PE&RC PhD PROJECT PROPOSAL

Please read the appendix with instructions first

1. GENERAL PROJECT INFORMATION	
Main PE&RC affiliated Institute / University	Wageningen University and Research
Main PE&RC research group	Wildlife Ecology and Conservation Group
Other PE&RC groups involved	NA
Project Title (English)	The ecology of snow leopard and blue sheep in the Trans-Himalaya of Nepal
Project duration	From 1 July 2019 to 30 June 2023
Where will the research be conducted (country)	Nepal
At which University will the thesis be defended?	Wageningen University
Funding source(s) for this project (1, 2, or 3?)	~~1 (internal) / 2 (NWO) /~~ 3 (external) (strikethrough) Name of funding source: Himalayan Tiger Foundation

2. THE PhD CANDIDATE	
Full name of the PhD candidate	Ashok Subedi
Gender	MALE / ~~FEMALE~~
Nationality	Nepali
Date of birth	06 January 1984
Period of appointment	FROM 1 July 2019 to 30 June 2023
Hours per week	38

3. SUPERVISION				
Project role	**Name + title**	**Specialisation**	**Organisation**	**Hours/week**
Promotor	1. Prof. Dr Herbert H.T. Prins	Animal ecology, natural resource management, high mountain ecology, plant-animal interactions.	Wageningen University and Research	2
Co-promotors	1. Dr Ir. Anouschka R. Hof	Animal ecology, climate change, mammals, ecological modelling and polar regions	Wageningen University and Research	2
	2. Dr Joost F. de Jong	Animal ecology, population genetics and wildlife management	Wageningen University and Research	2
Advisor	1. 2.			

Technician	1. Mr. Yorick Liefting 2. Mr. Om Bahadur Gurung	Animal identification systems, geographical information systems, remote sensing, , technical hardware, computer software. Field assistant, local interviews	Wageningen University and Research National Trust for Nature Conservation, Annapurna Conservation Area Project, Nepal (NTNC-ACAP)	As and when needed As and when needed
Other (Local supervisor)	1. Dr Naresh Subedi	Ecology, large herbivores and grasslands	National Trust for Nature Conservation, Nepal	As and when needed

4.		
Type of organisation	**Name of organisation**	**Name + title of collaborator(s)**
University	n.a.	
Research Institute	n.a.	
Government agency	1. Narpa Bhumi Rural Municipality, Nepal	
Others (e.g., FAO,WHO)	n.a.	

5. ETHICS	
Will vertebrates be used in animal experiments?	~~YES~~ / NO
Are there other ethical issues to be considered with respect to this project?	~~YES~~ / NO
If YES, please elaborate:	

PE&RC PhD PROJECT PROPOSAL

In case a peer-reviewed full project proposal is available (e.g., NWO or EU), please send that proposal along together with the reviewers comments and the acceptance letter.

6. SUMMARY (max. 250 words) (250 words)

A fundamental question in ecology is how biotic and abiotic factors determine the distribution and abundance of species. In predator-prey interactions, prey individuals must use space where they can obtain sufficient forage, avoid competition or predation and find the best environment, whereas predators favour areas preferred by prey. In such a race for space, prey try to minimize and predators try to maximize spatial overlap. However, we do not know how these multiple factors shape the distribution and abundance of the threatened snow leopard and its main wild prey, the blue sheep, in the human dominated and climatically harsh environments of the Trans-Himalayas of Nepal. I therefore aim to assess what determines the distribution of blue sheep and how its distribution and population dynamics affect the distribution and foraging pattern of snow leopard in the Nar valley of the Trans-Himalayas of Nepal. To answer the research questions, I will collect environmental data from weather stations, energy requirements for thermoregulation of snow leopard from artificial snow leopard models, assess the forage availability along the altitudinal gradient, examine diet overlap between blue sheep and livestock, assess the vigilance of blue sheep with and without livestock, analyze snow leopard scats for diet assessment across seasons and assess prey dynamics. Besides, I will conduct a questionnaire survey to assess the impact of tourism and fungus collection on livestock herding and its ultimate impact on distribution and abundance of snow leopard. My research will lead to recommendations for area prioritization to mitigate human-snow leopard conflicts.

7. DETAILED DESCRIPTION OF THE RESEARCH PLAN (max. 2500 words + 1 page literature list) (2499) words)

Introduction

Distribution and abundance of organisms is steered by abiotic vs. biotic [1, 2, 3, 4] and bottom-up vs. top-down factors [5, 6, 7,8]. Their distribution also depends on the trade-off among 'stay warm' vs. 'stay safe' [9, 10, 11] vs. 'stay well fed' [12]. In mountain ecosystems, environmental severity with strong seasonal and micro-scale spatial variation in climate [13] and food availability [14] is expected to influence a distribution and abundance of plant and animal species. On top of this, predation risk by carnivores, and, in human-dominated areas, inaccessibility of valleys (occupied by settlements and agriculture) and competition with livestock in the Trans-Himalayas of Nepal is therefore of scientific enquiry. Complex spatiotemporal variation of forage availability, potential cold/heat stress, and predation risk warrants a complex and little understood micro-scale habitat selection of wild herbivores and carnivores at high altitude.

Snow leopards (*Panthera uncia*) are sparsely distributed over the mountainous regions of Central Asia [15]. The species is listed as vulnerable on the Red List of Threatened Species by the IUCN [15]. The principal natural prey of the snow leopard are mesoherbivores; in Nepal, these are blue sheep (*Pseudois nayaur*) [16, 17]. Herbivores move through the landscape to track changes in food availability (quantity and quality), within and between habitats to forage efficiently [18, 19, 20]. Similarly, predator use areas with abundant prey [21]. Because blue sheep are the main wild prey of snow leopard in my research area [17], the distribution of snow leopard is expected to be influenced by the movement of blue sheep in the landscape. But in this same landscape, domestic goat and sheep move about too and they are also preyed up on [16]. In Nepal, both snow leopard and blue sheep are inhabitants of the arid Trans-Himalayas [17] which has rugged valleys and mountains with low moisture, high windspeed, intense radiation and strong variation on seasonal temperature (+26^{0}C to – 20^{0}C) [13]. Such variation in altitude, aspect and temperature in the Trans-Himalayas are expected to create an "energy landscape" with spatial and temporal variation in the amount of energy required to maintain body temperature and influence the distribution of both blue sheep and snow leopard.

In addition, snow leopards are often killed by local people because of livestock depredation. Furthermore, tourists and fungus ("aphrodisiac") collectors can cause an additional disturbance as has been observed in Bhutan [22]. Previous studies on snow leopard elsewhere were focused on prey selection [23, 24], habitat preference at present, and habitat suitability in future [25, 26], prey base estimation [27], and habitat overlap of blue sheep and livestock [28]. However, we lack knowledge on how these multiple factors together influence the distribution and abundance of both predator and prey in a human-dominated landscape. Therefore, my research aims to address how the variation in temperature, forage, caution and livestock pressure combinedly shape the distribution and abundance of snow leopard and blue sheep.

Objectives

The overall objective is to assess how multiple factors (temperature, forage, caution, and livestock pressure) affect the distribution of snow leopard and its main wild prey, the blue sheep, in the Trans-Himalayas of Nepal. The specific aims of the research are;

1. How does the presence of livestock affect the spatial distribution of blue sheep? (chapter 2)
2. How do abiotic and biotic factors affect spatial variation in forage availability? (chapter 3)
3. How does the relative abundance of blue sheep and livestock affect the diet composition of snow leopard (chapter-4) ?
4. How does the energy landscape affect the spatial distribution of snow leopards (chapter-5) ?

Study area

This research will be conducted in the Nar valley inside the Annapurna Conservation Area of the Trans-Himalayas in Nepal. The Annapurna Conservation Area covers 7.6 x 10^3 km^2 between 1000-8000m altitude and there are no specially protected areas. The annual temperature ranges from a minimum of -20℃ in winter to a maximum of +26℃ in summer [13]. The total annual rainfall is <200 mm and more than half of the total precipitation falls as snow during the winter. The study area is treeless and dominated by graminoids (*Carex spp*. and *Kobresia spp*.) [23]. Pastoral communities use all available rangelands for their traditional rotational grazing practices in the study area.

Chapter 1: General introduction

In this chapter, I will discuss different environmental and resource parameters of habitat suitability and how they influence the distribution and abundance of both prey and predator. Also, I will introduce the snow leopard and its main prey, the blue sheep, their ecology and the human-snow leopard conflict. Besides, I will discuss the research objectives and introduce the study area.

Chapter 2: Impact of livestock on distribution and abundance of blue sheep

In the landscape, animals prefer patches with high quality and quantity of forage and low predation risk [29]. Presence of livestock can reduce forage access for native ungulates [30, 31], disrupt predator-prey interactions, and increase the frequency and intensity of human-carnivore conflict [32, 33, 34]. According to the apparent competition hypothesis, presence of livestock can increase predation risk for prey if livestock attract predators [35, 36]. Also, the preferred prey species can reduce predation risk on less preferred prey [36, 37]. Former studies showed that intensive grazing by livestock negatively affects the performance of mountain ungulates. Mishra et al. [20] observed that the area with intensive grazing from livestock reduces the fecundity of blue sheep. Also, Shrestha and Wegge [28] conducted a similar study in Phu valley Manang, but their research did not consider the predation risk incurred by the livestock on blue sheep. Considering this research gap, I will assess how the presence of livestock affects the diet and predation risk of blue sheep.

Research question

How does the presence of livestock affect the spatial distribution of blue sheep?

Methodology

To assess the diet overlap, I will collect at least 20 samples of fresh dung of yak, horse, domestic goat, sheep, and blue sheep in every five hundred meter altitude band in the northern and southern aspect. I will also collect the information on space shared by both livestock and blue sheep (altitude, aspect and distance from the settlement). Similarly, I will collect vigilance behaviour data through direct observation of blue sheep without livestock and in the vicinity of livestock. Binoculars will be used to observe the vigilance behaviour of blue sheep. Any group (more than three individuals) with blue sheep, either together with or without the presence of livestock, will be observed and their behaviour will be recorded following name of author [38]. Observations will be taken over a minimum of 10 minutes, during which the focal animal's behaviour within a group will be recorded every minute [39].

Analyses

I will analyze the diet overlap of blue sheep and domestic livestock. I will also compare the mean foraging and vigilance time between groups with or without livestock to assess the effect of livestock on predation risk of blue sheep.

Chapter 3: Forage quality and quantity for blue sheep along altitudinal gradient

Altitude has been recognized as the most important factor that influences the abiotic environment by changing climatic variables and topography [40, 41]. Due to varied climatic and topographic conditions, available forage varies in both quantity and quality also at smaller spatial scales [42]. Grass quality, as mainly determined by the concentration of nitrogen, phosphorus, potassium, calcium, and sodium is an important factor influencing the distribution of grazing mammals [43, 44, 45, 46]. Therefore, in-depth knowledge on quality and quantity of prey forage is essential to understand the distribution of both blue sheep and snow leopard. Bhattacharya et al. [47] assessed the nutrient content of grass for wild ungulates in the Indian greater Himalayas and Aryal et. al [14] also assessed nutrient content in the diet of blue sheep in the Trans-Himalayas of Nepal but their research lacked the assessment of variation in the nutrient content along the altitudinal gradient and in relation to distance from settlement. In this chapter, I will bridge this gap by assessing the forage quality and quantity available to blue sheep along the altitudinal gradient and in relation to distance from settlement.

Research question

How do abiotic and biotic factors affect spatial variation in forage availability?

Methodology

For the assessment of forage quality, I will select six major graminoid species observed in the diet of blue sheep. I will collect at least twenty samples of every species in every five hundred meter altitude band both in northern and southern aspect. Then, I will lay a 30 x 30 m^2 main plot and a 3 x 3 m2 nested plot at the four corners of the main plot along the altitudinal gradient in between 3500m to 5500m in every five hundred meter altitude band in the northern and southern aspects. The portion of vegetation observed within a nested plot will be collected and air-dried in the field to calculate the amount of graminoids. I will measure coverage of herbs, shrubs, trees, bare soil and rock within a main plot (on a ten-point scale). I will collect forage in the fall, the months when vegetation is at its maximum standing biomass [30] and animals are fattening-up, and in late winter when animals have worst body condition.

Analyses

I will determine the spatiotemporal variation in the nutrient content (dry matter, crude protein, NDF, P, K, etc.) and quantity of each vegetation type available for blue sheep.

Chapter 4: Foraging pattern of snow leopard with changing blue sheep and livestock population

Predator-prey interactions are of great concern throughout central Asian highlands where local pastoralists often come in conflict with snow leopard because of livestock depredation [48]. Prey–predator interactions theory suggests that increasing wild prey populations can reduce predator's dependence on livestock for food in multiple-use landscapes. Bagchi et al. [49] observed that livestock depredation reduces with increasing wild prey population. In the proposed research site, Wegge et. al. [50] estimated there to be six snow leopards in the adjoining Phu valley of Manang district. They found that the annual average livestock loss was 5-6 sheep per snow leopard. But, we do not know the pattern of livestock depredation with changing blue sheep and livestock population. Therefore, in this chapter, I aim to address the research gap of the widely held predator-prey dynamics hypothesis by assessing the change in livestock depredation with changing predator and prey populations over the last 15 years in the Trans-Himalayas of Nepal as compared to [50].

Research question

How does the relative abundance of blue sheep and livestock affect the diet composition of snow leopard ?

Methodology

To assess the foraging pattern of snow leopard, I will collect snow leopard scats across all seasons. For scat collection, I will lay a fixed transect along the ridges, trails, and cliff base where snow leopard walks and stays. I will follow a fixed transect repeatedly to ensure the scat is of a particular season. Each transect will be traversed by two groups to increase the probability of scat detection. Collected scats will be stored in vials with silica gel for DNA and dietary analyses. I will estimate the snow leopard population by using genetic methods. Diet of snow leopard will be identified by comparing reference slides and photographs of the cuticle (cuticula) and the medulla of the hair of potential prey species [16, 51, 52]. I will estimate the blue sheep population by following double-observer survey methods [28, 53, 54]. Also, I will conduct a questionnaire survey with local people and collect data on changing demands for meat products, changing livestock numbers, livestock depredation and impact of tourism and fungus collection on the pattern of livestock herding and its impact on human-snow leopard conflict.

Analyses

I will compare the estimated population of snow leopard, blue sheep, livestock and livestock depredation with a similar study conducted by Wegge et al. [50] to assess the change in diet pattern of snow leopard with changing prey dynamics.

Chapter 5: Distribution of snow leopard in the "energy landscape"

Thermoregulation plays a major role in organism homeostasis, involving central, endocrine and metabolic functions [55]. Therefore, animals are constantly seeking the best environment following a specific thermo-reference [55]. Also, the ambient temperature influences the activity, behaviour, and movement patterns of animals [10, 11, 56]. Mammals precisely regulate metabolic heat production (MHP) and heat loss to maintain a stable core body temperature[57]. The weather patterns in the trans-Himalayas with its strong seasonal and micro-scale spatial variation [13] cause a variation in the amount of energy required for thermoregulation of animals [58]. Therefore, the distribution of snow leopard may be influenced by the ambient temperature. Watts et. al. [26] researched on habitat suitability of snow leopard and Aryal et al. [25] assessed potential habitat based on environmental data from WorldClim and snow leopard presence data. Their research lacked the calculation of energy requirement for the thermoregulation along the altitudinal gradient and aspect and its impact on snow leopard distribution. Therefore, I will assess the distribution of snow leopard in the "energy landscape" based on the amount of energy required for thermoregulation across different seasons.

Research question

How does the "energy landscape" affect the spatial distribution of snow leopards ?

Methodology

To 'chart' the "energy landscape", I will install weather stations within the potential habitat range of snow leopards. The weather stations will record data on ambient temperature, direct radiation from the sun, reflected radiation from the ground, wind speed, and wind direction. At least eight weather stations will be placed at regular intervals in between 3500m to 5500m on a northern and a southern aspect in the Nar valley of the Annapurna Conservation Area. I will collect seasonal presence data of snow leopards through a sign survey (following the methods mentioned in chapter four). In addition, I will prepare a snow leopard model having average surface area of adult snow leopard to acquire the energy data. The model will consist of a barrel filled with water and ethylene glycol in equal proportion. The model will have a heating and cooling system with a continuous solar power supply. Temperatures will be maintained at 37ºC (equivalent to the body temperature of terrestrial mammals). A data logger will keep the records of the energy needed to maintain the models at 37ºC.

Analyses

I will prepare a digital elevation model (DEM) of the landscape by using the latest satellite image obtained from Sentinel. Energy data acquired from the model will be overlaid on the DEM to prepare an energy landscape map. In combination with the energy landscape map and GPS points obtained from a sign survey, I will show the potential seasonal distribution of snow leopard in the energy landscape map.

Chapter 6: Synthesis

I will synthesize the overall findings of my research. I will prepare a detailed distribution map of snow leopard and blue sheep including priority area for snow leopard conservation in the Nar valley. This will be beneficial for conservation managers to concentrate on areas in which snow leopards are and could potentially be in high abundance to minimize human-wildlife conflict and optimize conservation effort.

8. TIME TABLE OF THE PROJECT AND WORK PROGRAMME (306 words)

The total duration of my PhD will be four years. My PhD period started at 1 July 2019 and will be completed on 30 June 2023. As per the WUR sandwich PhD format, of the total years, 15 months will be spent at the university and the rest in Nepal for field research. The detailed work plan is given in the table below. [Note: the “test weather station” (#5) refers to a complete weather station with logging facility that was placed in 2018 to test whether all modalities functioned properly especially during the winter (which is extreme at 4500 m above sea level]. The installation of more weather stations was done in the fall of 2019 and was planned to be continued in the spring of 2020. However, the Covid-19 outbreak caused delays and currently the spring 2020 activity is foreseen to take place in the fall of 2020. The start of the fieldwork for 2020 may be delayed too because of Covid-19 because I am not allowed to travel back to my duty station in Nepal from the Netherlands yet. An updated time table will be prepared once the health risk situation and government actions have become clear.

S.N.	Activities	Years/quarters															
		2019		2020				2021				2022				2023	
		3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
1	PhD enrollment	#															
2	Preparation and submission of TSP		#														
3	PhD Proposal Writing		#	#	#												
4	Go/no go for PhD				#												
5	Installation of test weather station																
6	Installation of weather station and model		#			#											
7	Data collection				#	#	#	#	#	#	#	#	#	#			
8	Data compilation and finalize methodology for statistical analyses													#	#	#	#
9	Writing scientific papers and PhD thesis													#	#	#	#
10	PhD thesis finalization and submission																#

9. SOCIETAL RELEVANCE (258 words)
I will develop insight into the distribution and abundance of snow leopard and its main wild prey, the blue sheep. In addition, it will give a clear idea about the impact of livestock management on the blue sheep and snow leopard. Furthermore, through my research I hope to find out whether the livestock depredation by snow leopard (which is a cause of anger, or even resentment, of local people and which undermines conservation efforts) takes place because of insufficient prey or because it is merely stochastic. Also, I will investigate the impact of recent socio-economic changes on the current practice of livestock herding and how that cascades into an impact on the human-snow leopard conflict. For instance, through preliminary interviews I found out that many of the high mountain herdsmen are not local people with local knowledge of the terrain anymore, but are poor, jobless men from elsewhere (even from India) who are hired to replace the local youth who find better jobs in the lowlands. On basis of my insights gained through my PhD but also as conservation officer, I will prepare a map of the area on which I will indicate which areas have to be prioritized for snow leopard conservation so that conservation managers can concentrate their management efforts, prepare a strategy to increase the prey base for snow leopards and find acceptable solutions for mitigating human-wildlife conflicts. Therefore, this research will directly benefit the local people by reducing economic loss from the livestock depredation and help to minimize retaliatory killing of the snow leopard.

10. DATA MANAGEMENT (max. 250 words) (165 words)
I will be responsible for collecting and managing data in consultation with my supervisors and support from the research technicians. I will collect data about the ambient temperature, solar radiation, wind speed, wind direction, grass distribution, grass quantity and forage nutrient content, blue sheep population, human-snow leopard conflict, and anthropogenic pressure. At the end of my PhD project, a full copy of the data will have been made available to supervisors and to the university. I will follow the standard format and norms of WEC as communicated to me by the group's data steward Mr. Yorick Liefting, but already at the onset of my data collection I will ensure that all data are captured according to an agreed format. All data will be stored in a personal computer and on an external hard drive; I will ensure that regular (but minimally every 3 months) back-ups are made and transmitted to the said data steward and then be transferred to the university server for safe keeping.

11. POTENTIAL REVIEWERS

#	Name + title	Organisation	Specialisation	Email address
1.	Dr Charudutt Mishra	Snow Leopard Trust	Snow leopard ecology; bharal ecology	charu@snowleopard.org
2.	Dr. Tsewang Namgail	Snow Leopard Conservancy, India Trsut	Ecology of high-altitude mammals	tsewang.namgail@gmail.com
3.	Dr. Örjan Johansson	Swedish University of Agriculture Science	Snow leopard ecology	orjan.johansson@slu.se
	Note doctores Mishra and Namgail are alumni of WUR and understand WUR's requirements			

12.SIGNATURES (this form needs to be signed by the PhD candidate as well as all supervisors)		
PhD candidate	**Promotor / Principal Supervisor**	**Co-promotor/Supervisor 2**
Name: Ashok Subedi	Name: Prof. Dr Herbert H.T. Prins	Name: Dr Joost F. de Jong
Date: 18/06/2020	Date: 16/6/20	Date: 17/06/2020
Co-promotor/Supervisor 3	**Supervisor 4**	**Supervisor 5**
Name: Dr. Anouschka R. Hof	Name: Dr. Naresh Subedi	Name:
Date: 17-06-2020	Date: 18/06/2020	Date:

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