us (Mahabalé and Inamdar 1973). The present species differed in some important characters from other commonly known species of the genus and hence we report here its cytoembryology.

Material and Methods

The material for the present work was collected from plants cultivated in the Government Nursery, Poona, Sambhaji Park, Poona and Ganeshkhind Fruit Research Centre, Poona. The flowers and fruits were fixed in F.A.A. with 70% or 95% alcohol. The perianth parts were removed or slightly loosened before fixing. Mature embryos were excised and cut separately. Material was dehydrated through alcohol-xylol series and embedded in paraffin. Sections were cut, 8–24 μ thick, and stained with Heidenhain's iron-haematoxylin and 0·5% erythrosin in clove oil. The chromosomes were studied from the squash preparations of fresh pollen mother cells or from the material fixed in Carnoy's fluid for 24 hours. The pollen sterility was determined by staining fresh pollen grains with basic fuchsin and acetocarmine. They germinated in 35% sugar solution supplemented with urea, borax (0·01%) and GA (2 ppm). The slides of germinated pollen grains were made permanent after staining with acetocarmine.

Observations

Morphology—The plant is a rhizomatous, perennial, unarmed xerophytic herb with many erect shoots on a warty rhizome and a large number of adventitious roots (Plate I, figures 1, 2). The rhizome bears yellowish white, triangular scales 8 × 6 mm which are thick in the centre and have entire margin. The roots are yellowish, swollen proximally tapering gradually towards the distal end (Text figure 1). Twenty to thirty or more tuberous roots occur on each plant, measuring 28 × 0·8 cm. They are not as thick as those in *A. racemosus* (1·5 cm) or tapering abruptly at both ends as those in *A. gonoclados*. They rather resemble the roots of *A. plumosus*. The leaves on aerial shoots are scaly, triangular, papery, pointed, and measure 8 × 3 mm in the basal part, gradually diminishing in size towards the apex. The basal spur of the scaly leaves does not develop into a spine as in other species like *A. racemosus* and *A. plumosus* (Plate I, figure 3, Text figure 2). Four to ten aerial shoots appear on a rhizome. The cladodes are in groups of 1–4, varying from 0·3–1 cm in length and 0·8–1 mm in thickness. They are straight, ascending and circular in cross-section (Text figure 3). The flowers are not grouped into recemes as in *A. racemosus*. They are solitary or in twos at a node and are actinomorphic and bisexual (Text figure 4). The solitary flowers may be with three cladodes at a node. The pedicels are 4 mm long with a joint in the upper $\frac{1}{4}$th part. Perianth

is bell-shaped, divisible in two whorls of three members each. Outer perianth members are ovate with a blunt apex, 4 × 2 mm and with a single vein going almost to the apex. The stamens of the two whorls differ in the lengths of their filaments. The outer ones measure 3–5 mm and the inner 4 mm. The anthers are basifixed. The pistil is 5 mm, ovary 1·5 mm, and style 3 mm. The stigma is lobed and capitate (Text figure 5). The globose berries are yellowish, 6 mm broad and contain 1, 2 or 3 seeds. The seeds are black, round and 5 mm in diameter. They have a finely rugose testa.

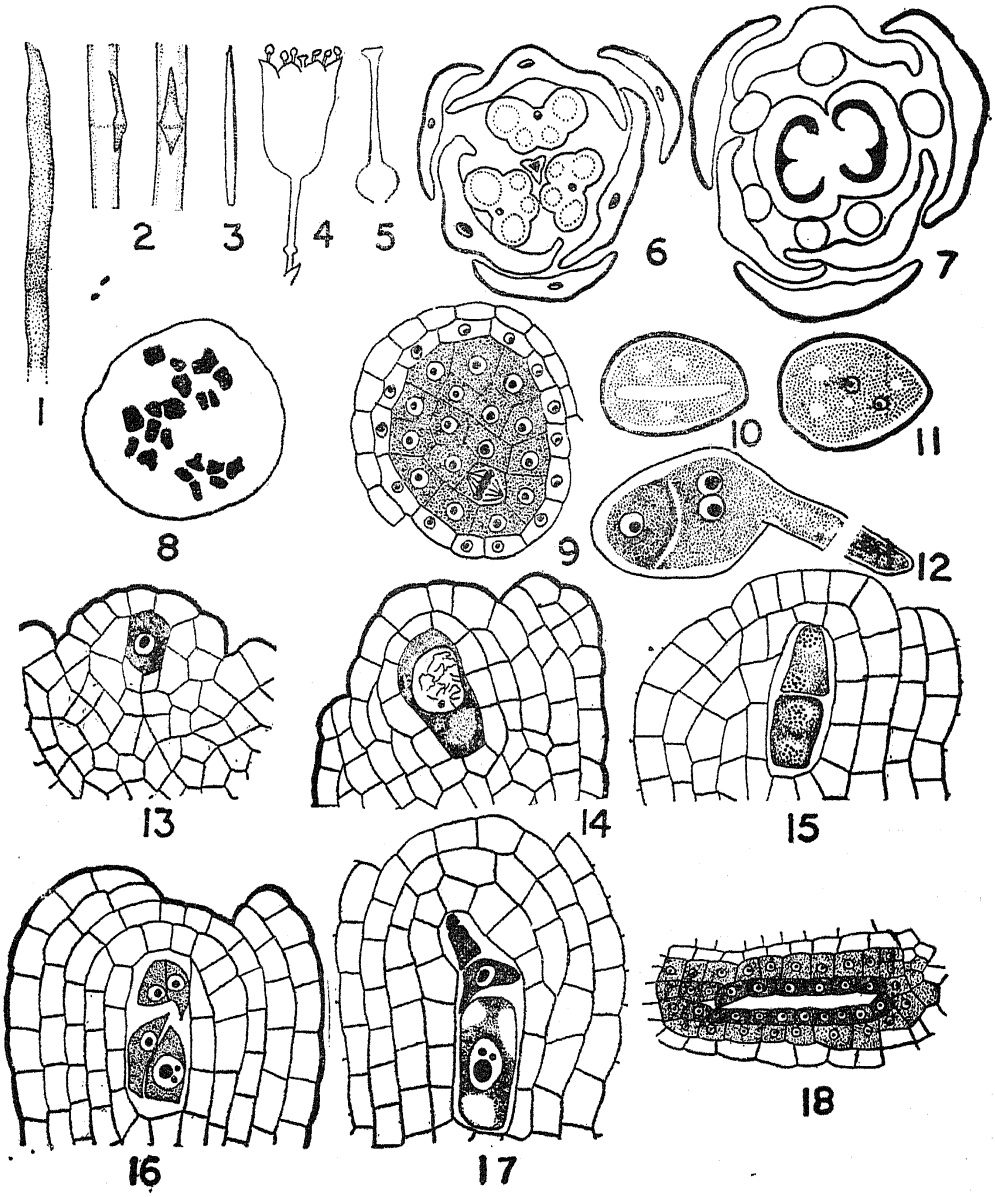
Microsporangium—The young anther is unlobed. The archesporial cell is hypodermal and large. The primary sporogenous tissue consists of 4 or 5 cells across the anther lobe (Text figure 9). The anther consists of epidermis, one middle layer which in a mature anther develops into endothecium and a single-layered tapetum (Plate I, figure 5). The cells of the tapetum elongate radially and become binucleate. It is of the secretory type. Each cell of the endothecium has 6 to 8 fibrous bands. The epidermis does not persist in the mature anther.

Microsporogenesis and chromosome number—The division of the pollen mother cells is of the successive type. Isobilateral, decussate, tetrahedral and linear pollen tetrads were observed. The isobilateral tetrads outnumber other types. There are six anthers in a bud but they do not divide synchronously. The meiosis is normal. Haploid number of chromosomes is 20 (Text figure 10, Plate I, figure 4).

Germination of pollen and the male gametophyte—Mature pollen is oval with a smooth, thick exine, thin intine and a colpus (Text figures 11, 12). Pollen grains start germinating in 2 hours in the liquid medium and it is completed in 6 hours. Germination is monosiphonous. Pollen tube may be straight or curved (Text figure 13). The pollen grain is usually shed in the three-nucleate condition. The male gametes are round and of equal size (2·92 × 2·72 μ). There is a high percentage of pollen sterility in this species. Basal flowers had 31% sterile flowers, those in the middle 30% and those in the apical region 37%. The mean pollen sterility is 32%.

Ovary and ovules—The gynoecium is tricarpellary and syncarpous. Ovary is trilocular, superior and with two ovules in each loculus in horizontal plane (Text figure 6). In one flower bicarpellary condition was noticed (Text figure 8); there were six stamens. The ovules are crassinucellate, anatropous and bitegmic. The outer intergument consists of 5 or 6 cell layers and the inner of 3 or 4 cell layers. A mature ovule measures 267 × 253 μ.

Megasporogenesis and the development of the female gametophyte—The wedge-shaped or hexagonal archesporial cell measures 17 × 11 μ (Text figure 14). It undergoes a transverse division and forms primary parietal



Text-figures 1–18. Morphology and embryology of *Asparagus virgatus* Baker. Fig. 1. A tuberous root, × N.S. Fig. 2. Side and front view of a scaly leaf, × 3. Fig. 3. A cladode, × 2. Fig. 4. A flower, × 3. Fig. 5. Pistil, × 4. Fig. 6. T.s. of flower at style level, × 75. Fig. 7. T.s. of a bicarpellate flower, × 350. Fig. 8. A pollen mother cell at metaphase showing 20 bivalents, × 1,000. Fig. 9. T.s. of an anther lobe with two wall layers and primary sporogenous tissue, × 410. Figs. 10 and 11. Pollen grain, × 665. Fig. 12. Age germinated pollen grain, × 665. Fig. 13. L.s. of young ovule with archesporial initial cell, × 665. Fig. 14. L.s. of young ovule with megaspore mother cell, × 500. Fig. 15. L.s. of young ovule with megaspore dyad with both cells dividing, × 500. Fig. 16. An isobilateral megaspore tetrad, × 500. Fig. 17. Uninucleate embryo-sac, × 500. Fig. 18. Nectary, × 115.

cell and a sporogenous cell. The primary sporogenous cell directly functions as a megaspore mother cell. It measures 18 × 12 μ (Text figure 15). In a single case two megaspore mother cells were noticed. The upper one had already formed an isobilateral megaspore tetrad and the lower one was on

its way to degeneration indicated by a large vacuole at the micropylar end (Plate. I, figure 6). The parietal tissue is three-layered. The dyad cells are equal (Text figure 16). The megaspore tetrads are varied: isobilateral, linear and T-shaped, the linear tetrads being more common (Text figure 17). The lowermost chalazal megaspore is usually functional in a linear tetrad. In an isobilateral tetrad any one of the lower megaspores may be functional. The parietal tissue starts disintegrating at this stage. The nucleus of the functional megaspore lies in the centre or slightly towards the chalazal side (Plate I, figure 7).

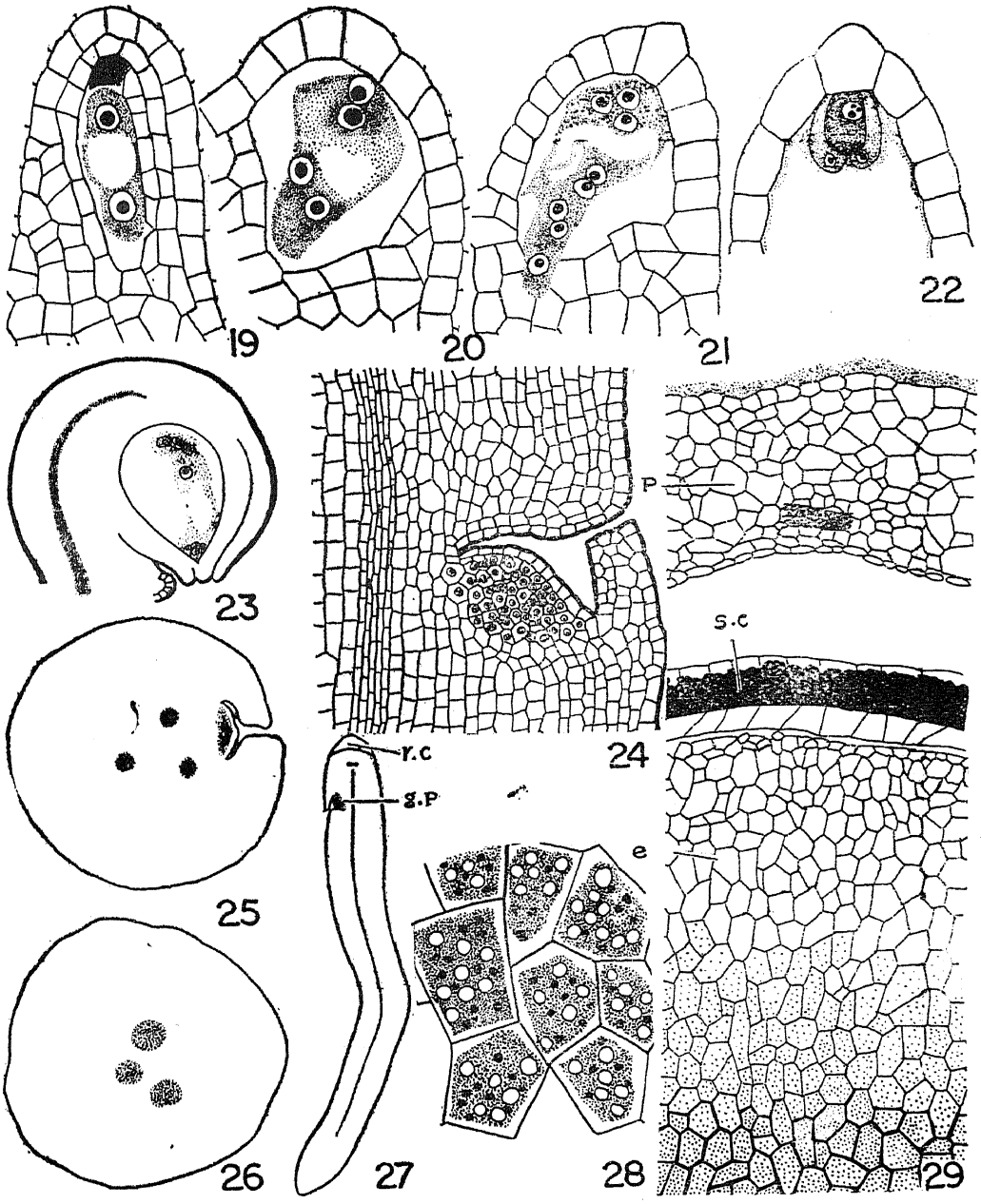
After three mitotic divisions in the functional megaspore, eight-nucleate embryo-sac of the Polygonum-type is formed (Text figures 18–21, Plate I, figures 8, 9). The three antipodal cells are rectangular. Position of the secondary nucleus is variable, usually in the chalazal half of the embryo-sac near the antipodal cells (Text figure 23). The egg is large and oval. Its nucleus lies in the centre or at the base. There is no vacuole either in the egg or in the semicircular synergids. Their nuclei lie in the upper pari (Text figure 22). They persist until fertilization. The nectaries are poorly developed (Text figure 7).

Early embryogeny could not be worked out for want of suitable material.

Mature embryo—It takes 21–30 days for an embryo to mature after anthesis. It is cylindrical, 4–5 mm long, blunt at both ends (Text figure 27, Plate. I, figure 10). The radicle has a root cap. The nodal plate is 200 μ below the radicle, and the growing point is 560 μ away from the radicle. The growing point is lateral and consists of about 20–25 meristematic cells (Text figures 24, 25). An overtopping cotyledon is present and it has three procambial strands (Text figure 26).

Fruit and seed—Fruits are globose berries, 5–8 mm in diameter, pale yellow. The perianth parts are persistent for some time. The cells of the perianth are turgid when young but shrivel up afterwards. The pericarp is not distinguishable into epi-, meso- and endocarp. The epidermis is single-layered and may develop stone cells. There is a thin layer of cuticle on the outer surface of the epidemis. The number of cell layers comprising pericarp is 8–10 (Text figure 29). Frequently raphides and sometimes drusses are formed in the cells of the pericarp below epidermis.

Seeds are black, round, 5 mm in diameter and have a finely rugose testa. The seed-coat has an outer layer and 3–4 inner layers of cells. The nucellus is represented by a thin streak staining deep red with safranin, lying immediately outside the endosperm, which completely fills the seed-cavity at maturity. Its cells are hard and horny. The inner cells have pits on their tangential and radial walls (Text figure 28). Plasmodesmatal connections were observed in them.



Text figures 19–29. Structure of embryo-sac, embryo and fruit in *Asparagus virgatus* Baker, Fig. 19. L.s. of ovule with two-nucleate embryo sac, × 500. Fig. 20. Four-nucleate embryo-sac, × 500. Fig. 21. Eight-nucleate embryo-sac, × 410. Fig. 22. Egg and synergids, × 500. Fig. 23. L.s. of mature ovule, × Fig. 24. Shoot apex of mature ovule enlarged, × 180. Figs. 25, 26. T.s. of the embryo at the level of shoot apex and cotyledon respectively, × 90. Fig. 27. L.s. of mature embryo, × 17. *r.c*, root cap, *g.p*, shoot apex. Fig. 28. Endosperm cells, × 180. Fig. 29. T.s. of fruit, × 90. *p*, pericarp, *s.c*, seed coat, *e*, endosperm.

Discussion

The genus *Aspargaus* is a xerophytic member of the Liliaceae. It shows three habit forms: (1) climbing, *e.g.*, *A. racemosus* and *A. sprengeri*,

(2) Scandent, *e.g.*, *A. gonoclados* with drooping shoots, (3) erect, *e.g.*, *A. officinalis* and *A. virgatus* with erect shoots. In *A. officinalis* shoots are essentially fleshy, herbaceous, tender and sappy. Those in *A. virgatus* are woody, with reduced and sclerose ground tissue. In both these species cladodes are erect and the basal part of the scaly leaf does not form a spiny spur. *A. officianlis* is cultivated for culinary and medicinal purposes but no such use of *A. virgatus* is known.

This species, however, differs from all other known species of the genus *Asparagus* in having capitate and aspirate stigma, on account of which it is included under a separate section, '*Kodiastigma*' by Bailey (1950). It is the only species under this section included by Bailey who has divided this genus into four sections. The species thus seems to have many characters different from those of wild or other cultivated species. Cytologically it differs from *A. officinalis* in having $n = 20$ chromosomes as against $n = 10$ in *A. officinalis*. The high chromosome number and extreme xerophytic nature of the vegetative parts such as cylindrical cladodes, absence of basal spur, reduction of the cortex in the stem, woody nature of shoots suggest reduction in this species due to xerophytic conditions under which it grows.

Its poor seed setting may be due to high percentage of pollen sterility, absence of well-developed nectaries and lack of particular insect vectors or local climatic conditions; or perhaps its embryo development may be defective. But this is not yet known. However, the fruits, when formed, contain viable seeds.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to Professor J. Heslop-Harrison and the staff of the Royal Botanic Gardens, Kew, for confirmation of the identification of this species. One of the authors (A. C. I.) wishes to thank the University Grants Commission and the University of Poona for the award of a research fellowship.

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EXPLANATION OF PLATE I

Figures 1–10. Morphology and embryology of *Asparagus virgatus* Baker.

Figure 1. Habit of the plant.
Figure 2. Rhizome 415 N-S *rh*, rhizome, *a.s*, aerial shoot.
Figure 3. L.s. of stem showing scaly leaf, × 8.
Figure 4. Pollen mother cell at metaphase showing 20 bivalents, × 160.
Figure 5. T.s. of half anther showing three wall layers and multinucleate tapetum, × 320.
Figure 6. L.s. of ovule with an isobilateral megaspore tetrad and lower degenerating m. m.c., × 408.
Figure 7. L.s. of ovule showing functional megaspore, × 410.
Figure 8. L.s. of ovule showing two-nucleate embryo-sac, × 450.
Figure 9. L.s. of ovule showing 4-nucleate embryo-sac, × 320.
Figure 10. L.s. of a mature embryo, × 20.