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Study on kill pattern of re-introduced tigers, demonstrating increased livestock preference in human dominated Sariska tiger reserve, India

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ABSTRACT

Based on individual tiger monitoring of all re-introduced tigers in Sariska Tiger Reserve for two years, from 2016 to 2018, tiger kill data was analysed for demonstrating prey preference by the tigers. The observation of maximum number of tiger kills of livestock (77%) followed by Sambar

Rusa unicolor (13.6%), chital *Axis axis* (3.6%), blue bull *Boselaphus tragocamelus* (2.4%) and wild pig *Sus scrofa* (0.95%) demonstrates very high livestock to natural prey ratio (L/N=3.3) indicating abundance of livestock population inside the reserve. The substantial increase of prey preference for livestock from 19.4% in 2011 (Mondal et al. 2012) to 77% can be corroborated with high observed increasing trend (y= 23.5x-7.43) of the cases of *ex gratia* relief for cattle killing by tigers from 2011 to 2017. We viewed this as evidence of increasing livestock pressure inside the reserve.

KEYWORDS: Human tiger conflict kill prey base dietary pattern

INTRODUCTION

Tiger is the largest of all the felids and inhabits diverse habitat types including dry deciduous, moist deciduous, semi evergreen, wet evergreen, riverine, swamp and mangrove forests. They are socially dominant over other sympatric carnivores (Karanth et al. 2004). Both felids, tiger and leopard, are territorial and wide ranging, but the effective size of the territory is the function of density and biomass of larger prey species in its habitat (Sunquist 1981; Karanth 1991). They show remarkable tolerance to variation in altitude, temperature and rainfall regimes (Sunquist et al. 1999). Tigers prey upon the large ungulates in all the ecosystems in which they occur (Seidensticker 1997; Karanth 2003). They can potentially hunt prey varying from small mammals to the largest of the bovids with the mean weight of the species hunted is reported to be 60 kg (Biswas and Sankar 2002). Although tiger do kill smaller prey, ranging from peafowl to prawns, they cannot survive and reproduce if a habitat does not support ungulates with adequate densities (Sunquist and Sunquist 1989). Thus, tiger is always found to be associated with large mammalian herbivorous prey species in all its habitat ranges across the globe. These include wild buffalo (*Bubalus bubalis*), gaur (*Bos gaurus*), nilgai (*Boselaphus tragocamelus*), swamp deer (*Cervus duvaucelii*), sambar (*Rusa unicolor*), barking deer (*Muntiacus muntjak*), spotted deer (*Axis axis*), and wild boar (*Sus scrofa*) (Schaller 1967, Johnsingh 1983, Johnsingh 1992, Sunquist 1981 and Karanth 1995). But according to Schaller (1967), occasionally they have been found to predate on other carnivores like leopards (*Panthera pardus*), sloth bears (*Melursus ursinus*), civet cats, and small vertebrate species like frogs also. These observations hold true where anthropogenic disturbances including livestock grazing is absent or minimum, not like the landscapes of Sariska where the abundance of livestock is far more than natural prey base. The tiger is reported to have failed to survive in areas wherever these key prey species including large ungulates and primates have been exterminated (Seidensticker 1999). The acquirement of food is a fundamental component for every predator's existence. Hence, prey selection is critical for understanding life history strategies of any carnivore (Miquelle et al. 1996). The survival of any predator is directly related to its habitat, presence of other competitor species and quality and quantity of its diet (Melville 2004). Prey selection of a predator determines spacing patterns, population growth rate and distribution of the species. Thus, the key factors that determine large carnivore habitats are prey abundance, amount of disturbance, water availability and forest continuity. Several hypotheses have been proposed to explain the prey selection by predators. The hypotheses pertain to ultimate causal factor such as energetic benefits and costs involved (Kruuk 1972; Schaller 1972; Griffiths 1975; Stephens & Krebs 1986) and seem to be affected by the change in development of prey predator assemblages due to recent extinctions and simultaneous human predation on prey and predator species (Karanth and Sunquist 1995).

Following the extermination of tiger in Sariska Tiger Reserve, western India in 2004 due to poaching, reintroduction of tigers was done from Ranthambhore Tiger Reserve by translocating an initial population of five tigers (two males and three females), with a supplementation of two tigers (male and female) in every three years for a period of six years (Sankar et al. 2005). This was first example of successful relocation of big cat in the Indian subcontinent. A total of 9 tigers from Ranthambhore have already translocated to Sariska using different means of transport. Three male (ST1, ST4, ST6) and three female tigers (ST2, ST3, ST5) were brought from Ranthambhore. In the year 2012, ST2 delivered two cubs (ST7 and ST8). Later, two female orphan cubs, ST9 and ST10 were brought from Ranthambhore in 2013.While ST10 delivered two cubs (ST11 and ST12) and ST2 delivered its second litter of two cubs (ST13 and ST14) in the year 2014. One cub (ST15) was reported to be borne from ST9 in the year 2016. In the beginning of year 2018 two cubs were borne by ST14 three cubs by ST12. ST16, a young male was brought from Ranthambhore in 2019. With the reported mortality of four tigers (ST1, ST11 and ST4 and ST16) and one missing (ST5) (possibly killed), the population of tigers in STR was 17 (11 adults, 5 sub-adults and 1 cub) during the end of Dec 2018. Five tigers were monitored with VHF/GPS collars and six tigers were monitored on the basis of their pugmarks. Although the significance of radio telemetry in providing data on carnivore home range size and social organization, which can be used to derive, estimates of densities (Sunquist 1981, Smith et al. 1987a, Smith et al. 1987b, Quigley et al. 1989), habitat use (Eric et al. 2008, Jhala et al. 2009) and survival rates (Trent and Rongstad 1974; Kelly et al. 2008) is widely acknowledged, its importance in averting possible human-carnivore conflicts, as well as knowing its dietary pattern through locating its kills can't be underestimated. Although the food preferences of tigers can be estimated from scat analysis as well as from kills (Reynolds & Aebischer 1991; Mukherjee et al. 1994, Biswas & Sankar 2002, Sankar & Johnsingh 2002), however the present study is entirely an attempt based on kills made by the predator. We attempted to demonstrate the extent of anthropogenic pressures in terms of livestock presence all around primarily based on the observations of the dietary pattern of re-introduced tigers through recovery of kills of tigers and co-predator common leopard in STR by tiger monitoring parties and beat in-charges from June 2016 to November 2018.

MATERIALS AND METHODS

STUDY AREA

Covering an area of 1213 km², Sariska Tiger Reserve (hereafter called STR); the study area is situated in Alwar district of Rajasthan in the Aravalli hill range and lies in the semi-arid part of Rajasthan (Rodgers and Panwar 1988). The terrain is undulating to hilly in nature and has numerous large to narrow valleys with altitude varying from 240 to 777 m. and three lakes, Silised, Mansarovar and Somasagar. The vegetation of the area is tropical dry deciduous forest (Champion and Seth 1968) which is scattered and sparse over a large area on various geological and soil formation and vary greatly in composition. *Anogeissus pendula* is dominant species in the undulating area and on the hills. *Boswellia serrata* and *Lannea coromandelica* grow on steep rocky areas. *Acacia catechu*, *Zizyphus mauritiana* and *Butea monosperma* are found in valleys. *Dendrocalamus strictus* is extremely limited in distribution and is found along the well drained reaches of the streams and moist and colder part of the hills. Among bushes, *Grewia flavescence* and *Capparis sepiaria* form important components of vegetation of the reserve.

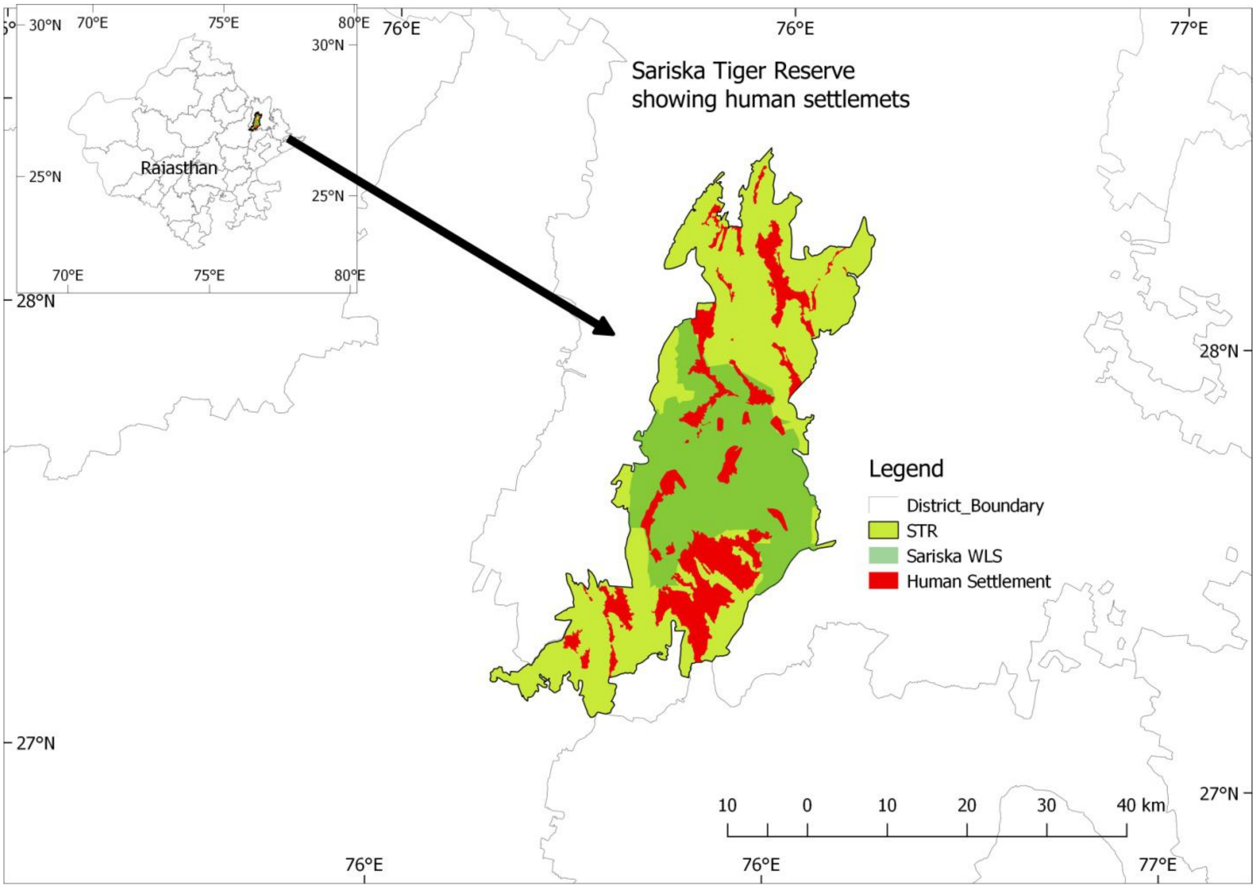

Fig.1. Map showing Sariska Tiger Reserve with human settlement inside

In addition to tiger *Panthera tigris* other carnivores include leopard *(Panthera pardus)*, striped hyaena *(Hyaena hyaena)*, jackal *(Canis aureus)*, jungle cat (*Felis chaus*), common mongoose *(Herpestes edwardsi*), small Indian mongoose (*H. auropunctatus*), ruddy mongoose (*H. smithi*), palm civet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*) and ratel (*Mellivora camensis*). Chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*) and wild pig (*Sus scrofa*) are the major prey species for tigers found in Sariska. Recent camera trap results have revealed the presence of Indian Pangolin (*Manis crassicaudata*), Asiatic wild cat (*Felis lybica ornata*)and Honey Badger (*Mellivora capensis*). Other wild prey species found are common langur (*Semnopethicus entellus*), Rhesus macaque (*Macaca mulatta*), porcupine (*Hystrix indica*), rufous tailed hare (*Lepus nigricollis ruficaudatus*), and Indian peafowl (*Pavo cristatus*). About 175 villages are situated in & around STR. Out of these, 29 villages (now 26 after relocation of three villages) are in Critical Tiger Habitat/ Core area and the rest 146 villages are outside the forest area. The human population is over 1700 in the villages of

National Park along with a population 10,000 livestock including buffalo, cow, goat and sheep (Sankar et al. 2009). The human population in rest of these villages is around 6000 and the livestock population is more than 20,000 (Sankar et al. 2009). Fig. 1 shows STR with a number of villages.

METHODS

The radio-collared tigers were monitored periodically through ground tracking using "homing in" and "triangulation" techniques (Deat et al. 1980, Macdonald and Amlaner 1980; White & Garrot 1990). Each monitoring party consists of two persons, one forest guard and other is local villager who has been trained in monitoring tigers using VHF collar and pugmarks. The information of location, movement pattern and type of animal kill was recorded by the monitoring parties/beat guards and same was sent to control room through wireless radio network. The kills were identified based on morphological identification. The kill data from June 2016 to November 2018 was analyzed using simple statistical method using MS Excel. Prey species density in the study area was estimated by line transects method under distance sampling technique (Burnham et al. 1980). For the estimation of dietary overlap index between tiger and leopard Pianka's niche overlap index was used (Pianka 1973). The mathematical expression of Pianka index is described below;

$$pi = \frac{\sum (pij * pik)}{\sqrt{\sum (pij)^2 * \sum (pik)^2}}$$

pij= percentage of prey items *i* of predator *j,*

pik= percentage of prey items *i* of predator *k*. The value of index distributes between 0 and 1; higher the value close is the similarity.

OBSERVATIONS

Food habits of tiger (*Panthera tigris*) and co-predator common leopard (*Panthera pardus*) was studied in the tropical dry deciduous forest of STR. An observation of 737 kills was made from June 2016 to November 2018. Among all 67.84% were those made by tigers and 30.80% by leopards. Table 1 shows the total kills recovered during the period.

Table 1. Total kills recovered from June 2016 to Nov 2018

Predator	Kills recovered	% age
Common Leopard (*Panthera pardus*)	227	30.80
Tiger (*Panthera tigris*)	500	67.84
Unknown predator	9	1.22
Rock Python (*Python sybae*)	1	0.14
Total	**737**	**100**

One case of kill was recovered killed by a rock python. Nine kills could not be identified because of maximum consumption of the reported kills. Table no. 2 shows the prey species which were killed by the predator and co-predators. Among all reported kills (n=737) buffalo contributed 44.48% followed by cow (22.12%), Sambar (11.53%), Goat (10.99%), Chital (3.66%), Nilgai (2.44%) and unidentified kills contributed 1.49%.

Table 2. Taxa of different kills reported during the period of observation

S. No.	Taxa	No. of kills	% age kills
1	Buffalo (*Bubalus bubalis*)	330	44.78
2	Cow (*Bos taurus*)	163	22.12
3	Sambar (*Rusa unicolor*)	85	11.53
4	Goat (*Capra aegagrus hircus*)	81	10.99
5	Chital (*Axis axis*)	27	3.66
6	Nilgai (*Boselaphus tragocamelus*)	18	2.44
7	Unknown	11	1.49
8	Wild Pig (*Sus scrofa*)	7	0.95
9	Camel (*Camelus dromedaries*)	4	0.54
10	Peacock (*Pavo cristatus*)	4	0.54
11	Hyena (*Hyaena hyaena*)	2	0.27
12	Sheep (*Ovis aries*)	2	0.27
13	Chinkara (*Gazella bennettii*)	1	0.14
14	Donkey (*Equus asinus*)	1	0.14

15	Porcupine (*Erethizon dorsaum*)	1	0.14
	Total	**737**	**100**

Livestock including buffaloes, cows, goats, sheep, camels and donkey contributed 78.83% of all kills made by large carnivores including both tiger and leopard. Fig 2 shows the bar chart depicting the number of kills as observed during the period (n=737).

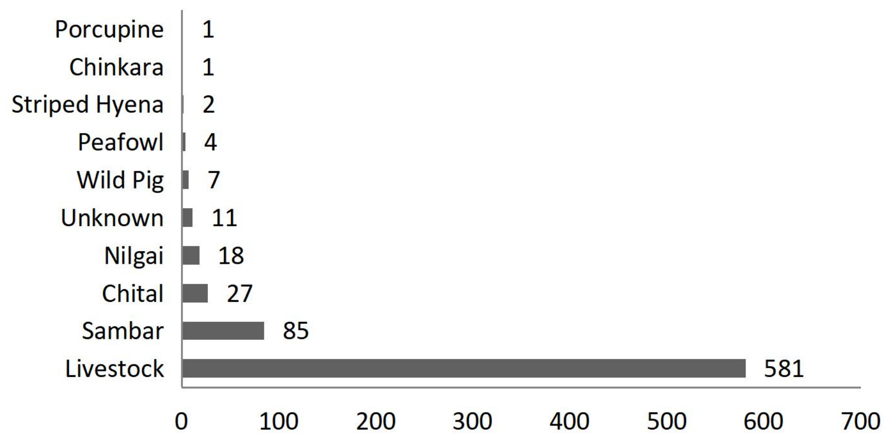

Fig 2. Bar chart showing the number of kills observed during the period in STR

Among all the identified kills (n=500) made tigers, livestock contributed 77% especially buffalo that contributed 75% of the total livestock and 58% of entire reported tiger kills. Sambar was observed to contribute 13.6% followed by chital (3.6%), nilgai (2.4%) and wild pig (1%). One Chinkara was rescued outside the STR and released in the area was killed by tiger in Karnakawas beat.

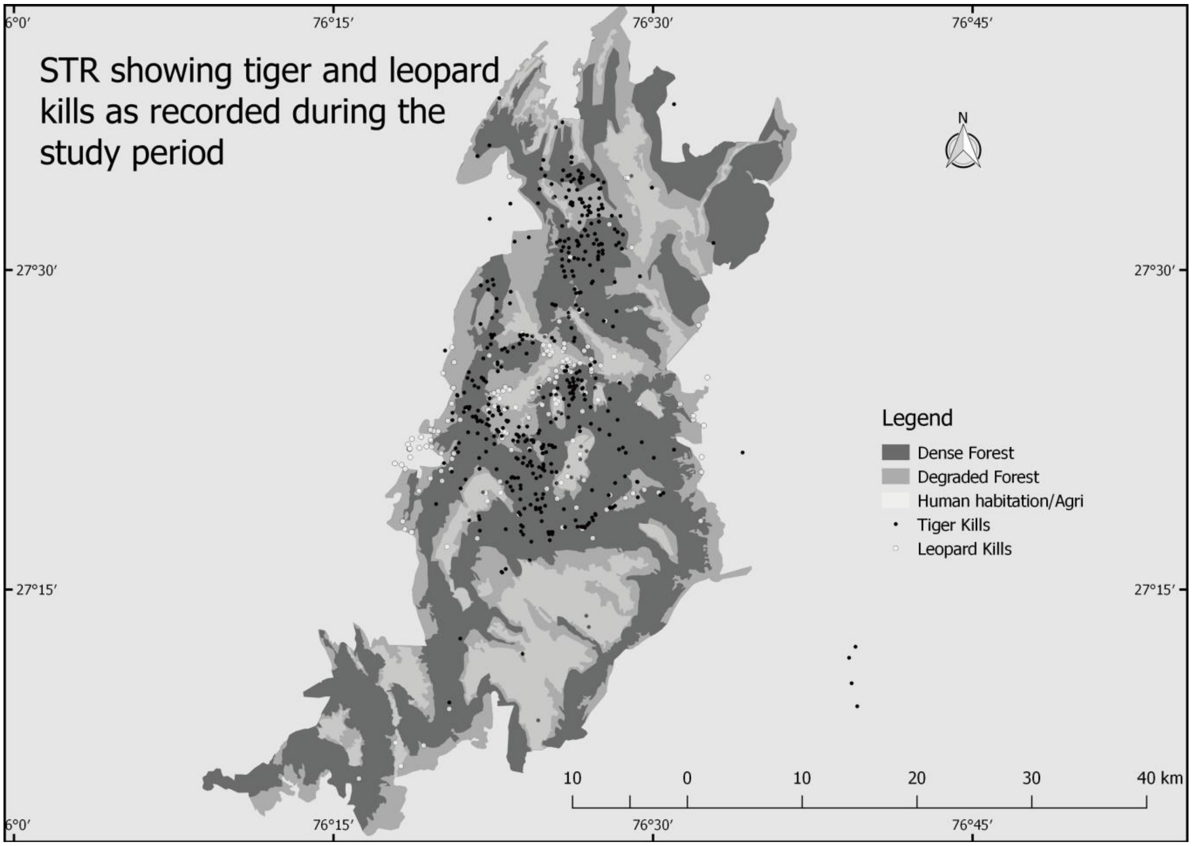

Fig 3. Location of kills as observed for tiger and leopard in STR during the study period

We attempted to analyse the type of kills made by individual tigers. Table 3 shows the observation of kills of different taxa found associated with different tigers. The pooled data of all domestic animals (livestock) and all wild animals constituting natural prey base are shown as comparative bar chart (Fig 4).

Table 3. Kills of different taxa made by different tigers from June 2016 to Nov 2018. >1 ST * is more than one tiger at a kill

Taxa	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST9	ST10	ST 11	S T 12	S T 13	S T 14	ST 15	>1ST *	Tota l
Buffalo	12	10	47	2	22	14	7	28	24	18	18	45	20	4	19	290
Cow	6	8	12	2	12	1	2	6	3	7	8	6	9	2	8	92
Sambar	3	7	2	2	1	6	4	12	10	1	8	3	7		2	68
Chital	2			1		7	3	2	0		2		1			18
Nilgai	1		2	2	1	1		2	0			1	1	1		12
Wild Pig		1							0	1			1	2		5
Camel												1				1
Chinkara												1				1
Goat		1							0					1		2

Hyena			1				1									2
Peafowl							1									1
Porcupine														1		1
Unknown			3						1			1			2	7
Total	24	27	67	9	36	29	18	50	38	27	36	58	39	11	31	500
Livestock	18	19	59	4	34	15	9	34	27	25	26	52	29	7	27	385
Natural	6	8	8	5	2	14	9	16	11	2	10	6	10	4	4	115
L/N ratio	3.0	2.4	7.4	0.8	17	1.1	1.0	2.1	2.5	12.5	2.6	8.7	2.9	1.8	6.8	3.3

The ratio of livestock kills to natural kills can be seen as indirect index for the anthropogenic disturbances in any protected area assuming tiger kills its prey in opportunistically pattern. The estimated livestock to natural prey base ratio for all tigers during the period was observed as 3.34. It was observed maximum for ST6 (L/N=17) followed by ST11 (L/N=12.5), ST13 (L/N=8.7). Minimum was observed for ST5, ST8 and ST7 *viz*. 0.8, 1 and 1.1 respectively (Table 3).

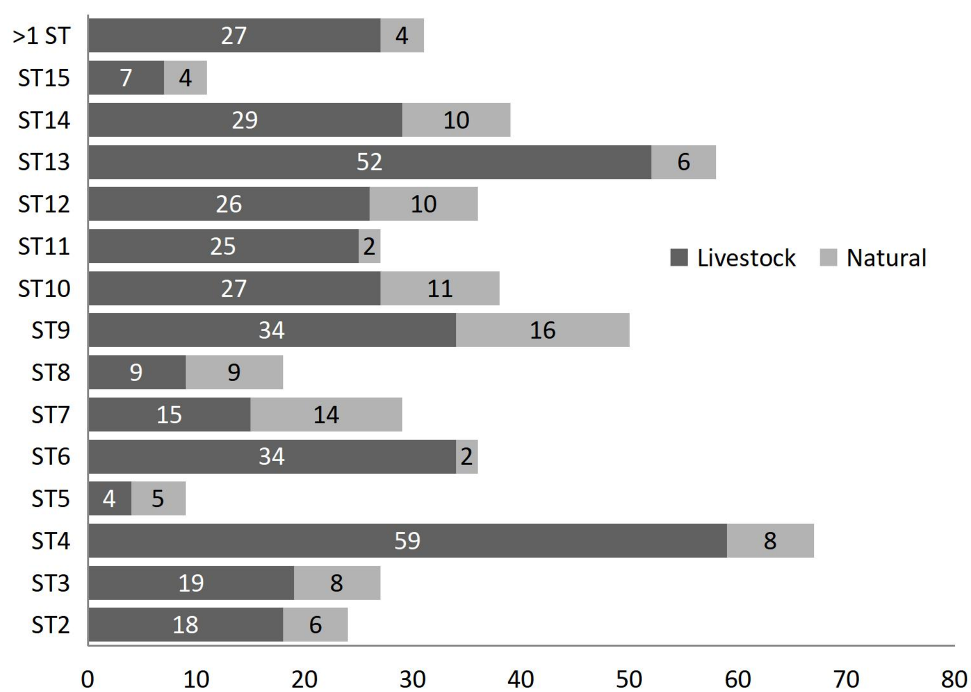

Fig 4. Bar chart showing the types of kills (natural/livestock) made by different tigers. >1 ST means more than one tiger at a kill

Among all 227 cases of leopard kills as reported in STR during the period, maximum percent of goats were killed (33.8%). It is followed by cow (31.1%), buffalo (16.7%), Sambar (7%), Chital (3.9%). It is observed that 84.2% of all the kills are contributed by livestock including goats, cows and buffaloes. Among all 37 kills of buffaloes 28 kills were of calves (eg.75.67%). The number 77 for goats which contributes 33.9% of total reports of kills does not mean actual number of goats killed but occasions. The total number of goats killed is 169. The observed range of no. of goats killed in one occasion varies from 1 to 12.

Based on Piankas dietary overlap index ($pi = \frac{\sum (pij * pik)}{\sqrt{\sum (pij)^2 * \sum (pik)^2}}$ (Pianka 1973) we attempted to know the dietary overlap index of tiger and leopards in STR.

Table 4. Pianka dietary overlap index when number of all domestic animals pools together

Tiger Kill	Tiger	Leopard	pT	pL	pT*pL	$(pT)^2$	$(pL)^2$
Livestock	385	191	0.77	0.84141	0.647885	0.5929	0.70797
Sambar	68	16	0.136	0.070485	0.009586	0.018496	0.004968
Chital	18	9	0.036	0.039648	0.001427	0.001296	0.001572
Nilgai	12	6	0.024	0.026432	0.000634	0.000576	0.000699
Wild Pig	5	2	0.01	0.008811	8.81E-05	0.0001	7.76E-05
Hyena	2	0	0.004	0	0	0.000016	0
Chinkara	1	0	0.002	0	0	0.000004	0
Peafowl	1	3	0.002	0.013216	2.64E-05	0.000004	0.000175
Porcupine	1	0	0.002	0	0	0.000004	0
Unidentified	7	0	0.014	0	0	0.000196	0
Total	500	227			0.659648	0.613592	0.715461

$pi = \frac{\sum (pij * pik)}{\sqrt{\sum (pij)^2 * \sum (pik)^2}}$ = 0..659648/$\sqrt{0.613592 * 0.715461}$ =0.9955

Table 5 Pianka dietary overlap index of tiger and leopard for all animals

Taxa	Tiger	Leopard	pT	pL	pT*pL	$(pT)^2$	$(pL)^2$
Buffalo	290	37	0.58	0.162995595	0.094537	0.3364	0.026568
Cow	92	71	0.184	0.31277533	0.057551	0.033856	0.097828
Sambar	68	16	0.136	0.070484581	0.009586	0.018496	0.004968
Goat	2	77	0.004	0.339207048	0.001357	0.000016	0.115061
Chital	18	9	0.036	0.039647577	0.001427	0.001296	0.001572
Nilgai	12	6	0.024	0.026431718	0.000634	0.000576	0.000699
Unknown	7		0.014	0	0	0.000196	0
Wild Pig	5	2	0.01	0.008810573	8.81E-05	0.0001	7.76E-05
Camel	1	3	0.002	0.013215859	2.64E-05	0.000004	0.000175
Peacock	1	3	0.002	0.013215859	2.64E-05	0.000004	0.000175
Hyena	2		0.004	0	0	0.000016	0
Sheep	0	2	0	0.008810573	0	0	7.76E-05
Chinkara	1		0.002	0	0	0.000004	0
Donkey	0	1	0	0.004405286	0	0	1.94E-05
Porcupine	1		0.002	0	0	0.000004	0
TOTAL	500	227	1	1	0.165233	0.390968	0.24722

$pi = \frac{\sum(pij*pik)}{\sqrt{\sum(pij)^2 * \sum(pik)^2}}$ = 0.165233/$\sqrt{0.390968 * 0.24722}$ =0.531

Although a significant percentage of dietary overlap was observed (99%) between tiger and leopard in terms of kills reported for different species when all types of data of domestic animals pooled together but comparatively less overlap (53%) was observed when the index was computed for individual taxon killed.

While demonstrating the comparison of spatial distribution recovered kills for tiger and leopard, we found 76% of kills in degraded areas and 24% in dense forest for leopard and 34% of kills in degraded areas and 66% in dense forest for tiger.

DISCUSSION

Quantification of diets has long been and continues to be one of the first steps in studying basic ecology of species (Sih & Christensen 2001). For the community ecologist, forager diets potentially play a central role in determining the predator-prey interactions and dynamics of competition between species (Sih et al 1985; Pianka 1981). Thus, the food habits of large carnivores occupy an important position in the ecological niche and play an important role in determining their social structure, behaviours and factors affecting the predator density (Kumaraguru et al. 2011). The availability and range of diet play a pivotal role in determining the dynamics of competition at inter- and intraspecific levels, predator-prey interactions, and other community interactions. An understanding of diets, and ideally, an ability to predict diet shifts in response to changes in prey biomass or prey availability are thus major issues, especially in conservation and management affairs.

Several hypotheses have been proposed to explain prey selection by predators. These hypotheses at times take into account ultimate causal factors such as energetic benefits and costs involved (Griffiths 1975; Stephens & Krebs 1987) and also proximate mechanisms of selection such as prey vulnerability (Curio 1970; Taylor 1976; Temple 1987). Tigers on an average, like most other cats, take more number of prey, which are generally less than their own body size (Packer 1986; Sunquist & Sunquist 1989) but are also reported to consume prey species larger than themselves, when large-sized preys are available in higher densities (Karanth 1995). Hence, prey selection of tigers in any area is ultimately the cumulative effect of different ecological, behavioral, and habitat factors which delineate the availability and vulnerability of prey species at any particular time (Shirbhate 2007).

Based on tiger kill report submitted by the tiger monitoring parties from June 2016 to Nov 2018, our analysis shows 77% of all reported kills (n=500) were observed to be of livestock especially buffaloes which is an alarming increase from 10.4% as observed in 2010 (Sankar et al. 2010). Sambar deer contributed 13.6% followed by chital (3.6%), nilgai (2.4%), wild pig (1%) etc. of total kills. The observed livestock to natural prey base ratio (L/N) for ST7 and ST8 are 1.1 and 1.0 respectively which is very low as compared to overall L/N for all tigers (3.34). This can be attributed to high density of natural prey base (sambar and chital) in their respective home ranges located in range Sariska (Table 7). In a monitoring study conducted by Sankar et al. (2010) in STR found that Sambar to be the most consumed prey species (45.2%) followed by nilgai (16.5%), chital (15.7%), livestock (buffalo and cattle) (10.4%), wild pig (9.6%), goat (1.7%), and porcupine (0.9%). Subsequently in another study in same landscape, it was recorded as maximum for Sambar (41.7%), followed by chital (26.2%), cattle (19.4%), nilgai (10.7%) and common langur (1.9%) (Mondal et al 2012). In Ranthambhore national park, a similar landscape in semi-arid region of Rajasthan and original habitat of re-introduced tigers, maximum percentage of kills are Samabar (54.54%), followed by Chital (28.86%), livestock (12.5%), nilgai (4.5%) and wild pig (1.14%) (Bhardwaj 2008). Thus the percent of livestock in Sariska tiger's menu escalated from 10.4% (2010) to 19.4% (2012) and we estimated it as 77% among all which is an alarming increase. We also compared the number of cattle kills by tiger based on *ex gratia* relief to the villagers for seven years (from 2011 to 2017) with that number of tigers.

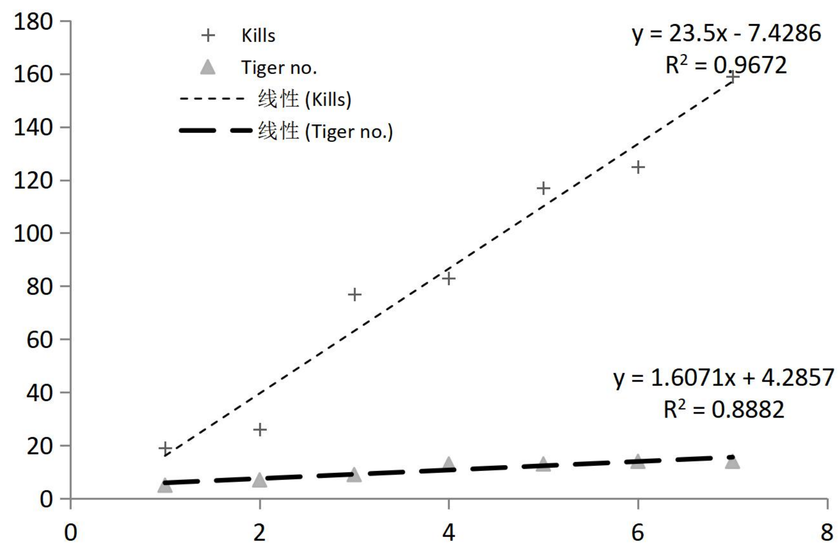

Fig 5

Very high increasing trend (y= 23.5x -7.43) was observed for the cases of *ex gratia* relief for livestock kill by tigers from 19 to 159 between 2011 and 2017 (Fig 5.This alarming rate of increase of livestock preying by tiger clearly suggests multifold increase in grazing intensity in the area. Similarly, our present observation of extremely high percent of livestock prey (84.2%) to all other taxa for leopard in Sariska as compared to that of earlier studies (7.1%) (Mondal et al. 2012) based on scat analysis further confirms very high infestation of the reserve with livestock grazing. In contrast to our present observations, past studies on food habits of leopard (Schaller 1967; Johnsingh 1983; Karanth & Sunquist 1995, 2000) shows wild ungulates especially Chital as dominant prey species of the leopard. This can be attributed to high predominance of livestock in STR landscape.

Table 6 Prey density per square km in different ranges of STR

	Tehla	Sariska	Talvriksh	Akbarpur	Ajabgadh	Buffer
Livestock	16.5 (2.3)*	14.9 (3.8)	14.5 (2.5)	13.8 (2.4)	38.4 (9.5)	111.7 (29.8)
Chital	0.9 (0.7)	13.4 (2.9)	1.7 (1.4)	2.6 (1.0)	1.0 (1.1)	0.0
Nilgai	14.6 (2.1)	31.4 (3.6)	27.6 (2.8)	19.0 (2.4)	36.6 (6.5)	91.3 (13)
Peafowl	15.1(1.7)	43.6 (4.5)	31.2 (3.9)	14.8 (2.2)	52.8 (11.2)	119.3 (21)
Sambar	4.7 (1.4)	27.1 (4.2)	4.1 (1.4)	6.8 (1.4)	4.9 (2.4)	61.8 (15.7)
Wild Pig	4.1 (1.0)	4.4 (0.9)	18.9 (2.6)	11.0 (2.3)	11.0 (2.1)	34.9 (8.5)
Langur	2.3 (0.8)	15.2 (2.8)	3.2 (0.9)	1.9 (0.8)	9.3 (2.9)	17 (5.7)

**standard error is shown in brackets*

Earlier studies have already demonstrated about the co-existence of leopard with other large carnivores including tigers, Asiatic lions and wild dogs (Karanth &Sunquist 1995, 2000) in their range. Johnsingh has already demonstrated about the opportunistic and flexible behavior of leopard in its diet (Johnsingh 1983). Although both tiger and leopard in STR are mainly livestock dependent (*viz*. 77% for tiger and 84% for leopard) the recovery of most of kills of leopards in open and degraded forests on the periphery of human settlements in highly disturbed habitats as compared to tigers whose kills were reported mainly from comparatively undisturbed forests separates these species in area utilization. Although the observed prey of tiger and leopard consists largely on livestock as observed by the kill reports, we observed clear difference in size of the species with leopard preferring smaller to medium sized individuals including fawns of buffaloes (75.7% of 37 buffalo kills).

Earlier studies in India reported high dietary overlap amongst tiger, leopard and wild dog (Johnsingh 1983; Karanth & Sunquist 1995; Ramesh et al. 2008). It was reported as 82% in Mudumulai TR (Ramesh et al 2008) and 94% in Nagarhole Tiger Reserve (Karanth & Sunquist 199). The observed high dietary overlap (Pianka index $pi = \frac{\sum(pij * pik)}{\sqrt{\sum(pij)^2 * \sum(pik)^2}}$) between tiger and leopard was 99% as against 94% in 2012 (Mondal et al 2012). This dietary overlap between tiger and leopard in terms of kills reported for different species is calculated when kills all taxa of livestock pooled together. Comparatively less overlap (53%) was observed when the data for all taxa of livestock are not pooled together. It can be attributed to differential preference for prey with in different taxa of livestock *viz*. Goat>Cow>Buffalo for leopard and Buffalo>Cow>Goat for tiger (Table 4 and 5).

Based on observations it is clearly understood that leopard is dependent on small to medium sized animals especially livestock with goats as preferred amongst all and followed by buffalo calves.

Livestock rearing has been observed as the primary occupation of the local communities in the landscape of STR. The famous milk cake business of Alwar town has further intensified the rearing of buffaloes by the local communities. The presence of 26 villages in CTH of STR and nearly around 146 villages on the periphery (Shekhawat 2015) is the reason behind the rampant livestock grazing in this human dominated landscape apart from other anthropogenic disturbances. Extremely low strength, motivation and commitment of frontline staff in wildlife law enforcement that is evident from observed declining trend in registration of forest offence/wildlife cases during last decade has resulted in very high anthropogenic disturbances in the reserve (Bhardwaj 2018) can be viewed as rampant grazing inside the reserve including the core area. The increasing high predation of livestock by large carnivores both in core and buffer area of STR can be seen as increasing human-carnivore interface that may lead to intolerance among the local communities towards the carnivore's presence around. Although the process of voluntary relocation of the villages from CTH is in progress, however the observed extremely slow speed of the same for last decade has brought the landscape to further stage of degradation. We suggest strict implementation of the existing laws in STR by the state through to halt the speed of degradation of the landscape.

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