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FLOWERS AND FRUITS IN FLACOURTIACEAE

II. The seeds of Pangium edule Reinw.

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The seeds are inferior. Only in the apical part of the seed the testa is integumental; for the greater part it is chalazal. A thick mesotesta is formed by a matted layer of sclereids. The chalazal part of the ectotesta is richly vascularized. A sheath of inverted vascular bundles occurs on the inside of the chalazal part of the mesotesta. The seeds are albuminous, the cotyledons foliaceous. An inside cavity may make the seeds float in water. The nucellar beak persists in the ripe seed. The endopyle is five-rayed in c.s., the ectopyle is a longitudinal slit.

THE FLOWERS

A brief characterization is presented here. For a full taxonomic description the reader is referred to Sleumer (1954).

The unisexual flowers are provided with an entire calyx and five or more petals. Inside at their base the petals have a thick broad scale which is truncated or sometimes bilobed.

The male flowers (*Brass 27673 A*, *Darbyshire 903*, *Hoogland 5218*) have many stamens which have thick lanceolate filaments provided with a median adaxial ridge. The anthers are versatile and introrse. The connective may be slightly extended between and beyond the thecae. In the adult flowers I could not find any trace of pistil development. However, in young male flowers (*NGF. 1884*) a rudiment of a pistil was observed.

The female flowers (*K.R. Bogor s.n.*, *BSIP 9570*, *10005*) have a terminal pistil. Five to ten small rather thick appendages are located between the petals and the pistil. They are lanceolate, apically pointed, and have their margins slightly folded inwards. The pistil is one-celled, and issues upwards in three or four narrow stigmatic tubes. There is no style. The stigma is composed of three or four symplicate portions of unequal size. In one case these portions were fused by their lateral faces only. The pistil wall is traversed by six to eight main vascular strands; normal collateral bundles alternate with complex bundles. The ovules are located opposite the complex bundles in double rows along the wall of the pistil. There are no placentae.

The fruits are reported to be indehiscent. Those used in the present study were pear-shaped, 10 cm long and 6 to 7 cm broad (*Burck s.n.*, *Lütjeharms 3884*, both preserved in alcohol). They contained unripe seeds. The seeds were 1—2.5 cm long and 1—2 cm wide, irregularly angular in shape, and appressed to each other in the fruit. In addition some ripe seeds could be studied (*Carr 16265*), measuring 6 by 4.5 cm. They were rounded toward the side of the fruit wall and had flat sides where they were appressed to each other.

THE SEEDS

The most conspicuous feature is their being inferior (cf. van Heel, 1973). The main portion of the testa is formed by the chalazal part of the seed, that is the region below the

attachment of the integuments. The part of the seed that is formed by the integuments can be seen in the top region of the seeds only.

On the surface of the ripe seeds the integumental part of the testa can be observed as a longitudinal, elliptic, distal scar, in the middle of which the ectopyle shows as a longitudinal groove which bursts open on pressure. In dried seeds the surface of the chalazal part shows the hard mesotesta with numerous prominent vascular bundles. In the integumental part of the testa vascular bundles are absent. After soaking the seeds, the presence of the vascular bundles on the mesotesta is obscured by the swelling of the ectotesta, by which the seeds appear to adhere to each other forming a bunch. Presumably the ectotesta functions as a sarcotesta. The mesotesta is entirely composed of an intricate matted pattern of long and heavily sclerified cells. Evidently it functions as a sclerotesta. To the inside of the testa a fleshy endosperm is located. Again more inwards the foliaceous cotyledons are appressed to the endosperm. Also there are scattered remains of nuclear endosperm. The centre of the seed appears hollow. Possibly this accounts for the floating capacity of the seed, as reported by Corner (1952) and Sleumer (1954). There is another empty space beneath the integumental testa, the endosperm and cotyledons being restricted to the chalazal part of the seed.

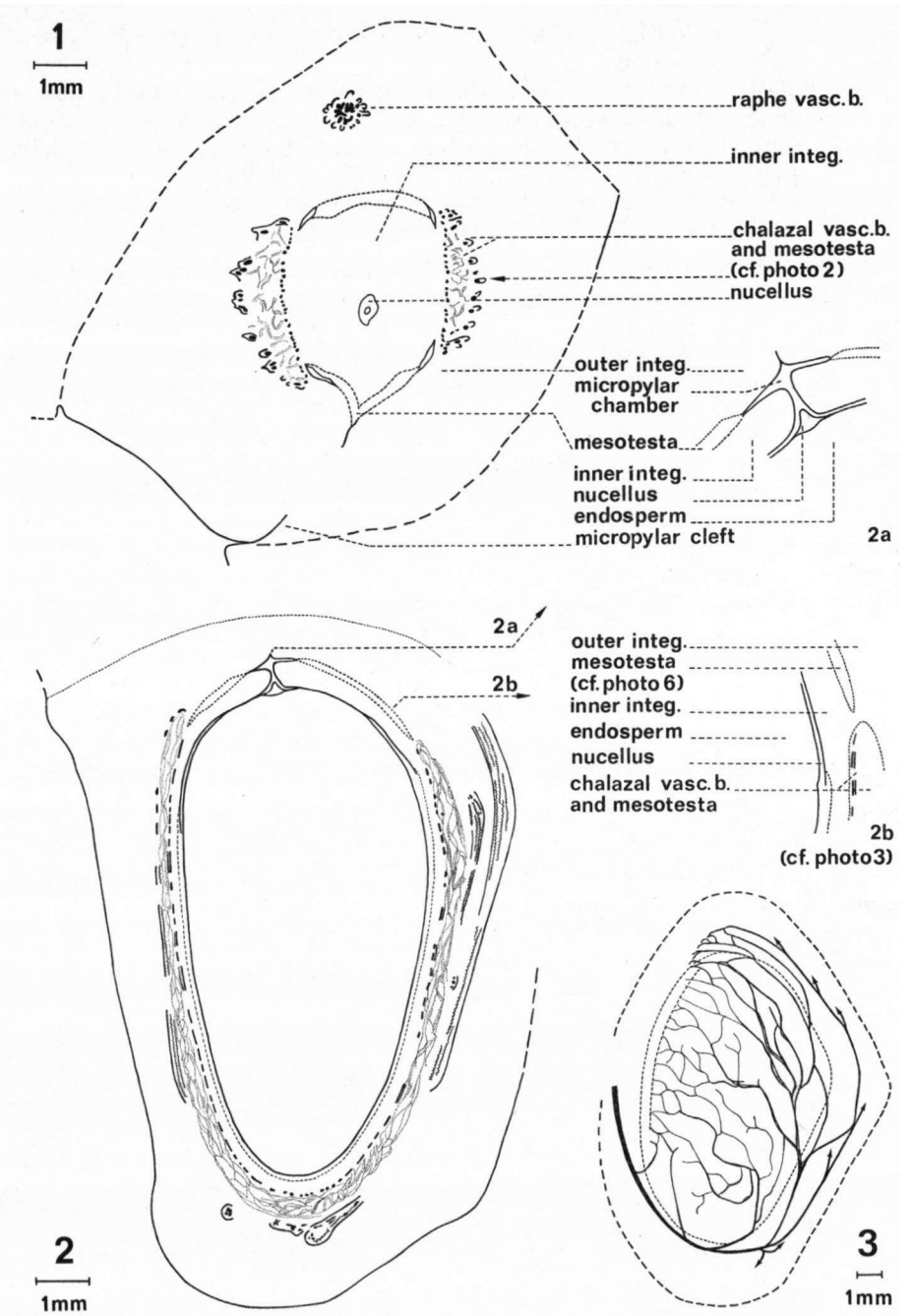
Studying unripe seeds, one is struck immediately by the rich vascularization (Netolitzky, 1926). The seeds range from hemitropous to anatropous. At the proximal pole of the seed the vascular bundle of the raphe divides in a number of branches of unequal size. The branching occurs at intervals, sometimes more or less palmately, sometimes with two prominent branches. The branches gradually ramify into smaller anastomosing branches (fig. 3). The ramification terminates at the distal pole of the seed, below the base line of the integumental portion of the testa.

At both sides of the seed, toward its apical region, the chalazal part reaches higher than in the median plane. Correspondingly the integumental part of the testa reaches down lower in the median plane of the seed than in the transverse plane. This is in conformity with the curved outline of the distal pole of the seed. As a result, in a distal cross-section the vascular system of the chalazal testa shows as two separate lateral portions (fig. 1). In the median region of this same cross-section the testa appears to consist of an inner and an outer integumental part. At their base these parts are free from each other (figs. 1, 2, photos 2, 3). However, upwards they are appressed. Again, apically they are free from each other, forming a micropylar chamber.

Between the integuments a mesotesta is formed by means of profuse divisions, probably in the outer cells of the inner integument (fig. 1, 3). The inner cells of the outer integument also divide profusely, adding to the thickness of the ectotesta. The cuticular layer between the integuments gets disrupted. However, the study of younger stages should give more precise information on the development of this region. The cells so formed elongate and become arranged in a matted pattern. Later on, they develop into sclereids, as mentioned above. The mesotesta formation in the chalazal part of the seed is comparable with and ahead of that in the integumental part.

The location of the vascular bundles relative to the chalazal mesotesta is notable. The vascular system of the seed, although strictly lying within the ectotesta, closely surrounds the mesotesta (photo 1). Another peculiar feature is that the mesotesta is provided with a sheath of vascular bundles on its inside (figs. 1, 2; photos 1, 2, 3). These collateral bundles are inverted, their xylem facing the mesotesta. Except for apical anastomoses (fig. 2), there is no contact between the two vascular systems.

The endopyle, in cross-section, appears as a five-rayed open space (photo 4). Probably



Pangium edule. — Fig. 1. Unripe seed, subdistal c.s. — Fig. 2 l.s. — Figs. 2a, b. Legend to 2. — Fig. 3. Halved and cleared seed. Vascular bundles seen from inside.

this is caused by the distal lobing of the inner integument (fig. 2a). As a contrast, the ectopyle is a median slit, extending as the seed ripens.

Beneath the integumental testa the nucellus is free and consists of a residual peripheral sheath of cells. On the inside of the chalazal testa a layer can be detected of more deeply staining cells (fig. 2). The remaining nucellar beak prominently projects between the lobes of the inner integument. It has glandular cells on top (fig. 2, photo 5).

CONCLUSION

The seeds of *Pangium edule* can be distinguished by the combination of being inferior and having a thick mesotesta and a rich vascular bundle supply. In contrast with crossing layers in *Scaphocalyx* and *Hydnocarpus* (Sleumer 1938), the mesotesta in *Pangium* consists of strands of sclereids in a matted pattern. Possibly a unique feature is formed by the sheath of inverted vascular bundles inside of the mesotesta. There may be an analogy with the middle network of vascular bundles in the inferior seeds of *Cycadaceae*. One can imagine that by this system a supply is made possible of the tissues to the inside of the sclerotesta. Whereas the distal lobing of the inner integument also occurs in *Scaphocalyx*, the distal slit of the outer integument is different. The five-rayed structure of the endopyle may be related with the 'plugging' of the micropyle, as described from some Gymnosperms, among them *Gnetum*. It may be added here that in *Scaphocalyx* I observed the formation of epidermal papillae which project into the micropylar chamber, becoming thick-walled, like this is known in *Ephedra*. These features were discussed by Singh and Johri (1972). It would be interesting to study the development of these seeds more closely.

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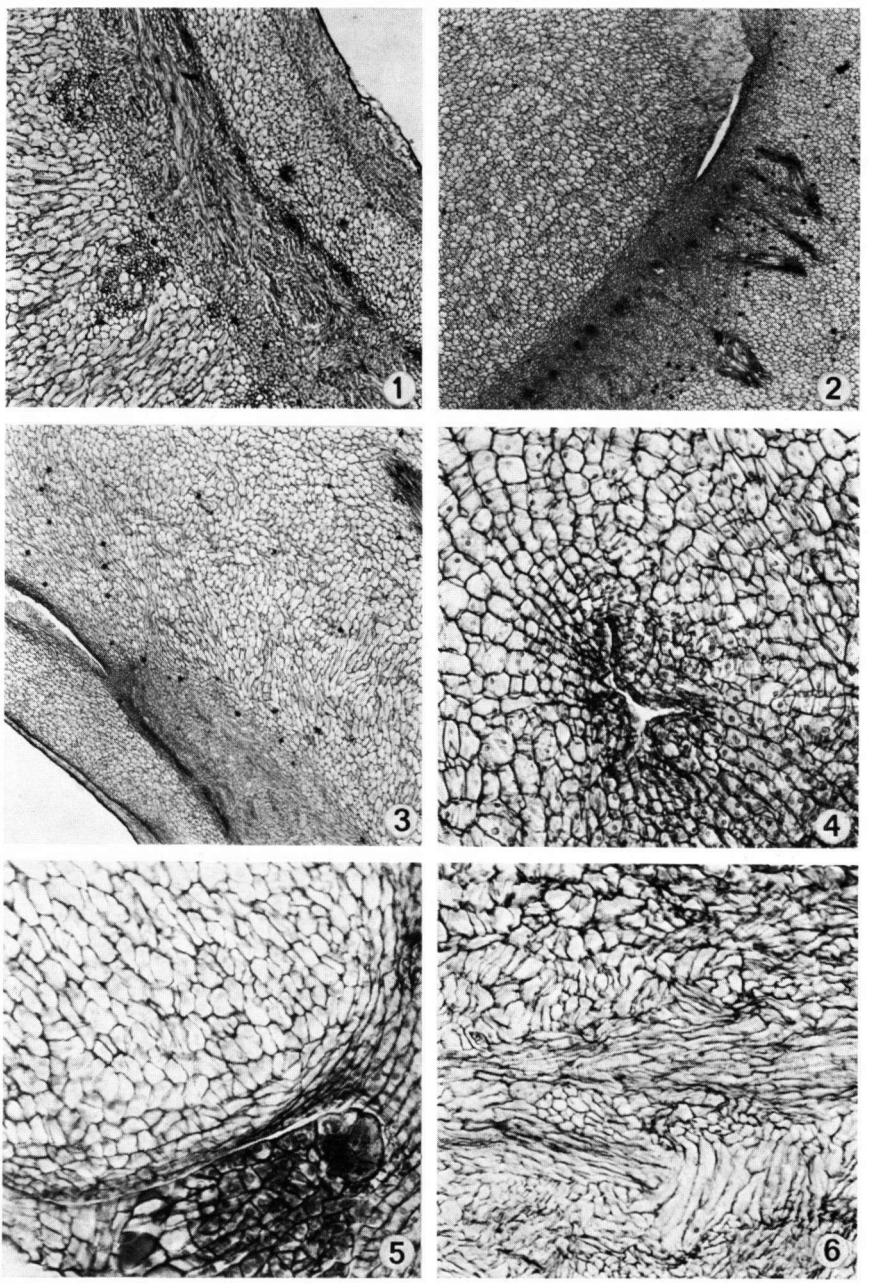

Pangium edule. — Photo 1. Chalazal testa, c.s. 60×. — Photo 2. Cf. fig. 1. 30×. — Photo 3. Cf. fig. 2b. 30× — Photo 4. Inner integument, apical c.s. 180×. — Photo 5. Nucellar beak. 180×. — Photo 6. Mesotesta formation. 180×.

A stand of *Alstonia spatulata* Bl. in the Kebar Valley (West New Guinea, Vogelkop Pen.). Photograph by Ch. Koster, March 1958.