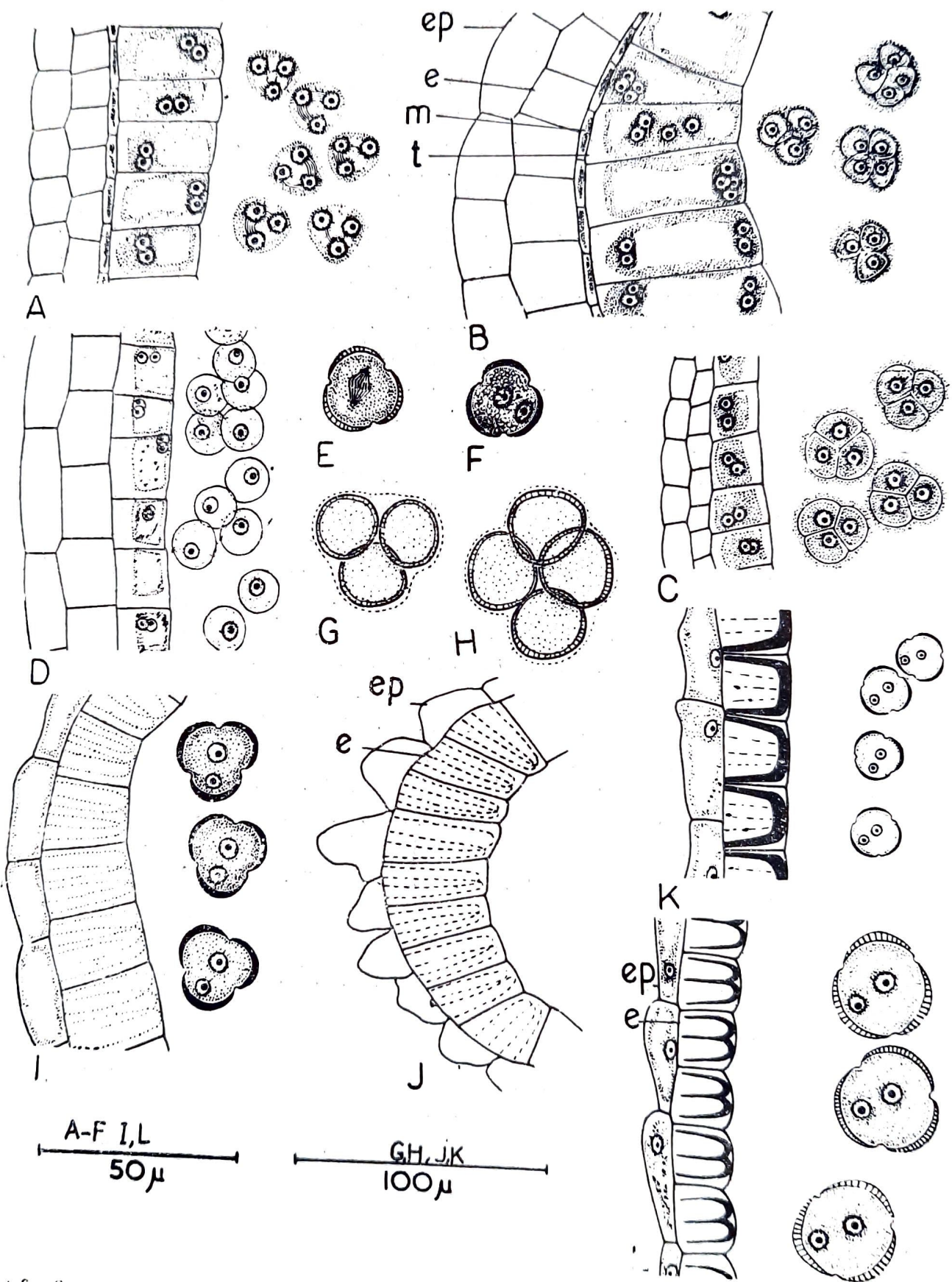
Concomittant with the development of anther wall layers, the sporogenous cells undergo a few mitotic divisions forming more cells (Text-fig. 1 H, I). These cells function as the microspore mother cells. The nucleus of each microspore mother cell undergoes meiosis (Text-fig. 1 J, K, L, M) and cytokinesis is of the simultaneous type. Soon after meiosis, the original cell wall of microspore mother cells becomes mucilagenous and surrounds the microspore tetrads (Text-fig. 2 B, C). Secondary spindles connecting the four nuclei are visible in the microspore mother cells before cytokinesis occurs (Text-fig. 2 A). Cytokinesis starts through invagination of the cytoplasm at the periphery and finally reaches the centre. The microspores are arranged mostly in tetrahedral manner (Text-fig. 2 B, C) in all the species except in *Russelia equisetiformis* and *Veronica anagallis-aquatica* where isobilateral and decussate arrangements are also met with (Text-fig. 2 B). In a very few cases in *Verbascum phlomoides* decussate arrangement also occurs.

The mucilagenous wall of the microspore mother cell gets dissolved and the individual microspores are liberated to form uninucleate pollen grains (Text-fig. 2 D). The nucleus of the pollen grain soon divides mitotically (Text-fig. 2 E) forming a small lenticular generative cell and a large tube cell. The pollen grains at the time of anther dehiscence is bicelled (Text-fig. 2 F, I, K, L). They have a thin intine and comparatively thick exine, and show three germ pores. In *Verbascum phlomoides*, besides individual pollen grains, triads and tetrads of mature pollen grains are also observed (Text-fig. 2 G, H).

Discussion

Anther is tetrasporangiate in all 10 species studied, a feature also reported in other species of Scrophulariaceae investigated (Davis, 1966). However, *Calceolaria* (Varghese, 1964) shows a reduction and sterilisation of their sporangia where the connective is extended laterally bearing two fertile and two sterile locules. Tiagi (1956) and Varghese (1964) report a bilocular anther in *Striga* and *Sopubia*, respectively.

Text-fig. 1—A-M. Stages in microsporogenesis and microgametogenesis in some Scrophulariaceae. **A, B.** T.S. in very young anther in *Verbascum phlomoides* and *Collinsia heterophylla*, respectively; **C, D, E.** T. S. part of anther in *Angelonia angustifolia*, *Mimulus luteus* and *Russelia equisetiformis*, respectively; **F, G.** T. S. part of anther showing wall layers and sporogenous tissue in *Mimulus luteus* and *Russelia equisetiformis*, respectively; **H, I, J, K.** T. S. part of anther to show the binucleate tapetum in *Angelonia angustifolia*, *Russelia sarmentosa*, *R. equisetiformis* and *Verbascum phlomoides*, respectively; **L.** Microspore mother cell in *Verbascum phlomoides* showing metaphase stage; **M.** L. S. part of anther showing telophase stage in microspore mother cells in *Veronica* and *galis-aquatica*. (**as**—archesporial cells; **e**, endothecium; **ep**, epidermis; **m**, middle layer; **pp**, primary parietal layer; **s**, sporogenous cells; **t**, tapetum)



Text-fig. 2—A-L. Stages in microsporogenesis and microgametogenesis in some Scrophulariaceae. For details see text. **A, B, I.** *Russelia equisetiformis*; **C, F.** *Lindenbergia indica*; **D.** *Collinista heterophylla*; **F, G, H, L.** *Verbascum phlomoides*; **J.** *Russelia sarmentosa*; **K.** *Angelonia angustifolia*. (**e**, endothecium; **ep**, epidermis; **m**, middle layer; **t**, tapetum)

The endothecium in all the species is single-layered and its cells develop fibrous thickening at the time of anther dehiscence. Varghese (1963) reports that in *Veronica agrestis* the cells of endothecium in an anther are with or without thickening. This is quite interesting, but such a feature has not been seen in *V. anagallis-aquatica* during the present study. The significance of occurrence of such a feature in the same species is not known at present. Arekal (1963) reports to 2 to 6 layered endothecium in *Chelone glabra* and cells of these layers develop fibrous thickening.

Only a single middle layer is seen during the present study, but in *Alectra parasitica* var. *chitrakutensis* 2-3 middle layers are found (Chandra *et al.*, 1980). Arekal (1963, 1964) also reports two middle layers in *Chelone glabra* and *Gerardia pedicularia*.

The tapetum is formed of a single layer of cells and is glandular in nature. Arekal (1964) reports the tapetal cells often becoming two-layered in *Gerardia pedicularia*, a feature also seen in *Striga euphrasioides* (Tiagi, 1956). In the latter species, however, many cells of the tapetum contain more than two nuclei which may fuse and become polyploid. Likewise, Joshi and Varghese (1963) record that in *Anticharis linearis* the tapetum becomes multilayered at some places. The tapetal cells are uninucleate to begin with but at the time of meiosis in the microspore mother cells they become binucleate. In *Russelia equisetiformis* the tapetal cells may remain either binucleate or may become tetranucleate. Millsaps (1936) finds bi-or multi-nucleate tapetal cells in *Paulownia tomentosa*, but on the other hand, Raghavan and Srinivasan (1951) and Varghese (1963) record only multi-nucleate tapetal cells in *Illysanthes parviflora* and *Veronica agrestis*, respectively. The tapetal nuclei have not been observed to fuse at any stage in the present study.

Acknowledgements

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