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# DETERMINING THE EFFECTS OF SOCIO-ECOLOGICAL FORCES SHAPING STRIPED HYAENA *(Hyaena Hyaena)* POPULATION IN THE WESTERN GHATS PART OF TAMIL NADU, SOUTHERN INDIA

Technical Report No. PR224

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Division of Conservation Ecology
Sálim Ali Centre for Ornithology and Natural History
(A Centre of Excellence under the Ministry of Environment
Forest & Climate Change, Govt. of India)
Coimbatore, Tamil Nadu, India - 641108

Science & Engineering
Research Board-DST

**T. Ramesh**
**Riddhika Ramesh**
**Ashish Kumar**

Sálim Ali Centre for Ornithology
and Natural History

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**Principal Investigator**

Dr. T. Ramesh

**Co-Principal Investigator**

Dr. Riddhika Ramesh

**Senior Project Fellow**

Ashish Kumar


**Sálim Ali Centre for Ornithology and Natural History**

**A Centre of Excellence under the Ministry of Environment, Forest and Climate Change,**

**Government of India**

**Coimbatore - 641108, Tamil Nadu, India**

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***For correspondence***: Dr. T. Ramesh, *ramesh81ngl@gmail.com*

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# GLOSSARY

| | |
|---|---|
| BRT | Biligiri Ranganathaswamy Tiger Reserve |
| CCMB | Centre for Cellular and Molecular Biology |
| CNWLS | Cauvery North Wildlife Sanctuary |
| DistRiver | Distance to River (in meter) |
| ESA | Extensive Study Area |
| FEC | Fecal Egg Count |
| FGC | Faecal Glucocorticoids |
| GBH | Girth at Breast Height |
| GCs | Glucocorticoid |
| GPS | Global Positioning System |
| HCC | Human-Carnivore Conflict |
| HPA | Hypothalamic-Pituitary-Adrenal |
| ISA | Intensive Study Area |
| IUCN | International Union for Conservation of Nature |
| LULC | Land Use Land Cover |
| MTR | Mudumalai Tiger Reserve |
| mtry | Number of variables randomly sampled at each split (Random Forest) |
| NA | Not Applicable |
| NBR | Nilgiri Biosphere Reserve |
| NSAIDs | Non-Steroidal Anti-Inflammatory Drugs |
| nTree | Number of Tress (Random Forest) |
| OOB | Out Of Bag |
| PAs | Protected Areas |
| RFs | Reserve Forests |
| ROC | Receiver Operating Characteristics |
| SNS | Sympathetic Nervous System |
| STR | Sathyamangalam Tiger Reserve |
| UNESCO | The United Nations Educational, Scientific and Cultural Organization |
| UTM | Universal Transverse Mercator |
| WEGPTN | Western and Eastern Ghats part of Tamil Nadu |

# TABLE OF CONTENTS

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# Executive Summary

Western and Eastern Ghats part of Tamil Nadu (WEGPTN) is an important area of "Nagarhole-Bandipur-Wayanad-Mudumalai-Sathyamangalam-Biligiri Ranganathaswamy Tiger Reserve (BRT) complex" identified for the conservation of large mammals in Southern India. This is the largest contiguous forest in the Western Ghats that supports significant populations of tiger, leopard, dhole, and their prey species. Many studies have been conducted on these species from the WEGPTN but detailed studies on the striped hyaena (*Hyaena hyaena*) (henceforth called hyenas) are lacking while there are large patches of suitable habitat available for the species in this landscape. Striped hyaena is one of the least studied carnivores, and only meagre information is available on its ecology and current population distribution. The landscape conformation has drastically changed over time due to the rise in human activities. This human wildlife interaction often results into livestock predation by carnivores and subsequent retaliatory killing of predators. Such interactions have emerged as pressing threats to existence of carnivores in this landscape. While minimal information is available on hyaena-human interactions from other regions, there is little information available on this crucial aspect from this landscape. Human induced changes and stochastic changes in ecosystem can also have impact on habitat selection and distribution of species. Over time, the distribution of hyenas has been shrinking in the landscape, hence a complete understanding on the patchy distribution patterns of the species is much needed from this landscape. Furthermore, crucial aspects of hyaena ecology such as den site selection and stress physiology provide insights on the ecological condition of a breeding population. Therefore, realizing the need for critical information on the species from Protected Areas (PAs) and Non-PAs of WEGPTN, this comprehensive project was conducted with the following four distinct objectives 1) assess the temporal variation in livestock depredations by striped hyaenas; 2) assess multi scale habitat requirements that determine the spatial distribution of hyaena population; 3) assess the influence of anthropogenic pressure on the stress level of striped hyaenas; and 4) Patch characterization of denning sites of the species.

We identified the potential habitats available in WEGPTN based on the occurrence records of the species from secondary sources such as forest department census data, newspaper reporting and published-unpublished literature. Subsequently, potential hyaena distribution areas were marked as an Extensive Study Area (ESA), predicted through a preliminary species distribution model, calibrated using secondary data. The identified ESA includes Mudumalai Tiger



Reserve, Sathyamangalam Tiger Reserve, Cauvery North Wildlife Sanctuary as well as Gudalur, Nilgiris, Coimbatore, Erode, Dharmapuri, and Hosur Forest Divisions. The ESA was further surveyed through camera traps in conjunction with indirect sign surveys, and current distribution ranges were ascertained in the landscape. We first divided the entire study area into 5x5 sq km grids and 2.5x2.5 sq km sub-grids to stratify our sampling efforts systematically throughout the ESA identified. We covered 248 grids on 2 km trails and collected information on current species occurrence along with its co-predators and prey species through indirect sign surveys. The current occurrence record of the species was supported by photographic evidences from 194 camera traps placed across seven forest divisions of ESA, with an effort of 4975 trap nights. We recorded a small population of the species in this landscape which is confined to a small geographic area (314 sq. km). The current distribution of the species majorly lies in the Sigur and Moyar valley comprising Bhavanisagar range of Sathyamangalam Tiger Reserve (STR), and Masinagudi, Sigur and parts of Nilgiri Eastern Slope ranges of Mudumalai Tiger Reserve (MTR) deemed to be intensive study area (ISA) for further detailed studies.

To assess the temporal variation in livestock depredations by striped hyaenas, we conducted 197 open-ended semi-structured questionnaire surveys in and around the ISA delineated areas. The surveys were conducted in Tamil with the help of local field assistants to collate information on the incidences of livestock predation by striped hyaena. We also gathered information on the socio-economic attributes of people, details on conflict with other carnivores and people's perception towards hyaena, at household scale. Overall, 69.54% (n=137) of people were uncertain about the predatory behavior of hyaenas whereas 07 percent (n=14) of respondents perceived hyaenas as a threat to their livestock and 23% did not perceive hyaena as a threat. Hyaena was alleged in only eight cases for depredation (six goats, two dogs) while 237 separate incidences of depredations by other large carnivores were reported. Despite low level of livestock depredation by hyaena, 20.81% of the respondants were found to be not in support of hyaena conservation in their vicinity, and had negative conservation attitude towards the species. Such an unjustified intolerance for this small population is really a matter of concern. Incidently, such intolerance has been reported for many less-inflicting carnivores throughout the globe. So far, there was no cogent justification present for such unproportionate intolerances. This is presumably because perception in this domain has been predominantly understood as a function of socio-economic status of people and associated cost-benefit with the species. Human cognition also plays a seminal role in such decision-making which has been merely explored. Furthermore, fear-induced generalization of threats to non-

inimical stimuli is a common behavioral tendency of humans that seeks by minimizing exposure to potential threats. It is evident that people generalize fear of predation and subsequent intolerance to non-obligate carnivores despite the disparity in predation rate by species in human-carnivore conflict zones. We investigated threat-generalization as an effect of a perceived threat of livestock depredation by obligate large predators on the tolerance level and perception towards striped hyaena in a human-carnivore conflict hotspot. We modeled the tolerance level as a function of loss to livestock predation, livestock disease, perceived threat of predation by hyaena, and other socio-economical attributes at the household scale, through random forest algorithm. The study established the interplay between threat generalization and economic instability mainly articulated with livestock predation, occupation, and cattle mortality due to disease and also underscored the role of ambiguous perception (uncertainty) in the ill-generalization. The study documented the prevalence of fear-induced generalization over a non-obligate predator like hyaena. The economic loss due to livestock predation by carnivores was the most important variable in explaining the conservation attitude of people and the same was reflected in measures of variable importance. The partial dependency graph of the random forest model showed decreasing trend in the conservation attitude of people on hyaena with the increase in economical loss to livestock predation by co-occurring large carnivores. The variable importance showed other top variables of the model were livestock dependency, number of people employed, annual income, age, loss to disease, and the threat to hyena.

Through 248 sign survey trails and camera trapping with an effort of 4975 trap nights, population of hyaena was found to be confined to the Moyar valley and Sigur plateau in a large landscape of WEGPTN. While a vast contiguous area to current distribution range (ISA) also shared similar climatic gradient, no signs on hyaenas were seen. Other than the geo-climatic factors, interspecific competition ubiquitously played a key role in shaping the structure of the carnivore community in an ecosystem through top-down control and it affected the distribution of sub-ordinate species like hyaena. The landscape holds a good population of sympatric carnivores, namely tiger, leopard and dhole but their abundance varies with space depending on several relevant factors. Thus, we investigated the distribution pattern of the striped hyaena population with respect to sympatric carnivores (e.g., tiger, leopard, and dhole) across a large landscape in southern India connecting the Western and Eastern Ghats. We extracted the presence/absence data for hyaenas, tigers, leopards, dholes, and their prey collected from both sign survey and camera trapping. We calibrated the model with 72 true presence and 65 absence

data of the species from intensive indirect sign surveys (1054 km), camera trapping (4975 trap nights) and secondary data sources. Post extraction, using a random forest algorithm, we modelled the local distribution of hyaenas as a function of important ecological variables, including climate, prey abundance, and the predicted probabilities of occurrence of other large carnivores. We identified 21% of the study area as high suitable habitat of hyaena. Elevation, Bio3, cattle density, and probability of chital and dhole occurance appeared to be important variables determining the distribution of hyaena in the landscape. In these contiguous forested landscapes, we found that striped hyaenas were confined to relatively small, discrete areas relative to the three other predators which is likely a mechanism for achieving coexistence at smaller spatiotemporal scales, and continued persistence across larger ones. Our most supported model suggested that hyaenas tended to avoid areas where other large predators were more likely to occur. Relatively more arid climatic conditions and complex topography, as well as differences in the relative abundance of potential prey, were the primary drivers of these "opportunity gaps" for hyaenas. Striped hyaenas also occurred at relativly lower abundance than their co-predators, possibly a delicate balance between the trade-offs between the need to optimize carcass acquisition and risks associated with living among other larger carnivores. Furthermore, hyaena chose to co-exist in an area with low to medium relative abundance of co-predators. We also found that "altitudinal heterogeneity" in a plateau region between two mountain ranges, may be providing more denning opportunities and/or "refugia" for hyaenas, further facilitating coexistence. We also believe that the association between striped hyaenas and sub-optimal thorn forests contributed to landscape-scale sympatry, as the occurrence of other large predators is lower in these habitats.

To assess the influence of anthropogenic pressure on the stress level of striped hyaenas, we conducted rigorous field work and collected their fresh scats (less than 24hrs old). Hyaenas are den-dwelling species, and known to defecate scats around their dens. Before sample collection, two hyaena den clusters were identified in potential den sites such as mountain slopes and rifts. Hyaena dens were confirmed based on indirect evidences such as presence/absence of hyaena tracks and scats, bone collection, and camera traps. Hyaena scats of less than 24 hrs old were collected and preserved in -20$^{o}$C and glucocorticoids were extracted from them. We identified the gender of hyaenas from the scats using genetic technique (level of glucocorticoid) between the genders. Totally, 110 hyaena scats were collected; among which only 30 (fresh samples) were processed in Centre for Cellular and Molecular Biology (CCMB), Hyderabad. These 30 fresh faecal samples were collected opportunistically and through regular visits to den sites.

Out of 30 samples, 27 scat samples were procured from the first den site cluster which was the cluster of 18 hyaena dens and situated at mountain slope. While two samples were gathered from another den site cluster located at close proximity to human settlement and one sample was opportunistically collected from an animal trail. We further categorised the collected scats of three age groups, namely juvenile, sub-adult and adults. Scat of sub-adult and adult were distinguished based on the dropping size and colour. Scat of juvenile was black in colour due to less calcium as they were dependent on flesh regurgitated by mother.

We found small differences in fecal glucocorticoid concentration between scats collected from two den clusters. Average glucocorticoid concentration of scats collected from first cluster was found to be 11.79 ng/g and the average concentration from second cluster situated near human settlement was 13.33 ng/g. We did not observe any significant difference in the glucocorticoid level between the age groups and gender. We expected females to go through more physiological stress as they take care of offsprings but we did not find any significant difference between gender as well as age group. This may be because of small sample size. Secondary stress response in an organism can be affected by many extraneous factors such as personality traits, reproductive stage, social stress, intra and inter-specific competition. The fecal samples represent the classic phyla of intestinal parasites: Nematoda, i.e., Strongyloides and Ancylostoma spp. Contrastingly, all the males with diagnosed parasites revealed the presence of only Strongyloides. However, to make any strong inferences it should be kept in mind that most of the scats were collected from single den cluster and needs further investigations on more scat samples across gradients to ascertain the impact of anthropogenic factors on the stress physiology of hyaena.

To study den site selection by the species in the landscape, we identified 18 hyaena dens from two clusters as described above. Data on the den structure, position, topography, and habitat characteristics of the site were collected to understand the den site preference of the species. Patch-specific attributes of dens were collected from three concentric circular plots of 10m, 5m, and 1m radius laid considering den at the center. In a 10m circular plot, we numerated individual trees of major species and collected data on different parameters such as tree height, tree girth at breast height (GBH), average canopy cover from four points, and average grass height from five places in the plot. From the 5m radius plot, we recorded the percentage of shrub and rock and weed cover in 1 m radius plot. To account any anthropogenic disturbances, we recorded different signs of human disturbances such as wood cutting, lopping, human-livestock trails in addition to sighting of people and livestock. All the ascertained dens were

rocky areas such as cave or under an outcropped rock, mound which were situated on the slope of two mountains and no burrow den was recorded. The pattern elucidated the stark preference of hyaena towards hillslope which supports numerous rock structures in the form of eroded rock, boulders, and scree. Furthermore, to understand the site-specific factors affecting den site selection in undulating terrain, we collected analogous site-specific data from other 18 alternative hill slopes located within 10 km radius of den clusters where maximum hyaena movement was recorded through our camera trap survey. We modeled den site selection as a function of vegetation patch characteristics, site-specific anthropogenic threats/activities, topographical variables using Bayesian generalized linear models (quasibinomial family) through field collected binomial data on den use by the species. Using actual dens and random den sites, the Bayesian model explained GBH, slope, grass height, and distance to river as the best predictors in the den site selection by hyaena. The model showed that the probability of den site selection decreased with increase in distance from the river and increased with the degree of slope. GBH and grass height also showed a positive relationship with den site selection. Our model suggested that hyaenas selected rocky refuge surrounded by trees and tall grasses, situated on a mountain slope proximate to a water body. The study consolidated the importance of hilly terrain in the species ecology and postulated the slope as an "energy-expensive" terrain that refrains frequent movement of other carnivores, in turn providing more affordable denning space for the striped hyaena. This study augments the existing information on striped hyaena, its denning ecology and also highlights the need for comprehensive studies exploring movement dynamics of competitors to comprehend denning behaviour of hyaena and other carnivores more cogently. Hyaena are generally seen together as two three individuals, all these active dens are found to be a communal den situated on the steep slope of a single mountain.

Hyaenas are one of the least studied species and little information is available on the distribution and other important aspects of the population studied under this project. This is the only major last remaining population of entire southern India, and also a potential source population to restore the species in its historical distribution range through befitting scientific management. The population is found to be confined to a small region which is highly vulnerable to inbreeding. The restoration of the population in the available habitat around the current distribution range will help establish the meta-population of the species in the region which can reduce the probability of inbreeding depression in the population. We recommend compensation against livestock depredation by large carnivores in the landscape and conduct awareness programs to locals to check unproportionate intolerance towards the species.

Overall, this project provides deep insights about the distribution pattern, people's perceptions and den site selection by the species in the landscape. Our study also elucidated stress physiology and parasitic load in the species across life history stages and between sex. Lack of optimal size and confined population in the landscape refrained us to explain more on stress physiology and parasitic load across anthropogenic gradients. Hyaenas live in close association with human settlement and are highly vulnerable to human induced changes in their habitat and other anthropogenic stresses. We recommend a long-term study investigating the impact of anthropogenic perturbations on stress physiology of the population across multiple landscapes in India. Relationship between pathological condition of the species and anthropogenic factors will provide more precise and prompt understanding on response of the hyaena to a range anthropogenic factor and aid scientific management of the population. There is no study available assessing the inbreeding depression from the population while it is one of the looming threats to the population which can adversely affect the long-term conservation of the population. Study assessing the inbreeding depression in the population should be prioritized. We still lack information on the demography of the population (sex ratio, population density, birth and death rate) which is very critical to devise a more comprehensive conservation plan. The hyaena is still a data deficient species on many critical aspects that needs urgent attention. Therefore, we recommend the state forest department to form a state-level hyaena conservation committee comprising experts from various fields such as conservation physiology, genetics, field ecology, computational ecology and conservation psychology so that a synergetic effort can be made in a direction to conserve this critical population of striped hyaena.