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HABITAT UTILIZATION BY ALPINE MUSK DEER, *MOSCHUS CHRYSOGASTER* (ARTIODACTYLA, MOSCHIDAE), IN KHAPTAD NATIONAL PARK, NEPAL

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Habitat Utilization by Alpine Musk Deer, *Moschus chrysogaster* (Artiodactyla, Moschidae), in Khaptad National Park, Nepal. Thapamagar, T., Bhandari, S., Acharya, H. R., Awasthi, B., K., Thapa Magar, K., Bhusal, D. R., Youlatos, D. — The Alpine musk deer is one of the least studied species that is distributed throughout an alpine ecosystem. The population of musk deer is declining because of anthropogenic pressure. Our study was conducted to understand the relationship between musk deer and their environments in the Khaptad National Park in western Nepal. We used a line transect survey to observe the pellets of the musk deer in the study site. Our study found that the pellets of the musk deer were found higher in the forested environment followed by open grassland, trails, and edge. Musk deer preferred an altitudinal range between 2,400 m and 3,200 m. Our study did not find any signs of musk deer below 2,400 m and above 3,200 m. We also found that the pellets of musk deer were mostly associated with close distance to a water body; however, they were at a far distance from villages. The presence of livestock and human pressure could have been the reasons for musk deer to avoid edge areas. Anthropogenic pressure should be reduced in the musk deer habitats for long-term musk deer conservation in Nepal.
Key words: musk deer, Khaptad National Park, alpine ecosystem, distribution.

Introduction

The Alpine musk deer (*Moschus chrysogaster*) is one of the native species in the Himalayan regions of Nepal, Bhutan, China, and India (Kattel, 1992; Wemmer, 1998; Timmins and Duckworth, 2015; Singh et al., 2018). They are distributed irregularly throughout the alpine ecosystem at an altitudinal range between 2,000 and 5,000 m. s. l. (Kattel, 1992; Khan et al., 2006; Subedi et al., 2012). The Alpine musk deer are solitary (Green, 1986) and inhabit moderate and steep slopes (Kattel and Alldredge, 1991; Zhixiao and Helin, 2002) with moderate canopy cover (Anwar and Minhas, 2008; Ilyas, 2015; Syed and Ilyas, 2016). They prefer forests of oak, fir, rhododendron, blue pine, juniper, as well as grasslands (Green, 1986; Ilyas, 2015; Syed and Ilyas, 2016). However, they select defecation sites in the fir forest and appear to avoid the blue pine and open grassland (Singh et al., 2018; Ilyas, 2015; Zhixiao and Helin, 2002). Alpine musk deer population has been declining because of anthropogenic pressure (Yang et al., 2003;Thapamagar et al., 2019) and climate change (Zhixiao and Helin, 2002; Qureshi et al., 2013; Singh et al., 2018). It is currently classified as "Endangered" by the IUCN red list and is also designated as a protected species by the Government of Nepal under NPWC Act 1972.

The Alpine musk deer population is under great pressure due to the over-exploitation of the musk pod (Zhixiao and Helin, 2002; Yang et al., 2003), triggered by high demands in the international black market of traditional medicine and perfume industries in China, India, and other countries (Green, 1986; Thapamagar et al., 2019). The male musk deer, which bears the musk pod, are the main target of poachers, but the snares kill indiscriminately male, female, and juvenile musk deer (Zhixiao and Helin, 2002; Zhou et al., 2004; Sheng and Liu, 2007). Poaching activities generally occur throughout the year, although winter is the most vulnerable season for the species (Dendup et al., 2018; Thapamagar et al., 2019). Besides poaching, musk deer are seriously affected by other anthropogenic activities, such as developmental activities, expansion of agricultural land, transhumance practices, and over-grazing that lead to habitat loss, and, in few parts of Nepal, attacks from feral dogs (Thapamagar et al., 2018).

These data indicate that habitat encroachment, degradation, and loss severely affect Alpine musk deer populations. However, there have been very few studies on Alpine musk deer habitat in Nepal. Thus, more research is required to identify the habitat types that Alpine musk deer prefer. Understanding habitat use by Alpine musk deer is even more vital in the highlands of Nepal, where Alpine musk deer and livestock share grazing grounds (Green, 1986; Thapamagar et al., 2018), increasing human-wildlife conflict. Similar information is necessary for designing and implementing either local or national action plans for the protection and long-term conservation of the species in Nepal. To fill this gap, the present study investigates the distribution and associated environmental factors of the Alpine musk deer in the Khaptad National Park (KNP) in western Nepal.

Study site and methods

Study site

The present study was carried out in the Khaptad National Park (hereafter KNP) in western Nepal (29°17′41″ N, 81°13′ 43″ E) (fig. 1). It covers an area of 225 km^2 at an average altitude of 3,000 m a .s. l. and is rich in floral and faunal diversity, that has not been systematically studied yet (Cameron, 1995). KNP consists of sub-tropical, temperate, and sub-alpine ecosystems, hosting a large diversity of plant species including *Quercus*, *Betula*, *Rhododendron*, *Pinus*, *Taxus*, etc. (Duwadee and Kunwar, 2001; Kunwar and Duwadee, 2003; Kunwar et al., 2015). In terms of mammalian diversity, the park is the prime habitat for wild boar (*Sus scrofa*), barking deer (*Muntiacus vaginalis*), yellow-throated marten (*Martes flavigula*), golden jackal (*Canis aureus*), Himalayan black bear (*Ursus thibetanus*), dhole (*Cuona alpinus*), and alpine musk deer (*Moschus chrysogaster*) (Shrestha, 1997; Majupuria and Majupuria, 2006).

Data collection and analysis

This study was carried out between October 2018 and February 2019.We used the line transects survey to detect the pellets of Alpine musk deer throughout the study site (Sutherland, 2006). A total of 46 transects were used. Transects varied in length from 1km to 1.5 km. Distance between transects was set at a minimum of 0.5 km. This study covered altitudes between 2,200 m and 3,300 m. a. s. l. (fig. 1). Field survey was restricted to daytime hours, between 10:00 and 15:00. For the purposes of the present study, detected Alpine musk deer pellets were classified into four categories: (a) very fresh: shiny black with a high amount of moisture, (b) fresh: shiny black but with less amount of moisture, (c) old: grayish-black without any shine, and (d) very old: discolored dried and cracked (Singh et al., 2018). Pellet categories were also double-checked by the experienced nature guide. Each pellet was considered as a single independent observation.

For every detected pellet, we recorded the coordinates and several habitat parameters: (a) habitat type, classified as forest, open grassland, trail/hill, and edge. Moreover, we recorded the distance from the water body and human settlement, classified as very close (0–2 km), close (2.1–4 km), and far (> 4 km). We used ANOVAs to determine statistically *significant* differences *between* the use of habitat parameters.

Additionally, we laid a total of 46Use plots (U) and 35 Availability plots (A) throughout the study area (Subedi et al., 2012). The Use plots were set at 50 m from a detected musk deer pellet, and Availability plots were set at a random direction at 150 m of the use plots (Aryal et al., 2010). If by chance, Availability plots contained musk deer pellets, they were counted as Use plots. To identify habitat preference or avoidance used the Ivlev′s

electivity index (IV) [IV= (U %–A %)/(U %+A %)] (range –1 to +1), where negative values indicate avoidance, positive values indicate a preference, and values close to 0 indicate random use (Ivlev, 1961; Aryal, 2009).

Results

We observed a total of six individuals of Alpine musk deer in the forested areas of KNP. We detected a total of 76 pellet groups (range: 1–3; average 1.1; ± 0.41 SD), found in all the examined sites (Triveni, Sahasralinga, Seleko Lek, Dhaule dhunga, and Buddha dhunga) of the study area (fig. 1). During the study, most pellets were old (45 %) and very old (28 %). Only a small proportion were either fresh (19 %) or very fresh (8 %).

Our study showed that all pellets recorded between 2,400 and 3,300 m. We did not find any pellets or any other Alpine musk deer sign above 3,200 m and below 2,400 m. Moreover, Ivlev´s index indicates that Alpine musk deer preferred altitudes between 3,000 and 3,200 m (fig. 2).

Most pellets were found significantly more frequently in forested habitat (40 %), compared to open grassland (31 %), trails/hills (18 %), and edge (10 %) ($F = 12.7$, d. f. = 15, $p < 0.0001$). Additionally, most pellets (62 %) were located close to water bodies, followed by very close (20 %) and far (18 %) ($F = 34.4$, d.f. = 20, $p < 0.0001$). Similarly, 69 % of pellets was found far from human settlements, followed by close (21 %) and very close (10 %) ($F = 47.0$, d. f. = 20; $p < 0.0001$).

Discussion

The present study showed that the Alpine musk deer is found in all the examined sites in KNP (Triveni, Sahasralinga, Seleko Lek, Dhauled hunga, and Buddha dhunga). As there was no previous study on the distribution of the Alpine musk deer in KNP, our study was necessary to identify the distribution of the species in the area as suggested by Aryal and Subedi (2011) in their basic outlines for KNP. Moreover, we showed that in KNP, defecation sites were significantly related to forests, close distance from water bodies, and far distance from human settlements. These sites are most likely related to dense humid vegetation cover and less anthropogenic disturbance. These results are supported by the findings of Aryal et al. (2005) in Sagarmatha National Park, Karki (2008) in Dhorpatan Hunting Reserve, Joshi (2011) in Mustang District, in Nepal, and of Ilyas (2015) in nearby Uttarakhand Himalayas (India), where animals and pellets were primarily found in relatively dense and less human-disturbed environments. Musk deer probably select undisturbed areas to mainly avoid anthropogenic pressure, such as poaching and agro-pas-

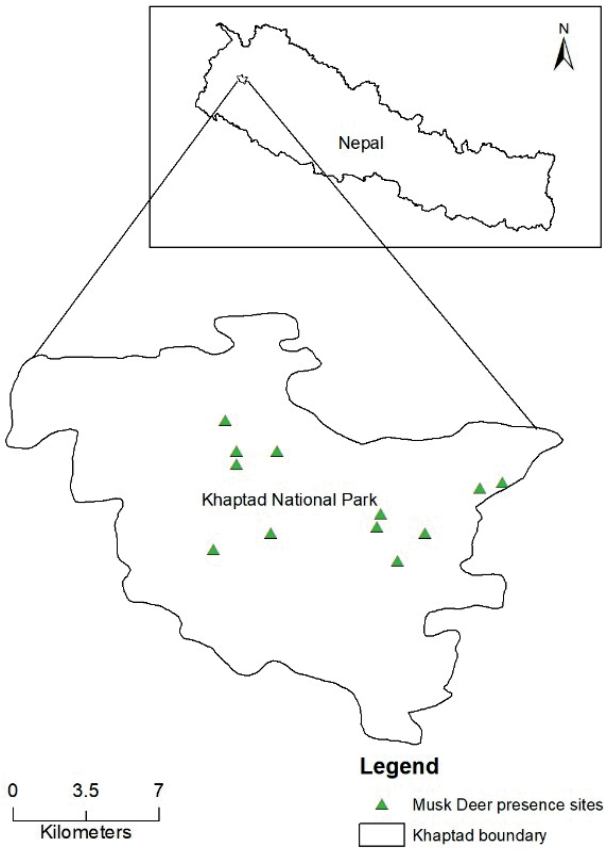

Fig. 1. Study area, the Khaptad National Park, Nepal.

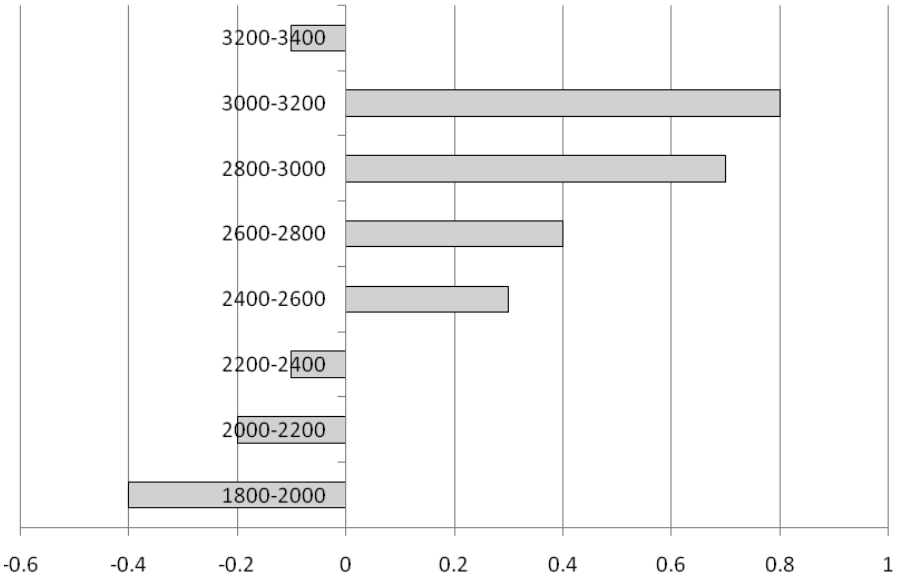

Fig. 2. Ivlev´s habitat electivity index of the musk deer in the Khaptad National Park, Nepal.

toral activities. Similarly, in KNP, musk deer mainly used forested areas, as also supported by Aryal (2005), Aryal et al. (2010); Subedi et al. (2012), and Khadka and James (2016).

This study also found that the Alpine musk deer prefer altitudes between 3,000–3,200 m followed by 2,800–3,000 m, whereas they avoid altitudes below 2,400 m and above 3,200 m. However, Subedi et al. (2012) found that 3,601–3,800 m was the most preferred elevation in Manaslu Conservation Area, and Singh et al. (2018) had observed that defecation sites were located between 3,200–4,200 m in the Annapurna Conservation Area. These contrasting results may be due to topographic differentiation between the different study areas. KNP has a maximum elevation of 3,300 m with the musk deer using habitats between 1,800–3,200 m. Alpine musk deer absence below 2,400 m may be related to the presence of increased anthropogenic activities (Aryal et al., 2010; Subedi et al., 2012; Khadka and James, 2016; Thapamagar et al., 2019). Moreover, this absence may be further related to the presence of large predators. Although we did not detect any predator signs during our field study, carcasses of deer have been frequently reported in the range of large predators (Duwadee and Kunwar, 2001; Bhandari et al., 2017; Bhandari et al., 2020). On the other hand, the absence of the species above 3,400 m may be related to reducing the availability of closed forested habitats and of plant food sources due to harsh and extreme conditions.

Conclusions

This study showed that in KNP, the Alpine musk deer is found in habitats, at altitudes between 2,400–3,200 m, which are forested, close of water bodies, and far from human settlements. These findings most likely indicate that, in lower altitudes, increased anthropogenic activities, such as poaching, agriculture, or livestock, limit the presence of Alpine musk deer in KNP. In middle elevations, Alpine musk deer avoids human settlements and use the safety of dense forests close to water bodies, where more food is available. Lastly, in high elevations, the lack of available forested habitats and available food sources in higher altitudes limit the presence of Alpine musk deer. All these factors may be challenging for the sustainable conservation of the Alpine musk deer in the KNP. As KNP represents one of the potential habitats for the Alpine musk deer population in Nepal, it requires more efforts on conservation management. This needs to take into account not only the well-being of the species but also consider the local communities and their active involvement and support.

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