A CONTRIBUTION TO THE MORPHOLOGY AND CYTOLOGY OF *MONOCHORIA HASTAEFOLIA* PRESL.

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Monochoria hastæfolia Presl. is one of the common marshy plants that is found all over the province of Bengal. According to Hooker (1875) it is distributed throughout India, Ceylon, Malay Islands, China and in the tropical and sub-tropical regions of the Old World.

The plant belongs to the family Pontederiaceæ to which the common Water-hyacinth (*Eichhornia crassipes*) also belongs. Both the plants are characterised by their gregarious habit. *Eichhornia crassipes* is a free floating and fresh water plant, whereas *Monochoria hastæfolia* is a sub-aquatic herb which occurs in marshy places and on the sides of tanks and 'jhils' and remains attached to the soil by means of a subterranean rootstock. The plants often attain a height of five to seven feet during the rains and have a tendency of adjusting their height with the rise of the water level as seen in some deep water paddy. The inflorescence is always borne above water.

The family Pontederiaceæ has not received much attention from morphologists and cytologists. Smith (1898) first gave an account of the development of seed in *Eichhornia crassipes* and *Pontederia cordata* and also figured the female gametophyte of *Heteranthera graminis*. Coker (1907) has also described the development of the female gametophyte and endosperm in *Pontederia cordata* and *Heteranthera limosum*. His observations on *Pontederia* were confirmed by Smith (1908). Palm (1920) has described the development of pollen grains in some members of the family. Juliano (1931) has recently given an account of the morphology of *Monochoria vaginalis*. Ono (1928) has studied the embryology of *Monochoria Korsakowii*, *M. vaginalis* and *Eichhornia crassipes*. He recorded for the first time a peculiar type of endosperm development in the two species of *Monochoria* he studied. Parija (1934) has carried out some physiological investigations on *Eichhornia crassipes* and Banerji and Ganguly (1937) have studied the mode of spermatogenesis in the same plant.

Material and Methods

The material used in this investigation was collected from marshy places in the suburbs of Calcutta. Flower buds, styles and ovaries in various stages of development were fixed in the following fixing fluids :— La Cour's 2BE, Allen's modified Bouin's fluid and Licent's fluid. As a rule fixation was done on bright sunny days between 8 A.M. and 2 P.M. The usual methods of washing, dehydration, clearing and embedding were followed. Sections were cut 8 to 16 microns thick depending on the material and the stage required for study. Heidenhain's iron-alum hæmatoxylin with or without Orange G as a counterstain was chiefly used. Newton's Iodine Gentian violet was also tried.

For the study of spermatogenesis *in vitro* pollen grains were artificially germinated on slides containing a thin film of dried agar-sugar solution. Slides were fixed and stained in the usual way.

General Morphology

The stem of *Monochoria hastæfolia* is a subterranean rootstock of spongy texture and remains covered by the remnants of old leaf sheaths. Adventitious roots appear from the lower surface of the stem. The leaves are radical. The petioles are long (varying from 16 to 28 inches), sheathing at the base and bear parallel veined leaves which show the characteristic hastate form. The apices of the full grown leaves are acute and the bases are somewhat rounded. The inflorescence is encased by a bract, which is again enclosed by the flattened petiole of the topmost leaf. The long pedicelled flowers are arranged spirally on a short, thick and spongy stalk and anthesis takes place from the top towards the base, *i.e.*, centrifugal type of flowering prevails. The inflorescence curves downwards after flowering is over, but does not come under water as in *Eichhornia crassipes*.

The flowers have an attractive blue colour, they are long pedicelled and show a trimerous symmetry. The perianth leaves are six in number, the lobes are distinct and subequal. Stamens six, adnate to the base of the perianth lobe, one is larger and has the filament toothed at one side. It has a violet tinge. The other five stamens are yellowish in colour. Comparative measurements of the stamens show that the average length of the filament of the biggest stamen is 7·3 mm. whereas of the others is 5·6 mm. The length of the anther varies likewise. The anthers are basifixed. Dehiscence is by terminal pores which later extend downwards. The ovary is syncarpous, superior, three locular and many ovuled. Placentation is axile. The style is long. It has three longitudinal canals extending up to the ovarian chamber. The stigma has three small lobes with hair-like

processes. The fruit is a loculicidal capsule which remains enclosed by the persistent, twisted and withered perianth. Seeds are small and are more or less ellipsoidal in outline. The outer coat is marked with furrows and ridges and is brown in colour.

Flowering commences from the month of May and extends up to the advent of winter, with occasional breaks. If the winter be late then flowering extends even up to the month of November. As a rule no flowers are produced during the winter and the upper ground parts of the plant die down during this season. If, however, the plants are kept in water, shoots appear from the rootstocks but they are stunted in growth and do not produce flowers.

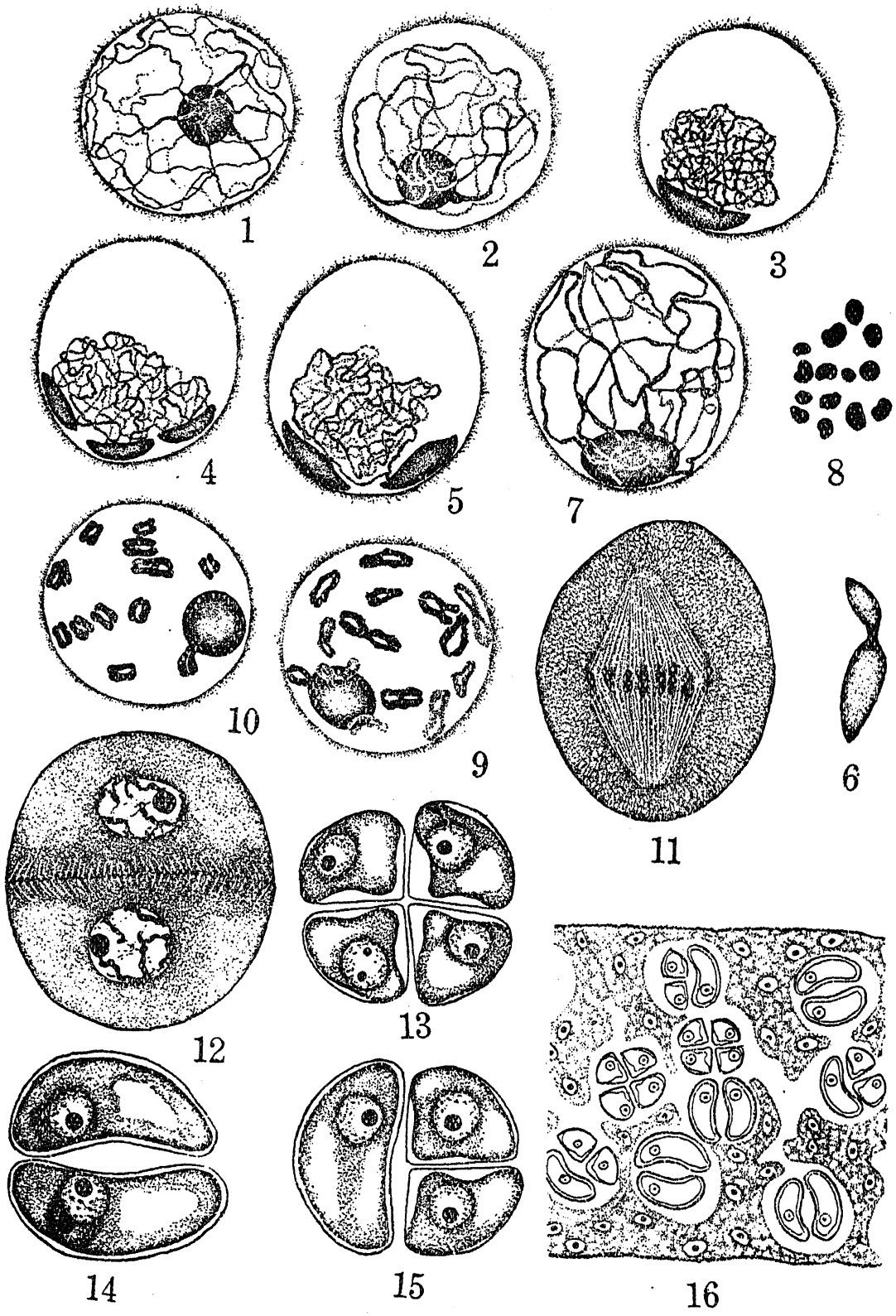
Anthesis takes place in the morning, generally before 8 A.M. The opening of the flowers is delayed by cloudy and humid weather. The number of flowers per inflorescence increases with the advent of the rains and decreases with the advent of winter. The flowers are as a rule self-pollinated, as bagging experiments show that seed formation takes place normally. Generally it takes from ten to fifteen days for the seeds to develop after syngamy. Seeds were germinated under laboratory conditions and germination was also observed in tanks in which a few experimental plants were grown. As a rule, the seeds germinate under water, and it takes from five to ten days for the plumule to emerge from the sheath. The germination is of the " Palm type " and our observations agree with that of Parija (1934).

Vegetative propagation appears to be extensive in this plant and is primarily the cause of " associations " that are commonly seen.

Microsporogenesis

The pollen mother cells arising from the last mitosis of the archesporial cells are more or less polygonal in shape and are closely packed inside the anther loculus. Each cell is bounded by a thin wall and is filled with densely granulated cytoplasm. The nucleus is spherical and occupies a central area and is filled with a peripheral granular matter which stains lightly with basic dyes. The nucleolus is situated in the centre and is surrounded by a clear zone. A small nucleolar bud is seen at this stage.

In early prophase a number of delicate threads are seen inside the nuclear cavity. Careful examination reveals the nature of the leptotene threads which at certain regions are seen to be distinctly double (Text-Fig. 1). The individuality of the threads could not be made out at this stage, but the connection of one of the threads with the bud-like protrusion of the nucleolus is apparent (Text-Figs. 1 and 2). The chromatic threads soon recede



TEXT-FIGS. 1–16. *Monochoria hastæfolia*

Fig. 1. Early prophase. ×2180. Fig. 2. Beginning of first contraction. ×2180. Figs. 3–5. Synizesis. Note the number and form of the nucleolus. ×2180. Fig. 6. A deeply constricted nucleolus at synizesis. ×2180. Fig. 7. Pachynema. ×2180. Fig. 8. Polar view of I-division showing 14*n* chromosomes. ×2180. Fig. 9. Diplonema. ×2180. Fig. 10. Diakinesis. Note connection of a pair of bivalents with the nucleolus. ×2180. Fig. 11. I-division. ×1626. Fig. 12. Interkinesis. Note cell plate at centre. ×1626. Figs. 13–15. Different forms of pollen tetrads. ×932. Fig. 16. Periplasmodium. ×286.

away from the periphery of the nuclear membrane and a tight knot is produced. The nucleolus bcomes flattened and is somewhat lens-shaped and lies close to the nuclear membrane, but it is never enclosed in the meshes of the threads (Text-Fig. 3). In a few preparations two or more such nucleoli have been noted (Text-Figs. 4 and 5). It is interesting to note that working on *Lathyrus odoratus*, Latter (1926) observed a similar form of the nucleolus at synizesis. Definite evidence regarding the connection of the nucleolus with the threads was not obtained at this stage due to the close nature of the synizetic knot. The paired condition of the threads become more evident during the opening of the synizetic knot. This stage, unlike the previous one, is of short duration. At the pachynema stage the threads become thicker and a distinct connection of a pair of threads with the knob-like protrusion of the nucleolus is clearly seen (Text-Fig. 7). The nucleolus recovers its original form but appears to be somewhat ellipsoidal. The pachytene threads overlap one another in all directions and give the appearance of a continuous spireme (Text-Fig. 7). It is at this stage that the pollen mother cells separate from one another and round off.

Transition from the pachynema to the diplonema stage was observed in a very few preparations. The pachytene threads undergo contraction and become thicker. The paired threads appear to open out at certain places but they are kept in contact on account of the formation of chiasma. On account of the small size of the chromosomes, the quadruple nature of the bivalents could not be made out, but that each chromosome is composed of two chromatids could be inferred from the wavy outline of the chromosomes (Text-Fig. 9). Contraction of the pairing homologues proceeds rapidly and at diakinesis they become compact in form and lie close to the nuclear membrane. The members of a bivalent pair are mostly in the form of short rods. One bivalent pair is always seen attached to the nucleolus which occupies a somewhat peripheral position (Text-Fig. 10). The nucleolus gradually becomes smaller in size and paler in appearance and finally it disappears. It is significant to note that the nucleolus maintains a spherical form till its disappearance by progressive reduction in size.

In the prometaphase stage the nuclear membrane becomes very faint and at last it disappears. The chromosomes which have become very much condensed approach towards the centre. At metaphase the chromosomes are aligned on the equatorial region of the spindle (Text-Fig. 11). A polar view of an equatorial plate shows clearly 14 chromosomes (Text-Fig. 8). Three of the gemini appear to be smaller in size. The anaphasic movement of the chromosomes appears to be quite regular. On reaching the poles the chromosomes at first come close together but they move apart and a

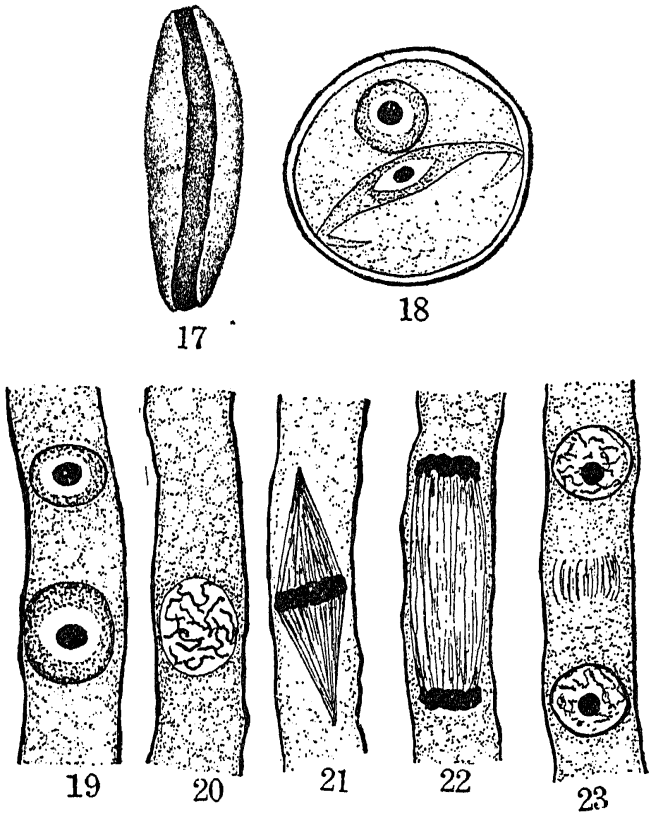
nuclear membrane is secreted. At this stage the protoplast assumes a phragmoplastic appearance and a hyaline membrane is noted in the central region of the spindle which gradually thickens and the two nuclei become separated by a cell plate (Text-Fig. 12). An interkinetic stage is passed through before the second division takes place. At this stage the chromosomes show their individuality and are mostly dispersed towards the nuclear membrane. They are somewhat elongated in form. The second division follows very soon. The spindles vary in their relative orientation and spatial arrangement, they may be parallel or at right angles to one another. During anaphase the sister halves of the chromosomes move regularly to the poles. In many preparations 14 chromosomes have been noted at this stage also. At telophase four nuclei are organised which show the presence of nucleoli and fine chromatin threads. The nuclei are separated by cell plates. The usual arrangement of the tetrads is isobilateral (Text-Fig. 13), but arrangements as shown in Text-Figs. 14 and 15 also appear to be very common. It is interesting to note that such modes of arrangement of the pollen tetrads have also been noted in *Eichhornia crassipes*. The young microspores are separated as a result of the splitting of the cell plates and at first have a somewhat shrunken appearance. Very soon they round up and the exine becomes differentiated. The pollen grains at this stage are uni-nucleate, the nucleus being situated at the periphery and a big vacuole lies at the centre of the cell.

At an early stage in the development of the microspores the tapetal cells become sharply delimited from the sporogenous cells and show the presence of a single nucleus in each cell. The nuclei soon divide and the cells become binucleate. During the synizetic stage of the pollen mother cells, the walls delimiting the individual cells disappear and the tapetal cells protrude inside the anther cavity from all directions. At diakinesis the plasmodium grows further inwards and the nuclei which lie embedded in the cytoplasm migrate in between the pollen mother cells. Gradually the entire cavity of the microsporangium becomes filled up with the plasmodial substance in which the pollen tetrads appear to lie embedded (Text-Fig. 16). With the liberation of the microspores from the tetrad, the plasmodial substance is gradually absorbed and the nuclei degenerate.

Pollen Grains and the Development of the Male Gametophyte

Examination of the pollen grains in methylene-green-gelatin as advocated by Wodehouse (1935) shows the occurrence of fine granulations all over the surface, and the presence of two furrows situated on diametrically opposite sides (Text-Fig. 17). The mature pollen grains are elongate when

dry, but become ovoid when mounted in a liquid medium. Mounted in water and lactic acid the grains burst and eject out their contents. The grains are light-yellow in colour and measure on an average 61·71 μ (length) by 21·38 μ (breadth) when dry. They are binucleate. The vegetative nucleus is larger and occupies a more or less peripheral position while the generative nucleus lies close to it and is embedded in a spindle-shaped cytoplasmic sheath, the ends of which are drawn out (Text-Fig. 18). Smith (1898), and also Banerji and Ganguli (1937) have noted similar form of the generative nucleus in the pollen grains of *Eichhornia crassipes*.



TEXT-FIGS. 17–23. *Monochoria hastæfolia*

Fig. 17. A pollen grain (dry). ×460. Fig. 18. Section of a mature pollen grain. Note the cytoplasmic sheath of the generative nucleus. ×420. Fig. 19. The vegetative and the generative nucleus inside the pollen tube. ×790. Figs. 20–23. Stages in the division of the generative nucleus inside the pollen tube. ×790.

Experiments conducted on the germination of pollen grains *in vivo* and *in vitro* show that the pollen grains absorb moisture and become ovoid in form before germination. Germination normally takes place within ten minutes after pollination and not more than a single pollen tube has been observed to come out of a pollen grain, nor were any branched tubes observed. In artificial media some spirally coiled pollen tubes were seen. Pollen grains obtained from the biggest anther as also from the other anthers showed no difference in germination tests or in shape and size.

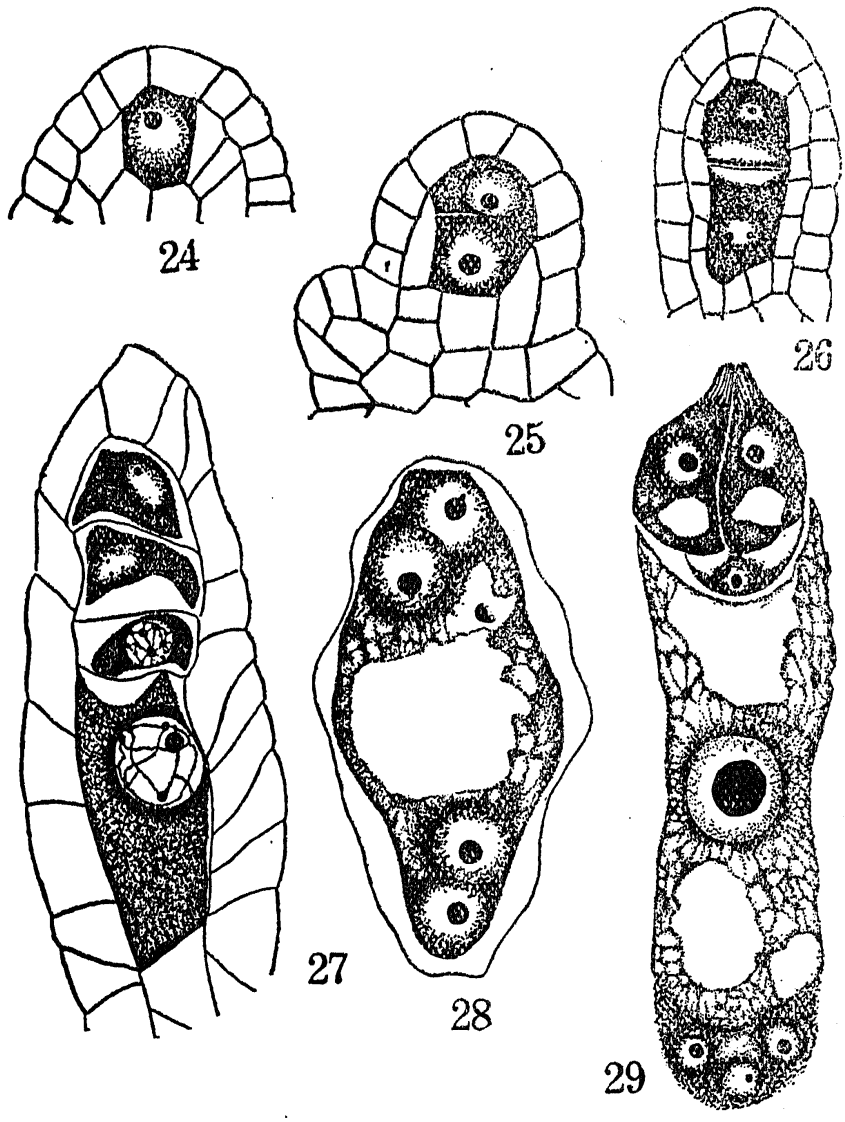
Pollen grains on germination on the stigma give out pollen tubes which take a sinous course and enter the stylar canals, which are lined by conducting cells. The vegetative nucleus passes first inside the pollen tube followed by the generative nucleus. They could be easily made out on account of their differences in size (Text-Fig. 19). The cytoplasmic sheath of the generative nucleus is not apparent at this stage. The generative nucleus soon undergoes division. At prophase a number of elongated bodies —the chromosomes—are seen inside the nucleus (Text-Fig. 20). Soon the nuclear membrane disappears and a well-defined metaphase spindle is organised, in which the chromosomes are aligned in the equatorial region (Text-fig. 21). The anaphasic movement of the chromosomes appears to be regular. On reaching the poles the chromosomes at first pass through a '*tassement polaire*' stage as in normal mitosis (Text-Fig. 22), but soon they move apart and a nuclear membrane is secreted. In late telophase the two nuclei are connected by cytoplasmic striations which disappear later. No evidence of cell plate formation or constriction has been obtained. The two generative nuclei lie very close together and appear to be bereft of any cytoplasmic membrane (Text-Fig. 23).

Development of the Ovule and the Female Gametophyte

The ovules first make their appearance as tiny papillate processes on the placenta. The primordia of the integuments appear very soon and are generally noted after the differentiation of the megaspore mother cell. At this stage the ovules are erect. The curvature of the ovules takes place after the I-division of the megaspore mother cell, and by the time the megaspores are produced the ovules assume an anatropous form. At this stage the integuments almost cover the nucellus. In the later stages the outer integument grows rapidly and envelops the inner. In the mature ovule the micropyle is formed by the two integuments and is straight. Both the integuments are composed of two layers of cells, except the tip of the outer integument which is composed of four layers.

The archesporial cell is hypodermal in origin (Text-Fig. 24). It divides to give rise to a parietal and the sporogenous cell, which later functions as the megaspore mother cell (Text-Fig. 25). Thus the megaspore mother cell is first noted in the third layer of the nucellar tissue. The megaspore mother cell increases in size before prophasic changes commence in the nucleus. After the first division the nuclei become separated by a wall (Text-Fig. 26). The second division soon follows and results in a linear tetrad of megaspores (Text-Fig. 27). The megaspores degenerate from above downwards and the chalazal one always becomes functional. By three successive divisions it

gives rise to an eight nucleate embryo-sac. During these stages the surrounding nucellar cells get crushed and degenerate on account of the pressure exerted by the growing embryo-sac.



Text-Figs. 24–29. *Monochoria hastæfelia*

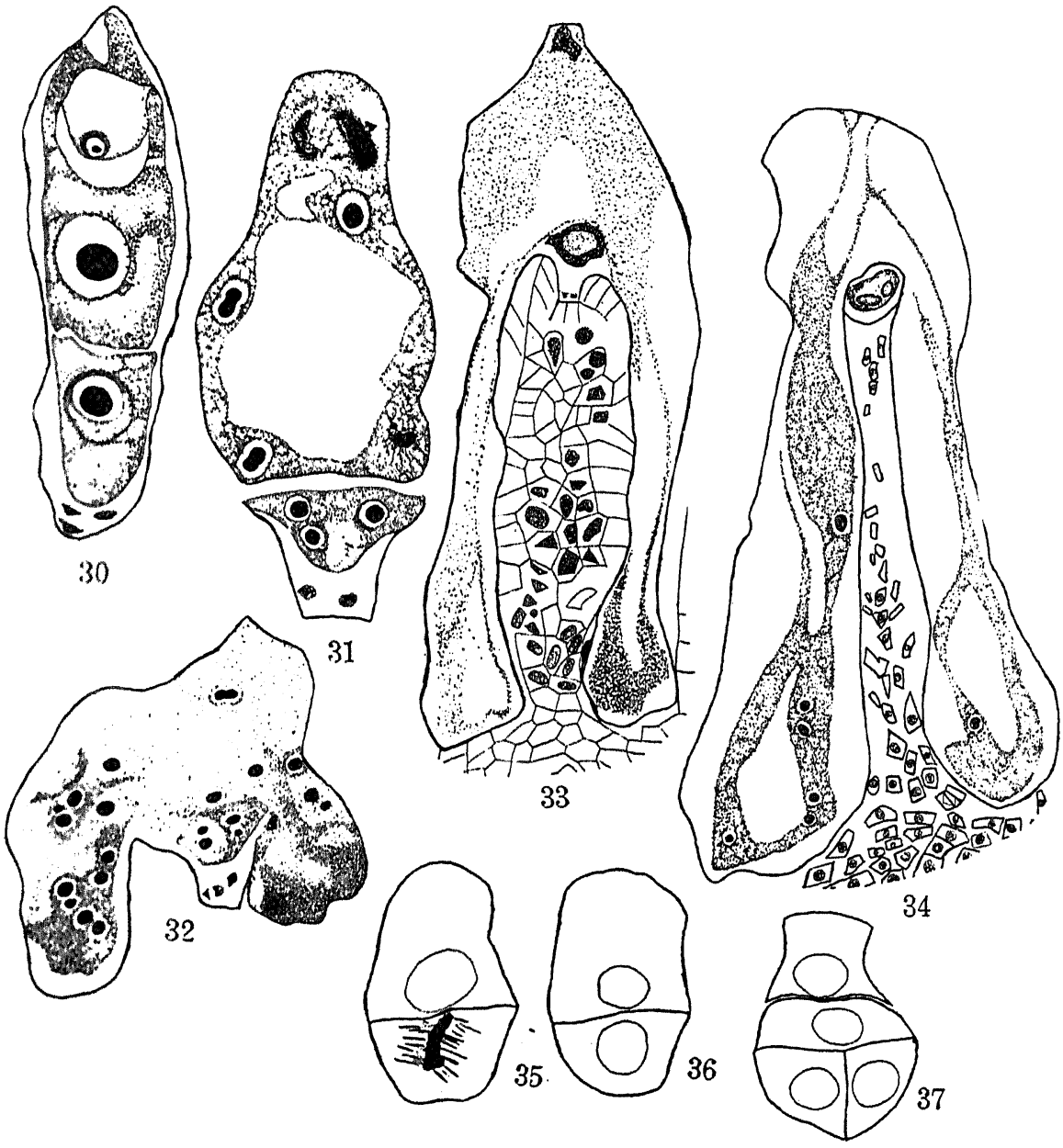
Fig. 24. Hypodermal origin of archesporial cell. ×1032. Fig. 25. The parietal cell has been cut off. ×1032. Fig. 26. A dyad. ×612. Fig. 27. A linear tetrad of megaspores. ×1032. Fig. 28. A four-nucleate embryo-sac. ×1032. Fig. 29. A mature embryo-sac. ×2180.

The mature embryo-sac is broad at the micropylar end. Its length is about 30·4 microns. The synergids are pear-shaped structures with vacuoles at the base and nuclei above them. Distinct filiform apparatus appears to be present. The egg lies below the synergids and has a vacuole at the top. The secondary nucleus lies near about the centre of the embryo-sac. The antipodals are not organised as definite cells but consist of three nuclei which degenerate very soon (Text-Fig. 29).

Development of the Endosperm and Embryo

The primary endosperm nucleus increases in size and undergoes a period of rest before commencing activity. It lies at the centre of the embryo-sac and undergoes division. As a result of the division, two nuclei are produced which are separated by a wall. Thus two chambers are formed, of which the upper or micropylar chamber is larger than the lower or basal chamber. At this stage the antipodals commonly degenerate and are noted as dark shapeless masses at the base of the basal chamber (Text-Fig. 30). The nuclei of the micropylar and basal chambers next divide by free nuclear division and produce as many as six to eight nuclei in the upper chamber and three to four in the lower. Further division of the nuclei of the lower chamber does not appear to take place. At this stage the embryo-sac increases in size and a big vacuole is noted in the central region of the upper chamber. In some preparations the disintegrating synergids could be seen at the top and the antipodals below (Text-Fig. 31). The ovule increases in size still further and the micropylar chamber now shows a tendency to bulge out at the two sides. The two arms containing dense cytoplasm and many free nuclei. Fig. 32 represents such a condition. This process of elongation of the two arms of the micropylar chamber becomes very pronounced and a tuning-fork like appearance is presented. The nuclei of the basal chamber lies at the top of the nucellar tissue which stands out as a column in the central region (Text-Fig. 33). On account of the rapid increase in size of the ovule as well as the protruding arms of the upper chamber, big vacuoles are noted in the latter. Gradually the basal chamber as also the central nucellar tissue disorganise, and the central space is filled up by the extension inwards of the lateral arms of the upper chamber (Text-Fig. 34). It now contains many nuclei which are irregularly distributed. Wall formation begins first at the micropylar end and then extends towards the chalazal region. When the endosperm cells are finally delimited they show a polygonal outline and contain a single nucleus with one or more nucleoli.

The fertilised egg undergoes a period of rest and divides long after the division of the primary endosperm nucleus. The oospore increases in length before division and the first division is by a transverse wall resulting in the production of a terminal and a basal cell (Text-Fig. 36). The basal cell divides again to produce a three-celled proembryo. In some ovules the terminal cell divides again by a periclinal wall resulting in the production of a four-celled proembryo. The terminal cell of the three-celled pro-embryo next divides by an anticlinal wall (Text-Fig. 37). Later stages obtained show a globular embryo in which the dermatogen has been clearly marked off. Due to rapid cell divisions in various planes the embryo becomes elongated



TEXT-FIGS. 30–37. *Monochoria hastæfolia*

Fig. 30. The micropylar and the basal endosperm chambers. ×790. Fig. 31. The enlargement of the micropylar chamber and the multinucleate condition of both the chambers. ×790. Fig. 32. The downward extension of the lateral arms of the micropylar chamber. ×465. Fig. 33. The two lateral arms of the micropylar chamber have reached the chalazal end. Note the degenerating basal chamber at the top of the nucellar column. ×225. Fig. 34. The disintegration of the cells of the central column and the inward extension of the lateral arms. ×2.5. Figs. 35–37. Some early stages in the development of the embryo. ×775.

and a notch appears at one side. The cells of this region show meristematic activity. This is the origin of the stem tip. In the mature seed the embryo does not fill up the entire space but is enclosed by the endosperm cells, the reserve matter of which seems to contain some crystalline structures which stain deeply.

Discussion

Cytology.—The presence of a specialized area in the nucleolus to which threads are attached in synizesis and later stages has been first observed by Latter (1926) working on *Lathyrus odoratus.* She referred to this as the nucleolar body which acted as an elaborating organ and transferred the elaborated materials on to the threads with which it remained in contact. Such relationship between the nucleolus and a 'loop of the spireme' has since been observed in *Lathrea* (Gates and Latter, 1927), *Oenothera* (Sheffield, 1927) and in a few other plants. It is now known that this nucleolar body with its attached threads represents a particular pair of chromosomes which have the power of organizing the nucleolus at telophase. Some observers, notably Heitz (1931) and others have noticed the attachment of a pair of Sat-chromosomes to the nucleolus and are of opinion that the nucleolus originates at telophase from the satellites of the particular chromosome pair. In some plants the presence of Sat-chromosomes have not been observed but secondary constricted chromosomes occur. In recent years the functional correspondence of the secondary constriction to the satellites has been recognised and generally speaking such constrictions have been referred to as 'nucleolar constrictions'.

In *Monochoria hastæfolia* definite connection of the nucleolus with a pair of threads has been noted in the later prophasic stages. During pachynema a single spherical dark staining body is always found lying at the side of the nucleolus to which a particular pair of chromosomes seem to be attached. This body which is commonly known as the "nucleolar body" has not the same position in all material where its presence has been detected. Im *Lathyrus*, as in the present material its position is apparently superficial, whereas in *Oenothera*, Sheffield (1927) states—"the body appears to be towards the periphery of the nucleolus, it does not usually project from the surface". At diakinesis a pair of bivalents are seen to be attached to the nucleolus, no satellites could be seen in this pair, but the close association from prophase to diakinesis leads one to infer that this particular set is endowed with the property of organizing the nucleolus, and it is likely that the nucleolus organizing body is located at the end of this pair of chromosomes as has been noted by Nandy (1937) in Rice.

The flattened or convex form of the nucleolus in synizesis and its position close to the nuclear membrane has also been observed by Latter (1926) in *Lathyrus odoratus.* She thinks that by the presentation of a large area of the nucleolus to the cytoplasm, absorption of a certain portion of the inflowing cytoplasmic substances is possible. This substance is later

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elaborated by the nucleolar body which transfers elaborated material on to the thread with which it is in contact. Evidence obtained in the course of this investigation, however, does not favour such a hypothesis. It appears that the lens-shaped form of the nucleolus in synizesis is due mainly to the effect of the fixing fluid. It is a well-known fact that synizesis represents a very delicate condition of the nucleus where the threads are ' balled up ' on account of the action of the fixing fluid. In this material, it appears that the nucleolus is also markedly affected at this stage and becomes biconvex in form. Sometimes it gives rise to two or more lens-shaped nucleoli as a result of constriction induced by the fixing agent (Text-Figs. 4 and 5). Fig. 6 shows a deeply constricted nucleolus which lends support to this view. Further, the typical spherical or ovoid form of the nucleolus in later stages of meiosis adduces additional evidence.

Binucleate pollen grains are commonly seen in this family, as also the spindle-shaped appearance of the generative nucleus. During gametogenesis a well-defined metaphase spindle is seen inside the pollen tube, as has been commonly observed by workers on non-Liliaceous plants. With regard to the process of cytokinesis, neither phragmoplasts with cell plates nor furrows have been observed, and it appears that the two nuclei become separated on the disappearance of the connecting fibres at telophase. Such a condition has been recorded by Maheshwari and Wulff (1938) for a number of plants. Swamy (1941) also did not find a separating membrane or cell wall between the separated male nuclei of *Cymbidium bicolor*.

Formation of a tapetal plasmodium has been recorded by previous workers in this family. Clausen (1927) has described four types of amœboid tapetum in monocotyledons. Following his classification it appears that plasmodium formation in *Monochoria hastæfolia* is of the " *Triglochin* " type.

Embryology.—The development of the female gametophyte in *Monochoria hastæfolia* is of the normal type and corresponds to the accounts given by Ono (1928) for *M. Karsakowii* and *M. vaginalis*, and by Juliano (1931) for the latter plant. None of these investigators, however, mention the presence of a filiform apparatus in the synergid. Regarding the antipodals, Juliano (1931) states, " the antipodals are distinct and they remain perfectly differentiated long after endosperm formation is well under way. They are separated by definite walls and may lie in a single row". Evidence obtained in the course of this investigation shows that the antipodals degenerate before the development of the endosperm and are bereft of any membrane.

able to observe the disintegration of the haustorial processes as mentioned by Ono.

Summary

The paper gives an account of the morphology, cytology and embryology of *Monochoria hastæfolia.*

1. *Monochoria hastæfolia* is a marshy plant. It has a subterranean root-stock and bears hastate leaves. The flowers show trimerous symmetry. Of the six stamens, one is larger and the anther is differently coloured. The pollen grains produced in this anther show no morphological or size-difference when compared to those produced in the other anthers. All are equally viable.

2. Anthesis of flowers takes place generally before 8 A.M. On cloudy and humid days it is delayed. Bagging of inflorescences shows that self-pollination is the rule. Seed formation takes place under natural conditions and it takes about 15 days for the seeds to develop after syngamy. The germination of the seed is of the " Palm-type ".

3. The development of the microspore appears to be of the successive type. During heterotypic prophase the nucleolus becomes adpressed against the nuclear wall and assumes a lens-shaped structure. At this stage a distinct connection of the nucleolus with the spireme is first noted. At pachynema a small spherical body is seen to lie at the side of the nucleolus to which the spireme is connected. This has been referred to as the nucleolar body. At diakinesis a pair of bivalents are also seen to lie attached to the nucleolus. The haploid number of chromosome is 14. Cytokinesis takes place by cell plate formation.

4. The pollen grains have an elongated appearance when dry. The exine shows the presence of fine granulations all over the surface and has two furrows situated diametrically opposite to each other. The pollen grains are bi-nucleate at the time they are shed. The generative nucleus lies within a cytoplasmic sheath, the ends of which are drawn out.

5. The pollen grains germinate on the stigma within ten minutes after pollination. The pollen tubes pass through the stylar canals and the division of the generative nucleus takes place inside the pollen tube. The metaphase spindle is well organised. Furrows or cell plates have not been observed and it appears that the sperm-nuclei become separated by the disappearance of the spindle fibres.

6. A single archesporial cell develops in the hypodermal layer of the nucellus. It cuts off a parietal cell and then functions as the megaspore

mother cell. A normal linear tetrad of megaspores is produced of which the chalazal one becomes functional and produces an eight-nucleate embryo-sac. The mature embryo-sac is of the normal angiospermous type. The antipodals are ephemeral.

7. Endosperm formation is of the "Helobiales" type. At an early stage of the development of the endosperm, the micropylar chamber extends at the sides leaving a central column of nucellar cells, at the top of which the basal chamber lies. These micropylar processes reach the chalazal end of the embryo-sac. At this time the central nucellar column and the basal chamber degenerate and the two lateral arms of the micropylar chamber extend inwards and fill up the central space.

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