STRUCTURE OF EMBRYO IN THE SEEDS OF *ENIGMOCARPON PARIJAI* SAHNI

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ABSTRACT

The paper gives an account of the mature embryo, free nuclear endosperm, and the development of an operculum in the seeds of *Enigmocarpon parijai* Sahni — not reported previously. Only the epistase and hypostase were known before (Sahni, 1934, 1943; Mahabale & Deshpande, 1957).

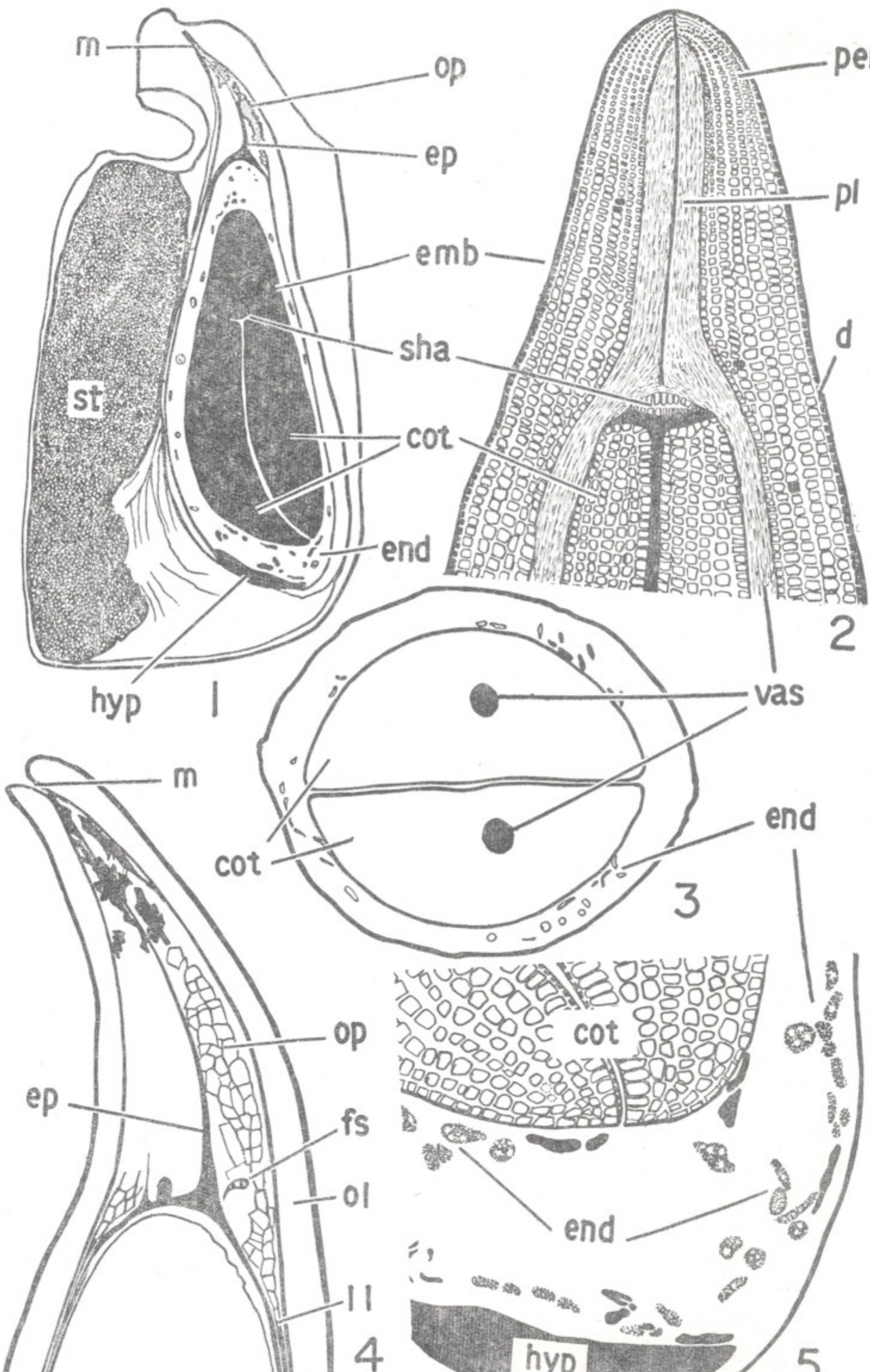
INTRODUCTION

THE genus *Enigmocarpon* was created by Sahni (1934) for the silicified fruits discovered at Mohgaonkalan (Dist. Chhindwara, M.P., India) by Rode (1933). He, however, thought them to be the fruits of the genus *Cucumites* of Bowerbank, earlier casually referred to by Hislop and Hunter (1885) in the Intertrappean beds around Nagpur, more than 90 years ago. However, the present generic name was given to these fruits by Sahni (1934) who also described them in detail in 1943 (Sahni, 1943). Shukla (1944) discovered the silicified flower — *Sahnianthus*, and from the nature of ovary, placentation, ovule and cohesion of anthers, showed that they are of the same plant — *Sahnianthus* being the flower, of which *Enigmocarpon* is the fruit and that both belonged to the family Lythraceae. However, later Mahabale and Deshpande (1957) redescribed them and compared them with those of the Sonneratiaceae and Lythraceae and found that there is a distinct epistase in it as in the genus *Sonneratia*, and suggested that *Enigmocarpon* shows rather the characters which indicate its affinity with the members of living Sonneratiaceae than of the Lythraceae. We, therefore, made some fresh collections at the type locality of Mohgaonkalan (22°1′N; 79°11′E) Dist. Chhindwara, M.P., India and studied them. In one specimen no. — MK 8/70 a number of beautifully preserved fruits and some loose seeds were found embedded in the matrix. The present paper is based on the histological features of both fruits and seeds which were restudied. T.S., L.S. and even some obliquely cut sections of fruits were taken to study them.

DESCRIPTION

The seeds of *Enigmocarpon* as shown by Sahni (1943), Shukla (1944), Mahabale and Deshpande (1957) are anatropous. They are characterised by curved micropyle, whip-like epistase, saucer-shaped hypostase, elongated raphae, considerable mass of spongy tissue lying opposite the embryo and a very short funiculus (Pl. 1, fig. 1; Text-figs. 1, 4). A vascular strand passes through the funiculus and ends in the chalazal region of the seed (ovule).

Each seed (ovule) is crassinucellate and bitegmic. The outer integument is multilayered and massive. The inner integument is few-layered. It gets highly compressed between the outer integument and the inner nucellar mass. Due to this many seeds do not reveal its presence. In a few seeds the cells of inner integument in the micropylar region formed a cap-like structure known as operculum (Pl. 1, fig. 2; Text-figs. 1, 4). The term " Operculum " was used by Hegelmair (1868) as early as 1868 for a stopper-like structure observed at the micropylar end in the seeds of Lemnaceae. Caldwell (1899) suggested that the operculum should be originating partly from the inner integument and partly from the outer integument. Recently S. C. Maheshwari (1954, 1956) showed that the operculum is formed exclusively from the persistent apical cells of the inner integument, and that the cells down below get crushed. The situation here seems to be somewhat similar, as there is a distinct layer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TEXT-FIGS. 1-5

of cells around the embryo sac cavity in micropylar region. Its development appears to be similar to that in *Wolffia microscopica* and *Lemna paucicostata* described by S. C. Maheshwari (1954, 1956). As a rule in most of the taxa operculum remains enclosed by outer integument, but in a few species it remains partly exposed. Such an operculum is noticeable in the living members of the Araceae (Buell, 1935), Droseraceae (Smith, 1929) and Lemnaceae (S. C. Maheshwari, 1954, 1956).

Some fungal mycelium and spores were observed in the micropylar part in the seeds of *Enigmocarpon* in association with the opercular cells (Text-fig. 4). Probably due to the invading fungal mycelium and its spores, cells of the operculum were disintegrated in many cases, or digested partly or fully. However, in a few seeds, the operculum was seen more or less intact although at places its cells were not clear (Pl. 1, figs. 1, 2; Text-figs. 1, 4).

The structure and nature of the mature embryo was studied in L.S. and T.S. in some well preserved seeds (Pl. 1, figs. 1, 3, 4, 5; Text-figs. 1, 2, 3). The embryo in them undoubtedly showed the dicotyledonous nature (Sahni, 1943). It is $16 \times 5{\cdot}6$ mm, straight, massive and broad. The two well developed cotyledons face each other. Out of these two, the one towards the spongy side is curved, slightly larger than the other cotyledon which is short and straight (Pl. 1, figs. 1, 3; Text-fig. 1). Both the cotyledons show the presence of vascular traces in L.S. and T.S. of the embryo (Text-figs. 2, 3). The radicle end is cylindrical 4×2 mm, but its tip is round. It is well differentiated into long hypocotyl and somewhat rounded flat shoot apex (Pl. 1, figs. 1, 3, 4; Text-figs. 1, 2).

The shoot apex is an undifferentiated mass of tissue occupying a median position between two cotyledons on either side (Pl. 1, fig. 4; Text-figs. 1, 2). The plumule-radicle complex is clearly differentiated into outermost single-layered dermatogen; its each cell measures $3{\cdot}5 \times 6\ \mu$. It is followed by periblem 7 cells wide, each cell measuring $9{\cdot}5 \times 12\ \mu$, and the plerome 7-8 cells wide placed in the centre. Each cell of it measures $9 \times 2{\cdot}5\ \mu$ (Pl. 1, figs. 3, 4; Text-fig. 2) and future epidermis, cortex and stelar system are formed respectively from them. The vascular traces going to cotyledons and plumule-radicle complex lie in continuation of each other and form a single unit. In mature seeds the embryo occupies the whole of what it appears to be the embryo sac cavity (Pl. 1, fig. 1; Text-figs. 1, 2, 3).

Suspensor and root cap were not seen. But from the position of the embryo deep in embryosac cavity, it seems that in early embryogeny the suspensor might have been present in the seed. The embryo seems to have been pushed down into the endosperm, suggesting its endoscopic nature (Wardlaw, 1955). The shoot apex of mature embryo in the present specimen was undifferentiated Probably this mass of cells at apical meristem seems to get differentiated during the germination of seeds as in the living plants.

There are many cells in the peripheral region of the embryo sac cavity, surrounding the embryo. They appear to be of endosperm from their position. These cells do not show any wall, and therefore, endosperm seems to be free nuclear. Concentration of these free endosperm cells was more in the chalazal region than in the micropylar region of the embryo sac cavity (Pl. 1, figs.

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TEXT-FIGS. 1-5. Structure of embryo in the seeds of *Enigmocarpon parijai* Sahni.

Fig. 1. L.S. of a seed showing micropyle — *m*, operculum — *op* (hatched), epistase — *ep*, hypostase — *hyp*, endosperm — *end*, spongy tissue — *st*, and embryo — *emb*: Note the median position of shoot apex — *sha* and cotyledons — *cot* in embryo × 44. 2. L.S. of mature embryo showing outermost layer dermatogen — *d*, periblem — *per*, plerome — *pl*, median shoot apex — *sha* and cotyledons — *cot* with vascular strands — *vas* × 220. 3. T. S. of seed with two cotyledons — *cot*, showing vascular strands — *vas*: Note the endosperm cells — *end* in the peripheral region of embryo sac surrounding cotyledons × 128. 4. A magnified part of micropylar end of a seed in L.S. showing curved micropyle — *m*, whip-like epistase — *ep*, operculum — *op*, fungal spores — *fs*, inner integument — *ii* and outer integument — *oi* × 200. 5. A part magnified from the chalazal region of a seed in L.S. showing two cotyledons — *cot*, free nuclear endosperm — *end* and a saucer-shaped hypostase — *hyp* × 330.

1, 5; Text-figs. 1, 3, 5). These features have not been described by previous workers. No doubt, Sahni (1943) thought that these cells surrounding the embryo in embryo sac were perhaps of endosperm. He only suggested them to be so, but did not study their nature and hence made no comments whether they constituted cellular or free nuclear endosperm. He had only noticed a clear cavity around the embryo. But as he did not observe any cell, he thought that the embryo digested the endosperm cells on account of which the seed looked exalbuminous (Sahni, 1943, p. 77). During development and maturation of the seed the endosperm cells seem to be digested by it. On account of this the seed looks exalbuminous. Thus from the nature of the cavity around embryo, cells of endosperm and its development, it seems to be of the free nuclear type.

Some botanists (Maheshwari, 1950, p. 254) have correlated the occurrence of the endosperm tissue with the spatial conditions in the embryo sac. According to them the cellular endosperm occurs in long and narrow types of embryo sac; on the other hand, the free nuclear endosperm occurs in broad and short embryo sac. These observations on the embryo sac and endosperm in the living plants appear to support the free nuclear nature of the endosperm in *Enigmocarpon*, as its embryo sac cavity is quite broad, and there is well differentiated mature embryo (Pl. 1, figs. 1, 3; Text-fig. 1). The endosperm cells are without any particular orientation. They appear round, elongated or irregular. In none of the seeds persistent nucellus could be observed.

Locality — Mohgaonkalan, Dist. Chhindwara, M.P., India.

Horizon — Tertiary (Eocene).

Specimen No.— MK 8/70 Botany Department, University, of Poona, Poona-7, India.

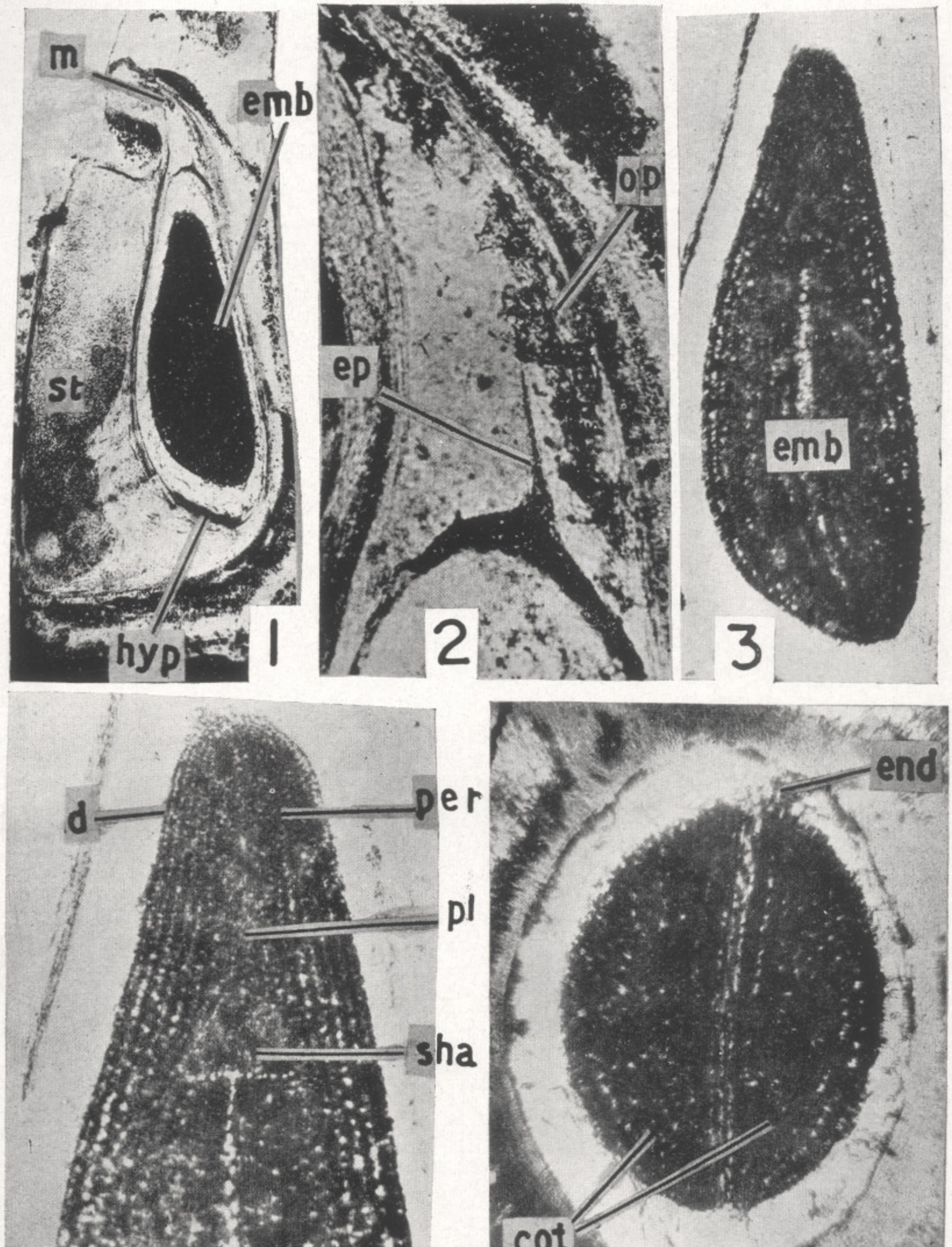
Revised Diagnosis — Seeds (ovules) anatropous, bitegmic, crassinucellate, having short funiculus, whip-like epistase, saucer-shaped hypostase, operculum, free nuclear endosperm and a well developed dicotyledonous type of embryo in mature seeds. The embryo shows differentiation of dermatogen, periblem, plerome, shoot apex between the two cotyledons and a long hypocotyledonary region with a single vascular supply.

DISCUSSION

Available literature regarding the affinities of the genus *Enigmocarpon* has been discussed at length by different authors. Sahni (1943), Shukla (1944) showed its relationship with the members of Lythraceae whereas Mahabale and Deshpande (1957) showed it with the members of Sonneratiaceae.

However, from study of the mature embryo, endosperm and seed structure in *Enigmocarpon*, it is clear that so far the endosperm formation is concerned it is more like that in Lythraceae in which the endosperm is of the free nuclear type, whereas in the Sonneratiaceae it is said to be of cellular type (Joshi & Venkateshwarlu, 1936; Venkateshwarlu, 1937). The embryo structure on the other hand, shows distinct resemblance with that in the Sonneratiaceae rather than with that in the Lythraceae. It is, therefore, quite possible that *Enigmocarpon* represents an extinct genus which must have been a very early member of a complex having characters of both Lythraceae and Sonneratiaceae, particularly in fruits, and in seeds of *Enigmocarpon*. The position thus seems to be that *Enigmocarpon*, *Lawsonia* and *Sonneratia* seem to represent a complex, all having a common origin, and they got split up later as shown below:

Enigmocarpon	—	*Sonneratia*	—	*Lawsonia*	complex	.... Eocene
Enigmocarpon	—	,,	—	,,	,,	.... Early Eocene
Lawsonia	—	,,	—	,,	,,	.... Eocene
Diclidocarya	—	,,	—	,,	,,	.... Lower Miocene
Decodon	—	,,	—	,,	,,	.... Lower Miocene
Sonneratia	—	,,	—	,,	,,	.... Late Eocene to Modern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EXPLANATION OF PLATE

Pl. 1, figs. 1-5. Structure of embryo in the seeds of *Enigmocarpon parijai* Sahni.

1. L.S. of a single seed showing micropyle — *m*, spongy tissue — *st*, hypostase — *hyp*, and embryo — *emb* × 22.

2. A part of seed magnified in the micropylar region showing whip-like epistase — *ep*, and an operculum — *op* × 150.

3. L.S. of mature embryo — *emb*: Note the broad massive cotyledons and cylindrical tapering radicle end × 54.

4. L.S. of embryo showing dermatogen — *d*, periblem — *per*, plerome — *pl*, shoot apex — *sha*, and cotyledons — *cot* × 110.

5. T.S. of seed showing two cotyledons — *cot*, and endosperm — *end* × 65.