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Flowering characteristics of *Phyllostachys heteroclada* Oliver in China

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Abstract: The flowering characteristics of *Phyllostachys heteroclada* were studied. The occurrence of flowering was random in a year, mostly between November and May, which led to death of the bamboo clumps. Environmental factors, such as illumination period, temperature and humidity had significant influence on flowering.

Key words: Phyllostachys heteroclada, flowering characteristics, illumination period, flowering cycle.

INTRODUCTION

Phyllostachys heteroclada Oliver is one of the dominant bamboos in the Changjiang River Valley (Institutum of Kunmingense Academiae Sinicae, 2003). This bamboo has high adaptability to both fertile and infertile soils, resistance to pests and diseases and multifarious uses (Jin *et al.*, 1999; Ou, 2002). Hence, *P. heteroclada* is regarded as an important bamboo locally.

In 2002, *P. heteroclada* began to flower in Yaan district. The flowering occurred sporadically and flowered clumps died. Thus, the co-existence of flowering and non-flowering clumps provided an opportunity to investigate the flowering traits which will be useful to develop strategies to control the flowering event in this bamboo.

MATERIALS AND METHODS

Approximately 1 ha of flowering *P. heteroclada* forest near the Yaan Bifengxia base of CCRCGP (The China Conservation and Research Centre for Giant Panda) was used for observation of flowering traits. Bamboo in this site began to flower from October 2003, and about 40 per cent of clumps were in flower at the time of this study. About 30 per cent clumps had already died and another 30 per cent were yet to

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flower. A total of 15 clumps in flower and 15 clumps which had not flowered were selected for the study. The soil of the site was yellow-brown and fertile. Annual rainfall in the area was 1250 −1800 mm and the annual average temperature ranged between 14−19 °C.

Field survey and interview with local residents were done for 19 months, from November 2004 to June 2006. Observations on flower appearance time, floral morphology, anthesis, *etc.*, were recorded during the survey. The illumination time per day was recorded on bright days for three times successively and the mean was calculated. Soil temperature at surface and at 10, 15 and 20 cm depths was determined by geothermometer at four random points in each sample area. The soil moisture and pH were determined from soil samples obtained from 0 to 20 cm depths. The atmospheric humidity and temperature were determined with the psychrometer and thermometer at the interval of fifteen days.

RESULTS AND DISCUSSION

Flowering cycle

So far, the flowering cycle of *P. heteroclada* has not been reported. The local residents at Yaan, who were interviewed ranged from seven to ninety years old. They were not aware of any earlier flowering events in the species. Thus, it is suggested that the flowering cycle of this bamboo species may be over eighty years.

The sporadic flowering mainly happened in the period of November-May. Flower buds appeared most densely during December - March usually at the terminal parts of plant, and then gradually progressed downwards. The buds were purplish when young, then turned to purplish-brown when mature (Figs. 1,2). The development of buds was inconspicuous during the whole winter, but became apparent after March. The spread of pollen was dependent upon the season and temperature. Pollination mostly occurred between mid-March and mid-April. The spikelets and the whole plant dried up after fertilisation. All the flowered plants dried up by mid-May. The whole process of pollination and fertilization lasted for about six months. Sporadic flowering was also noticed in summer and autumn between May and November in a small proportion (2%) of the population. This flowering took about two months and the spikelets were much smaller with less pollen.

Morphology of flowers

The inflorescence in *P. heteroclada* is racemose, three to five spathes inserting together each main culm and minor branch (Fig. 2), broader and larger below, narrowest above, without auricle, ligulate obvious; the bottom of spathe bears a tuft of bracts with dense minutely pubescent along the edges; each spathe possesses 1-2 fake spikelets, each spikelet possesses 4-6 florets (Fig. 3), 1-2 glumes usually smaller than lemma.

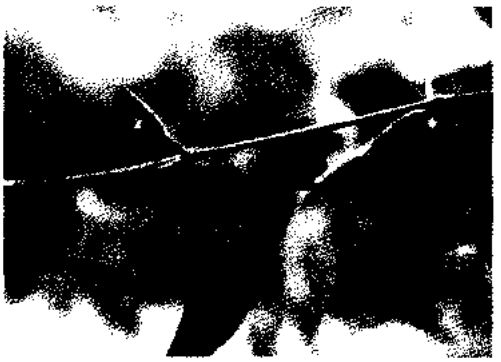

Figure 1. *P. heteroclada* flower buds

Figure 2. Inflorescence of *P. heteroclada*

membrano-chartaceous, with long pubes, apex appears like awn; lemma with long pubes and many nerves; apex appears like short awn; the lemma of first floret 12-14 mm long, the palea, stamen and pistil are very small because of hypogenesis; paleas of other florets are shorter than lemmas, with long pubes, apex bifid. When maturing, paleas and lemmas stretch, filament stick out, about 1.5 cm long; anther canary, stigma trifid. Anther is relatively rich, but pistil hypogenesis (Figs. 4,5).

Influence of environmental factors on flowering

Among the twenty bamboos growing areas studied, bamboos under longer illumination period were more prone to flower than those in shorter illumination period (Table 1). The illumination period received by flowering bamboo in the former areas was 1.47 times to that of the latter. However, bamboos growing in areas with shorter illumination period showed luxuriant vegetative growth with no sign of flowering. The relationship between flowering and illumination was consistent with the results reported on *Fargseia robusta* Yi and *F. denudate* Yi (Liao, 1990; Li, 1997;). Li (1997) suggested that light was the most influencing factor that led to flowering. It was also reported

Figure 3. Spathe and anthers

Figure 4. Floret, showing lemma and anthers

Table 1. The aspect and illumination on flowering and non-flowering bamboo forests

Type	South slope	North slope	East and west slope	Illumination period (hour/day)
Flowering	6	2	2	7.6
Non-flowering	3	5	2	5.2

that in *F. denudate*, the number of flowered plants increased with decreasing canopy density (Liao, 1990).

Statistical analysis of the field data also revealed that flowering had significant correlation with the atmospheric temperature and humidity (Table. 2). Both temperature and humidity were higher in bamboo flowering areas than in areas that did not flower. The average temperature of flowering bamboo areas was 1.5 times at 9:00 h and 1.1 times at 14:00 h relative to that of non-flowering areas respectively. The humidity of

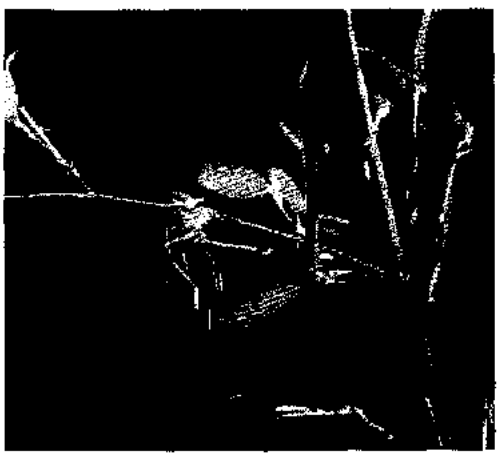

Figure 5. Inflorescence of *P. heteroclada* showing paleas and lemmas already stretched and filament sticking out; leaves are still green.

Table 2. Relationship between environmental factors and flowering in *P. heteroclada*

Time	Bamboo areas	Ground surface temp. (°C)	Under-ground (10 cm depth) temp (°C)	Under-ground (15 cm depth) temp (°C)	Under-ground (20 cm depth) temp (°C)	Temp. (°C)	Humidity (RH)	Soil pH	Soil moisture (%)
9:00	Flowering	5.25[a]	5.70[a]	5.24[a]	6.08[a]	10.6[b]	93.4[c]	7.15[a]	23.16[a]
	Non-flowering	4.72[a]	5.56[a]	5.00[a]	5.76[a]	6.80[b]	81.0[c]	6.47[a]	32.98[a]
14:00	Flowering	15.72[a]	13.90[a]	13.58[a]	13.84[a]	20.94[c]	83.4[c]	-	-
	Non-flowering	14.60[a]	13.44[a]	12.88[a]	13.10[a]	19.68[c]	65.8[c]	-	-

[a]a: Not significantly different; b: Significantly different ($P<0.01$); c: Significantly different ($P<0.05$).

flowering areas increased by 12.4 per cent at 9:00 h and 17.4 per cent at 14:00 h compared to that of non-flowering areas respectively. Other factors, like soil temperature, pH and soil moisture, had no significant effect on flowering. The soil pH was neutral in flowering areas and near neutral to acidic in non-flowering areas. The above observations showed that higher atmospheric temperature, humidity and illumination period influenced bamboo flowering.

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