

Comparative characteristics of the fauna of terrestrial vertebrates of the Zagatala Nature Reserve (Azerbaijan) and the Lishan Nature Reserve (the People's Republic of China)

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This study aims to compare terrestrial vertebrate mammals in two protected areas located in different countries, each characterized by unique natural-ecological conditions and disparate management methods. Research focuses on terrestrial vertebrates of the Lishan Nature Reserve in the People's Republic of China (24,200 hectares) and the Zagatala Nature Reserve in the Republic of Azerbaijan (47,349 hectares). We examine various indicators, such as size, weight, age, habitat, altitude, climate, and eating habits, to understand the factors that contribute to the differences between the two reserves. Field research was conducted from July 6–10, 2022, in the Zagatala Reserve and from June 15–21, 2023, in the Lishan Reserve. A systematic literature review was performed on the scientific, theoretical, and methodological foundations of protected area research. Additionally, we analyzed the natural and ecological characteristics (relief, climate, hydrography, soil cover, and vegetation) of both reserves and explored the taxonomy and distribution of terrestrial vertebrate species. We specifically studied rare and endemic species that inhabit these reserves, culminating in a comparative analysis of the fauna of amphibians and mammals in both locations, focusing on their size, weight, age, habitat, altitude, climate, and dietary patterns.

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Protected areas, terrestrial vertebrates, comparison, natural-ecological conditions, species diversity

Introduction

Biodiversity is crucial for humanity, serving as the foundation upon which our societies are built (Convention on Biological Diversity 2017). Although the significance of protected areas in conserving biodiversity is widely acknowledged, evaluating their effectiveness has proven challenging, with ongoing studies beginning to shed light on this issue (IUCN Press release 2016). Case study reviews indicate that protected areas often promote biodiversity conservation, serving as the last strongholds for many species globally (Barnes et al. 2017; Dinerstein et al. 2017; Coad et al. 2019). Numerous researchers from various countries are actively investigating biodiversity conservation and the pivotal role that protected areas play in this endeavor (Jenkins et al. 2013; Pfaff et al. 2015; Joppa et al. 2016; Oldekop et al. 2016; Corlett 2018; Johnson et al. 2017; Waldron et al. 2017; Jones et al. 2018; Schulze et al. 2018; Tesfaw et al. 2018; Geldmann et al. 2019; Bieberstein et al. 2019).

To enhance international collaboration in biodiversity conservation, Azerbaijan acceded to the UN Convention on Biological Diversity in 2000. To meet the obligations established under this convention, the country approved the “National Strategy and Action Plan for the Protection and Sustainable Use of Biological Diversity” through Decree No. 1368 on March 24, 2006 (reference).

Significant restoration projects have been underway in China since the early twentieth century, including initiatives to convert agricultural land back to forests, manage the Northern Forest Belt, protect natural forests, control sources of sandstorms in Tianjin, and manage small watersheds (Song et al. 2001). Studying protected areas, which serve as reference sites where anthropogenic impacts are minimized, is of great interest; dynamic processes in these areas are mainly influenced by endogenous factors (UNEP-WCMC and IUCN 2017). The protected areas in Azerbaijan and China, along with their surrounding natural ecological systems, represent an unparalleled natural heritage. The aim of this study is to assess and compare the current state of terrestrial vertebrates in these two regions, which are characterized by different natural and ecological conditions, as well as management practices.

Materials and methods

This study focuses on terrestrial vertebrates found in the Lishan Nature Reserve of the People's Republic of China and the Zagatala Nature Reserve of the Republic of Azerbaijan. We investigate the reasons for the differences between vertebrate groups in terms of size, weight, age, habitat, altitude, climate of distribution, diet, and other ecological parameters. The main reason for conducting this research is the work on the master's dissertation of BSU from the People's Republic of China, Jing Weitao.

The Lishan National Nature Reserve, located at the convergence of Yicheng, Yuanqu, Yangcheng, and Qinshui counties in Shanxi Province, encompasses an area of 24,800 hectares. It is recognized as the largest reserve with the richest species diversity in Shanxi and is one of the relatively pristine vegetative regions in northern China. The geographic coordinates of the reserve range from 111°51'10" to 112°5'35" east longitude and from 35°16'30" to 35°27'20" north latitude

(Fengxia et al. 2019).

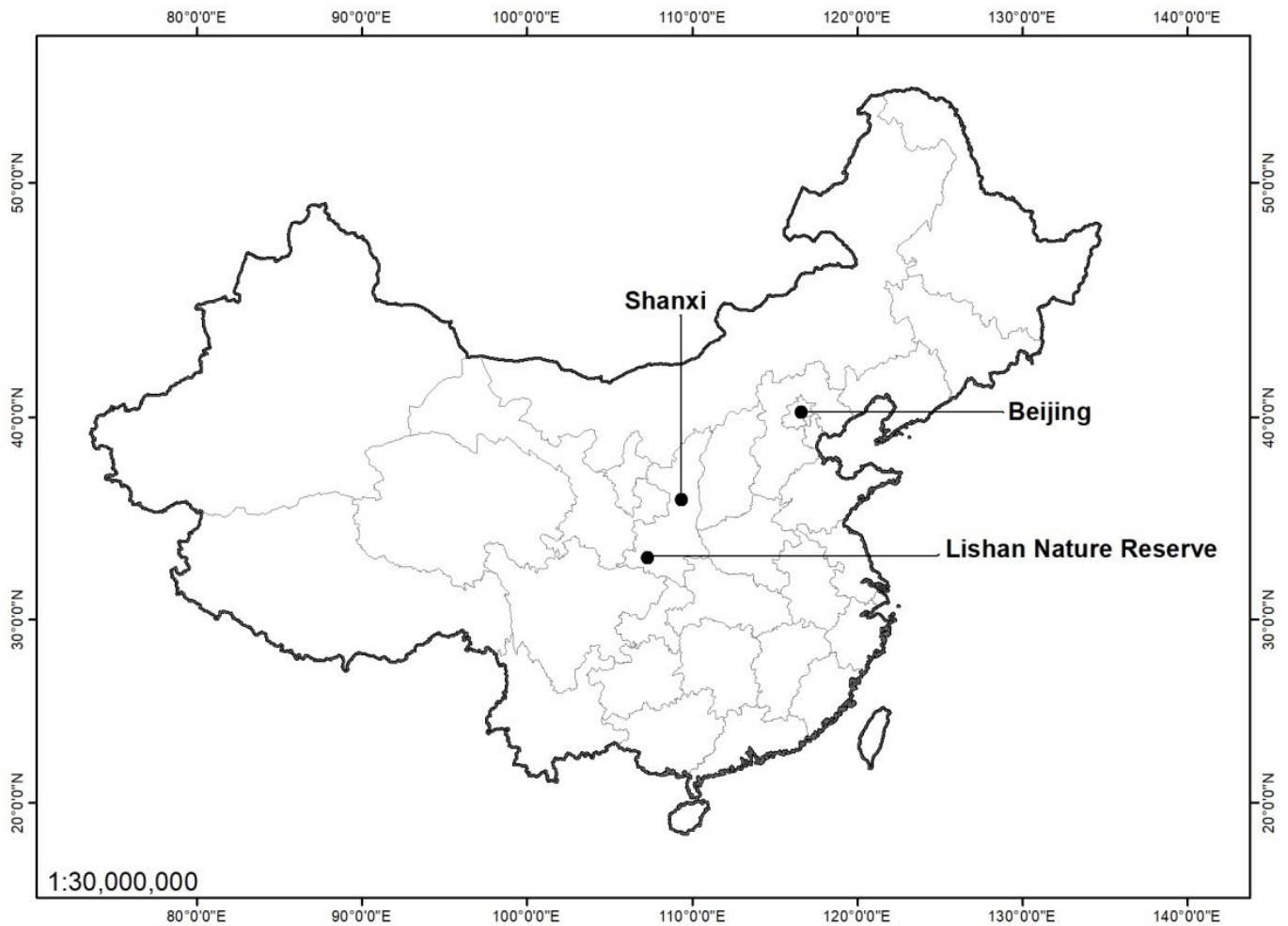


Figure 1. Geographical location of the Lishan Reserve.

Lishan, part of the Shanxi Plateau, was shaped by the folding associated with the Yanshan movement and significantly influenced by the tectonic activity of the Himalayas (Lishan Reserve 2024). The Lishan Mountain Range stretches approximately 23 kilometers from east to west and about 20 kilometers from north to south, oriented northwest to southeast. Characterized by its rocky terrain, Lishan features complex geological layers and diverse rock formations. The mountain range primarily consists of steep mid-elevation mountains and relatively flat rocky belts of lower hills (Huiling 2003).

The Zagatala State Nature Reserve, established in 1929, is one of the oldest protected areas in Azerbaijan. It spans the Zagatala and Balakan administrative regions at the southern foothills of the central part of the Main Caucasus Range (Fig. 2), originally covering 23,844 hectares. Following a resolution by the Cabinet of Ministers of the Azerbaijan Republic (No. 370c) on October 17, 2008, the reserve's area was expanded to 47,349 hectares, incorporating land from the Zagatala and Balaken forest protection and restoration enterprises (Zagatala State Nature Reserve 2022). This nature reserve borders the Republic of Georgia.

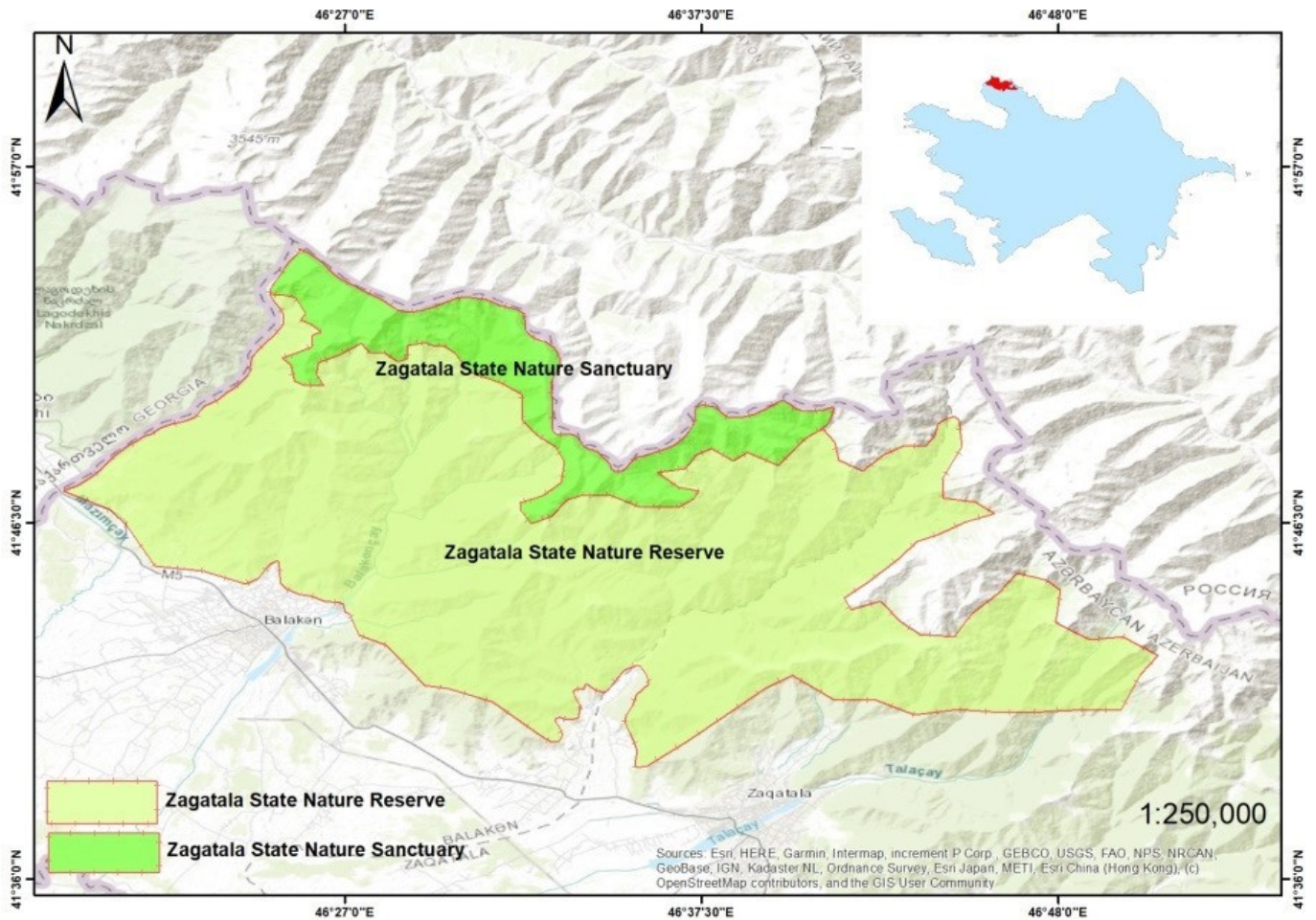


Figure 2. Geographical location of the Zagatala State Nature Reserve.

The primary purpose of establishing the Zagatala State Nature Reserve was to safeguard the vital soil-protective and water-retention functions of its forests. This action aimed to protect nearby settlements and agricultural lands from flooding while preserving the natural landscape, flora, and fauna on the southern slope of the Greater Caucasus. Located in the northwestern part of Azerbaijan, the reserve encompasses the foothills and mountainous regions of the Zagatala-Balaken area. It is bordered by the Republic of Dagestan (Russian Federation) to the north, the Republic of Georgia to the west, and a low mountain belt reaching the Alazan-Eyrichay Valley to the south. The reserve's elevation ranges from 400 meters to 3,668 m a.s.l. (Zagatala State Nature Reserve 2022).

The research was conducted in three stages: the desk-preparatory stage, the field stage, and the final synthesizing stage.

Desk-Preparatory Stage: During this phase, we gathered information on the natural and ecological conditions, such as relief, climate, hydrography, soil, and vegetation cover, of both the Lishan Nature Reserve in the People's Republic of China and the Zagatala Nature Reserve in Azerbaijan. We also reviewed literature on recent biodiversity protection efforts and assessed existing data on terrestrial vertebrates in both reserves from historical records.

Field Stage: Field research was conducted during similar seasons in 2022 at the Zagatala Reserve and in 2023 at the Lishan Reserve. For the field studies, we employed direct observation methods alongside observations using animal study techniques (Formozov 1952; Hasanov and Mustafaeva 2009; Aulagnier et al. 2008). The excursion routes were pre-planned in collaboration with reserve staff, ensuring comprehensive coverage. Additionally, we utilized camera traps (Bushnell 32MP CORE DS-4K) for remote monitoring of wildlife.

Final Synthesizing Stage: In the concluding phase, we summarized, categorized, and systematized the results from both fieldwork and literature reviews. This included conducting a comparative analysis of the terrestrial vertebrate fauna such as: amphibians, bats, rodents, martens, and artiodactyls between the Lishan Nature Reserve in the People's Republic of China and the Zagatala Nature Reserve in Azerbaijan related with altitude, climate conditions, and habitat parameters.

Results and discussion

Climatic factors

The different climatic zones significantly influence the diversity of species between the two reserves. To understand these differences, we analyzed temperature and precipitation data over the past ten years. Our findings indicate that while the average annual temperature and total annual precipitation are relatively similar in both locations, the Lishan Protected Area in China has a higher average temperature and a lower annual precipitation compared to the Zagatala Nature Reserve.

Vegetation conditions and soil moisture

The Lishan Nature Reserve is home to approximately 1,100 plant species, with a forest cover rate of 81%. On the contrary, the Zagatala Nature Reserve hosts approximately 800 species, with a forested area. Given that soil composition and properties directly influence vegetation, we compared soil indicators from both reserves. We discovered that soil temperature and moisture levels in Zagatala are lower than those in Lishan at various depths. This may be attributed to the presence of three main rivers, Mazimchay, Balakenchay, and Katekhchay, which flow through the Zagatala Nature Reserve, which significantly enhance the local soil moisture. Meanwhile, the Lishan Nature Reserve relies primarily on the Yellow River and its tributaries, leading to a marginal difference in forest cover between the two areas.

Geographical structure

Our investigation into geographical conditions revealed that the formation of the Caucasian Mountain system occurred due to Alpine Mountain building processes during the Tertiary to Quaternary periods. The northern slope of the Greater Caucasus gradually rises from the gentle plains and small hills to the main mountain range, contrasting sharply with the steep southern slope. The altitudes in the Western Caucasus are generally lower than those in the Central Caucasus (Hajiyev et al. 1985). Due to the limited impact of glaciation in this area, the morphology of its glacial and snow-covered terrain remains underdeveloped, resulting in a significant alteration of the ancient landscape. On the contrary, Lishan in China was not affected by glacial activity during the Quaternary period, preserving its intact vegetation and ecological environment (Lishan Reserve 2024). As a result, species in southern China tend to be more tolerant to higher temperatures.

Species diversity

The data indicate that both reserves exhibit high species diversity. In the Lishan Nature Reserve, bird species account for 71.7%, reptiles for 7.0%, amphibians for 3.2%, and mammals for 12.3% (Lishan Reserve 2024, see Table 1). In contrast, the Zagatala Nature Reserve contains 62.2% bird species, 9.2% reptiles, 4.1% amphibians, and 24.5% mammals (Mustafayev and Maherramova 2005; Mustafayeva 2016). Thus, Lishan Nature Reserve is richer in bird diversity, likely due to its proximity to other large reserves such as Lingqiu and Yangcheng and 43 additional large reserves in Shanxi (Maoyi and Kaimin 2020). However, if we exclude non-resident bird species, it is plausible that the bird diversity in the Zagatala Nature Reserve is comparable to that of Lishan (reference). Overall, the species richness of the Zagatala Nature Reserve is substantial, with a similar

geographical setting and climate, but more mammal species than Lishan.

	Birds	Reptiles	Amphibians	Mammals
Lishan Nature Reserve	264	24	11	44
Zagatala Nature Reserve	122	18	8	48

Table 1. Species diversity in Lishan and Zagatala Nature Reserves

Amphibians

Our research identified several rare amphibian species in the Zagatala Nature Reserve, including local species such as *Pelodytes caucasicus* and *Bufo verrucosissimus*, which primarily inhabit humid lowland forests. The total population of these species in the Greater Caucasus is estimated at about 100,000 (Animal World of Azerbaijan, Vertebrates 2000). Caucasian toads are typically found in numbers ranging from 10 to 20 individuals every 10 kilometers; however, their population is threatened by the introduction of raccoons, which have become a significant natural enemy of this species (Ganiev 2006).

In contrast, the Lishan Nature Reserve, located at the transition zone between the subtropical and warm temperate regions, hosts a larger and more diverse range of amphibians, many of which are unique to China. Our findings also reveal that amphibians from Zagatala are generally larger in size compared to those in the Lishan Nature Reserve and are often found at higher altitudes (Lin et al. 2004). Factors contributing to these differences include the relatively higher temperatures in Lishan and the preservation of its vegetation and ecological environment due to a lack of glaciation during the Quaternary period. Consequently, Lishan is home to more temperature-resistant amphibian species, which may account for the observed differences in size (Table 2).

Zagatala				
Species	<i>Pelodytes caucasicus</i>		<i>Bufo verrucosissimus</i>	
Elevation	2300m		1900 m	
Climate	Temperate zone		Temperate, subtropical zone	
Habitat	Dense bush, rivers, intermittent rivers, freshwater swamps, intermittent freshwater swamps and freshwater springs		Foothill and mountain belt south of the forest-steppe zone	
Lishan				
Species	<i>Megophrys boettgeri</i>	<i>Strauchbufo raddei</i>	<i>Bufo raddei</i>	<i>Rana chensinensis</i>
Elevation	330 m~1600 m	600-2700 m	600-2700 m	335-1830 m
Climate	Subtropical, tropical zone	Temperate zone	Temperate zone	Subtropical, tropical zone
Habitat	In the cracks between the gravel where weeds and shrubs grow and the soil is damp	Under a rock or in a soil cave	Under grass and stones or in a hole in the soil	In or near a stream, small stream, or flooded swamp

Table 2. Habitat characteristics of amphibians in Lishan and Zagatala Nature Reserves

Additionally, analysis of terrestrial vertebrate species in the Zagatala Nature Reserve indicates that natural enemies of Caucasian frogs primarily include raccoons, snakes, and skunks, resulting in fewer threats to their populations. In contrast, the frogs in Lishan Nature Reserve face predation from a broader range of species, including eight weasel species and sixteen snake species. Thus, the species structure of frogs in Azerbaijan appears to be less complex than that in China.

Reptiles

Karelin's Newt (*Triturus karelinii*) and Chinese Giant Salamander (*Andrias davidianus*)

Based on our analysis of the collected data, we found that despite their similar morphology, the giant salamander and Karelin's newt are distinct species (Table 3). Our comparative evaluation yielded the following results:

- 1. Body Size:** The size difference between these two species is significant. The Chinese giant salamander is notably larger, with some individuals exceeding 1 meter in length. In contrast, *Triturus karelinii* typically measures around 10 centimeters, although some may be even smaller. Additionally, *Andrias davidianus* is monochromatic, exhibiting a black coloration, while *Triturus karelinii* displays a lighter and more varied color palette.
- 2. Differences in Appearance:** The giant salamander has distinctive skin folds on its sides, while *Triturus karelinii* has smoother skin with less prominent warts. Moreover, the webbing between the toes of *Andrias davidianus* is less visible compared to the non-webbed toes of the common salamander.
- 3. Diet:** *Andrias davidianus* primarily preys on larger animals such as fish, shrimp, frogs, and snakes (reference). In contrast, *Triturus karelinii* feeds on worms, snails, and small insects.
- 4. Habitat and Behavior:** Giant salamanders inhabit high-altitude rivers, whereas common salamanders are found in swampy ponds. The giant salamander exhibits a more aggressive behavior, while *Triturus karelinii* tends to be calmer.
- 5. Toxicity:** *Triturus karelinii* contains small amounts of toxins, a trait not found in *Andrias davidianus*.

	<i>Triturus karelinii</i>	<i>Andrias davidianus</i>
Size	18 cm	1.1-1.8 m
Body color	Brown to gray, with dark spots on the back	Mostly light brown, with small dark spots, without back
Life span	Males up to 11 years, females up to 5 years	200 years
Habitat	Mountainous regions, deciduous and coniferous forests, slopes and plateaus swamps, lakes, creeks, ditches and temporary pools, as well as streams	Caves and stone grottoes at 1,500 m a.s.l.
Food	Insects, invertebrates	Crabs, frogs, fish, shrimp, aquatic insects and their larvae
Weight	16-20 g	30 kg

Table 3. Comparative characteristics of Karelin's newt and Chinese giant salamander

Greek Tortoise (*Testudo graeca*) and Chinese Softshell Turtle (*Pelodiscus sinensis*)

We also revealed the differences between the tortoises in the two reserves (Table 4). Although their sizes are similar, their diets are notably different. The Chinese softshell turtle primarily consumes meat and carrion and has a long lifespan, while the Mediterranean Greek tortoise mainly feeds on leafy plants and fish, leading to a shorter lifespan. Additionally, the Mediterranean tortoise inhabits higher altitudes compared to its Chinese counterpart. The Chinese softshell turtle demonstrates remarkable adaptability, thriving in a variety of freshwater environments.

In terms of ecology, tortoises occupy lower trophic levels and face numerous natural enemies, predominantly rodents. This predation pressure suggests that the species structure of Chinese turtles in Lishan Nature Reserve is relatively complex.

	<i>Testudo graeca</i>	<i>Pelodiscus sinensis</i>
Size	25 cm	30 cm
Body color	Olive or tan with black spots	Brown
Life span	30–35 years	60 years
Habitat	Everytopic	Freshwater with sandy and silty substrate
Food	Deciduous plants	Fish, shrimp, insects, aquatic plants, grains, and other plant foods, stinking fish and rotten shrimp

Table 4. Comparative characteristics of Greek tortoise and Chinese softshell turtle

Mammals

Bats

There is a notable size difference between bats in the two reserves (Table 5). The bats in Zagatala tend to be significantly larger, often weighing almost twice as much as those found in Lishan. Their greater body mass correlates with a more diverse diet (Rakhmatulina 2005).

	<i>Rhinolophus ferrumequinum</i>	<i>Myotis blythii</i> Thom	<i>Barbastella barbastellus</i>	<i>Myotis emarginatus</i>
Body length	52–71 mm	58–77 mm	40–55 mm	44–55 mm
Wingspan	35–40 cm	38–40 cm	26–31 cm	22–28 cm
Weight	13–34 g	15–30 g	6–15 g	5–10 g
Habitat	Foothills and low mountains	Forests and drylands	Broadleaf forest	Drylands
Height	3500 m	-	1900 m	-
Activity	After dark	After dark	At twilight	At twilight
Food	Large and medium-sized nocturnal insects	Orthoptera and other insects	Beetle, butterfly, mosquito	Insects
Sound wave	77–81 kHz	90–30 kHz	30–38 kHz	95–40 kHz
Breeding time	Summer	Summer	Summer	Spring
Microhabitat	Caves, tunnels	Various underground shelters in the northern part of the mountains	Caves, mines, basements, cracks in rocks, tree hollows	Caves, grottoes and attics of large buildings

Table 5. Comparison of bats in Lishan and Zagatala Nature Reserves

Habitat preferences reveal that bats in both reserves inhabit high-altitude forests and caves; however, those in Lishan typically nest closer to populated areas in low-mountain regions. We attribute these differences to varying climate and temperature conditions. Additionally, breeding seasons differ, with bats in China's reserves starting earlier and producing more offspring. Notably, bats in the Chinese protected areas also exhibit a smaller sound wavelength amplitude.

Rodents

Data analysis suggests that rodents in Azerbaijan tend to occupy lower elevations but exhibit relatively larger body sizes (Table 6). Conversely, rodents in the Lishan Nature Reserve breed less frequently each year, although the total population of new individuals continues to increase.

Rodents from both reserves primarily feed on crops and insects. The lowmountain regions of Lishan support a greater diversity of small and medium-sized predators (such as snakes and weasels), which may influence species distribution. Climate and temperature differences also play a role in shaping these dynamics.

Mustelids

We noted the contrasts mustelids from both reserves, indicating that those in Lishan are predominantly yellow, while those in Zagatala are typically brown or black.

This difference in coloration may be linked to the varied habitats in regions, including elements such as the Gobi Desert in China. Furthermore, mustelids in Zagatala are generally longer and heavier than their Lishan counterparts (Table 7).

The breeding seasons also differ, with mustelids in Lishan breeding earlier. The latter enjoy a wider range of food choices due to the presence of 16 rodent species in the area.

	Zagatala		Lishan		
	<i>Chionomys</i>	<i>Chionomys gud</i>	<i>Crioetulus longicaudatus</i>	<i>Eothenomys iner</i>	<i>Myospalax fontanieri</i>
Height	500–3200 m	500–3000 m	1900 m	800–2800 m	3800–3900 m
Body length	160 mm	126–150 mm	85–135 mm	68–74 mm	15–27 mm
Activity	Daytime	Daytime	Night time	Day and night time	Night time
Food	Fern leaves, elderberries and azaleas	Plants and mosses	Succulents, seeds and insects	Succulents, seeds and insects	Succulents, seeds
Reproductions per year	2–3	4	2	1	1–2
Cubs	3	-	9	2–6	1–2
Habitat	Temperate forest	Temperate forest	Foothill, densely forested slope	Mountain thickets and grassy slopes	Alpine meadow

Table 6. Comparison of rodents in Lishan and Zagatala Nature Reserves

	Zagatala		Lishan	
	<i>Martes martes</i>	<i>Martes flavigula</i>	<i>Mustela sibirica</i>	<i>Mustela altaica</i>
Size	53 cm	56–65 cm	28–39 cm	20–28 cm
Weight	1.5–1.7 kg	2–3 kg	650–820 g (male), 360–430 g (female)	80–350 g
Body color	Brown	The head and limbs are black, the back and belly are tan	Red yellow	Yellow
Activity	Night and twilight	Night and twilight	Night and twilight	Diurnal and nocturnal species, activity peaks at night and at dusk
Mating	June–April	June–July	Spring	March–April
Food	Small mammals, birds, insects, frogs, strawberries, birds eggs, nuts, and honey	Typical carnivore, insects, fish	Rodents	Rodents

Table 7. Comparison of mustelids in Lishan and Zagatala Nature Reserves

Artiodactyls

Artiodactyls in the Zagatala Nature Reserve are comparatively larger and longerlived, inhabiting higher altitudes (Sokolov and Tembotov 1993; Hasanov and Mustafaeva 2009). In contrast, artiodactyls in the Lishan Nature Reserve have shorter lifespans and primarily reside at middle to low altitudes, often in forest underbrush (Table 8). Their reproductive rates tend to be lower (Askerov et al., 2006; reference).

A contributing factor to these differences appears to be the presence of more natural enemies in the Lishan Nature Reserve, including wolves, foxes, leopards, and jackals. These predators primarily rely on artiodactyls and small mammals for food, necessitating that these animals develop

smaller sizes and heightened sensitivity to evade predation.

	Zagatala	Lishan	
	<i>Rupicapra rupicapra</i>	<i>Cervus elaphus</i>	Moschus
Size	107–137 cm	150–200 cm	100 cm
Weight	50 kg	200–300 kg	11–18 kg
Altitude	3600 m	700–3000 m	600+
Food	Plants	Herbs, grains, and legumes	Higher and lower plants
Life span	20	20	12–15 years
Mating	November	September	January
Pregnancy	20 weeks	34 weeks	24 weeks
Habitat	Steep, rough and rocky terrains	Deciduous, subtropical, and coniferous forests, river banks, mountain alpine meadows	Cliffs and rocky mountain habitats in mixed coniferous, coniferous-deciduous forests, and sparse forest thickets
Cubs	1–3	1	1–2

Table 8. Comparison of artiodactyls in Lishan and Zagatala Nature Reserves

Felids

Bengal cat (*Prionailurus bengalensis*) and Caucasian wildcat (*Felis silvestris caucasica*)

We highlight the differences between the Bengal cat and the Caucasian wildcat (Table 9). The Greater Caucasian wildcat found in Azerbaijan is generally smaller than the Bengal cat residing in protected areas of China. Additionally, the Caucasian wildcat typically inhabits higher altitudes compared to the Bengal cat (Red Data Book 2013).

In terms of breeding, Bengal cats tend to breed earlier than the Greater Caucasian wildcat. Furthermore, the breeding duration for the Caucasian wildcat is longer, resulting in a greater number of cubs compared to the Bengal cat found in Alexandra. From a habitat perspective, Bengal cats are more likely to be found in areas closer to human populations.

	<i>Prionailurus bengalensis</i>	<i>Felis silvestris caucasica</i>
Habitat	Mountain forests, suburban thickets, and forest edges	Forested areas (mostly broad-leaved forests)
Size	65–100 cm	50–67 cm
Altitude	up to 3240 m	2500–3000 m
Mating	March–April	March
Pregnancy	60–70 days	68–70 days
Cubs	2	3

Table 9. Comparison of Bengal cat and Caucasian wildcat

Conclusions

Through the analysis of literature, archival materials, and our own field research, we studied the systematics and distribution of terrestrial vertebrate species in both the Lishan Nature Reserve and the Zagatala Nature Reserve. This included an examination of rare and endemic species residing in each reserve. We conducted a comparative analysis of the natural and ecological conditions of the Lishan Nature Reserve in the People's Republic of China and the Zagatala Nature Reserve in Azerbaijan. Additionally, we provided a comparative description of the terrestrial vertebrate fauna, specifically focusing on amphibians and mammals, in both reserves. This analysis considered various factors, including size, weight, age, habitat, altitude, climate of the distribution area, and

dietary composition. Our findings indicate that, in general, many terrestrial vertebrate species in the Zagatala Nature Reserve, such as amphibians, bats, rodents, martens, and artiodactyls, tend to be larger and heavier than their counterparts in the Lishan Nature Reserve, and they are often found at higher altitudes.

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