DEVELOPMENT OF THE FEMALE GAMETOPHYTE AND EMBRYO IN *FIMBRISTYLIS DIPHYLLA* VAHL.

By Y. S. Murty and V. Kumar

(*School of Plant Morphology, Meerut College, Meerut*)

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Introduction

Schnarf reviewed the embryological literature of the family Cyperaceae in 1931. Since then several papers have appeared mostly confined to the study of microsporogenesis (*see* Tanaka, 1939), some on the female gametophytes (Khanna, 1956; Padhya and Moharir, 1958; Shah, 1961) and a few on embryogeny (Schneider, 1932; Guttenberg and Semlow, 1957 and Shah, 1965). The female gametophyte of *Fimbristylis* of the tribe Scirpae of Cyperaceae has been studied by Dnyansagar and Tiwari (1956) and Gupta (1958 and 1962). The genus *Fibristylis* is represented by more than half a dozen species in Uttar Pradesh. *Fimbristylis diphylla* Vahl. is common at Meerut, and this has remained untouched morphologically. Hence the observations on the development of the female gametophyte and embryo of this species, are recorded here.

Material and Methods

The material was collected from the marshy sandy localities and from the Meerut College campus as well. The spikes were fixed in formalin-acetic-alcohol and after passing through proper alcohol-xylene grades and embedding in paraffin wax, were cut at 6–12 μ thickness. The sections were stained in safranin and fast green combination and also with Heidenhain's Iron Haematoxylin.

Observations

It is a small tufted plant. From the centre of the tuft of the linear leaves arises a culm bearing umbellets of spikes. Each spike is somewhat palebrown and bears 5–12 flowers.

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The single ovule, situated basally, is anatropous, bitegmic and crassinucellate. In the later stages the integuments are appressed so closely that it becomes difficult to differentiate their individuality. The ovule becomes anatropous even before the megaspore mother cell divides.

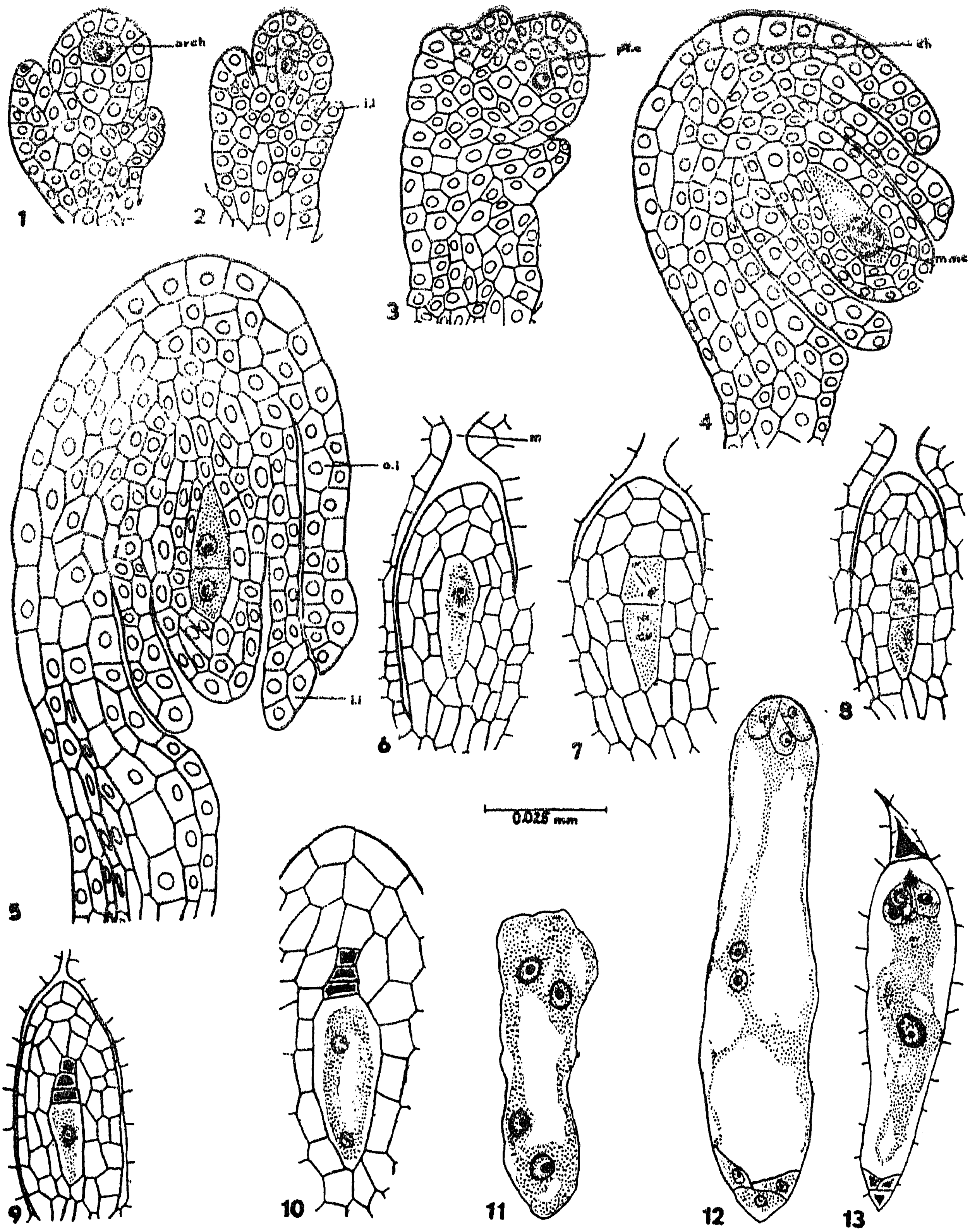
Archesporial initial differentiates hypodermally by the enlargement of one of the cells. It has a large nucleus and dense cytoplasm (Fig. 1). This divides periclinally into an outer primary parietal cell and an inner sporogenous cell which directly functions as the megaspore mother cell (Figs. 2–3). The primary parietal cell undergoes both anticlinal and periclinal divisions so that at maturity there are two to four parietal layers of cells (Figs. 4 and 5).

The megaspore mother cell enlarges considerably (Fig. 4) reaching a length of 20 μ and width of 8 μ. As a result of meiosis (Figs. 6 and 7) a linear tetrad of four megaspores is formed (Fig. 8). In some cases the division of the dyad is slightly delayed. By the time the dyads are formed the ovules become completely anatropous (Fig. 5).

The three magaspores on micropylar end degenerate, while the one on the chalazal end remains functional (Fig. 9). The functional megaspore undergoes three usual mitotic divisions so as to form a 8-nucleate embryo sac (Figs. 10–12). The nuclei arrange themselves in 3-2-3 scheme. The mature embryo sac is elongated 65–109 μ long and 16–27 μ broad. By the time the polars fuse to form the secondary nucleus, the antipodal cells show signs of degeneration (Fig. 13).

Embryogeny.—The first division in the zygote is transverse and results in 2 cells a distal cell Cb and a proximal cell Ca (Figs. 14 and 15). The second division takes place generally, first in Ca cell but there may be a transverse division first in Cb cell. In the latter case a proembryo with a linear row of three cells is formed (Fig. 16). When the cell Ca divides prior to Cb by two vertical divisions at right angles to one another, the proembryo has a single Cb cell and a quadrant of cells formed from Ca (Fig. 17). After the formation of quadrant *q* there is a transverse division in Cb forming an upper (*m*) and a lower (Ci) cell (Figs. 18–19).

With the formation of oblique walls in the *q* an outer jacket of cells (*d*) and an inner core (*pl*) are formed (Figs. 20–21). There appear one or two radial divisions in the *d* cells and after that there is one transverse division in *pl* cells so as to differentiate upper *l* and lower *l′* tiers (Figs. 22, 23). Two or three vertical divisions occur in the cell *m* to form a tier of 4 or more cells (Fig. 24). Sometimes these cells divide transversely into two tiers *iec* and



FIGS. 1–13. Megasporogenesis and Megagametogenesis. Figs. 1–5. Ovules showing the curvature during development. Figs. 6–9. Megasporogenesis. Fig. 6. Megaspore mother cell; Fig. 7. Dyad, both the dyad cells are under division. Fig. 8. Linear tetrad; Fig. 9. Functional megaspore. Figs. 10–13. Megagametogenesis. Figs. 10 and 11. 2- and 4-nucleate embryo sacs. Fig. 12. Organised embryo sac with polar nuclei and healthy antipodal cells. Fig. 13. mature embryo sac with secondary nucleus and degenerated antipodal cells. The degenerated mass of megaspores is also seen.

(*arch.*, archesporium; *ch.*, chalaza; *ii.*, inner integument; *m.*, micropyle; *m.m.c.*, megaspore mother cell; *o.i.*, outer integument; *pt.c.*, parietal cell.)

ico which contribute to the formation of root cap (Fig. 25). A division in Ci cell results in *n* and *n′* cells which form the suspensor of the embryo (Figs. 22–25).

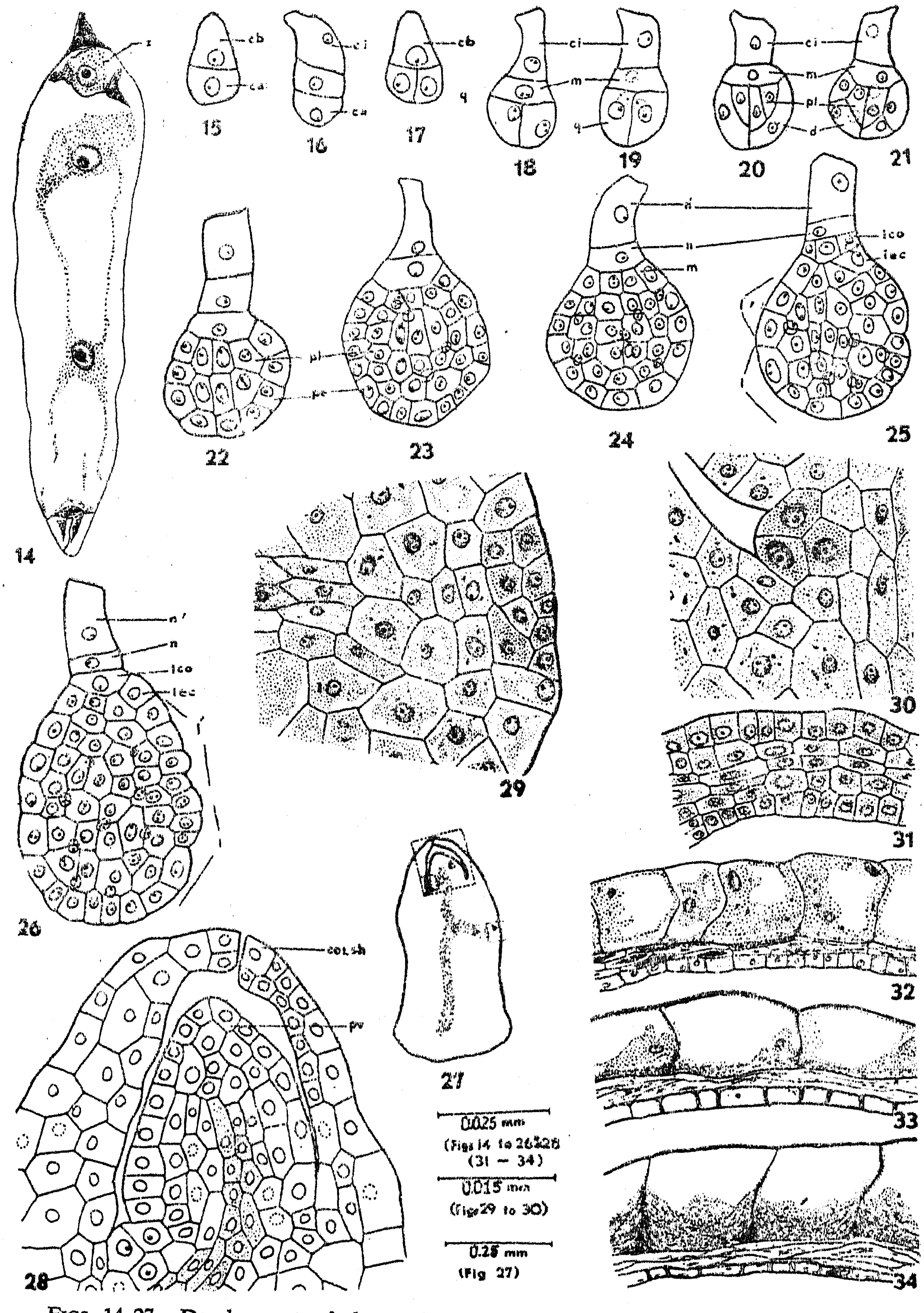
A slight indentation occurs on the lateral side of the globular proembryo which marks the upper lip of the cotylar sheath and such an indentation is also seen downwards which marks the lower lip and demarcates the shoot apex from the cotyledonary part (Fig. 25). The upper lip arises from the *l* tier while the lower lip is drived from *l′* tier. The sheath at this stage appears as a rim around the shoot apex. The rim develops parietally and covers the plumule all around (Figs. 26 and 27).

The vasculature of embryo becomes differentiated as procambial strands supplying the plumule, cotyledon and radicle. The plumule is somewhat conical in shape covered by the cotylar sheath all around (Fig. 28). From its first position (which is lateral) it is shifted towards the micropyle by the rapid increase in the size of the cells of the single cotyledon or scutellum.

The cotyledon consists of large cells loaded with food material and is facing the chalazal end. The radicle appears towards the micropyle, but on shifting of the plumule towards micropyle by cotylar growth it takes a lateral position. The cells of the embryo destined to give rise to radicle show conspicuous nuclei and dense cytoplasm and divide rapidly (Fig. 29). In one case a bud is observed in the axil of cotylar sheath (Fig. 30).

Development of the pericarp.—The ovary wall consists of 5–6 layers of cells showing thin walls, dense cytoplasm and large nuclei (Fig. 31). As the ovule develops, the innermost and the outermost layers of the ovary wall show some changes. The innermost layer becomes hard probably due to accumulation of some chitinous material. The cells in the outermost layer of the wall enlarge and as a result show vacuolation. Some thickening material appears on the tangential walls and the lower part of the radial walls (Fig. 32). The cells of middle layers gradually show signs of degeneration.

By the time the gametophyte is ready for fertilization the nuclei in the cells of the outer layer of ovary wall disintegrate and the cytoplasm also starts receding from the walls (Fig. 33). At the mature embryo stage the thickening in the cells of outer layer is so much that it fills near about half the lumen of the cells. The middle layers also get the same type of thickening but is not so conspicuous as that of the outer layer. The innermost layer of the pericarp is chitinous (Fig. 34).



FIGS. 14–27. Development of the embryo. Figs. 28–30. Portions marked in Fig. 27. *a*, *b* and *c* respectively enlarged. Fig. 28. The portion of the plumule. Fig. 29. The portion of the embryo from which the future radicle is to develop. Fig. 30. Prominent cells in the axil of the cotyledonay sheath. Figs. 31–34. Development of the pericarp. Fig. 31. Ovary wall at the archesporial cell stage. Fig. 32. Same at the 2-nucleate embryo sac stage. Fig. 33. pericarp after fertilization. Fig. 34. Fruit wall at the mature embryo stage.

(*cot. sh.*, cotyledonary sheath; *pe.*, periblem; *pl.*, plerome; *pv.*, plumule.)

At maturity the pericarp wall cells show hardly any cytoplasm. The outer walls of the cell of outer layer get broken exposing the thickened region directly.

SUMMARY AND CONCLUSIONS

The unilocular ovary has a single anatropous bitegmic and crassinucellate ovule. The inner integuments form the micropyle as has also been reported in *Fimbristylis quinquangularis* by Dnyansagar and Tiwari (1956). The archesporium is single celled, hypodermal and cuts a single parietal cell. The megaspore mother cell forms a linear tetrad of megaspores of which only chalazal one develops. The development of the embryo sac is monosporic polygonum type (Maheswhari, 1950). While antipodal cells degenerate before fertilization the synergids follow the same fate after fertilization.

The early stages in development of the embryo follow the pattern of divisions reported by Shah (1965) in *Bulbostylis barbata* but the embryo of *F. diphylla* is not oriented as that in *B. barbata*. The mature embryo is oriented as:

Plumule	..	Basal
Radicle	..	Lateral
Cotyledon	..	Apical

In this orientation the embryo resembles that of the Cyperus type of Shah (1965) and Scirpus type of Schneider (1932).

The development of embryo of *F. diphylla* resembles the Juncus variation of the Onagrad type (Johansen, 1950). Its parallelism is seen only in Juncaceae (Souèges, 1923, 1933).

The thin walled cells of pericarp of young fruit show thickenings at maturity, especially in the outer and inner wall cells. The innermost layer gets much of chitinous thickening and becomes too hard. The middle layers get crushed showing some chitinous thickening and add to the strength of the fruit wall.

The integuments remain as such except that they become too appressed to each other and develop some thickening.

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Literature Cited

Dnyansagar, V. R. and Tiwari, D. K. "Sporogenesis and gametophytes of *Fimbristylis quinquangularis*," *Kunth. Bull. Bot. Soc. Univ. Sagar*, 1956, **8**, 3–6.

Gupta, M. N. .. "Development of Ovule and Gametophytes in *Fimbristylis tenera* Roem and Schult," *Proc. 45th Indian Sci. Cong., Pt. IV. Abs.*, 1958, *Abs.* 289.

———— .. "Morphological studies in Cyperaceae. 1. Development of Ovule and the Gametophytes in *Fimbristylis dichotoma* Vahl.," *Agra. Univ. Jour. Res. Sci.*, 1962, **2** (1), 59–67.

Guttenberg, H. V. and Semlow, A. "Die Entwicklung des Embryos und der Keimpflanze von Cyperaceen," *Botanische studien*, 1957, **7**, 127–41.

Hofmeister, W. .. "Neue Beiträge zur Kenntnis der *Embryo-bildung* der Phanerogamen. II. Monocotyledonen," *Abh. Sachs. Ges. (Akad.) Wiss.*, 1981, **7**, 629–760.

Johansen, D. A. .. *Plant Embryology.* Waltham, Mass., U.S.A., 1950.

Khanna, P. .. "A contribution to the embryology of *Cyperus rotundus* Linn.," *Proc. 43rd Indian Sci. Cong.*, Part III, 1956, 236–37.

Maheshwari, P. .. *Introduction to Embryology of Angiosperm*, McGraw Hill, New York, 1950.

Padhye, M. D. and Moharir, S. K. "Studies in Embryology of *Cyperus tagetum* Roxb.," *Proc. Indian Acad. Sci.*, 1958, **B 48**, 89–95.

Schneider, M. .. "Untersuchungen uber die Embryobildung und entwicklung der Cyperaceen," *Beih. Bot. Zib.*, 1932, **49**, 649–74.

Shah, C. K. .. "Female gametophyte in some Cyperaceae," *Proc. 48th Indian Sci. Cong.*, Pt. III, 1961, Abstracts, p. 274.

———— .. "Embryogeny in some Cyperaceae," *Phytomorphology*, 1965, **15** (1), 1–9.

Souéges, R. .. "Embryogénie des Joncacées. Dévelopment de L'embryon chez de *Luzula forsteri* Dc. C.R.," *Acad. Sci. Paris*, 1923, **177**, 705–08.

———— .. "Recherches sur 1' embryogénie des Joncacées," *Bull. Soc. Bot. Fr.*, 1933, **80**, 51–69.

Tanaka, N. .. "Chromosome studies in Cyperaceae. VII—Chromosome number and pollen development of *Fimbristylis*," *Bot, Mag. (Tokyo)*, 1939, **53**, 480–487.