LONG-TERM MONITORING OF LEOPARDS IN BILIGIRI RANGASWAMY TEMPLE TIGER RESERVE

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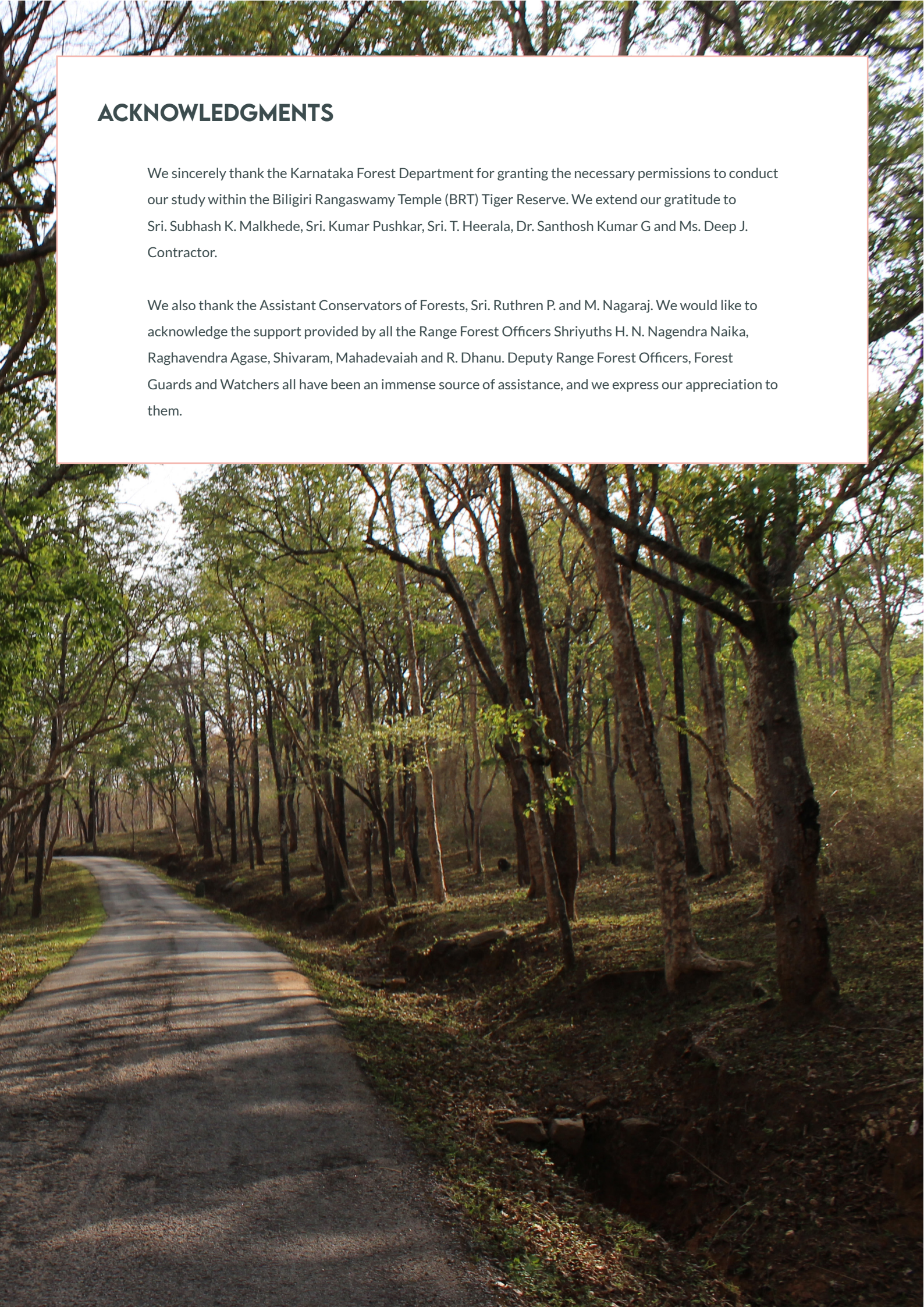

ACKNOWLEDGMENTS

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INTRODUCTION

The leopard (*Panthera pardus*) is a solitary carnivore highly adapted to survive in various landscapes including human-dominated areas. They have a widespread distribution and inhabit an extensive range of habitats. Due to their wide distribution range as well as their catholic diet, they are an increasingly conflict-prone species.

As per the Red List of Threatened Species of the International Union for Conservation of Nature , the leopard is currently listed as a Vulnerable species (IUCN 2024). In India, the leopard is designated as a Schedule I (Part A) species under the Wildlife Protection Act 1972, and is afforded the highest level of protection. Habitat loss and fragmentation, retaliatory killing, vehicular collisions, loss of prey species are some of the main and immediate threats that contribute to a declining leopard population (Gubbi et al. 2014; Jacobson et al. 2016; Gubbi et al. 2020; Gubbi et al. 2021). Despite these losses leopards continue to thrive in certain areas. However, monitoring leopard populations in different habitats and under different management regimes over temporal scale could provide us with valuable information for their conservation.

Long-term studies relating to abundance and density of the leopard is the need of the hour to build a reliable, systematic, and robust population assessment for the species. These studies need to be conducted across Protected Areas (PAs) as well as lesser studied leopard habitats outside PAs. In the southern Indian state of Karnataka, previous studies have established baseline leopard population estimation in PAs as well as human-dense habitats (Gubbi et al. 2017). However, these populations have to be monitored over a longer time period to assess population fluctuations, distribution, and model their population trends. This will help managers to make informed decisions and assess conservation actions, thus allowing improved management over time. Such decisions are especially key for highly conflict-prone species such as the leopard for which there is a paucity of long-term data across the country.

In 2017, Gubbi et al. estimated a mean abundance of ~ 300 (SD ± 15.2) leopards in a ~3,170 km^2 area comprising PAs and multiple use forests in Karnataka. As part of that exercise to assess leopard populations in Karnataka Gubbi et al. (2019) estimated a mean abundance of ~ 58 (SD ± 5.12) leopards in BRT Tiger Reserve. As a continuation of the previous studies, this report provides results of a long-term-population monitoring exercise carried out in the years of 2018, 2019 and 2022 at BRT Tiger Reserve. Our study is among the first in the literature to report long-term large carnivore population trends with absolute estimates from this landscape.

THE MAIN OBJECTIVES OF THIS STUDY ARE

- **To monitor long-term variation in abundance and density of leopards;**
- **To understand the population of leopards in relation to conspecific carnivores such as the tiger;**
- **Observe differences in the detection rate between male and female leopards; and**
- **To monitor the relative abundance of large carnivore prey.**

Studies like these will be useful to compare against baseline estimates that have been previously established (Gubbi et al. 2019). Establishing trends related to leopard population and distribution in regions also co-habited by other carnivorous conspecifics like tigers can help understand inter and intraspecific competition and other factors. Such population trends can also be compared against other habitats that are similar in size or habitat characteristics.

STUDY AREA

Situated in southeastern Karnataka, BRT Tiger Reserve lies at the confluence of the Western and Eastern Ghats and is located in the Chamarajanagara district. Declared as a tiger reserve in 2011, it covers an area of 574.8 km^2. The tiger reserve has an altitude range between 620 to 1950 masl and receives an average annual rainfall of 650 mm in low lying plateaus and 1,990 mm in the higher altitudes. The temperature inside the reserve fluctuates over a range of 18 to 38°C (Lingaraja et al. 2017).

BRT Tiger Reserve, along with Satyamangalam Tiger Reserve (1,411.1 km^2), Malai Mahadeshwara Wildlife Sanctuary (906.1 km^2), Cauvery Wildlife Sanctuary (1,080.9 km^2), other PAs and reserved forests constitute a larger network of 9,561 km^2 of wildlife habitat. It is connected to both Satymangalam Tiger Reserve in the south and Malai Mahadeshwara Wildlife Sanctuary in the east by forest corridors.

LATITUDE

11° 43' 11.3772" N TO 12° 8' 46.3272" N

LONGITUDE

77° 0' 32.6808" E TO 77° 15' 44.4852" E

FLORA

BRT Tiger Reserve exhibits a diverse range of habitats due to variations in altitude and climatic conditions. Within the tiger reserve, there are dry open scrub forests at lower elevations, deciduous forests between 500 and 1000 metres, riparian and moist deciduous forests at mid-elevations, and sholas and evergreen forests at higher elevations (Kumara et al. 2014).

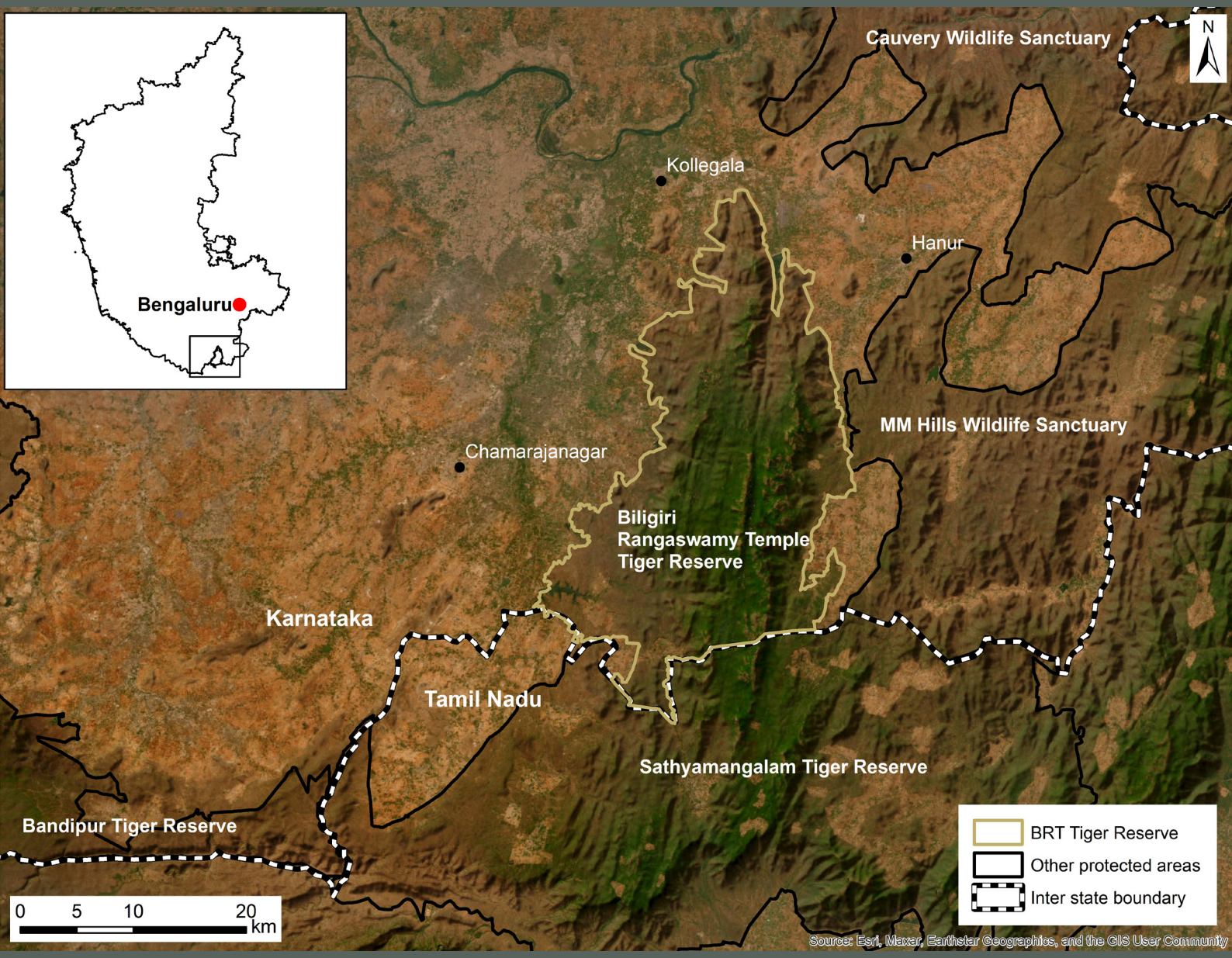
BRT Tiger Reserve boasts a rich plethora of floral species, featuring important species such as *Elaeocarpus tuberculatus*, *Salix tetrasperma*, *Syzygium malabaricum*, *Cocculus laurifolius*, *Viburnum punctatum*, *Pterocarpus marsupium*, *Terminalia alata*, *Terminalia paniculata*, *Canthium dicoccum*, *Catunaregam torulosa*, *Meyna laxiflora*, *Dimocarpus longan*, *Boswellia serrata*, *Chloroxylon swietenia*, and *Commiphora caudata* (Lingaraja et al. 2015). In certain areas of the reserve, plantations including eucalyptus (*Eucalyptus spp.*) and teak (*Tectona grandis*) are predominant. Three large coffee plantations fall within the tiger reserve boundaries and the local forest dwelling community Soligas live in 61 hamlets in the tiger reserve.

FAUNA

BRT Tiger Reserve is a crucial habitat for large carnivores, including tigers (*Panthera tigris*), leopards (*Panthera pardus*),and dholes (*Cuon alpinus*). Additionally, it houses a variety of prey species such as gaur (*Bos gaurus*), sambar (*Rusa unicolor*), chital (*Axis axis*), wild pig (*Sus scrofa*), barking deer (*Muntiacus vaginalis*), four-horned antelope (*Tetracerus quadricornis*), Indian chevrotain (*Moschiola indica*), tufted gray langur (*Semnopithecus priam*) and bonnet macaque (*Macaca radiata*) (Kumara et al. 2012a). These prey species play a significant role in sustaining the populations of large carnivores in this reserve (Lingaraja et al. 2017). BRT Tiger Reserve is also a critical habitat for elephants (*Elephas maximus*) and it is estimated that there are 1.7 elephants/km^2 in BRT Tiger Reserve (Kumara et al. 2012b).

Moreover, the tiger reserve also provides a habitat for a range of other carnivores, including sloth bear (*Melursus ursinus*), golden jackal (*Canis aureus*), Bengal fox (*Vulpes bengalensis*), jungle cat (*Felis chaus*), rusty spotted cat (*Prionailurus rubiginosus*), leopard cat (*Prionailurus bengalensis*), small Indian civet (*Viverricula indica*), common palm civet (*Paradoxurus hermaphrodites*), common mongoose (*Herpestes edwardsii*), ruddy mongoose (*Herpestes smithii*), stripe-necked mongoose (*Herpestes vitticollis*), Indian smooth-coated otter (*Lutrogale perspicillata*), and others (Kumara et al. 2012; Lingaraja et al. 2015). It's worth noting that the presence of brown mongoose (*Herpestes fuscus*) in BRT Tiger Reserve was documented for the first time in 2018 (Suthar et al. 2020).

Figure 1. BRT Tiger Reserve is home to a diverse range of habitats.



Map 1. BRT Tiger Reserve and adjoining protected areas.

METHODOLOGY

CAMERA TRAPPING

The study area was divided into 4 blocks due to logistical constraints such as limited resources like camera traps to cover the entire tiger reserve as a single block. Each block was monitored for 16 days. The locations to deploy the camera traps were identified before initial deployment to ensure high capture probability of leopards. Locations with indirect evidence of leopard presence, such as scats, pugmarks, and scrape marks, were prioritised for placing camera traps.

Panthera V4, V6, and Spartan lumen SR3-CX motion detection cameras were fastened to tree trunks or stumps at optimal heights of ~40 cm from the ground, using high strength python cables. The traps were placed on either side of the identified trails and roads to ensure that both, the right and left, flanks of the leopard were effectively photo-captured.

The camera trap survey was conducted in 2018, 2019 and in 2022 and details are provided in Table 1. Camera trapping effort was determined by multiplying the number of surveyed locations by the number of functional occasions, when the camera trap was operational. The total effort more or less remained uniform through the three study periods.

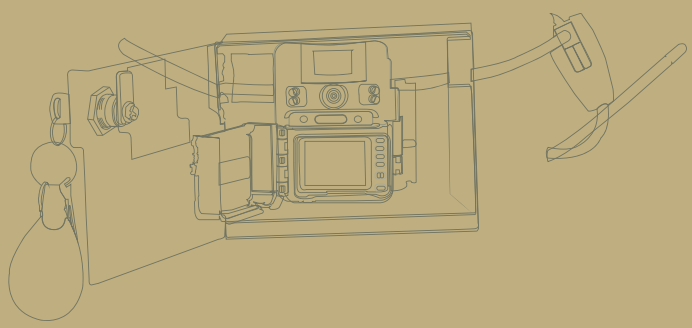
Throughout the study period, the leopard population was assumed closed. Mortality, natality, immigration, or emigration were considered to be nil within the study area for the study period due to the short span of the survey period.

Table 1. *Survey period, number of locations, occasions per block, and camera trap effort for each survey year in BRT Tiger Reserve*

YEAR	SURVEY PERIOD	NUMBER OF CAMERA TRAP LOCATIONS	OCCASIONS PER BLOCK	CAMERA TRAPPING EFFORT
2018	January, February, March 2018	209	16	3,342
2019	September, October, November 2019	210	16	3,355
2022	March, April, May 2022	229	16	3,725

The camera traps operated continuously throughout the day and were periodically checked every 2-3 days to perform maintenance tasks like downloading images, replacing batteries, and ensuring their proper functioning. An automated image classifier, developed on the Python platform (version 3.6), was employed to categorise the downloaded images into folders based on species (Rampi et al., unpublished). These categorised images underwent manual validation, and the identified species were integrated into the image metadata using Digikam software (Version 5.8.0, Gilles et al., 2018).

Each captured image was marked with a unique combination of camera trap location and camera ID, allowing for the extraction of date, time, and location coordinates for reference. Subsequently, images containing leopards were extracted from the curated dataset, and individual leopards were identified by matching the rosette patterns on their flanks, utilising the Wild ID software (Bolger et al., 2011). Images that were blurry or unclear were excluded from the process of individual identification. The flanks containing the maximum number of unique individuals were selected for further analysis.



DENSITY AND ABUNDANCE ESTIMATION

Estimation of the population size was conducted by utilising Spatially Explicit Capture-Recapture (SECR) modelling approach. By using the locations of camera traps in the study area, in which each individual leopard was photo-captured, the movement pattern of the animal is determined. Using such spatial information, capture histories of individuals can be built in the SECR framework. Multiple capture histories for each individual animal (minimum of 2 photo captures) and the GPS coordinates of those camera trap locations is built using the maximum likelihood or Bayesian modelling (Efford 2004, Borchers & Efford 2008, Royle & Young 2008).

SECR Input files, including the detector layout, capture history matrix, and mask layer, were prepared following the guidelines outlined in SECR operational manuals. The detector layout file accounted for whether camera traps were operational during various sampling occasions. The mask layer conveyed spatial information regarding suitable habitats within a 2 km buffer area that connected the outermost camera trap locations (Efford, 2018). The capture history matrix consisted of individual rows for each identified leopard at a specific location and sampling occasion.

This spatial information was utilised by the program to estimate capture probabilities and fit models by maximising likelihood (Borchers and Efford 2008). In solitary felids like leopards, males are known to range more than females (Fattebert et al. 2015) which would influence their detection probability (g0) and ranging parameter (σ). Thus we used sex as a covariate for both parameters. Since sex of some of the individuals could not be identified in 2018 and 2022 we used hybrid mixture (h2) models which also allow for estimation of the sex-ratio of the populations. A standard half-normal function was used for modelling the detection functions (Green et al. 2020). For estimating the leopard density and abundance in the study region we used maximum likelihood modelling in the R-package SECR (Efford 2023, v 4.6.4).

DETECTION RATES

The number of detections per individual leopard was recorded for each survey year. A detection was registered if an individual was photo-captured at a particular location on a unique occasion. i.e. 24 hours apart. Detection rates were computed separately for males and females for each survey year as given below

$$\text{Detection rate} = \frac{\textit{Total number of male/female detections}}{\textit{Number of male/females identified}}$$

The presence of individual leopards within the tiger reserve was assessed by compiling the location and dates for each individual photo-captured in a single survey year. The recorded individuals from each year were then compared to the database of the pre-existing surveys to assess individual leopard's persistence within the reserve.

RELATIVE ABUNDANCE INDEX (RAI)

Camera trapping also yields data on unmarked animals which can be used to understand species distribution, or indices to assess trends. However such indices do not provide information on absolute abundance as it does not account for detectability. Hence Relative Abundance Index (RAI) was used to compare temporal trends of some important large carnivore prey species.

RAI was computed based on the photographic capture rates. This rate represents the number of independent photo captures of a particular species per 100 trap days. It's important to note that photographic capture rates have a correlation with density estimates for large terrestrial mammals, making RAI a valid indicator for the density of unmarked species (Rovero and Marshall, 2009; Palmer et al. in 2018).

Images of important prey species were organised into separate folders. Timestamp information from metadata of each image was used to match and subsequently calculate the total number of individual events for each species. To identify independent events for each species, a predefined threshold time interval (or event duration) was applied, which was determined based on the time different species (individually or in groups) typically took to traverse the camera trap location (see Appendix-2). In cases where multiple individuals of the same species appeared in a single photo, it was counted as one event. Once the count of independent events for each species was recorded, it was divided by the total number of camera trapping days and then multiplied by 100 to yield the RAI for each species per 100 trap days. An Excel Visual Basic for Applications (VBA) script was employed for this purpose. For livestock, such as cows, buffaloes, donkeys, and domestic pigs, they were categorised as large livestock, while sheep and goats were grouped as small livestock.

RESULTS

Between 2018 and 2022, the camera traps captured a total of 818 images of leopards, leading to the identification of 95 individual adult leopards. The breakdown of the number of individually identified leopards for each survey year is provided in Table 2. Of these identified individuals, 48 were females, 38 were males, and the sex of 09 individuals could not be identified. Additionally, 01 cub and 07 subadults were also identified but were excluded from the analysis. This was primarily due to the lower capture probabilities of cubs. As for subadults, they tend to be transient as they haven't established fixed home ranges and also have higher mortality (Karanth 1995; Grey et al. 2013).

Accounting for individual variations in detection probabilities, the identified leopards were categorised into two groups with distinct detection probabilities. They were categorised into respective sexes (with 9.47% individuals of unknown sex) and this was used as a covariate for modelling detection probability and ranging parameter.

The SECR analysis yielded mean leopard abundance and density estimates for the different years are as given in Table 2 (Also see Figures 2 and 3). The σ values and ranges for all estimated figures can be found in Table 3. To visually depict the trends in population abundance and density estimates in BRT Tiger Reserve, refer to Figure 2 and Figure 3.

Table 2. *Results of leopard individuals identified from camera trapping in BRT Tiger Reserve*

YEAR	NUMBER OF IMAGES	NUMBER OF INDIVIDUALS CAMERA TRAPPED	NUMBER OF FEMALES, MALES, AND UNIDENTIFIED INDIVIDUALS	NUMBER OF CUBS AND SUBADULTS
2018	288	44	17, 20, 7	1, 5
2019	208	30	15, 15, 0	0, 2
2022	322	49	25, 22, 2	0, 0

Table 3. *SECR analysis results for leopards in all three survey years (2018, 2019, 2022) in BRT Tiger Reserve*

YEAR	*N*(SE)	*N* RANGE	D(SE)	D RANGE	σ (SE) IN METRES [FEMALES]	σ (SE) IN METRES [MALES]	σ RANGE [FEMALES]	σ RANGE [MALES]
2018	56.61 (8.92)	41.65-76.96	6.8 (1.07)	5.00-9.25	3331.47 (343.21)	7952.0 (1002.0)	2723.79-4074.71	6217.56-10170.27
2019	38.85 (7.44)	26.78-56.36	4.67 (0.89)	3.22-6.77	2650.9 (342.28)	7169.3 (1027.55)	2060.22-3410.9	5421.21-9481.04
2022	80.45 (12.7)	59.16-109.4	9.67 (1.53)	7.11-13.15	1138.27 (123.62)	2061.9 (141.9)	920.6-1407.4	1802.05-2359.2

N - Estimate of total number of individuals in the study area, D – No of leopards/100 km^2, σ – Spatial scale of detection function in meters.

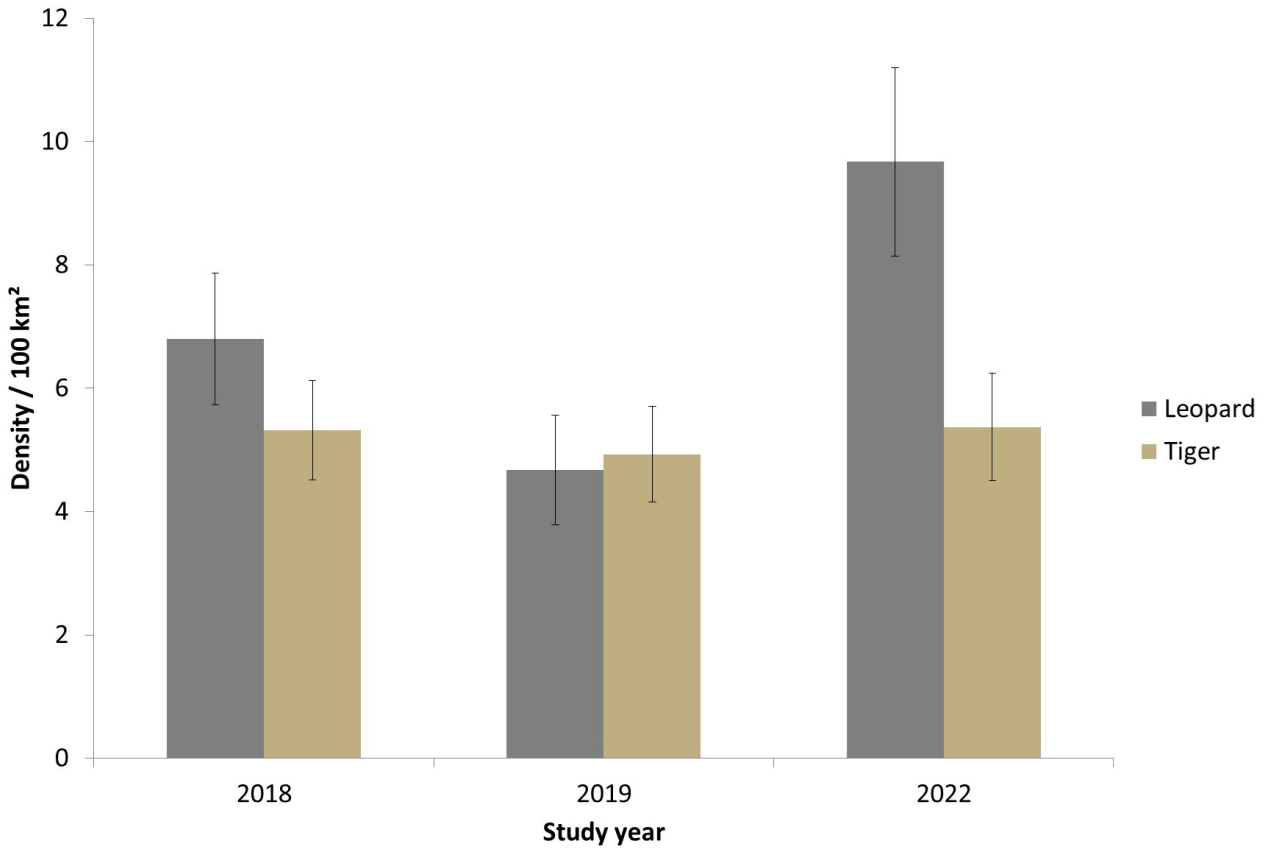


Figure 2. *Trends of leopard and tiger density estimates in BRT Tiger Reserve.*

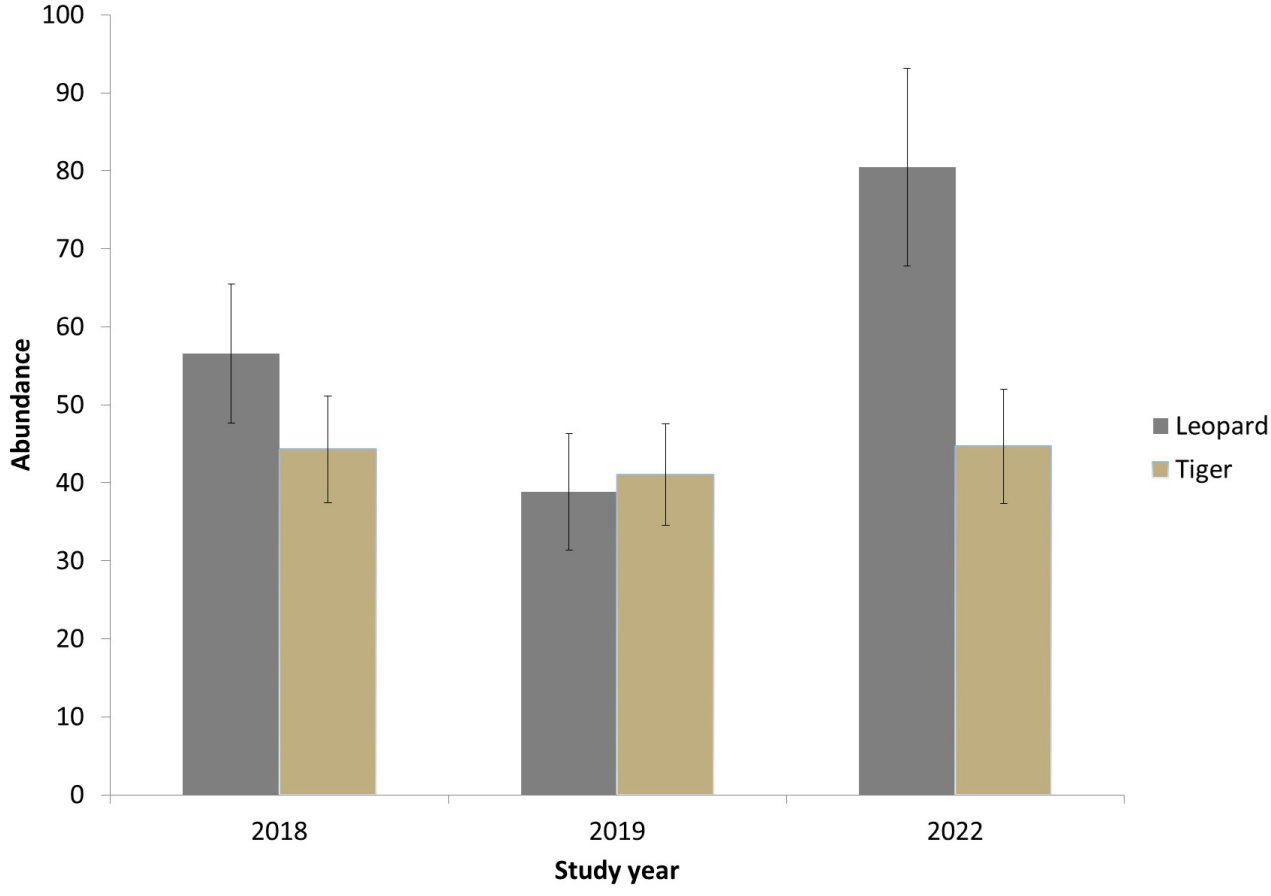


Figure 3. *Trends of leopard and tiger abundance estimates in BRT Tiger Reserve.*

DETECTION RATES

The number of detections and their corresponding detection rates are presented in Table 4. Additionally, the mean detection rate for males and females are provided in table 4, and illustrated in Figure 4.

Table 4. *The number of detections and detection rates for males and females leopard in BRT Tiger Reserve*

YEAR	DETECTIONS# (MALES)	DETECTION RATE* (MALES)	DETECTIONS# (FEMALES)	DETECTION RATE* (FEMALES)
2018	62	3.65	55	2.75
2019	60	4	35	2.33
2022	83	3.77	50	2

 # Number of times an individual was captured in camera traps

***** $\frac{\textit{Total number of male/female detections}}{\textit{Number of male/females identified}}$

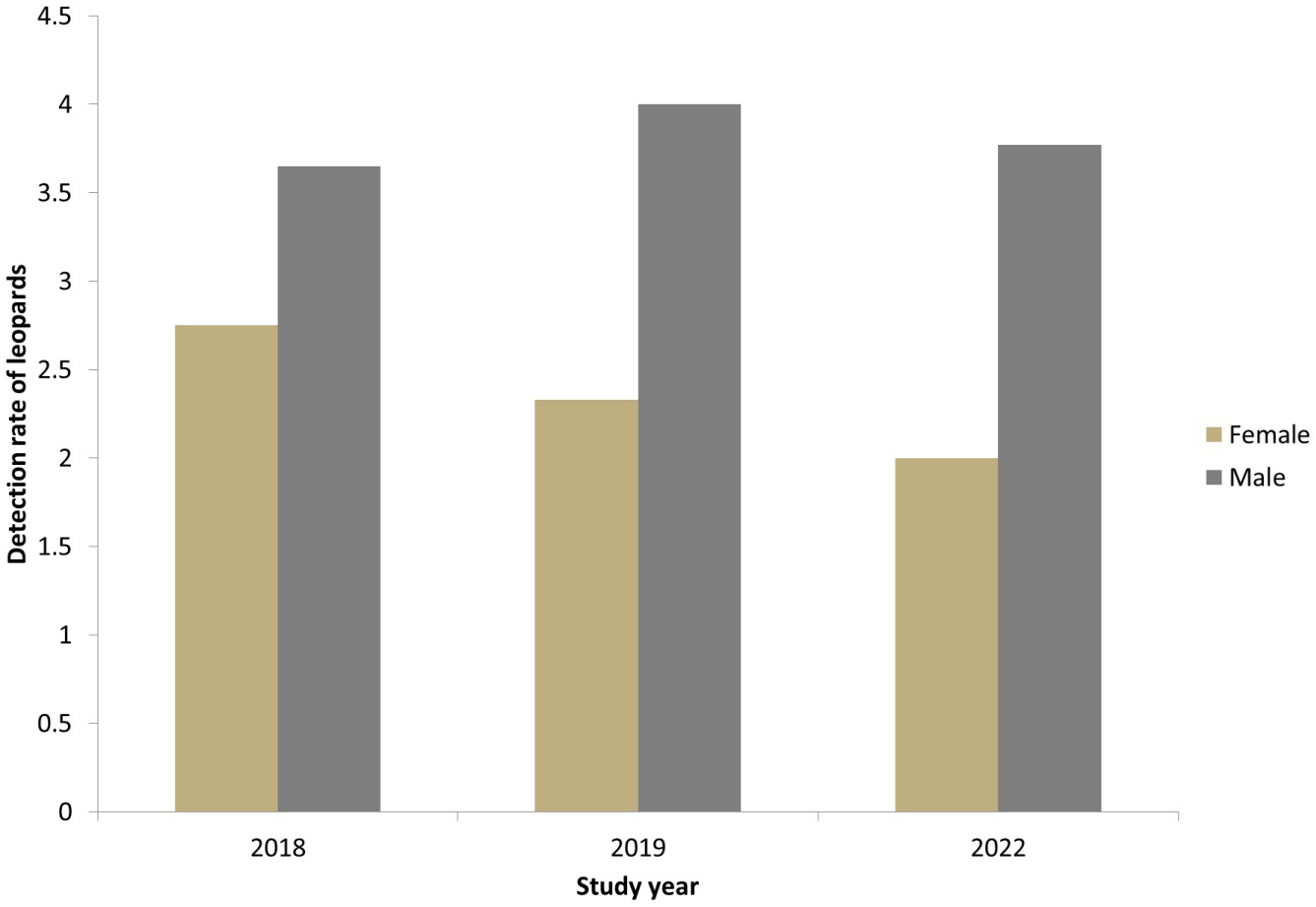


Figure 4. *Detection rates of male and female leopards from camera trapping exercise in BRT Tiger Reserve.*

RELATIVE ABUNDANCE INDEX (RAI) OF LEOPARD PREY

The results of RAI of leopards' natural and domestic prey are provided in Table 7. Domestic prey encompassed all livestock and domestic dogs, while wild prey species were classified into two groups based on their weight, namely large (>20kg) and small (<20kg). Appendix-2 lists the species included in each category. Figure 7 illustrates the variations in RAI for each of these prey categories.

OTHER FAUNA

During the study period, camera traps captured a total of 28 different wild mammal species at BRT Tiger Reserve (Table 05 and 07). Mammal species that are not primary leopard prey species are tabulated in Table 8. As a conspecific predator, tigers could have an impact on leopard abundance, images of tiger individuals were also identified for the period of the study. From 2,342 images, 80 adults, 10 sub-adults and 05 cubs were identified over the duration of the study (2018 - 2022).

Table 5. *Results of tiger individuals identified from camera trapping in BRT Tiger Reserve*

YEAR	NUMBER OF IMAGES	NUMBER OF INDIVIDUALS CAMERA TRAPPED	NUMBER OF FEMALES, MALES, AND UNIDENTIFIED INDIVIDUALS	NUMBER OF CUBS AND SUBADULTS
2018	722	43	24, 18, 1	5, 2
2019	604	40	20, 15, 5	0, 5
2022	1016	38	24, 13, 1	0, 3

Table 6. *Tiger density and abundance estimates derived from SECR analysis results during three survey years (2018, 2019, 2022) in BRT Tiger Reserve.*

YEAR	*N*(SE)	*N* RANGE	D(SE)	D RANGE
2018	44.28 (6.80)	32.84 - 59.73	5.32 (0.81)	3.95 - 7.15
2019	41.04 (6.53)	30.10 - 55.96	4.93 (0.78)	3.63 - 6.72
2022	44.65 (7.30)	32.48 - 61.38	5.37 (0.87)	3.91 - 7.37

N - ESTIMATE OF TOTAL NUMBER OF INDIVIDUALS IN THE STUDY AREA, D – NO OF TIGERS/100 KM^2

INTERESTING OBSERVATIONS

RANGE EXTENSION OF BROWN MONGOOSE

In 2018, camera traps also captured a brown mongoose in BRT. This photocapture marks the first such documentation of the species in this PA but also the first known occurrence of this species beyond its known distribution range within Karnataka. In Karnataka, the earlier documented records of brown mongoose were from Virajpete taluk in Kodagu district (Jathanna 2014).

PRESENCE OF MELANISTIC LEOPARD

In May 2022, we recorded the presence of a melanistic leopard at three different camera trap locations in the Byluru Range. This male melanistic leopard was earlier photo-captured in August 2020 in the Byluru Range as well as in December 2020 in the PG Palya range of MM Hills Wildlife Sanctuary by the Karnataka Forest Department.

DOCUMENTATION OF RHESUS MACAQUE

Another interesting photocapture was that of a rhesus macaque in 2019, a species not naturally found in this landscape. During our camera-trapping exercise in 2019, a rhesus macaque (Macaca mulatta) was photo captured in Kollegala Range of BRT Tiger Reserve on 16th November 2019 at location 12° 4' 35.31"N, 77° 13' 39.85" E. It has probably never been reported from BRT Tiger Reserve as this is beyond the known distribution range of rhesus macaque.

Figure 5. *A melanistic male leopard photo-captured in the Byluru range of BRT in May 2022.*

DISCUSSION

Though published leopard estimates are available for tiger range areas (Jhala et al. 2020), there is little information available at the reserve level. In addition, population data on a temporal scale would be highly beneficial. Perhaps this is the first such exercise for BRT Tiger Reserve that provides tiger reserve level estimates on a temporal scale. BRT Tiger Reserve reports one of the highest or comparable abundance of leopards in comparison to other PAs (Kalle et al. 2011; Borah et al. 2014; Noor et al. 2020; Gubbi et al. 2019; Gubbi et al. 2021a, Gubbi et al. 2021b). We document high variation in leopard abundance in BRT Tiger Reserve varying from ~39 leopards in 2019 to 80 individuals in 2022. There are three possible causes for this.

We found a greater variation in the overall (combined for both sexes) σ values in the 3 sampling seasons. In 2018 and 2019 the sigma values were 4,823.94 and 4,459.614 metres whereas in 2022, the σ values are nearly 3 times lower at 1,731.593 metres. The sigma parameter of the detection function indicates the movement range of the captured individuals which then influences the density and abundance estimations. Lower values of sigma indicate that recaptures of the individuals happened in camera traps in close proximity to one another (e.g, on the same trail), which was observed in 2022. This raises further questions on why the recaptures were limited to closely placed camera traps. Since the number of camera trap locations and efforts did not change significantly between the sampling seasons, it probably points to a different movement pattern of the leopards in 2022 compared to previous years. The year 2022 also saw higher pre-monsoon showers that coincided with our study period (March, April, May) which could be one possible reason why we observe this reduced movement of leopards in 2022 leading to an augmentation of the estimated abundance.

Taking into account the sympatric nature of leopard-tiger dynamics, it is noticeable that the dynamics of leopard-tiger abundance and density were in-tune with earlier studies (Lovari et al 2015; Li et al. 2018; Rather et al. 2021) except for 2022 where a spike in leopard abundance is documented.

In the last couple of years several leopards have been released into BRT Tiger Reserve that were captured elsewhere due to human-leopard conflict. Though translocated leopards are known to have homing instincts and could have attempted to move out of BRT Tiger Reserve there are possibilities of some that have established themselves in the release location contributing to higher leopard populations within the release site.

Since BRT Tiger Reserve has good prey resources hence the two large carnivores-leopards and tigers are perhaps able to coexist by making spatio-temporal adjustments.

Provided the severe lack of reserve level long-term data and in the background of increasing human-leopard conflict in the landscape our study provides valuable insights into leopard abundance and its variation in BRT Tiger Reserve.

BROWN MONGOOSE

The documentation of brown mongoose (Suthar et al. 2020) was an important finding for BRT Tiger Reserve. Such by-product information provides important natural history documentation on other species.

PRESENCE OF RHESUS MACAQUE

The natural distribution range of rhesus macaques is restricted to northern parts of Karnataka hence record of rhesus macaque presence in BRT Tiger Reserve is of high significance. This individual may have been released by someone who had kept it as a pet. Such artificial introduction can have consequences on local primate species as rhesus macaques are known to outcompete bonnet macaques in their natural ranges due to their aggressive behaviour and species-typical temperament (Clarke & Boinski 1995; Kumar et al. 2011). Such individuals should be immediately captured and removed from the tiger reserve.

RECOMMENDATIONS

In the background of our study results we recommend the following:

- Populations of leopards have to be monitored on a long-term basis in BRT Tiger Reserve as there is baseline data established for both tigers and leopards. Such information could provide valuable insights into the interactions between these two large carnivores.
- Release of leopards translocated from other areas into BRT Tiger Reserve should be discouraged as it could lead to artificial increase in leopard populations and also cause increased conflict in the release location.
- Immediate capture of any alien mammalian species such as the rhesus macaque found in BRT Tiger Reserve.

Table 7. *Results of the Relative Abundance Index (RAI) per 100 trap days calculated for leopards' natural and domestic prey in BRT Tiger Reserve for each survey year.*

SPECIES	SCHEDULE STATUS UNDER THE WILDLIFE PROTECTION ACT 1972	GLOBAL STATUS UNDER THE IUCN RED LIST	2018 (SE)	2019 (SE)	2022 (SE)
Wild prey					
Barking deer *Muntiacus vaginalis*	I	Least Concern	9.19 (0.005)	7.54 (0.006)	3.97 (0.003)
Black-naped hare *Lepus nigricollis*	II	Least Concern	64.66 (0.033)	14.31 (0.010)	25.72 (0.017)
Bonnet macaque *Macaca radiata*	I	Least Concern	2.51 (0.002)	1.25 (0.001)	1.23 (0.001)
Chital *Axis axis*	II	Least Concern	31.09 (0.026)	17.68 (0.015)	8.11 (0.012)
Four-horned antelope *Tetracerus quadricornis*	I	Vulnerable	1.32 (0.002)	0.51 (0.001)	0.54 (0.001)
Gaur *Bos gaurus*	I	Vulnerable	7.72 (0.005)	8.97 (0.005)	14.36 (0.007)
Indian chevrotain *Moschiola indica*	I	Least Concern	4.49 (0.004)	2.95 (0.003)	1.61 (0.001)
Porcupine *Hystrix indica*	I	Least Concern	28.49 (0.013)	22.44 (0.012)	22.09 (0.009)
Sambar *Rusa unicolor*	I	Vulnerable	53.68 (0.025)	16.72 (0.007)	31.19 (0.015)
Tufted grey langur *Semnopithecus priam*	I	Near Threatened	10.86 (0.010)	2.21 (0.002)	11.73 (0.009)

SPECIES	SCHEDULE STATUS UNDER THE WILDLIFE PROTECTION ACT 1972	GLOBAL STATUS UNDER THE IUCN RED LIST	2018 (SE)	2019 (SE)	2022 (SE)
Wild pig *Sus scrofa*	II	Least Concern	11.82 (0.007)	12.61 (0.022)	9.15 (0.005)
Wild prey combined	NA	NA	212.45 (0.061)	103.73 (0.032)	116.75 (0.031)
Domestic prey					
Domestic dog	NA	NA	9.96 (0.010)	12.19 (0.012)	13.74 (0.013)
Large livestock	NA	NA	6.73 (0.012)	27.72 (0.028)	8.81 (0.007)
Small livestock	NA	NA	7.75 (0.010)	10.25 (0.014)	6.39 (0.007)
Livestock combined	NA	NA	12.03 (0.017)	33.47 (0.033)	13.53 (0.011)

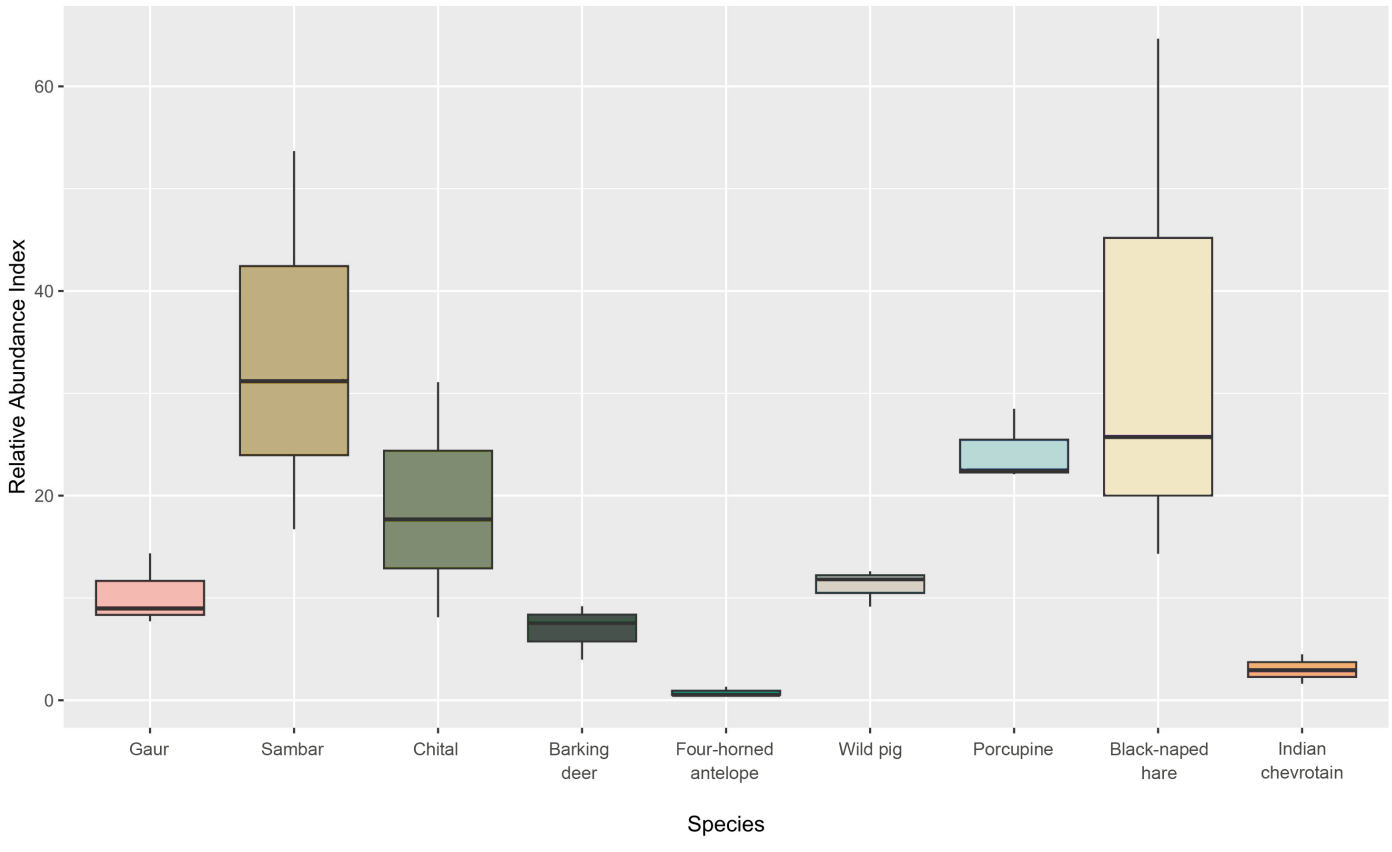


Figure 6. *Relative Abundance Indices of the mammals during the three survey periods (2018, 2019 and 2022) in BRT Tiger Reserve.*

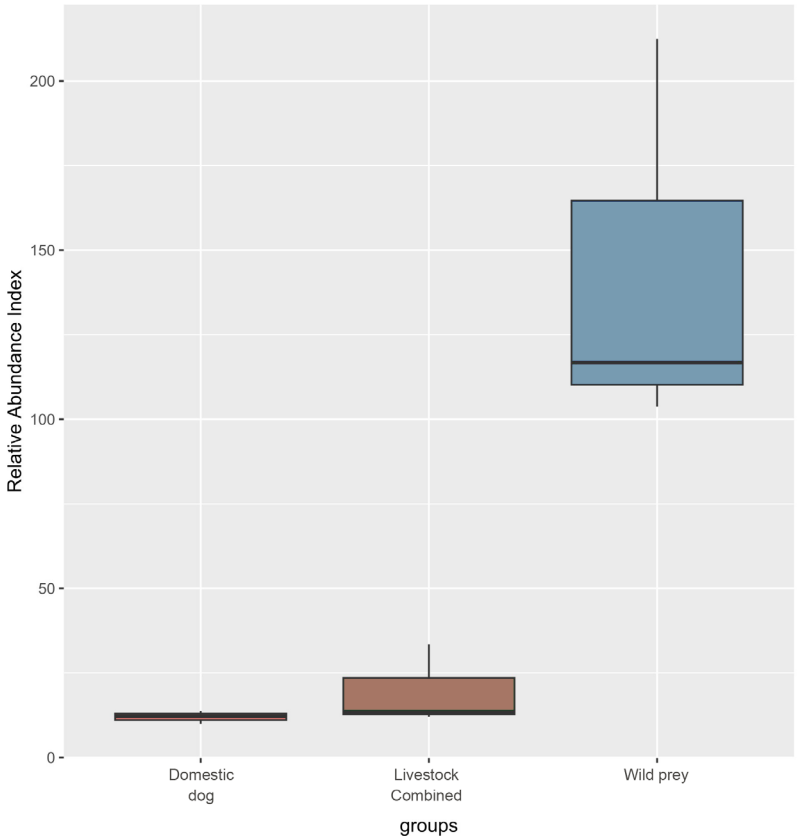
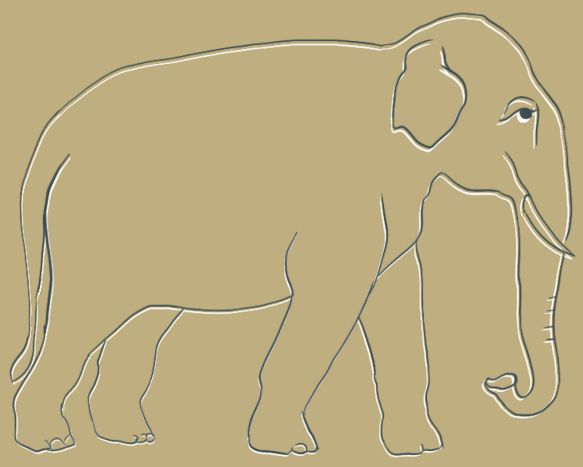


Figure 7. *Relative Abundance Indices for domestic dogs, livestock (small and large livestock combined) and combined wild prey.*

Table 8. *Other mammal species photo-captured in camera traps in BRT Tiger Reserve during 2018-2022*

SPECIES	SCHEDULE STATUS UNDER THE WILDLIFE PROTECTION ACT 1972	GLOBAL STATUS UNDER THE IUCN RED LIST
Tiger (*Panthera tigris*)	I	Endangered
Dhole (*Cuon alpinus*)	I	Endangered
Sloth bear (*Melursus ursinus*)	I	Vulnerable
Common palm civet (*Paradoxurus hermaphroditus*)	I	Least Concern
Small Indian civet (*Viverricula indica*)	I	Least Concern
Brown palm civet (*Paradoxurus jerdoni*)	I	Least Concern
Jungle cat (*Felis chaus*)	I	Least Concern
Leopard cat (*Prionailurus bengalensis*)	I	Least Concern
Rusty-spotted cat (*Prionailurus rubiginosus*)	I	Near Threatened
Brown mongoose (*Herpestes fuscus*)	I	Least Concern
Stripe-necked mongoose (*Herpestes vitticollis*)	I	Least Concern
Grey mongoose (*Herpestes edwardsii*)	I	Least Concern
Ruddy mongoose (*Herpestes smithii*)	I	Least Concern
Elephant (*Elephas maximus*)	I	Endangered



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APPENDIX – 1

Photographs of mammal species captured in BRT Tiger Reserve during camera trapping in 2018, 2019 and 2022.

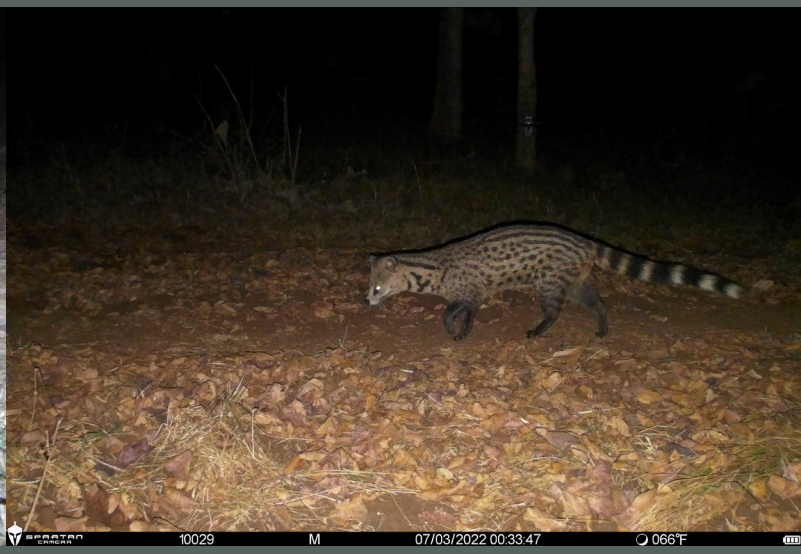
Tiger
Panthera tigris

Leopard
Panthera pardus fusca

Dhole
Cuon alpinus

Sloth bear
Melursus ursinus

Common palm civet
Paradoxurus hermaphroditus



Small Indian civet
Viverricula indica

Brown palm civet
Paradoxurus jerdoni

Jungle cat
Felis chaus

Leopard cat
Prionailurus bengalensis

Rusty spotted cat
Prionailurus rubiginosus

Brown mongoose
Herpestes fuscus

Stripe-necked mongoose
Herpestes vitticollis

Grey mongoose
Herpestes edwardsii

Ruddy mongoose
Herpestes smithii

Elephant
Elephas maximus

Gaur
Bos gaurus

Sambar
Rusa unicolor

Chital
Axis axis

Barking deer
Muntiacus vaginalis

Four-horned antelope
Tetracerus quadricornis

Wild pig
Sus scrofa

Porcupine
Hystrix indica

Black-naped hare
Lepus nigricollis

Indian chevrotain
Moschiola indica

Tufted grey langur
Semnopithecus priam

Rhesus macaque
Macaca mulatta

Bonnet macaque
Macaca radiata

Malabar giant squirrel
Ratufa indica

APPENDIX - 2

Event duration used for calculating Relative Abundance Index (RAI) of leopards' natural and domestic prey.

SPECIES	EVENT DURATION (SECONDS)
SMALL WILD PREY	
Black-naped hare (*Lepus nigricollis*)	60
Bonnet macaque (*Macaca radiata*)	360
Indian chevrotain (*Moschiola indica*)	60
Malabar giant squirrel (*Ratufa indica*)	60
Porcupine (*Hystrix indica*)	60
Rhesus macaque (*Macaca mulatta*)	360
Tufted grey langur (*Semnopithecus priam*)	180
LARGE WILD PREY	
Barking deer (*Muntiacus vaginalis*)	60
Chital (*Axis axis*)	120
Four-horned antelope (*Tetracerus quadricornis*)	60
Gaur (*Bos gaurus*)	180
Sambar (*Rusa unicolor*)	60
Wild pig (*Sus scrofa*)	60
DOMESTIC PREY	
Domestic dog	60
Livestock	300

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