

Systematic Significance of Mature Embryo of Bamboos

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Abstract: The mature embryo of seven species belonging to five genera of Indian bamboos is described. In all these the basic pattern of embryo organisation is same: the scutellar and coleoptilar bundles are not separated by an internode, the epiblast is absent, the lower portion of the scutellum and the coleorhiza are separated by a cleft and the margins of embryonic leaves overlap. The features unique to fleshy fruited bamboos are: presence of a massive scutellum, the juxtaposition of plumule and radicle and the occurrence of a bud in the axil of the coleoptile. The fleshy fruit bearing bamboos should be classified into one group, the tribe *Melocanneae*. Evidence is provided to recognise additional groups in the subfamily *Bambusoideae*.

The structure of caryopsis, embryo and seedling has been used for classifying the family *Gramineae* into major natural groups. The grass embryo has been studied, particularly with reference to its systematic significance by several workers (BRUNS 1892, VAN TIEGHEM 1897, YAKOVLEV 1950, STEBBINS 1956, REEDER 1957, 1962, KINGES 1961). REEDER (1957, 1962) recognised six kinds of graminaceous embryo including the “bambusoid embryo”. Out of 1000 species of bamboos recorded from the world, the embryo has been studied in only about a dozen. The aim of the present work was to investigate the form of mature embryo in both endospermic and non-endospermic fruits of bamboos and to ascertain its significance in the refinement of circumscription of the tribes in the subfamily *Bambusoideae*. Four characters of the embryo, considered important by REEDER (1957, 1962), have been used for comparison.

Materials and Methods

Embryos of *Bambusa tulda* ROXB., *Dendrocalamus hamiltonii* NESS & ARN., *D. longispathus* KURZ, *Melocalamus maclellandii*, *M. compactiflorus* BENTH & HOOK.,

Ochlandra travancorica BENTH & HOOK. and *Pseudostachyum polymorphum* MUNRO were studied. Mature fruits of *B. tulda*, *D. longispathus*, *P. polymorphum*, and *M. compactiflorus* were collected by the first author (B. H. G.) from the forests of Mizoram, of *D. hamiltonii* from Assam and Meghalaya and of *M. maclellandii* from the arboretum of the Forest Research Institute, Dehra Dun. Voucher specimens are preserved in the Herbarium of the Department of Botany, University of Delhi. Dr. K. N. SUBRAMANIAN of the Southern Forest Research Centre, Coimbatore, kindly passed on some mature fruits of *O. travancorica* collected from Kerala. The fruits were fixed and processed for microtomy following the procedure given by HARI GOPAL & MANASI RAM (1981).

Results

A thorough investigation of early embryogenesis was hampered in spite of sectioning a large quantity of embedded material because of (i) heavy sterility in the bamboos which showed sporadic flowering (*D. hamiltonii*, *P. polymorphum*), (ii) degeneration of the embryo sac at the pre- and post-fertilization stages and (iii) insect damage to the ovaries in bamboos that flowered gregariously (*B. tulda*, *M. compactiflorus*). Consequently attention was focussed on the study of the mature embryo. A species-wise account follows:

***Dendrocalamus hamiltonii*.** A longitudinal section of the mature embryo along the anticotyledonary plane is shown in Fig. 1A. The coleorhiza and the lower part of the scutellum are separated from each other by a distinct cleft (Fig. 1A, arrow). The coleorhiza does not extend beyond the point of attachment of the coleoptile, that is, no epiblast is formed. The vascular supply to the coleoptile, shoot apex and the scutellum arises from the same point (not separated by a node). Transverse sections of mature embryos in the coleoptilar region show two vascular bundles in the coleoptile and the overlapping of leaf margins.

***D. longispathus*.** The structure of the mature embryo of this species resembles that of *D. hamiltonii* and is shown in Fig. 1B.

***Bambusa tulda*.** The structure of embryo of *B. tulda* also resembles that of *Dendrocalamus*. However, it differs from it in having a well-developed axillary bud between the coleoptile and the first foliage leaf (Fig. 1D). The lower portion of the scutellum is less developed and the coleorhiza and the radicle grow beyond it (Fig. 1C).

Fig. 1. Median sagittal sections of embryos of bamboos. — A *Dendrocalamus hamiltonii*; B *Dendrocalamus longispathus*; C, D *Bambusa tulda*; D enlarged view of the bud in the axil of coleoptile; E, F *Pseudostachyum polymorphum*; G *Ochlandra travancorica*; H a portion of the embryo of *Melocalamus compactiflorus*: note the bud primordia in the axils of leaves. — b = bud, col = coleoptile, cr = coleorhiza, end = endosperm, fw = fruit wall, l = leaf, p = plumule, r = radicle, s = scutellum

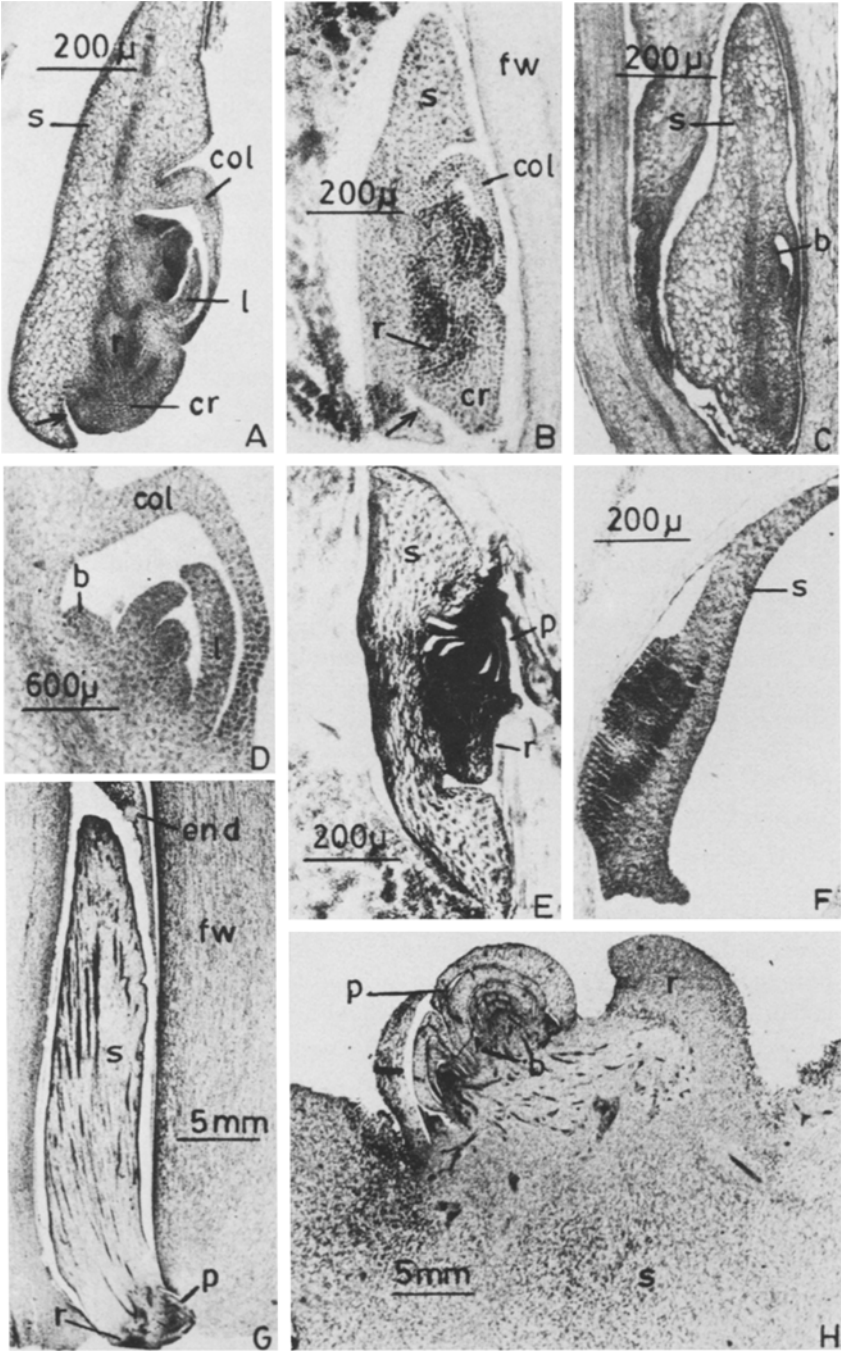


Fig. 1

Pseudostachyum polymorphum. As viewed in a longitudinal (anti-cotyledonary) section, the scutellum is generally equally developed on either side of the embryonal axis with a depression in the middle, resembling a bowl in which the plumule and radicle come to be situated in a juxtaposed condition (Fig. 1E). The radicle is curved towards the plumule. In very rare instances, however, the upper portion of the scutellum is more elongated and pointed than the lower (Fig. 1F). The scutellar cells contain abundant starch grains.

Melocalamus maclellandii. In a mature embryo the scutellum is the largest part and is spherical or oblate with a depression towards the apex in which the plumule and radicle are situated (Fig. 2A, B). The outer surface of the scutellum is wavy and remnants of endosperm can be noticed in the depressions (Fig. 2B, arrow). The cells of the scutellum are parenchymatous and contain a large amount of starch. The vascular supply in the scutellum is much branched.

The plumule and radicle do not occur in the same longitudinal axis but lie parallel to each other (Fig. 2C). In a mature embryo the plumule consists of a coleoptile with a bud in its axil, about 7 to 9 young leaves and a conical growing point (Fig. 2C). The coleoptile is hairy and has 9 to 15 vascular bundles. The leaf margins overlap and each leaf has a varying number (6 to 10) of vascular bundles.

The radicle has the shape of an oblique cone and is smaller than the plumule. The coleorhiza tends to grow more on the side proximal to the plumule (Fig. 2C).

M. compactiflorus. The structure of the mature embryo of this species resembles that of *M. maclellandii* except for the following details. The plumular leaves have one bud each in their axils (Fig. 1H). The buds at the lower nodes have two or three leaf primordia each. The basal nodes of the plumule also bear adventitious root primordia. The epidermis of the coleorhiza and the coleoptile are covered with two-celled hairs.

Ochlandra travancorica. The mature embryo resembles that of *Melocalamus* in all the characters except in the shape and size of the scutellum and the position of the embryonal axis. The scutellum is oval-oblong with the embryonal axis situated towards the base of the fruit (Fig. 1G). The upper part of the scutellum is embedded in the endosperm which does not contain starch.

Discussion

REEDER has examined embryos of over 300 species representing more than 150 genera and all the tribes of the family *Gramineae* (REEDER 1957, 1962). According to him the bambusoid embryo has the formula F + PP

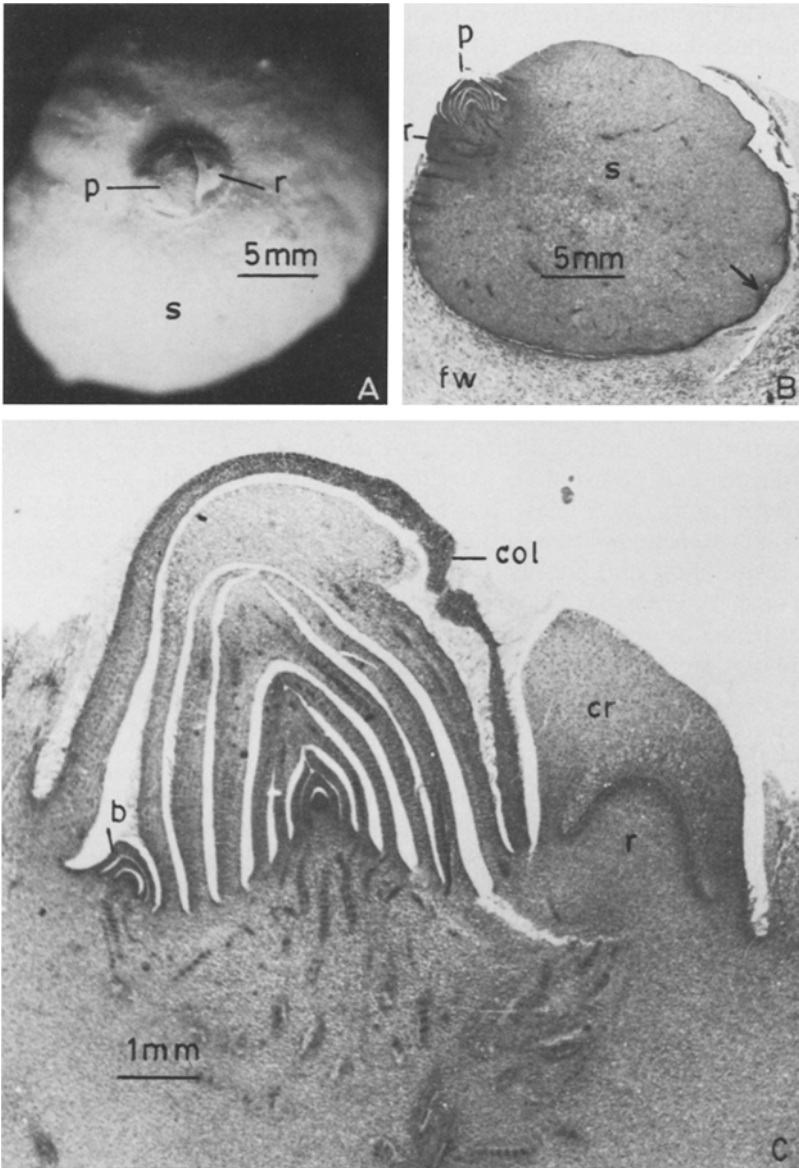


Fig. 2. Embryo of *Melocalamus maclellandii*.—*A* Top view of the embryo dissected from the fruit; *B* l. s. of fruit showing a massive scutellum with a wavy outline and embryonal axis: the endosperm is scanty and is present only in the depressions of the scutellum (arrow); *C* apical portion of l. s. of embryo enlarged to show the plumule, radicle and portions of the scutellar girdle: note the bud in the axil of coleoptile. — For abbreviations see Fig. 1

(F plus PP) meaning that the coleoptilar and the scutellar bundles are not separated by an internode (F), an epiblast is present (+), a cleft occurs between the lower portion of the scutellum and the coleorhiza (P) and the margins of the leaves overlap (P). PHILIP & HACCIOUS (1976) studied the structure of embryo in *Arundinaria alpina* and *Bambusa arundinacea* and noted the formula F + PP as reported by REEDER. However, the presence of a bud in the axil of the coleoptile was a new finding in this study (PHILIP & HACCIOUS 1976).

Concerning the structure of the fruits of *Melocanna bambusoides*, STAPF (1904) had commented: "The most striking feature of the embryo next to the scutellum is the curvature of the embryo, which is so strong that the inner faces of the plumule and radicle are contiguous. It is evidently due to this condition that no trace of an epiblast is seen. Its place would be the inner angle of the bend, where there is no room for such an organ." REEDER (1962) investigated the embryo of *M. baccifera* (= *M. bambusoides*) and observed the curvature of the embryo but mistook the coleorhiza for the epiblast. It is quite likely that the embryos studied by REEDER were not mature because the shape of the scutellum in *Melocanna* is oval-oblong and not like that presented by him (STAPF 1904, MOHAN RAM & HARI GOPAL 1981).

In the bamboos investigated by us the coleoptilar and the scutellar bundles are not separated by a node, the epiblast is absent, the lower portion of the scutellum and the coleorhiza are separated by a cleft and the margins of the embryonic leaves overlap. Thus the bambusoid embryo has the formula F - PP (F minus PP).

HOLTUM's (1956) classification of bamboos into four types: Schizostachyum type, Oxytenanthera type, Bambusa-Dendrocalamus type and Arundinaria type was based on external morphology of the ovary. The development of pericarp and embryo structure were not studied by him on account of paucity of material. However, he stated that detailed investigations are needed before this scheme is placed on a firm basis. He placed *Dinochloa* with *Melocalamus* in one and *Melocanna* with *Ochlandra* in a different group. However, we have reported here that the embryos of *Melocalamus* and *Ochlandra* have a massive scutellum, marked curvature of the embryonal axis and an axillary bud in the axil of the coleoptile. The same features were also recorded in the genera *Melocanna* and *Dinochloa* by STAPF (1904) and DRANSFIELD (1981) respectively (also our observation). The structure of the ovule, absence of endosperm in the mature fruit (or the presence of an occasionally thin discontinuous layer) and fleshy pericarp are common to all these genera (STAPF 1904, PETROVA & YAKOVLEV 1968, DRANSFIELD 1981, HARI GOPAL 1982). In the light of these features it is proposed that all the above genera be placed in the tribe *Melocanneae* (as *Melocanna* was the first genus to have been described in

detail by STAPF 1904). There are two genera of fleshy fruited bamboos reported from the New World. These are *Alvimia*, an undescribed genus (only abstract published) from Brazil (CALDERON 1978) and *Olmeca* from Mexico (SODERSTROM 1981). The structure of the embryo in these two taxa has not been examined but the seedlings and the fruit wall resemble that of fleshy fruited bamboos investigated, and hence these may also be placed in the *Melocanneae*.

In *Pseudostachyum* the scutellum is equally developed on either side of the curved embryonal axis and is not massive. In this respect it does not fit into the *Melocanneae*. On the basis of gross morphology of ovary HOLTUM (1956) has argued that the genera *Pseudostachyum*, *Teinostachyum*, *Cephalostachyum* and *Schizostachyum* should be merged into a single genus. The drawings (showing the) of fruits in these genera as given in GAMBLE'S atlas of Indian bamboos (GAMBLE 1896) indicate the possibility of similarity of form of the embryos. As no other mature embryo of bamboos studied so far resembles the embryo of *Pseudostachyum*, we believe that this genus should be placed in the *Pseudostachyaeae*. REEDER (1962) has studied embryo structure in *Cephalostachyum fuchsianum* and nine other species of bamboos. Though he has not described the structure in detail, the figure showing the embryo of *C. fuchsianum* (REEDER 1962, Fig. 7) indicates that it resembles the embryo of *P. polymorphum*. Nevertheless, a detailed investigation of the structure of embryo and fruit wall in all the three genera (*Pseudostachyum* is monotypic) is necessary before establishing the validity of our view.

The embryo in *Bambusa* has a large bud in the axil of the coleoptile. The lower part of the scutellum is less prominent than the upper. The ovule characters and the fruit wall development are similar in *Bambusa* and *Dendrocalamus* (HARI GOPAL & MANASI RAM 1981, HARI GOPAL 1982). Thus, a *Bambusa-Dendrocalamus* group of bamboos may be recognized.

References

- BRUNS, E., 1892: Der Grasembryo. — *Flora* **76**, 1–33.
 CALDERON, C. E., 1978: *Alvimia*, el primer bambú Americano con frutos carnosos (*Poaceae: Bambusoideae*). Resumos dos Trabalhos: 377–378. (Abstract of the paper presented at the Congresso Latino-Americano de Botânica, 21–27 January 1978, Brasilia, Brazil.) (Original not seen; see SODERSTROM 1981).
 DRANSFIELD, S., 1981: The genus *Dinochloa* (*Gramineae/Bambusoideae*) in Sabah. — *Kew Bull.* **36**, 613–633.
 GAMBLE, J. S., 1896: *Bambuseae* of British India. — *Ann. R. Bot. Gard. Calcutta*.
 HARI GOPAL, B., 1982: Reproductive Biology of Some Indian Bamboos. — Ph.D. Thesis, Department of Botany, Univ. of Delhi, Delhi.
 — MANASI RAM, 1981: Floral morphology, development of sporangia and sporogenesis in *Dendrocalamus hamiltonii*. — *Proc. Indian Natn. Sci. Acad.* **47**, 519–526.

- HOLTUM, R. E., 1956: The classification of bamboos. — *Phytomorphology* **6**, 73–90.
- KINGES, H., 1961: Merkmale des Gramineenembryos. — *Bot. Jahrb.* **81** (1962), 50–93.
- MOHAN RAM, H. Y., HARI GOPAL, B., 1981: Some observations on the flowering of bamboos in Mizoram. — *Curr. Sci.* **50**, 708–710.
- PETROVA, L. R., YAKOVLEV, M. S., 1968: Morphology and anatomy of fruits and seeds of the bamboos *Melocanna bambusoides* and *Phyllostachys bambusoides*. — *Bot. Žurn.* **53**, 1688–1703.
- PHILIP, V. J., HACCUS, B., 1976: Embryogenesis in *Bambusa arundinacea* WILLD. and structure of the mature embryo. — *Beitr. Biol. Pfl.* **52**, 83–100.
- REEDER, J. R., 1957: The embryo in grass systematics. — *Am. J. Bot.* **44**, 756–768. — 1962: The bambusoid embryo: a reappraisal. — *Am. J. Bot.* **49**, 639–641.
- SODERSTROM, T. R., 1981: *Olmeca*, a new genus of Mexican bamboos with fleshy fruits. — *Am. J. Bot.* **68**, 1361–1373.
- STAPF, O., 1904: On the fruits of *Melocanna bambusoides* TRIN. an endospermless, viviparous genus of *Bambuseae*. — *Trans. Linn. Soc. (Lond.) (Botany)* **6**, 401–425.
- STEBBINS, G. L., 1956: Taxonomy and evolution of genera with special reference to the family *Gramineae*. — *Evolution* **10**, 225–245.
- VAN TIEGHEM, P., 1897: Morphology de l'embryon et la plantule chez les Graminées et les Cypéracées. — *Ann. Sci. Nat. Bot.* **8**, 259–309.
- YAKOVLEV, M. S., 1950: The fine structure of endosperm and embryo in cereals as a systematic feature. — *Izv. Akad. Nauk Armjan. S.S.R. Bot.* **1**, 121–218.

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