# Reproductive Biology and Flowering Populations with Diversities in Muli Bamboo, *Melocanna baccifera* (Roxb.) Kurz

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## Abstract

The life cycle of *Melocanna baccifera* (Roxb.) Kurz plant ends with flowering, so the species is a semelparous in nature. In a population flowering is initially sporadic which gradually becomes gregarious and then again turns into sporadic before mass scale death of the clumps. The flowering continues in a specific direction like a "wave", with a period of 12 to 14 years or more, spreading over the whole forest area. Details of inflorescence character, flowering nature, anthesis and fruiting behaviour have been discussed. Unlike most other bamboos, this species produces fleshy green pear-shaped fruits (seeds). The "seed" viability and germination pattern were studied. The problem and management system of natural regeneration after the death of flowering clumps were also discussed.

It was estimated that the species exhibited more than one flowering cycle (interseeding period) in different localities of Bangladesh-India-Myanmar region. Some populations have 30-35 years of flowering cycle, and others may have further longer (45, 60, 65 years) or shorter (7-10, 19-21, 25, 26, 27 years) duration. It appears that there exists a number of flowering population in the region and they might be isolated from each other by reproductive time. In the boundary areas, however, populations are likely to overlap with each other and some of the clumps may flower after shorter, and others after longer periods or in between. Enormous genetic variabilities are expected within this vast natural habitat due to such diversities in flowering cycle that offers opportunities for selection and improvement of the species.

সারসংক্ষেপ

মূলি বাঁশে তার জীবনকালে একবারই ফুল ফোটে এবং তারপর মরে যায়। কোন স্থানে ফুল ফোটাকালীন সময়ে প্রথমে অল্প অল্প ঝাড়ে ফুল ফোটে এবং পরে ব্যাপকভাবে অনেক ঝাড়ে ফুল ফোটা শুরু হয়। তারপর চূড়ান্ত পর্যায়ে পুনরায় বিচ্ছিন্নভাবে ফুল ফোটে এবং ঐ এলাকায় সমস্ত ঝাড় মরে যায়। পুষ্পমঞ্জরী, ফুল, পরাগায়ন ইত্যাদি বিষয়ে আলোচনা হয়েছে। মূলি বাঁশের বীজ দেখতে সবুজ, মাংসল ও বড় পিঁয়াজ আকৃতির হয়ে থাকে যা অন্যান্য বাঁশের মত নয়। বাংলাদেশ-ভারত-মায়ানমার এলাকার বিভিন্ন স্থানে মূলি বাঁশের জীবন চক্রের সময়কাল বিভিন্ন রূপ পরিলক্ষিত হয়েছে। কোন অঞ্চলে জীবন চক্র ৩০-৩৫ বছর এবং কিছু কিছু স্থানে আরো বেশী (৪৫, ৬০, ৬৫ বছর) অথবা কম (৭-১০, ১৯-২১, ২৫, ২৬, ২৭ বছর)। বর্ণিত জীবন চক্রের সময়কাল ভিত্তিক অঞ্চল সমূহের সীমানা সংলগ্ন এলাকায় কোন কোন ঝাড়ে স্বাভাবিক সময়ে অথবা দীর্ঘ সময় পরে অথবা মাঝামাঝি সময়ে ফুল ফোটা স্বাভাবিক। পুষ্পায়নকালের ভিন্নতার জন্য এতদঞ্চলে মূলি বাঁশ প্রজাতিতে অধিক জেনেটিক বৈচিত্র্য আশা করা যায় যা এ প্রজাতির উন্নয়নের সহায়ক হবে।

**Key words :** Flowering cycle, flowering diversities, flowering wave, *Melocanna baccifera*, muli bamboo, reproductive biology

## Introduction

*Melocanna baccifera* (Roxb.) Kurz is a natural and most priority bamboo species growing extensively both as pure and mixed vegetation throughout the hill forests of Bangladesh, northeast (Assam, Arunachal, Meghalaya) and eastern part (Tripura, Nagaland, Manipur, Mizoram) of India and Myanmar. It is believed that the natural home of the species is Chittagong Hill Tracts (Bangladesh) where it grows abundantly (Prasad 1948, McClure 1966). It is more or less an evergreen bamboo species having open clump with many single culms arising 0.5 to 2 m apart from a ramifying underground rhizome system. All these regions of the world have the highest monsoon rainfall (3000 to 6350 mm) and are extremely vulnerable to soil erosion. The rhizomes of many different individual clumps of this species intermingle with each other forming an underground strong network and thus bind the soil. The nature has produced and selected this bamboo species in these hilly regions probably for protecting the soil from erosion by its elongated ramifying intermingled rhizome system (Banik 1989). Besides this ecologic importance, *M. baccifera* is the main raw material for rural housing, agricultural implements, cottage and pulp and paper industries.

This bamboo species is locally known by the name *Muli. Nali, Paiya, Bazali* (Bangladesh) ; *Muli, Watri, Tarai* (India) ; *Lahure bans* (Nepal, Bhutan) and *Kayoungwa* (Myanmar). *Muli* constitutes 70-95 per cent of the total bamboo resources present in different hill forests of Bangladesh, and 60-80 per cent in the provinces of northeast and eastern part of India. The species occurs as pure stands over 7800 km$^2$ in Arakan and Yoma of Myanmar. Thus both from ecological and economic point of view this bamboo is an important and priority species of this region.

It was reported that whenever there was gregarious flowering in a *Melocanna* forest almost all the clumps died covering a large tract of land creating shortage and scarcity of bamboo resources in different parts of Bangladesh, India and Myanmar (Brandis 1906), Troup 1921, McClure 1966). During the last 12 years the species has also started flowering in northern Chittagong Hill Tracts of Bangladesh (Banik 1989) and in Cachar Hills of India (Gupta 1988). So, the present flowering in *M. baccifera* is likely to create a similar alarming condition for bamboo resources of Bangladesh and neighbouring areas as reported to happen earlier. Thus it becomes important to understand the reproductive biology including the natural regeneration of the species so that in future quick replenishment of the resource is possible. Accordingly a study has been undertaken and the findings are reported herein.

## Materials and methods

Since 1986 *Melocanna baccifera* has been sporadically flowering in naturally grown forest areas of Chittagong and Chittagong Hill Tracts (CHTs) of Bangladesh. The inflorescence character, flowering and fruiting nature including process of natural regeneration in this bamboo species were observed till 1990 and recorded from the randomly selected flowering clumps growing in the forest of Fatehabad (Chittagong) and Hyanko (CHTs) of Bangladesh. The nature of "seed" (fruit) germination and the character of seedlings were described.

Out of 10,000 seedlings five seedlings of 10-12 months old have flowered in the nursery of Bangladesh Forest Research Institute during May 1989. The seeding nature of these precociously flowering seedlings was also observed.

The dates of previous incidence of flowering in the species at different localities of Bangladesh-India-Myanmar region were reviewed from existing literature. All the available flowering dates have been tabulated and arranged chronologically on the basis of locality for estimating the flowering intervals/cycles of the species. The reported flowering dates are also plotted in the map on the basis of sporadic and gregarious flowering nature. This map was assessed to identify, if any, different flowering populations in the region.

## Results and discussion

### Inflorescence character and flowers

The culms in a clump do not always flower synchronously, some clumps may have clums in two or more different phenological states. During flowering year culms in a clump start producing floral shoots always at the apex of thin leafy branches, generally in the month of September to October. These floral shoots are leafless, somewhat brown, and 12-60 cm long. After about two and a half months the floral shoot start blooming during November to December. The floral buds are borne at nodes along one side of the axis of a floral shoot and thus the pseudospikelets are produced on one side of the branches (Fig. 1a).

The inflorescence is a large compound panicle, usually remains drooping in nature. The *spikelet* is cylindrical and about 40-60 mm long. *Palea* is convolute, mucronate and 7 veined. *Lodicules* 2 and fimbricate. The number of *florets* on the spikelet is 3-8, out of which 1-2 are fertile and 1-7 are sterile. The *ovaries* in florets are diagnostically prominent and have elongated styles. The ovary is ovoid and narrowed upward with short recurved feathery purple *stigma*, the major portion of which is exposed (Fig. 1b). *Stamens* are 5-6, filaments short, free, and 7-9 mm long. *Anther* is yellow, obtuse, and 2-4 mm long.

### Anthesis and pollinations

The florets mostly open in the morning up to 10 a. m. Generally upper floret opens first and the lower floret opens after 2-5 days. Anthers come out in the morning and burst in the afternoon at 3-5 p.m. Some may come out in the afternoon and burst in the morning of next day. Dehiscence starts from the apex and moves longitudinally down of the anther. During anthesis time honey bees and few ants visit the fresh florets. Flowering is random in the branches which could stimulate greater movement of pollinators between inflorescences different flowering clumps. Fruit setting starts within a week of pollination. Pollination, fruit setting and maturation take place within next four to five months, April and May. However, caryopsis (fruit) maturation is quicker in early part of seeding season. Both flowering and fruiting in a clump are simultaneous.

Soon after blooming in the apical floral shoot, all the leaves below it on the branches turn yellow and gradually wither. The buds on the axil of the withered leaves then start producing short panicles. Accordingly within a few weeks the main and secondary branches become leafless and form a large compound panicle. Thus finally all the branches on the culms become leafless and produce flowers. All the leafless flowering culms in a clump look like a giant inflorescence.

### Fruit characters

Fruits or caryopses of *M. baccifera* are fleshy, onion or pear like *(bacoid caryopses, baccate caryopses)*, big and green (Fig. 1c). The caryopses are not covered with any glume, and their weight varies from 7 to 150 g, length from 35 to 110 mm and diameter 22 to 60 mm (Banik 1991). However, a field forester usually terms the caryopsis (fruit) as "seed". Sometimes, a "seed" may weigh up to 275 g. In general one kg contains 45-70 seeds.

### Seed production

Seed production is poor in sporadic flowering condition where possibility of cross-pollination is very low. Gregarious flowering over a large tract of land facilitates cross-pollination resulting higher production of viable "seeds". One medium sized full-grown clump usually produces 5-7 kg "seeds" in one flush and 25-40 kg within whole flowering period before dying. In general, "seed" production is optimum during May to June and poor from later part of September to November.

### Seed dispersal

The mature "seeds" usually drop near the mother clumps and may also disperse far away from mother clumps by rolling over the hill slopes. They are also naturally dispersed widely covering a large area along the flow of rain water through different streams and fountains. According to Stapf (1904) during 1867, a surveyor reported that in a

6000 square mile patch the pear-sized seeds of *Melocanna* were falling so thickly that he had to give up work because he could not place his plane table and theodolites on the ground.

The seeds are eaten heavily by rats, wild boars, porcupines, deers and other animals. The local hill-tribes also eat the fleshy "seeds" as vegetables.

**"Seed" germination and viability**

Fresh "seeds" germinate in higher percentage (70-80%) under partial shade (negatively *photoblastic)* than in direct sun light (33%). Germination starts within 5-7 days of sowing and continues for the next 20-25 days. The seedlings raised from light-weight seeds have usually low (56%) survival rate. Different types of abnormalities such as rootless plumules, stunted radicles, radicles growing upward and albino character, etc. are not uncommon in the seedlings produced from light-weight "seeds" (Banik 1991). Big and heavy seeds (above 50 g per seed) usually do not produce any abnormal seedlings and about 60% of them produce 2-shoots at the initial stage of germination. These seedlings are generally healthy and survive in higher (70-80%) rate. During later part of flowering season, September to November, a few "seeds" were found in germinating stage even on the flowering culms (vivipary germination). The seeds have 35-40 days viability period.

**Seedling character**

The seedling up to 9-10 months of age prossesses soft, tender unbranched stem bearing single leaf alternately at the nodes (Fig. 2a). The leaves produced by seedlings are usually one and a half times bigger in length and width than those of the adult plants (Fig. 2b).

**Natural regeneration**

Dead standing mother clumps influence better growth of bamboo seedlings by providing partial shade. Harvesting or burning of dead mother bamboos within 2-3 months of seed germination hinders the regeneration process by destroying almost all the bamboo seedlings. Therefore, felling operation of dead bamboos in the early stage of regeneration should be discouraged to obtain higher survival and establishment of regenerating bamboo seedlings. As the flowering mother clumps are leafless and dead, the forest floor becomes exposed to the sun, and the population of weeds and vines increases. Regenerating bamboo seedlings thus face competition for their survival. Frequent weeding, vine cutting and protection from grazing or predation are found essential in protecting, nursing and enhancing the natural regeneration of wild seedlings of *Melocanna* bamboo. Past records suggest that the new seedlings grow vegetatively usually for the same length of time as did their parents and repeat the process (McClure 1966, Janzen 1976).

**Flowering in seedling (precocious flowering)**

Among 10,000 seedling population raised during May 1989 from the seeds collected from Hyanko, four seedlings started flowering precociously at the age of 10 months (March 1990) and another seedling at 12 months (May 1990) of age. In total five seedlings (parental generation) flowered and all produced seeds. But some seeds from two mothers germinated and developed into seedlings. These seedlings (first generation) again flowered and produced seeds and seedlings similar to those reported for *Bambusa tulda* (Banik 1980). Unlike adult flowering clump the precociously flowering seedling produced new culms simultaneously (Fig. 2c) and did not die within one year. These seedlings, however, died within 30 to 36 months of age. One seedling of third generation was surviving and again started producing floral shoots in the months of March 1997 and fruited in August 1997 in Bangladesh Forest Research Institute Nursery and finally died in 1998 at the age of five years. Chatterjee (1960) also reported that in Mizohills the species exhibited 7-10 years short flowering cycle.

**Flowering nature**

The clumps of the species generally flower

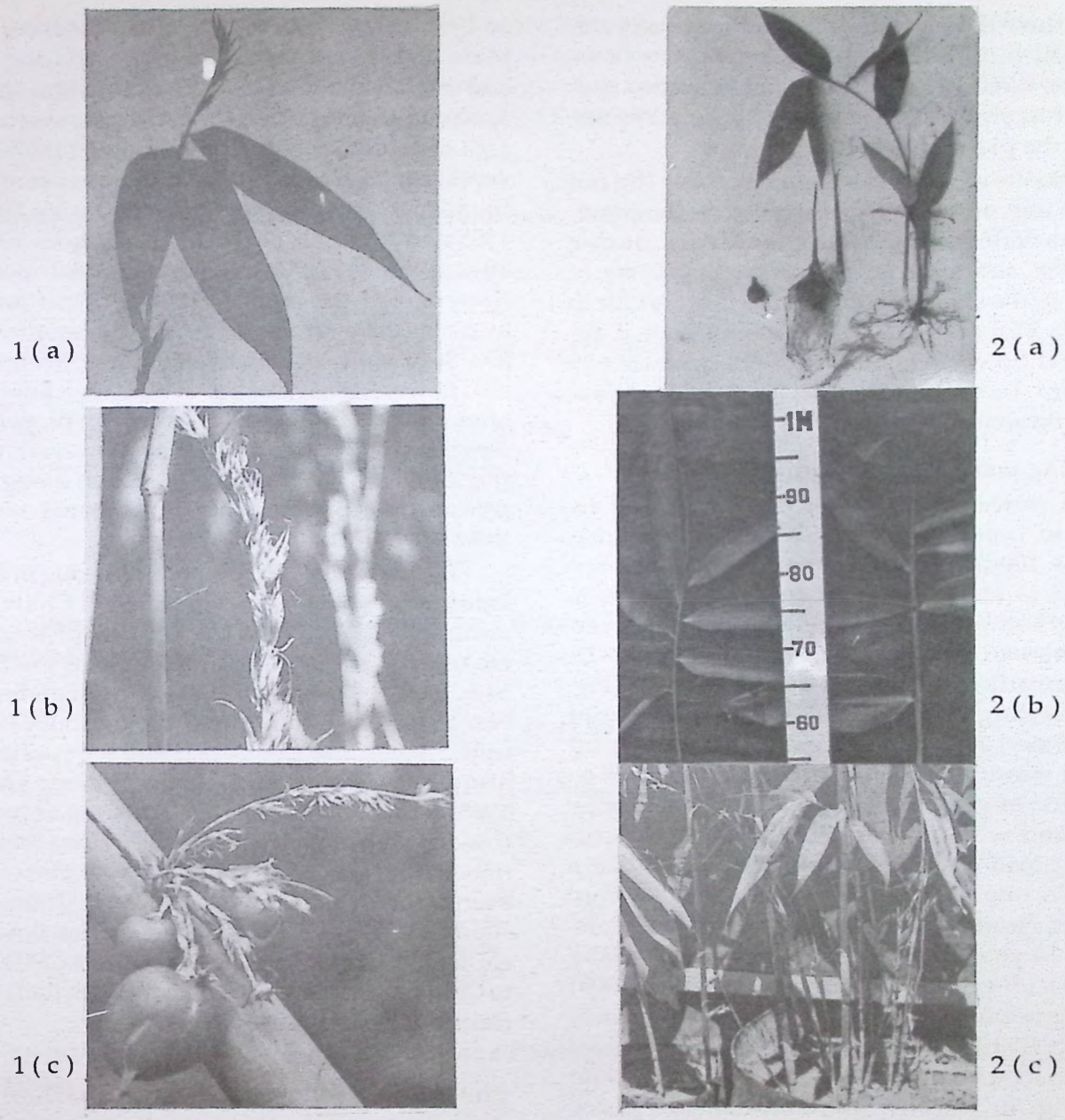



Figure 1. Floral shoot and flowers of *Melocanna baccifera*.
a. One-sided spikelets at the branch apex, b. Purple stigma, the major portion of which in exposed, c. Onion or pear-like big and green fruits *(bacoid caryopses)*.

Figure 2. Seedling of *Melocanna baccifera*.
a. Leaves are directly produced on the unbranched stem of a seedling (up to 9-10 months of age), b. Leaves of seedlings (right) are bigger than the leaves of adult (left) plants, c. A precociously flowering seedling produced new culms simultaneously.

once in their life time and take almost one year, very rarely more than one year, to complete flowering and then die. Like most other bamboo species *M. baccifera* is also semelparous, i.e. the life cycle of the plant ends with flowering.

All the flowering clumps under study did not produce any new culms. However, in the previous years of flowering year 1990-1991, i. e. during 1989, 1988 and 1987 (1, 2, 3 preceding years of flowering) the average culm production per clump were 8.0, 17.0 and 12.0 respectively. Thus it appears that flowering clumps do not produce any new culm, but in the immediate preceding year culm production decreases significantly.

**Flowering wave and three phase flowering**

The flowering in *M. baccifera* was first reported to occur during 1863-1866 in Myanmar (Brandis 1906). After that the species had been reported to start flowering again in the area in 1902 and completed in 1916 (Table 1). The flowering continued like a "wave" for 14 years (1902-1916) spreading over the whole forest area (Fig. 3a). According to Raitt (1929) "the flowering is not concentrated into one season, it may be spread over 12 years". A clump does not continue to flower for 14 years, each year many new clumps flower and within this period flowering successively spread over the whole forest area like a wave. So one can have fruits every year from different clumps flowered in successive years. During 14 years time the flowering was initially sporadic (*Si*-phase) for four years (1902-1905) which gradualy became gregarious (*Gr*-phase) during 1910-1913, and then again turned into final sporadic (*Sf*-phase) for the last two (1915-1916) years (Fig. 3). Thus the species exhibited 3-phase flowering characters (Troup 1921).

Such 3-phase flowering nature could also be observed in India and Bangladesh. The first flowering reports from Chittagong south, Chittagong north and Chittagong Hill Tracts were of around 1863 to 1866. In Chittagong south the last flowering was reported to occur in 1952 which was sporadic and continued for eight years up to 1958 or 1959. Thereafter a gregarious flowering took place and continued for two years during 1960 and 1961 (Table 1). During this time the species flowered in Bangladesh like a wave covering an area of about 10,000 sq. miles in four (1957-1961) years time (Hasan 1973). Before that, as per record, the species flowered sporadically during 1901 to 1905 and then started gregariously from 1908 to 1912 (Table 1, Fig. 3b). Reports on final sporadic flowering in these areas of Bangladesh are not available in literature. However, it is assumed that like 3-phase flowering in Myanmar the species also flowered sporadically at least for a few years after gregarious flowering in different parts of Bangladesh. So the duration of flowering wave (Fig. 3b) in *M. baccifera*, in Bangladesh though not completely reported, could be estimated as more than 12 years (1901-1912).

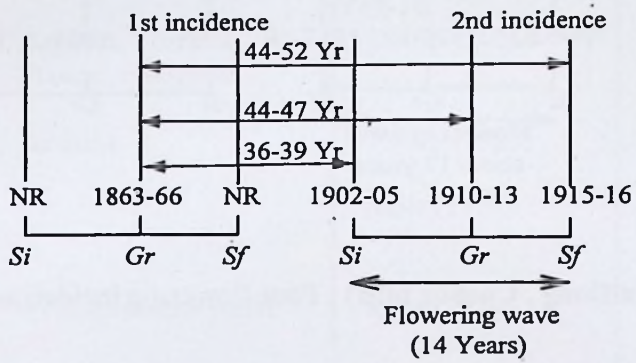
The present initial sporadic flowering in Bangladesh started in different localities of Chittagong north and CHTs (Kamalchari, Hyanko, Fatikchari, etc.) during 1986 and have been moving gradually like 'waves' towards the south (Fatehabad, Nazirhat, etc.) within 1998 covering about 400 sq. miles. According to Gupta (1988) the species has also started flowering in Assam (Haflong area) in 1985. This flowering has been moving as 'waves' towards the south to the Sylhet forests (Dholaichara) in 1996. The species has also not yet been reported or observed to flower in Chittagong south and Cox's Bazar. So the species flowered earlier (1985) in Chittagong north and CHTs than to Chittagong south, Cox's Bazar and Sylhet (1996) forests of Bangladesh.

**Flowering cycle (interseeding period) and diversities**

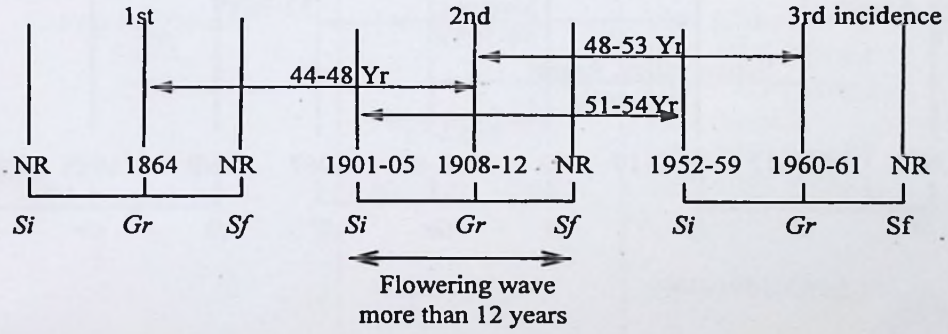
The documented flowering years (Table 1) were mostly on the basis of reports made by ones who might have observed flowering at any time during the wave of a flowering incidence, and these observations were mostly dependent on the chances of visits. The durations of interval (flowering cycle) between two flowering incidences in

Figure 3. Estimation of flowering cycle in *Melocanna baccifera* (Roxb.) Kurz from the illustration of number of incidences of flowering in different localities of india-Bangladesh Myanmar region during the last 150 years. (Note : 3 phase flowering nature : *Si* =initial sporadic flowering, *Gr* = gregarious flowering, *Sf* = final sporadic flowering. NR = flowering date not reported, NH = flowering not yet happened).

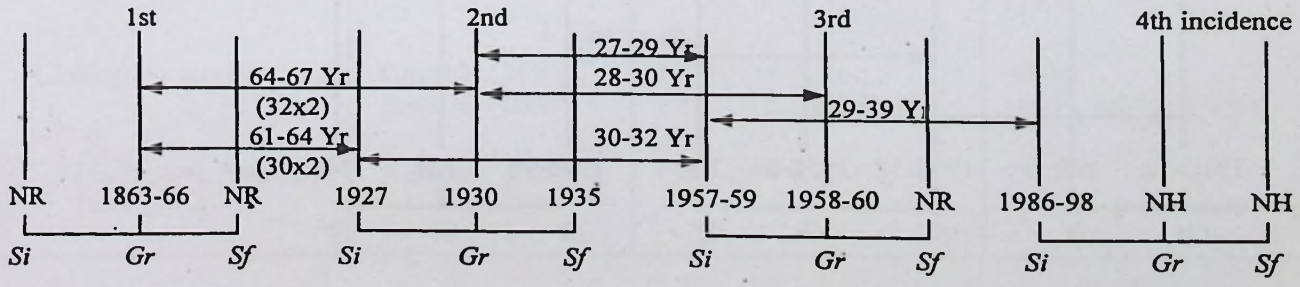
(a) **Myanmar (Arakan) :** Two flowering incidences each one having 3-phase flowering wave



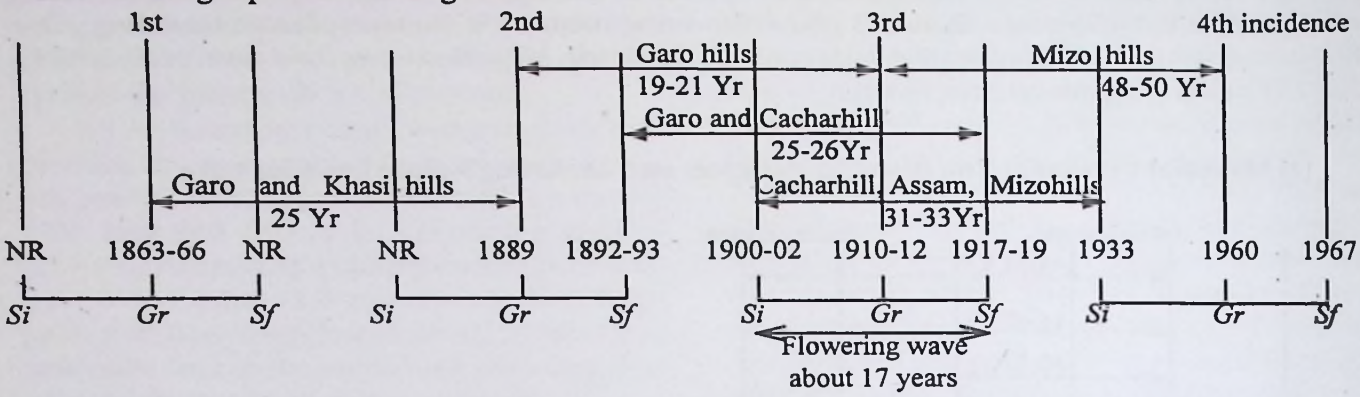

(b) **Bangladesh (Chittagong south and Cox's Bazar):** Three flowering incidences each one having 3-phase flowering wave



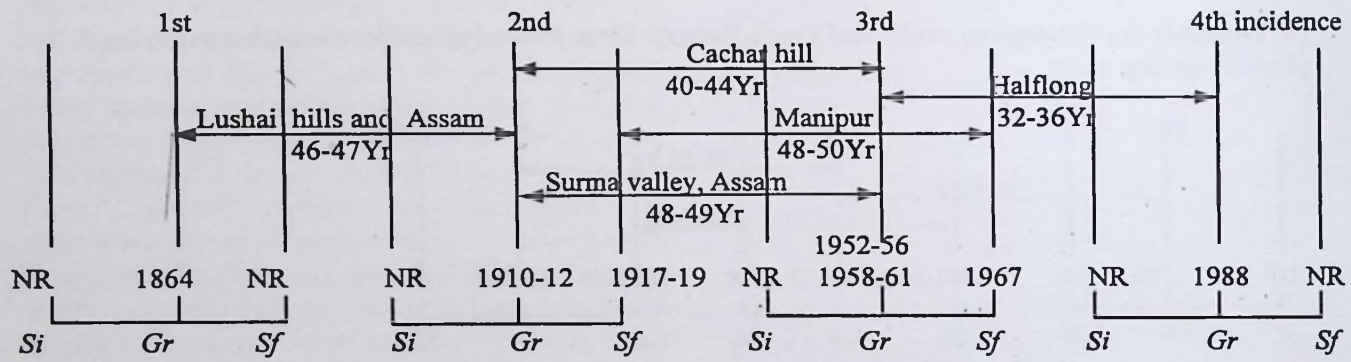

(c) **Bangladesh (Chittagong Hill Tracts and Chittagong north):** Four flowering incidences each one having 3-phase flowering wave



(d) **India (Assam, Tarai, Garo and Khasi hills, Mizo hills, Lushai hills) :** Four flowering incidences each one having 3-phase flowering wave




(e) **India (Lushai hills, Surma valley, Manipur, Halflong , Cachar hills) :** Four flowering incidences each one having 3-phase flowering wave




(f) **Bangladesh (Sylhet) :** Three flowering incidences each one having 3-phase flowering wave.

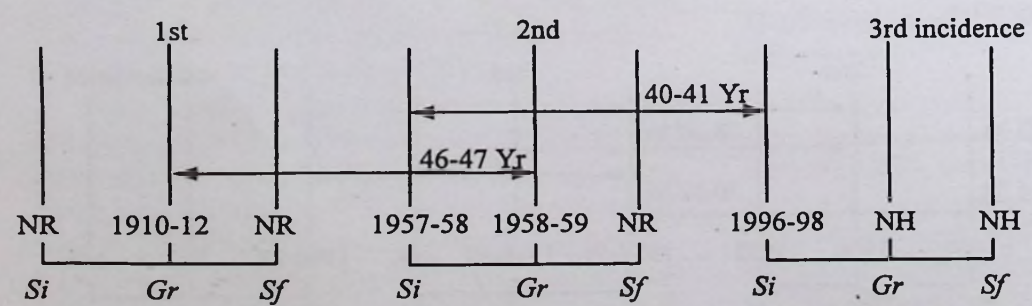


**Table 1.** Flowering dates and estimated flowering cycle (interseeding period) in *Melocanna baccifera.*

| Country/locality | References | Flowering date (calendar year) | Estimated flowering cycle (years) |
|---|---|---|---|
| **Myanmar** | | | |
| *Arakan* | Brandis (1906), Troup (1921) | 1863-1866 (Greg.)<br>1902, 1904-1905 (Spor.) | 36-39<br>(1863, 66-1902) |
| Arakan, Yoma Prome, Henzada | Troup (1921) | 1910-1913 (Greg.)<br>Hossain (1962) | 44-47<br>(1863, 66-1910, 13) |
| Arakan | Troup (1921) | 1915-1916 (Spor.) | 44-52<br>(1863-1909, 16) |
| | Raitt (1929) | 1909-1916 | 45-51<br>(1864-1909, 16) |
| Arakan (some part) | Raitt (1929) | upto 1928 not flowered | About 60<br>(1866-1928) |
| ? ? | McClure (1966) | 1957-1959 (Spor.) | About 60<br>(1900-1959) |
| **Bangladesh** | | | |
| *Chittagong (south)* | Troup (1921) | 1864 (Greg.)<br>1901-1905 (Spor.)<br>1908-1912 (Greg.) | 44-48<br>(1864-1908, 12) |
| | Hossain (1962) | 1952 (Spor.)<br>1958-1959 (Spor.) | |
| | McClure (1966) | 1957-1959 (Spor.) | 52-59<br>(1900, 05-1952, 59) |
| | Hasan (1973) | 1960-1961(Greg.) | 48-52<br>(1908, 12-1960, 61) |
| *Cox's Bazar* | Troup (1921)<br>Hossain (1962)<br>Hossain (1962) | 1908-1912 (Greg.)<br>1959-1960 (Spor.)<br>1960-1961 (Greg.) | 48-53<br>(1908, 1912-61) |
| *Chittagong (north)* | Gamble (1896), Brandis (1906) | 1863-1866 (Greg.)<br>1901-1905 (Spor.) | 35-38<br>(1863, 66-1901, 05) |
| Hathazari, Nazirhat Fatehabad | Author | 1988-1997 (Spor.) | 28-32<br>(1960, 61-1988, 97) |

| Country/locality | References | Flowering date (calendar year) | Estimated flowering cycle (years) |
|---|---|---|---|
| *Chittagong Hill-Tracts (CHT)* | Brandis (1899)<br>Hossain (1962) | 1863-1866 (Greg.)<br>1927 (Spor.) | <br>61 or (30x2) (1866-1927) |
| Rangamati | Nath (1930)<br>Hossan (1962) | 1930 (Greg.)<br>1935 Spor.) | 64 or (32x2) (1866-1930) |
| Kassalong | Hossain (1962) | 1958-1959 (Spor.) | 31 (1927-1958) |
| | Hasan (1973) | 1959-1960 (Greg.) | 30 (1930-1960) |
| *CHT north* | Hossain (1962) | 1957-1958 (Spor.)<br>1958-1959 (Greg.) | |
| Kamalchari, Hyanko Haludia, Fatickari Naranhat, Shisak. | Banik (1989), Author | 1986-1998(Spor.) | 29-40 (1957, 58-1986, 98) |
| **India** | | | |
| *Assam, Calcutta Botanic garden Assam, Tarai* | Gamble (1896), Brandis (1899) | 1863-1866 (Greg.)<br>(1892-1893 (Spor.) | 27-29 (1863, 66-1892, 93) |
| *Lushai hills, Assam Garo and Khasi hills* | Brandis (1906)<br>Troup (1921)<br>Parry (1931) | 1864 (Greg.)<br>1889 (Greg.)<br>1900, 1902 (Spor.) | <br>25 (1864-1889) |
| *Mizo hills, Cachar hills Assam* | Chatterjee (1960) | 1863-1966 (Greg.)<br>1892-1893 (Spor.)<br>1900-1902 (Spor.) | <br>26-30 (1863, 66-1892, 93) |
| | Troup (1921)<br>Chatterjee (1960) | 1910-1912 (Greg.)<br>1933 (Spor.) | <br>31-33 (1900, 02-1933) |
| | Chatterjee (1960) | 1960 (Greg.) | 48-50 (1910, 12-1960) |
| *Garo hills, Cachar hill Lushai hills, Assam* | Hossain (1962) | 1910-1912 (Greg.)<br>1917-1919 (Spor.) | 19-21 (1889-1910, 12)<br>25-26 (1892, 93-1917, 19) |

| Country/locality | References | Flowering date (calendar year) | Estimated flowering cycle (years) |
|---|---|---|---|
| *Lushai hills*, Assam | Troup (1921)<br>Parry (1931) | 1911-1912 (Greg.) | 46-47<br>(1864-1911,12) |
| *Surma valley* | Hadfield (1958)<br>Nath (1959, 1960, 1962) | 1958-1961 (Greg.) | 48-49<br>(1910, 12-1958,61) |
| *Cachar hill* (Halflong) | Gupta (1988) | 1952-1956 (Greg.)<br>1967 (Spor.) | 40-44<br>(1910, 12-1952, 56) |
| *Manipur* | Nath (1968) | 1967 (Spor.) | 48-50<br>(1917, 19-1967) |
| *Haflong* | Gupta (1988) | 1988 (Greg.) | 32-36<br>(1952, 56, 1988) |
| **Bangladesh** | | | |
| *Sylhet* | Troup (1921)<br>Hossain (1962)<br>Hasan (1973) | 1910-1912 (Greg.)<br>19571958 (Spor.)<br>1958-1959 (Greg.) | 46-47<br>(1910-12, 1957, 59) |
| Dholaichara<br>Madhav Chara | Author | 1996 (Spor.)<br>9997 Spor.) | 40-41<br>(1957-1996, 97) |
| *Mymensingh* | | | |
| North Range<br>Rasulpur<br>(New Kalibari) | Hasan (1973) | 1974 (Spor.)<br>1975 (Spor.) | 63-64 (32c2)<br>(1911,12 of Garo-hills - 1974, 75) |

**Note :** Spor. = sporadic flowering, Greg. = Gregarious flowering.

*M. baccifera* were found to be different when considered on dissimilar phases of 3 -phase flowering nature. The estimated duration of flowering cycle in Arakan was 36-39 years when considered between *Gr*-phase of 1st incidence to *Si*-phase of 2nd incidence of flowering, and 44-52 years when the gap period was calculated on the basis of *Gr* phase of 1st to *Sf*-phase of 2nd flowering (Fig. 3a). The estimated duration of flowering interval was 44-47 years in Arakan when calculated on the basis of similar phases of flowering (*Gr*-phase of 1st to *Gr*-phase of 2nd flowering incidences)

It seems logical to count the gap period between the similar phases of two flowering incidences of a given locality. Therefore, gap period either between sporadic to sporadic (*Si* to *Si* or *Sf* to *Sf*) or gregarious to gregarious (*Gr* to *Gr*) phases of two different flowering incidences have been considered as representative of a given locality in the present analysis. Accordingly, the flowering cycle of *M. baccifera* has been estimated for different localities in the region (Table 1, Fig. 3). It is also evident from the past records (Table 1, Fig. 3) that the species flowered in some areas at a time but not in all the areas of the region.

In Myanmar (Arakan) the estimated flowering cycle is about 44-47 years (Fig. 3a, *Gr*-phase to *Gr*-phase). In Chittagong south the estimated flowering cycles are 44-48 years (Fig. 3b, *Gr*-phase of 1st flowering incidence to *Gr*-phase of 2nd flowering incidence), 48-53 years (Fig. 3b, *Gr*-phase of 2nd incidences to *Gr*- phase of 3rd incidences) and 52-59 years (Fig. 3b, *Si*-phase of 2nd incidence to *Si*-phase of 3rd phase). Such long flowering intervals of 45-60 years are also in conformity with the reports of Hossain (1962), Parry (1931), McClure (1966) and Troup (1921). In some parts of Arakan and south Chittagong the estimated cycle was about 60 years (Table 1; Raitt 1929, McClure 1966). Presently the species in further southern part of Bangladesh (Cox's Bazar) and neighbouring area of Myanmar (Arakan, Yoma, etc.) has also not yet been reported or observed to flower. Arakan, Cox's Bazar and Chittagong south are neighbouring areas. The species in these localities appears to exhibit similar longer (44-53 or about 59-60 years) flowering cycle (Table 1, Figs. 3a, b, c).

In Chittagong Hill Tracts (CHTs) and neighbouring areas (Chittagong north), the species is reported to flower lastly during 1863-66, 1927, 1930, 1935 and 1957-1960. Presently it has started flowering since 1986. From the past records, it appears that here the species exhibits comparatively shorter duration of flowering cycle of 30-35 years (Table 1, Fig. 3c) similar to the estimated cycle reported by Kurz (1876), Gamble (1896), and Gupta (1988). The estimated period of 61-64, 64-67 years are approximate multiple of 30+5 years. It may be also due to the fact that the species also flowered in any time during 1900-1910 as did in some part of Chittagong south and remain unreported, or some populations of the species in this locality might have exhibited long flowering interval if did not flower during 1900-1910. Such estimated long cycles of 61-64 and 64-67 years in some part of CHT areas have similarity to the duration of estimated cycle for some part of Arakan, Chittagong south and Cox's Bazar.

The species started flowering simultaneously in Halflong (Assam, India), Chittagong north and CHTs (Bangladesh) during 1986-88. The estimated cycle of 25-33 years is same to that of most parts of Assam, Tarai and Mizohills (Table 1). In most of the areas of Assam (India) including Garo and Khasi hills the species exhibited short duration (19-21, 25, 26-30, 27, 29, 31-33 years) of flowering cycle (Table 1, Fig. 3d). It was also estimated to be 32-36 years in Halflong areas of Assam (Table 1, Fig. 3e). Thus it seems, the majority of *Melocanna* population in CHTs and northern Chittagong have similar duration of interseeding period to the most of the areas of Assam and Mizoram though these two regions are located in two different latitudes. In some areas of Mizohills the species also exhibited longer (48-50 years) flowering interval (Table 1, Fig. 3d).

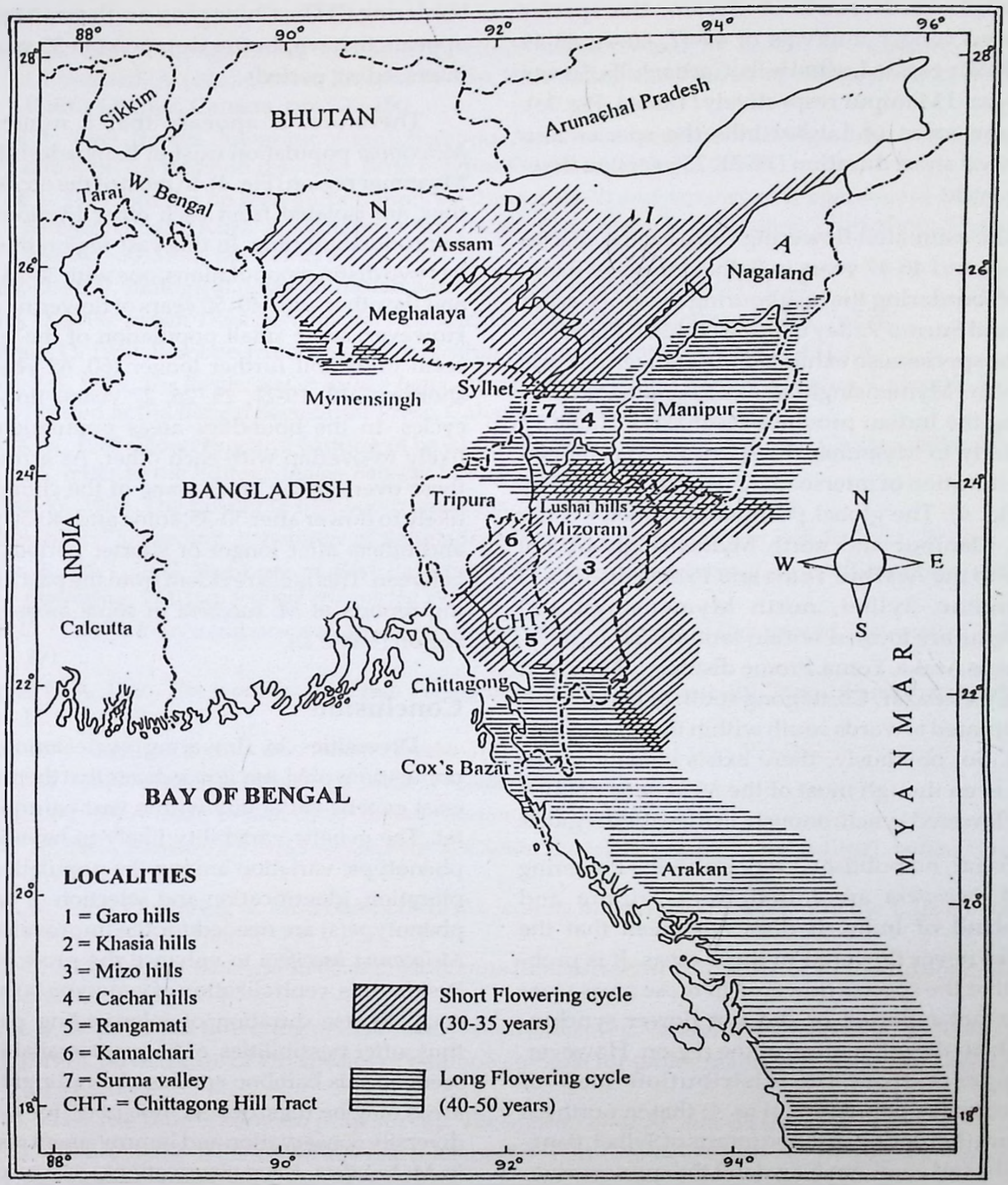



**Figure 4.** Distribution map of different reproductive populations of *Melocanna baccifera* in Bangladesh-India-Myanmar region.

But towards south of Assam, the species exhibited longer intervals of 46-47, 40-44, 48-49 and 48-50 years in Lushai hills, Cachar hills, Surma Valley and Manipur respectively (Table 1, Fig. 3e). In some areas of Lushai hills the species also exhibited short duration (19-21, 25 years) of flowering cycle.

The estimated flowering cycle for the species is 40-41 and 46-47 years in Sylhet forests of Bangladesh bordering the neigbouring areas of Cachar hills and Surma Valley of India (Table 1, Fig.3, Fig. 4). The species also exhibited long flowering cycle in north Mymensingh areas of Bangladesh bordering the Indian province Meghalaya (Table 1). Similarly in Myanmar the species also exhibited long duration of interseeding period (Table 1, Fig. 3a, Fig. 4). The global position of Sylhet, Cachar hills, Manipur and north Mymensingh are not same to the Arakan, Yoma and Prome districts of Myanmar. Sylhet, north Mymensingh and Manipur are located within latitude $24^0$ to $26^0$ N, whereas Araka, Yoma, Prome districts of Myanmar and Cox's Bazar, Chittagong south of Bangladesh are situated towards south within that of $17.5^0$N to $21^0$N. So, obviously, there exists climatic variation, even though most of the *Melocanna* population flowered synchronously in these two regions.

So far, no published reports on the flowering of *M. baccifera* are found from Tripura and Nagaland of India. It does not mean that the species never flowered in those areas. It is probable that the species flowered in those areas were either not reported or did not flower synchronously to the other areas of the region. However, it appears from the distribution map of reporductive population (Fig. 4) that in northern Tripura (bordering bamboo forests of Sylhet, Bangladesh) and southern Nagaland the species exhibits long (40-50 years) duration of interseeding period. The population in southern Tripura bordering CHTs, Chittagong north and Mizoram appears to have shorter duration (30-35 years) of interseeding periods.

Therefore, it appears that a number of *Melocanna* population exist in Bangladesh-India-Myanmar region (Fig. 4). In most of the occassions they are isolated from each other by flowering (reproduction) time. In this vast region there exists two distinct populations, one with 30-35 years and the other with 40-50 years of flowering cycle. However, some small population of the species seem to exhibit further longer (60, 65 years) or shorter (7-10, 19-21, 25, 26, 27 years) flowering cycles. In the boundary areas populations are likely to overlap with each other. As a result in these overlapping areas some of the clumps are likely to flower after 30-35, some after 40-50 years, and others after longer or shorter periods or in between. This is also evident from the past flowering reports of *M. baccifera* in some areas of the region (Table 1.)

## Conclusion

Diversities in flowering cycle among the populations of *M. baccifera* indicate that there might exist genetic variability within vast natural habitat. The genetic variability likely to have lots of phenotypic variation among the population. Exploration, identification and selection of desired phenotype(s) are needed for the improvement of *Melocanna baccifera* to enhance the productivity. Besides this, centralization of genotype (s) having such diverse duration of interseeding periods, thus, offer possibilities of frequent availability of seeds in this bamboo species. Accordingly these areas may be regarded as "hotspots" for genetic-diversity conservation and improvement research in *M. baccifera*. Keen observations, proper phase-wise flowering reports along with localities and their documentation are important in this regard.

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