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REVIEW ARTICLE

Bamboo resources, utilization and ex-situ conservation in Xishuangbanna, South-eastern China

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Abstract: This paper describes the geographical distribution, utilization, cultural value and *ex-situ* conservation of bamboo resources in Xishuangbanna, Yunan Province, China. Sixty species of bamboo in 19 genera are recorded in Xishuangbanna. The area of natural bamboo forest is 14319 ha, accounting for 5.92% of whole area of Xishuangbanna. The abundant resource of bamboo plays an important role in the economics and culture of national minorities in Xishuangbanna. Xishuangbanna Tropic Botanic Garden, Chinese Academy of Sciences (CAS), started to introduce bamboo species in 1961 and established the *ex-situ* conservation reserve (8 ha) of bamboo in 1981. Up to now, 211 species in 27 genera collected from tropic and sub-tropic of China and South-east Asia have been planted in the bamboo reserve, of which 11 species have bloomed and seeded, and their seeds were cultivated in Xishuangbanna Tropical Botanic Gardens, CAS, China.

Keywords: Xishuangbanna; bamboo resources; utilization; ex-situ conservation.

Introduction

In the world, more than 1250 species under 75 genera of bamboo are unevenly distributed in the humid tropical, sub-tropical and temperate regions of the world (Sharma 1980). Bamboo is the most diverse group of the plants in the grass family. Bamboo generated offspring by a complex and generally robust rhizome system with woody culms and branches (Soderstrom et al. 1979). Bamboo has a cosmopolitan distribution, ranging from 46° to 47° N latitude, reaching an elevation of 4 000 m in China. Bamboo is very adaptable, of which some species are deciduous and others evergreen, although at least some species seem to be able to change their habit when environment factors are changed.

Bamboo is difficult to hybridize since its flowers are monocarp and most species flower gregariously at long periodic intervals (60–120a). This can help to explain why bamboo propagation by seeds is not very popular. Bamboo has a useful efficiency in soil reserves and can be directly propagated as rhizomes, culms cuttings, or nursery-raised seeding. Bamboos can be used to controlling soil erosion, building road and stream embankment for its extensive rhizome and root system. Bamboo can produce leafy mulch on the soil surface and provide vegetative coverage to deforest areas. Xishuangbanna harbors have the characteristics of valuable tropical rainforests with abundant biodiversity and it is acknowledged as a treasure habitat for wildlife. Today mankind is faced with the global forest reduction and ever-increasing aggravation of ecological fragility. Biodiversity is gradually lost and its conservation is confronted with potential crises as forests are exposed to the effects of poor management and unbridled development. The diversity of bamboo germplasm resource, nature bamboo community, ethnic culture and conservation measure are systematically discussed and analyzed in this paper.

Location and topography

The study was conducted in Xishuangbanna (21°8′ and 22°36′ N, 99°56′ and 101°51′ E) in the south part of Yunnan Province, China. Xishuangbanna is biogeographically situated in a transitional zone from tropical South-east Asia to temperate East-Asia (Fig. 1). Altitude varies from 477 m at the bottom of the lowest valley in the south to 2429 m at the top of highest mountain (Hua Zhuliangzi Mountain).

Xishuangbanna region has a typical monsoon climate with hot warmth and humidness. Annual mean temperature ranges from 22°C (600 m alt.) to 18.4°C (1600 m alt.), annual accumulation temperature (the daily mean temperature is >10 °C) is from 8000°C to 6600°C, and the monthly mean temperature is from 15.9°C to 12.3°C in the coldest month and 25.7°C to 22°C in the hottest month. Annual precipitation varies from 1200 mm to 1556 mm, of which more than 80% falls during the rainy season

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from May to the end of October. There are 146 foggy days per year averagely and 1-mm precipitation per foggy day in Menglun Town (Liu et al. 2001). This phenomenon compensates for the insufficient precipitation in this region.

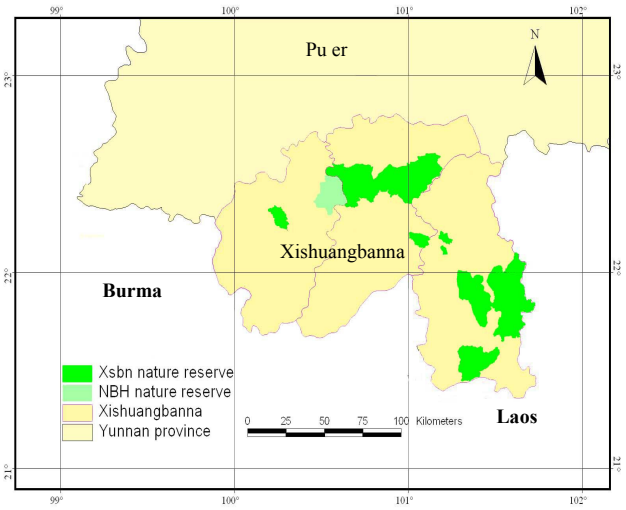

Fig. 1 Map of Xishuangbanna showing the study area

Taxonomy and distribution

Dransfield (1981) estimated generally that bamboo of 60–75 genera and 1250–1500 species in the world, of which, sixty-four percent are native to South-east Asia, thirty-three percent grows in Latin America, and the rest in Africa and Oceania. In North America, there are three native species of bamboo as opposed to the 440 species native to Latin America. Sharma (1980) provided a list of 192 species of bamboo from the Asia-Pacific region, including both native and cultivated species. In China, there are about 48 genera and over 500 species of bamboo, of which 28 genera and over 200 species are distributed in Yunnan Province.

Xishuangbanna is one of the richest areas of bamboo in the world but the taxonomy of bamboo in Xishuangbanna is not clear. Wang (1994) claimed that Xishuangbanna has 60 species of bamboo in 19 genera (Table 1), inhabiting 14317 ha of native bamboo forests areas in the Xishuangbanna national natural reserve (Dao et al. 2001). The species of bamboos in Xishuangbanna was more than that in Papua New Guinea, Thailand, Burma, Philippines, Indonesia, Malaysia and Bangladesh (Table 1). The area of Xishuangbanna is only 0.2% of the whole area of China, but there are 10 species that belong to mon-species. The largest genus is *Dendrocalamus* with 13 species.

Geographical distribution and types of bamboo

Bamboo generally forms in the under-storey in the natural forests. It is found to grow practically all over the country, particularly in the tropical, sub-tropical and temperate regions where the annual rainfall ranges between 1 200 mm to 4 000 mm and the temperature varies between 16°C and 38°C. Most bamboos are found in the elevation between 770 m and 1080 m.

Xishuangbanna is very rich in bamboo diversity. In total of 19 genera and 60 indigenous and exotic species, including natural and cultivation species, have been reported. The natural bamboo forests reach 9.91×10^4 ha in Xishuangbanna, and a large area of bamboo/tree mixed forests belongs to the state/communities and individual landowners (Wang et al. 1994). Bamboo can be divided into two main categories according to growth pattern, (1) symposia or clump forming, and (2) monopodium or non-clump forming, runner bamboo. Bamboo from clump accounts for 80% of the total growing stock, of which *Dendrocalamus* is 45%. A non-clump forming bamboo accounts for 20% of the growing stock.

Table 1. Geographical distribution of bamboo genera and species

Genera	Xishuangbanna	India	Thailand	Burma	Bengal
Ampelocalamus	1	0	0	0	0
Bammusa	14	22	14	19	9
Cephalostachyum	2	7	2	2	1
Chimonobambus	1	1	0	1	0
Chimonocalamus	1	1	0	1	0
Dendrocalamus	13	12	8	11	6
Dinochloa	1	2	2	2	0
Fargesia.	1	0	0	0	0
Gigantochloa	6	5	3	9	0
Indosasa	3	0	0	0	0
Leptocanna	1	0	0	0	0
Melocalamus	4	1	1	1	2
Neohouzeaua	1	2	0	4	1
Pleioblastus	1	1	0	0	0
Pseudostachyum	1	1	0	2	0
Phyllostachys	4	5	0	3	0
Schizostachyum	3	2	2	1	0
Thyrsostachys	2	2	2	2	1
Yushania.	1	0	0	0	0
Total	60	64	34	58	20

Use of Bamboo resources

Bamboo is used mainly as raw materials for construction, furniture, farm implements, etc.. In recent years, bamboo culm is used as the raw material for the manufacture of pulp and plywood. Bamboo's role in stabilizing river or water reservoir embankments has also been widely recognized. Many species of bamboo are beautiful in appearance, and this has come to be appreciated by gardeners, interior designers and landscape artists who use it to beautify the environment.

Cultural values of bamboo

In China, bamboo is one of the four noble plants and the others are the orchid, the plum tree and the chrysanthemum. Bamboo was closely connected with the daily living of people in ancient China. Su Dongpo, a literary giant of the Song Dynasty (960–1279), said that "A meal should have meat and a house should have bamboo". Without meat we become thin, without bamboo we lose serenity and culture itself. The bamboo was used as firewood, tiles, paper, rafts, hats, etc. At that time, bam-

boo shoots were considered as a popular food because of bamboo being crispness and fresh and sweet taste. Bamboo shoot also contains vitamins, sugar, crude fat and protein (Soderstrom, et al. 1979). In the Han Dynasty (206 B.C.-A.D.220) bamboo was used for raw materials of paper because it produced high-quality paper and was inexpensive. Three tons of bamboo could yield one ton of paper pulp. Moreover, bamboo is still an important raw material for paper making today. Since 1600, People have written with brushes on Xuan paper made from young bamboo. Xuan paper is still popular for Chinese calligraphy and paintings.

Bamboo is an ideal material for construction and supporting pillars. Due to bamboo with graceful and luxuriant foliage, it is also an ideal plant for decorating courtyards and parks for people. It has a resistance against the high or low temperature in summer or winter.

Bamboo and construction

In construction, bamboo is a kind of native materials for making pillars, floors, walls, doors and window frames, etc. In ancient Xishuangbanna, especially Dai nationality people's houses were built of bamboo. Bamboo can be used to build different types of bridges. Generally, the bamboo species with big stems, such as *Dendrocalamus ginanteus*, *D. sinieus*, *D. membranceus*, *D. barbatus*, *Gigantochloa ligulata*, and *Bambusa sinospinosa*, can be used to build pillars, walls and floors. In addition, the bamboo species with middle or small stems such as *Chimonobambusa quandrangulasis*, *Thyrsostachys siamensis*, *Gigantochloa nigrociliata* are used for rafters, which have good hardness and thick stems..

Today, bamboo is widely used for furnishings household, such as mats, beds, pillows, benches, chairs, cabinets, buckets, chopsticks, spoons, baskets, and handheld fans.

Food and cooking

The bamboo has been used as food since ancient times. In Xishuangbanna, *Cephalostachyum pergracile* was superior for cooking rice that is enfold in bamboo and then steamed or roasted over a fire, called "Stem meal of Bamboo". In general, bamboo is used to construct frameworks for cooking pots over hearths in longhouses, and provides beakers for drinking water, beer, and various kinds of liquor.

The different kinds of bamboo shoots have different taste. Sweat bamboo shoot such as *Dendrocalamus hamitonii*, *D. semiscandens,* and *Schizostachyum funghomi* can be used directly for cooking, while bitterness bamboo shoots of *D. giganteus*, *D. barbatus, D. membranaceus*, *Pseudostachyum polymorphum*, *Gigantochloa nigrociliata*, *Leptocanna chinensis* are good materials for making acid bamboo shoot and dry bamboo shoot. Acid bamboo shoot is a good kind of food in Xishuangbana, for example, "boiling fish with acid bamboo shoot", "boiling check with acid bamboo shoot", and "fry beef with acid bamboo". In general, *D. giganteus*, *D. barbatus*, *D. sinicus* and *D. embranaceus* can be used to make acid bamboo shoot.

The bamboo shoot has the largest production in Xishuangbanna, which is easy to produce, reserve and transportation. Most species of bamboo in Xishuangbanna can be used to make dry bamboo shoot. Among the edible bamboo species, the shoot of *D. hamilttonii* is most favored, followed by *D. randisii*, *C. pergracile*, and *D. embraanaceus***.**

Folk feast and religion activity

Bamboo is closely relative with folk feast and religion activity for Dai nationality people in Xishuangbanna. In water-splashing Festival every year, Dai people must make and set off "gaosheng" (original rocket), which is made of the bamboo stem with *Schizostachyum funghomii*, *S. pseudolima*. And most Dai people make and set off "kongming lamp" in the evening, which is made of bamboo stem of *C. fuchsianum*. "Gaoshen"(original pyrotechnic) is very popular in Xishuangbanan, which was made of powder and saltpeter and load into the stick of bamboo. Most of *Dendrocalamus* spp. can be used to make pipestem of "Gaoshen", such as *D. giganteus*, *D. inicus*, *D. arbatus*, *D. membranaceus*.

In Dai temple, people planted "temple plant", which was a symbol of every Buddha around the temple. It is said, *Bambusa sinospinosa* McClure is the twenty-eighth temple plant.

Bamboo and the arts

In the rich art culture of China and Japan, bamboo provides paper, brush, and artist's subject. Some of the fine brushes used in Chinese paintings are made from fine bamboo shavings with a small holder of bamboo. Bamboo is used to make traditional Chinese musical instruments such as the "Sheng", "dizi" and "xiao" (one flute). Bamboo weave is popular in the provinces of Guangdong, Fujian, Hunan, Sichuan, Anhui and Zhejiang, which has a history of bamboo weave for more than 2 000 years. In Xishuangbanna, a popular dance for Aka nationality people is called the "bamboo pole dance", when two people sit and hold two bamboo poles at both ends. As the dancers' feet skip in and out of the space between the poles, the bamboos are brought together in time with the rhythm.

Hunting and gathering

Bamboo can be also used to make a wide variety of weapons. In Xishuangbanna, some people are using bamboo to make blowpipes for hunting small animals, such as monkeys and squirrels. Bamboo reeds are used as fish arrows. It is also widely used to make handles of spears and knives. And villagers gather shellfish and worms by quivering a twig of bamboo down a hole and luring up the prey.

The sophisticated cage traps made of Bamboo are widely used to catch some animal or fish. The bamboo pipe is blown to imitate the sounds of deer and some birds to lure deer and some birds.

Bamboo and medicine

The juice of bamboo leaves is a good kind of medicine to eliminate asthma, a kind of disease caused by excessive phlegm. The juice of root is also a useful kind of medicine to stimulate the

vital forces, quench thirst, and promote lactation. In Xishuangbanna, the famous medicine book of Dai nationality people reported that Dai medicine was made of the stem of some bamboo species, which was an invigorant medicine for kidney, including *D. hamilttonii*, *Thyrsostachys siamensis*, *P. polymorphum* and *Dendrocalamus* spp..

Bamboo is an extremely valuable grass in Xishuangbanna, with a commercial economic value of about 10 million RMB per year. Because of the bulkiness of bamboo culms and limiting radius of economic transport, most bamboo is only used near the centers of Xishuangbanna.

Conservation of Bamboo

The natural resources of bamboo are diminishing day by day. There are two approaches for conservation of Plant Genetic Resources: *ex-situ* and *in-situ. In-situ* conservation is important to save genetic resources based on the indigenous knowledge system. One of the important *ex-situ* conservation methods is to set up bamboo gardens, which are easy to manage and conduct experiments. *In-situ* conservation measures include establishment of Natural Reserve in Xishuangbanna. In addition, there are five biosphere reserves (Dao 2001), which include the natural habitat of bamboo as well. The local people in sacred groves also protect these species. However, *in-situ* conservation sites with specific emphasis on conservation of bamboo are yet to be established.

The collections of living bamboos are now available only in a few centers in China. For example, Zhejiang Bamboo Botanic Garden (250), Bamboo Garden of Fuzhou Arboretum (222), Xishuangbanna Tropical BG (245), South China BG (170), Hangzhou BG (100), Nanjing Forestry University BG (100). In Xishuangbanna, there is only one *ex-situ* conservation of Bamboo, which is Xishuangbanna Tropical Botanical Garden (XTBG) , Chinese Academy of Sciences, for bamboo collection.

In XTBG, Bamboo was introduced in 1961, and conservation of bamboo was built in 1981. Up to now, about 211species in 27 genera was reserved in the *ex-situ* conservation of bamboo, and 54 species with 18 genera was collected from Xishuangbanna, which covers 90% species of recorded bamboo in Xishuangbanna; 49 species with 17 genera were collected from Yunnan Province (except Xishuangbanna); 95species with 19 genera was collected from other provinces in China (except Yunnan province). Only 13 species with 4 genera was collected from foreign country, and all species from Laos or Burma (Table 2).

Table 2. Genera and species in *ex-situ* conservation of bamboo in XTBG

Genera	No. of Species	No. of Species in Xishuangbanna *	No. of Species in Yunnan	No. of Species in other provinces	No. of Species in foreign countries
Bambusa	58	12 (14)	8	34	4
Cephalostachyum	5	2 (2)	3	0	0
Chimonobambusa	6	1 (1)	3	2	0
Chimonocalamus	4	1 (1)	2	1	0
Dendrocalamopsis	2	0 (0)	0	2	0
Dendrocalamus	33	11 (12)	12	10	0
Drepanostachyum	3	0 (0)	0	3	0
Dinochloa	4	1 (1)	3	0	0
Fargesia	3	1 (1)	2	0	0
Gigantochloa	9	5 (6)	2	2	0
Indocalamus	4	0 (0)	1	3	0
Indosasa	11	2 (3)	2	3	3
Lingnania	3	0 (0)	0	3	0
Leptocanna	3	1 (1)	1	1	0
Melocalamus	4	3 (4)	0	1	0
Neosinocalamus	2	1 (1)	1	0	0
Oligostachyum	1	1 (1)	0	0	0
Pieioblastus	5	1 (1)	0	3	1
Pseudostachyum	2	1 (1)	0	0	1
Phyllostachys	13	4 (4)	1	5	3
Pseudosasa	10	0 (0)	2	7	1
Sasa	1	0 (0)	0	1	0
Schizostachyum	8	3 (3)	3	2	0
Sinocalamus	11	0 (0)	1	10	0
Teinostachyum	1	0/0	0	1	0
Thyrostachys	2	2/2	0	0	0
Yushania	3	1/1	2	0	0
Total	211	54/60	49	95	13

Note: * 12(14) means that 12 species was conserved in XTBG and 14 species was found naturally and/or under cultivation in Xishuangbanna.

Before flowering, the bamboo stands or clumps show some abnormal features. The flowering is not related with the age of the individual. To now, there is 11 species of bamboo being abloom and seed in XTBG..

Conclusions and suggestion

Bamboo, a giant grass takes on tree-like functions in forest ecosystems. Approximately 75 genera and 1250 species of bamboo are known to exist throughout the world, of which 500 species in 40 genera were recorded in China, mostly in the monsoon areas of south and southwest China. And 60 species in 19 genera grow naturally in Xishuangbanna. The species of bamboos in Xishuangbanna are more than that in Papua New Guinea, Thailand, Burma, Philippines, Indonesia, Malaysia and Bangladesh, which takes 20% of Chinese bamboo flora. Xishuangbanna occupies only 0.2% land area of China, but has 10 mon-species of bamboo, indicating that Xishuangbanna is one of the richest areas of bamboo in the world, and the largest genus is *Dendrocalamus* with 13 species.

Bamboo has of outstanding cultural, economic and biological value and has a potential development prospect in the future. With increasing human population and expanding their demands on bamboo resources, more approaches are required for managing bamboo forest. Thereby more scientific researches need to be conducted toward a better understanding on the taxonomy, distribution, and biology of bamboo. It is suggested that species of bamboo should be collected and conserved from Southeast Asia. The protected areas or collection (bamboo garden) of bamboo should be established to conserve bamboo resource.

In XTBG, Bamboo was introduced in 1961, and reserve of bamboo was built in 1981. Up to now, about 211 species with 27 genera were collected from Tropic-Sub-tropic China and South-east Asia and planted in a bamboo reserve with an area of 8 ha. In the past years, 11 species have been bloomed and seeded, and their seeds were cultivated in XTBG.

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乙酰化竹材的制备及其热塑性研究/李雪芳(福建师范大学化学与材料学院，福建福州，350007)，陈钦慧(福建师范大学化学与材料学院，福建福州，350007)，林金火(福建师范大学化学与材料学院，福建福州，350007；福建师范大学高分子研究所，福建省高分子重点实验室，福建福州，350007)，卓东贤(福建师范大学化学与材料学院，福建福州，350007)，吴秀玲(福建师范大学化学与材料学院，福建福州，350007) //Journal of Forestry Research .-2008, 19(1): 69−71.

利用三氯乙酸作为预处理剂，超声波作用后以乙酸-乙酸酐作酰化剂对竹材进行乙酰化改性，并总结出竹材的乙酰化最佳反应条件。利用 FT-IR、DSC、SEM 等对乙酰化竹材的微观结构和热塑性进行了研究和表征，并对三氯乙酸活化竹材的机理进行了讨论。此外，乙酰化竹材在温度为 130 ℃，热压压力为 10 MPa 时可以单独热压成片，显示出良好的热塑性。为改性竹材在新材料领域的应用提供了理论依据。图 7 参 7。

关键词：乙酰化； 热塑性； 竹粉

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孟加拉的非木材林产品在美容业的应用/Sayma Akhter[1], Md. Abdul Halim, Md. Shawkat Islam Sohel (Department of Forestry and Environmental Science, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh), Swapan Kumar Sarker (School of Geography and Environmental Science, Monash University, Claytan Campus, Victoria 3800, Australia), Mohammad Shaheed Hossain Chowdhury (Forest Policy Laboratory, Department of Forest Science, Faculty of Agriculture, Shinshu University, 8304 Minamiminowa-Mura, 399-4598 Nagano-Ken, Japan), Sanjay Saha Sonet ((Department of Forestry and Environmental Science, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh) // Journal of Forestry Research.−2008, 19(1): 72-78.

在查阅大量非木材林产品文献的基础上，作者总结了非木材林产品在孟加拉美容业的应用情况。本文评述了孟加拉的非木材产品在身体，面部和头发等的美容方面的应用,并对可用于美容产品的非木材树种进行归纳总结。本研究可以作为美容产品应用的可持续发展的原则指导生物多样性的保护。为了更有效的管理这些资源，了解产品的利用和收获的模式是非常必要的。表 13 参 23。

关键词：美容；非木材林产品；孟加拉

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西双版纳竹类种质资源、利用和迁地保护/杨清(中科院西双版纳热带植物园，云南勐腊 666303；国际竹藤网络中心研究生院，北京 100102), 段柱标, 王正良, 何开红(中科院西双版纳热带植物园，云南勐腊 666303), 孙启祥, 彭镇华(中国林业科学研究院林业研究所，北京 100091）// Journal of Forestry Research .-2008, 19(1): 79−83.

西双版纳境内自然分布竹类资源 19 属 60 种，天然竹林面积 14317 hm^2，占西双版纳总面积的 5.92%。最为丰富的竹类资源在西双版纳的社会经济和民族文化扮演重要角色。中国科学院西双版纳热带植物园从 20 世纪 60 年代初就开始进行竹类资源的种类、分布、人工栽培与利用以及迁地保护等方面研究，在 1981 年建立了一个面积为 8 hm^2 竹类资源迁地保护区。到目前为止，已从中国热带、亚热带地区和东南亚国家收集保存竹类资源 27 属 211 种，现已有 11 种竹开花结果，用其种子繁殖育苗并栽培在同一区内，长势较好。本文通过对西双版纳竹类资源的多样性、利用和保护状况的研究，旨在引起人们对西双版纳竹类资源的永续利用和保护的重视。图 1 表 2 参 7。

关键词：西双版纳；竹类资源；利用；迁地保护

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