A NOTE ON THE EMBRYO SAC AND EMBRYO OF *MORINGA OLEIFERA* LAMK.

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1. *Introduction.*

The development of the female gametophyte and the embryo of *Moringa oleifera* was worked out by Rutgers (1923). He found that the archesporial cell (in some cases more than one) is deep-seated and functions directly as the megaspore mother cell, without cutting off any parietal tissue. This enlarges and divides twice to form a T-shaped tetrad of megaspores of which the chalazal functions, and up to the four-nucleate stage the development of the embryo sac is quite normal. After this only one of the micropylar nuclei is said to divide again, so that the mature embryo sac is five-nucleate. Three of the nuclei enter into the formation of the egg-apparatus, the remaining two function as polars and the antipodals are entirely missing.

The second important and striking statement made by Rutgers is that there are free nuclear divisions in the fertilised egg and wall-formation starts only after sixteen free nuclei have been formed. So far as I know this is the only Angiosperm alleged to have a free nuclear embryo.

As these results have generally been regarded as doubtful by recent workers (Schnarf, 1927, p. 122) and the plant is available here in abundance, Dr. P. Maheshwari suggested to me that I should re-investigate its life-history. Since I have made a thorough study and my observations are, in many respects, fundamentally different from those of Rutgers, I have thought it worthwhile to publish them without delay in the form of a preliminary note. The full paper will appear later on.

2. *Megasporogenesis.*

There is a single hypodermal archesporial cell in the nucellus but often a group of two or three has been noticed (Fig. 1). This cuts off a primary wall cell which by further periclinal divisions forms three or four wall layers. Rutgers' contention that "parietal tissue is totally suppressed" is quite unfounded.

The megaspore mother cell after two normal divisions gives rise to a tetrad which may be either T-shaped* or linear (Figs. 4 and 5). There are two integuments of which the outer has three vascular bundles, one at each angle (Fig. 11). As mentioned by Kershaw (1909) the appearance of vascular tissue in the integuments recalls the condition seen in Gymnosperms. I have recently learnt, however, that Kühn (1928) has found this phenomenon to be of a wider occurrence in the Angiosperms also.

3. The Embryo Sac.

The nucleus of the functioning megaspore divides thrice in the usual manner to produce a normal eight-nucleate embryo sac (Figs. 6, 7 and 8). In all the younger embryo sacs and in some cases even in the older ones I have always found three distinct antipodal cells, but they usually disappear at an advanced stage (Fig. 9). Rutgers' statement that the embryo sac is only five-nucleate might have been based on observations of such embryo sacs. This is, however, quite incorrect, for originally all eight nuclei are present in the embryo sac.

4. The Endosperm and Embryo.

The oospore remains dormant for a long time and undergoes the first division only when the fruit has attained a length of about 4 inches. The endosperm nucleus divides much earlier and forms a mass of nuclei specially crowded at the micropylar end of the embryo sac. Some of these nuclei arrange themselves in such a form that the whole body appears to be a free-nucleate egg. However, a more careful study of serial sections showed that the fertilised egg is really situated just above this mass of nuclei (Fig. 10), though it is rather inconspicuous due to its small size.

The first division of the egg is followed by a transverse wall as in other Angiosperms and the mature embryo is dicotyledonous. In some cases where one of the cotyledons is larger than the other it bifurcates to form a tri-cotyledonous embryo.

5. Abnormalities.

Connected with the embryo sac there have been noticed several abnormal features which are enumerated below :—

1. In one case there were two nucelli enclosed within the same outer integument but having their separate inner ones (Fig. 12).

2. In several cases two embryo sacs were seen in the same ovule, but one is usually somewhat older than the other.

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* Rutgers found only T-shaped tetrads.

3. Occasionally one or both the synergids may enlarge and assume the form of the egg, with the nucleus migrating down to the lower end.

4. In later stages many irregularities are exhibited in connection with the total number of nuclei in the embryo sac. Several cases were observed where the egg-apparatus was composed of four cells. Many smaller bodies looking like small nuclei are often present within the egg and the synergids. Rutgers also figures these but makes no mention of them in the text. Johansen (1931 *a*) also met with several similar cases " which defy all logical interpretation ".

The number of polar nuclei is also variable. In several cases two distinct pairs of polars have been observed. In one case six nuclei were found in the middle of the embryo sac. I am not yet in a position to make any definite statement regarding the origin of these supernumerary nuclei, but two explanations are possible: (1) either they are vegetative nuclei which have by some method found their way into the cavity of the embryo sac; or (2) they are formed due to some irregularities in nuclear division. It is interesting to note that Johansen (1931 *b*) has recently reported a repeated amitotic division of the polar nucleus in *Anogra pallida,* resulting in as many as 140 small nuclei in well-nourished embryo sacs.

My heartfelt thanks are due to Dr. P. Maheshwari under whose guidance this work was done and to Prof. K. Schnarf of Vienna who kindly examined some of my preparations and confirmed my observations.

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EXPLANATION OF FIGURES.

FIG. 1.—A young nucellus with a pair of hypodermal archesporial cells. × 630.

FIG. 2.—Primary wall cell and megaspore mother cell. × 630.

FIG. 3.—Megaspore mother cell enlarging. × 630.

FIG. 4.—Nucellus with a linear tetrad of megaspores separated from the nucellar epidermis by three wall layers. × 630.

FIG. 5.—The same, with a T-shaped tetrad. × 630.

FIG. 6.—Two-nucleate embryo sac. × 630.

FIG. 7.—Four-nucleate embryo sac. × 790.

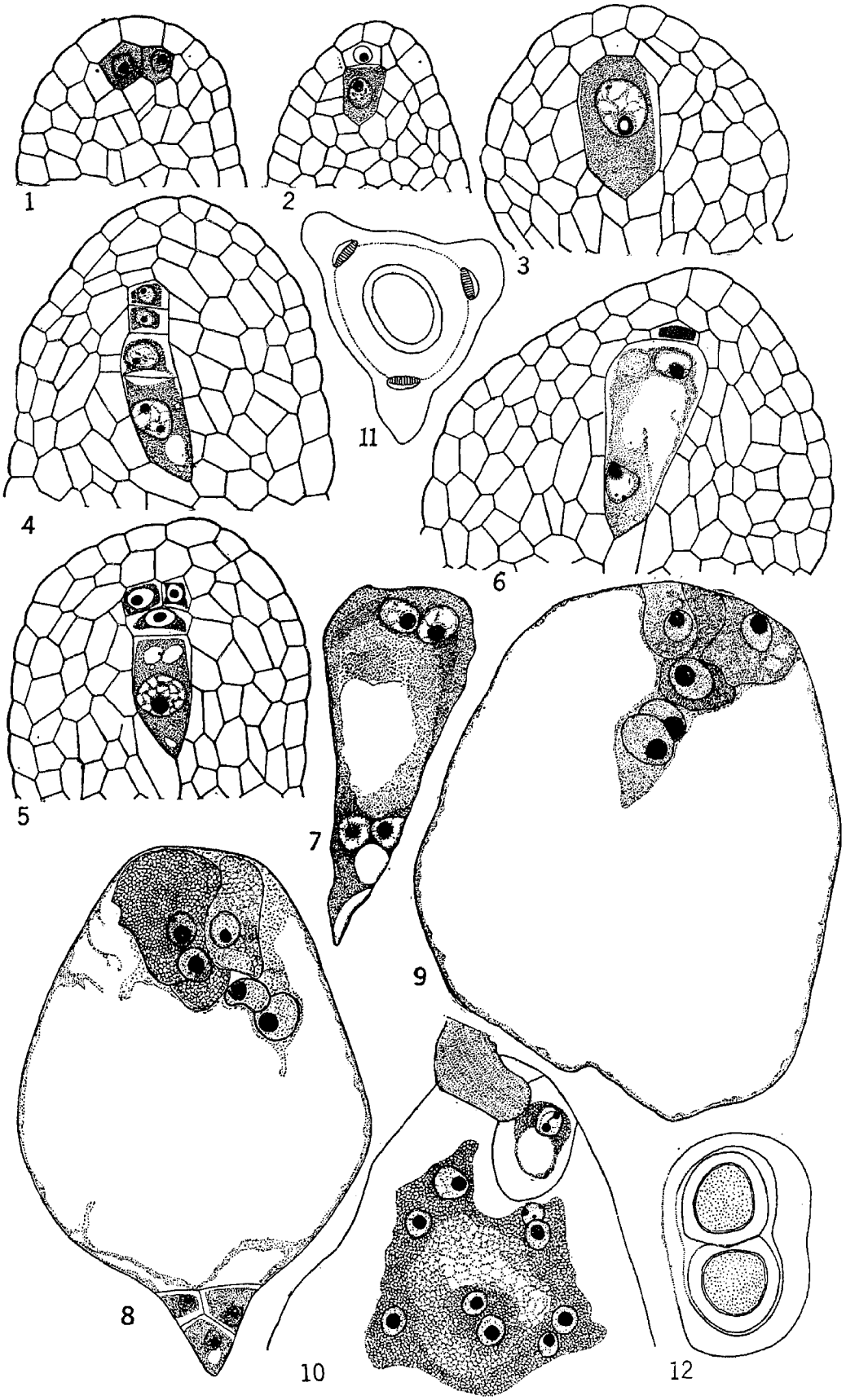
FIG. 8.—Eight-nucleate mature embryo sac. × 630.

FIG. 9.—Same, older stage, the three antipodals have disappeared. × 630.

FIG. 10.—Fertilised egg with a portion of the pollen tube and a mass of endosperm nuclei at the micropylar end. × 630.

FIG. 11.—T. S. mature ovule showing three vascular bundles, one at each corner of the outer integument. × 630.

FIG. 12.—T. S. ovule showing two nucelli enclosed within the same outer integument but having their separate inner integuments. × 96.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