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HABITAT SELECTION BY A SNOW LEOPARD IN HEMIS NATIONAL PARK, INDIA

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INTRODUCTION AND STUDY AREA

Ecological information on the free ranging snow leopard *(Panthera uncia)* is limited to anecdotal accounts (e.g., Dang 1967, Schaller 1977, Mallon 1984) and a few scientific studies (Jackson and Ahlborn 1989, Fox et a1. 1988, Koshkarev 1988). An in-depth study on the ecology *of* snow leopard and its prey is currently being conducted in the trans-Himalayan region *of* India. During these studies one snow leopard was captured and radio-tracked for two and a half months. Information on this individual's movement pattern, habitat utilization and habitat overlap with its major prey, the blue sheep (Pseudois *nayaur)* is presented in this paper.

The study was conducted in the northwest part *of* Hemis High Altitude National Park in the Zanskar range *of* the trans-Himalayan mountains *of* Ladakh, Jammu and Kashmir. The study area encompasses the entire catchment (ca. 100 km) *of* the Rumbak nalla, a small tributary *of* the Indus river about 25 km southwest *of* the town *of* Leh. Elevation ranges from 3,200 m at the confluence *of* the Rumbak and Indus rivers in the north to 6,000 m at the watershed 14 km to the south. The Zanskar range falls in the rain shadow zone *of* the Himalaya, resulting in very low precipitation.

The blue sheep is the major wild ungulate in the study area; others include small populations *of* Great Tibetan sheep *(Ovis ammon hodgsoni),* Ladakh urial *(Ovis vignei),* and Siberian ibex *(Capra ibex sibirica).* Other herbivorous mammals include the Himalayan marmot *(Marmota bobak),* Tibetan woolly hare *(Lepus oiostolus),* and mouse hare *(Ochotona roylei).* Predators other than snow leopard include the *wolf* (Canis *lupus),* wild dog *(Cuon alpinus),* red fox *(Vulpes vulpes),* stone marten *(Martes foina)* and the Himalayan weasel *(Mustela sibirica).*

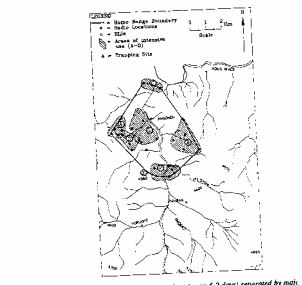

Figure 1. Areas of snow leopard presence for some days (mean 6.2 days) separated by majo movements within the study area, from the first locations (A) to the last ones (G).

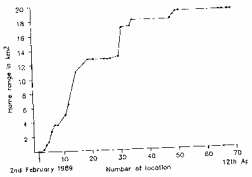

Figure 2. Cumulative increase in home range of the radio collared snow leopard

METHODS

In order to radio-tag, a snow leopard was captured in a cage and tranquilized (Chundawat et aI. 1990). The snow leopard was radio-collared on 2nd February 1989. The radio-collar was dropped by the animal and was recovered from an active scree slope on 12th April 1989. The animal was searched for with the radio receiver on 35 days and on 28 days contact was made. Location of the collared snow leopard was determined by triangulation from homing methods. Signal bounce caused severe problems in determining accurate bearings and because of this problem large amounts of time were spent in getting reliable locations. The signal bounce problem was overcome by taking bearings primarily from ridgetops or slopes opposite to that of the animal. The animal was located on consecutive days whenever possible but tracking was interrupted when it was necessary to carry out other aspects of the study.

Information presented here on snow leopard habitat use is based on the 2 1/2 months of radio-telemetry data during late winter. Once the location of the animal was determined on the map, data on elevation, aspect, ruggedness of the terrain, steepness of slope, and position on slope were noted for each location. To determine the extent of overlap of habitat use with its major prey, data on blue sheep habitat use is restricted to the same season during which the collared snow leopard was monitored. Between the minimum and maximum elevationallimits for both snow leopard and blue sheep, the availability of different habitat parametres was determined from a random sample of points on maps of these variables for the study area (Marcum and Loftsgaarden 1980). Habitat preference was determined with chi-square tests using the method suggested by Neu et aI. (1974).

RESULTS

Movement pattern

Locations made on the same day and on the successive days suggest the collared snow leopard used the same area for a number of days (mean 6.2 days) without moving large distances (mean 0.8 km/day). Within the day it shifted frequently but it was extremely difficult to monitor every change in location because of the rugged terrain. Six major shifts in locale were observed over the 2 1/2 months of monitoring (Figure 1). After spending some days in an area the snow leopard made a major movement covering an average distance of 3.5 kIn (2.4 - 4.8 km) and remained in the area until another major move was made. A similar movement pattern for snow leopard was also observed by Jackson and Ahlborn (1988) in Nepal.

Estimation or home range

For the purpose of estimating home range area, the first daily locations on each of the 28 days were used. They were plotted on a map and the outer locations were joined with straight lines to give a minimum area polygon. The 70-day late winter home range area of the collared snow leopard was thus calculated to be about 19 km . The home range size increased rapidly up

Table 1. Selection of habitat by a radiO-collared snow leopard during late winter-earlY spring.

HABITAT	% of habitat available	%of snow leopard locations	APparent selection
ASPEct			NS
North	25	37	
East	22	13	
south	28	27	
West	25	23	
Chi square = 4.6			
SLOPE			**
0-25°	36	31	ns
26-40°	52	40	ns
>40°	12	29	preference**
Ch1 square = 13.9			
TERRAIN			**
Smooth	43	23	Avoidance*
Broken	26	26	ns
Very broken	31	50	preference*
Ch1 square = 12.2			
TOPOGRAPHIC POSITION			NS
Ridge top		30	
Upper slope		36	
Middle slope		17	
Lower slope		13	
Valley	6	1	
Ch1 square = 5.9			

* = P < 0.05, ** = P < 0.01, NS,ns = P > 0.05.

Table 2. Snow leopard use of habitats used by blue sheep.

HaBITAT	percent of use: Blue h eo	percent of use: Snow leooard	Difference between Snow leopard & blue sheep use of habitat
ASPEct			NS
North	36	36	
East	13	13	
south	34	26	
West	17	23	
TERRAIN			
Smooth		23	D1fferent
Broken		26	
Very Broken		50	D1fferent
TOPOGRAPHIC POSITION			NS
Ridge top	12		
upper slope	28		
Middle slope	27		
Lower slope	31		

to about the 21st location (ca. 40th day), after which only small increments were noted up to the 70th or last day of tracking (Figure 2). The home range size therefore appeared to reach an asymptote after 40-50 days of monitoring. It may be reasonable then, to conclude that the home range of 19 km2 during the observation period gives a reliable estimate for late winter.

Observations of the collared snow leopard

The collared snow leopard was seen twice, on two different kills. It was first seen over a 4-day period on an adult female blue sheep kill. The kill was taken over from another snow leopard after a severe fight, evident from the tracks of two different individuals, hairs of snow leopard littering the area, and from new injuries seen on the face of the collared snow leopard. The collared snow leopard was seen once again 3 days later by a local shepherd when it killed a domestic goat in the vicinity of Jingchen village. The collar was dropped soon after this kill.

Habitat use/preferences

Habitat data were collected for a total of 52 snow leopard locations. All the snow leopard locations were within an elevational range of 3,400 - 4,700 m. Aspects were used almost in proportion to their occurrence; there was no apparent preference or avoidance (Table 1). Although here in Ladakh the northern aspect was used more than others (37%), Jackson and Ahlborn (1988) found snow leopards in Nepal to prefer southern and western aspects at this time of year. The snow leopard showed strong preference for very steep slopes (> 40 degrees), whereas gentle and moderately steep slopes were used in proportion to their availability (Table 1).

Although most of the locations (40 %) were on steep slopes and much of the study area is comprised of such steep slopes, the snow leopard still showed a strong preference for the broken terrain characteristic of the steep and very steep slopes. Moderately broken terrain was used in proportion to its occurrence while smooth terrain was avoided by the snow leopard. Some of the locations on smooth terrain were within 20 m of the very broken terrain, mostly on top of the cliffs and on ridgetops. These are ideal resting places with good views of the valley and opposite slope. More than 57 % of all the locations were within 20 m of very broken terrain and 32 % of the locations were either on the broken terrain or very close to it. At further than 20 m from broken terrain, the percentage of use decreases sharply (20 - 50 m, 17 %; 50 - 100 m, 15%; and > 100 m 10%).

No preference was shown for any of the five topographic locations related to position on slope; all were used in proportion to their abundance (Table 1), although there appeared to be a tendency toward greater use of ridgetops. A similar pattern of habitat use was also observed by Jackson and Ahlborn (1988) in west Nepal.

Habitat overlap with blue sheep

Predators have adapted to the quality, quantity and availability of items in their diet in

an attempt to maximize energy intake within various ecological constraints such as the habitat requirements' density, and distribution of their prey (Sunquist and Sunquist 1989). Similarl y , within the habitat requirements of the predator its major prey presen1s important constraints on its own'" of different habitat types for efficient capture of its food. This has been documented in several studies were predators select the"" profitable prey, which is, 0ften the largest prey they can easily kill (Sunquist and Sunquist 1989).

Within the study area bluesheep is probably the most economic prey fo".ow leopard during winter as it is the most common and largest prey avoilabln. Is the bobitat use pattern of snow leopard dependen' on the distribution of i'ts major prey the blue sheep, Can the use of aspect, terrain and position on slope by snow leopard be predicted from the preferences by blue sheep' If we we may expect snow leopard to use habitat characteristics in the same frequency ditributions that by the blue sheep. The expected distribution of snow 1eopard **habitat** use can be **estimated as: expected snow leopard proportion of blue total no. of snowhabitat utilization x sheep habitat** use = **leopard locations**

The elevational ranges for' both blue sheep (3,600 - 4,600 m) and snow leopard (3,400 - 4,700 m) 0verlap considerably during late winter. Within this elevational range snow leopards use the same distribution of aspects a, used by blue sheep (tabl, 2). During th' latewinter season blue sheep use northern aspects more than often. Similarily ,most of the collared snow 100",,",' , locations (37 %) were on the northern aspect at this time. Within the same elevationa lrange and aspect. blue sheep and snow leopard do usesomewhat different terrain type which may be expected because the requirements for prey and predator are somewhat different. The snow leopard uses more rugged terrain show preferences for very broken **terrain and very steep slopes, terrain types which provide the cover needed to stalk its prey** (table 2). The blue sheep show preferences for ,smooth terrain (used for feeding)and avoid the very steep and broken habitat preferred by snow leopard. The snow leopards distribution in **use of different positions on the slope (e.g., ridge tops, mid-slope, valley) was the same as that of the blue sheep.**

DISCUSSION

If we were to include other seeasons. especiall y summer when most of the blue sheep move some 10 - 12 km to high elevation pastures. the availability of Prey within the late winter snow

leopard home range would be greatly reduced. The density of blue sheep in this area decreases from 3.0 - 3.5/km2 in late winter to O.S/km2 in summer. On the other hand' prey is readily available at high pastures'. Besides the blue sheep. marmots have come out of hibernation and

are abundant along with snowcocks and hares. Some studies have shown a high percentage of marmots in the scats of snow leopard during summer (Fox 1989), and this prey species is available at higher elevations in the study area during summer. We might thus expect a substantial proportion of marmot in the diet of snow leopard in the study area during summer (an hypothesis to be tested with the analysis of over 200 scats).

It is reasonable to expect that snow leopard follow the movement of blue sheep and the increased abundance of other prey to higher elevations in summer. This can be accomplished either by extending its range or by shifting it to higher elevations. Such a phenomenon of either shifting home range or changing to an alternate prey has been documented in other large felids such as the mountain lion *(Felis concolor)* (Seidensticker et aI. 1973) and lion *(Panthera leo)* (Schaller 1972). The ongoing field work suggests such a seasonal movement and some change in diet by snow leopard in the study area. This is an important aspect of snow leopard ecology that will require further clarification and the knowledge gained will be of great importance in the management of this species in the region.

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