

Project Title

Prescription for coping with a changing world climate: Medicinal diet of the virtually unknown Central Himalayan langurs in the high-altitude regions of the Garhwal Himalayas, India

- 1- Project Results Summary (maximum 500 words) State what you proposed to do, and what you did. Please try to be as specific as possible and avoid general statements (i.e., 'The project aimed to work with the Baltics aquaculture industry reduce pollution through their operations by...' vs. 'The project addresses marine environmental concerns in the Baltics.')
- a) **Quantification of diet composition :** - Langurs inhabiting alpine meadows of Rudranath spent their maximum time feeding on leaves and fruits of the tree species in the nearby timberline forests. However, herbs growing in the open meadows also constituted an important part of their diet. In total, 27 plant species were observed being eaten, of which 17 (~ 67%) were herbs. The top three most preferred herbs by langurs, *Pedicularis hoffmeisteri*, *Potentilla microphylla* and *Anemone tetrasepala* may be helpful in maintaining their health.
- b) **Determination of parasite loads in this species:** All the major groups of intestinal parasite such as Nematodes, Protozoans and Trematodes were recorded in langurs. The quantitative analysis of both sample sets was done using the McMaster technique. EPG (eggs per gram feces) and CPG (cysts per gram feces) were calculated to determine the intensity of parasite load. *Dicrocoelium* sp (Trematodes) *Eimeria* sp (Protozoa) and *Capillariidae*, *Oesophagostomum*, *Strongyle*, *Strongyloides*, *Trichostrongylus*, *Trichuris* (Nematodes) were quantified. Langurs were predominantly infected by a *Trichuris* sp. (1500 EPG), while the intensity of other parasites such as *Capillariidae* (165 EPG), *Eimeria* sp. (7 CPG), *Dicrocoelium* sp. (61 EPG), *Oesophagostomum* sp. (31 EPG), *Strongyle* sp. (13 EPG), *Strongyloides* sp. (28 EPG) and *Trichostrongylus* sp. (39 EPG) were relatively low. The prevalence of infection (number of samples containing the eggs of this species) was higher for *Trichuris* sp. (92%) while for other parasites, it was marginally high for *Oesophagostomum* sp. (31%), *Strongyloides* sp. (31%), *Trichostrongylus* sp. (27%), and slightly lower for *Capillariidae* sp. (12%), *Eimeria* sp. (15%), *Dicrocoelium* sp. (15%), and *Strongyle* sp. (19%).
- c) **Documentation of the medicinal plant knowledge of indigenous people:** In total, 80% of the 167 households were sampled. 14 major medicinal plant species were reported to be used by the local people for various type of sickness. *Dactylorhiza hatagire* (17%), *Delphinium denudatum* (15%) and *Girardinia diversifolia* (15%) medicinal plants were particularly used for cuts, piles and boils, respectively. 4 plants species found in the langur diet were reported by locals for their medicinal use. Roots of *Dactylorhiza hatagire* was used by locals for cuts. The leaves of this species constituted 1.06% of the total diet of langurs. Villagers uses the leaves of *Bistorta mscrophyllid* for dysentery, which was also consumed by langurs (0.90 % of the diet). Langurs were observed to feed on the root and leaves of *Potentilla microphylla* (1.55% of the diet), which locals reported was a cure for mouth ulcers. Apart from this, leaves

and roots of *Anemone tetrasepala* were reported to be used for cuts and wounds, which also constituted 1.31% of the langur's diet. Though these are basic data about the potential use of medicinal plants by langurs in the higher Himalayas, the detail study will be needed for its confirmation and quantification.

2) What was your hypothesis or research question? (100)

The principle objective of this project was to collect baseline information and currently, it does not address any specific hypotheses but following up on the questions, the information has provided a strong platform to build hypotheses for future studies.

- A) What is the intensity and prevalence of parasite infections in langurs inhabiting these high alpine meadows, and could this be biological pressure for langurs to ingest herbal plants to maintain health?
- B) Is there any overlap of medicinal plants found in Langur diet with that of consumed by local people sharing same habitat at higher elevations?

3) How did your project answer your research question(s) or hypothesis? (350)

This project reported firsthand information on the composition of the diet of langurs in the alpine meadows through systematic quantification and analysis. Various herbs comprised about 67% of the langur diet, which they might be consuming for their medicinal value based partially on responses obtained from the local people. The level of parasite infection was investigated, as it is critical to explore its relation with the medicinal diet of langurs since the literature on primate self-medication strongly suggests that parasites are driving a majority of these behaviors. The intensity and prevalence of parasite infection in langurs at higher elevation as investigated and quantified for their occurrence, to quantify the level of pressure on the langur health. The infection rates for different groups of parasites such as Nematodes, Protozoans and Trematodes varied, suggesting some species may be more important than others for understanding the mechanism and target(s) of possible self-medication. It was found that Langurs were predominantly infected by nematode species. Documentation the knowledge of local people sharing the same habitat with langurs, it was observed that langurs also consumed plenty of medicinal plants used by locals for injury and disease. It has yielded very important base-line information for future research towards to deepen our understanding of role of medicinal plants in the langurs' diet.

4) Did your project work on entities or places of note (e.g., threatened, endangered, or critically endangered species; World Heritage natural or cultural site)?

The Rudranath Sanctuary is area of natural human cultural priority in India. The study species is classified into the least concerned category according to IUCN, but it is also one of the least studied species, especially in the alpine meadows. The alpine meadows are very sensitive to global climate change that provides science with a natural laboratory to study the behavior of primate species inhabiting these higher elevations. It could be a good model to investigate and quantify the impact of global climate change on primates and potentially can be extended to humans.

5) Did your project contribute to methodological innovations?

This project did not contribute to methodological innovations. The methodology followed under this project is widely reviewed and accepted for other studies.

6) Were your approaches and/or methods successful? Will you modify/change the current approach/methods in the future? How you will modify them?

The methods used in this project were successful to address all its objectives. But the current method will be modified and updated as is required, considering specific future questions. This will help to improve our outputs and provide more valuable data. For example, in current study, scan animal sampling method was used to record behavior of the langur troop, but in future, we will use focal animal sampling to record the behavior, of individual members in greater detail, depending upon the questions to be asked. It will include following and observing identified sick individuals over longer periods of time, recording their diet of medicinal plants, and will allow us to investigate the diet's effect on the rate and intensity of parasite infection(s). In case of parasite infection, only quantitative analysis has been used so far, but in future qualitative analysis will be used for deepening our understanding of parasite infection over longer periods of time.

7) Did your project contribute to theoretical advancements?

This project is conducted in alpine zone of the Himalayas which is very sensitive to global climate change. As per the current research, there is no information about the impact of global climate change on the behavior and ecology of the primate or animal living in the higher Himalayas. This project aims to provide an appropriate theoretical model in the future by observing various factors like environmental variables, diet, social behavior, range extension and parasite infection, with long term monitoring. This model will be helpful to predict the potential change or effect on primates or other animals with ongoing climate change. It can be potentially extended to investigate the effect on humans as well as to predict the changes of disease transmission with changes in certain environmental variables.

8) Did your project contribute to capacity-building of local institutions, communities, and/or individuals, including students?

The participation of local people was one the key parameter for the successful execution of this project in the higher Himalayas. The study site (Rudranath) is about 32 km from the nearest motor road so local people were hired as porters to carry necessary supplies up in to the mountain for the campsite. This has provided them continuous employment and a source of income throughout the months of the project for their sustenance which is

otherwise a very rare opportunity in this region. Local field assistants and the camp caretaker were hired from Mandal village (selected based on their economic condition and eagerness to learn). Local field assistants were thoroughly trained in scientific data collection, its systematic entry using MS office on computer and data keeping. These newly acquired skills, their knowledge of the region and participation in research projects make them very good candidates for future field assistantship opportunities working with other scientific projects in higher Himalayas, of which there are many. Some of the local people were hired and trained to set up the vegetation plots. It has benefitted them economically but they also learned about scientific techniques of vegetation sampling; another useful skill for future work in other scientific projects.

Apart from locals, four volunteers were scientifically trained and mentored under this project to collect behavioral and ecological data of primates using various standard techniques. Benefitting from this training and scientific grooming, one student volunteer, Mr. Takhe Bamin has successfully started a project in the eastern Himalayas with the support of a National Geographic Young Explorers grant to understand the pressure on wildlife due to hunting and cultural practices by the Apatani Tribe (his tribe). Another student Mr. Akash Verma, a college teacher in India, started a project dedicated to fuelwood consumption and its impact on the alpine meadows at my study site with local assistants and his students.

- 9) If your project had outreach, communication, awareness objectives and activities, did it have the impact that you expected?

One of the important aspects of this project was to generate awareness in local people especially amongst women (whose thoughts impacts her family) and children (future decision makers) about their surrounding forest and its wildlife. To raise awareness amongst children, a painting competition was carried out in local government elementary schools in Mandal valley (the nearest village from the study site). The elementary school was selected to carry out these activities, as it is easier to mold kids to be more compassionate towards the surrounding forests and its wildlife due to their immense curiosity and eagerness to learn. The painting competition was perfect for kids to motivate them to learn more about the wildlife, while having fun drawing and coloring their favorite animals. The majority of students drew elephants and monkeys, thanks to the awareness activities we have conducted the year before. Its impact was evident as the majority of kids this year know much about their langur friends which was reflected in their paintings. Last year, I have interacted with the students in the same school talking about the life of langurs mentioning that they also have families like we do. The kids had remembered this and not only drew just a single langur but also families of langurs, with adults and infants. With the help of volunteers and local field assistants, we were able to do multiple activities at the same time. Kids from junior KG were taught to draw various animals so they could enjoy painting too. We also explained to them about the basic ecology of the animals they are observing in their day-to-day life or what they see on the television. I also explained that the plants which langurs eat are becoming less abundant in the forest. This drives them

to the village for food, so we have to do selective plantations inside the forest to ensure langurs will have enough food in the future for their families. All the students said that they were happy to contribute to help the raising and planting of seedlings with us in the near future.

- 10) Did this NGS grant help you to raise additional funds for yourself or an associated project/program? This refers to successful applications for funds after you received this NGS Grant

YES! The NGS grant helped me to improve my CV. After this I received the Baldwin Fellowship (USD 15000) from the Leakey Foundation to pursue my PhD at the Primate Research Institute, Kyoto University, Japan. They highlighted me as a National Geographic Young Explorer on their website (https://leakeyfoundation.org/page/9/?option=com_content&view=article&id=11223&Itemid=1), which shows that NGS grant played an important role towards my selection for this fellowship.

- 11) What were the benefits of this grant to you, and/or your institution, and/or your discipline? (350)

The NGS grant helped in multiple ways. Firstly, it has provided all the financial support required to execute this project in the harsh terrain of the Himalayas, benefitting many locals by providing employment opportunities earning me their goodwill, support and cooperation. The reference to the National Geographic Channel during awareness activities has immensely helped me to connect with locals as they are aware about it. Local people were quickly able to relate and appreciate the information on langurs and their ecology as was explained to them on various occasions. I also got benefit of this grant in academia and it has boosted my personal confidence as a researcher.

- 12) Has your project attracted media attention (including but not limited to National Geographic)?

Yes, I have published an article in one of the reputed on-line platforms for wildlife and conservation called 'Nature in Focus' titled "Living with Langurs" (<https://www.natureinfocus.in/author/himani-nautiyal>). I have also published a photo story titled "Adventurous Life of Langurs in the Himalayas" on the website of a very popular TV channel in India called NDTV (<https://www.ndtv.com/education/blog-adventurous-life-of-langurs-in-the-himalayas-1780589>). I have also published a lecture on 'A career in wildlife sciences' with India's biggest on-line education platform called Study IQ education, which has 1.8 million subscribers (<https://www.youtube.com/watch?v=J00OfC8N6L0>), enabling me to reach wider audiences.

- 13) Please list ones that have already occurred or are definitely going to take place in the near future (i.e., 'NG Live on September 10, 2014 in Stockholm' or 'NG Magazine has

approached me for an interview in May 2014' and not, 'Planning to approach NG Magazine...'). (200)

I am planning to approach NG with a photo story based on my field experiences working in the harsh Himalayas at higher elevations. Under this story, I will share my daily life at the campsite and in field along with the many amazing experiences in the Himalayan landscape during this study period.

- 14) What are the key findings and/or accomplishments that make this project/grant media-worthy? List/describe. (350)

Though least concerned, Central Himalayan Langur are the least studied species in the higher elevations of the Himalayas. With the rapidly changing environment in this region due to climate change, this project has provided a rare opportunity to have a glimpse about how primate species will cope and how they adapt themselves their survival. A long-term study on this species in this region will definitely provide an opportunity to observe how species will adapt with global warming and climate change. Apart from that, this is the first project to describe the composition of langur diet and parasite infection in the alpine meadows of the Himalayas. Another important finding of this project is that the langurs consume medical plants and herbs which are also used by local people to cure various diseases; making it media worthy.

- 15) Have you submitted manuscripts to or published in a peer-reviewed journal, book, or newspaper or popular magazine resulting from your NGS supported project?

The following manuscript is in press, and reports the first record of this Interspecific feeding association.

Himani Nautiyal and Michal A Huffman, "Interspecific feeding association between Central Himalayan langurs (*Semnopithecus schistaceus*) and Himalayan black bears (*Ursus thibetanus*), in a temperate forest of the Western Indian Himalayas", *Mammal Study* (2018): In press.

My experience with regards to communication with NGS was really good. Application process was to the point and easy to follow. Administrative paperwork was easy to follow too and for any kind of doubts, I got quick help from NGS staff. Overall, I had very good experience right from the application and communication with NGS stall. I would like to thank the NGS Grant for making this study possible and continued support. I hope that the NGS will continue its support for my research and conservation activities in the future.