JOURNAL OF ECOLOGY AND CONSERVATION
Jan-Mar 2026, VOL. 4, ISSUE 1, pp. 1-7
https://doi.org/10.61577/jec.2026.100001

RESEAPRO JOURNALS

ORIGINAL ARTICLE

OPEN ACCESS

Factors Influencing the distribution of spotted deer (*Axis axis*) in isolated forest patches of Hetauda, Central Nepal

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ABSTRACT

Habitat fragmentation and rapid urban expansion are increasingly affecting wildlife populations in peri-urban landscapes. This study investigated the distribution pattern and habitat determinants of chital (Axis axis) in two isolated forest patches Forestry Complex Forest and Brindaban Forest in Hetauda, central Nepal. A systematic grid-based sampling design was employed, and species occurrence was recorded through indirect pellet group surveys. Environmental variables including vegetation structure (grass and canopy cover), elevation, and distances to water sources and human settlements were measured. Spatial distribution was mapped using GIS, and habitat associations were analyzed using a Poisson Generalized Linear Model (GLM), with model selection based on Akaike's Information Criterion (AIC).

Results showed that chital distribution was highly non-random and strongly concentrated in grassland and secondary *Shorea robusta* forests. The GLM indicated that proximity to water sources and higher grass cover significantly increased chital occurrence, while greater distance from settlements also positively influenced distribution, reflecting avoidance of human disturbance. Canopy cover showed a significant negative effect, 'whereas elevation was not a significant predictor. Human activity was strongly negatively correlated with species sign abundance, further highlighting disturbance sensitivity. Overall, the findings suggest that fine-scale habitat characteristics and resource availability play a more critical role than topographic factors in shaping chital distribution in fragmented urban forest ecosystems. Conservation efforts should prioritize maintaining grass-dominated understories, protecting water resources, and reducing anthropogenic pressure to support the long-term persistence of A. axis in peri-urban landscapes.

KEY WORDS

Axis axis; Habitat fragmentation; Urban forests; Pellet count survey; Habitat determinants

ARTICLE HISTORY

Received 07 February 2026; Revised 04 March 2026; Accepted 11 March 2026

Introduction

The chital or spotted deer (A. axis) is a member of the family Cervidae and is one of the most common ungulates inhabiting tropical and subtropical forests of South Asia. In Nepal, the species is widely known as chital [1]. Taxonomically, it belongs to the order Artiodactyla under the family Cervidae. The species is easily recognized by its reddish-brown coat marked with distinct white spots distributed across the body. A dark stripe runs along the dorsal midline from the neck to the tail. The underside, including the abdomen, throat, rump, inner limbs, ears, and tail, is comparatively lighter in color. Adult males generally appear darker and more robust than females. Seasonal changes in coat coloration are not very pronounced; however, during colder periods the coat tends to become slightly darker, thicker, and shinier than during the warmer months [1]. According to the International Union for Conservation of Nature (IUCN), chital is currently listed as Least Concern due to its wide distribution and relatively large population across its range [2]. In Nepal, the species is primarily distributed in the lowland regions and occurs both inside protected areas and in nearby forest landscapes. Chital occupy a variety of habitats including grasslands, scrub forests, and woodland areas, particularly those located near agricultural land. Their habitat use often changes with seasons [3]. For instance, during the hot and dry season they are commonly observed in riverine forests, while during the monsoon they tend to use Sal (S. robusta) dominated forests more frequently [4]. The species is generally found at elevations below 1000 m, although occasional sightings of small groups have been reported from warmer valleys and forested mid-hill regions [5,6]. Chital are herbivorous and feed on a variety of grasses, leaves, fruits, and other plant materials. They usually remain close to permanent water sources, which are important for their survival [4,7]. Although they are considered mixed feeders, they show a strong preference for tender grasses and green vegetation. In some areas, they also consume agricultural crops such as wheat and mustard [8]. Despite being categorized as a species of low conservation concern globally, chital populations in Nepal are increasingly affected by human-induced pressures such as habitat encroachment, illegal hunting, forest fires, and fragmentation of forest landscapes [9].

Historically, the Forestry Complex Forest and Brindaban Forest have supported suitable habitats for chital populations. However, in recent years these forests have become increasingly surrounded by expanding settlements and urban infrastructure, leading to growing habitat isolation. Such changes highlight the need to better understand the ecological and human-related factors influencing chital populations in these areas. Therefore, this study aims to assess the factors affecting chital populations in these forests and to map the spatial distribution of A. axis using GIS. Understanding these patterns is important for developing effective conservation measures to reduce the risk of population decline and possible local extinction in these fragmented forest ecosystems.

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Materials and Methods

Study area

Hetauda is a sub-metropolitan city situated in Makwanpur District of Bagmati Province in central Nepal. Geographically, it lies at approximately 27°25′ N latitude and 85°02′ E longitude, with elevations ranging from about 300 to 390 m above sea level. The total area of Hetauda Sub-metropolitan City is around 261 km², of which about 254 km² (97%) is land and approximately 7 km² (3%) consists of water bodies. The landscape of the city is shaped by three major rivers: the Rapti River to the west, the Samari River to the north, and the Karra River to the south. The present study was carried out in two adjoining forest patches: the Forestry Complex Forest and the Brindaban Forest. The Forestry Complex Forest covers approximately 114 ha, while Brindaban Forest spans about 188 ha. Together, these forests occupy nearly 302 hectares in the southwestern part of Hetauda city. The area supports considerable habitat diversity and rich biological resources, including more than 150 plant species, 98 species of butterflies, and 91 species of birds [10-12]. Despite this biodiversity, the forests are increasingly becoming isolated due to expanding human settlements around them. This forest is bordered by the East–West National Highway on its eastern side, while the Rapti River flows along the northwestern boundary, influencing the surrounding landscape. The study area contains a mosaic of habitat types, including Sal (S. robusta) dominated forest, riverine forest, mixed forest, grasslands, and seasonal wetlands associated with a perennial river [12]. This variety of habitats provides suitable ecological conditions for supporting populations of spotted deer (A. axis) (Figure 1).

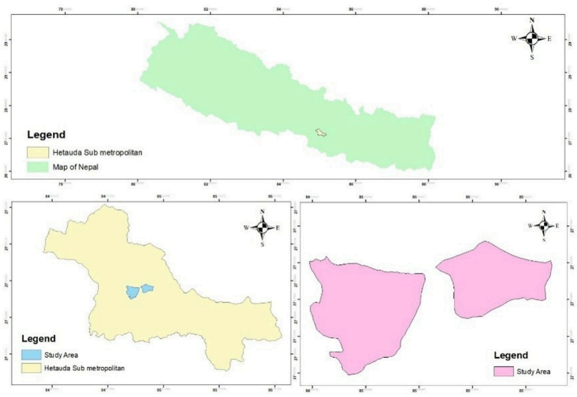

Figure 1. Map of study area.

Sampling design

A systematic sampling approach was adopted to capture habitat variation within the study area. The entire study site was divided into 94 grids, each measuring 1 ha, using the "fishnet" tool in ArcGIS 10.4.1 (ESRI, 2020) (Figure 1). A spacing of 100 m between grids was maintained to ensure uniform coverage across the forest patches. Out of the 94 grids, 85 were selected for field sampling, while grids containing built-up areas were excluded based on observations from Google Earth imagery to avoid sampling in non-habitat locations. Within each selected grid, a 100 × 100 m² plot was established at the center following standard field sampling procedures [13]. The geographic coordinates of each plot were recorded using a handheld GPS to facilitate accurate navigation during field surveys. The presence or absence of chital was determined through indirect sign surveys, primarily by recording pellet groups. When a pellet group was detected within a plot, the site was recorded as "presence," and the number of pellet groups was also counted to estimate frequency of occurrence. The sampling procedure followed previously established guidelines [14,15]. These included avoiding ridge tops in steep terrain during sampling, defining a pellet group as a cluster of five or more pellets with similar size, shape, texture, and color, and estimating pellet group numbers by considering characteristics such as pellet age, color, surface sheen, and level of decomposition [16]. These criteria helped ensure accurate identification and representation of chital presence within the study area (Figure 2).

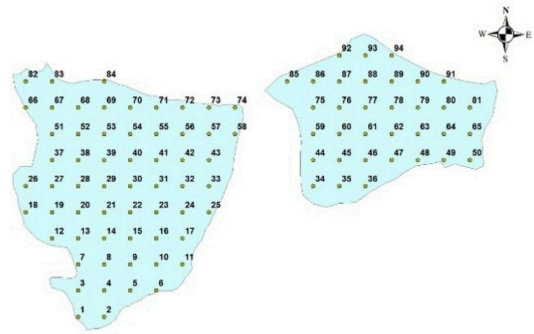

Figure 2. Sample plot for grid sign survey.

Vegetation survey

To characterize habitat conditions associated with A. axis, systematic vegetation surveys were conducted across the study area using a grid-based sampling design aligned with the pellet sign survey. Vegetation was sampled using a nested quadrat approach with three plot sizes: 4 × 4 m for trees, 2 × 2 m for shrubs, and 1 × 1 m for herbaceous species. All tree, shrub, and herb species present within each quadrat were identified.

Canopy cover was measured in the field using a convex spherical densiometer following Lemmon [17]. The instrument consists of a fixed grid of reference points, and canopy cover was estimated by recording the proportion of points obscured by vegetation relative to open sky.

Canopy cover was measured in the field using a convex spherical densiometer following Lemmon [17]. The instrument consists of a fixed grid of reference points, and canopy cover was estimated by recording the proportion of points obscured by vegetation relative to open sky. Crown cover (%) was calculated as:

CC (%) = (Number of canopy-covered grid points / Total number of grid points) × 100

Grass cover within each 1 × 1 m herbaceous quadrat was estimated to quantify ground-level vegetation density. Visual estimation was performed by dividing each quadrat into smaller sections and assessing the proportion of area covered by grasses versus bare ground or non-grass herbaceous plants. Care was taken to differentiate grasses from other herbaceous species. Grass cover (%) was calculated as:

Grass Cover (%) = (Area covered by grass / Total quadrat area) × 100

To reduce observer bias, estimates were made consistently from eye level under similar lighting conditions, and a subset of

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plots was cross-checked by multiple observers to ensure accuracy and repeatability. Grass cover provides an important measure of ground-level habitat structure, which is relevant for understanding food availability and overall habitat quality for A. axis.

Estimation of Human Activity Level (HAL)

Human activity in each plot was quantified based on direct observations over a 15-minute period, considering both the number of individuals encountered and the presence of livestock.

Human encounters

- High activity: more than 7 people observed
- Moderate activity: 3–7 people observed
- Low activity: fewer than 3 people observed

Livestock presence

- High activity: more than 20 livestock observed
- Moderate activity: 7–20 livestock observed
- Low activity: fewer than 7 livestock observed

The overall HAL of a plot was then determined by combining these two components, providing a categorical measure of anthropogenic disturbance ranging from low to high. This method allowed us to capture both direct human presence and indirect disturbance through livestock grazing, which are key factors influencing wildlife activity. All variables were recorded as shown in Table 1.

Table 1. Environmental variables used for habitat assessment of *A. axis*.

S.N	Variable Category	Variables	Unit	Data Source
1	Topography	Elevation	Meters (m)	GPS
2	HAL	Distance From Settlement (DFS)	Meters (m)	Visually estimated in field
		• Number of individuals recorded in sample plot during survey	Number	Visually counted in field
		• Number of livestock encountered during survey		
3	Habitat	Distance From Water Source (DFW)	Meters (m)	Visually estimated in field
		Vegetation Structure (Tree, Shrub, Herb Cover) to determine Crown cover % (CC) and Grass Cover% (GC)	Percent cover (%)	Field Quadrats

Pellet group identification and sampling procedure for A. *axis*

Pellet groups of A. axis (chital) were distinguished from livestock, as goats were the only other species present in the study area that could cause misidentification, using morphological characteristics following Gurung et al. [18]. Chital pellets are small, oval to slightly elongated, and smooth. Fresh pellets are dark brown to black and shiny, whereas older pellets become lighter, dry, and cracked. Goat pellets, in contrast, are typically smaller, rounder, harder, and often found in loose clusters or along grazing paths. Only pellets clearly matching the chital characteristics were recorded, minimizing misidentification risk. Sampling followed established protocols [14,15]. A pellet group was defined as a cluster of five or more pellets deposited close together with similar size, shape, and color, while scattered or ambiguous pellets were excluded. Ridge tops in steep terrain were avoided to reduce sampling bias [16]. Only pellets deposited within the previous 7 days were recorded using handheld GPS points (GPPs). Freshness was assessed based on color, surface sheen, moisture, and degree of decomposition, reflecting local decay rates. Sampling was conducted during the dry season to minimize environmental variability in pellet decay. During field surveys, any pellets that were ambiguous or potentially from goats were excluded. Field observers compared suspected chital pellets with known goat pellet samples to confirm identification.

Data Analysis

Data were analyzed using R studio. Results are presented through tables to ensure clear visualization and interpretation.

Distribution and GIS mapping

The distribution of A. axis in isolated forest patches of Hetauda was estimated and mapped using ArcMap 10.8. During field surveys, only fresh pellet groups were recorded to represent recent species presence. The geographic coordinates of each pellet group were collected using a handheld GPS device (WGS 84 datum) along survey transects. The recorded coordinates were imported into ArcMap 10.8 and overlaid onto high-resolution base layers, including Google Earth imagery and Landsat satellite data, to visualize the spatial distribution pattern. Pellet group locations from the two forest patches were integrated into GIS layers to produce the distribution map. Each point on the map represents the exact GPS location of a fresh pellet group, and the map displays point-level observations without spatial interpolation or grid-based aggregation.

Model collinearity test and model selections

Prior to model fitting, multicollinearity among predictor variables was assessed using the Variance Inflation Factor (VIF) calculated with the vif () function from the car package as shown in Table 2. All predictors showed low VIF values (DFS = 1.573, DFW = 1.637, Elevation = 1.020, GC = 1.052, CC = 1.029), which were well below the commonly accepted threshold of 5. This indicates that multicollinearity was not a concern and that regression coefficients were not inflated due to intercorrelation among predictors. Therefore, all selected variables were retained for model development.

Table 2. Multicollinearity VIF.

Predictor	VIF
DFS	1.573
DFW	1.637
Elevation	1.020
GC (Grass Cover)	1.052
CC (Crown Cover)	1.029

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Species sign counts (NOS) were analysed using a Poisson Generalized Linear Model (GLM) with a log link function, implemented using the glm () function with family = poisson(link = "log"). The full model included DFS, DFW, elevation, ground cover (GC), and canopy cover (CC) as predictors. Model selection was performed using AIC computed with the AIC () function. Stepwise selection was conducted using the step () function to identify the most parsimonious model. The reduced model excluding elevation (AIC = 462.03) showed slightly better support than the full model (AIC = 463.35), indicating improved parsimony with minimal information loss. Model performance was evaluated by comparing null deviance and residual deviance obtained from summary(glm_model). The reduction from null deviance (204.12) to residual deviance (116.64) demonstrated that the predictors explained a substantial portion of variation in species sign counts. The dispersion parameter ($\hat{c}$) was calculated as the ratio of the residual deviance to the residual degrees of freedom, yielding a value of 1.32, indicating slight but acceptable overdispersion (< 2) (Table 3).

Table 3. Model fit statistics.

Metric	Value
Null Deviance	204.12
Residual Deviance	116.64
AIC	463.35
AIC reduced model	462.03
Dispersion ($\hat{c}$)	1.32

Statistical significance of predictors was evaluated using Wald z-tests provided in the summary () output of the GLM. Associations were considered statistically significant at $\alpha = 0.05$.

Logistic regression analysis

Species sign counts (NOS) were analysed using a Poisson generalized linear model (GLM) with a log link function to evaluate the relationship between species signs and selected environmental predictors. The model was specified as:

$$\lambda_i = \exp(\beta_0 + \beta_1 \times DFS + \beta_2 \times DFW + \beta_3 \times Elevation + \beta_4 \times GC + \beta_5 \times CC)$$

Where λ_i denotes the expected number of species signs at site i. Predictor variables included DFS, DFW, elevation, ground cover (%) (GC), and canopy cover (%) (CC). All predictors were entered simultaneously to evaluate their combined influence on species sign counts.

Regression coefficients (β) indicate the direction and magnitude of each predictor's effect on the expected log-count of species signs. Statistical significance of predictor effects was assessed using z-tests, with p-values ≤ 0.05 considered significant, indicating a meaningful association between the predictor and species sign counts. Predictors with p-values > 0.05 were considered not statistically significant within the model.

HAL

The relationship between human activity and wildlife presence was examined by analyzing the correlation between HAL and the number of species signs (NOS) observed within study area.

Results

Status and distributions of A. axis within Hetauda

In the isolated forest patches of Hetauda, the Brindaban Forest and the Forestry Complex chital (A. axis) were recorded across multiple habitat types (Figure 3), but their distribution was uneven. Signs of fresh pellets were more frequently observed in the Forestry Complex than in Brindaban Forest. Overall, the species showed greater use of grasslands and secondary Sal (S. robusta) forests, particularly areas with well-developed understory vegetation, including grasses, forbs, and tender shoots. This pattern indicates clear habitat preference rather than random habitat use. Grasslands were the most frequently utilized habitats, likely due to the abundance of key forage species such as *Imperata cylindrica, Saccharum spontaneum, Cynodon dactylon, and Digitaria spp*. Open habitats may also reduce predation risk by improving visibility and enabling early detection of threats. In contrast, riverine forests were the least preferred, possibly due to lower availability of grazing resources. The higher pellet density in the Forestry Complex suggests relatively greater habitat use in this patch. Additionally, the concentration of individuals in central forest areas indicates avoidance of edge disturbances and a preference for interior zones with abundant forage and reliable water sources.

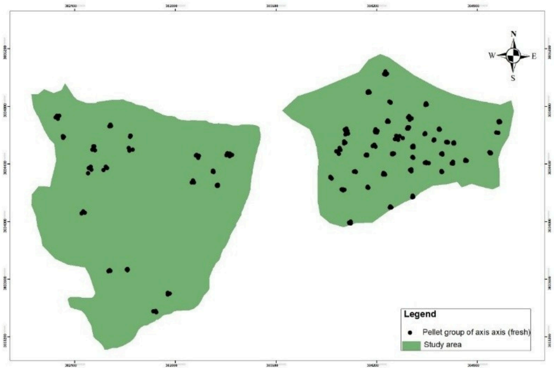

Figure 3. GIS map showing the spatial distribution of pellet groups of A. axis within the study area in Hetauda, Central Nepal.

Factor influencing the distribution of the A. axis in isolated forest patches of Hetauda

The Poisson GLM analysis revealed that several habitat variables significantly affected the occurrence of A. axis (Table 4). The intercept was positive and highly significant ($\beta = 2.254$, $p < 0.001$), indicating a high baseline probability of occurrence under reference conditions. Elevation had a negative but non-significant effect ($\beta = -0.00043$, $p = 0.412$), suggesting that altitude did not strongly influence distribution within the study area.

DFW had a significant negative effect ($\beta = -0.00067$, $p < 0.001$), indicating that the probability of occurrence declined with increasing DFW sources. Conversely, (DFS) showed a significant positive effect ($\beta = 0.00029$, $p = 0.015$), with higher occurrence observed farther from human habitation. Grass cover (GC) had a strong positive and highly significant influence ($\beta = 0.00497$, $p = 0.001$), reflecting a preference for areas with abundant grass. Canopy cover (CC) exhibited a significant negative relationship ($\beta = -0.03717$, $p = 0.047$), indicating reduced presence in denser canopy areas.

https://doi.org/10.61577/jec.2026.100001

Overall, the results suggest that proximity to water, DFS, grass cover, and canopy cover are key determinants of A. axis distribution in these isolated forest patches (Figure 4).

Table 4. Factor influencing the distribution of A. axis in isolated forest patches.

Predictor	Estimate	Std. Error	z value	p-value	Significance
Intercept	2.254	0.318	7.089	<0.001 ***	**
Elevation	-0.00043	0.00052	-0.821	0.412	ns
DFW	-0.00067	0.00016	-4.191	<0.001	***
DFS	0.00029	0.00012	2.428	0.015	*
GC	0.00497	0.00192	2.587	0.0010	***
CC	-0.03717	0.00191	-1.770	0.047	*

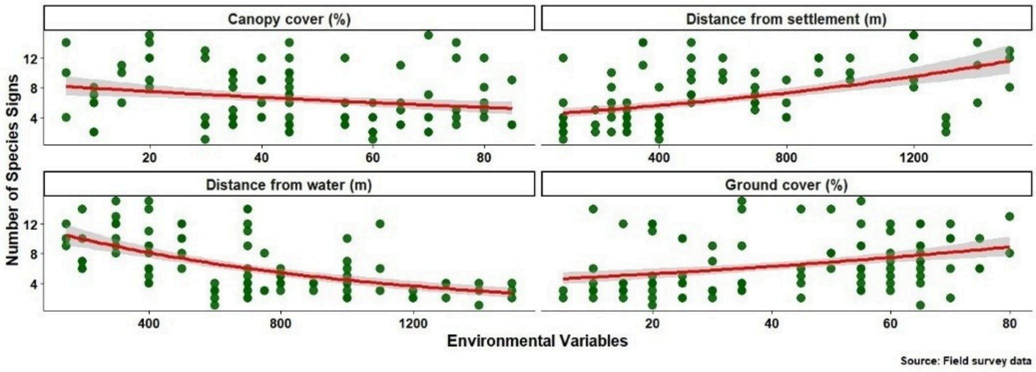

Figure 4. Scatter plot graph showing relationship between predicted probability of species presence and Environmental variables.

Relationship between HAL and number of species sign

A strong negative correlation was observed between the NOS and HALs (r = -0.768), indicating that sites with higher human activity supported fewer species signs as shown in Figure 5.

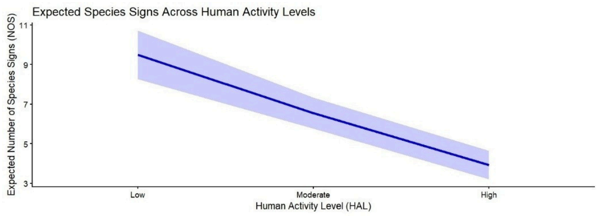

Figure 5. Expected species sign across HALs.

Discussions

Status and distribution of A. axis in an isolated forest patch of Hetauda

The present study in the isolated forest patches of Hetauda revealed that Chital (A. axis) were unevenly distributed across habitats, showing clear preference for grassland and secondary Sal (S. robusta) forest, while riverine forest was least utilized. This pattern indicates selective habitat use rather than random occupation, suggesting that habitat characteristics strongly influence spatial distribution.

The greater use of grassland habitats is likely associated with the availability of palatable forage species such as I. cylindrica, S. spontaneum, C. dactylon, and Digitaria spp. As a predominantly grazing ungulate, Chital depend heavily on grasses, which explains their higher occurrence in open habitats with abundant ground vegetation. Similar findings were reported from Parsa National Park, Nepal, where grassland was identified as the most preferred habitat [19]. Likewise, grassland use by females during the hot season in the lowlands of Nepal was documented by Moe and Wegge, emphasizing the importance of forage and seasonal resource availability [20]. In contrast, riverine forest was least preferred in the present study, possibly due to limited grass availability and denser vegetation structure that may restrict movement and reduce grazing efficiency. However, habitat preference of Chital varies across landscapes. Moe and Wegge reported riverine forest as the most preferred habitat during the hot-dry season and Sal Forest during the monsoon in Nepal's lowlands [20]. Similarly, Sal Forest was highly preferred in Suklaphanta National Park, mixed forest with dense grass cover in Kuno Wildlife Sanctuary, and hardwood forest in the Karnali floodplain of Bardia National Park [21-23].

These variations suggest that Chital habitat preference is context-dependent and largely driven by forage availability, vegetation structure, water access, and disturbance levels. In the isolated forest patches of Hetauda, grassland and secondary Sal forests provide optimal feeding grounds and reduced disturbance in interior zones, thereby supporting higher Chital occurrence.

Factor influencing the distribution of the A. axis in isolated forest patches of Hetauda

The present study provides detailed insight into the factors governing the distribution of A. *axis* within the highly fragmented and human-dominated forest landscape of Hetauda. The observed marginally positive effect of DFS indicates a tendency for chital to reduce use of areas with high human activity. Similar avoidance of settlements and frequent human presence has been documented in the Forestry Complex Forest of Hetauda, as well as in lowland forests of

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Nepal and India, where livestock grazing, fuelwood collection, and recreational use significantly influence ungulate spatial behavior [24,25]. In small forest patches such as Brindaban and the Forestry Complex, even subtle gradients of disturbance appear sufficient to alter habitat use. DFW emerged as a significant negative predictor, emphasizing the strong ecological dependence of A. axis on nearby water sources. This finding is consistent with classical and contemporary studies across South Asia, which highlight water availability as a critical driver of chital distribution, particularly during the dry season when forage moisture declines [26,27]. In Chitwan National Park, Gupta similarly reported higher pellet densities closer to rivers and waterholes, reinforcing the role of riparian habitats as key foraging and resting sites [28]. In the context of isolated forest patches in Hetauda, proximity to the Rapti River and smaller seasonal water sources likely compensates for limited habitat extent and quality. The strong positive influence of ground cover indicates that understory vegetation plays a central role in habitat suitability. Dense ground cover not only provides high-quality forage but also offers concealment from humans and free-ranging dogs, which are common in peri-urban forests. Comparable associations between chital occurrence and ground vegetation have been reported from Hetauda forests, Bardia National Park, and Rajaji National Park, India, where chital showed higher use of grass-rich forest edges and open patches [24,27,28]. This suggests that fine-scale vegetation structure is more influential than canopy characteristics in determining habitat use. The negative relationship with distance to roads contrasts with findings from large protected areas, where ungulates generally avoid linear infrastructure due to disturbance and mortality risk [29]. However, similar patterns of higher use near roads have been reported in small forest fragments, where roadside verges support productive grasses and improved visibility [24]. In Hetauda, roads and clearings may function as surrogate grasslands rather than disturbance features per se. The non-significant effects of elevation and canopy cover reflect the relatively narrow altitudinal range and structurally similar canopy conditions of the study area. This aligns with earlier work from Nepal's Terai, which reported broad ecological tolerance of A. axis to canopy variation as long as forage and water are available [25,30].

Overall, the findings indicate that in urban-proximate and isolated forest patches, A. axis distribution is shaped primarily by resource availability and microhabitat features rather than landscape-scale variables. Conservation strategies in Hetauda should therefore focus on maintaining ground vegetation, safeguarding water sources, and managing human disturbance to sustain viable chital populations in fragmented forests (Table 5).

Table 5. Comparison of key factors influencing A. axis distribution across South Asian studies.

Predictor / Factor	Present study (Hetauda, Nepal)	Forestry Complex Forest, Hetauda	Chitwan NP, Nepal	Bardia NP, Nepal	Rajaji NP, India
DFS	Positive effect (avoidance)	Avoidance of human activity	Lower use near villages	Strong avoidance	Avoidance in core areas
DFW	Negative (preference for proximity)	High activity near water	Higher pellet density near rivers	Strong riparian dependence	Frequent riverine use
Ground cover	Strong positive influence	Dense ground vegetation preferred	Grass-rich patches favoured	Understory and grasslands preferred	Grass-dominated patches preferred
Distance to roads / linear features	Negative (higher use closer)	Higher use near roadsides	Avoidance in core forests	Strong avoidance	Mostly avoidance
Canopy cover	Not significant	Weak influence	Moderate preference for open canopy	Broad tolerance	Variable response
Elevation	Not significant	Not significant	Limited effect (lowland range)	Lowland specialist	Lowland specialist
Landscape context	Isolated urban forest patches	Fragmented forest	Large protected area	Large protected area	Large protected area

Conclusion

This study demonstrates that the distribution of A. axis in the isolated forest patches of Hetauda is primarily shaped by resource availability and human disturbance. Proximity to water and higher grass cover significantly increased occurrence, while dense canopy covers reduced habitat use. Chital showed avoidance of areas closer to settlements, indicating sensitivity to anthropogenic pressure even within small urban forests. Overall, fine-scale habitat features rather than broad landscape factors determined spatial patterns. Conservation should focus on maintaining ground vegetation, protecting water sources, regulating human activities, and enhancing connectivity through ecological corridors. Long-term monitoring and wildlife-sensitive urban planning are essential to reduce the risk of population decline or local extirpation of A. axis in these fragmented forests Maintaining grassland structure, protecting water sources, and minimizing disturbance are essential for sustaining viable populations in fragmented ecosystems.

Author Contribution

The study was conceptualized by Ruchi and Nilima. Fieldwork was conducted by Nilima, Ruchi, and Nilima, while data analysis was performed by Samik and Dinesh. The manuscript was written and prepared by Ruchi.

Acknowledgement

We sincerely thank the Faculty of Forestry, Hetauda, for their continuous support, institutional guidance, and provision of a conducive environment that enabled the successful completion

https://doi.org/10.61577/jec.2026.100001

of this research. Their encouragement and resources were essential throughout the study. We also extend our heartfelt gratitude to Assistant Professors Mr. Gyan Bandhu Sharma and Mr. Bishnu Thapa (Ecologist), graduates of the Central Department of Zoology, Tribhuvan University, for dedicating their time to provide insightful reviews and constructive feedback on our manuscript. Their expert guidance significantly enhanced the quality, clarity, and scientific rigor of this work.

Competing Interests

The authors declare no competing interests.

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