Feeding Dynamics and Interspecific Interactions of Vulture at a Supplementary Feeding Site in Tanahun District, Nepal

Prabesh Pandey[1], Krishnaa Dahal[1*], Krishna Prasad Bhusal[2], Deu Bahadur Rana[2,3], Ankit Bilash Joshi[3]

[1] Tribhuvan University, Institute of Forestry, Pokhara Campus, Pokhara, Nepal
[2] Biodiversity Research Institute (CSIC – University of Oviedo – Principality of Asturias), 33600 Mieres, Spain
[3] Bird Conservation Nepal, Lazimpat, Kathmandu 44600, Nepal
**Corresponding author: kasishdahal123@gmail.com*

ABSTRACT

Vulture populations in South Asia have declined sharply due to veterinary diclofenac, leaving four of Nepal's nine species listed as Critically Endangered. In response, Nepal has promoted conservation interventions through Vulture Safe Zones and supplementary feeding sites. This study examined species composition, feeding dynamics, and interspecific interactions at a community-managed site in Gachhepani, Tanahun District, from February to May 2024. Six carcasses on separate days were observed using total counts and scan sampling at 10-minute intervals over 30 minutes. Social interactions, including attacks, chases, displacements, and snatches, were documented. Six vulture species were recorded, with Himalayan vultures (Gyps himalayensis) being most abundant (50%), followed by White-rumped vultures (Gyps bengalensis) (30%). A total of 239 attacks, 67 chases, 68 displacements, and 47 snatches were observed, mainly involving Himalayan vultures, indicating dominance due to large size and aggression. Carcass mass strongly correlated with consumption time ($p<0.001$, $r=0.96$). Longer feeding durations were significantly associated with more chases ($r=0.83$) and displacements ($r=0.89$). Findings highlight the role of feeding sites in sustaining vultures and the need to optimize carcass provisioning for conservation.

Keywords : *Attack, feeding behavior, gyps, scan sampling, vulture, total count*

INTRODUCTION

Vultures are obligate scavengers that play a critical role in maintaining ecosystem health by consuming animal carcasses, thereby contributing to nutrient cycling and disease control (Buechley and Şekercioğlu, 2016). Globally, 23 vulture species have been recorded, of which nine occur in Nepal. Among these, White-rumped (WRV), Slender-billed (SBV), Red-headed (RHV), Long-billed, and Egyptian Vultures (EV) are currently listed as threatened due to dramatic population declines (Grimmett *et al*., 2016; Bhusal *et al.,* 2018).

One of the primary causes of vulture population collapse in South Asia was the veterinary use of non-steroidal

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anti-inflammatory drugs (NSAIDs), particularly diclofenac. This drug was responsible for a decline of over 95% in Gyps vulture populations during the 1990s (Chaudhary *et al.,* 2012; Oaks *et al.*, 2004). Additional threats such as accidental poisoning, electrocution, habitat loss, and the decline of natural food sources continue to impede population recovery (Bhusal, 2018).

In response, Nepal implemented a conservation strategy focused on establishing Vulture Safe Zones (VSZs) and supplementary feeding sites, including community-managed cow rescue centers that supply safe, uncontaminated carcasses (DNPWC, 2015; Galligan *et al.*, 2021). These feeding stations not only help reduce food scarcity but also offer critical opportunities to study vulture ecology, particularly their social behaviors and species interactions.

Vultures, being non-predatory, rely exclusively on carrion and consume carcasses rapidly (Markandya *et al.*, 2008). When multiple species interact with a single carcass, complex social interactions emerge, influenced by morphological, ecological, and behavioral traits (König, 1983; Houston, 1988; Hertel, 1994). These interactions include competition and cooperation, resulting in dominance hierarchies that influence access to food. Understanding these inter- and intra-specific interactions is vital for designing effective supplementary feeding strategies (Moreno-Opo *et al.*, 2015). Studies show that factors such as body size, age, and species identity govern behaviors like displacement, snatching, and aggression (van Overveld *et al.*, 2020).

Although research in Nepal has addressed vulture distribution, breeding success, and nesting ecology, studies focusing on feeding behavior and social dynamics remain scarce. This knowledge gap is significant, as effective vulture conservation must account for behavioral ecology and dominance patterns at feeding sites. Vulture safe feeding stations such as the Cow Rescue Center in Gachhepani, Tanahun District, offer a unique opportunity to examine these dynamics in a natural setting, and they provide diclofenac-free carcasses to vultures (Pandey *et al.*, 2024).

This study aims to assess the species diversity, feeding patterns, and social interactions among vultures visiting the Gachhepani feeding site. By documenting behavioral interactions and correlating them with carcass size and vulture abundance, this research seeks to contribute to evidence-based management of feeding sites and enhance our understanding of vulture ecology in Nepal.

MATERIAL AND METHODS

Study area

This study was carried out in the Gachhepani Cow Rescue Center of Tanahun District, Nepal. Tanahun District typically encompasses Lower Tropical, Upper Tropical, and Subtropical climatic zones, with the study area situated on the bank of the Seti River at an elevation of approximately 692 meters. The dominant vegetation assemblage in the area includes *Schima wallichii*, *Shorea robusta*, and *Castanopsis indica*, which are ecologically significant for vultures. These large-canopy tree species provide elevated perches for thermoregulation, resting, and scanning for food resources. In addition, their structural complexity and height offer potential roosting and nesting sites, especially for species such as the White-rumped Vulture (*Gyps bengalensis*) and Slender-billed Vulture (*Gyps tenuirostris*), which are known to prefer tall, mature trees in undisturbed landscapes (Gautam *et al.*, 2024). The Shuklagandaki Municipality has provisioned the Cow Rescue Center, called *Gau rakshya kendra*, at Gachhepani. This facility also functions as a vulture feeding site, as naturally dead cattle are provided for scavengers. The site was selected for this study due to the observed presence of multiple vulture species and its conservation relevance as a locally managed supplementary feeding site.

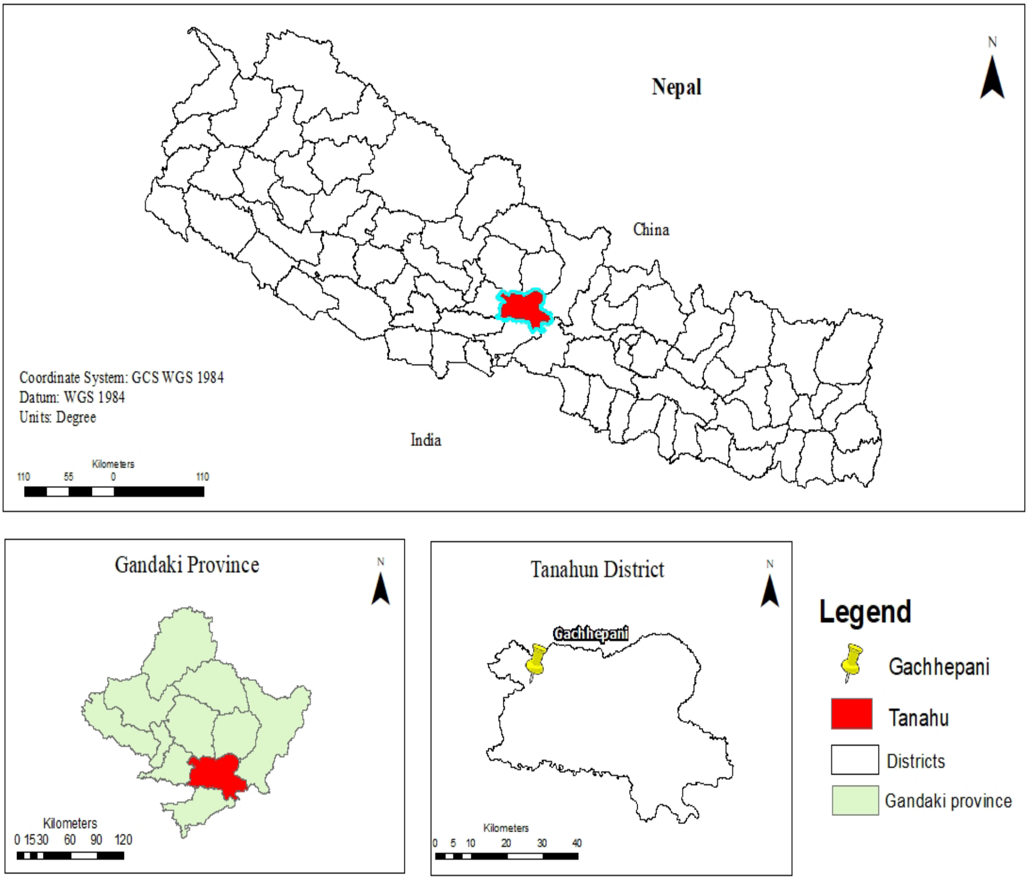

Figure 1: *Map of the study area*

Data collection

Total count

A total count method was employed to record the number and species composition of vultures feeding at the site during the study period. Observations were carried out from February to May 2024 on six separate days, with each observation session corresponding to a different carcass provided at the supplementary feeding site. Two trained observers stationed at distinct vantage points recorded feeding activity using binoculars (Nikon 10×42 mm), a spotting scope (Blazer 20–60×60 mm Zoom), and a DSLR camera (Nikon D5600) to document species identity and behavior for later verification. Observations commenced at the time the carcass was placed and continued until the vultures stopped attending the carcass, ensuring complete coverage of the feeding period.

To minimize inter-observer variation, both observers underwent a calibration phase prior to data collection, during which simultaneous recordings at a test site were independently completed and subsequently compared. Inter-observer consistency was evaluated through direct comparison of recorded behavioral categories, scan counts, and carcass use events. Discrepancies were identified, discussed, and resolved through retraining to ensure consistent interpretation of behavioral definitions (Burghardt *et al.*, 2012; Hartmann & Wood, 1990). Consistency was further maintained through periodic cross-checking of photographs and field notes, as well as repeated observer reliability checks during the study period (*Garcia*, 2010). Scan sampling followed the standardized behavioral protocol described by Altmann (1974).

Scan sampling was conducted for 30 minutes per carcass at 10-minute intervals. The choice of interval length and observation duration was informed by pilot observations conducted before the formal data collection, during which different observation lengths were observed and evaluated to ensure adequate capture of feeding and social behaviors while maintaining field feasibility (Altmann, 1974). This approach allowed systematic documentation of vulture activity while reducing observer bias. The species and age composition of vultures were identified using *Birds of Nepal* (Grimmett *et al.*, 2016), and expert ornithologists verified identifications through photographic evidence.

Scan sampling

Scan Sampling survey method was used to record feeding behavior of vulture and the competitive interactions within its own species and with other species. The parameters of the study were first divided among the observers so that the interactions would not be repeated.

Table 1: *Descriptive ethogram of observed Social behavior, adapted from van Overveld et al. (2020) and field observations*

Social behavior	Description
Attack	Lunging using beak or feet at another bird, including head butts, kicks, etc. This may or may not change the original position of bird.
Chase	Vulture lunges at another bird with its beak or feet and follows the other bird while that other individual moves away which does not leaves the carcass away.
Displace	Vulture takes the exact place of another bird with or without overt aggressive interaction, which results in the abandonment of carcass for a time being.
Snatch	The vulture acquires the carcass pieces from within the holding of another bird.

Carcass mass estimation

The mass of each carcass was estimated using the empirical judgment of experienced staff at the Gachhepani Cow Rescue Center. Prior knowledge of live cattle weights and decomposition stages was used to approximate the post-mortem weight. Carcasses were visually assessed based on body size, fat coverage, and stage of decomposition. The staff relied on comparative referencing with known weights of cattle from recent deaths. These estimates were supported by photographic documentation and cross-verification between staff members to minimize subjective error. While not exact, this method provides sufficiently accurate approximations for ecological behavior studies where carcass size significantly influences vulture feeding behavior and interaction rates (Moreno-Opo *et al.*, 2015; Moleón *et al.*, 2015).

For future studies, it is recommended to use portable livestock weighing scales or volume-based models (length × girth × conversion factor) to improve accuracy in carcass mass measurement (Bibby *et al.*, 1998).

Data analysis

Data were analyzed both qualitatively and quantitatively to examine species composition and social interactions during feeding. Descriptive statistics were used to summarize vulture abundance, age composition, and frequencies of interspecific and intraspecific interactions (attacks, chases, displacements, and snatches).

Inferential statistical analyses were performed to evaluate relationships among carcass mass, number of vultures attending, consumption time,

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and frequencies of social interactions (total counts per carcass). Interaction frequencies were analyzed in relation to feeding duration to account for differences in carcass consumption time. Pearson's correlation coefficients were calculated to assess linear relationships between these variables. In addition, simple linear regression models were applied to explore whether carcass mass could predict consumption time and social interaction rates.

All analyses were performed in R (version 4.3.2, e.g., RCT (2024)), using the following packages: *ggplot2* (Wickham, 2016) for data visualization, *psych* for correlation analysis, and *car* for assumption testing. Results are presented as means ± standard deviation (SD) and visualized using bar graphs and scatterplots with fitted regression lines. Statistical significance was assessed using two-tailed tests and set at a significance level of $p < 0.05$. Where applicable, test statistics are reported with corresponding degrees of freedom (df).

Study limitations

The use of visual estimation to approximate carcass mass introduces potential measurement bias, as estimated weights may not precisely reflect true carcass mass. This uncertainty could influence the observed correlations between carcass size and feeding time or rates of social interaction. Although carcass mass was estimated rather than directly measured, triangulation with staff experience and visual assessment ensured reasonably consistent values. Future studies could incorporate portable weighing tools and longitudinal surveys across seasons to capture temporal variation in social dynamics.

RESULTS

Six different species of vultures attended the carcass during the study period. There was a total of 34 vultures at carcass 1; 59 vultures at carcass 2; 38 vultures at carcass 3; 30 vultures at carcass 4; 35 vultures at carcass 5; and 46 vultures at carcass 6. There were 7 RHV, 2 CV, 126 HV, 97 WRV, 13 SBV, and 8 EV (Table 2).

Table 2: *Number of vultures feeding at six different carcasses*

Species	Carcass 1	Carcass 2	Carcass 3	Carcass 4	Carcass 5	Carcass 6
Red Headed Vulture (RHV)	1	1	2	1	1	1
Cinereous Vulture (CV)	0	1	0	1	0	0
White Rumped Vulture (WRV)	12	22	12	14	19	18
Himalayan Vulture (HV)	24	30	18	16	13	25
Slender billed Vulture (SBV)	2	3	3	2	1	2
Egyptian Vulture (EV)	1	2	3	1	1	0
Total	34	59	38	30	35	46

Figure 2 shows the relatively higher number of HV and WRV, while the rest of the other are comparatively rarer. Other avian species like Black Drongo, Red-wattled Lapwing, Long-tailed Shrike, and Common Myna, as well as a dog, were seen around the carcasses.

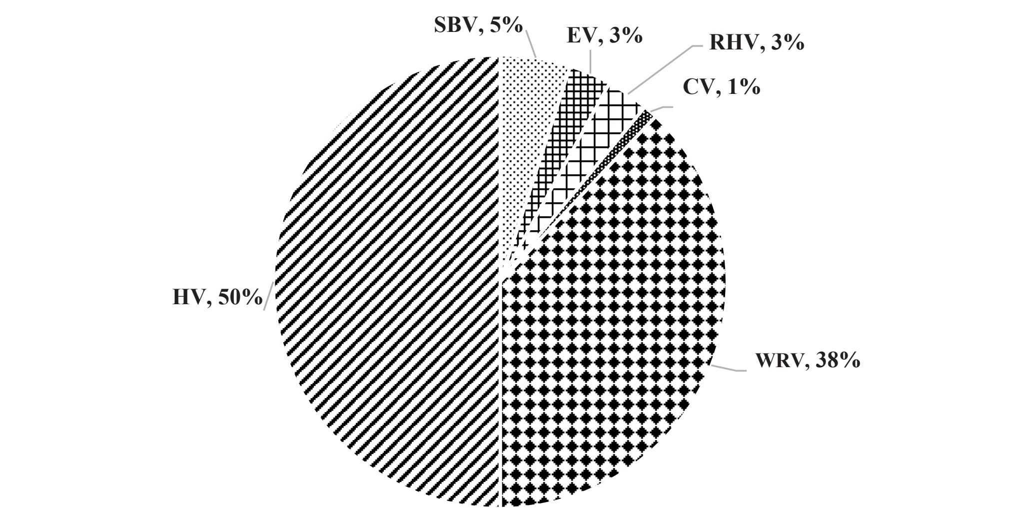

***Figure** 2: Proportion of vultures attending the carcasses*

3.1. Age composition of the vultures feeding on the carcasses

Only three species of sub-adult vultures have attended the carcass for feeding. The maximum number of HV was recorded in all carcasses, while EV was the least.

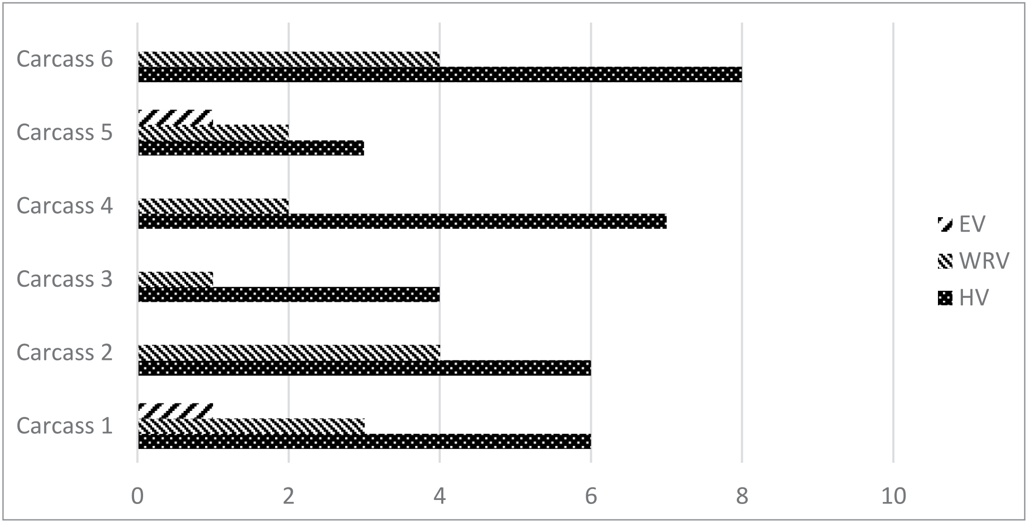

***Figure 3:** Sub-adult vultures attending the carcasses*

Interaction of vultures during feeding

Inter-specific interaction of vulture

The ethogram chart by Bist (2019) was followed to determine and record the social interactions of vultures. Altogether, 4 interactions viz. Chase, Displacement, Attack, and Snatch were observed among all the vultures. Since we watched all the vultures doing these activities, every single vulture was seen to be both initiator (Stimulant) and receiver (Recipient) of the interaction.

Table 3: *Total number of interspecific interactions pooled across chase, attack, snatch and displacement behaviours across six carcasses*

Stimulant → Recipient	RHV	CV	WRV	HV	SBV	EV
Red Headed Vulture (RHV)	1	0	5	3	0	0
Cinereous Vulture (CV)	1	0	3	2	2	0
White Rumped Vulture (WRV)	6	3	78	68	66	1
Himalayan Vulture (HV)	6	2	174	421	90	1
Slender-billed Vulture (SBV)	0	0	66	49	26	0
Egyptian Vulture (EV)	0	0	0	0	0	5

Note: Detailed behavior-specific interspecific interaction matrices are provided in the Supplementary Material (Table S1-S4).

HV were the most dominant species, resulting in the highest number of interactions. Among the noted interspecific interactions, HV most frequently directed aggression towards WRV and SBV, which reflects their competitive superiority during feeding. WV ranked second, followed by SBV. On the other hand, RHV, CV, and EV showed relatively limited presence and lower involvement in competitive encounters at the feeding site.

Intra-specific interaction of the vulture feeding

The intra-specific attack has been maximum

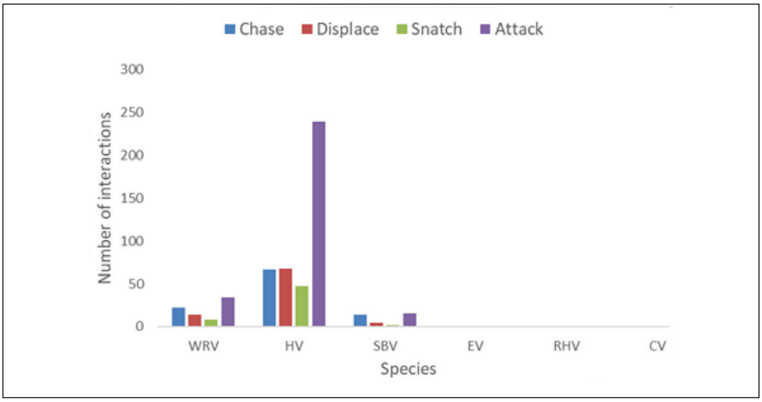

Figure 4: *Intra-specific interactions among vultures during feeding at the supplementary feeding site*

among the vultures. Bars represent the frequency of chase, displacement, snatch, and attack behaviours occurring within each species. The attack by HV to HV being highest, displacement and chase being similar, while snatch is the lowest among HVs. The WRV attacking WRV is highest while chase, displace, and snatch remain in descending order. There are no intra-specific interactions among CV, while RHV has only a single attack on itself.

Estimation of time and carcass budget of the vulture feeding

Mass, time and number of vultures attending the carcass

The estimated mass of each carcass, the total time required for consumption, and the number of vultures attending each of the six carcasses observed at the supplementary feeding site. The total of 6 carcasses, 525 kg of estimated carcass, was attended by 253 vultures, and the carcass was completely consumed in 2297 minutes. Carcass mass showed a positive relationship with both the number of vultures attending feeding events (Figure 5a) and the time required for complete consumption (Figure 5b), followed by the concept that larger carcasses attract more vultures and require longer feeding durations.

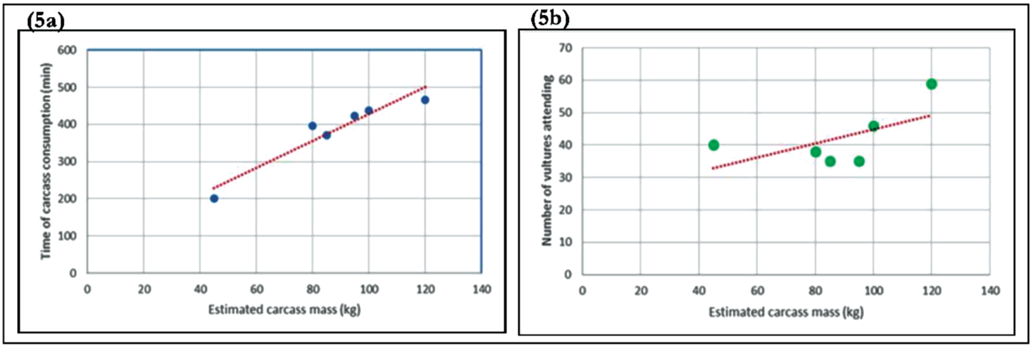

***Figure 5**: Relationship between carcass mass and number (5a), and carcass mass and time (5b) of vultures attending feeding events*

Mass and time co-relation with social behavior parameters

The number of vulture attending the carcass is very highly correlated with Snatch ($p<0.05$, $r=0.81$), Consumption time highly correlated with Chase ($p<0.05$, $r=0.83$) and Displace ($p<0.05$, $r=0.89$) while Carcass mass also being highly positively correlated with Consumption time ($p<0.001$, $r= 0.96$), Chase ($p<0.01$, $r=0.87$) and Displace ($p<0.001$, $r=0.88$). Chase is also highly positively correlated with Displace ($p<0.001$, $r=0.94$). The other social behavior showed no significance relation with mass of carcass, time of consumption and number of vulture attending.

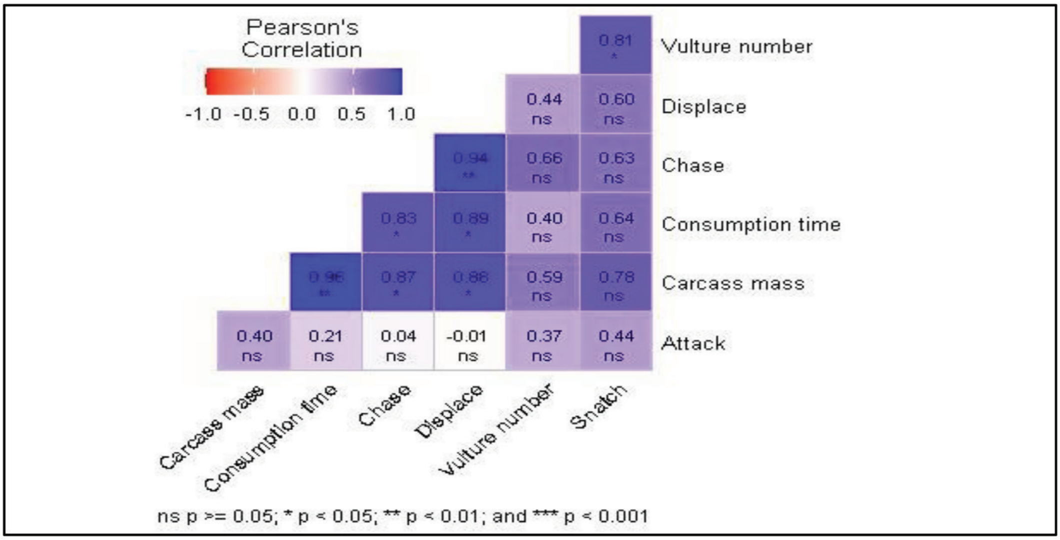

Figure 6: *Correlation between mass, number and time with social interactions*

DISCUSSION

This study documented inter- and intra-specific social behaviors among vultures at a community-managed feeding site in Gachhepani, Tanahun District. Six vulture species were recorded, with *Gyps himalayensis* (Himalayan Vulture) and *Gyps bengalensis* (White-rumped Vulture) being the most dominant in both abundance and competitive behaviors. The Himalayan Vulture, being the largest species observed, demonstrated the highest frequency of aggressive behaviors including displacements, attacks, and snatches, consistent with its dominance status reported in previous field studies (van Overveld *et al.*, 2020; Panja *et al.*, 2025).

Social dominance at the carcass followed a predictable pattern strongly influenced by body size, age class, and possibly prior social experience. Larger-bodied *G. himalayensis* consistently displaced smaller vultures including *Neophron percnopterus* (Egyptian Vulture) and *Aegypius monachus* (Cinereous Vulture), confirming previous assertions that body mass is a principal determinant in competitive access to carrion (Moreno-Opo *et al.*, 2015). Interestingly, *G. bengalensis*, while smaller than *G. himalayensis*, maintained a significant share of feeding opportunities through persistent threat displays and snatching behavior, particularly when arriving in larger flocks.

These interactions align with observations at feeding sites in India and Nepal, where size-based hierarchies, reinforced by group dynamics and individual boldness, regulate carcass partitioning (van Overveld *et al.*, 2020; Mallord *et al.*, 2024). The occurrence of aggressive behaviors such as displacement and snatching reflects the limited nature of the resource and the ecological importance of establishing dominance to ensure energy intake.

Feeding duration and species richness showed a positive correlation with carcass mass, a pattern well supported in vulture ecology literature. Larger carcasses likely reduce competition per unit biomass and allow prolonged feeding enabling even subordinate species to access remains (Moleón *et al.*, 2015). This supports the notion that carcass size is not only a nutritional resource but also a behavioral modulator influencing group dynamics and interspecies tolerance (Moreno-Opo *et al.*, 2015).

The observed dominance hierarchy and species interaction dynamics have clear implications for supplementary feeding strategies. Specifically, provisioning of larger carcasses at regular intervals may reduce intra-guild competition and support a broader spectrum of vulture species, including threatened ones like *G. bengalensis* and *N. percnopterus* (Galligan *et al.*, 2021). Additionally, understanding behavioral tendencies can help refine site design, e.g., increasing landing space or spreading carcass parts to reduce monopolization.

This site-specific behavioral insight also reaffirms the role of Vulture Safe Zones (VSZs) and community-managed feeding stations in species recovery (DNPWC, 2015). However, recent reviews emphasize that recovery in population size remains slow, particularly in South Asia, and that conservation efforts must continue addressing poisoning risks, NSAID residues, and carcass availability (Mallord *et al.*, 2024).

CONCLUSION

This study documented six vulture species at the Gachhepani Cow Rescue Center, a locally managed supplementary feeding site in Tanahun, Nepal. Himalayan Vulture (*Gyps himalayensis*) and White-rumped Vulture (*Gyps bengalensis*) were the most abundant species, with the former exhibiting dominance at carcasses through frequent aggressive interactions, including attacks, snatches, displacements, and chases. The high rate of intra- and interspecific interactions, particularly among Himalayan Vultures, suggests increased competition for food resources, likely exacerbated by the limited availability of uncontaminated carcasses in the broader landscape. Larger carcasses were associated with prolonged feeding durations and higher rates of social interactions, highlighting the influence of resource size on vulture behavior.

Despite the conservation value of the feeding site, potential threats such as electrocution from nearby power lines, and unregulated dumping practices warrant attention. To enhance conservation outcomes, future studies should examine vulture behavior across seasons, assess the impact of carcass preparation (skinned *vs.* unskinned), and employ precise carcass mass measurements to better understand correlations with social parameters. Additionally, insulating power lines near feeding areas and ensuring drug-free carcasses are critical management interventions to reduce vulture mortality and support population recovery.

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SUPLEMENTARY FILES

Table S1: *Inter-specific chase interactions*

Chase	RHV	CV	WRV	HV	SBV	EV
RHV	0	0	3	2	0	0
CV	0	0	2	1	1	0
WRV	4	2	22	13	16	0
HV	3	1	29	67	23	1
SBV	0	0	8	14	3	0
EV	0	0	0	0	0	4

Table S2: *Inter-specific attack interactions*

Attack	RHV	CV	WRV	HV	SBV	EV
RHV	1	0	2	1	0	0
CV	0	0	1	1	1	0
WRV	0	0	34	16	33	0
HV	0	0	76	239	48	0
SBV	0	0	53	14	16	0
EV	0	0	0	0	0	0
Total	1	0	166	271	98	0

Table S3: *Inter-specific snatch interactions*

Snatch	RHV	CV	WRV	HV	SBV	EV
RHV	0	0	0	0	0	0
CV	0	0	0	0	0	0
WRV	0	0	8	33	9	0
HV	0	0	23	47	12	0
SBV	0	0	5	7	2	0
EV	0	0	0	0	0	0
Total	0	0	36	87	23	0

Table S4: *Inter-specific displacement interactions*

Displace	RHV	CV	WRV	HV	SBV	EV
RHV	0	0	0	0	0	0
CV	1	0	0	0	0	0
WRV	2	1	14	6	8	1
HV	3	1	46	68	7	0
SBV	0	0	0	14	5	0
EV	0	0	0	0	0	1