# "Moso Bamboo" in China

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More than 70 bamboo genera with 1,000 species exist throughout the world. The numerous bamboo species are members of the subfamily *Bambusoideae* of the family *Gramineae*. The global bamboo forest area extends to about 49.4 million acres (20 million hectares), (Zhu, 1994). Except for Europe and Antarctica, bamboos occur naturally in the tropical, subtropical and temperate regions of all continents, between 46° N and 47°S, from the lowlands up to 13,000 feet (4,000 meters) above sea level (Dransfield, 1992). Fig. 1.1 shows the global distribution of bamboos.

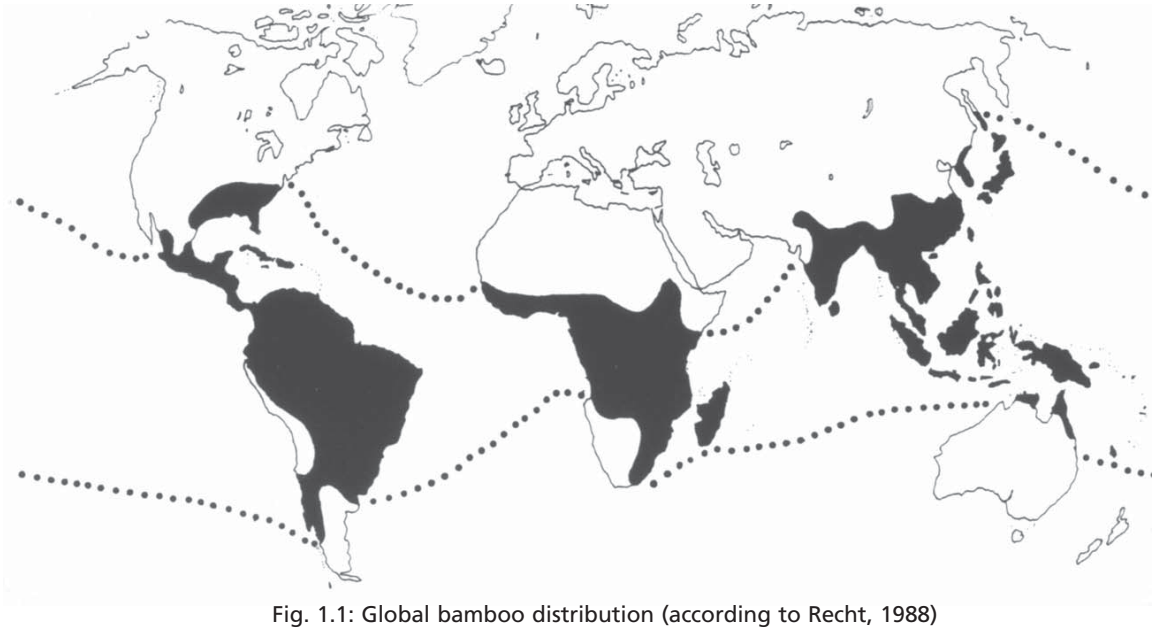


Fig. 1.1: Global bamboo distribution (according to Recht, 1988)

Bamboos are perennial, extremely fast-growing and very important commercial plants widely used in the daily life of Asian people. The management of bamboo production groves can be easily sustained. The groves benefit from selective felling, encouraging regeneration via underground rhizomes.

China is one of the world's main bamboo distribution and production regions with 39 genera and about 500 species. China's bamboo forests cover nearly 10 million acres (4 million hectares). The bamboo forests of China include monopodial and sympodial bamboos.

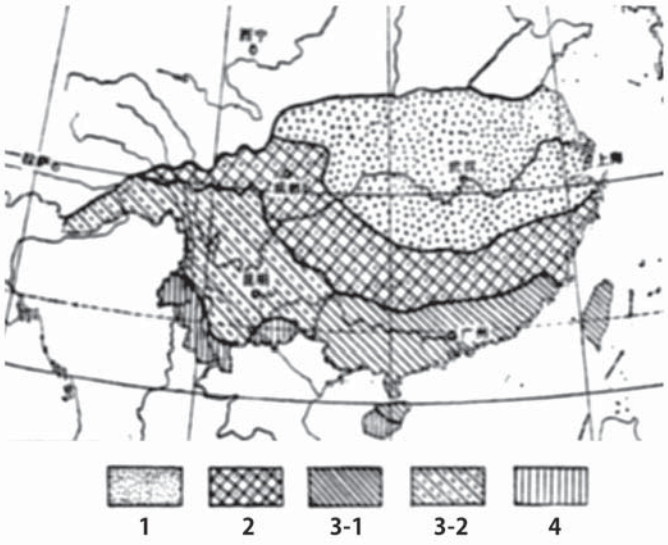
In 1997, the total value of China's bamboo output was approximately 2 billion US$. About 400 million US$ of that is exported. Since 1990, the production and value of bamboo has been increasing very fast (Fu, 1999).

China's bamboo distribution is divided into 4 regions and 2 sub-regions (Fig. 1.2) (He, 1980).

Moso bamboo is the most important commercial bamboo species in China. It covers more than 6.7 million acres (2.7 million hectares) about 65 % of China's total bamboo area and 2% of the total forest area of China. The main timber species in south China, *Pinus massoniana* covers 39.8 million acres (16 million hectares) in area, *Cunninghamia lanceolata* ("Chinese Fir") covers 19 million acres (7.7 million hectares) and there is more than 6.7 million acres (2.7 million hectares) of *Phyllostachys heterocycla* var. *pubescens*, the so-called "Moso Bamboo" (Ministry of Forestry, 1995).

Fig. 1.2: Bamboo distribution area of China (after He, 1980)

1. Subtropical monopodial bamboo region in Central China
2. Subtropical amphipodial bamboo region in Central China
3. Tropical-Subtropical sympodial bamboo region:
   3.1 South China sympodial bamboo sub-region
   3.2 Southwestern China sympodial bamboo sub-region
4. Hainan-Yunnan tropical climbing bamboo region



There are several reasons that led to an increase of the Moso forest area from 3.7 million acres (1.5 million hectares) to more than 6.7 million acres (2.7 million hectares) in the time from 1957 to 1995 (see Tab.1.1). Moso bamboo is of excellent quality and properties for multiple uses. Both the timber and shoots are easy to process.

Another important aspect is the general deficiency of timber resources in China. With the growth of the Chinese population from 450 million people in 1949 to more than 1.2 billion people in 1995, there has been a rapid reduction in forest resources to the extent that in some districts tree felling is generally prohibited. The majority of the natural forests do not exist anymore. Additional Moso bamboo was planted in order to meet the needs of a rising population.

Tab. 1.1: Forest area and standing culms of Moso bamboo forests (Chen, 1996)

| Year | 1957 | 1965 | 1975 | 1985 | 1990 | 1995 (predicated) |
|---|---|---|---|---|---|---|
| Area (mil Ac) | 3.70 | 3.95 | 4.94 | 5.93 | 6.18 | 7.17 |
| Culms (mil.) | 2875 | 2921 | 3542 | 3795 | 4700 | 5243 |

## Status of Forestry and Bamboos in China

China is poor in terms of forest resources when compared to the world average. The established forest plantation area has reached 81.5 million acres (33 million hectares) in 1998, compared with 650 million acres (263 million hectares) of total forest land. The total forest cover is estimated to be 331 million acres (134 million hectares) or about 14% of the land area. China has to import an increasing amount of wood and wood products in order to satisfy the growing demand for timber.

Tab. 2.1: The Chinese population and resource status

| | Human Population | Forest Area | Forest Cover Area | Per Capita Forest Area |
|---|---|---|---|---|
| China | 1200 mil. | 331 (3.9%) | 14% | 0.276 Acres |
| World | 6000 mil. | 8429 (100%) | 26% | 6.447 Acres |

Bamboo processing and the demand for bamboo timber increased since the 1980's (Fu, 1999). In order to gain the highest yield in the shortest period of time, more and more mixed broad-leaved species and bamboo forests have been converted into bamboo monoculture, but whether all mixed Moso forests should be converted into pure stands is debatable.

The evergreen broadleaf forest is the typical climax vegetation in China's subtropical zone. Human impact caused a change in species structure of this typical forest type. The mixed forest types that developed now consist of Moso bamboo and broad-leaved trees. These forests function as an excellent water and soil conservation environment (Wu, 1992). Compared to a pure Moso forest, this forest type has a higher amount of litter, a more differentiated forest structure, higher biodiversity, and a higher capacity for water and soil conservation. Most of these mixed forest trees grow on middle and upper slopes of mountains, where felling the broad-leaved trees can result in serious soil erosion.

Besides many evergreen broadleaf trees being economically valuable and rare, their coexistence with Moso bamboo is regarded as beneficial for the growth of the bamboo. Due to the rapid depletion of the soil nutrients in a pure Moso plantation, these stands have to be fertilized to avoid deterioration. Fertilizing on the other hand is not practicable for various ecological and economical reasons since many areas where these mixed forests grow are hard to reach. The standard management technique for pure Moso plantations consists of two brush cuttings per year to clear the forest floor, as well as top soil tillage every one to two years. This common practice can easily lead to soil erosion with nutrient loss. So far, there has been no research on the competition of bamboo and broad-leaved tree species in mixed Moso bamboo forests.

Competition may be defined as the negative effects that one organism has upon another by consuming, or controlling access to a resource that is limited in availability (Keddy, 1989). In forests, these resources are space, air, light and solar energy, water, soil and nutrients, whereas the temporal and spatial distribution of these resources can be of great importance. Keddy (1998) pointed out that simple descriptions and classifications have dominated competition studies, namely the intraspecific (that is, the competitive interactions occurring among individuals of the same species) and the interspecific (that is, the competitive interactions occurring among individuals of different species).

## Moso Bamboo and the Mixed Evergreen Subtropical Forests of China

### Characteristics of Moso Bamboo

The culms of Moso bamboo grow over 65 feet (20 meters) high with a DBH (diameter at breast height) ranging from 2½ to 7½ inches (6 to 18 centimeters). The internodes at mid-culm can reach a length of 16 inches (40 centimeters). Culm walls are thick and young culms are densely pubescent and thickly pruinose on the branchless nodes below the crown, culm annuli are indistinct and sheath annuli are thickly convex with deciduous setae; sheath scars are prominent, thickly covered with brown hair and dark brown specks. The sheath auricles are short, with developed humeral hair, whereas the sheath ligules are short and broad, bow-shaped, with both sides drooping. Sheath blades are green, long triangular or lanceolate, and the leaves are narrow and small, 1½ to 4½ inches (4 to 11 centimeters) long and between 1/5 and ½ inch (0.5 to 1.2 centimeters) wide. The shooting period lasts from the end of March to the beginning of April.

Fig. 3.1 (on the next page) shows the anatomical aspects of Moso bamboo.

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**Moso in China** Continued…

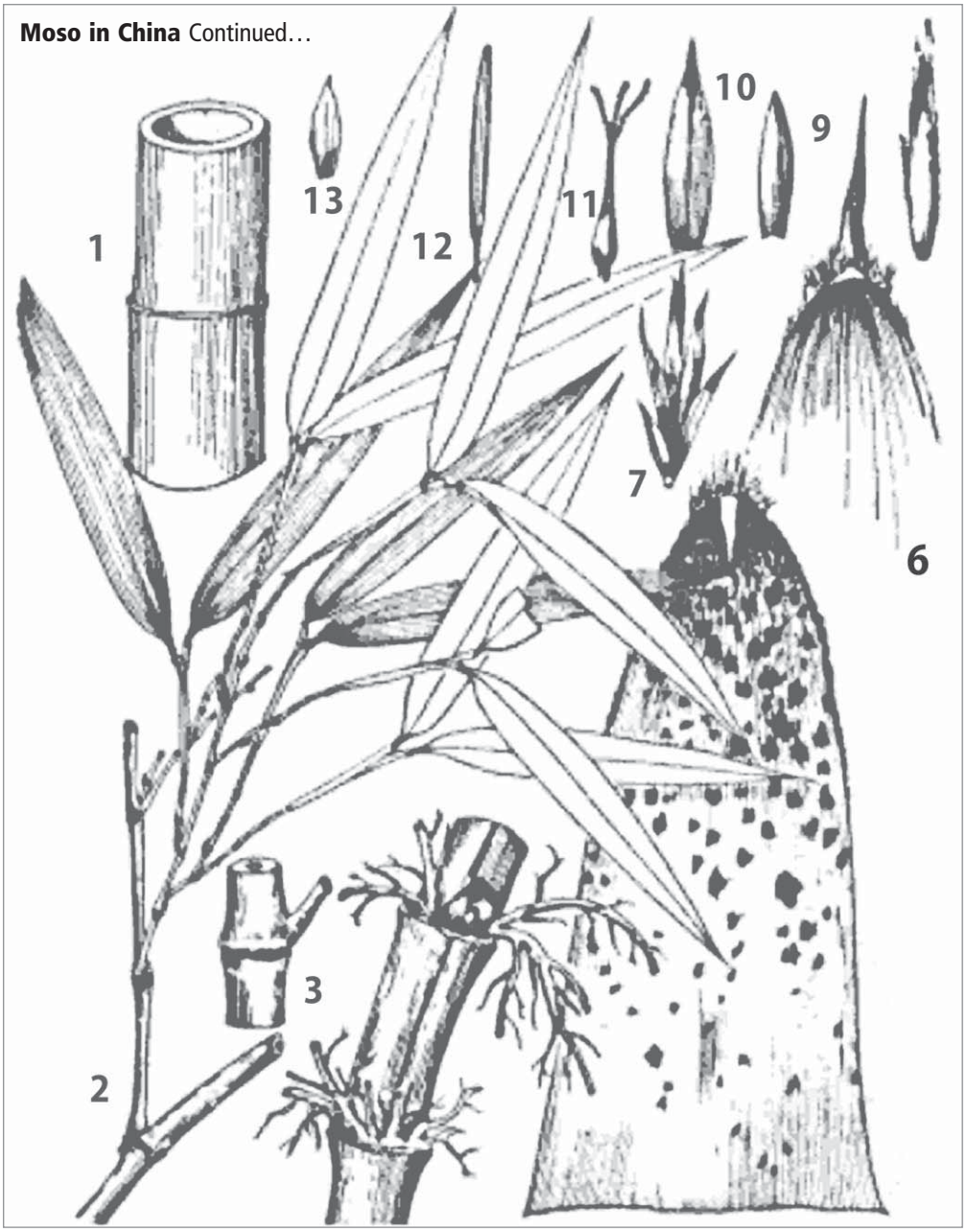



Fig. 3.1: *Phyllostachys hererocycla* var. *pubescens* (Hui, 1996). 2. Branch and leaf; 3. Small branch; 4. Rhizome; 5. Sheath (back); 6. Sheath (front); 7. Spikelet; 8. Flowerlet; 9. Proleaf; 10. Glume; 11. Pistil; 12. Stamen and 13. Lodicule.

### Sprouting and Shoot Growth

Moso bamboo has monopodial rhizomes type of bamboo. The growth includes that of the of the rhizome 1), the culm 2) and the stand as a whole 3) (Hui, 1996):

#### 1) Rhizome Growth

Rhizomes grow mostly horizontal and undulate in the top soil to a depth of 6 to 16 inches (15 to 40 centimeters). Each rhizome is composed of a rhizome tip, rhizome body and rhizome handle, which all derive from the rhizome tip. The growth period of the rhizome tip lasts 5 to 6 months after shooting and occurs from April to May until the end of October. Growth reaches its peak between July and September.

#### 2) Shooting and Culm Growth

From July to September, lateral buds of the rhizomes differentiate into culm buds. The culm buds turn into new shoots in winter, or the so-called winter shoots. During the time from March to April, the soil temperature rises and the humidity begins to increase. These conditions are favorable for the growth of the winter-shoots. The whole shooting period lasts between 40 to 45 days with a peak of about 15 days.

It takes about 50 days for the shoots to emerge and grow into new culms. The time of shoot height growth follows an s-shaped curve, namely in a slow-fast-slow rhythm. The mean daily growth rate of young culms can be 12 to 19 inches (30 to 50 centimeters) with exceptional rates of more than 39 inches (100 centimeters) per day.

Before the shoots emerge from the soil, the full complement of nodes is already contained in the compressed buds. Shoot emergence is followed by the internodes elongating from cell division of the intermediate tissue. Young culms are formed by the elongation of the internodes. When growth of the young culms starts, the upward growth rate is relatively weak, while the horizontal growth rate of the internodes is pronounced. Thereafter, the internodes below the soil surface stop growing and the bamboo roots dominate growth. At the same time, the culm internode growth accelerates upwards at its peak. Now, internodes grow fast and steadily, with the culm sheaths falling at the culm base, spreading of the upper branches and a decrease in culm growth rate. Finally, the top of the young culm bends, its branches spread fast until the growth comes to an end. At this stage, when all the sheaths fall off and all the branches and their leaves are unfolded, the new culm is fully developed. Now the dimensions, that is, the height, diameter and volume of the culm are stable and do not change noticeably, but within the culm, the following stages the quality of the culm will change:

a) Culm age 0 to 5 years, the improvement of the quality of the timber stage

This stage is marked by the vigorous growth of the young culm, which is supported by strong rhizomes. Parallel to the root system and leaf growth, chlorophyll, sugar, and other organic matter contents increase. During this time, physiological activities are the strongest, reaching the peak of rhizome growth and shooting. As the water content in the cells decreases and the dry substances increase by further cell wall development, the lignification of the culm is completed.

b) Culm age 5 to 9 years, the stable stage

The metabolism of the culm is stabilized, its nutrient content is rich and physiological activities are sound.

c) Culm age up to 9 years, the declining stage

The physiological activities are declining, culm weight, mechanical strength and nutrient content being gradually reduced, which results in the deterioration of the culm quality. Table 3.1 shows the growth stages of Moso bamboo as well as timber quality aspects.

**3) Stand Growth**

The growth habit of bamboo groves can be classified into two types: on-and-off year groves and even-year groves, in China the on-and-off year groves dominate. In an off-year, the number of shoots is relatively low compared to the on-year. Rhizomes are mainly developed in off-years, when leaves are exchanged as well. Shooting and rhizome growth habits are relatively equal in even-years. On-years and off-years alternate regularly.

According to Fig. 3.2 (Hui, 1997, modified) the Moso bamboo growth curve can be classified into several phases as shown in Tab. 3.1. This explains why for several technological types of timber uses Moso bamboo is harvested after 7 years, although culm growth is already completed within one year.

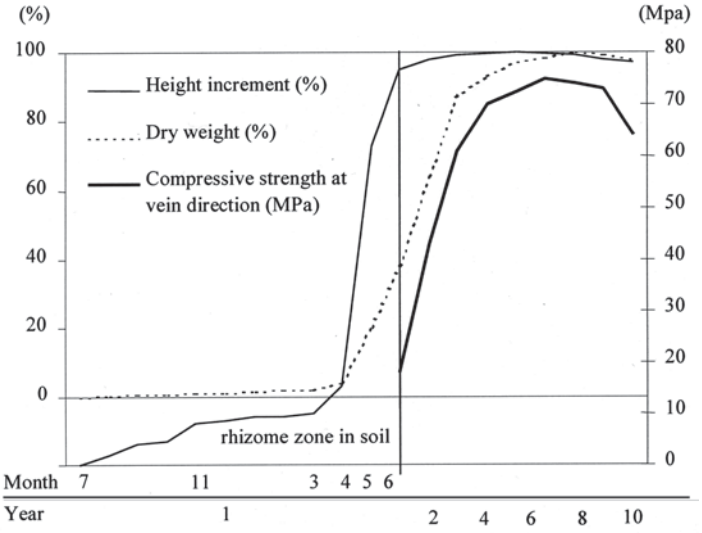
Tab. 3.1: The phases of growth of Moso bamboo

| Date | Underground | Culm Growth | Culm Quality |
|---|---|---|---|
| Month 7-11 | Differentiation | | |
| Month 11-3 | Growth Stops | | |
| 01.Mar-15.Mar | Sprouting | | |
| 16.Mar-01.Apr | | Start | |
| 01.Apr-10.Apr | | Ascending | |
| 11.Apr-30.May | | Peak | |
| 01.Jun-30.Jun | | Final Phase | |
| Year 0-5 | | | Improvement |
| Year 5-9 | | | Stable |
| Year > 9 | | | Declining |

## Distribution of Moso Bamboo in China

The natural habitat of Moso bamboo extends approximately between 23° 30' to 32° 20' N and 104° 30' to 122° E. It grows at

Fig. 3.2: The growth curves of shoots, young and adult culms of Moso bamboo.




elevations between 32 to 5,525 feet (10 to 1,700 meters) above sea level, but is concentrated in areas below 2,600 feet (800 meters) as well as in hills and mountains.

Moso bamboo is mostly found in the provinces Zhejiang; Fujian; Jiangxi; Hunan; Hubei; Sichuan; Anhui; Jiangsu; Guizhou; Guangdong; Guangxi; Yunnan and Shan'xi. The central forest area is situated between 25° to 30° N and 110° to 122° E. About 81% of the Moso bamboo area is concentrated within the provinces Fujian, Hunan, Zhejiang and Jiangxi. Fig. 3.3 shows the distribution of Moso bamboo in China according to the Forest Planning Office of Forestry Ministry, 1992 (modified).

At the highest elevation limits of moso bamboo, its limit is higher in mountain ranges than on an isolated mountain, as well as, in mountains with higher altitudes than with lower altitudes. This species is rarely found at lower altitudes. When found in these ranges, it grows in pure and mixed stands that are sporadically planted on plains. The best suitable sites, according to Wang, (1996) are within 1625 to 2600 feet (500 to 800 meters) above sea level.

According to the Chinese "Hardiness Zones" (after Wirdlechner, 1997) Moso bamboo is located in the so-called zones no. 7, 8, 9, and 10, whereas central distribution lies within zones 8 and 9. The author characterizes these zones with respect to their mean annual minimum temperature:

Zone 7: 0 to 10°F (-17.7 to –12.3°C)

Zone 8: 10 to 20°F (-12.2 to –6.7°C)

Zone 9: 20 to 30°F (-6.6 to –1.2°C)

Zone 10: to 40°F (-1.1 to +4.4°C)

Moso bamboo was introduced to Japan in 1736, and currently covers up to 123,500 acres (50,000 hectares) today (Farrelly, 1980; Hui, 1996). It reached Europe by 1880, and the United States of America by about 1890.

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**Moso in China** Continued…

## Site Requirements

### Climate

The natural distribution of Moso bamboo is confined to the subtropical monsoon climate. The mean annual temperatures vary between 30 and 40°F (15 and 21°C) with mean temperatures in the coldest month ranging from 33 to 53°F (1 to 12°C) and 80 to 85°F (26 to 29°C) in the warmest month. Moso can withstand temperatures as low as 0 to –5°F (-18 to -20.9°C) in the winter (Wang, 1996). Annual precipitation varies between 32 to 71 inches (80 to 180 centiimeters). The limiting climatic factors for the Moso bamboo distribution are obviously the annual precipitation in the north, that is, below 32 inches (below 80 centiimeters) per annum and the mean annual temperature in the south above 70°F (21°C).

Precipitation seems to be the key factor for Moso growth. Optimum conditions are cumulative rainfall up to 16 to 24 inches (40 to 60 centiimeters) during shooting time (from March to June). Drought conditions in the fall may affect the shoot bud division and will consequently limit the production in the following year.

### Soil and Geology

Within the Moso bamboo distribution zone, soil types vary from red soils over yellow soils to yellowish brown soils. Red soils are dominant in the distribution area, whereas suitable conditions include 24 inches (60 centimeters) of deep fertile loam with a pH ranging from 4.5 to 7.0. Moist conditions are favorable, but not water-logged soil. The growth of Moso bamboo is seriously affected if the salt content of the soil solution is higher than 1%, or if the pH value exceeds 8.0 (Wang, 1996).

Southern slopes offer better growth conditions than northern and south eastern slopes, even though these are still more favorable than north western slopes. Ravine, piedmont and gentle slope are favorable sites for Moso growing (Wang, 1996).

Fig. 3-3: Distribution of Moso bamboo.


## Forests of the Moso Bamboo Region

### Natural Vegetation

The Evergreen Broad Leaf Forest Formation is among the most important in eastern Asia, covering large areas of China; Vietnam; Laos; Thailand; Myanmar and Japan. In China, this formation extends to 675,500 square miles (1,750,000 square kilometers) across the south eastern provinces, and including Zhejiang; Fujian; Anhui; Jianxsi; Guangdog; Hubei; Hunan; Guizhou; Sichuan; the Guangxi Zhuangzu autonomous region; and most of the autonomous districts within these provinces, as well as the eastern counties of Tibet (Richardson, 1990).

### Bamboo Age and Age Distribution

Bamboo does not have secondary growth and thus no annual rings, so other methods have to be used to determine the age of a stand. In China, the age of Moso bamboo is recorded in "Du", showing the growth habit in "on" and "off year" bamboo stands. One "Du" corresponds to 1 to 2 years of age, 2, 3, 4 and 5 "Du" are 3 to 4, 5 to 6, 7 to 8 and 9 to 10 years respectively.

The age of the stand is a very important aspect in Moso bamboo management. It is recommended to use four year old culms for pulp and papermaking and six to eight year old culms as timber (Wang, 1996). Within a stand it is difficult to determine the age of bamboo. The following methods are generally used for age estimation:

1. Marking the new culm with a special painting ink. For example, "1" means the culm developed in 1991, "9" the culm developed in 1999. The marks last about 10 years.

2. Eyeballing of culm color, (see Tab. 5.8).

3. Counting twig scars. New bamboo culms change leaves for the first time in their second year. Moso bamboo exchanges its leaves every second year and twig scars remain. The age of bamboo can be determined using the following equation: 2n – 1 + A, with n = number of twig scars, A = 1, when leaves exchange, otherwise, if no leaves are changed, A = 2.

Tab. 5.8: Eyeballing of culm color for age estimation of Moso bamboo.

| Character | Age (years) | | | | |
|---|---|---|---|---|---|
| | 1-2 | 3-4 | 5-6 | 7-8 | 9-10 |
| Culm color | Dark green | Green | Yellowish green | Greenish yellow | Bronze |
| Eyelash on cycle of culm sheath | Brown | Sparse | | | |
| Powder under cycle of culm sheath | White | Grayish white | Grayish black | | |
| Other | With sheath in culm base | | Wax layer on culm | Wax layer on culm | Wax layer begins to fall |

Experienced foresters used the visual examination of the culm color and counted twig scars to determine the age of the bamboo on the research plots. Age V includes 9 to 10 and older than ten years.

The bamboo age distribution ratio should be I: II: III: IV: V = 1:1:1:1:1 or 1:2:2:2:1 (Zhou, 1988; He, 1993) or 2:2:2:1:1 (Wang, 1996) under ideal circumstances. Three aspects are important to determine the optimal bamboo stand age distribution ratio:

1. Unevenly aged bamboo stands: then a selective felling system is used for harvesting.

2. The development of the bamboo rhizome: 1 year old new rhizome, 2 years old rhizome sprouting buds, 3 to 4 years old rhizome sprouting shoots, 4 to 5 years old rhizomes developing new rhizomes, and 6 to 7 years old rhizomes starting to degenerate.

3. Bamboo timber quality improves from the 1st to 5th year, stabilizes from 6 to 9 years and starts to deteriorate at age 9.

The age composition mentioned above is in practice regulated by felling. The ideal case is to have culms of age factors I, II and III to have a proportion of 25% each and the ages IV and V combined to make a total of 25%. Old, small and unhealthy culms should be the first ones to be cut.

**References**

Fu, M.Y, 1999, Bamboo and rattan in China. National report of INBAR.

Cheng, X.F., 1996: Cultivation and Utilization of Moso Bamboo. China Forestry Publishing House.

Dransfield, S., 1992: The bamboos of Sabah. Sabah forest report, No.14. Mylasia.

Forest Planning Office of Forest Ministry, 1992: Research of eco-economic planning and development strategy of Moso bamboo in China. China Forestry Publishing House.

He, S.Y., 1983, Chapter 8: Bamboo forest. In : Wu, Z.Y., Chinese flora. Science publishing house.

Hui, C.M., Du, H., Yang, Y.M., 1996: Bamboo Cultivation and Utilization. China Forestry Publishing House.

Keddy, P.A., 1989: Competition. Chapman and Hall.

Ministry of forestry, 1995: Chinese Forestry.

Recht, C., Wetterwald, M.F., 1988: Bambus. Ulmer, Stuttgart.

Wu, B.S., Xie, H., Tan, S., 1992: A preliminary study on the function of water and soil conservation in different community types of *Phyllostachys pubecens* forest. Journal of bamboo research, 11(4).

Wang, Q.H., Huang, B.H., 1996: Chinese Moso Bamboo. Zhejiang Science and Technology Publishing House.

He, M., 1993: The rational age distribution and growth process of Moso bamboo forest for shoot. Journal of bamboo research, 12(3).

Zhou, F.C., 1988: Research report on the stand structure of Moso bamboo. Bamboo Research, Vol.1.

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Moso culm and sheath detail, La Bambouseraie, France. Photo by Ian Connor.