Camera-Trapping of Snow Leopards

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Solitary felids like tigers and snow leopards are notoriously difficult to enumerate, and indirect techniques like pugmark surveys often produce ambiguous information that is difficult to interpret because many factors influence marking behavior and frequency (Ahlborn & Jackson 1988). Considering the snow leopard's rugged habitat, it is not surprising then that information on its current status and occupied range is very limited.

We adapted the camera-trapping techniques pioneered by Ullas Karanth and his associates for counting Bengal tigers to the census taking of snow leopards in the Rumbak watershed of the India's Hemis High Altitude National Park (HNP), located in Ladakh near Leh (76° 50' to 77° 45' East; 33° 15' to 34° 20'North), with the following key objectives:

1) To develop a standardized field method and sampling strategy for applying capture-recapture models to snow leopards using remotely triggered camera traps;

2) To estimate snow leopard density over two consecutive (winter) seasons;

3) To develop a camera-trapping protocol that could be applied in other parts of snow leopard range within high and low density areas in order to estimate total numbers better; and

4) To develop a snow leopard identification protocol based on their distinct pelage patterns.

HNP was selected because of frequent snow leopard sightings, the low incidence of poaching, a relatively stable ungulate prey population, and the presence of well-defined travel corridors where remotely-triggered camera traps could be placed to achieve consistent photo capture success.

Methods

Camera trap sites were located along narrow ridgelines and in valley bottoms close to scent-sprayed rocks or scrape sites where movement is narrowly constrained by topography, boulders or vegetation. We used up to 18 TrailMaster 1550 ™ active infrared detectors since they performed best at low temperatures with significantly longer battery life than less expensive passive infra-red sensors like the CamTrakker™. Each station had two 35 mm cameras synchronized with a multi-camera trigger and then placed 2-3 meters from the infrared beam. In the first year, we faced each camera directly up or down the anticipated travel path in an effort to obtain close-up photographs of the leopard's face for quick identification, but this proved difficult and somewhat unreliable. In the following year, cameras were oriented at 45° or 90° angles from the anticipated travel path to capture simultaneous photographs of either sides of the snow leopard's body, which like other spotted cats has asymmetric pelage patterning. No baits or lures were used, and cameras were not moved during the survey because rapid, simultaneous shifts in trapping locations were precluded by the difficult terrain and lack of road access. Camera traps were checked every 2-10 days or immediately following sustained snowfall in order to prevent accumulated snow from blocking the sensors and thus disabling the cameras. We sampled between mid-January and mid-March for 65 consecutive days in 2003 and 60 days in 2004.

We developed detailed guidelines for identifying individual snow leopards based on their pelage pattern, specifically the spots, rosettes and rosette groupings, which are detailed in a manuscript submitted for publication. Camera density was about 1.5 stations per 16-25 km^2. Snow leopard abundance estimates were made using the program CAPTURE following standard capture-recapture procedures (Otis *et al*. 1978, Karanth & Nichols 1998).

Fig. 1. Adult male # 1 sniffing a well-visited scent-sprayed boulder in Husing Nullah, Hemis High Altitude National Park, Ladakh, prior to remarking the site on March 23, 2003 (Photo: R. Jackson, Snow Leopard Conservancy).

Results

A total of 112 and 82 pictures of snow leopards were obtained during 66 and 49 capture events resulting in a capture success of 8.91 and 5.63 individuals per 100 trap-nights during 2003 and 2004 respectively. This equals one snow leopard for every 11.2 and 17.7 nights of trapping during these two winter periods we sampled (Table 1). Falsely triggered images

Table 1. Trap success and related capture statistics for 2003 and 2004. Trap nights were adjusted to account for malfunctions in sensors or cameras, as well as various environmental factors (especially heavy snowfall), causing camera traps to be periodically inoperative. Trapping success in the text is based on the number of captures (last column) rather than the number of photos.

Year	Sampling period	Trapping effort (trap nights)	Number of trap stations	Total photos	Non-target species	False images	Snow leopard Number of Photos	Snow leopard Number of Captures
2003	21 Jan - 25 March (65 days)	741	18	476	86	278	112	66
2004	15 Jan - 14 March (60 days)	871	19	1014	174	758	82	49

comprised 63% and 75% of all images in 2003 and 2004, caused mostly by snowfall and errant infrared light which is most prevalent above 3,500 m elevation.

Livestock (primarily sheep and goats) represented 55% and 19.2% of the non-target species captured over the two years, while canids (mostly red fox and wolves) and birds were responsible for most of the remaining non-target captures (2003 = 5.4%; 2004 = 2.5%). A total of 112 images of snow leopards were taken in 2003 compared to 82 during the 2004 survey. We attribute this difference to the greater number of trap stations placed within marginal habitat in 2004, along with greater trap effort. In 2003 it required 58 days to detect all individuals, compared to 11 days in 2004. However, we detected nearly two-thirds of all individuals within the first 14 days of trapping in 2003.

Photographs taken in 2003 mostly captured snow leopards looking toward or away from the camera, but there was much variability in posture, especially for those images captured at scent-sprayed rocks. Photographs from the 2004 survey mostly depicted lateral views, with reduced success in photographing the leopard's distinctive dorsal surface of the tail. Factors contributing to this high variability in posture and subject angle are the typically narrow travel lane favored by snow leopard (<2-5 meters in width), its tendency to walk immediately adjacent to a cliff base or rock, and differences in the way individuals approach a scented rock. The best body parts for identification proved to be the lower forelimbs, forequarters, flanks and the dorsal surface of the tail. The small spots on the snow leopard's forehead commonly employed for identification by zoo keepers (Blomqvist & Nystrom 1980) are usually too faint or grainy for individual recognition. We found individual identification more difficult compared to tigers, cheetahs, common leopards or jaguars for two reasons: the snow leopard's extremely long, soft fur and numerous open grayish black rings or rosettes vary in prominence or shape with body movement and posture.

Over 96% of all photographs were assigned to one of 10 individuals. In 2003 we trapped six snow leopards (HNP-1 through HNP-6) judged to be 2 adult males, 1 subadult male, 2 adult females and a juvenile of unknown gender. In 2004 we recaptured two individuals (HNP-2 and HNP-3, an adult female and subadult male), along with 4 new animals (HNP-7 to 10, judged as 2 adult males, 1 adult female, and a juvenile of unknown gender). We documented 2 females with cubs, both litters judged at about 6 months of age at first capture.

Statistical tests for closure supported the assumption of population closure (i.e. no immigration, emigration, births or deaths) during each survey. However, the sample was too small to assess the relative fit of the different models, although there was no evidence for a behavioral response after the initial capture or for time variation in capture probabilities. Furthermore, small sample size was undoubtedly the main major reason for our inability to select a more sophisticated model than the overgeneralized null model known as Mo.

Relatively high capture probabilities (0.333-0.461) were noted during both surveys. Density estimates ranged from 8.49 ± 0.22 individuals per 100 km^2 in 2003 to 4.45 ± 0.16 in 2004, with the disparity between years largely attributed to different trapping densities. The mean maximum distances moved by individual snow leopards between successive captures during the two surveys were 3.15 km and 4.03 km respectively. Therefore, we effectively sampled areas in the Rumbak watershed amounting to about 71 km^2 and 135 km^2, of which approximately 60-70% is considered good snow leopard habitat

Discussion

Our study suggests that photographic capture-recapture sampling can be a useful tool for monitoring demographic patterns; however, a larger sample size would be necessary for generating a statistically robust estimate of population density and abundance based on capture-recapture models.

Snow leopards were successfully identified from their pelage patterns; however, subject orientation proved to be the most difficult problem. Various camera set-up scenarios were explored, and the most reliable proved to be two cameras oriented at 45° angle to the path of travel (or 90° where permitted by terrain), with camera trapping working best at narrow funnel points.

Tigers are readily identified by the striping on their flanks (Karanth & Nichols 1998), while common leopards and jaguars also have clearly distinct patterning. Obtaining good quality side profile photographs of snow leopards proved surprisingly elusive as snow leopards typically walk very close to objects like boulders or the base of a cliff, making it difficult to capture simultaneous images of both flanks for positive identification at the first capture. It may be better to set cameras at rock-scents or scrape sites where animals tend to linger, although one cannot be guaranteed of obtaining comparable views from different snow leopards.

Our capture history data fitted best with the closed capture-recapture null model Mo or the alternative model Mh which incorporates individual heterogeneity into capture probabilities and represents the model of choice for tigers (Karanth & Nichols 1998). The ability to select the most suitable model is a function of sample size. Owing to our small sample, we had no choice but to accept the over-generalized null model, an inevitable consequence of working with a shy species occurring at low or very low density over extensive mountainous terrain. On the other hand, we recorded notably higher capture probabilities than reported for tigers in good habitat (0.11-0.26; Karanth & Nichols 1998: 2857) or dry forest (0.039; Karanth *et al*. 2004: 288). Capture probability was readily maximized by placing traps at or near communal scenting sites along narrow "choke" points where topography constrains and funnels the animal's movements, especially if these happen to be located within core use areas. Most importantly, there should be no gap large enough for a snow leopard to escape detection entirely or to have too low a probability of detection, and trap stations should not have visual or other cues to alert snow leopards to the nearby presence of a trap.

Sample size will nearly always be a major constraint to any snow leopard camera-trap survey. Karanth & Nichols (1998) noted that CAPTURE performs poorly with populations of 20 or fewer individuals. Unfortunately, small populations are characteristic of the snow leopard, even in optimal habitat. The only remedy is to sample very large areas (200-400 km^2) concurrently or within an eight-week or shorter period in order to meet requirements of population closure. One's ability to trap over large areas is severely hampered by the rugged terrain and lack of ready access. Moving traps from one site to another can be very time-consuming. Cumulative capture curves indicate that camera-trap surveys need to be at least 35 days in duration to detect sufficient individuals, but 45-50 or more days may be necessary for ensuring adequate recaptures. We recommend a minimum trap density of about 1.5 cameras per 16-25 km^2. Camera-trap estimates should be supported by ungulate prey abundance surveys and calibrated data from standardized snow leopard sign transects wherever possible.

While population estimates are difficult to obtain, camera trapping can easily provide the minimum number of individual snow leopards present, provided traps cover a sufficiently large area and are run for at least 2-3 months, with the winter and early spring being the best time of year for such a survey. Our survey of the Rumbak watershed suggests a density of approximately 6 snow leopards per 100 km^2 in areas of good habitat and no more than 4 per 100 km^2 in marginal habitat. Thus HNP could support up to 175 snow leopards, a figure that is substantially more than Fox & Norbu's (1990) estimate of 50-75 individuals. The difference may partially reflect recent conservation initiatives aimed at protecting the snow leopard and its prey by reducing livestock loss, poaching and retributive killing (Jackson & Wangchuk 2001).

Obtaining statistically valid population estimates is expensive, time-consuming and not feasible in many situations. However, the use of inexpensive passive infrared-sensing cameras deployed over long time spans at frequently visited rock-scents by suitably trained wildlife guards or local villagers could be used to monitor the number of individuals and demographic patterns. Knowing the individual snow leopards that inhabit a particular area might promote stewardship of the species among interested households in the local community.

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References

Ahlborn G. and Jackson R. 1988. Marking in free-ranging snow leopards in west Nepal: a preliminary assessment. Pages 25-49. *In*: Freeman H. (ed). Proceedings. 5th International Snow Leopard Symposium. International Snow Leopard Trust, Seattle and Wildlife Institute of India, Dehradun, India. 269 pages.

Blomqvist L. and Nystrom V. 1980. On identifying snow leopards by their facial markings. International Pedigree Book of Snow Leopards 2: 159-167.

Fox J. L. and Nurbu C. 1990. Hemis, a National Park for Snow Leopard in India's Trans-Himalaya. International Pedigree Book of Snow Leopards 6:71-84.

Jackson R and Wangchuk R. 2001. Linking Snow Leopard Conservation and People-Wildlife Conflict Resolution: Grassroots Measures to Protect the Endangered Snow Leopard from Herder Retribution. Endangered Species UPDATE 18: 138-141.

Karanth K. U. and Nichols J. D. 1998. Estimation of tiger densities in India using photographic captures and recaptures. Ecology 29: 2852-2862.

Karanth K. U., Chundawat R. S., Nichols J. D. and Kumar N. S. 2004. Estimation of tiger densities in the tropical dry forests of Panna, Central India, using photographic capture–recapture sampling. Animal Conservation 7: 285-290.

Otis D. L., Burnham K. P., White G. C. and Anderson, D. R. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monograph 62, 135 pages.

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