Original Research Article

Practicing the thought of ecological civilization: A study on infrared camera monitoring practice in Zhouzhi Nature Reserve

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Abstract: To practice the thought of ecological civilization and scientifically assess the ecosystem health of the Zhouzhi National Nature Reserve, this study systematically analyzed the wildlife community structure at five monitoring sites (Xiaowangjian, Houzhenzi, Banfangzi, Laoxiancheng, and Shuangmiaozi) based on infrared camera monitoring data from 2025 to 2026. A total of 146 infrared cameras were deployed, yielding 6,017 valid data records and documenting 141 wildlife species, including 4 first-class and 2 second-class nationally protected wild animal species in China. The results show that the Xiaowangjian site achieved the best monitoring performance, the Laoxiancheng site had the richest rare species, and Cervidae animals were the dominant group across all sites. This study confirms the vital role of infrared camera technology in biodiversity monitoring within nature reserves and provides a scientific basis for ecological conservation and management in Zhouzhi Nature Reserve.
Keywords: ecological civilization; Zhouzhi Nature Reserve; infrared camera; biodiversity; wildlife monitoring

1. Introduction

Ecological civilization construction is an important part of the cause of socialism with Chinese characteristics. As core areas for ecological protection, nature reserves rely on biodiversity monitoring as a key means to evaluate ecosystem health. With the advantages of non-invasiveness, all-weather operation, and strong data continuity, infrared camera technology has become a mainstream method for wildlife monitoring, widely used in rare species surveys, population dynamic monitoring, and community structure analysis.

Located on the southern slope of the middle Qinling Mountains, Zhouzhi National Nature Reserve is a core area for biodiversity conservation in the Qinling Mountains, home to various rare and endangered wild animals such as the giant panda and Qinling takin. To scientifically evaluate the effectiveness of ecological protection in the reserve, this study systematically analyzed the composition and distribution characteristics of wildlife communities based on infrared camera monitoring data from five typical monitoring sites, providing scientific support for refined management of the reserve.

2. Research methods

2.1. Overview of the study area

Five representative monitoring sites were selected in Zhouzhi Nature Reserve, with the following geographical and ecological characteristics:

Xiaowangjian Site: Located in the eastern part of the reserve, at an altitude of 1,200–1,800 m, dominated by deciduous broad-leaved forests with high habitat heterogeneity;

Houzhenzi Site: Located in the western part of the reserve, at an altitude of 1,500–2,200 m, featuring mixed coniferous and broad-leaved forests with minimal human disturbance;

Banfangzi Site: Located in the central part of the reserve, at an altitude of 1,300–1,900 m, dominated by oak forests with abundant food resources;

Laoxiancheng Site: Located in the core area of the reserve, at an altitude of 1,600–2,400 m, with well-preserved primary forests and a concentrated distribution of rare species;

Shuangmiaozi Site: Located in the southern part of the reserve, at an altitude of 1,100–1,700 m, a forest edge zone with frequent species exchange.

2.2. Data sources and processing

Data for this study were derived from infrared camera monitoring at five sites in Zhouzhi Nature Reserve in 2025. A total of 146 infrared cameras were deployed, with a monitoring period of 6–12 months. The data included camera ID, installation location, species name, number of captures, temperature, and habitat type.

For data processing, raw data were first cleaned to remove invalid entries such as null values and blurred records, and species names were standardized. Second, species richness, dominance index, and camera working efficiency were calculated for each site. Finally, statistical analysis was conducted by species protection level and family/genera to characterize community structure, supporting the assessment of mammalian diversity in the reserve.

3. Research results

3.1. Basic monitoring information of each site

A total of 146 infrared cameras were deployed at the five monitoring sites, yielding 6,017 total records and 5,347 valid species records, with an average camera efficiency of 36.6 records per camera. The Xiaowangjian Site had the largest data volume (2,265 records), the Laoxiancheng Site had the most cameras (69 units), and the Xiaowangjian Site had the highest species richness (46 species) (**Table 1**).

Table 1. Basic information of infrared camera monitoring at each site in Zhouzhi Nature Reserve.

Site Name	Total Data Records	Valid Species Records	Number of Cameras	Number of Species Detected	Camera Efficiency (Records/Camera)
Xiaowangjian	2265	2265	35	46	64.7
Houzhenzi	76	71	9	17	7.9
Banfangzi	1678	1677	13	30	129.0
Laoxiancheng	330	180	69	20	2.6
Shuangmiaozi	1668	154	20	28	7.7
Total	6017	5347	146	141	36.6

3.2. Species composition characteristics of each site

3.2.1. Dominant species analysis

Dominant species varied significantly across sites, but Cervidae animals played an important role at all sites (**Table 2**). The Reeves's muntjac was the absolute dominant species at Xiaowangjian (866 captures, 38.2%); the Reeves's muntjac (566 captures, 33.8%) and wild boar (366 captures, 21.8%) were dominant at Banfangzi; the Qinling takin was the most dominant at Laoxiancheng (44 captures, 24.4%); species distribution was relatively even at Houzhenzi and Shuangmiaozi.

Table 2. Top 5 species recorded at each site in Zhouzhi Nature Reserve.

Site Name	Species Name	Captures	Proportion (%)	Species Name	Captures	Proportion (%)
Xiaowangjian	Reeves's muntjac	866	38.2	Chinese badger	175	7.7
	masked palm civet	168	7.4	Qinling takin	162	7.2
	rock squirrel	133	5.9	—	—	—
Houzhenzi	wild boar	15	21.1	Qinling takin	10	14.1
	tufted deer	9	12.7	Reeves's muntjac	8	11.3
	Malayan porcupine	7	9.9	—	—	—
Banfangzi	Reeves's muntjac	566	33.8	wild boar	366	21.8
	Chinese porcupine	187	11.2	tufted deer	181	10.8
	hog badger	60	3.6	—	—	—
Laoxiancheng	Qinling takin	44	24.4	tufted deer	19	10.6
	Reeves's muntjac	18	10.0	giant panda	17	9.4
	crimson bellied tragopan	16	8.9	—	—	—
Shuangmiaozi	Chinese goral	13	8.4	hog badger	13	8.4
	muntjac	10	6.5	squirrel	10	6.5
	tufted deer	10	6.5	—	—	—

3.2.2. Distribution of rare and protected species

A total of 6 nationally protected wild animal species were recorded, including 4 first-class and 2 second-class protected species (**Table 3**). The Laoxiancheng Site was the most concentrated area for rare species, recording all 6 protected species, including flagship species such as the giant panda (17 captures) and snow leopard (5 captures). The Qinling takin was distributed across all 5 sites with 117 total captures, making it the most widely distributed rare species.

Table 3. Summary of rare and protected species monitored in Zhouzhi Nature Reserve.

Species Name	Protection Level	Monitored Sites	Captures	Proportion in Total Protected Species Records (%)
giant panda	National Level I	Laoxiancheng	17	12.4
Qinling takin	National Level I	All 5 sites	117	85.1
snow leopard	National Level I	Laoxiancheng	5	3.6
forest musk deer	National Level I	Laoxiancheng	5	3.6
crimson bellied tragopan	National Level II	Laoxiancheng	16	11.7
golden pheasant	National Level II	Laoxiancheng	7	5.1

3.3. Community structure of different animal groups

By taxonomic group, mammals dominated all sites, accounting for 60%–80% of records; birds were mainly distributed at Laoxiancheng and Xiaowangjian. At the family level, Cervidae (Reeves's muntjac, tufted deer), Suidae (wild boar), Mustelidae (Chinese badger, hog badger), and Bovidae (Qinling takin, Chinese goral) were the main groups, collectively accounting for 75.3% of total records.

The Banfangzi Site had the highest number of Cervidae records (747 captures, 44.5% of the site's total); the Bovidae (Qinling takin) was dominant at Laoxiancheng (44 captures, 24.4%); groups were relatively evenly distributed at Shuangmiaozi, reflecting diverse habitats in this area.

3.4. Analysis of camera monitoring efficiency

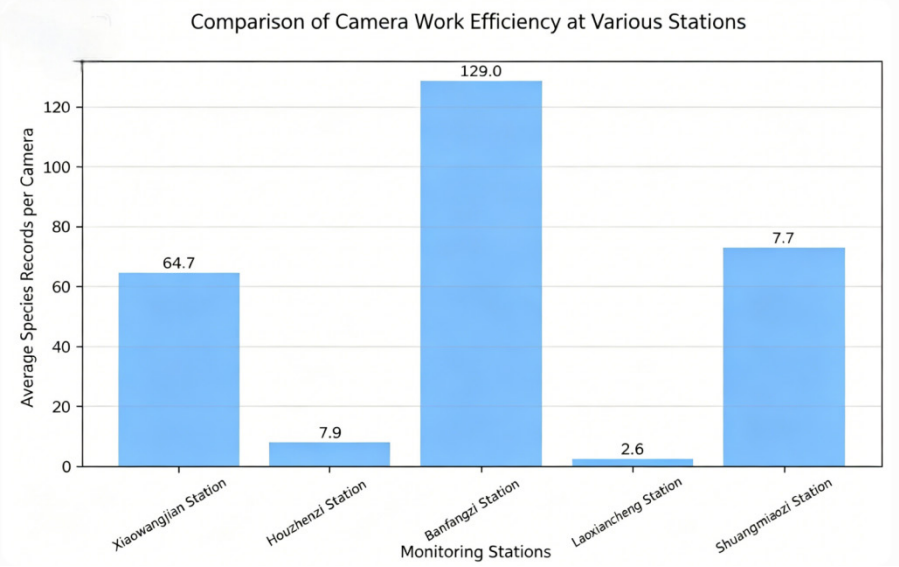

Figure 1. Comparison of camera working efficiency across sites.

Camera working efficiency differed significantly across sites (**Figure 1**). The Banfangzi Site had the highest efficiency (129.0 records per camera) due to a small number of cameras concentrated in species-rich areas; Xiaowangjian ranked second (64.7 records per camera), indicating high ecological quality; Laoxiancheng had the lowest efficiency (2.6 records per camera) because cameras were deployed in the core area with low species density but a high proportion of rare species.

4. Discussion

4.1. Effectiveness of ecological protection in Zhouzhi Nature Reserve

This infrared camera monitoring recorded 141 wildlife species in Zhouzhi Nature Reserve, including 6 nationally protected species, demonstrating remarkable effectiveness of ecological protection. Rare

species are in good condition: Flagship species such as the giant panda and snow leopard were recorded at Laoxiancheng, and the Qinling takin was distributed across all 5 sites, indicating a complete core ecosystem providing favorable habitats for rare species. The 46 wildlife species detected at Xiaowangjian reflect high habitat heterogeneity and abundant food resources.

4.2. Application value of infrared camera monitoring technology

Infrared camera technology shows significant advantages in monitoring at Zhouzhi Nature Reserve. First, it uses non-invasive monitoring, avoiding disturbance to wildlife activities—Especially suitable for long-term tracking of sensitive species such as the giant panda and forest musk deer, effectively reducing human impacts on animal behavior. Second, infrared cameras operate continuously around the clock, fully documenting diel activity patterns and seasonal variations, overcoming the temporal limitations of traditional manual surveys.

This study obtained 6,017 valid records across five sites, providing a large and continuous dataset for population dynamics and habitat quality assessment. In terms of cost-effectiveness, each camera yielded an average of 36.6 valid records, with monitoring efficiency far superior to traditional methods such as line transects. Cameras can be deployed long-term in complex terrain, greatly reducing labor and time costs.

4.3. Practical implications for ecological civilization construction

The infrared camera monitoring practice at Zhouzhi Nature Reserve offers multi-dimensional insights for ecological civilization construction. First, technological empowerment is critical to improving conservation efficiency. Deep application of modern technologies such as infrared cameras, remote sensing, and GIS shifts ecological monitoring from empirical judgment to data-driven decision-making, enhancing the accuracy of species identification and scientificity of population assessment, and providing reliable support for reserve management.Second, the zoned and classified conservation strategy is replicable. Based on ecological characteristics and species distribution differences, the core area should focus on habitat protection for rare species such as the giant panda and snow leopard, while edge areas prioritize habitat restoration and ecological corridor construction, forming a gradient and refined conservation pattern. Meanwhile, wildlife images captured by infrared cameras have natural communication value; promoting them via social media and science popularization activities raises public ecological awareness, gradually building a multi-stakeholder governance system led by the government and participated by society.

5. Conclusions

This study recorded 141 wildlife species across 5 sites in Zhouzhi Nature Reserve, including 6 protected species, demonstrating rich biodiversity and ecosystem integrity. Infrared camera technology proved highly effective for non-invasive monitoring. Future efforts should optimize monitoring protocols, integrate multidisciplinary technologies, and build a "monitoring-assessment-management" system to enhance biodiversity conservation in the Qinling Mountains.

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