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Study on Terrestrial Wild Vertebrate Diversity and Geographical Fauna in Qinghai Area of Qilian Mountain National Park, China

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Abstract: To gain an in-depth understanding of the resource status of terrestrial wild vertebrates in the Qinghai Area of Qilian Mountain National Park, a total of 10 field surveys were conducted in the reserve from May 2019 to May 2022, and the diversity and geographical fauna of terrestrial wild vertebrates in the study area were studied combined with literature. The results show that in the Qinghai Area of the Qilian Mountain National Park, there are 265 species of terrestrial vertebrates in 4 classes, 30 orders, 71 families and 167 genera. Among them, Amphibia has 1 order, 2 families, 2 genera and 3 species; Reptilia has 2 orders, 4 families, 5 genera and 5 species; Aves has 21 orders, 51 families, 131 genera and 214 species; Mammalia has 6 orders, 15 families, 29 genera and 43 species. The composition of terrestrial wild vertebrate species in the study area shows that Aves account for 80.75%, Mammalia account for 16.23%; Reptilia account for 1.89% and Amphibia account for only 1.13%. The geographical fauna is dominated by Cosmopolitan species (218), followed by Palaearctic species (48) and a few Oriental species (3). Data from the G-F analysis shows that birds are more diverse at both family and genus levels, followed by mammals, with amphibians lower and reptiles lowest.

Keywords: species diversity; geographical distribution; species check-list

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1. Introduction

Biodiversity is inseparable from human life and is one of the conditions for the sustainable development of human society. Biodiversity is the material basis for human survival and plays a vital role in maintaining the stability and functionality of ecosystems. The terrestrial vertebrates are an important component of biodiversity.

China is one of the richest countries in the world in terms of biodiversity, with 3232 species of terrestrial vertebrates, including 687 species of mammals, 1445 species of birds, 548 species of amphibians and 552 species of reptiles [1,2]. In recent years, vertebrates are under great threat of extinction around the world, due mainly to exotic species, conversion, degradation and fragmentation of habitats, climate change, over-exploitation and pollution caused by anthropogenic activities [3–7]. Studies on "terrestrial vertebrate diversity" have focused on the biodiversity and geographical fauna of terrestrial wild vertebrates in different areas [8–35] (see Appendix A Table A1) and the impact of human activities on terrestrial wild vertebrates [36,37]. In addition, based on the research on terrestrial wild vertebrate biodiversity and fauna, scholars have also studied the conservation measures, conservation policies to terrestrial wild vertebrates and utilization of wildlife-related resources [38–40], and constructed an index system for evaluating the effectiveness of conservation in national nature reserves [41]. Therefore, it is an important task for China's wildlife diversity conservation research to identify the number, distribution, population dynamics, habitat and its conservation and utilization

status of each species, and to recognize the objective factors that affect and endanger the survival and development of wildlife.

Qilian Mountain National Park is located at the southeast edge of the Qinghai–Tibet Plateau, known as the "Third Pole". As one of the first ten national parks in China, Qilian Mountain National Park aims to protect the integrity and authenticity of regional biodiversity and natural ecosystems and is China's major ecological function area, as well as an important ecological security barrier and a water-conserving area in western China. The Park is rich in animal resources and unique in species, where the unique geographical location and the complex and diverse ecosystem environment have nurtured relatively rich biological resources. At present, the only related studies on terrestrial wild vertebrates in Qilian Mountain National Park are those on terrestrial wild vertebrate diversity and geographical fauna in Tianzhu County, the Gansu Area of this Park. As an important part of Qilian Mountains National Park, The Qinghai Area accounts for 31.5% of the total area of the Park. Studying the terrestrial wild vertebrate diversity and geographical fauna in this area will not only acquire the basic data of wildlife resources in the Park and improve the animal data of the reserve, but also provide some reference point for biodiversity conservation in the area.

2. Materials and Methods

2.1. The Study Area

Qilian Mountain National Park is located on the northeastern edge of the Qinghai-Tibet Plateau (see Figure 1), it is located in the northern foot of the Qilian Mountain, which is the intersection of the three major plateaus of Qinghai-Tibet, Mengxin and Loess. It is situated in an alpine zone with a continental plateau climate, strong solar radiation, large temperature differences between day and night, and significant vertical changes in temperature and precipitation. The Park covers a total area of 50,200 square kilometers and is divided into 2 areas, Gansu and Qinghai, of which the Qinghai Area has a total area of 15,800 square kilometers, accounting for 31.5% of the total area, including Menyuan County and Qilian County in Haibei Tibetan Autonomous Prefecture, Qinghai Province, and Tianjun County and Delingha City in Haixi Prefecture. Qilian Mountain National Park Qinghai Area has a unique ecosystem and diverse natural landscape, with an average altitude of 4000~5000 m, extensive glacial cover, making it an important "solid reservoir" in the northeastern part of the Qinghai-Tibet Plateau [42], and is the Source of Heihe River, Shule River, Shiyang River and Datong River.

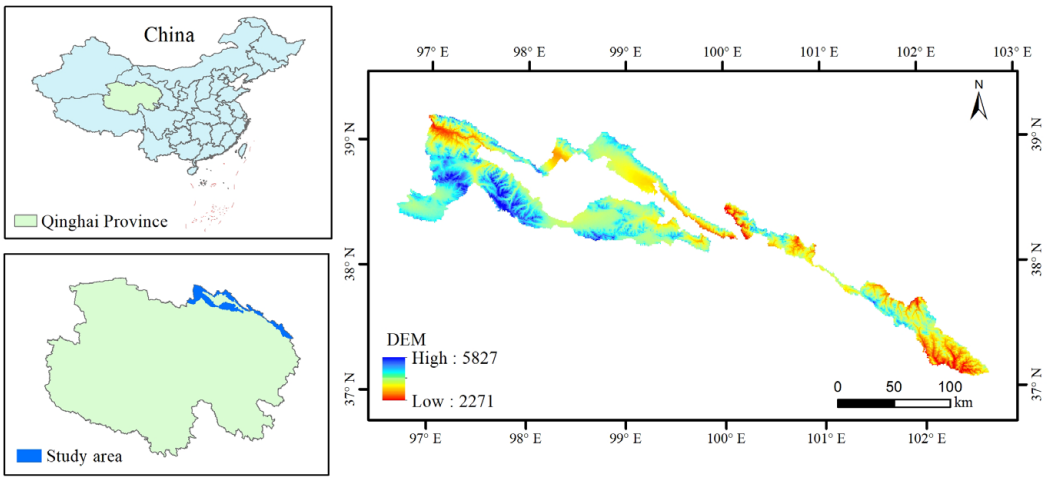

Figure 1. Location of the Qinghai Area of Qilian Mountain National Park.

2.2. Data Sources and Processing

Field survey was used as well as a combination of long-term monitoring data from the study area and historical documentation such as scientific expedition collections. Field

surveys of the species and numbers of inland wild vertebrates in the reserve were conducted based on vegetation types, topography and landform and distribution of each animal taxon, and geographical information such as topography, landform, elevation and habitat of the survey area were recorded.

Ten surveys were conducted in May, July and October each year from 2019 to 2021 and in May 2022 in the Qinghai Area of Qilian Mountain National Park. The sample line method and infrared camera monitoring method were mainly used to survey the terrestrial wild vertebrates distributed in the area. Due to the influence of climate and topography, the sample line method was mainly used to survey the eastern part of the park, while the infrared camera monitoring method was mainly used in the western part of the park. In addition to field surveys, visits to farmers, foresters and herders to understand the changes in local animal resources and their current status were conducted as a supplement.

2.2.1. Sample Line Method

In the sample line survey, the sample line length was set at least 3 km, the survey time was 8:00–20:00 every day, and the walking speed of the investigators was 1–1.5 km/h. 40 sample lines were laid out, taking into account these issues of functional area, vegetation type, elevation gradient, and frequency of animal occurrence. (see Figure 2).

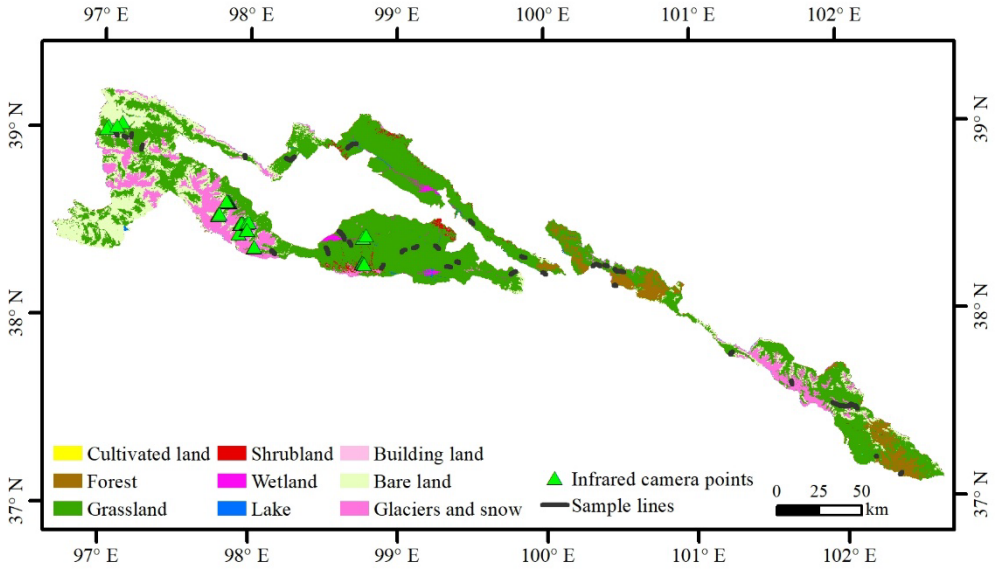

Figure 2. Location of Sample Lines and Infrared camera points in the Qinghai Area of Qilian Mountain National Park.

2.2.2. Infrared Camera Monitoring Method

A total of 70 infrared cameras (LTL-6210 PLUS) were deployed in the park (see Figure 2). In order to improve the efficiency of the infrared cameras, three principles were followed in the selection and deployment of the sites: (1) As far as possible, the sites with more animal tracks, scat, food traces, markers and other activity traces were selected or the animal trails with abundant food and close to water sources. (2) Infrared camera fixed at 50–100 cm from the ground on the trunk of the camera lens to maintain a horizontal or slightly downward, as far as possible to avoid direct sunlight. (3) The distance between adjacent sites should be greater than 500 m. At the same time, the number, date of placement, latitude, longitude, elevation and vegetation type of each camera should be recorded. Infrared cameras are replaced with batteries and memory cards every 2–3 months, and lost cameras are maintained and replenished in a timely manner. The working time of the infrared camera is set to 24 h, and each time the trigger takes three consecutive photos with 1 video of 10–15 s to form 1 group of photos, and the trigger interval is 30 s.

2.3. Species Identification Methods

Species were identified and systematically classified according to the Vertebrate Species and Distribution in Qinghai [43], Qinghai Economic Zoology [44], A Guide to the Mammals of China [45], Catalogue of mammals in China (2021) [46], The Updated Checklists of Amphibians and Reptiles of China [47], A Field Guide to the Birds of China [48], A Checklist on the Classification and Distribution of Birds in China (Third Edition) [49]. Rare species were identified with reference to the List of National Key Protected Wildlife [50] and the Red List of Chinese Vertebrates [51], and species were classified by geographical fauna and distribution type according to the Zoogeography of China [52].

2.4. Research Methods

The G-F index formula [53] was used to calculate the diversity of terrestrial wild vertebrates in the reserve for the aggregated terrestrial wild vertebrate list.

(1) F-index (diversity of families).

$$D_F = -\sum_{k=1}^{m} D_{FK} \tag{1}$$

D_{FK} is the species diversity in family k, calculated as

$$D_{FK} = -\sum_{i=1}^{n} p_i \ln p_i \tag{2}$$

In the formula, P_i is the ratio of the number of species in genus i of family k to the total number of species in family k in mammals, n is the number of genera in family k, and m is the number of families in mammals.

(2) G index (diversity of genera):

$$D_G = -\sum_{j=1}^{p} q_j \ln q_j \tag{3}$$

q_j is the ratio of the number of species in genus j to the total number of species in an order, and p is the number of genera in an order.

(3) G-F index:

$$D_{G-F} = 1 - \frac{D_G}{D_F} \tag{4}$$

3. Results

3.1. Species Composition

The survey results showed that there were 265 species of terrestrial wild vertebrates in 4 classes, 30 orders, 71 families and 167 genera in the study area, accounting for 64.4% of the number of terrestrial wild vertebrate species (418 species) in Qinghai Province (see Appendix A Table A2).

There were 214 species of birds in 21 orders, 51 families and 131 genera in the study area, accounting for 80.75% of the total number of species. The birds of the order Passeriformes (95 species) were absolutely dominant with 44.39% of the total species number. This was followed by Charadriiformes (23 species), with the proportion of 10.75%, Falconiformes (20 species) and Anseriformes (20 species), each accounting for 9.35%.

There were 43 species of mammals in 6 orders, 15 families and 29 genera in the study area, accounting for 16.23% of the total number of species. The largest number of species of carnivores (16 species) accounted for 37.21% of the total number of species, followed

by Artiodactyla (9 species) at 20.93%, Lagomorpha (8 species) at 18.6%, and Rodentia (7 species) at 16.28%. The least common species was Perissodactyla, only the *Equus kiang*.

There were 5 species of Reptilia in 2 orders, 4 families, 5 genera in the study area, accounting for 1.89% of the total number of species. They were *Eremias multiocellata*, *Phrynocephalus vlangalii*, *Rhabdophis tigrinus*, *Elaphe dione*, *Gloydius cognatus*, etc.

There were 3 species of Amphibia in only 1 order, 2 families, 2 genera in the study area, accounting for 1.13% of the total number of species, and all of them were Anura, namely, *Rana kukunoris*, *Bufo gargarizans minshanicus* and *Bufo gargarizans*.

There were 98 species of terrestrial vertebrates found by the sample line method, including four species of mammals, three species of reptiles, and 91 species of birds. 35 species of terrestrial vertebrates were found by the infrared camera monitoring method, including 20 species of mammals and 15 species of birds. 132 species of terrestrial vertebrates were found by searching published books [43,44] and press reports. (see Table A2)

Figure 3 records the distribution of species found by the sample line method and the infrared camera monitoring method within the park. The amphibians were discovered by reviewing the literature and we presume that they are mainly distributed near rivers and lakes, so we provide maps of the distribution of rivers and lakes in the Park (see Figure 3).

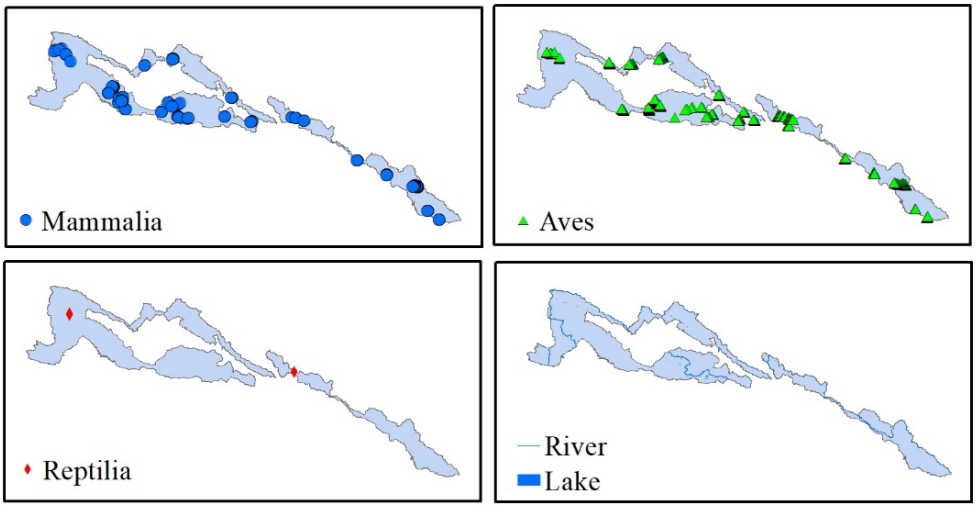

Figure 3. Distribution of Mammalia, Aves, Reptilia, River and Lake in the Qinghai Area of Qilian Mountain National Park.

3.2. Rare and Endangered Species Composition of the Reserve

According to the newly released *National List of Key Protection Wildlife*, there are 77 species of national key protection wildlife in the reserve, accounting for 29% of the number of wildlife species in the reserve. Among them, there are 20 species of China's national first-class key protected wild animals, with 13 species of birds and 7 species of mammals; 57 species of China's national second-class key protected wild animals, with 43 species of birds and 14 species of mammals (see Table A2); China's national first-class and second-class protected animals account for 7.6% and 16% of the vertebrate species in the reserve.

In addition, there are 55 threatened species listed in the Red List of Chinese Vertebrates, accounting for 20.75% of the number of wildlife species in the reserve. One species, *Felis bieti*, is classified as Critically Endangered (CR). Ten species are classified as Endangered (EN), including 4 species of birds and 6 species of mammals, including *Falco cherrug*, *Haliaeetus leucoryphus*, *Aquila heliaca*, *Pelecanus onocrotalus*, *Cervus elaphus*, *Cervus albirostris*, *Lynx lynx*, *Felis manul*, *Panthera uncia* and *Martes foina*. Thirteen species are classified as Vulnerable (VU), including 9 species of birds and 4 species of mammals. Meanwhile, there are also 16 species of wildlife listed as Near Threatened (LC), including 15 species of birds and 1 species of mammals (see Table A2).

3.3. Geographical Fauna Features

The number of Cosmopolitan species (214 species) was absolutely dominant, accounting for 80.75% of the total number of species, followed by the Palaearctic (48 species), accounting for 18.11%, and the Oriental species (3 species), accounting for 1.13% of the least number of species. Among them, the number of species in Cosmopolitan species: Aves > Mammalia > Amphibian = Reptilia; the number of species in Palaearctic species: Aves > Mammalia > Reptilia > Amphibian; the number of species in Oriental species: Aves > Mammalia, with no distribution in Amphibian and Reptilia (see Table 1).

Table 1. Fauna composition of terrestrial wild vertebrates.

Fauna		Number of Species	Total Number of Species	Proportion of Total Species (%)	Proportion of Classes (%)
Cosmopolitan species	Amphibia	3	214	1.13	100
	Reptilia	3		1.13	60
	Mammalia	27		10.19	62.79
	Aves	181		68.3	84.58
Palaearctic realm	Amphibia	0	48	0	0
	Reptilia	2		0.75	40
	Mammalia	15		5.66	34.88
	Aves	31		11.7	14.49
Oriental realm	Amphibia	0	3	0	0
	Reptilia	0		0	0
	Mammalia	1		0.38	2.33
	Aves	2		0.75	1.03

3.4. Distribution Type

In terms of species distribution type, Palaearctic type (U) accounted for 22.64%, followed by Highland type (P) accounting for 20%, Palaearctic & Nearctic type (C) and south China type (O) accounting for 15.09% and 14.34%, Central Asian type (D), Himalayan-Transverse mountain type (H) and Oriental type (W) accounting for 8.68%, 7.17% and 5.28%, and the remaining Northeastern type (M), Monsoon type (E), North China type (B), Northeast-North China type (X), Not-easily-categorized type (S) and Local type (L) all accounted for less than 5%. Mammalia occupied 11 distribution types, among which Palaearctic and Highland types were dominant, with no Northeast type; Aves occupied 11 distribution types, among which Palaearctic and Himalayan-Transverse type were dominant, with no North China type; Reptilia had Palaearctic & Nearctic type (1 species), Monsoon type (1 species) and Himalayan-Transverse type (1 species); Amphibia occupied 4 distribution types and were more evenly distributed (see Table 2).

Table 2. Fauna composition of terrestrial wild vertebrates.

Class	Amphibia	Reptilia	Mammalia	Aves	Total	Percentage (%)
U	0	1	7	52	60	22.64
P	1	1	18	33	53	20
C	0	0	5	35	40	15.09
O	0	0	1	37	38	14.34
D	0	2	7	14	23	8.68
H	0	0	1	18	19	7.17
W	0	0	2	12	14	5.28
M	0	0	0	9	9	3.40
E	1	1	1	1	4	1.51
B	0	0	1	1	2	0.75
X	0	0	0	1	1	0.38
S	0	0	0	1	1	0.38
L	1	0	0	0	1	0.38

3.5. G-F Index Features

The data show that in terms of the number of orders, families, genera, species, G-index and F-index: Aves > Mammalia > Reptilia > Amphibian, which shows that birds in the reserve have the highest species diversity and are richer in both families and genera; in terms of G-F index: Aves >Mammalia >Amphibian > Reptilia, which shows that birds and mammals have higher species diversity than the other two groups, while reptiles have the lowest species diversity level with negative values (see Table 3).

Table 3. Analysis of G-F indexes of terrestrial wild vertebrates.

Class	Order	Family	Genus	Number of Species	G Index	F Index	G-F Index
Amphibia	1	2	2	3	0.64	0	0
Reptilia	2	4	5	5	1.61	0.69	−1.33
Mammalia	6	14	28	43	3.15	6.54	0.52
Aves	21	51	131	214	4.68	29.74	0.84

4. Discussion

In this study, a total of 265 species of terrestrial wild vertebrates in Qinghai Area of Qilian Mountain National Park were recorded and collated, including 4 classes, 30 orders, 71 families, 167 genera. Among them, there are 21 orders, 51 families, 131 genera, 214 species of birds, 6 orders, 15 families, 29 genera, 43 species of mammals, 2 orders, 4 families, 5 genera, 5 species of reptiles, and only 1 order, 2 families, 2 genera, 3 species of amphibians. Rare and endemic species and their distribution forms are important indicators of the biodiversity of an area [54,55]. Protected species in the study area accounted for 29.06% of the total species, and the discovery of numerous protected animals proves that the conservation measures of the reserve have achieved a certain degree of success.

There are 214 species of Aves in the study area. The area is rich in rivers and water resources, and the fish, invertebrates and aquatic plants in rivers and wetlands provide abundant food for birds. Among them, the Passeriformes (95 species) occupy an absolute advantage with 44.39% proportion, indicating that medium and small finches are highly adaptable and can radiate into various ecological environments, becoming the dominant bird species in the reserve. There are 43 species of Mammalia, whose species composition, geographical fauna composition and distribution characteristics are related to the geographical location of the reserve. The Park has high vegetation cover, diverse habitat types and vast grasslands, resulting in a high number of species of Artiodactyla, Lagomorpha and Rodentia, while species of Carnivora, which feed on the above-mentioned orders, are predominant. The small number of amphibian and reptilian species is probably due to the geographical location of the park. Amphibia and Reptilia cannot migrate long distances due to their morphological and functional characteristics, and their habitats are relatively fixed, especially for Amphibians, which cannot breed without a water environment, while the Park has a series of high mountains running northwest to southeast, with an average altitude of about 4000 m, which, to large extent, limits the penetration of Amphibia and Reptilia species from other areas, and the Park is located in the alpine zone with an alpine climate unsuitable for the breeding and survival of Amphibia and Reptilia. Consequently, the level of species diversity of Amphibia and Reptilia is not high.

Wildlife, through long-term evolution, will interact with the regional habitats they live in and adapt to each other, so that wild animals with the same distribution range and same distribution environment have the same geographical fauna characteristics [17]. The size of the range of a wildlife is closely related to the extent to which it is adapted to its environment. The migratory nature of wildlife can lead to a complex regional geographical fauna, mostly characterized by a cross-fertilization of different distribution types and zones. In terms of geographical fauna distribution types, the Park is dominated by Palaearctic type, Highland type, Palaearctic & Nearctic type and South China type, with Central Asian type,

Himalayan-Transverse Mountain type and Oriental types occupying a certain proportion, and a smaller number of Northeast type, Monsoon type, North China type, Northeast-North China type, Not-easily-categorized type and local type. The multi-distribution pattern is probably related to the typical plateau geographical features of the Park. The Park is the source of inland rivers such as the Shule River, with good habitat quality, and has the highest peak in the Qilian Mountain, Tuanjie Feng, with relatively undulating areas on the north and south sides and east part of the mountain, and a part of this area is close to no man's land, and benefits from religious influence, which is a "paradise" for wildlife.

5. Conclusions

In the Qinghai Area of Qilian Mountain National Park, there are 265 species of terrestrial wild vertebrates in 4 classes, 30 orders, 71 families and 167 genera. 98 species were identified by the sample line method,35 species were identified by the infrared camera monitoring method. The species geographical fauna is dominated by the following types: Palaearctic and Highland types, with more species of Palaearctic & Nearctic type and south China type, and a certain pro-portion of Central Asian type, Himalayan-Transverse Mountains type, Oriental type and Northeast China type. But the number of species of these types are smaller: monsoon type, North China type, Northeast-North China type, Not-easily-categorized type and local type. The G-F index indicates high levels of species diversity in birds and mammals and low levels in amphibians and reptiles.

Author Contributions: Conceptualization, methodology, formal analysis, writing—original draft preparation: S.X.; investigation, data curation, validation, visualization: H.M.; writing—review and editing: J.X.; investigation, data curation, software: F.W.; resources, supervision, project administration, funding acquisition, Z.R. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Diversity of terrestrial vertebrates in different parts of the China.

Province		Aves	Mammalia	Reptilia	Amphibia	Total	Year
Hubei	Northwestern Hubei Province	405	108	55	51	619	2017
Hubei	Shennongjia World Natural Heritage Site	400	87	53	37	577	2018
Hubei	Dongting Lake Wetlands	180	19	18	12	229	2017
Hubei	Zhonghua Mountain Nature Reserve	165	39	31	15	250	2018
Gansu	Taizishan National Nature Reserve	138	60	3	7	208	2022
Gansu	Guazhou Tangdun Hu Nature Reserve	120	29	9	2	160	2020
Gansu	Mazongshan	48	25	7	0	80	2017

Table A1. *Cont.*

Province		Aves	Mammalia	Reptilia	Amphibia	Total	Year
Tibet	Ngari	71	26	2	0	99	2018
Tibet	Niyang River Basin	52	15	2	1	70	2013
Tibet	National Reserve of Lhalu Wetland, Lhasa	62	6	2	1	71	2010
Hebei	Chagannur wetlands	141	19	8	4	172	2022
Hebei	Hebei Province	440	83	25	8	556	2012
Shanxi	Gucheng National Wetland Park	159	11	7	4	181	2018
Shanxi	Xi County Seat	77	30	5	0	122	2015
Guangdong	Zhongshan Xiangshan Nature Reserve	106	10	36	16	168	2021
Guangdong	Nanling National Nature Reserve	259	89	94	44	486	2012
Guangdong	Meijiang Basin	201	42	42	17	302	2012
Guangxi	Wanggangshan Nature Reserve	122	18	39	14	193	2018
Guangxi	Mulun Nature Reserve	203	60	64	33	360	2014
Sichuang	Ruoerge Wetland National Nature Reserve	187	38	4	3	232	2021
Yunnan	Pu'er City	499	182	87	69	837	2020
Inner Mongolia	Tumuji Nature Reserve	276	23	8	6	313	2020
Qinghai	Tianzhu County Seat	166	64	7	3	240	2020
	Tengger Desert	201	33	12	3	249	2020
Heilongjiang	Shuanghe Nature Reserve	180	28	7	6	281	2017
Guizhou	Chishui Suoluo National Nature Reserve	182	60	35	23	300	2013
Jiangxi	Mountain National Forest Park	149	34	38	16	237	2013
Ningxia	Liupan Mountain National Nature Reserve	160	47	8	5	220	2013

Table A2. Checklist of terrestrial wild vertebrates in Qinghai Area of Qilian Mountain National Park.

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Rana kukunoris	Anura	Cosmopolitan species	*P*			
Bufo gargarizans minshanicus	Anura	Cosmopolitan species	*L*			
Bufo gargarizans	Anura	Cosmopolitan species	*E*			
Rhabdophis tigrinus	Squamata	Cosmopolitan species	*E*			
Elaphe dione	Squamata	Cosmopolitan species	*U*			Simple line method
Gloydius cognatus	Squamata	Cosmopolitan species	*D*			
Phrynocephalus vlangalii	Squamata	Palaearctic realm	P			Simple line method
Eremias multiocellata	Squamata	Palaearctic realm	*D*			Simple line method
Jynx torquilla	Piciformes	Cosmopolitan species	*U*			
Picus canus	Piciformes	Cosmopolitan species	*U*			Simple line method
Dendrocopos major	Piciformes	Cosmopolitan species	*U*			Simple line method

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Picoides tridactylus	Piciformes	Cosmopolitan species	*C*	II	LC	
Dryocopus martius	Piciformes	Cosmopolitan species	*U*	II	LC	Simple line method
Apus pacificus	Caprimulgiformes	Cosmopolitan species	*M*			Simple line method
Anser anser	Anseriformes	Palaearctic realm	*U*			
Anser indicus	Anseriformes	Cosmopolitan species	*P*			Simple line method
Mareca strepera	Anseriformes	Palaearctic realm	*U*			Simple line method
Anas platyrhynchos	Anseriformes	Palaearctic realm	*C*			Simple line method
Anas crecca	Anseriformes	Palaearctic realm	*C*			Simple line method
Anas zonorhyncha	Anseriformes	Palaearctic realm	*W*			Simple line method
Spatula clypeata	Anseriformes	Cosmopolitan species	*C*			
Anas penelope	Anseriformes	Cosmopolitan species	*C*			Simple line method
Anas acuta	Anseriformes	Cosmopolitan species	*C*			
Netta rufina	Anseriformes	Palaearctic realm	*O*			Simple line method
Bucephala clangula	Anseriformes	Cosmopolitan species	*C*			
Mergus merganser	Anseriformes	Cosmopolitan species	*C*			Simple line method
Aythya ferina	Anseriformes	Palaearctic realm	*C*			
Aythya fuligula	Anseriformes	Palaearctic realm	*U*			Simple line method
Aythya nyroca	Anseriformes	Cosmopolitan species	*O*			Simple line method
Tadorna ferruginea	Anseriformes	Cosmopolitan species	*U*			Simple line method
Anser cygnoides	Anseriformes	Cosmopolitan species	*M*	II	VU	
Cygnus cygnus	Anseriformes	Palaearctic realm	*C*	II	NT	Simple line method
Cygnus olor	Anseriformes	Cosmopolitan species	*U*	II	NT	
Mergellus albellus	Anseriformes	Cosmopolitan species	*U*	II	LC	
Ithaginis cruentus	Galliformes	Cosmopolitan species	H	II	NT	Simple line method
Tetraogallus tibetanus	Galliformes	Cosmopolitan species	P	II	NT	Infrared camera monitoring method
Tetraogallus himalayensis	Galliformes	Palaearctic realm	P	II	NT	Infrared camera monitoring method
Crossoptilon auritum	Galliformes	Cosmopolitan species	*P*	II	NT	Simple line method

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Alectoris magna	Galliformes	Palaearctic realm	*P*	II	NT	Infrared camera monitoring method
Tetraophasis obscurus	Galliformes	Cosmopolitan species	H	I	VU	Simple line method
Tetrastes sewerzowi	Galliformes	Cosmopolitan species	H	I		Simple line method
Phasianus colchicus	Galliformes	Cosmopolitan species	*O*			Simple line method
Alectoris chukar	Galliformes	Palaearctic realm	D			Simple line method
Perdix dauurica	Galliformes	Palaearctic realm	D			Simple line method
Perdix hodgsoniae	Galliformes	Cosmopolitan species	*H*			Simple line method
Upupa epops	Bucerotiformes	Cosmopolitan species	*O*			Simple line method
Nycticorax nycticorax	Ciconiiformes	Cosmopolitan species	*O*			
Egretta garzetta	Ciconiiformes	Cosmopolitan species	*W*			Simple line method
Ciconia nigra	Ciconiiformes	Cosmopolitan species	*U*	I	VU	Simple line method
Podiceps nigricollis	Podicipediformes	Cosmopolitan species	*C*	II	LC	Simple line method
Tachybaptus ruficollis	Podicipediformes	Cosmopolitan species	*W*			
Podiceps cristatus	Podicipediformes	Cosmopolitan species	*U*			
Urocynchramus pylzowi	Passeriformes	Cosmopolitan species	*P*	II	NT	
Alauda arvensis	Passeriformes	Cosmopolitan species	*U*	II	LC	Simple line method
Melanocorypha mongolica	Passeriformes	Palaearctic realm	*D*	II	VU	Simple line method
Alauda gulgula	Passeriformes	Cosmopolitan species	*C*			Simple line method
Eremophila alpestris	Passeriformes	Cosmopolitan species	*C*			Simple line method
Galerida cristata	Passeriformes	Cosmopolitan species	*O*			Simple line method
Calandrella acutirostris	Passeriformes	Cosmopolitan species	*P*			Simple line method
Calandrella brachydactyla	Passeriformes	Cosmopolitan species	*O*			Simple line method
Melanocorypha maxima	Passeriformes	Cosmopolitan species	*P*			Simple line method
Loxia curvirostra	Passeriformes	Cosmopolitan species	*C*	II	LC	Simple line method
Carpodacus erythrinus	Passeriformes	Cosmopolitan species	*U*			Simple line method
Carpodacus rubicilloides	Passeriformes	Cosmopolitan species	*P*			
Carpodacus rubicilla	Passeriformes	Palaearctic realm	*P*			
Carpodacus pulcherrimus	Passeriformes	Cosmopolitan species	*H*			

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Carpodacus puniceus	Passeriformes	Cosmopolitan species	*P*			
Carpodacus dubius	Passeriformes	Cosmopolitan species	W			
Linaria flavirostris	Passeriformes	Cosmopolitan species	*U*			
Mycerobas carnipes	Passeriformes	Cosmopolitan species	*P*			
Leucosticte brandti	Passeriformes	Cosmopolitan species	*P*			Infrared camera monitoring method
Leucosticte nemoricola	Passeriformes	Cosmopolitan species	*P*			Infrared camera monitoring method
Phoenicurus alaschanicus	Passeriformes	Palaearctic realm	*D*	II		Simple line method
Luscinia calliope	Passeriformes	Cosmopolitan species	*U*	II		Simple line method
Chaimarrornis leucocephalus	Passeriformes	Cosmopolitan species	*H*			Infrared camera monitoring method
Saxicola maurus	Passeriformes	Cosmopolitan species	*O*			
Tarsiger cyanurus	Passeriformes	Cosmopolitan species	*M*			Simple line method
Oenanthe isabellina	Passeriformes	Palaearctic realm	D			
Oenanthe pleschanka	Passeriformes	Palaearctic realm	*D*			
Oenanthe deserti	Passeriformes	Palaearctic realm	*D*			Infrared camera monitoring method
Phoenicuropsis schisticeps	Passeriformes	Cosmopolitan species	*H*			Simple line method
Phoenicuropsis frontalis	Passeriformes	Cosmopolitan species	*H*			
Phoenicurus ochruros	Passeriformes	Cosmopolitan species	*O*			Infrared camera monitoring method
Phoenicurus hodgsoni	Passeriformes	Cosmopolitan species	*H*			Simple line method
Phoenicurus auroreus	Passeriformes	Cosmopolitan species	*M*			Simple line method
Phoenicurus erythrogastrus	Passeriformes	Palaearctic realm	*P*			Infrared camera monitoring method
Calliope pectoralis	Passeriformes	Cosmopolitan species	H			
Grandala coelicolor	Passeriformes	Cosmopolitan species	*H*			
Luscinia svecica	Passeriformes	Cosmopolitan species	*U*	II		
Turdus kessleri	Passeriformes	Cosmopolitan species	*H*			Simple line method
Turdus ruficollis	Passeriformes	Cosmopolitan species	*O*			
Poecile superciliosus	Passeriformes	Cosmopolitan species	*P*	II	NT	Simple line method

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Aegithalos glaucogularis	Passeriformes	Cosmopolitan species	*U*			
Periparus rubidiventris	Passeriformes	Cosmopolitan species	*H*			Simple line method
Poecile montanus	Passeriformes	Cosmopolitan species	*C*			
Pseudopodoces humilis	Passeriformes	Cosmopolitan species	*P*			
Trochalopteron elliotii	Passeriformes	Cosmopolitan species	*H*	II	LC	Simple line method
Garrulax davidi	Passeriformes	Palaearctic realm	B			Simple line method
Syrrhaptes paradoxus	Pterocliformes	Cosmopolitan species	D			Simple line method
Syrrhaptes tibetanus	Pterocliformes	Palaearctic realm	*P*			Simple line method
Hirundo rustica	Passeriformes	Cosmopolitan species	*C*			Simple line method
Delichon urbicum	Passeriformes	Cosmopolitan species	*U*			
Cecropis daurica	Passeriformes	Cosmopolitan species	*U*			Simple line method
Prunella fulvescens	Passeriformes	Cosmopolitan species	*P*			Infrared camera monitoring method
Prunella collaris	Passeriformes	Cosmopolitan species	*U*			Infrared camera monitoring method
Prunella rubeculoides	Passeriformes	Cosmopolitan species	P			
Corvus corax	Passeriformes	Cosmopolitan species	*C*			
Corvus monedula	Passeriformes	Cosmopolitan species	*U*			
Corvus dauuricus	Passeriformes	Palaearctic realm	*U*			
Corvus macrorhynchos	Passeriformes	Cosmopolitan species	*E*			Simple line method
Pyrrhocorax graculus	Passeriformes	Cosmopolitan species	*O*			
Pyrrhocorax pyrrhocorax	Passeriformes	Cosmopolitan species	*O*			Infrared camera monitoring method
Pica pica	Passeriformes	Cosmopolitan species	C			Simple line method
Pseudopodoces humilis	Passeriformes	Cosmopolitan species	*P*			Simple line method
Cyanopica cyanus	Passeriformes	Cosmopolitan species	*U*			Simple line method
Podoces hendersoni	Passeriformes	Palaearctic realm	*D*			
Montifringilla henrici	Passeriformes	Cosmopolitan species	*P*			Infrared camera monitoring method
Montifringilla nivalis	Passeriformes	Palaearctic realm	*P*			Simple line method
Montifringilla adamsi	Passeriformes	Cosmopolitan species	*P*			Simple line method

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Petronia petronia	Passeriformes	Cosmopolitan species	*O*			
Passer montanus	Passeriformes	Cosmopolitan species	*U*			Simple line method
Pyrgilauda davidiana	Passeriformes	Cosmopolitan species	*P*			Simple line method
Pyrgilauda ruficollis	Passeriformes	Cosmopolitan species	*P*			Infrared camera monitoring method
Onychostruthus taczanowskii	Passeriformes	Cosmopolitan species	*P*			Simple line method
Pyrgilauda blanfordi	Passeriformes	Cosmopolitan species	*P*			
Certhia familiaris	Passeriformes	Cosmopolitan species	*C*			Simple line method
Tichodroma muraria	Passeriformes	Cosmopolitan species	*O*			Simple line method
Emberiza leucocephalos	Passeriformes	Palaearctic realm	*U*			Simple line method
Emberiza godlewskii	Passeriformes	Cosmopolitan species	*O*			
Leptopoecile sophiae	Passeriformes	Cosmopolitan species	P			
Leptopoecile elegans	Passeriformes	Cosmopolitan species	H			
Anthus richardi	Passeriformes	Cosmopolitan species	*M*			
Anthus roseatus	Passeriformes	Cosmopolitan species	*P*			
Anthus spinoletta	Passeriformes	Cosmopolitan species	*C*			
Motacilla alba	Passeriformes	Cosmopolitan species	*U*			Simple line method
Motacilla tschutschensis	Passeriformes	Cosmopolitan species	*U*			
Motacilla citreola	Passeriformes	Cosmopolitan species	*U*			
Phylloscopus inornatus	Passeriformes	Palaearctic realm	U			
Phylloscopus fuscatus	Passeriformes	Cosmopolitan species	*M*			
Phylloscopus affinis	Passeriformes	Cosmopolitan species	*H*			
Phylloscopus subaffinis	Passeriformes	Oriental realm	*S*			
Phylloscopus proregulus	Passeriformes	Cosmopolitan species	*U*			
Sturnus vulgaris	Passeriformes	Cosmopolitan species	*O*			
Dicrurus hottentottus	Passeriformes	Cosmopolitan species	*W*			
Troglodytes troglodytes	Passeriformes	Cosmopolitan species	*C*			
Cinclus cinclus	Passeriformes	Cosmopolitan species	*O*			Simple line method
Regulus regulus	Passeriformes	Cosmopolitan species	*C*			

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Lanius tephronotus	Passeriformes	Cosmopolitan species	*H*			
Lanius sphenocercus	Passeriformes	Cosmopolitan species	*M*			
Lanius isabellinus	Passeriformes	Cosmopolitan species	*X*			
Aegypius monachus	Accipitriformes	Cosmopolitan species	*O*	I	NT	
Milvus migrans	Accipitriformes	Cosmopolitan species	*U*	II	LC	
Accipiter nisus	Accipitriformes	Cosmopolitan species	*U*	II	LC	
Circus cyaneus	Accipitriformes	Cosmopolitan species	*C*	II	NT	
Gyps fulvus	Accipitriformes	Oriental realm	*W*	II	NT	
Gyps himalayensis	Accipitriformes	Cosmopolitan species	*O*	II	NT	Simple line method
Buteo hemilasius	Accipitriformes	Cosmopolitan species	*D*	II	NT	Simple line method
Buteo japonicus	Accipitriformes	Cosmopolitan species	*U*	II	LC	Simple line method
Gypaetus barbatus	Accipitriformes	Cosmopolitan species	*O*	I	NT	
Pandion haliaetus	Accipitriformes	Cosmopolitan species	*C*	II	NT	
Haliaeetus leucoryphus	Accipitriformes	Cosmopolitan species	*D*	I	EN	
Haliaeetus albicilla	Accipitriformes	Cosmopolitan species	*U*	I	VU	
Aquila nipalensis	Accipitriformes	Cosmopolitan species	*D*	I	VU	
Aquila chrysaetos	Accipitriformes	Cosmopolitan species	*C*	I	VU	Simple line method
Red-legged Falcon	Accipitriformes	Cosmopolitan species	*U*			
Falco tinnunculus	Falconiformes	Cosmopolitan species	*O*	II	LC	
Falco columbarius	Falconiformes	Cosmopolitan species	*C*	II	NT	
Falco cherrug	Falconiformes	Cosmopolitan species	*C*	I	EN	Simple line method
Falco peregrinus	Falconiformes	Cosmopolitan species	*C*	II	NT	
Aquila heliaca	Falconiformes	Cosmopolitan species	*O*	I	EN	
Athene noctua	Strigiformes	Cosmopolitan species	*U*	II	LC	Infrared camera monitoring method
Aegolius funereus	Strigiformes	Cosmopolitan species	*C*	II	VU	
Asio otus	Strigiformes	Cosmopolitan species	*C*	II	LC	Simple line method
Asio flammeus	Strigiformes	Cosmopolitan species	*C*	II	NT	Simple line method
Bubo bubo	Strigiformes	Cosmopolitan species	*U*	II	NT	

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Sterna hirundo	Lariformes	Cosmopolitan species	*C*			
Larus brunnicephalus Jerdon	Lariformes	Cosmopolitan species	*P*			Simple line method
Chlidonias leucopterus	Lariformes	Cosmopolitan species	*U*			
Cuculus canorus	Cuculiformes	Cosmopolitan species	*O*			Simple line method
Phalacrocorax carbo	Suliformes	Cosmopolitan species	*O*			Simple line method
Phoenicopterus roseus	Phoenicopteriformes	Palaearctic realm	*O*			
Ibidorhyncha struthersii	Charadriiformes	Cosmopolitan species	*P*	II	NT	
Arenaria interpres	Charadriiformes	Cosmopolitan species	*C*	II	LC	
Numenius minutus	Charadriiformes	Cosmopolitan species	*M*	II	NT	
Tringa totanus	Charadriiformes	Cosmopolitan species	*U*			Simple line method
Tringa nebularia	Charadriiformes	Cosmopolitan species	*U*			
Xenus cinereus	Charadriiformes	Cosmopolitan species	*U*			
Actitis hypoleucos	Charadriiformes	Cosmopolitan species	*C*			Simple line method
Limosa lapponica	Charadriiformes	Cosmopolitan species	*U*			
Calidris alpina	Charadriiformes	Cosmopolitan species	*C*			
Calidris ruficollis	Charadriiformes	Cosmopolitan species	*M*			
Calidris temminckii	Charadriiformes	Cosmopolitan species	*U*			
Calidris ferruginea	Charadriiformes	Cosmopolitan species	*U*			
Ichthyaetus ichthyaetus	Charadriiformes	Cosmopolitan species	*D*			Simple line method
Himantopus himantopus	Charadriiformes	Cosmopolitan species	*O*			
Recurvirostra avosetta	Charadriiformes	Cosmopolitan species	*O*			
Tringa ochropus	Charadriiformes	Cosmopolitan species	*U*			Simple line method
Tringa glareola	Charadriiformes	Cosmopolitan species	*U*			
Tringa erythropus	Charadriiformes	Cosmopolitan species	*U*			
Vanellus vanellus	Charadriiformes	Cosmopolitan species	*U*			Simple line method
Charadrius dubius	Charadriiformes	Cosmopolitan species	*O*			Simple line method
Charadrius alexandrinus	Charadriiformes	Cosmopolitan species	*O*			
Charadrius mongolus	Charadriiformes	Cosmopolitan species	*D*			

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Pluvialis fulva	Charadriiformes	Cosmopolitan species	*C*			Simple line method
Grus virgo	Gruiformes	Cosmopolitan species	*W*	II	LC	
Grus grus	Gruiformes	Cosmopolitan species	*U*	II	NT	
Grus nigricollis	Gruiformes	Cosmopolitan species	*P*	I	VU	Simple line method
Rallus aquaticus	Gruiformes	Cosmopolitan species	*U*			Simple line method
Fulica atra	Gruiformes	Cosmopolitan species	*O*			Simple line method
Gallinula chloropus	Gruiformes	Cosmopolitan species	*O*			
Ixobrychus sinensis	Pelecaniformes	Cosmopolitan species	*W*			
Bubulcus ibis	Pelecaniformes	Cosmopolitan species	*W*			
Ardea cinerea	Pelecaniformes	Cosmopolitan species	*U*			
Ardea alba	Pelecaniformes	Cosmopolitan species	*O*			
Ardeola bacchus	Pelecaniformes	Cosmopolitan species	*W*			
Platalea leucorodia	Pelecaniformes	Cosmopolitan species	*O*	II	NT	
Pelecanus onocrotalus	Pelecaniformes	Cosmopolitan species	*O*	I	EN	
Columba livia	Columbiformes	Palaearctic realm	*O*			Simple line method
Columba rupestris	Columbiformes	Palaearctic realm	*O*			Simple line method
Columba leuconota	Columbiformes	Palaearctic realm	*H*			Simple line method
Streptopelia decaocto	Columbiformes	Cosmopolitan species	*W*			Simple line method
Alcedo atthis	Coracheiiformes	Cosmopolitan species	*O*			
Naemorhedus griseus	Artiodactyla	Palaearctic realm	*E*	II	VU	
Procapra picticaudata	Artiodactyla	Palaearctic realm	*P*	II	NT	Infrared camera monitoring method
Pseudois nayaur	Artiodactyla	Cosmopolitan species	*P*	II	LC	Infrared camera monitoring method
Ovis ammon	Artiodactyla	Cosmopolitan species	*P*	II		Infrared camera monitoring method
Bos grunniens	Artiodactyla	Oriental realm	*P*	I	VU	Infrared camera monitoring method
Lepus oiostalus	Lagomorpha	Cosmopolitan species	*P*			Infrared camera monitoring method
Lepus oiostolus	Lagomorpha	Cosmopolitan species	*P*			Infrared camera monitoring method

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Ochotona macrotis	Lagomorpha	Palaearctic realm	*P*			
Ochotona erythrotis	Lagomorpha	Palaearctic realm	*P*			
Ochotona curzoniae	Lagomorpha	Cosmopolitan species	*P*			Infrared camera monitoring method
Ochotona thomasi	Lagomorpha	Palaearctic realm	*P*			
Ochotona cansus	Lagomorpha	Cosmopolitan species	*P*			
Ochotona dauurica	Lagomorpha	Palaearctic realm	*D*			
Cervus elaphus	Artiodactyla	Cosmopolitan species	*C*	II	EN	Simple line method
Moschus chrysogaster	Artiodactyla	Cosmopolitan species	*P*	I		Infrared camera monitoring method
Capreolus capreolus	Artiodactyla	Cosmopolitan species	*U*			Simple line method
Cervus albirostris	Artiodactyla	Palaearctic realm	*P*	I	EN	Infrared camera monitoring method
Equus kiang	Perissodactyla	Palaearctic realm	*P*	I	NT	Infrared camera monitoring method
Felis bieti	Carnivora	Cosmopolitan species	*D*	I	CR	Infrared camera monitoring method
Lynx lynx	Carnivora	Cosmopolitan species	*C*	II	EN	Infrared camera monitoring method
Felis manul	Carnivora	Cosmopolitan species	*D*	II	EN	Infrared camera monitoring method
Felis bengalensis	Carnivora	Cosmopolitan species	*W*	II	VU	
Panthera uncia	Carnivora	Palaearctic realm	*P*	I	EN	Infrared camera monitoring method
Vulpes ferrilata	Carnivora	Cosmopolitan species	*P*	II	NT	Infrared camera monitoring method
Cuon alpinus	Carnivora	Cosmopolitan species	*W*	I	NT	Simple line method
Canis lupus	Carnivora	Cosmopolitan species	*C*	II	NT	Infrared camera monitoring method
Vulpes vulpes	Carnivora	Cosmopolitan species	*C*	II	NT	Infrared camera monitoring method
Vulpes corsac	Carnivora	Palaearctic realm	*D*	II	NT	
Mustela altaica	Carnivora	Cosmopolitan species	*O*			
Mustela sibirica	Carnivora	Cosmopolitan species	*U*			
Ursus arctos	Carnivora	Palaearctic realm	*C*	II	VU	Infrared camera monitoring method

Table A2. *Cont.*

Name	Order	Fauna	Fauna Types	Animal Protection Class	Conservation Status	Survey Methodology
Meles meles	Carnivora	Cosmopolitan species	*U*			Simple line method
Mustela eversmanii	Carnivora	Cosmopolitan species	*U*			
Martes foina	Carnivora	Cosmopolitan species	*U*	II	EN	Infrared camera monitoring method
Allactaga sibirica	Rodentia	Palaearctic realm	*D*			
Petaurista xanthotis	Rodentia	Cosmopolitan species	*H*			
Marmota himalayana	Rodentia	Cosmopolitan species	*P*			
Myospalax bailyi	Rodentia	Palaearctic realm	*B*			Infrared camera monitoring method
Cricetulus kamensis	Rodentia	Cosmopolitan species	*P*			
Cricetulus longicandatus	Rodentia	Palaearctic realm	*D*			
Alticola stracheyinus	Rodentia	Palaearctic realm	*P*			
Sorex caecutiens	Insectivora	Cosmopolitan species	*U*			
Sorex thibetanus	Insectivora	Cosmopolitan species	*U*			

Figure A1. Photos of wildlife in the study area (All photos were taken by Z.R).

Figure A2. Photos of wildlife in the study area (All photos were taken by Z.R).

Figure A3. Photos of *Panthera uncia* in the study area (All photos were taken by Z.R).

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