Integrative Conservation

WILEY

RESEARCH ARTICLE OPEN ACCESS

Effects of the Grazing Exclusion Policy on Pheasant Nesting Success and Predation Risk in the Protected Areas of Southwestern China

Yifei Zhang[1] | Xiaotong Shang[2] | Wenjun Ming[1] | Lianjun Zhao[3] | Yong Zheng[3] | Sheng Li[4] | Li Li[5] | Li Zhang[1]

[1]MOE Key Laboratory for Biodiversity Science and Ecological Engineering, College of Life Sciences, Beijing Normal University, Beijing, China | [2]School of Ecology and State Key Laboratory of Biocontrol, Sun Yat-Sen University, Shenzhen, China | [3]Wanglang National Nature Reserve, Sichuan, China | [4]School of Life Sciences, Peking University, Beijing, China | [5]Sino-French Joint Laboratory of Wildlife and Ecosystem Health, Leshan Normal University, Leshan, China

Correspondence: Li Zhang (asterzhang@bnu.edu.cn)

Received: 26 April 2025 | **Revised:** 11 June 2025 | **Accepted:** 1 July 2025

Editor-in-Chief: Binbin Li | **Handling Editor:** Eric Ameca

Funding: This research was funded by Wanglang National Nature Reserve through its special survey and research project on pheasants in Wanglang (grant number: Ping Gong Jiao Cai Tan [2017] No. 1-1).

Keywords: forest ecosystem | grazing exclusion policy | nest predation | pheasants | simulated nest experiment

ABSTRACT

Grazing has a profound impact on forest ecosystems and biodiversity. In recent years, grazing exclusion has been widely implemented as a conservation policy in many protected areas. However, its effects on wildlife populations, particularly on the reproductive ecology of pheasants, remain insufficiently explored. This study focuses on the Wanglang National Nature Reserve in Sichuan Province. Using data from before (2018) and after (2024) the implementation of an exclusion policy, we combined infrared camera monitoring and simulated nest experiments to assess the influence of grazing exclusion on pheasant nesting success and predation risk. Historically impacted by grazing, the Wanglang Reserve is located in the Himalaya–Hengduan Mountains of southwestern China, a global hotspot for pheasant diversity and a key climate refugium. Grazing exclusion was gradually implemented beginning in 2017, providing an ideal natural experimental site for this study. Our results show that pheasant nesting success significantly declined after exclusion, whereas both predator diversity and predation frequency increased. These findings suggest that grazing exclusion may indirectly reduce reproductive success by altering predator activity and distribution. Although exclusion promoted vegetation recovery and improved habitat conditions, it did not effectively reduce short-term predation risk. This study provides important scientific evidence regarding post-exclusion wildlife dynamics in forest ecosystems and reveals the limitations of the umbrella species strategy in predicting wildlife responses to human disturbance. Future research should incorporate detailed temporal and spatial analyses of wildlife–livestock interactions, along with long-term monitoring data to optimize grazing exclusion policies and provide theoretical support for effective forest ecosystem management and wildlife conservation.

1 | Introduction

In the context of global environmental change, grazing significantly affects the species diversity and the stability of forest ecosystems (Wake and Vredenburg 2008; Barnosky et al. 2012; Filazzola et al. 2020). Overgrazing often leads to a decline in species richness, with particularly severe effects on medium- and large-sized mammals, trees, and understory vegetation,

Summary

Many protected areas have banned livestock grazing to help plants recover and improve habitats for wildlife. But we do not yet fully understand how this affects animals like pheasants, which nest on the ground and are vulnerable to predators. In this study, we looked at a forest reserve in southwestern China where grazing was banned starting in 2017. We used camera traps and artificial nests to compare pheasant nesting before and after the ban. Although vegetation improved after grazing stopped, we found that more predators appeared and pheasant nests were attacked more often. Our results suggest that banning grazing can have unintended effects—it helps plants, but may also change where and how predators hunt, which can make life harder for ground-nesting birds. This study shows why conservation policies need to consider the full picture—not just plants but also how animals interact. Managing nature is not always simple, and we need more long-term research to find the best balance between protecting ecosystems and helping all kinds of wildlife thrive.

- **Practitioner points**
  - Grazing exclusion in forest reserves can unintentionally reduce pheasant nesting success by increasing predator diversity and activity, highlighting the need to consider predator–prey dynamics when designing habitat restoration policies.
  - Vegetation recovery alone is not sufficient to improve breeding success for ground-nesting birds; concealment benefits must be balanced with predator management to avoid increased nest predation during early successional stages post-exclusion.
  - Conservation strategies should avoid one-size-fits-all approaches: Site-specific monitoring of wildlife responses, including seasonal and habitat-level variation, is essential for fine-tuning grazing exclusion policies to optimize biodiversity outcomes.

ultimately undermining ecosystem stability (B. V. Li and Jiang 2021). Livestock activity is known to extensively alter wildlife habitats, causing displacement and population declines among native species. For example, B. V. Li et al. (2017) reported a substantial reduction in suitable habitat for giant pandas (*Ailuropoda melanoleuca*) due to livestock grazing. In addition, grazing has been shown to influence the relative abundance, spatial distribution, and possibly the activity patterns of wildlife, with different species exhibiting varied responses (Fraser et al. 2015; Gossner et al. 2016).

Although most research emphasizes the negative ecological impacts of grazing, some studies suggest that it may offer ecological benefits under certain conditions. For instance, livestock grazing has been shown to increase species abundance among small mammals by shortening vegetation height and improving visibility, thereby reducing predation risk and enhancing foraging efficiency (Wells et al. 2021). Grazing can also reduce wildfire risk and promote biodiversity conservation. It may also enhance ecosystem services, suggesting its potential as an adaptive strategy for climate change mitigation (Pillar and Overbeck 2025).

Pheasants, as an essential component of forest ecosystems, play crucial roles in maintaining ecological stability and serve as key indicators of forest type, quality, and conservation status (Zheng 2015). As ground-nesting birds, pheasants rely heavily on habitat quality for reproductive success and are particularly susceptible to grazing disturbances (Beja et al. 2014; Johnson et al. 2012). Nesting success has been shown to decline significantly due to trampling by free-ranging livestock, which also deteriorates habitat suitability (X. T. Shang et al. 2024). Beyond direct physical disturbance, livestock can also indirectly affect pheasant activity patterns by modifying vegetation structure and food availability. For example, Fan et al. (2020) found that grazing influenced the habitat preferences of blood pheasants (*Ithaginis cruentus*), whereas Chen et al. (2023) reported that grazing reduced suitable habitat and increased nest destruction rates for blue eared pheasants (*Crossoptilon auritum*). However, the effects of grazing on pheasants depend on its intensity and local environmental conditions. Moran (2014) reported that grazing during the breeding season significantly increased arthropod abundance and diversity, potentially providing additional food resources for pheasants. Similarly, Gu et al. (2022) observed that green peafowls (*Pavo muticus*) could adapt to low-to-moderate levels of grazing intensities, potentially due to increased insect availability associated with livestock dung, which provides an additional food source for the peafowl. These findings indicate that the impact of grazing on pheasants is complex and shaped by multiple ecological factors.

The complex topography and diverse landforms of southwestern China result in varied climatic conditions, making it a global biodiversity hotspot and one of China's most important ecological conservation areas (Myers et al. 2000). This region is characterized by exceptional biodiversity, serving as one of China's most important biodiversity refuges and providing essential habitats for numerous endangered and endemic pheasant species (Zheng 2015; Feng et al. 2020; Ye et al. 2015). Recent studies have indicated that livestock grazing in this region alters forest ecosystem structure, decreases vegetation cover, deteriorates habitat quality, and negatively impacts biodiversity (B. V. Li et al. 2017; Z. Li et al. 2019). In protected areas, grazing can accelerate habitat degradation, further threatening the survival and reproductive success of target species (Namgail et al. 2007; Hull et al. 2014). Like many other vertebrates, pheasants have experienced significant range contractions and population declines due to human activity, rendering some species vulnerable to extinction. Consequently, pheasant conservation remains a global conservation priority (McGowan et al. 2012; IUCN 2018; Wang et al. 2021). With increasing enforcement of wildlife protection policies, numerous studies advocate for restricting or prohibiting grazing in protected areas to promote forest ecosystem recovery and improve conservation outcomes (B. V. Li et al. 2017; Wang et al. 2021; Chen et al. 2023).

The Wanglang National Nature Reserve, located in the mountainous region of southwestern China (Figure 1), has experienced a substantial increase in free-ranging livestock over the past two decades, resulting in significant grazing disturbances (Chen et al. 2023). To improve forest habitat quality and enhance the protection of key conservation species, the reserve began implementing a grazing exclusion policy in 2017. Following the establishment of Giant Panda National Park in 2021,

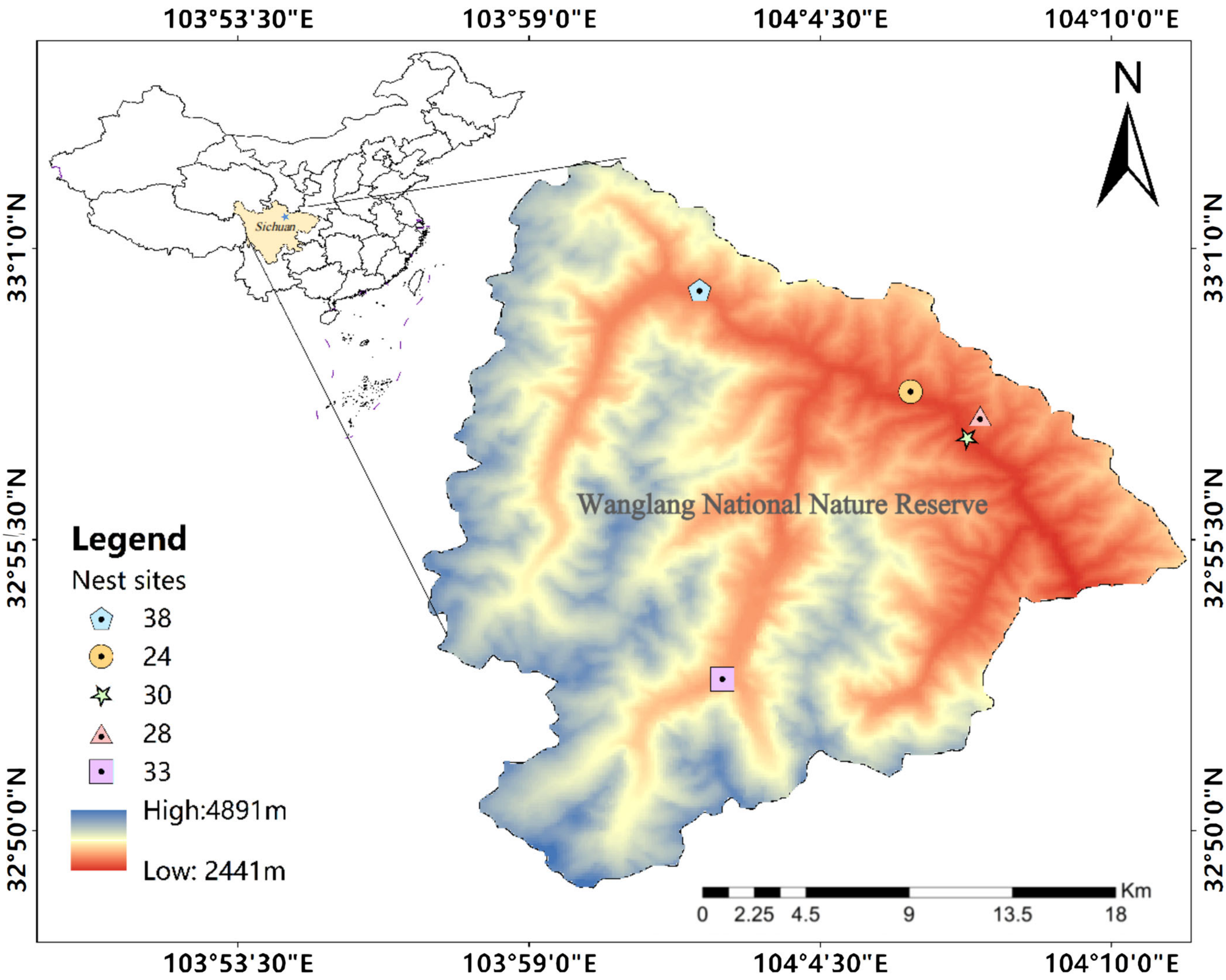

FIGURE 1 | Study area and distribution of artificial nests in Wanglang Nature Reserve, Pingwu County, Mianyang City, Sichuan Province, China (32°49′–33°02′ N, 103°55′–104°10′ E). The color gradient indicates elevation, with blue representing higher elevations (maximum of 4891 m) and red indicating lower elevations (minimum of 2441 m). The legend shows the number of artificial nests at each location. Data were collected during the breeding seasons of 2018 and 2024.

the Wanglang section further strengthened livestock management and effectively regulated grazing activities within the reserve.

Research on grassland ecosystems indicates that although grazing exclusion promotes vegetation recovery, prolonged exclusion may lead to vegetation homogenization, decreased ecosystem heterogeneity, and diminished ecosystem resilience to environmental disturbances (Davies et al. 2009; Huo et al. 2024). In contrast, owing to their structural complexity and intricate interspecies relationships, forest ecosystems are likely to exhibit more diverse ecological responses to grazing exclusion. However, empirical data on the specific ecological impacts of grazing exclusion in forest ecosystems remains scarce.

The strict grazing exclusion implemented in Wanglang Nature Reserve provides a unique natural experimental setting for studying ecological dynamics in forest ecosystems following grazing exclusion. This context allows for the assessment of grazing exclusion's ecological impacts and provides scientific data to inform future forest management and biodiversity conservation strategies. A study conducted in 2018 (before grazing exclusion) found that free-ranging livestock in the understory increased the trampling risk to pheasant ground nests, altered the distribution of habitat resources and associated risks, and decreased overall habitat suitability (X. T. Shang et al. 2024). Understanding how these resources and risks change during the breeding season following the grazing exclusion remains a critical ecological question that requires further investigation.

Given the difficulty of locating and monitoring sufficient natural pheasant nests in subalpine forests without causing disturbance, and the high risk of nest abandonment due to repeated human visits, we employed artificial simulated nests in combination with infrared camera monitoring to assess nest predation risk after grazing exclusion (Steenweg et al. 2017; Delisle et al. 2021). Artificial nests provide a standardized and minimally invasive method that is widely used in studies of ground-nesting birds and other oviparous animals (Major and Kendal 1996). Although real pheasants may remain motionless on the nest and rely on crypsis to avoid detection, a behavior which artificial nests cannot replicate, previous studies suggest that artificial nests can still reliably reflect the relative patterns and intensity of nest predation (Sugden and Beyersbergen 1986; Zheng 2015). This makes them a practical tool for evaluating the effects of habitat-level management interventions.

This study aims to investigate four key questions: (1) How does the implementation of grazing exclusion influence the nesting success rate of simulated pheasant nests? (2) What factors affect variation in simulated nest success rates? (3) Does grazing exclusion alter the abundance or activity patterns of simulated nest predators, thereby affecting the predation risk? (4) How does the survival probability of simulated nests vary over the breeding season following grazing exclusion?

To investigate these questions, we propose two hypotheses. Hypothesis 1: Grazing exclusion reduces trampling damage to vegetation by free-ranging livestock, promoting vegetation recovery. Improved vegetation cover enhances nest site concealment, decreases the likelihood of predator detection, and increases pheasant nesting success. Hypothesis 2: Reduced human and livestock activity after grazing exclusion leads to increased predator activity, counteracting the benefits of vegetation recovery and ultimately decreasing pheasant nesting success.

Data from 2024 were compared with those from 2018 to assess the impact of grazing exclusion on pheasant reproductive ecology. This study fills a research gap regarding how pheasant habitat responds to grazing exclusion in forest ecosystems. The results provide scientific evidence to support conservation measures targeting pheasants in Giant Panda National Park and offer theoretical guidance for optimizing grazing exclusion strategies and forest ecosystem management.

2 | Materials and Methods

2.1 | Study Area

The Wanglang National Nature Reserve (323 km^2, 103°55′–104°10′ E, 32°49′–33°02′ N) is located in Pingwu County, Sichuan Province, China (Figure 1). The reserve was established in 1965 as one of the country's first four giant panda reserves. In 2002, it was upgraded to a national nature reserve and subsequently integrated into the Giant Panda National Park system. Characterized by complex topography, steep elevation gradients, and diverse climatic conditions ranging from subtropical to alpine zones, the reserve supports a wide array of ecological niches and diverse habitats (X. Shang et al. 2020).

Studies have identified the Himalaya–Hengduan Mountain region as not only a biodiversity hotspot for pheasants but also a critical wildlife corridor. In the context of climate change, this region also serves as an important refuge for pheasant populations (Cai et al. 2018; Wu et al. 2017). The Wanglang National Nature Reserve supports a rich pheasant community, with a total of 11 species recorded: Severtzov's grouse (*Tetrastes sewerzowi*), Verreaux's monal-partridge (*Tetraophasis obscurus*), Chinese monal (*Lophophorus lhuysii*), blood pheasant, blue eared pheasant, golden pheasant (*Chrysolophus pictus*), Temminck's tragopan (*Tragopan temminckii*), Tibetan snowcock (*Tetraogallus tibetanus*), Koklass pheasant (*Pucrasia macrolopha*), snow partridge (*Lerwa lerwa*), and common pheasant (*Phasianus colchicus*; X. Shang et al. 2020).

Since 2015, the Wanglang Nature Reserve has worked in conjunction with various governmental agencies to implement a grazing exclusion policy. Through a phased approach, measures such as livestock removal and the closure of reserve entrances were adopted to completely prohibit grazing. In 2017, the grazing exclusion policy was formally incorporated into the provincial environmental supervision and remediation plan. A joint task force was established to oversee policy enforcement, develop detailed implementation strategies, and guide the phased rollout of exclusion measures.

By 2018, grazing exclusion had been gradually implemented, with livestock relocated by local farmers and a significant reduction in grazing activities observed within the reserve. However, following a major flood in 2020, some livestock were able to reenter the reserve. In response, the task force reinforced management efforts, combining compensation mechanisms with law enforcement measures. The grazing exclusion initiative was ultimately completed in 2021, paving the way for ecological restoration within the reserve.

2.2 | Data Collection

The study area was selected within habitats characterized by high pheasant activity. Stratified sampling was conducted, taking terrain and vegetation characteristics into account. Stratification factors included habitat type (coniferous forest, broadleaf forest, mixed conifer–broadleaf forest, shrubland, and open land), horizontal openness, canopy density, and slope. The simulated nests were placed at designated sampling points spaced 100 m apart. This spacing was chosen to reflect ecologically realistic nest distributions in the region, as pheasants and other ground-nesting birds in the reserve typically maintain inter-nest distances ranging from 50 to 200 m (Zheng 2015). Moreover, the 100-m interval helped minimize spatial autocorrelation and ensured the independence of each nest site, consistent with established protocols in artificial nest studies.

We used two types of domestic eggs to simulate those of local pheasant species with different color variations. Ordinary eggs (standard 70 g) were used to mimic the eggs of blue eared pheasants and similar species, whereas spotted eggs (standard 60 g), coated with odorless acrylic paint, were used to simulate the speckled eggs of blood pheasants and related taxa.

An infrared camera was installed 1–2 m from each simulated nest in an optimal position for monitoring. The cameras operated continuously, 24 h per day, on medium sensitivity settings. Upon each motion trigger, the camera captured a burst of three consecutive photos followed by a 20-s video. No delay was set between consecutive triggers, allowing uninterrupted monitoring of predation events. Cameras were checked every 30 days, with batteries and memory cards replaced accordingly. Along each transect, ordinary and spotted eggs were alternated in adjacent simulated nests to minimize potential bias in predation risk associated with egg coloration. To further ensure independence between experimental units, nest locations and egg types were adjusted within a 10 m radius at each study site.

After simulated nests were placed at each sampling site, researchers measured and recorded habitat variables using a GPS toolkit, compass, and clinometer. The recorded habitat factors included horizontal openness, canopy density, slope, habitat type, and shrub type. Each experiment lasted for 30 days, corresponding to the average incubation period of pheasants (22–38 days). Each nesting site was used for one 30-day cycle before relocation. Nesting was considered successful if the eggs remained intact and undisturbed; otherwise, they were classified as failures due to predation, breakage, or displacement.

Field experiments were conducted in both 2018 and 2024. In 2018, four 30-day rounds yielded a total of 146 nest sites for analysis. In 2024, three 30-day rounds were conducted, resulting in 153 nest sites, with infrared cameras used to monitor predation events. In total, 299 simulated nests were included in the analysis. In 2024, the infrared cameras operated for a total of 80,557.63 h, equivalent to 3356.57 nest days. At the conclusion of each trial, researchers assessed nest predation status and identified predator species using infrared footage and field survey data. These findings provide empirical evidence to evaluate the impact of the grazing exclusion policy on pheasant nesting success and predation risk.

2.3 | Data Analysis Methods

Statistical analyses, including significance testing, were performed using IBM SPSS Statistics 27. Nesting success rates of the simulated nests were calculated for both the pre-grazing exclusion and post-grazing exclusion periods, and trends across the different post-exclusion phases (Rounds 1–3) were examined.

To assess the effect of egg color (ordinary/spotted) on nesting outcomes (intact/destroyed), a chi-square test was applied. As both variables are categorical, the chi-square test is appropriate for determining whether a statistically significant association exists between them.

A total of 299 data points were used to analyze the factors influencing nesting outcomes. Binary logistic regression analysis was employed to evaluate the effects of nest-site environmental factors on the fate of simulated nests (intact/destroyed). The dependent variable was dichotomous (destroyed/intact), and the logit link function was used to model the relationship between linear predictors and the probability of an event occurring, which effectively handles nonlinear response relationships (Hosmer et al. 2013). The independent variables included categorical variables (habitat type and shrub type) and continuous variables (canopy density and horizontal openness). Logistic regression allows for the simultaneous inclusion of mixed predictor types and enables the calculation of adjusted odds ratios (AORs), controlling for potential interactions among variables. In this analysis, nesting outcome was designated as the dependent variable, and egg color (ordinary/spotted), habitat type (open land, shrubland, deciduous broadleaf forest, mixed conifer–broadleaf forest, or coniferous forest), and shrub type (evergreen, mixed, deciduous, or bamboo forest) were included as categorical independent variables. Canopy density and horizontal openness were treated as continuous covariates. Binary logistic regression analysis was conducted using IBM SPSS Statistics 27.0 (Bu et al. 2019).

To further evaluate the impact of grazing exclusion on simulated nest survival rates, the Cox proportional hazards model was applied for survival analysis. This model is suitable for time-to-event data, as it accommodates censored data and does not require survival times to follow a specific distribution. Additionally, it estimates the dynamic impact of various factors on predation risk through hazard ratios (HRs; Therneau 2023). The model was implemented using the "survival" (Therneau 2023) and "survminer" (Kassambara et al. 2021) packages in R software. The Kaplan–Meier method and log-rank test were used to compare survival curves of the simulated nests before and after grazing exclusion. The survival time for all successful simulated nests was set to 30 days, whereas the survival time for failed nests was calculated based on the timing of predation or destruction.

Through these analyses, this study reveals the effects of grazing exclusion on predation risk and survival rates, as well as the influence of habitat factors on predation risk. All data were processed using R and SPSS, with the significance level set at $p < 0.05$.

3 | Results

3.1 | Changes in Nesting Success Rates of Simulated Nests Before and After Grazing Exclusion

In 2018, within the Wanglang Nature Reserve, 146 simulated nests yielded definitive results after 30 days. Among these, 87 nests remained intact, resulting in a nesting success rate of 59.59%. In 2024, following the implementation of grazing exclusion, 153 nest sites produced definitive results after 30 days, with 40 nests remaining intact, yielding a nesting success rate of 26.14%.

The difference in nesting success rate between the pre- and post-grazing exclusion periods was statistically significant ($\chi^2 = 34.202$, df = 1, $p < 0.001$). Nesting success in 2024 was significantly lower than that in 2018.

For ordinary eggs, a total of 151 simulated nests were deployed, with a nesting success rate of 43.05%. For the spotted eggs, 148 simulated nests were used, with a success rate of 43.24%. Egg color (ordinary vs. spotted) had no significant effect on nesting success or failure ($\chi^2 = 0.239$, df = 1, $p = 0.625$; Table 1).

In 2024, during the first round of experiments (April–May) post-grazing exclusion, the nesting success rate was only 8.2%, significantly lower than that observed in the two subsequent

TABLE 1 | Nesting results of artificial nests with two egg colors in 2018 and 2024 (OEs, ordinary eggs; SEs, spotted eggs). Chi-square tests were used to assess the effects of egg color (ordinary/spotted) on nesting outcomes (intact/destroyed).

Chi-square test term		Intact	Destroyed	Chi-square	Expected lower limit	p
OEs	2018 ($N = 72$)	42	30	13.12	30.99	0.001
	2024 ($N = 79$)	23	56			
SEs	2018 ($N = 74$)	45	29	18.61	32.00	0.001
	2024 ($N = 74$)	19	55			
2018 in total ($N = 146$)		87	59	30.16	62.99	0.000
2024 in total ($N = 153$)		42	111			
2018	OEs ($N = 72$)	42	30	0.09	29.10	0.876
	SEs ($N = 74$)	45	29			
2024	OEs ($N = 79$)	23	56	0.23	20.31	0.711
	SEs ($N = 74$)	19	55			
OEs in total ($N = 151$)		65	86	0.00	63.85	1.000
SEs in total ($N = 148$)		64	84			

TABLE 2 | Results of binary logistic regression analysis assessing factors influencing nest outcomes. The dependent variable was nesting outcome. Independent variables included egg color (ordinary/spotted), habitat type (open land, shrubland, deciduous broadleaf forest, mixed conifer–broadleaf forest, or coniferous forest), shrub type (evergreen, mixed, deciduous, or bamboo), canopy density, and horizontal openness. Analysis was conducted using IBM SPSS Statistics 27.0.

Study time		2018 and 2024			2018			2024		
Test value		χ^2	df	p	χ^2	df	p	χ^2	df	p
Model fitting information		49.53	1	0.000	46.99	10	0.000	27.05	9	0.001
Likelihood ratio test (LRT)	Horizontal openness	7.38	1	0.007	0.07	1	0.798	4.63	1	0.031
	Canopy density	5.72	1	0.017	0.75	1	0.388	8.22	1	0.004
	Egg color	0.24	1	0.625	0.61	1	0.435	0.80	1	0.370
	Habitat type	19.46	4	0.001	26.24	4	0.000	17.88	4	0.001
	Shrub type	10.30	3	0.016	5.16	3	0.160	6.60	2	0.037

rounds. In the second round (May–June) post-grazing exclusion, the nesting success rate increased to 34%, and by the third round (June–July), it rose further to 45%.

3.2 | Environmental Factors Influencing Nesting Success Rates

Statistical analysis of the impacts of nest-site environmental factors revealed significant differences in the influence of various environmental factors on simulated nest outcomes before and after grazing exclusion (Table 2). Before the grazing exclusion (2018), nesting success was primarily influenced by habitat type ($\chi^2 = 26.241$, df = 4, $p < 0.001$), with significant variation across different habitat types. In contrast, horizontal openness, canopy density, egg color, and shrub type did not significantly affect nesting outcomes ($p > 0.05$). After grazing exclusion (2024), multiple environmental factors had significant effects on nesting success: horizontal openness ($\chi^2 = 4.629$, df = 1, $p = 0.031$), canopy density ($\chi^2 = 8.217$, df = 1, $p = 0.004$), habitat type ($\chi^2 = 17.882$, df = 4, $p = 0.001$), and shrub type ($\chi^2 = 6.600$, df = 2, $p = 0.037$).

Further analysis of temporal changes post-exclusion revealed significant changes in canopy density ($\chi^2 = 8.22$, df = 1, $p = 0.004$) and horizontal openness ($\chi^2 = 4.63$, df = 1, $p = 0.03$; Figure 2). Specifically, mean canopy density increased from 0.497 in the first round to 0.635 in the third round, whereas horizontal openness decreased from 0.628 in the first round to 0.419 in the third round.

3.3 | Comparison of Predation Frequency Before and After Grazing Exclusion

Following grazing exclusion, predation risk to simulated pheasant nests increased, with notable changes in the predator composition and activity patterns (Figure 3). Specifically, the frequency of predation by large-billed crows (*Corvus macrorhynchos*) was lower in the second and third

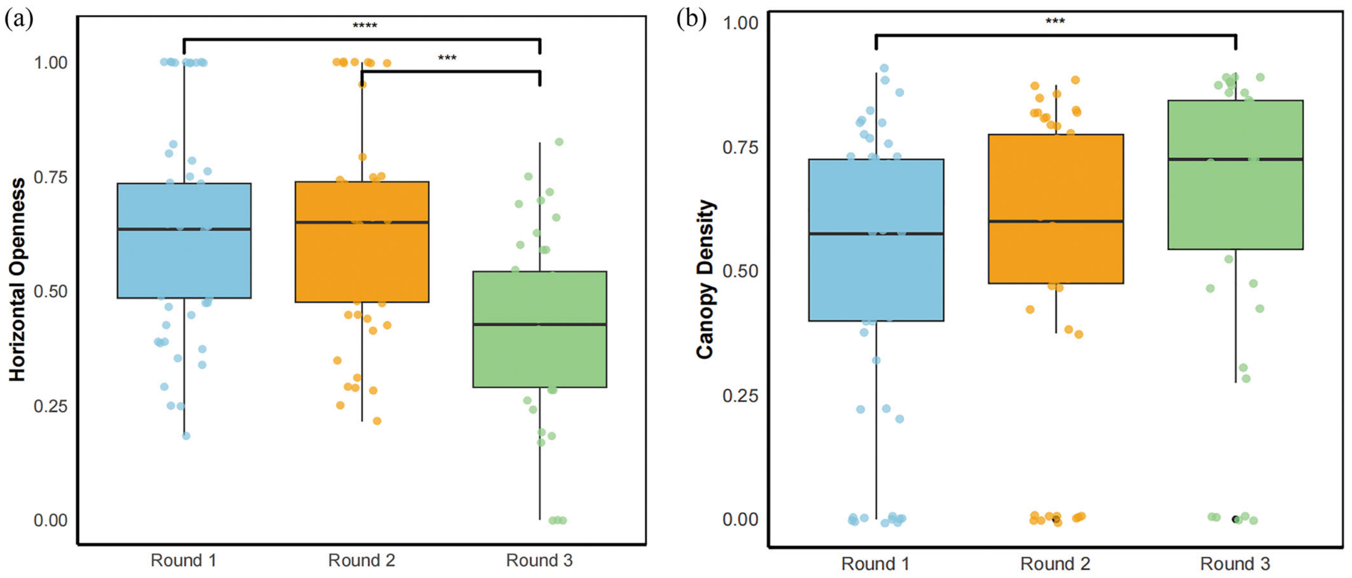

FIGURE 2 | Changes in horizontal openness and canopy density across three survey rounds following grazing exclusion in Wanglang Nature Reserve in 2024. (a) Horizontal Openness and (b) Canopy Density. Data were collected from 153 sampling sites. Significant differences are indicated as $***p < 0.001$ and $****p < 0.0001$. Error bars represent ± SE.

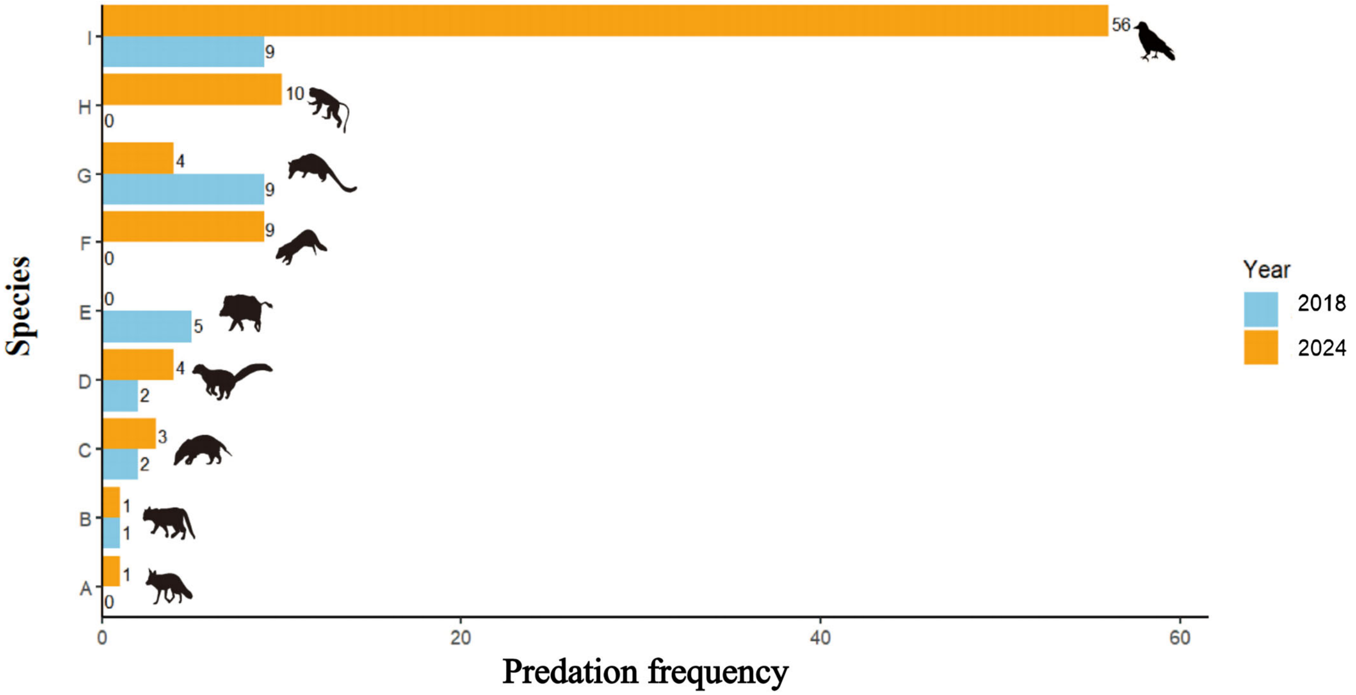

FIGURE 3 | Artificial nest destroyers and destruction frequency in different time periods in 2018 and 2024. A–I respectively stands for *Vulpes vulpes*, *Prionailurus bengalensis*, *Arctonyx collaris*, *Martes flavigula*, *Sus scrofa*, *Mustela sibirica*, *Paguma larvata*, *Rhinopithecus roxellana*, and *Corvus macrorhynchos*. All the silhouettes are sourced from Phylopic (https://www.phylopic.org/).

rounds compared with the first, although they remained the dominant predator both before and after exclusion. Golden snub-nosed monkeys (*Rhinopithecus roxellana*) were recorded preying on nests only during the first round, whereas red foxes (*Vulpes vulpes*) appeared as new predators following grazing exclusion.

During the grazing period, the proportion of predation events attributed to different predators on simulated nests was as follows: large-billed crows, 32.14%; masked palm civets (*Paguma larvata*), 32.14%; wild boars (*Sus scrofa*), 17.86%; yellow-throated martens (*Martes flavigula*), 7.14%; hog badgers (*Arctonyx collaris*), 7.14%; and leopard cats (*Prionailurus bengalensis*), 3.58%. After grazing exclusion, the proportion of predation events shifted: large-billed crows, 62%; golden snub-nosed monkeys, 11%; Siberian weasels (*Mustela sibirica*); yellow-throated martens, 4%; masked palm civets, 4%; hog badgers, 3%; red foxes,1%; and leopard cats, 1%.

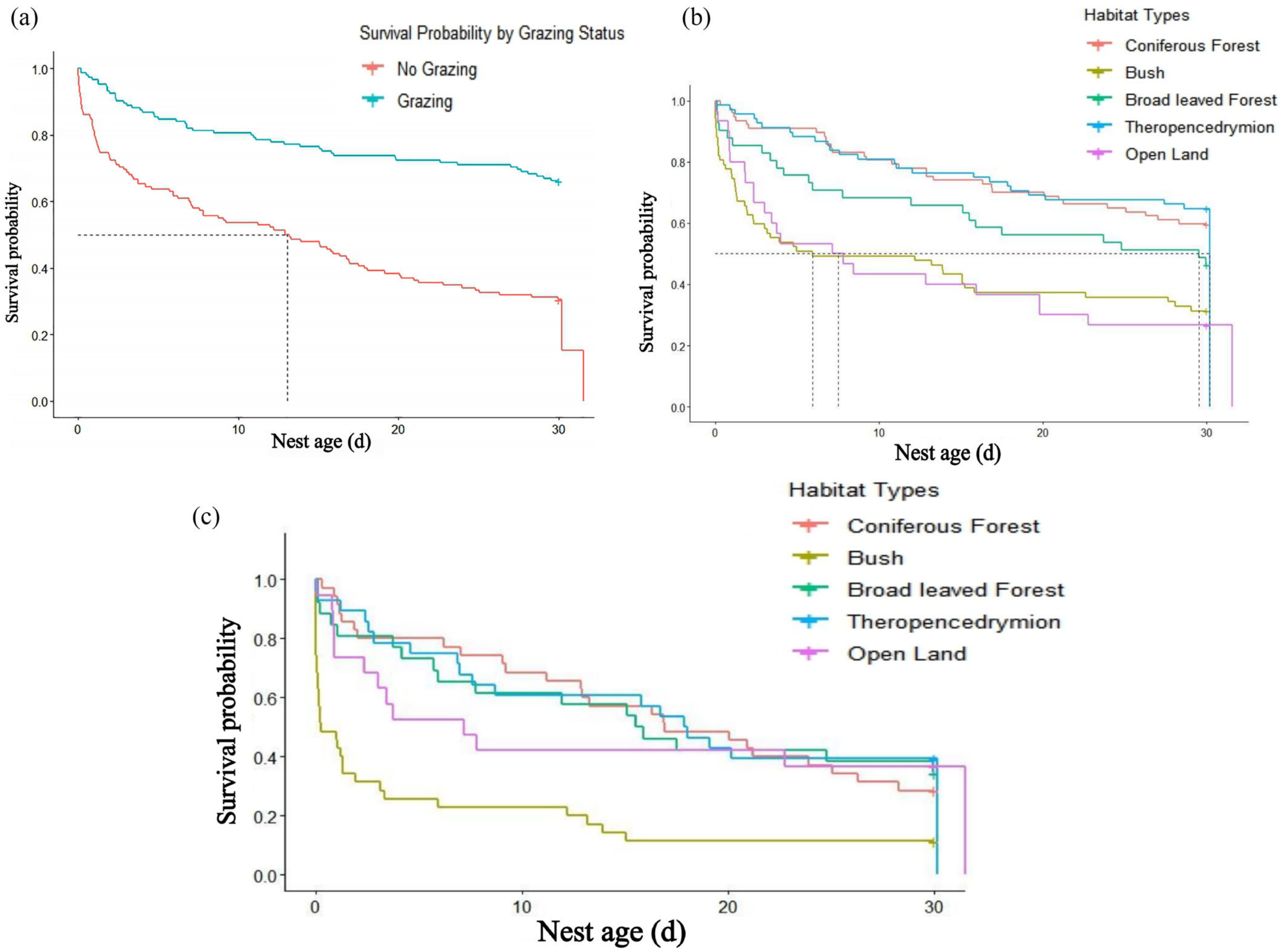

FIGURE 4 | Survival analysis of artificial nests in 2018 and 2024. (a) Survival analysis of artificial nests in 2018 and 2024, (b) artificial nest survival curves of different habitat types in 2018, and (c) artificial nest survival curves of different habitat types in 2024.

These results highlight the potential ecological risks associated with grazing exclusion, particularly its impact on predator dynamics and pheasant nest vulnerability.

3.4 | Survival Analysis Before and After Grazing Exclusion

The results of the simulated nest survival analysis before grazing exclusion revealed only minor differences in survival probability across habitat types (Figure 4a). Throughout the monitoring period, the survival probability curves for coniferous and broadleaf forests were largely similar. Survival probabilities in shrubland and broadleaf forest habitats were slightly higher than those in open land (Figure 4b).

After grazing exclusion in 2024, significant differences in nest survival probability emerged across habitat types (Figure 4c). Survival curves for coniferous and broadleaf forests declined most gradually, indicating higher nest persistence. In contrast, survival curves for open land and shrubland declined more rapidly, especially during the first 10 days of the experiment. The survival probability in mixed conifer–broadleaf forests was intermediate, falling between that of more stable forest habitats and the more vulnerable open land.

4 | Discussion

Following the implementation of strict understory grazing exclusion, we observed a marked decline in pheasant nesting success and an increase in predation frequency during the breeding season in subalpine forest ecosystems. This key finding suggests that such conservation interventions, while intended to reduce human disturbance and improve habitat quality, may temporarily elevate predation risk for ground-nesting birds. Notably, these results highlight the potential risks of basing conservation decisions on human disturbance interventions targeting “umbrella species,” given the variable responses of wildlife communities to forest management measures. Therefore, forest grazing exclusion may not be a suitable “one-size-fits-all” solution. Future strategies should be refined using empirical monitoring data, and effective, integrated management approaches should be explored to support the long-term development of Giant Panda National Park.

4.1 | Changes in Nest Success Rate and Factors Influencing Its Variation

We found that the nesting success rate of artificial nests declined significantly after grazing exclusion, indicating that this intervention may indirectly reduce the reproductive success of pheasants through complex ecological mechanisms. Although grazing exclusion is typically implemented to reduce livestock disturbance and enhance habitat suitability, our results suggest that it may lead to increased predator activity frequency and range expansion, thereby reducing nesting success.

The rise in predator activity following grazing exclusion may have arisen from multiple ecological mechanisms. First, reduced human and livestock presence likely allows predators easier access to the area. Second, vegetation recovery may increase the abundance of small mammals (Sullivan and Sullivan 2014), which in turn attracts more mesopredators and indirectly increases nest predation risk. Although egg color can influence predation risk by interacting with predator visual preferences and environmental context, this effect varies across ecosystems (Ibanez-Alamo et al. 2015) and does not appear to account for the observed decline in nesting success. In the subalpine forest ecosystems of the southwestern China mountains, egg color did not significantly affect nesting outcomes either before or after grazing exclusion. Our findings demonstrate that the impacts of grazing exclusion extend beyond vegetation restoration and may alter predator–prey relationships, ultimately affecting the reproductive success of target species.

The analysis of environmental factors revealed that, following grazing exclusion, both canopy density and horizontal openness significantly influenced nest outcomes. Greater canopy density may increase nest survival via two primary mechanisms: (1) improving visual concealment, thus reducing predator detection, and (2) impeding the movement of medium-to-large predators, thereby lowering predation risk. However, the protective effects of canopy density may differ depending on predator species, indicating a need for further study into predator-specific activity patterns under varying canopy density conditions.

Habitat type was also a significant determinant of nesting success both before and after grazing exclusion, highlighting the critical role of habitat heterogeneity in pheasant reproduction. Nesting success rates varied significantly across habitat types, with densely vegetated habitats likely offering greater concealment and more abundant food resources. These findings are consistent with those of previous studies emphasizing the importance of vegetation structure in avian reproductive ecology (Chalfoun and Martin 2007).

Although overall nesting success declined following grazing exclusion, a distinct temporal trend was observed: nesting success rates increased over time. This trend likely reflects seasonal changes in vegetation cover and predator activity. During the first round of experiments in April, limited vegetation growth provided poor nest concealment, exposing nests to higher predation risk. As the season progressed, increased vegetation cover improved concealment and likely reduced visibility to predators, contributing to higher nest survival in later rounds.

Together, these results underscore the importance of vegetation structure—particularly canopy density and horizontal openness—in shaping nest survival. From a conservation perspective, managing vegetation structure to enhance nest concealment could help improve reproductive outcomes for ground-nesting birds.

4.2 | Changes in Predators

Our study shows that although grazing exclusion reduces human disturbance and promotes vegetation recovery, creating a potentially more suitable nesting environment for pheasants, it also significantly decreases nesting success following exclusion. Additionally, increases in both predator diversity and activity frequency were observed, which contradicts the initial hypothesis that grazing exclusion would improve reproductive success. Previous studies suggest that ungrazed areas accumulate biodiversity over time (Filazzola et al. 2020), and vegetation recovery may offer resources that attract both small mammals and large predators, thereby elevating predation pressure on nests.

The predation frequency of large-billed crows decreased during the second (May–June) and third (June–July) rounds of the experiment compared with the first round (April–May). This decline may be attributed to vegetation recovery, which improved nest concealment and made artificial nests less detectable. Additionally, seasonal shifts in predator behavior and food availability may have reduced the crow's reliance on bird eggs over time (Madden et al. 2015). The presence of other predators, such as the Siberian weasel and the masked palm civet, may have introduced interspecific competition, potentially affecting crow foraging patterns. Large-billed crows have high protein requirements during the breeding season, which may explain their higher activity in early spring. Ground-level predation by golden snub-nosed monkey occurred only in the first round, likely due to limited food availability in early spring.

Before the grazing exclusion, the large-billed crow was the primary predator, with stable predation frequencies. Studies have shown that this species can use human activity as a cue to locate nests and can remember nesting sites over time (Sugden and Beyersbergen 1986; Ibanez-Alamo et al. 2015). In this study, nests were spaced 100 m apart and were relatively concentrated, potentially making them easier to locate. As efficient aerial predators, foraging crows may have been attracted to these clustered nest sites, increasing the frequency of predation. By removing livestock, grazing exclusion reduces competition for resources and facilitates the redistribution of wildlife populations and the reoccupation of habitats (Filazzola et al. 2020). Consequently, food resources and habitat space previously occupied by livestock become accessible to other species. Some predators, such as small mammals, may gradually occupy these released ecological niches, intensifying predation pressure on pheasant nests (Sullivan and Sullivan 2014). Golden snub-nosed monkeys and red foxes, as omnivores, have broad dietary requirements that include both plant matter and potentially bird eggs (Cox et al. 2012; Cockle et al. 2016). Overall, the ecological consequences of grazing exclusion are multifaceted and context dependent, highlighting the need for long-term, multitrophic monitoring to fully understand predator–prey dynamics in these systems (Svejcar et al. 2014).

4.3 | Changes in Survival Probability

In this study, survival analysis of artificial pheasant nests following grazing exclusion revealed a significant decrease in survival probability across habitats. Open land and shrublands showed particularly sharp declines as predation risk intensified. The survival curves of coniferous and broadleaf forests were similar, whereas shrubland and broadleaf forest areas had slightly higher survival probabilities than open land. Overall, the survival probability curve before grazing exclusion was relatively flat, indicating minimal variation among habitat types. This is likely attributable to the suppression of predator populations by livestock presence and associated human activity (Pudyatmoko 2017).

After grazing exclusion, differences in nest survival probability among habitat types increased, and predation pressure varied across different phases of the breeding season. The survival curves for coniferous and broadleaf forests declined more gradually, with higher survival probabilities and longer survival durations. In contrast, open land and shrubland showed the steepest declines, especially during the first 10 days of monitoring, when survival probabilities dropped sharply to nearly 50%. This early drop was driven primarily by the large-billed crow, whose peak predation during this period may be linked to increased protein demands during breeding. From Days 10 to 20, a slower decline in survival probability was observed, with predators such as the yellow-throated marten, golden snub-nosed monkey, and hog badger becoming more active. During the final 10 days (20–30 days), survival probabilities stabilized somewhat, yet the large-billed crow and yellow-throated marten continued to pose a significant threat to nests.

Grazing exclusion enhanced vegetation recovery, which may in turn have created more favorable habitat conditions for predators. Additionally, reduced human activity likely minimized disturbances to predators, further heightening the degree of nest predation risk.

4.4 | Research Prospects

Grazing exclusion is implemented to reduce livestock disturbance, promote vegetation recovery, improve habitat quality, and enhance ecosystem stability (Song et al. 2018; Xu et al. 2020). Moreover, free-ranging livestock and human activity can increase the risk of zoonotic disease transmission. These diseases not only threaten livestock health but can also affect wildlife populations, potentially endangering vulnerable species through cross-species pathogen dispersal (Gortázar et al. 2006; Gortázar et al. 2007). Grazing exclusion can therefore reduce pathogen transmission risk and minimize human–wildlife contact, contributing to ecosystem stability (Jori et al. 2021). However, its implementation must be science-based and tailored to local ecological conditions.

In the present context, low-intensity grazing and other human disturbances may partially alleviate nest predation pressure on pheasants. However, the mechanisms involved still remain unclear, especially whether a "human shield effect" exists or whether short-term changes in wildlife habitat use occur after livestock are removed. For example, a 2019 study in Jiuzhaigou, where grazing disturbance was minimal, found lower nest predation risk compared to Wanglang both before and after the grazing exclusion. This difference warrants further investigation (X. T. Shang et al. 2024). Additionally, in the context of climate change, the interaction between grazing exclusion, food resource distribution, and vegetation response requires long-term monitoring and analysis to comprehensively assess its ecological impacts (Filazzola et al. 2020).

This study has several limitations. First, we used simulated nests as substitutes for natural nests during the experiment. Although this method is commonly used in nest predation studies, it may not fully replicate the predation risks faced by actual nests (Burke et al. 2004). In natural settings, the presence and behavior of incubating females—such as nest defense, crypsis, or early predator detection—can influence predator success rates, factors that cannot be captured by artificial nests (Montgomerie and Weatherhead 1988). Furthermore, locating sufficient numbers of pheasant nests in subalpine forests remains challenging. Future research should incorporate natural nest monitoring whenever feasible, using long-term population surveys, systematic transects, infrared-triggered camera monitoring, and noninvasive genetic techniques. These methods could help assess actual nesting success and predation dynamics under grazing exclusion. Integrating data from both artificial and natural nests would provide a more comprehensive understanding of how habitat management interventions affect pheasant reproduction and survival.

In addition, our study did not explicitly assess potential edge effects, which are known to influence microhabitat conditions, predator activity, and human disturbance levels. Due to constraints in site selection, the spatial distribution of artificial nests relative to forest edges was not quantified. Future studies should incorporate edge distance as a variable to better understand how landscape context influences nest outcomes under grazing exclusion.

Finally, our data set spans only 2 years—one before and one after grazing exclusion—and does not capture the long-term effects of the exclusion on predator behavior, interspecific relationships, or pheasant survival and reproduction. Future research should expand temporal and spatial scales, including additional years and ecological seasons. Long-term data collection could reveal the full effects of the grazing exclusion on vegetation dynamics, habitat quality, predator behavior, and species persistence (Sullivan and Sullivan 2014; Filazzola et al. 2020). Comparative studies across multiple regions and seasons are also needed. Such efforts would allow exploration of the integrated impacts of grazing exclusion with moderate grazing, ecological restoration, and other management measures. These findings could inform more robust and adaptive policy design.

In conclusion, this study investigated the effects of grazing exclusion on pheasant nesting success and simulated nest predation risk. The findings emphasize the critical roles of vegetation concealment and predation pressure in determining pheasant reproduction outcomes. This research addresses a gap in our understanding of the ecological consequences of grazing exclusion and provides new insights into the complex relationships among vegetation recovery, predator activity, and predation risk for pheasants.

Although grazing exclusion can enhance vegetation and biodiversity, its implementation may also adversely affect local herders who are dependent on grazing for their livelihoods. Because local communities are integral to long-term conservation goals, grazing exclusion policies must consider potential socioeconomic consequences. These policies can directly impact herder income and ways of life. Therefore, conservation measures must strike a balance between ecological benefits and social equity (Acebes et al. 2024).

We recommend a management approach that balances protection and development within areas such as Giant Panda National Park. This should include the evidence-based regulation of grazing exclusion and habitat restoration, alongside the careful management of predator–prey interactions. Such strategies can help mitigate the potential negative impacts of single-focus conservation policies, support both environmental conservation and human well-being, and promote sustainable environmental and socioeconomic development (Zhang et al. 2017).

Author Contributions

Yifei Zhang: conceptualization, methodology, formal analysis, investigation, data curation, visualization, writing – original draft. **Xiaotong Shang:** writing – review and editing, conceptualization, methodology, supervision. **Wenjun Ming:** visualization, investigation, software. **Lianjun Zhao:** resources, project administration. **Yong Zheng:** investigation. **Sheng Li:** conceptualization, methodology, resources, data curation, supervision. **Li Li:** writing – review and editing, methodology, conceptualization, resources. **Li Zhang:** conceptualization, methodology, data curation, resources, writing – review and editing, project administration, supervision, funding acquisition.

Acknowledgments

We appreciated Y. Zheng, C. P. Luo, H. X. Zhao, X. R. Wang, C. J. Nie, Z. Q. Zhou, Z. W. Yuan, and H. L. Zhou for their assistance in the field, which made this research possible. This research was funded by Wanglang National Nature Reserve through its special survey and research project on pheasants in Wanglang (grant number: Ping Gong Jiao Cai Tan [2017] No. 1-1).

Ethics Statement

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to.

Conflicts of Interest

The authors declare no conflicts of interest.

Article Impact Statement

Grazing exclusion increased predator activity and nest predation risk, reducing nesting success of ground-nesting pheasants and revealing conservation trade-offs.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Acebes, P., F. J. Munoz-Galvez, Z. Iglesias-Gonzalez, M. Garcia-Llorente, and D. Lopez-Garcia. 2024. "Unveiling Human-Wildlife Interactions in the Context of Livestock Grazing Abandonment and the Return of Large Carnivores, Ungulates and Vultures: A Stakeholder Perspective." *People and Nature*: 1–13.

Barnosky, A. D., E. A. Hadly, J. Bascompte, et al. 2012. "Approaching a State Shift in Earth's Biosphere." *Nature* 486, no. 7401: 52–58.

Beja, P., S. Schindler, J. Santana, et al. 2014. "Predators and Livestock Reduce Bird Nest Survival in Intensive Mediterranean Farmland." *European Journal of Wildlife Research* 60, no. 2: 249–258.

Bu, H., X. Shen, and S. Li. 2019. "Predation Patterns on Artificial Nests of Ground Nesting Pheasants in the Montane Forest, Southwest China." *Acta Ornithologica* 54, no. 1: 35–43.

Burke, D. M., K. Elliott, L. Moore, et al. 2004. "Patterns of Nest Predation on Artificial and Natural Nests in Forests." *Conservation Biology* 18, no. 2: 381–388.

Cai, T., J. Fjeldså, Y. Wu, et al. 2018. "What Makes the Sino-Himalayan Mountains the Major Diversity Hotspots for Pheasants?" *Journal of Biogeography* 45, no. 3: 640–651.

Chalfoun, A. D., and T. E. Martin. 2007. "Assessments of Habitat Preferences and Quality Depend on Spatial Scale and Metrics of Fitness." *Journal of Applied Ecology* 44, no. 5: 983–992.

Chen, X., X. T. Shang, F. Fan, et al. 2023. "Impacts of Livestock Grazing on Blue-Eared Pheasants (*Crossoptilon auritum*) Survival in Subalpine Forests of Southwest China." *Integrative Conservation* 2, no. 4: 201–213.

Cockle, K. L., A. Bodrati, M. Lammertink, E. B. Bonaparte, C. Ferreyra, and F. G. Di Sallo. 2016. "Predators of Bird Nests in the Atlantic Forest of Argentina and Paraguay." *Wilson Journal of Ornithology* 128, no. 1: 120–131.

Cox, W. A., F. R. Thompson, and J. Faaborg. 2012. "Landscape Forest Cover and Edge Effects on Songbird Nest Predation Vary by Nest Predator." *Landscape Ecology* 27, no. 5: 659–669.

Davies, K. W., T. J. Svejcar, and J. D. Bates. 2009. "Interaction of Historical and Nonhistorical Disturbances Maintains Native Plant Communities." *Ecological Applications* 19, no. 6: 1536–1545.

Delisle, Z. J., E. A. Flaherty, M. R. Nobbe, C. M. Wzientek, and R. K. Swihart. 2021. "Next-Generation Camera Trapping: Systematic Review of Historic Trends Suggests Keys to Expanded Research Applications in Ecology and Conservation." *Frontiers in Ecology and Evolution* 9: 617996.

Fan, F., H. Bu, W. J. McShea, X. Shen, B. V. Li, and S. Li. 2020. "Seasonal Habitat Use and Activity Patterns of Blood Pheasant *Ithaginis cruentusbe* in the Presence of Free-Ranging Livestock." *Global Ecology and Conservation* 23: e01155.

Feng, G., X. Huang, L. Mao, N. Wang, X. Yang, and Y. Wang. 2020. "More Endemic Birds Occur in Regions With Stable Climate, More Plant Species and High Altitudinal Range in China." *Avian Research* 11, no. 1: 17.

Filazzola, A., C. Brown, M. A. Dettlaff, et al. 2020. "The Effects of Livestock Grazing on Biodiversity Are Multi-Trophic: A Meta-Analysis." *Ecology Letters* 23, no. 8: 1298–1309.

Fraser, L. H., W. L. Harrower, H. W. Garris, et al. 2015. "A Call for Applying Trophic Structure in Ecological Restoration." *Restoration Ecology* 23, no. 5: 503–507.

Gortázar, C., P. Acevedo, F. Ruiz-Fons, and J. Vicente. 2006. "Disease Risks and Overabundance of Game Species." *European Journal of Wildlife Research* 52, no. 2: 81–87.

Gortázar, C., E. Ferroglio, U. Höfle, K. Frölich, and J. Vicente. 2007. "Diseases Shared Between Wildlife and Livestock: A European Perspective." *European Journal of Wildlife Research* 53, no. 4: 241–256.

Gossner, M. M., T. M. Lewinsohn, T. Kahl, et al. 2016. "Land-Use Intensification Causes Multitrophic Homogenization of Grassland Communities." *Nature* 540, no. 7632: 266–269.

Gu, B., Y. Weng, Y. Diao, et al. 2022. "Is Livestock Grazing Compatible With Green Peafowl (*Pavo muticus*) Conservation? Potential Chance of Peafowl-Human Coexistence." *Biological Conservation* 275: 109772.

Hosmer, D. W., S. Lemeshow, and R. X. Sturdivant. 2013. *Applied Logistic Regression*. John Wiley & Sons.

Hull, V., J. Zhang, S. Zhou, et al. 2014. "Impact of Livestock on Giant Pandas and Their Habitat." *Journal for Nature Conservation* 22, no. 3: 256–264.

Huo, T., J. Wang, Y. Zhang, et al. 2024. "Temperate Grassland Vegetation Restoration Influenced by Grazing Exclusion and Climate Change." *Science of the Total Environment* 912: 168842.

Ibanez-Alamo, J. D., R. D. Magrath, J. C. Oteyza, et al. 2015. "Nest Predation Research: Recent Findings and Future Perspectives." *Journal of Ornithology* 156: S247–S262.

IUCN. 2018. The IUCN Red List of Threatened Species. Version 2018–2. http://www.iucnredlist.org.

Johnson, T. N., P. L. Kennedy, and M. A. Etterson. 2012. "Nest Success and Cause-Specific Nest Failure of Grassland Passerines Breeding in Prairie Grazed by Livestock." *Journal of Wildlife Management* 76, no. 8: 1607–1616.

Jori, F., M. Hernandez-Jover, I. Magouras, S. Dürr, and V. J. Brookes. 2021. "Wildlife–Livestock Interactions in Animal Production Systems: What Are the Biosecurity and Health Implications?" *Animal Frontiers* 11, no. 5: 8–19.

Kassambara, A., M. Kosinski, P. Biecek, and S. Fabian. 2021. Survminer_0.4.9.tar.gz. https://CRAN.R-project.org/package=surXZvminer.

Li, B. V., and B. Jiang. 2021. "Responses of Forest Structure, Functions, and Biodiversity to Livestock Disturbances: A Global Meta-Analysis." *Global Change Biology* 27, no. 19: 4745–4757.

Li, B. V., S. L. Pimm, S. Li, L. Zhao, and C. Luo. 2017. "Free-Ranging Livestock Threaten the Long-Term Survival of Giant Pandas." *Biological Conservation* 216: 18–25.

Li, Z., T. Wang, J. L. D. Smith, et al. 2019. "Coexistence of Two Sympatric Flagship Carnivores in the Human-Dominated Forest Landscapes of Northeast Asia." *Landscape Ecology* 34, no. 2: 291–305.

Madden, C. F., B. Arroyo, and A. Amar. 2015. "A Review of the Impacts of Corvids on Bird Productivity and Abundance." *Ibis* 157, no. 1: 1–16.

Major, R. E., and C. E. Kendal. 1996. "The Contribution of Artificial Nest Experiments to Understanding Avian Reproductive Success: A Review of Methods and Conclusions." *Ibis* 138: 298–307.

McGowan, P. J. K., L. L. Owens, and M. J. Grainger. 2012. "Galliformes Science and Species Extinctions: What We Know and What We Need to Know." *Animal Biodiversity and Conservation* 35, no. 2: 321–331.

Montgomerie, R. D., and P. J. Weatherhead. 1988. "Risks and Rewards of Nest Defence by Parent Birds." *Quarterly Review of Biology* 63, no. 2: 167–187.

Moran, M. D. 2014. "Bison Grazing Increases Arthropod Abundance and Diversity in a Tallgrass Prairie." *Environmental Entomology* 43, no. 5: 1174–1184.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent. 2000. "Biodiversity Hotspots for Conservation Priorities." *Nature* 403, no. 6772: 853–858.

Namgail, T., J. L. Fox, and Y. V. Bhatnagar. 2007. "Habitat Shift and Time Budget of the Tibetan Argali: The Influence of Livestock Grazing." *Ecological Research* 22, no. 1: 25–31.

Pillar, V. D., and G. E. Overbeck. 2025. "Grazing Can Reduce Wildfire Risk Amid Climate Change." *Science* 387, no. 6730: eadu7471.

Pudyatmoko, S. 2017. "Free-Ranging Livestock Influence Species Richness, Occupancy, and Daily Behaviour of Wild Mammalian Species in Baluran National Park, Indonesia." *Mammalian Biology* 86: 33–41.

Shang, X., C. Luo, B. Li, et al. 2020. "Diversity and Fauna Composition of Birds in the Wanglang National Nature Reserve, Sichuan." *Sichuan Journal of Zoology* 39: 93–106.

Shang, X. T., F. Fan, X. L. Shen, et al. 2024. "Free-Ranging Livestock Reduces the Habitat Suitability of Subalpine Pheasants During Breeding Season in Southwest China." *Conservation Science and Practice* 6, no. 4: e13104.

Song, J., S. Wan, S. Peng, et al. 2018. "The Carbon Sequestration Potential of China's Grasslands." *Ecosphere* 9, no. 10: e02452.

Steenweg, R., M. Hebblewhite, R. Kays, et al. 2017. "Scaling-Up Camera Traps: Monitoring the Planet's Biodiversity With Networks of Remote Sensors." *Frontiers in Ecology and the Environment* 15, no. 1: 26–34.

Sugden, L. G., and G. W. Beyersbergen. 1986. "Effect of Density and Concealment on American Crow Predation of Simulated Duck Nests." *Journal of Wildlife Management* 50, no. 1: 9–14.

Sullivan, T. P., and D. S. Sullivan. 2014. "Fertilisation, Cattle Grazing and Voles: Collapse of Meadow Vole Populations in Young Forests?" *Wildlife Research* 41, no. 5: 367.

Svejcar, T., C. Boyd, K. Davies, et al. 2014. "Western Land Managers Will Need All Available Tools for Adapting to Climate Change, Including Grazing: A Critique of Beschta et al." *Environmental Management* 53, no. 6: 1035–1038.

Therneau, T. 2023. *A Package for Survival Analysis in R. R Package Version 3.5-5*.

Wake, D. B., and V. T. Vredenburg. 2008. "Are We in the Midst of the Sixth Mass Extinction? A View From the World of Amphibians." *Proceedings of the National Academy of Sciences* 105: 11466–11473.

Wang, B., Y. Xu, M. Price, et al. 2021. "Niche Partitioning Among Three Montane Ground-Dwelling Pheasant Species Along Multiple Ecological Dimensions." *Ibis* 163, no. 1: 171–182.

Wells, H. B. M., D. M. Kimuyu, W. O. Odadi, A. J. Dougill, L. C. Stringer, and T. P. Young. 2021. "Wild and Domestic Savanna Herbivores Increase Smaller Vertebrate Diversity, but Less Than Additively." *Journal of Applied Ecology* 58, no. 5: 953–963.

Wu, Y., S. G. DuBay, R. K. Colwell, J. Ran, and F. Lei. 2017. "Mobile Hotspots and Refugia of Avian Diversity in the Mountains of South-West China Under Past and Contemporary Global Climate Change." *Journal of Biogeography* 44, no. 3: 615–626.

Xu, L., Y. Nie, B. Chen, et al. 2020. "Effects of Fence Enclosure on Vegetation Community Characteristics and Productivity of a Degraded Temperate Meadow Steppe in Northern China." *Applied Sciences* 10, no. 8: 2952.

Ye, X., G. Liu, Z. Li, H. Wang, and Y. Zeng. 2015. "Assessing Local and Surrounding Threats to the Protected Area Network in a Biodiversity Hotspot: The Hengduan Mountains of Southwest China." *PLoS One* 10, no. 9: e0138533.

Zhang, J., V. Hull, Z. Ouyang, et al. 2017. "Divergent Responses of Sympatric Species to Livestock Encroachment at Fine Spatiotemporal Scales." *Biological Conservation* 209: 119–129.

Zheng, G. 2015. *Pheasants in China*. Higher Education Press.