Infrared Camera-Based Monitoring of Mammal and Bird Diversity in Qimantag Mountain, Altun Shan Nature Reserve: A Preliminary Study (Postprint)

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Date: 2024-12-03T00:00:00+00:00

Abstract

To understand the basic status of wildlife in the Xinjiang Altun Mountain National Nature Reserve, a wildlife resource survey was conducted using infrared camera technology in the Qimantag Mountain area in the northeastern part of the reserve from January 2021 to January 2022 and from December 2022 to January 2024. During the survey period, the infrared cameras accumulated 17,529 effective camera-days and captured 7,237 effective independent photographs of wildlife. The results showed that: (1) 6,045 effective independent photographs of wild mammals were captured, identifying 19 species of wild mammals belonging to 5 orders and 8 families, with a Shannon-Wiener diversity index of 3.05 and a Pielou evenness index of 0.71; the top 5 wild mammal species ranked by Relative Abundance Index (RAI) were Tibetan wild ass (Equus kiang, RAI=85.85), woolly hare (Lepus oiostolus, RAI=82.26), blue sheep (Pseudois nayaur, RAI=44.04), wild yak (Bos mutus, RAI=35.26), and wolf (Canis lupus, RAI=26.41). (2) 1,182 effective independent photographs of wild birds were captured, identifying 50 species of wild birds belonging to 10 orders and 21 families, with a Shannon-Wiener diversity index of 4.31 and a Pielou evenness index of 0.76; the top 5 wild bird species were Himalayan snowcock (Tetraogallus himalayensis, RAI=9.81), desert wheatear (Oenanthe deserti, RAI=8.04), red-billed chough (Pyrrhocorax pyrrhocorax, RAI=7.25), black-necked crane (Grus nigricollis, RAI=6.33), and horned lark (Eremophila alpestris, RAI=5.42). (3) There were 11 and 18 National Class I and Class II key protected wildlife species, respectively; the China Biodiversity Red List classified 6 species as Endangered, 7 as Vulnerable, and 13 as Near Threatened; stone marten (Meles fonia), dhole (Cuon alpinus), white-winged lark (Alauda leucoptera), and Chinese blackbird (Turdus mandarinus) were new records for the Altun Mountain Reserve. (4) Daily activity rhythm analysis indicated that

blue sheep, wild yak, and wolf are diurnal animals, woolly hare is a predominantly nocturnal animal, while Tibetan wild ass is a cathemeral animal. The research results provide baseline data for the establishment of Kunlun Mountain National Park and wildlife resource monitoring, and also provide a scientific basis for strengthening the conservation and management of the Altun Mountain Reserve.

Full Text

A Preliminary Survey of Mammal and Bird Diversity Based on Camera Trapping in Qimantag Mountain of Altun Mountain National Nature Reserve, Xinjiang

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Abstract

To understand the status of wildlife in the Altun Mountain National Nature Reserve, Xinjiang, we conducted a camera-trap survey in the Qimantag Mountain area of the reserve' s northeastern region between January 2021 and January 2022, and again from December 2022 to January 2024. Over 17,529 effective camera-trap days, we obtained 7,237 independent detections of wildlife. The results showed: (1) For mammals, we recorded 6,045 independent detections, identifying 19 species across 5 orders and 8 families. The Shannon-Wiener diversity index and Pielou evenness index were 3.05 and 0.71, respectively. Based on the relative abundance index (RAI), the five most abundant species were Tibetan wild ass (*Equus kiang*, RAI = 85.85), woolly hare (*Lepus oiostolus*, RAI = 82.26), blue sheep (*Pseudois nayaur*, RAI = 44.04), wild yak (*Bos mutus*, RAI = 35.26), and wolf (*Canis lupus*, RAI = 26.41). (2) For birds, we recorded 1,182 independent detections, identifying 50 species across 10 orders and 21 families. The Shannon-Wiener diversity index and Pielou evenness index were 4.31 and 0.76, respectively. The five most abundant bird species were Himalayan snowcock (*Tetraogallus himalayensis*, RAI = 9.81), desert wheatear (*Oenanthe deserti*, RAI = 8.04), red-billed chough (*Pyrrhocorax pyrrhocorax*, RAI = 7.25), black-necked crane (*Grus nigricollis*, RAI = 6.33), and horned lark (*Eremophila alpestris*, RAI = 5.42). (3) Among recorded species, 11 are Class I and 18 are Class II nationally protected wildlife in China. According to the Red List of China' s Vertebrates, 6 species are endangered, 7 are vulnerable, and 13 are

near-threatened. Additionally, four species—dhole (*Cuon alpinus*), stone marten (*Meles fonia*), Chinese blackbird (*Turdus mandarinus*), and white-winged lark (*Alauda leucoptera*)—represent new records for the Altun Mountain Reserve. (4) Activity pattern analysis revealed that blue sheep, wild yak, and wolf are diurnal, woolly hare is nocturnal, and Tibetan wild ass shows both diurnal and nocturnal activity. These findings provide baseline data for wildlife resources in the Altun Mountain Reserve and offer scientific support for the establishment of Kunlun Mountain National Park and long-term wildlife monitoring.

Keywords: Altun Mountain National Nature Reserve; species list; endangered species; relative abundance index; activity selection index

Introduction

China' s nature reserves represent the most resource-rich and species-diverse areas for wildlife, serving as critical strongholds for rare and endangered species. These protected areas play an essential role in conserving wildlife resources and their habitats. However, most reserves were established under urgent circumstances when wildlife populations were severely threatened, and many lack long-term monitoring programs, leaving resource status poorly understood. Traditional survey methods—including line transects, fixed-point observations, and questionnaires—have significant limitations in efficiency, temporal coverage, and spatial extent, making them inadequate for comprehensively assessing cryptic and low-density species.

In contrast, camera-trap technology offers advantages of being non-invasive, accurate, and capable of long-term monitoring, making it widely applicable for wildlife surveys in Chinese nature reserves. This technology has substantially accelerated wildlife inventories and improved conservation management. The Altun Mountain National Nature Reserve (hereafter "Altun Reserve") is located in the "Kumkuli" plateau basin on the northern slopes of the central East Kunlun Mountains, bordering Lop Nur to the east and connecting with the Qiangtang Nature Reserve in Tibet and the Hoh Xil region in Qinghai—collectively known as one of China' s "Four Great Uninhabited Areas." Established as China' s first plateau desert ecosystem reserve focused on ungulate conservation, Altun Reserve protects a unique assemblage of endemic and rare wildlife, including snow leopard (*Panthera uncia*), Tibetan antelope (*Pantholops hodgsonii*), and wild yak (*Bos mutus*), along with endemic plants such as *Pomatosace filicula* and *Rhodiola quadrifida*.

Due to its remote location, high altitude, and harsh conditions, biodiversity surveys in Altun Reserve have been extremely challenging. Previous surveys in 2013 using line-transect methods documented 35 mammal and 122 bird species, providing a foundation for subsequent monitoring. The proposed establishment of Kunlun Mountain National Park presents unprecedented opportunities for wildlife conservation, yet Altun Reserve—as a key component—lacks systematic wildlife data needed for park planning. This study addresses this gap by con-

ducting camera-trap surveys of mammals and birds in the Qimantag Mountain region to provide baseline data for national park creation and biodiversity conservation.

1. Study Area

Altun Reserve is situated at the junction of Xinjiang, Qinghai, and Tibet within Ruoqiang and Qiemo counties of Bayingol Mongolian Autonomous Prefecture, Xinjiang (87°10 -91°18 E, 36°00 -37°49 N), covering approximately 45,000 km^2. The reserve lies in the Kumkuli large depression basin on the northern slopes of the central East Kunlun Mountains, with an average elevation exceeding 4,500 m and a highest peak (Muztagh) at 6,973 m. The climate is typical alpine, with no absolute frost-free period, no distinct four seasons, only cold and warm season alternation with prolonged cold periods, mean annual temperature of -4.2°C, and annual precipitation of 300 mm. The reserve is dominated by alpine desert and desert steppe, with diverse landscapes including high mountains, glaciers, karst formations, meadows, grasslands, and lakes, supporting rich biodiversity.

2. Methods

2.1 Camera Trap Deployment

From January 2021 to January 2022 and December 2022 to January 2024, we deployed camera traps in the Qimantag Mountain region of northeastern Altun Reserve. Cameras were placed at 77 sites (Fig. 1) along animal trails, near water sources, and in areas with signs such as feces, tracks, and carcasses. Cameras were mounted on iron stakes 100 cm above ground to avoid flood damage. We primarily used Ltl Acorn models initially, later switching to ULM5P models, both set to "photo + video"mode with 1-minute intervals for 24-hour monitoring. Memory cards and batteries were checked every 1–3 months. Due to summer flooding, only 43 sites yielded usable data, with cameras operating for an average of 77 $\pm$ 40 days per site, totaling 4,389 effective camera-days in the first phase and 13,140 in the second phase (17,529 total).

2.2 Data Analysis

We identified mammals using *A Guide to the Mammals of China* (3rd edition) and *Catalogue of Mammals in China (2021)*, and birds using *A Field Guide to the Birds of China* and *A Checklist on the Classification and Distribution of the Birds of China* (4th edition). Protection status followed China' s National List of Wildlife under Special Protection (2021) and the Red List of China' s Vertebrates (2020), plus CITES appendices.

We converted image timestamps to local true solar time using sunrise/sunset data from Mang' ai City, Qinghai (07:31 and 19:55, respectively). The day was divided into three periods: dawn/dusk ($±$2 hours from sunrise/sunset), daytime (post-sunrise to pre-sunset), and nighttime (post-sunset to pre-sunrise).

For analysis, we defined independent detections as consecutive photos/videos of the same species at a site separated by >30 minutes.

Relative Abundance Index (RAI):

$$AI = (A_i \times 1000)/N$$

where A_i is the number of independent detections of species i, and N is the total number of effective camera-days.

Shannon-Wiener Diversity Index (H):

$$H = -\sum_{i=1}^{S} P_i \log_2 P_i$$

where S is the number of species and P_i is the proportion of species i.

Pielou Evenness Index (E):

$$E = H/\log_2 S$$

Activity Selection Index (w_i):

$$w_i = o_i/e_i$$

where w_i is the selection index for time period i (dawn/dusk, daytime, nighttime), o_i is the proportion of independent detections during period i, and e_i is the proportion of the 24-hour day represented by period i. Values >1 indicate preference, $ $1 indicate avoidance.

We used non-parametric kernel density estimation to analyze daily activity patterns of the five most-detected mammals: Tibetan wild ass, woolly hare, blue sheep, wild yak, and wolf.

3. Results

3.1 Overall Results

Camera traps operated for 17,529 effective days, yielding 7,237 independent wildlife detections after removing consecutive images within 30 minutes. Mammals comprised 6,045 detections (19 species, 5 orders, 8 families) and birds comprised 1,182 detections (50 species, 10 orders, 21 families).

3.2 Mammal Diversity

Mammal Shannon-Wiener diversity and Pielou evenness indices were 3.05 and 0.71, respectively. The five most abundant species by RAI were Tibetan wild ass (85.85), woolly hare (82.26), blue sheep (44.04), wild yak (35.26), and wolf

(26.41). Among the 19 species, 11 are Class I and 5 are Class II nationally protected wildlife. According to the Red List, 1 species is endangered (wild yak), 5 are vulnerable (Tibetan antelope, Tibetan wild ass, blue sheep, argali, and Tibetan gazelle), and 7 are near-threatened (brown bear, stone marten, Pallas' s cat, wolf, Eurasian lynx, red fox, and Tibetan fox). Four species represent new records for Altun Reserve: dhole, stone marten, Chinese blackbird, and white-winged lark .

3.3 Bird Diversity

Bird Shannon-Wiener diversity and Pielou evenness indices were 4.31 and 0.76, respectively. The five most abundant species by RAI were Himalayan snowcock (9.81), desert wheatear (8.04), red-billed chough (7.25), black-necked crane (6.33), and horned lark (5.42). Among the 50 species, 6 are Class I nationally protected: black-necked crane, cinereous vulture, bearded vulture, golden eagle, saker falcon, and Himalayan vulture. Seven are Class II protected, including upland buzzard, Eurasian eagle-owl, and Tibetan snowcock. According to the Red List, 1 species is endangered (saker falcon), 6 are vulnerable, and 6 are near-threatened. One endemic species, the ground tit (*Pseudopodoces humilis*), was recorded .

3.4 Activity Patterns

Daily activity patterns of the five most abundant mammals showed distinct temporal niches [Figure 3: see original paper]. Tibetan wild ass exhibited relatively constant activity throughout the day (daytime $w_i = 1.01$, dawn/dusk $w_i = 0.97$, nighttime $w_i = 0.78$). Woolly hare was primarily nocturnal (nighttime $w_i = 1.52$) with reduced daytime activity ($w_i = 0.47$). Blue sheep showed a clear unimodal diurnal pattern (daytime $w_i = 1.43$) with activity peaks at 10:00–12:00 and 16:00–18:00, and minimal nighttime activity ($w_i = 0.13$). Wild yak was diurnal (daytime $w_i = 1.35$) with peaks at 12:00–16:00 and 20:00–22:00. Wolf showed a unimodal diurnal pattern (daytime $w_i = 1.30$) with peaks at 12:00–18:00 and reduced nighttime activity ($w_i = 0.52$) .

Discussion

Wildlife resource investigation is a fundamental responsibility of nature reserves and essential for developing conservation strategies. Previous comprehensive surveys in Altun Reserve documented 35 mammals and 122 birds, but lacked systematic monitoring data for scientific assessment. Our camera-trap survey in Qimantag Mountain recorded 19 mammals and 50 birds, including cryptic species like stone marten and pack-living dhole, demonstrating the effectiveness of camera traps. Two bird species—white-winged lark and Chinese blackbird—represent new reserve records.

The Qimantag Mountain region shows relatively high wildlife diversity, consistent with its complex topography and heterogeneous habitats. As part of the

northern Qinghai-Tibet Plateau, the area' s diverse landscapes—from wetlands to alpine deserts—support a rich assemblage of plateau-adapted species. The high diversity indices indicate a stable and healthy ecosystem. Carnivores such as snow leopard, lynx, wolf, and raptors, along with their prey (Himalayan marmot, woolly hare, blue sheep, and ungulates), occupy various trophic levels, maintaining ecosystem balance.

Activity patterns reflect behavioral adaptations to environmental pressures. Wild yak, the largest species, dominates the landscape, forcing other species to adjust activity timing. Tibetan wild ass, a potential competitor, shows temporal partitioning to reduce interspecific competition. Blue sheep and wild yak exhibit similar diurnal patterns but occupy different habitats—blue sheep on steep rocky slopes and wild yak in open alpine meadows—demonstrating spatial niche separation that facilitates coexistence. Woolly hare' s nocturnal activity likely reduces predation risk from diurnal predators like wolves and raptors.

Camera-trap technology effectively overcomes limitations of traditional methods in this rugged terrain, providing valuable baseline data for Altun Reserve and Kunlun Mountain National Park planning. However, our survey was limited to northeastern Qimantag Mountain, representing only a fraction of the proposed national park area. Future work should expand spatial coverage and implement standardized, long-term monitoring protocols to better assess wildlife diversity and distribution across the entire region.

References

[1] Xue Dayuan, Zhang Yuanyuan. Achievement and outlook of biodiversity conservation in China[J]. Environmental Protection, 2019, 47(17): 38-42.

[2] Wang Wei, Li Junsheng. In situ conservation of biodiversity in China: Advances and prospects[J]. Biodiversity Science, 2021, 29(2): 133-149.

[3] Mi Xiangcheng. Biodiversity monitoring and research are basis of national park conservation[J]. Biodiversity Science, 2019, 27(1): 1-4.

[4] Liz A V, Gonçalves D V, Velo Antón G, et al. Adapt biodiversity targets to climate change[J]. Science, 2022, 376(6593): 589-590.

[5] Roberts C M, O' Leary B C, Hawkins J P. Climate change mitigation and nature conservation both require higher protected area targets[J]. Philosophical Transactions B, 2020, 375(1794): 20190121, doi: 10.1098/rstb.2019.0121.

[6] McShea W J, Shen Xiaoli, Liu Fang, et al. China' s wildlife camera trap monitoring needs a unified standard[J]. Biodiversity Science, 2020, 28(9): 1125-1131.

[7] Xiao Zhishu, Xiao Wenhong, Wang Tianming, et al. Wildlife monitoring and research using camera trapping technology across China: The current status and future issues[J]. Biodiversity Science, 2022, 30(10): 230-255.

[8] Fisher Jason T. Camera trapping in ecology: A new section for wildlife research[J]. Ecology and Evolution, 2023, 13(3): e9925, doi: 10.1002/ece3.9925.

[9] Li Sheng, Wang Dajun, Xiao Zhishu, et al. Camera trapping in wildlife research and conservation in China: Review and outlook[J]. Biodiversity Science, 2014, 22(6): 685-695.

[10] Li Weidong, Du Ao, Zhang Xiang, Zhang Huibin. Comprehensive scientific investigation of Altun Mountain National Nature Reserve in Xinjiang[M]. Urumqi: Xinjiang People' s Publishing House, 2013.

[11] Lu Feiying, Shi Jianbin, Zhang Zihui, et al. Surveys of Tibetan antelope, kiang and wild yak in Arjinshan Nature Reserve, Xinjiang, China[J]. Journal of Beijing Normal University (Natural Science Edition), 2015, 51(4): 374-381.

[12] Dong Shikui, Wu Xiaoyu, Liu Shiliang, et al. Estimation of ecological carrying capacity for wild yak, kiang, and Tibetan antelope based on habitat suitability in the Aerjin Mountains Nature Reserve, China[J]. Acta Ecologica Sinica, 2015, 35(23): 7598-7607.

[13] Buzzard P J, Zhang H B, Xu D H, et al. A globally important wild *Bos mutus* population in the Arjinshan Nature Reserve, Xinjiang, China[J]. Oryx, 2010, 44(4): 577, doi: 10.1017/S0030605310000591.

[14] Ma Ming, Zhang Tong, Zhang Huibin, et al. Survey of avifauna in Kunlun and Altun Mountains[J]. Chinese Journal of Zoology, 2013, 48(1): 64-74.

[15] Ouyang Zhiyun, Xu Weihua, Du Ao, et al. Research on overall spatial planning for China national park system[M]. Beijing: China Environmental Publishing Group, 2018.

[16] Jiang Yafang, Ma Wei, Liu Zengli, et al. Planning of spatial distribution of national parks in China[J]. Journal of Beijing Forestry University (Social Sciences Edition), 2021, 20(2): 1-7.

[17] Xue Yadong, Li Jia, Hu Yang, et al. Camera trapping survey of the mammals and birds in the Qilian Mountain National Park (Qinghai area)[J]. Acta Theriologica Sinica, 2019, 39(4): 466-475.

[18] Liu Shaoying, Wu Yi, Li Sheng. Handbook of the mammals of China[M]. 3rd ed. Fuzhou: Strait Press, 2022: 269-271.

[19] Wei Fuwei, Yang Qisen, Wu Yi, et al. Catalogue of mammals in China (2021)[J]. Acta Theriologica Sinica, 2021, 41(5): 487-501.

[20] John Mackinnon. Guide to the birds of China[M]. Beijing: Commercial Press, 2021.

[21] Zheng Guangmei. A checklist on the classification and distribution of the birds of China[M]. 4th ed. Beijing: Science Press, 2023.

[22] National Forestry and Grassland Administration, Ministry of Agriculture and Rural Affairs. National list of wildlife under special protection 2021[EB/OL].

2021. [2021-02-01]. http://www.forestry.gov.cn/main/5461/20210205/122418860831352.html.

[23] Ministry of Ecological Environment, Chinese Academy of Sciences. Red list of China' s biodiversity: Vertebrate (2020)[EB/OL]. 2023. [2023-05-19]. http://www.mee.gov.cn.

[24] Import and Export of Endangered Species Management Office of the People' s Republic of China. Convention on International Trade of Endangered Species (CITES), Appendix I, II, III[EB/OL]. 2023. [2024-09-03]. http://www.cites.org.cn.

[25] O' Connell A F, Nichols J D, Karanth K. Camera traps in animal ecology: Methods and analyses[M]. New York: Springer, 2011.

[26] Li Jia, Xue Yadong, Liao M F, et al. Temporal and spatial activity patterns of sympatric wild ungulates in Qinling Mountains, China[J]. Animals, 2022, 12: 1666, doi: 10.3390/ani12131666.

[27] Sun Ruyong. Principles of animal ecology[M]. 3rd ed. Beijing: Beijing Normal University Press, 2001.

[28] Nouvellet P, Rasmussen G S A, MacDonald D W, et al. Noisy clocks and silent sunrises: Measurement methods of daily activity pattern[J]. Journal of Zoology, 2012, 286(3): 179-184.

[29] Meredith M, Ridout M. Overlap: Estimates of coefficient of overlapping for animal activity patterns[EB/OL]. 2021. [2022-07-03]. https://cran.r-project.org/web/packages/overlap.

[30] Mella Méndez I, Flores Peredo R, Pérez Torres J, et al. Activity patterns and temporal niche partitioning of dogs and medium-sized wild mammals in urban parks of Xalapa, Mexico[J]. Urban Ecosystem, 2019, 22: 1061-1070.

[31] Ripple W J, Estes J A, Beschta R L, et al. Status and ecological effects of the world' s largest carnivores[J]. Science, 2014, 343(6167): 1241484, doi: 10.1126/science.1241484.

[32] Vilella M, Ferrandiz Rovira M, Sayol F. Coexistence of predators in time: Effects of season and prey availability on species activity within a Mediterranean carnivore guild[J]. Ecology and Evolution, 2020, 10: 11408-11422.

[33] Santos F, Carbone C, Wearn O R, et al. Prey availability and temporal partitioning modulate felid coexistence in Neotropical forests[J]. Plos One, 2019, 14(3): e0213671, doi: 10.1371/journal.pone.0213671.

[34] Norris D, Michalski F, Peres C A. Habitat patch size modulates terrestrial mammal activity patterns in Amazonian forest fragments[J]. Journal of Mammalogy, 2010, 91(3): 551-560.

[35] Qi J Z, Holyoak M, Dobbins M, et al. Wavelet methods reveal big cat activity patterns and synchrony of activity with preys[J]. Integrative Zoology, 2022, 17: 246-260.

[36] Garrote G, Ayala R P D. Spatial segregation between Iberian lynx and other carnivores[J]. Animal Biodiversity and Conservation, 2019, 42: 347-354.

[37] O' Malley C, Elbroch L K, Lendrum P E, et al. Motion triggered video cameras reveal spatial and temporal patterns of red fox foraging on carrion provided by mountain lions[J]. PeerJ, 2018, 6: e5324, doi: 10.7717/peerj.5324.

[38] Li Jia, Liu Fang, Ye Lixin, et al. Camera trapping survey of the diversity of mammals and birds in Fengyang Mountain of Zhejiang Province, China[J]. Acta Theriologica Sinica, 2018, 38(1): 95-103.

[39] Wu Hao, Ma Yongsheng, Wang Tianhui, et al. Diversity of mammals and birds in water source of Annanba Wild Camel National Nature Reserve in Gansu Province[J]. Forest and Grassland Resources Research, 2024, 291(1): 48-55.

[40] Xiao Zhishu, Li Xinhai, Jiang Guangshun. Wildlife resource inventory using camera trapping in natural reserves in China[J]. Biodiversity Science, 2016, 36(3): 270-271.

[41] Zhu Shuyi, Duan Fei, Li Sheng. Promoting diversity inventory and monitoring of birds through the camera trapping network in China: Status, challenges and future outlook[J]. Biodiversity Science, 2017, 25(10): 1114-1122.

[42] Xue Yadong, Liu Fang, Guo Tiezheng, et al. Using camera traps to survey wildlife at water sources on the northern slope of the Altun Mountains, China[J]. Acta Theriologica Sinica, 2014, 34(2): 164-171.

Note: Figure translations are in progress. See original paper for figures.