World Journal of Zoology 6 (1): 80-85, 2011
ISSN 1817-3098

Feeding Ecology and Distribution of Himalayan Serow *(Capricornis thar)* in Annapurna Conservation Area, Nepal

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Abstract: Serow *(Capricornis thar)* is a threatened species distributed across the protected mountainous areas of Nepal. Since very little is known about the ecology of serows, we conducted a study into the feeding ecology and distribution of this species in the Annapurna Conservation Area (ACA), with a view towards identifying threats to their conservation. We found serow to be distributed across the lower belt of ACA, which comprised 722.22 Km^2 of potential habitat spanning four districts of the conservation area. Microhistological analysis of plant remains in fecal samples established that serow is generalist herbivores. A total of thirty four plant species were identified, with *Arundinaria spp* being the most prevalent component *(*9.4%) followed *Urtica spp* (7.4%), *Strobilanthes spp* (7.1%), *Oplismlaus composites* (6.1%), *Leontopodium jacotianum* (6.1%), *Rhododendron spp* (6.1%), *Eqmesetum debile* (4.0%), *Reinwardtia indica* (4.0%), *Rubus spp* (3.0%) and *Themada triandra* (2.0%). Two important challenges for the conservation of serow were identified: i. Competition with local people, who rely on many of the plants in the diet of serow, including the important *Arundinaria spp* for medicines, foods and sources of structural materials. ii. Populations are becoming isolated as a result of habitat degradation due to settlements disrupting the corridors connecting different regions.

Key words: Serow % Thar % Generalist herbivore % Diet % Distribution % Potential habitat % Conservation

INTRODUCTION

The Himalayan serow (*Capricornis thar)*, commonly known in Nepal as thar, is a solitary mammal [1-3] belonging to the tribe Rupicaprinae (goat antelopes [2]), in the sub-family Caprinae, family Bovidae and order Artiodactyla. Five sub-species of *Capricornis sumatraensis* are known, viz. *C.s. maritimus, C.s. milneedwardsi, C.s. rubidus, C.s. sumatraensis and C.s. thar* [4]. Of these sub-species, only *Capricornis sumatraensis thar* is found in Nepal [1, 2, 4].

Serows are herbivores, feeding on grasses, shoots and leaves. They prefer damp and thickly wooded gorges typically between 1500-4000 m [3, 5], but are also seen on open cliffs and rocky slopes. The species is oriental in origin [5], with current geographic range being bordered by Jammu and Kashmir (India) in the west and extending to Japan in the far north east [5]. They are native to eastern and south eastern Bangladesh, the Himalayas (Bhutan, Northern India and Nepal), north eastern India and probably western Burma and China (Tibet), but have uncertain presence in Myanmar. Serow habitat stretches from Indian Kashmir in the foothills of the Himalayas to Assam in western India, southern China and Burma. The species has also been found in Thailand, Malaysia and Sumatra [2].

In Nepal, Serow has been reported form Annapurna Conservation Area (ACA), Sagarmatha National Park (NP), Makalu Barun NP and CA, Dhorpatan Hunting Reserve, Langtang NP, Khaptad NP, Rara NP and perhaps in Shey-Phoksundo NP and Chitwan NP. They have also been reported from Kanchanpur, Taplejung, Ramechhap and Illam districts [6]. The serow population in ACA is isolated in a small patch of the southern part of the area,

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with an estimated population density of 1.17 individual/km^2 and a population sex ratio of 1:1.6 (Male: Female) [6].

Himalayan serow have the status of Near Threatened (NT) in the IUCN Red List [1] and are listed in Appendix I of CITES [6]. Owing to their population decline, the hunting of serow has been prohibited throughout Nepal [7].

Considering its threatened status, very little is known about the ecology of serow. Of particular importance for conserving suitable habitat is knowledge of the habitat and dietary preferences of the species. Our aim in this study was to conduct a survey of the distribution of serow in the Annapurna Conservation Area of Nepal during June and July 2010 and used microhistological analysis of fecal pellets to quantify their dietary preferences throughout this part of their range.

METHODS AND MATERIALS

Study Area: The study was conducted in the lower belt of ACA region and pellet sample were collected around the Bamboo area, which lies in Ghandruk VDC in western Nepal (Fig. 1). ACA is the oldest and largest conservation area in Nepal. ACA is the first protected area that has allowed local residents to live within the boundaries and maintain their traditional rights to utilize natural resources [6]. The geography of the study area is steep forest, with the slopes ranging from about 3° to about 75° and land features ranging from flat land to cliffs. The altitudinal range varies from about 2100m at the river to above 3500 m at the top of the cliff. The forest lies to the west of Modi River, which flows from north to south. The river serves as the boundary between Ghandruk and Landruk VDCs. Sub-tropical deciduous hill forest makes up the river's

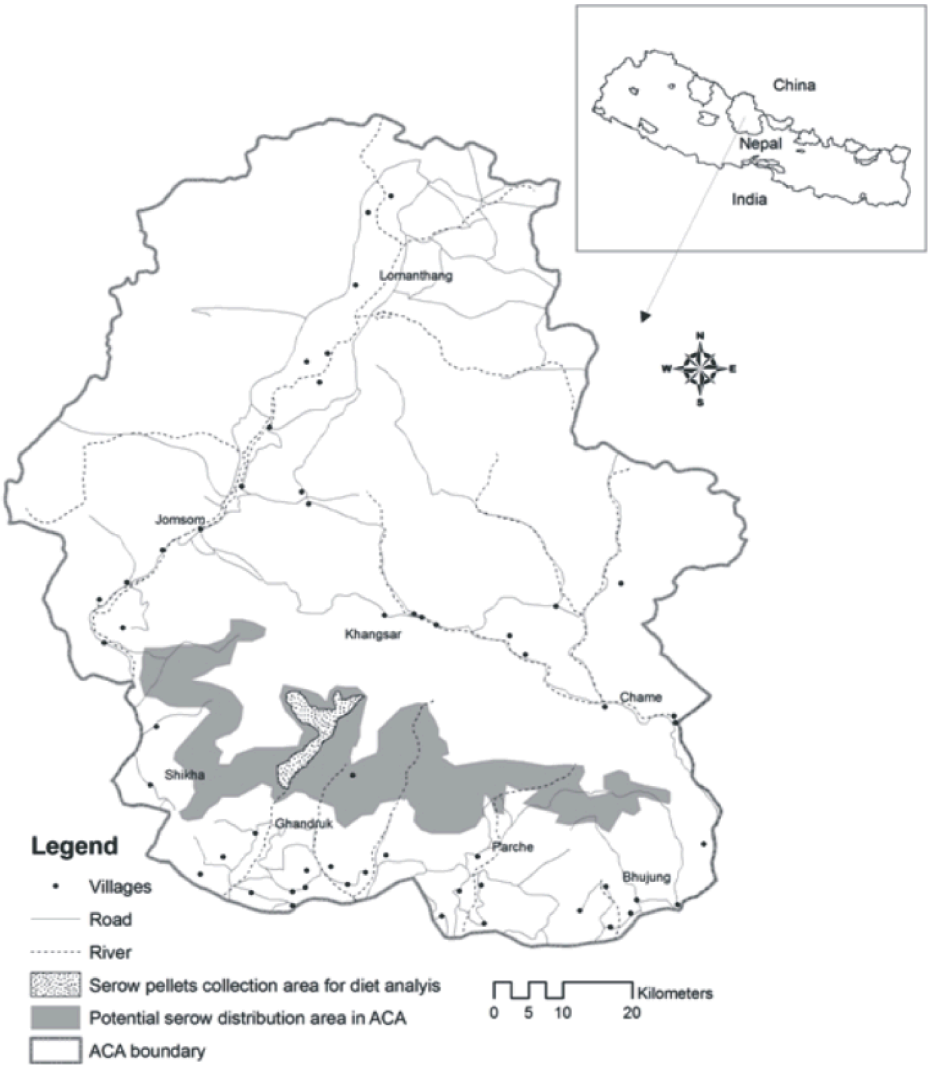

Fig. 1: Potential distribution area of serow in ACA

alluvial fan. The hill is completely forested up to an altitude of approximately 2550 m, above which there is a mixture of forest and cliff. The cliff is used by serow both for grazing and resting.

Climate in ACA region ranges from sub-tropical to arctic. Within a short span of 120 km, the altitude rises from 1,000 m to over 8,000 m. The average daily temperature reaches a minimum of 2.5°C and a maximum of 18°C during winter (December to February). During summer (May to July), the average daily temperature ranges from 19°C to about 30°C. The seasonal climate is dominated by southerly monsoon which occurs between June to September. Bamboo lies in the southern part of ACA and one the way to Annapurna base camp. This region experiences 2,987mm of rainfall annually, which is the highest precipitation in the country.

The ACA has a rich biodiversity, including more than 1200 plants with around 40 orchids and 9 species of rhododendron, the national flower. According to a recent study, the area harbors 197 important NTFP (non-timber forest products) plant species, 102 mammals including the rare snow leopard (*Panthera uncia*) in the upper sub-alpine area, 478 species of birds including the protected multi coloured Impheyan, koklas and blood pheasants, 39 reptiles, 22 amphibians and many types of butterflies [6].

Methodology

Distribution Map: A distribution map was prepared on the basis of the ground truth GPS data from a previous study [6, 8] and data collected in the present study on the presence and absence of serow. In the present study, information on the distribution of serow was collected by recording GPS points associated with observed presence/absence of the species and also obtained from local people and ACAP staff. We used ArcGIS-9.3software (free available in http://geoportal.icimod.org) and chose the elevation, settlement, river, road and ecological vector layers with 30 meter resolution to identify the serow study area. We assumed that birch, rhododentron, fir and oak forest were the main habitats for serow [6] and that the species is potentially distributed across an altitude range of 2000-4500m.

Diet Analysis: We used microhistological fecal analysis to establish the diet of serow. This is a widely used method for studying diets in ungulates [9-12] and is considered the most accurate of all the methods for estimating diets of wild herbivores [13]. We opportunistically collected fresh fecal pellets (N=60) from 45.15 km^2 area of Ghandruk VDC of ACA (Fig. 1) in June-July 2010. The samples were identified as originating from serow due to the large size of single pellets compared with other members of the goat family and also their typical occurrence in a large mass. Individual samples were air dried for a 3-5 days. Every fifth pellet in each of the 60 samples was selected for microhistological analysis. The samples were soaked in 2% alcohol for 24 hrs for softening and washed with a boiling solution of 10% sodium hydroxide (NaOH) until the black colour disappeared. Samples were then washed with distilled water to remove the bleach and passed through alcohol series (30, 60, 80 and 99%) before being treated with xylene for complete dehydration. The dehydrated samples were then mounted in DPX solution for careful observation and comparison with DPX mounted vegetation samples.

Vegetation reference samples were prepared as follows. After collection and drying, the vegetation samples (n=89) were manually ground in a grinder and then passed through 3 mm sieve to obtain relatively uniform fragments, this procedure reducing error that might result from differential fragmentation. These fragments were then boiled in 5% NaOH solution until the solution appeared transparent. Subsequent steps in the preparation were the same as followed for fecal samples.

Five permanent slides were prepared from each sample for comparison. The reference slides were studied thoroughly as recommended by Holechek and Gross [9]. We read 20 fragments from each fecal sample, noting distinctive histological features (e.g. cell wall structure, shape and size of cells, hairs and trichomes, shape and size of stomata and inter-stomatal cells, fibre structure and arrangement of veins) and comparing them the reference slides (plant fragments). Photographs were taken using a photomicroscope and a computer. The samples were identified under a compound microscope at 100X or 400X magnification. Finally, we calculated the Relative Frequency (RF) of each species to estimate the percentage of that species in the diet of serow [14].

RESULTS

Distribution of Serow in ACA: Serow were distributed in the lower belt of ACA, spanning Kaski, Lamjung and lower regions of Manang and Mustang districts, as well as Kunjo, Narchang, Ghandruk, Lwangghalel, Machhapurchhre, Parche, Namarjung, Bhujung, Ghanpokhara, Simpani, Khudi, Tagring, regions (Fig. 1). Collectively, this area spanned 722.22 Km^2 as a potential habitat for the species (Fig. 1).

Table 1: Plants found in the serow fecal pellets (diet composition of serow)

Scientific Name	Frequency Percent
Arundinaria spp	9.4
Urtica spp	7.4
Strobilanthes spp	7.1
Rhododendron spp	6.1
Oplismlaus compositus	6.1
Leontopodium jacotianum	5.1
Eqmesetum debile	4.0
Reinwardtia indica	4.0
Alonogonum molle	4.0
Rubus spp	3.0
Vigna spp	2.7
Hedena spp	2.4
Elaegnus conferata	2.4
Lyonia villoza	2.0
Themeda triandra	2.0
Fern	1.7
Bidens spp	1.7
Permilia spp	1.7
Corydalis spp	1.7
Thalyctrum spp	1.7
Acer pectinatum	1.7
Themeda triandra	1.7
Hypericum spp	1.7
Salix spp	1.4
Anaphalis spp	1.4
Hedena spp	1.4
Equisetum debile	1.0
Pericaia spp	0.7
Elatostema spp	0.7
Berberis spp	0.7
Viburnum spp	0.3
Potentilla fulgens	0.3
Lichen	0.3
Unidentified	9.4

Dietary Composition of Serow: Thirty four identifiable plants were found in the diet of serow, with 9.4% of the diet being unidentifiable (Table 1). The major dietary species were *Arundinaria spp (*9.4%), *Urtica spp* (7.4%), *Strobilanthes* spp (7.1%), *Oplismlaus composites* (6.1%), *Rhododendron spp (6.1%), Leontopodium jacotianum (6.1%), Eqmesetum debile(4.0%), Reinwardtia indica (4.0%, Rubus spp (3.0%), Themada triandra (2.0%) etc* (Table 1).

DISCUSSION

Serow are distributed in the forested area of the lower belt of the ACA. These forests are used extensively by local people for their livelihood, including the collection of various timber and non-timber forest product (NTFP) species. Additionally, the resulting development of human settlments, human trails and agriculture lands have led to the fragmentation of serow habitat. This has had negative impacts on serow and other wildlife species in the area [6, 15]. Serow are a shy species, preferring to live away from human disturbance, but in the study area human settlement had encroached as close as 400m to the habitat of these animals.

The accurate identification of the diet of wild herbivores is challenging. The approach we chose to use in our study, microhistological analysis, is considered the most reliable method [13], but it is not without it its problems. One of the complicating factors in determining diet composition using this method is that not all items eaten are equally represented in the residue. This is due to various factors, such as differing specificity in the digestive system, chewing habits and morphology of the animal, as well as the morphology and digestibility of the eaten items [16, 17]. Jnawali [18] found that herbaceous and delicate species had little chance to appear in the fecal samples due to complete digestion. Further, fecal analysis does not identify all species in a herbivore‘s diet [19], leaving a portion of unidentifiable fragments. The magnitude of this unidentified portion is seasonally dependent, being higher during April when the animals target new shoots, which have higher digestibility than the mature plants [20, 21]. We therefore collected pellet samples during June and July, after the new growth had hardened thus reducing the proportion of unidentifiable dietary items. Being a ruminant, serow has high digestive efficiency, but the microhistological analysis in our study was nonetheless quite effective in the identification of plant remains for serow. The portion of unidentified plant fragment was low (9.4%) in the serow pellets.

Our study of fecal pellets indicated that serows are generalist feeders, taking a range of different species rather than concentrating on one or a few. However, the most abundant plant species in the diet was *Arundinaria spp* and it was also the most abundant in the environment. It is difficult to tell from our data the extent to which the relationship between abundance of this species in the environment and in the diet results from serow feeding non-selectively according to plant availability, or specifically selecting habitats that have a high density of a preferred food plant. The latter is the more threatening scenario, because the villagers in the study area are also highly dependent upon this species which they use for a variety of purposes. These include the use of this species as edible vegetables (at a young

stage), to make pickles, as poles, as a source of materials for making handicrafts and also as firewood. Judging from the close correspondence between the distribution of serow in ACA and *Arundinaria spp*, it is likely that these plants are a preferred part of the diet of this ungulate, rather than a component incorporated just because of its availability in the environment. If so, the competition between humans and serow for this species is clearly a cause for concern.

It is not only *Arundinaria spp* for which serow compete with villagers in ACA. The tree species used as food and cover by serow. *Salix spp, Rhododendron spp, Lyonia spp, Acer spp etc.* are also important fire wood and timber production species of the area and are harvested at high rates for infrastructure development. Further, some of the herbs and shrubs that we identified in the diet of serow are collected for their medicinal value and for other domestic use value. These include *Anaphalis spp, Hypericum spp, Themeda spp, Berberis spp* and *Rubus spp etc.*

Direct competition with humans is thus clearly a cause for concern in the conservation of serow. There is, furthermore, another immediate threat to serow populations. Human settlements and associated use of land for agriculture are fragmenting serow habitat, in some cases causing populations to become isolated. For example, the main corridor connecting the serow populations of Landruk and Ghandruk (Tadapani forest) has been fragmented by settlement and agricultural land and as a consequence these populations are now isolated [6, 15].

The pressures due to direct competition for resources with humans and habitat fragmentation are important concerns for the conservation of serow in ACA. Together, they present the threat that serow in the region could become fragmented into a series of isolated populations, which due to habitat destruction each drop below the viable threshold for sustaining the species. There is clearly a case for the development of of sound policy and management interventions to avert such scenarios before they arise.

ACKNOWLEDGEMENT

We thank to NTNC/ACAP (National Trust For Nature Conservation/Annapurna Conservation Area Project) for providing permission and funding support for this study. We thank to Institute of Forestry, Tribhuwan University, Pokhara for providing us lab facilities. We thank to Mr. Abadhesh K. Shingh and Mr. Y.P. Timilsina for technical edits and others Mr. Arun Parajuli, Mr. Prabal Jung Rana, Mr. Sumit Giri and Mr. Sagar Giri also deserve special thanks for helping us through our field. This project was part-funded by the Massey University Research Fund.

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