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Area sharing among tigers in re-introduced population of Sariska tiger reserve demonstrating space crunch in Human dominated landscape

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Abstract

We examined the home range dynamics, dispersal patterns, and space-sharing behaviour of reintroduced tigers and their progenies in different generations in Sariska Tiger Reserve (STR) from 2018 to 2022. During the study period, the tiger population increased from four males and eight females to seven males, 11 females, and three sub-adult females. Mean home ranges were 34 ± 2 km^2 (SE) for female tigers (n=11) and 95 ± 6 km^2 for male tigers (n=10), while core activity areas (50% KDE) averaged 6 ± 1 km^2 for females and 23 ± 3 km^2 for males. Female home ranges showed a decreasing trend due to natal dispersal by sub-adults, whereas male home ranges expanded due to territorial consolidation. Instances of territorial overlap, including fatal conflicts, highlighted the competitive pressures in this human-dominated landscape. To accommodate the growing tiger population and mitigate human-tiger conflicts, we recommend enhanced monitoring, relocation of villages to create inviolate spaces, and strengthening the protection regime.

Keywords: Home range, tiger dispersal, Kernel Density Estimation (KDE), human-wildlife conflict, tiger conservation, natal dispersal, territorial overlap.

Introduction

One of the most charismatic wildlife species, the tiger (*Panthera tigris* L.) is the largest among felids. It acts as an umbrella or flagship species for the conservation of natural ecosystems throughout its range in Asia (Tilson & Seal, 1987). It is found in a wide range of climates and habitats, from tropical forests of south Asia to the temperate forests of far east Russia and shows remarkable tolerance to the variation in altitude, temperature and rainfall regimes (Sunquist *et al.*, 1999). A total of eight tiger subspecies are commonly recognized: Bengal tiger (*Panthera tigris tigris*), Sumatran tiger (*P. t. sumatrae*), Amur tiger (*P. t. altaica*), Indo-China tiger (*P. t. corbetti*), South China tiger (*P. t. amoyensis*), Caspian tiger (*P. t. virgata*), Javan tiger (*P. t. sondaica*) and Bali tiger (*P. t. balica*) (Luo *et al.*, 2004). Out of the eight sub-species, three – Caspian, Javan and Bali tigers – went extinct in the last century. The last Bali tiger was killed in 1937, the Caspian tiger became extinct in the 1950s, and the last wild Javan tiger was seen in the seventies (Seidensticker, 1986). The wild South China tiger has not been directly observed since the 1970s and is now believed to be extinct in the wild too (Ronald *et al.*, 2004).

In the conservation discourses in Asian countries, the tiger has been the centre of attention for the last few decades. Decision makers and managers often view the tiger number as the measure of the performance indicator for the managerial inputs at many sites in the tiger landscape. However, tigers are highly threatened by habitat loss, prey depletion, and poaching across their range, resulting in substantial population declines over the past century (Kenny *et al.*, 1995; Wikramanayake *et al.*, 1998; Hemley & Mills, 1999; Karanth *et al.*, 2004). Therefore, conservation efforts are required to secure the tiger population, such as restoration of tiger habitat, re-establishing habitat connectivity, restoring prey populations, reducing poaching and reintroducing animals in the wild (Dinerstein *et al.*, 1997; Seidensticker, 2010).

India holds the majority of the global tiger population and has been a pioneer in tiger conservation through initiatives such as Project Tiger, launched in 1973. This program, now covering approximately 2.21% of the total geographical area of India under 55 tiger reserves, has been instrumental in increasing tiger numbers to an estimated 3,682 individuals (Jhala *et al.*, 2022). Sariska Tiger Reserve (STR) was declared the eleventh tiger reserve in 1978 under the Project Tiger. STR, a critical tiger habitat in Rajasthan, faced complete local extinction in 2004 due to poaching and related anthropogenic pressures. In a landmark effort, STR became the first reserve globally to attempt reintroducing wild tigers (Sankar *et al.*, 2005). Between 2008 and 2023, a total of 13 tigers (7 males, 5 females) were translocated from Ranthambore Tiger Reserve (RTR) to STR (Figure 1), leading to a gradual recovery of the population which reached 43 individuals in March 2024 (Supplementary Table S1). All the tigers are monitored daily through radio-telemetry and pugmark tracing by different monitoring teams assigned to individual tigers.

Home ranges represent the spatial extent required by individuals to meet their ecological needs, such as feeding, reproduction, and dispersal (Burt, 1943; Harestad & Bunnell, 1979; Sanderson, 1966). Factors influencing home range size include prey density, habitat quality, and population dynamics, along with external pressures like human disturbance and terrain features (Sunquist, 1981; Karanth, 1991; Miquelle *et al.*, 2010). Male home ranges can be substantially larger than female home ranges in felids (Sandell, 1989; Simcharoen *et al.*, 2014; Rodrigo & Briyan, 2019). In human-dominated landscapes like Sariska Tiger Reserve, where livestock often outnumber wild prey, home range dynamics are further shaped by the availability of natural cover, water sources, and reduced inviolate space (Bhardwaj *et al.*, 2020a). Analysis of tiger kills in STR from 2016 to 2018 revealed that 77% were livestock, indicating a dependence on domestic prey (Bhardwaj *et al.*, 2020b). These spatial and ecological dynamics are particularly critical in STR, where the dense forest area available to tigers is limited to 548 km^2, despite the reserve's total area spanning 1,216 km^2 (Bhardwaj *et al.*, 2020c). The growing tiger population heightens the likelihood of conflicts, as young dispersing males seek new territories, often venturing into human-dominated areas (Bhardwaj *et al.*, 2020c). Therefore, understanding home range dynamics is vital for mitigating such conflicts and ensuring the long-term coexistence of tigers and humans in fragmented landscapes.

STR also deals with very high human interference with 26 villages within critical tiger habitat, a national highway passing through the core area, and several religious sites (Bhardwaj *et al.*, 2020a). Understanding how the subsequent generations of reintroduced tigers share and partition space in Sariska Tiger Reserve is critical to assessing their adaptation and the reserve's carrying capacity. This study examines the home range dynamics and space-sharing patterns of tigers in STR from 2018 to 2022. We aim to investigate the homing patterns of sub-adult cubs dispersing from their natal areas, hypothesizing that the home ranges of established tigers, particularly females, will contract as sub-adults explore and establish new territories.

Materials & Methods

Study Area

The Sariska Tiger Reserve, a representative of the biodiversity of the Aravalli ranges, is located in the semi-arid biogeographic region of Alwar district, Rajasthan. It spans over 1216.35 km^2, with 881 km^2 designated as critical tiger habitat. The reserve is part of the ancient Aravalli hill range, reaching up to 777 meters in altitude, and features tropical dry deciduous forests (Champion & Seth, 1968). The landscape includes undulating terrain, wide and narrow valleys, three large plateaus, *viz.*, Kiraska, Dabli, and Kankwari, and three major lakes, *viz.*, Siliserh, Mansarovar, and Somasagar.

The dominant tree species in the reserve are *Anogeissus pendula* in the undulating areas and hills, B*oswellia serrata*, and *Lannea coromandelica* on rocky slopes, with *Acacia catechu*, *Butea monosperma*, and *Zizyphus mauritiana* found in the valleys. Bamboo (*Dendrocalamus strictus*) is limited to well-drained stream reaches and shaded hillsides. *Grewia flavescens* and *Capparis sepiaria* are also notable.

STR hosts various carnivores, including tigers (*Panthera tigris*), leopards (*Panthera pardus*), striped hyenas (*Hyaena hyaena*), and several species of mongoose, civets, and jackals. Spotted deer (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), and wild pigs (*Sus scrofa*) are the main prey species. Indian pangolins (*Manis crassicaudata*) and abundant honey badgers (*Mellivora capensis*) are reported during camera trapping syrveys (Singh *et al.* 2021). Other wildlife includes langurs, macaques, porcupines, hares, and peafowls.

There are about 175 villages in and around STR, with 26 villages inside the core area after the relocation of five villages. The core villages have a population of over 1,700 people and 10,000 livestock, while the surrounding villages house around 6,000 people and over 20,000 livestock.

Methods

All tigers translocated from Ranthambore Tiger Reserve (RTR) were radio-collared during translocation. Data on tiger movement and habitat use were collected between 2018 and 2022 through a combination of radio-collaring and direct field observations. Malfunctioning collars on ST9, ST3, and ST10 were replaced with Vertex plus VHF/GPS collars from Vectronic Aerospace using Iridium satellite communication. Tigers born in STR were monitored using pugmarks and camera traps (Table 1). Monitoring teams tracked uncollared individuals using indirect evidence such as pugmarks and scat, supplemented by camera-trap images. All individuals were assigned unique IDs to facilitate identification and tracking, and their locations were recorded using handheld GPS devices (Table 1). The age of each tiger was estimated based on re-introduction records, known birth dates of offspring from radio-collared mothers, evidence of reproduction, and observed breeding behaviours (Supplementary Table S1).

Home ranges were estimated using Kernel Density Estimation (KDE) with 95% and 50% isopleths to represent total and core activity areas, respectively (Worton, 1989). KDE was selected due to its ability to provide a probabilistic estimate of space use. KDE has been widely validated in ecological studies to account for non-uniform habitat use and is suitable for semi-arid and fragmented landscapes like STR. Analyses were performed using Graphical Model Builder in QGIS 3.26.

Spatial data from 48 months (July 2018 to June 2022) were divided into 8 six-month intervals to reflect seasonal changes (pre- and post-monsoon periods). Minimum Convex Polygon (MCP) was used alongside KDE for cross-validation, and to calculate territorial overlaps and conflicts. Home range metrics were analysed for trends in seasonal variations, gender-based differences, and life-stage influences. The overlap of home range areas of different tigers was calculated using the intersection options of the geo-processing tool in QGIS 3.26. Shapefiles for dense forests, degraded forests, and agricultural settlements were generated by tracing and georeferencing high-resolution Google Earth imagery, viewed at 12,675 feet altitude to overlay tiger movement data and assess habitat use patterns within Sariska Tiger Reserve (Bhardwaj, 2020c).

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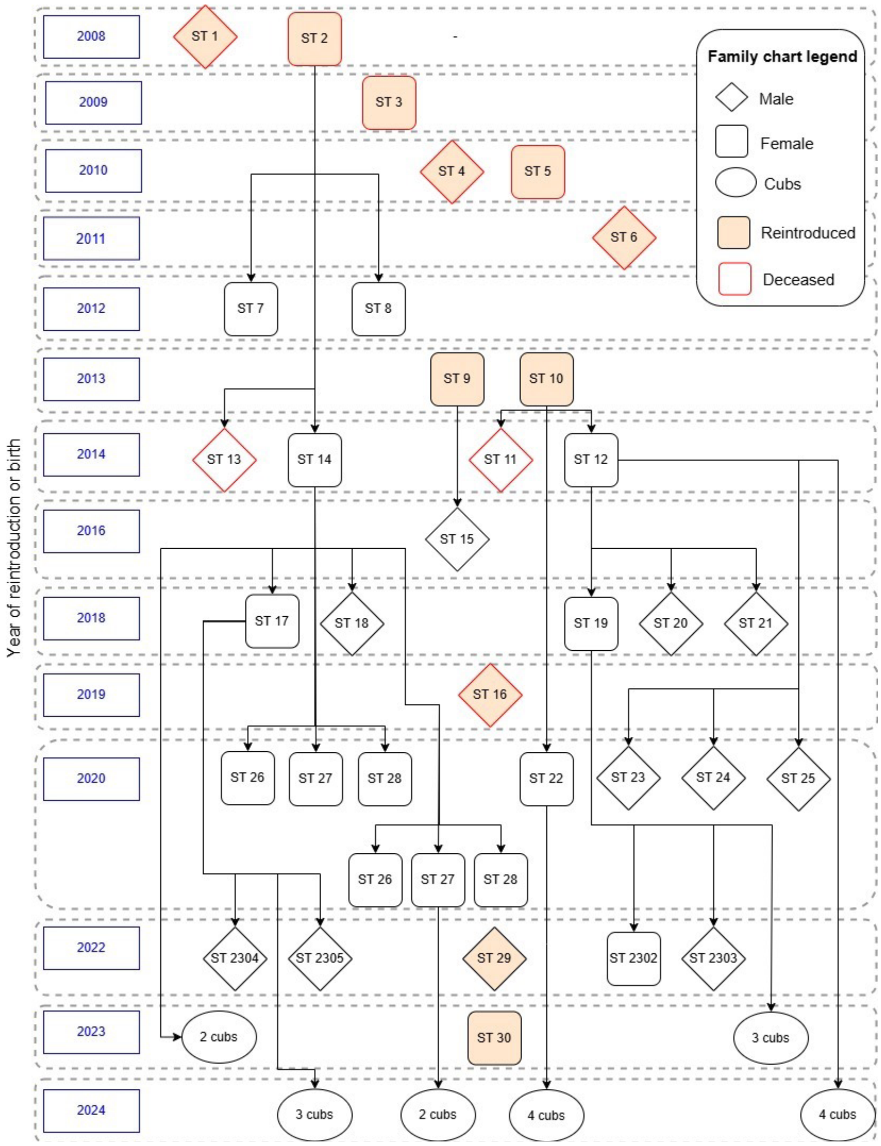

Figure 1. Family tree of reintroduced and naturally born tigers in Sariska Tiger Reserve, India, spanning the years 2008 to 2024. All the reintroduced tigers were brought from Ranthamore Tiger Reserve. The timeline highlights reintroduction events, natural births, and spatial lineage dynamics in a human-dominated landscape.

Results

The home range for adult female tigers (n=11) ranged from 17 km^2 to 65 km^2 with a mean of 34 ±2 km^2 (95% KDE). For adult male tigers (n=10), the home range varied from 45 km^2 to 220 km^2, with a mean of 95 ± 6 km^2. Core activity areas (50% KDE) ranged from 4 km^2 to 10 km^2 for females (mean 6 ±1) and from 7 km^2 to 39 km^2 for males (mean 23 ±2) (Table 2). Male tigers showed significantly larger home ranges and core areas compared to females, consistent with gender-based differences in territorial and resource-use patterns (Figure 3).

Female Tigers

The female tigers (n=11) displayed varying home range sizes based on age, reproductive status, and sub-adult dispersal. ST14, for instance, exhibited the smallest mean home range (17 ± 2 km^2), while ST3 had the largest (58 ± 8 km^2). ST2, who was part of the founder population, initially had a minimal home range of 10 km^2, which expanded to 112 km^2 by early 2022.

Sub-adult dispersal in 2019 (ST17, ST18, ST19, ST20, and ST21) triggered a contraction in home ranges for several tigresses, including ST3, ST9, ST10, ST12, and ST14, while area coverage increased for ST2 (from mid-2021) and ST7 (from mid-2019) (Table 2). ST14's female litter ST17, while initially overlapping 15.5% with her natal area, eventually established her own territory with minimal overlap (Supplementary Figure S1).

Areas occupied by female tiger also showed overlaps with male tigers, such as ST6, which completely intruded on the core activity areas of ST2, ST7, ST8, and ST9 from July to November 2018 (Supplementary Figure S2).

Male Tigers

During the initial phase of the study period, there were four male tigers in the reserve: ST4, ST6, ST13, and ST15. Following the death of ST4 due to territorial fight with ST6 at the end of 2018, the number of adult male tigers decreased to three. However, the population later increased when the males born in STR dispersed and established their home ranges within STR (ST18, ST20, and ST21 in 2021, ST23, ST24, and ST25 in 2022). A breeding male, ST13, went missing at the beginning of the study's final phase. Although a young male, ST16, was translocated from

Table 1. Details of radio-collared and non-collared tigers monitored in Sariska Tiger Reserve during the study period (2018–2022).

S. no	Tiger ID	Sex	Radio Collar Details	Number of Locations
1	ST2	F	Vectronic VHF	890
2	ST3	F	Vectronic VHF/ Satellite	920
3	ST41	M	Vectronic VHF	1102
4	ST6	M	Vectronic VHF	650
5	ST7	F	Non collar	597
6	ST8	F	Non collar	985
7	ST9	F	Vectronic VHF/ Satellite	1245
8	ST10	F	Vectronic VHF/ Satellite	987
9	ST12	F	Non collar	781
10	ST13	M	Vectronic VHF	954
11	ST14	F	Non collar	680
12	ST15	M	Non collar	871
13	ST17	F	Non collar	974
14	ST18	M	Non collar	764
15	ST19	F	Non collar	851
16	ST20	M	Non collar	685
17	ST21	M	Non collar	987
18	ST22	F	Non collar	587
19	ST23	M	Non collar	611
20	ST24	M	Non collar	458
21	ST25	M	Non collar	327

Ranthambhore Tiger Reserve in 2019, but it died quite immediately post-relocation (Figure 1).

Adult males (n=10) exhibited larger and more dynamic home ranges compared to females. For example, ST25 recorded the largest home range at 220 ± 61 km², while ST21 had the smallest at 45 ± 14 km² (Table 2).

Sub-adult Tigers and Natal Dispersal

Sub-adult tigers (n=5) demonstrated significant variability in exploration and settlement patterns (Table 2). Female cub ST17, born to ST14, showed an increase in home range from 17 km² during initial territory exploration (July-Dec 2019) to 27 km² in 2020 and early 2021, overlapping with her mother's range, before contracting to 5 km² (January-June 2022) adjacent to her natal area. Similarly, ST19, after occupying 115 km² (July-Dec 2019), settled at 14 km² (January-June 2022) with minimal overlap (3.9% in January-June 2020) with her mother, ST12 (Supplementary Figure S3).

Sub-adult males ST20 and ST21 showed high initial overlap (68% and 81%, respectively, in July-December 2019) with ST12. By July-December 2020, their home range area expanded six and four times for ST20 and ST21 respectively. In the next six months, their areas contracted to 41 km² and 25 km², respectively, as they separated from each other and their natal areas. Young dispersing males ST18 displayed exploratory behaviour, which included distinct movement clusters, with a clear shift in spatial preference after dispersal. ST18 initially explored 221 km² of its natal area (July-Dec 2019), overlapping 11% with its mother ST14. After dispersing from its natal area, its home range contracted to 55 km² by July-December 2021) before expanding again to 80 km² in January-July 2022 (Table 2). During the initial exploration period (January-June 2020), the home range of ST18 shifted by 20 km within 6 months with distinct activity canters (Supplementary Figure S4).

Home Range Overlap and Territorial Conflicts

Overlapping ranges led to several instances of competition and conflict, especially among males. The most notable case was the fatal conflict between ST4 and ST6 in the latter half of 2018, where overlapping home ranges (95% MCP) ranged between 84 km² and 109 km² (Table 3, Supplementary Figure S5). The home range of ST4 was 109 km² (MCP 95%) from July 2018 until its death in December 2018 (Supplementary Figure S6). Following the death of ST4, the home range of ST6 expanded progressively, from 84 km² in July–December 2018 to 132 km² in January–June 2020 (Table 2). The regression line (R^2=0.745) confirmed the increasing trend in ST6's home range area post-conflict (Figure 4).

Female philopatry was evident in ST14 and her daughter ST17, as well as ST12 and her daughter ST19. These dynamics were characterized by partial overlap during dispersal and eventual establishment of adjoining territories (Supplementary Figures S1 & S3).

Discussion

This study highlights the spatial dynamics and home range characteristics of the tigers in Sariska Tiger Reserve (STR), focusing on territorial behaviours, gender-based differences, and the implications of increasing tiger populations in a human-dominated landscape. STR, spanning 1,216 km², is characterized by fragmented habitats and significant anthropogenic pressures, including over two dozen villages and state highways (Bhardwaj *et al.* 2020a), which present unique challenges to tiger conservation.

The tigers from the founder population established home ranges in key areas and male territories overlapped with several female tigers (ST2, ST3, ST5, ST7, ST8, ST9, and ST14). The territorial conflict between male tigers ST4 and ST6 in 2018 displays the impact of spatial overlap on space and resource-sharing dynamics. The death of ST4 in this fatal conflict allowed ST6 to expand his range significantly, reaching 132 km² by mid-2020. This expansion enabled ST6 to consolidate control over the home ranges of female tigers ST2, ST7, ST8, and ST9. Such conflicts highlight the competitive pressures within the male population, especially in limited spaces, and underscore the need to monitor male territorial dynamics closely.

The average home range of female tigers in STR, measured at 34 km², is consistent with findings from the surrounding semi-arid landscape (Sankar et al, 2010; Bhardwaj & Sharma, 2013; Sankar *et al.* 2013; Bhardwaj *et al.* 2020c). However, these ranges are influenced by female philopatry, where female litters

Table2. Kernel density home range areas (in km²) of tigers in Sariska Tiger Reserve were computed for six-month intervals between July 2018 and June 2022. Values without parentheses represent home range areas at MCP 95%, while values in parentheses denote core activity areas at 50% KDE. The table summarises spatial dynamics, including mean home ranges (±SE) for both sexes over the study period.

Tiger	Sex	July-December 2018	January-June 2019	July-December 2019	January-June 2020	July-December 2020	January-June 2021	July-December 2021	January-June 2022	Mean home range (SE)
ST2	F	12(2)	9(2)	12(3)	12(2)	7(2)	8(2)	71(4)	112(20)	30(5)
ST3	F	106(55)	54(5)	61(3)	64(3)	58(4)	38(2)	52(4)	34(1)	58(10)
ST4^	M	109(7)	*	*	*	*	*	*	*	109(7)
ST6	M	84(14)	90(32)	119(49)	132(48)	119(47)	#	#	#	109(38)
ST7	F	15(2)	18(4)	88(10)	54(10)	55(14)	28(5)	34(7)	27(4)	40(7)
ST8	F	46(11)	34(3)	54(5)	28(4)	27(6)	18(4)	21(6)	18(4)	31(5)
ST9	F	43(6)	39(5)	21(5)	26(5)	28(6)	42(5)	24(6)	14(3)	30(5)
ST10	F	43(7)	44(2)	14(1)	14(1)	12(3)	33(3)	38(11)	40(17)	30(6)
ST12	F	11(2)	21(5)	21(5)	22(3)	15(3)	17(5)	21(5)	14(7)	18(4)
ST13	M	112(22)	107(16)	120(14)	160(17)	127(8)	159(61)	111(41)	##	128(25)
ST14	F	15(3)	18(4)	24(5)	18(5)	12(3)	12(3)	13(4)	20(3)	17(4)
ST15	M	60(20)	98(7)	73(4)	67(3)	130(22)	81(18)	144(36)	124(53)	97(20)
ST17	F			17(3)	27(21)	27(5)	27(6)	24(4)	5(1)	21(7)
ST18	M			221(68)	189(71)	71(13)	59(21)	55(6)	80(17)	113(33)
ST19	F			115(14)	112(15)	85(12)	41(5)	24(3)	14(1)	65(8)
ST20	M			26(5)	27(7)	155(65)	41(9)	45(29)	66(19)	60(23)
ST21	M			21(5)	28(5)	113(55)	25(3)	42(6)	39(5)	45(13)
ST22	F							40(4)	44(6)	42(5)
ST23	M							7(1)	109(17)	58(9)
ST24	M							183(34)	155(19)	169(27)
ST25	M							159(22)	281(57)	220(39)
Mean	F	36(11)	30(4)	43(5)	38(7)	33(6)	26(4)	33(5)	33(6)	34(6)
Mean	M	91(16)	74(14)	97(24)	101(25)	119(35)	73(22)	93(22)	114(24)	95(23)
ST-14cubs									57(5)	

^ST4 died at the age of 12 years due to infighting with ST6. *Data unavailable due to the mortality of ST4. #ST6 was confined to a soft closure due to injury during this period. ##ST13 went missing or was presumed dead.

establish territories adjoining their natal areas (Waser & Jones, 1983; Smith *et al.* 1987). For instance, ST17, the female litters of ST14, initially exhibited a 15.5% overlap with her mother's home range before settling in an adjacent area. Similarly, ST19, born to ST12, exhibited a gradual contraction of her exploratory range before establishing her territory with minimal overlap. In contrast, male tigers such as ST18 displayed dispersal behaviour (Dobson, 1982; Smith, 1993), initially exploring large areas (*e.g.*, 221 km²) before settling in buffer zones. Male ST13 showed an extensive home range (128 km² on average), overlapping with multiple females. Although resident female tigers, ST10 and ST12, were within his territory, both were focused on rearing cubs, leaving ST13 frequently searching for ST14, whose cubs had dispersed. Additionally, the presence of a sub-adult male ST18 near his home range may have prompted boundary patrolling to deter potential threats to his cubs, as observed in similar behaviours (Sandell, 1989). The presence of sub-adults in STR's northern buffer prompted female tigers ST8, ST9, and ST14 to adjust their ranges. Additionally, ST2's home range expanded in response to overlaps, ultimately extending beyond STR to 112 km² in

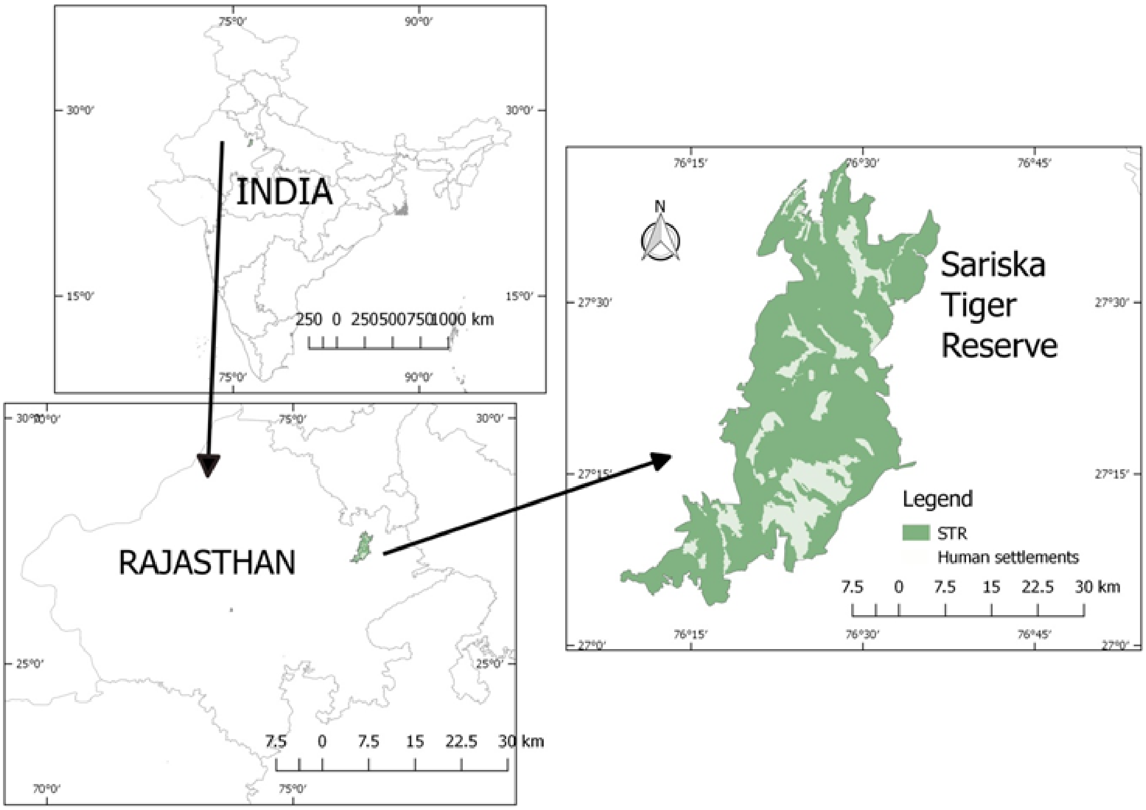

Figure 2. Map of Sariska Tiger Reserve depicting its core and buffer zones, with human settlements located within the reserve boundaries.

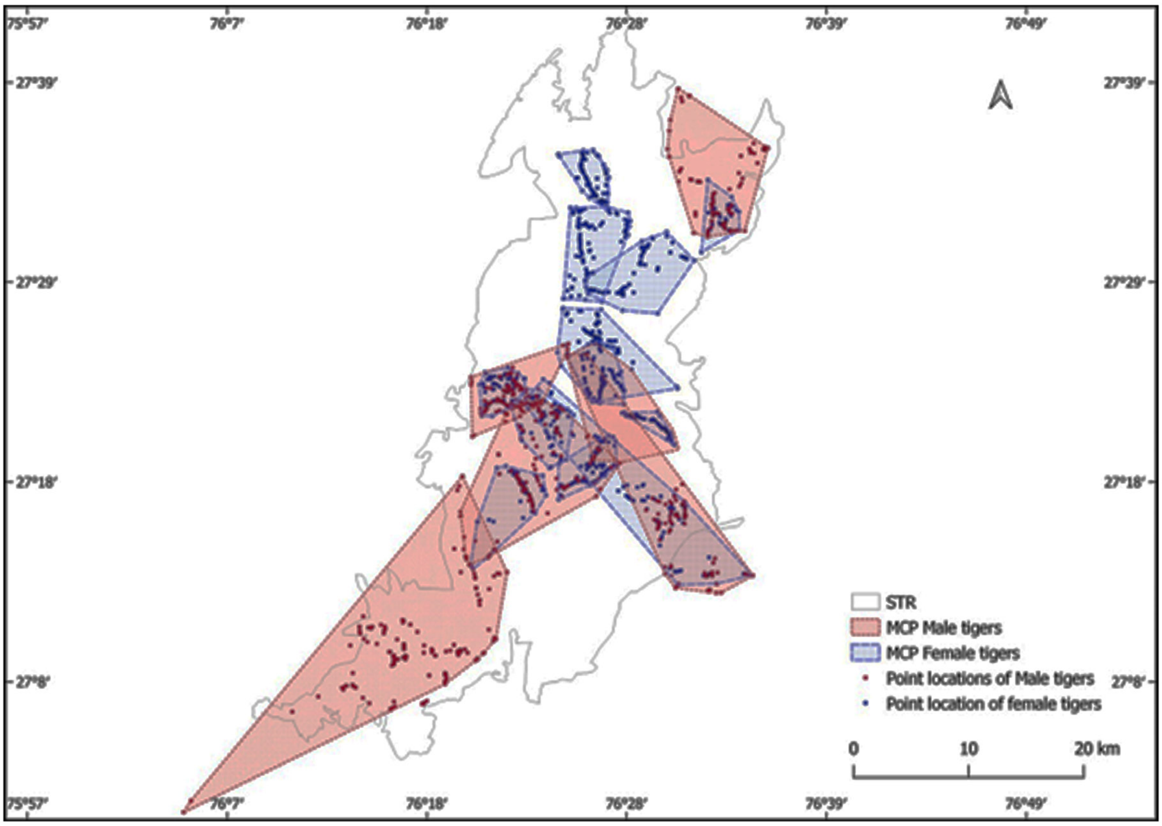

Figure 3. Spatial distribution of tiger home ranges (95% MCP) in Sariska Tiger Reserve, illustrating male and female tiger territories based on GPS location data from January to June 2022.

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Table 3. Monthly home range areas (95% MCP) of male tigers ST4 and ST6 in Sariska Tiger Reserve from July to November 2018, including overlap area (km^2) and percent overlap (%). The table highlights the spatial dynamics and territorial interactions between the two males during this period, leading up to the conflict resulting in ST4's mortality.

	Area occupied by ST4	Area occupied by ST6	Overlap area	Percent Overlap (%)
July 2018	79.19	74.17	8.36	5.8
Aug 2018	42.36	78.66	3.84	3.3
Sep 2018	29.66	72.13	4.62	4.8
Oct 2018	26.10	65.98	0.00	0.00
Nov 2018	25.55	40.80	10.15	18.1
Mean (x̄)	40.57	66.35	5.39	6.4
SD	22.63	14.99	3.99	6.9
SE (σ)	10.12	6.70	1.78	3.1

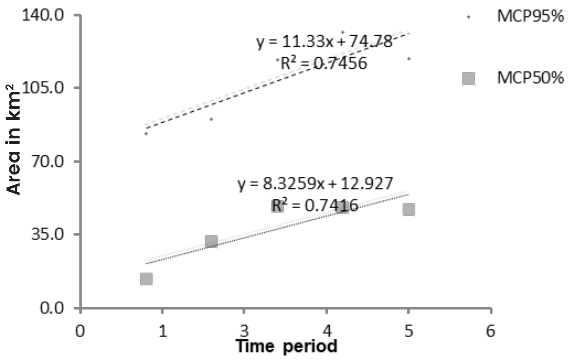

Figure 4. The home range area of ST6 male tiger increased following the mortality of ST4. Data points correspond to five time intervals: July–Dec 2018, Jan–June 2019, July–Dec 2019, Jan–June 2020, and July–Dec 2020. The trend illustrates the progressive expansion of ST6's territory after the conflict.

Rajgarh by mid-2022. This behaviour aligns with female philopatry, where female tigers inherit natal ranges, while males generally disperse further—a dispersal pattern observed with males like ST18. These dispersal patterns reflect gender-based ecological strategies and increase the likelihood of human-tiger interactions as tigers venture beyond protected areas.

The presence of over two dozen villages within STR creates a highly mosaic and patchy habitat with an extremely high perimeter interface per unit area (Bhardwaj & Kumar, 2019), which further complicates tiger management. Only 548 km^2 of the reserve constitutes dense forest, representing approximately 45% of the total area (Bhardwaj *et al.*, 2020b). This limited inviolate space restricts tiger movements, often forcing them into degraded habitats and human-dominated landscapes. With 77% of tiger kills attributed to livestock (Bhardwaj *et al.*, 2020a) and cases of anthropogenic mortality, such as the wire snaring of ST11 in 2018, and disappearance of ST5 (in 2018) and ST13 (in 2022), the risk of human-tiger conflict is heightened. Dispersing sub-adults, such as ST25, exemplify this challenge. ST25 ventured beyond STR into Jamwa Ramgarh Wildlife Sanctuary, demonstrating "frustrated dispersal" as it struggled to establish a territory. Similarly, the movement of the oldest tigress, ST2, into the Rajgarh area indicates that even experienced tigers are pushed into peripheral zones due to spatial constraints.

The reintroduction program in STR aimed to prevent local extinction through regular supplementation based on mathematical models (Re-introduction plan of Sariska 2007-2008). However, this approach relied on the creation of inviolate spaces—a prerequisite that remains unfulfilled. The continued supplementation of the tiger population, such as the introduction of male ST29 from Ranthambore in 2022, aggravates the existing space crunch. While regular recruitment of cubs signifies conservation success (Figure 1), the lack of adequate space and persistent human pressures pose significant threats to both tiger survival and community tolerance.

The tiger carrying capacity of STR, under ideal conditions of uniform prey distribution, suggests potential support for up to 32 female tigers using Karanth *et al.* (2004) equation. However, the reality of a patchy habitat significantly reduces the effective carrying capacity. Tigers competing for limited resources within dense and degraded forests are increasingly likely to interact with humans, escalating the risk of conflict. Such conflicts, often stemming from livestock predation (Bhardwaj *et al.* 2020b) or territorial spillovers, can undermine conservation efforts if local communities perceive economic losses as unsustainable (Treves & Karanth, 2003; Woodroffe *et al.*, 2005). The extent of local communities' tolerance towards economic losses due to the presence of mega carnivores ultimately determines the desired number of tigers in landscapes like STR—a quantification beyond the scope of the present study.

To mitigate these challenges, it is important to reassess STR's management strategies. The relocation of villages from the reserve must be prioritised to create inviolate spaces essential for supporting a growing tiger population (Dinerstein *et al.* 1997). Simultaneously, translocation strategies should be re-evaluated to balance population growth with habitat availability, minimising competition and dispersal beyond protected areas. Strengthening community engagement and compensation mechanisms for livestock depredation is critical to fostering coexistence in human-dominated landscapes. These measures will be crucial to ensuring the long-term survival of tigers in STR and similar fragmented habitats.

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CONFLICT OF INTEREST

The authors have no competing interests to declare that are relevant to the content of this article.

DATA AVAILABILITY

Data available from the corresponding author on request.

AUTHOR CONTRIBUTIONS

All authors participated in conceptualisation, data collection, analyses, writing, final edits and review of this manuscript.

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