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Density and Distribution of Principal Prey Species of Tigers and Leopards in Pench Tiger Reserve, Madhya Pradesh

Anindita Bidisha Chatterjee[1]*, Kalyansundaram Sankar[1,2] and Qamar Qureshi[1]

[1]Department of Population Management, Capture and Rehabilitation, Wildlife Institute of India, Dehradun – 248001, Uttarakhand, India; aninditabidisha1@gmail.com

[2]Ex-director, Salim Ali Centre for Ornithology and Natural History, Coimbatore – 641108, Tamil Nadu, India

Abstract

Conservation of large carnivores is dependent on a viable population of their principal prey species. Line transect based density estimation has been established as a robust method for monitoring prey population trend. Chital (*Axis axis*) and sambar (*Rusa unicolor*) are the major ungulates in Pench tiger reserve, Madhya Pradesh that are principal tiger and leopard prey. Estimated densities using line transect surveys were highest for chital in the study area with a range of 44–52 individuals per sq. km. from 2013–16. Sambar density remained stable ranging from 5–8 individuals per sq. km. over the three years (2013–16). Camera trap-based encounter rate was used to calculate the Relative Abundance Index of the principal prey species of tigers and leopards in the study area. Spatial distribution pattern using the Relative Abundance Index showed that 47.16% chital captures were congregated near the submergence area whereas 38.53% sambar captures were near rugged areas. Abundant resources and lack of competition from domestic livestock in the core zone contribute to such high estimates of prey population in the study area.

Keywords: Camera Trap Based Encounter Rate, Chital, Line-transect Based Density, Relative Abundance Index, Sambar

1. Introduction

The importance of large herbivores comprising of primates and ungulates with a body weight of more than or equal to 5 kilograms has been well documented in ecological studies. They can influence forest structure, composition, productivity of the ecosystem, soil composition and succession in a tropical ecosystem to a significant extent[1,2]. More importantly they form majority of the prey base of large carnivore diet worldwide[3–6]. Hence, in the face of the global challenge of declining large carnivore populations, understanding population dynamics of major prey species is pivotal. Robust scientific estimates of population, abundance and distribution are fundamental for such monitoring exercises.

Line transect based density estimation has been extensively used in such monitoring exercises because of its robustness[4,5,7]. This method overcomes the shortcomings of previously used techniques by incorporating detection probability in the sampled area along with modelling the width of the line depending on the detectability[8]. Line transects are placed in the study area random to the distribution of target species. The probability of detecting an individual declines with increasing distance from the line due to factors like habitat features, terrain and inherent animal heterogeneity. Using this information and modelling detection probability, the proportion of animals detected on the line are calculated which is in turn used to calculate the abundance and density of the target species in the entire study area[9,10].

In addition to abundance and density of major ungulate species, estimating their distribution pattern bears equal significance. Investigating spatial distribution of animals is fundamental in understanding their ecology as well as an integral part of their monitoring[11]. Detailed understanding of distribution pattern can explain species-habitat relationships. Additionally, predator movements are also likely to be governed by their preferred prey which makes monitoring distribution pattern even more useful for management practices[12]. Counts from camera-trap surveys have been widely used to study various matrices of population recently[7,11,12]. Photographic rate through camera traps have been used to estimate different

*Author for correspondence

indices of both individually identifiable and non-identifiable species[13,14].

Camera trap-based surveys are routinely conducted in Pench Tiger Reserve, Madhya Pradesh to estimate population parameters like density, distribution, survival probability of tigers since 2008[15,16]. As a result, enough amount of information is generated on the principal prey species of both tigers and leopards in the study area. Previous studies have established chital (*Axis axis*) and sambar (*Rusa unicolor*) as major ungulate prey in Pench Tiger Reserve for endangered carnivores like tiger (*Panthera tigris tigris*), leopard (*Panthera pardus fusca*) and dhole (*Cuon alpinus*) in the study area[5,17]. Chital is an endemic ungulate species of South Asia mainly occurring in India, Nepal, Bangladesh and Sri Lanka[18]. They are habitat generalist, residing in a variety of habitats starting from moist, dry deciduous forest to scrublands[15,16]. Sambar is a large deer native to South-east Asia namely India, Sri Lanka, Pakistan, Nepal, Myanmar, Thailand, Cambodia and the Malay Peninsula[18]. Their habitat generalist nature arises from broad spectrum of its diet and ability to both graze and browse depending on available resource[18,19]. Although, a number of studies[20–22] have demonstrated the importance of maintaining a healthy herbivore population to sustain viable large carnivore populations, there is a paucity of information on long-term population trends of the target species. Such long-term studies not only help understand the prey population dynamics over the years but also help formulate effective management strategies for conservation of both large carnivores and their prey. So, in this study we focus on the density and distribution pattern of chital and sambar over three years (2013–16) of study period.

2. Materials and Methods

2.1 Study Area

The core zone of Pench Tiger Reserve (hereafter PTR) in the state of Madhya Pradesh (MP) (78° 55' E to 79° 35' E and 21° 40' N to 21° 57' N) is comprised of Indira Priyadarshini Pench National Park and Pench Mowgli Sanctuary. It is part of one of the major 11 tiger conservation units (TCU) of India[23]. The buffer zone is comprised of six ranges. Biogeographically PTR falls within the Deccan Peninsula Central highlands. Major forest types vary from slightly moist teak forest to dry teak forest and Southern dry mixed deciduous forest. Other dominant vegetation types include southern moist mixed deciduous forest and *Boswellia* forest. The *Totladoh* reservoir has created a very unique and productive submergence area of 65 sq. km. in PTR. Wild ungulates found in the study area are chital (*Axis axis*), sambar (*Rusa unicolor*), gaur (*Bos gaurus*), nilgai (*Boselaphus tragocamelus*), wild pig (*Sus scrofa*), barking deer (*Muntiacus muntjac*), chowsingha (*Tetraceros quadricornis*), chinkara (*Gazella bennetti*) and blackbuck (*Antelope cervicapra*). Although there are no villages inside the core zone, substantial human population resides in the surrounding buffer zone in 99 villages[15].

2.2 Density of Wild Ungulates

In the core zone, 44 transects were distributed in systematic random manner (Figure 1). Each transect was sampled at least twice during winter season over the entire study period (2013–16). Total effort invested in this exercise was 528 kilometres. We used animal clusters as the analytical unit since individual data tends to underestimate true variance[24]. For each detection, we recorded the GPS co-ordinates, the exact time, species, group size, group composition (age classes and sex, whenever possible) sighting angle and the sighting (radial) distance from the transect line.

We estimated density of each species separately for each session (2013–16). We examined distribution of the data by assigning very small cut-off points to the distance intervals during the curve fitting, to detect evidences of evasive movements by the animals or heaping of data. Data was truncated at suitable distances from the line. Most parsimonious model was selected after applying different set of parameters. The best model was selected based on their AIC values[25] and by visually judging the fit of the proposed model to the observed distance data close to the transect line. Average probability of detection (p), group density (Dg), group size (Sg), animal density (Dind) and effective strip width (ESW) were estimated. The population densities and other parameters of interest were calculated with respect to this effective strip width[9]. All analyses were conducted in DISTANCE software ver. 6.0[9].

2.3 Distribution Pattern of Wild Ungulates

Camera trap based encounter rate[13] was used to estimate the distribution pattern of chital, sambar and wild pigs in PTR. Two-sided camera traps were deployed at 82 locations over the entire core zone and same locations were sampled across three years (Figure 1). Cameras were operational for a period of 50-55 days in each session.

We prepared a temporal capture history of all the study species. Only the photographs which were at least 15 minutes apart from each other were taken for this analysis to maintain the independence of the events occurred at the same camera location. This information was then transformed into per 100 trap night encounter rate of chital and sambar to calculate the Relative Abundance Index (RAI) at each camera location[13]. We then used this abundance index to estimate the spatial

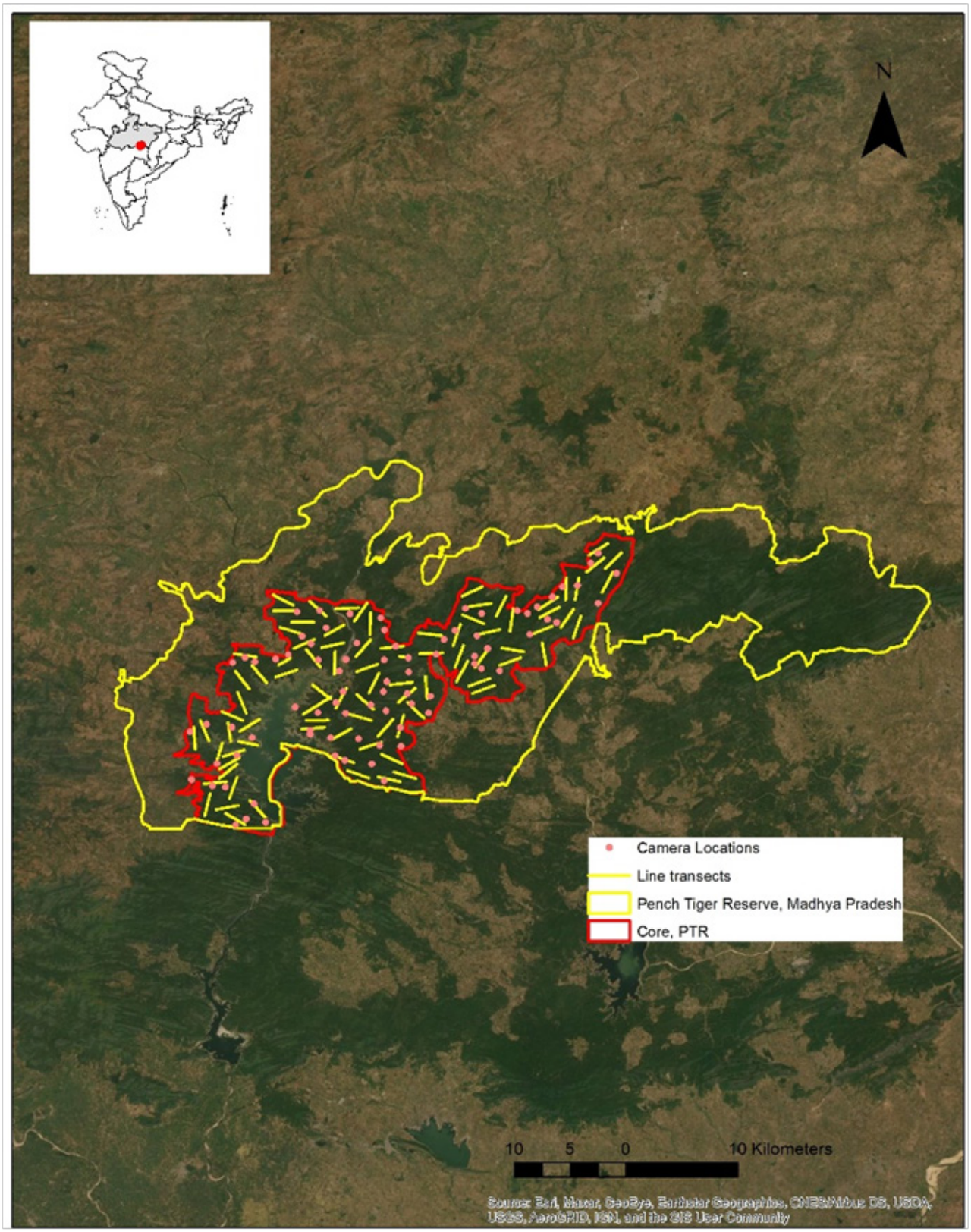

Figure 1. Locations of 44 line transects and 82 camera trapping stations in the core zone of Pench Tiger Reserve (2013-16). The inset map is geographical representation of the study area in India.

Table 1. Year-wise and pooled individual density, group density, cluster size and Effective Strip Width (ESW) for chital and sambar throughout the entire study period (2013–16)

Species	Year	Total no. of observations	Selected models	Chi-p	Density per/ sq. km. (SE)	Group Density/ sq. km. (SE)	ESW in metres (SE)	Cluster Size (SE)
Chital	2013-14	264	Half-Normal Cosine	0.705	54.12 (12.27)	7.9 (1.66)	63.98 (4.22)	6.85 (0.57)
Chital	2014-15	192	Half-Normal Cosine	0.986	52.75 (7.57)	9.94 (1.42)	50.88 (3.18)	5.48 (0.1.)
Chital	2015-16	121	Half-Normal Cosine	0.956	44.56 (9.82)	8.71 (1.65)	31.44 (2.93)	6.29 (0.65)
Chital	Pooled	577	Half-Normal Cosine	0.948	51.4 (9.5)	10.97 (2.03)	48.23 (3.0)	4.68 (0.00)
Sambar	2013-14	79	Uniform Cosine	0.97	7.68 (1.58)	2.73 (0.51)	53.65 (4.57)	1.76 (0.31)
Sambar	2014-15	51	Uniform Cosine	0.95	4.64 (1.01)	2.37 (0.49)	59.64 (6.62)	2.16 (0.23)
Sambar	2015-16	48	Uniform Cosine	0.95	6.75 (1.57)	3.59 (0.78)	38.94 (4.76)	1.88 (0.15)
Sambar	Pooled	178	Uniform Cosine	0.98	6.64 (1.11)	2.90 (0.48)	53.36 (4.67)	1.75 (0.00)

distribution pattern of the target species using Kriging in ArcMap ver. 10.5.1. Kriging is a spatial interpolation tool which uses known values to predict values for points whose values are not known[26].

3. Results

3.1 Density of Wild Ungulates

Of all three study species, chital had the highest abundance. Individual density of chital varied from 44.52 (SE 9.82) per sq. km. to 54.12 (SE 12.27) per sq. km (Table 1) but the population remained stable over the years as demonstrated by overlapping confidence intervals (Figure 2). Individual density of sambar ranged from 4.64 (SE 1.01) to 7.68 (SE 1.58) per sq. km. (Table 1) which also didn't vary over the years (Figure 3).

3.2 Distribution Pattern of Wild Ungulates

3693 independent photocaptures of chital and 1073 independent photocaptures of sambar were used to calculate their Relative Abundance Index (RAI) in the study area. Estimated average RAI of chital and sambar were 70.08 (SE 12.91) and 10.88 (SE 2.00) respectively. Chital congregations were seen near the submergence area and the bordering woodlands in the central zone of the core area. 47.16% of total photocaptures of chital were from cameras deployed in this region (Figure 4). Sambars were found more near the undulating terrain with miscellaneous dry deciduous forest as 38.53% of total photocaptures from deployed camera traps were seen in this area (Figure 5).

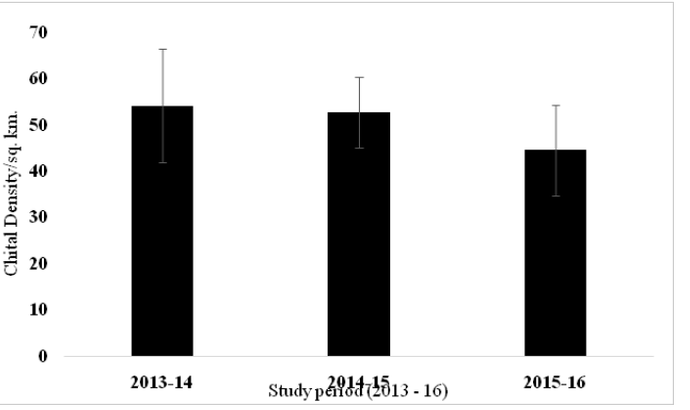

Figure 2. Comparison of individual density estimates of chital in Pench Tiger Reserve, Madhya Pradesh over the study period (2013–16).

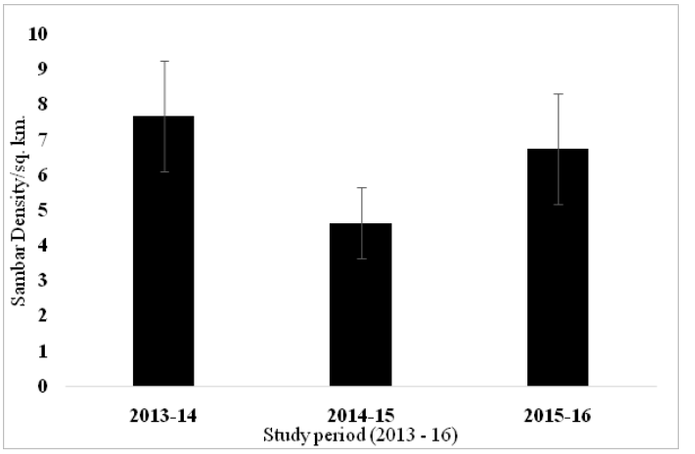

Figure 3. Comparison of individual density estimates of sambar in Pench Tiger Reserve, Madhya Pradesh over the study period (2013–16).

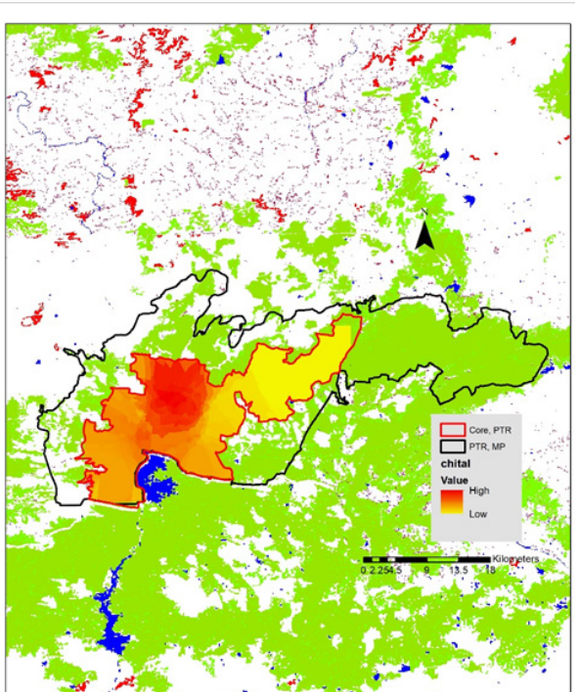

Figure 4. Estimated spatial distribution patternof chital using camera trap-based encounter rate in Pench Tiger Reserve, Madhya Pradesh.

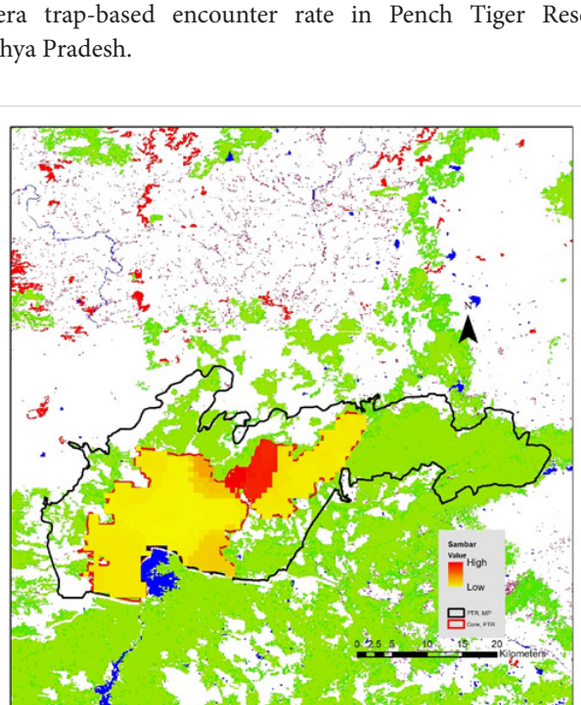

Figure 5. Estimated spatial distribution pattern of sambar using camera trap-based encounter rate in Pench Tiger Reserve, Madhya Pradesh.

4. Discussion

Use of line transect based distance sampling have been well established for prey population estimation of tigers as well as other large carnivores[5,15,27]. Data didn't show any sign of heaping of heaping or evasive movements[9]. Major variation in the data was from encounter rate of individuals on line transects. The encounter rate of animals on a line transect was hugely dependent on different habitat features like visibility, terrain and presence of *Lantana* spp.

Chital was found to be the most abundant ungulate in the study area. Sambar is primarily a dense forest dwelling species and its congregation was seen near the rugged areas. Distribution of chital in the study area were mostly governed by the surrounding habitat features. The submergence of *Totladoh* reservoir has created a unique productive habitat of grassland and bordering woodlands which results in such high numbers of chital in this area. Camera trap based RAI revealed that larger groups of chital were also seen in these areas. RAI for sambar showed higher occurrence of captures were in dense forested areas. PTR being a part of Satpura-Maikal landscape offers heterogeneity in habitat. This diversity from grassland to moist deciduous forest is very well suited for the survival of both grazers and browsers[15,29] which has resulted in such high concentration of ungulates in this area.

We compared the results of the present study with the available literature[7,15,30] from the study area. The findings show that population of chital in PTR has remained stable over the years (Figure 6)

We also compared our results with other tiger reserves with similar habitat features in the landscape. As per the latest available estimates[7], PTR has one of the highest estimated densities of wild ungulates across India. Both chital and sambar has higher density estimates in the study area when compared with areas with similar habitat types like Bandhavgarh Tiger Reserve, Kanha Tiger Reserve and the bordering Pench Tiger Reserve, Maharashtra (Figure 7). Not only that, no livestock is permitted to graze inside the core zone which translates to undisturbed food resources for the wild ungulates. This might be another reason for observing such high numbers of them in the study area[17].

As PTR is part of the one of the major level – 1 TCUs[23], tigers have the highest probability of survival here. The positive relationship between prey biomass and carnivore density has been well established[31,32]. The carrying capacity of predators in any area is dependent on the prey density[7]. Hence these kinds of long-term estimates can help decide the viability of large carnivore population of those area. Additionally, the congregation of prey is also likely to result in higher occurrence of predator. So, investigating the distribution pattern of prey can help prioritise areas for conservation. Hence, it can be

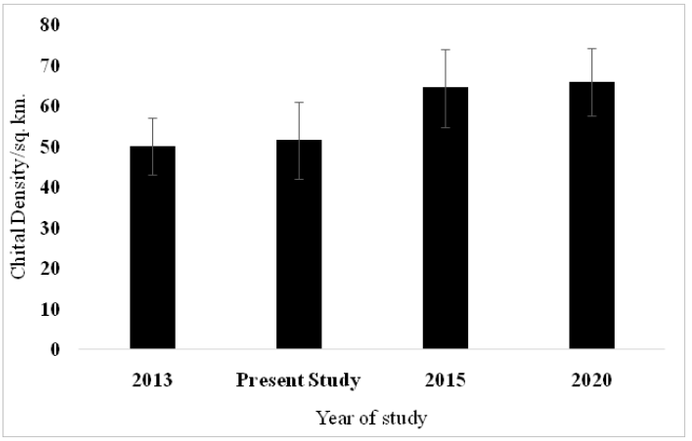

Figure 6. Comparison of individual density estimates of chita l7,15,24 in Pench Tiger Reserve over the years.

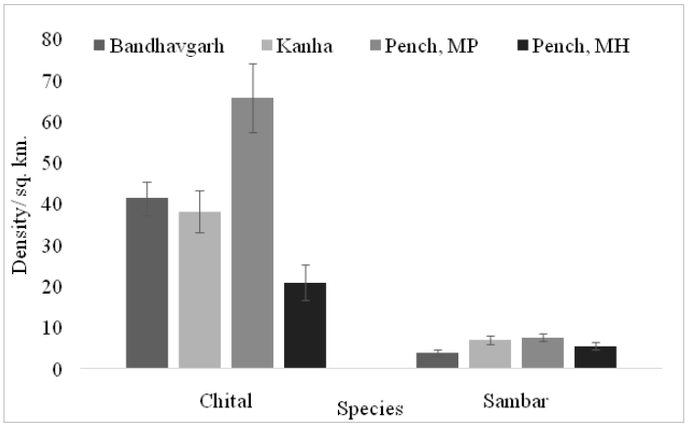

Figure 7. Comparison of density estimates of Chital and Sambar of PTR, MP with that of Kanha TR*, Bandhavgarh TR and Pench TR, Maharashtra (MH)(TR = Tiger Reserve).

said that to protect the large carnivore population in PTR, it is crucial to monitor the prey population on a regular basis to observe their population trends.

5. Acknowledgement

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6. Statements

6.1 Statements about Contributorship

All the authors have contributed in this study.

6.2 Study Design

Kalyansundaram Sankar and Qamar Qureshi designed this study.

6.3 Data Analysis and Manuscript Writing

Anindita Bidisha Chatterjee wrote the manuscript. The final draft was edited and approved by all the authors.

6.4 Statements for Competing Interest

There is no competing interest among the authors.

6.5 Statement for Data Sharing

All relevant data has been given in the manuscript.

6.6 Statement of Ethical Approval

This study was conducted after receiving proper permissions from Madhya Pradesh Forest Department and all rules were adhered by diligently.

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