ON A FRUCTIFICATION FROM THE INTERTRAPPEAN FLORA OF THE MADHYA PRADESH, INDIA

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ABSTRACT

A new specimen identical with *Viracarpon hexaspermum* Sahni is investigated and described in detail. The stalked axis of the fructification bears sessile, ebracteate fruits in close vertical rows; the individual fruits are six-angular, six-carpellary and hexalocular with a single pendulous seed in each loculus; the fruit top has depressions and bears a crown of hairy spines. Comparison with the modern families shows that this monocotyledonous genus is an extinct one, and does not readily fall into any existing family.

INTRODUCTION

THIS paper describes some fruits of *Viracarpon hexaspermum* Sahni in as much detail as possible. *V. hexaspermum* is only known from some preliminary descriptions by Sahni (1934 and 1944). All the specimens studied here come from the village Mohgaon-Kalan which lies on the latitude 22·1 N. and longitude 79·11′18″E. in the Chhindwara district of the Madhya Pradesh, India (SAHNI & RODE, 1937). Here are some outcrops of the Deccan Intertrappean Series. In 1949 the author collected a loose piece of chert exhibiting two petrified fruits from a field in the north-west of the village. These specimens of fructifications were exposed on the chert in oblique longitudinal sections resembling each other in appearance. After sectioning the chert into two, one more specimen (No. 3) was discovered embedded inside. All these three specimens of fructifications were studied and found to be one and the same in external features, size and general appearance.

Age — The age of the Deccan Intertrappean Series of this region is believed to be Eocene (SAHNI, 1940; SAHNI & RODE, 1937; RAMA RAO, 1936).

DIAGNOSIS OF THE GENUS

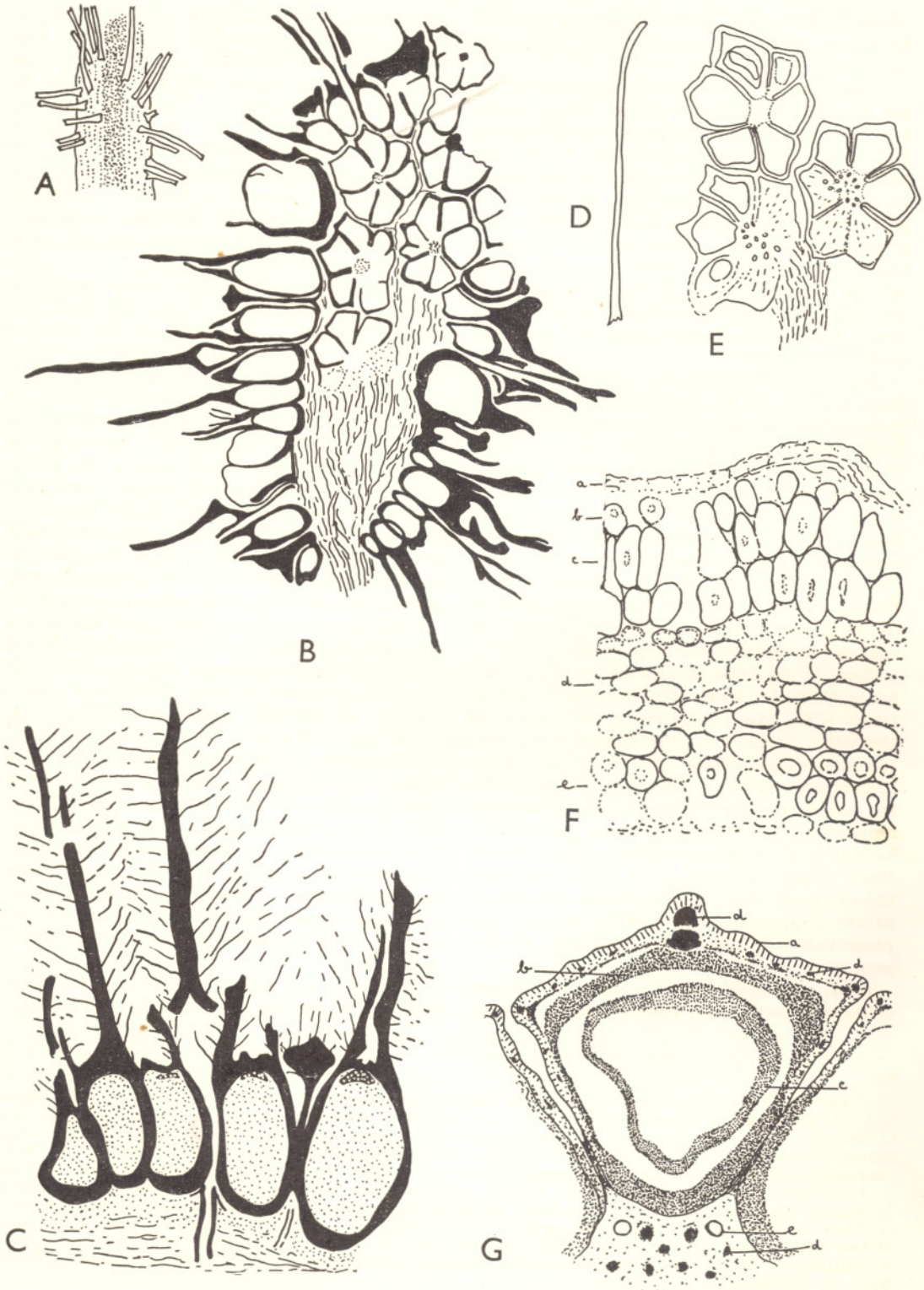
Pedunculate, spiny, aggregate fructification consisting of a central, unbranched axis continuous with peduncle and bearing crowded fruits in longitudinal rows. Fruits sessile, ebracteate. Individual fruit prism-shaped, 6-angular with 6 equal loculi round a central core; each loculus containing one pendulous seed. Top of ovary wall bearing projecting spines. Peduncle with monocotyledonous scattered bundles.

DIAGNOSIS OF THE SPECIES

Peduncle $17 \times 2{\cdot}5$ mm. Body of fructification 30×19 mm. (excluding spines). Individual fruits arranged on fructification axis in 8 or more vertical rows, each row containing at least 5 fruits. Individual fruit 5×5 mm. in size, with a crown of 12 long, narrow, hairy, straight spines in two whorls, projecting outwards in plane roughly radial to fructification axis; members of two adjoining whorls are opposite each other in six radial planes on the top of the fruit, fusing at base and free for rest of the length. Each spine at least $15 \times 0{\cdot}75$ mm. covered with more or less straight unicellular hairs, each at least 2·5 mm. in length. Fruit-wall and fruit-core with heavily thickened fibres. Inner epidermis of fruit-wall consisting of cells with thick sinuous walls in surface view. Top of fruit marked with a central depression surrounded by 6 others in plane of septa, these surrounded by 6 others also in plane of septa. Seed $3 \times 1{\cdot}5$ mm. Inner ring of vascular bundles in peduncle, comprising about nine bundles; central pith aerenchymatous.

DESCRIPTION

The three specimens, now deposited in the Geological Survey of India, are numbered 1, 2 and 3 in the following description. The size of the fructification is exactly the same (30×19 mm.) in all. No. 1 has a stalk at least $17 \times 2{\cdot}0$ mm. and No. 3 has a stalk at least $17 \times 2{\cdot}5$ mm. The stalk of No. 2 is unknown. No. 3 proved the best and the following account is based primarily on it. A preliminary report of the fructification was given by me in 1954 (CHITALEY, 1954).



TEXT-FIG. 1

The specimen (No. 3) was originally exposed in a cut which happened to be obliquely tangential to it.

Arrangement of the Individual Fruits on the Fructification Axis — Four longitudinal rows are apparent in the section shown in Fig. 1, B. There must, therefore, be at least eight rows. Another view at a rather deeper level suggests that there may be twelve or more rows (but Sahni's Fig. 26, 1944, suggests about eight). There is some evidence that the fruits are borne in alternating whorls (TEXT-FIG. 1, B & E). Allowing for the obliquity of the top and bottom fruits, there is room for about 6-7 fruits in each vertical row.

Axis of the Fructification — The axis of the fructification is in continuation with the stalk or the peduncle and is elongated, broad in the middle part and tapering at both ends. It measures about 25 mm. in length and the diameter varies from 5 mm. at the base to 9 mm. in the middle part. The oblique longitudinal section of the axis shows the scattered vascular bundles running longitudinally (TEXT-FIG. 1, B), each with a thick fibrous sheath. There is much soft tissue in the centre of compact parenchymatous cells with a few isolated thickened cells.

Axis of the Individual Fruit — The fruits are ebracteate, and virtually sessile and so the "fruit axis" is merely the region of transition from the fructification core into the base of the ovary. In T.S., i.e. a deep tangential section of the whole fructification the tissue is highly fibrous. Two vascular bundles lie underneath the inner end of each loculus and there are a few others inside these (TEXT-FIG. 1, E). I could not trace the origin of the vascular bundle which lies in the ridge of the fruit-wall, because the preservation of the base of the fruit is very poor.

Fruit as a Whole — The fruit is roughly cylindrical with six equally deep grooves extending about half way to the centre. These grooves become less deep at the top of the ovary (TEXT-FIG. 2, H). The six portions of the ovary which I describe as carpels are thus fused. They are of equal size. At the top of the ovary the tissue becomes massive and densely fibrous; its form is complex, as explained later. Between the six loculi (TEXT-FIG. 2, K & L) there is a considerable central core which is largely fibrous with compact parenchymatous cells in between.

There is no clear evidence of the existence of the perianth, but it is possible that the flanges (TEXT-FIG. 2, D-F) at the base of the outer spines are of this nature.

No stigma or style has been recognized.

Fruit-wall — The outer wall, which is moderately well preserved, is composed of two zones (TEXT-FIG. 1, G) the outer of which is illustrated in Text-fig. 1, F, where I have labelled all the cell layers I could see in the transverse section. As the preservation is poor, I cannot be sure that the tissues are all rightly identified. In a longitudinal section of the same zone, the large and small fibres are both seen to be strongly elongated. At the lateral corners of the carpel, the tissue is much the same, but there are in addition some inner small fibres. There is probably a small vascular bundle at each of these angles. Inside the above zone there is a small gap (TEXT-FIG. 1, G) which is constantly present. This may be original or else caused by shrinkage or decay of tissue. Then follows a zone of rather uniform fibres (TEXT-FIG. 1, G) which, again, are elongated in L.S. This zone becomes thinner and joins the outer part of the fruit-wall at the sides of the furrows. The innermost layer is an epidermis formed by cells with thick, sinuous walls. This is seen in surface view in Text-fig. 2, C.

Spines — The spines are clearly seen in radial L.S. of the fructification (TEXT-FIG. 1, C),

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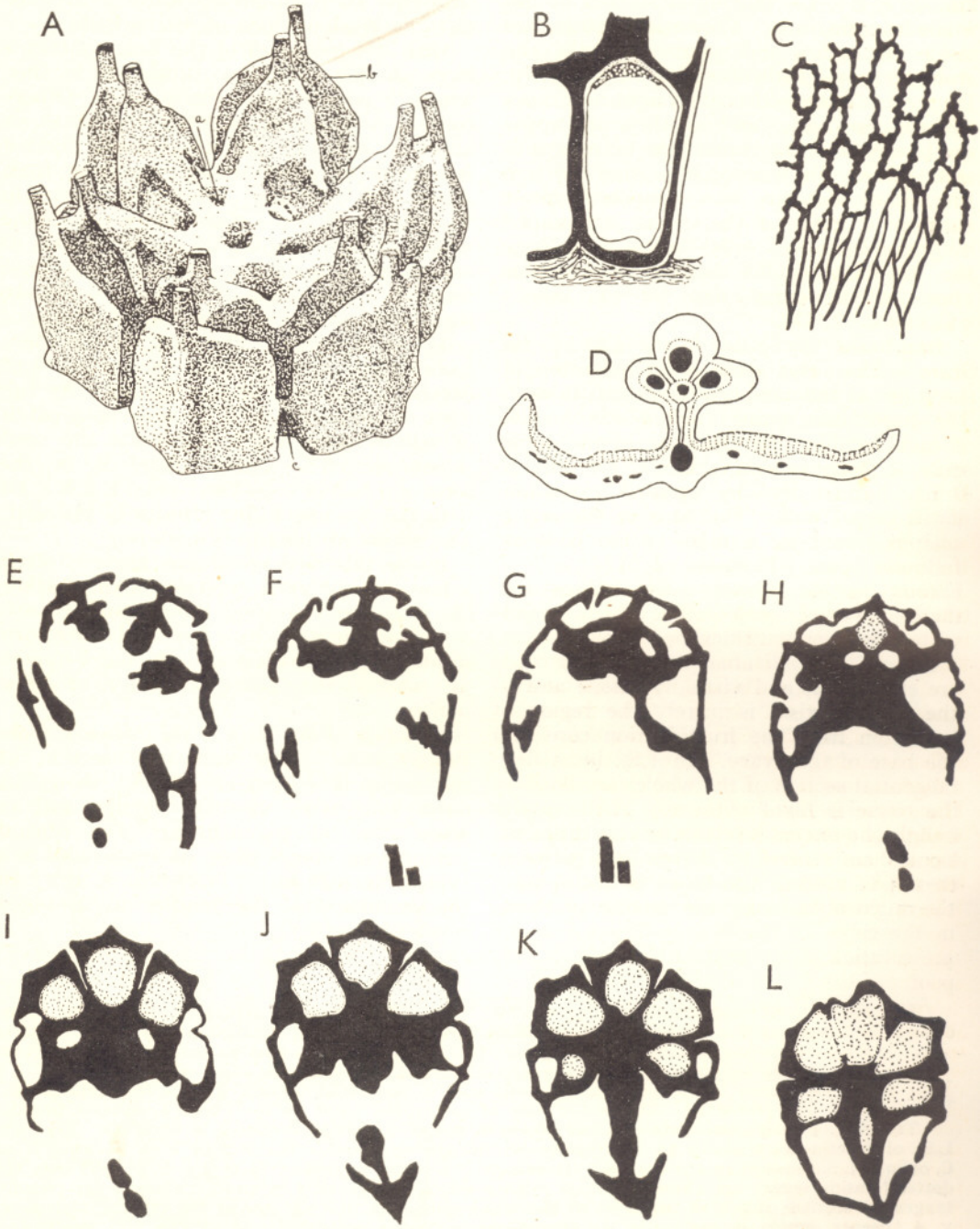
TEXT-FIG. 1 — A, small portion of spine showing attachment of hairs. × 15 (Slide 1). B, obique L.S. of fructification showing arrangement of individual fruits. × 3 (deeper section in Slide 1). C, oblique L.S. through two fruits showing long, straight hairy spines and cap of yellow tissue (white dotted) inside seeds. × 5 (Slide 1). D, single complete unicellular hair. × 20 (Slide 1). E, deep tangential section of fructification showing three fruits; two of them show vascular bundles in axis. × 4 (deeper section in Slide 1). F, part of outer zone of fruit-wall: (a) outer layer? epidermis; (b) heavily thickened small fibres; (c) heavily thickened large fibres; (d) layers of parenchymatous cells; (e) fibres seen at lateral angles of carpel. × 500 (Slide 2). G, T.S. of single carpel with parts of two neighbours and a portion of the central core: (a) outer zone of fruit wall; (b) inner zone; (c) portion of cap of seed; (d) fibrovascular bundles; (e) depressions of ovary top in central core of fruit. × 20 (Slide 2).



TEXT-FIG. 2

but are most satisfactorily followed in serial oblique sections of the fruit (TEXT-FIG. 2, E-L), i.e. tangential section of the whole fructification. They arise in pairs, one inside the other and point outwards, the group from one fruit diverging very slightly. They are almost perfectly straight and taper towards the apex, and as they are apparently very stiff, they must have been formidable spines. In transverse section through the middle they are seen composed almost entirely of fibres at the centre surrounded by parenchymatous cells, but near the base the vascular bundles become conspicuous (one for the outer, four for the inner) (TEXT-FIG. 2, D).

Attachment of Spines to the Top of the Ovary — The outer spine is an extension of the ridge at the outside of each carpel wall. The inner one springs above the middle of each loculus. At the base of the outer spine, a flange is seen in T.S. (TEXT-FIG. 2, D-F), formed by an upward extension of the carpel wall. The base of the outer spine is joined by a ridge to the base of the inner spine (TEXT-FIG. 2, A).

Hairs on the Spines — The spines are thickly covered with hairs which stand roughly at right angles to the spine (TEXT-FIG. 1, A & C). Hairs are unicellular and have very thick walls and are often nearly straight (TEXT-FIG. 1, D). The preservation is remarkably good and they thus form a characteristic feature of the fructification.

Depressions at the Top of the Ovary Wall — Transverse sections of the top of the ovary at slightly different levels show very different appearances caused by depressions between the ridges uniting the bases of the spines. I have tried to make the nature of these clear in my reconstruction (TEXT-FIG. 2, A). Serial sections (TEXT-FIG. 2, E-L) make it clear that what appears as closed cavities are mere depressions open on the outside.

Seed — Some loculi of the fruit contain a large sac-like membrane filling the loculus, which I regard as a single seed. Others contain a small sac which I regard as an abortive seed and still others finely divided fragments of other tissues, resulting from some sort of decay. The seed shown in Text-fig. 2, B, has a thin surface membrane which at high magnification can be seen to consist of at least two distinct layers close together. Something of the same layers are seen in transverse sections, but no details of cells can be given. The seed, that is these membranes, is free from the ovary wall except at the top of the loculus. At the apex of the seed there is a conspicuous patch of yellow tissue which lies inside the seed membrane. The yellow tissue is in the form of a hollow cap (TEXT-FIGS. 1, C & 2, B) with the opening facing interior of the seed. The nature of this cap is unknown.

Inside this seed membrane there is often a mass of spherical crystals looking rather like cells, but I presume they apparently are of mineral origin. In a few seeds there are shreds of parenchymatous cells, but I cannot say whether they belong to embryo or endosperm.

Structure of the Stalk or the Peduncle of the Fructification — The transverse section of the peduncle (TEXT-FIG. 3, A) shows an outer zone with vascular bundles and an inner zone of parenchyma. The central parenchyma shows large air spaces and is a typical aerenchyma (TEXT-FIG. 3, B). In the vascular zone the bundles are arranged

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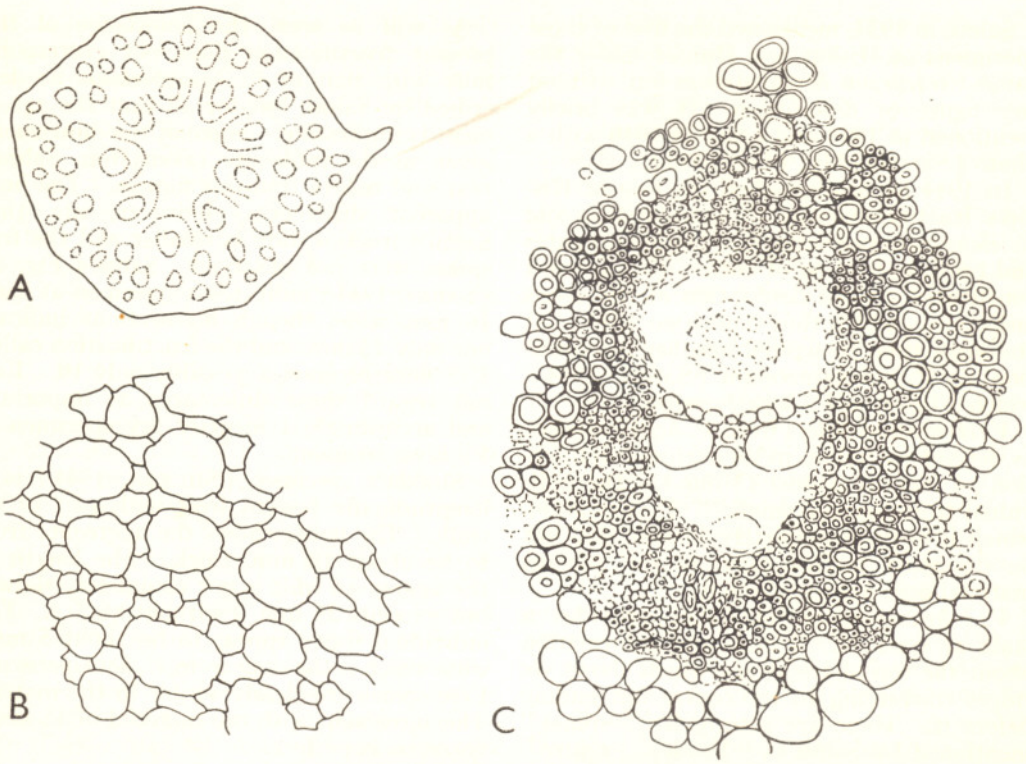
TEXT-FIG. 2 — A, reconstruction of top of fruit. × 12. The spines are shown cut off at about ½ mm. above their bases: (a) one of six inner depressions surrounding central depression; (b) flange of outer spine; (c) ridge connecting flanges of outer spines. B, L.S. through a loculus enclosing a seed; seed coat is indicated by a line except at the apex where it encloses the yellowish cap (white spotted). × 8 (Slide 1). C, cells from inner epidermis of fruit-wall in tangential section with a few hypodermal; fibres below. × 150 (Slide 1). D, T.S. at base of spines, the inner (above) with 4 vascular bundles the outer (below) with one main one and others in flange. × 20 (later section in Slide 2). E-L, sections selected from a series of 18, cut obliquely through one fruit. The top of each drawing is at about 2·5 mm. deeper than the bottom. Drawings × 5 (final section in Slide 2). E, at 3·71 mm. the inner and outer spines are already uniting (union was first seen at 4·28 mm.). Flanges are present. F, at 3·57 mm. the ridges at the sides of the inner spines are uniting around the central depression. G, at 3·42 the inner six and outer six depressions are being separated. H, at 3·08 mm. the flanges are uniting and a loculus is becoming visible (stippled), the central depression now disappears. I, at 2·83 mm. three loculi now visible; two of the inner six depressions have disappeared and two new ones visible; the last pair of spines uniting. J, at 2·63 mm. two more inner depressions have disappeared. K, at 2·44 mm. two more loculi appear. L, at 1·87 mm. all loculi now seen (the septa above have been destroyed in preservation).



TEXT-FIG. 3 — A, T.S. of peduncle showing arrangement of vascular bundles. × 20 (Slide 3). B, aerenchymatous pith of peduncle. × 150 (Slide 3). C, single vascular bundle with bundle sheath; two metaxylem vessels are clear; phloem badly preserved. × 250 (Slide 3).

in a rather definite inner ring of nine large ones surrounded by smaller ones which are more numerous and scattered. The outermost ones are very small. The ground tissue of the vascular zone is almost entirely fibrous at the outside, but there is some parenchyma between inner bundles. Each vascular bundle (TEXT-FIG. 3, C) is collateral, endarch and without any secondary thickening. The wide outer part of the bundle which I presume includes the phloem is very badly preserved. But the metaxylem is represented by two large vessels and is separate from the phloem by a few thick-walled cells. The epidermis was not recognized. No surface hairs were seen.

DISCUSSION

Identification of the Specimen

Hislop and Hunter had collected specimens which were labelled " Aroid fruit from Takli, recd. from Rev. S. H., Oct. 1860 ". Others were labelled " Fruit of sp. No. 47, Takli " and " six-seeded elongate fruit from Takli " (SAHNI, 1944).

In 1853 Hislop briefly described them as " . . . and the other genus bearing a distant resemblance to a mulberry, having, however, the seeds in each vessel symmetrically disposed in sixes. This latter genus contains two species: one that must have had a rich purple pulp was upwards of an inch in length and half an inch in breadth and the other extended to 2 inches long with a breadth not exceeding $\frac{1}{8}$ of an inch " (HISLOP, 1853).

In 1861 he added some more information as " To the fruits there have been few additions since the publication of the Memoir submitted to the Bombay Asiatic Society in 1853. One or two new species have been found of the compound fruits; which were believed to belong to the Aroideae and to approach nearest to the genus *Pothos* or *Scindapsus* " (HISLOP, 1861).

Sahni, in 1934, mentioned the first of these specimens of Hislop and Hunter under the name *Viracarpon hexaspermum* but without any figure or description. It was briefly mentioned in 1938 and again in 1940 with a photo (SAHNI, 1934; 1938; 1940).

In 1944 he distinguished the two of Hislop's fructifications as *V. hexaspermum* and *V. elongatum* respectively. He gave figures and brief description of both. This account constitutes a valid description of the genus and species which thus date from 1944. At the same time he figured another fructification as *V.? hexaspermum* (SAHNI, 1944), which I belive is *V. hexaspermum.*

V. elongatum differs from *V. hexaspermum,* as defined by Sahni, in its narrow fructification (4 mm. as against 13 mm.). The individual fruits are also smaller. *V. elongatum,* which is very incompletely known, will not be discussed further here as the present material does not approach it.

V.? hexaspermum of Sahni provides a stalk at least 30 × 2 mm. and information about the top of the ovary which shows six ridges converging to the centre but ending before it. These are plainly the "spines" mentioned by Sahni as "From . . . centre" (SAHNI, 1944). Both fructifications are incomplete, but their widths are probably similar (up to 13 mm. in *V. hexaspermum,* at least 10 mm. in *V.? hexaspermum*). The individual fruits are just the same in size at their apex, i.e. about 5 mm. wide. I conclude that Sahni's *V.? hexaspermum* is to be identified with *V. hexaspermum* and is merely a specimen in a different state of preservation. I have, therefore, put together the characters of *V. hexaspermum* and *V.? hexaspermum* and compared the whole species with my specimen in Table 1.

As will be seen, the knowledge of the present fructification does not correspond fully with that of *V. hexaspermum* as described by Sahni, but for all that the agreement is impressive. Some of the dimensions given in the table are taken from Sahni's text and others from his figures. The only apparent differences, however, are that Sahni's fructification is smaller and the free spines were not observed. Sahni's Fig. 25 (SAHNI, 1944) indicates a specimen at least 16 mm. wide, though his sections indicate one only 13 mm. and the fructification called *V.? hexaspermum* is possibly only 10. I do not regard these differences as important and accordingly I identify my specimen as *V. hexaspermum.*

Shukla's specimen (SHUKLA, 1944) is a longitudinally broken fruit with part of its stalk. The figure shows the aggregate fruit to be about 19 mm. thick. The length of the aggregate fruit is not completely shown, but exceeds 25 mm. (without stalk). The individual fruits appear to be about 5 mm. wide which is the same as in *V. hexaspermum.* Free spines are clearly visible in the matrix. The agreement with my material of *V. hexaspermum* is perfect.

AFFINITIES

We have information only about the female fructification, the individual fruits, a little about the seeds, and the peduncle. The peduncle shows structure which is typically monocotyledonous, and I will assume that *Viracarpon hexaspermum* is a monocotyledon and will limit my comparison with monocotyledonous families (ENGLER & PRANTL, 1889). Many of these families have cylindrical aggregate fruits so that this, by itself,

TABLE 1

ORGAN	*V. hexaspermum*	PRESENT SPECIMEN
Stalk of fructification	30 × 2 mm.	At least 17 × 2-2·5 mm.
Length and width of body of fructification	At least 21 mm. long × 10-13·2 or possibly 16 mm. wide	30 × 19 mm.
Central core of the fructification	5·6-6 mm.	5 mm. at the lower end, 9 mm. at the middle end
Dimensions of fruit	4 × 5 mm.	5 × 5 mm.
Largest loculus of fruit	3·3 × 1·2-1·5 mm.	3·5 × 2 mm.
Ridges on top of ovary	Six stopping short of central depression about 1·0 mm. wide	Six stopping short of central depression about 1·0-1·5 mm. wide
Spines at top of fruit	Not observed	Crown of long, narrow, tapering, straight hairy spines projecting outwards in planes roughly radial to fructification axis

is not exclusive. On the other hand, rather few have ovaries with more than three carpels, which are united for their whole length. These include the members of the following only: Pandanaceae, Scheuchzeriaceae, Hydrocharitaceae, Cyclanthaceae and Araceae.

Pandanaceae — Here there is a strong tendency to form a compact female fructification and as in *Viracarpon* the perianth is absent or of scales or bristles. Also as in *Viracarpon* there is one ovule in each loculus. An important difference is that the ovule is basal and ascending in each loculus while in *Viracarpon* it is pendulous from the apex.

Scheuchzeriaceae — There are often six carpels and they are often one-seeded though with a basal ovule. Important differences are that the fructification is not compact and each flower has a well-developed perianth or bract.

Hydrocharitaceae have no such compact fructification, and the ovary differs greatly in being unilocular with parietal placentation and many more ovules than the carpels.

Cyclanthaceae have a compact fructification, but this is very different in its alternate zones of male and female flowers. The fruit is described as embedded in a fleshy disc, not at all as in *Viracarpon*. The unilocular ovary has many seeds.

Araceae — Here the ebracteate flowers are normally closely aggregate. There is great variety in the ovary. The carpels may be one-seeded, but are commonly fleshy and form berries. The gynaecium is so varied that comparison is rather difficult. The great majority of genera have less than six carpels, or if six, then this is merely one possible number among adjacent ovaries with fewer. Again, most genera show more than one ovule per loculus and the great majority have berry-like fruits and many otherwise slightly similar genera have staminodes around the ovary. I can find no similar genus and the best that can be said is that individual characters of the *Viracarpon* ovary are to be found scattered among the genera of the Araceae.

This means that the closest family is the Pandanaceae and the second is doubtfully the Araceae. The agreement with the Pandanaceae also is imperfect; a definite difference is in the apical attachment of the ovule in *Viracarpon hexaspermum*. The only Pandanaceous ovary I have studied in detail, *Pandanus odoratissimus*, differs considerably in its far more massive construction with many more fibrovascular bundles. The ovaries are here in two rings and varied in number, but in other species they form a single ring and are fairly constant in number. In *Pandanus spinifer* (WARBURG, 1900) the styles are said to form spines, but I do not consider that the spines or at least the outer ones of *Viracarpon* are likely to be styles. In *Pandanus furcatus* (WARBURG, 1900) the spines are furcate but forked in a very different way.

The evidence available is not enough to place *Viracarpon hexaspermum* in any existing family though there are points of agreement in several and perhaps the most points with the Pandanaceae and after that with the Araceae. It clearly is an extinct genus, but only further facts can show whether it is an aberrant member of a known family or a member of an extinct family.

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