



Otros

Trabajo Original

Characteristic and protection of rare and endangered *Taxus chinensis var. mairei* in the Taihang Mountains

Características y protección de la especie en peligro de extinción Taxus chinensis var. mairei en las montañas de Taihang

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Abstract

The endangered causes of *Taxus chinensis var. mairei* in the Taihang Mountains are analyzed in three sides in connection with the situation that is resources increasing attenuation.

The first is biological factors such as pollination barriers, deeply dormancy seed, cannot vegetative propagation under natural conditions, poor adaptability of seedling to environment and slow growth. The second is environmental factors such as very limited distribution environment and position in community. The third is interference of persons and other animals.

According to these factors, we provide three measures to protect *Taxus chinensis var. mairei* in three sides that protect existing resources, breed subsequent resources and find new pathway of producing taxol.

Key words:

Taxus chinensis var. mairei. Endangered plant. Protection.

Resumen

Las razones por las que la especie *Taxus chinensis var. mairei* está en peligro de extinción en las montañas de Taihang giran en torno a tres ejes distintos en relación a la disminución de ejemplares.

En primer lugar contamos con factores biológicos, como las barreras de polinización, el alto grado de inactividad de sus semillas, la imposibilidad de propagación vegetal por medios naturales, la escasa adaptación de los vástagos al medio y su lento crecimiento. El segundo factor es de carácter ambiental: medio de distribución y posición en la comunidad muy limitados. Por último, la tercera causa es la interferencia de personas y animales.

De acuerdo con estos factores, proponemos tres medidas para proteger la especie *Taxus chinensis var. mairei* con el fin de conservar los ejemplares existentes, cultivar nuevos ejemplares y encontrar nuevas vías para producir taxol.

Palabras clave:

Taxus chinensis var. mairei. Planta en peligro de extinción. Protección.

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INTRODUCTION

The *Taxus chinensis* var. *mairei* distributes in the south, east, central, southwest, Henan, Shaanxi, Shanxi and other places of China. It is a precious medicinal woody plant and is considered as important for the pharmaceutical industry as there is anti-cancer taxol in its bark, branches and leaves. *Taxus* is also a precious and rare species used as an ornamental plant because it is ever-green and beautiful (1,2). The wild *Taxus* in the Taihang Mountains is identified as *Taxus chinensis* var. *mairei* in morphology. There are *Taxus chinensis* var. *mairei* mainly in Jiyuan, Jiaozuo, Xiuwu, Huixian of Henan province, Lingchuan of Shanxi province and other places in the Taihang Mountains (4,5). The Taihang Mountains are the northern boundary of *Taxus chinensis* var. *mairei* distribution in China. In recent years, the resources of *Taxus* in the Taihang Mountains have been seriously damaged by people and it is in endangered status. The resource of *Taxus* in the Taihang Mountains should be immediately protected. There are lots of reports about the distribution, ecology of population, breed and usage of *Taxus chinensis* var. *mairei*. But the report about resource protection, introduction and domestication of *Taxus* in the Taihang Mountains is seldom reported. The endangered status of this species and its causes are discussed in this paper. The programs and strategies of introduction and domestication are also proposed based on the study carried out for years to provide a theoretical basis of this resource restoration and domestication.

OVERVIEW OF TAXUS RESOURCE IN THE TAIHANG MOUNTAINS

The *Taxus chinensis* var. *mairei* most widely distributes in *Taxus* in China. Most of them grow in the hillside, valley or banks of the streams in the middle-low mountain, in which there is sufficient water and the elevation is 750 m to 1,000 m. The soil where the *Taxus chinensis* var. *mairei* grows is mainly mountain cinnamon soil. The Taihang Mountains are the northern boundary of *Taxus chinensis* var. *mairei* distribution in China. The wild *Taxus* mainly distributes in Jiyuan, Jiaozuo, Xiuwu, Huixian of Henan province, Lingchuan of Shanxi province and other places in the Taihang Mountains. The range of *Taxus* distribution in the Taihang Mountains is 110°31'-114°24'E and 34°45'-36°21'N. In this area, the highest peak is 1,929.6 m in elevation, the hills are very steep, with slopes above 30°, and there are many cliffs and deep canyons. There is thin soil and exposed stone in this area. The average temperature is about 13 °C in a year, 4 °C in the coldest month or 20 °C in July, and the lowest temperature is -20 °C in a year. The forest-free period is about 200 d. The annual accumulated temperature is about 2,500-2,990 °C. The rainfall is about 610.9 mm in a year. The PH of the soil is about 6.1 (4,5). The *Taxus* in the Taihang Mountains in Shanxi distributes mainly in Mohe town, Duohuo town and Mgedang town of Liuquan town in Linchuan county, Huguangqiao town and Xiaotihe town of Huguang county, and so on. Among these places, the *Taxus* densely distributes in Mohe town and Huguangqiao town (6,7).

In the past, the *Taxus chinensis* var. *mairei* very generally distributed in the Taihang Mountains and was called as Zi Bai. There are four places named as this name in Jiyuan, namely Zi Bai Zhuang in Wangwu Mountain, Zi Bai Gou beside the river Manghe, Zi Bai Tan and Zi Bai Po, beside the river Qinhe. These data show the number and distribution of *Taxus* in the Taihang Mountains (4,5).

POPULATION DISTRIBUTION OF TAXUS IN THE TAIHANG MOUNTAINS

HEILONGGOU POPULATION IN JIYUAN

There are about 72 plants disperse in the bottom about 800 m in long in the northwest of Heilonggou, which is located in Huanglianshu forest in Jiyuan. These plants are all above 30 years old. The oldest one is more than 300 years in age, and its diameter at breast height is 58 cm. This *Taxus* population belongs to recession type, which lies in the second or third layer in arboreal. Most of these plants grow poorly, have weak competitiveness and renew slowly (8,9).

XIGOU TAXUS POPULATION IN HUIXIAN

There is a *Taxus* population in the Xigou valley about 10 km in long at the junction of Huixian city and Xiuwu county. The valley appears as northwest to southwest trend. The *Taxus* distributes on both river banks at the bottom and on the second level. These *Taxus* grow well. There are all kinds of *Taxus* in age. The biggest *Taxus* is about 10 m in high and 42 cm in diameter at breast height. The youngest one is about 10 cm in high. There are lots of seedlings in there. This *Taxus* population belongs to the developmental type, whose age composition is reasonable and renew ability is fine (8,9). This *Taxus* population is the biggest in the area, the largest in number and the best in growth in the Henan province. But some plants have been cut in recent years.

BALIGOU TAXUS POPULATION IN HUIXIAN

Baligou is a famous scenic in Huixian. The resource of *Taxus* in Baligou was seriously damaged due to the development of tourism in recent years. *Taxus* sporadically distribute on the cliffs in Baligou, Baodugou and Xilian (8,9). The seedlings of *Taxus* have been completely dug out by local residents and tourists. The rest are all big trees above 50 years in age which grow unhealthy. This *Taxus* population will disappear unless it is protected.

HUANGWEI TAXUS POPULATION IN LINCHUAN

The *Taxus* in the south of the Taihang Mountains in Shanxi distribute mainly in Mohe town, Duohuo town and Mgedang town of Liuquan town in the Linchuan county, Huguangqiao town and

Xiaotie town of the Huguan county, and so on. Among these places, the taxus densely distributes in Mohe town and Huguan-qiao town. Here the climate is moderate, the rain is sufficient and there are lush forest and cinnamon (6,7). Most of taxus in this area grow in the hillside, valley or stream banks in the middle-low mountain, where there is sufficient water and the elevation is 750-1,000 m. There are plenty of adult plants and seedlings. The age composition of this taxus population is reasonable and stable. But several adult taxus plants have been cut and some taxus seedlings have been dug to develop tourism projects. This taxus population should be protected.

WHY IS TAXUS ENDANGERED IN THE TAIHANG MOUNTAINS?

According to our investigation, the taxus in the Taihang Mountains mainly distribute in the south. The number of taxus here is very limited and its population has been endangered. Many factors have contributed to this for a long time.

BIOLOGY FACTOR

Pollination obstacle

According to the reports, taxus seeds after 30-40 years of age and have plenty seeds only in one year every 6-7 years. Our investigation shows that most taxus in the Taihang Mountains are above 30 years old and are adults. But these taxus have very few seeds. Even there have not been seeds in many years. The pollination obstacle is a key cause for the result according to our analysis. The taxus is dioecious and has no bright flowers or fragrance. Taxus pollen is spherical, small and light, and therefore it can be carried away, so the taxus is a typical wind pollinated plant (11). Generally, wind pollinated plants in nature are characterized by focus distribution, and there few barrier in their surround. However, the hills in the Taihang Mountains are very steep, 300-1,600 m in elevation, and present three levels cliffs, with heights about 150-250 m. In this population, most wild disperse at the bottom of the valley and lie at the second or third layers in arbores. Long way of pollination, poor ventilation, hill and forest stop the pollination and fertilization of taxus. We also find in our investigation that the ratio of female plants to male ones is not coordinate. Most of the taxus of the Xigou and Heilonggou populations are female plants. Thus, the female plants lack enough pollens to pollinate normally (6,9).

Characteristic of seeds germination

Taxus chinensis var. mairei seeds have long dormancy. Seeds germinate in the third year after getting through two winters and a summer in nature (12,13). We did experiment with *Taxus chinensis var. mairei* seeds in 2004. The biological incubator and refrigerator were used in the experiment to simulate the temperature, humidity

and other ecological conditions of *Taxus chinensis var. mairei* seeds germination in the Taihang Mountains in the Henan province. Stratifications with variable temperature and hormone (GA3 + 6BA) were used also in the experiment. The accumulated ratio of germinated seeds is only 10% after half a year. The climate in wild environment is complex. The weather is dry and windy in spring in the Taihang Mountains. The humidity of the soil and the air are also low in spring. Therefore, conditions for taxus germination are not good enough and so the seeds loss their vitality because of decay. All of these hinder the development of taxus population (6-10).

Lack of vegetative propagation in nature

There are two ways for taxus to renew in nature. One is propagation by seed and another is shooting. Huang Yuqing et al. found in their investigation on *Taxus chinensis var. mairei* population in the Yuanbao Mountains, in the autonomous region of Guangxi, that there were not seedlings from seeds; most of the young plants come from the branches of trunks. The branches generate adventitious roots and the adventitious roots grow down. Thus the branch becomes a taxus tree and the population develops (14). But we did not find this phenomenon in our research on taxus in the Taihang Mountains. All of the cuttings or layering done by local workers in nature did not succeed. Cuttings with 1-2 years old branches of taxus in the Taihang Mountains done by us in our laboratory succeeded. The rooting rate was about 70% in three months after cutting. Conditions such as temperature and air and soil humidity are not good enough for taxus vegetative propagation in the Taihang Mountains. Therefore, single seed propagation of taxus in the Taihang Mountains limited the development of this population.

Characteristic of growth

We found in our investigation that young taxus are few although there are plenty of seedlings below female taxus. We think that one reason is that young plants need moist and a very appropriate surrounding, and they grow very slowly. There are ten taxus in the Huanglianshu forest in Jiyuan cultivated by workers. Their average height is about 42.5 cm, namely they grew 8.41 cm in height every year. The average diameter of their trunk is about 0.88 cm, namely they grew 1.76 mm in diameter every year. The long term of seedling and poor resistance make the risk of seedling eliminated by environment increase. Another cause is the sun. The seedling needs enough sun to ensure its normal growth (6-9). After comparing the growth of ten taxus plants on a sunny slope with those growing on a shady slope with the same diameter at breast height, we found that the taxus in the sunny slope grew better than the one growing on the shady slope. The limited environment determines the number of population in a common plant community. The slow growth of taxus and different demand on sun of taxus with different age make taxus inferior to other species in contesting for space and sun. Lots of taxus seedlings die from this situation. And the growth of taxus population is limited from development.

ENVIRONMENTAL FACTOR

Distribution location

According to the relation of species origin and systematic evolution, climate and landscape in a certain region not only play an important role in maintaining the existence and reproduction of species, but also limit largely the development of species in space, particularly of these species distributed in a limited region or endemic species. According to our investigation, the characteristic of the distribution region of taxus in the Taihang Mountains are deep and narrow valleys, continuous flow of water, widths of valley bottoms of about 100 m, widths of upper valleys only of about 200-300 m and valleys heights of about 300-400 m. The sun cannot reach easily the bottom of deep and narrow valleys and they are filled with large arbor. Therefore, the vapor in the bottom of the valley loss little and forms an environment with high air humidity and high soil humidity in the lower part of these valley. Most of the taxus grow on the shady banks of these valleys or on the second levels. We can find in literature that the taxus seed needs shady and damp surround in its dormancy, germinating and growth. But the climate in the Taihang Mountains is dry in the whole. Most of the rivers in the Taihang Mountains are seasonal and easy to stop. Therefore, the environment that can meet the needs of taxus in the Taihang Mountains is reduced. All of these limit the distribution of taxus in the Taihang Mountains (8,9).

Community characteristic

The characteristic vertical distribution of communities containing taxus in the Taihang Mountains is obvious. The large arbors such as *Sinowilsonia henryi*, *Acer mono*, *Cornus macrophylla* and *Acer davidii* are 10-15 m in height, 15-20 cm in diameter of trunk and grow well. Also, there are *Hovenia acerba*, *Diospyros lotus*, *Cerasus tomentosa*, *Cornus officinalis*, *Fraxinus chinensis*, and *Carpinus cordata*, among others, in the community. The rate of young trees and adult trees of these arbors is reasonable in the community. Large adult trees are big, grow well, reproduce rapidly and have powerful competitiveness. Therefore they take the dominance in the population competition and community succession (8,9). *Taxus chinensis* var. *mairei* lies in the second or third layers in arborens in the community. The sun they can receive is limited. Although the literature shows that taxus is shade and slow-growth botany, the limited sun and temperature are threatening the taxus growth according to our investigation. The taxus with ages between 30 and 50 years growing in shady areas are 3-5 m in height and 9-15 cm in diameter at breast height. Their branches are few and scattered. They grow weakly with little increment on new branches. Their flower buds cannot develop normally and so their reproduction is seriously affected. All of these show that the composition of forest and the vertical location of taxus in community seriously affect the development of taxus population.

INTERFERENCE BY MAN AND OTHER FACTORS

Taxus was formerly unknown by people in the Taihang Mountains in the cities of Huixian and Jiyuan and it was often taken as hardwood cut as stick or firewood. Recently, people is gradually getting familiar with its medicinal and economical value, which causes taxus seedlings are dug to be sold or planted in courtyards as ornamental plants (3,15). But people did not know the habits of taxus, so the survival rate of taxus was very low. In addition, cultivation and management procedures did not suit taxus. Therefore, most of the taxus seedlings dug died. Otherwise, a large number of taxus seedlings are trampled and grazed by cows and sheep when grazing in the forest in which taxus grow. Grazing affects the renewal of taxus population seriously (16). The mature fruit of the taxus is red and sweet. Birds and other animals like to eat it. Although it was reported that seeds excreted by bird could germinate easily, seeds germination is affected by the kind of bird and the surrounding. Moreover, the seed structure is damaged by the animal during grazing. Therefore, the renewal of taxus in the Taihang Mountains is affected when birds or other animals eat its seeds.

PROTECTION METHOD

Due to the endanger status of taxus in the Taihang Mountains and its causes, we propose the following measures to effectively protect the precious taxus resource.

PROTECTING EXISTING TAXUS RESOURCES IN NATURE

First, local government should give great importance to the protection of taxus resource, formulate operational policies to protect taxus resources and strengthen the force to attack illegal logging, cutting taxus and other crimes. Second, the local government should establish the record of taxus resources based on the existing resource investigation and assign the protection duty to each person (16,17). Third, the local administration should implement measures appropriately to manage taxus resource, such as artificial pollination, grafting female branches on male branches, reasonable trim and thinning other arbors. These actions can provide good surrounding for taxus and promote its growth.

STRENGTHEN THE STUDY ON SOME FIELDS SUCH AS TAXUS BIOLOGY, TAXUS PHYSIOLOGY OR TAXUS ECOLOGY AND BREED SUBSEQUENT TAXUS RESOURCE

The local forestry management should cooperate with colleges or research institutes to study on some fields such as taxus biology, taxus physiology or taxus ecology to reveal its growth mech-

anisms and provide cultivation methods (17). These studies can instruct nursery or cultivate taxus to implement the protection of taxus in location or in other places and quickly breed subsequent taxus resource.

STUDY THE NEW WAY TO PRODUCE TAXOL

The taxus grows slowly and its resource is rare. The low content of taxol in taxus contradicts the increase of requirement on taxol. Reference the research progress on taxus, we should study the efficient, stable and easy way to produce taxol by modern biotechnology taxus cell culture, taxus tissue culture, fungi ferment or genetic engineering (18). With this we can solve the problem of taxol source shortage, protect, maintain and restore taxus resource.

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