Nature Watch

Enigmatic Bamboos

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Bamboos form a group of enigmatic plants that have attracted the attention of mankind from time immemorial. The 'peculiar' behaviour of many woody bamboos, of flowering only once at the end of very long vegetative growth phases (3-120 years or more), and dying thereafter, has intrigued mankind for long. This interesting natural phenomenon still remains a mystery. The abundance and variety of bamboos, their fast growth, innumerable uses, their emergence as ornamental plants, and the curious way in which their peculiar flowering behaviour is entangled with the survival of the giant pandas, are interesting.

Biology of the Bamboo Plant

Though it may be difficult to believe, bamboos are also 'grasses' (members of the family Poaceae), and are relatives of more common and familiar grasses such as rice, wheat, etc. Most bamboos differ from other grasses in their perennial and tree like growth habit. Because of this they are often called 'giant grasses' or 'tree grasses'. There are 1200-1500 species of bamboos, classified under about 75 genera. Bamboos occur mostly in tropical and sub-tropical areas as well as in some mild temperate regions.

The bamboo plant has an underground stem, known as the rhizome system, and an aerial part consisting of erect stems (culms), branches and foliage. There are two types of rhizome systems: sympodial or clump forming and monopodial or runner type. Most of the tropical bamboos belong to the first category and the temperate ones to the second. Owing to this, tropical bamboos grow as clumps (either loosely or compactly tufted), and in their temperate counterparts the underground

rhizome system spreads over a large area (invasive) and gives out culms which stand apart. The clump forming habit of tropical bamboos is thought to be an adaptation to increase shade, and accumulation of more mulch at the base of the clump so as to preserve moisture. This is very essential for survival in a hot and dry environment. Sympodial bamboos, in general, are less tolerant to frost. Monopodial bamboos, on the other hand, are more frost resistant. In both the types of bamboo, the rhizomes grow mostly in the top half metre of soil and their fibrous root system spreads very well in the top soil. This makes bamboos good soil binders as their roots protect the top soil from being washed away. Growing bamboos on steep slopes and riverbanks is very beneficial as it protects them from the fury of floods.

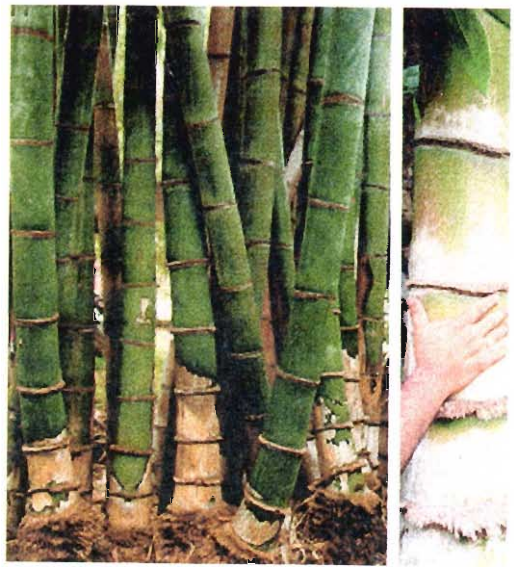

Figure 1. A clump of Dendrocalamus asper, in Pune where it grows as an exotic. Individual culms of this bamboo are 6-10 inches in diameter and approximately 30-40 ft. tall.

Bamboos present an enormous variety in size. The culms of one Chinese bamboo *Dendrocalamus giganteus* attain a height of about 30m and a diameter of 30 cm. Cross sections of its culms can be used as buckets. Another bamboo from the West Indies *Arthrostylidium cappillifoilium* has culms only as thick as a pencil, and hair-like leaves which are only 3 mm wide.

Figure 2. Just emerging sprouts of bamboo (Dendrocalamus asper) shoots which are used as food.

Bamboos are among the fastest growing plants. When new culms emerge, a growth rate of about 5 cm per hour is recorded. As they grow fast, bursting of the sheaths which cover the sprouts makes an audible sound. Bamboo seedlings take about 5-7 years to establish themselves. The shoots produced initially are thin and slender. Gradually the underground rhizome system gets established. Then the rhizome system starts giving out erect, thick and tall shoots (culms) every

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year. In monopodial (runner type) bamboos, the onset of shooting occurs in spring, and is controlled by temperature. In sympodial (clump forming) bamboos onset of shooting occurs by the end of summer to autumn, mostly during the rainy season, and is controlled by the availability of moisture. Usually a culm has a life of about 5 years. Yet, culms of Chinese timber bamboo live as long as 20 years.

Peculiar Flowering Behaviour of Bamboos

Most woody bamboos flower at long intervals. Unlike popular belief, bamboos fall in between two extremes, constant sterility and constant flowering. Some bamboos remain in a vegetative (non-flowering) state for indefinite periods of time. On the other hand there are some which tend to flower constantly. The rest grow vegetatively for varying lengths of time before flowering. There is a wide gradation; *Schyzostachyum elegantessimum*, one Javan bamboo, flowers at an interval of about 3 years, and *Phyllostachys bambusoides*, the well-known timber bamboo from China, flowers only at about 120-year intervals. The popular belief that the intermast periods (intervals between two successive flowerings) of different bamboo species are constants, is not correct: it typically varies within a range (e.g. 115-125 years in case of Chinese timber bamboo). As Geoffrey Chapman, a bamboo expert from Wye College (University of London), puts it in a recent appraisal on current research on bamboos "*The prevailing myth about bamboo flowering is that all members of a species, or at least of a particular clone, wherever they happen to be, will flower simultaneously. The assumption, perhaps, is of an imperturbable inner clock ticking away until the pre-set alarm goes off, flowering takes place and then the plants invariably die. For many bamboos this is quite simply not the case, although the idea is so deeply rooted in popular mind as to be virtually ineradicable.*" Because of its occurrence only at very long time intervals, an incidence of bamboo flowering is often compared with the visits of comets. Witnessing both these events are once in a lifetime experiences.

There are two types of flowering in bamboos, gregarious and

sporadic. In gregarious flowering all individuals of one species (a variety or a clone) flower more or less at the same time, even at widely separated geographical locations. Many bamboos with gregarious flowering habit also show some out-of phase flowering in between the normal flowering cycles. This is known as sporadic flowering, which is often restricted to only few clumps, few culms in a clump or a few branches of a culm.

There are 1200-1500 species of bamboo, classified under about 75 genera, occuring mostly in tropical and sub-tropical areas.

Bamboo flowers, like other grass flowers, are tiny, and are borne on compound inflorescences. These flowers, because of their small size, are often referred to as florets. The basic structural unit of an inflorescence is a spikelet which is a small spike consisting of an axis bearing stalkless florets. Typically a spikelet consists of few empty bracts (referred to as 'empty' because they do not subtend buds), few fertile florets and a few to nil vestigial florets. A fertile floret is enclosed by a 'lemma' (a modified sheath and a 'palea' (prophyll); 3 lodicules; 3, 6 or many stamens which are either separate or united at the filaments into a tube; and gynoecium consisting of ovule, style and 1-3 stigmas. After pollination and fertilisation, the gynoecium develops into a fruit (mostly a caryopsis or grain).

Most bamboos die after a gregarious flowering. Death of bamboo parent, immediately after its first and only flowering, used to be considered as a peculiarity of only bamboos. This was mostly because of the huge size of the bamboo plants, and because the death of the entire bamboo forests as a whole, were in sharp contrast with other forest trees. However, this behaviour, known as 'monocarpy', is very common among members of the grass family. Rice, wheat and barley also grow for a season or a year, flower, set large quantities of seeds, and die. The peculiarity of bamboos is in the extension of their vegetative growth phases, from few to many years; in some, to more than a century. Why this has happened is not known.

For indigenous people who are dependent on bamboo shoots for food and livelihood, bamboo flowering foretells days of hardship. Flowered clumps die, and the new generation of seedlings

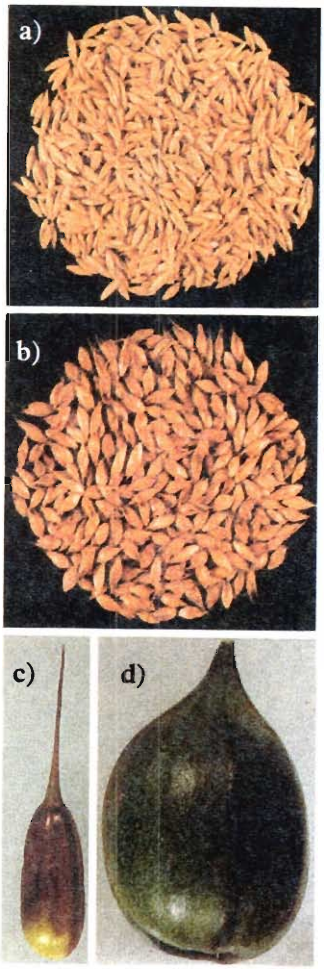

Figure 3. Bamboo seeds: Grain like seeds of a) Bambusa arundinacea and b) Dendrocalamus strictus, and fleshy (berry like) seeds of c) Ochlandra ebractiata (reed bamboo) and Melocanna bambusoides d) ('Muli bamboo' – this bamboo has one the largest seeds among grasses.)

take a few years to get established. The seedling shoots are thin and slender, and are of no use. Normal shoots (culms) are produced only after the development of a rhizome system, and that can take upto five years.

Many Uses of Bamboos

Bamboos are, perhaps, one of the most useful group of plants known to mankind and are used for a wide variety of purposes. Kurz, a 19th century bamboo specialist, recorded more than one thousand uses of bamboos: the Japanese use them in more than 1500 ways, and for the Chinese, bamboo is like a 'friend'. In China and Japan as well as parts of north-eastern India, bamboo shoots constitute an important food ingredient. It is the just emerging tender shoots (not the aerial shoots – culms and branches) that are eaten. Bamboo shoots are valued as a food because of their crisp texture. Bamboo seeds which have a nutritional quality slightly greater than rice and wheat are also eaten. Bamboo seeds (`fruits' to be more correct) are of two types, grain-like (seeds of *Bambusa arundinacea*, *Dendrocalamus strictus*, etc.), and large and fleshy (those of *Melocanna bambusoides*, species of *Ochlandra*, etc.). In fact, one of the largest grass fruits is that of 'muli bamboo' (*Melocanna bambusoides*), a native of Assam and Bangladesh (flowering cycle in the range of 30-33 years, or more). Native people in areas where this bamboo is indigenous are known to eat its fruits, either raw or cooked. However, most bamboos produce grain like seeds, more or less similar to rice or wheat grains in appearance. Indigenous tribal people in some areas collect and store bamboo seeds for use in

Box 1. Approximate Nutrient Content of Fresh Bamboo Shoots

Every 100 grams of fresh bamboo shoots contain 92.5% water; 3.9 grams of total carbohydrates (1.0 gram crude fibre and 2.9 grams sugar); 2.5 grams crude proteins; 1.0 mg calcium; 43.0 mg phosphorus; 7.0 mg iron; 50.00 i u. (international units) vitamin A; 0.01 mg vitamin B_1; 0.05 mg vitamin B_2 and 10 mg vitamin C.

times of scarcity. Bamboo seeds can also be baked into flakes, which taste very much like corn-flakes.

Bamboos is also used for economical housing: in some places, whole houses are made of bamboo. Because of this bamboo is also called 'poor man's timber'. A range of agricultural implements, household utensils and handicrafts are also made from bamboo. Bamboo is also an ingredient of many herbal remedies in China. *Tabasheer* or banslochan, the precipitated amorphous silica obtained from some of the tropical bamboos has medicinal value as a remedy for cough and asthma. It is also used as a cooling tonic and as an aphrodisiac. Bamboo leaves are much valued as fodder, particularly when there is scarcity of pasture. Cattle and horses relish it and bamboo foliage forms the favourite food of elephants

Bamboos are used for such diverse applications as making of acupuncture needles and bridges. Many articles of daily use, such as baskets, blinds, fans, ladders, mats, musical instruments, pipes, tool handles, toys, umbrellas, etc. are also made from them. Bamboo finds use also in the making of weapons, such as bow and arrows, lathi, etc. Thomas Alva Edison used charred fibers of a Japanese bamboo for the filament of his first electric bulb. Because of its lightweight, bamboo is also used in artificial limb making. In some parts of rural Japan, even today, the umbilical cord of the newborn is severed with a bamboo knife. Imagination can be the only limit to the novel and innovative uses to which bamboo can be put.

Bamboo is also an important industrial raw material and more than half the annual produce of bamboo in India finds use in paper making. Another industrial use of bamboo is in the manufacture of bamboo mat-boards (bamboo ply) which are fast gaining popularity for use in interior decoration.

Although bamboos have been the mainstay in Chinese and Japanese gardens for long, their value as an ornamental is only slowly being realized in India. From the ornamental point of

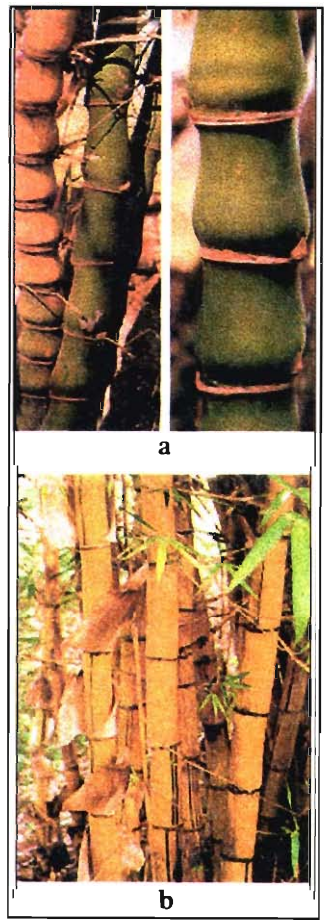

Figure 4. Two bamboos commonly grown as ornamentals: (a) Buddha's belly bamboo (Bambus ventricosa – note the inflated lower portions of the internodes) and (b) tiger/yellow bamboo (Bambus vulgaris var. 'vittata' – this bamboo has green striped golden yellow culms.).

view a good assortment is available in both tropical and sub-tropical bamboos. Bamboos derive their ornamental value from their growth habit, size, shape, colour and variegation of the culms, shape of the canopy, and size, shape, colour and variegation of the leaves. Because of the availability of wide range of sizes, shapes and growth habits, bamboos can be grown as groves (larger ones), individual plants, in the courtyard, or as hedges, ground cover and pot/container plants. They can also be grown in balconies, terraces and roof gardens. Bamboos also make beautiful 'bonsais'.

Bamboo and the Giant Panda

The giant panda needs no introduction. It is one of the most endangered animals on earth. The giant panda conservation problem first drew widespread attention in the mid 1970s. The giant pandas live in parts of the cool and temperate montane and sub-alpine forests of three southwestern provinces of China, namely Sichuan, Gansu and Shanxii. Within these forest zones, the panda habitat is confined to areas which has a dense bamboo understorey. According to recent estimates, there are only about 1500 of them in the wild (only in China). Pandas were once very common in most of eastern China., and their range extended even up to Myanmar (Burma) and Vietnam. Now they are restricted to six forested tracts which cover approximately 10,000 square kilometers. This drastic reduction in the panda range is believed to be due to the change in climate during

Box 2. The Giant Panda

The scientific name of the giant panda is *Ailuropoda melanoleuca*. It is the only member of the genus *Ailuropoda*. .The giant panda is believed to have evolved, independently, either from the raccoon or the bear. The closest relative of the giant panda is the lesser panda. Since the Pleistocene the appearance of the giant panda has remained unchanged. Its dark and white fur is a very effective camouflage in its natural habitat. When it sits on its hind legs on tall trees, its dark fur merges with the tree trunk and white fur merges with the sky in the background, rendering it invisible. Despite its large size (5 ft, 110-120 Kg), the giant panda is gentle as a sheep, and very friendly. Pandas make a variety of sounds. They blurt, chirp, huff and snort. When startled they even bark like a dog.

Figure 5. The giant Pandas; mother panda nurtures only one offspring at a time.

Figure 6. The distribution of giant pandas during the Pleistocene and at present. At present the giant pandas are restricted to six isolated forest tracts which cover approximately 10,000 square kilometres.

The overwhelming dependence of the giant panda on bamboos, and the peculiar flowering behaviour of bamboos, have been generally held responsible for the endangered status of giant pandas which are obligate bamboo grazers.

Pleistocene period. Overall, about half of the forest cover in the panda range has been cleared or modified by people during the past 15 years or so. Human activities result in fragmentation of panda habitats and increasing isolation of pandas within their ranges.

All that the giant pandas need is bamboo, and if this resource is available they remain in self imposed solitary confinement in their individual ranges of 4-6 square kilometres. The overwhelming dependence of the giant panda on bamboos, and the peculiar flowering behaviour of bamboos, have been generally held responsible for the endangered status of giant pandas which are obligate bamboo grazers. The gastro-intestinal tract of the giant panda is anatomically similar to that of a carnivorous animal. It consists of a simple stomach, no caecum, and a short and straight colon, with no morphological specialization for microbial fermentation of the plant material ingested. Consequently, the digestive capacity of the giant panda is limited to about 20% of the bamboo dry matter it consumes. Though the nutritive value of bamboo is low, its supply and nutritional quality remains constant throughout the year. Pandas spend most of their time searching-out and eating bamboo. They have an extra digit in the forefoot that is essentially a bamboo-handling device.

Pandas of different regions eat different bamboos and bamboo parts in different seasons. In Wolong (in China), pandas eat *Bashania fangiana* (arrow bamboo) culms less than one year old, in winter and shift to older culms in the spring. In summer they eat only leaves, and for a two-month period (May-June) they migrate to lower altitudes and eat nutritionally rich, just-emerging shoots of *Fargesia robusta* (umbrella bamboo). Pandas respond to bamboo die-off by altering their food habits.

In a major 1974-77 bamboo die-off, large numbers of giant pandas perished. However, giant pandas died only in places where all bamboo species synchronously flowered and died, and where bamboos at alternate landscape positions had been re-

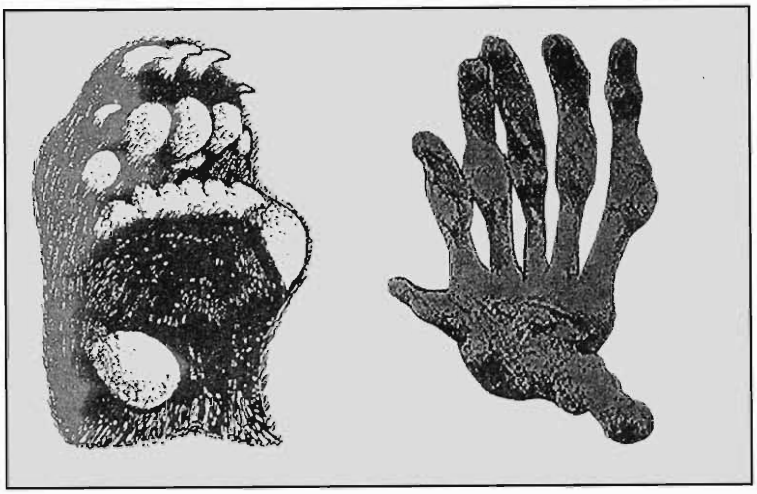

Figure 7. The extra digit (actually an extension of the wrist) in the forefoot of the giant panda is essentially a bamboo handling device.

moved. In areas where only one of the several bamboo species flowered, pandas survived the bamboo die-off. Though habitat destruction and poaching are the immediate threats, dwindling numbers and isolation of populations also pose a serious threat of inbreeding depression in panda communities of fewer than 100 individuals. Very recently Chinese scientists have initiated an ambitious project aimed at cloning the giant panda.

Pandas are omnivorous. In addition to bamboo, they eat small game, chicken and honey. Though their staple food is bamboo, more than 25 other wild plants are eaten by pandas, when bamboo is in short supply. Their dependence on bamboo reflects the lack of a large and stable alternative food supply rather than an inability to assimilate other foods.

Compounds present in newly emerging grasses have been shown to trigger reproduction in some animals. This may be true also for the giant pandas. There is a possibility that a reproductive stimulant is present in bamboo shoots. And the connection between the dwindling number of giant pandas and bamboo die-off may even be lowered reproduction at times when bamboo diet is unavailable due to die-off, rather than out-right starvation. That possibly may be one of the reasons for their low rates of multiplication in captivity, and their dependence on bamboos.

Understanding more about the panda-bamboo love affair is essential for formulating an effective strategy for the giant panda conservation.

Box 3. Low Multiplication Rate may have Contributed to the Plight of the Giant Pandas

Though elusive, vagrant and eccentric by nature, the giant pandas pair off during the mating season (April-May). Females, smaller than the males, reach reproductive age at about five years. After a gestation period of about 90-160 days, usually two young ones are delivered. However, the mother focuses her attention only on one of them and lets the other die. The mother nurses the young one in the safety of a cave or the hollow of a tree. The infant remains with the mother till it is nutritionally independent. The infants are taught the relevant bamboo parts, and the seasons and altitudes. This takes about 18 months. This total concentration of maternal care on the infant may be one of the reasons why a mother cannot nurse more than one infant at a time. In the wild a female panda, in the whole of her life, conceives about five times on an average, and delivers about 10 babies of which she nurtures only five. Of these five the odds are that only two will survive and reach adulthood. This low rate of multiplication also makes giant pandas vulnerable to extinction.

Understanding more about the panda-bamboo love affair is essential for formulating an effective strategy for the giant panda conservation. For example, their preference for one bamboo over another, and their preference for particular bamboo parts, depending on the season and altitude is not understood. Another interesting question is, will we be able to break the synchrony of bamboo flowering? And more importantly, even if we succeed, will it help the giant pandas?

Bamboo and the Scientist

Why are bamboos so fascinating to the scientist? There are many reasons. First and foremost is their 'peculiar' flowering behaviour. This eccentricity of bamboos, of flowering only once at the end of very long intervals, has been intriguing laymen and scientists for long. The answer to the question 'Why bamboos wait so long to flower?' still evades us. The peculiar flowering behaviour makes bamboo propagation difficult, because of the availability of seeds only at long intervals. Increasing use of bamboo as a raw material in paper and pulp industries is resulting in ever-increasing demand for bamboos. In recent years scientists have developed tissue culture methods for the rapid, large scale propagation of bamboos.

Use of bamboos in the garden is also increasing the scientific

interest. To satisfy the customer demand, finding exotic bamboo varieties suitable for growth in diverse geographical locations, and exploring the wild for hitherto unknown varieties having ornamental value are essential.

Bamboo biology is also related to the giant panda conservation. Two aspects are involved in this: understanding (i) bamboo biology in relation to forest management and (ii) the giant panda biology. Though earlier the peculiar flowering behaviour of bamboos and the bamboo die-off used to be considered as the only reason for the plight of pandas, as we understand more about the bamboos and the giant pandas, it is becoming increasingly clear that the bamboo die-off is only one of the aspects involved. This realization can go a long way in the giant panda conservation.

It is said "bamboo is all things to some men and something to all men". Scientists are no exception.

Suggested Reading

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If you wish to make an apple pie from scratch, you must first invent the universe.

Carl Sagan
Cosmos