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Sporadic flowering of *Bambusa* striata Lodd. ex Lindl. an ornamental sympodial bamboo in Kottayam Distirct, Kerala, India

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Abstract

Bambusa striata Lodd. Ex Lindl. is a woody ornamental sympodial bamboo species usually found in cultivation initiated flowering during 2007 in a homestead near Thiruvalla in Kottayam district of Kerala. Other than the reports of flowering, studies on detailed reproductive biology of this bamboo species is lacking. The present investigation was carried out to study the floral morphometry, anthesis, mode of pollination, in vitro and in vivo pollen viability and pollen germination and post-flowering behaviour of the species. The inflorescence was a large leafy panicle of flat spikes clustered at the nodes. The spikelets were several in the verticals in the axil of bracts. The flowers were dichogamous, protogynous and open. Stigma matured prior to anther dehiscence and 5 lobes were present. Pollens were numerous and monoporate. Highly sterile pollens were observed and viability and in vitro pollen germination also was absent. Pollination was anemophilous. Seed production was absent in this species following the flowering.

Keywords: Sporadic flowering, *Bambusa* striata Lodd, ornamental sympodial bamboo.

Introduction

Bambusa striata Lodd. ex Lindl. (*B. vulgaris var. striata (*Lodd. ex Lindl) Gamble; *B. vulgaris var. vittata* A and C. Riviere) commonly known as painted bamboo, golden bamboo, is a woody ornamental sympodial bamboo species usually found in cultivation. Native of China and Japan, common bamboo of Hawaii, introduced to many other tropical and subtropical countries, the species is grown in botanical gardens, homesteads and widely used for landscaping and erosion control. The mature bamboos are used for papermaking, scaffolding, construction, poles, curios and handicrafts and young shoots are edible. The species is also reported to have frost and salt tolerance[1] *B. striata* flowers rarely and at long intervals and the flowering reports are scanty. Its recent flowering is reported in 1996 from Cherthala, in Alappuzha district in Kerala is the report of flowering from India published after 100 years[2]. From Bangladesh sporadic flowering has been reported in 1851, 1863, 1879, 1890 and 1892 and then in 1977-1985. Careful observation of flowering during1980-81 and 1983-84 did not reveal any seed production[3-4]. Flowering cycle is believed to be 80 years[5]. Other than reports on incidence on flowering and the floral morphology, detailed account on reproductive biology is lacking in this species. Reproductive biology studies are inevitable for the conservation and highlight the reproductive constrains of plants. It also helps in developing protocols combat the problems that impede regeneration. During the field explorations in February, 2007 sporadic flowering of *B. striata* was observed in a homestead near MC road, 2 km after Thiruvalla in Kottayam district in Kerala. The present paper describes the reproductive biology of the species.

Materials and methods

Sporadic flowering of *Bambusa striata* was observed in a homestead near MC road, 2 km after Thiruvalla in Kottayam district in Kerala (N 9° 23' 055" E 76° 35' 369" GPS map 60c). The clump width and the number of flowering and non-flowering culms per clump were recorded. The culm characteristics like average height, girth at fifth node, number of nodes and internodal length in the clump were recorded. Morphology and dimensions of the inflorescence and spikelets were studied from the fresh inflorescences in the field and from those fixed in FAA (Formalin Acetic acid Alcohol) in lab under dissection microscope. There were twenty replications for each dimension and they was confirmed with flowers in the field. Fifty flowers were randomly tagged and the time of anthesis and anther dehiscence and stigma receptivity were observed. The possibility of insect pollination was checked by recording insect visitations at the time of anthesis. In order to find the presence of anemophily, adhesive tapes fixed near the flowers and observed for the pollen deposition. Nearly 100 flowers were observed in the field for insect visits and the duration ranged from 10 min to 1 h during daylight hours (6.00 am to 6.00 pm).

Pollen viability at the time of dehiscence was tested using 1% acetocarmine, considering stained pollen grains as viable and the shrivelled as non-viable[6-8]. The viable pollen in the microscopic field was counted and expressed as percentage. *In vitro* germination of pollen was tested in 6 different germination media as given in table-1.

Table- 1
Composition of pollen germination media

Components	M1	M2	M3	M4	M5
Sucrose (g)	10	10	10	0	10
Boric acid (g)	0.01	0.01	0	0.01	0
Calcium nitrate (g)	0.03	0	0.03	0.03	0
Distilled water (ml)	100	100	100	100	100

In order to test *in vitro* pollen germination, fresh matured anthers were collected from the field during flower opening and pollen grains were carefully dusted in cavity slides containing the different combinations of germination media. After one hour inoculation, the number of pollen grains germinated and the number of grains per field of view were recorded. Pollen grains were considered to be germinated when the pollen tube length was greater than the diameter of the pollen grain[9]. The flowered clump was observed for seed production, a polythene sheet was spread on ground and floral mass was collected by shaking the culms and winnowed and examined for viable and fertile seeds.

Results and Discussion

Field observations indicated that none other than the present clump in the adjacent areas were in bloom indicating the sporadic nature of flowering. Out of the 29 culms in the clump only eight were flowered of which three were already died. In the clump, two of the non-flowered culms formed in the previous year were completely green showing similarity to the cultural variety *B. vulgaris* of this species and the rest were yellow with green stripes (figure-1). Width of the clump was 7.5 m and average culm height ranged from eight to 20 m, diameter from 30 to 60 cm in and on an average there were 16 nodes with an internodal length of 30 to 45 cm.

Figure-1
The flowered *Bambusa striata* clump showing green culms

Floral morphology: The dimensions of inflorescence and spikelets are given in table-2.

Table- 2
Details of spike, spikelets, florets in *Bambusa striata*

Sl. No.	Characters	Mean
1	The number of spikes per branch	17.6 ± 1.26
2	Number of spikelets with exposed stigma	3-7
3	Number of spikelet with exposed anthers	2-5
4	Width of spike (cm)	2.77± 0.34
5	Number of spikelets per head	21.1±1.28
6	Length and width of the spikelets (cm)	1.42±0.06, 0.48±0.09
8	Length and width of lemma (cm)	0.91± 0.07, 0.19±0.02
9	Length and width of Palea (cm)	0.85±0.09, 0.19±0.02
10	Number and Length of stamen (cm)	6, 1.05±0.05
11	Anther length (cm)	0.46±0.05
12	Length of the stigma + style (cm)	0.5-0.6
13	Ovary length (cm)	0.1 to 0.2 cm
14	Number of stigma	5
15	Diameter of pollen grains (µm)	39.38

The flowered branches possessed 17.6 ± 1.26 spikes of width 2.77± 0.34 cm (figure-2). The Inflorescence was a large leafy panicle consisting of flat spikes clustered at the nodes separated at 2 to 4 cm. Each spike contained 21.1±1.28 spikelets of width 0.48±0.09 cm. Each spikelet consisted of 3 to 7 female phase and 2 to 5 male phase in different combinations. All florets often do not open.

Figure- 2
The flowered branches of *Bambusa striata*

The spikelets were three to eight flowered, laterally compressed, dichogamous, protogynous, and pale green in colour. Occurrence of protogyny was revealed by presence of young anthers with matured pistil in the FAA fixed flowers as well as the presence of matured of pistil three to four days prior to anther emergence in the field. Florets had two lodicule, those are fleshy organs located at the base of the ovary that swell and force apart the palea and lemma to open the floret. The floret length ranged from 0.6 to 1.0 cm. Lemma was 0.91± 0.07 cm long and without keel (figure 3). Palea, which encloses sex organs was ciliated, two keeled, 0.85±0.09 cm in length and 0.1 to 0.2 cm in width (figure 4). Length of the entire gynoecium was 0.86 ± 0.11 cm and two to three stigmas was 0.3 to 0.4 cm long (figure 5). The third one is not well developed. The gynoecium falls into three categories viz. the length of the entire gynoecium (a) less than the length of the palea (b) as long as palea and (c) slightly longer than the lemma. Ovary was umbonate and 0.1 to 0.2 cm in length. The androecium consisted of six exerted stamens and 1.05±0.05 cm long (figure 6)**.** Anthers were deep purple, with white filaments, apiculate, hairy at the tip and 0.46±0.05 cm long. The pollens were monoporous.

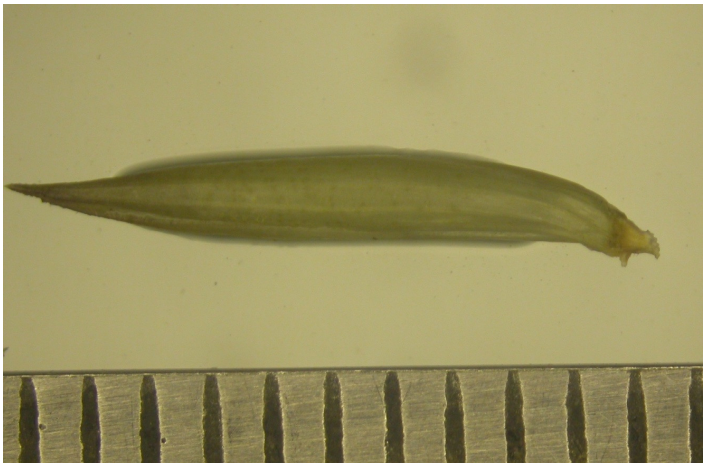

Figure-3
Lemma of *Bambusa striata floret*

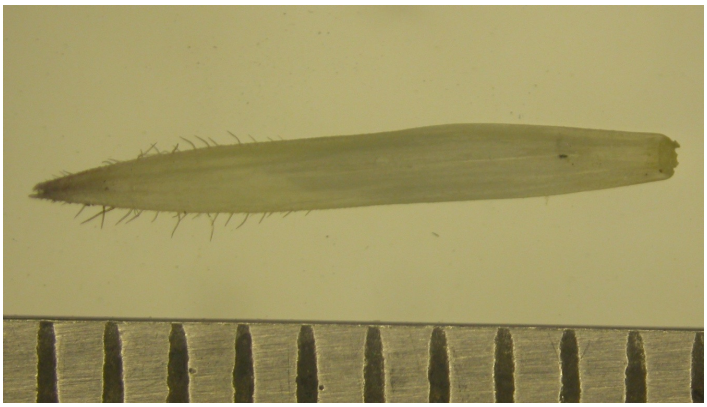

Figure- 4
Palea of *Bambusa striata floret*

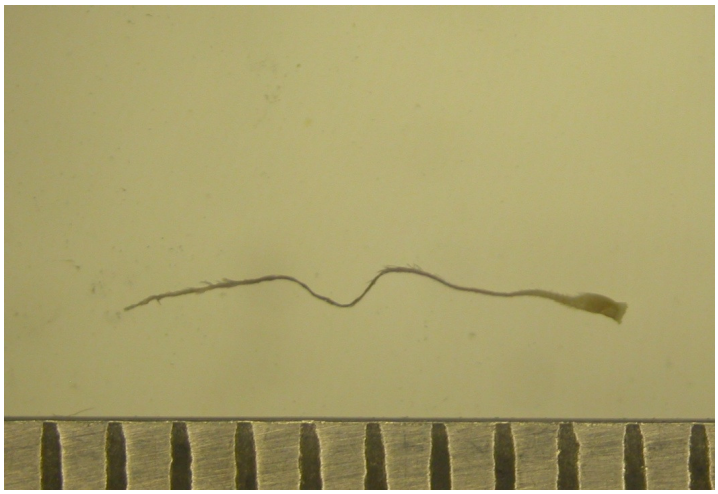

Figure -5
Gynoecium of *Bambusa striata floret*

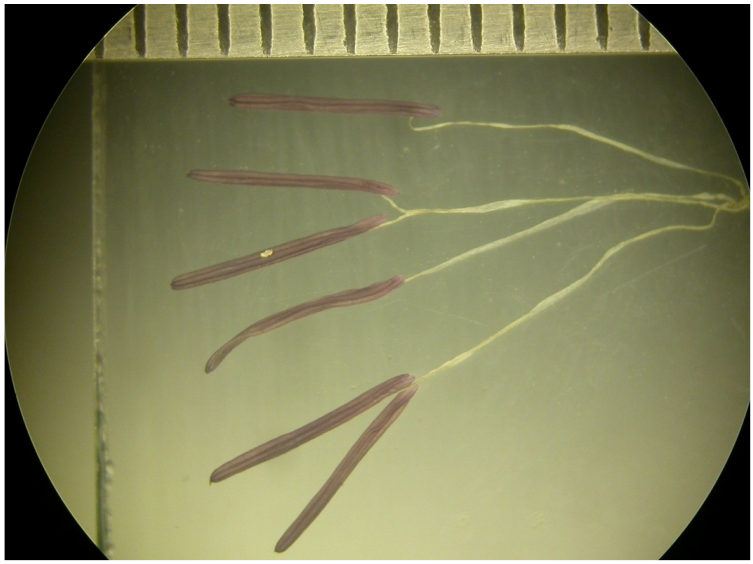

Figure 6.
Androecium *of Bambusa striata floret*

Most of the flowers opened between 6.00 am and 6.30 am and the anthers and stigma emerged out. The pollen dehiscence started at 9.00 am. At the time of dehiscence, pollen grains were dusted in a cavity slide containing sucrose medium for *in-vitro* germination. Pollen germination studies indicated that the pollens were highly sterile and failed to germinate under *in vitro* conditions. Pollen grains failed to germinate both *in vitro* and *in vivo*. No insect pollinators could be observed during anthesis. Occurrence of abundant pollen grains on the adhesive tapes fixed near the flowers under microscope also revealed the anemophily. Generally, wind pollinated species produce large anthers with abundant uniform pollen grains which is was obvious in our studies which confirmed the presence of anemophily.

The flowered clumps were shaken and the fallen mass was collected to assess the seed availability. The fallen mass was winnowed to separate fertile seeds. No seeds were obtained. A revisit to the same area after monsoon showers in April, to trace any wildlings was also in vain. The flowered clump is in a highly disturbed state. The entire clump was destroyed by the owner when visited the same area in subsequent year.

Discussion: The present observations on flowering of *B. striata* agree with the earlier reports on the species with regard to floral morphology, especially three types of gynoecium, pollen viability and seed set[2]. Although insects visit were recorded in some of the previous reports their role in pollination could not be ascertained[10]. No seed formation is reported for this species in any of the flowering records [2,7,10-12]. Factors responsible for failure of seed set appear to be many. High rate of pollen sterility (as observed in present investigations), absence of natural pollination and inhibition of pollen tubes in stigmatic papillae act as cumulative factor for absence of seed set in this species[7]. The inherent unhealthy nature of stigma to receive pollen and the possible role of brisle-like hair as barriers preventing pollination has also been reported[2]. Anthesis, time of stigma receptivity, pollination etc. agrees with the earlier reports from other bamboo species such as *Ochlandra wightii, D. sikkimensis, Pseudoxytenanthera monodelpha Schizostachyum dullooa* etc[13-16].

Since seed formation has not been observed in this species, vegetative propagation is going on for a long time. All three names *Bambusa vulgaris* var. *striata*, *B. striata*, *B. vulgaris* var. *vittiata* has been used to describe this species. Three types are seen in nature – yellow culm with green stripes, complete green culms and green culm with yellow stripes. In the same clump both yellow with green stripes and full green culms are also observed. Since it is a vegetatively propagated species and synchronous flowering is known to occur, gregarious flowering and death of the entire population is likely. Hence continuous observations on flowering and seed production and clear documentation of flowering are very essential to locate its different flowering cohorts. Since it can tolerate adverse conditions like frost and salinity it can be developed as an ideal species for establishment of plantations in difficult sites.

Bamboo flowering is rare and unusual phenomenon and the mechanism of flowering is still a mystery and a challenge to scientists. Whenever flowering is observed in any bamboo species attention need to be given to document nature of flowering, post flowering behavior, seed set and location of flowering precisely to generate information on flowering behavior and seed formation in many commercially important bamboo species that are lacking currently.

Conclusion

The present investigation throws light on the reproductive biology of a sporadic flowering bamboo species. The flower morphology agreed with previous descriptions. The poor pollen viability and germination are the major constraints in seed production in this species.

Acknowledgements

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