SOME ABNORMALITIES IN THE FEMALE STROBILUS OF GINKGO BILOBA L.

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A NUMBER of abnormal female strobili have been collected by the writer from a single female tree of Ginkgo biloba, grown in a garden at Amritsar, Punjab. This is the only tree of the species in the Punjab plain and in the absence of any male tree the seeds are never formed.

It is known that a normal female strobilus possesses two ovules at the apex each surrounded by its own collar. One of these usually aborts while the other grows to its mature size but under favourable conditions both may grow to maturity.

In the present case the tree bears strobili mostly with three ovules, one in the centre terminating the axis of the strobilus and two lateral ones, arising at about the same level, one on either side. The central ovule usually comes to maturity and the lateral ones abort (Pt. IX, Fig. 1). In some cases the central and one of the lateral ovules abort while the other lateral one develops. Rather rarely normal strobili bearing only two ovules are observed on this tree. In rare cases more than three ovules are found on a strobilus. In one instance four ovules and in another five are observed (Pt. IX, Figs. 2, 3). In both these strobili as in preceding ones only one ovule matures while the others abort. Instances of a number of ovules on a strobilus have also been recorded by Sprecher (Chamberlain)¹, Fugii (quoted in 2) and Seward and Gowan.²

The ovules mature in the Punjab about the middle of July when the female gametophyte is fully developed. The normal ovules are smooth, more or less oval and the integument differentiated into the usual three layers, outer fleshy, middle stony and inner papery, completely encloses the female gametophyte. In addition to the normal ones a number of abnormal ovules are observed.

In some the lower region of the integument is smooth but the apical region is formed of irregular tumor-like swelling. The tissue here is rather loose and fluffy and is not differentiated into the usual three layers. The
top portion of these ovules is usually open so that the female gametophyte is exposed (Pt. IX, Figs. 4, 5). In one case the top one-third of the female gametophyte was exposed and consequently became green in colour. The gametophyte in some of these ovules may be more or less conical at the apex (Pt. IX, Fig. 4).

In one case two ovules were invested by a common collar instead of each having its own. One of the ovules was, however, aborted while the other fully developed (Pt. IX, Fig. 6).

A most interesting abnormality is the occurrence of 'double ovules' to the extent of 20 per cent. in the strobili collected. These unlike the normal ones, are broad and flat with a depression in the middle running vertically all over (Pt. X, Fig. 7). Each possesses a single collar. A vertical section shows that there are two chambers separated from one another by a wall of the middle stony layer of the integument and each possessing a fully developed female gametophyte (Pt. X, Fig. 8). The outer fleshy layer of the integument is continuous, the middle stony layer is also continuous but also forms a partition separating the two loculi while the inner papery layers of the two chambers are distinct.

All degrees of abortion of one of the two female gametophytes in such 'double ovules' are observed. In these cases the second chamber is always present, however poorly developed it may be, depending upon the stage of abortion of the female gametophyte within. These ovules therefore are asymmetrical possessing a large lobe within which is the fully developed gametophyte and a small lobe of variable size with the aborted gametophyte within (Pt. X, Figs. 9, 10).

Occasionally ovules with an aperture on one of the lateral sides are observed (Pt. X, Fig. 11). These in vertical section show that the chamber with aborted female gametophyte possesses an orifice communicating with the exterior (Pt. X, Fig. 12).

In rare instances 'double ovules' with both the chambers sterile are seen and then the ovules remain small in size.

Anatomy of the Axis of a Strobilus with two Ovules each with a Short Stalk.

Two vascular bundles enter the strobilus axis from the stem and run through it as such. Near the apex of the strobilus each bundle enters the short stalk of each of the two ovules. The stalk thus receives only a single bundle which as it reaches the ovule expands in the form of an arc.

This observation differs from that of Seward and Gowan, who found in a two-ovulate strobilus axis four bundles in two pairs.
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Anatomy of the Axis of Abnormal Strobili.

A. 3-ovulate strobilus of which the terminal ovule alone is fertile (Pt. IX, Fig. 1).

Two vascular bundles opposite one another enter the base of the strobilus from the stem (Text-Fig. 1a) and proceed as such upto about 3/ the length of the axis. From the margins of one of these, two bundles are cut off towards the inside (Text-Fig. 1b). These two new bundles also receive their share from the margins of the other bundle as well. Thus four bundles are formed, two lateral larger and two central smaller (Text-Fig. 1c). The central bundles gradually increase in size till near the place of attachment of the lateral ovules (which arise at about the same level) they become bigger than the lateral bundles (Text-Fig. 1d). This is because the former have to supply the fully developed terminal ovule. Each lateral bundle passes into the pedicel of the aborted ovule on its side (Text-Fig. 1e).

Text-Fig. 1. × 25

Upwards the two central bundles become continuous in the form of a ring in the collar region to which traces are supplied from all sides and the stele enters the placenta on which the ovule is borne. The vascular ring contracts here and divides into two traces which pass through the fleshy and the stony layer into the innermost papery layer where they run along its
length on either side. The outermost fleshy and the middle stony layers are devoid of any vascular supply.

B. 3-ovulate strobilus with one of the lateral ovules only fertile.

Only two bundles enter the strobilus axis from the stem and become converted into four as described previously. The two central bundles which supply the central ovule remain small since it is aborted. Each one of the lateral bundles supplies the pedicel of the ovule on its side. In the lateral fertile ovule the single bundle passes upwards and without dividing enters the collar region. Here it forms a continuous ring and supplies the usual traces to the collar. The further course is as described for the fertile ovule in A.

C. 4-ovulate strobilus in which the two lateral ovules are aborted and the terminal one is a "double ovule" (Pt. X, Fig. 7).

The history of the strobilus axis is the same as in previous cases until a vascular ring with 4 bundles is formed. The two lateral ones pass into the pedicels of the lateral aborted ovules—one in each and the two central bundles enlarge and form a more or less continuous vascular ring (shown at K in Text-Fig. 2 a). Because of the presence of a 'double ovule' at the apex, the

Text-Fig. 2.  x 25
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following interesting changes take place. The vascular ring splits into two vascular bundles which separately enter the placenta through the collar to which traces are given from both. The placenta, on which the ovule is borne, is transversely elongated and possesses two papillae separated from one another by a depression. It gives the appearance as if it is formed of the fusion of two placentae. Each papilla receives one of the two vascular bundles from below. Here each vascular bundle divides into two in each papilla and the two pairs pass through the outer fleshy and middle stony regions to the inner papery integuments of the two chambers one pair in each chamber. Thus the papery integument of each chamber of the double ovule receives a pair of bundles as the papery integument of a normal ovule.

In the asymmetrical double ovule (Pt. X, Fig. 9) where the female gametophyte in one chamber is abortive and the chamber consequently ill-developed while the other chamber is fully developed with fully developed gametophyte, the size of the pair of vascular bundles in the two papillae of the placenta is naturally different (Text-Fig. 2b, b').

D. 5-ovulate strobilus with only one ovule fertile (Pt. IX, Fig. 3).

The anatomy of the axis in this case differs from the others by the fact that four bundles instead of two enter its base from the stem (Text-Fig. 3a). They are arranged in the form of a ring. Higher up, one of these divides into two so that five bundles are formed—as many as there are the number of ovules (Text-Fig. 3b). One vascular bundle enters the pedicel of each of the five ovules. The further history of the vascular bundle entering the pedicel of the fertile ovule is the same as that in the fertile ovule described previously in B.

Conclusion.

The 'double ovule' which is of fairly common occurrence seem to have arisen by the fusion of the primordia for development of two normal ovules at the apex of the strobilus. The presence of two distinct papillae on the elongated placenta, the two pairs of vascular bundles, one pair in

![Image](image-url)
each papilla, and the two loculi each with its separate inner papery integument and female gametophyte corroborate this view. Even externally the groove running longitudinally in the middle of the ovule is indicative of two ovules having fused together.

The anatomy of the axis of the female strobilus and that of the ovuliferous stalk in *Ginkgo biloba* appear to be variable.

Fugii found in the words of Seward and Gowan\(^2\) that “A penduncle bearing several ovules is usually traversed by *as many vascular bundles as there are the ovules* : each of the bundles in the penduncle divides into two in the ovule stalks, so that each possesses two small strands similar to those in an ordinary leaf stalk”. On the other hand, Seward and Gowan\(^2\) find in the axis of an ovulate strobilus with three ovules, *as many pairs of bundles as there are the ovules*, and each pair in the ovuliferous stalk unites into an arc-shaped bundle.

In the present investigation it is found that usually two bundles enter the strobilus axis from the stem (excepting in the 5-ovulate strobilus when four bundles enter). The number of bundles in the strobilus *may be the same as the number of ovules it bears* (as in 2-ovulate and 5-ovulate strobili) or different (as in 3-ovulate strobilus when four bundles are found). Again the ovuliferous stalk receives only a single vascular bundle (unless it is the terminal ovule of a 3-ovulate strobilus) and that this single bundle *never divides into two in the stalk* of the ovule.

**Summary.**

Some abnormalities in the female strobilus of *Ginkgo biloba* are recorded from the only tree growing in the Punjab plain.

2-ovulate normal strobili are rather rare while 3-ovulate strobili with only the terminal ovule fertile are very common on the tree. Occasionally 4-ovulate and 5-ovulate strobili are met with.

‘Double ovules’ formed by the fusion of the primordia of two ovules during development are met with to the extent of 20 per cent. These are flat, with a median groove. In vertical section they possess two loculi both of which may have fully developed gametophyte or only one of them. In the former case the ovules are symmetrical, in the latter asymmetrical.

Abnormal ovules having the female gametophyte exposed at the apex are frequently met with.

Anatomy of the axis of abnormal strobili has been worked out and differences from that described by previous authors pointed.
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BIBLIOGRAPHY.


EXPLANATION OF PLATES.

PLATE IX.

Figs. 1, 2, 3.—Abnormal Female Strobili with 3, 4 and 5 ovules respectively. In each case only one ovule is fertile. × 2.
Figs. 4, 5.—Abnormal ovules with female gametophyte exposed at the apex. × 2.
Fig. 6.—Two ovules possessing a common collar. One of these is sterile. × 2.

PLATE X.

Fig. 7.—A Symmetrical double ovule in which female gametophyte in both loculi is developed. × 2.
Fig. 8.—Vertical section of the above. × 2.
Fig. 9.—An asymmetrical double ovule in which the female gametophyte in the smaller chamber is abortive. × 2.
Fig. 10.—Vertical section of the above. × 2.
Fig. 11.—An asymmetrical double ovule in which the loculus with abortive gametophyte communicates with the outside by an opening. × 2.
Fig. 12.—Vertical section of the same. × 2.