T. PULLAIAH* & P. S. LAKSHMI*:　**Embryology
of *Cirsium acaule* Scop.**

T. プライア* & P. S. ラクシュミ*:　*Cirsium acaule* Scop. の胚発生

Cirsium, a large genus of about 150 species belonging to the tribe Cardueae of the family Compositae, is mainly distributed in the north temperate regions. Embryological studies on the genus are scanty. Poddubnaja-Arnoldi (1931) studied embryology of *Cirsium arvense.* Dahlgren (1924) reported nuclear type of endosperm development in. *C. arachnoideum,* while Mestre (1963–1964) reported *Senecio* variation of asterad type of embryo development in *C. acaule, C. lanceolatum* and *C. palustre.* The plant was chosen for embryological investigation in view of the paucity of literature on the genus.

Material and methods　Capitula at different stages of development were collected by the senior author from the plants grown in the Botanical gardens of Moscow State University, U. S. S. R. during August 1978.　The capitula were fixed in formalin-acetic-alcohol (F. A. A.).　The material was dehydrated in tertiary butyl alcohol series.　Embedding was done in paraffin of 58–60°C melting point.　Microtome sections were cut at 8–10 μm thickness.　Staining was done in Delafield's haematoxylin.

Observations

Microsporangium, microsporogenesis and male gametophyte.　The young anther in cross section shows an oval mass of cells surrounded by epidermis. When a four-lobed contour is formed a hypodermal row of 6 archesporial cells gets differentiated.　They become prominent with their larger size and conspicuous nuclei (Fig. 1A).　These archesporial cells expand radially and undergo periclinal division forming a primary sporogenous layer inside and a primary parietal layer towards outside (Fig. 1B).　The primary parietal layer divides periclinally to form two layers (Fig. 1C), of which the inner functions as the tapetum and the outer one undergoes one more transverse division forming a hypodermal layer and a middle layer (Fig. 1D).　This type of wall development is known as the

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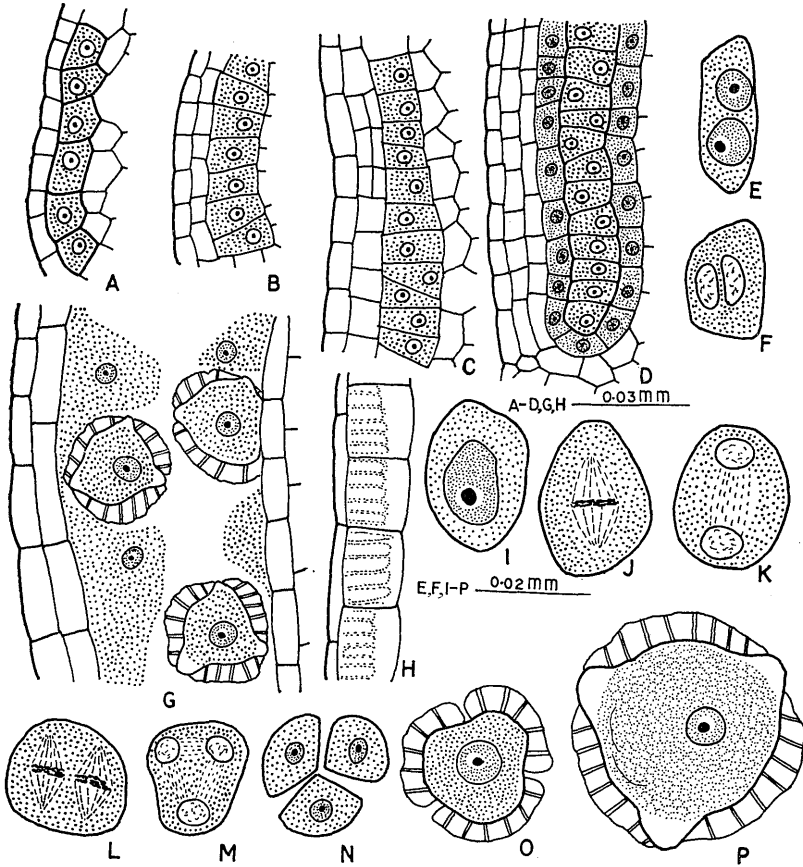
Fig. 1. *Cirsium acaule*. A–D. Longitudinal section of part of anther lobes showing development of wall layers. E, F. Tapetal cells. G. Longitudinal section of part of anther lobe showing periplasmodial tapetum. H. Fibrous endothecium. I. Pollen mother cells. J–M. Pollen mother cells in meiotic divisions. N. Microspore tetrad. O. One-nucleate pollen grain. P. Mature pollen grain.

dicotyledonous type of Davis (1966).

The epidermal cells undergo only anticlinal divisions and keep pace with the expanding anther. Later on these cells get much stretched and flattened. The hypodermal cells develop fibrous thickenings at about the time of formation of

3-celled pollen grains (Fig. 1H). The middle layer gets crushed and degenerated at the time of first meiotic divisions of pollen mother cells.

The innermost layer of the anther wall is the anther tapetum. Tapetal cells towards the connective side develop from the cells of the connective tissue. Tapetal cells undergo nuclear division resulting in two-nucleate cells (Fig. 1E). In some cases tapetal cells with two polyploid nuclei have been met with (Fig. 1F). The tapetum is of the periplasmodial type. When one-nucleate pollen grains have already started developing exine, the walls of the anther tapetum breakdown and the cytoplasm protrudes in (Fig. 1G). The tapetum gets absorbed even before the cytoplasm of different tapetal cells fuse.

The primary sporogenous cells undergo only transverse divisions and form a single row of pollen mother cells (Fig. 1D). The pollen mother cells round off and undergo meiotic divisions (Fig. 1L, M). Cytokinesis is simultaneous. The tetrads are of the tetrahedral type (Fig. 1N). The microspore after its release from the pollen tetrad enlarges, gradually becomes spherical and develops a thick exine (Fig. 1O, P). The pollen grains are three-celled at the shedding stage with three germ pores (Fig. 1P). The sperm cells are filiform and much elongated.

Ovary and ovule. The ovary as characteristic of Compositae is bicarpellary syncarpous and unilocular with anatropous, unitegmic and tenuinucellate ovule. The ovule arises as a papillate outgrowth from the base of the ovary. Later on due to anticlinal divisions the ovule gets curved and becomes anatropous (Fig. 2A, B).

A feature of special interest in *C. acaule* is the occurrence of obturator. The cells of the funicle lining the micropylar canal elongate radially, acquire dense cytoplasm and function as obturatory cells (Fig. 2C). As they are pointed towards the micropyle, they may help in directing the pollen tube towards the micropyle.

The innermost layer of the integument becomes differentiated as the endothelium during megaspore tetrad formation (Fig. 2D). During further development, this layer remains uniseriate (Fig. 3A, C), but at places it is two-celled thick. The cells of the endothelium remain uninucleate.

Megasporogenesis and female gametophyte. A female archesporial cell is differentiated hypodermally in the ovule. This cell directly functions as the megaspore mother cell and enlarges considerably. A linear tetrad of megaspores is formed consequent upon the two meiotic divisions. The chalazal megaspore
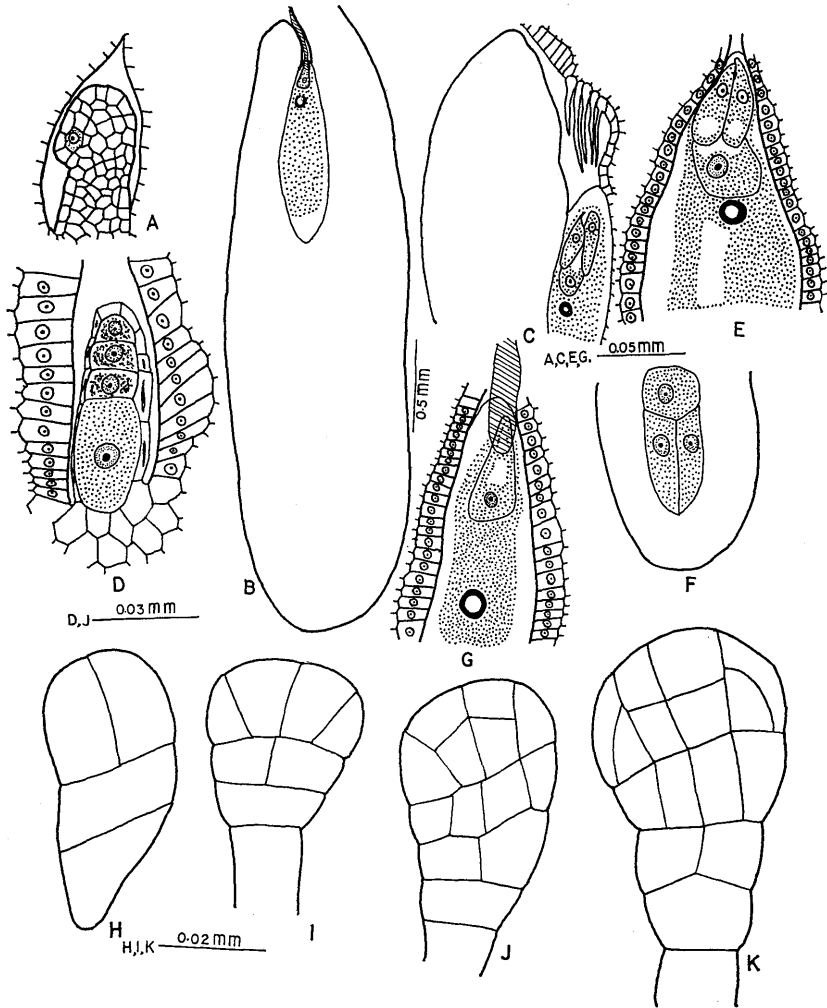
Fig. 2. *Cirsium acaule*. A. Young ovule. B. Anatropous ovule. C. Longitudinal section of part of ovule showing obturatory cells. D. Linear megaspore tetrad. E. Micropylar part of the embryo sac showing egg apparatus and secondary nucleus. F. Antipodal cells. G. Micropylar part of the embryo sac showing zygote, triple fusion nucleus and pollen tube. H–K. Development of the embryo.

is functional while the micropylar three degenerate (Fig. 2D). The functional megaspore undergoes three mitotic divisions resulting in an eight-nucleate embryo sac of the *Polygonum* type. The embryo sac is narrow. It elongates considerably after organisation and continues to elongate even during endosperm formation (Fig. 3A–C). The synergids are hooked (Fig. 2E). The antipodal cells simulate the egg apparatus in arrangement (Fig. 2F). Antipodal cells are persistent and they are seen up to globular stage of the embryo (Fig. 3 A–C).

Fertilisation, endosperm and embryo. The pollen tube enters the ovule through the micropyle and hence it is refered as porogamous (Fig. 2B, G). Syngamy and triple fusion occur more or less simultaneously.

The primary endosperm nucleus divides much earlier than the zygote forming two nuclei. These two nuclei undergo many more divisions and the resulting nuclei are mostly distributed in the micropylar part of the embryo sac. Wall formation commences at the micropylar end and proceeds towards the chalazal end (Fig. 3 B, C). Finally the embryo sac is completely filled with cellular tissue. Endosperm is completely absorbed by the growing embryo but for one or two layers of cells.

Embryo development (Fig. 2 H–K) is in complete conformity with that studied by Mestre (1963–64). The embryo development follows the *Senecio* variation of the Asterad type.

Discussion Banerji (1940) reported that pollen grains in *Carthamus tinctorius* at maturity are 1-celled. Maheswari Devi & Pullaiah (1976) reinvestigated and found that pollen grains are shed at 3-celled stage. In
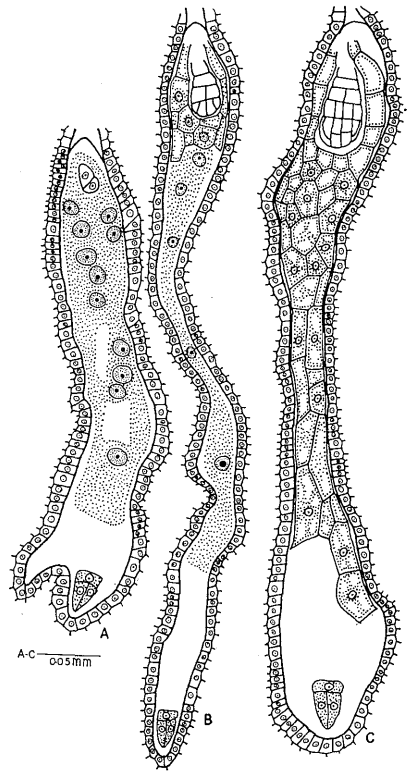

Fig. 3. *Cirsium acaule*. A–C. Various stages in the development of endosperm.

fact 3-celled pollen grains at shedding stage is the characteristic feature of Compositae (Brewbaker 1967) except for some apomictic species. In *Cirsium acaule* (present study) also pollen grains are 3-celled.

In *Cirsium acaule* obturatory cells have been observed (present study). In the family Compositae presence of obturatory cells is a rare feature and has been reported only in a few members like *Lactuca muralis, Mutisia candolleana* (Dahlgren 1920, 1924), *Ainsliaea aptera* (Kapil & Sethi 1962), *Carthamus tinctorius* (Maheswari Devi & Pullaiah 1976) and *Gerbera jamesonii* (Pande & Chopra 1976).

Embryo sac development in the tribe Cardueae is of the monosporic *Polygonum* type. Such a type has been reported in *Centaurea cirrhata* (Lavaille 1911), *Carduus acanthoides, Onopordon acanthium, Cirsium arvense, Jurinea arachnoidea, Sassurea amara, Centaurea scabiosa, Cnicus benedictus, Serratula coronata, Crupina crupinastrum, C. vulgaris, Xeranthemum squarrosum, X. cylindricum, X. annuum, Echinops sphaerocephalus* (Poddubnaja-Arnoldi 1931), *Carthamus tinctorius* (Banerji 1940, Maheswari Devi & Pullaiah 1976), *Volutarella ramosa* (Deshpande 1964), *Centaurea cineraria* (Renzoni-Cela 1963) and *Cirsium acaule* (present data).

Endosperm development in all the members of the tribe Cardueae so far investigated is of the nuclear type while embryo development conforms to the *Senecio* variation of the asterad type.

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アザミ属 Cirsium acaule の花粉，胚嚢，胚乳，胚形成を報告した。葯室の壁は細胞層からなり，その最内層は2核の細胞からなる periplasmoidal tapetum を作る。花粉母細胞は同時分裂を行って四面体の四分子を作る。花粉は3細胞期に放出される。胚珠は薄層珠心で1枚の珠皮をもち倒生である。胚柄には腺細胞状の obturator がある。大胞子母細胞は珠心組織内に1個作られ，減数分裂を経て1列の4細胞となり，そのうちカラザ方向の1個が胚嚢母細となる。胚嚢形成は *Polygonum* type である。胚乳形成は多核型である。胚形成は Asterad type の *Senecio* variation である。

□萩原博光・伊沢正名 : **森の魔術師たち** 110 pp. 1983. 朝日新聞社，東京. ￥1,600. 変形菌研究者の萩原氏と，特にキノコの写真を得意とするプロカメラマンの伊沢氏とによる，いわゆる真正粘菌 (Ceratiomyxales を含む) についてのすぐれた案内書である。萩原氏の解説は変形菌類の生活史，代表的な属や種の説明，研究小史，採集と標本作製などに及び，森の魔術師たち (変形菌類) の世界を平易に，しかもレベルを下げることなく紹介している。伊沢氏の80葉をこえるカラー写真は「変形菌の華麗な世界」(本書副題) をみごとにとらえ，プロの実力に改めて感服させられる。変形菌類の話をする時に，ぜひ学生に紹介したいと思う本である。なお，従来「○○ホコリカビ」と呼んでいた変形菌類の和名を，本書では「○○ホコリ」に統一してある。これによって和名の共通語尾が縮小され，個々の和名が印象上たいへん区別しやすくなり，すっきりしたものになっている。今後踏襲せられるべきものと考え，評者はここに支持を表明しておきたい。

(三浦宏一郎)