CRAB-EATING MONGOOSE *Herpestes urva*: OCCURRENCE AND ITS ACTIVITY IN MID-HILLS OF NEPAL

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ABSTRACT

Small carnivores are able to adapt to patchy forests and human dominated landscape in proximity to water sources. Small carnivore's population is declining due to anthropogenic effects, and in most of the areas, their occurrence is little known. We aimed to identify the spatial occurrence of crab-eating mongoose, the factors affecting the occurrence of species and coexistence with other species using camera trap. The crab-eating mongoose mostly preferred the shrub-land habitat (65%) and followed by agriculture land, forest and grassland. Almost all preferred habitats were near to water sources. The occurrence of crab-eating mongoose was influenced by human disturbances. Their occurrences were decreased with increasing disturbances. In addition, the crab-eating mongoose's occurrence was also decreased with increasing distance to water sources. The movement activities of crab-eating mongoose were varied according to time period (F = 6; df = 14; p < 0.013), and was mostly active at day to mid-night (16.00 to 12.00 hours) and mid-night to early morning (12.00 to 8.00 hours). The crab-eating mongoose co-exists with other carnivores including Leopard, Jungle cat, Masked-palm civet, Small Indian mongoose, Leopard cat, Yellow-throated martin, and Large Indian civet. In addition, its occurrence was affected by human interference. The data available from this study can be used to develop site/species-specific conservation plans that aid stewardship for biodiversity conservation.

Keywords: Co-existence, conservation, crab-eating mongoose, habitat, *Herpestes urva*

INTRODUCTION

Mostly small carnivores are adapted at patchy forests, human dominated landscape, grasslands and close to streams and waterholes (Sauvajot *et al.*, 1998; Basille *et al.*, 2009; DeFries *et al.*, 2010; Athreya *et al.*, 2013; Katuwal *et al.*, 2018; 2020). Because of trophic cascade and anthropogenic effects on small carnivores (for example, habitat specialist mammal species and their species richness were decreased in East African savanna between 1962 to 2010 due to habitat alteration), their population is believed to be declining worldwide (Kalle *et al.*, 2013; Byrom *et al.*, 2015; King *et al.*, 2017). Furthermore, the shrinking habitat is affecting species ecology and their behavior (DeFries *et al.*, 2010; Kalle *et al.*, 2013); however, they are found to be capable of adapting in varied habitat conditions (DeFries *et al.*, 2010; Athreya *et al.*, 2013), and can play an important role in ecosystem functioning at forest and grassland habitats (Roemer *et al.*, 2009; Kalle *et al.*, 2013; King *et al.*, 2017; Williams *et al.*, 2018). The conservation status of the small carnivores such as wild small cats, martens, mongooses and civets is poorly understood as there is little information available on small carnivores than those of

large carnivores such as tigers *Panthera tigris*, leopards *P. pardus* and hyenas *Hyaena hyaena* (Joshi *et al.*, 1995; Athreya *et al.*, 2013; Kalle *et al.*, 2013; Kalle *et al.*, 2014; Bhandari *et al.*, 2020). In Nepal, small carnivores represent 20 species out of 212 mammalian species (Amin *et al.*, 2018). Except for the red panda *Ailurus fulgens* (Endangered), Greater hog badger *Arctonyx collaris* (Vulnerable) and Binturong *Arctictis binturong* (Vulnerable); all species are either listed under the least concern or near threatened in the IUCN red least (Duckworth *et al.*, 2010; Glatston *et al.*, 2015; Willcox *et al.*, 2016).

In Nepal, four species of mongoose (ruddy mongoose, *Herpestes smithii*; small Indian mongoose *Herpestes javanicus*; Indian grey mongoose *Herpestes edwardsii*; and crab-eating mongoose *Herpestes urva*) have been recorded (Jnawali *et al.*, 2011; Sharma & Lamichhane, 2017). The crab-eating mongoose (Fig. 1a) is one of the small carnivores (body weight: 1-2.5 kg) having body length of 47 to 56 cm with 35 cm long tail, and the pelage is noticed as iron-grey brown to blackish. It is easily identified because of its guard hairs coarse and usually white-tipped with multiband including

yellowish, blackish, pale brown and whitish (*See* Rompaey, 2001; Baral & Shah, 2008, Fig. 1a). The top of head with pale grayish brown and white speckled, which appeared

from the corner of the mouth to the shoulder, is another identifying feature (Rompaey, 2001; Baral & Shah, 2008).
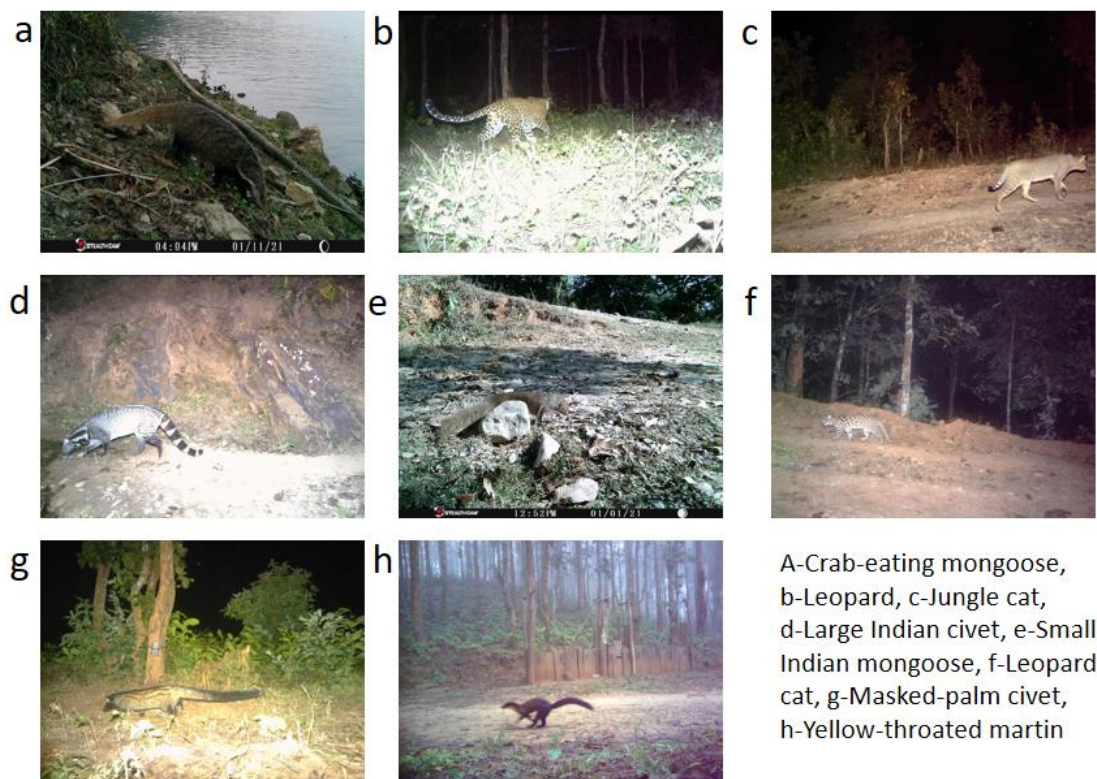
A-Crab-eating mongoose, b-Leopard, c-Jungle cat, d-Large Indian civet, e-Small Indian mongoose, f-Leopard cat, g-Masked-palm civet, h-Yellow-throated martin

Figure 1. Wild animals captured at camera traps between October 2020 and February 2021 at Bhanu Municipality, Nepal

The global distribution of crab-eating mongoose is reported from Bangladesh, Bhutan, Cambodia, China, Hong Kong, India, Laos, Malaysia, Myanmar, Nepal, Taiwan, Thailand and Vietnam up to 1800 m of elevation above the sea level (Choudhury *et al.*, 2015). In Nepal, the species has been reported from low land Nepal between 100 m to 1300 m of elevation including within the protected areas of Bardia National Park, Chitwan National Park, Koshi Tappu Wildlife Reserve, Parsa National Park, Shukla Phanta National Park and with little information outside the protected areas (Baral & Shah, 2008; Jnawali *et al.*, 2011). Within these habitats the crab-eating mongoose inhabits in tropical and subtropical evergreen and moist deciduous forests having abundant crabs, birds, rodents, lizards and snakes as a diet (Choudhury *et al.*, 2015). Diminutive information is available on the population of the species; however, based on the existing threats and loss of food species it is assumed that the global population of crab-eating mongoose is declining (Sauvajot *et al.*, 1998; Glennon & Porter, 2007; Wells *et al.*, 2009, Choudhury *et al.*, 2015). Based on the few evidence on the occurrence of species, its geographic distribution range and occupancy the species is listed as Least Concern under IUCN red list of threatened category (Choudhury *et al.*, 2015), however in

Nepal the species is listed under Vulnerable category in Nepal's National red list and protected mammal species under National Parks and Wildlife Conservation Act 1973 (Baral & Shah, 2008; Jnawali *et al.*, 2011). Besides of the morphological characteristics, little knowledge is known about the ecology and co-existence of this species with other sympatric species.

In Nepal, the crab-eating mongoose is also speculated to occur from the mid-hill mountain region having the mixed forests at the vicinity of the lake. However, its distribution and occurrence is threatening from anthropogenic activities such as habitat encroachment, habitat loss and degradation from draining of wetlands, pollution at waterways, forest clearing for livestock and agriculture (Hunter & Yonzon, 1993; Majupuria & Majupuria, 2006; Jnawali *et al.*, 2011). Till date data on the distribution of crab-eating mongoose is little know in Nepal, which creates problem for developing conservation action plan for its long term conservation. Therefore, we aimed to identify the occurrence and activities of crab-eating mongoose at existing habitats of central mid-hill region of Nepal for providing the baseline data for the conservation of species.

MATERIALS AND METHODS
Study Area
The study was conducted in Bhanu Municipality (27.433 to 28.0300N, 84.440002, 85.566E) of Tanahu district at Gandaki Province of Nepal (Fig. 1) and comprises 1,84 km². The study area is historically famous for Maharisi Veda Vyash and Bhanubhakta Acharya the writer of famous books Mahabharat and Ramayen, respectively. The

bio-climate of the area is ranged from tropical <300 m to subtropical 1000 – 2000 m to temperate 2000 – 3000 m of elevation above the sea level. The annual average precipitation is approximately 2345.9 mm (about 90% of rainfall occurring between May and September) and monthly minimum and maximum temperatures were about 2°C and 37.7°C, respectively.
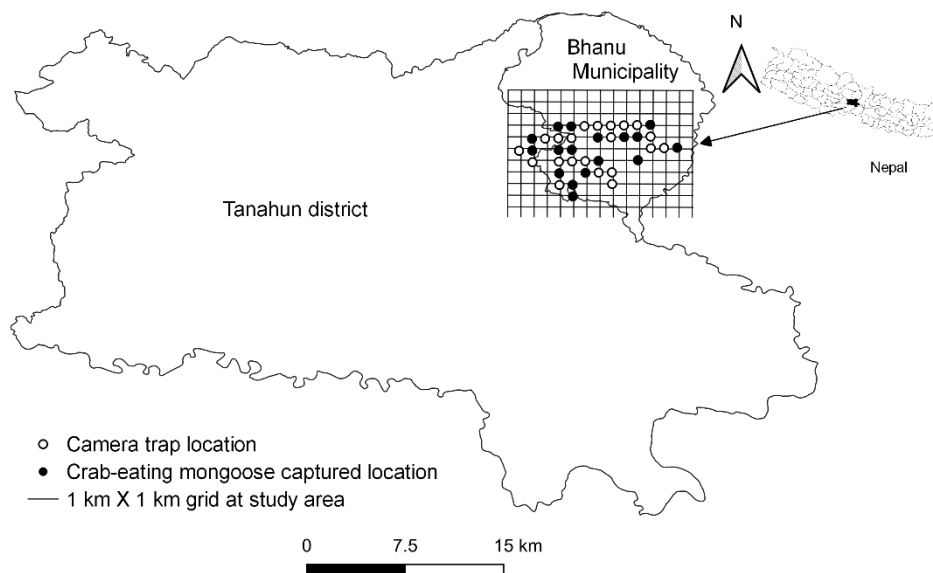

Figure 2. Camera trap deployed stations for Crab-eating mongoose occurrence study at Bhanu Municipality between October 2020 and February 2021 at Bhanu Municipality in mid-hills of Nepal.

The area supports the occurrences of many floral species such as *Sorea robusta*, *Acacia catechu*, *Dalbergia sissoo*, *Bombax ceiba*, *Sapium insigne*, *Schima wallichii*, *Lagerstroemia parviflora*, *Bauhinia vahlii*, *Desmodium oojeinense*, and *Murraya koenigii* (Uprety *et al.*, 2011), and faunal species such as Great evening bat *La io*, Common bentwing bat *Miniopterus schreibersii*, Nepal myotis *Myotis nipalensis*, Woolly horseshoe bat *Rhinolophus luctus*, Least horseshoe bat *Rhinolophus pusillus*, Leopard *Panthera pardus*, Asiatic black bear *Ursus thibetanus*, Assamese monkey *Macaca assamensis* (Jnawali *et al.*, 2011).

Methods
We confirmed the occurrence of crab-eating mongoose in the study area after the consultation with forest officials, local people, and wildlife experts between October 2019 to February 2020. We developed 126 grids of 1 km X 1 km for Bhanu Municipality (Fig. 2). We excluded the grids which lie at human settlements and urban areas including infrastructure development area and build up. Finally, a total of 41 grids were found suitable for camera traps deploying. We chose 38 grids to deploy camera traps based on 95% Confidence Interval at 5% margin of error (Krebs, 2014). We installed these camera traps (Stealth CAM; 12.0 mp, Infrared Megapixel Trail Camera Grey) in between

October 2019 and February 2021. The camera traps were randomly installed within four habitats such as forest (35%), agricultural land (35%), shrub land (25%), and grassland (5%) between the elevation of 450 m to 800 m. We deployed proportionately equal number of camera traps randomly with replacement in forest, shrub land, agricultural land and grassland. The camera traps were set at the approximately at the center of each 1 km X 1 km, except at agricultural land. In agricultural lands, we set cameras at the exist area or at the edge of cropping area within the plot. In addition, we scrutinized the potential route of wildlife movement in the area so that animals can be trapped by camera. The distance between two camera traps was >1 km, and left these for one week in the study area in each habitat. The camera traps were operated for 24 hours for two weeks for 1512 trap nights. The records of camera traps were inspected once a week. To understand whether crab-eating mongoose habitat is affected by human disturbances, we recorded the presence of anthropogenic disturbance (movement of human/livestock/littering). The presence and absence of anthropogenic disturbance was attributed the values of 0 for absence and 1 for presence in each camera trap location. We also measured distance attribute between camera trap location and water sources (very close <99 m; close 100 -

499 m; far >500 m) using GIS. In addition, we visually observed the tree canopy cover and recorded for each camera trap location. Furthermore, we recorded the time spent by crab-eating mongoose in each camera trap station.

Data analysis
Each image of the crab-eating mongoose was counted to confirm the occurrence in that camera trap. We performed generalized linear model with Poisson distribution identify factors affecting the Crab-eating mongoose occurrence at Bhanu Municipality. We ranked models using Akaike Information Criterion (AICc) adjusted for small samples and Akaike model weights to estimate relative strength of evidence for each model (Burnham & Anderson, 2002). We considered models with AICc scores within 4 of the most parsimonious models to have support. We conducted model averaging using competing models and estimated 95% confidence intervals for each variable and accepted statistical significance at α = 0.05. Animals split their time between a variety of activities, with a clear boundary between activity and rest (Halle & Stenseth, 2000; Rowcliffe *et al.*, 2014), which are essential for survival, yet it consumes more energy than relaxing. Activity index is a behavioral and ecological metric that provide an indicator of energetic, foraging effort and exposure to risk of the species. Therefore, we estimated the activity pattern of the crab-eating mongoose from camera trap data images. We recorded date and time to calculate the activity index of the crab-eating mongoose during this study. For that we identified variation on the time spent on the activities of crab-eating mongoose using ANOVA test in three different time intervals mid-night to early morning (12.00 to 8.00

hours), day (8.00 to 16.00 hours) and day to mid-night (16.00 to 12.00 hours).

The activities were identified as movement or active movement time if the crab-eating mongoose captured in the camera trap. We compared the distribution of crab-eating mongoose between human disturbed and undisturbed habitat using Chi-squired test. We calculated the Relative Abundance Index (RAI) for each species that was captured in the camera trap. The capture frequency of the camera trap data was used as a RAI, which was calculated as the number of captured species per camera trap days (i.e., number of cameras times with number of operational days; Carbone *et al.*, 2002). We followed published guidelines of Carbone *et al.* (2002) and Palmer *et al.* (2018) to calculate RAI for Crab-eating mongoose.

RAI = (E/TN) * 100, where E is the number of events and TN is the total number of trap nights

RESULTS
The crab eating mongoose was recorded in 17 of our 38 camera trap locations and based on our physio-graphic position each record can represent single individual. The average canopy of camera trap station was 31.31%. The occurrence of Crab-eating mongoose was mostly influenced by human disturbances; their occurrences decreased with increasing disturbances (Table 1). In addition, the Crab-eating mongoose's occurrence was also decreased with increasing distance to water sources, increased canopy cover percentages, and in the forest habitat, however, the occurrence was supported by presence of other carnivores (Table 1).

Table 1 Model-averaged parameter estimates and 95% confidence limits (CL) describing the factors affecting on the occurrence of crab-eating mongoose *Herpestes urva* between October 2020 to February 2021 at Bhanu Municipality, Tanahun, Nepal. Model parameters include disturbances (presence/absence of human; livestock), presence/absence of other carnivores, canopy cover (% in log), habitat (Forest, Agricultural land, Shrub land, and grassland) and nearest distance to water sources (meter in log) used for predictive variables and number of Crab-eating mongoose in camera traps as response variable.

Variables	Estimate	Lower CL	Upper Cl	z	p
(Intercept)	5.414	-3047.556	3058.384	0.003	0.997
Disturbance	-1.846	-3.592	-0.0993	2.071	0.038
Presence of other carnivores	1.965	-0.986	4.915	1.305	0.192
Canopy cover	-0.604	-1.778	0.570	1.009	0.313
Forest	-16.318	-4893.536	4860.899	0.007	0.995
Distance to water sources	-0.645	-1.623	2.913	0.558	0.577

The movement activities of crab-eating mongoose were varied according to time period (F = 6; df = 14; p < 0.013, Table 2), and was mostly active at day to mid-night (16.00 to 12.00) and mid-night to early morning (12.00 to 8.00) (Fig. 3). The total variability (R^2 = 51%) of the crab-eating mongoose was explained by time variation (i.e., day to mid-night, mid-night to early morning and early morning to

daytime). Out the 17 sites where crab-eating mongoose were captured, 14 sites showed sign of anthropogenic pressure, while three were without signs. There were effects of anthropogenic activities including human and livestock presence to the occurrence of crab eating mongoose (χ^2 = 5.5; df = 3; p < 0.05) in the study area.
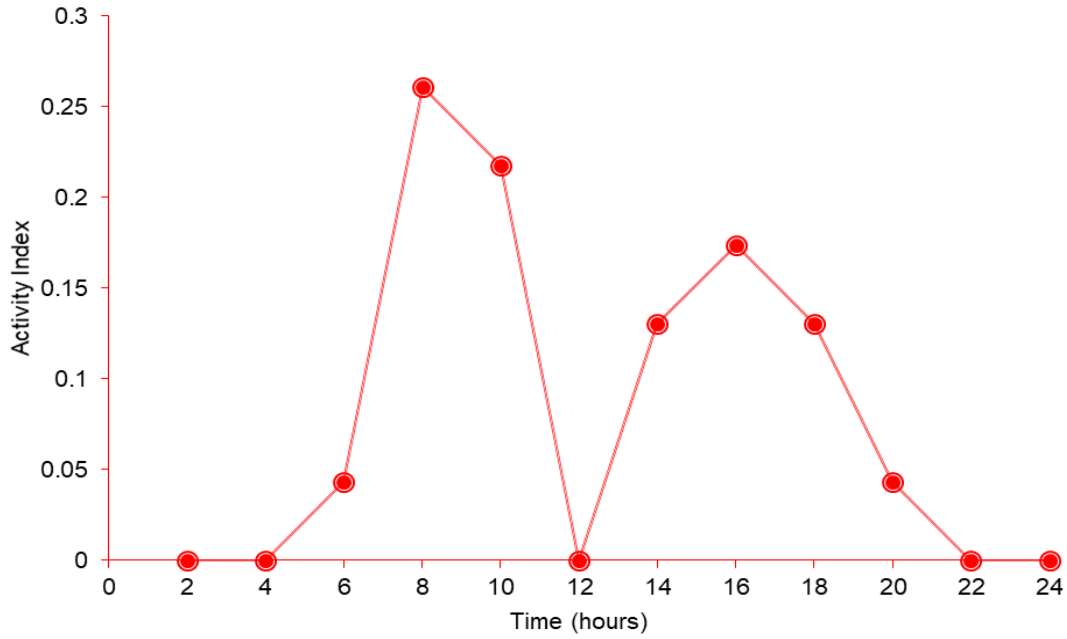
Figure 3. Daily activity patterns of Crab-eating mongoose *Herpestes urva* between October 2020 and February 2021 at Bhanu Municipality, Nepal

Table 2. Summary of analysis of variation of crab-eating mongoose *Herpestes urva* captured in different time periods (day to mid-night, mid-night to early morning and early morning till day) between October 2020 and February 2021 at Bhanu Municipality, Nepal.

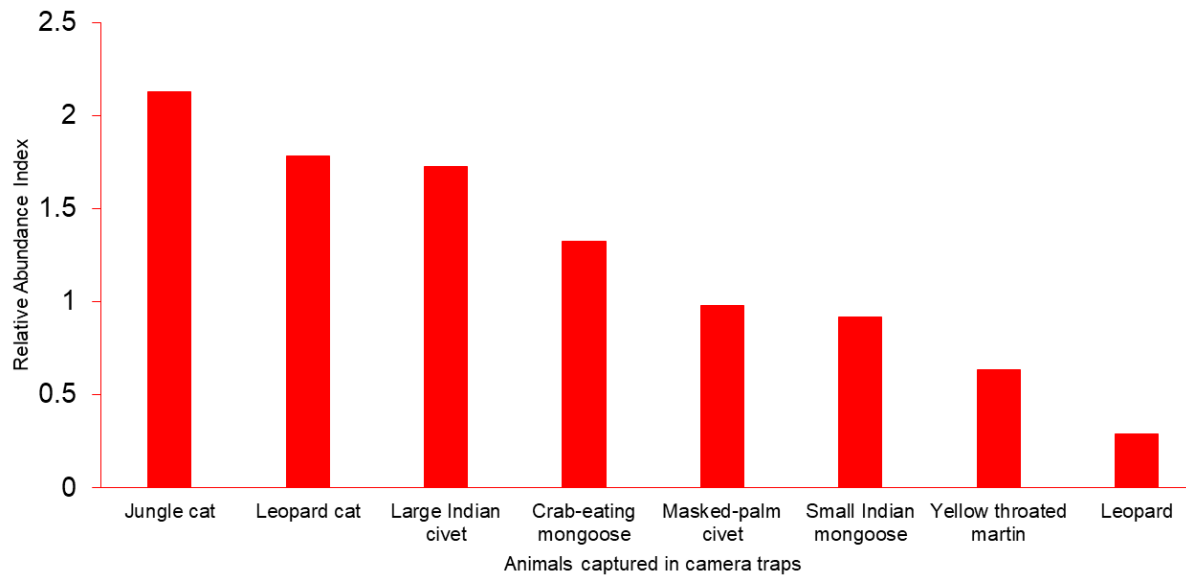| Source of Variation	SS	df	MS	F	P
Between different time	9.733	2	4.867	6.348	0.013
Within time	9.2	12	0.767		
Total	18.933	14			

Figure 4. Relative abundance of wild animals captured at camera traps between October 2020 and February 2021 at Bhanu Municipality, Nepal.

The highest RAI value greater than 1.0 was found for small and medium body sized carnivores including Jungle cat (2.1), Leopard cat (1.8), Large Indian civet (1.7), crab eating mongoose (1.3), Masked palm civet (1.0), and less than 1 for Small Indian mongoose (0.9), Yellow throated martin (0.67) and Leopard (0.3) (Fig. 4).

DISCUSSION

Our study indicated that the relative abundance of small carnivores including crab-eating mongoose is higher than large carnivore such as leopards. The crab-eating mongoose is relatively common in Southeastern Asian countries but the number of individuals of this species is speculated to be quite low in Nepal (Jnawali *et al.*, 2011). The camera traps study indicated that the crab-eating mongoose is mostly occurred in the land dominated by shrubs having estimated canopy cover less than 20% and is not mostly supported by forest. This could be due to the fact that dense shrubs and bushes offer suitable habitat for crab eating mongoose with efficient cover to protect themselves from predators such as leopards. However, the preferred habitat of crab-eating mongoose in this area is varied than the habitats mentioned as tropical and subtropical evergreen and moist deciduous forests by Jnawali *et al.* (2011), and wet evergreen forests and deciduous forests by Duckworth (2008) and Van (2001). The higher occurrence of crab-eating mongoose in shrub land might be due to the proximity to water sources which provides their preferred food such as fish, crabs and frogs. Their occurrences in these areas were less human disturbances (personal observations). In addition to our records, the crab eating mongoose are frequently reported from riverbed (Sinha & Das, 2012), stream banks (Sharma & Lamichhane, 2017), and agricultural fields with small water bodies (Thapa, 2013).

During this study, the crab eating mongoose was captured throughout various days irrespective of weather conditions, such as foggy, sunny, cloudy and rainy. The camera trapped images of crab eating mongoose in our study area were mostly captured during nighttime indicating the crepuscular and nocturnal behavior of the species (Zaw *et al.*, 2008; Chen *et al.*, 2009; Thapa, 2013; Rayamajhi *et al.*, 2019).

Our study indicated that the occurrence of crab-eating mongoose was affected by the human presence or their activities including livestock because both human, livestock and mongoose use the same walking path. However, their activities time seems varied; by working nature of human mostly actives during daytime while crab-eating mongoose at night. It supports the coexistence of crab-eating mongoose with human (Duckworth, 2008; Sethy *et al.*, 2014). In addition to human the crab-eating mongooses are known to coexist with other small carnivore species such as large Indian civet, common palm civet, yellow throated martin, leopard cat and jungle cat. The relative abundance index of crab eating mongoose is comparatively similar to other small mammal species. Their co-occurrence in the

same habitat might be due to habitat use at small areas, food habits and ecological niche (Sunquist & Sunquist, 1989; Duckworth, 2008; Sethy *et al.*, 2014).

CONCLUSIONS

We conclude that the crab-eating mongoose presence in areas having less human disturbances, low canopy cover, near to water sources. This mongoose co-exists with other carnivores species including leopards, jungle cat and leopard cat and human. To avoid unintentional killing of this species and biodiversity conservation, a site- and species-specific conservation plan can be developed and implemented using similar baseline data and findings.

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AUTHOR CONTRIBUTIONS
HPS: designed, analyzed, and wrote manuscript; BA: designed, field data collected and wrote manuscript; SB: designed, analyzed, field data collected and wrote manuscript, KB: designed, and edited manuscript, and RMK: edited manuscript.

CONFLICT OF INTEREST

The authors declare no competing interests.

DATA AVAILABILITY STATEMENT

The data used in this study are available from the corresponding author, upon reasonable request.

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