A FURTHER REPORT ON THE SNOW LEOPARD IN LADAKH

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This paper follows the first report which was given at the Fourth International Snow Leopard Symposium (Mallon, 1984). It Is based on the same long-term study of the ecology of Ladakh and brings up to date the information so far gathered on the snow leopard in that area. A further field survey was conducted in summer-autumn 1986 whose main aims were to collect more data on the distribution of the snow leopard in Ladakh. and to evaluate areas of good snow leopard habitat for possible Protected Area status.

Ladakh is a Trans-Himalayan region of the Indian State of Jammu and Kashmir, bordered on the east by the Tibetan Plateau and on the north by the Karakoram Range. Precipitation decreases sharply away from the main Himalayan Range: Leh, the chief town, averages approximately 115 mm annually. The environment is mountainous, rocky and arid and ecologically Ladakh is closer to Tibet and Central Asia than to the monsoon side of the Himalaya. The only forest consists of gallery woods and remnant steppe juniper forest which are found in a few areas remote from human habitation.

Information on the snow leopard was collected during surveys on foot, using sign-based techniques, from local reports and printed sources.

SIGN-BASED SURVEYS

As snow leopards are difficult to observe in the field, sign surveys are a valuable method of gathering information. They are particularly suited to the current phase of the project where emphasis has been placed on covering as much ground as possible in order to obtain information on distribution, and they are inexpensive and simple to operate. As well as distribution data, it was also intended to use sign-surveys to obtain information on snow leopard habitat preferences and to identify networks of travel lanes and heavily used areas so as to incorporate a known series of home ranges into Protected Areas. A further aim was to assess the usefulness of sign-survey techniques for utilization by Department of Wildlife Protection field personnel in a regular program to monitor snow leopard population levels and to conduct surveys in other areas.

Some types of sign, such as scrapes and scent-sprays, are a form of marking behavior and appear to play a role in the spatial and temporal separation of individual snow leopards (Ahlborn and Jackson, this volume). The communication value of marking is most efficient if made in places used by other snow leopards, such as overlapping parts of home ranges and common travel lanes, and least efficient if made randomly, where communication will also be random. A series of transects was done to test for random marking and movement.

SIGN CONFUSION

The most visible types of snow leopard sign consist of tracks,

scrapes and droppings and the first priority is to ensure that the sign was made by the target species. Therefore the absence of sympatry between snow leopard and common leopard *Panthera pardus* is important and was a factor In the selection of the study area. Common leopard have been known to stray to the borders of Ladakh from other parts of Kashmir (Gergan, 1962), but there are no records away from *the* border area, and none at all in recent years.

The tracks of both species are similar in form and are not easily distinguishable in the field. Common leopards make scrapes in similar situations to snow leopards {Schaller, 1977), and zoo observations revealed few differences tn appearance between scrapes of the two species and so they too may be impossible to differentiate in the field. There is considerable altitudinal overlap between both species in the Himalaya: snow leopards have been recorded below 3,000m, while Wilson (1981) refers to records of common leopard up to 4,115m in central Nepal.

The species tn Ladakh with which confusion is possible are the Lynx *Felis lynx* and wolf Canis lupus. There are some differences in habitat preference, but both overlap with the snow leopard in many places.

Droppings are difficult to differentiate by visual Identification owing to the overlap in scat size between species and variation in form depending on size of the individual animal and the amount of indigestible material in the prey consumed. The possibility of "token scats" (Schaller, 1972; Sunquist, 1981) increases the possibility of confusion with smaller species. The presence of other target species sign and the absence of other species sign can aid in the process of identification, but in the field, identification may often be probable but not conclusive. The scats of related species may be differentiated in the laboratory by techniques such as gas-chromatography of fecal bile acids (Johnson, Belden and Aldred, 1984).

Tracks vary in appearance depending on the size of the individual animal and nature of the substrate, especially in snow when melting causes enlargement or distortion of the print.

Lynx tracks are very similar in shape to those of snow leopards and there appears to be some overlap in size. Pikunov and Korkishko (1985} differentiated lynx and common leopard tracks on the basis of the lynx's heavily furred soles which cover the pads and obscure the shape of the print, but according Pocock (1939) the pads in the Himalayan race, *F.l. isabellinus,* are not covered with hair In winter. Bjarvall and Ullstrom (1986) reported that a feature of lynx tracks is the different size of the two central pads, the inner one being slightly larger, a difference visible even in indistinct prints. In snow, a print made by the snow leopard's tail often shows between the tracks and this is a diagnostic identification feature since the lynx has a short tail.

Wolf tracks show some differences in shape and the claw-print is normally visible, whereas snow leopard claws rarely show and only when it has had to hold onto something, such as an icy boulder. A wolf trail usually follows a direct line, while a snow leopard moves from side to side of a valley bed investigating caves and overhangs and may lead up steep cliffs, which a wolf does not do. While single prints may present problems, a length of trail should be relatively easy to distinguish.

DISTRIBUTION

The results of the survey show that snow leopards are distributed throughout Ladakh. Most records were obtained in the area of the central mountains, between the Indus valley and main Himalayan Range, where field surveys were conducted. Records from

the Shyok and Nubra valleys to the north of the Indus, and the Rupshu plateau area in the east of Ladakh depend on local reports and no systematic surveys have been carried out there. Such surveys can be expected to provide records from more localities, especially in Shyok-Nubra where there is extensive habitat similar to the central mountain area and good prey populations.

The distribution of the snow leopard is continuous over the main Himalayan Range into Kishtwar and more extensively across the Trans-Himalayan districts of Lahul and Spiti to the southeast.

HABITAT

Snow leopard sign was found at altitudes between 3,400m and 5,300m and other records were obtained from elevations of circa 3,000m. Records from the lowest areas, along the major river valleys were related to attacks on livestock in winter and are relatively isolated occurrences. The absence of a permanent snow leopard pres- ence from these areas is probably related to the fact that the human population Is concentrated along these valleys, rather than to altitude alone.

There are marked differences in the density of sign found in different areas. The least sign was found in a band of steep, but relatively smooth, rounded hills along the Indus valley, which contained few cliffs or broken areas.

The heaviest concentrations of sign were found in a distinctive geological zone across the central mountains. This consists of a band of hard limestones and other sediments which have been raised and tilted almost vertically and cut through by numerous rivers and streams, forming a series of gorges opening to valley basins above circa 4,500m. The topography is characterized by extreme ruggedness, a high proportion of cliffs, rocks and slopes over 50°. Four areas within this zone, with the heaviest sign concentrations had the following features in common: a medium sized gorge-valley 20-60m wide, with a network of tributary valleys; gorge-sides consisting of cliffs broken by numerous terraces, ledges and scree-chutes; relatively dense riverine scrub along the valley bed; a good population of either ibex or bharal; no permanent human habitation and a low level of human land-use.

The rocky nature of this habitat is clearly important, since the snow leopard is associated throughout its range with rocky areas. Heptner and Sludskij (19801 even suggested that it should not be regarded as a high-altitude animal, but seen as characteristic of rocky landscapes. It is not certain which other factors are crucial in making this habitat so favored. The brokenness of the terrain may provide near-optimal foraging conditions for a predator such as the snow leopard and the lack of disturbance is also likely to be important.

TRACKS

Tracks were recorded in sand, snow and mud and varied in length from single prints to continuous sections up to 14 km, and totalling 96 km. Repeated transects showed regular use of certain routes, which varied somewhat according to the relief.

In gorge areas, snow leopards moved frequently along valley bottoms usually along the cliff line on one bank, or moving from side to side, and frequently in winter using the ice of the frozen bed. Terraces and cliff ledges were also utilized but the extent was difficult to assess owing to the problems in following the animals in the steepest situations.

In more open situations, snow leopards used existing paths along valley sides, river terraces, cliff lines and ridges, especially when

these had a rocky or broken crest. One common factor was that in given terrain the route selected was almost always the one which appeared to provide the easiest access.

Trails sometimes led across wide, open slopes but they more often seemed to avoid open areas for movement (perhaps to avoid detection by prey) by keeping to cliffs, passing under rock overhangs when possible, moving along narrow ridges and terraces. Koshkarev (1984) reported the show leopards crossed valleys at the 'narrowest point and in wooded areas without exception passed below the crowns of spruce trees.

SCRAPES

Scrapes are a very useful kind of sign since they are visible at all seasons and last for a long time. They are made with the hind feet In any scrapeable medium and have a characteristic shape. During this survey, they were recorded in the following substrates: snow, sand, soil. dust, gravel, stones, shale, woodshavings, ash, charcoal, sheep and goat droppings.

Scrapes give a clear indication of the presence of snow leopards in an area and could be used to monitor levels of population change along regularly repeated transects. There is a problem In aging scrapes on first-time transects as different substrates change at different rates. Scrapes made in stones or shale may show little discernable change over a period of one year, while those containing snow change their appearance in a short time. On repeated transects the position of scrapes can be mapped or they can be marked (at a distance far enough away so as not to interfere with any olfactory signal).

Six-hundred-fifteen scrapes were identified, and a further 92 possible ones disregarded as they could not be identified with certainty as a snow leopard scrape: some were very old. but most had apparently been affected by washouts during the spring and summer of 1986. which were much wetter than usual.

Each scrape was mapped and its position noted with regard to altitude, aspect, topographic features and other site-specific indicators. Of the 615 scrapes. 51% were made between 3,750m and 4.000m; 15% below 3,750m; 22% between 4.000m and 4,250m and 12% over 4,250m (of which fewer than 1% were above 5,000m).

Eighty-four percent were made at the base of a rock, cliff or overhang, along valley bottoms or valley sides. Cliffs are obvious landmarks, and snow leopards often travel along cliff-base lines. Steep and overhanging cliffs and rocks protect scrapes from rain and snow, which could Interfere with the visual and olfactory signal. Other frequently used locations were at prominent knolls on paths, at the base of a bush, between stones, along ridgelines and pass crests. Very occasionally scrapes were made by the side of a path across an open hillside, but this was exceptional: scrapes were generally associated with some obvious topographic feature or placed where paths were forced by the relief into narrow situations.

Scrapes were made singly or in clusters. Heaviest concentrations invariably occurred around stream confluences and presumably indicated areas of home-range overlap. Plotting a series of such areas on maps may prove useful in a comparison of snow leopard densities in different areas. Whether it would be feasible to relate the quantity of scrapes to number of snow leopards making them, and thus infer actual numbers using an area, is an interesting possibility requiring

further research.

POPULATION DENSITY AND HOME RANGE

Sign-surveys contribute little information on home range size: it is difficult to identify individuals, to distinguish between resident and transient animals and to establish the limits of an individual's movements. They do show that the pattern of snow leopard sign distribution, with several frequently used areas, regular travel corridors and areas of unused terrain corresponds to the type of cat "territory" described by Leyhausen (1979).

Population density is also difficult to assess. Some attempts were made, during winter expeditions, by carrying out systematic searches of limited areas using several observers, to count tracks following new snow. The aim was to obtain a crude estimate of snow leopards active in that area. Disadvantages are that it assumes all the animals in the area are active soon after the snowfall, and it cannot distinguish between residents and transients.

The figures for the best areas showed two to four snow leopards per 100 km^2. This figure could not be realistically applied to the whole of Ladakh because sign density varies greatly.

A further problem concerns the dispersal of young adults away from their parent's home range. Dispersal distances are unknown and have important implications for conservation. There is great pressure on out-movement of young Siberian tigers *Panthera tigris altaica* (Bragin, 1986) and young adult mountain lion Feiis *concolor* disperse long distances, even if space is available and apparently regardless of adult density (Seidensticker et al, 1973; Hemker et al, 1984). If snow leopard dispersal is similar, then replacement of resident adults depends on immigration from other areas, which requires either extremely large reserves or the provision of safe corridors between them as well as protection of the snow leopard outside the Protected Area system.

Snow leopard population levels in Ladakh appear to have remained unchanged over several years. No evidence was found of a decline over large areas, or of sharp increases in the snow leopard population as reported by Heptner and Sludskij (1980) and Bold and Dorzhzunduy (1976).

PREY

The more specialized a species is. the more vulnerable it will be to changes in environmental conditions, whereas a more versatile species is better able to adapt to those changes. Therefore a predator which utilizes more than one hunting method and which takes a wide variety of prey will have a better chance of adapting to the local disappearance of one or more prey sources.

Snow leopards are often reported to hunt by stealth and they are also known to ambush prey by lying in wait for them. It can also be assumed that they will optimize foraging by preying opportunistically on whatever they encounter by chance, including carrion, which is energy efficient.

Snow leopards have been recorded as preying on eight species of domestic animal, from dogs to camels and yaks; 23 species of wild mammal, from voles (Microtus sp.) and other small rodents to large ungulates, and five species of bird from doves (Co(umba) to Snowcock *(Tetraogallus spp.}* as well as carrion and vegetation (Bannikov, 1954; Bold and Dorzhzunduy. 1976: Dang, 1967; Dash et al, 1977; Green. 1982; Gromov and Yanushevich. 1972; Gvozdev, 1978; Heptner and Sludskij, 1980; Schaller, 1977; this study). Bold and Dorzhzunduy

(1976) recorded the only case so far of insect prey, grasshoppers *(Orthoptera, Acrididae).*

Information on prey species in Ladakh was collected during the surveys, and repeated prey transects were carried out in the best snow leopard areas. A list of potential prey species of the snow leopard in I^adakh was provided in an earlier report (Mallon, 1984). Scat analysis so far shows only one new prey species, red fox *Vulpes uulpes.* Vegetation was present in 29 out of 50 scats examined, and four of these appeared to consist entirely of plant matter, mainly twigs of Myricaria bushes with some Salix. They had been partly chewed but not digested. Such quantities of vegetable material are unlikely to have been ingested fortuitously along with prey; whether they are starvation-related or have some mineral-content value is unclear. Schaller (1977) reported vegetation in 22% of snow leopard scats he examined, and Bold and Dorzhzunduy (1976) said, on the basis of scat analysis, that snow leopards in Mongolia eat grass to a significant extent in summer and autumn.

The largest amount of prey biomass available in Ladakh is represented by bharal Pseudois *nayaur* and ibex *Capra ibex sibirica* which are relatively numerous and widely distributed, but the extent to which they, and other prey, are important in the diet of the snow leopard, awaits detailed analysis.

Several attempts have been made to relate predator numbers to total prey biomass available in an area, but the usefulness of this is questionable; the most important factor is the number of prey which are vulnerable, rather than available, and other factors to be taken into account include habitat, and numbers of competing predators. More importantly still, several authors have reported that predator numbers were set below the level suggested by prey numbers: Kuhme (19661 for lion *Panthera leo;* Seidensticker et al. (1973) for mountain lion *Felis concolor,* and Bragin (1986) for Siberian tiger Panthera rigrts aftaica.

CONCLUSION

A detailed knowledge of the ecology of a species is fundamental to the drawing up of effective conservation measures, and wide scope exists for further research. One aim of the current project was to identify good areas of snow leopard habitat and evaluate them for possible inclusion within the Protected Area Network. Several good areas were surveyed and an outstanding area identified, and included in a report to the Chief Wildlife Warden (Mallon. 1986). A conservation program is discussed In a separate paper (Mallon and Nurbu, this volume).

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