“藏茵陈”——川西獐牙菜的大孢子发生及雌配子体发育

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摘 要: 首次报道了藏茵陈川西獐牙菜的大孢子发生及雌配子体发育。川西獐牙菜为倒生胚珠, 薄珠心, 单珠被, 线形大孢子四分体, 胚囊发育为蓼型, 反足细胞分裂为 5～8 个, 宿存, 每个细胞均异常膨大, 并多核。反足细胞在龙胆科一些一年生高山植物中的宿存和分裂具有重要的生殖适应和进化意义, 这对于这些植物在青藏高原严酷的自然环境下, 在短时间内完成其生活史是非常重要的。

关键词: 川西獐牙菜; 大孢子发生; 雌配子体发育; “藏茵陈”

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Megasporogenesis and female gametogenesis development of the Tibetan medicine “Zang Yin Chen”——Swertia mussotii (Gentianaceae)

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Abstract: The present paper firstly reports the development of megasporogenesis, female gametophyte in *Swertia mussotii*, a famous Tibetan medicine. The ovule is anatropus, tenuinucellate, initegmic, the megaspore tetrad is linear and embryo sac development is of the Polygonum type. The three antipodal cells can be divided into 5～8 cells with enlarged and polyploid nuclei. The dividing and persisting of the antipodal cells in alpine annual Gentianaceae plant are of significance in reproductive adaptation and evolution, which is important for those ephemeral species of Gentianaceae to complete their life cycle under the arid surrounding of Qinghai-Xizang plateau within a few weeks' growing season.

Key words: *S. mussotii*; megasporogenesis; female gametophyte; Tibetan medicine; “Zang Yin Chen”

Swertia mussotii (Gentianaceae), an effective Tibetan medicine to cure liver disease, is mainly distributed in the Qinghai-Xizang Plateau, with a cold climate and short growing season. The annual species complete their life cycle within a few weeks in this arid surrounding. It is a mystery why and

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how these plants acquire their reproductive adaptations to the plateau and normally produce their offspring. This ephemeral species relies on the seeds to reproduce in natural conditions. But during the propagation of this species, it is difficult to germinate seeds.

The present paper reports the ovary of *S. mussotii* for investigating its reproductive pattern and adaptation to the Qinghai-Xizang Plateau.

1 Materials and Methods

Materials investigated for the present study were collected from Yushu, Qinghai province, China. The voucher (Liu Jian-quan) is deposited in the Herbarium of Northwest Plateau Institute of Biology, Chinese Academy of Sciences, China (HNWP).

Ovules at different stages of development were fixed in the formalin-acetic-alcohol (FAA). After being stained in Ehrfich's hematoxylin, the material was embedded in paraffin by the conventional method and sectioned at the thickness of 5～10 μm, sections were stained with safranin-fast green. Observation and photographs were taken under Olympus BH2 microscope.

2 Observations and Results

2.1 Macrosporangium and macrosporogensis

The ovary was superior, bicarpellary, syncarpous and unilocular with parietal placentae. There were 8 rows of ovules in the transection of ovary (Fig. 10). The integument initiated by periclinal and oblique division at the base of nucellus. The ovule of *S. mussotii* is unitegmic. The integument reached the top of nucellus and formed a micropyle by continued division. The type of ovule is anatropous.

At the stage of microsporocyte, a single hypodermal archesporial cell differentiated in the young nucellus and functioned directly as the megasporocyte (Fig. 1) which was characterized by a large nucleus and dense cytoplasm. Thus, the ovule of *S. mussotii* was tenuinucellate. The megasporocyte underwent meiosis, forming a linear tetrad of megaspores (Figs. 2、3). The three micropylar megaspores eventually degenerated, while the chalazal one became functional (Fig. 4).

2.2 Embryo sac and female gametophyte

A 7-cells and 8-nucleate female gametophyte of the Polygonum type formed by three meiosis divisions of the functional megaspore (Figs. 5、6). The three micropylar nuclei became the egg and the two synergids, they consisted the egg apparatus (Figs. 7、8). The two nuclei became the polar nuclei. The chalazal nuclei became the three antipodals. The polar nuclei fused at the center and the resulted secondary nuclens then moved close to the egg apparatus (Fig. 8).

In the mature 8-nucleate embryo sac, the egg cell was recognized by nucleus at the chalazal end and a large vacuole at the micropylar end; the two synergids (Figs. 7～8) were recognized by their nuclei at the micropylar end and a large vacuole at the chalazal end.

2.3 Antipodal cells

Three antipodal cells of *S. mussotii* were not ephemeral as observed in most angiosperms[6]. They persist at the mature embryo sac stage. Afterward, three cells divide into 5-8 cells with enlarged and multiseriate nuclei and persist like a layer of "out endosperm" around embryo sac (Fig. 9).

3 Discussion

(1) The present study reveals the annual *S. mussotii* with persistent and secondly multiplication antipodal cells, which may account for it speedy seeds development under the arid surrounding of the Qinghai-Xizang Plateau. The time's span in *S. mussotii* between flowering to shedding seed amounts to no more than 20 days. It is easy for it to produce normal seeds and complete recruitment of offspring in spite of short growing season in the arid habits of the plateau. Akhalkatsi and Wagn-

er[2] found similar results in the arid Alps mountain, that the persistent antipodal cells of the annual gentiana accelerate the embryogensis and shorten the time of seed development. Because of the short growing season, the ephemeral plants in the alpine mountains must acquire some peculiar traits to help them to complete their life histories within such short time. As for Gentianaceae plants, most annual species have persistent antipodal cells to help them accelerate seeds developing[3~4]. It might be one of reasons why so many ephemeral Gentianaceae species distributed widely on the arid mountains especially on the arid Qinghai-Xizang Plateau. The dividing and persisting of the antipodal cells in alpine annual Gentianaceae plants are of significance in reproductive adaptation and evolution, which is important for those ephemeral species of Gentianaceae to complete their life cycle under the arid surrounding of Qinghai-Xizang Plateau within a few weeks' growing season.

(2) As regards the embryological features of *Swertia* s. l., there are eight species (*S. carolinesis*, *S. corymobosa*, *S. angustifolia*, *S. minor*, *S. iberica* *S. franchetiana*, *S. erythrosticta*, *S. tetraptera*,)[5~10] concerning to earlier reports and recent studies. The results show that these species of *Swertia* s. l. share the following ovary characters: tenuinucellate, with a single integument, the megaspore tetrad is linear, embryo sac development is of the Polygonum type. The abovementioned features have been found in *S. mussotii*.

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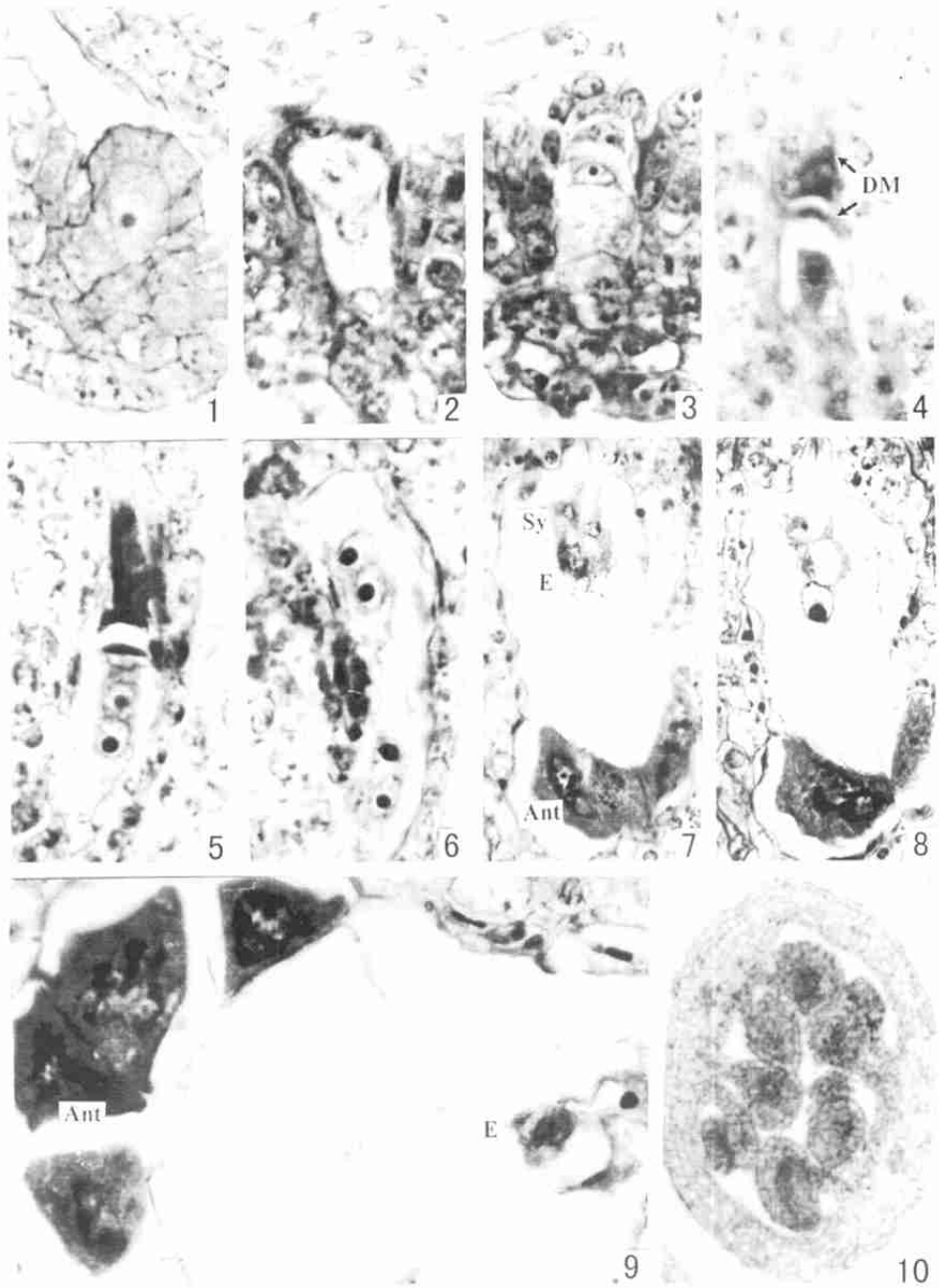
Explanation of Plates

Ant, antipodal cell. DM, Degenerating megaspore. E, Egg, SN, Secondary nucleus, Sy, Synergid.

Fig. 1. A unitegmic ovule and megasporocyte; 2. Anaphase I of meiosis in megaspoRocyte; 3. Linear megaspore tetrad; 4. The functional chalazal megaspore, with other three degenerating. A one-nucleate embryo sac and showing the other three degenerated megaspores; 5. The two-nucleate embryo sac; 6. The four-nucleate embryo sac; 7~8. consecutive transactions of an eight-nucleate embryo sac, showing an egg, two synegids, and secondary nucleus; 9. The mature embryo sac stage showing 5-8 antipodal cells; 10. Transverse section showing eight rows of ovules (1-3×768, 4-8×684, 9×1168, 10×136).



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