J. Bamboo and Rattan, Vol. 9, Nos. 3&4, pp. 159-165 (2010)

Influence of environmental factors on bamboo flowering

Wang Xiaohong[1*], Zhang Hong[2] and **Zhou Zuji[3]**

[1] *College of Tourism and Culture Industry, Chengdu University, Shiling Town, Chengdu 610106, China*

[2] *College of Town and Country Construction, Chengdu University, Chengdu 610106, China*

[3] *College of Forestry, Sichuan Agricultural University, Yaan 625014, China*

Abstract: Bamboo is not only an important forestry resource, but is also food for the Giant Panda in China. Wild bamboo typically flowers synchronously and gregariously and dies at the end of the event. Bamboo flowering is a serious problem in conservation of the endangered Panda. In order to find environmental factors that can influence bamboo flowering, a survey and analysis of climatic factors was undertaken in Yaan district in China, where bamboo flowered from 2001 to 2007. The result showed that both the average temperature in January and July in the FY (flowering years) were higher than that of NFY (non-flowering years), the annual precipitation in FY lower than that of NFY, and there were obvious drought years before bamboo flowering. The paper discusses the correlation between the climate factors and bamboo flowering based on the statistical analysis. The result showed that flowering had significant correlation with the average temperature in July and annual precipitation, high temperature in July and less precipitation contribute to bamboo flowering.

Keywords: Environmental factors, bamboo flowering, influence, *Bashania,* Yaan District.

INTRODUCTION

The Giant panda *(Ailuropoda melanoleuca)* besides being a charming animal has very high research and conservation value. Panda food is very specialized and more than 90 per cent is bamboo. Bamboo is different from other perennial plants in its typical flowering behavior where it flowers only once in its lifetime and nearly all will die after the gregarious and synchronous blooming. In the last half a century, bamboo flowering in panda habitat has threatened the animal's existence.

From 1974 to 1976, large areas under bamboo bloomed in Min Mountain and Qionglai Mountain. Pandas were found with malnutrition in these areas and many pandas died from starvation and illness, and in some areas the death rate was as high as 80 per cent (Li, 1997). From 1983 to 1985, bamboo bloomed very extensively in Qionglai

* To whom correspondence should be addressed; E-mail: wxh1702@163.com

Mountain, Minshan Mountain, Big Xiangling, and Small Xiangling in Sichuan Province, and Qingling in Shaanxi Province. This investigation was done at that time in twenty prefectures of Sichuan, Shaanxi and Gansu Province which are habitats for the Panda. The results showed that 82 per cent of *Bashania fangiana* Keng *f.et* Wen and *Fargesia spathacea* Franeh bloomed in these areas, which resulted in a shortage of food and was a disaster for the panda. According to the data collected, more than 250 pandas died because of two flowering events (Panda Survey Team Report, 1985). From 2001 to 2007, the thorny bamboo *(Bambusa stenostachya* Hack*)* and *Phyllostachys heteroclada* Oliver bloomed extensively in Yaan district which is renowned for being "panda's hometown" because the first panda was discovered in Yaan, and it still remains a panda distribution area (Fig 1).

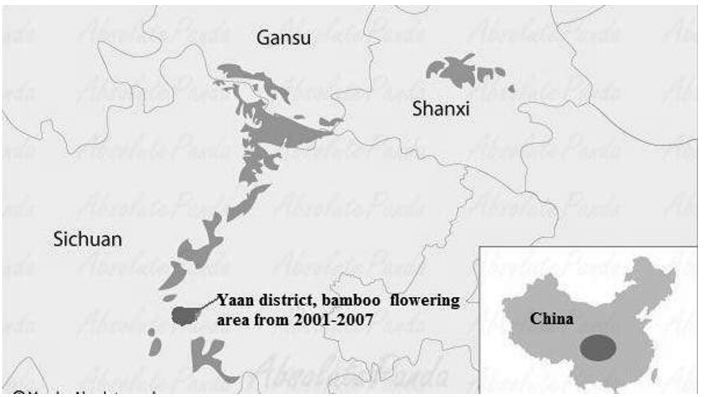

Figure 1. Distribution of panda habitat and bamboo flowering area from 2001-2007 (Yaan district)

Bamboo flowers at periodic intervals and dies in large areas. This behavior is normal for bamboo although in the wild the flowering is always unexpected. Since it needs at least eight to ten years to recover and renew the vegetative growth, the availability of food for the panda is affected. The blooming of bamboo has already become a very important natural factor that threatens the survival of the Panda, and no effective solution is available at present.

Research on the bamboo flowering mechanisms has been carried out for more than one hundred years (Janzen, 1976). In many countries, people always associate gregarious bamboo flowering with earthquakes, droughts, famine and even death (Sharma, 1994); this shows that people noticed that the environment can influence bamboo flowering a long time ago. As seen from the basic rule of plant growth and development, bamboo flowering is restricted by biological and physiological laws, but the influence of the external environment should not be ignored.

The gregarious bamboo flowering over a large area in Yaan district began in 2001,

beginning with the Thorny bamboo, and nearly all of this bamboo bloomed and died by 2004; *P. heteroclada* began to bloom in 2003 and 70 per cent of this bamboo bloomed and died by 2007 and nearly all of it by 2009. *Sinocalamus affinis (Neosinocalamus affinis* Keng) was also found blooming sporadically in Bifengxia in Yaan. This time bamboo blooming in Yaan did not just involve one species and in a small sector, but it involved three species and the flowering scope was very wide. Yaan still is the wild habitat of the panda. Both Thorny bamboo and *P. heteroclada* are food for the panda, and 90 per cent of these two bamboos died in this district until 2007. It is necessary to study and find a solution to resolve this problem.

In this study the climate data of Yaan district from 1985 to 2009 was analysed for NFY (non-flowering years) and FY (flowering years) to look for influence of environmental factors in bamboo flowering, and find feasible methods to deal with bamboo flowering and protect the food source of pandas.

SURVEY METHOD

Weather data, including average temperature of January and July, annual precipitation from 1985 to 2009 was collected from the Yaan Weather Bureau. Analyzed to study the pattern of climate change, and made a comparative analysis of meteorological factors between the bamboo FY and the NFY, in order to confirm the relationship between the change in climate and bamboo flowering. The data were analysed using SPSS software.

RESULTS AND ANALYSIS

The relationship between bamboo flowering and temperature

From Figure 2 and Table 1, it can be seen that the average temperature of January in

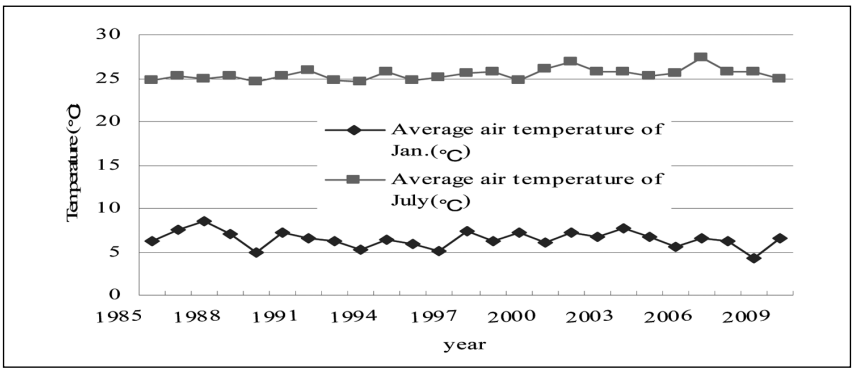

Figure 2. The change of average air temperature of January and July from 1985 to 2009 in Yaan district

Table 1. The average air temperature of January, July and annual precipitation from 1985 to 2009 in Yaan district

Year		Average air temperature of January (°C)	Average air temperature of July (°C)	Annual precipitation (mm)
	1985	6.2	24.7	2293.7
	1986	7.6	25.2	1569.8
	1987	8.5	25.0	1462.0
	1988	7.0	25.2	1943.9
	1989	5.0	24.6	1839.3
NFY (Non-flowering	1990	7.2	25.2	2013.6
	1991	6.5	25.9	1932.9
year)	1992	6.3	24.8	1715.7
	1993	5.2	24.6	1388.5
	1994	6.4	25.7	1508.3
	1995	5.9	24.8	1816.7
	1996	5.1	25.1	1632.2
	1997	7.4	25.5	1321.9
	1998	6.2	25.7	1046.2
	1999	7.2	24.7	1692.7
	2000	6.0	26.1	1619.5
	Average	**6.48**	**25.18**	**1674.81**
	2001	7.2	26.9	1670.6
	2002	6.7	25.8	1376.5
FY	2003	7.7	25.8	1888.2
(Flowering	2004	6.7	25.3	1519.3
year)	2005	5.5	25.6	1530.9
	2006	6.5	27.4	1313.6
	2007	6.3	25.7	1594.0
	Average	**6.66**	**26.07**	**1556.16**
AFY	2008	4.2	25.8	1464
(Years after	2009	6.5	24.9	1785.7
flowering)				
	Average	**5.35**	**25.35**	**1624.85**
Ensemble Average		**6.44**	**25.44**	**1637.59**

All data from Yaan Weather Bureau

bamboo FY (from 2001 to 2007) was 6.66°C, which is 0.18°C higher than that of NFY (1985 to 2000), 1.31°C higher than that of AFY (years after flowering, 2008 to 2009) and 0.22°C higher than average temperature (1985 to 2009). During these years, the temperature during January in 2003 is the highest during the period 1985 to 2009, and the average temperature in July is similar to January. The analysis of data reveals that the average temperature of July in FY was 26.07°C which was 0.97°C higher than NFY, 0.72°C higher than the average temperature of AFY, and 0.63°C higher than the ensemble average. Therefore we can deduce that the warmer winter and warmer summer contributed to bamboo flowering.

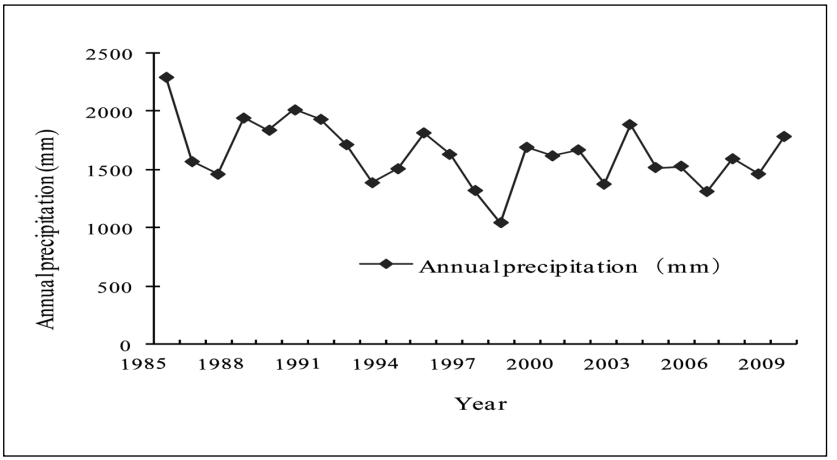

Figure 3. The change of annual precipitation from 1985 to 2009 in Yaan district

The relationship between bamboo flowering and rainfall

Figure 3 showed that in the rainfall variation in Yaan district from 1985 to 2009, there was a very obvious drought year before gregarious bamboo flowering in Yaan district. Thorny bamboo began to flower in 2001, and 1998 is the driest since 1985. The annual precipitation of this year was 1046.6 mm which was only 63.9 per cent of the average from 1985 to 2009. *P. heteroclada* began to flower in 2003, and 2002 also was a drought year, the annual precipitation of this year too was 1376.5 mm which was less than the average. At the same time, the average precipitation of FY 1556.16 mm, but the NFY was 1674.81 mm, the average precipitation from 1985 to 2009 was 1637.59 mm, the annual precipitation of FY was 118.65mm lower than NFY, 81.43 mm less than ensemble average, and it was obviously lower than normal years.

The correlation between climate factors and bamboo flowering

Statistical analysis of weather data (Table 2) revealed that flowering had significant correlation with the temperature of July and annual precipitation. The temperature of July and annual precipitation had significant difference between FY, NFY and AFY, the temperature of January had significant between AFY, FY and NFY, but the temperature of January had no significant effect on flowering. The analysis showed

Table 2. Relationship between climate factors and bamboo flowering

Type	Average air temperature of January (°C)	Average air temperature of July (°C)	Annual precipitation (mm)
Non-Flowering Year	6.48[a]	25.18[a]	1674.81[a]
Flowering Year	6.66[a]	26.07[b]	1556.16[b]
Years after flowering	5.35[b]	25.35[a]	1624.85[a]

a: Non-significant; b: significant at $P \leq 0.05$

that high temperature in July and less annual precipitation contribute to bamboo flowering.

CONCLUSION AND DISCUSSION

The process of plants growing from vegetative to reproductive growth depends on several factors, such as genetics, physiological and environmental. Although genetic is very important, environmental factors still have a significant role. During the transition from vegetative to reproductive growth, nearly every environmental factor can alter plant flowering responses (Ma and Dai, 2003). In Yaan, the average temperature of January and July of bamboo flowering years were higher than that of non-flowering years, and the temperature of July had significant correlation with bamboo flowering. This indicate that there is an obvious relationship between higher temperature and bamboo flowering. The result is similar to those of Qing *et al.,* (1989) in *Bashania fangiana*, where they found that high altitude, good weather conditions (cool and enough rainfall) and suitable forest crown density can postpone *B. fangiana* flowering, but low altitude, drought, and high temperature can induce bamboo to flower. The external environment therefore is the critical variable that contributes to bamboo flowering. But the research results of Hu *et al.* (1997) are different from our findings. They found that bamboo flowering years always have warmer winters and cooler summers, and the main meteorological factor that influences *B. fangiana* to flower is warmer winters rather than cooler summers. Although the mechanism is different, it still demonstrates that environmental factors can influence bamboo flowering, especially unusual weather.

On examining the precipitation data, we find that the average annual precipitation in Yaan of FY was 118.65 mm less than average of NFY, and that the annual precipitation had significant correlation with bamboo flowering. There were very obvious drought years before bamboo flowering. The year 1998 was a drought year before Thorny bamboo bloomed in 2001 and 2002 also was a drought year before *P. heteroclada* bloomed in 2003. This result is in accordance with Ueda (1960) that the rainy season after drought might lead to bamboo bloom, and it also showed that drought has obvious influence on induction of bamboo flowering. An earlier study by Wang and Zhou (2007) on the ecological niche of flowering *P. heteroclada* found higher air temperature, humidity and illumination can cause this bamboo to bloom.

The study concluded that extensive bamboo flowering might be a stress reaction to changing external environments and a strategy for its population survival, in the face of imminent disaster, especially drought. Determining the exact mechanism will need more research.

ACKNOWLEDGEMENTS

We are thankful to Mr. Huang Yan (Director of Yaan Bi Fengxia base of CCRCGP) for encouragement and Jia Shuangtang for his help during the study.

REFERENCES

Hu Y., Xiang, W.G., Zhu K. Y., Lin R. Z., Wang J. X. and Wang W. 1997. The study on the growth and flowering meteorological condition of *Bashania fangiana*. *J. Chengdu Inst. Meteorol.* 12(3): 225-233. (in Chinese)

Janzen, D.H. 1976. Why bamboos wait so long to flower? *Ann. Rev. Ecol. Syst.* 7: 347-391

Li, C.B. 1997. *Study on the staple food bamboo for the Giant Panda*. Gui Zhou Science and Technology Press, Gui Yang, China. pp. 108-130 (in Chinese)

Ma,Y.P. and Dai, S.L. 2003. Flower bud differentiation mechanism of Anthophyta. *Molecular Plant Breeding* 1 (4): 539-545.

Qing, Z.S., Zhang, Y., Zhang, H.D. and Pu, S.J. 1989. The statistic analysis on the environment effect upon the flowering of *Bashania fangiana*. *J. Sichuan Normal University* 10(1): 36-44 (in Chinese).

Sharma, M.L. 1994. The flowering of bamboo: Fallacies and Facts. *Bamboo in Asia and the Pacific*. Thailand, Chiangmai. pp. 68-70.

Panda Survey Team of Sichuan Province in China. 1985. The report of bamboo flowering. Internal data of Forestry Department of Sichuan Province in China. pp. 3-7 (in Chinese)

Ueda, K. 1960. Studies on the physiology of bamboo, with references to practical application. Prime Minister's Office, Tokyo. p. 167.

Wang, X.H. and Zhou, Z.J. 2007. Flowering characteristics of *Phyllostachys heteroclada* Olive in China. *J. Bamboo and Rattan* 6: 123-127.