# A STUDY ON SYMPATRIC CARNIVORES (TIGER, LEOPARD AND WILD DOG) IN MUDUMALAI TIGER RESERVE, TAMIL NADU, INDIA

**FINAL REPORT**

**(2011)**

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

# A STUDY ON SYMPATRIC CARNIVORES (TIGER, LEOPARD AND WILD DOG) IN MUDUMALAI TIGER RESERVE, TAMIL NADU, INDIA

Final Report

(2011)


Principal Investigators

**Dr. K. Sankar and Sh. Qamar Qureshi**

Researchers

**T. Ramesh and Riddhika Kalle**



भारतीय वन्यजीव संस्थान

**Wildlife Institute of India**

**Citation:** Sankar, K., Qureshi, Q., Ramesh, T. and Kalle, R. 2011. A study on sympatric carnivores (tiger, leopard and wild dog) in Mudumalai Tiger Reserve, Tamil Nadu, India. Final Report. Wildlife Institute of India, Dehra Dun. Pp. 268.

# Contents

## Executive Summary

A detailed long-term study on prey selection, food habits and population status of sympatric large carnivores (tiger, leopard and dhole) was documented in Mudumalai Tiger Reserve, Tamil Nadu from January 2008 to April 2010.

The objectives of the study were to estimate density, group size and composition for prey species of sympatric carnivores, study the food habits and prey selectivity of sympatric carnivores and to estimate the population of sympatric carnivores.

The study area was divided into 3 x 3 $km^2$ grids for line transect sampling. In each grid, a line transect (1.5 to 3.13 km) was laid (n = 33) along which the prey density was estimated for two successive years (January 2008 to December 2010). Prey species availability was estimated using line transect method in an intensive study area of 180 $km^2$ comprising dry thorn, deciduous and semi-evergreen forests. The total length of line transects was 41.3 km. Each line transect was walked thrice in the dry season (January to April) and wet season (May to December) yielding a total effort of 369.45 km. Vehicle transects were used to estimate group size and composition of prey species in the intensive study area. Five vehicle transect routes ranging from 15 to 23 km were monitored. Total transect length of 93.5 km was monitored twice a month resulting in a total effort of 3740 km.

Prey species population was analysed using program Distance 6 (Thomas et al., 2009) by fitting different detection functions to the observed data. The best model was selected on the basis of the lowest Akaike Information Criteria (AIC) values. Sightings were pooled together for dry and wet seasons for both years as there was no significant difference ($P > 0.05$) in the angular sighting distance observed between seasons. Data was analysed yearly and overall for both the years. Half-normal Cosine-Binomial model was fitted for the species sighted > 5 to 15 times. Pooled species effective strip width (ESW) was used to derive density for species sighted ≤ 5 times presuming that related species have similar visibility w.r.t chital (*Axis axis*) ESW for ungulates species such as wild pig (*Sus scrofa*), barking deer (*Muntiacus muntjak*), mouse deer (*Tragulus meminna*) while common langur (*Seminopethicus entellus*) ESW for bonnet macaque (*Macaca radiata*) and grey jungle fowl (*Gallus sonneratti*)

ESW for peafowl (*Pavo cristatus*), red spur fowl (*Galloperdix spadicea*) and black-naped hare (*Lepus nigricollis*).

In total, 14 prey species were detected on line transects in the study area. The estimated overall prey densities were 110.0/km$^2$ in semi–evergreen forest (wild ungulates – 57.0/km$^2$, arboreal – 46.0/km$^2$, elephant – 7.0/km$^2$) followed by 99.1 individuals/km$^2$ (wild ungulates – 57.97/km$^2$, arboreal – 16.84/km$^2$ and others- 25.27/km$^2$) and 95.6/km$^2$ (wild ungulates – 42.2/km$^2$, arboreal mammals – 42.2/km$^2$, elephant– 5.5/km$^2$ and others 5.7/km$^2$) in dry thorn and deciduous forests respectively. Major prey species of large carnivores was found to be highest (75.9/km$^2$) in deciduous forest followed by dry thorn forest (73.3/km$^2$) and semi-evergreen forest (61.6/km$^2$). Minor prey species density was higher in semi-evergreen (48.4/km$^2$) than dry thorn (25.8/km$^2$) and deciduous (19.3 km$^2$) forests. The estimated mean biomass of ungulate prey species was 6076.9 kg/km$^2$.

The mean group size and male:female:fawn ratio of chital was observed to be 13.1 ± 0.5SE and 61.1:100:14.8 respectively (Combined data n = 13366 individuals). Sambar mean group size and male:female:fawn ratio was 3.6 ± 0.3SE and 43.9:100:18.8 respectively (Combined data n = 1341 individuals). The average mean group size and male:female:calf ratio of gaur was 7.5 ± 0.4SE and 42.1:100:25.8 respectively (Combined data n = 2944 individuals). Wild pig mean group size was 3.3 ± 0.4SE and the overall male:female:piglet ratio was 60.4:100:113.6 (Combined data n = 381 individuals). The overall mean group size of common langur was 5.3 ± 0.1SE (Combined data n = 3583 individuals). Barking deer mean group size was 1.2 ± 0.06SE (Combined data n = 70 individuals). The male:female:fawn ratio was 50.8:100:14.8 for all seasons. The estimated overall mean group size and male:female:calf ratio of elephant was 5.2 ± 0.2SE and 17.7:100:18.4 respectively.

Prey selection and food habits of large carnivores were studied using scat and kill analysis. Scats were collected whenever encountered in the study area along pre-determined roads and trails. Scats were broken, washed and processed. Prey remains in scats were observed microscopically and identified with reference slides in the Research Laboratory of Wildlife institute of India. Kills of large carnivores were located in the field with the aid of signs and cues like a flock of vultures or crows over decomposed carcasses, and alarm calls of prey. On locating kills, detail information on age and sex of prey species and bone marrow condition (solid, semi – solid, liquid) were also recorded.

Scat samples were analysed season wise (dry and wet season) separately, year wise and overall for both the years using respective prey densities as estimated during the study period. Percentage occurrence of different prey species in large carnivore scats was calculated by enumerating the number of scats with remains of that particular prey out of the total number of scats with prey remains depicted in the form of percentage. The relative frequency occurrence of a prey species was calculated as the number of occurrence of that prey species divided by the total number of scats analysed and expressed in percentage. The biomass and relative number of prey consumed was calculated in terms of relative numbers of prey species using regression equation for tiger, leopard (Ackerman et al., 1984) and dhole (Floyd et al., 1978). In order to account for the exact variability of prey items in scats, sensitivity analysis was done using program SCATMAN (Hines 2002) with 1000 bootstraps. To assess similarity of food composition between tiger, leopard and dhole, the Pianka's niche overlap index was used. Percent of each prey species killed by predators was compared with percent occurrence of each prey species found in predator scats.

In total, 875 tiger scats, 413 leopard scats and 1070 dhole scats were collected. Scat analysis revealed the presence of 19 prey species in tiger scats, 20 prey species in leopard scats and 13 in dhole scats with a high predominance of medium to large sized ungulates in tiger, leopard and dhole diet. Of the prey species identified from tiger scats, ungulates constituted 96.9% followed by primates (2.3%), cattle (0.9%), buffalo (0.3%) and others (2.3%). Leopard scats contained 84.1% ungulates, 12.8% primates, 1.9% cattle, 0.2% buffalo and 4.8% others. Dhole scats contained 94.4% ungulates followed by 1.6% primates, 0.3% cattle and 5.6% others. The overall biomass composition of large sized prey (> 50 kg) in tiger, leopard and dhole scats was found to be 70% , 36.2% and 19.3% respectively, medium sized prey (20 to 50 kg) was 28.2%, 54.4% and 72.4% respectively, while small sized prey (< 20 kg) was 1.8%, 19.4% and 8.3% respectively. Chital and sambar together contributed to the bulk of the diet (> 77%) in all three predators. In addition to this, gaur and wild pig were the important prey for tiger in terms of frequency occurrence while common langur for leopard and black-naped hare and mouse deer for dhole. The overall Ivlev's prey selection index showed that sambar and chital were utilized more than their availability by tiger, leopard and dhole. In comparison to leopard and dhole, tiger utilized chital in less proportion. Common langur was utilized less than its availability by leopard, tiger and dhole. The index of prey selection showed that mouse deer and black-naped hare were found to be the most utilized prey among other prey species consumed by tiger, leopard and dhole and this may be due to the underestimation of availability of small sized prey. Wild pig was utilized more than its availability by tiger, in proportion to the availability by leopard and less consumed by dhole. All three predators exhibited significant ($P = < 0.1$) selection or avoidance of prey species in the study area. The dietary overlap was 82% between tiger and leopard, 84% between tiger and dhole and 98% between leopard and dhole using percentage occurrence of prey remains in the diet. Of the total tiger kills (n = 41), 7.3% comprised of small sized prey, 24.4 % medium and 68.3% large sized prey. Kills of leopard (n = 20) comprised of 35% small sized prey, 58.8% medium and 5.9% large sized prey. Dhole kills (n = 35) consisted of 10.3% small sized prey, 74.4% medium and 15.4% large sized prey. Kill data showed gaur, sambar and chital as important prey for tiger and chital for leopard and dhole. Sambar and chital might be underestimated while gaur might be overestimated in predator kills. Even though kills underestimated medium sized prey and overestimated large sized prey, for tiger and leopard both kill and scat data showed almost similar prey selection pattern. Dhole kills showed that chital was the dominant prey which is similar to the finding of scat data since dholes tend to hunt in open areas which is the ideal habitat for chital. Analysis revealed that scat samples depict predator diets more accurately while kill data underestimates the presence of diverse prey species and proportions of smaller prey. However kill and scat data showed almost similar prey selection pattern of the three predators and kill data was biased towards gaur for tiger. Based on the evaluation of bone marrow condition of prey species killed by predators, > 95% were in good health condition.

The analysis of scats and kills confirmed that tiger predated mainly on large body sized prey while dhole and leopard largely consumed medium sized prey. All three predator scats contained 26 prey species where major ungulates and a primate species were commonly shared in their diet. These predators largely depended on principle prey such as sambar, chital, gaur, wild pig and langur forming > 90% of their diet. The dietary overlap between predators was high because of shared inclusion of major ungulates by predators in their diet. Even though a female biased sex ratio is found in prey (cervids) populations, males were more prone to tiger predation and fawns towards dhole.

Scat analysis revealed that chital and sambar were important prey for all three predators though they have a wider prey intake. Other prey species such as gaur and wild pig were important prey for tiger while langur was important for leopard and black naped hare and mouse deer for dhole. Predator scats revealed that they also predated on livestock from villages inside and at the periphery of the Tiger Reserve. Male sambar, chital and gaur were recorded higher in tiger kills while male and female chital were utilized equally by leopard. Dhole largely killed chital sub-adults and fawns of both sexes. The selective male predation in adult cervids may be attributed to their solitary habits and the presence of large antlers that may hamper their navigation through thick bushes. The solitary behaviour of males increases their individual probability of encountering predators and keeping them away from group vigilance which makes them vulnerable to predation. The average mean body weight of prey killed by three predators was 253 kg for tiger, 37 kg for leopard and 44.5 kg for dhole. It is likely that risk of injury during hunting may be the reason underlying the lower preference for large prey by leopard and dhole.

Camera trapping was conducted following a 3 x 3 $km^2$ grid sampling for large carnivores between March 2008 and April 2010 in Mudumalai in an intensive study area of 180 $km^2$ comprising dry thorn, deciduous and semi-evergreen forests. Each grid had atleast a pair of cameras to ensure uniform distribution of camera locations (n = 20) and trapping was conducted between November and May for three consecutive years with a minimum of 70 days to a maximum of 100 days. The camera stations were placed on roads, trails, nullahs or near water holes to maximize tiger, leopard and dhole captures based on observations of indirect signs (pugmark, scat, scrapes and kills) and direct sightings. Each station comprised a pair of passive infrared cameras (DEERCAM DC 300 or STEALTH CAM$^{TM}$) to simultaneously photograph both flanks of large carnivores. Cameras were loaded with 36-print, 200 American Standard Association (ASA) 35-mm film. Cameras were set active for 24 hrs with lowest photographic delay (15 seconds in DEER CAM$^{TM}$ and 60 seconds in STEALTH CAM$^{TM}$). Cameras were mounted on wooden posts at a height of 30–40 cm from the ground and placed at 2–3 m on either side from the centre of the trail or road. In the prey rich forest habitat of Mudumalai, adult female home range of tiger and leopard can be as small as 15 $km^2$, therefore we placed at least two camera trap stations in an area of this size, which translated to a trap spacing of ca 2-3 km. Each camera was checked every two to three days to replace film and batteries.

Data on population estimation of dhole was collected between January 2008 and December 2009. Five vehicle transect routes ranging from 15 to 23 km were monitored to record dhole sightings. The total transect length of 93.5 km was monitored twice in a month in the early morning and late afternoon which resulted in a total effort of 3740 km. On each sighting of dhole along vehicle transects, the following information was recorded; group size, sex and age classes wherever possible and perpendicular distance from the road to the centre of the pack. Sighting data was pooled for two years together and further analysis was done in DISTANCE 6 (Thomas et al., 2009) to estimate dhole density and population in Mudumalai.

Capture histories in 'X matrix' from camera trapping data was analyzed using softwares MARK (White and Burnham 2000), DENSITY (Efford 2004) and SPACECAP (Singh et al., 2010) to estimate tiger and leopard density from capture-recapture data. We assessed the relative abundance index of tiger, leopard and dhole by using a camera trap-based abundance index used previously in studies on tigers and their prey.

For dhole density analysis, the best model was selected on the basis of lowest Akaike Information Criteria (AIC) values. To get better estimates of species, a minimum number of observations are required in order to model the detection function hence sightings from morning and evening were pooled together for two years (2008 and 2009) and analysed for deciduous forest. This analytical part could not be carried out for semi-evergreen and dry thorn forests due to low sampling effort which yielded few sightings of dhole.

A total of 9600 trap nights over a period of three years in the study area yielded independent photographic captures (including right, left and unidentified photos) of 214 tigers and 307 leopards and 164 dhole photographs. Total number of males, females and unidentified individuals of tiger was 9, 25 and 4 respectively based on right flank and 11, 24 and 3 respectively from left flank. Identified male, female and unidentified leopard was 16, 27 and 8 respectively based on right flank and 17, 34 and 2 respectively based on left flank. Based on maximum capture probability of either right or left flank, the identified individuals of tiger and leopard varied from 16 to 22 for tiger and 18 to 27 for leopard from camera trapping in each year and the sampling period varied from 70 to 100 days. The estimated average male: female ratio was 0.41: 1 for tiger and 0.54: 1 for leopard based on both right and left flank. Mh model ranked second as the most appropriate model followed by Mo model for both tiger and leopard in this study. Mh model was best fitted for tiger and leopard in all the years. The population size estimate was computed using Mh jackknife model. Test for population closure was not significant for tiger, indicating that the assumption of demographic closure was not violated during the study period while for leopard, only in 2009 the closure assumption was violated significantly ($P = 0.05$). The capture probabilities for Mh model ranged from 0.06 to 0.09 for tiger and 0.05 to 0.1 for leopard. The estimated population size ranged from 26.7 to 28.9 individuals for tiger and 26.0 to 34.9 individuals for leopard. The present estimate of tiger and leopard density (± SE)/100 $km^2$ using Maximum Likelihood methods was 9.2 ± 2.4 and 15.1 ± 5 respectively. The overall mean maximum distance moved (MMDM) by tiger and leopard was 3.2 km and 1.6 km respectively. The average value of relative abundance index (RAI) capture/100 trap night was 2.3 for tiger, 3.2 for leopard and 1.8 for dhole. Estimated dhole density was 43.7 ± 21 / 100 $km^2$ (excluding pups) with average group size of 5.6 ± 1.0. Totally, 31 dhole sightings were obtained during vehicle transect and number of individuals on each sighting varied from one to 28. Half normal detection function with Hermite adjustment fitted dhole data well for overall analysis.

Methods like ½ MMDM, Full MMDM are based on site specificity and strip width. Maximum Likelihood (ML) method appeared to be more robust as density estimate did not vary over the years and this estimate can be extended to the adjoining areas. Density estimate for tiger and leopard excluded cubs $< 1$yr old during the present study. Dhole density in Mudumalai appeared to be the second highest in India after Bandipur. Camera-trap and vehicle transect studies revealed high densities of large carnivores in Mudumalai.

Key insights gathered from the present study of large predator population status indirectly delineate habitat quality of persistent forest and prey base availability. The landscape of Mudumalai Tiger Reserve is an exceptional case where tiger, leopard and dhole coexist in high density by selecting different sized prey. Our results support that vertebrate predators would be selective in maximizing energy in prey rich habitats and non - selective number maximizers where large prey were scarce. These sympatric carnivores in Mudumalai largely depend on wild ungulates than domestic livestock. This showed that carnivores usually prey upon herbivores of about their own size and weight. Large predators are conservation dependent species requiring large contiguous forests with less interspersion of undisturbed breeding habitats. It can be expected that larger forest continuity proximal to high population of large predators provide a better chance for long-term survival in the Mudumalai landscape.