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Editorial 2

Resilience at the Edge, Landscape and Altitudinal Patterns of the Kashmir Red Deer (Cervus hanglu hanglu) in a Shared Mountain Realm of Kashmir, India.
Mohsin Javid, Khursheed Ahmad , Orus Ilyas, Intesar Suhail, Rashid Naqash , Parag Nigam 3

Habitat Suitability Index Modeling for Axis deer (Axis axis) An RS & GIS approach.
Orus Ilyas and Abdul Haleem 17

Reassessing historical sources and their implications for the conservation of huemul (Hippocamelus bisulcus).
Norma I. Díaz and Paulo Corti 32

Ancient antlers, bones and historic literature add support to the huemul's historical presence in the Patagonian steppe.
J.M Smith-Flueck and Werner T. Flueck 44

Deer of the World: Ecology, Conservation and Management.
Mario Melletti 54

11th International Deer Biology Congress report. 56
David Stevens and Jo Anne Smith Flueck

Editorial

Dear DSG members,

These years have been both a challenge and a privilege to accompany you and to coordinate activities at regional and global levels. In the coming period, the new Chair of the SSC is reviewing the leadership of Specialist Groups in accordance with the new guidelines approved during the previous term.

For this reason, I would like to take this opportunity to step down from the role I have held for many years. I will remain engaged and continue contributing from a different capacity. I sincerely thank all of you for your dedication and for being a constant source of inspiration in the conservation of deer as indicators of biodiversity.

One of the initiatives I have led, with the sustained and invaluable support of Dr. Patricia Black, is one that we hope new members will embrace, sustain, and further strengthen.

This issue features two articles focused on the conservation of Asian deer: the critically endangered Hangul and the Axis deer. We also include two articles that offer evolutionary and historical perspectives on the huemul. These contributions highlight that the Newsletter remains open to experts wishing to submit articles, all of which undergo review by two referees and are expected to provide evidence-based insights and valuable information on the species.

Lastly, we want to thank all those who contributed to this edition of the newsletter and invite all of you to submit manuscripts for the next issue.

Warm regards,

Susana González and Noam Werner,
Co-Chairs, IUCN/SSC Deer Specialist Group.

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Resilience at the Edge, Landscape and Altitudinal Patterns of the Kashmir Red Deer (*Cervus hanglu hanglu*) in a Shared Mountain Realm of Kashmir, India

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Abstract

Camera trapping across Kashmir's montane systems (2022–2025) captured 5,700 independent detections of the critically endangered Hangul (*Cervus hanglu hanglu*), the only surviving species of the red deer lineage endemic to the Indian subcontinent. Detections from Dachigam National Park, Mammar Reserve Forest, Tral Wildlife Sanctuary, Wangat Conservation Reserve, and Brain Nishat Conservation Reserve indicate that Hangul persists within a narrow ecological refuge bounded by settlements, transhumant grazing routes, and forest-edge disturbance. Hangul activity was concentrated between 1,700 and 3,200 m a.s.l., with a median elevation near 1,800 m. Dachigam National Park accounted for about 70% of detections, whereas peripheral valleys showed declining use with increasing livestock overlap. Co-detections with other mammals including common leopard (*Panthera pardus*), Himalayan black bear (*Ursus thibetanus*), yellow-throated marten (*Martes flavigula*), and Kashmir grey langur (*Semnopithecus ajax*) were more frequent inside protected area cameras, while cattle, goats, and sheep dominated lower interfaces. Kruskal–Wallis H test ($H = 64.2$, $df = 2$, $p < 0.001$) indicated significantly reduced wild-mammal detections at sites with high livestock presence. Our results identify Dachigam as the principal demographic refuge for Hangul and underline the need for landscape-level grazing regulation and participatory buffer management to reduce edge disturbance and maintain connectivity around this critically endangered species habitat.

Resumen

El fototrampeo en los sistemas montanos de Cachemira (2022–2025) registró 5.700 detecciones independientes del hangul (*Cervus hanglu hanglu*), una especie en peligro crítico de extinción y el único representante sobreviviente del linaje de ciervos rojos endémico del subcontinente indio. Las detecciones en el Parque Nacional Dachigam, el Bosque de Reserva Mammar, el Santuario de Vida Silvestre de Tral, la Reserva de Conservación

Wangat y la Reserva de Conservación Brain Nishat indican que el hangul persiste dentro de un refugio ecológico estrecho, limitado por asentamientos humanos, rutas de pastoreo trashumante y perturbaciones en los bordes del bosque. La actividad del Hangul se concentró entre los 1.700 y 3.200 m s.n.m., con una altitud mediana cercana a los 1.800 m. El Parque Nacional Dachigam concentró aproximadamente el 70% de las detecciones, mientras que los valles periféricos mostraron un uso decreciente a medida que aumentaba la superposición con el ganado. Las co-detecciones con otros mamíferos, incluyendo el leopardo común (*Panthera pardus*), el oso negro del Himalaya (*Ursus thibetanus*), la marta de garganta amarilla (*Martes flavigula*) y el langur gris de Cachemira (*Semnopithecus ajax*), fueron más frecuentes en cámaras ubicadas dentro de áreas protegidas, mientras que el ganado bovino, caprino y ovino dominó en las zonas de interfaz más bajas. La prueba H de Kruskal–Wallis (H = 64,2; gl = 2; p < 0,001) indicó una reducción significativa en las detecciones de mamíferos silvestres en sitios con alta presencia de ganado. Nuestros resultados identifican a Dachigam como el principal refugio demográfico para el Hangul y subrayan la necesidad de regular el pastoreo a escala de paisaje y de implementar una gestión participativa de las zonas de amortiguación para reducir la perturbación en los bordes y mantener la conectividad del hábitat de esta especie en peligro crítico.

Keywords: Hangul; camera trapping; livestock overlap; altitudinal distribution; Kashmir Himalaya)

Introduction

The Kashmir Red Deer or Hangul (*Cervus hanglu hanglu*) is the only surviving species of the red deer lineage endemic to the Indian subcontinent and represents the southernmost remnant of a broader temperate cervid assemblage that spans Central and western Eurasia (Brook et al. 2017; Ahmad et al. 2023a; Ahmad et al. 2023b). Taxonomically, Hangul is embedded within the Tarim red deer complex (*Cervus hanglu sensu lato*), a western clade that is genetically distinct from the eastern wapitoid assemblage, and Indian Kashmir populations have been explicitly recognized within this Tarim grouping in a recent study (Ahmad et al., 2023a). The species is assessed as being under severe conservation risk because of its very small population size and continuing decline. The IUCN Red List assessment (2017) estimated 110–130 individuals in Dachigam National Park (NP) and 150–200 individuals overall (2015), with a decline plausibly ≥25% within one generation (14 years), alongside a biased sex ratio and an extremely low fawn-to-hind ratio (Brook et al. 2017). Range-wide consolidation further highlighted the geographic restriction of Hangul, estimating an area of occupancy of ~228 km² (Brook et al. 2017).

Over the last two decades, biennial population monitoring conducted by the Department of Wildlife Protection, Government of Jammu & Kashmir indicates that the Hangul population in the Dachigam landscape declined from

197 in 2004 to a low of 127 in 2008, followed by a gradual increase to 175 (2009), 218 (2011), 183 (2015), 214 (2017), 237 (2019),261 (2021), 289 (2023); the most recent monitoring in 2025 reported 323 Hangul individuals in and around Dachigam National Park and adjacent areas. Although this recent rise is encouraging, a peer-reviewed analysis of long-term monitoring data cautions that growth is often weak/variable and that the population could still remain vulnerable to decline without strong, sustained interventions (Ahmad et al. 2023b).

In practice, the only consistently viable concentration is associated with the Dachigam landscape, and occurrences outside this core are widely described as fragmented and vulnerable to local loss in the absence of restored connectivity and reduced edge pressures (Ahmad et al. 2023b). Multiple interacting drivers underpin this contraction. Across its current distribution, the major threats repeatedly implicated include poaching, habitat loss and fragmentation, and resource competition and disease risk linked to livestock pressures that intensify along forest edges, seasonal grazing routes, and human settlement interfaces. These mechanisms plausibly affect Hangul not only through forage depletion and displacement, but also via indirect pathways such as disturbance by herders and guard dogs in calving areas, which can depress recruitment even where adult survival is maintained.

Genetic evidence strengthens the urgency of conserving Hangul because the lineage represents a disproportionate component of cervid evolutionary diversity. Mitogenome-based phylogenies place Hangul in a distinct clade with *C. h. yarkandensis* and support its placement within the Tarim red deer group. Divergence-time analyses further suggest that Tarim deer split from European red deer around ~1.55 Mya, and Hangul diverged from *C. h. yarkandensis* around ~0.75 Mya, consistent with Pleistocene biogeographic structuring (Ahmad et al. 2023a; Shah et al., 2011).

In addition to direct anthropogenic pressures, climate change is expected to amplify risk by reducing and redistributing suitable habitat. MaxEnt-based projections for the Dachigam landscape indicate progressive loss of suitability with time, with some scenarios projecting severe contraction or near-complete habitat loss by 2080. Importantly, current "very highly suitable" habitat was estimated to be far larger in unprotected areas (30,445 ha) than inside protected regions (2,220 ha), emphasizing that long-term persistence cannot rely on the core protected area alone and must be supported by corridor-oriented landscape planning and buffer governance (Haq et al. 2025; Javid et al., 2024).

Life-history timing may further increase sensitivity to seasonal disturbance. Non-invasive physiological monitoring indicates that fecal glucocorticoid metabolites rise in females from March and peak in May, while males also show a May stress spike (Srivastava et al., 2025). The timing coincides with upslope migration and the movement of migratory herders, livestock, and guard dogs into subalpine pastures, suggesting that human livestock activity may elevate stress during a critical seasonal transition. Such stress-mediated pathways can plausibly interact with displacement, reduced habitat quality, and predation risk to suppress recruitment and slow recovery in small, isolated populations.

Given this convergence of pressures (small population size, demographic constraints, fragmentation, livestock-associated impacts, and climate-driven habitat shifts) there is a strong need for landscape-scale evidence to guide targeted management. This study deployed 185 camera traps throughout the Kashmir Valley from 2022 to 2025 for more than 20,000 trap-nights. Camera trapping provides a robust, non-invasive basis to quantify spatial patterns of use across elevational gradients, evaluate associations with livestock and sympatric mammal communities, and identify edge conditions where Hangul detections decline. Accordingly, this study uses multi-season camera-trap detections across Kashmir's montane systems to characterize Hangul's elevational and landscape distribution and assess co-occurrence patterns with other mammals, and test how livestock presence corresponds with Hangul detections across core and peripheral landscapes. It intends to provide information for grazing regulation, participatory buffer management, and corridor stewardship required for recovery in a shared mountain realm.

Figure 1: Hangul photographed in the Wangat sector (Wangat Conservation Reserve); the lighter appearance likely reflects illumination and camera settings rather than inferred body condition.

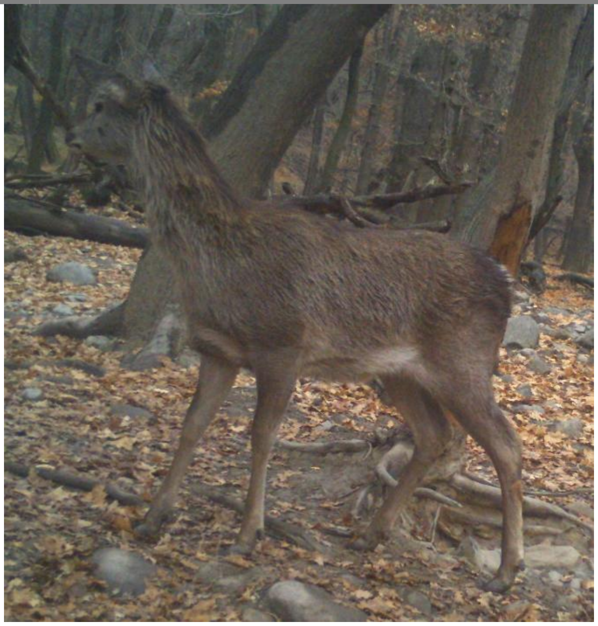


Figure 2: Subadult female Hangul photographed in Dachigam National Park, foraging among leaf litter in a temperate Himalayan forest.

Figure 3: Two adult male Hangul engage in a territorial fight, locking antlers on a cold winter afternoon in Dachigam National Park during the rutting season.

Figure 4: Male and female Hangul captured together in open grassland during late autumn, highlighting the peak rutting period when mating occurs before the onset of winter.

Figure 5: Male Hangul resting in Tral Wildlife Sanctuary, ~2 km from the nearest village—an edge location with regular human activity and grazing access.

Study area and Methodology

The study was conducted across the Kashmir region of the northwestern Himalaya (33.5°–35.0° N, 73.0°–75.5° E) (Figure 6). Camera traps were deployed using a systematic grid-based framework in which the landscape was divided into 25 km² sampling units. Within each grid, camera stations were distributed to ensure broad coverage of available habitats while maintaining spatial independence, and placement ensured ≥1 km spacing between adjacent cameras. In total, 185 camera stations were established across an elevational gradient of 1,500–3,400 m a.s.l., encompassing moist temperate conifer forests, mixed broad-leaved belts, and subalpine scrub zones typical of the Kashmir Valley.

From this landscape-level deployment, Hangul-focused analyses were restricted to landscapes and regions where Hangul presence was confirmed. These Hangul landscapes comprised Dachigam National Park (Lower and Upper Dachigam), Brain Nishat Conservation Reserve, Wangat Conservation Reserve, Tral Wildlife Sanctuary, Mammar, and the Haknar Reserved Forest. Together, these sites form a semi-protected valley system characterized by high water availability but fragmented by roads and human land use. Vegetation structure varies with topography and aspect, riverine rills support broad-leaved assemblages dominated by *Aesculus indica, Juglans regia, Populus spp., Salix spp.,* and *Ulmus wallichiana*, while cooler/northern aspects are characterized by conifer stands of *Pinus wallichiana, Picea smithiana,* and *Abies pindrow*. Southern aspects include open grasslands and rills with dense shrub cover, notably *Parrotiopsis jacquemontiana* (Hatab), which provides concealment and daytime refuge for Hangul herds in edge landscapes.

From the complete dataset of 185 camera stations, only cameras located within Hangul-present regions were retained for analysis, resulting in 40 camera traps used for the core analyses. Sampling effort extended across multiple seasons/years as per the deployment schedule, with a minimum deployment duration of approximately 3 to 6 months at most of the sites and some control stations maintained for up to two years. Cameras were set to operate continuously, generating more than 120,000 images, including domestic and wild animals. All photographs were screened and classified by species, and detection histories were built following the study's independence criteria (consecutive records of the same species at a camera were treated as independent events when separated by ≥30 minutes). In total, 92,000 mammal records were extracted from the full dataset. For Hangul specifically, 5,700 independent detections were retained for analysis over 2,500 trap-nights.

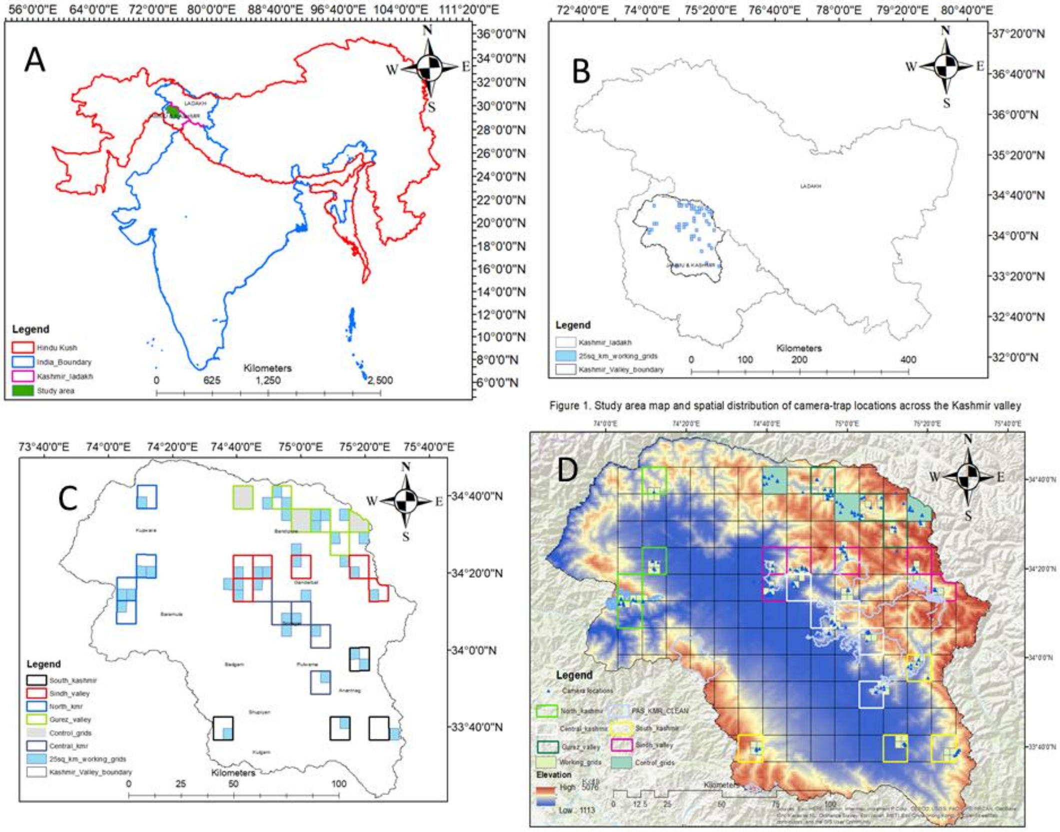
We would like to clarify that camera trapping was conducted valley-wide, covering the full range of available habitats across Kashmir. A total of 185 camera traps were deployed using a grid-based design (10 cameras per 25 km² grid), ensuring systematic and representative sampling effort across 25 grids (as shown in the Study Area map and described earlier in the Methodology). However, it is important to emphasize that ungulates in the Kashmir Himalaya are not randomly distributed across the landscape. In particular, Hangul (*Cervus hanglu hanglu*) shows a highly patchy and spatially restricted distribution, largely concentrated in and around Dachigam National Park, extending up to approximately 30 km beyond its boundary, and not occurring beyond this range during the study period.

Despite valley-wide sampling effort, Hangul presence was recorded in only four grids out of the total 25 sampled grids. The remaining grids, although sampled with equal effort, fall outside the current ecological range of the species. Therefore, including all 180 camera stations in analyses would introduce a large number of structural zeros from areas where Hangul are ecologically absent rather than undetected. Including all camera stations would artificially bias parameter estimation by conflating true absence with non-detection and would reduce biological interpretable. For this reason, analyses were restricted to the 40 camera stations located within the four grids where Hangul presence was confirmed. This approach ensures that inference is made within the species' ecological landscape of occurrence rather than across the entire valley where the species is known to be absent.

The deployment of 180 camera traps remains critical and is clearly reported to demonstrate valley-wide sampling effort, and coverage of all major habitat types.

Elevational patterns of Hangul detections were summarized using medians and interquartile ranges, and differences among focal regions were evaluated using a Kruskal–Wallis test followed by Dunn's post hoc pairwise comparisons. To examine associations with sympatric species and anthropogenic pressures, we quantified pairwise relationships between Hangul detections and detections of other mammals including common leopard, Himalayan black bear, Kashmir grey langur, yellow-throated marten, porcupine, and livestock using Spearman rank correlations. We further tested the relationship between Hangul counts and livestock frequency using a generalized linear model with a Poisson error distribution, with livestock frequency log-transformed where appropriate. To account for unequal sampling effort among cameras, we standardized detection rates by trap-nights and included log(trap-nights) as an offset in count models where applicable. Diversity indices (Shannon H') were calculated to compare mammal community structure across focal regions. Additional proximity analyses assessed whether Hangul detections declined near roads, settlements, and grazing trails, using distance buffers as categorical predictors.

Study area, sampling design, and camera-trap deployment across the Kashmir Valley (Northwest Himalaya).



(A) Geographic context of the study area showing the location of the Kashmir Valley within the Hindu Kush–Himalayan region and India, with national boundary and the Kashmir–Ladakh extent highlighted.
(B) Extent of the Kashmir Valley study region within Ladakh and Jammu & Kashmir, with the distribution of camera-trap locations shown.
(C) Sampling grid framework illustrating the spatial layout of grid cells used for deployment and their assignment to survey strata/landscapes (North Kashmir, South Kashmir, Sindh Valley, Gurez Valley, and central/working grids).
(D) Altitudinal (elevation) map of the study area showing camera-trap deployment locations overlaid on elevation gradients, with protected area boundaries indicated for the Kashmir region.

Figure 6: Study area map and sampling design.

Results

Hangul detections occurred across 1,685–3,239 m a.s.l., with the highest concentration between 1,800 and 2,100 m, corresponding to the oak (*Quercus robur*) and horse chestnut (*Aesculus indica*) forest belt and the upper conifer–scrub ecotone. Significant elevation differences were observed among focal regions (Kruskal–Wallis test ($H = 46.7$, $df = 2$, $p < 0.001$)). Median elevations were 1,790 m in Dachigam NP and Brain Nishat CR, 2,120 m in Mammar and Tral WLS, and 2,480 m in Wangat CR and Haknar, with post hoc contrasts indicating higher altitude use in the Wangat–Haknar region ($p < 0.01$).

Across the Hangul-present stations (n = 40), 26 mammalian species were recorded. Large carnivores, including common leopard (*Panthera pardus*), Himalayan black bear (*Ursus thibetanus*), and small carnivores as yellow-throated marten (Martes flavigula), red fox (Vulpes vulpes). Leopard Cat (*Prionailurus bengalensis*), occurred infrequently outside Dachigam's core zone. Dachigam NP exhibited the highest mammalian diversity (H' = 2.18), followed by Mammar, Tral WLS (H' =1.96), and Wangat CR (H' =1.77), with Brain Nishat CR showing the lowest diversity (H' =1.42) likely due to grazing pressure and edge disturbance.

Livestock detections comprised 41% of total camera captures of mammals outside the protected area. Regression analysis revealed a strong negative association between Hangul and livestock (GLM $\beta = -0.72 \pm 0.15$ SE, $z = -4.8$, $p < 0.001$). Brain Nishat CR and Wangat CR showed rare detections of fawns and mixed groups of Hangul. In Dachigam, livestock detections were negligible, and Hangul detections remained consistent across seasons.

Correlation analysis showed positive associations between Hangul and Himalayan Black Bear ($\rho = 0.42$) and Langur ($\rho = 0.31$), and negative correlations with Leopard ($\rho = -0.29$) and Livestock ($\rho = -0.51$). Multivariate ordination segregated Dachigam sites with native wildlife and high canopy cover, whereas Tral and Wangat grouped with livestock and human-influenced variables. . Proximity analysis indicated a steep decline in Hangul detections within 3 km of roads or settlements (Mann–Whitney $U = 412$, $p < 0.001$), while sites within 2 km of grazing routes contained twice as many livestock frames and only one-third as many Hangul photographs as interior protected area cameras.

Discussion

Hangul, once spread across Kashmir's river valleys, now survives largely within a narrow elevational refuge ringed by human activity. Although the species exhibits flexibility in elevation and seasonal migration moving upslope to 2,600–3,000 m in summer and descending to 1,700–1,900 m in winter, it faces elevated risks of predation and hunting because connectivity between seasonal ranges has been reduced. The Wangat CR to Overa- Aru WLS corridor, once a natural conduit linking Dachigam to peripheral hangul landscapes including Tral WLS, is now fragmented by road expansion and seasonal grazing, weakening movement between core and peripheral habitats. Our findings confirm Dachigam National Park as the principal refuge, accounting for the majority of detections and retaining higher community diversity and lower livestock disturbance.

Our camera-trap data show that Hangul detections in Mammar reserve forest and Wangat CR peak during April–May and October–November, coinciding with transhumant livestock movements. It appears that this temporal overlap results in displacement of the species rather than coexistence. Similar spatial segregation between livestock and wild cervids has been reported from Himalayan ecosystems of Nepal and Central Asia (Shrestha et al. 2019). Displacement by livestock is widely documented for cervids and other ungulates. For example, studies show that conservation grazing can displace red deer and reduce habitat use in otherwise suitable grassland–forest mosaics (Weiss et al. 2022, Kinka et al. 2021). In Kashmir, livestock pressure not only competes directly for forage but may also introduce guard dogs, which can alter wildlife movement and increase stress. Such effects may be particularly severe during spring when females approach calving and require safe cover.

Habitat shrinkage also alters the community structure associated with Hangul. Declines in carnivore presence outside Dachigam may imply trophic simplification driven by human and livestock expansion. Within intact canopies, positive co-occurrence between Hangul, black bears, and langurs indicates shared reliance on fruiting shrubs and undisturbed forest cover resources, and this association may be weakened if uncontrolled livestock grazing continues within available corridors. At a landscape scale, Hangul appears to occupy a multi-species refuge system where co-occurrence is possible only when disturbance remains low. In contrast, areas of high livestock density exhibit lower wildlife diversity and reduced detections across multiple taxa, suggesting a broader displacement effect beyond Hangul alone.

An additional emerging concern is fragmentation caused by National Highway 1 (NH 1), which connects Srinagar to Leh and cuts across Hangul's potential dispersal zone between Dachigam NP and Wangat CR. This arterial route already restricts nocturnal movement of wildlife, and if NH 1 is widened without appropriate wildlife overpasses, it could become a near-permanent barrier to gene flow and seasonal migration. During a field interaction with night-shift army personnel in March 2025, they revealed that a herd of approximately 20 Hangul comprising adult males, females, and sub-adults was observed crossing NH 1 before dawn (around 04:00 h IST). The group, led by a mature stag, vocalized repeatedly to recruit trailing animals before moving northward from Dachigam through Mammar toward Wangat. This rare nocturnal movement indicates that corridors still retain functional permeability, but such behaviour also exposes animals to traffic and poaching risk. Evidence from road ecology studies globally emphasizes that mitigation measures such as overpasses, underpasses, and fencing can significantly improve wildlife permeability and reduce mortality (Brennan et al., 2022; Rytwinski et al., 2016). Therefore, integrating such measures in planned highway development could be vital for long-term Hangul conservation.

Camera traps recorded suspected illegal hunting activity (people carrying firearms) in the outer fringes of Wangat Conservation Reserve and Tral Wildlife Sanctuary, particularly in reserved forests that receive minimal protection. These observations substantiate local reports that poaching pressure persists outside formal park limits, especially where livestock herding and fuelwood collection overlap. The combination of unregulated roads, hunting access, and limited night enforcement creates conditions for illegal hunting. Strengthening patrols in reserved forests and establishing community-based reporting networks are therefore essential to reduce offtake outside Dachigam.

Camera-trap data further indicate that livestock movement peaks between May and October, overlapping with Hangul's calving and antler-growth period. Repeated incursions by large livestock herds, often accompanied by dogs, may lead to prolonged avoidance or local absence of Hangul if this practice continues over long periods. These disturbances are compounded by fuelwood extraction, tourism, and portable saw machines, all of which contribute to chronic noise and olfactory disturbance. Poaching, although episodic, may be facilitated by the presence of grazing herders and newly created trails, increasing accessibility for hunters.

Despite these pressures, Hangul displays notable resilience. Its vertical migrations, nocturnal adjustments, and fidelity to secluded slopes illustrate behavioural plasticity under constraint. Yet, this resilience has limits. The coherence of results of strong negative Hangul–livestock relationships, fewer detections near roads, and regionally distinct elevation use indicate increasing ecological isolation. Dachigam remains the last viable refuge, but without managing surrounding valleys and addressing corridor fragmentation, the population may become functionally trapped, with reduced gene flow and heightened vulnerability to stochastic events.

Effective conservation now hinges on community-based coexistence. Establishing livestock-free buffer zones around Dachigam's upper and lower limits, coupled with rotational grazing agreements and compensation schemes, could reduce direct conflict and disturbance. Rehabilitation of corridors such as Wangat CR, Tral WLS through native shrub restoration (Berberis, Viburnum) and dog-control measures could help reconnect seasonal ranges. Involving Gujjar and Bakarwal herders in co-monitoring programs with performance incentives could also create shared stewardship. Additionally, the creation of disease surveillance programs at livestock–Hangul interface zones is needed to detect and prevent outbreaks that could devastate small populations (Bohm et al., 2007).

Beyond management, communication is crucial. Hangul must be portrayed not only as a flagship species but also as an indicator of temperate-forest integrity and the wider health of Kashmir's montane ecosystems. Communication can be operationalized as coordinated messaging and planning among (i) the Jammu & Kashmir Wildlife Department and protected-area managers, (ii) local governance institutions and village committees in fringe forests, (iii) Gujjar–Bakarwal pastoral leaders and herding networks, and (iv) tourism stakeholders, emphasizing the shared long-term value of conserving Hangul habitat.

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Habitat Suitability Index Modeling for Axis deer (*Axis axis*) using RS & GIS approach

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Abstract

The concept of wildlife conservation begins with identifying suitable habitat, because it provides essential information for refuge design and management. In the present study, we assessed habitat suitability for Axis deer (*Axis axis*) in Pench Tiger Reserve (PTR), Central India, using remote sensing (RS) and geographic information systems (GIS). We used Landsat-8 OLI imagery (4 April 2015), ASTER DEM, topographic maps, and the digital boundary of PTR obtained from the Forest Department. Field surveys (2013–2015; excluding monsoon) and ground-truthing supported habitat interpretation. ERDAS IMAGINE 13 and ArcGIS 10 were used for image processing and GIS analysis. We applied the Analytical Hierarchy Process (AHP) to assign relative weights to habitat factors and produced a Habitat Suitability Index (HSI) map using a linear additive model. The HSI map indicated that 233 km² (28.38%) of PTR was highly suitable for Axis deer, 196 km² (23.87%) moderately suitable, 212 km² (25.82%) suitable, and 130 km² (15.83%) least suitable, while ~50 km² (6.09%) was classified as avoided.

Resumen

El concepto de conservación de la vida silvestre comienza con la identificación del hábitat adecuado, ya que este proporciona información esencial para el diseño y la gestión de refugios. En el presente estudio, evaluamos la idoneidad del hábitat para el ciervo axis (*Axis axis*) en la Reserva de Tigres de Pench (PTR), en el centro de la India, utilizando teledetección (RS) y sistemas de información geográfica (SIG). Se emplearon imágenes Landsat-8 OLI (4 de abril de 2015), un modelo digital de elevación ASTER (DEM), mapas topográficos y el límite digital de la PTR proporcionado por el Departamento Forestal. Los relevamientos de campo (2013–2015; excluyendo el período del monzón) y la verificación en terreno respaldaron la interpretación del hábitat. Se utilizaron ERDAS IMAGINE 13 y ArcGIS 10 para el procesamiento de imágenes y el análisis SIG. Aplicamos el Proceso Analítico Jerárquico (AHP) para asignar pesos relativos a los factores del hábitat y generamos un mapa del Índice de Idoneidad del Hábitat (HSI) mediante un modelo lineal aditivo. El mapa de HSI indicó que 233 km² (28,38%) de la PTR eran altamente adecuados para el ciervo axis, 196 km² (23,87%) moderadamente adecuados, 212 km² (25,82%) adecuados y 130 km² (15,83%) poco adecuados, mientras que aproximadamente 50 km² (6,09%) se clasificaron como evitados.

Keywords: Axis deer; Habitat suitability model; Analytical Hierarchy Process (AHP) ; Pench Tiger Reserve; RS & GIS.

Introduction

Understanding relationships between the spatial distribution of animals and their habitats is central to conservation science because habitat conditions ultimately govern survival, reproduction, and population persistence (Lecis & Norris 2004). For large and medium herbivores in tropical forests, habitat selection is rarely random; it reflects the spatial patterning of forage, cover, water availability, terrain constraints, and human disturbance, all of which vary across seasons and management zones. Consequently, identifying and mapping suitable habitat is a first practical step for designing protected-area management plans, prioritising restoration, and evaluating how land-use change or infrastructure development may alter wildlife populations. In this context, habitat suitability represents the degree to which a landscape can support a species, and suitability maps provide an explicit spatial framework for targeting patrolling, regulating resource use, and planning habitat improvement interventions.

Conventional ground-based habitat surveys remain valuable because they provide fine-scale ecological information and allow direct observation of animal signs, vegetation structure, and local disturbance patterns. However, these surveys are often time-consuming, expensive, and difficult to standardise across large landscapes or rugged terrain, and they may be constrained by accessibility and observer bias (Panwar 1986). The limitations of purely field-based approaches become more pronounced in large protected areas where habitat heterogeneity is high and management decisions require spatially continuous information. Further, ground surveys alone may not capture rapid habitat change driven by fire, invasive species, extraction, or expansion of roads and settlements, which can modify habitat quality within short time frames. Therefore, while field observations remain essential for ecological interpretation and validation, there is a clear need for complementary approaches that can deliver landscape-scale, repeatable, and spatially explicit habitat assessments.

Geospatial technologies particularly remote sensing (RS) and geographic information systems (GIS) have transformed habitat assessment by enabling consistent mapping of land cover, terrain, and proximity-based variables across entire landscapes. Satellite imagery provides synoptic coverage and supports classification of vegetation types and land use, while digital elevation models allow derivation of topographic descriptors such as slope and aspect that influence accessibility, microclimate, and vegetation composition. When integrated within a GIS, these layers can be combined with ecological knowledge and field evidence to generate habitat suitability index (HSI) models that identify potential core areas, corridors, and zones of low suitability (Davis et al. 1990; Kushwaha & Roy 2002; Kushwaha et al. 2004). HSI-based outputs are typically intuitive and easy to communicate to managers, and they have been widely applied to guide conservation prioritisation, habitat management, and environmental impact assessment (Kushwaha et al. 2004; Zarri et al. 2008). Importantly, RS–GIS approaches can be updated as new imagery becomes available, enabling monitoring of habitat change and supporting adaptive management.

Among different approaches to habitat suitability mapping, multi-criteria decision analysis (MCDA) has gained prominence because it can incorporate multiple ecological drivers in a structured manner even when presence–absence data are limited or when managers require interpretable, rule-based outputs. The Analytical Hierarchy Process (AHP) is a commonly used MCDA framework that assigns relative importance (weights) to habitat variables through pairwise comparisons and then integrates them in a weighted overlay to generate a suitability surface. AHP is particularly useful in protected-area contexts where expert knowledge and field experience can be formalised, and where the goal is to integrate diverse criteria such as vegetation condition, slope constraints, water availability, and disturbance gradients into a single decision-support product. While AHP-based HSI models do not replace statistical species distribution models, they provide a transparent, operational tool for management planning, especially when combined with ground-truthing and iterative refinement.

Axis deer (*Axis axis*), a key prey species in many Indian forest ecosystems, is strongly influenced by habitat features that regulate forage and cover. The species typically benefits from heterogeneous forest–grassland mosaics, availability of water, and moderate terrain that supports efficient movement and vigilance, while it may be constrained by steep slopes, dense disturbance near roads, or highly degraded edges. As a prey species, Axis deer distribution also has cascading implications for predator ecology, particularly in tiger reserves where prey density is a critical determinant of carnivore carrying capacity. Therefore, identifying areas that are suitable for Axis deer can support broader ecosystem management objectives, including prey-base strengthening, restoration of degraded patches, and maintenance of movement connectivity within and beyond the reserve boundaries.

Pench Tiger Reserve (PTR) is an important landscape in Central India representing tropical dry deciduous and tropical moist deciduous forest ecosystems, and it supports high predator and prey densities (Sankar et al. 2001). PTR's habitat mosaic, shaped by vegetation types, topography, rivers and reservoirs, and varying levels of human use along the periphery, makes it a suitable setting for RS–GIS based habitat suitability mapping. Spatially explicit assessment is particularly valuable in such multi-use landscapes because management must balance wildlife conservation with regulated tourism, infrastructure, and local resource dependency. Moreover, suitability mapping can help identify zones where habitat improvement efforts (e.g., grassland management, waterhole maintenance, control of disturbance along roads) may yield the greatest benefit for herbivore populations.

In this study, we apply an RS–GIS framework integrated with AHP to model habitat suitability for Axis deer in PTR. Specifically, we develop spatial layers representing land use/land cover, slope, distance to water bodies, and distance to roads, and integrate these using a weighted overlay to produce an HSI map. The resulting suitability classes are used to quantify the proportion of the reserve that is highly suitable, moderately suitable, suitable, least suitable, and avoided, and to interpret how landscape structure may influence Axis deer distribution. By providing a practical, map-based decision-support product, this study aims to assist reserve managers in identifying priority habitats and planning targeted interventions for sustaining prey resources and strengthening overall conservation outcomes in PTR.

Study Area

Pench Tiger Reserve, Madhya Pradesh, is a major protected area in the Satpura–Maikal ranges of Central India. An area of 449.392 km² was declared Pench Sanctuary in 1977. Of this, 292.857 km² became Pench National Park in 1983, and 118.473 km² remained as Pench Sanctuary. In 1992, the Government of India declared 757.85 km² (including the National Park and Sanctuary) as the 19th Tiger Reserve of the country. The reserve lies approximately between 77°55′E and 79°35′E, and 21°08′N and 22°00′N (Figure 1). PTR experiences four seasons (summer, monsoon, post-monsoon and winter) with temperatures ranging from ~0°C in peak winter to ~45°C in peak summer and receives ~1400 mm mean annual rainfall (Sankar et al. 2001). The forest is dominated by *Tectona grandis, Boswellia serrata, Anogeissus latifolia, Sterculia urens and Gardenia latifolia,* and supports diverse carnivores (e.g., tiger, leopard, dhole) and herbivores (e.g., sambar, gaur, nilgai) alongside Axis deer (Figure 1).

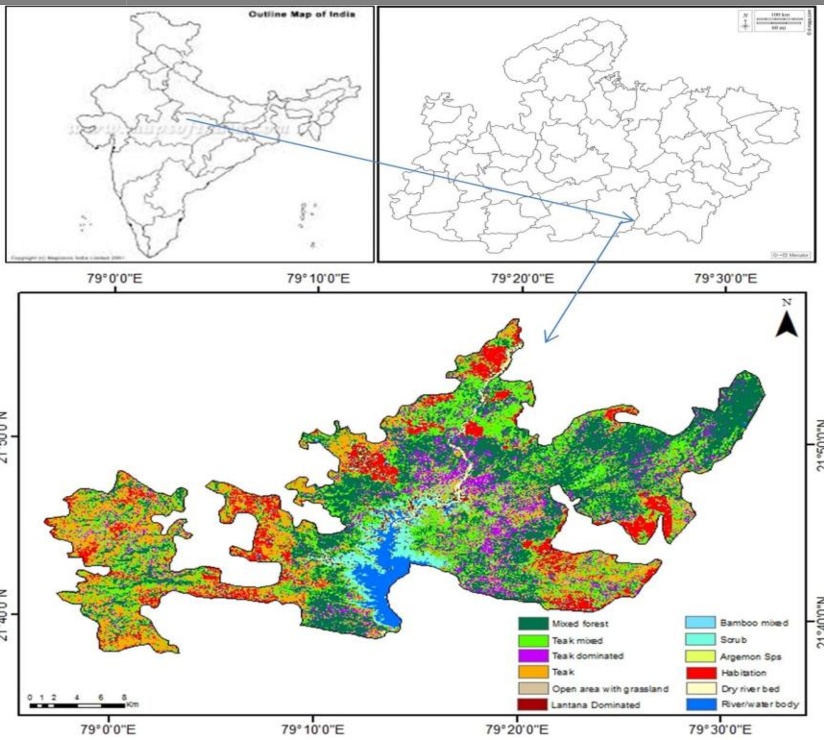

Figure 1. Study area map Pench Tiger reserve

Methodology

We evaluated Axis deer habitat suitability in PTR using RS–GIS processing, field surveys, and an AHP-based weighted overlay to produce an HSI map. Spatial layers included land use/land cover (LULC), slope, distance to water bodies, and distance to roads.

Landsat-8 OLI (4 April 2015; Path 144, Row 45; 30 m resolution) was downloaded from the USGS and processed in ERDAS IMAGINE 2013. An area of interest (AOI) was created and false colour composites prepared. ASTER data were downloaded from USGS to generate a 30 m digital elevation model (DEM); the DEM was used to derive the slope layer. Topographic maps were scanned, geo-referenced (root mean square error ≤ one-third pixel), re-sampled using nearest-neighbour, and projected to UTM WGS-84.

Field surveys were conducted during 2013–2015 (excluding the monsoon season). PTR has three ranges (Kurai, Karmajhiri and Gumtara). The Karmajhiri range was selected as the intensive study area. Fifteen line transects were laid across representative habitats, and on each transect 10 circular plots were established at 200 m intervals (n = 150 plots). Axis deer presence was recorded across seasons, and GPS locations were captured. Additional variables such as tree cover, shrub cover, distance to nearest waterhole, and distance to the nearest human habitation were recorded (Figure 2). Slope and distance to roads were derived from RS–GIS layers for consistency and spatial completeness (Imam et al. 2009).

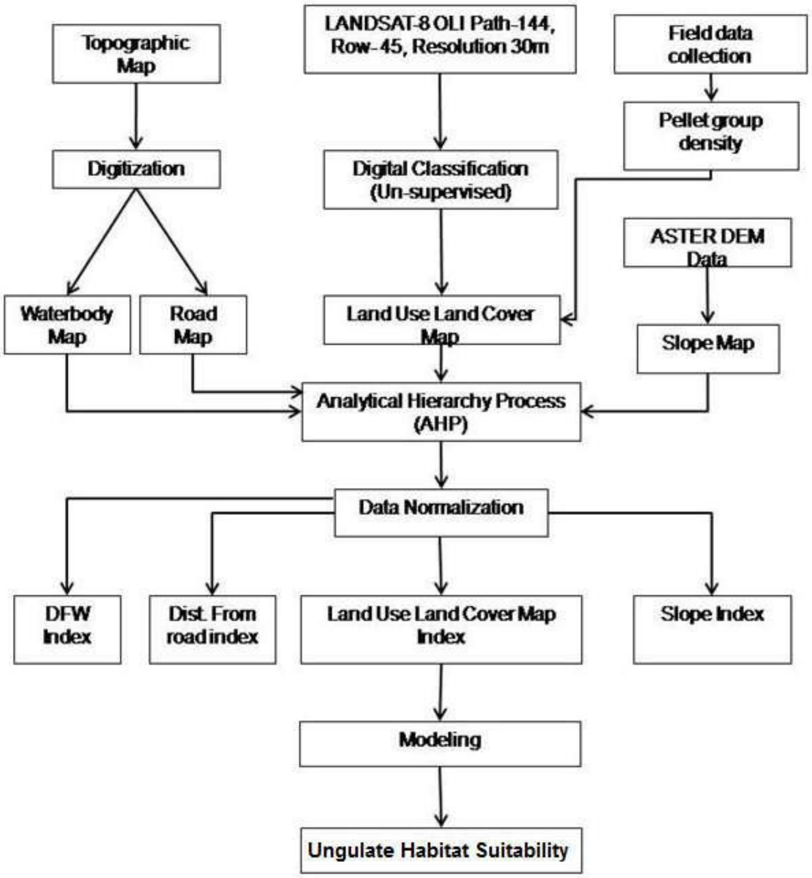

Figure 2. Workflow for developing the axis deer habitat suitability model in Pench Tiger Reserve using RS–GIS inputs and the Analytic Hierarchy Process (AHP).

Land use/land cover mapping and accuracy assessment

LULC was derived from the geo-coded Landsat-8 false colour composite using unsupervised classification (ISODATA clustering) followed by maximum likelihood classification and then validated using an accuracy assessment based on 100 random points. Map accuracy was evaluated using Cohen's Kappa statistics (Lillesand & Kiefer 2000). The overall classification accuracy was 82.0% and the overall Kappa value was 0.7793 (Table 1).

Table 1. Accuracy assessment summary for vegetation and land cover classes in Pench Tiger Reserve, Madhya Pradesh.

Class	Correct (n)	Total reference (n)	Total mapped (n)	Producer's Acc. (%)	User's Acc. (%)
River & Waterbody	2	2	2	100	100
Mixed Forests	27	30	31	90	87.10
Bamboo mixed	1	1	1	100	100
Teak mixed	16	21	19	76.19	84.21
Open area with grassland	1	2	1	50	100
Argemon spp.	1	1	1	100	100
Lantana Patch	2	3	2	66.67	100
Scrub	2	4	3	50	66.67
Teak-dominated	11	14	15	78.57	73.33
Teak	10	12	14	83.33	71.43
Human Habitation	9	10	11	90	81.82
Dry River Bed	1	1	1	100	100

Map accuracy was evaluated using an error matrix, producer's accuracy, user's accuracy, overall accuracy and Cohen's kappa statistic following standard remote-sensing accuracy assessment(Cohen 1960; Congalton 1991; Congalton & Green 2009; Lillesand & Kiefer 2000).

AHP weighting and HSI modelling

Factors influencing Axis deer distribution were identified from literature, field observations, and expert consultation, focusing on LULC, distance from water bodies, slope, and distance from roads. Relative weights were derived using the Analytical Hierarchy Process (AHP) (Saaty 1977; Saaty and Vargas 1991). To assess the rationality of judgments, we evaluated matrix consistency following Saaty (1977) using the Consistency Index (CI) and Consistency Ratio (CR):$CR = CI / RI$, where RI is the Random Index for a matrix of order n, and $CI = (\lambda\_max - n) / (n - 1)$, with λ_max as the principal eigenvalue.
Lower CR indicates more consistent judgments, and $CR < 0.1$ is typically considered acceptable.

HSI was calculated as the sum of habitat suitability factor ratings (I_i) multiplied by AHP-derived weights (W_i) (Eastman et al. 1995; Wang et al. 2008):$HSI = \Sigma (W\_i \times I\_i)$.

For Axis deer, the final weighted model was:
$HSI = (2.44 \times LULCI) + (0.90 \times DFWI) - (0.41 \times SI) - (0.25 \times DFRI)$,
where LULCI = Land use/land cover index; DFWI = Distance from water-body index; SI = Slope index; and DFRI = Distance from road index. Negative coefficients indicate reduced suitability with increasing slope and with proximity to roads (i.e., disturbance effects) (Table 2).

Table 2. Ranks and weights assigned to habitat layers used in the HSI model.

S. No.	Layer	Assigned rank	Weight
1	Land use/Land cover	1	2.44
2	Distance from water body	2	0.90
3	Slope map	3	0.41
4	Distance from road	4	0.25

Results and Discussion

The Habitat Suitability Index (HSI) model developed using a linear additive framework and AHP-derived weights revealed that Axis deer in Pench Tiger Reserve (PTR) are strongly concentrated in low-relief forested tracts with high vegetation heterogeneity and landscape connectivity. Approximately 233 km² (28.38%) of the reserve was classified as highly suitable, while moderately suitable and suitable classes covered 196 km² (23.87%) and 212 km² (25.82%), respectively. Together, these categories encompassed 78.08% of PTR, indicating that the reserve currently retains extensive habitat capable of supporting large chital populations. In contrast, 130 km² (15.83%) was categorised as least suitable and nearly 50 km² (6.09%) as avoided habitat, largely corresponding to rugged terrain, steep slopes, and sections adjoining the reservoir (Figure 3).

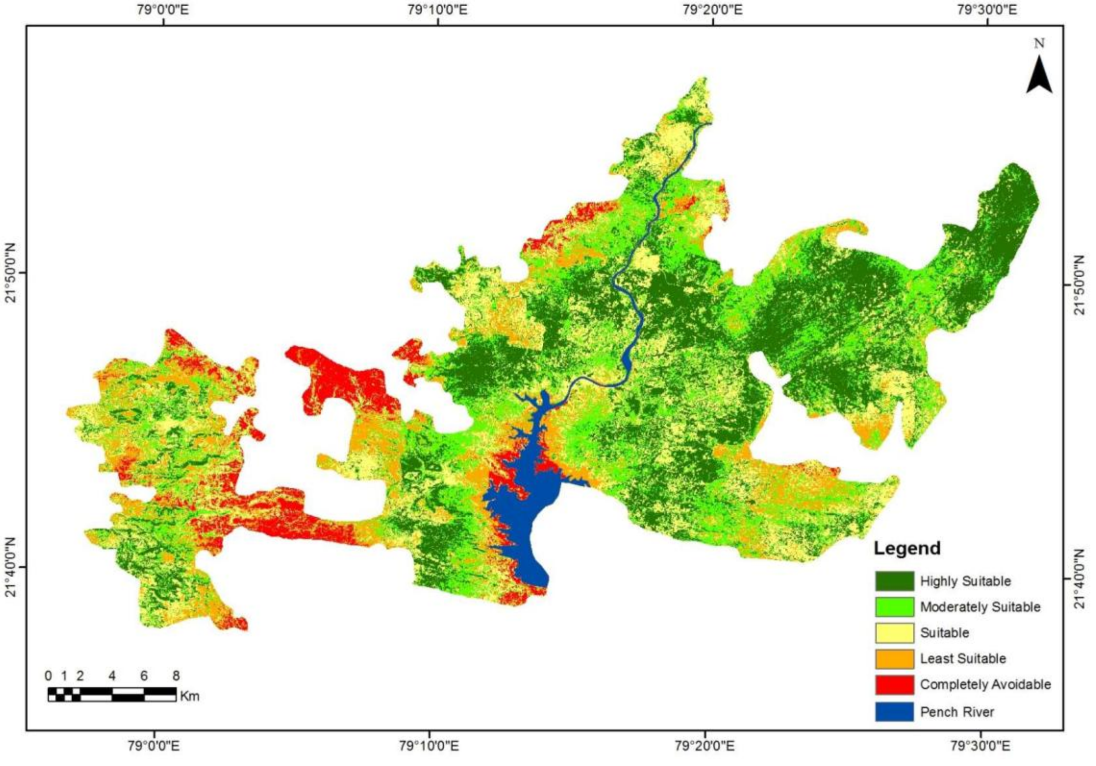

Figure 3. Habitat Suitability Index (HSI) map for Axis deer in Pench Tiger Reserve showing five suitability classes and the Pench River.

Highly suitable areas were predominantly associated with mixed deciduous and teak-mixed forests, vegetation types known to provide abundant forage, patchy canopy cover, and grassy understories preferred by chital. Similar habitat associations have been reported from several central Indian landscapes, including Kanha, Bandhavgarh, and Nagarahole, where Axis deer densities peak in open to moderately closed forests with productive grass layers and proximity to water (Schaller 1967; Khan 1996; Sankar et al. 2001; Jhala et al. 2019). Kushwaha & Roy (2002) and Kushwaha et al. (2004) likewise demonstrated that forest composition and canopy openness were among the strongest predictors of ungulate suitability in tropical dry deciduous systems.

The preference for mixed forest mosaics reflects the feeding ecology of Axis deer as selective grazers–browsers that rely heavily on grasses and herbs during the monsoon and post-monsoon periods but shift towards browse and fallen leaves during the dry season (Schaller 1967; Bagchi et al. 2004). Teak-mixed forests in PTR are often interspersed with natural grasslands, fire-maintained blanks, and riparian strips, creating fine-scale foraging opportunities while offering escape cover from predators. This structural heterogeneity is widely recognised as a key determinant of chital distribution across Indian reserves (Karanth & Sunquist 1995; Sankar et al. 2001).

Moderately suitable areas occurred mainly in contiguous forest interiors with fewer grassy openings, while least-suitable and avoided classes overlapped with rocky ridges, steep slopes, and heavily inundated reservoir margins. Avoidance of rugged terrain is consistent with behavioural observations that Axis deer favour flat to gently undulating ground that facilitates group vigilance, rapid escape, and efficient grazing (Schaller 1967; Khan 1996). Similar negative responses to slope and terrain ruggedness have been reported in RS-based suitability models for cervids across central India and Southeast Asia (Kushwaha et al. 2004; Zarri et al. 2008).

The partial avoidance of reservoir edges likely reflects a combination of fluctuating water levels, reduced forage quality, and elevated human activity associated with fisheries, tourism, and patrol infrastructure. Although proximity to water is generally beneficial for chital particularly during the dry season several studies have noted that heavily disturbed riparian zones may become functionally unsuitable despite their hydrological importance (Bagchi et al. 2004; Jhala et al. 2019). In PTR, the juxtaposition of high predator densities and human presence along the reservoir margins may further displace deer into more secure forest interiors.

One of the most ecologically significant results is the occurrence of two large, continuous suitable habitat blocks west of the Pench River, connected to the Pench–Kanha corridor. Landscape-scale connectivity is increasingly recognised as fundamental for maintaining ungulate populations and facilitating gene flow between reserves in central India (Qureshi et al. 2014; Thatte et al. 2018). Corridors linking PTR with Kanha and surrounding forest divisions are known to be used by tigers, leopards, and their prey, and the high suitability predicted along these routes reinforces their conservation value. From a metapopulation perspective, such patches likely function as demographic sources that sustain both resident chital herds and the large carnivore assemblage dependent on them (Karanth et al. 2004).

The proportion of PTR classified as suitable or better was 78.08%. higher than values reported for other well-protected reserves in central India using RS–GIS and multi-criteria approaches. For example, Kushwaha et al. (2004) reported that approximately 60–70% of Kanha Tiger Reserve fell within moderate-to-high suitability zones for major herbivores, while Zarri et al. (2008) identified 65% suitable habitat for chital and sambar in Pench–Satpura landscapes using vegetation structure and topographic variables. Davis et al. (1990) and Roy et al. (1996) similarly emphasised that large proportions of Indian reserves can remain suitable when forest continuity and grassland management are maintained.

The strong agreement between the present model and earlier field-based studies enhances confidence in the ecological realism of the AHP-weighted HSI approach. By integrating forest type, terrain, hydrology, and landscape configuration, the model reproduces known behavioural patterns of Axis deer while also highlighting spatial priorities not immediately evident from ground surveys alone.

Ecological and Management Implications

From a trophic perspective, the concentration of highly suitable habitat in forest–grassland mosaics underscores the critical role of chital as a principal prey species for tigers and leopards in PTR (Sankar et al. 2001; Karanth et al. 2004). Maintaining these areas through controlled burning, prevention of woody encroachment, and regulation of livestock grazing in buffer zones will likely have cascading benefits for the predator community.

The identification of avoided zones along steep ridges and disturbed reservoir margins suggests potential targets for restoration or management interventions. Grassland enrichment, regulation of tourist pressure near water bodies, and maintenance of low-disturbance riparian buffers could gradually increase functional habitat availability in these marginal areas. Moreover, safeguarding corridor habitats west of the Pench River should be a top conservation priority, as disruption through infrastructure development or land-use change could fragment what appears to be one of the most important movement routes for both prey and predators in the region.

RS–GIS-based HSI modelling is a decision-support tool for reserve management and landscape-level planning. When combined with field density estimates, telemetry, or camera-trap data, such spatial products can guide anti-poaching deployment, habitat restoration, tourism zoning, and corridor protection—applications increasingly emphasised in Indian tiger-landscape conservation strategies (Qureshi et al. 2014; Thatte et al. 2018).

In the context of accelerating development pressures around PTR, the present analysis provides a spatially explicit baseline against which future land-use change, climate impacts, or management interventions can be evaluated. The extensive area currently classified as suitable indicates that PTR remains a stronghold for Axis deer, but the clustering of optimal habitat into a few major blocks highlights the need for proactive landscape connectivity conservation to ensure long-term population viability.

Model scope and limitations

This HSI represents a static suitability assessment based on the spatial layers used (LULC, slope, distance to water and roads) and the available RS imagery (April 2015) and DEM products. Landscape structure and disturbance can change over time; therefore, future updates should incorporate more recent high-resolution imagery (e.g., Sentinel-2 at 10 m) and additional predictors such as vegetation productivity (e.g., NDVI), human disturbance layers, and predation risk proxies where data allow. Similarly, formal sensitivity analysis of AHP weights and independent validation using withheld field locations would further strengthen inference.

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Author contributions

The project was conceptualized by Dr Orus Ilyas and funded by DST-SERB. to Dr. Orus Ilyas. Dr. Abdul Haleem worked as a researcher under the project. Both authors contributed to data collection, analysis, and manuscript preparation.

Conflict of interest and ethics statement

The authors declare no conflict of interest. All field surveys were non-invasive and conducted under official permissions from the forest department and in accordance with applicable wildlife research guidelines.

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Reassessing historical sources and their implications for the conservation of huemul (*Hippocamelus bisulcus*)

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Abstract

The huemul (*Hippocamelus bisulcus*) is one of the most endangered deer species in the Neotropics. Understanding its historical distribution and ecological requirements is essential for guiding effective conservation strategies. Yet, written historical sources often provide fragmentary, biased, and largely unquantifiable evidence. In two recent publications, we demonstrated how such documentary gaps and biases can produce misleading conclusions about the huemul's past distribution and population trends. A subsequent global review of the literature revealed a striking lack of methodological frameworks for evaluating these sources. To address this gap, we recently proposed a seven-step protocol for critically assessing historical data. Here we demonstrate the suitability of our proposed protocol for understanding the historical distribution and ecological interactions of the huemul. We discuss five key conclusions that highlight the risk of uncritical reliance on limited and scattered historical records. Overall, we underscore the importance of using historical evidence responsibly to avoid conservation decisions based on misinterpretation.

Resumen

El huemul (*Hippocamelus bisulcus*) es uno de los ciervos más amenazados de la región Neotropical. Comprender su distribución histórica y sus requerimientos ecológicos es fundamental para orientar estrategias de conservación efectivas. Sin embargo, las fuentes históricas escritas suelen ofrecer evidencia fragmentaria, sesgada y en gran medida no cuantificable. En dos publicaciones recientes demostramos cómo estas lagunas y sesgos documentales pueden generar conclusiones engañosas sobre la distribución pasada y las tendencias poblacionales del huemul. Una revisión global posterior de la literatura reveló una notable falta de marcos metodológicos para evaluar este tipo de fuentes. Para abordar esta carencia, propusimos recientemente un protocolo de siete pasos para analizar críticamente la información histórica. Aquí demostramos la utilidad de dicho protocolo para comprender la distribución histórica y las interacciones ecológicas del huemul. Discutimos cinco conclusiones clave que resaltan el riesgo de depender de manera acrítica de registros históricos limitados y dispersos. En conjunto, enfatizamos la importancia de utilizar la evidencia histórica de manera responsable para evitar decisiones de conservación basadas en interpretaciones erróneas.

Keywords: evaluation process; historical records; huemul; long-term population trends.

Introduction

Historical written sources are valuable tools for reconstructing past species interactions, tracking shifts in distribution patterns, identifying underlying drivers of change, and informing recovery strategies for declining populations (e.g., Clavero & Delibes 2013, Boshoff et al. 2016, Naulak & Pradhan 2020). A common approach integrates these data with other evidence, such as archaeological findings, paleontological records, and ecological research (e.g., Bernard & Parker 2006, Loponte & Acosta 2006, Grace et al. 2019, Martin et al. 2022). In regions such as Patagonia, where paleontological and archaeological records are sparse, historical records serve as a key resource for inferring past distributions, abundances, and behaviors of many species. Nevertheless, these data are subject to gaps, biases, and contextual limitations making it critical to evaluate the reliability of historical sources, and particularly understand the circumstances under which these records were obtained.

Improving the effective use of historical written records requires recognizing their inherent limitations and biases. Failure to use these sources responsibly can result in the loss of valuable information. When historical data are underutilized or misinterpreted, the consequences may include inaccurate scientific conclusions, flawed assessments of wildlife trends, misguided conservation policies, and distorted media coverage that misleads public opinion. To address these challenges, Díaz & Corti (2025) have proposed a systematic framework for critically evaluating key aspects of correctly interpreting historical data, thereby reducing the risk of drawing erroneous conclusions. This framework consists of seven sequential steps: 1) source identification and collection, 2) authenticity verification, 3) contextual analysis, 4) content analysis, 5) bias and perspective assessment, 6) cross-referencing, and 7) analysis and interpretation. The framework ensures that each stage builds upon the foundation established in the previous one.

As a result, conservationists and policymakers can develop more accurate, informed, and effective conservation strategies informed by historical data.

Current populations of huemul (*Hippocamelus bisulcus*) are highly fragmented, occupying primarily the eastern slopes of the Patagonian Andes, the southwestern coastal areas, and the adjacent fjords of coastal Chile (Riquelme et al. 2018). Recent studies have attempted to reconstruct the species' historical distribution using accounts from chroniclers, travelers, and naturalists spanning the 16th to 20th century, combined with archaeological evidence (Flueck et al. 2022, 2023). However, these reconstructions face methodological challenges, including the literal interpretation of historical sources, unsupported geographical extrapolations, and the use of ambiguous references as if they provided definitive evidence (Corti & Díaz 2023, Díaz & Corti 2024). Such practices have contributed to a misleading interpretation of the huemul's past distribution, particularly regarding its presence in steppe environments (Fig. 1). Based on their studies, Flueck et al. (2022, 2023) proposed that huemul's distribution in Patagonia once encompassed the entire steppe region, where they co-occurred with guanacos (*Lama guanicoe*) at comparable abundances. They also suggested shifts in the species' northern range limit over time. Here, we synthesize the historical distribution of huemul by applying our proposed systematic seven-step assessment process (Díaz & Corti 2025), enabling a rigorous comparison with previous reconstructions that employed less stringent methodologies.

Huemul's occurrence in the steppe

Nine records document huemul sightings in the Patagonian steppe east of 70° 77'W in Argentine Patagonia between 1764 and 1904 (Díaz 1993, 2000). Four were located on the Atlantic coastline and five in the inland steppe. None of these accounts reported the species' abundance. Based on these sparse historical accounts, the processes and environmental conditions determining huemul occurrence in these areas, or whether its presence was consistent through time, remain unknown. Several Isolated observations kilometers from the known range do not necessarily indicate that these areas formed part of the species' distribution, particularly when only nine records exist across an area of ca. 573,674 km^2.

Figure 1. Endangered huemul (*Hippocamelus bisulcus*) male in southern Chile.

Some reports complicate interpretation. For example, despite observing three huemul individuals 80 to 200 km from the Andes, Hatcher (1903, p. 185) noted that this species had never been seen in the plains. Hatcher's observations derive from his work during the Princeton University expeditions in Patagonia (March 1896 – September 1899). In another case, Onelli (1905) mentioned huemul near Choique Nilahue, Chubut Province (44° 94'S; 70° 09'W), but described them as inhabiting forests and clearings (p. 371)**.** Conversely, extensive surveys by some explorers failed to document huemul in the steppe. For instance, Prichard (1902) traveled ca. 3,200 km between 1900 and 1901 and concluded that the range of huemul was restricted to the Andes mountains and their foothills (p. 248). Many similar examples underscore the complexity of interpreting historical records of huemul presence in the steppe. Zooarchaeological remains further emphasize the importance of forests and ecotones in huemul's past distribution (Fernández et al. 2015). A critical review of historical accounts thus provides no robust evidence to support the conclusion that huemul historically occurred across the entire steppe region.

Confusion with other ungulate species

One of the main challenges faced by early explorers in Patagonia was identifying unfamiliar native fauna. To describe these animals, they often compared them to familiar European species, using morphological similarities to propose tentative taxonomic equivalents (Loponte & Acosta 2006). A well-known example is

Antonio Pigafetta's account (1874): "This beast has its head and ears of the size of a mule, the neck and body shaped like a camel, the legs of a deer, and the tail like that of a horse, and it neighs like a horse." This ambiguous description later contributed to false records of huemul presence on the Atlantic coastline. According to Eastman (1915, p. 353), both Pigafetta and Olivier van Noort were in fact observing guanacos in Puerto San Julián and Puerto Deseado, rather than huemul. Such analogies highlight the need to carefully verify the authenticity of historical records in a way that considers and integrates morphological descriptions with ecological and cultural context. Roulin (1835) also noted similar uncertainties in species identification when discussing the López de Gomara expedition (2003). Consequently, any analysis of historical Patagonian records must carefully assess how explorers distinguished guanacos from huemul, as well as the broader observational context in which those accounts were produced.

Northern limit of distribution

The northernmost historically documented limit of the huemul's range is the Cachapoal River basin (34° S) in Chile (Philippi 1892, Osgood 1943). Zooarchaeological evidence for the species occurring further north remains inconclusive. At Las Pozas de Chacabuco in Chilean Patagonia (32°50′ S, 70°43′ W), Labarca et al. (2005) questioned the taxonomic identification of remains, suggesting they may belong to an extinct species. At San Pedro Viejo de Pichasca (30°21′ S, 70°52′ W), the specimens have not been identified to species level (Ampuero & Hidalgo 1975, Ale 2014). A particularly debated case is Tagua Tagua (34°30′ S, 71°06′ W), where Casamiquela (1976) initially attributed remains to *H. bisulcus*. Núñez et al. (1987), with Casamiquela as a co-author, later reclassified them as *Hippocamelus* sp., and more recently, Labarca et al. (2020) argued that they do not belong to huemul. Thus, while the historical accounts suggest the range may have extended further north, current zooarchaeological evidence does not conclusively support this. Additional research is required to confirm the presence of huemul in central Chile. To date, the northernmost confirmed huemul remains are from Marifilo 1 (39° S, 72° W) in Chile and Alero IV del Tromen (38° S, 70° W) in Argentina (Fernández et al. 2015, 2016).

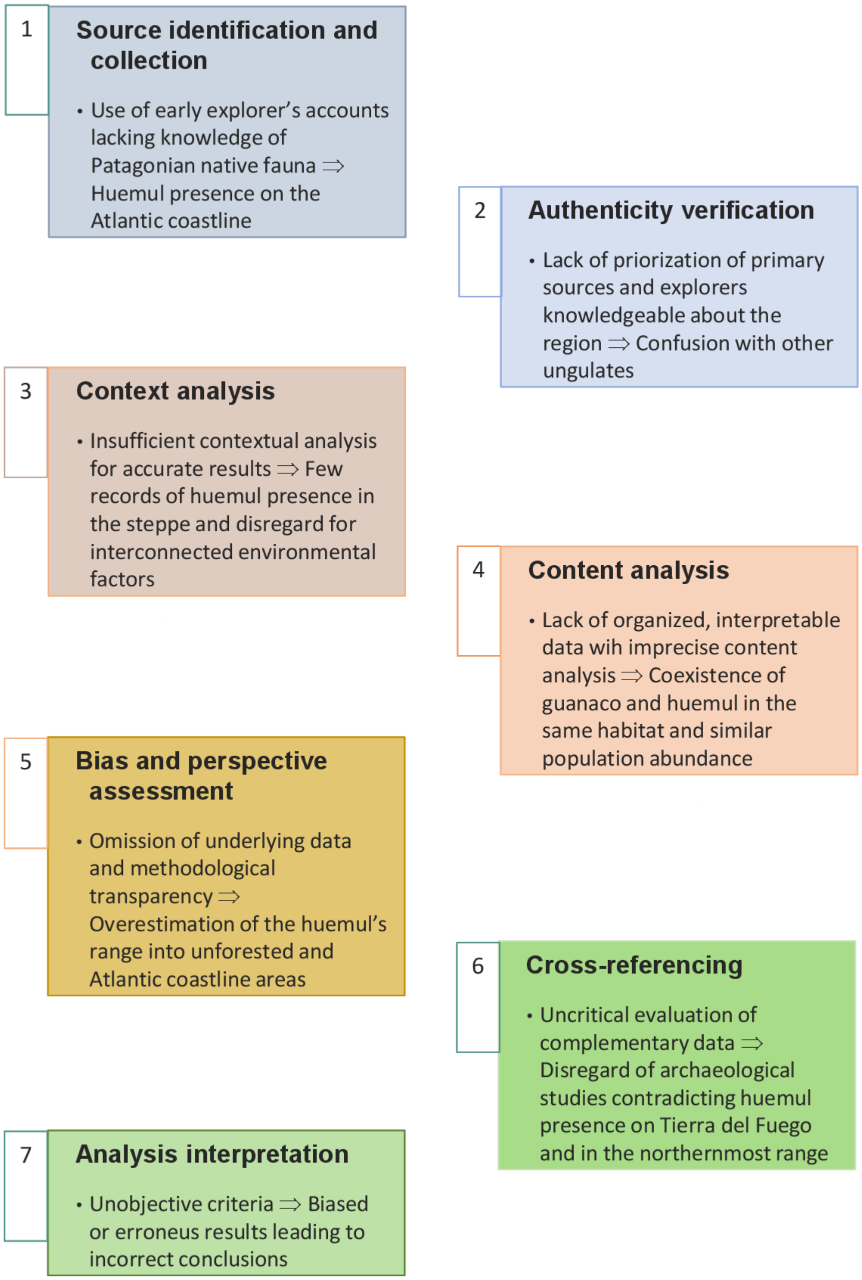
Presence in Tierra del Fuego

Historical accounts by Darwin (1839) and Lista (1881) reported the presence of huemul in Tierra del Fuego Island. In contrast, Osgood (1943, p. 38) highlighted the lack of reliable records, Texera (1973) noted its absence on the island, and Hershkovitz (1987) cited Darwin without providing additional evidence. Only one zooarchaeological record suggests the presence of huemul in Tierra del Fuego Island, corresponding to the Marazzi 1 site (Marazzi river; 53°28′ S, 69°17′ W), first described by Laming-Emperaire et al. (1972). Subsequent analyses of materials from this site (Morello 1999; Calás 2009, 2014) make no further mention of such remains, and no bones attributable to huemul have been identified in other sectors of Marazzi 1 or at nearby sites. Franklin (2022) further argued that these faunal analyses were methodologically superficial. Ethnography provides no additional support: Thomas Bridges (1952, p. 454), a missionary and linguist who lived in Tierra del Fuego Island during the late 19th and early 20th centuries, remarked that “the Onas have no legends about pumas, skunks, or mountain deer, animals found in Patagonia.” Collectively, these historical, archaeological, and ethnographic lines of evidence highlight the lack of conclusive proof for the huemul’s occurrence in Tierra del Fuego and underscore the need for further research.

Coexistence with guanaco

The guanaco exhibits high tolerance for arid conditions and is adapted to a broad range of ecosystems, including deserts, xeric shrublands, mountain grasslands, savannas, and marginal temperate forests (Franklin 1982, González et al. 2006, Puig et al. 2019). In contrast, the huemul has a much more restricted range, primarily associated with Andean environments characterized by southern beech (*Nothofagus* spp.) forests with sparse understory vegetation (Sandvig et al. 2016, Riquelme et al. 2018). Spatial overlaps between guanacos and huemul may occur in transitional ecotones or forest clearings. However, the two species do not necessarily share microhabitats or compete directly for the same resources. This pattern reflects a mosaic distribution and differential habitat use, where each species occupies adjacent but distinct ecological niches. Consequently, spatial overlaps do not imply full ecological coexistence.

A notable example of misleading inference is the use of Burmeister’s (1873) account to assert the coexistence of huemul and guanaco. When Burmeister stated that both species inhabit the same “territory”, it is more reasonable to interpret this as referring to the broader geographical region rather than shared habitat. This interpretation becomes clear when the text is analyzed in full: Burmeister explicitly describes huemul as primarily inhabiting mountain valleys and only occasionally descending to lowlands or steppe. This suggests that while the huemul and guanaco occur within overlapping geographical areas, they do not necessarily share the same ecological niches. Burmeister contrasts the two species, noting that the guanaco is “much more common” and” almost the only animal hunted” by indigenous groups. This implies that the guanaco was more accessible due to their presence in open steppe habitats, where hunting was easier than in the rugged terrain of huemul. Therefore, in this context,” territory” should be interpreted as broad, regional distribution, while the actual habitats used by the two species differ markedly (Vila et al. 2010, Baldi et al. 2016).



1 **Source identification and collection**

- Use of early explorer's accounts lacking knowledge of Patagonian native fauna ⇒ Huemul presence on the Atlantic coastline

2 **Authenticity verification**

- Lack of priorization of primary sources and explorers knowledgeable about the region ⇒ Confusion with other ungulates

3 **Context analysis**

- Insufficient contextual analysis for accurate results ⇒ Few records of huemul presence in the steppe and disregard for interconnected environmental factors

4 **Content analysis**

- Lack of organized, interpretable data wih imprecise content analysis ⇒ Coexistence of guanaco and huemul in the same habitat and similar population abundance

5 **Bias and perspective assessment**

- Omission of underlying data and methodological transparency ⇒ Overestimation of the huemul's range into unforested and Atlantic coastline areas

6 **Cross-referencing**

- Uncritical evaluation of complementary data ⇒ Disregard of archaeological studies contradicting huemul presence on Tierra del Fuego and in the northernmost range

7 **Analysis interpretation**

- Unobjective criteria ⇒ Biased or erroneus results leading to incorrect conclusions

Figure 2. Main methodological weaknesses in Flueck et al. (2022, 2023) analyses of huemul historical range integrated into a seven-step protocol (modified from Díaz & Corti 2025). Errors include misuse of non-expert explorer accounts, poor contextual validation, confusion with other ungulates, omission of contradictory evidence, and biased interpretations leading to an overestimated distribution (see Corti & Díaz 2023, Díaz & Corti 2024).

Conclusions and Recommendations

The huemul is one of the most endangered Neotropical deer species (IUCN 2014). National management plans in Chile and Argentina emphasize the importance of reconstructing the species' historical distribution to establish reference conditions and set effective conservation targets (APN 2002, CONAF et al. 2009). Nevertheless, written historical sources often provide fragmentary and biased evidence, with insufficient information to reliably quantify long-term wildlife trends. Oversimplified interpretations of such data can easily lead to misguided conclusions, particularly in the case of the huemul.

Our previous evaluations challenge the assumptions made by Flueck et al. (2022, 2023) regarding the use of historical sources and archaeological records. Critically, maps depicting a species' historical range must accurately reflect the quality and reliability of the underlying data. In the huemul's case, a small number of scattered records have been used to suggest a widespread past distribution across the entire steppe biome of Patagonia, as reiterated in the distribution map by Smith-Flueck et al. (2024). Although historical sighting records in the steppe do exist, the species' overall presence in this biome remains uncertain and warrants further research.

In this context, we (Díaz & Corti 2025) proposed a seven-step framework for critically assessing historical sources to enhance the accuracy and reliability of such data. Recognizing the inherent gaps and limitations of long-term historical records is essential (Fig. 2). Neglecting these constraints risks producing distorted reconstructions of past species' distribution, which in turn can lead to misinformed conservation strategies.

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Ancient antlers, bones and historic literature add support to the huemul's historical presence in the Patagonian steppe

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Abstract

Discoveries of ancient huemul (*Hippocamelus bisulcus*) remains in steppe areas of Patagonia and historical sightings provide additional evidence that this species once inhabited open environments beyond its present forested range in the Andean foothills and mountain terrain. In this short communication, we present four additional remains, plus four historic references, providing new evidence to complement previous archaeological and historical data (reviewed in Flueck et al. 2022,2023), reinforcing the view that the huemul's former distribution was broader and ecologically more diverse than currently observed. These findings not only enrich our understanding of the species' past ecology but also have important implications for interpreting its decline and guiding future conservation efforts.

Resumen

Los hallazgos de restos antiguas de huemul (*Hippocamelus bisulcus*) en las zonas esteparias de la Patagonia y los avistamientos históricos proporcionan pruebas adicionales de que esta especie habitó en su día en ambientes abiertos más allá de su actual área de distribución forestal en la cordillera y montañas de los Andes. En esta comunicación breve, presentamos cuatro restos adicionales, además de cuatro referencias históricas, que aportan nuevas pruebas para complementan los datos arqueológicos e históricos anteriores (revisados en Flueck et al. 2022, 2023), lo que refuerza la opinión de que la distribución anterior del huemul era más amplia y ecológicamente más diversa de lo que se observa actualmente. Estos hallazgos no solo enriquecen nuestra comprensión de la ecología pasada de la especie, sino que también tienen importantes implicaciones para interpretar su declive y orientar los futuros esfuerzos de conservación.

Keywords: historical range, migration, plasticity, conservation ecology, antlers, zooarchaeology, distribution

Introduction

The huemul (*Hippocamelus bisulcus*) has long been mischaracterized as a strictly mountain-dwelling species (Flueck & Smith-Flueck 2011). However, recent reviews of explorer accounts, archaeological findings, and historical records reveal that this deer once occupied a much broader range across Patagonia, extending well into the steppe. Some populations were resident year-round in these open habitats, while others migrated seasonally between lowland and mountain environments (Flueck et al. 2022, 2023). Unregulated killing and the expansion of cattle and sheep ranching into the most fertile valleys led to the species' disappearance from much of its former range, leaving remnant populations isolated in remote mountain refuges (Flueck et al. 2022, Zuliani et al. 2023). These high-elevation areas, characterized by soils severely deficient in essential trace minerals, now pose additional health challenges to the few surviving huemul (Smith-Flueck et al. 2025). With only an estimated 300–500 individuals remaining in Argentina and no more than about 1,500 across the species' total range (Black-Decima et al. 2015), and numbers continuing to decline, a new conservation strategy is underway that includes reintroductions to former, more productive lowland habitats. Given continued skepticism regarding the huemul's historical presence in the Patagonian steppe, the goal of this study was to determine whether new findings of huemul carcasses further support earlier evidence of the species' former occupation of this region.

Material and Methods

The study area includes the Patagonian steppe of Argentina. We are continually updating our data base at DeerLab on newly discovered huemul antlers and remains and literature related to the historical distribution of this species. In this report, we include those finds not mentioned in our prior publications (Flueck et al. 2022, 2023), narrowed to those discoveries in steppe environments -- in places where huemul have not been sighted in modern times. For four new examples, we include the name of the collector, coordinates of collection site and illustrative map of geography surrounding the discovery site, photo if available or description of antler or bone, and approximate collection date if available. Earth.google.com/web was used to generate maps that show general location of each collected antler for the corresponding latitude and longitude coordinates: the geographic coordinate system (GCS) was used and expressed in the degrees, minutes, seconds (DMS) format. We also include new data on huemul hunted in the steppe and other observations in historic literature, to provide further supporting evidence of their existence in the steppe.

Results

All four skeletal samples plus data on hunted huemul were from the province of Santa Cruz (Table 1, Fig. 1). Collection sites were all in the steppe habitat as seen by the Google Earth generated maps in Fig. 1. Only photos of sample number 2 were available for this publication (Fig. 2).

Table 1. Huemul remains collected and evidence of huemul hunted in the steppe environment of Patagonia, Argentina along with collection data.

SAMPLE NUMBER	SAMPLE DESCRIPTION	LOCATION COORDINATES	LOCATION DESCRIPTION	MAPPED LOCATION	COLLECTORS
1	Antler. We had direct communication with collector.	49° 9'19.50"S, 72° 2'50.00"W	Found close to Cerro Cach Aike, Santa Cruz	See Fig. 1a	Mario Diaz-ex-director Fauna Santa Cruz
2	2-pointed left antler (See Fig. 2)	51° 8'0.91"S, 72° 19'6.66"W	Santa Cruz	See Fig. 1b	Enrique Segundo Ibañez, Estancia El Cazador
3	An antler stored by Ana María and Lidia Hernando that father collected in 1938.	47° 12'49.62"S,70°35'38.35"W	Santa Cruz	See Fig. 1c	Don Procopio Hernando from El Carmen, Santa Cruz
4	Front of cervid cranium from late Holocene.	47° 27'00" S, 68°50'00" W	Santa Cruz	See Fig. 1d	Miotto & Marchionini (2023)
5	Two huemul were hunted during expedition 1877-1880. Collected measurement data from one, a female.	48°10'10.33"S, 71 °3'23.23"W	Ay-Aiken, Rio Chico, Santa Cruz; 70 km from forest	See Fig. 1e	Ramon Lista (1880)

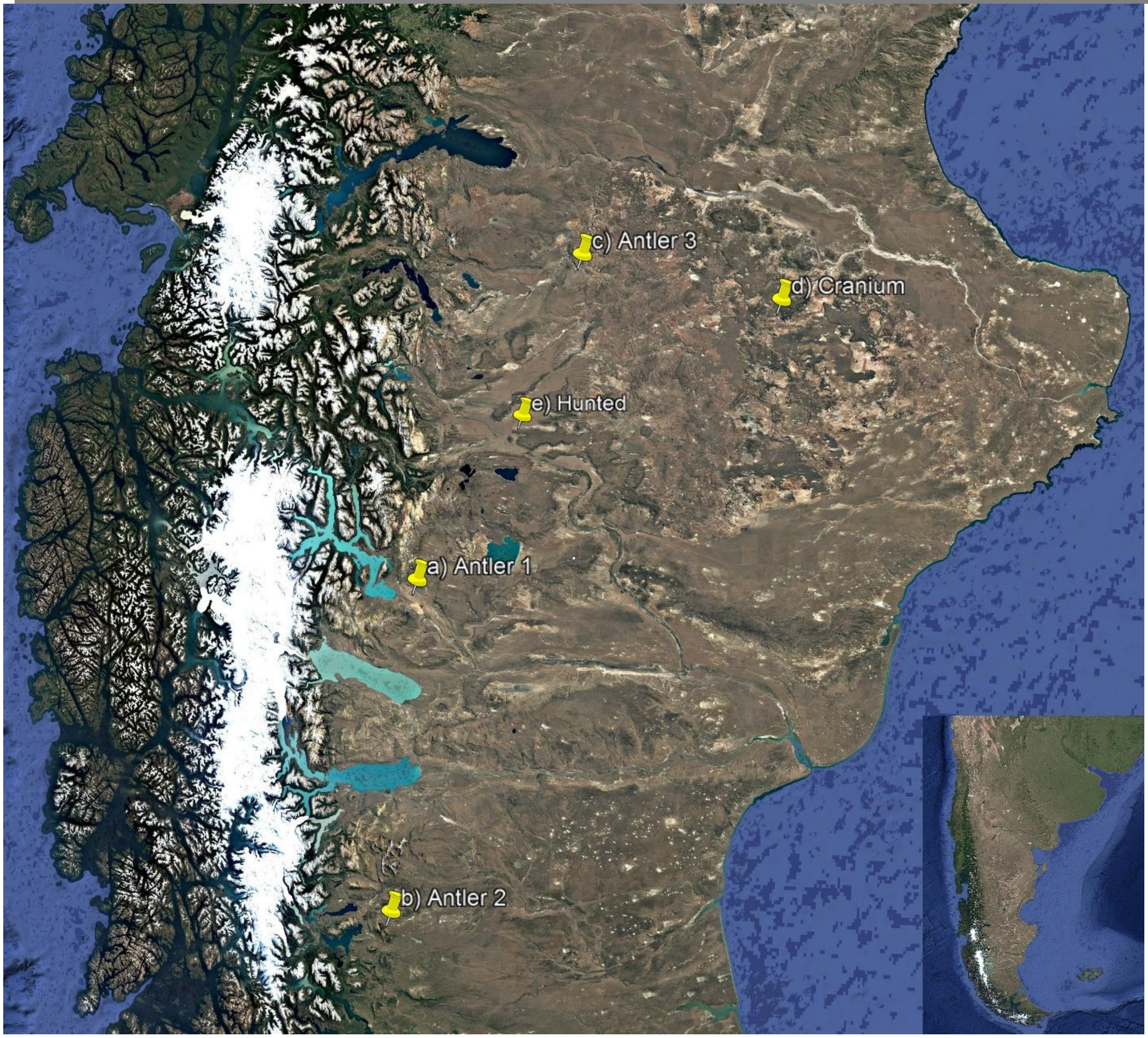

Figure 1. Sites in Santa Cruz province Argentina where three antlers (a-c) and one partial cranium (d) were found, and huemul were hunted (e), revealing a steppe landscape void of forests.

Figure 2. Front and back of a left antler, specimen number #2, collected by Enrique Segundo Ibañez at the Estancia El Cazador.

Furthermore, we located two additional historic publications that mention huemul in relation to the steppe, and one more in relation to migration patterns. Firstly, Minde (1839) wrote, “The *Equus bisulcus* Molina (Huemul or Guemul) is a fabulous animal, whose name nobody in Chile knows. The government probably is likely too weak to sustain their presence in their systems. The huemul likes large and plain grassland and steppe areas to move around in herds.” Secondly, Moreteau (1895) included a photo of a huemul in the open (Figure 3), location unidentified.

Figure 3. Photo of huemul and gaucho on horse in open habitat (Moreteau 1895).

Thirdly, Crivelli (1994) wrote that before the horse arrived, the indigenous Pehuenches, using bow and arrow, mainly hunted guanaco, huemul, greater rhea, and armadillos. The Pehuenches more to the south also went up in summer and back down in winter in pursuit of these same two ungulate prey species.

Discussion

The endangered Patagonian huemul may be the only cervid species in modern times confined year-round to what was once its historical summer range in the mountains. The loss of its former migratory behavior—driven by human activities that extirpated and displaced the species from the more fertile lowland valleys—has left remaining populations restricted to areas with poor soils. This confinement likely explains the severe trace mineral deficiencies and associated health problems observed in many of today's huemul subpopulations (Flueck & Smith-Flueck 2017). A current initiative in Argentina, under the direction of the Directorate of Fauna and Flora of Chubut Province, aims to reintroduce the species to parts of its historical range to alleviate nutritional limitations, improve overall health, and promote population recovery. The success of this effort will depend on close collaboration with local landowners surrounding the reintroduction sites and, in the reestablishment and conservation of historical migratory corridors to connect seasonal ranges.

Some have suggested that the remains found in steppe habitats may have been transported from the western Andean slopes and cordillera by Indigenous people (Díaz 2000). While this possibility cannot be entirely excluded, several lines of evidence argue against it for the antler samples. These samples (Antlers #1, 2, and 3) were not found in archaeological contexts such as middens or caves containing other animal remains, but rather buried in the soil after long exposure to natural processes. In the absence of associated huemul bones or other faunal material, the most plausible explanation is that they were shed naturally by males during the annual antler drop in mid to late winter (Smith-Flueck et al. 2025). This period coincides with both migratory and resident huemul occupying steppe habitats (Flueck et al. 2022), increasing the likelihood that shed antlers were occasionally deposited and preserved in the region’s dry soils. The rarity of such finds is likely influenced by the extremely low human population density throughout the Patagonian steppe (1–2 persons per km^2) and by the fact that most travel across these grasslands occurs on horseback, limiting ground-level visibility for locating such remains.

Conclusion

The additional evidence presented here strengthens the case that huemul once occupied steppe environments as part of their natural range, alongside migratory and resident populations. Recognizing this broader historical distribution is essential for guiding current recovery efforts, including planned reintroductions into more productive lowland habitats with connectivity to summer ranges, thus allowing potential to re-establish migratory behavior. Restoring access to such environments may not only help address the severe nutritional limitations observed in present mountain populations but also contribute to rebuilding a more resilient and self-sustaining huemul population across Patagonia.

Acknowledgments.

We thank Lucas Thomas, Sebastián di Martino, and Mario Díaz for contributing antler data essential to this research project.

Ethical statement

None of these samples are in our collection, nor were government permits required for this research.

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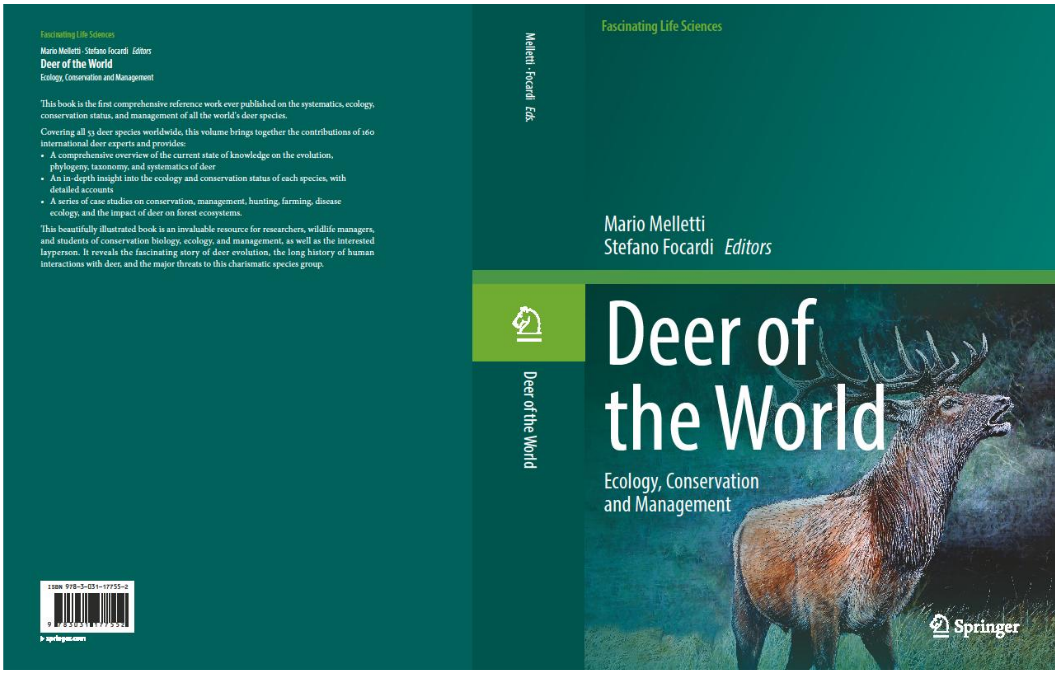
Deer of the World: Ecology, Conservation and Management

Mario Melletti, PhD
Deer Specialist Group (DSG), SSC, IUCN
Wild Pig Specialist Group (WPSG), SSC, IUCN
African Buffalo Initiative Group (AfBIG), SSC, ASG, IUCN

The proposal to produce a comprehensive volume on all deer species worldwide originated in 2018 during a wild boar symposium in the Czech Republic, when Stefano and I recognized that such a work would serve as a valuable resource not only for specialists—researchers, wildlife managers, and conservation practitioners—but also for a broader, non-specialist readership. In 2019, we started the project framework during fieldwork in Kibale National Park, Uganda. From the outset we sought to condensate the most salient topics that would be useful across a wide spectrum of users, while acknowledging the practical constraints of scope: it was not feasible to treat every conceivable aspect of cervid biology, ecology, management, and conservation given limitations of space, length, time, and cost inherent to a project of this magnitude.

We contacted more than 160 deer experts worldwide; many responded positively and expressed enthusiasm for contributing. Ultimately, the book includes contributions from 160 authors, whose geographic coverage extends from Alaska to New Zealand and from the Russian Far East to Patagonia. These contributors represent more than 30 countries and are affiliated with a variety of institutions, research centres, non-governmental organizations, and the IUCN SSC Deer Specialist Group.



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Deer of the World

Fascinating Life Sciences

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Deer of the World

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Figure 1. Cover of the book Deer of the World (Melletti & Focardi). Link: https://link.springer.com/book/10.1007/978-3-031-17756-9

The compilation required five years of concerted effort and encountered several delays, a common outcome when coordinating a large, multi-author volume. A notable impediment was limited cooperation from researchers in China, which regrettably delayed the preparation of certain chapters and, consequently, the overall schedule. Another significant challenge was reconciling divergent viewpoints among contributors regarding systematics and taxonomy for particular deer groups. We have tried to maintain consistency across the book's 63 chapters, although achieving unanimous agreement among all authors was not always possible.

We acknowledge that, despite rigorous efforts, some errors or inconsistencies may remain; we have taken care to minimize these and ask the reader's understanding where imperfections persist. It has been a lengthy and demanding process to assemble this extensive body of information, and we have valued the close collaboration with so many colleagues. We trust that this volume will be appreciated by the scientific community and by a wider audience alike.

Looking forward, the conservation prospects for deer—especially threatened species in tropical regions—will depend on the effective application of both traditional and innovative conservation strategies in the field, and on achieving an appropriate balance between the needs of local human communities and those of deer populations.

11th International Deer Biology Congress report.

David Stevens[1] and Jo Anne Smith Flueck[2]
Local Organizing Committee Chair
Scientific Steering Committee Chair

After 43 years since the original *Biology of Deer* congress was held in Dunedin in 1983, the 11th International Deer Biology Congress returned to Dunedin, New Zealand, from 10–13 February 2026. The meeting brought together 162 participants from at least 19 countries, including representatives from New Zealand (70), North America (40), Europe (28), Asia (17; Japan, China, and India), Australia (4), and South America (3; Brazil and Argentina).

The Congress was opened by Dr Ken Drew (New Zealand) who inaugurated the original Congress in 1983, with supporting remarks from Dr Laszlo Sugar (Hungary). An overview of the New Zealand Deer Industry was provided by Deer Industry NZ Chief Executive, Rhys Griffiths.

Sessions included Deer farming, Ecology, Environmental impacts and ecosystems services, Deer Health, Disease and well-being, Genetics and genomics of deer, Game management and hunting: wild and Estate, Deer Physiology and nutrition, Deer biology and behaviour, Conservation: in situ and breeding centres and Deer products, and finally Policy and management of overabundant deer. Each of these topics was well received with 105 papers being accepted. Of these, eight of nine plenaries, an additional full paper and 50 extended abstracts (3+ pages each) will be published in 2026 as a Special Collection in Animal Production Science, the Australian CSIRO Publishing peer-reviewed journal. The 8 plenary papers and the one other full paper have all passed through the APS review process. The 50 extended abstracts have all been reviewed for "soundness" by the Local Organizing Committee and the Scientific Steering Committee. All of the Collection articles are citable.

There were nine Plenary talks given. These included *Cam Speedy (New Zealand)* presenting '*The value and consequence of your deer here: A cultural paradox'* outlining the history of deer in New Zealand, impacts on the native flora and fauna, and contribution to New Zealand culture. Professor *Iain Gordon (Scotland and Australia)* presented '*Forty-five years of studying deer: a personal reflection of the past, present and future of deer research'* providing a view on the future of deer research, given the body of understanding that has been developed in deer biology and behaviour. Dr *Kurt VerCauteren (USA)* described the development of practical and scientifically robust strategies for addressing challenges when wild and domestic species interact in his presentation *'Managing agricultural damage and disease of deer through applied research: One team's contribution'.* The '*Development of genomic tools for genetic improvement in New Zealand deer*' by Dr *Suzanne Rowe (New Zealand)* highlighted the progress available to understand genetic variations and achieve breeding targets within managed deer populations. The complexity of achieving good outcomes for the management of Cervids across multiple jurisdictions was highlighted by Dr *Jim Heffelfinger (USA)* when presenting '*Cervid conservation in North America: Managing across a mosaic of jurisdictions*. The lessons from chronobiology were explored by Dr *David Hazlerigg (Norway)* providing perspectives into the impacts of chronobiology on animal responses and management implications with *''What can chronobiology tell us about cervids? What can cervids tell us about chronobiology and why should we care?'*. Dr *Kevin Monteith (USA)* proposed the framework of nutritional ecotypes as a way to understand and manage populations of deer presenting '*Nutritional legacies across space and time: Evidence for a nutritional ecotype'*. The advances in using deer products were highlighted by Dr *Chunyi Li (China)* talking on '*Antler stem cells: Discovery attributes and potential clinical applications'* outlining recent progress in therapy of a range of debilitating diseases (Fig. 1 B).

Figures 1. A) Amanda VanBuskirk- Bubenik Award 2026, and B) Chunyi Li plenary speaker.

Figures 2. A) Gordon Dyden & Francisco Cacaero , and B) David Stevens and Jim Heffelfingerat deer farmer

At the 10th IDBC, the George Bubenik Award was introduced for the best young presenter, replacing the former Tony Bubenik Memorial Award (Bubenik 2002; Sugar et al. 2023). For the 11th IDBC, the award was renamed the Tony and George Bubenik Memorial Award to commemorate both scientists. A six-member panel (chair: Jimmy Suttie; Eva Wiklund; Randall DeYoung; Koichi Kaji; Jo Anne Smith-Flueck; and Gordon Dryden) evaluated presentations, with a minimum of two reviewers assigned to each. The award was presented to Amanda Van Buskirk (West Virginia University, USA) for her work integrating camera trap data with population models to improve predictions of local deer populations (Fig. 1 A).

There were two half-day fieldtrips, which included visiting a local farming enterprise (Puketapu farm) and the Invermay Research and Commercial Deer Processing Facility. Topics included genetics, production systems, GHG measurement, disease control and pasture management. Participants also visited the Orokonui Ecosanctuary - Te Korowai o Mihiwaka – to learn about past and present flora and fauna of New Zealand, with guides presenting the natural history of the various flightless Moa birds that were hunted to extinction by the Māori around 1400–1445 AD Fg. 2B=.

Sponsors of the event included Deer Industry NZ, BSI AgResearch, TR Ellett Research Trust, Kamahi Electronics, MPI On-Farm, Genomnz, Silver Fern Farms, Vectronic Aerospace, Lotek, Tourism NZ, and Ian Spiers Memorial Trust.

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