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Rapid reconnaissance counts and distribution of the Endangered Hog Deer (*Axis porcinus*) in Corbett Tiger Reserve, India

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Abstract

The hog deer (*Axis porcinus*), an Endangered grassland specialist of South and Southeast Asia, occurs at low densities across much of its range due to habitat loss and fragmentation. In Corbett Tiger Reserve, populations are mainly restricted to isolated alluvial grasslands, with major declines following the submergence of prime habitat by the Kalagarh Dam in 1974. To document distribution and provide rapid count indices, a three-day reconnaissance survey (22-24 May 2025) was undertaken in all 12 forest ranges, covering 141 beats during peak activity hours (06:00-10:00 am). Direct sighting counts were made daily, with the highest tally used as an index of relative abundance. Hog deer were recorded in only four ranges, indicating a restricted distribution. A total of 189 individuals were recorded, with observations expressed as relative abundance indices (CTR 0.15 ind/km^2; Dhikala 2.31 ind/km^2). Dhikala accounted for 175 individuals, concentrated in the Dhikala Chaur and Jalashay beats, underscoring the role of high-quality alluvial grasslands and perennial water. As a rapid count without detection correction, findings represent indices rather than true population estimates. Results highlight the need for grassland management, invasive species control, and habitat connectivity to ensure long-term conservation of hog deer in CTR.

Keywords: Grassland, habitat fragmentation, population distribution, relative abundance, ungulate

Introduction

The hog deer (*Axis porcinus*) is a species belonging to the genus Axis, endemic to the tall, moist grasslands of South and Southeast Asia. Its robust build and characteristic behavior of dashing through dense vegetation with its head held low are thought to have inspired its common name (Schaller, 1967; Prater, 1980; Biswas & Mathur, 2000; Gupta *et al.*, 2018). Within the Terai Arc Landscape of India, the species is regarded as an obligate grassland specialist, with a strong affinity for habitats dominated by blady grass (*Imperata cylindrica*), which offers both forage and concealment (Biswas, 2004; Arshad *et al.*, 2012). In Thailand and Indo-China, the species is associated with alluvial floodplain grasslands, which similarly support its ecological requirements (Maxwell *et al.*, 2007; Arshad *et al.*, 2012; Hill *et al.*, 2019).

The hog deer is currently classified as Endangered as per the IUCN Red List and is protected under Schedule I of the Indian Wildlife (Protection) Act, 1972, due to continuing declines in population and habitat quality (Timmins *et al.*, 2015; Gupta *et al.*, 2018). Two subspecies are recognized: *A. p. porcinus*, occurring in India, Nepal, Bangladesh, and Myanmar, and *A. p. annamiticus*, historically distributed across Vietnam, Laos, Cambodia, Thailand, and parts of southern China (Biswas & Mathur, 2000; Angom *et al.*, 2020).

The moist floodplain grasslands, typically located along river corridors, are often dominated by *Imperata cylindrica*, *Saccharum spontaneum*, and other early-successional grasses. These habitats are crucial for hog deer, especially during fawning and foraging periods, offering an optimal balance of visibility and cover (Dhungel & O'Gara, 1991; Arshad *et al.*, 2012). However, habitat degradation is a major conservation challenge. Key threats include agricultural expansion, unsustainable livestock grazing, grass harvesting, and altered hydrological regimes due to infrastructure development (Biswas, 2004; Odden *et al.*, 2005).

Moreover, suppression of fire and the decline of traditional habitat management have allowed woody vegetation to colonize open grasslands, rendering them unsuitable for *A. porcinus* (Hussain *et al.*, 2025). Although conservation areas have introduced burning and cutting regimes to maintain grassland structure, mistimed interventions

may inadvertently reduce protective cover and increase the risk of predation (Biswas, 2004).

The Indian subspecies faces elevated conservation concern due to genetic isolation, habitat fragmentation, and limited connectivity across populations (Gupta *et al.*, 2018; Angom *et al.*, 2020). These conditions raise concerns over reduced gene flow, inbreeding, and long-term viability. Despite its ecological importance and legal protection, the hog deer remains underrepresented in wildlife research and monitoring programs in India. While substantial research has been conducted in regions like Assam and Kaziranga, there remains a significant data gap in the western Terai, including Uttarakhand (Hussain *et al.*, 2025).

In Corbett Tiger Reserve (CTR), the hog deer occurs in low densities and is mainly confined to isolated grassland patches within the Dhikala, Phulai, Khinanauli, Paterpani, and Dhela ranges. A major population decline was observed following the submergence of large grassland areas due to the construction of the Kalagarh Dam on the Ramganga River in 1974, which led to habitat loss, fragmentation, and isolation of populations. These changes impeded natural movement and regeneration, rendering the species increasingly vulnerable to local extinction. The current localized existence of hog deer in CTR continues to face pressure from both ecological and anthropogenic factors. Accurate assessment of its population status is therefore essential, as it informs demographic understanding and helps identify priority areas for conservation management (O'Brien, 2011).

In this context, a field-based census of hog deer was conducted in CTR, covering key habitats historically known for the species. This assessment offers updated insights into the distribution, population status, and demographic structure of *A. porcinus* within the reserve. Given the limited and shrinking habitat within CTR, such targeted evaluations are crucial for prioritizing conservation zones and ensuring the continued persistence of this endangered grassland specialist. The present study represents an initial reconnaissance, intended to provide a baseline count and distribution update for hog deer in CTR.

Material & Methods

Study Area

CTR is situated in the foothills of the western Himalayas, encompassing parts of Nainital and Pauri Garhwal districts in Uttarakhand, India. Geographically, it lies between 29°25′–29°40′ N latitude and 78°5′–79°50′ E longitude. Established in 1936 as Hailey's National Park, it holds the distinction of being India's first national park. It was later renamed Ramganga National Park in 1954 and finally Corbett National Park in 1957, honoring Jim Corbett for his pivotal role in wildlife conservation (Rastogi *et al.*, 2010).

Initially covering 323.75 km^2, the park's area was increased to 520.82 km^2 in 1966. The present-day CTR spans 1,288.32 km^2, comprising the core area, Sonanadi Wildlife Sanctuary (301.18 km^2), and an additional buffer zone (466.32 km^2). In 1973–74, it was brought under India's Project Tiger, recognizing it as a critical habitat with one of the highest tiger densities in the country (Jhala *et al.*, 2008).

The reserve comprises 12 forest ranges, namely Bijrani, Dhela, Dhikala, Jhirna, Kalagarh, Adnala, Mandal, Maidawan, Pakhrau, Palain, Sarpduli, and Sonanadi. The census focused on prominent grassland habitats where hog deer are known to occur. These areas predominantly consist of alluvial grasslands, often influenced by the Ramganga River and its tributaries. (Figure 1)

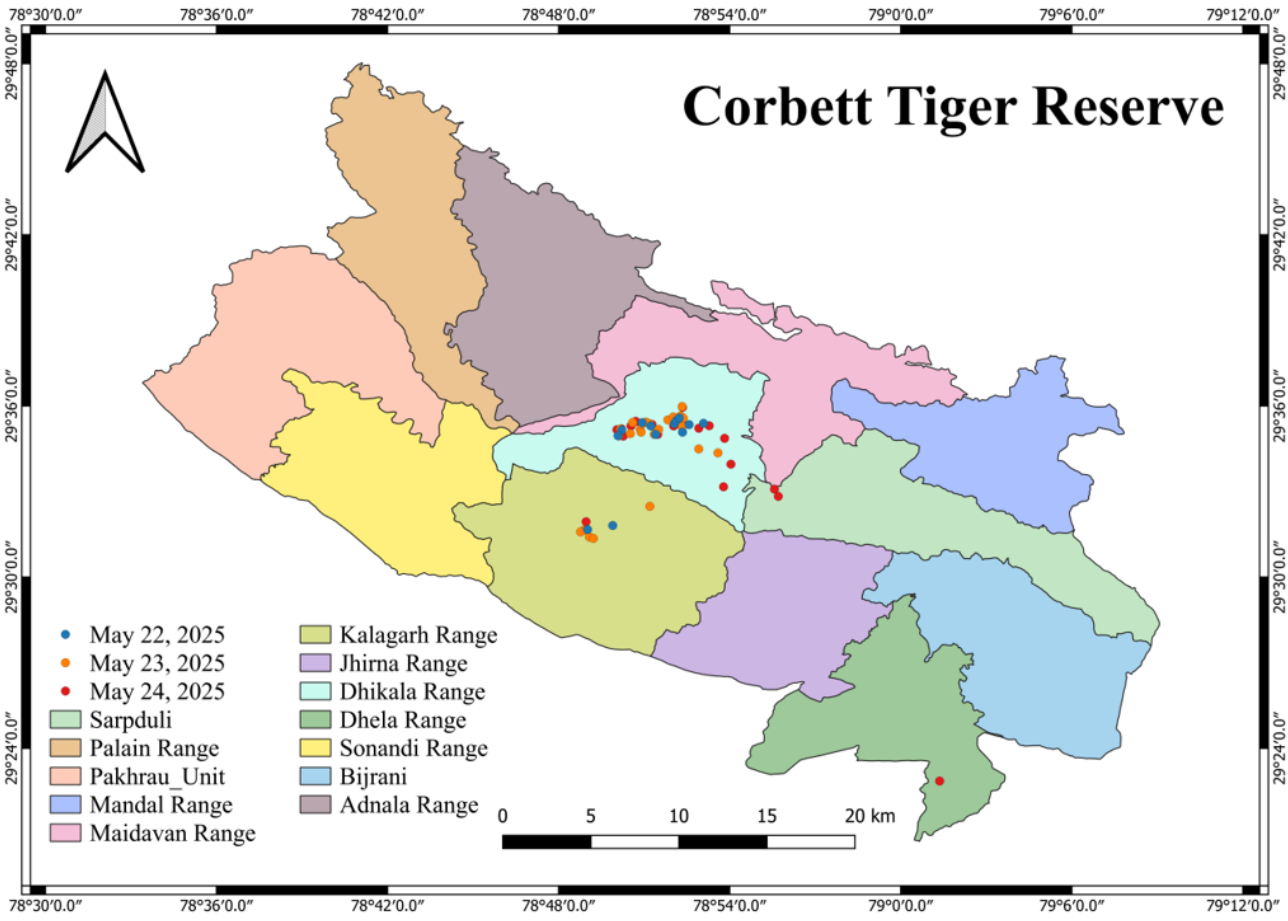

Figure 1: Spatial distribution of hog deer direct sightings across Corbett Tiger Reserve recorded during the three-day census.

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Data collection

A training program was conducted collaboratively with The Corbett Foundation (TCF) and WWF-India on April 17th, 2025, at Kalagarh training centre, CTR. Five to six officials from each of the 12 ranges attended the training for hog deer identification. Later, the information was circulated to all the beats and staff through trained attendees.

We conducted direct sighting counts instead of formal distance sampling (Buckland *et al.*, 2001; Thomas *et al.*, 2010). The reconnaissance survey of hog deer in CTR was carried out over a three-day period from 22nd to 24th May 2025 in all 12 ranges of the reserve, including 141 beats. The census was conducted during the early morning hours between 06:00 AM and 10:00 AM, when animal activity and visibility are optimal. The census was carried out through direct observation methods, involving systematic field surveys along pre-established routes within identified grassland habitats. The survey team consisted of forest guards, research staff, and volunteers (The Corbett Foundation & WWF-India) of 4-6 observers and covered approximately 12 km each day (Table 1). The total distance covered across all ranges during the three-day survey was 4042.8 km. Data from all three days were treated as replicates. For reporting purposes, the maximum daily count was used as an index of relative abundance. Relative encounter rate was calculated as individuals observed per km^2 of available grassland (Miller *et al.*, 2019). We emphasize that these counts are not corrected for detection probability and should therefore be interpreted as indices rather than true densities. The extent of grassland habitat within CTR was derived from the Tiger Conservation Plan (2016–2025), which outlines the reserve's vegetation types and management zones.

Data Analysis

To evaluate whether hog deer presence varied significantly across ranges, contingency tables were created from daily detection records. The data were analyzed using Fisher's Exact test of independence in SPSS version 26.0. Both asymptotic and exact significance values are reported, and results were interpreted at a significance level of $p < 0.05$.

Results

During the three-day census in CTR, the presence of hog deer was confirmed only in a few forest ranges, indicating a spatially restricted distribution pattern. Hog deer sightings were consistently recorded in the Dhikala and Kalagarh ranges on all three days of the survey, highlighting these areas as core habitats for the species within the reserve.

Additional observations were made in the Sarpduli range on the 23rd and 24th , and a single sighting was reported from the Dhela range on 24th May. No individuals were encountered in other surveyed ranges, including Bijrani, Jhirna, or any of the ranges falling under the Kalagarh Tiger Reserve Division, namely Adnala, Mandal, Maidavan, Palain, Pakhrao, and Sonanadi (Table 1).

Across the three-day census, the recorded number of hog deer ranged between 169 and 189 individuals with a mean of 182.33 ± 6.64 (SE) and a coefficient of variation of 6.3%, depending on daily environmental factors such as visibility, weather conditions, and animal movement patterns. The corresponding 95% confidence interval was 169 to 195 individuals, reflecting the uncertainty inherent in raw count-based indices. These fluctuations underscore the importance of multi-day surveys for achieving a more accurate population estimate.

On the final day of the census, 24th May 2025, a total of 189 hog deer individuals were sighted across all forest ranges of CTR. This represents the maximum count and was reported as an index of relative abundance. This included 153 adults and 36 fawns, representing the highest adult count recorded during the three-day survey. In contrast, the highest number of fawns (46) was observed on the second day of the census. Among all surveyed locations, the Dhikala Range remained the key habitat, holding 175 individuals (141 adults and 34 fawns), which accounted for over 92% of the total sightings on the final day (Table 2). The total relative abundance for CTR (area = 1288.31 km^2) was estimated at 0.15 ind/km^2 and in the Dhikala range itself, a grassland with an area of 75.64 km^2, the relative abundance was estimated at 2.31 ind/km^2. Please note that these figures should not be confused with actual density estimates.

A breakdown of observations within Dhikala revealed that Dhikala Chaur (79 individuals) and Jalashay beat (area that remains submerged during monsoon; 77 individuals) were the two primary hotspots for Hog Deer, followed by smaller numbers in Phoolai West (14) and Phoolai East (5). This concentration is likely due to the availability of suitable

Table 1: Survey effort and hog deer presence across ranges in Corbett Tiger Reserve

Range	No. of Beats	Distance covered in all 3 days (km)	Team Size	Total hog deer observations (3-days)	Encounter rate (ind/km)
Bijrani	16	484.8	5	0	0
Dhikala	8	295.2	6	334	1.131
Sarpduli	15	463.5	5	19	0.041
Dhela	12	385.2	5	1	0.003
Jhirna	9	315.9	4	0	0
Kalagarh	12	327.6	5	16	0.048
Adnala	14	348.6	6	0	0
Mandal	9	259.2	4	0	0
Maidavan	11	310.2	5	0	0
Palain	14	331.8	4	0	0
Pakhrao	11	277.2	6	0	0
Sonanadi	10	243.6	5	0	0

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grassland habitats, perennial water sources, and lower levels of human disturbance within this range. The Sarpduli Range recorded 11 individuals (10 adults and 1 fawn), indicating a small but stable sub-population. On the other hand, Kalagarh and Dhela reported only 2 and 1 individuals, respectively. (Table 2).

A Fisher's Exact Test indicated a significant association between survey range and hog deer presence (two-sided exact p = 0.001), confirming that detections were not uniformly distributed across the reserve. Instead, sightings were strongly clustered in a few key ranges, particularly Dhikala, which supported the majority of individuals, and parts of Kalagarh, where small sub-populations were observed.

Discussion

When compared with other protected areas across South Asia, hog deer numbers in CTR appear low. Reported hog deer densities vary considerably across South and Southeast Asia, largely reflecting differences in habitat quality, management, and survey methods. In Chitwan National Park, Nepal, Dhungel & O'Gara (1991) estimated densities of 15.5–19.1 individuals/km^2 in savanna grasslands using distance sampling, while much higher densities of 77.3 individuals/km^2 were reported from the floodplain grasslands of Bardia National Park, Nepal (Odden *et al.*, 2005). Similarly, Karanth & Nichols (2000) recorded 38.6 individuals/km^2 in the floodplain grasslands of Kaziranga National Park, India. In contrast, lower densities have been reported from other sites such as Keibul Lamjao National Park, India (2.51 individuals/km^2; Angom, 2020), and Taunsa Barrage Wildlife Sanctuary, Pakistan (11.8 individuals/km^2; Arshad *et al.*, 2012). Within India, Goswami & Ganesh (2014) estimated a density of 4.59 individuals/km^2 in Manas National Park, whereas Sinha *et al.* (2019) reported a higher density of 18.22 individuals/km^2 from the same site. In Sukhlaphanta Wildlife Reserve, Nepal, Lovari *et al.* (2015) recorded densities of 4.1 and 11.6 individuals/km^2 in 2010 and 2011, respectively. In comparison, the present study yielded much lower relative abundance indices, 0.15 individuals/km^2 across the reserve and 2.31 individuals/km^2 within the Dhikala Range.

However, it is important to note that nearly all of these estimates were generated using distance sampling or other model-based methods that explicitly account for detection probability. In contrast, our study relied on rapid reconnaissance counts without correction for detectability, and should therefore be interpreted only as indices of relative abundance. Direct comparisons between these values and formal density estimates from other sites are not appropriate, but the contrast does emphasize that hog deer in CTR are far more localized and occur at a possibly lower abundance than in other South Asian strongholds.

Hog deer occurrence was largely confined to the Dhikala Range, with a few records from Sarpduli (23–24 May) and a single sighting from Dhela on the final day. No individuals were detected in other surveyed ranges. This restricted distribution underscores the species' dependence on alluvial grasslands and wetlands concentrated in the Dhikala–Sarpduli landscape.

Table 2: Daily counts of hog deer recorded during reconnaissance survey (22–24 May 2025) in Corbett Tiger Reserve

Date	Range	Beat	Survey Effort (km)	Adult	Fawn	Total No.
22/05/2025	Kalagarh	Paterpani North	8.5	6	2	8
	Dhikala	Phoolai East	10.9	3	0	3
		Jalashay	11.5	65	23	88
		Dhikala Chaur	13.2	60	10	70
TOTAL				**134**	**35**	**169**
23/05/2025	Kalagarh	Paterpani North	9.7	3	3	6
		Boxad	9.3	1	1	2
	Dhikala	Phoolai West	11.1	6	1	7
		Jalashay	11.4	61	20	81
		Dhikala Chaur	13.3	67	18	85
	Sarpduli	Khinanauli	10.4	5	3	8
TOTAL				**143**	**46**	**189**
24/05/2025	Kalagarh	Paterpani North	8.9	1	1	2
	Dhikala	Phoolai West	13.7	11	3	14
		Phoolai East	12.4	5	0	5
		Jalashay	13.1	61	16	77
		Dhikala Chaur	12.3	64	15	79
	Sarpduli	Khinanauli	9.4	9	0	9
		Bhumakiya	11.1	1	1	2
	Dhela	Dhela Hill	10.7	1	0	1
TOTAL				**153**	**36**	**189**

Note: Counts represent raw sightings during the three-day survey. Encounter rates (individuals/km^2 of available grassland) are presented in the text as indices only, not as absolute density estimates, since detection probability was not estimated.

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The absence from other areas likely reflects local extirpation or very low densities due to habitat loss and fragmentation. These results highlight the need for grassland restoration, invasive species control, and continued monitoring to support the species' persistence in CTR (Figure 1; Table 1).The absence of records from several other ranges underscores the highly localized distribution of hog deer within CTR, reflecting the fragmented and limited extent of suitable grassland habitats. These results reaffirm the Dhikala Range as the primary stronghold for the species, highlighting the importance of preserving its alluvial grasslands that provide essential resources for foraging, breeding, and fawn rearing. The observed presence of fawns indicates ongoing recruitment and a potentially stable breeding population in this core area. In contrast, the scarcity of sightings elsewhere points to the need for habitat restoration, improved survey coverage, and reduction of anthropogenic disturbances to facilitate recolonization and ensure the long-term persistence of hog deer across the reserve.

Due to resource constraints, habitat covariates could not be formally analyzed. However, >90% of sightings in alluvial grasslands with perennial water availability strongly indicate habitat preference. Future studies should incorporate GIS-based layers and occupancy models to test for habitat associations statistically.

Conclusion

The persistence of hog deer in CTR now depends largely on the quality of a few grassland refuges. Habitat loss from the Kalagarh Dam, woody succession, and invasive plant spread continue to limit their range. Focused management through controlled burning, timely cutting, removal of invasive species, and restoration of connectivity between grassland patches will be essential to stabilize and expand the population.

Future monitoring must adopt more rigorous methods, such as distance sampling, to provide reliable population estimates and track trends. By combining improved monitoring with habitat restoration, CTR can continue to serve as an important stronghold for this endangered grassland specialist in the western Himalaya.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

DATA AVAILABILITY

The data used in the study are available upon request from the corresponding author

AUTHOR CONTRIBUTIONS

Saket Badola: Original concept, drafting the manuscript, supervision, reviewed the manuscript.
Shahbaz Ali: Drafting the manuscript, analysis of material, reviewed the manuscript.

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