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Distribution and conservation of the narrow sub-endemic shrub, *Lonicera paradoxa* in Pamir-Alay, Central Asia

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Abstract. *Daminova N, Nosirov S, Akbarov F, Tojibaev K, Temirov E. 2024. Distribution and conservation of the narrow sub-endemic shrub,* Lonicera paradoxa *in Pamir-Alay, Central Asia. Biodiversitas 25: 439-448. Lonicera paradoxa* Pojark. (*Lonicera* ser. *Alpigenae* Pojark. ex A.Byalt) is a shrub with a geographically limited range. This species is included in the national red book lists of Uzbekistan, Kyrgyzstan, and Tajikistan and is considered one of the rare species in danger of extinction in nature. The species grows in a significant elevation from 1600 to 3200 m on the Northern slopes of the Alay Range, Central Asia. In this study, we investigated the geographic distribution of *L. paradoxa* based on scientific literature, herbarium data collections, and field surveys. We then modeled the current and potential future geographic distribution using Maxent. We also conducted a propagation study for its conservation under laboratory and greenhouse conditions. Our fieldwork in 2021-2022 found new records of *L. paradoxa* in Uzbekistan and Kyrgyzstan. We calculated the Extent of Occurrence (EOO) and Area of Occupancy (AOO) of the species, which were 5.08 km^2 (VU) and 28 km^2 (EN), respectively. Therefore, based on the IUCN Red List and Criteria, we recommend the conservation status of *L. paradoxa* as endangered (EN) in categories B2 ab (ii, iii, iv) + D. Our modeling prediction suggested that compared to the current, suitable habitat of *L. paradoxa* to reduce significantly in the future with very suitable habitats are expected to expand to the south and high mountain areas. For the first time, the conservation measures of *L. paradoxa* were carried out at the Tashkent Botanical Garden. The conducted research made it possible to preserve *L. paradoxa* in *ex-situ* conditions. The results of this research can be helpful in determining and planning measures for the protection of *L. paradoxa* in the territory of the Kyrgyz and Tajikistan Republics, both now and in the future.

Keywords: Alay, Ferghana Valley, Kyrgyzstan, Shakhimardan, sub-endemic, Tajikistan, Uzbekistan

INTRODUCTION

Central Asia is an important global biodiversity hotspot (Tian et al. 2022; Volis 2022). This region is situated in some of the world's highest mountain ranges, such as the Tian Shan and the Pamir-Alay, and has many sub-regions and a wide range of altitudinal belts (Li et al. 2020; Tojibaev et al. 2020). Due to the harsh environmental conditions, Central Asia has unique biological diversity. The region's plant diversity is represented by 9341 taxa belonging to 161 families and 1288 genera, over 40% of which are endemic to this region (Khassanov 2015). Nonetheless, the unique floristic diversity in Central Asia, especially its endemic taxa, suffers greatly from high anthropogenic pressures, mainly due to urbanization and habitat fragmentation (Volis and Tojibaev 2021).

Developing conservation priorities in light of environmental degradation requires sound knowledge of the distribution of plant biodiversity (Kandziora et al. 2013; Wulff et al. 2013; Baral et al. 2014), the current state of populations of endemic species and the critical habitats of highly endangered species (Volis and Tojibaev 2021). The main point to pay attention to when preserving rare species in nature is to know the territory occupied by the species (Marcer et al. 2013). This type of information is of great importance in creating a map in the format of GIS (Geo-Information System) to inform the distribution of the species, assess the risk of its extinction, predict the areas of potential distribution in the future, and determine conservation measures (Rakhimova et al. 2020; Daminova et al. 2023). However, such information is not sufficiently available for most species. The lack of such information means that scientific research aimed at the study and protection of rare species should be given great priority (Abduraimov et al. 2022).

Notwithstanding their relatively small coverage area, Central Asian forests play a crucial role in biodiversity conservation. Mountainous forests are particularly rich in the genetic diversity of wild fruit and nut tree species (Yin et al. 2017; Abduraimov et al. 2023) and endemic species with a very narrow distribution area. A certain part of the mountain forest in Central Asia is located in the Ferghana Valley. This valley has a rich flora due to its geographical location and other natural and climatic conditions (Daminova 2023). The valley has a unique plant diversity and high endemism. In the 2019 edition of the Red Book of the Republic of Uzbekistan, 314 species belonging to the flora of Uzbekistan are listed as rare, endemic and relict species in need of serious protection, of which 47 of these species have geographical distribution in the Fergana Valley (Khassanov 2019). In particular, Chodaksoy and Shahimardan River basins in the Fergana Valley are identified as geographically limited and functionally different areas. They are characterized by a wealth of interesting species compared to other river basins.

Among such interesting species is *Lonicera paradoxa*, Pojark. which has a limited distribution area. This species was included in the IUCN Red List on March 1, 2007 by A. Newton and A. Eastwood, with Endangered (EN) status. However, until now, no measures have been taken to protect the species (https://www.iucnredlist.org/species/63475/12681394). The *L. paradoxa*, from the family Caprifoliaceae, is a narrow endemic plant species of Ferghana Valley (Central Asia), known from only three localities in the Alay and Turkestan Ranges (Pamir-Alay Mountain system). Morphologically, among Central Asian species of Lonicera, *L. paradoxa* can easily be recognized by sinuate-pinnated or pinnate leaves (in contrast to smooth-edged leaves) (Pojarkova 1946; Daminova 2023). This morphological feature was used as a species epithet (Pojarkova 1946), distinguishing *L. paradoxa* from all other closely related species in Central Asia. A narrow geographic distribution and rarity within its range have led to extremely poor knowledge about this species' biogeography and state of populations. Therefore, the goals of this study were to (a) increase the number of documented populations of *L. paradoxa*, (b) clarify the geographic range of the species through an examination of herbarium specimens and fieldwork, (c) provide insight into the habit and habitat range of the species using Species Distribution Modelling and GeoCat tools. The findings of this study might serve as baseline information to fill the gap in ecological knowledge of the species and to develop its conservation strategies.

MATERIALS AND METHODS

Studied species

The *L. paradoxa* was first described by Pojarkova (1946) based on specimens collected by E. Varivzeva and G. Nepli from the Northern slopes of Turkestan ridge, Central Asia, 2800 m (11. IX, 1940, n°219, LE). The species is endemic to Southern Ferghana Valley. It is listed as a rare species in the Red Book of Uzbekistan (Khassanov 2019), Kyrgyzstan, and Tajikistan (Rahimi 2017). This species is of interest in conservation due to its small population and limited range.

Study area

According to the botanical geographical regionalization of Central Asia, mountain parts of Ferghana Valley lie under the Mountain Middle Asian Province (Kamelin 1973; Tojibaev et al. 2017). The *L. paradoxa* grows in Alay, Turkestan, and Zerafshan ridges, which surround the Ferghana Valley from the north and northeast and comprise most of the Ferghana-Alay and Kuhistan region (Figure 1). The area is located on the northern slopes of the Alay mountain system, at an elevation of about 1550 meters above sea level. Shahimardan (39°59′N, 71°48′E) is a geographically enclosed enclave with the small village of Iardan (39°57′N, 71°45′E) in the Batken region of Kyrgyzstan. The area of the Shahimardan exclave is 90 km^2. The average temperature in July is 22°C, and in January, it is -3 to 3°C. The geomorphology of the study area is characterized by stony and rubbly slopes of mountains in the upper belt. The vegetation comprises evergreen and deciduous mixed forests and mountain shrubs above 1850 m. The local flora of the Shakhimardan River basin comprises more than 1353 vascular plants belonging to 86 families and 530 general (Tojibaev et al. 2017). This region contains high species diversity and is rich in endemism and relict taxa. This area has 21 nationally rare and endangered plants (Tojibaev et al. 2019).

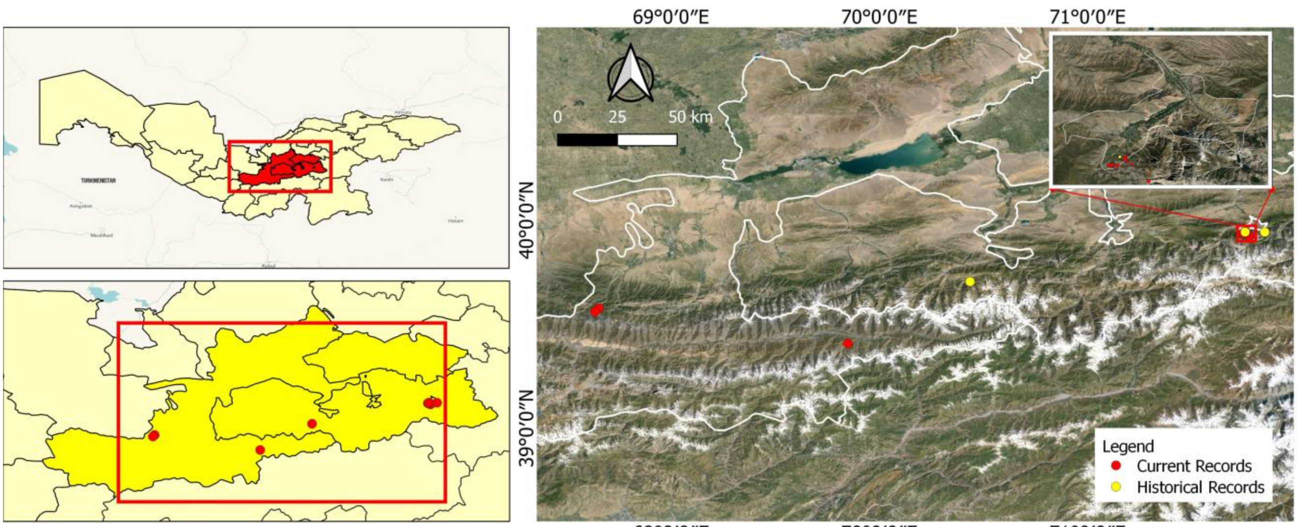

Figure 1. Map of the distribution area with records of *Lonicera paradoxa* in Turkestan, Central Asia

Table 1. The Environmental variables for habitat suitability modeling of *Lonicera paradoxa* in Pamir-Alay, Turkestan, Central Asia

Type	Variable	Description	Unit
Bioclimatic variables	BIO1	Annual Mean Temperature	°C
	BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))	°C
	BIO3	Isothermality (BIO2/BIO7) (×100)	-
	BIO4	Temperature Seasonality (standard deviation ×100)	°C
	BIO5	Max Temperature of Warmest Month	°C
	BIO6	Min Temperature of Coldest Month	°C
	BIO7	Temperature Annual Range (BIO5-BIO6)	°C
	BIO8	Mean Temperature of Wettest Quarter	°C
	BIO9	Mean Temperature of Driest Quarter	°C
	BIO10	Mean Temperature of Warmest Quarter	°C
	BIO11	Mean Temperature of Coldest Quarter	°C
	BIO12	Annual Precipitation	mm
	BIO13	Precipitation of Wettest Month	mm
	BIO14	Precipitation of Driest Month	mm
	BIO15	Precipitation Seasonality (Coefficient of Variation)	1
	BIO16	Precipitation of Wettest Quarter	mm
	BIO17	Precipitation of Driest Quarter	mm
	BIO18	Precipitation of Warmest Quarter	mm
	BIO19	Precipitation of Coldest Quarter	mm
Topographic variables	ALT	Altitude	m
	BDRICM	Depth to bedrock (R horizon) up to 200 cm	cm
	BDRLOG	Probability of occurrence (0-100%) of R horizon	0-100%
	BDTICM	Absolute depth to bedrock (in cm)	cm
	BLDFIE	Bulk density (fine earth) in kg / cubic-meter	kg
	CECSOL	The cation exchange capacity of soil in cmolc/kg	kg
	CLYPPT	Clay content (0-2 micrometer) mass fraction in %	%
	CRVVOL	Coarse fragments volumetric in %	%
	OCSTHA	Soil organic carbon stock in tons per ha	tons
	ORCDRS	Soil organic carbon content (fine earth fraction) in g per kg	kg
	PHIHOX	Soil pH x 10 in H2O	-
	PHIKCL	Soil pH x 10 in KCl	-

Data and specimen collection

In the preliminary stage of research, the main emphasis was placed on the study of previously collected herbarium specimens since the use of herbarium records to obtain data on the distribution of rare species is already heavily used in conservation assessments (Callmander et al. 2005; Besnard et al. 2018). Fieldwork to locate occurrences of *L. paradoxa* was concentrated in Alay Ridge, with five collecting missions to potential localities during 2020 and 2022 (Figure 1). The specimens of *L. paradoxa* gathered from our fieldwork, along with specimens stored in the National Herbarium of Uzbekistan (TASH), Komarov Botanical Institute (LE), Institute of Biology, Bishkek, Kyrgyzstan (FRU), were included in the chronological analysis. Specimens from MW (Herbarium of Moscow State University) herbaria were analyzed from online sources (http://en.herbariumle.ru/).

SDM modeling

We used SDM to predict the geographic distribution of suitable habitats for *Lonicera paradoxa*. The climate and elevation data used in the study were obtained from WorldClim v2.1 (Fick and Hijmans 2017). These data were acquired at a resolution of 2.5 arc minutes (about ~ 5 x 5 km; Hijmans et al. 2005). Soil variables (physicochemical properties of soil) were downloaded from SoilGrids (https://soilgrids.org/) under 250 m spatial resolution (Hengl et al. 2015, 2017). The environmental variables used in the study are listed in Table 1. Climatic factors were selected for two periods: current (1970-2000) and 2070s ((2060-2080), Zhao et al. 2020). For future data, we used a set of global climate models from two Representative Concentration Pathways (RCPs), 2.6 and 8.5, based on carbon dioxide emissions scenarios (Mohammadi et al. 2019; Hosni et al. 2020; Keane et al. 2020; Khanal et al. 2022). All these data were converted from GeoTIFF to ASCII format in ArcGIS v10.6.1 (Islam et al. 2020). The SDMtoolbox panel of the ArcGIS version 10.6.1 Sofware (ESRI Inc., California, USA) program was used for correlation analysis (Brown 2014), and the most important environmental factors with a correlation less than 0.8 were selected (Radosavljevic and Anderson 2014). The MaxEnt v3.4.1 (Phillips and Dudik 2008; Phillips et al. 2017, 2021) was used to estimate the probability of the presence of the species that varies from 0 to 1, where 0 is the lowest and 1 is the highest probability. In this study, 25% of the distribution points were selected as the test set, and 75% were utilized as a training set for the MaxEnt model (Phillips and Dudik 2008; Syfert et al. 2013; Pacifici et al. 2017). For MaxEnt modeling (Wei et al. 2018; Hosni et al. 2020; Yan et al. 2020), we used data sets with 21 records, four of which belong to herbarium records (1940-1966). The ASCII grid layer format model predictions were loaded into ArcGIS 10.6.1 to produce the species' predicted distribution maps.

Indicators of the variables that contributed the most to the creation of the model were analyzed in the R 4.1.2 program (Figure 5). The R 4.1.2 program provides an accurate assessment of the effects of environmental variables on the potential habitats of rare plant species and the indicators of the variables with the greatest contribution.

Propagation study

Despite its narrow geographic distribution, no comprehensive study on protecting L. paradoxa exists. To protect the species *L. paradoxa*, the following initiatives were carried out: (1) the seeds and cuttings of the wooded branches were brought from the natural population of *L. paradoxa* species to determine the fertility of seeds under laboratory conditions (28 September 2021). The stem cuttings were prepared at the end of the plant vegetation. The cuttings were taken from the branches in the middle part to increase the rooting rate. The cutting length was 10-12 cm, depending on the position of the buds. A total of 150 cuttings were placed for 12-14 hours in Corneivn stimulants (indole butyric acid IBA, which is effective in rooting) and control (simple water) variants (29 September 2021). To scrape the roots of the cuttings, special places were prepared for the greenhouse complex 1.2x1 m in length, and river sand was put 8-10 cm thick. The depth of planting the cuttings was 4-6 cm. The range was 5x7 cm. The cuttings were held by pouring water with the help of a moisture stain on the sand (Solonkin et al. 2020; Sporbert et al. 2022). The greenhouse temperature was an average of 20-22°C.

RESULTS AND DISCUSSION

Species description

The *L. paradoxa* Pojark. in Bot. Mater. Gerb. Bot. Inst. Komarova Akad. Nauk S.S.S.R. 9: 210 (1946) (Figure 2).

Morphological characteristics

Woody shrubby plants with thick branches, preserving dense pith, covered with light grey or grey-brownish bark. Leaves elliptic or elliptic-obovate, 9-20 × 6-17 mm; lower leaves often undivided, others irregularly pinnatisect or pinnately incised into 2-3 obtuse, ovate or oblong-ovate lobes or segments on each side, base 2-2.5 mm, margins setose, ciliate, sometimes mixed with glands, apex 2-3 mm, glaucescent-green, paler beneath, with several prominent primary and secondary vein. Buds ovate, acute, terminal 4-5 mm long, axillary 3-3.5 mm, provided with 4-5 pairs of outer, opposite decussate scales. Flowers in the axils of the upper leaves of short young twigs on glandular and bristly-hairy peduncles 5-7 mm long, shorter than the leaves; bracts narrow, almost linear, 2 mm long, with fruits not falling off; bracts 1.5 mm long, ovate, insular; both, as well as the teeth of the calyx, along the edge, are short-crenulate from stalked, glabrous, adhesive glands; the teeth of the calyx are well developed, obovate or elliptical, insular, or obtuse. Corolla 1.5-2 cm long, double-lipped, covered with small glands, and dark pink and raspberry-colored. The number of stamens 5 and carpel 1 that are located in a tube. Fruits are red, globose, 4-5 mm long, and wide. Seeds 3-4, almost elliptic, somewhat tapered toward the base, 3-4 mm long. Flowering occurs from the end of May to the middle of June. Fruiting in September (Figures 2 and 3).

According to Pojarkova (1946), the species is a very original representative of the genus and stands out among all known species for its lobed leaves. On this feature, *L. paradoxa* is closely related to the *Lonicera webbiana* Wall. (= *Lonicera heterophylla* Decne.). However, pinnatisect or pinnately incised leaves are observed in *L. webbiana* and its variations.

Distribution

Central Asia: Pamir-Alay (South slopes of Alay, Northern slopes of Turkestan range, and Eastern part of Zeravshan Range) is scant scattered and sub-endemic.

Specimens examined:

UZBEKISTAN. -Shakhimardan River basin, Uvlardi gorge, 12.06.1966, *Khalkuziev*; Valley in river Shakhimardan, Uvlardi-say gorge, 13.05.1966, *Khalkuziev*. *New locality for Uzbekistan:* Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2029, 05.30.2021, *Daminova 437*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2090, 07.08.2021, *Daminova 138*2, *1384*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=1986, 07.08.2021, *Daminova 1398*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2167, 07.08.2021, *Daminova 1399*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2208, 09.08.2021, *Daminova 1400*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2103, 09.08.2021, *Daminova 1401*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2213, 09.08.2021, *Daminova 1416*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2212, 07.08.2021, *Daminova 1417*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2237, 09.08.2021, *Daminova 1449*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2266, 09.08.2021, *Daminova 1450*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2191, 23.09.2021, *Nosirov and Daminova 1418*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2209, 23.09.2021, *Nosirov and Daminova 1445*.

Figure 2. The *L. paradoxa* 1: General view, 2: Upper branches with bud, 3: Young branches, 4-8: Lobil shape leaves, 9: Flowers, 10: Fruits, 12: Bract, 13: Bracts, 14: Seed. Note: *Holotype:* Right bank of the river Myn-teke. Sparse juniper forests on a steep, gravelly, crumbling prominent primary and secondary vein. Buds ovate, acute, terminal 4-5 mm long, axillary 3-3.5 mm, slope. h=2850 m. 09.11.1940, *Varivtseva,* Nepli, *219*. (LE01056033)

KYRGYZSTAN. -Right bank of the river Myn-teke. Sparse juniper forests on a steep, gravelly, crumbling slope. h=2850 m. 09.11.1940, *Varivtseva*, Nepli, *219*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=2636, 09.08.2021, *Daminova 1452*; Alay ridge, river basin Shakhimardan, village Iardan, environs Archamazar, h=3184, 28.05.2022, *Daminova, Kurbaniyazova, Jabbarov, Madaminov, 1767*.

TAJIKISTAN. -Valley of the river Matcha, demior limestone rocks h=3000, 09.23.1945, *Zokirov*.

According to the prologue (Pojarkova 1946), the first specimens of the species (*locus classicus*) were from the territory of Uzbekistan. However, based on the study and analysis of herbarium specimens and the results obtained on Google Earth, the *locus classicus* falls to the Turkestan ridge in Kyrgyzstan.

IUCN and habitat risk assessments

According to Eastwood et al. (2009), the conservation status of *L. paradoxa* is classified as Endangered (EN) in category B2 ab (iii, v). Our fieldwork in 2021-2022 found new records in Uzbekistan and Kyrgyzstan. Based on that, we revised the conservation status of the species according to the IUCN Red List and Criteria (2019). Using the GeoCat tool (Figure 4), we have calculated the Extent of Occurrence (EOO) and Area of Occupancy (AOO) of the species, which were equal to 5.08 km^2 (VU) and 28 km^2 (EN) respectively (Figure 4). Based on the data presented, *L. paradoxa* was reevaluated as Endangered (EN) in categories B2 ab (ii, iii, iv) + D.

Currently, the habitat of *L. paradoxa* is exposed to anthropogenic impacts. All populations are under high grazing pressure. Most of the plants are located on steep and rocky slopes. The whole species range is outside any existing protected areas, and the whole habitat is under threat. Until now, there have been no attempts to introduce *L. paradoxa* into cultivation in botanical gardens of Central Asia.

Species distribution modeling

Important variables

The 10 variables that contributed the most to the creation of the model are given in Figure 5. The results showed that the highest percentage contribution among the variables was PHIKCL (pH index measured in KCl solution) of 27.2%, and the highest replacement value belonged to BIO8 (average temperature of the wettest temperature). Of the 10 variables with the highest overall percentage, 3 were soil data, and 7 were climate data. Thus, 69.8% of species distribution can be explained by climate data and 30.2% by soil data. In addition, 1.9% of permutation importance belongs to soil variables (physicochemical properties of soil) and 98.1% to climatic variables (Figure 5). This shows that climate data has played a significant role in the development of this model.

Habitat suitability under present and future climatic

Compared to the current situation, the corresponding distribution sites of the *L. paradoxa* have been observed to change significantly in future scenarios (Figure 6). We divided the results of Maxent into five classes of potentially suitable habitats, namely unsuitable (0-20), low potential (0.21-0.40), moderate potential (0.41-0.80) and high potential (0.81-1.0). Areas of habitat suitability classes are shown in Table 2.

Figure 3. The *L. paradoxa.* River basin Shakhimardan, Village Iardan, Turkestan, Central Asia. (Photo: Daminova N.E. 7 August 2021)

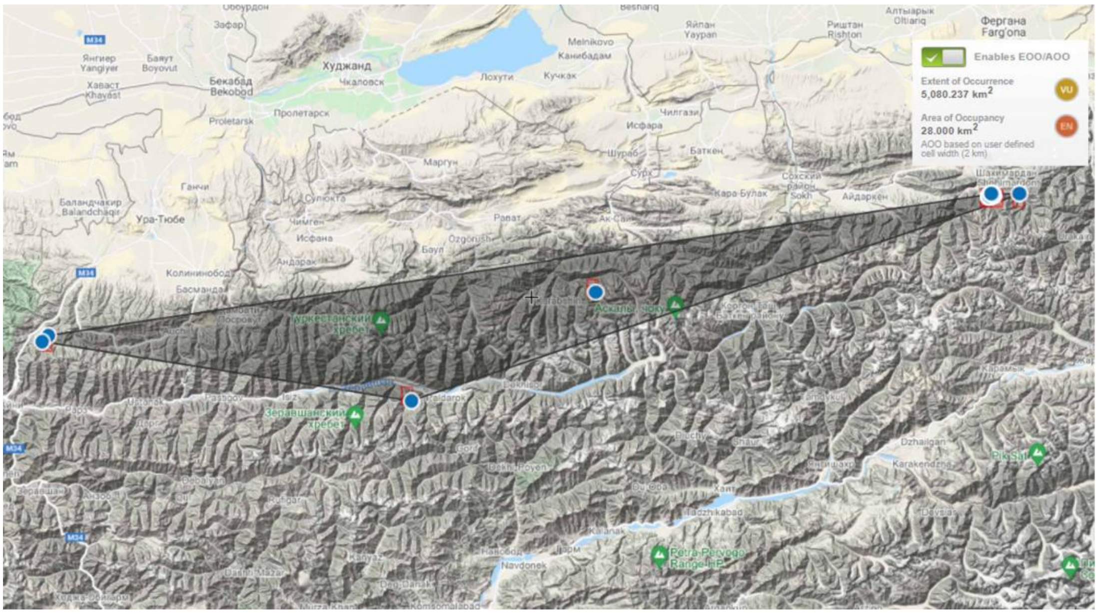

Figure 4. Geographical range map of *L. paradoxa* in Turkestan, Central Asia (based on geocat.kew.org/)

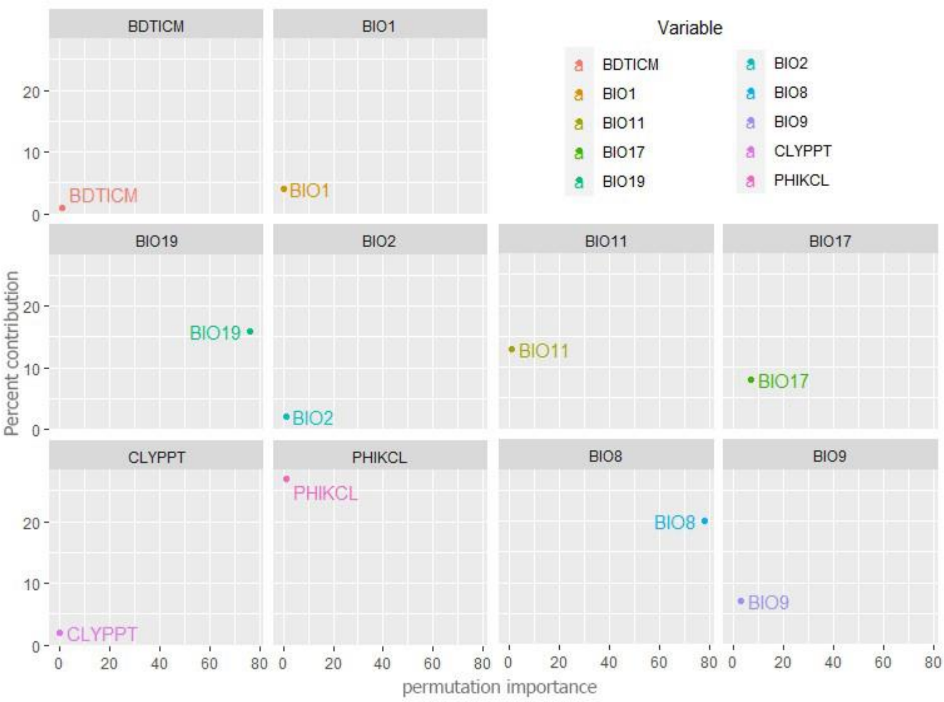

Figure 5. Environmental variables, their percent contribution and permutation importance

Table 2. Potentially suitable areas of *L. paradoxa* according to current and future climate change scenarios

Suitability Classes	Current	RCP2.6 (2070)	RCP8.5 (2070)
	Area (km²)		
unsuitable	1,094,804	1,097,548	1,095,303
low suitable	6,187	4,376	5,817
moderate suitable	1,638	1,109	1,566
high suitable	579	291	558
very high suitable	205	89	169
Total	1,103,413	1,103,413	1,103413

The results show that the most suitable habitats for the current period are 205 km². According to RCP 2.6, the most suitable habitats are reduced to 89 km², while the most suitable habitats in RCP 8.5 are projected to shrink to 169 km². Most suitable habitats are located in the Pamir-Alay Mountains, with less area on the Tian Shan ridges. In the future, the living environment in Tian Shan will decrease, but in the Pamir-Alay mountains will remain unchanged. In summary, suitable habitats for *L. paradoxa* in Mount Tian Shan will suffer losses in the future, and losses in RCP 8.5 (0.15%) will be less than in RCP 2.6 (0.08%). In future scenarios, suitable habitats are expected to expand to the south and high mountain areas.

Propagation study

The propagation study to inform the conservation strategies of *L. paradoxa* focused on two aspects, i.e., the biology of seeds and seedlings and the growth performance of cuttings. The biological characteristics of the *L. paradoxa* were studied using the methodology developed by Rabotnov (1950) and Kirillova et al. (2017). Special attention is paid to seeds' fertility and growth energy in different temperatures. To determine the germination of seeds in laboratory conditions, the germination of seeds from 50 grains of the plant on a printed paper moistened with distilled water in a Petri dish was studied by affecting 3 different temperatures (Figure 7). Fresh harvested seeds were used to determine seed regeneration in laboratory conditions. To determine the fluidity, 20-22°C, 24-26°C and 28-30°C were collected at 3 times repetitions in the warm-ups. In laboratory conditions, the optimum temperature for the germination of seeds was 20-22°C, while the germination rate was 54%, at 24-26°C 13%, at 28-30ºC temperature, the germination rate was 1% (Figure 8).

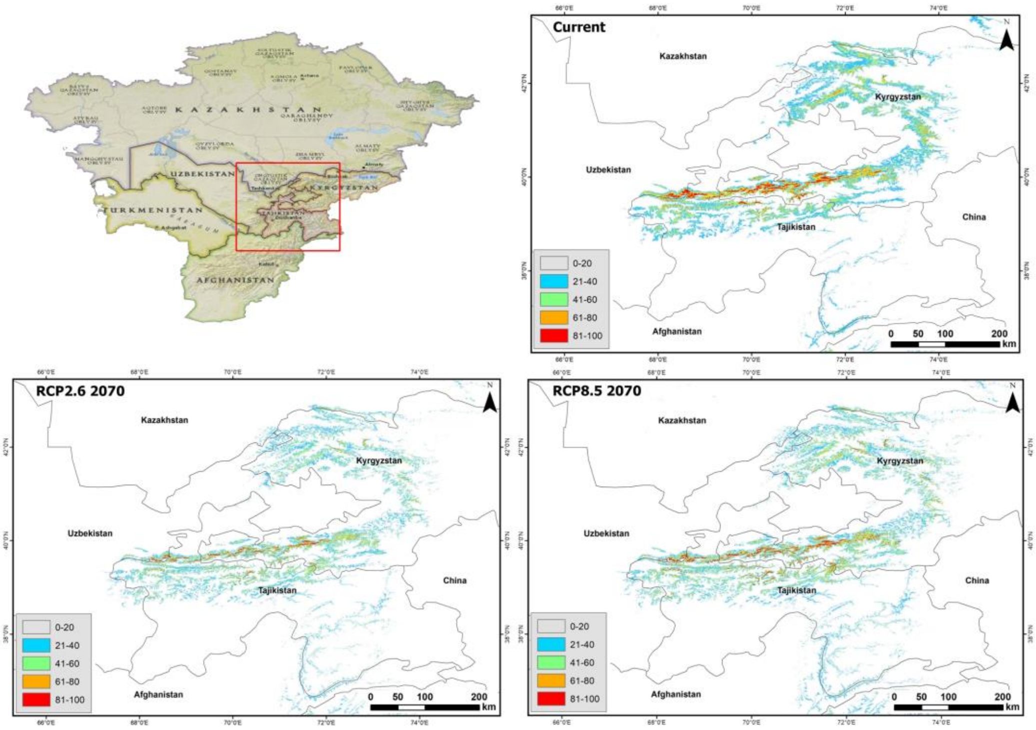

Figure 6. Map showing the predicted habitat suitability of *L. paradoxa* in the current and future climatic scenarios

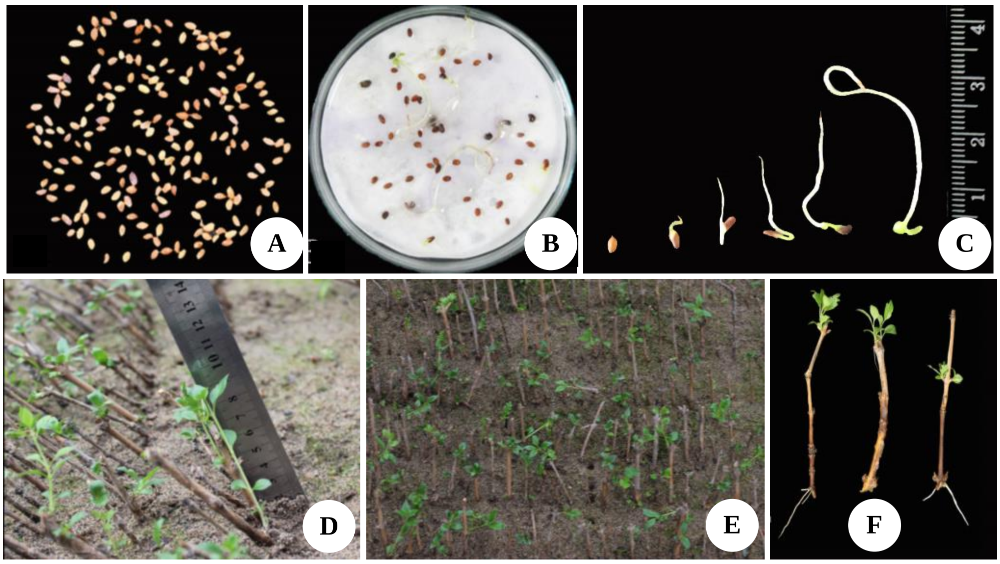

Figure 7. Conservation measures: A. Seeds of *L. paradoxa*, B. Seeds germination in the laboratory conditions, C. Seeds germinated in field conditions, D-E. Cuttings in greenhouse

Table 3. The length of the stem and root of the cuttings of different treatments

Days	Corneivn		Days	Control	
	Stem Length (cm)	Root Length (cm)		Stem Length (cm)	Root Length (cm)
18-20 (15.10.2021)	1.5±0.07		22-23 (22.10.2021)	0.6±0.02	
38-40 (4.11.2021)	4.0±0.46		40-45 (13.11.2021)	1.3±0.15	
42-44 (11.11.2021)	6.0±0.69	2.7±0.31	52 (20.11.2021)	2.1±0.17	1.5±0.27

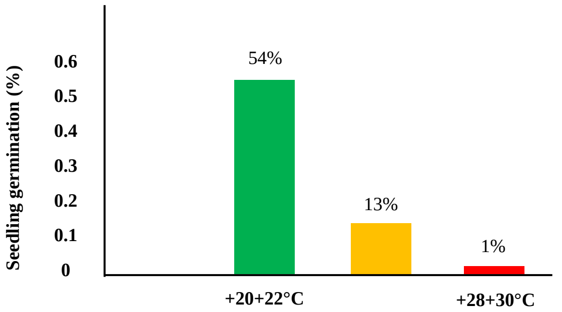

Figure 8. Germination of the seedlings of *L. paradoxa* in laboratory conditions

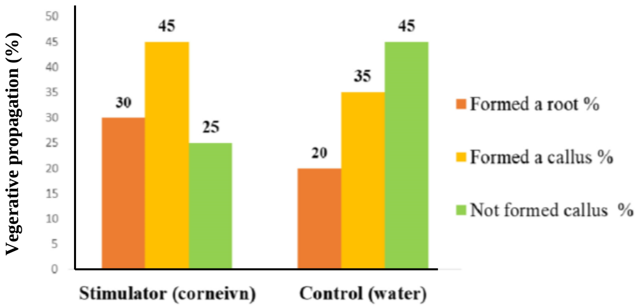

Figure 9. The *L. paradoxa* results obtained by vegetative propagation

Cuttings were prepared from one-year-old twigs, based on Z.Y. Ivanova's method (1982). For green cuttings of woody plants, corneivn is usually 50-200 mg/L; indolylmonic acid IMC is used in 25-100 mg/L concentrations. "Corneivn" is a biostimulant for plants, the composition of which includes a concentration of indolymic acid (IMA) (5 g/kg). When it falls on the plant, it slightly absorbs its covering tissues, forming callus ("living" cells) and roots.

For cuttings treated with Corneivn stimulant, cuttings formed branches with a length of 1.5±0.07 cm in 18-20 days (15.10.2021 y.). It was noted that the callus was formed in 38-40 days (4.11.2021 y.), and the length of the branches reached 4.0±0.46 cm. From the beginning of the second ten days of November (11.11.2021 y.), primary roots were formed, the length of which was 2.7±0.31 cm, and the length of the branches grew to 6.0±0.69 cm. It was observed that 30% of the cuttings formed roots, 45% formed callus, and the remaining 25% did not form callus (Figure 9, Table 3).

On the other hand, for the control treatment, it was observed that the cuttings began to form the first branches between 22-24 days (22.10.2021 y.), and the length of these bars was 0.6±0.02 cm. The callus formation was observed in 40-45 days, and the length of the branches reached 1.3±0.15 cm (13.11.2021 y.). The first roots began to appear in the cuttings; the length of the stem was 1.5±0.27 cm, and the length of the branches was 2.1±0.17 cm in 52 days (20.11.2021 y). It was observed that 20% of the cuttings formed a root, 35% formed a callus, and 45% did not (Figure 9; Table 3).

In the Kyrgyzstan part of Alay Ridge, from 1969 to 1973 the number of *L. paradoxa* individuals decreased from 22 to 12. In Turkestan Ridge, around 20 plants. Exact data from Uzbekistan part were absent (Davletkeldiev 2006). Before our research, the total number of plants of L. paradoxa did not exceed 30-40 individuals. However, our field surveys in 2020-2021 found 23 plants in the Shakhimardan enclave. Besides them, three plants were observed in the Kyrgyzstan part of Alay Ridge. Thus, at present, the species' population contains no more than 70-75 plants of various ages with most of them mature plants that can produce flowers and seeds. The territory of modern-day Ferghana Valley has been continuously inhabited since the early Stone Age and has been affected by human communities for tens of thousands of years. Only small populations of *L. paradoxa* remain in Alay Ridge's mid-and-high mountain areas, including Shakhimardan River Valley. Regarding the conservation of *L. paradoxa* populations and similar narrow endemic species, there are two main problems in the modern age: anthropogenic impact (agricultural development, overgrazing, firewood, etc.) and global climate change.

In conclusion, this article presents maps created by regional-scale dispersal and bio-climatic modeling of *L. paradoxa*, a rare, endemic plant of the Pamir-Alay Mountain ranges. It recommends effective conservation methods for planning conservation activities for the species. The maps generated by the modeling help assess the knowledge of species protection and the threat level of information about potential distribution areas on a regional scale now and in the future. It also provides the basis for future research to identify knowledge and data gaps and to build new knowledge that is scientifically based to improve the living environment.

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