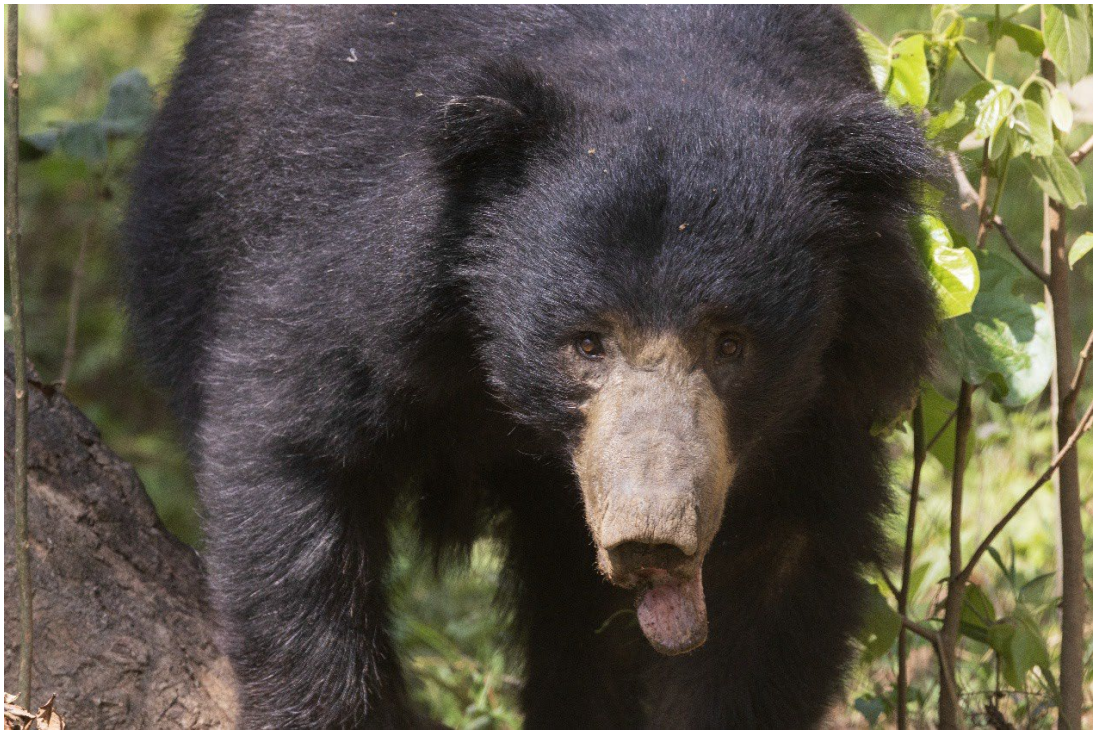
Dry Season Dietary Ecology of Sloth Bears (*Melursus ursinus)* in Chitwan National Park, Nepal

Shirish Acharya



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Dry Season Dietary Ecology of Sloth Bears (Melursus ursinus) in Chitwan National Park, Nepal

Foraging strategies shaped by elevation, habitat type, and tiger presence.

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Abstract

The sloth bear (*Melursus ursinus*) is a myrmecophagous species that depends heavily on termites and ants during the dry season when fruit resources decline. Studying this dietary reliance is vital for understanding how sloth bears adapt to seasonal shortages while navigating ecological pressures such as predators and human disturbance. In the Madi–Bagai sector of Chitwan National Park, Nepal—a landscape marked by habitat diversity and human–wildlife conflict—this study used scat analysis (n = 61) and habitat surveys across 291.85 km² to examine how diet varies with elevation, forest type, predator presence, and human disturbance. Termites were the dominant prey (80.3%), followed by ants (15.5%), particularly *Camponotus* and *Pheidole*. Termite occurrence increased with elevation and was highest in grasslands and riverine forests, while ant fragments declined with elevation and were most common in Sal forests. Tiger detections correlated with higher termite intake and reduced ant consumption. This suggests a predator-driven dietary shift consistent with the "landscape of fear" mechanism, where sloth bears adjust foraging to avoid predation risk. Human disturbance scores showed no significant relationship with scat density. These termite and ant use patterns reflect a flexible foraging strategy that responds to environmental gradients and predator cues. By linking diet composition to ecological variables and spatial risk, the study highlights the need to conserve diverse microhabitats, especially termite-rich zones, within human-impacted landscapes.

Keywords: Sloth bear, myrmecophagy, predator-mediated foraging, Chitwan National Park, scat analysis, dry season diet, habitat use, HDI, Nepal

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Abbreviations

Abbreviation	Description
CNP	Chitwan National Park
GLM	Generalized Linear Model
PFO	Percent Frequency of Occurrence
SE	Standard Error
HDI	Human-Disturbance Index
CI	Confidence Interval

1. Introduction

The sloth bear (*Melursus ursinus,* Shaw & Nodder (1790))is a medium-sized bear species listed as "Vulnerable" on the IUCN Red List of Threatened Species, indicating a risk of extinction in the wild (Dharaiya et al., 2020). This species is endemic to the Indian subcontinent and exhibits a range of unique morphological adaptations. These adaptations include a protrusible snout, long and flexible lips, powerful forelimbs, and a lack of upper incisors, all of which are specialised for myrmecophagy—feeding on social insects such as termites and ants (Ewer, 1973; Laurie & Seidensticker, 1977; Prater, 1971).

Termites and ants make up the primary diet of sloth bears throughout the year (Joshi et al., 1997; Laurie & Seidensticker, 1977; Rabari & Dharaiya, 2022). Fruits comprise 70 to 90% of the diet during the fruiting season. Outside of this period, termites and other insects account for more than 80% of the dietary intake (Ratnayeke et al., 2007; Seidensticker et al., 2011; Yoganand et al., 2012). Termite mound density and fruiting tree presence strongly predict foraging behaviour and spatial use in sloth bears (Paudel et al., 2022). Seasonal shifts in resource use are standard, with termites dominating the non-fruiting season diet and fruits like *Ziziphus*, *Ficus*, and *Aegle marmelos* becoming more important during the fruiting season (Joshi et al., 1997; Palei et al., 2020).

In addition to termites, ants represent a seasonally variable and spatially important insect prey group, although their contribution has been less frequently quantified. Recent surveys in Nepal have documented over 128 species and 48 genera of ants, particularly within the Myrmicinae and Formicinae subfamilies, across diverse habitats including Sal, *Schima–Castanopsis*, and riverine forests (Subedi et al., 2020, 2021). Chitwan National Park (CNP) supports the highest ant diversity. Subfamilies such as Myrmicinae and Formicinae—dominated by genera like *Camponotus*, *Pheidole*, *Crematogaster*, and *Tetramorium*—are especially common in these habitats (Subedi et al., 2021). These genera form large, conspicuous colonies in microhabitats accessible to sloth bears. They potentially contribute to the diet, particularly when termite abundance is low or in structurally complex environments supporting diverse invertebrate communities. Sal forest is the dominant cover in CNP, occupying roughly 70 % of the landscape, followed by grassland (12 %), riverine forest (7 %), exposed surfaces (5 %), and open water (3 %) (CNP, 2013). The mosaic of Sal, grassland, and riverine habitats within CNP provides critical foraging and denning sites for sloth bears (Dinerstein, 1979). In contrast, Churia hills recorded extremely low sloth bear occupancy, attributed to habitat degradation and extraction pressure from unsustainable harvesting of timber, fodder, and firewood (Sharma et al., 2023). Sloth bears exhibited scale-dependent habitat selection, responding to key environmental variables such as river density at fine scales (~1 km) and land

cover types—including sal forest, dry deciduous forest, farmlands, and degraded patches—at broader scales (>5 km). This hierarchical selection enables them to use natural and human-modified landscapes in central India (Rather et al., 2021) and potentially in Nepal.

Sloth bears exhibit notably aggressive behaviours when confronted by tigers, their principal natural predator. Rather than fleeing, they often engage in defensive posturing, such as standing on their hind legs and initiating rapid charges. A study analysing 43 documented encounters found that in 86% of cases, the confrontation ended without physical conflict, suggesting the efficacy of these defensive displays in deterring predation—particularly given that sloth bears, adapted to digging termites with blunt claws, lack arboreal escape options and often forage with their heads down, leaving them vulnerable to surprise attacks (Sharp et al., 2024). Sloth bears often display intense aggression toward humans, a behaviour believed to be an extension of their evolved defensive strategy against natural predators. When surprised at close quarters—common in fragmented or degraded habitats—they may charge without provocation, causing severe injuries (Sharp et al., 2024). This aggressive response is not predatory but defensive, shaped by their sensory limitations, head-down foraging behaviour, and inability to escape by climbing.

The sloth bear, distributed across fragmented habitats in India, Nepal, and Sri Lanka, faces threats from habitat degradation and human encroachment. Anthropogenic pressures, including agricultural expansion, livestock grazing, fuelwood collection, and the harvest of non-timber forest products, have intensified bear–human encounters, particularly in buffer zones where human activity intersects with degraded forest edges (Ghimire & Thapa, 2014; Silwal et al., 2017). Sloth bear persistence in human-dominated landscapes is shaped by habitat loss, fine-scale patterns of disturbance, and resource distribution (Pokharel et al., 2022). Paudel (2023) linked disturbance to reduced occupancy, but the composite index limits clarity on which disturbance types are most impactful. Sharma et al. (2023) using site-level camera trap data, we showed that bears may tolerate some human presence but avoid areas with high livestock activity.

The present study, conducted during the dry season in CNP's Madi–Thori sector, (a) quantifies sloth-bear diet composition with ants resolved to genus, (b) tests whether elevation, forest type, and predator detections (tiger, leopard) are associated with the occurrence of termite and ant fragments in scats, and (c) evaluates whether a grid-level Human-Disturbance Index (HDI) correlates with scat density. Insights from these analyses are intended to guide habitat-based strategies that reduce human–bear conflict while maintaining critical foraging areas.

2. Materials and Methods

2.1 Study Area

CNP in Nepal's lowland Terai is one of the region's most important strongholds for sloth bears. As a representative of the Terai ecosystem, CNP has been prominently featured in various regional ecological assessments due to its critical role in preserving large mammal communities, including sloth bears and their prey base (Stillfried et al., 2015). CNP spans 952.63 km² in south-central Nepal, with an additional 729.37 km² designated as a buffer zone under the Buffer Zone Management Regulation (1996). The park is divided into four management sectors: Eastern (Sauraha), Mid (Kasara), Western (Amaltari), and Southern (Madi–Bagai) (CNP, 2013). The study was conducted in the Madi–Bagai sector, which covers 319.64 km² and borders the Someshwar Hill Range and the Churia Hills. This landscape is home to a variety of unique species, including the Bengal tiger (*Panthera tigris*), one-horned rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus),* and common leopard (*Panthera pardus*). The area is a human–wildlife conflict hotspot due to its proximity to settlements and subsistence agriculture (Joshi et al., 1999).

2.2 Grid Design, Sampling Strategy, and Field Survey

To facilitate systematic data collection, the study area was divided into 40 grid cells of approximately 4 × 4 km using ArcGIS, consistent with approaches used in sloth bear occupancy studies (Paudel, 2023). Segments obstructed or inaccessible due to natural or anthropogenic reasons were not analysed. Given access limitations and unsuitable terrain, 12 grids were excluded from sampling—eight due to insufficient effective area (yellow fill), two due to inaccessibility along the international border (solid red fill), and two due to hazardous terrain and presence of wild elephants (brown diagonal hatching)—resulting in a total of 28 surveyed grids covering 291.85 km² (see *Figure 1*).

Sample collection occurred from October 18, 2024, to February 4, 2025. Each grid was surveyed for 4km along the pathway with a random starting point, subdivided into twenty 200-meter segments, including roads, forest trails, and riverbanks (Appendix 1). Trained technicians identified scat samples using supporting cues like pugmarks, foraging signs, and local ecological knowledge.

With the help of GPS units (Garmin eTrex 10), 506 GPS-referenced locations were surveyed. Microhabitat features were recorded at each site, including footprints, tree markings, dens, dig sites, and new or old termite mounds. Termite mounds were further classified based on whether they showed evidence of sloth bears foraging. Mounds exhibiting broken surfaces, claw marks, or nearby tracks

were categorised as foraged. Observations of fruiting trees and signs of human disturbance—including army patrols, tourists, jungle walks, jeep safaris, elephant rides, and residents collecting firewood or feeding livestock—were documented to assess habitat disturbance. The type of land cover at each site (e.g., sal forest, grassland, mixed forest, riverine forest, and swamp land) and water availability were also recorded.

When sloth bear scat samples were encountered in the field, their estimated age and any evidence of leopard or tiger presence, such as tracks or other signs within a 500-meter radius, were recorded. Ants and termites were collected within a 200-meter radius of each scat sample using pitfall traps or hand collection methods, depending on whether the trail would be reused. All specimens were preserved in 99% ethanol and tagged for later identification. Pitfall trapping is a widely accepted method for sampling ground-dwelling insects (Andersen, 1991; Schmidt & Solar, 2010), while hand collection is used in settings with logistical constraints (AntWiki, 2023; Bestelmeyer et al., 2000). Collected samples were labelled, georeferenced, sun-dried, and stored in a cool, dry location until laboratory analysis, following procedures described by Joshi et al. (1997) and Khanal & Thapa (2014).

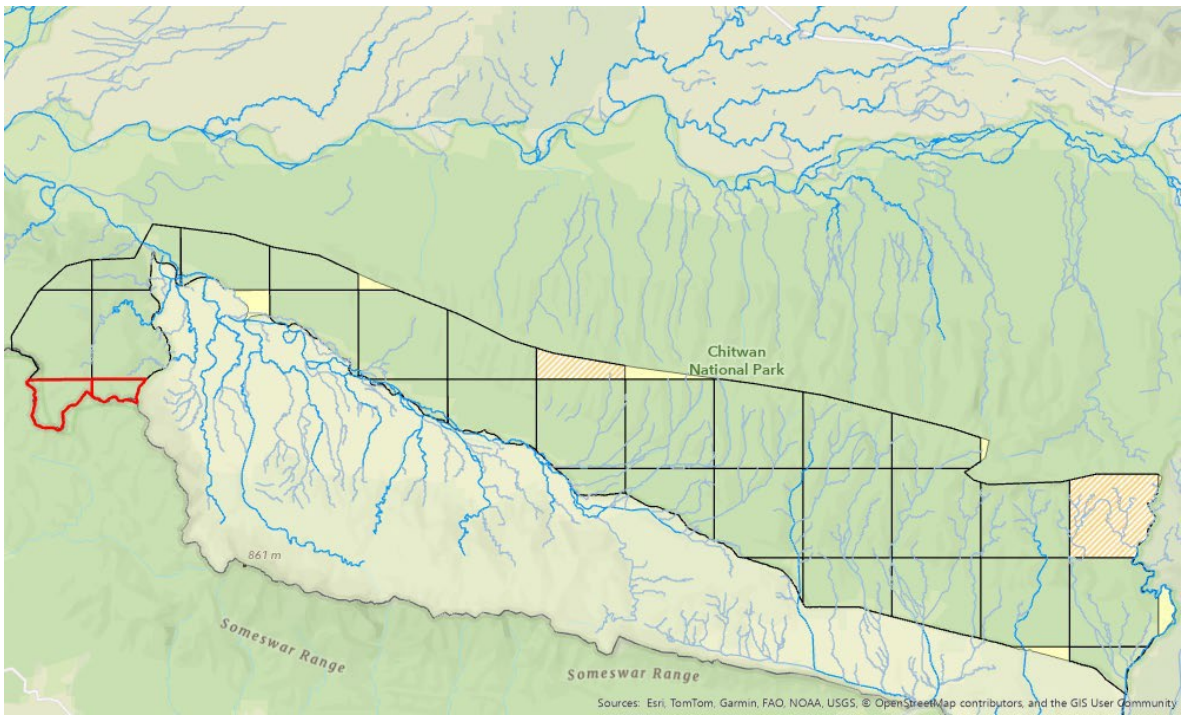

Figure 1 Study area map of the Madi–Bagai sector, Chitwan National Park, showing surveyed grid cells. (Photo credit: Esri ArcGIS Pro)

2.3 Human-Disturbance Index (HDI)

At every 200-m habitat–survey waypoint, observers assigned a Human Invasion score on a four-point ordinal scale (0 = no visible human influence; 1 = faint footpath or occasional litter; 2 = army patrol, tourist, clear trail, recent grazing or active litter; 3 = excessive human track, safari vehicle, wide vehicle track, active livestock, multiple cut stumps or fresh campfire). Scores from all waypoints within a 4 × 4 km grid were averaged to yield a raw Human-Disturbance Index (HDI; range 0–3). Because this metric describes habitat rather than bears, grids with no scats still retained an HDI value. Raw scores were then centred and divided by their standard deviation to create a standardised predictor $HHHHHH_{zz}$, which was entered as (a) a continuous variable in a Pearson correlation with encounter rate and (b) a fixed effect in a negative-binomial generalised linear model (GLM) predicting grid-level scat counts, with log(kilometres walked) included as an offset.

2.4 Laboratory Procedures

Once transported to the field laboratory, each sample was weighed and soaked in tap water in a plastic container for approximately 24 hours. Following the soaking period, samples were thoroughly rinsed under running water using a two-stage sieve system (0.7 mm and 0.4 mm mesh) to separate undigested residues from fine soil and digested material (Joshi et al., 1997; Mewada, 2015). After washing, the remaining material was weighed again.

The retained material was evenly distributed across two Petri dishes, each corresponding to one of the sieve mesh sizes. The larger Petri dish contained coarser fragments, including seeds, insect heads, and other sizable components, while the smaller dish held finer elements, such as legs and antennae. These were later reconstructed for taxonomic identification using visual matching techniques.

Undigested items were categorised into six groups: plant fragments, ants, termites, bees, beetles, and miscellaneous materials. Food components were identified using a dissecting microscope and compared against a curated reference collection of seed and insect specimens (Bestelmeyer et al., 2000). The percent frequency of occurrence (PFO) for each category was determined by dividing the number of samples in which the item appeared by the total number of samples and multiplying the result by 100. This method is widely used in dietary studies of carnivores (Klare et al., 2011) and provides a standardised measure of how frequently different dietary components occur across the population. This approach detects subtle patterns in sloth bear feeding behaviour and reduces bias in digestibility across food categories. This method minimised the risk of overestimating indigestible components and underrepresenting more easily digested ones.

3. Results

3.1 Scat Survey Effort and Habitat Distribution of Scats

The survey efforts resulted in 90 sloth bear scats detected in and around the study grid. Of these, 19 were located outside the systematic 4 × 4 km cells and excluded, leaving 61 scats for ecological analyses. Of these, 55 were detected along the 466 planned transect waypoints (93.2 km total search effort), while 6 were found opportunistically between transects. Only the transect scats were used in the encounter-rate calculation to avoid inflating effort-standardised density, yielding $\lambda = 55 / 93.2$ km = 0.590 scats km^{1}. All 61 in-grid scats were retained for diet and habitat-correlation models. Scats were observed in 21 of the 28 sampled cells, indicating a naive occupancy of 75%. Habitat-wise, 45 samples were found in Sal forest (73.8%), 9 in mixed forest (14.8%), 4 in riverine forest (6.6%), and 3 in grassland (4.9%).

3.2 Diet Composition

The scat analysis revealed diet composition (Figure 2, Left): Termites constitute 80.30 % of all items, while Ants represent 15.54 % as a combined category. Beetles, plant material, bees, and unknown items each account for less than 2 %. Furthermore, the 15.54% ant content was analysed in detail (Figure 2, Right), presenting the taxonomic breakdown at the genus level based on the microscopic identification of diagnostic sclerites.

The breakdown of ant genera reveals that *Camponotus* and *Pheidole* comprised the majority of identifiable ant remains, accounting for 42.83% and 28.80%, respectively. Other genera—*Crematogaster* (9.07%), *Odontoponera* (6.12%), *Dorylus* (4.75%), *Polyrhachis* (3.69%), *Carebara* (1.90%), and *Ectomomyrmex* (0.84%)—formed smaller but consistent components. Genera such as *Oecophylla*, *Monomorium*, *Leptogenys*, *Pseudomyrmex*, and *Diacamma* appeared only in trace amounts (< 0.60% each).

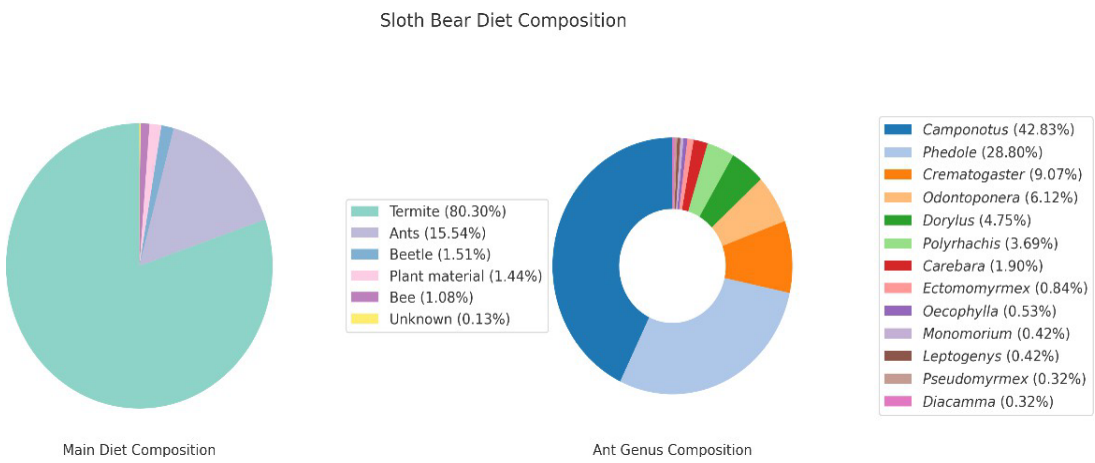

Figure 2 Left: Full pie shows proportions of main diet components(n=61). Right: Donut chart breaks down all ant genera. (Generated in Python 3.x)

3.3 Altitudinal Correlations

Binomial Generalized Linear Model (GLM) analyses revealed distinct dietary shifts with elevation in sloth bear scats across the study transects (Table 1). After z-scaling elevation, where one unit corresponds to a 92.35-meter increase from the mean, the odds of detecting termite fragments increased by approximately 22% per standard deviation. Plant material showed a more pronounced rise of 73%, and bee fragments increased modestly by about 27%. In contrast, beetle fragments declined by nearly 50%, and ant fragments, aggregated across 13 identified genera, dropped by roughly 25%.

Table 1 Effects of scaled elevation on the presence of dietary components in sloth-bear scats (n = 61).

Dietary Component	Estimation	SE	z-value	p-value	95% CI
Termite	+0.197	0.035	5.645	< .001	[0.129, 0.266]
Plant Material	+0.548	0.091	6.036	< .001	[0.368, 0.725]
Beetle	–0.830	0.170	–4.870	< .001	[–1.186, –0.516]
Bee	+0.241	0.112	2.145	.032	[0.014, 0.457]
Ant (13 genera)	–0.290	0.040	–7.191	< .001	[–0.369, –0.212]

3.4 Habitat-type correlations

Forest type showed a strong, habitat-specific signature in the insect-based diet of sloth bears (Table 2). Binomial GLMs revealed that the odds of detecting termite and ant fragments in scats varied significantly across habitat types. Termite fragments were significantly to occur in grassland and riverine forests, with the odds five times higher in grassland than in the mean ($b = 1.52$, $p < .001$). In contrast, termite fragments were less in Sal ($b = –0.16$, $p = .032$) and mixed forests ($b = –0.27$, $p = .002$).

Ant fragments followed an inverse trend. The odds of detecting ants were significantly higher in the Sal forest ($b = 0.39$, $p < .001$), but dropped sharply in the grassland ($b = –2.44$, $p < .001$), where they were approximately 92% less. Riverine forest showed a marginal, non-significant decline in ant occurrence ($b = –0.29$, $p = .061$), while mixed forest did not differ significantly from the mean ($b = –0.01$, $p = .931$).

Table 2 Associations between forest type and insect fragments in sloth-bear scats.

Forest Type	Diet Component	b	SE	z	p
Sal forest	Termite	–0.16	0.08	–2.14	.032
Sal forest	Ants	0.39	0.09	4.45	<0.001
Mixed forest	Termite	–0.27	0.09	–3.14	.002
Mixed forest	Ants	–0.01	0.10	–0.09	.931
Riverine forest	Termite	0.39	0.15	2.69	.007
Riverine forest	Ants	–0.29	0.16	–1.87	.061
Grassland	Termite	1.52	0.26	5.86	< .001
Grassland	Ants	–2.44	0.45	–5.39	< .001

3.5 Predator Detections

Binomial logistic regressions evaluated whether tigers or leopards were associated with the odds of detecting termite and ant fragments in sloth-bear scats (Table 3). Tiger presence correlated positively with termite occurrence and negatively with ant occurrence. Leopard presence showed a weaker positive correlation with termite fragments and was not significantly related to ant fragments.

Table 3 Associations Between Predator Identity and Insect Fragments (Termites and Ants) in Scats

Predator	Diet Component	b	SE	z	p
Tiger	Termite	0.68	0.07	9.62	< .001
Tiger	Ants	–0.76	0.08	–10.05	< .001
Leopard	Termite	0.16	0.06	2.45	.014
Leopard	Ants	–0.02	0.07	–0.28	.779

3.6 Human Disturbance

The mean HDI across the 28 surveyed grids was 1.45 (SD = 1.18, range 0–3). HDI was not correlated with the effort-standardised scat-encounter rate, r (26) = .12, p = .56, 95 % CI [–.27, .47]. Consistent with this finding, the negative-binomial GLM revealed no significant relationship between $HHHHHH_{zz}$ and the number of scats per grid, β = 0.19, SE = 0.19, z = 0.98, p = .33, 95 % CI [–0.19, 0.57]; the intercept predicted 0.59 scats·km^{-1} at the mean disturbance level.

Table 4 The negative-binomial model of scat counts as a function of standardised HDI (n = 28).

Term	Estimate (β)	SE	z	p	Rate ratio
Intercept	–0.473	0.186	–2.54	.011	0.62
$HHHHHH_{zz}$	0.188	0.192	0.98	.329	1.21

4. Discussion

GLMs with a binomial error distribution and logit link were used to examine diet composition patterns. Each diet item—termite, ants (summed across 13 genera), beetles, plant material, and bees—was modelled independently using the proportion of presence per scat sample (`cbind(present, 100 - present))` as the response variable. Scaled elevation (z-transformed) was included as a continuous predictor in a separate model for each component. Additional binomial GLMs assessed the effect of individual predator species and forest types (e.g., Sal, riverine, grassland) as binary predictors.

To evaluate the effect of human disturbance on sloth bear activity, a negative binomial GLM was fitted with the number of scats collected per grid as the response and the scaled Human Disturbance Index (HDI) as the predictor. An offset term (log-transformed survey effort in km walked) was included to account for unequal sampling effort across grids. All analyses were conducted in R using

base `glm()` and `Mass::glm.nb()`, and model outputs were interpreted using estimated coefficients, confidence intervals, and p-values.

4.1 Significant role of insect prey

Termites overwhelmingly dominated the sloth bear diet, accounting for 80.3% of all prey items, reinforcing their role as specialised myrmecophages. Camponotus (6.7%) and Pheidole (4.5%) were most frequently identified among ant fragments at the genus level. These taxa form large colonies and possess heavily sclerotised exoskeletons, enhancing their detectability in scat due to fragment durability. This detection bias has been documented in bear diet studies, including American black bears and Asian black bears, where insect taxa with harder exoskeletons were disproportionately represented in scat samples (Greenleaf et al., 2009; Tezuka et al., 2022). The prominence of these genera may also reflect genuine selectivity, as similar foraging patterns have been observed in other ursids, such as the American black bear, which targets large-bodied ants (Noyce et al., 1997).

This dry-season reliance on termites and ants reflects a strategy that maximises nutrient yield when fruits are scarce. Termites, especially winged alates from the genus *Macrotermes*, contain high levels of protein (32.2–44.8%) and fat (41.2–49.1%), making them a vital energy resource (Cheseto et al., 2024; Kinyuru et al., 2013). While this nutritional value underscores their importance in the dry-season diet, reliance on PFO as a dietary metric has inherent limitations. PFO does not account for the biomass or digestibility of prey items, which may result in an overrepresentation of taxa with durable structures. Hard-bodied insects such as ants and termites may thus appear disproportionately abundant in scat-based analyses due to fragment survivability, a pattern corroborated by video and molecular comparisons in other bear species (Tezuka et al., 2022).

4.2 Altitude and seasonal movement

Elevation showed opposing correlations for subterranean versus surface prey: odds of termite fragments and plant material rose with altitude, whereas ants and beetles declined. One explanation is that cooler, moister upland soils favour termite mound persistence while dampening surface ant activity (Seidensticker et al., 2011). Elevation also proxies seasonal habitat use; radio-tracked bears in Chitwan move upslope in late monsoon to exploit ripening fruits (Joshi et al., 1995). Similarly, saturated ground after heavy monsoon rain may push bears toward better-drained upland Sal-mixed mosaics (Laurie & Seidensticker, 1977). Although this data is only from the dry season, the positive termite–altitude trend fits this shift toward upland foraging. Taken together, the pattern suggests that at higher elevations, bears shift toward subterranean or sessile resources—termites,

roots, and occasional bees—while relying less on surface-foraging ants and beetles, prey that possibly less abundant or less accessible in cooler, moister upland soils (Ratnayeke et al., 2007; Seidensticker et al., 2011). Additionally, the increased presence of plant material at higher elevations may reflect bears' movement to upland areas searching for fruits during the late monsoon season, as documented by Joshi et al. (1995) and (Yoganand et al., 2006).

4.3 Habitat-specific patterns

Termite fragments were most frequent in grassland and riverine grids—habitats known for dense mound networks owing to well-aerated, humid soils (Joshi et al., 1997). Ant fragments, by contrast, were markedly rarer in grasslands, suggesting that bears reduce surface foraging in open vegetation where both prey and predator exposure are high (Klare et al., 2011; Suraci et al., 2016). A previous habitat-preference analysis in CNP by Ghimire & Thapa (2014) found that sloth bears preferentially used mixed forest and grassland habitats, while Sal and riverine forests were less favoured. This pattern mirrors these findings, where most scat samples were in Sal and mixed forest, suggesting that sloth bear space use is consistent with habitat selection trends observed through independent methods. Such alignment reinforces the ecological significance of these habitat types for sloth bear foraging behaviour in the region, emphasising the importance of ecological corridors and habitat quality. These dietary results add a trophic dimension to that spatial pattern: grasslands and mixed forests attract bears and provide abundant subterranean prey. Sal forest supports higher ant use, possibly because tree cavities host large *Camponotus* and *Pheidole* colonies. Mix forest and Sal forest also support more beetles than riverine forest and grassland, according to fragment samples from the scats (Appendix 2). This study model shows that the places sloth bears use (spatial data — where the scats are) match the kinds of insect prey (diet data) found in those habitats. There is a chance that this suggests that vegetation structure (e.g., Sal vs. mixed forest vs. grassland) plays a significant role in shaping their foraging behaviour.

4.4 Predator detections

In regions where apex predators are present, bears may favour subterranean termites and plants (Appendix 3) that require less surface exposure, potentially reducing predation risk (Ripple & Beschta, 2004; Stillfried et al., 2015; Suraci et al., 2016). The observed association between tiger presence and termite-heavy sloth bear diets may reflect more than a coincidental overlap. Termite-rich habitats could simultaneously attract both species, making it challenging to disentangle true predator-mediated dietary shifts from shared habitat preferences. Additionally, prey detectability likely varies across these areas, influencing what

is found in scat. To clarify these dynamics, future studies should integrate fine-scale GPS tracking of both sloth bears and their predators during habitat and prey surveys.

4.5 Human disturbance

The spatial distribution of these high-value prey aligns with forest edges and degraded zones, which also overlap with areas of human activity. This convergence elevates the likelihood of accidental encounters, particularly during daylight hours when both bears and people are active. Similar spatial conflict patterns have been reported across Nepal and India, where wildlife movement into anthropogenic zones is often driven by habitat degradation and resource scarcity (Joshi et al., 1997; Yoganand et al., 2012).

Over 80% of recorded human-sloth bear conflict incidents in Chitwan have occurred in the southwestern Madi management sector (Paudel et al., 2022). The HDI used in this study was not significantly associated with sloth bear spatial use.

Human disturbance, quantified using observer-assigned scores from 0 to 3 at each habitat-survey waypoint, did not show a strong predictive relationship with sloth bear activity. While regression analysis suggested a 21% increase in scat counts per standard deviation of the HDI, the confidence intervals for this estimate overlapped zero. Additionally, the correlation between HDI and scat encounter rate remained weak ($r = 0.12$), indicating limited influence of moderate disturbance on bear presence within the study area. These results indicate that sloth bears neither actively avoid nor preferentially select human-modified habitats within the observed disturbance gradient.

The HDI was measured independently from scat data, it avoids feedback loops in the analysis—an important step when trying to isolate the effects of disturbance. In places like Madi, where signs of sloth bears and ongoing human activity often overlap, this separation provides useful context for interpreting space use. Bears may not be avoiding these areas, but their consistent presence near settlements could still raise the odds of unplanned encounters.

5. Conclusion

Across the dry-season landscape of Chitwan National Park, sloth bears emerge as insect-centred omnivores whose foraging patterns are shaped primarily by habitat structure and local microhabitat conditions, with limited influence from predators or human activity. Termites remain a consistent, protein-rich resource, especially in upland and predator-associated settings, while ant consumption appears modulated by vegetation openness, soil substrate, and perceived predation risk. This dietary analysis reveals that termites and ants comprised over 95% of all

identifiable scat fragments. As in earlier studies, *Camponotus* and *Pheidole* dominate the ant fraction, a taxonomic detail that would have been lost had ants been lumped into a single category.

Habitat correlations were clear: grassland and riverine mosaics, with moist and well-aerated soils, were strongly associated with termite-rich scats, whereas Sal forest was linked to greater ant representation. Elevational gradients further shaped prey use, with higher elevations showing increased termite and plant material, and reduced surface-foraging ants and beetles. Predator detections, particularly of tigers and to a lesser extent leopards, co-occurred with termite-heavy, ant-light diet signatures. However, these associations reflect shared habitat preferences rather than fear-mediated dietary shifts. After accounting for search effort, human-disturbance scores were uncorrelated with scat density or prey composition, suggesting that sloth bears neither avoid nor prefer human-used areas within the observed disturbance gradient.

Methodologically, this study underscores the value of integrating genus-level prey identification with presence–absence GLMs to disentangle complex ecological drivers of foraging behaviour, while also acknowledging the biases inherent to fragment-based diet analyses, particularly those related to digestibility and PFO limitations. From a conservation standpoint, our findings highlight the ecological importance of grassland and riverine habitats, rich in termite resources, as dry season foraging areas warrant management priority. Future research combining DNA metabarcoding, GPS telemetry, and direct prey availability surveys will be critical to assessing the causal pathways suggested here and advancing our understanding of how habitat quality, predator dynamics, and anthropogenic pressure jointly shape the ecological niche of the sloth bear.

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Popular science summary

This study provides spatial and dietary insights that inform habitat-based strategies for sloth bear conservation and conflict mitigation in Chitwan National Park (CNP). Although human disturbance, elevation, and predator presence were only correlational with scat occurrence and diet composition, several clear ecological patterns appeared that can guide local management.

1. Prioritise the protection of grassland and riverine mosaics.

Scats found in these habitats were strongly associated with termite fragments, which dominate the sloth bear's dry-season diet. Grasslands with well-aerated soils and riverine belts with humid microclimates support dense termite colonies. Maintaining these mosaics, particularly in the southern Madi–Bagai sector, will help ensure access to reliable protein-rich prey during dry periods.

2. Do not assume moderate disturbance prevents bear use.

The Human-Disturbance Index (HDI) showed no meaningful relationship with sloth-bear spatial use within the range of observed disturbance. This suggests that moderate, non-extractive human activity (e.g., trails, edge harvesting, ecotourism corridors) may be compatible with sloth-bear foraging, so long as critical foraging habitat is still available.

3. Strengthen habitat continuity in buffer zones.

While bears tolerate low-to-moderate disturbance inside the park, human–bear conflict is concentrated on fragmented edges, especially in Madi. Habitat discontinuity and sharp agricultural interfaces may heighten risk. Buffer-zone management should improve functional connectivity (e.g., through reforestation corridors or reduced fencing) to reduce pressure on conflict-prone hotspots.

4. Integrate fine-scale prey ecology into land-use planning.

Ant composition varied with forest type and elevation. Ant genera such as *Camponotus* and *Pheidole* were prevalent in Sal-dominated areas, suggesting that tree cover heterogeneity supports prey diversity. Forest thinning, monoculture planting, or clearing in Sal zones could reduce prey availability even if the macrohabitat remains unchanged.

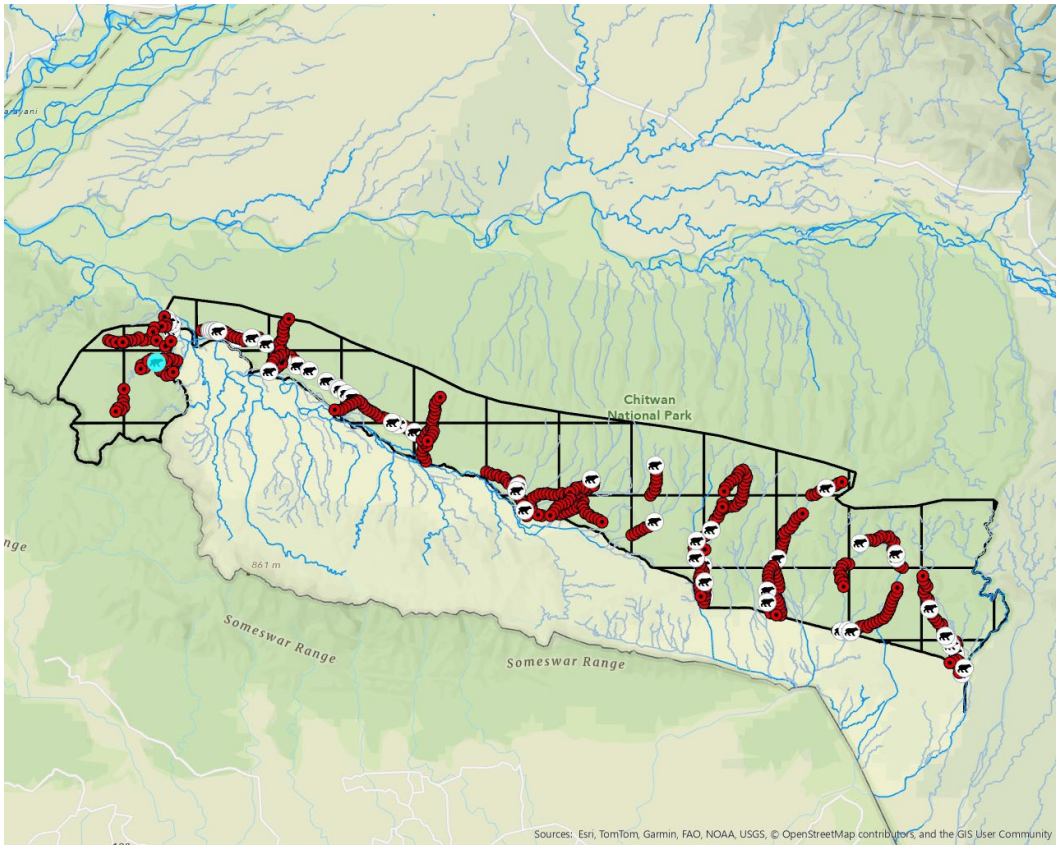
5. Target outreach and intervention in conflict-prone areas.

Most conflict incidents occur in the southwestern CNP (Paudel et al., 2022). Although bears do not appear to avoid moderate disturbance, their presence near settlements increases the chance of conflict, especially where fruiting trees or termite-rich soils overlap with human activity. Community-based efforts—such as early-warning systems, fruit-tree zoning, conservation education or regulated seasonal access—may reduce encounters.

This study discusses how ecological and social landscapes intersect with diet, elevation, predator pressure, and human activity. These can offer target land-use policies, habitat restoration, and community outreach in conflict hotspots.

Appendix 1: Field Waypoints

Figure 3 Spatial distribution of habitat survey waypoints and sloth bear scat locations in the Madi–Bagai sector, Chitwan National Park. Red dots represent 200-meter habitat survey intervals conducted along transects. Bear icons indicate locations where sloth bear scat were found. (Photo credit: Esri ArcGIS Pro)



Appendix 2: Diet vs. Sloth Bear

Table 5 Full binomial GLM outputs examining how forest type influences presence of dietary components (termites, ants, bees, beetles, and plant material) in sloth bear scats.

Forest Type	Diet Component	b	SE	z	p	CI
Sal forest	Termite	–0.16	0.08	–2.14	.032	[0.73, 0.99]
Sal forest	Plant Material	-0.68	0.22	-3.10	0.002	[0.33, 0.79]
Sal forest	Beetle	1.64	0.42	3.88	<.001	[2.46, 13.32]
Sal forest	Bees	-2.04	0.28	-7.34	<.001	[0.07, 0.22]
Sal forest	Ants	0.39	0.09	4.45	<.001	[1.24, 1.75]
Mixed forest	Termite	–0.27	0.09	–3.14	.002	[0.65, 0.91]
Mixed forest	Plant Material	1.22	0.22	5.43	<.001	[2.16, 5.22]
Mixed forest	Beetle	-17.29	857.81	-0.02	0.984	[0, 496273.34]
Mixed forest	Bees	2.29	0.26	8.93	<.001	[6.02, 16.54]
Mixed forest	Ants	–0.01	0.10	–0.09	.931	[0.81, 1.2]
Riverine forest	Termite	0.39	0.15	2.69	.007	[1.12, 1.99]
Riverine forest	Plant Material	-0.39	0.51	-0.76	0.445	[0.21, 1.63]
Riverine forest	Beetle	-1.16	0.72	-1.62	0.105	[0.05, 0.99]
Riverine forest	Bees	-15.86	780.43	-0.02	0.984	[0, 3945268.33]
Riverine forest	Ants	–0.29	0.16	–1.87	0.061	[0.54, 1]
Grassland	Termite	1.52	0.26	5.86	< .001	[2.84, 7.9]
Grassland	Plant Material	-15.14	546.58	-0.03	0.978	[0, 94.88]
Grassland	Beetle	-0.13	0.51	-0.25	0.799	[0.27, 2.12]
Grassland	Bees	0.84	0.40	2.09	0.037	[0.96, 4.8]
Grassland	Ants	–2.44	0.45	–5.39	< .001	[0.03, 0.19]

Appendix 3: Predator vs. Sloth Bear

Table 6 Binomial GLM outputs assessing the influence of predator identity (tiger vs. leopard) on presence of dietary components in sloth bear scats.

Predator	Diet Component	b	SE	z	p	CI
Tiger	Termite	0.68	0.07	9.62	< .001	[1.72, 2.27]
Tiger	Plant Material	1.85	0.51	3.61	<.001	[2.64, 20.82]
Tiger	Beetle	0.51	0.29	1.76	0.079	[0.97, 3.09]
Tiger	Bee	-2.07	0.27	-7.69	<.001	[0.07, 0.21]
Tiger	Ants	–0.76	0.08	–10.05	< .001	[0.4, 0.54]
Leopard	Termite	0.16	0.06	2.45	.014	[1.03, 1.33]
Leopard	Plant Material	-2.27	0.32	-7.02	< .001	[0.05, 0.19]
Leopard	Beetle	0.93	0.25	3.74	< .001	[1.59, 4.25]
Leopard	Bee	-0.80	0.26	-3.14	0.002	[0.27, 0.73]
Leopard	Ants	–0.02	0.07	–0.28	.779	[0.85, 1.13]

Appendix 4: Statistical Models Used in Dietary Analysis

A. **Scaled-Elevation Models**

To model the effect of elevation on the proportion of dietary components, we used a binomial Generalized Linear Model (GLM) with a logit link:

$$\log\left(\frac{pp}{1-pp}\right) = \beta\beta_0 + \beta\beta_1 . \mathrm{Z}$$

Where:

- pp: Probability of detecting a specific dietary component in sloth bear scat
- $\beta\beta_0$: Intercept (log-odds at mean elevation)
- $\beta\beta_1$: Coefficient for z-scaled elevation
- Z: Standardized elevation value, computed as:

$$\mathrm{Z} = \frac{\mathrm{X} - \mu\mu}{\sigma\sigma}$$

- X: Raw elevation value
- $\mu\mu$ = 415.88 meters (mean elevation)
- $\sigma\sigma$ = 92.35 meters (standard deviation)

Separate models were fitted for: Termite, Plant Material, Beetle, Bee, and Ants.

B. **Predator-Presence Models**

To assess the effect of predator presence on diet components, we used GLMs with binary predictors for presence (1) or absence (0) of Tiger, Leopard, or Rhino:

$$\log\left(\frac{pp}{1-pp}\right) = \beta\beta_0 + \beta\beta_1 . HH$$

Where:

- D: Binary variable indicating presence of a predator
- $\beta\beta_1$: Log-odds change in dietary component when predator is present

This model was applied to each diet component and predator combination.

C. **Forest-Type Presence Models**

To model the association between diet components and forest type, we used GLMs with binary forest-type indicators:

$$\log\left(\frac{pp}{1-pp}\right) = \beta\beta_0 + \beta\beta_1 . FF$$

Where:
- FF: Binary variable for presence (1) or absence (0) of a specific forest type (Sal, Mixed, Riverine, Grassland)
- $\beta\beta_1$: Change in log-odds for a dietary component when the sample is found in that forest type
Each forest type and diet component pair were modelled separately.

D. **Human Disturbance Index (HDI) Models**
To evaluate whether sloth bear scat density varied with human disturbance, we used two models:

1. Pearson Correlation Test between raw HDI scores and scat encounter rate:

$$rr = 0.116, pp = 0.558, 95\%\ CCHH = [0.269, 0.469]$$

2. Negative Binomial GLM for count data with effort-standardized offset:

$$\log(\lambda\lambda) = \beta\beta_0 + \beta\beta_1 . HHHHHH_2 + \log\left(Kmm_{wwwwwwwwwww}\right)$$

Where:
- $\lambda\lambda$: Expected count of scats
- $HHHHHH_{zz}$: Standardized Human Disturbance Index
- $Kmm_{wwwwwwwwwww}$: Search effort per grid (used as offset)
- $\beta\beta_1 = 0.188, SSSS = 0.192, zz = 0.977, pp = 0.329, 95\%\ CCHH = [-0.19, 0.57]$

This model indicated that HDI was not a statistically significant predictor of scat counts.

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