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ESTIMATING SAIR KHATUU, DARVI, KHUVCH RIDGES, AND KHASAGT KHAIRKHAN MOUNTAIN'S SNOW LEOPARD (*PANTHERA UNCIA* (SCHREBER, 1775)) POPULATION SIZE AND DENSITY

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Abstract. During the previous two centuries, many carnivores have experienced substantial population declines, geographic range contractions, and fragmentation of their habitat (Ceballos & Ehrlich, 2002; Swenson et al., 2011). And the snow leopard is endemic to mountainous areas of Central Asia and occurs in 12 countries (McCarthy & Chapron, 2014). The snow leopard recently had its status changed by IUCN from Endangered to Vulnerable species in 2017 (McCarthy et al., 2017). In this research we have identified individuals based on specific spot patterns of snow leopard camera trapping, and combined it with spatially explicit capture-recapture (SECR) methods. This allowed us to estimate successfully snow leopard population abundance and density. WWF-Mongolia initiated a comprehensive study of snow leopard population size and density in the Mongolian part of Sair Khatuu, Darvi, Khuvch ridges, and Khasagt Khairkhan mountain. We have estimated population size and density using identification of individuals by spot patterns and spatially explicit capture-recapture (SECR) analysis. Individual identification based on the spot pattern result in Sair Khatuu ridge's individual number 7, Darvi's individual number 6, Khuvch's individual number 13, Khasgat Khairkhan's individual number 15. Using Bayesian statistic analysis for SECR we have identified for Sair Khatuu ridge N=8.30±2.48 (CI=7.11-21.74) individuals, Darvi — N=6.22±1.15 (CI=6-13.95) individuals, Khuvch — N=28.38±5.95 (CI=20.39–44.99) individuals, Khasagt Khairkhan mountain — N=15.74 ± 1.08 (CI=15.09–21.04) individuals.
Keywords: snow leopard, spot pattern, SECR, camera trapping, territory geography factors.

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Population Size and Density. *Bulletin of Buryat State University. Biology, Geography.* 2022; 2: 25–31.

Study area

Mongolia is home to the second-largest population of snow leopards in the world [7]. It is estimated that there are approximately 1,000 snow leopards across the Mongolian Altai, Gobi Altai, Khangai mountain ranges, and isolated mountains of Trans-Altai Gobi and Khuvsgul Mountains containing around 103,000 km^2 area [6; 7]. In figure 1 shows automat camera locations in Sair Khatuu ridge, Darvi ridge, Khuvch ridge, and Khasagt Khairkhan mountain respectively. These areas are Mongolian snow leopard population distribution's important region. The assessment found the Mongolian country's snow leopard population to be stable and confirmed the presence of approximately 953 snow leopard [1].

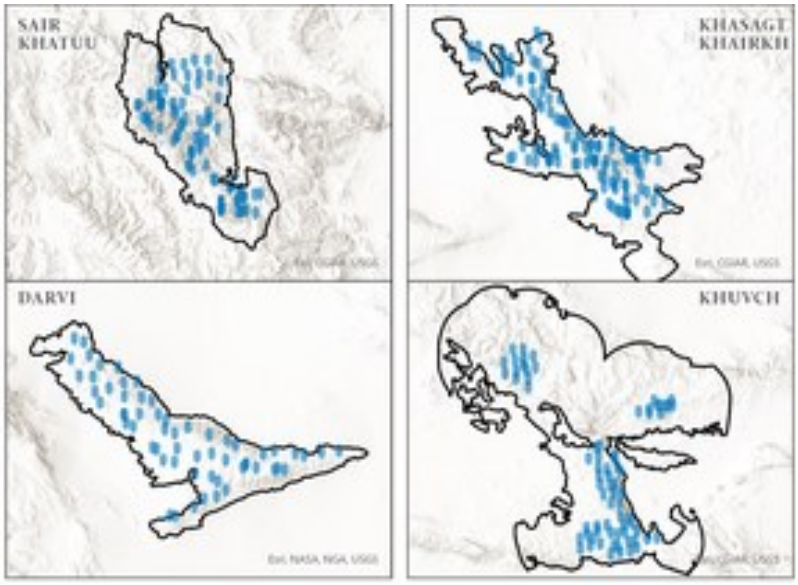

Fig. 1. Located automatic cameras in the study area

Research methodology

We collected field data using automatic cameras for 90 days. Estimating the snow leopard's population size and density we used 2 types of methods. The first type is based on the snow leopard pelage's specific pattern. The second method is using spatially explicit capture-recapture (SECR). We using for identified snow leopard individual from 433 photos from snow leopard detected camera in Sair Khatuu. Using for identified individuals 153 photos from snow leopard detected camera in Darvi ridge. Khuvch ridge in using snow leopard detected camera's 260 photos for identified individual. Detected snow leopard camera's 767 snow photos of snow leopard using for identified individual in Khasagt Khairkhan mountain. Showing Identifying individual based on spot pattern in (figure 2). We examined each photograph for clarity, subject orientation, and framing to locate unique markings useful for identification based on guidelines modified from Heilbrun [4] shows in below list:

1. A photograph was considered an initial capture only if it could not be positively matched with a previously photographed individual. 2. A recapture need not have been a photograph of the entire animal, but one that could be positively matched to a previously identified individual. 3. A poor photograph or one that could not be classified.

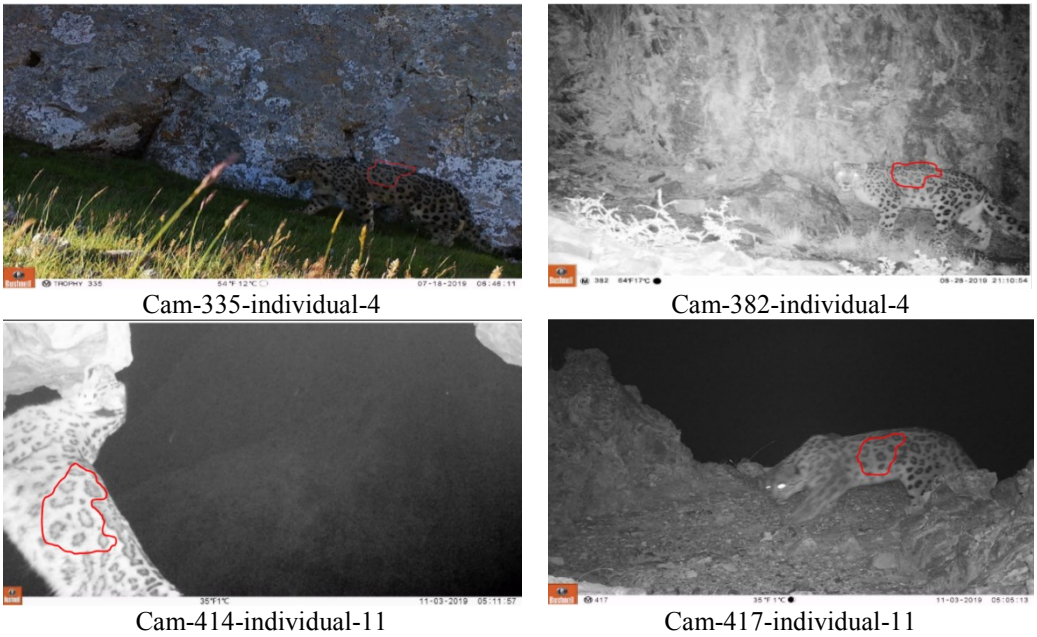

Fig. 2. Identification of individuals based on spot patterns.
Khasagt Khairkhan mountain's snow leopard individual 4 detected camera 335 and camera 382, individual 11 detected camera 414 and 417

2. A recapture need not have been a photograph of the entire animal, but one that could be positively matched to a previously identified individual.

3. A poor photograph or one that could not be classified as an initial or recaptured individual was classified as a non capture.

4. Areas used for identification consisted of uniquely shaped rosettes or spots, or groupings thereof, and their spatial arrangement on the forelimbs, flanks, and dorsal surface of the tail.

5. Distinct areas used for identification were classified as either primary or secondary features. A single primary feature was designated for each photograph and was defined as the most distinct and clearly visible group of markings or individual marks useful for identification. All other useful markings were classified as secondary features.

6. A positive identification was made by comparing the primary feature and at least one secondary feature to determine if the animal was an initial capture or recapture.

7. Identification of 1 different feature was considered sufficient to determine that 2 photographs depicted different individuals.

Statistical analysis using "SECR" package in R Software program. Statistically analyze fitting 20–25 models for each study area model selection established on 7 covariates quantitative data which are Snow leopard detected and non-detected area's difference of geography data, national protected area (NPA), ibex density, elevation, ruggedness, aspect, snow leopard habitat suit. Our covariates were established on snow leopard's prey and habitat.

Results

Capture success

We are estimating snow leopard population size and density using automatic camera's photography. In 2020 we located automatic cameras 90 days each study area. Sair Khatuu ridge's area size is 2658 km^2, the highest elevation 3570 m Darvi ridge's study area size is 1776 km^2, the highest elevation 2660 m Khuvch ridge's study area size is 10060 km^2 , the highest elevation 2759 m, Khasagt Khairkhan mountain's study area size is 5167 km^2, the highest elevation 3073 m.

Table 1

Study area	DN	DV	DS	N
Sair Khatuu ridge	175	29	87	15
Darvi ridge	59	10	18	7
Khuvch ridge	70	22	43	13
Khasagt Khairkhan mountain	175	32	87	15

DN — a total of located camera numbers, DV — detected snow leopard camera numbers, DS — a total of detection snow leopard, N — a total snow leopard individuals

Population size and density based on identification of individual spot patterns

Table 2

Individual identification of snow leopards based on their pelage on specific spot patterns. Estimated population density

Study area names	Population size based on a spot pattern	Snow leopard population density 100km^2
Sair Khatuu ridge	7	0.23
Khuvch ridge	13	0.28
Darvi ridge	6	0.46
Khasagt Khairkhan mountain	15	0.30

Population and territory size using spatial explicit capture-recapture (SECR)

Table 3

Bayesian statistical analysis for SECR estimating population size and one snow leopard individual's territory radius

Study area names	One snow leopard's territory radius (km)	Snow leopard population size mean number (n)	95% confidence interval	
			Mean number (min)	Mean number (max)
Sair Khatuu ridge	σ = 9.035	8.30	7.02	15.12
Darvi ridge	σ =10.01	6.23	6.04	13.19
Khuvch ridge	σ = 8.11	28.38	19.28	48.47
Khasagt Khairkhan mountain	σ = 9.57	15.75	15.23	22.81

Influence factors on snow leopard population size and density

Snow leopard population size and density depend on geography factors. Specially elevation, ruggedness, aspect and slope effect on snow leopard's habitat selection. We have fitted the model in each study area using "SECR" package in R software programm showing table 4. We fitted 25 models in Sair Khatuu ridge, 20 models in Khasagt Khairkhan mountain, 19 models in Darvi ridge, 23 models in Khuvch ridge. Model rankings are based on Akaike's Information Criterion (AIC).

Table 4

Study area	Covariate models	Best model ranked by AIC	AICwt (%)
Sair Khatuu ridge	HS+NDVI+λSLOcc	SairKhatuu.HabitatSuitNDVI.lambdaSLOcc	0.6006
Darvi ridge	E+ID+λR+ σIbexOcc	Darvi.ElevationIbexDensity.lambdaRuggedness.sigmaIbexOcc	0.2422
Khuvch ridge	R+σS	Khuvch.ruggedness.sigmaSlope	0.2421
Khasagt Khairkhan mountain	SLOcc+NDVI+λS	Khasagt.SLOccNDVI.lambdaSlope	0.3539

Weighted by AIC best models of each study area. HS — habitat suit, LOcc — snow leopard occupancy, E — elevation, ID — ibexdensity, IbexOcc — ibex occupaqncy, R — ruggedness, S — slope, Lamda — detection probability, Sigma — one snow leopard's mean of territory radius

Conclusion

Located automatic camera numbers, study area size, camera trap positions, and covariate quantity data are whereas fitted models are fellowless each study area also similar models fitting is not relevant. Influence to snow leopard population size and density geography factors are different in each study area. In addition prey abundance, livestock grazing, illegal hunting, human activities affected in Snow leopard population size and density therefore need to improve conservation initiative and management of snow leopard. Estimating population size and density using automatic camera pictures for Identification individual based on snow leopard spot pattern cannot determine completely snow leopard population in whole study area therefore we combined analysis (SECR) with identifying individual by spot pattern.

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ОЦЕНКА ЧИСЛЕННОСТИ И ПЛОТНОСТИ ПОПУЛЯЦИИ СНЕЖНОГО БАРСА *PANTHERA UNCIA* (SCHREBER, 1775) ХРЕБТОВ САИР-ХАТУУ, ДАРВИ, ХУВЧ И ГОРЫ ХАСАГТ-ХАЙРХАН

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Аннотация. В течение двух прошедших столетий произошло значительное сокращение численности многих хищников, а также географического ареала и фрагментация среды обитания (Ceballos & Ehrlich, 2002; Swenson et al., 2011). Снежный барс, или ирбис, является эндемичным видом горных районов Центральной Азии, встречается в 12 странах (McCarthy & Chapron, 2014). В 2017 г. МСОП изменил статус вида с находящегося под угрозой исчезновения на вид, находящийся в уязвимом положении (McCarthy et al., 2017). На основе фиксаций на камеру с последующим отловом животных и выявлением индивидуальных рисунков окраски шерсти (SECR) по разработанной монгольским отделением Всемирного фонда дикой природы методике удалось выявить численность и плотность популяции снежного барса на хребтах Саир-Хатуу, Дарви, Хувч и горе Хасагт-Хайрхан. Идентификация была проведена на основе изучения точечного рисунка шерсти: индивидуальный номер хребта Саир Хатуу 7, индивидуальный номер Дарви 6, индивидуальный номер Хувч 13, индивидуальный номер Хасгата хайрхана 15. Проведенный байесовский статистический анализ для хребта Сайрхатуу выявил N=8,30±2,48 (CI=7,11- 21,74) особей, Дарви N=6,22±1,15 (CI=6,0-13,95) особей, Хувч N=28,38 ± 5,95 (CI=20,39-44,99) особей, гора Хасагт Хайрхан N=15,74 ± 1,08 (CI=15,09-21,04) особей.

Ключевые слова: снежный барс, рисунок пятен, фиксация на камеру с последующим отловом животных и выявлением индивидуальных рисунков окраски шерсти (SECR), фотоловушка, физико-географические особенности территории обитания, Монголия.

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