

Modeling the effect of top predators and habitat on the distribution of mesocarnivores in large-carnivore landscapes of India and central Europe

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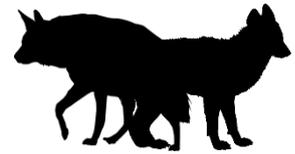
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Executive Summary



Scavengers are critical to a healthy ecosystem and provide important ecosystem services by removing putrefying carcasses, which minimizes the risk of disease spread to both humans and wildlife. The striped hyaena (*Hyaena hyaena*) and golden jackal (*Canis aureus*) are among the most important scavengers, yet they have undergone rapid population declines across much of their distribution range. Major threats identified to the scavengers includes the loss of preferred habitats such as grasslands and open scrublands, disease risk from feral dogs, roadkills, reduced scavenging opportunities, and poaching. These scavengers often occur with large predators such as tigers, leopards, and wolves across their ranges, particularly in and around protected areas. However, no primary study has been conducted to assess the potential top-down impacts of large predators on scavengers at a macroecological scale. In this study, we assessed and mapped the current population status (potential current distribution) of hyaena and jackal in India, and assessed the influence of tiger (*Panthera tigris*), leopard (*Panthera leo*) on striped hyaena and golden jackal in India, and of wolves on jackal in Austria.

Interspecific interactions are complex and influenced by several environmental factors such as prey availability, guild structure, microclimatic conditions, human footprint, and the availability of competition refugia. These factors are critical, and their spatial variation can lead to non-stationarity (change) in impact of large predators on scavengers across different ecological contexts. Non-stationarity refers to variation in effects of factors on an ecological process or patterns differ across space and/or time. India is a huge country with significant variation in its local environment across the space. Therefore, in this study we also assessed the non-stationarity in responses of scavengers to prey, tiger, leopard, and other important environmental variables. We conducted this study in three tiger conservation landscapes Shivalik, Central India and Western Ghats delineated as part of All India Tiger Monitoring program. These landscapes support populations of both hyaena and jackal, along with tiger and leopard, and they differ substantially in landscape features, anthropogenic pressures, and prey and predator densities. This variation provides a relevant ecological setting to test for non-stationarity in the influence of large predators and environmental variables on the focal scavenger species.

To assess top-down control on scavengers and associated non-stationarity in India, a total of 14,064 data points on the detection or non-detection of hyaenas, jackals, leopard, tigers, and



their two major prey species, chital (*Axis axis*) and sambar (*Rusa unicolor*), across the three landscapes were digitized from the All India Tiger Monitoring Report for the year 2022. Leopard data, available in a separate 2018 report, were digitized. Based on available literatures on Jackal and hyaena, we also considered environmental variables such as climatic factors, tree density, human footprints and cattle density. We employed a Random Forest algorithm to assess scavenger responses to the occurrence of predators while accounting for availability of prey and environmental variables through regional models for each landscape. Additionally, we fitted a global random forest model at India scale. Our results indicated no top-down control across landscapes; instead, the distribution of scavengers was primarily driven by geoclimatic variables. Regional models by contrast exhibited significant variation in their predictions of scavenger occurrence probabilities in response to prey, predators, and other covariates, confirming non-stationarity across regions. Ecological models often assume that biotic and abiotic covariates exhibit spatial stationarity, yet our study showed non-stationarity in effect of predictor variables on hyaena and jackal occurrence across landscapes. However, regional predictions from the global model proved robust and can help overcome the bias–variance trade-off of regional models when data are limited. Furthermore, in this study we have also mapped the potential distribution of Jackal and hyaena for data informed conservation management of these important scavengers.

To assess the impact of wolves on jackals in Austria, we used presence–absence data of jackals collated from three different sources: camera trap surveys, occasional records, and acoustic data collected between 2015 and 2023, at a spatial resolution of 1 sq km. The occurrence records were further categorized into three timelines: (a) 2015–2017, (b) 2018–2020, and (c) 2021–2023, to assign weights to each grid cell with jackal presence. The weight was calculated based on the number of timelines during which jackals were recorded as present between 2015 and 2023. Occurrence data for wolves were collected from secondary sources. As wolves have only recently begun recolonizing Austria, there were limited reliable absence records. Therefore, we calculated Euclidean distance from wolf presence locations and tested its effect along with other environmental variables using the Random Forest algorithm. In Austria, we found that proximity to wolves was the most important factor determining the spatial distribution of jackals, showing a significant negative relationship. The distribution of jackals was also associated with areas that had relatively lower and more stable temperatures throughout the year. In this study we also predicted suitable areas for Jackal in Austria.





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