Study on Biology and Ecology of Rare Tree Acer miaotaiense

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Abstract: Acer miaotaiense is a third-grade nationally protected plant in China. It was originally recorded as sporadically distributed in a few areas of the western section of the Qin ling Mountains. In recent years, a wild population of Acer miaotaiense was discovered for the first time in the Fu Niu Mountains of Henan Province. This discovery has refined and corrected the delineation of the distribution range of this species in China over the past half-century, and it is of great significance for research on its origin, resource protection, and cultivation techniques. The morphological characteristics and biological traits of Acer miaotaiense were observed and described, and its wild populations were investigated. The results show that the species has stringent habitat requirements. Although it is one of the dominant species in the surveyed community, its age structure is extremely incomplete, and the population shows a trend of gradual decline. This paper also explores the reasons for the endangerment of Acer miaotaiense and proposes conservation strategies.

Keywords: Acer miaotaiense, Biological characteristics, Ecological characteristics

1. Introduction

Acer miaotaiense P. C. T soong, a species of the genus Acer in the family Sapindaceae, was discovered and named by the senior Chinese botanist Mr. Zhong Bu Qiu in 1954.The species was named after its type specimen which was collected from Miao tai, in Bao County, Shaanxi Province, and is also known as Bao Acer[1].Original records indicate that the species is sporadically distributed in the middle and western sections of the Qin ling Mountains in Shaanxi and Gansu provinces. It is found in Ning Qiang, Bao County, Feng County, Foping, Mei County, and Tai bai in Shaanxi [2], and Tian shui, Long nan, and Cheng County in Gansu [3]. It is a unique species to the Qin ling-Bashan region of China. Due to its limited distribution and small population size, the species is considered endangered and has been listed as a third-grade nationally protected plant in China [4]. The species is also listed as Vulnerable in the Red Data Book of Chinese Plants [5].

In August 2012, the author discovered a wild population of Acer miaotaiense for the first time in Luan Chuan County, Funiu Mountains, Henan Province. The discovery of the wild population of Acer miaotaiense in Henan not only enriched the rare plant resources and biodiversity of Henan Province but also refined and corrected the delineation of the species' distribution range in China over the past half-century. This discovery is of great significance for research on the origin, resource protection, and cultivation techniques of Acer miaotaiense. Over the past few years, the author and his research team have continuously studied the distribution, community characteristics, and artificial propagation and cultivation techniques of Acer miaotaiense in Henan.

2. Morphological characteristics

Acer miaotaiense is a deciduous tree, growing up to 20–25 meters in height. The bark is light gray and slightly rough. The young branches are nearly cylindrical, with the current year's growth being purplish-brown and glabrous(hairless), while older branches are gray with light yellow lenticels (small openings in the bark) that are nearly elliptical in shape. The leaves are papery, broadly ovate in appearance, measuring 7–9 cm in length and 6–8 cm in width. The base of the leaf is cordate(heart-shaped) or nearly so, rarely truncate, and the leaf is usually 3–5 lobed. The lobes are ovate with short, sharp tips, and the edges

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are slightly undulate(wavy). The sinuses(indentations)between the lobes are rounded. The upper surface of the leaf is dark green and glabrous, while the lower surface is pale green with short, soft hairs, especially dense along the veins. The petiole (leaf stalk) is slender,6–7 cm long, with a swollen base and is also glabrous. The tree has both male and bisexual flowers on the same plant. The flowers are borne in terminal racemose-paniculate inflorescences(clusters),4–4.5 cm long. The peduncle (main stalk of the inflorescence) is 0.5–0.7 cm long, and the individual flower stalks are 4–6 mm long. The flowers are yellowish-green, with 5 sepals,5 petals,8 stamens (male reproductive parts) with yellow anthers (pollen-bearing part of the stamen), and a nearly circular, wavy-edged,5-lobed disc [6]. The fruiting inflorescence is paniculate, about 5 cm long including the 8–10 mm long peduncle, and is glabrous. The fruit stalks are slender, about 3 cm long. The samara (winged fruit) is flat, about 8 mm in both length and width, densely covered with yellowish down. The wings are oblong,8–9 mm wide, and together with the samara, they are about 2.5 cm long and spread nearly horizontally. The flowering period is in May, and the fruiting period is in September [7].

The genus Acer is a large group of woody plants, with about 200 species worldwide, and over 150 species are naturally distributed in China alone [8]. The distinguishing features of the various species of Acer mainly include leaves, flowers, and fruits. In terms of morphology, Acer miaotaiense is most similar to Acer yanjuechi within the genus, but it is very distinct from other species, mainly in the following aspects: ① Branches and trunk: The first-year branches are green turning to reddish-brown. The second-year branches have bark that initially constricts inward into six longitudinal grooves, which then gradually become corky and raised. This is most evident in young plants and is similar to the introduced species Acer campestre. The bark of the main trunk of mature trees is corky, soft to the touch, and flakes off in patches. When touched, it feels as soft and warm as the bark of Meliosma veitchiorum. ② Leaves: The leaves are usually 3–5 lobed, with deep, ovate-triangular lobes and slightly wavy edges. The sinuses between the lobes are rounded, and the overall shape is somewhat shoulder-like [9]. The leaf lobes generally have three main pairs, with considerable variability in lobe depth and the presence of smaller lobes, making it the most distinctive leaf shape in the genus. ③ Fruits: The samaras are flat, about 8 mm in both length and width, densely covered with yellowish down. The fruit skin is woody, hard, and light gray. The seeds are disc-shaped, flattened, with a diameter of about 0.4 mm, and have a reddish-brown, shiny seed coat.

3. Biological characteristics

3.1. Phenological observations of acer Miaotaiense

From 2013 to 2015, the phenological periods of wild Acer miaotaiense plants were continuously observed and recorded in Lao Jie ling, Luan Chuan County, for three years. These observations were compared with the phenological performance of cultivated Acer miaotaiense plants at the Ru Zhou base, where the species had been introduced.

In its native habitat in the Funiu Mountains of Henan, the phenological periods of Acer miaotaiense are as follows: bud break occurs from March 30 to April 10;leaf expansion from April 11 to 25;bud appearance from April 15 to 25;flowering from April 26 to May 10;fruit maturation from September 15 to 30;the beginning of leaf fall from September 15 to 20;and complete leaf fall from September 21 to October 5.The entire growing season, from bud break to complete leaf fall, lasts 170–180 days.

Under artificial cultivation conditions at the Ruzhou base, the phenological periods of young Acer miaotaiense trees are as follows: bud break from March 5 to 13; leaf expansion from March 14 to 25; the beginning of leaf fall from October 25 to November 3; and complete leaf fall from November 8 to 18.

Comparing the native habitat with the introduction site, it can be seen that when the altitude is reduced from 1,400 meters to 200 meters, the budding period of the trees is advanced by 25–28 days, the complete leaf fall period is delayed by 44–48 days, and the entire growing season is extended by more than two months.

3.2. Biological characteristics of acer miaotaiense

Acer miaotaiense is a shade-tolerant tree species. Seedlings and young plants can grow normally under full sunlight in low-altitude plain areas, and no leaf scorching or sunburn was observed during the summer.

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Mature trees grow vigorously at the forest edge and under full sunlight, producing abundant fruit, but they cannot bear fruit normally within the forest. The species prefers cool and humid climatic conditions. In the Funiu Mountains of Henan, it can withstand extreme winter low temperatures of-20℃and does not favor dry and hot climates. It has a strong adaptability to soil, preferring deep, fertile, and moist acidic soils but can also adapt well to neutral and slightly alkaline soils. Under artificial cultivation, the seedling stage grows relatively quickly, while the growth rate of mature trees is moderate. In the natural state, the seed viability rate is less than 10%, and its sexual reproduction ability is weak. However, the species has a strong ability to sprout and form branches, and wild plants are often seen to renew themselves through suckering.

4. Ecological characteristics

4.1. Natural distribution area environment

Surveys have found that Acer miaotaiense is mainly distributed in the mid-mountain area between 1,300 and 1,600 meters on the north slope of the Fu Niu Mountains. In terms of topography and geomorphology, it mainly grows on the sides of valleys on shady and semi-sunny slopes, at the bottom of enclosed valleys, and in the middle and lower parts of slopes. This area is located in the transitional zone from the north subtropical to the warm temperate zone and has a continental monsoon climate[10].The average annual temperature is 12.2℃,the average temperature in January is-0.8℃,the average temperature in July is 24.2℃,and the extreme minimum temperature in winter is below-20℃.The average annual rainfall is 880 mm, the average annual sunshine duration is 2,134.7 hours, the frost-free period is 200 days, and the average annual relative humidity is 80%.

The bedrock in the distribution area of Acer miaotaiense is granite, which is relatively difficult to weather. The soil is a kind of brown soil, and the parent material of the soil is the slope and residual materials weathered from granite, with a pH value of around 6.0 and a sandy loam texture. The soil layer is 50–100 cm thick, and the soil profile configuration is as follows: the litter layer is 5–10 cm thick; the humus layer is 10–20 cm thick and dark brown; the middle layers are the leaching and illuviation layers, which are brown to yellowish-brown; and the underlying layer is the bedrock.

4.2. Community characteristics

The typical zonal vegetation of the mid-mountain section on the north slope of the Fu Niu Mountains is the warm temperate deciduous broadleaf forest, of which Acer miaotaiense is a component. Since the first discovery of the natural distribution of Acer miaotaiense in the Fu Niu Mountains, the author has conducted surveys in similar ecological regions, including the north and south slopes of the Fu Niu Mountains in the eastern section of the Qin Ling Mountains, Xiong' er Mountains, Wai Fang Mountains, and Xiao Qin ling Mountains, more than 20 times over the past few years, and has found more than 10 distribution sites of Acer miaotaiense. A relatively typical distribution site on the north slope of the Fu Niu Mountains in Luan Chuan County was selected for community investigation.

4.2.1. Community habitat

The distribution site is located in the middle part of the third valley to the east of the saddle of Lao Jie ling in the Lin zi Kou Forest Area of Long-Yu-bay Forestry Farm on the north slope of the Fu Niu Mountains. The valley runs in a north-south direction. The geographical coordinates are 33°40′57.24″N,111°42′12.40″E, at an altitude of 1,460 meters. It is situated in the middle of the valley, with a slope of 15°.The alluvial deposit is thick, consisting of a mixture of large stones, gravel, and sandy soil, with a rock exposure rate of 30%. The plot area is 20 m×30 m.

This community is one of the most concentrated growth sites of Acer miaotaiense discovered in recent years.

4.2.2. Community plant composition

According to the survey and statistical results, he plot (600 m²) contains a total of 36 species from 31 genera and 25 families. mong them, he arbor layer consists of 12 species and 33 individuals, including 15 individuals of Acer miaotaiense with a DBH(diameter at breast height)of 5.8–33.3 cm and a height of 5–14.5 m;3 individuals of Dipteronia sinensis with a DBH of 10–18.5 cm and a height of 8–12 m;2 individuals

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of Carpinus fargesiana with a DBH of 15 cm and a height of 8 m;2 individuals of Celtis bungeana with a DBH of 11 cm and 17.5 cm and a height of 8–9 m;2 individuals of Juglans cathayensis with a DBH of 13.5 cm and 40 cm and a height of 10–12 m;1 individual of Staphylea holocarpa with a DBH of 14 cm and a height of 8 m;1 individual of Cerasus serrulata with a DBH of 20 cm and a height of 8 m;1 individual of Acer davidii with a DBH of 12.5 cm and a height of 9 m;1 individual of Acer tsinglingense with a DBH of 20.2 cm and a height of 11 m;2 individuals of Quercus aliena with a DBH of 23 cm and 28 cm and a height of 12 m each;2 individuals of Padus racemosa with a DBH of 7.5 cm and 10 cm and a height of 5–7 m; and 1 individual of Euptelea pleiosperma with a DBH of 11 cm and a height of 7 m.

The shrub layer consists of 12 species, including saplings or suppressed trees of Dipteronia sinensis, Juglans cathayensis, Acer tsinglingense, Acer davidii, and Staphylea holocarpa from the arbor layer, as well as saplings or young trees of Alangium Chinense and Toxicodendron vernicifluum. Other species include Sambucus williamsii, Deutzia grandiflora, Euonymus alatus, Acanthopanax stenophyllus, and A. senticosus.

The herb layer contains 15 species, namely Coniogramme intermedia, Tribus dryopterideae, Pteridium aquilinum, Urtica fissa, Laportea bulbifera, Laportea macrostachya, Parasenecio forrestii, Rodgersia aesculifolia, Phlomis umbrosa, Panax japonica, Physalis alkekengi, Glechoma longituba, Smilax riparia, Geranium sibiricum, and Impatiens noli-tangere, with shade-loving plants being dominant.

The interlayer vegetation in the forest is not well developed, with only one individual of Celastrus hypoleucus and three clumps of Euonymus fortunei observed.

4.2.3. Vertical structure of the community

The vertical structure of a community, which refers to the stratification in terms of height, reflects the spatial arrangement of plants within a specific space in the community [11]. The Acer miaotaiense community is primarily divided into three layers: the arbor layer, the shrub layer, and the herb layer. The arbor layer is the dominant layer of the community, while the shrub and herb layers are secondary. The trees in the arbor layer range in height from 5 to 15 meters, with a DBH (diameter at breast height) of 5.8–33.3 cm and a canopy closure of 0.80. This layer can be further divided into two sublayers. The first sublayer, with a height of 8–15 meters and a canopy closure of 0.7, consists of 26 individuals from 9 species. The second sublayer, with a height of 5–8 meters and a canopy closure of 0.3, includes 7 individuals from 3 species. Among the arbor layer, Acer miaotaiense is one of the dominant species.

The shrub layer has a height ranging from 0.3 to 5 meters and a coverage of 50%, with young trees of Sambucus williamsii(elderberry)and Staphylea holocarpa (bladder nut) being the dominant species. The distribution of the shrub layer is uneven throughout the community. In particular, the coverage is greater than 80%near the valley bottom, while it is only about 20%on the mid-slope due to the dense distribution of the arbor layer.

The herb layer is not well developed and only grows in patches under several forest gaps near the valley, with sporadic distribution elsewhere under the forest canopy. It is less than 0.3 meters in height and has a cover of about 20%, with ferns and plants from the Urticaceae family being the dominant species.

4.2.4. Importance value analysis of acer miaotaiense in the community

The importance value is a comprehensive numerical measure that indicates the relative importance of different plants in a community. It is an important index for measuring the dominance of plant populations in a community and can accurately reveal the ecological adaptability of each plant and its position and role in the community [12]. Based on the survey and statistical results, the importance values of each tree species in the arbor layer of the Acer miaotaiense community were calculated separately (Table 1).

Table 1 Importance Values of Tree Species in the Arbor Layer of the Acer miaotaiense Community

Species	Relative Abundance/%	Relative Frequency/%	Relative Dominance/%	Importance Value	Species	Relative Abundance/%	Relative Frequency/%	Relative Dominance/%	Importance Value
Temple	45.4	30.7	43.2	119.3	Wild	3.0	4.3	3.7	11.0

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Maple					Cherry				
Bird Cherry	6.1	4.3	1.5	11.9	Acer davidii	3.0	4.3	1.5	8.8
Carpinus fargesiana	6.1	8.7	2.7	17.5	Euptelea pleiosperma	3.0	4.3	1.1	8.4
Dipteronia sinensis	9.1	8.7	7.1	24.9	Acer tsinglingense	3.0	4.3	3.8	11.1
Celtis bungeana	6.1	8.7	4.6	19.4	Quercus aliena	6.1	8.7	12.3	27.3
Juglans cathayensis	6.1	8.7	16.7	31.5	Staphylea holocarpa	3.0	4.3	1.8	9.1

As can be seen from Table 1, in this community, the importance value of Acer miaotaiense reaches 119.3, making it the dominant species in the community. In addition to Acer miaotaiense, although there are only a few individuals of Juglans cathayensis (wild walnut), Quercus variabilis (Chinese cork oak), and Dipteronia sinensis (Chinese dove tree) in the arbor layer, with 2,2, and 3 individuals respectively, their importance values reach 27.3,31.5, and 24.9 respectively due to their larger DBH (diameter at breast height),making them the secondary dominant species in the community.

4.2.5. Population structure characteristics of acer miaotaiense

For perennial trees and shrubs, the use of static life tables to analyze population dynamic structure characteristics is a common method [13]. Based on the community survey data, the population of Acer miaotaiense was analyzed using diameter classes to represent age classes, and the static life table of the Acer miaotaiense population in the Funiu Mountains was listed (Table 2). The classification criteria are based on a combination of DBH (diameter at breast height) and tree height, dividing individuals of different ages into five categories: seedlings(I),with a height of less than 33 cm; saplings (II),with a height of more than 33 cm and a DBH of less than 2.5 cm; pole trees(III),with a DBH of 2.5–7.5 cm; mature trees(IV),with a DBH of 7.5–22.5 cm; and large trees(V),with a DBH of more than 22.5 cm.

Table 2 Static Life Table of the Acer miaotaiense Population in the Fu Niu Mountains

Diameter	Number of Existing Individuals	Percentage (%)	Diameter Class	Number of Existing Individuals	Percentage
I	0	0	IV	9	60
II	0	0	V	3	20
III	3	20	Total	15	100.0

The age structure of a population reflects the patterns of change in the population over time and space, thereby indicating the population dynamics and the trend of community succession [14]. The age structure of plant populations is commonly divided into three types: increasing, stable, and declining. In the age structure of a population, the presence of a complete range of age classes and a large number of seedlings is considered indicative of a stable population.

From the static life table of the Acer miaotaiense population, it can be seen that among the existing 15 individuals of this population, the majority are in the IV class, accounting for 60%; those in the III and V classes follow, each making up 20%; while there are no individuals in the I and II classes, which represent seedlings and saplings. This indicates that the age structure of the Acer miaotaiense population is highly incomplete and is a typical declining population. The absence of young individuals suggests that natural regeneration is hindered. Moreover, the small number of large-sized individuals is mainly due to human activities during the community's development. The community is likely a secondary forest that regenerated

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naturally after logging in the 1950s and 1960s. Therefore, from the perspective of long-term community succession, the Acer miaotaiense population exhibits a dynamic trend of gradual decline.

5. Discussion on the reasons for Endangermen

5.1. Intrinsic phylogenetic reasons

During the phylogenetic development of Acer miaotaiense, the species' inherent genetic characteristics and the long-term natural selection of its habitat have led to poor ecological adaptability, a narrow range of suitable habitats, and a decline in natural reproductive capacity. These characteristics are the main intrinsic reasons for its endangered status [15]. Acer miaotaiense has strict environmental requirements, which limit its population expansion and put it at a disadvantage in the struggle for survival. From the commonalities of the 13 distribution sites discovered by the author in the Fu Niu Mountains of Henan, all sites are located at altitudes between 1,300 and 1,600 meters, on the valley floors or lower parts of shady or semi-sunny slopes. The soil layer under the forest is relatively thick, with abundant litter and humus layers, and good water and nutrient conditions. This sufficiently illustrates the stringent habitat requirements of Acer miaotaiense. According to studies by Cao Xiaoyong et al. [16-17], during the sexual reproduction of Acer miaotaiense, the formation of sterile pollen and ovules leads to the production of a large number of empty and shriveled seeds. Additionally, the long dormancy period of the seeds and the stringent germination conditions make it difficult to expand the population size through natural seed reproduction.

5.2. The impact of human activities

Human economic activities are an important external cause of the endangerment of Acer miaotaiense [18]. This is first manifested in the destruction of natural vegetation and changes in plant habitats caused by or about to be caused by various economic development activities, such as road construction, tourism development, and mineral exploitation, all of which will directly or indirectly lead to changes in the surrounding habitats. For example, in the Acer miaotaiense distribution area of Lao Jie ling in Luan Chuan, the original G311 National Highway traversed the main ridge of the Fu Niu Mountains through a series of switchbacks. Multiple Acer miaotaiense populations were located within 30 meters of the original roadside, with the nearest ones just below the highway. At the bottom of the valley directly beneath the highway, there were many large rocks piled up around the remaining Acer miaotaiense trees, undoubtedly a byproduct of the mountain excavation during road construction. Moreover, with convenient transportation, it is conceivable that the forest species in this area were severely logged in the 1950s and 1960s. Additionally, the construction of a tourist area on the north and south slopes of the area poses a challenge to the future survival of Acer miaotaiense. Logging, destruction, and illegal excavation of Acer miaotaiense also occur due to the acquisition of timber, seed collection, or the “big tree transplanting” practice.

6. Conservation strategies

6.1. In-Situ conservation

In the Fu Niu Mountains of Henan Province, at the distribution sites of Acer miaotaiense, efforts should be made to establish nature reserves where they do not yet exist. For those areas that are already designated as nature reserves, targeted management and nurturing of the relevant communities should be implemented. It is essential not only to ensure the normal growth of Acer miaotaiense individuals but also to maintain the normal growth of other species in the same habitat. Necessary measures should be taken to protect their living environment and gradually restore it to its original natural state[19].

6.2. Ex-Situ conservation

Ex-situ conservation is an important complementary measure to in-situ conservation of plant diversity [20]. Field surveys have found that the number of Acer miaotaiense individuals at many distribution sites has become extremely scarce, with some sites having only one large tree. Moreover, in many communities, no fruiting mother trees have been observed, indicating that natural regeneration is no longer possible under the current habitat conditions. Therefore, ex-situ conservation is highly necessary.

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6.3. Enhancing research on introduction, domestication, and cultivation

Firstly, seed propagation and asexual reproduction methods should be used to explore the seedling propagation techniques of Acer miaotaiense and gradually achieve large-scale propagation. Secondly, re-introduction should be carried out in the original habitat or in forest farms or nature reserves with similar ecological types in various counties of the Fu Niu Mountains. After that, the techniques should be demonstrated and promoted throughout the province to rapidly increase the population size and quickly remove the species from the endangered status.

7. Conclusion

To effectively protect this rare tree species, we have proposed a range of conservation strategies, including in-situ conservation, ex-situ conservation, and enhancing research on introduction, domestication, and artificial cultivation techniques. The implementation of these measures will not only help protect the species Acer miaotaiense but also promote the recovery of its ecological environment and the conservation of biodiversity. We call on all sectors of society to work together, enhance their awareness of protecting Acer miaotaiense, and actively participate in conservation actions to create favorable conditions for the survival and reproduction of this rare tree species. Only in this way can we ensure the continuation of this precious natural resource and leave more ecological wealth for future generations.

8. References

[1] Li Ang, Ge Song. Advances in plant conservation genetics[J].Biodiversity Science, 2002, 10(1):61-71.

[2] Di Wei zhong, Yu Bei yin. The First Batch of National Rare and Endangered Plants in Shaanxi Province[M]. Xi'an: Northwest University Press,1989.

[3] Zhao Jianlin. Spatial analysis of Acer miaotaiense populations in the western Qin ling Mountains based on GPS and GIS[J]. Journal of Gansu Agricultural University,2006,41(6):71-74.

[4] Institute of Botany, Chinese Academy of Sciences. Rare and Endangered Plants in China[M]. Shang Hai: Shanghai Educational Publishing House,1989:73.

[5] Wang Song, Xie Yan. China Species Red Data Book[M]. Beijing: Higher Education Press,2004:27-44.

[6] Yao De sheng, Ren Ji wen, Chen Xi Cang. Supplementary notes on the morphological characteristics of Acer miaotaiense[J]. Bulletin of Botanical Research,2004,24(2):135-136.

[7] Fang Wen Pei. Flora of China: Volume 46[M]. Beijing: Science Press,1981:66-273.

[8] Xu Ting Zhi. The geographical distribution of the Aceraceae[J]. Yun nan Botanical Research,1996,18(1):43-50.

[9] Li Hongjie, Cui Wei, L v Zhipeng. Study on the cutting propagation and ornamental characteristics of the rare tree species Acer miaotaiense[J]. Journal of Northwest Forestry University, 2009, 24(1):78-81.

[10] Shi Ziming. Natural conditions and natural resources of Henan[M]. Zheng Zhou: Henan Science and Technology Publishing House,1983:48-61.

[11] Han Yuping, Li Xuemei, Liu Yucheng. The relationship between vertical structure and species diversity in the secondary succession sequence of Jin Yun Mountain forest communities[J]. Journal of Southwest Agricultural University,1999,21(4):391-396.

[12] Qu Zhong Xiang, Wu Yushu, Wang Huan xiao, et al. Plant Ecology[M].2nd ed. Beijing: Higher Education Press,1983:25-30.

[13] Zhong Zhang Cheng. Achievements and prospects of plant population ecology research in China[J]. Acta Ecologica Sinica,1992,11(1):1-8.

[14] Zhang Yuxin, Ma Kemin, Qi Jian, et al. Population structure and spatial distribution of Quercus wutaishanica along an altitudinal gradient in Dong ling Shan, Beijing[J]. Acta Ecologica Sinica,2009,29(6):2789-2796.

[15] Cao Xiao Yong, Chen Kai. Discussion on the endangered reasons of Acer miaotaiense[J]. Acta Botanica Boreali-Occidentalia Sinica,1996,16(5):12-15.

https://doi.org/10.62852/csa/2025/173

[16] Cao Xiaoyong, Chen Kai. Reproductive biology of the endangered plant Acer miaotaiense—I. Morphology and development of inflorescences and flowers[J]. Acta Botanica Boreali-Occidentalia Sinica,1997,17(5):107-111.
[17] Cao Xiao Yong. Reproductive biology of the endangered plant Acer miaotaiense—II. Development of microspores, megaspores, and gametophytes[J]. Journal of Hanzhong Normal University: Natural Science,1999,17(1):50-54.
[18] Meng Qing Fa, Tian Chao yang. Introduction and Cultivation of Rare Tree Species in Henan Province[M]. Bei Jing: China Forestry Publishing House,2009:17-19.
[19] Li Shan, Yan Gui Qin, Zhao Gui fang. Population genetic structure and genetic diversity of Acer miaotaiense[J]. Journal of Northwest University: Natural Science Edition,2005,35(1):71-75.
[20] Xu Zai fu, Huang Jiayuan, Hu Hua bin, et al. A review of plant ex-situ conservation and its research in China over the past 30 years[J]. Guihaia,2008,28(6):764-774.

https://doi.org/10.62852/csa/2025/173