CORRESPONDENCE

Comments on "Spatial Utilization and Microhabitat Selection of the Snow Leopard (*Panthera uncia*) under Different Livestock Grazing Intensities"

NISAM MANG LUXOM[a] AND RISHI KUMAR SHARMA[a]

[a] *Worldwide Fund for Nature–India, Lodhi Estate, New Delhi, India*

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ABSTRACT: Large expanses of snow leopard habitat overlap with extensively used areas for livestock grazing. A fundamental question for conservationists is to determine whether livestock production can be reconciled with the conservation of rare and threatened large carnivores. Therefore, numerous studies focus on the relationship between carnivore densities and space use and environmental, anthropogenic, and topographic variables. Using snow leopard sign surveys in areas with high and low grazing disturbance, Hong et al. posit that livestock grazing directly impacts fine-scale habitat selection by snow leopards. The authors recommend controlling livestock grazing to help restore habitat complexity and alpine environment diversity. However, the approach by which Hong et al. have reached this conclusion is inadequate and is based on a methodology that fails to address the research question appropriately. We argue that 1) identification of a biologically relevant scale of study is the first essential step toward inferring carnivore–habitat relationships, 2) the authors draw inconsistent conclusions from their data on sign densities in high and low grazing disturbance areas, 3) ideally, the snow leopard–livestock relationship needs to be examined across a gradient of livestock grazing intensities and at multiple spatial scales, and 4) it is inappropriate to draw conclusions for landscape/regional scales from a study conducted at a finer and undefined scale. We suggest that future studies should clearly define the scale of the study, identify appropriate habitat variables of interest, and use meaningful measurement instruments to serve as proxies for variables of interest.

KEYWORDS: Ecology; Asia; Animal studies

1. Comment

Factors influencing snow leopard habitat use have been the focal area of numerous studies across the snow leopard range (e.g., Alexander et al. 2016; Chundawat 1990; Forrest et al. 2012; Schaller 1998; Sharma et al. 2021; Wolf and Ale 2009; Yang et al. 2021). These studies are often conducted at landscape or regional scales to better understand species–habitat relationships and to establish conservation priorities. Large expanses of snow leopard habitat overlap with extensively used areas for livestock rearing. While livestock has been reported to contribute to a significant portion of the snow leopard diet across its distribution, how livestock impacts microhabitat use and habitat selection by snow leopards has rarely been addressed. Using snow leopard sign surveys in areas with high and low grazing disturbance, Hong et al. (2021) posit that livestock grazing has a direct negative impact on fine-scale habitat selection by snow leopards. The authors have also recommended controlling livestock grazing to help restore habitat complexity and alpine environment diversity in snow leopard habitats. However, the approach by which Hong et al. have reached this conclusion is inadequate and is based on a methodology that fails to address the research question appropriately.

a. Scale of consideration for studying habitat use

The issue of scale is the fundamental basis of all habitat use and habitat selection studies (Johnson 1980). Identifying the scale at which to conduct habitat studies should be biologically relevant to the species in question. Johnson (1980) has put forth four spatial scales to evaluate habitat selection: overall geographic distribution (first order), home range (second order), habitat patch (third order), and resources within patch (fourth order). Literature suggests examining large carnivore habitat use at a broader scale to capture biologically relevant data to draw useful conclusions effectively (Fisher et al. 2011). Previous studies focusing on finer-scale habitat use by large felids have initially clarified resource use and/or selection at the level of the home range, that is, the second order of hierarchical habitat selection, before interpreting data at the finer scale, that is, the third and fourth orders of hierarchical habitat selection (Dickson and Beier 2002; Elbroch et al. 2015; Kusler et al. 2017; Rostro-García et al. 2015). It is not advisable to extrapolate habitat use findings to make definitive broadscale conclusions that affect resource management options at a larger scale. The scale at which the concerned study has been conducted is unclear and leaves room for misinterpretation of the results.

Corresponding author: Rishi Kumar Sharma, rksharma@wwfindia.net

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Hong et al. (2021) have discussed "microhabitat" use and selection by snow leopards without specifying the scale at which they have conducted their sampling, beyond stating "mesoscale" as a reference point. In addition, the total sampling effort and the number and nature of replicates requires further clarification.

b. *Inconsistent conclusions are drawn from sign density data*

Using sign density as a metric, the authors support their conclusion that livestock negatively impact snow leopard habitat use by reporting findings at two major scales. Livestock sign densities have been used as a proxy to initially identify a high-grazing-disturbance area (HGDA) and a low-grazing-disturbance area (LGDA). At this broad scale, snow leopard and blue sheep sign densities have been reported to be higher in areas with high livestock sign densities. However, the authors report that snow leopard signs exhibited a greater degree of concentration despite being present in higher densities in the areas with larger livestock-related disturbance. They posit that snow leopards would tend to avoid specific areas with increased human activity, which should ideally emerge from the fine-scale habitat selection analysis. At a finer scale, the authors have used resource selection function analysis to determine whether snow leopards are actively selecting for habitat variables in the two areas with high and low livestock grazing disturbance. The study reports that snow leopards are significantly selecting for habitat variables in areas less disturbed by livestock grazing, whereas no significant selection was found in areas with higher livestock pressure. Such a conclusion contradicts the earlier result of site use being more aggregated in areas with high livestock grazing disturbance.

c. *Absence of an appropriate proxy for the impact of livestock grazing*

The livestock and snow leopard interface involves a number of components, including direct predation by snow leopards, habitat changes resulting from livestock grazing, and changes in wild prey population density in the presence of livestock. Habitat use/selection studies that focus on the impact of any agent on the distribution and habitat use of a species in a landscape should aim to examine at least one major element of the concerned interface. The methodology used by Hong et al. has instead focused on collecting general habitat use data in two areas with varying livestock grazing disturbance, without examining any elements that are able to serve as a proxy for livestock impacts at a finer scale. While the study provides valuable information about site use by snow leopards, only using broad umbrella terms (low and high grazing disturbance) and a livestock sign density metric without providing more nuance about the scale of the study as well as characterization of the landscape, it is not advisable to draw definite conclusions about the negative impact of livestock on snow leopard habitat use. Another study examining snow leopard site use has refrained from drawing similar distinctive conclusions because of the scale of the study being too small (Alexander et al. 2016).

2. Conclusions

While the study contributes toward gaining a better understanding of snow leopard habitat use, the dimension of livestock impact on snow leopard habitat use has not been incorporated well enough in the study design for the authors to conclude that livestock grazing has directly impacted microhabitat use by snow leopards in the landscape. In fact, the higher density of snow leopard signs in HGDA, coupled with the lower geographical concentration index [reported as 61.68 in the results section of Hong et al. (2021, p. 155), as compared with 80.13 for LGDA], shows the potential for livestock and snow leopard coexistence; however, the authors have concluded otherwise. Future studies should instead focus on, initially, defining the scale of the study and identifying appropriate habitat parameters for sampling, after which relationships between explanatory habitat variables should be clarified to be able to come to relevant conclusions about how different factors influence snow leopard habitat use.

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