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Postprint: Nationally Protected Wild Plant Resources and Conservation Status in Shaanxi Province

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Abstract

Based on the 2021 edition of the National Key Protected Wild Plant Catalog and the Catalog of National Key Protected Wild Plants Distributed in Shaanxi Province, an investigation and study was conducted on the distribution characteristics and conservation status of nationally protected wild plants in Shaanxi Province. The results showed: (1) There are a total of 104 species (including infraspecific taxa) of national key protected wild plants, belonging to 38 families and 67 genera, including 3 species of lycophytes in 1 family and 1 genus, accounting for 2.88% of the total; 6 species and 2 varieties of gymnosperms in 2 families and 6 genera, accounting for 6.73%; and 85 species, 1 subspecies, and 10 varieties of angiosperms in 35 families and 60 genera, accounting for as much as 90.38%. (2) The protected plants account for approximately 18.18% of families, 5.09% of genera, and 2% of species of vascular plants in the entire province, with *Petrocosmea qinlingensis* and *Scrophularia stylosa* being endemic to Shaanxi. (3) The new catalog retains 26 species from the 1999 edition of the national key protected plants, with 78 newly added species, including 24 species formerly under provincial key protection in Shaanxi, and 54 species such as *Phalaenopsis zhejiangensis*, *Dendrobium flexicaule*, and *Paeonia rockii* that were directly listed without previous protection status, accounting for 52% of the total number of national key protected plants distributed in the province. Endangerment grade analysis shows that critically endangered (CR) accounts for 4.81%, endangered (EN) and vulnerable (VU) each account for 24.04%. (4) National key protected plants in Shaanxi Province exhibit a distribution pattern of more in the south and fewer in the north, with Zhenping County having as many as 60 species, accounting for 57.69% of the province's protected plants, and both Pingli County and Foping County having 47 species each. (5) There are a total of 249 nature reserves, wetland parks, forest parks, etc. at various levels in the province, with approximately 70 protected plant species

distributed within these protected areas, accounting for 67.31% of the total. It is recommended to conduct resource and distribution surveys and research on newly added species, especially the 54 species that previously had no protection status, update protected plant information in nature reserves and conduct dynamic monitoring, increase the construction of botanical gardens in the Loess Plateau region of Shaanxi, and provide a scientific basis for in-situ and ex-situ conservation.

Full Text

Resource and Conservation Status of National Key Protected Wild Plants in Shaanxi Province, China

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Abstract

Based on the 2021 edition of the *List of National Key Protected Wild Plants* and the *List of National Key Protected Wild Plants Distributed in Shaanxi Province*, we investigated the distribution patterns and conservation status of national key protected wild plants in Shaanxi Province. The results show that: (1) A total of 104 species (including infraspecific taxa) belonging to 67 genera and 38 families are under national protection in Shaanxi, comprising 3 lycophyte species (2.88%), 6 gymnosperm species and 2 varieties (6.73%), and 85 angiosperm species, 1 subspecies, and 10 varieties (90.38%). (2) These protected plants account for approximately 18.18% of families, 5.09% of genera, and 2% of species among all vascular plants in the province, with *Petrocosmea qinlingensis* and *Scrophularia stylosa* being endemic to Shaanxi. (3) The new list retains 26 species from the 1999 version and adds 78 species, including 24 formerly under provincial protection and 54 previously unprotected species such as *Phalaenopsis zhejiangensis*, *Dendrobium flexicaule*, and *Paeonia rockii*, representing 52% of the total. Endangerment analysis reveals that 4.81% are Critically Endangered (CR), while Endangered (EN) and Vulnerable (VU) species each account for 24.04%. (4) National key protected plants show a clear south-to-north decreasing gradient in Shaanxi, with Zhenping County hosting the maximum of 60 species (57.69% of the provincial total), followed by Pingli and Foping counties with 47 species each. (5) The province has 249 nature reserves, wetland parks, and forest parks at various levels, with approximately 70 protected plant species (67.31%) occurring within these reserves. We recommend conducting resource and distribution surveys for newly added species, particularly the 54 previously

unprotected ones, updating protected plant information in nature reserves with dynamic monitoring, and strengthening botanical garden construction in the Loess Plateau region of Shaanxi to provide scientific foundations for both in situ and ex situ conservation.

Keywords: national key protected wild plants, distribution characteristics, conservation status, Loess Plateau, Qinling-Bashan region, Shaanxi Province

The extinction of a plant species represents not only the loss of its genetic, cultural, and scientific value but can also trigger cascading extinctions of other organisms and destabilize ecosystems. Biodiversity loss constitutes one of the three major global environmental crises. On December 19, 2022, the 15th Conference of the Parties to the Convention on Biological Diversity adopted the Kunming-Montreal Global Biodiversity Framework, which establishes the overarching goal of “taking urgent action to halt and reverse biodiversity loss” by 2030, providing clear direction and priorities for global biodiversity conservation. Plant diversity represents a strategic resource related to national ecological and biological security, and its protection is crucial for advancing ecological civilization and high-quality development in China. Research on the distribution patterns, conservation status, and potential distribution areas of national key protected wild plants is essential for formulating and supporting biodiversity conservation strategies.

Shaanxi Province, located in the interior of China and spanning both the Yangtze and Yellow River basins, features the east-west oriented Qinling Mountains. Its unique geographic position creates transitional climate zones from north to south: mid-temperate, warm-temperate, and north subtropical zones. The topography includes the northern Shaanxi desert plateau, Loess Plateau, Guanzhong Basin, and Qinling-Bashan mountainous region. The highest point is Baxian Terrace on Taibai Mountain at 3,771.2 m, while the lowest is 168.6 m on the southern bank of the Han River in Baihe County. As a convergence zone for northern and southern flora, Shaanxi harbors rich wild plant resources, with 5,161 species and infraspecific taxa of wild, naturalized, and cultivated vascular plants, including 4,701 species in 1,316 genera and 209 families, plus 112 subspecies, 488 varieties, and 17 forms. The Qinling-Bashan region within Shaanxi features complex terrain, with the Qinling and Bashan Mountains representing one of 13 hotspots for national key protected plant species richness. Endangered plants are concentrated in the southeast, making this a priority area for protecting Chinese endemic plant families and genera. However, comprehensive data on resource inventories, geographic distribution patterns, and threat factors for national key protected wild plants in Shaanxi remain lacking. This study analyzes the resources and conservation status of national key protected plants in Shaanxi based on the new *List of National Key Protected Wild Plants*, providing a scientific basis for their protection and conservation strategy development.

1. Research Methods

1.1 Data Sources and Analysis

We compiled data from the *List of National Key Protected Wild Plants* (State Forestry and Grassland Administration Announcement No. 15, 2021) and the *List of National Key Protected Wild Plants Distributed in Shaanxi Province* (Shaanxi Forestry Protection [2022] No. 128), supplemented by digitized herbarium specimens from the Chinese Virtual Herbarium (CVH), *Flora of China*, *Flora of the Qinling Mountains*, *Flora of the Loess Plateau*, *Checklist of Shaanxi Vascular Plants*, *Key Protected Plants in Shaanxi*, *Native Orchids of Shaanxi*, the 2019 second national survey of key protected wild plant resources in Shaanxi, and literature from nature reserve surveys including *Plants of Giant Panda Habitat in the Qinling Mountains*, *Flora and Fauna Resources of Changqing National Nature Reserve*, *Biodiversity Research and Management of Taibai Mountain Nature Reserve*, *Comprehensive Scientific Investigation Report on Shaanxi Micang Mountain Nature Reserve*, *Biodiversity and Conservation of Shaanxi Taian Nature Reserve*, and *Plant Resources and Conservation of Shaanxi Hualongshan National Nature Reserve*. Species were verified by consulting *Flora of China* and comparing Latin names with those in the national protection list. For example, *Fagus pashanica* mentioned in original literature has been synonymized with *Fagus hayatae*.

1.2 Analytical Methods

Geographic distribution was analyzed based on species occurrence in county-level reserves. Endangerment status was assessed according to IUCN Red List Categories and Criteria (Version 3.1) and the *China Biodiversity Red List—Higher Plants* (2020). Shaanxi provincial map data were obtained from the National Geomatics Center of China (2023 edition) in WGS84 coordinate system, and distribution maps were generated using ArcGIS 10.8.

2. Results

2.1 Overview and Distribution of National Key Protected Wild Plants in Shaanxi

Following the 2021 release of the *List of National Key Protected Wild Plants*, Shaanxi revised and published its provincial list (Shaanxi Forestry Protection [2022] No. 128) containing 103 species and infraspecific taxa. Adding *Rosa chinensis* var. *spontanea* as a new provincial record, the total reaches 104 species (including infraspecific taxa) in 67 genera and 38 families, representing approximately 2.00% of species, 5.09% of genera, and 18.18% of families among all vascular plants in the province. The composition includes 3 lycophyte species (2.88%), 7 gymnosperm species (6.73%), and 94 angiosperm species (90.38%).

The list comprises 6 species, 1 subspecies, and 2 varieties under first-class national protection, including *Taxus wallichiana* var. *chinensis*, *Taxus wallichiana*

var. *mairei*, *Psathyrostachys huashanica*, *Phalaenopsis zhejiangensis*, *Dendrobium flexicaule*, *Paeonia rockii*, and *Paeonia rockii* subsp. *atava*, belonging to 5 families and 6 genera. Second-class protection covers 88 species and 10 varieties in 37 families and 63 genera, including *Huperzia chinensis*, *Abies chensiensis*, *Cypripedium taibaiense*, and *Kingdonia uniflora*. *Petrocosmea qinlingensis* and *Scrophularia stylosa* are endemic to Shaanxi.

Compared with the 1999 *List of National Key Protected Wild Plants (First Batch)*, the 2022 revised list retains 26 original species and adds 78 species (including infraspecific taxa), comprising 24 formerly under provincial protection and 54 previously unprotected species such as *Phalaenopsis zhejiangensis*, *Dendrobium flexicaule*, and *Paeonia rockii*. One species was downgraded: *Kingdonia uniflora* moved from first-class to second-class protection. Two species were removed: *Camptotheca acuminata* due to its wide distribution, large populations, and inability to distinguish wild from cultivated individuals; and *Larix taibaiensis*, which was synonymized as *Larix potaninii* var. *chinensis*, resulting in taxonomic status changes. Among the 248 species in the China Biodiversity Red List (Higher Plants) distributed in Shaanxi, 51 (20.56%) are national key protected plants, including 2 lycophytes, 4 gymnosperms, and 45 angiosperms.

Based on available data from 107 counties (districts) in Shaanxi, Zhenping County has the highest richness with 60 species (57.69% of the provincial total). Pingli and Foping counties each host 47 species (41-50 species range). Five counties—Mei County, Taibai, Yang County, Xixiang, and Zhouzhi—have 31-40 species. Four counties—Ningqiang, Liuba, Langao, and Ningshan—have 21-30 species. Twelve counties have 11-20 species, while 83 counties (77.57%) have 10 or fewer species, including 37 counties (34%) with no recorded protected plants, such as Fuping, Heyang, Jingyang, Chengcheng, Dali, Fengxiang, and Baishui [Figure 1: see original paper].

2.2 Conservation Status of National Key Protected Plants in Shaanxi

Shaanxi has 249 nature reserves, wetland parks, and forest parks at various levels, including 61 national, provincial, and municipal/county-level nature reserves. These effectively protect the native habitats of approximately 70 national key protected plant species (67.31% of the total). Protected plants such as *Taxus* species and *Davidia involucrata* show generally healthy populations with seed-bearing individuals and seedlings observed. For species like *Abies chensiensis* and *Picea neoveitchii*, over 90% of individuals occur within protected areas. However, some species including *Changnienia amoena* and *Citrus cavaleriei* have low in-situ protection ratios. For *Ulmus elongata* and *Petrocosmea qinlingensis* occurring outside reserves, small conservation plots have been established, and scattered old-growth trees are fenced and tagged for protection.

For species with harsh habitats unfavorable for natural regeneration or facing frequent natural disasters, ex-situ conservation should be prioritized. Xi'an Botanical Garden and Qinling National Botanical Garden have achieved notable

success, with over 70 endangered species conserved at Xi'an Botanical Garden. Propagation techniques including seed germination, cutting, and tissue culture have been developed for species such as *Acer miaotaiense*, *Pleione bulbocodioides*, and *Paeonia rockii*, producing nearly 4,000 cultivated individuals. *Echinocodon draco* has been successfully introduced, and seed germination rates of *Saruma henryi* have reached 98% through sand storage treatment. Qinling National Botanical Garden employs multiple conservation methods including living plant cultivation, seed propagation, cutting, layering, and tissue culture, successfully introducing 40 national key protected species such as *Paeonia rockii*, *Taxus* species, and *Davidia involucrata*. For Qinling endemics, habitat simulation is emphasized—for example, *Psathyrostachys huashanica* conservation involves creating conditions with strong light, large diurnal temperature variation, low water content, and high inorganic salt concentrations to maintain stable stress resistance inheritance. Habitat-limited species are conserved through introduction and domestication, such as *Elaeagnus mollis* for arid regions. For species with reproductive barriers, key challenges are addressed: seeds of *Davidia involucrata* and *Taxus* species with thick seed coats and inhibitors achieve 70-80% germination after one-year sand storage, while *Bletilla striata* with underdeveloped seeds is primarily propagated through division.

Research on artificial propagation and reintroduction is progressing for species such as *Petrocosmea qinlingensis*, *Ulmus elongata*, and *Psathyrostachys huashanica*. Jiang et al. studied the endangerment mechanisms of *P. qinlingensis*, using rapid propagation to produce numerous seedlings and establishing three reintroduction sites in Hantai District's Baohe Forest Park with similar topography, humidity, light, and soil conditions to native habitats, finding that microclimate investigation and site selection are critical success factors. For *U. elongata*, reintroduction trials selected sites similar to native habitats, transplanting approximately 2,100 one-year-old seedlings across 10 sites including Niutoudian, Zengjia, Shangzhu, and Baxian stations within Hualongshan Nature Reserve, with survival and growth varying by elevation, habitat conditions, and rodent damage.

2.3 Endangerment Status and Threat Factors

The IUCN Red List Categories and Criteria (2002) and *China Biodiversity Red List—Higher Plants* (2020) provide clear, objective frameworks for assessing endangerment status and identifying threat factors, which are essential for effective conservation measures. Among protected plants in Shaanxi, five species are Critically Endangered (CR: *Dendrobium flexicaule*, *Dendrobium catenatum*, *Psathyrostachys huashanica*, *Petrocosmea qinlingensis*, *Echinocodon draco*; 4.81%), 25 are Endangered (EN: including *Paeonia rockii* and *Saruma henryi*; 24.04%), and 25 are Vulnerable (VU: including *Taxus* species, *Picea neoveitchii*, *Torreya fargesii*; 24.04%). Additionally, 22 species are Near Threatened (NT; 21.15%), 24 are Least Concern (LC; 23.08%), and three are Data Deficient (DD: *Huperzia appressa*, *Amentotaxus argotaenia*, *Citrus cavaleriei*; 2.88%) [Figure 2:

see original paper].

Primary threat factors include overexploitation, low genetic diversity, extremely small populations, reproductive failure, habitat limitation, and human disturbance. (1) **Direct harvesting:** Species such as *Taxus* species, *Paeonia rockii*, *Amentotaxus argotaenia*, *Torreya fargesii*, *Picea neveitchii*, *Abies chensiensis*, *Pseudotsuga sinensis*, *Houpoea officinalis*, *Liriodendron chinense*, *Cinnamomum longepaniculatum*, *Dendrobium catenatum*, *Zelkova schneideriana*, *Emmenopterys henryi*, and *Gastrodia elata* have experienced population declines due to historical logging and collection. (2) **Low genetic diversity:** Factors affecting genetic diversity include breeding systems, genetic drift, mutation, gene flow, and external factors like population isolation and habitat fragmentation caused by environmental changes and human disturbance. Species such as *Paris polyphylla*, *Kingdonia uniflora*, *Petrocosmea qinlingensis*, and *Abies chensiensis* show low genetic diversity; *K. uniflora*'s reliance on clonal reproduction via underground rhizomes is a primary cause. (3) **Extremely small, scattered populations:** Species like *Changnienia amoena*, *Houpoea officinalis*, *Coptis chinensis*, and *Ulmus elongata* have very few individuals. *C. amoena*, a Chinese endemic monotypic genus, was first collected in Pingli County during the 1970 Shaanxi herbal medicine survey, but subsequent surveys at the original location failed to relocate it until 11 individuals were rediscovered in Zengjiaba, Hualongshan, in 2012. *U. elongata* occurs only at Xiaohe in Zhenping County, with three mature trees, eight saplings, and three seedlings. *Picea neveitchii* is restricted to a few locations on the southern slopes of the Qinling and Bashan Mountains, with only 23 individuals found across three sites. (4) **Reproductive failure and poor natural regeneration:** Species such as *Abies chensiensis*, *Kingdonia uniflora*, *Ormosia hosiei*, and *Acer miaotaiense* produce seeds but rarely have seedlings, likely due to low seed production, poor viability, after-ripening obstacles, and severe pest damage. *A. chensiensis* shows biennial fruiting with only 6.10% natural seed germination and declining populations. *K. uniflora* experiences high abortion rates during seed after-ripening. *O. hosiei* has low seed production and poor dispersal, with some trees producing only 19 seeds and 95% pest infestation rates. (5) **Habitat limitation and vulnerability:** *U. elongata* occurs only in a single rocky river valley bottom site in Zhenping County, where harsh conditions hinder seedling growth and make the species vulnerable to local extinction from human or natural disturbances. *A. miaotaiense* grows in river valleys, with its largest known wild population in Foping National Nature Reserve currently threatened by flooding. *P. qinlingensis* grows only on thin soil or rock surfaces in Mian County and Lüeyang County. (6) **Human disturbance:** Tourism development on Huashan Mountain threatens *Psathyrostachys huashanica*, which grows in rock crevices. Road construction has eliminated *P. qinlingensis* from its type locality at Miandiancha, Mian County. Urban development severely threatens the limited habitat of *U. elongata*.

3. Recommendations

3.1 Conduct Specialized Surveys and Basic Research on Newly Added Species

Of the 104 national key protected plant species in Shaanxi, previous research has focused primarily on economically valuable, germplasm-important, or scientifically significant species such as *Taxus* species, *Davidia involucrata*, *Kingdonia uniflora*, and orchids. In contrast, newly added species, newly described taxa, recent taxonomic revisions, and species with extremely narrow distributions or scattered populations remain severely understudied. The 78 newly added species (including infraspecific taxa) represent 75% of the total, with 54 species (52%) previously lacking any protection status, including four first-class species (*Phalaenopsis zhejiangensis*, *Dendrobium flexicaule*, *Paeonia rockii*, *Paeonia rockii* subsp. *atava*) and 50 second-class species such as *Huperzia chinensis*, *Huperzia serrata*, and *Cardiocrinum cathayanum*. Basic data for these newly protected plants are lacking, with only sporadic reports and limited research on endangerment mechanisms. Field data are virtually absent for *Scrophularia stylosa*, *Lagerstroemia villosa*, *Achnatherum breviaristatum*, *Elymus alashanicus*, and *Aristida trisetata*, leaving their status and threats unclear. Surveying national key protected plant diversity is a priority action for achieving the 2030 targets of the Kunming-Montreal Global Biodiversity Framework. Therefore, specialized surveys and basic research are urgently needed for previously unstudied national key protected wild plants to clarify their distribution and conservation status.

3.2 Update Information and Implement Dynamic Monitoring in Nature Reserves

The conservation strategy for key protected plants combines in situ and ex situ approaches, with in situ conservation relying on nature reserves. Shaanxi's 61 nature reserves at various levels provide in situ protection for about 70 national key protected plant species (67.31% of the total). However, most plant resource surveys in these reserves are outdated. For example, in the Giant Panda National Park Changqing Division, the latest survey identified 44 national key protected plant species, an increase of 31 species including *Phalaenopsis zhejiangensis*, *Acer miaotaiense*, and *Pleione bulbocodioides* compared with 2002 data, primarily due to field data updates, list revisions, and taxonomic changes. Following the release of the new protection list, timely field assessments and improved survey methods are essential for updating geographic distribution and habitat information, enabling targeted conservation plans and maximizing the effectiveness of nature reserves. Predictive studies indicate decreasing distribution areas for national key protected plants in southern Shaanxi, necessitating strengthened biodiversity monitoring of population sizes, distribution ranges, and habitat quality.

3.3 Develop Differentiated Conservation Strategies

Chinese botanical gardens have implemented “one species, one strategy” plans, with approximately 1,500 threatened species under ex situ conservation (39% of native threatened species). Research on national key protected plants in Shaanxi is highly uneven, focusing primarily on species with high scientific or germplasm value such as *Psathyrostachys huashanica*, *Kingdonia uniflora*, *Petrocosmea qinlingensis*, and *Abies chensiensis*, covering reproductive biology, endangerment factors, population genetics, phylogeography, ecological niche modeling, and rapid propagation techniques. To understand endangerment mechanisms, genetic diversity, and climate change responses, and to guide effective conservation, we recommend differentiated strategies based on conservation status: (1) Prioritize field surveys for species lacking basic data, such as *Phalaenopsis zhejiangensis*, *Cypripedium taibaiense*, and *Scrophularia stylosa*. (2) Conduct multidisciplinary basic research on reproductive biology, genetic diversity, and phylogeography for well-documented species to clarify threat factors and endangerment mechanisms. (3) Focus on artificial propagation, domestication, and preliminary reintroduction for species with clear threat factors. For genetically depauperate species, establish multiple in situ and ex situ sites and enhance gene flow between populations, as for *Davidia involucrata* and *Cypripedium macranthos*. (4) Expand reintroduction and post-reintroduction monitoring for species with established propagation systems to increase wild populations, as demonstrated for *Psathyrostachys huashanica*, *Petrocosmea qinlingensis*, and *Ulmus longata*.

3.4 Strengthen Research and Botanical Garden Construction in the Northern Loess Plateau

National key protected plants in Shaanxi show a horizontal distribution pattern with the Loess Plateau accounting for 11.7%, while the Qinling and Bashan regions dominate at 72.8% and 68.0%, respectively. Previous research has concentrated in the Qinling-Bashan region. The Loess Plateau hosts 15 national key protected wild plant species (13 newly added), including first-class species *Paeonia jishanensis* and *Paeonia rockii*, and six species found only in this region: *Cynomorium songaricum*, *Lycium ruthenicum*, *Elymus villifer*, *Elymus alashanicus*, *Elymus purpuraristatus*, and *Agropyron mongolicum* (5.78% of protected plants). Notably, *E. alashanicus* and *E. purpuraristatus* were listed based on uncertain single herbarium records, with unclear field status and threats. Resource surveys and basic research are urgently needed for Loess Plateau protected plants, requiring establishment of ex situ conservation bases in existing botanical gardens, arboreta, and central nurseries to support research on endangerment mechanisms, artificial propagation, and ex situ conservation.

3.5 Establish Germplasm Banks for Economically Important Protected Plants

Biodiversity conservation extends beyond species to include intraspecific genetic diversity. Among Shaanxi's national key protected plants, 41 species and infraspecific taxa fall under agricultural and rural authorities, most having important medicinal value (*Panax bipinnatifidus*, *Dendrobium flexicaule*, *Gastrodia elata*) or being wild relatives of crops (*Citrus cavaleriei*, *Prunus kansuensis*, *Actinidia arguta*). Germplasm banks should be established to collect and preserve resources from various provenances and habitats, along with breeding bases for provenance development. This is crucial for cultivar selection, future domestication, variety development, and restoration of wild populations while maintaining genetic diversity.

References

- CHEN F, XIE WY, ZHANG FY, et al., 2022. Diversity and endangered status of Chinese key protected wild plants in Zhejiang Province [J]. *J Zhejiang A & F Univ*, 39(5): 923-930.
- CHEN J, 2023. Kunming-montreal global biodiversity framework and the construction of the national botanical garden system [J]. *Biodivers Sci*, 31(9): 23257.
- CHEN Y, MA T, ZHANG LS, et al., 2020. Genomic analyses of a "living fossil": the endangered dove-tree [J]. *Mol Ecol Resour*, 20(3): 756-769.
- CHEN YS, 2016. *The checklist of Shaanxi vascular plants* [M]. Beijing: Higher Education Press.
- CHENG HY, WANG Y, YAN YG, 2019. Genetic diversity analysis of germplasm resources of *Paris* genus in Shaanxi Province by SCoT molecular markers [J]. *Chin Tradit Herb Drugs*, 50(16): 3917-3922.
- CHU YN, XU YF, LEI MC, et al., 2023. Rare endangered plants in China are natural treasures of humanity [J]. *For Hum*, 382(5): 6-17.
- DU WB, PAN JB, LUO FD, et al., 2021. The diversity characteristics of National Key Protected Wild Plants in the Gansu province [J]. *J Gansu For Sci Technol*, 46(6): 12-16.
- DI WZ, YU ZY, 1989. *Rare endangered plants in Shaanxi province* [M]. Xi'an: Northwest University Press.
- FU KJ, 2000. *Flora Loess-Plateaus Sinicae* [M]. Beijing: Science Press.
- FU ZJ, 2008. The Conservation of the rare and endangered plant resources in Hualong mountain range [J]. *J Mount Sci*, 26(5): 627-631.
- GAO L, LI YL, KANG XY, et al., 2023. Endemic and habitat-limited plants and ex situ conservation techniques of endangered species in qinling [J/OL]. *For*

Sci Technol, 8: 1-11.

HU XP, JING JL, WANG Q, et al., 2022. Invitro tissue culture technology of leaves of *Petrocomea qinlingensis* [J]. *N Hortic*, 10: 70-76.

HUANG HW, 2018. *The Chinese botanical gardens* [M]. Beijing: China Forestry Publishing House.

HUANG HW, LIAO JP, 2022. On China's national botanical gardens: building a comprehensive system of ex situ conservation of national botanical gardens with task-oriented disciplines [J]. *Biodivers Sci*, 30(6): 22220.

HUANG J, LU X, HUANG J, et al., 2016. Conservation priority of endemic Chinese flora at family and genus levels [J]. *Biodivers Conserv*, 25: 23-35.

HUANG ZH, 2020. The research progress of endangered causes and protection strategy of rare and endangered plants in China [J]. *J S Chin Agric Univ (Sci Technol)*, 34(3): 42-50.

JIA HR, CHEN Y, ZHANG X, et al., 2016. Preliminary analysis of the cause of *Abies chensiensis* mortality in Xiaoqinling national nature reserve [J]. *Acta Ecol Sin*, 36(7): 1936-1945.

JIANG JL, SUN W, HU XP, et al., 2019. Research status of the breeding of rare and endangered plant *Petrocosmea qinlingensis* [J]. *Mol Plant Breed*, 17(9): 3024-3029.

JIANG JL, YAN WB, HU FC, et al., 2023. Preliminary examination of the reintroduction of the endangered plant *Petrocosmea qinlingensis* [J]. *Biodivers Sci*, 31(3): 5-13.

JIAO Y, SHAO YY, LIAO JP, et al., 2019. Status and future strategies of chinese botanical gardens [J]. *China Academic Journal Electronic Publishing House*.

LEI YJ, REN Y, YUE M, 2000. A survey on the distribution and status of the endangered plant *Kingdonia uniflora* [J]. *J NW Univ (Nat Sci Ed)*, 30(3): 239-243.

LI B, LIU GZ, 2023. *Native orchids in Shaanxi* [M]. Shaanxi Science and Technology Press.

LI H, 2002. Reproductive ecological research on endangered plant, *Kingdonia uniflora* populations [D]. Northwest A & F University.

LI WM, LI SF, LI B, 2012. Genetic diversity in natural populations of *Abies chensiensis* based on nuclear simple sequence repeat markers [J]. *Chin Bull Bot*, 47(4): 413-421.

LI YL, GAO L, KANG XY, et al., 2023. Geographical components and distribution characteristics of National Key Protected Wild Plants distributed in Shaanxi province [J]. *J Plant Resour Environ*, 32(5): 62-69.

- LIU P, QUE SQ, LIU LT, et al., 2017. Research status and endangered conservation strategy of *Ormosia hosiei* [J]. *Subtrop Plant Sci*, 46(1): 96-100.
- LIU PL, LU Y, DU C, et al., 2022. A checklist of vascular plants in Shaanxi province, China (Version 2021) [J]. *Biodivers Sci*, 30(6): 22061, 1-5.
- LIU W, ZHAO RN, SHENG QQ, et al., 2021. Geographical distribution and potential distribution area prediction of *Paeonia jishanensis* in China [J]. *J Beijing For Univ*, 43(12): 83-92.
- LIU ZL, LI S, YAN GQ, et al., 2001. Genetic structure and intraspecific genetic polymorphisms in natural populations of *Psathyrostachys huashanica* [J]. *Acta Genet Sin*, 28(8): 769-777.
- LU ZL, QIN HN, JIN XH, et al., 2021. On the necessity, principle, and process of updating the List of National Key Protected Wild Plants [J]. *Biodivers Sci*, 29(12): 1577-1582.
- LUO MF, YANG M, MA KP, 2023. Core targets of Kunming-Montreal global framework and recommendations for conservation action in China [J]. *Guihaia*, 43(8): 1350-1355.
- MA KP, 2023. Kunming-Montreal global biodiversity framework: an important global agenda for biodiversity conservation [J]. *Biodivers Sci*, 31, 23133.
- MIAO T, LI B, XUN LL, et al., 2023. Some newly recorded spermatophyte in Shaanxi Province, China [J]. *Acta Bot Boreal-Occident Sin*.
- REN H, WEN XY, LIAO JP, et al., 2022. The view on functional changes of botanical gardens and the establishment of China's national botanical garden system [J]. *Biodivers Sci*, 30(4): 197-207.
- REN Y, LI Z, LEI Y, 2003. Acene and seed abortion contribute to the rarity of *Kingdonia uniflora* [J]. *Israel J Pl Sci*, 51: 39-44.
- REN Y, LIU X, GE S, 2005. Low genetic diversity among populations of the rare Chinese endemic *Kingdonia uniflora* revealed by RAPD analysis [J]. *Israel J Pl Sci*, 53(1): 65-73.
- REN Y, 1998. *Plants of giant pandas habitat of Qingling mountains* [M]. Xi'an: Shaanxi Science and Technology Press.
- REN Y, TIAN LH, TIAN XH, et al., 2006. *Biodiversity, conservation and management of Taibaishan nature reserve* [M]. Beijing: China Forestry Publishing House.
- REN Y, WEN ZQ, LI G, 2008. *Comprehensive scientific investigation reports on Shaanxi Micangshan nature reserve* [M]. Beijing: Science Press.
- REN Y, YANG XZ, WANG XJ et al., 2002. *The animal and plant resources of Changqing national nature reserve* [M]. Xi'an: Northwest University Press.

- REN Y, ZHANG XP, ZHOU LG, et al., 2010. *Biodiversity and conservation on Shaanxi Taian nature reserve* [M]. Xi'an: Northwest University Press.
- REN Y, ZHANG JC, CHEN Q, 2023. *The plant resources of Hualongshan national nature reserve* [M]. Xianyang: Northwest A & F Univ Press.
- REN Y, ZHOU LG, LI ZJ, et al., 2017. *Key Protected Wild Plants in Shaanxi province* [M]. Xi'an: Shaanxi Science and Technology Press.
- SONG BY, 2021. Study on breeding technology of *Ulmus elongate* [D]. Xi'an: Northwest A & F University.
- SONG YQ, WANG WD, REN Y, 2012. Rediscovery of the rare plant of *Changnienia amoena* in Shaanxi [J]. *Shaanxi For Sci Technol*, (6): 55-56.
- SUN W, JIANG JL, HU XP, et al., 2020. Genetic diversity analysis of endangered plant *Petrocosmea qinlingensis* based on SCoT [J]. *Acta Bot Boreal-Occident Sin*, 40(3): 425-431.
- SUN YL, LI QM, XIE ZQ, 2005. Fruiting characteristics of the endangered species *Abies chensiensis* [J]. *Acta Ecol Sin*, 29(2): 251-257.
- WANG XM, ZHANG P, DU QG, et al., 2012. Heterodichogamy in *Kingdonia* (Circaceasteraceae, Ranunculales) [J]. *Ann Bot*, 109(6): 1125-1132.
- WU G, XIAO H, LI J, et al., 2000. Relationship between human activities and survival of rare and endangered species *Davidia involucreata* [J]. *Chin J Appl Ecol*, 11(4): 493-496.
- WU Q, DONG S, ZHAO YX, et al., 2023. Genetic diversity, population genetic structure and gene flow in the rare and endangered wild plant *Cypripedium macranthos* revealed by genotyping-by-sequencing [J]. *BMC Plant Biol*, 23(1): 254.
- XU ZF, 2023. The “principle of plan as a whole” for the national botanical gardens constructive system [J]. *Biodivers Sci*, 31(1): 229-233.
- YANG P, LU T, QIU ZJ, et al., Analyses on ecological characteristics and endangered reason of endangered plant *Petrocosmea qinlingensis* [J]. *J Plant Resour Environ*, 25(3): 90-95.
- YU BX, 2013. Distribution of *Ormosia hosiei* in Qinling Mountains and cause to its being endangered [J]. *Shaanxi For Sci Technol*, 2: 9-10.
- YU JH, QIN F, XUE TT, et al., 2023. Conservation status and prediction analysis of potential distribution of National Key Protected Wild Plants [J]. *Guihaia*, 43(8): 1404-1413.
- YUE M, ZHANG LJ, MA K, et al., 2001. Endangering reason and reproductive strategy of *Psathyrostachys huashanica* population [J]. *Acta Ecol Sin*, 21(8): 1314-1320.

ZHANG CG, 2018. The study on the distribution at small-scale clonal structure and genetic diversity of *Kingdonia uniflora* on Taibai Mountain [D]. Xi' an: Northwest University.

ZHANG WH, XU XB, ZHOU JY, 2006. Study on reproduction ecology of endangered species *Abies chensiensis* [J]. *Acta Ecol Sin*, 26(8): 2417-2424.

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