immersion of the cultures in liquid medium which improves the quality of plants multiplied through somatic embryogenesis as well as shoot proliferation. Immersion of cultures four times a day, for 15 min each time, gave excellent results with a wide range of crop plants (*Citrus*, *Coffea*, *Eleis*, *Hevea* and *Musa*). The use of robots has not made the expected breakthrough in micropropagation (Debergh, Belgium).

Although date palm micropropagation has been commercialized, several laboratories are involved in developing more efficient protocols for somatic embryogenesis in this crop. Scientists from the Philippines reported success with the micropropagation of coconut palm from immature embryos (Orense *et al*) and rachilla explants (Ebert *et al.*). This finding should be important for India as coconut is an important, open-pollinated crop with erratic yields and all attempts for *in vitro* propagation have so far been unsuccessful. High frequency regeneration of shoots (some of which also rooted) from the callus derived from microcuttings of cashewnut, reported by Bessa (Portugal), should be of equal interest to Indian scientists.

Disease-free micropropagated banana plants have been produced in Taiwan at the rate of 2 million per year. So far over 15 million plants have been distributed for field plantation throughout the country, which has stabilized their banana export industry.

It was gratifying that the workshop on 'Technical Problems in Plant Tissue Culture', chaired by me, was most well attended. Problems of systemic infection and use of antibiotics were discussed at length. The consensus was that it is impossible to establish bacteria-free cultures and undue concern should not be directed to eliminate benign bacteria in cultured tissues or regenerating plants. The use of antibiotics to control harmful bacteria should be based on a detailed study of the nature of bacteria and their sensitivity to various antibiotics. Some bacteria may be useful for the growth of plant tissues. Use of bactericidal compounds other than the traditional antibiotics, such as neem products, to contain this problem was also recommended. Nairn (New Zealand) presented experimental evidence to suggest that the hyperhydration effect of gelrite is due to its constituent, sulphated galactans.

The next Congress of Plant Tissue and Cell Culture will be held in 1998, in Jerusalem, Israel.

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SCIENTIFIC CORRESPONDENCE

Reproductive biology: An aid in the classification of bamboos

The importance of bamboos to the national economy as an industrial raw material, besides their more than thousand uses in day to day life, is well known. Bamboos have fascinated scientists and laymen for centuries. To laymen all bamboos look similar but there are more than 1200 species described under nearly 50 genera. Most of the woody bamboos (in which there is no sporadic flowering) flower and seed after an exclusive vegetative growth for a species specific supra-annual interval, ranging between 3 and 120 years[1]. There are two types of flowering: (i) gregarious and (ii) sporadic. In gregarious flowering all members of a cohort (plants from seeds of common origin) enter the reproductive phase approximately at the same time, and after flowering and seeding the parents die *en masse*. This death of the bamboo parents used to be given more importance, probably because of their long intermast periods and arborescent habits. It has to be considered as a character bamboos share as members of the grass family[2]. In sporadic flowering, members of a cohort enter the reproductive phase at different times, or at irregular intervals, and after flowering (and seeding?) the parents do not die but revert to vegetative growth. Due to this peculiar flowering behaviour in bamboos, flowers and seeds are available only at very long intervals. This has resulted in a poor understanding of their inter-relationships, besides making the perennial raising of plantations using seeds and hybridizations difficult. Selection is the only method available at present for bamboo improvement[3]. It is possible now to induce flowering in bamboos by tissue culture methods[4]. Induction of flowering *in vitro* can be used for perennial seed production and hybridizations. To plan a hybridization programme it is necessary that the inter-relationships between the bamboo species and genera are well understood.

Bamboos and herbaceous bambusoid grasses are grouped into the sub-family Bambusoideae or tribe Bambuseae under the family Graminae (Poaceae). Most botanists agree to this sub-family or tribe position. There are also arguments in favour of conferring an independent family status to this group[5]. Soderstrom and Calderon[6] are of the opinion that the bamboos and the bambusoid grasses evolved from a common stock. In herbaceous bambusoid grasses botanists have satisfactorily delimited the genera. In bamboos the generic delimitations still remain incomplete[7]. In 1913 Camus[8] proposed a modification of Bentham's[9] classification for Bambuseae. In 1935 Camus[10] expanded it and suggested seven tribes, *Arundinareae*, *Arthrostylidae*, *Chusqueae*, *Bambuseae verae*, *Hickelieae*, *Synandrae* and *Bacciferae*. He divided the tribe *Bacciferae* into four sub-tribes – *Dendrocalaminae*, *Melocanninae*, *Pseudocoixinae* and *Perrierbambusinae*. In Holttum's[11] opinion both the systems of classifications (Bentham's modification of Munro's and Camus') do not conform with the natural order. He stressed the need for a natural system of classification based on many characters, and proposed a system based on the structure of the ovary[12]. According to this system there are four types of ovaries: *Schyzostachyum*, *Oxytenanthera*, *Bam-*

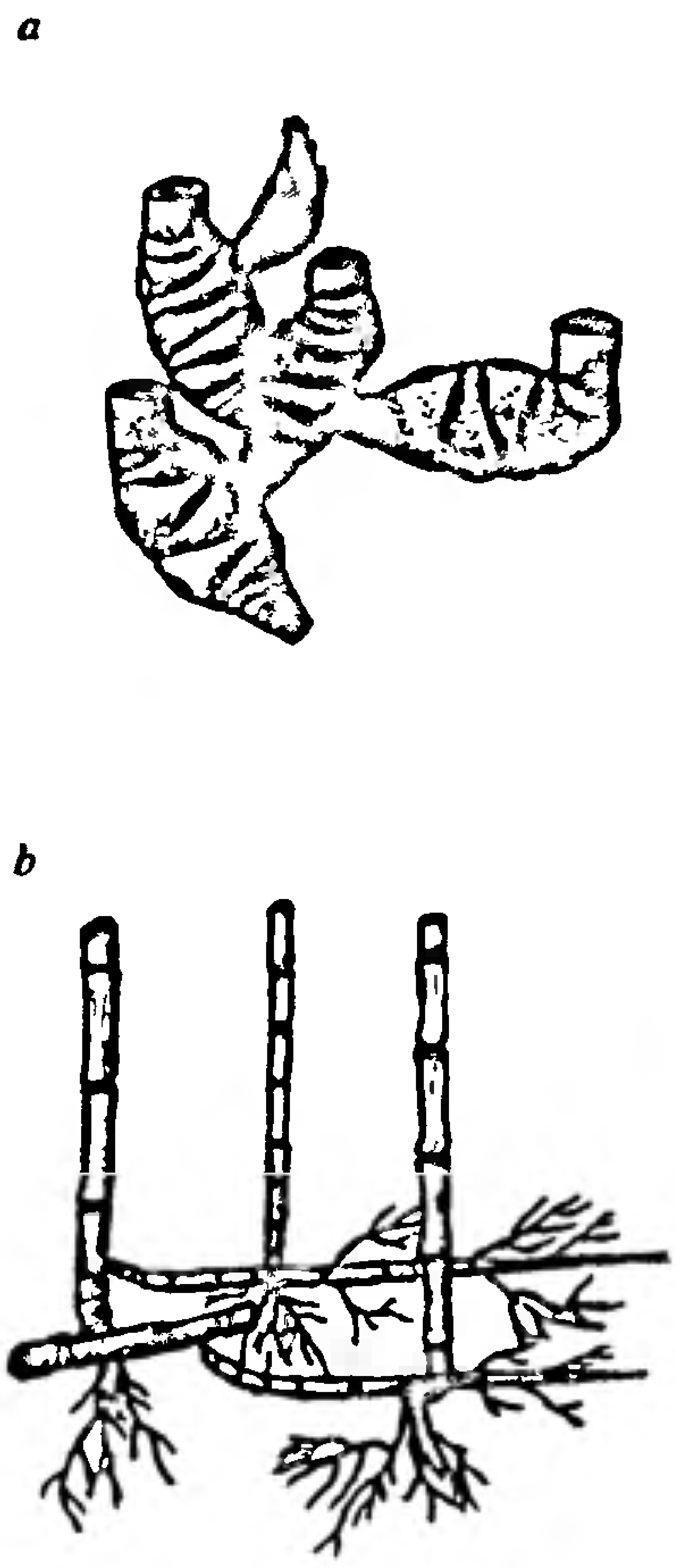

Figure 1. Rhizome branching patterns in bamboos *a*, pachymorphic (sympodial) and *b*, leptomorphic (monopodial).

busa-Dendrocalamus and *Arundinaria* types. Grosser and Liese[13], based on the morphology of vascular bundles (in 52 species belonging to 14 genera) grouped them into four categories. According to them, all the species with pachymorph rhizomes come under three basic vascular bundle types and all the species with leptomorph rhizomes come under one basic vascular bundle type. Clayton and Renvoize[14] classified the sub-family Bambusoideae into thirteen tribes. The herbaceous bambusoid grasses are classified into twelve tribes, which are not sub-divided into sub-tribes. All the woody bamboos are placed under the tribe Bambuseae which is further divided into three sub-tribes: *Arundiniae*, *Bambusinae* and *Melocanninae*. From the above description, the need to consider more characters for a better elucidation of inter-relationships between bamboo genera and species are very clear. Among these, characters which divide bamboos into major categories, characters of reproductive structures and characters which are easily observable (in the field) will be of much use. Earlier Munro[15], Brandis[16] and McClure[17] have divided bamboos into major categories on the basis of different characters.

Munro[15] classified bamboos into three categories: (i) species in general having 3 stamens and 3 lodicules as *Triglossae* or *Arundinariae*, (ii) species having 6 stamens and the fruit a caryopsis as *Bambusae verae* or true bamboos and (iii) species having 6 or more stamens and the fruit a berry or nut as *Bacciferae* or Berry bearing bamboos.

Based on the flowering behaviour, Brandis[16] classified the bamboos into three categories: (i) those which flower annually, (ii) those which flower gregariously and periodically, and (iii) those which flower irregularly. According to Blatter[18] these three categories are fairly complete and all those species which cannot be grouped under the first and second category will go under the third category.

McClure[17] divided bamboos on the basis of the pattern of rhizome growth into two categories (Figure 1*a*,*b*): (i) species having sympodial (pachymorph) rhizomes, which are solid, usually short and thick, and their lateral buds producing solitary culms (each new culm having its own root system to provide water and nutrients) and (ii) species having monopodial (leptomorph) rhizomes (which are long, slender and hollow), continuing horizontal growth until constrained, and most of the lateral buds on them giving rise to new culms.

Our studies on the reproductive biology in bamboos[19–21] have shown that there are two major categories: (i) the species in which the androecium and gynoecium mature at the same time as observed in *Bambusa arundinacea*, and (ii) the species in which the gynoecium matures earlier than the androecium as in *Dendrocalamus strictus* (Figure 2*a*,*b*,*c*). In the first category the 'lemma' and 'palea' open up and expose the reproductive structures to the pollinating agent (wind). Stigma

Figure 2. Differences in the maturing of reproductive structures (androecium and gynoecium) in bamboos. *a*, A floret of *Bambusa arundinacea* showing the parted 'lemma' and 'palea' and the mature androecium and gynoecium (note that the stigma remains at a higher plane compared to stamens); *b* and *c*, Florets of *Dendrocalamus strictus* at female and male phases respectively (note that the 'lemma' and 'palea' are not parted and the receptive stigma and mature anthers exerted at different times).

and anthers remain at two different planes; the filaments being very long and slender, anthers remain at a much lower plane than the stigma. Thus there is a physical barrier to pollination of a stigma by pollen from anthers of the same flower (self-pollination). There can be some seeding during sporadic flowering (in species where there is no self-incompatibility). In the second category 'lemma' and 'palea' do not open up but stigma and anthers are exerted at different times, when they mature. There is a gap between the female and male phases (3–4 days or more depending on the species). Thus, it is a physiological barrier. In species under this category there may not be seed-set during sporadic flowering and also in gregarious flowering of isolated clumps. We propose a division of the tribe *Bambuseae* into two groups: (i) *Bambusa* type and (ii) *Dendrocalamus* type. A survey of the literature and published photographs, diagrams and descriptions indicate that the genera *Bambusa*, *Phyllostachys*, and *Pseudosasa* belong to the first category and *Dendrocalamus*, *Melocanna* and *Ochlandra*[22] belong to the second category. When reproductive biology is studied in more and more species and genera (as and when they flower), it would be apparent how they are distributed under these two broad categories.

Both *Bambusa arundinacea* and *Dendrocalamus strictus* belong to the group *Bambusae verae* (true bamboos) according to Munro's[15] system of classification, to the gregariously and periodically flowering category according to Brandis'[16] system of classification and to the group having pachymorph (sympodial) rhizomes according to McClure's[17] system of classification of bamboos. However, according to our system (on the basis of maturing of the reproductive structures) they show marked difference These observations show the importance of studies on reproductive biology in bamboos for planning breeding in them as well as in understanding their inter-relationships better.

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First report of a fossil marsh crocodile *Crocodylus palustris* from the Manneru Valley, Andhra Pradesh

Fossil representatives of *Crocodylus palustris* were so far known only from the Himalayan foreland[1,2]. We report here part of a fossilized skull of this species from riverine silts overlying a volcanic ash bed exposed in Manneru valley near Pamuru (15°5′ 40″ N, 79°25′ E), Prakasam district, Andhra Pradesh (Figure 1). The volcanic ash bed compares well with that of the youngest (74,000 BP) Toba tuff from Sumatra[3]. The fossil is described below and its significance is discussed.

Class	:	Reptilia
Order	:	Crocodilia
Sub order	:	Eusuchia (Huxley, 1875)
Family	:	Crocodilidae
Genus	:	Crocodylus, Linn
		Crocodylus palustris, Lesson (Figures 2, 3, 4)

The specimen consists of the right portion of a skull preserving maxilla with dentition, partial premaxilla, jugal and epipterygoid. The sutures are intact. The seventh and eleventh teeth are not preserved. All the teeth are broken mechanically near the base showing the circular pulp cavity. The specimen has suffered from prolonged erosive/weathering action that has obliterated many of external sculptural details. The characteristic shape of the specimen appears to be the result of mechanical breaking along a twisted plane.

Length of specimen is 30 6 cm. Snout is short. Teeth are unequal in size. Cra-