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Habitat Ecology of Himalayan Musk Deer (*Moschus chrysogaster*) in Manaslu Conservation Area, Nepal

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ABSTRACT

The Himalayan musk deer (*Moschus chrysogaster*) is an endangered species found in the Himalayan region of Nepal. This research was conducted in the Manaslu Conservation Area to explore the deer's general population status, distribution, habitat preference and conservation threats. Musk deer are distributed within the altitudinal range of 3128-4039 m spanning 35.43 km^2, with the most potential habitat in the Prok VDC (Village Development Committee). Within this area the Musk deer highly preferred altitudes between 3601-3800 m, with a 21-30° slope, 26-50% crown cover and 26-50% ground cover. There are significant differences in the use of different habitat types in terms of altitude, slope, crown cover, ground cover and topography. The preferred tree species were *Abies spectabilis*, *Betula utilis* and *Rhododendron* species. Poaching of deer for their musk is the major conservation threat.

Key words: Himalayan musk deer, Manaslu conservation area, habitat preference, poaching

INTRODUCTION

The Himalayan musk deer (*Moschus chrysogaster*), is a shy solitary, Himalayan mammal listed as endangered under the IUCN category (CITES-appendix I and IUCN Red Data Book). Musk deer are commonly known as Kasturi Mriga in Nepali and Lah in the Tibetan language spoken in the mountainous western region of Nepal. There are five species of musk deer; the Siberian (*Moschus moschiferus*), black (*Moschus fuscus*), forest (*M. berezovskii*), alpine (*M. sifanicus*) and Himalayan musk deer (*M. chrysogaster*). They are distributed through at least 13 countries in South Asia, East Asia, Southeast Asia and Eastern Russia (Homes, 2004; Xiuxianga *et al*., 2006; Aryal *et al*., 2010). Populations are currently in decline-the result of habitat loss and intensive illegal hunting for musk (Homes, 1999). The Himalayan musk deer, one of six deer species that occur in Nepal, belong to order Artiodactyla, family Moschidae. The species is protected in Nepal by the National Park and Wildlife Conservation act 1973.

The Himalayan musk deer are distributed throughout the mountainous regions of the country, which covers 30177.19 km^2 with 5815.08 km^2 of potential habitat used inside protected areas

(Aryal and Subedi, 2011) including: Api Namppa Conservation Area (ANCA), Khaptad National Park (KNP), Rara National Park (RNP), Shey Phoksundo National Park (SPNP), Dhorpatan Hunting Reserve (DHR), Annapurna Conservation Area (ACA), Manaslu Conservation Area (MCA), Langtang National Park (LNP), Gaurishankar Conservation Area (GCA), Sagarmatha National Park (SNP), Makalu Barun National Park (MBNP) and Kanchanjanga National Park (KCP) from the western to the eastern part of the country (Aryal and Subedi, 2011; Aryal *et al*., 2010).

Himalayan musk deer are the most primitive and smallest of the Himalayan ungulates living in a cold environment (Schaller, 1977). Extensive hunting (legal or illegal) over a long period for musk has resulted in a sharp decline of populations such that *Moschus* spp. have become endangered and in some areas, locally extinct. Since 1979, all musk deer have been included in the Appendices of CITES (Zhou *et al*., 2004).

Research on musk deer has been undertaken only in a few protected areas of Nepal and includes conservation needs, initial population status, habitat ecology of the species and threats in order to determine the necessary conservation initiatives. This is the first study regarding the musk deer in the Manaslu Conservation Area. The research aims were to explore the current population status, habitat ecology (in terms of preference/avoidance) and conservation issues of Himalayan musk deer specific to the MCA of western Nepal.

MATERIALS AND METHODS

Status and distribution: Field work was conducted in June and July 2010. A faecal pellet count method was used to determine the current population status of musk deer in the study area. Fifteen transect strips each 500 m long and 20 m wide (10 m each side), were established in the forest representing altitudinal variation and potential habitat. Wherever possible, livestock and human tracks were used. Very fresh to 30 day old pellets were counted and categorized on the basis of freshness and deposited layer of the pellet by researchers and local people. Standardized protocols were developed to ensure uniformity while walking in the transects e.g., time of day, search effort etc. Distribution sites were verified by field observation and GPS locations were recorded for each encounter of musk deer sign (Giriraj *et al*., 2008). Arc GIS 9.3 was used to prepare musk deer distribution maps.

Assessment to determine habitat ecology: Random sampling was used to determine habitat parameters in the field. Habitat use plots (U) and availability plots (A) were taken throughout the study area. Habitat use plots were laid out with the spacing of at least 50 m from musk deer sign (e.g., pellet, hair, foot print, resting site). At the same time other parameters such as slope, altitude, crown cover, ground cover and topography were recorded at each plot. The habitat availability plots (A) were selected in a random direction from the use plots at a distance of 100-150 m (Aryal *et al*., 2010) with the same additional parameters from the use plots recorded. If musk deer sign was found within an availability plot then they were counted as use plots. In total, vegetation analysis was completed for 86 use and availability plots and evaluated as by Schemnitz (1980). Analysis included 10×10 m crown cover (i.e., tree layer-plants above 3 m height and 10 cm DBH-Diameter at Breast Height), 4×4 m shrub layer (woody plants below 3 m height) and 1×1 m plots for herbs (plants up to 1 m height). Slope at each site was measured using Abney's level. In each plot, we recorded DBH, height, crown cover, ground cover, frequency of trees shrubs and herbs and other animal sign (Zakaria *et al*., 2009; Md-Zain and Chng, 2011). The presence of

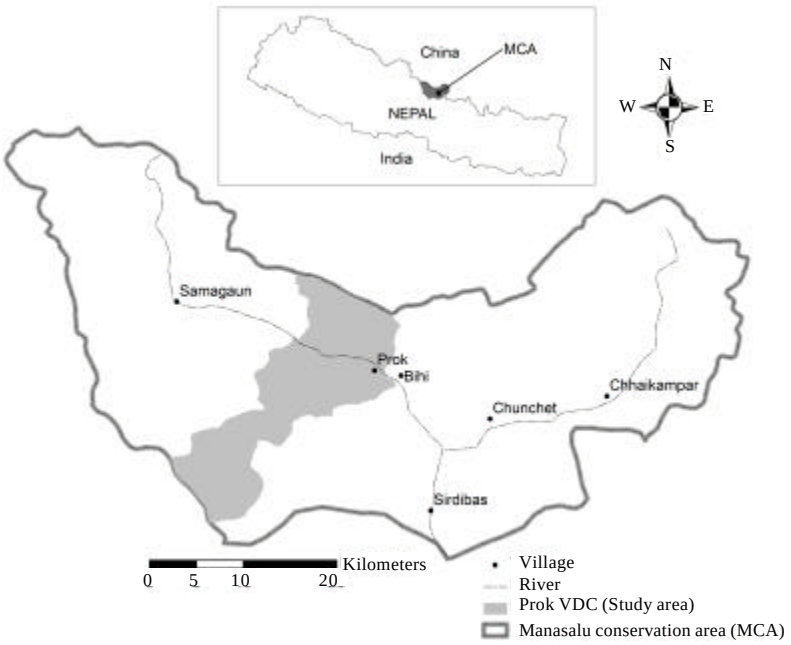

Fig. 1: Study area (Pork VDC) inside the Manaslu conservation area (MCA)

other animals was recorded to determine habitat overlap with musk deer. The level of anthropogenic activity within each site was also noted (Moradi *et al*., 2009; Mokonnen *et al*., 2011).

Ivlev's electivity index (IV): Habitat preference of musk deer was calculated using Ivlev's electivity index (IV), the values of which range from -1.0 to+1.0. Positive values indicate habitat preference, negative values avoidance and 0 indicates random use (Ivlev, 1961). A one way ANOVA was used to test the significance of habitat parameters (Ivlev, 1961; Krebs, 1989 followed by Aryal *et al*., 2010):

$$IV = \frac{(U\% - A\%)}{(U\% + A\%)}$$

Threat identification: To identify the threats of musk deer a questionnaire schedule was used. Informal discussions were also held with the local staff, local people and herders to further identify threats and conservation issues. Field observation was used to evaluate anthropogenic pressure and domestic grazing in the potential habitat of musk deer.

Study area: Manaslu was declared a conservation area in December 1998 by Government of Nepal (GON) under the National Parks and Wildlife Conservation Act 1973. It covers an area of 1663^2 km (Fig. 1). The region harbours a mosaic of habitats for 38 species of mammals, 201 species of birds, 13 species of butterflies and 5 species of reptiles (NTNC, 2011). There are approx 2000 species of plants, 13 types of forests. The bio-climatic zones vary from sub-tropical to nival. Altitude

increases from 600 m (msl) to 8,163 m at the summit of Mt. Manaslu, the eighth highest peak in the world (DNPWC, 2011). The major ethnic group in the region is Bhotia (Tibetan origin) in all VDCs except Sirdibas, however, some would prefer to be referred to as lamas. In Sirdibas, Gurung and Karki are the major ethnic group. Most of the residents are Buddhist. The topography of the region consists of steep rocky mountains. The land is poor and not suitable for agricultural crops. Local agriculture barely supplies sufficient food for three months in the MCA. Mules are the major source of transportation. The main occupations are agriculture, animal husbandry, wage labour and NTFPs collection.

RESULTS

Musk deer were found to be distributed in all seven VDCs of the Manaslu Conservation Area but mostly within a 35.43 km² area of Prok VDC (Fig. 2). Major distribution areas were Mayar Danda, Thopa Ghyapsa, Gumba, Dhama, Kaal Tal, Sima and Thuldhunga forest area, ranging from 3128-4039 m with the pellet density of 22.21 pellets ha^{-1}.

Habitat preference

Altitude preference: Altitude was divided into six categories of 200 m intervals from <3200 to >4000 m to analyze the habitat preference. Musk deer mostly preferred the altitudinal range of 3601 to 3800 m (IV = 0.2). Altitudinal preference gradually increased from 3201 to 3800 m and randomly used 3801 to 4000 m (IV = 0). The deer avoided areas below 3200 m (IV = -0.2) and above 4000 m (IV = -0.67). There was a significant difference in use of different altitude intervals in proportion to their availability ($F = 5.87$, $p<0.05$) (Fig. 3).

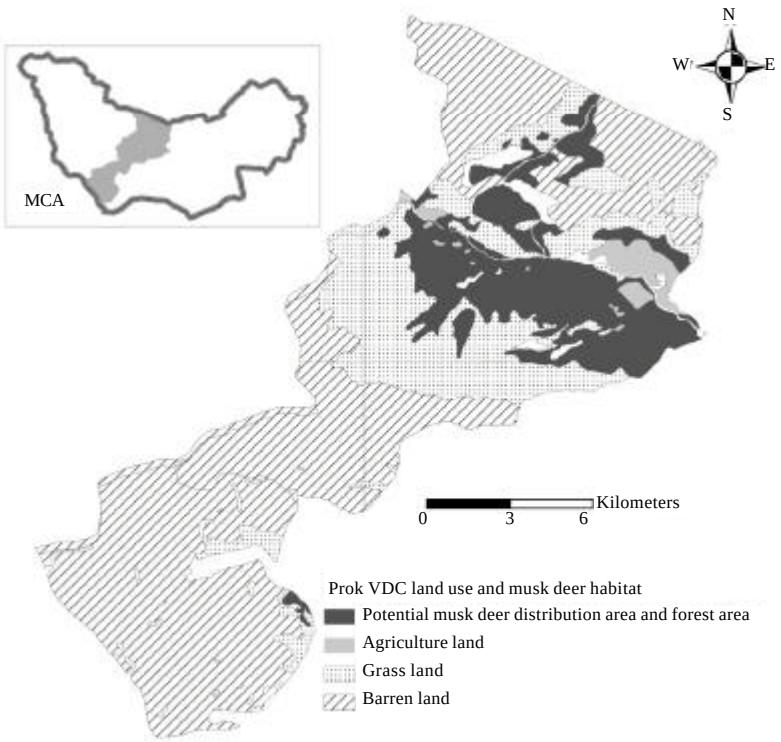

Fig. 2: Distribution of Himalayan musk deer in prok VDC of MCA

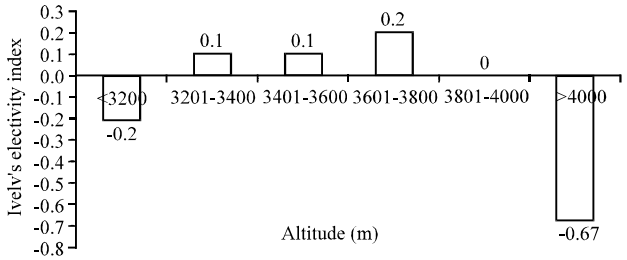

Fig. 3: Altitude preferences

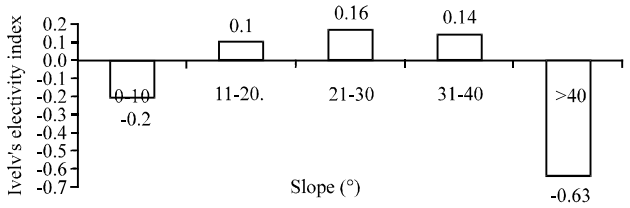

Fig. 4: Slope preferences

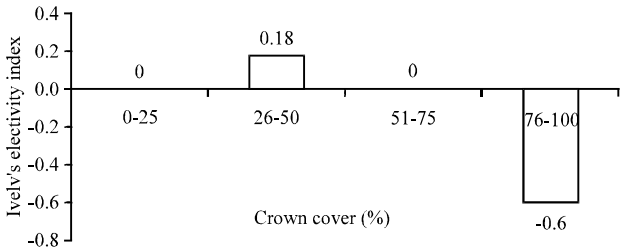

Fig. 5: Crown cover preferences

Slope preference: Slope was divided into 5 categories of 10° intervals from 0 to >40°. Musk deer mostly preferred a 21 to 30° slope (IV = 0.18). Slope preference gradually increased from 11 to 30° and slightly decreased up to 40°. The deer avoided slopes less than 10° (IV = -0.2) and greater than 40° (IV = -0.63). There was a significant difference between the use of different slopes in proportion to their availability ($F = 5.22$, $p<0.05$) (Fig. 4).

Crown cover preference: Crown cover was divided in to four categories for analysis. Musk deer used the crown cover for camouflage and thermal regulation. The deer preferred the crown cover of 26 to 50% (IV = 0.18) with 0 to 25% and 51 to 75% found to be used randomly. The 76 to 100% (IV = -0.6) slope was completely avoided. There was a significant difference in the use of different crown cover in proportion to their availability by musk deer ($F = 5.40$, $p<0.05$) (Fig. 5).

Ground cover preference: Musk deer used the ground cover for grazing, camouflage and thermal regulation. Ground cover was divided in to four categories for the analysis. The deer preferred 0 to 25% (IV = 0.05) and 26 to 50% (IV = 0.10) ground cover and avoided 76 to 100% (IV = - 0.72), while 51 to 75% (IV = 0) ground cover was used randomly. This shows that musk deer preferred sparse and moderate ground cover. There was significant difference in the use of different ground cover in proportion to their availability ($F = 4.81$, $p<0.05$) (Fig. 6).

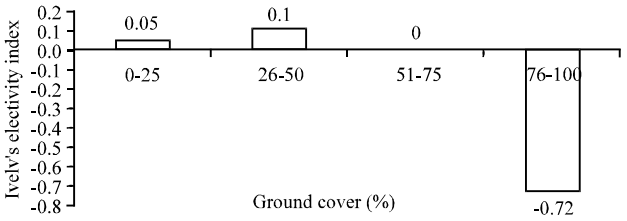

Fig. 6: Ground cover preferences

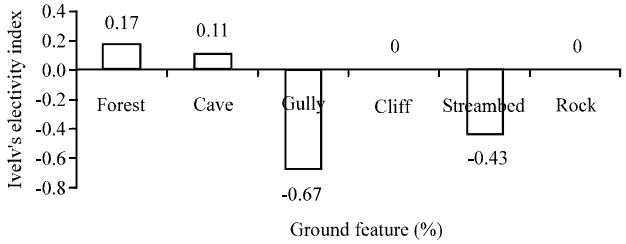

Fig. 7: Ground feature preference

Table 1: Tree species preference

Species	IVI	Ivlev's value	Status
Betula utilis	17.33	0.03	Prefer
Pinus wallichiana	3.64	-0.43	Avoid
Abies spectabilis	96.70	0.04	Prefer
Cupressus spp.	4.69	-0.39	Avoid
Sorbus spp.	5.94	-0.65	Avoid
Acer spp.	0.70	0.27	Prefer
Rhododendron arboreum	9.63	0.01	Prefer
Rhododendron campanulatum	5.40	0.02	Prefer
Rhododendron anthopogon	3.58	0.15	Prefer

Ground feature preference: Ground condition is divided in to six categories for analysis and the pellet group in each category recorded. Most pellets were recorded in forest and so it is concluded that musk deer prefer forest habitat (IV = 0.17). Cliff (IV = 0) and rock (IV = 0) was found to be used randomly and gullies (IV = -0.67) and streambeds (IV = -0.43) were found to be avoided completely. There was a significant difference in use of different ground feature in proportion to their availability ($F = 3.29$, $p<0.05$) (Fig. 7).

Tree species preference: Plants above 3 m in height and 10 cm in dbh were categorised as trees and recorded in the 10×10 m^2 plots. Altogether 9 species of tree were identified in 86 plots. Musk deer showed preference for 6 species (especially *Betula utilis* (IVI = 17.33, IV = 0.03), *Abies spectabilis* (IVI = 96.70, IV = 0.04), *Acer* spp. (IVI = 0.70, IV = 0.27) and *Rhododendron* spp. and avoidance for 3; *Pinus wallichiana* (IVI = 3.64, IV = -0.43), *Cupressus* spp. (IVI = 4.69, IV = -0.39) and *Sorbus* spp. (IVI = 5.94, IV = -0.65) (Table 1).

Shrub species preference: Woody plants below 3 m in height were categorised as the shrubs and recorded in 4×4 m^2 plots nested within the tree plots. A total of 10 species of shrub were recorded in 86 plots. Musk deer preferred *Cupressus* spp. (IV = 0.46), *Abies spectabilis* (IV = 0.35), *Acer* spp.

Table 2: Shrub species preference

Species	Ivlev's value	Status
Betula utilis	-0.16	Avoid
Pinus wallichiana	-0.16	Avoid
Berberis angulosa	-0.16	Avoid
Cupressus spp.	0.46	Prefer
Sorbus spp.	-0.42	Avoid
Abies spectabilis	0.35	Prefer
Acer spp.	0.37	Prefer
Rhododendron spp.	-0.11	Avoid
Hydrangea spp.	0.04	Prefer
Viburnum spp.	-0.47	Avoid

Table 3: Herb species preference

Species	Ivlev's value	Status
Geranium nakaoanum	-0.10	Avoid
Primula sikkimensis	-0.10	Avoid
Anemone obtusiloba	-0.17	Avoid
Oplismenus compositus	0.03	Prefer
Equisetum debile	0.41	Prefer
Oxyria digyna	-0.12	Avoid
Primula macrophylla	-0.42	Avoid
Potentilla fruticosa	-0.10	Avoid
Iris goniocarpa	-0.13	Avoid
Arundinaria species	0.03	Prefer
Moss	0.57	Prefer
Capsella bursa-pastoris	0.10	Prefer
Fern	0.15	Prefer
Polygonatum species	0.10	Prefer
Bergenia ciliata	0.24	Prefer
Cassiope fastigiata	0.10	Prefer

(IV = 0.37) and *Hydrangea* spp. (IV = 0.04), while *Betula utilis* (IV= -0.160, *Pinus wallichiana* (IV = -0.16), *Berberis angulosa* (IV = -0.16), *Sorbus* spp. -0.42, *Rhododendron* spp. (IV = -0.11) and *Viburnum* spp. (IV = -0.47) were avoided (Table 2).

Herb species preference by musk deer: Out of 16 recorded herb species, 9 were preferred and 7 were avoided by musk deer. *Oplismenus compositus* (IV = 0.03), *Equisetum debile* (IV = 0.41), *Arundinaria* spp. (IV = 0.03), Moss (IV = 0.57), *Capsella bursa-pastoris* (IV = 0.10), Fern (IV = 0.15), *Polygonatum* spp. (IV = 0.10), *Bergenia ciliate* (IV = 0.24) *and Cassiope fastigiata* (IV = 0.10) were the preferred species. *Geranium nakaoanum* (IV = -0.10), *Primula sikkimensis* (IV = -0.10), *Anemone obtusiloba* (IV = -0.17), *Oxyria digyna* (IV = - 0.12), *Primula macrophylla* (IV = -0.42), *Potentilla fruticosa* (IV = -0.10) and *Iris goniocarpa* (IV = -0.13) were the avoided species (Table 3).

DISCUSSION

Aryal *et al.* (2010) found that the musk deer randomly use the habitat below 3000 m and completely avoid habitat above 4000 m in Sagarmatha National Park of Nepal, while, Green (1985) recorded the musk deer within the altitudinal range of 2500-4500 m. This research shows a distribution within the altitudinal range 3128-4039 m. In general, ranges below 3200 m and above

4000 m are avoided by the Himalayan musk deer. Below 3200 m, blue pine forest is dominant in the MCA, with the deposition of the needles suppressing growth of ground level browse. Deposition of pine needles without decomposition on the steep slopes also causes difficulties for fast moving animals when they need to escape predators. Above 4000 m the land is a treeless, rocky terrain lacking in sufficient water.

Habitat preference increased above the 3200 m up to 3800 m in altitude and is highly preferred between 3600 to 3800 m. This may be because of the dominance of *Betula utilis*, *Abies spectabilis* and *Rhododendron* spp. forest. The preference for these major tree species is similar with the findings of Aryal *et al.* (2010). A lake lies at an altitude of 3700 m which provides a necessary water source for the musk deer both summer and winter. The permanent water source and gentle slope are thought to be the reason for the high preference of this range by the musk deer. Although livestock herding covers a small area concentrated near the lake, musk deer concentrate in the same area because of the water. Thus there is a habitat overlap with the livestock in this area.

This overlap results in a high impact zone due the animal herding by the local community. The herders graze their livestock in the high mountains, especially in the summer season, bringing the cattle down to the village in winter. Although, this altitudinal range has high cattle pressure, musk deer are recorded as close as 300 m from the cattle. This is because of the preference for the habitat (e.g., slope) plus the presence of many small caves. Caves are found to be highly utilised by the deer for the thermal and escape cover. Musk deer randomly used open areas while completely avoiding highly dense forest with very low light penetration. Similarly, gullies and streambeds are completely avoided because they are difficult to traverse.

Poaching was found to be the major conservation threat in the MCA. Since the musk deer area is far from the village and also from the conservation area project office there is lack of sufficient monitoring to control poaching. The main reason for the intense hunting of musk deer has always been the demand for musk. A significant increase in the price of musk in the international market has lead to a parallel increase in poaching and smuggling from the Himalayan habitat and in different parts of the world, particularly in Hong Kong, China and Japan (Xiuxianga *et al.*, 2006; Aryal, 2006; Aryal *et al.*, 2010; Aryal and Subedi, 2011).

Most questionnaire respondents are Buddhists and denied the involvement of local people in poaching and illegal trade. This is because it is against the Buddhist faith to kill livestock or cattle, even for meat, which ultimately helps to reduce poaching. Poachers are believed to be outsiders from the different parts of Nepal who generally come over the winter season-when the herders have brought their livestock down to the village-and therefore are less likely to be seen. However, the herders are aware of the poaching. Poachers use snares to kill the musk deer in frequently travelled areas. At times, herders have arrested the poachers from the neighbouring district turning them over to the police. There is a local level Conservation Area Management Committee (CAMC) in this VDC formed by the conservation area management authority with the aim of conservation and management of the overall forest, controlling poaching and illegal activities at the local level.

It is suggested community involvement could be strengthened to control the poaching through frequent participation in monitoring with the conservation area management authorities. In addition a separate conservation action plan should be developed and implemented. Eco-friendly income generating initiatives should be encouraged to support local livelihoods and contribute to the sustainable conservation of the musk deer species and biodiversity as a whole.

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REFERENCES

Aryal, A. and A. Subedi, 2011. The conservation and potential habitat of the Himalayan musk deer, *Moschus chrysogaster*, in the protected areas of Nepal. Int. J. Conserv. Sci., 2: 127-141.

Aryal, A., 2006. Himalayan musk deer in Annapurna conservation area, Nepal. Tiger Pap., 33: 11-18.

Aryal, A., D. Raubenheimer, S. Subedi and B. Kattel, 2010. Spatial habitat overlap and habitat preference of Himalayan musk deer (*Moschus chrysogaster*) in Sagarmatha (Mt. Everest) National Park, Nepal. Curr. Res. J. Biol. Sci., 2: 217-225.

DNPWC, 2011. Protected areas of Nepal. Department of National Park and Wildlife Conservation, Nepal.

Giriraj, A., S. Babar and C.S. Reddy. 2008. Monitoring of forest cover change in pranahita wildlife sanctuary, Andhra Pradesh, India using remote sensing and GIS. J. Environ. Sci. Technol., 1: 73-79.

Green, M.J.B., 1985. Aspects of the ecology of the Himalayan musk deer. Ph.D. Thesis, University of Cambridge, Cambridge, UK.

Homes, V., 1999. On the scent: Conserving musk deer: The uses of musk and Europes role in its trade. A Traffic Europe Report.

Homes, V., 2004. No licence to kill: The population and harvest of musk deer and trade in musk in the Russian Federation and Mongolia. Traffic Europe, pp: 8.

Ivlev, V.S., 1961. Experimental Ecology of the Feeding Fishes. Yale Univ., Press, New Havens.

Krebs, C.J., 1989. Ecological Methodology. 1st Edn., Harper and Row, New York, ISBN: 0060437847.

Md-Zain, B.M. and C.E. Chng, 2011. The activity patterns of a group of cantor dusky leaf monkeys (*Trachypithecus obscurus halonifer*). Int. J. Zool. Res., 7: 59-67.

Mokonnen, T., M. Yab, A. Bekele and J. Malcolm, 2011. Food selection and habitat association of Starck's hare (*Lepus starcki* Petter, 1963) in the Bale Mountains National Park, Ethiopia. Asian J. Applied Sci., 4: 728-734.

Moradi, H.V., M. Zakaria, A.B. Mohd and E. Yusof, 2009. Insectivorous birds and environmental factors across an edge-interioir gradient in tropical rainforest of Malaysia. Int. J. Zool. Res., 5: 27-41.

NTNC, 2011. Manaslu conservation area project. National Trust for Nature Conservation. http://www.ntnc.org.np/project/manaslu-conservation-area-project

Schaller, G.B., 1977. Mountain Monarchs: Wild Sheep and Goats of the Himalaya. University of Chicago Press, Chicago, IL., USA., ISBN-13: 9780226736419, Pages: 425.

Schemnitz, S.D., 1980. Wildlife Management Technique Manual. 4th Edn., Wildlife Society, Washington, DC., USA., ISBN-13: 9780933564084, Pages: 686.

Xiuxianga, M., Z. Caiquana, H. Jinchu, L. Cao and M. Zhibin *et al*., 2006. Musk deer farming in China. Anim. Sci., 82: 1-6.

Zakaria, M., M.N. Rajpar and A.S. Sajap, 2009. Species diversity and feeding guilds of birds in Paya Indah wetland reserve, Peninsular Malaysia. Int. J. Zool. Res., 5: 86-100.

Zhou, Y., X. Meng, J. Feng, Q. Yang, Z. Feng, L. Xia and L. Bartos, 2004. Review of the distribution, status and conservation of musk deer in China. Folia Zool., 53: 129-140.