BRINGING BACK THE CHEETAH TO INDIA

Annual Progress Report

2023-24

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project cheetah

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EXECUTIVE SUMMARY

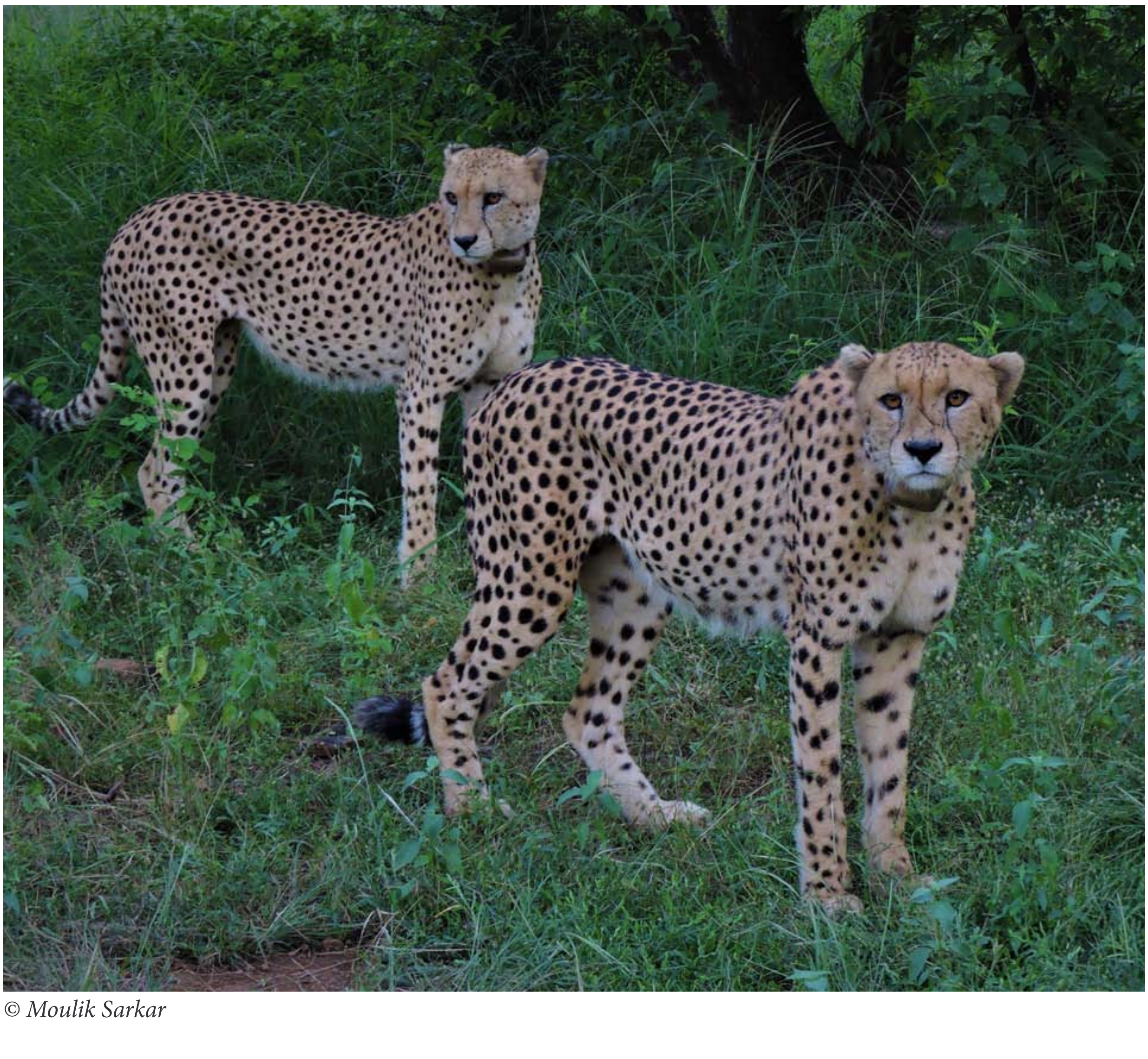
The world is witnessing a large-scale decline of biodiversity, particularly large carnivores at a rapid rate barring a few species. As a first step towards arresting and reversing this trend as well as to conserve these threatened species and revive ecosystem functions, interventions such as reintroductions/conservation translocations of large carnivores have increasingly been recognised as an important strategy. India has lost only one large carnivore, the cheetah (*Acinonyx jubatus*) in recent history during the early 1950s primarily due to overhunting and habitat loss. Reaffirming India's commitment to biodiversity conservation, cheetahs were brought back to the country in a first-ever intercontinental wild to wild conservation translocation of a large carnivore in September 2022. The first batch of eight cheetahs was were transported by air from Namibia and was released in Kuno National Park, Madhya Pradesh by the Hon. Prime Minister of India and subsequently, the second batch of twelve cheetahs was translocated from South Africa in February 2023.

The primary goal is to establish free-ranging viable metapopulation of cheetahs in India as a flagship along with restoration of open natural ecosystems, degraded natural landscapes, and threatened species in the country's drier regions; scientific management of wildlife populations, habitat, and human-wildlife interface; landscape level enhancement of livelihood options through eco-development as well as eco-tourism and the larger cause of climate change mitigation through ecosystem restoration activities. Currently, there are 24 cheetahs in Kuno National Park including 12 adults and 12 cubs. A few mortalities occurred due to natural causes during the last one year. Further, cheetahs have managed to successfully coexist with the large carnivores in the area. The cheetahs are continuously monitored by teams of forest staff, veterinarians, and researchers for their well-being, to understand their ecology such as predation, movement as well as habitat use; and management interventions were administered as and when the situation demanded. Additionally, as conservation translocations/introductions can potentially shape the ecosystem with cascading effects throughout the food web, examining the dynamics, especially between existing carnivores and cheetahs in the introduction sites, helps elucidate the mechanisms that regulate their coexistence, competition for resources, and potential impacts on prey species. This holistic approach provides a comprehensive understanding of ecosystem health and functioning for which, research in aspects of system recovery and interactions including ecology, physiology, and behaviour of the cheetahs, co-predators (large and small) as well as of their prey species and their population trends as well as habitat monitoring are being undertaken. So far, cheetahs have predated on chital, sambar, chowsingha, chinkara, blackbuck, nilgai, and Indian hare. The free-ranging cheetahs covered large distances exploring the landscape and were shifted back to the Protected Area in a few cases.

As an initial step to understand ecosystem response and function, some of the species that are being intensively monitored through radio-telemetry are leopards, striped hyenas, golden jackals, jungle cats, and chital, for which preliminary patterns of movement and habitat use have been generated and additional spatial and temporal information is required for interpreting interactions and drawing robust inferences. Increasing the ungulate prey abundance through augmentation and multiple breeding enclosures (nurseries) as well as habitat restoration in Kuno National Park and the adjoining Wildlife Division is essential to sustain the current population of leopards and cheetahs. Outreach activities have been carried out by the Park management in villages outside the Protected Areas.

The landscape management of the cheetah population would require an integrated approach through the development of a multi-sectoral masterplan for cheetah conservation incorporating Protected Area(s) and the surrounding areas as well as adjacent territorial forest divisions, community outreach, awareness, capacity building, eco-development, and eco-tourism. The contiguous forest habitat is ~6800 km² in Kuno landscape with a potential cheetah habitat of ~3200 km² and has to be secured for cheetah conservation over a period of the next ten years. The cheetahs in Kuno is envisioned to be managed as a metapopulation with three-five sites as prescribed by the action plan for the introduction of cheetah in India. As the second site for cheetah introduction, preparations in Gandhi Sagar Wildlife Sanctuary, Madhya Pradesh include the construction of a ~28 km long predator-proof fence securing an area of ~64 km^2 for initial release of cheetahs; near completion of veterinary, monitoring, and protection infrastructure; partial prey augmentation (more are required) and breeding enclosures for prey; water, grassland and large predator management; and community outreach. Simultaneous efforts are needed to initiate efforts towards restoration of habitat and prey outside the fenced area in Gandhi Sagar Wildlife Sanctuary so that cheetahs can be released into free-ranging conditions in the next five years.

In the Gandhi Sagar landscape surrounding the Protected Area, securing a suitable contiguous large landscape as a transboundary management unit with an area of ~2500 km^2 potential cheetah habitat can be ensured with efforts towards conservation and sustainable management over the next 10-15 years. For strategizing and prioritizing actions as well as for management of these landscapes including habitat restoration/ consolidation, spatial depiction of multiple human activities/infrastructure and invasive species along with administrative units in the areas have been identified. Both these landscapes along the interstate border of Madhya Pradesh and Rajasthan are adjacent to each other and the combined landscapes together can constitute the Kuno-Gandhi Sagar cheetah landscape for metapopulation management of 60-70 cheetahs after restorative measures, prey, availability, and scientific management are effectively in place, as an interstate cheetah conservation complex within the next 25 years under the umbrella of Project Cheetah.



Bringing back the

CHEETAH

to India

Restoring Nation's Natural Heritage
Reviving Open Natural Ecosystems


LIVE
ANIMALS

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1. Introduction

Apex predators are instrumental in maintaining the integrity and functionality of ecosystems (Ripple *et al.* 2014). Beyond their ecological significance, as powerful icons of conservation, large mammalian carnivores also play an important role in shaping international environmental policies (multilateral biodiversity conservation agreements such as the Convention on Biological Diversity (CBD)) and global economics (environmental diplomacy and biodiversity funding) (Lindsey *et al.* 2013). Additionally, they contribute to the stimulation of local economies through ecotourism, resulting in the creation of job opportunities, infrastructure development, and facilitating cultural exchanges (Woodroffe *et al.* 2005). Moreover, these charismatic animals often hold deep cultural and symbolic value for Indigenous communities and societies (Holmes 2014). Despite their importance, most large mammalian carnivores face various threats impacting their existence and survival in rapidly changing landscapes (Treves & Karanth 2003). Human activities such as habitat destruction, encroachment, and fragmentation isolate carnivore populations, while poaching and illegal wildlife trade pose severe risks to their survival (Woodroffe *et al.* 2005). Human-wildlife conflict cases of livestock depredation, attacks on humans, and, retaliatory killings, are becoming commonplace worldwide. Furthermore, climate change exacerbates the challenges by altering prey distribution and habitat conditions (Prugh *et al.* 2009).

The world is currently witnessing an unprecedented level of concern for the conservation of large carnivores and their habitats (Mech 1996, Weber & Rabinowitz 1996, Schaller 2009). To further this cause, reintroduction/conservation translocation of large carnivores represents crucial efforts in combating and potentially reversing the decline of these species and restoring ecosystem components. Breitenmoser *et al.* (2001) highlight the importance of these strategies in reversing the disappearance of large carnivores from their historical habitats. Through reintroductions/ conservation translocations, threatened species get a fighting chance for survival as well as the revival of critical ecosystem functions. However, it's essential to approach these endeavours with a thorough scientific understanding. While such initiatives have shown successes, they've also encountered failures, as noted by Smith & Bangs (2009) and Johnsingh & Madhusudan (2009). This underscores the complexity of reintroduction and translocation efforts, which necessitate careful planning, consideration of ecological factors, and adaptive management practices. Successful reintroductions and conservation translocations require comprehensive assessments/management of habitat suitability, prey availability, genetic diversity, and potential conflicts with human activities. Moreover, long-term monitoring and evaluation are vital to gauge the effectiveness of these interventions and adapt strategies accordingly. Ultimately, while the challenges are significant, the potential benefits of reintroducing large carnivores extend beyond species conservation to the restoration of entire ecosystems. Thus, a balanced approach that integrates scientific knowledge, stakeholder engagement, and adaptive management is essential for the success of such initiatives.

Despite tremendous demographic pressures, India has lost only one large wild mammalian species, the cheetah since gaining independence in 1947. Renowned for its speed and elegance, the cheetah holds a distinctive position in India's national conservation ethos. The word "Cheetah," is of Sanskrit origin, translating to "the spotted one." Evidence of the cheetah's historical presence in India is documented in ancient texts and depicted in Neolithic cave paintings found in central India, dating back as far as 10,000 to 20,000 years ago (Divyabhanusinh, 2006). Reviving the population of cheetahs entails the protection of their prey base, which includes several threatened species, and also the conservation of other endangered species inhabiting grasslands and open forest ecosystems. For example, the caracal (*Caracal caracal*), the Indian wolf (*Canis lupus pallipes*), and three species of the bustard family: the vulnerable Asian houbara (*Chlamydotis macqueenii*), critically endangered lesser florican (*Sypheotides indica*) and the most imperiled great Indian bustard (GIB) (*Ardeotis nigriceps*). Moreover, the decline of grassland and open forest-dependent species, both avian and terrestrial fauna, has been exacerbated by the need for appropriate policies. Consequently, these species have experienced more severe declines than those adapted to other biomes, primarily due to the qualitative and quantitative degradation of their habitats in the Indian subcontinent. Addressing these habitat challenges is imperative for the successful long-term conservation of the cheetah and other vulnerable species inhabiting these ecosystems. Therefore, the establishment of a cheetah metapopulation in India represents a significant endeavor with profound conservation implications.

To revive the country's lost natural heritage and restore the open natural ecosystems, the Government of India translocated cheetahs from Namibia and South Africa to Kuno National Park in Madhya Pradesh during 2022-23. The first batch of eight cheetahs shipped from Namibia were released by the Hon. Prime Minister of India. From the 20 animals that were translocated in two batches during 2022-23, at present, the total number of cheetahs in Kuno is 24 animals including 12 adults and 12 cubs, with a few mortalities (eight adult cheetahs and five cubs died due to various natural causes during 2023 & 24). During July-August 2023, all the free-ranging cheetahs were captured for treatment and housed in quarantine bomas due to health reasons and subsequently shifted to soft-release enclosures. Currently, all the cheetahs are in soft-release enclosures and will be released in a phased manner post-monsoon. In addition to continuous monitoring and management of the cheetahs, to understand the ecosystem functioning and response, a plethora of activities such as research and monitoring of co-predators, prey, and habitat; park and landscape management; community outreach, awareness, and capacity building activities are being carried out. The cheetahs in Kuno will be managed as a metapopulation with three-five sites as envisioned by the action plan for the introduction of cheetah in India. To this end, Gandhi Sagar Wildlife Sanctuary in Madhya Pradesh is being prepared as the second site for the introduction of cheetahs and the animals are likely to be brought here by the end of the year.

Image 1.1. *Cheetah in Kuno National Park © Shivang Mehta team/WII (Project Cheetah)*

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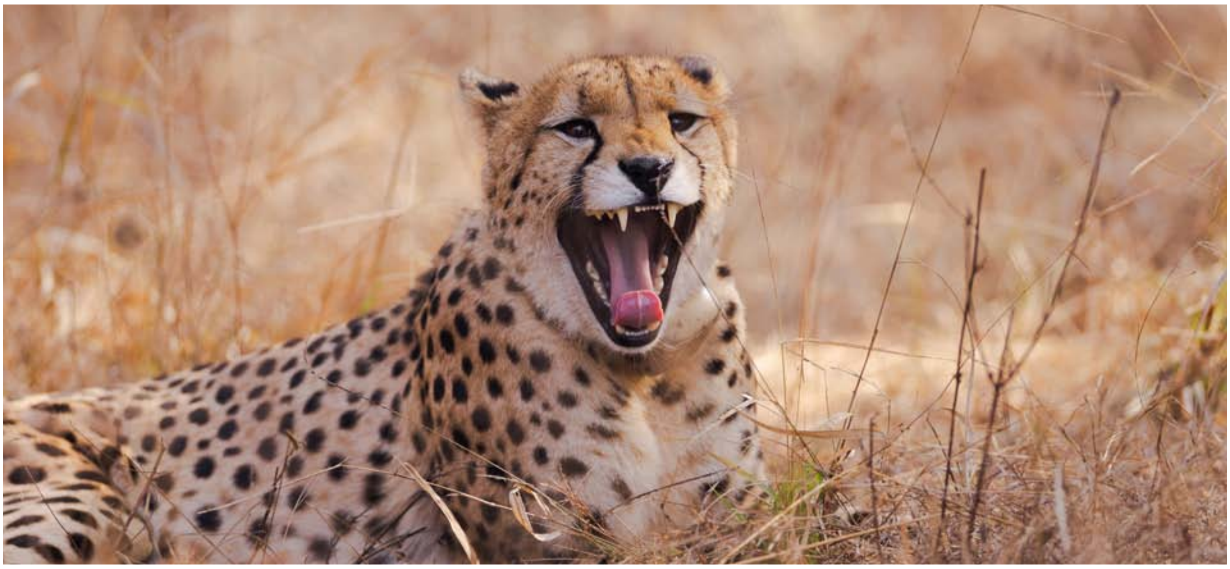
2.

Kuno-Gandhi Sagar cheetah meta-population management landscape

As recommended by the action plan, cheetahs in Kuno National Park (NP), as well as Gandhi Sagar Wildlife Sanctuary (WLS) and their adjacent landscapes will be managed as a metapopulation subsequently along with a couple of other sites. As the landscapes surrounding these two sites abut each other, the combined landscapes of Kuno and Gandhi Sagar together can constitute the Kuno-Gandhi Sagar cheetah landscape for metapopulation management of cheetah as an interstate cheetah conservation complex. This area is located along the State border of Rajasthan and Madhya Pradesh (M.P.) with the majority of the area situated in the Chambal River basin. Kuno NP is patchily connected to Gandhi Sagar WLS on the southwest through the territorial forest divisions of Baran, Jhalawar, Kota, and Chittorgarh along with Mukundara Tiger Reserve (TR) in Rajasthan and Mandsaur forest division in M.P. On the northwest, the connectivity is through Ranthambore TR, Ramgarh-Vishdari TR, and the forest division of Bundi and Bhainsrodgarh WLS in Rajasthan. These forest patches cumulatively cover an area of ~17,000 km^2 in M.P. (Area ~10,500 km^2) and Rajasthan (Area ~ 6,500 km^2). This larger Kuno Gandhi Sagar landscape is situated in the districts of Sheopur, Shivpuri, Gwalior, Morena, Guna, Ashoknagar, Mandsaur, Neemuch in M.P.; and Baran, Sawai Madhopur, Karauli, Kota, Jhalawar, Bundi, and Chittorgarh in Rajasthan. Districts of Bhind and Datia in M.P., Dholpur in Rajasthan as well as Lalitpur and Jhansi in Uttar Pradesh adjacent to this landscape would be incorporated as part of the landscape depending on cheetah's movement and use of these areas.



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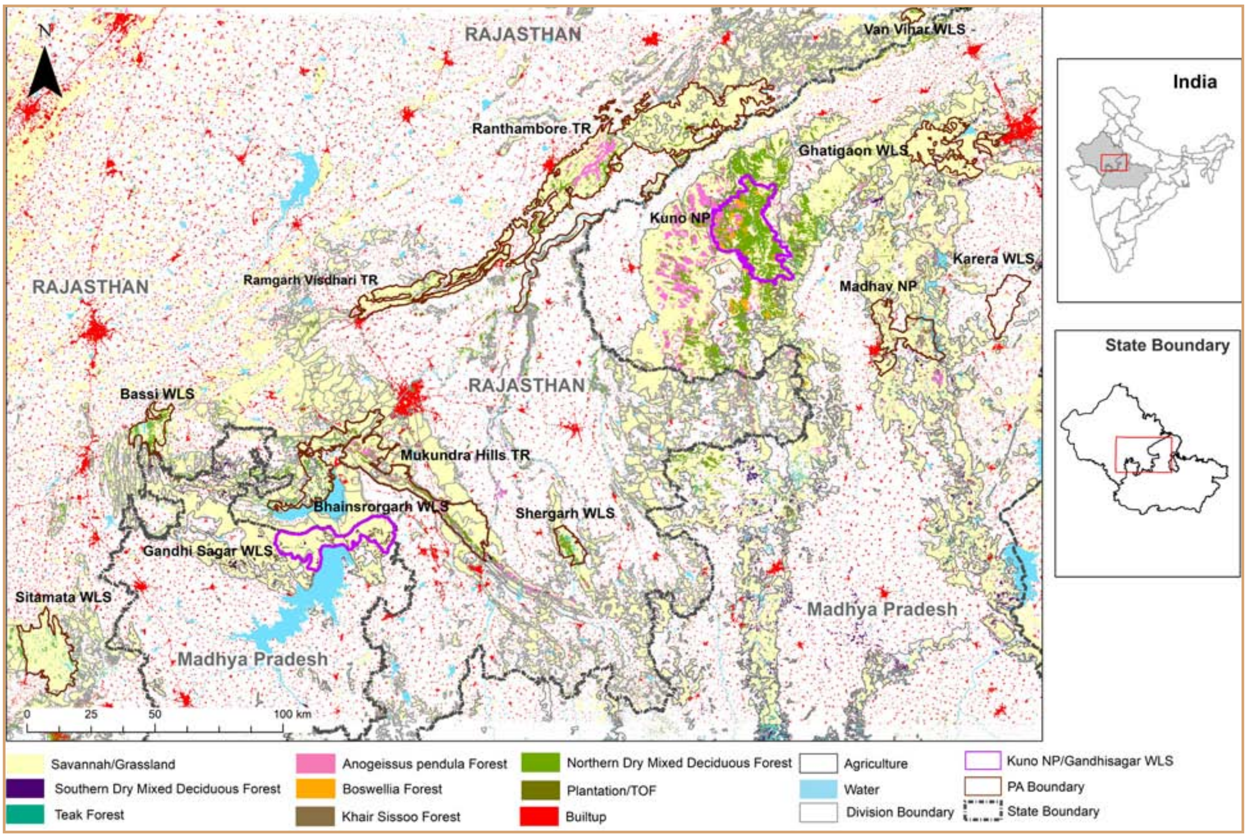

Figure 2.1. *Map of Kuno-Gandhi Sagar cheetah metapopulation landscape in the States of Madhya Pradesh and Rajasthan*

Table 2.1. *Administrative units in the cheetah metapopulation landscape of Kuno-Gandhi Sagar in the States of Madhya Pradesh and Rajasthan*

State	Division	District	Tehsil(s)	Forest Division(s)
Madhya Pradesh	Chambal (Morena)	Sheopur	Sheopur, Karahal, Bijaipur, Beerpur, Baroda	Kuno Wildlife & Sheopur Territorial
		Morena	Sabalgarh, Kailaras, Joura	Morena Territorial
	Gwalior	Shivpuri	Pohri, Shivpuri, Kolaras, Nar-war, Karera, Pichhore, Khani-yadhana	Shivpuri Territorial, Mad-hav NP
		Gwalior	Gwalior	Gwalior Territorial
		Guna	Guna, Raghogarh, Aron	Guna Territorial
		Ashoknagar	Isagarh, Chanderi, Maungaoli	Ashoknagar Territorial
	Ujjain	Mandsaur	Bhanpura, Garoth	Mandsaur Territorial
		Neemuch	Manasa, Jawad	Neemuch Territorial
Rajasthan	Bharatpur	Sawai Madhopur	Sawai Madhopur, Khandar	Ranthambore TR, Sawai Madhopur Territorial
		Karauli	Karauli, Sapotra, Mandrayal	Ranthambore TR & Karauli Territorial
	Kota	Baran	Shahbad, Kishanganj, Atru, Chhabra, Antah, Chippabarod	Baran Territorial & Kota Wildlife
		Kota	Ladpura (Kota), Sangod, Ramganj Mandi	Kota Wildlife, Mukandara Hills TR & Kota Territo-rial
		Jhalawar	Khanpur, Aklera, Asnawar	Jhalawar
		Bundi	Bundi, Hindoli, Nainwa, In-dragarh, Talera	Bundi Territorial & Ramgarh Vishdhari TR
	Udaipur	Chittorgarh	Rawatbhata, Begun, Nimbhera, Chittorgarh	Chittorgarh Wildlife & Chittorgarh Territorial

The Protected Areas situated in the landscape are -

Kuno NP, Madhav NP and Ghatigaon WLS in M.P., Ranthambore TR, Mukundara Hills TR, Ramgarh-Vishdhari TR, Bhainsrodgarh WLS, National Gharial WLS, Shergarh WLS, Bassi WLS, Shahabad Talheti Conservation Reserve (CR), Shahabad CR, Sorsan CR, Banjh Amli CR, Ummedganj Pakshi Vihar CR and Ramgarh CR in Rajasthan.

Table 2.2. *Land use/Land cover (Karra, Kontgis et al. 2021) in the Protected Areas and Forest Divisions of Kuno-Gandhi Sagar cheetah metapopulation landscape*

Land cover/use	Area (km^2) in the landscape			Percent		
	Kuno	Gandhi Sagar	Total	Kuno	Gandhi Sagar	Total
Grassland/ Savanna	11501.90	5315.47	16817.36	66.92	77.43	69.92
Agriculture	2815.13	699.88	3515.01	16.38	10.20	14.61
Forest	2683.53	711.59	3395.12	15.61	10.37	14.12
Water	122.73	76.92	199.65	0.71	1.12	0.83
Built area	64.89	60.80	125.69	0.38	0.89	0.52
Total	**17188.16**	**6864.66**	**24052.83**			

***Table 2.3.** Human footprint index (Mu et al. 2022) in the Forest Divisions and Protected Areas in Kuno-Gandhi Sagar cheetah metapopulation landscape*

Forest Division/Protected Area name (State)	Human footprint index	Road length	Railway track length
Kuno Wildlife Division (including Kuno NP) (M.P)	8.06	241.57	0.00
Sheopur (M.P)	9.04	708.39	54.24
Morena (M.P)	11.00	342.22	40.80
Shivpuri (M.P)	11.40	1253.04	107.69
Ranthambore TR Division II (Raj.)	12.40	534.10	0.00
Madhav NP (M.P)	13.06	121.92	0.00
Gwalior (including Ghatigaon WLS) (M.P)	13.12	919.56	261.15
Mandsaur (M.P)	13.20	688.48	0.00
Neemuch (M.P)	13.63	1242.96	0.00
Ashoknagar (M.P)	13.89	387.54	36.13
Shergarh WLS (Raj.)	14.46	35.11	0.00
Ramgarh Vishdari TR (Raj.)	15.08	214.86	0.00
Guna (M.P)	15.59	4428.91	27.09
Bhainsarogarh WLS (Raj.)	15.98	164.37	0.00
Chittorgarh (Raj.)	16.13	2000.56	7.17
Mukundra Hills TR (Raj.)	16.17	645.81	18.62
Ranthambore TR Division I (Raj.)	16.31	1214.79	33.97
Baran (Raj.)	16.33	2715.20	41.67
Karauli (Raj.)	16.63	973.13	26.49
Bundi (Raj.)	18.97	1876.39	139.68
Jhalawar (Raj.)	20.59	2512.08	33.64
Sawai Madhopur (Raj.)	22.35	406.55	30.97
Kota (Raj.)	24.00	3181.28	98.66

TR- Tiger Reserve, NP- National Park, WLS- Wildlife Sanctuary, M.P.-Madhya Pradesh, Raj.- Rajasthan

***Image 2.2.** A female cheetah with cubs in Kuno National Park © Sumit Patel*

2.1. Requirements in Kuno - Gandhi Sagar cheetah metapopulation landscape

• Under the umbrella of cheetah conservation, developing a multisectoral masterplan for effective coordination of forest department with other government departments such as district administration, police, agriculture, revenue, animal husbandry, fisheries, transportation, panchayat and rural development, social welfare, tribal welfare etc. incorporating legal, administrative and financial mechanisms for implementation and monitoring (Gopal *et al.* 2023) with delegation of roles and responsibilities as well as accountability overseen by a competent authority.

• Constitution of multiple cheetah Rapid Response teams at the district level to provide safe passages for cheetahs in human-dominated areas of the landscape.

• Continuous awareness and sensitization programs at schools, colleges, and villages about wildlife, biodiversity, and nature emphasizing on the cheetah as well as biodiversity conservation issues and various schemes available with the forest department and other departments aligning with wildlife conservation. Dissemination of public opinion (pro-cheetah/conservation) developed by elected representatives as well as authorized government officials will be a regular process. There are no historically documented or known fatal attacks by cheetahs on humans, and this message along with the benefits of cheetah conservation through enhanced livelihood options has to be emphasized through outreach and awareness programs.

• Implementation of a modern smart patrol monitoring system such as MSTrIPES (Monitoring System for Tigers – Intensive Protection and Ecological Status) in the larger landscape. Monitoring prey populations, other carnivores, vegetation, anthropogenic disturbances, and understanding human-wildlife interactions in the landscape as well as capacity building of forest department staff.

• Livelihood securities of the local communities need to be ensured at any cost. Measures such as compensation/ex-gratia payment schemes for wildlife-related damages to property and life play a very important role in shaping successful conservation programs worldwide. Activities like timely and adequate payment for losses incurred due to wildlife would have to be considered as ecosystem maintenance costs that need to be paid to the local communities. Compensation cannot buy one's tolerance but is often perceived as an instant financial relief. Compensation rates for livestock predation for various livestock productivity classes would have to be decided after a thorough market survey and revised every couple of years. Options for provision of payment for crop losses due to wildlife as well as insurance schemes would have to be explored for losses against property and life.

• Veterinary initiatives in coordination with the animal husbandry department focusing on the vaccination of livestock including dogs and cats, and managing the dog population.

• Identification of potential wildlife corridors in the larger landscape on priority so that they can be safeguarded against conservation antagonistic land use patterns. This should be concomitant with the ecological restoration of the larger landscape.

• Vehicular traffic management in roads traversing forest areas in coordination with the transport department, particularly in wildlife-rich areas and potential wildlife corridors.

• During the summer season in this region, water can be a limiting resource and requires water management in drier parts of the PA and the landscape with at least one water hole within a radius of 4 km from each other, which would enhance the use of these areas by prey species and enhance the carrying capacity of the PA and the landscape.

• Grassland management by deterring the growth of woody species to promote natural prey base for cheetahs, leopards, and other endangered wildlife species of the region.

• Continuous efforts to eradicate weed species like *Lantana camara, Prosopis juliflora, Cassia tora, Ageratum conyzoides, Eupatorium spp.* etc from the grasslands. Another threat is the encroachment of grasslands by unpalatable species, which can reduce the area of productive grasslands (Rawat 2003). Woody tree growth would have to be regularly thinned to enable the existence of savannah-grasslands as an arrested successional stage, to promote a high density of wild ungulates.

• Measures to prevent fire are mostly in place as part of park management in Protected Areas and have to be implemented in the forest divisions of the landscape. Management of Non-timber Forest Produce (NTFP) collection and incidence of fire through increased surveillance and regulation.

• Restoration activity in the larger landscape that would involve the forest departments of M.P. and Rajasthan include managing grasslands, perennial water management, plantation of miscellaneous forage species like *Ziziphus, Acacia, Carissa, Dichrostachys, Aegle, Terminalia, Diospyros,* etc. to enhance the productivity and carrying capacity of the landscape.

• Eco-tourism which is sustainable and conservative, subservient to the conservation needs of the PA and of the project so that livelihood options for the local people can be created and the conservation agenda gets adequate public goodwill. Exploring options in complete consonance with the conservation objectives to generate revenues through brand building, marketing, sponsorships, merchandising, etc. would have to be carried out.

• Implementation of guidelines similar to the one provided by the NTCA's landscape management strategy in the Tiger Conservation Plan underlining the provision of incentives and enhancement of livelihood of resident communities, compensation for livestock kills, mitigation of human-wildlife negative interactions, and curtailment of high impact infrastructure as well as industrial developmental activities.

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***Image 2.3**. Female cheetah in the scrub forests of Kuno landscape © Geet Kale*

2.2. Kuno landscape

The forest patches in the Kuno landscape (Figure 2.2.1) span an area of ~11,500 km^2 spread across M.P. (Area~8833 km^2) and Rajasthan (Area~2733 km^2). In the landscape, contiguous forested habitat covers an area of about 6800 km^2, within which an area of over 3200 km^2 has high potential for cheetah occupancy. The region is classified under the Semi-arid - Gujarat Rajputana (zone 4B) bio-geographic zone (Rodgers *et al.* 2002). The average maximum summer temperature is reported as 42° C, while the lowest winter temperatures can get as low as 6° C (Chaudhary 2001). The average annual rainfall in the area is about 760 mm (Banerjee 2005).

Kuno NP located in the Sheopur district of M.P. covers an area of 748 km^2. The NP and adjoining buffer zone together constitute the Kuno Wildlife Division covering an area of 1235 km^2 (Kuno Management Plan 2020). The perennial Kuno River bisects the Park into almost two halves. The western side of the Park is situated on a plateau sloping into the river valley, whereas the eastern side has mostly flat terrain with gentle medium slopes (Chaudhary 2001). Kuno NP forms a contiguous forest landscape through the Shivpuri forest area with patchy connectivity to Panna TR. Towards the north-western boundary of the NP, the forest area is connected with Ranthambore TR across the River Chambal (Jhala *et al.* 2008). Kuno landscape is situated in the districts of Sheopur, Shivpuri, Morena, Gwalior, Guna, and Ashoknagar in M.P. along with Baran, Sawai Madhopur, and Karuali in Rajasthan. These areas were also traversed by free-ranging cheetahs during the last two years (Figure 2.2.2).

Image 2.2.1. *Kuno River flowing through dry deciduous forest in the National Park © Kesha Patel*

The predominant livelihood of the region is crop agriculture and livestock rearing. The human population density of the districts in the landscape is 242 per km^2 ranging from 104 per km^2 in Sheopur district to 445 per km^2 in Gwalior district. Livestock density of large stock (cattle and buffalo) is 91 animals per km^2, whereas the density of small stock (goat and sheep) is 39 animals per km^2. The largest urban centre of the landscape is Gwalior city followed by Shivpuri and Sawai Madhopur cities. Within the potential cheetah habitat of 3200 km^2 outside of the National Park there are 169 villages in this area.

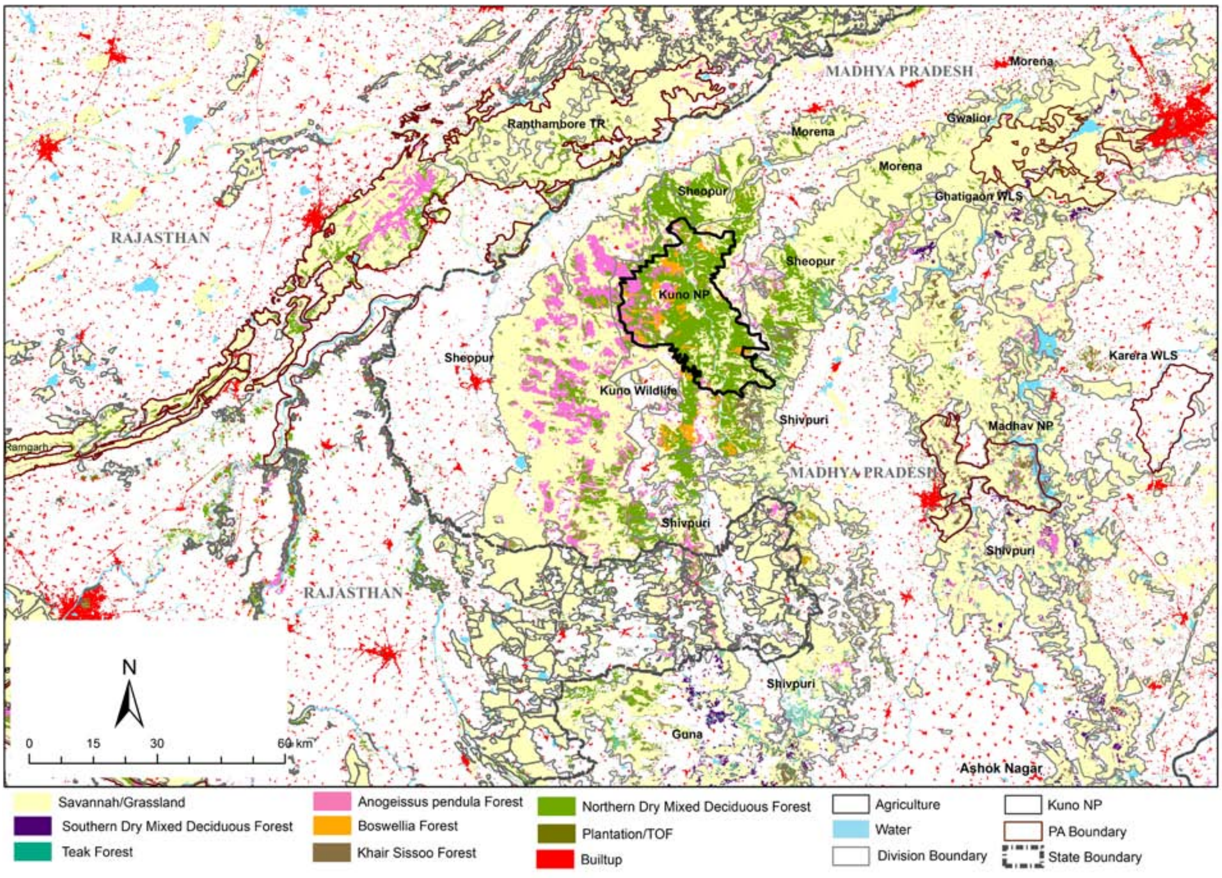

Figure 2.2.1. *Map of Kuno landscape depicted with various land cover/ land use categories*

According to the revised classification forest types of India (Champion & Seth 1968), the forests of Kuno NP and the surrounding region belong to the category of northern tropical dry deciduous. The tree species in the forests of the landscape are predominantly *Anogeissus pendula, Boswellia serrata, Acacia catechu, Acacia leucophlea, Diospyros melanoxylon, and Ziziphus spp.* A few of the shrub species found are *Grewia flavescens, Helicteres isora,* and *Vitex negundo*. Grass species comprise *Apluda mutica, Aristida hystrix, Cenchrus ciliaris, Dichanthium annulatum, Desmostachya bipinnata, Heteropogon contortus,* and *Themeda quadrivalvis*.

Commonly found mammals in the area are chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), wild pig (*Sus scrofa*), chinkara (*Gazella bennettii*), chowsingha (*Tetracerus quadricornis*), blackbuck (*Antilope cervicapra*), northern plains gray langur (*Semnopithecus entellus*), rhesus macaque (*Macaca mulatta*), Indian porcupine (*Hystrix indica*) and black-naped hare (*Lepus nigricollis*). Carnivorous mammals include leopard (*Panthera pardus*), striped hyaena (*Hyaena hyaena*), Indian wolf, sloth bear (*Melursus ursinus*), golden jackal (*Canis aureus*), ratel (*Mellivora capensis*), jungle cat (*Felis chaus*), Asiatic wild cat (*Felis lybica ornata*), rusty-spotted cat (*Prionailurus rubiginosus*), Indian fox (*Vulpes bengalensis*), Asian palm civet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*), Indian gray mongoose (*Herpestes edwardsii*), and ruddy mongoose (*Herpestes smithii*). Tiger (*Panthera tigris*) intermittently comes to the area mostly from Ranthambore TR.

Image 2.2.2. Grasslands of Kuno National Park © Shivang Mehta team/WII (Project Cheetah)

The major communities in the area are the Sahariya tribe, a sub-caste of Gonds; Gujjar, Yadav, Dhakad, Jatav, Bhil, and Moghiya. The main livelihoods of people are crop agriculture, pastoralism, casual labor, and collection of NTFP. Kuno NP is free of human settlements, owing to voluntary relocations that were carried out from the late 1990s onwards. Most of the villages (24) were resettled outside the Park boundary by the early 2000s and the latest relocation was completed by 2023.

Image 2.2.3. Leopard in Kuno National Park © Geet Kale

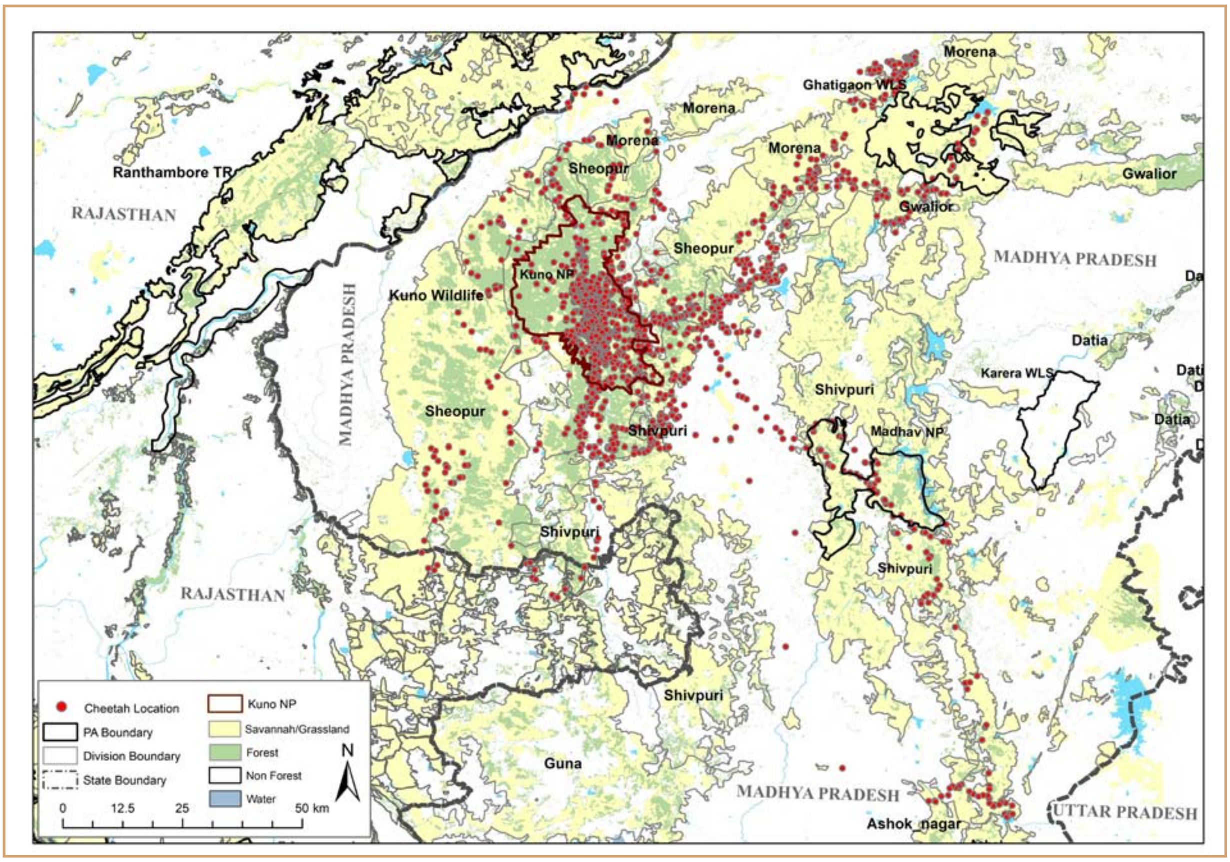

Figure 2.2.2. Map of cheetah movement in Kuno landscape

2.2.1. Human disturbances and invasive plant species in Kuno landscape

Based on data collected during the All India Tiger Estimation conducted in 2022, information on human disturbances and the presence of invasive species in forest divisions/PAs were collated for the landscape along with the human footprint index (Mu *et al.* 2022) and mapped to identify areas that require management as well as planning for prioritizing actions.

Human disturbances include tree cutting/lopping, grass/bamboo cutting, presence of humans/ livestock and their trails. Additionally, the road and railway network in the landscape was mapped. The invasive species depicted here include *L. camara, P. juliflora, Parthenium hysterophorous, Senna tora, A. conyzoides, Mesophaerum suaveolens,* and *Xanthium strumarium.*

© Nupur Rautela

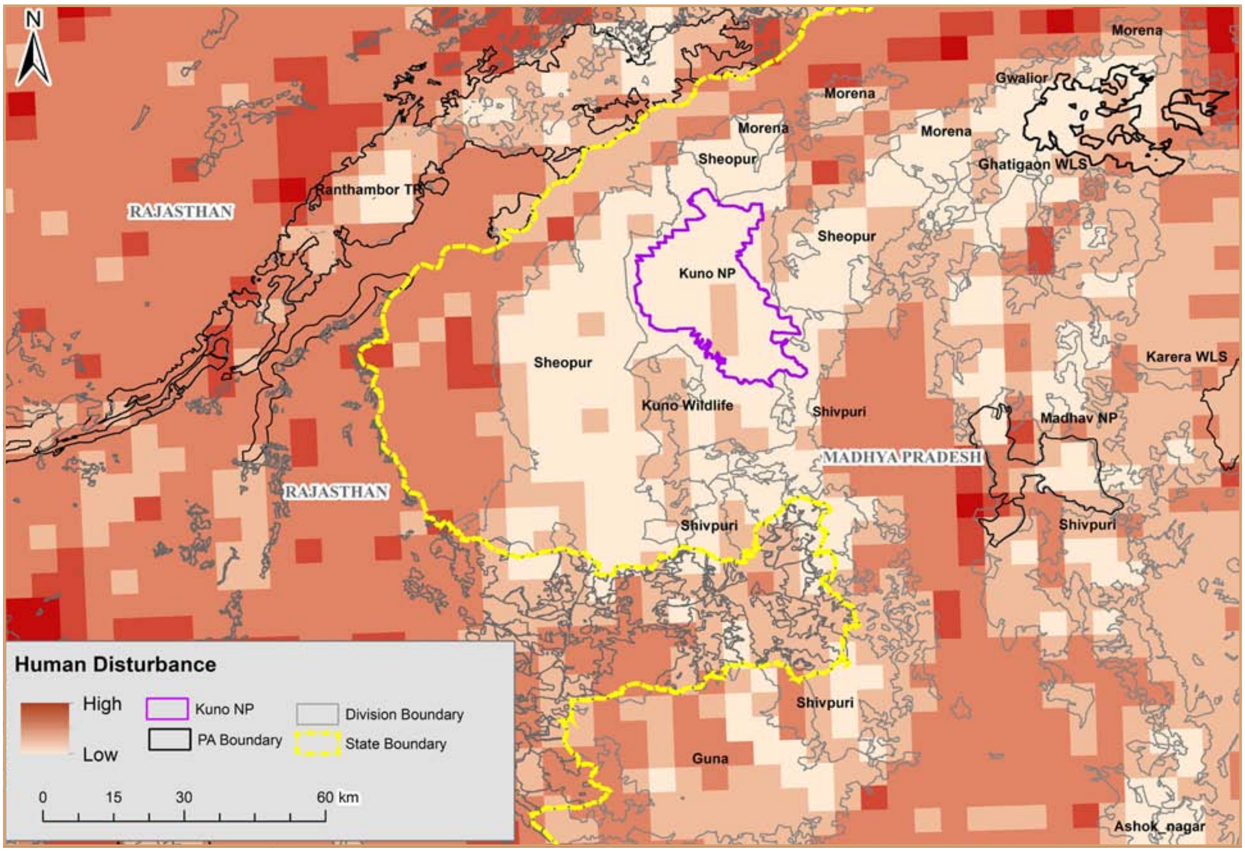

Figure 2.2.3. Map of human disturbances in Kuno landscape

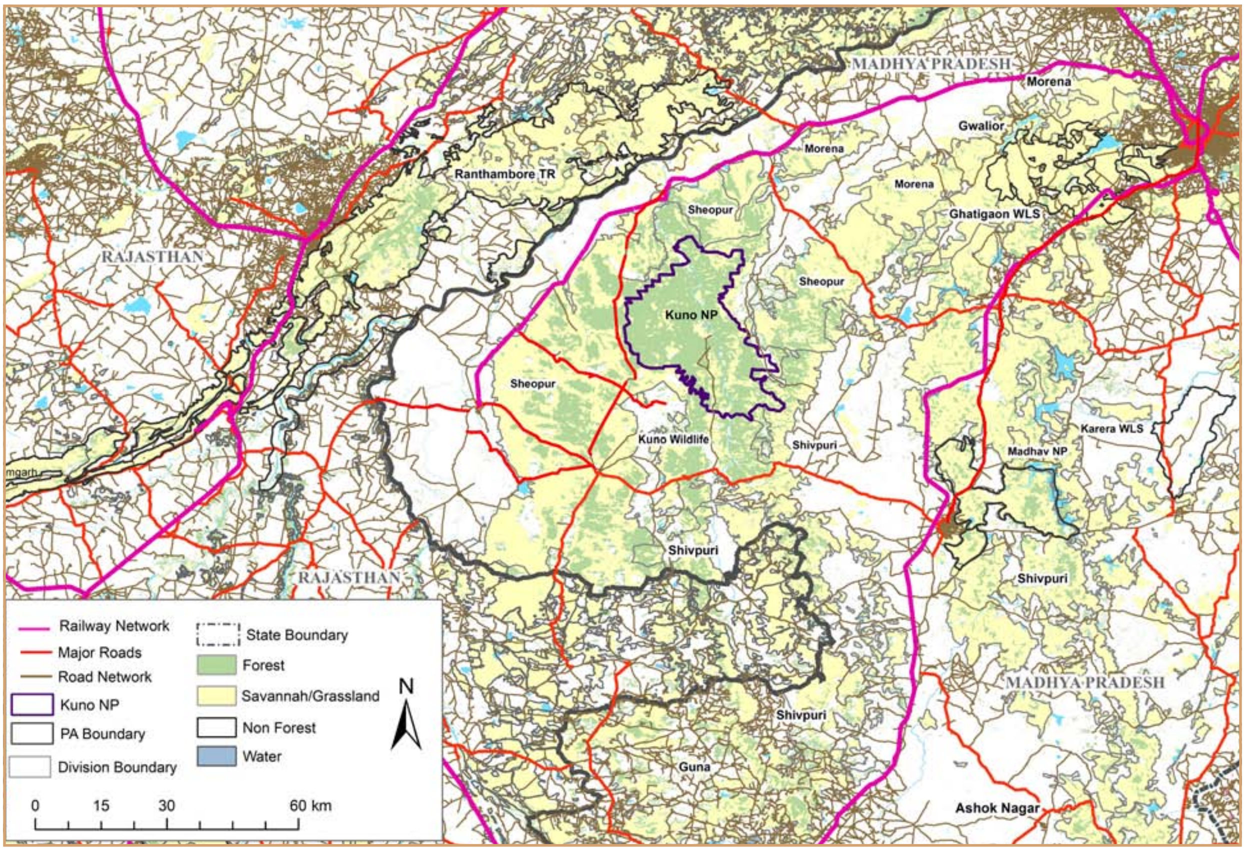

Figure 2.2.4. Road and Railway network in Kuno landscape

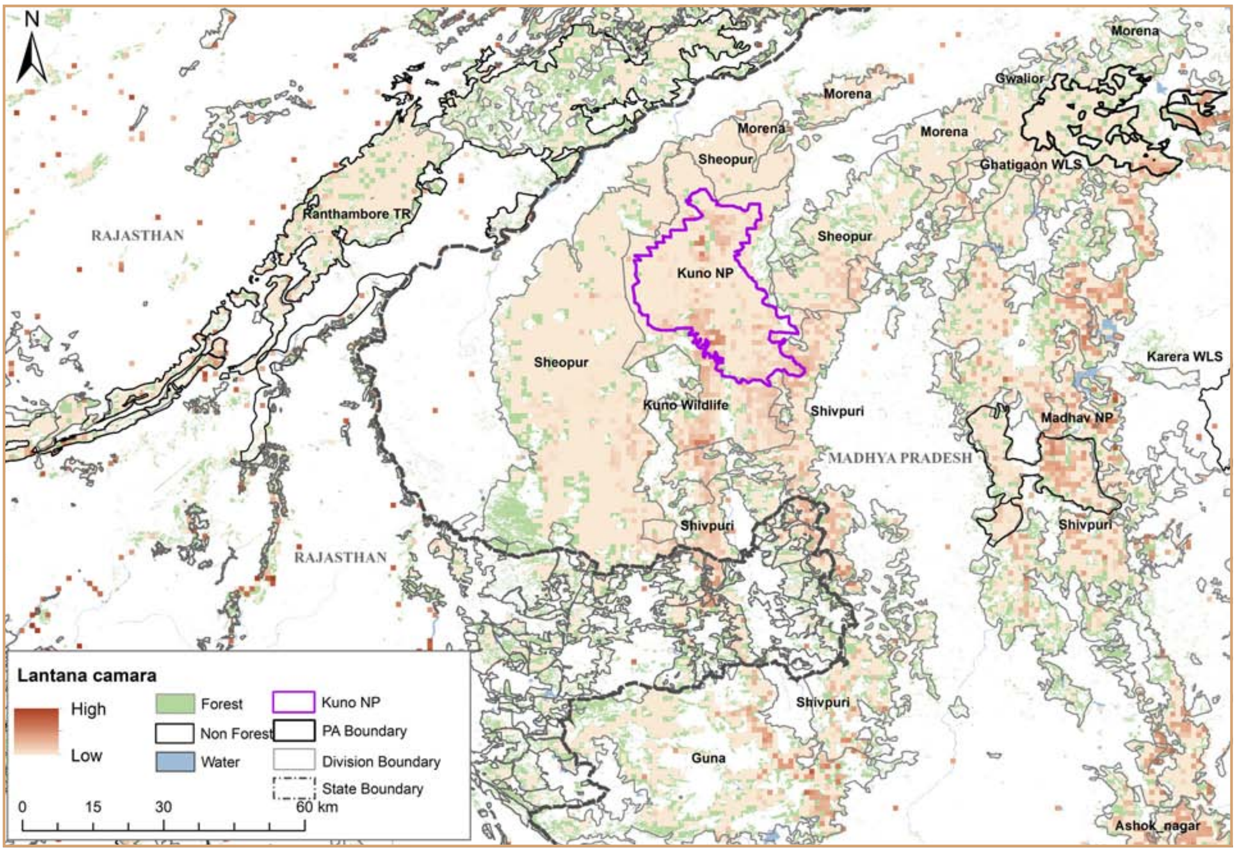

Figure 2.2.5. Potential distribution of Lantana camara in Kuno landscape

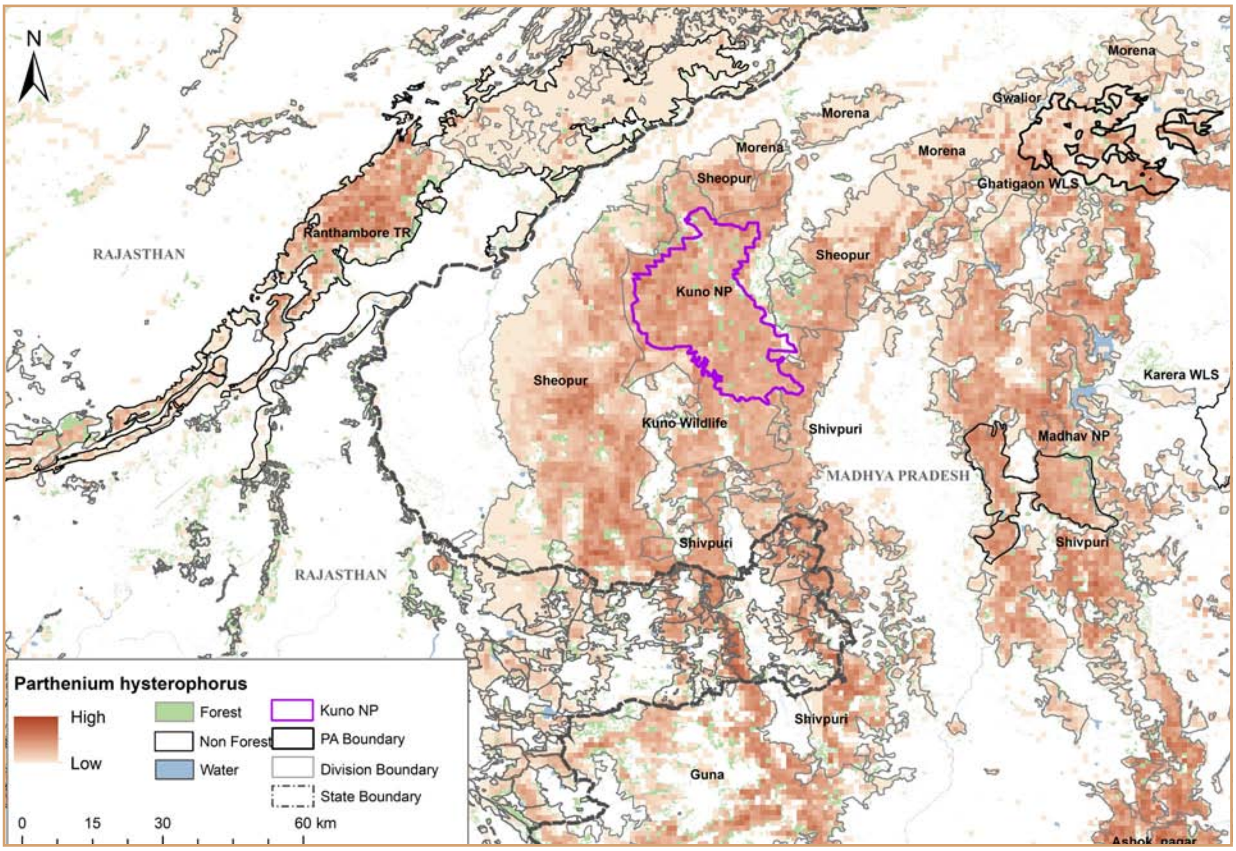

Figure 2.2.6. Potential distribution of Parthenium hysterophorus in Kuno landscape

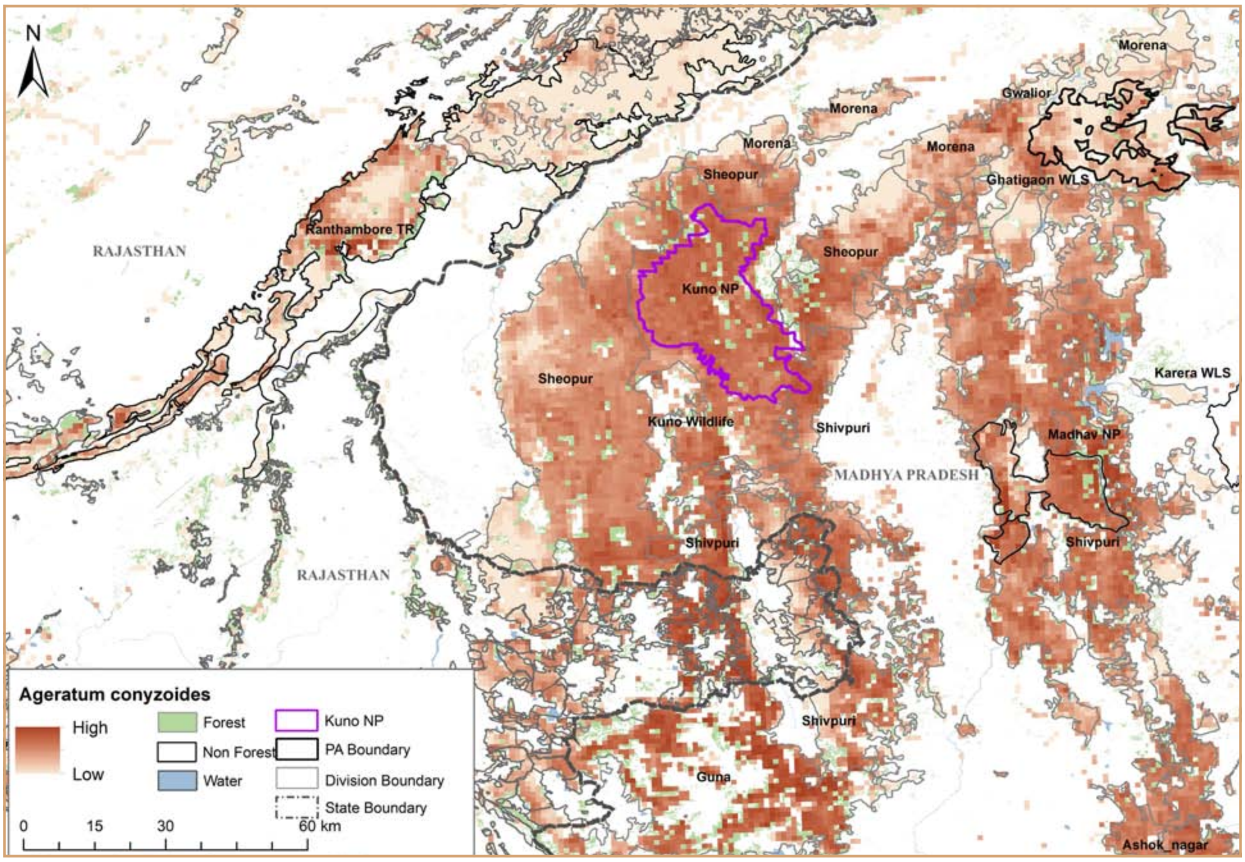

Figure 2.2.7. Potential distribution of Ageratum conyzoides in Kuno landscape

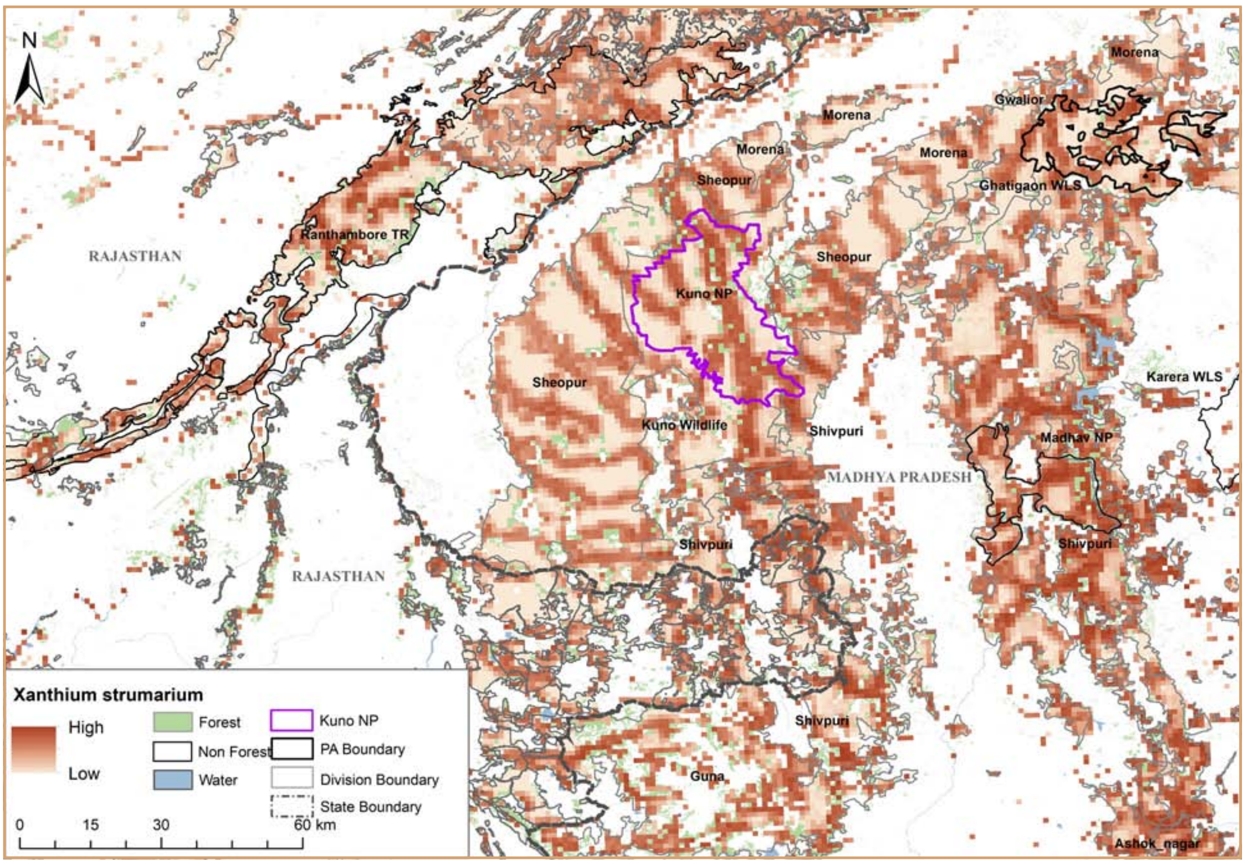

Figure 2.2.8. Potential distribution of Xanthium strumarium in Kuno landscape

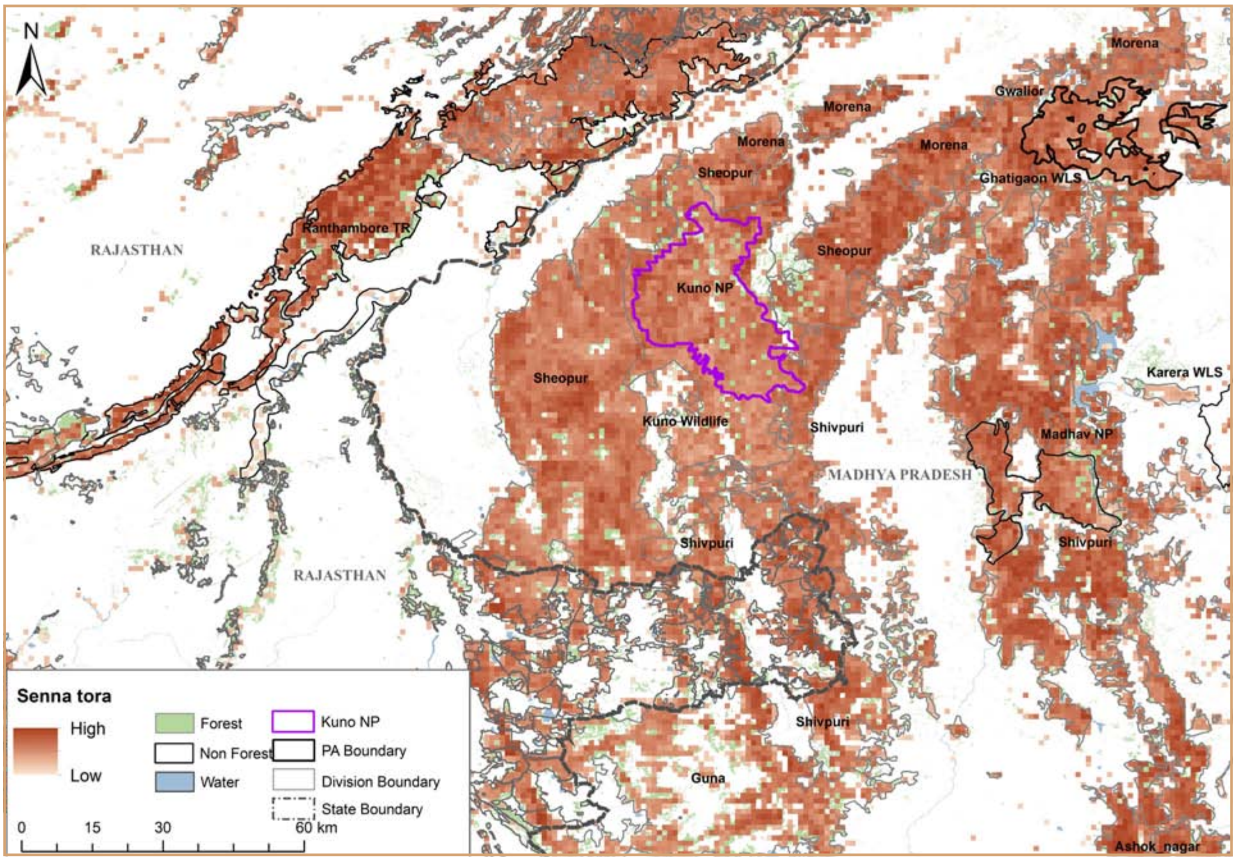

Figure 2.2.9. Potential distribution of Senna tora in Kuno landscape

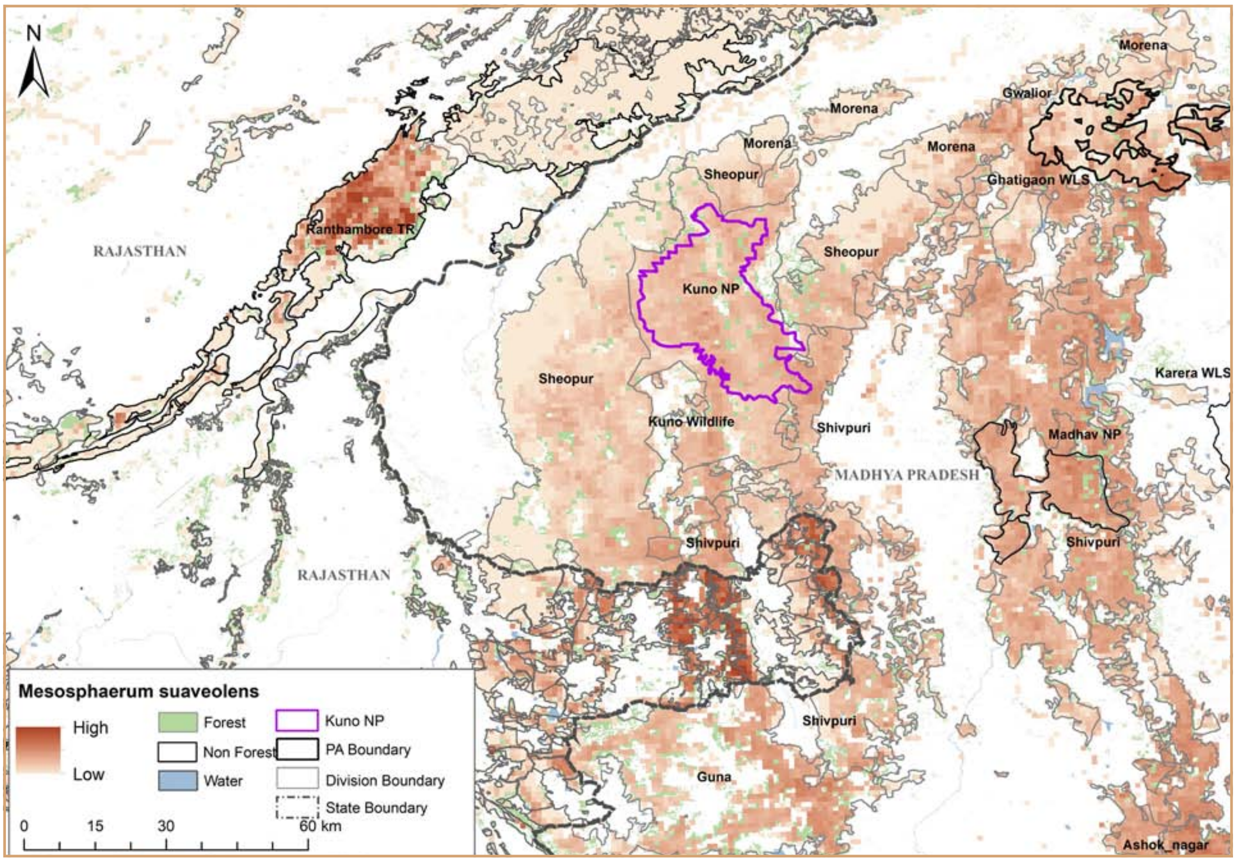

Figure 2.2.10. Potential distribution of Mesosphaerum suaveolens in Kuno landscape

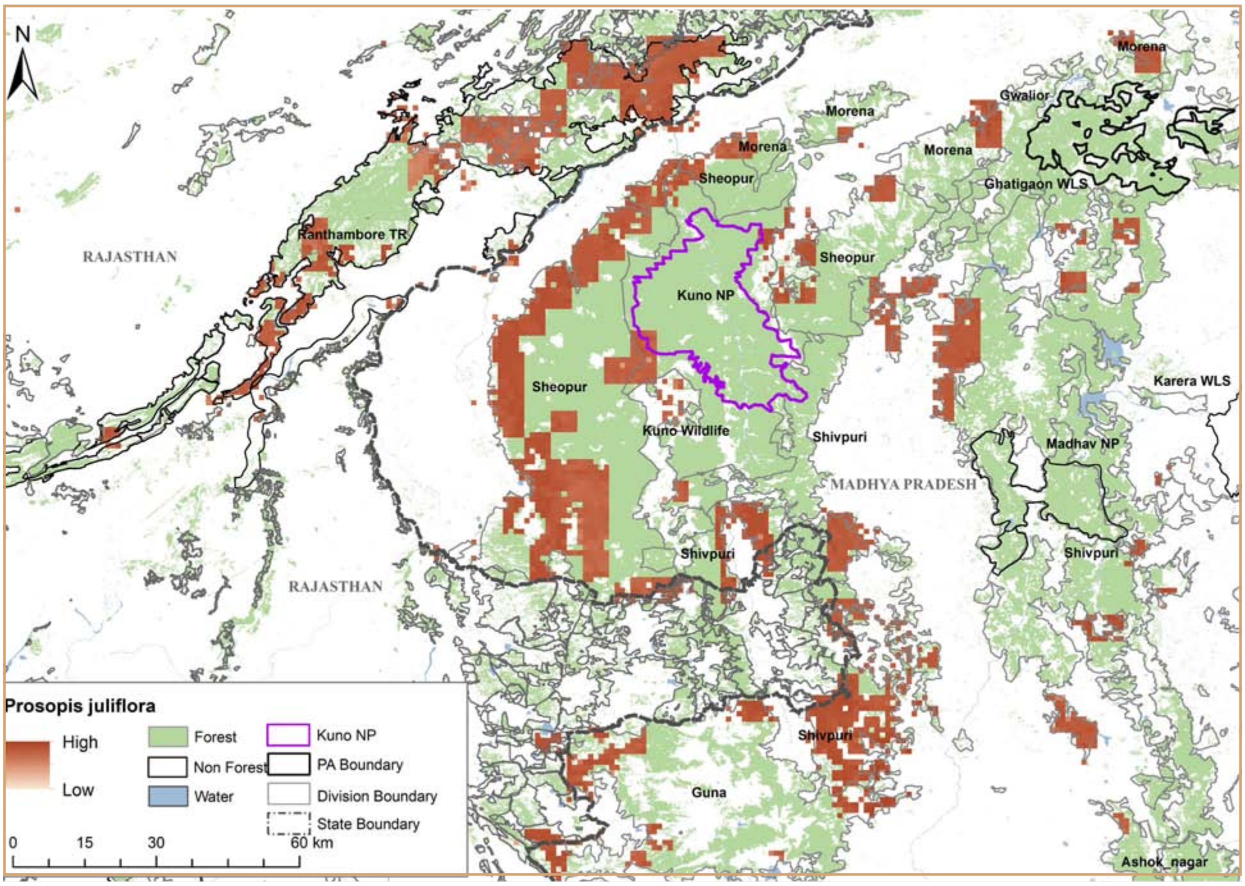

__Figure 2.2.11.__ Distribution of Prosopis juliflora in Kuno landscape

__Image 2.2.4.__ Dhonk forest in Kuno National Park © Kesha Patel

2.3. Gandhi Sagar landscape

In the long-term, along with the restoration of habitat and prey, this region comprised of vast savannah, grassland, and open woodlands has immense potential for cheetah conservation in a large landscape. The adjacent territorial divisions of Gandhi Sagar WLS- Neemuch (Area~1000 km^2), Mandsaur (Area~500 km^2) in M.P. as well as Bhainsrodgarh WLS (Area~ 208 km^2) part of Mukundara Hills TR and territorial division of Chittorgarh (Area~1000 km^2) in Rajasthan combined can form a large contiguous habitat of ~2500 km^2 for the cheetah. To enable the cheetah introduction and its expansion, commitments are required from the Government of M.P. for the allocation of Neemuch and Mandsaur territorial division as a buffer (or part) of Gandhi Sagar WLS and from the Government of Rajasthan for allocation of Bhainsrodgarh WLS, predator-proof enclosure in Mukundara Hills Tiger Reserve and territorial forests of Chittorgarh Division. The total forested area in this landscape covers about ~6500 km^2 across M.P. (~3850 km^2) and Rajasthan (~1600 km^2). Gandhi Sagar landscape is situated in the districts of Mandsaur and Neemuch in M.P. along with Chittorgarh, Baran, Jhalawar, and Bundi in Rajasthan. Securing a suitable contiguous large landscape area of ~2500 km^2 potential cheetah habitat can be ensured with efforts towards conservation and sustainable management as a transboundary management unit.

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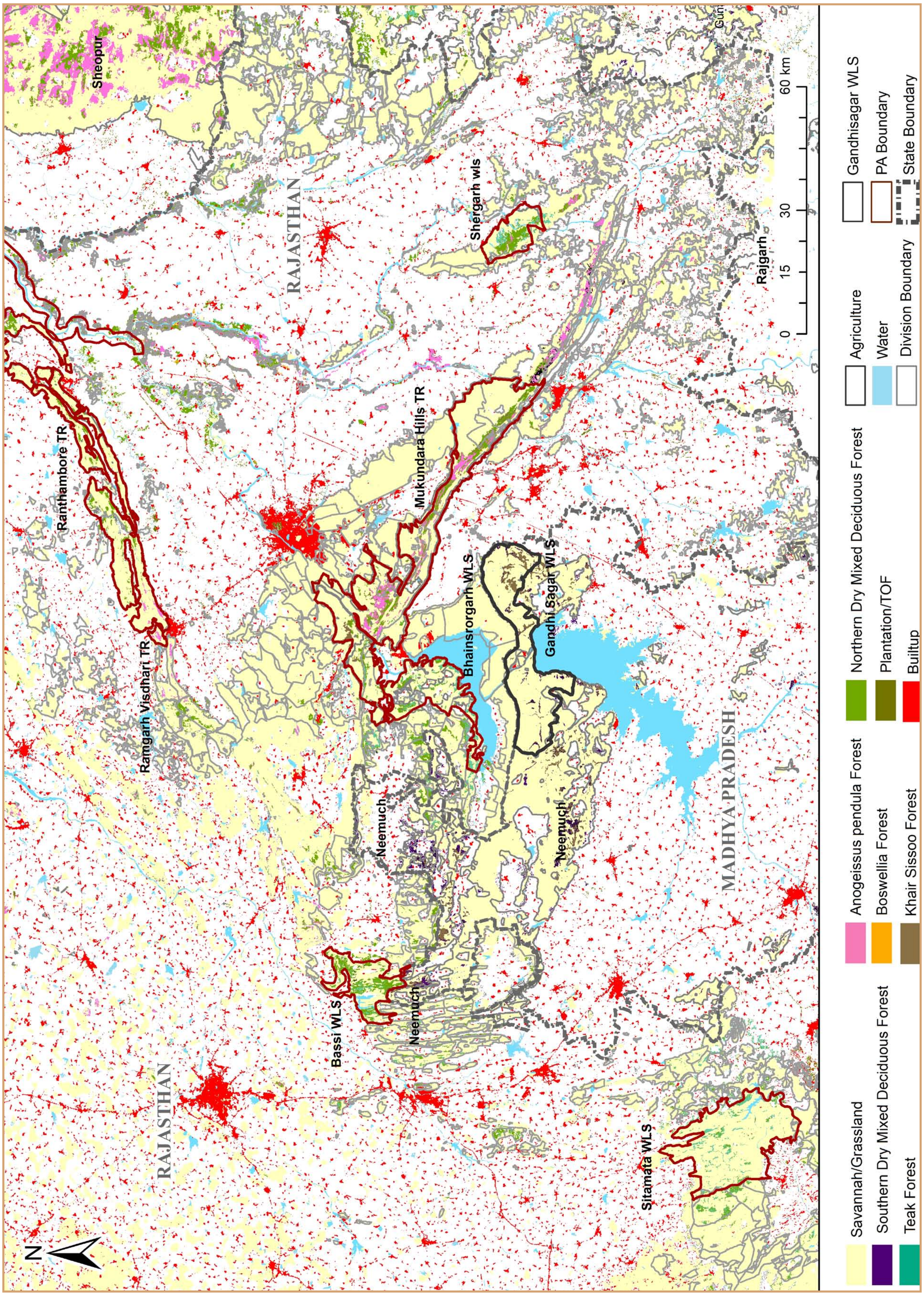

Figure 2.3.1. Map of Gandhi Sagar landscape depicted with various land cover/land use categories

Image 2.3.1. Open savannah in Gandhi Sagar Wildlife Sanctuary © Moulik Sarkar

Mostly crop agriculture and livestock rearing are the predominant livelihoods of the people in the landscape. The human population density of the districts in the landscape is 237 per km^2 ranging from 193 per km^2 in Neemuch district to 374 per km^2 in Kota district. Livestock density of large stock (cattle and buffalo) is 88 animals per km^2, whereas the density of small stock (goat and sheep) is 45 animals per km^2. The cities of Kota and Chittorgarh are the largest urban areas in the landscape.

Gandhi Sagar WLS (368.62 km^2) is situated in the districts of Mandsaur and Neemuch on the western part of M.P. The Sanctuary is part of the Malwa plateau, abutting either side of the Chambal River in almost two equal halves, and was notified in 1974. Bisected by River Chambal, the Sanctuary is administered by the Mandsaur Forest Division. Adjacent to the northern and eastern boundary (~60 km) of the park, lies the State of Rajasthan, whereas portions of the southern boundary are bordered by the reservoir of Gandhi Sagar dam. The reservoir of the dam spanning a wide area of ~750 km^2 acts as a natural boundary of the Sanctuary. The PA is patchily connected to Kuno NP through the forest of Kota and Baran divisions. In the West Range of the park, an area of ~64 km^2 has been cordoned off with predator-proof fencing within which the cheetahs will be released during the initial years. Multiple quarantine bomas for holding cheetahs as well as enclosures for prey stocking and breeding, with predator-proof fencing have been constructed inside the fenced area.

The Sanctuary is situated between 74°13’ and 75° 57’ east longitude and 23°46’ and 25°03’ north latitude. Gandhi Sagar WLS falls within the semi-arid zone (4b) of the Gujarat-Rajputana biogeographic region (Rodgers *et al.* 2002). The annual rainfall varies between 880 and 1000 mm whereas, the average maximum summer temperature reaches 42°C and the average minimum winter temperature is 10°C. The average elevation is 300-500 meters above mean sea level and consists of a rocky flat plateau top and river valleys scattered across the area. The majority of the area in the Sanctuary is flat with mild slopes in certain portions and the section along the length of Chambal River gorge is interspersed with rift valleys and steep cliffs.

The anthropogenic pressures present in the area are primarily due to livestock grazing and crop agriculture along the banks of the Chambal River. Additionally, fishery activities are prevalent in the reservoir, and particularly, fishing communities from West Bengal have been settled in the region by the Government. As the Sanctuary is situated on the interstate border, two busy main roads traverse the PA (State Highway 31A and Rawatbhata-Gandhi Sagar interstate road) and would require vehicular traffic management. Gandhi Sagar Township developed during the period of dam construction houses employees of the hydroelectric project of the dam, has been expanding gradually, and is centrally located between the two ranges. Within a distance of 10 km from the PA boundary, there are about 30 villages. Bhil, Banjara, Gurjar, Chamar, and Thakurs are the main communities of people living around the Sanctuary. Some of the crops cultivated in the region are wheat, gram, jawar, bajra, dhania, saunf, orange, and maize as well as vegetables. This area is well known for opium cultivation which is regulated by the Government.

Image 2.3.2. *Reservoir of Gandhi Sagar Dam bordering the Wildlife Sanctuary © Lakshman Gunukula*

The forest type of Gandhi Sagar WLS is northern tropical dry deciduous forest, northern tropical dry mixed deciduous forest, and dry deciduous scrub (Champion & Seth, 1968) and dominated by tree species such as *A. pendula, B. serrata, Diospyros melanoxylon, Ziziphus jujuba, Terminalia arjuna, and Butea monosperma*. Commonly found grass species are *A. mutica, Cynodon dactylon, Dichanthium annulatum, Digitaria ciliaris, Eragrostis spp., H. contortus, Sporobolus diandrus, T. quadrivalvis, and Vetiveria zizanioides*.

Carnivores found in the area include leopard, sloth bear, striped hyena, Indian wolf, golden jackal, Indian fox, ratel, jungle cat, rusty-spotted cat, Asiatic wild cat, Indian pangolin, common palm civet, small Indian civet, Indian gray mongoose, nilgai, chinkara, wild pig, gray langur, Indian porcupine and black-naped hare. Smooth-coated otter (*Lutrogale perspicillata*), and marsh crocodile (*Crocodylus palustris*) also inhabit the area. The Sanctuary and the surrounding areas are known to harbor red-headed vulture (*Sarcogyps calvus*), Indian vulture (*Gyps indicus*), and white-rumped vulture (*Gyps bengalensis*).

Image 2.3.3. Chinkara in Gandhi Sagar Wildlife Sanctuary © Lakshman Gunukula

2.3.1. Human disturbances and invasive plant species in the Gandhi Sagar landscape

As described above in section 2.2.1., using the data collected during the All India Tiger Estimation conducted in 2022, information on human disturbances and the presence of invasive species in forest divisions/PAs were mapped in the landscape for management and strategizing interventions.

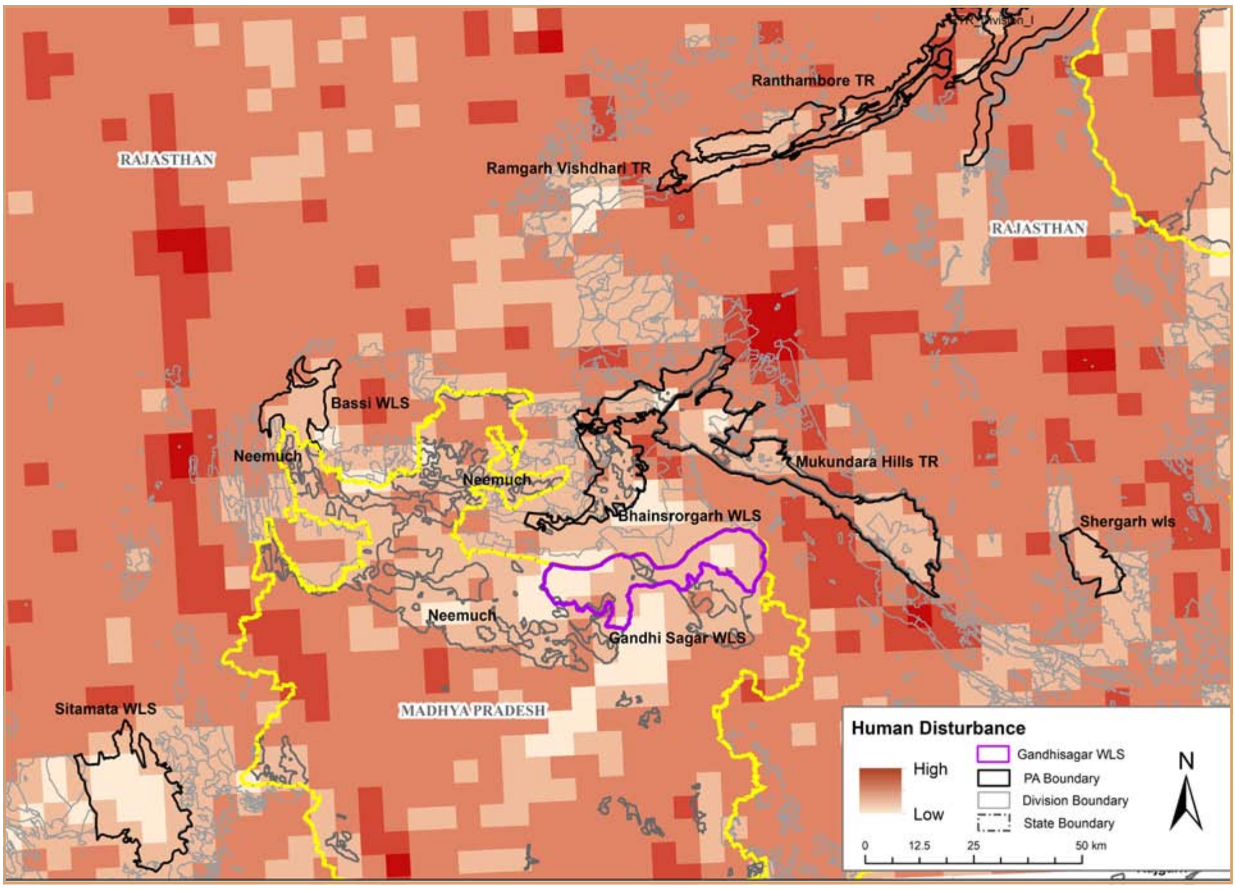

Figure 2.3.2. Map of human disturbances in Gandhi Sagar landscape

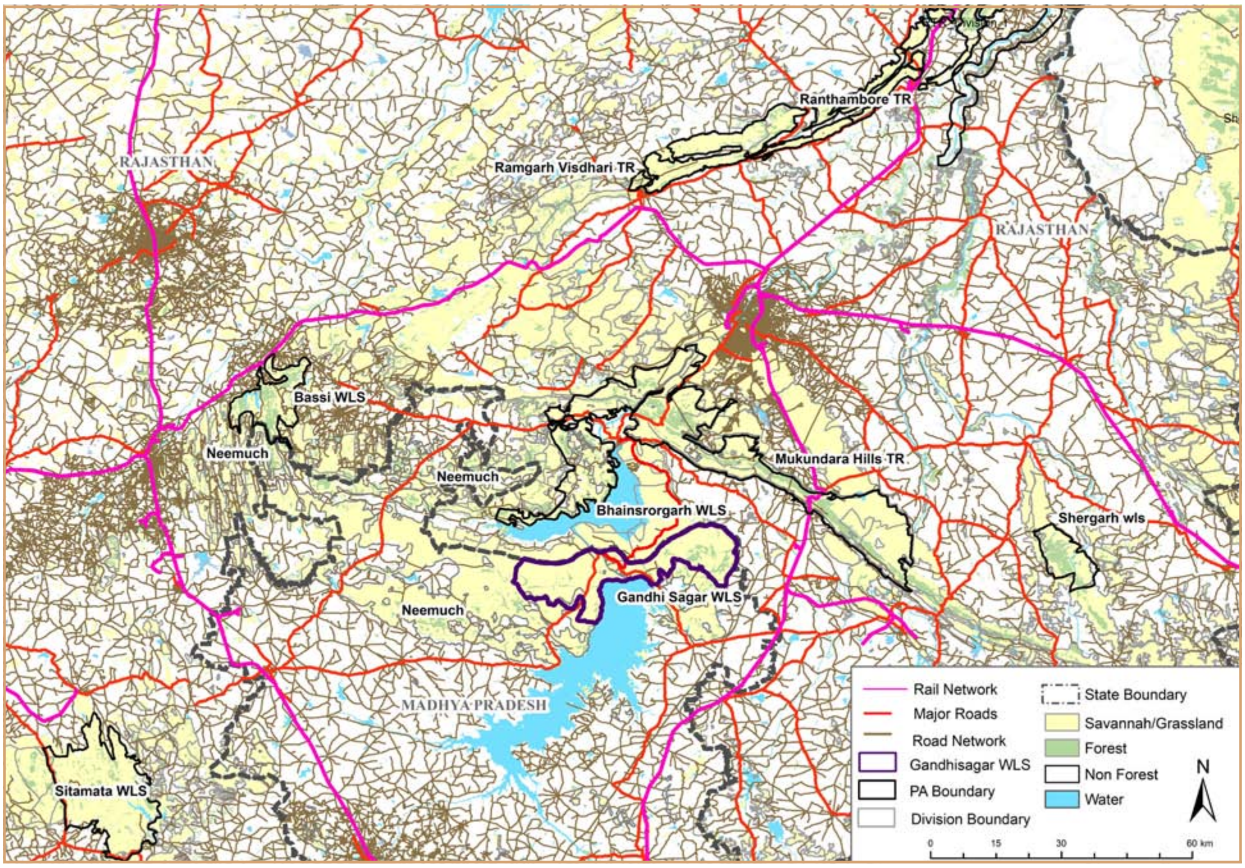

Figure 2.3.3. *Road and Railway network in Gandhi Sagar landscape*

Image 2.3.4. Livestock in Gandhi Sagar Wildlife Sanctuary © Moulik Sarkar

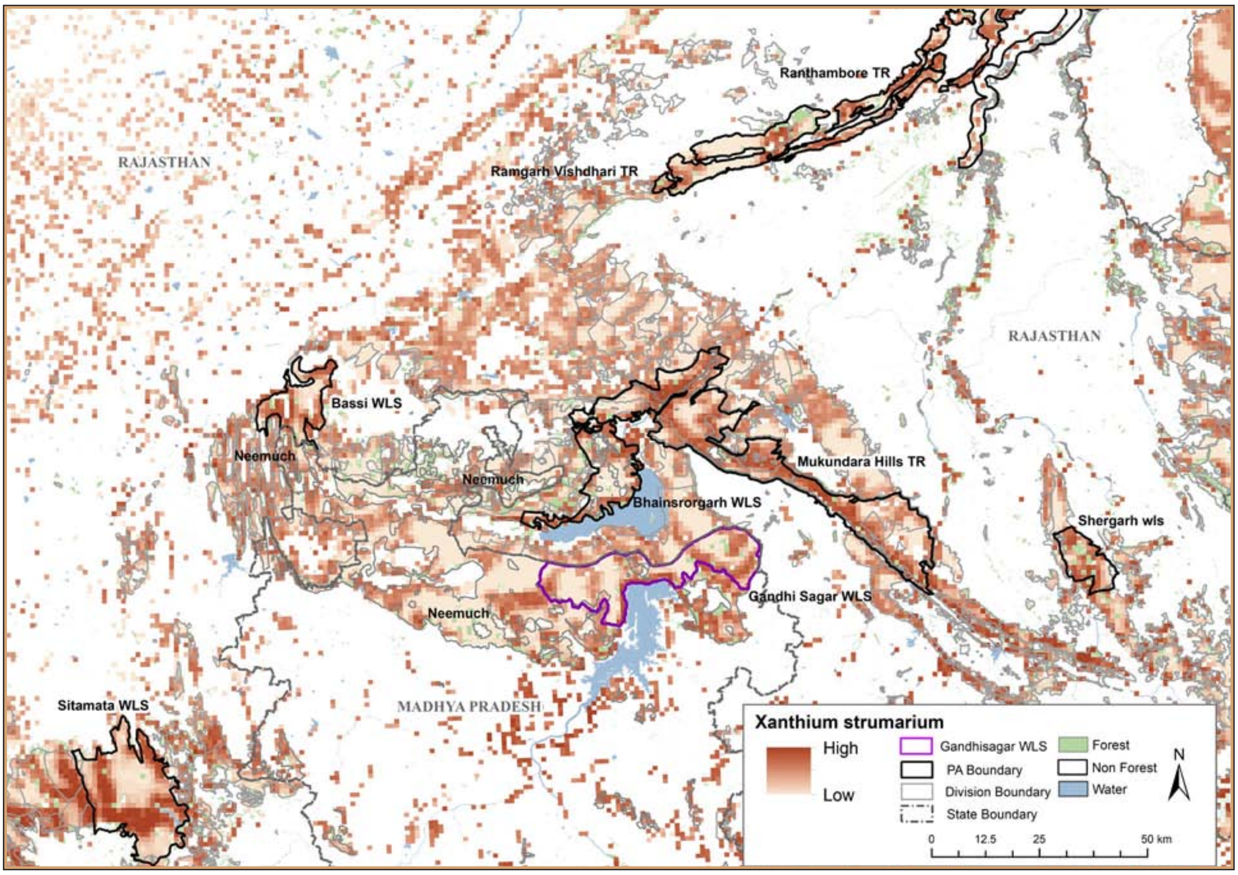

Figure 2.3.4. Potential distribution of Xanthium strumarium in Gandhi Sagar landscape

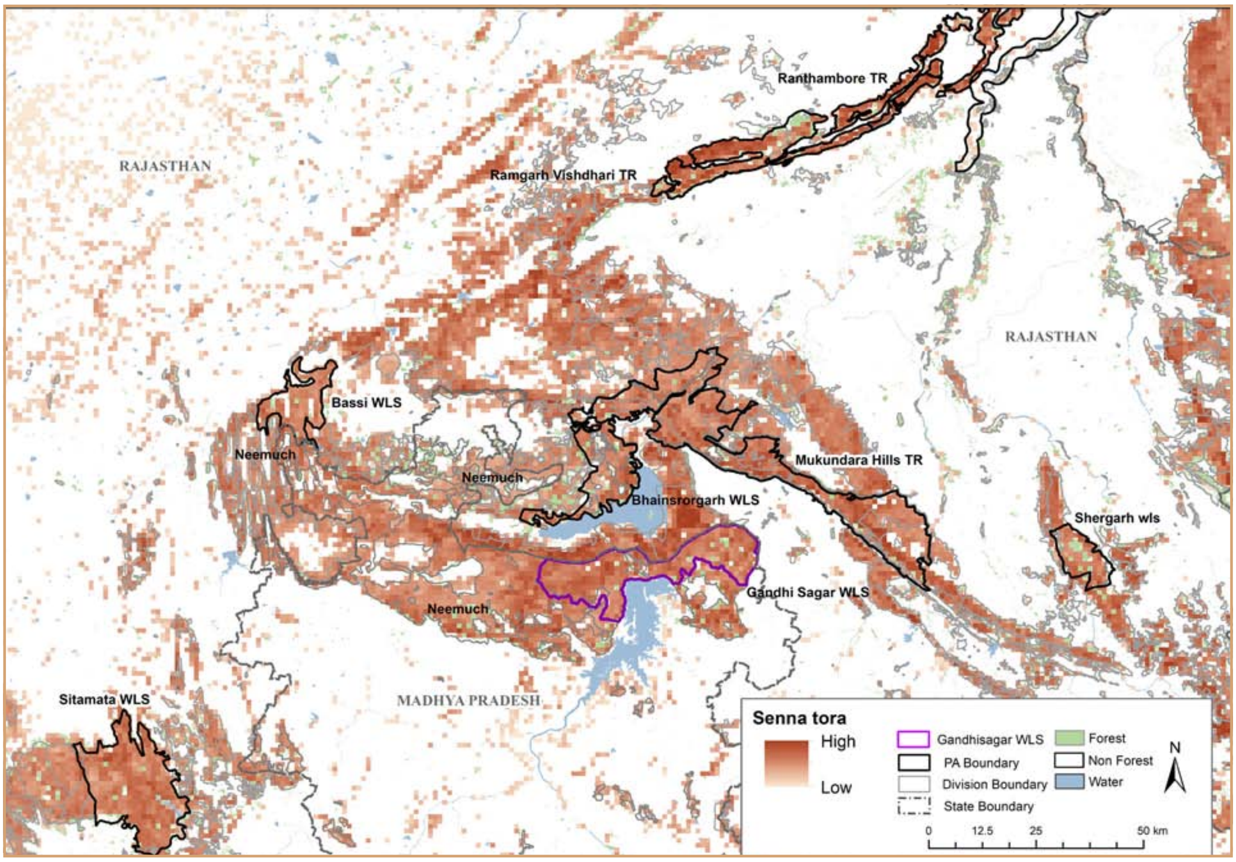

Figure 2.3.5. Potential distribution of Senna tora in Gandhi Sagar landscape

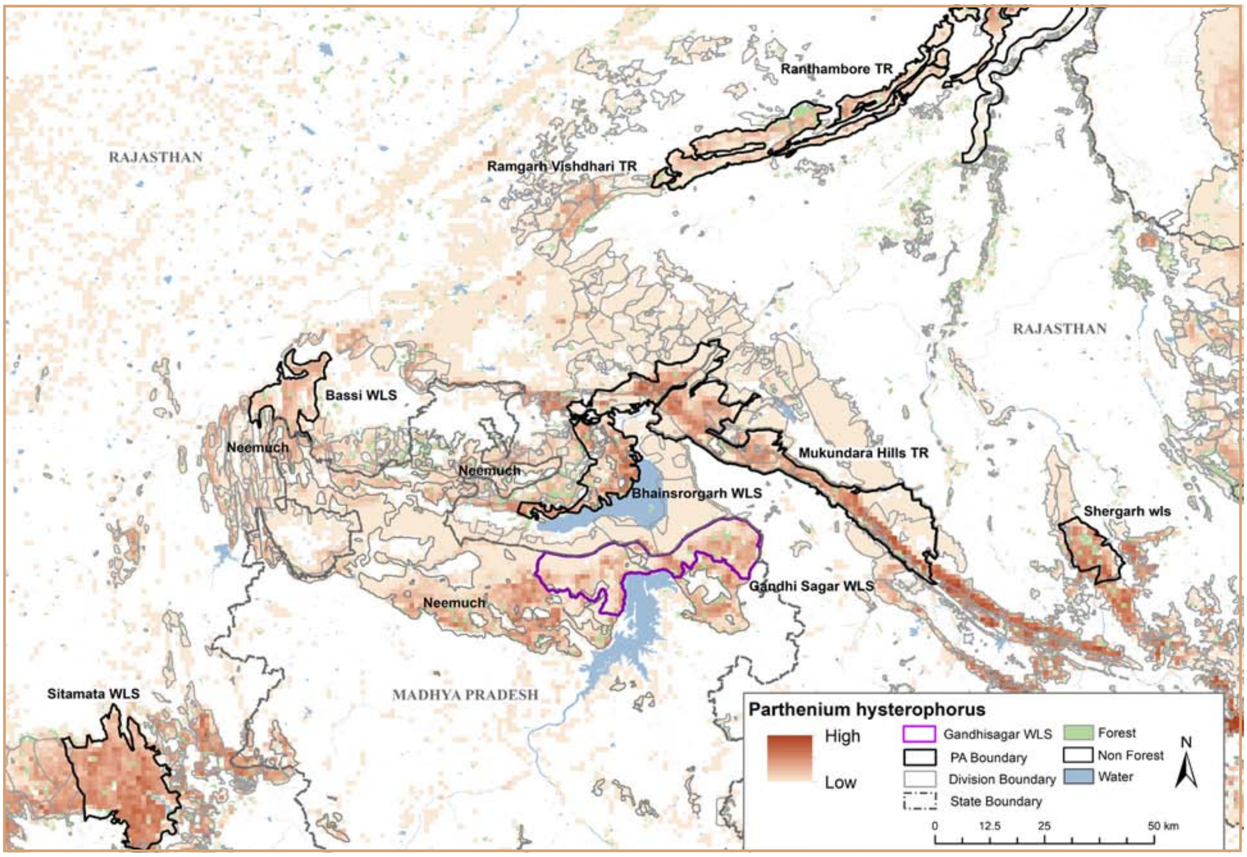

Figure 2.3.6. Potential distribution of Parthenium hysterophorus in Gandhi Sagar landscape

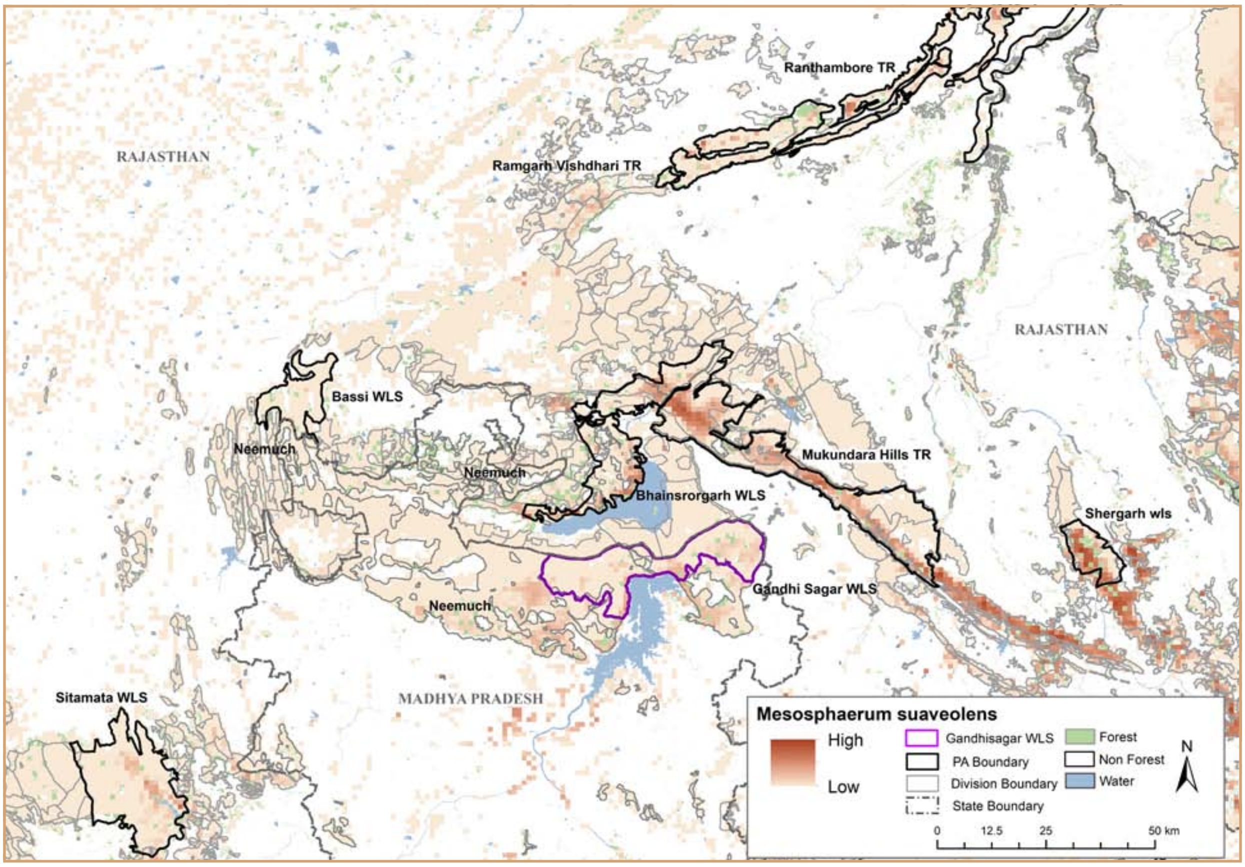

Figure 2.3.7. Potential distribution of Mesosphaerum suaveolens in Gandhi Sagar landscape

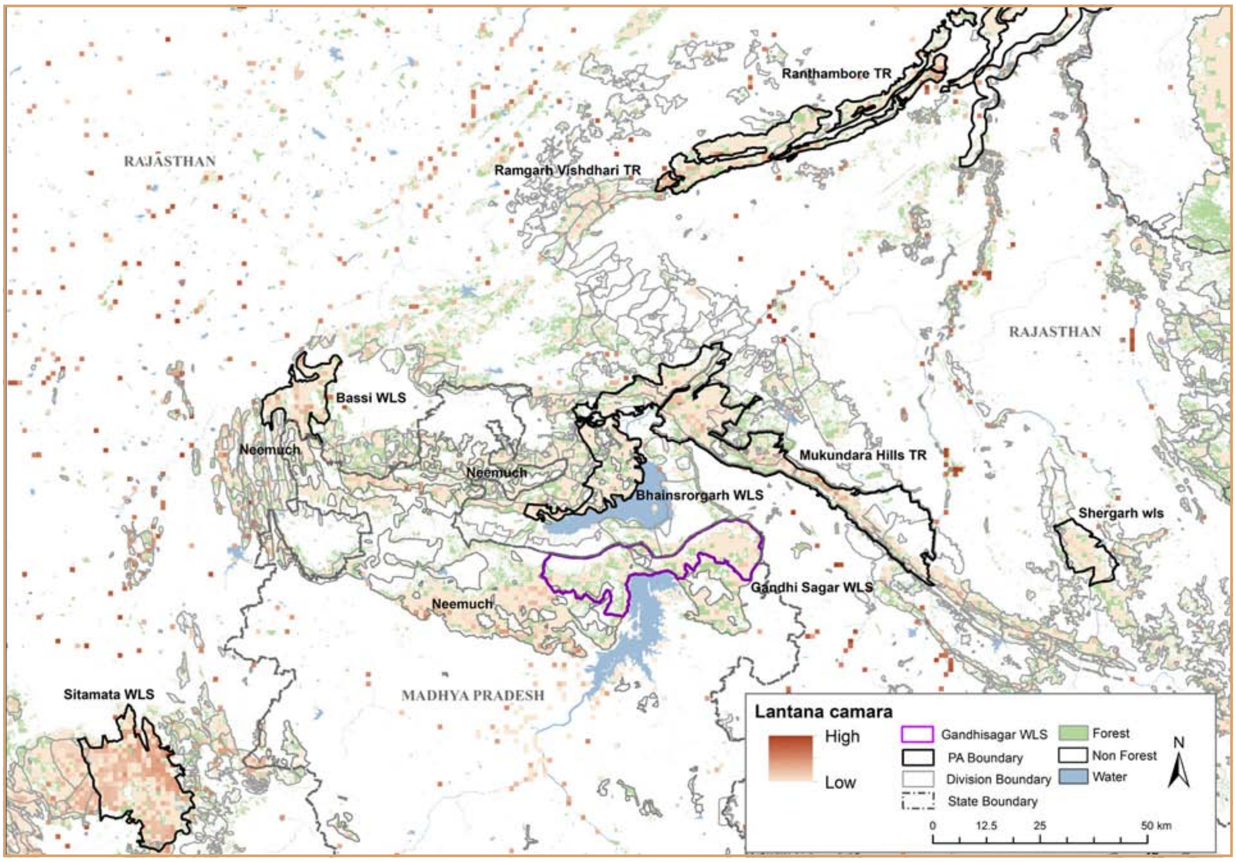

Figure 2.3.8. Potential distribution of Lantana camara in Gandhi Sagar landscape

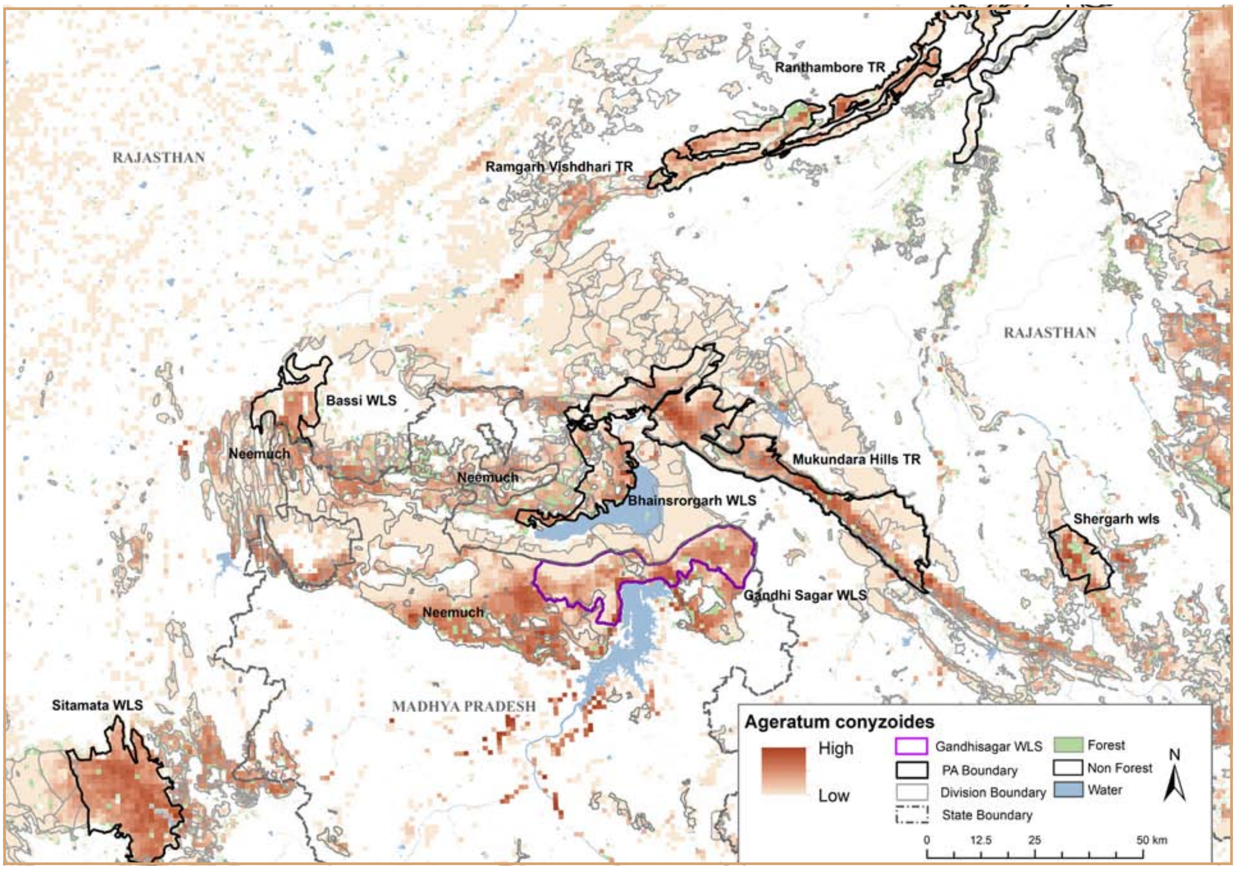

Figure 2.3.9. Potential distribution of Ageratum conyzoides in Gandhi Sagar landscape

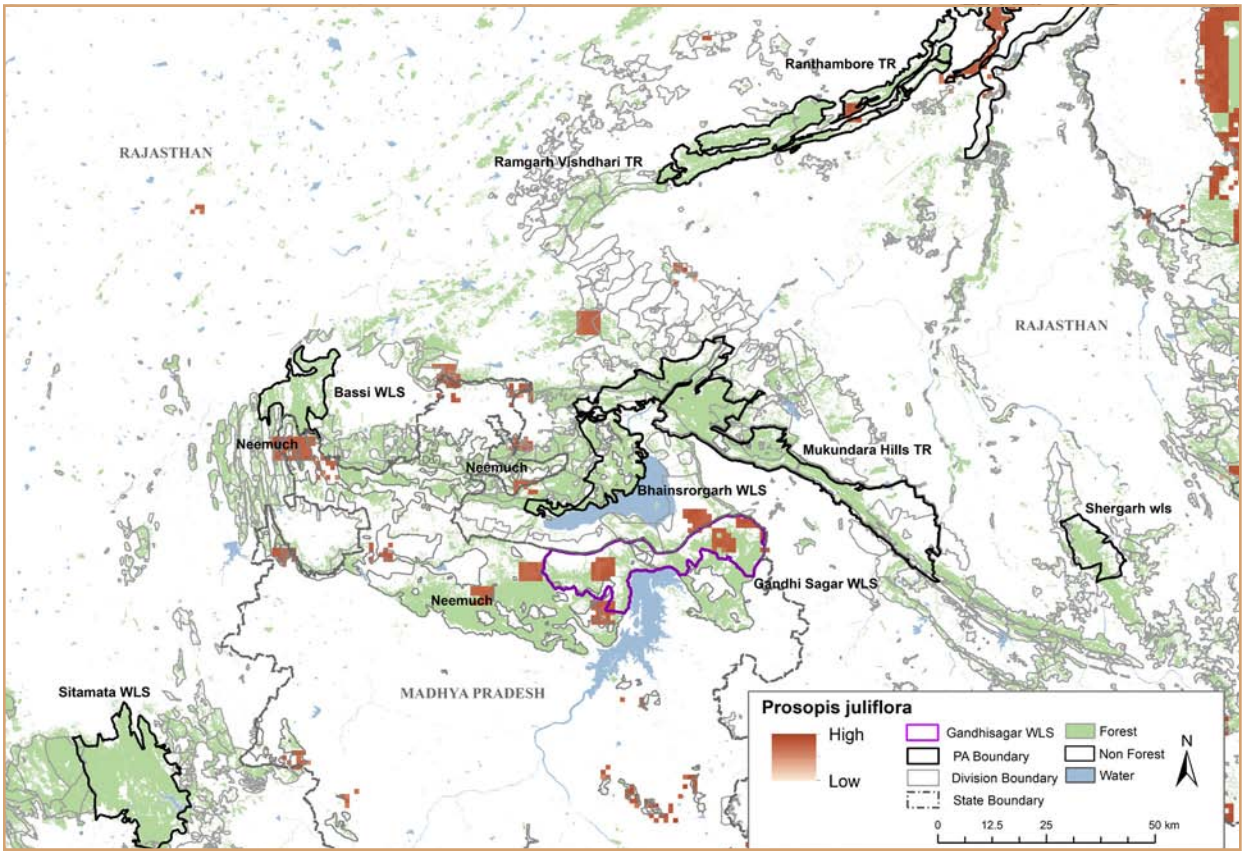

Figure 2.3.10. Distribution of Prosopis juliflora in Gandhi Sagar landscape

Image 2.3.5. A lake in Gandhi Sagar Wildlife Sanctuary © Lakshman Gunukula

©Nupur Rautela

©Parul Sen

3.

Prey status and monitoring

Distance sampling based line transect method was used to estimate the population density of prey (Buckland *et al.* 2001) in Kuno and Gandhi Sagar. After considering the shape, size, vegetation, and terrain type of the forest beat (which is a ~10 km^2 unit for forest protection and management), a transect line of a minimum of 2 km and not exceeding 4 km was marked for sampling (Jhala *et al.* 2021). All the data was recorded in the MSTrIPES ecological mobile application according to the All-India Tiger Estimation protocol. Each of the line transects was walked early in the morning by a member of the WII research team accompanied by a forest guard and a watcher. The counts of various prey species encountered during sampling along with the sighting distance and bearing of the animal(s) were recorded. Habitat plots were sampled at every 400m distance on the left and right side of the transect line i.e. at least six different plots on one transect line. A circular plot of 15m radius was visually marked, where, trees and human disturbance signs were recorded, inside which, shrubs and weedy/invasive shrubs were recorded in 5m radius, and herbs, grasses and ground cover were recorded within 1m radius inside the larger circular plot. Additionally, at these points, an area of 2m×20m, perpendicular to the transect line was sampled for fecal pellet counts of prey species.

For the analysis, DISTANCE 7.5 software (Thomas *et al.* 2010) was used for animal sightings recorded through line transect surveys. Distance analysis calculates the likelihood of detecting animals observed along the line transects (Buckland 1985, Buckland *et al.* 1993, Karanth & Nichols 2017). By employing this approach, the abundance of animal populations can be estimated by accounting for potential biases in animal detection, which might stem from differences in habitat characteristics, animal size, or group composition.

As part of the analysis, prescribed detection models were scrutinized, adjusting intervals of perpendicular distances of observed animal(s) and truncating these distances to identify the model that best matched the data. The detection function was modeled using half normal, hazard rate, and uniform models, complemented by cosine and polynomial adjustment keys. Outliers within the data were addressed by truncation. The selection of the best model for each prey species was done using AIC value, goodness-of-fit tests, visual estimations of the detection function, and the variance associated with the estimated values (Buckland *et al.* 2001).

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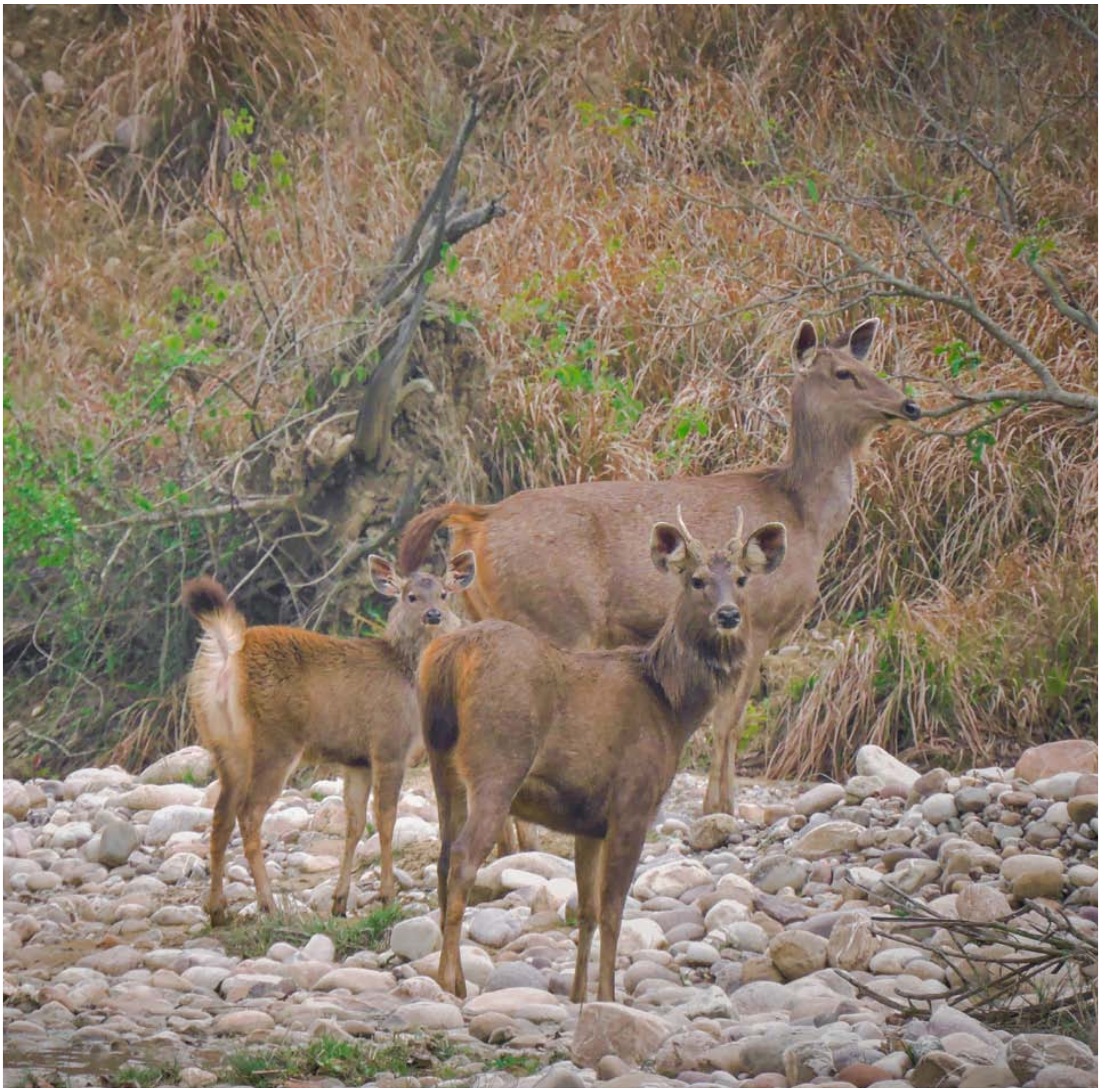

Image 3.1. *Sambar in Kuno National Park © Moulik Sarkar*

3.1. Prey assessment in Kuno Wildlife Division

Kuno NP (Area~750 km^2) is situated within Kuno Wildlife Division (Area~1235 km^2) and was managed as an NP created in 2018 with the addition of two ranges to the erstwhile Kuno WLS (Area~350 km^2). The erstwhile WLS had a very different management regime compared to the surrounding areas in the Wildlife Division and has been regularly monitored for prey and habitat starting in 2005. Hence, prey estimates have been provided for three management categories for ease of comparison viz. Erstwhile Kuno WLS, Rest of Kuno NP (Area~400 km^2) and Rest of Kuno Wildlife Division (Area~ 485 km^2).

Line transect sampling to assess prey populations in Kuno was conducted during the winter (November 2023) and summer (May 2024) seasons. A total of 36 line transects were walked in the erstwhile WLS area of Kuno NP in November 2023 (total effort= 210 km) and 134 line transects were walked in the entire Kuno Wildlife Division in 2024 (total effort= 738 km) surveyed by foot. Chital was the most sighted ungulate species, and other prey species encountered were sambar, nilgai, wild pig, chinkara, hare, peafowl, and grey langur. Additionally, the presence of livestock such as feral as well as domestic cattle was also observed.

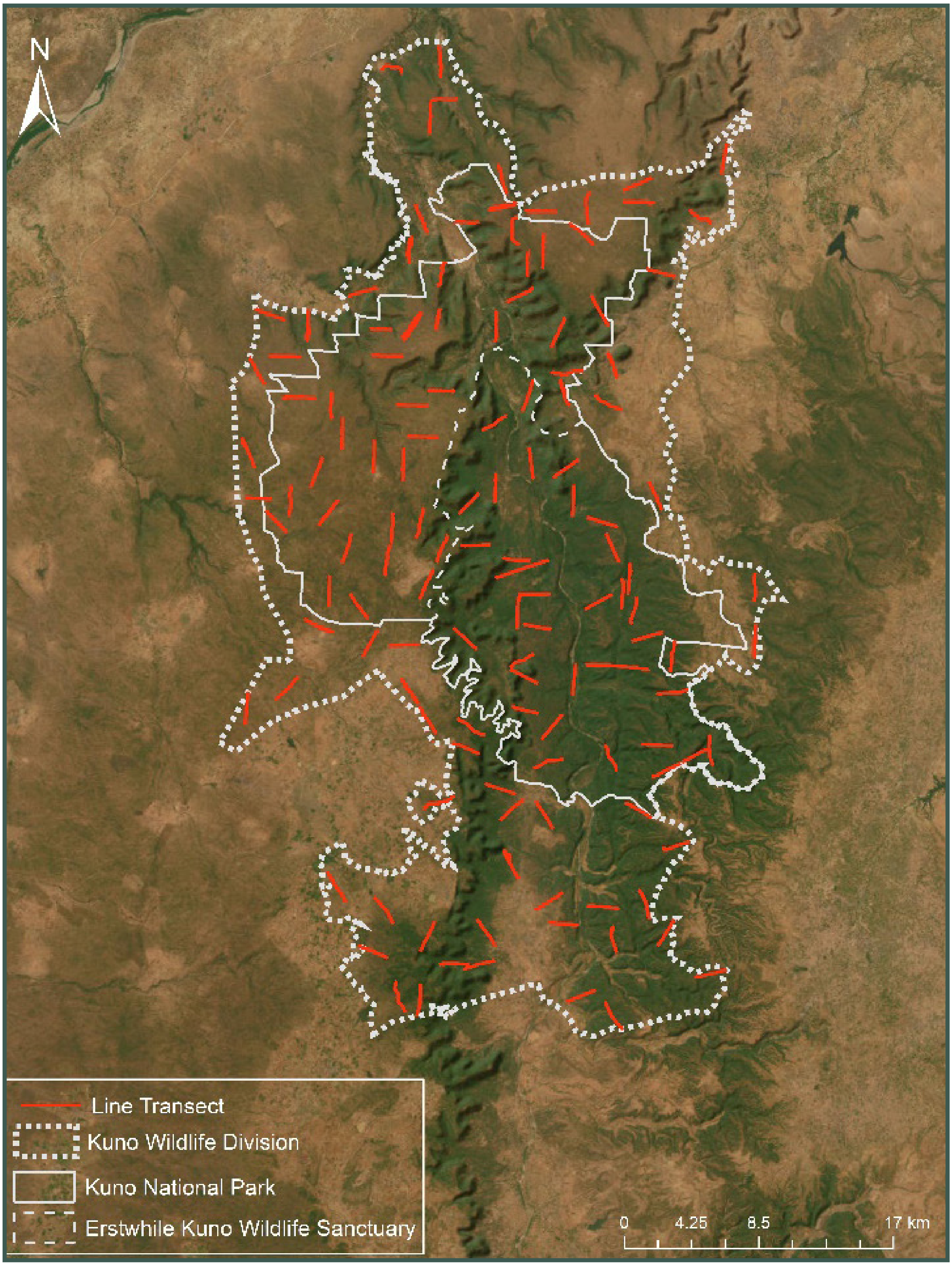

Figure 3.1.1. Map of line transects surveyed based on distance sampling in Kuno Wildlife Division

During the analysis, post-stratification was done using the global detection function to estimate the densities of chital, nilgai, sambar, hare, wild pig, langur, and feral cattle across the three management categories including the erstwhile Kuno WLS, rest of Kuno NP and rest of Kuno Wildlife Division. Density surface model was generated to understand the distribution of chital in the Kuno Wildlife Division using habitat variables such as elevation, human footprint index, and aridity index.

Among prey species encountered during distance sampling in May 2024, chital had the highest density with 17.5(3.39SE) animals per km^2 in the erstwhile WLS (Table 3.1.4). The estimated density of chital in the rest of the Kuno NP area and the rest of the Kuno Wildlife Division area was 1.36(0.77SE) and 0.13(0.09SE) respectively. The total estimated population of chital in the entire Kuno Wildlife Division was 6732 animals, whereas the population of chital in Kuno NP was 6669 animals.

Table 3.1.1. *Species wise encounter rate detected during the line transect based distance sampling conducted in the erstwhile Wildlife Sanctuary area of Kuno National Park during November 2023*

Effort	210 km	
Species	**No of observations -Groups (individuals)**	**Encounter rate per km -Groups (individuals)**
Chital	62 (299)	0.29 (1.42)
Sambar	20 (39)	0.09 (0.18)
Nilgai	9 (15)	0.04 (0.07)
Peafowl	14 (35)	0.06 (0.16)
Wild pig	3 (4)	0.014 (0.02)
Rhesus macaque	1 (7)	0.005 (0.03)
Hare	1 (1)	0.005 (0.005)
Feral cattle	11 (37)	0.05 (0.18)

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Table 3.1.2. *Summary of prey densities in the erstwhile Wildlife Sanctuary area of Kuno National Park obtained from line transect based distance sampling conducted during November 2023*

Species	Density(SE) per km²	CV of Density (%)	MCS(SE)	ESW (m)	Model	Adjustment key	Estimated population
Chital	16.56(4.55)	27.48	4.77(0.80)	40.35	Half normal	Cosine	5796
Sambar	1.67(0.65)	39.04	1.89(0.29)	50.38	Half normal	Hermite Polynomial	585
Nilgai	0.66(0.27)	41.72	2.18(0.27)	68.79	Half normal	Cosine	231
Peafowl	3.56(2.3)	64.73	2.50(0.55)	22.96	Hazard rate	Hermite Polynomial	1246
Wild pig	0.21(0.14)	65.14	1.25(0.16)	48.64	Half normal	Cosine	74
Feral cattle	1.24(0.17)	57.52	3.36(0.77)	69.64	Hazard rate	Hermite Polynomial	434

SE- Standard Error, CV- Coefficient of Variation, MCS- Mean Cluster Size, ESW- Effective Strip Width

Image 3.1.2. *Wild pig in Kuno National Park © Sumit Patel*

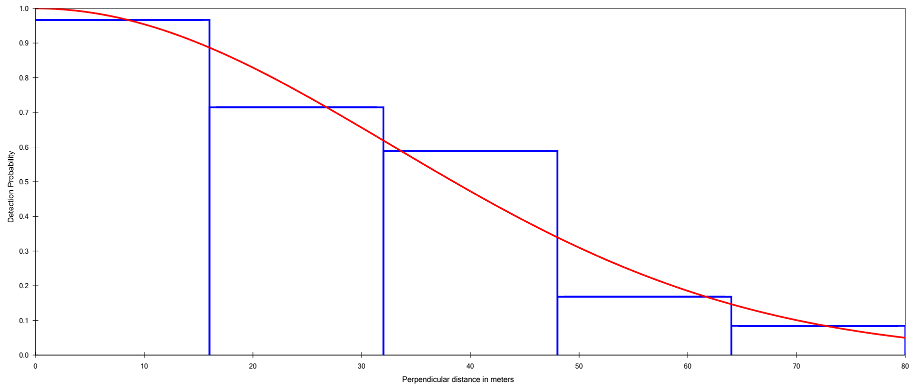

Figure 3.1.2. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- half-normal (cosine adjustment) in DISTANCE analysis for population density estimation of chital during November 2023 (goodness of fit X^2- p= 0.75, number of observations- 62)*

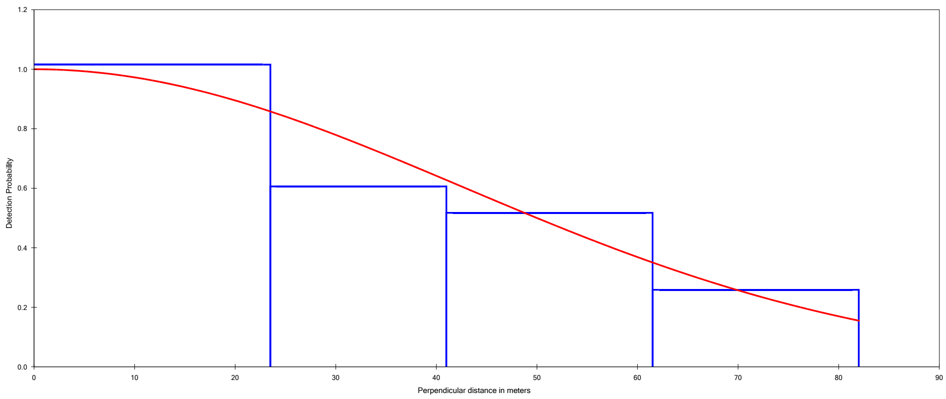

Figure 3.1.3. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- half-normal (hermite polynomial adjustment) in DISTANCE analysis for population density estimation of sambar during November 2023 (goodness of fit X^2- p= 0.89, number of observations- 20)*

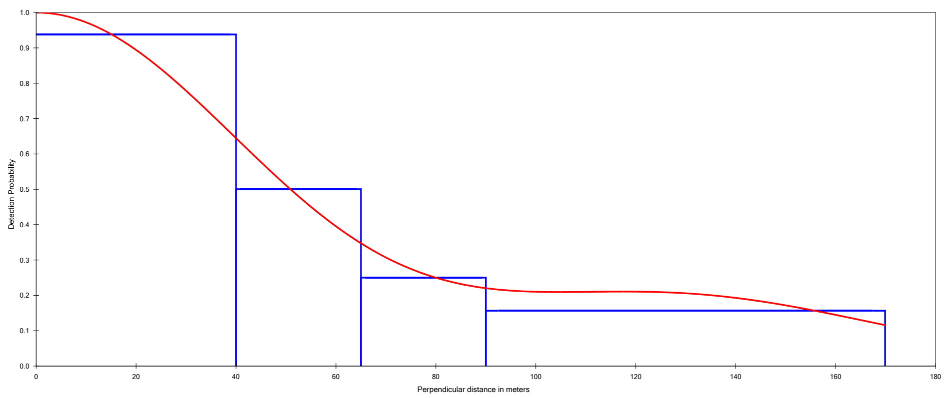

Figure 3.1.4. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- half-normal (cosine adjustment) in DISTANCE analysis for population density estimation of nilgai during November 2023 (goodness of fit X^2- p= 0.63, number of observations- 9)*

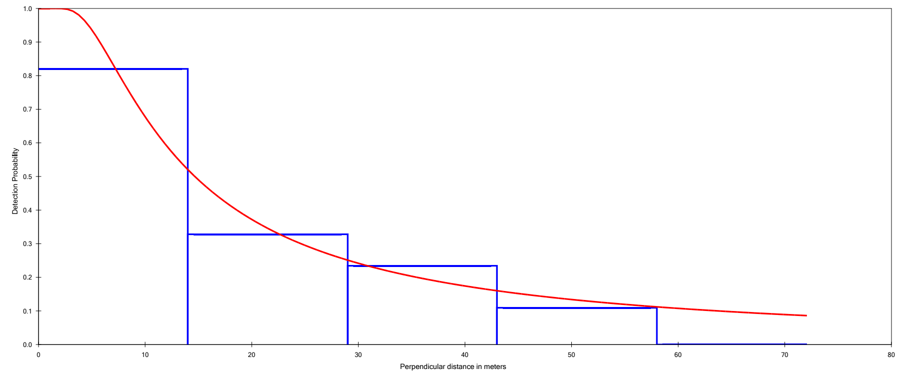

Figure 3.1.5. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- hazard-rate (hermite polynomial adjustment) in DISTANCE analysis for population density estimation of peafowl during November 2023 (goodness of fit X^2- p= 0.62, number of observations- 14)*

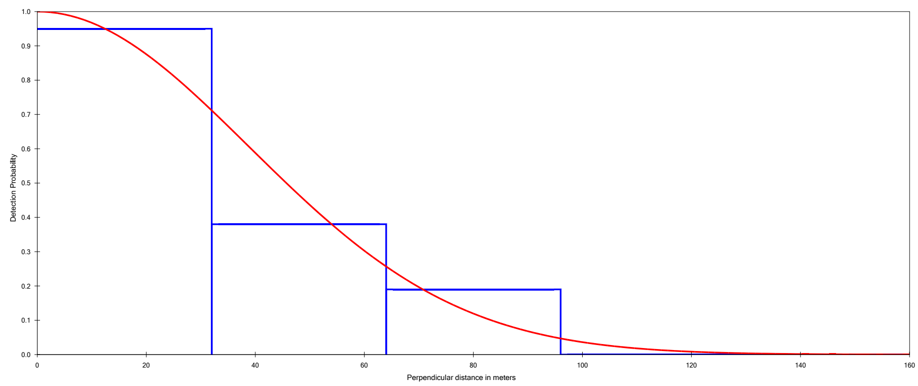

Figure 3.1.6. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- half-normal (cosine adjustment) in DISTANCE analysis for population density estimation of wild pig (goodness of fit X^2- p= 0.95, number of observations- 3)*

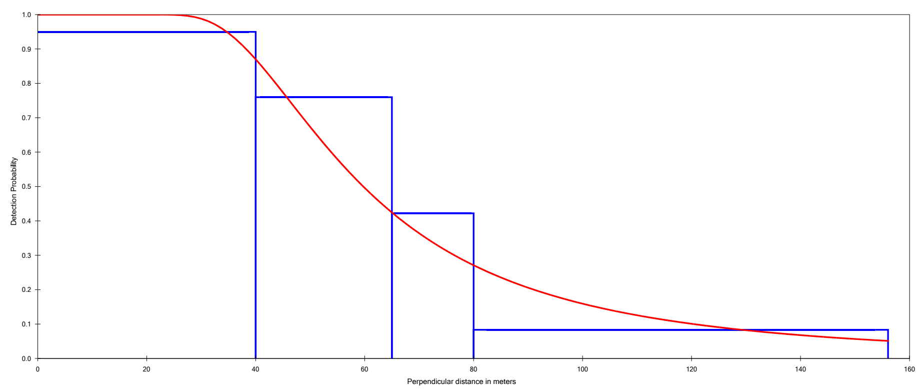

Figure 3.1.7. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- hazard-rate (hermite polynomial adjustment) in DISTANCE analysis for population density estimation of feral cattle during November 2023 (goodness of fit X^2- p= 0.58, number of observations- 11).*

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Table 3.1.3. *Species wise encounter rate detected during the line transect based distance sampling conducted in Kuno Wildlife Division (Area~ 1235 km²) during May 2024.*

	The erstwhile Kuno Wildlife Sanctuary (Area~350 km²)		Rest of the area in Kuno National Park (Area~400 km²)		Rest of the area in Kuno Wildlife Division (Area~485 km²)	
Effort	208 km		196 km		334 km	
Species	**No of observations-Groups (individuals)**	**Encounter rate per km -Groups (individuals)**	**No of observations-Groups (individuals)**	**Encounter rate per km -Groups (individuals)**	**No of observations-Groups (individuals)**	**Encounter rate per km -Groups (individuals)**
Chital	81 (491)	0.39 (2.36)	8 (36)	0.04 (0.18)	3 (8)	0.01 (0.02)
Sambar	17 (39)	0.08 (0.19)	3 (3)	0.02 (0.02)	1 (1)	0.003 (0.003)
Nilgai	12 (18)	0.06 (0.09)	8 (16)	0.04 (0.08)	6 (10)	0.02 (0.03)
Hare	7 (8)	0.03 (0.04)	8 (9)	0.04 (0.05)	24 (26)	0.07 (0.08)
Peafowl	19 (49)	0.09 (0.24)	3 (13)	0.02 (0.07)	2 (9)	0.01 (0.03)
Wild pig	10 (54)	0.05 (0.26)	2 (7)	0.01 (0.04)	8 (26)	0.02 (0.08)
Chinkara	1 (1)	0.004 (0.004)	0	0	6 (14)	0.02 (0.04)
Grey langur	15 (146)	0.07 (0.7)	9 (67)	0.05 (0.34)	30 (154)	0.09 (0.46)
Feral*/ Domestic cattle	5 (33)*	0.02 (0.16)*	7 (51)	0.04 (0.26)	35 (153)	0.1 (0.46)

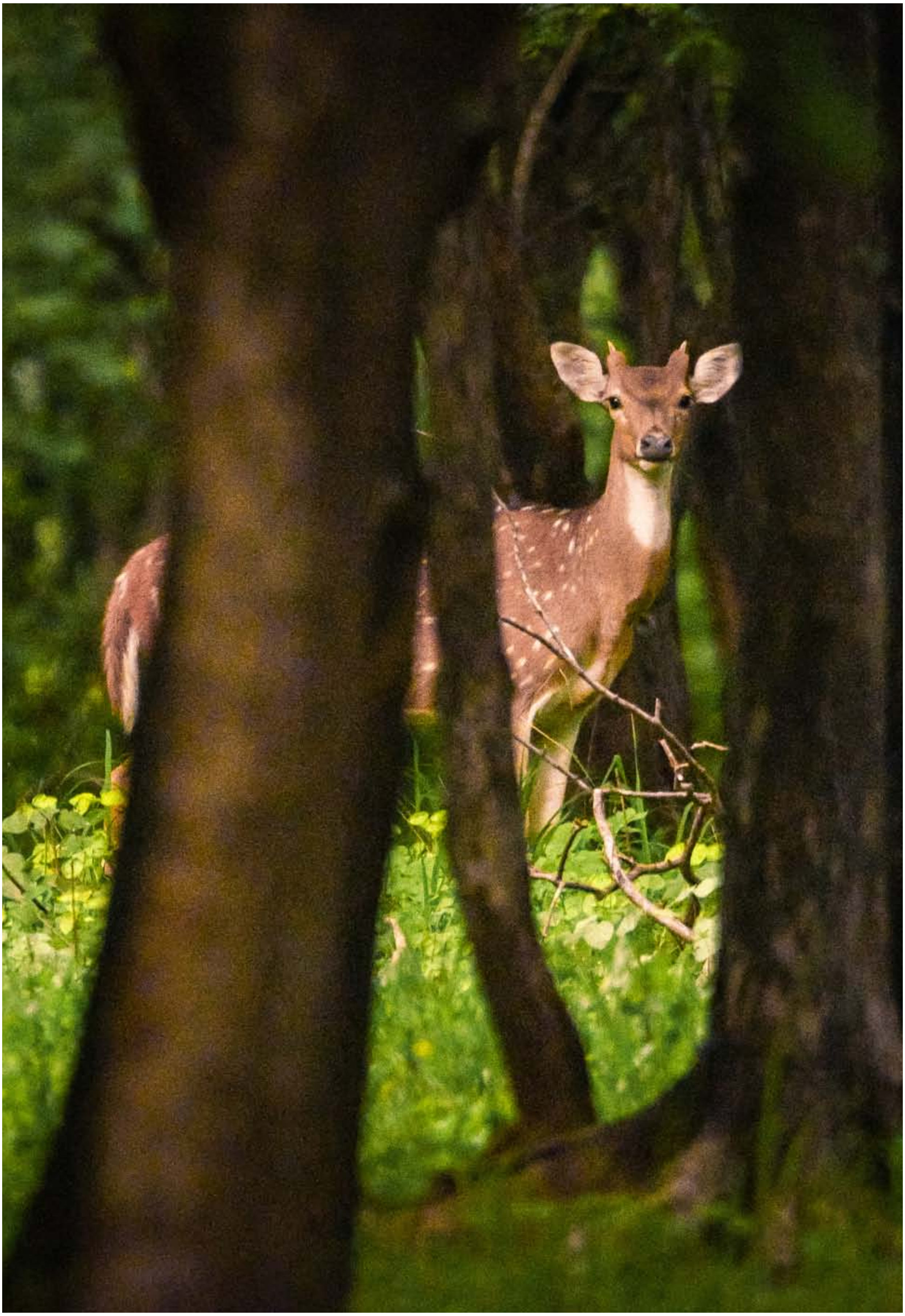


Image 3.1.3. *Male chital in Kuno National Park © Nupur Rautela*

Table 3.1.4. *Summary of prey densities obtained from line transect based distance sampling conducted in May 2024 for the erstwhile Kuno Wildlife Sanctuary (Area~350 km²), rest of Kuno National Park (Area~400 km²), and rest of Kuno Wildlife Division (Area~485 km²)*

Species	Area	Density (SE) per km²	CV of Density (%)	MCS(SE)	ESW (m)	Model	Adjustment key	Estimated population
Chital	E Kuno WLS	17.5(3.39)	19.40	6.06(0.71)	67.61	Hazard rate	Cosine	6125
	Kuno NP (Rest)	1.36(0.77)	56.84	4.50(0.73)				544
	Kuno Wildlife Division (Rest)	0.13(0.09)	74.12	2.67(0.67)				63
Nilgai	E Kuno WLS	1.77(0.73)	41.46	1.5(0.26)	36.14	Hazard rate	Simple polynomial	620
	Kuno NP(Rest)	0.43(0.20)	46.72	2(0.38)				172
	Kuno Wildlife Division (Rest)	0.40(0.21)	51.86	1.67(0.21)				194
Sambar	E Kuno WLS	1.61(0.51)	31.48	2.29(0.36)	58.13	Uniform	Cosine	564
	Kuno NP (Rest)	0.13(0.07)	56.77	1				52
	Kuno Wildlife Division (Rest)	0.03(0.03)	100.53	1				15
Hare	Kuno WLS	0.98(0.56)	56.67	1.14(0.14)	17.88	Hazard rate	Cosine	343
	Kuno NP (Rest)	1.29(0.53)	40.56	1.13(0.13)				516
	Kuno Wildlife Division (Rest)	2.26(0.67)	29.54	1.08(0.058)				1096
Peafowl	E Kuno WLS	3.93(1.59)	40.51	2.58(0.44)	36.79	Hazard rate	Simple polynomial	1376
	Kuno NP (Rest)	0.42(0.32)	77.04	4.33(1.20)				168
	Kuno Wildlife Division (Rest)	0.37(0.39)	106.13	4.5(3.5)				180
Wild pig	E Kuno WLS	2.64(1.19)	45.44	5.4(1.23)	49.18	Uniform	Cosine	924
	Kuno NP (Rest)	0.36(0.37)	100.53	3.5(2.5)				144
	Kuno Wildlife Division (Rest)	0.79(0.43)	54.12	3.25(1.32)				383
Grey langur	E Kuno WLS	6.93(2.63)	37.91	9.73(1.29)	50.64	Hazard rate	Cosine	2426
	Kuno NP (Rest)	3.38(2.04)	60.29	7.44(1.61)				1352
	Kuno Wildlife Division (Rest)	4.55(1.61)	35.46	5.13(0.89)				2207
Feral*/ Domestic cattle	E Kuno WLS*	1.63(1.31)	80.20	6.60(3.04)	48.56	Hazard rate	Simple polynomial	570
	Kuno NP(Rest)	0.95(0.59)	63.19	2.57(1.09)				380
	Kuno Wildlife Division (Rest)	4.72(1.68)	35.75	4.37(0.84)				2290

E- Erstwhile, SE- Standard Error, CV- Coefficient of Variation, MCS- Mean Cluster Size, ESW- Effective Strip Width

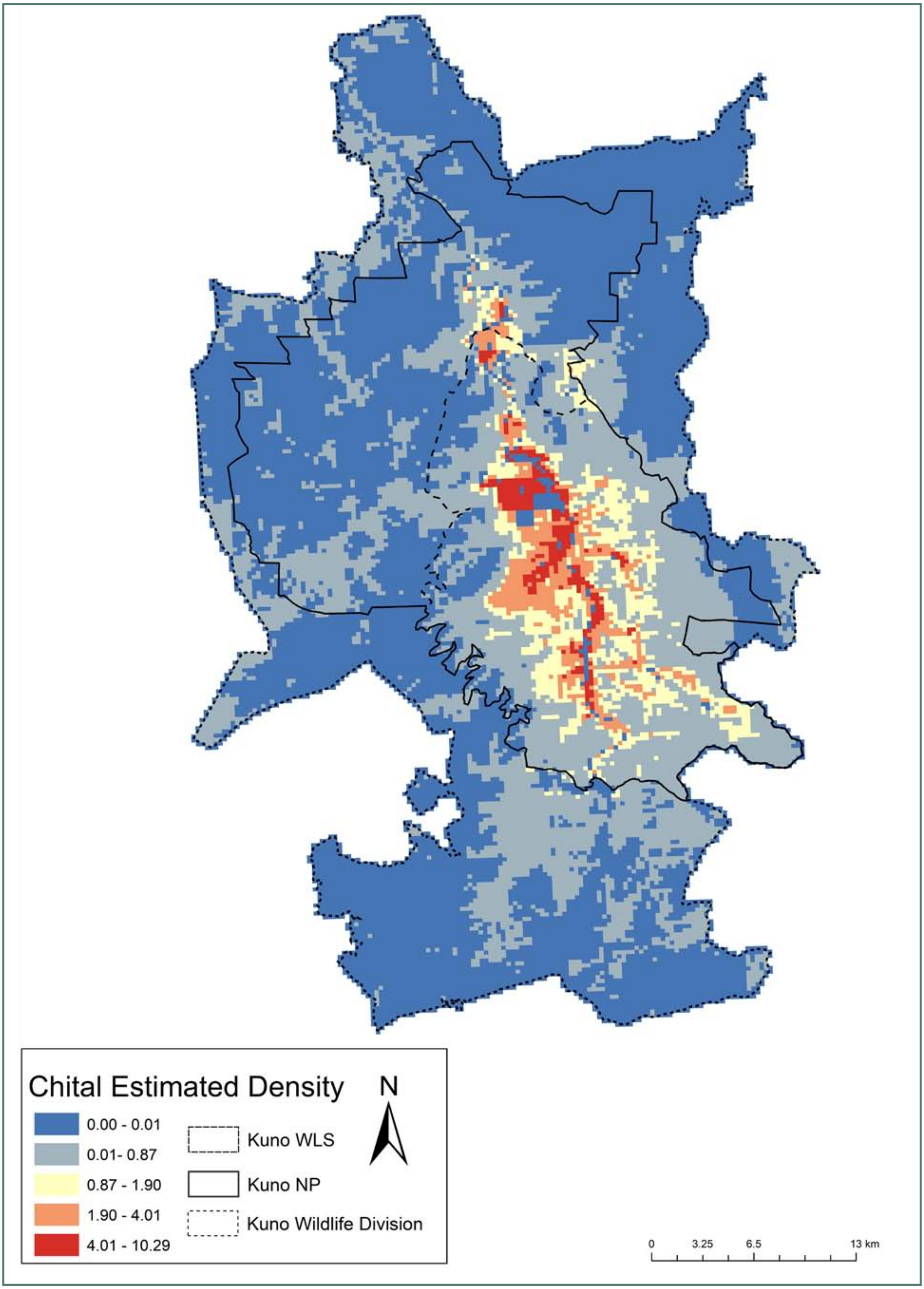


__Figure 3.1.8.__ Distribution of chital in Kuno Wildlife Division based on distance sampling conducted in May 2024 using density surface modelling

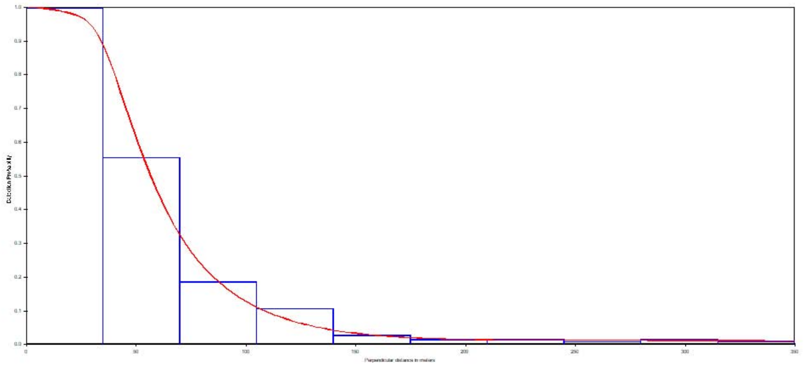


Figure 3.1.9. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- hazard rate (cosine adjustment) in DISTANCE analysis for population density estimation of chital during May 2024 (goodness of fit X^2- p= 0.71, number of observations- 92)*

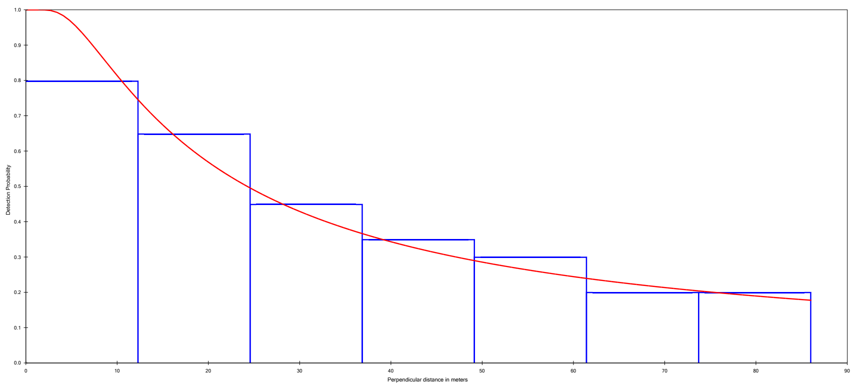


Figure 3.1.10. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- hazard rate (simple polynomial adjustment) in DISTANCE analysis for population density estimation of nilgai during May 2024 (goodness of fit X^2- p= 0.97, number of observations-26)*

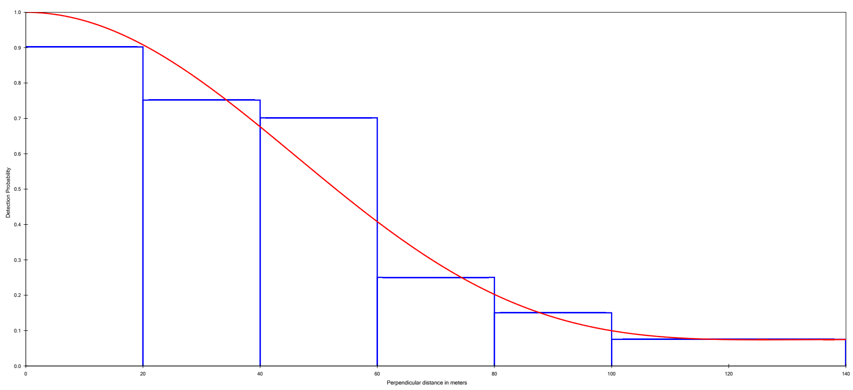


Figure 3.1.11. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- uniform (cosine adjustment) in DISTANCE analysis for population density estimation of sambar during May 2024 (goodness of fit X^2- p= 0.74, number of observations-21)*

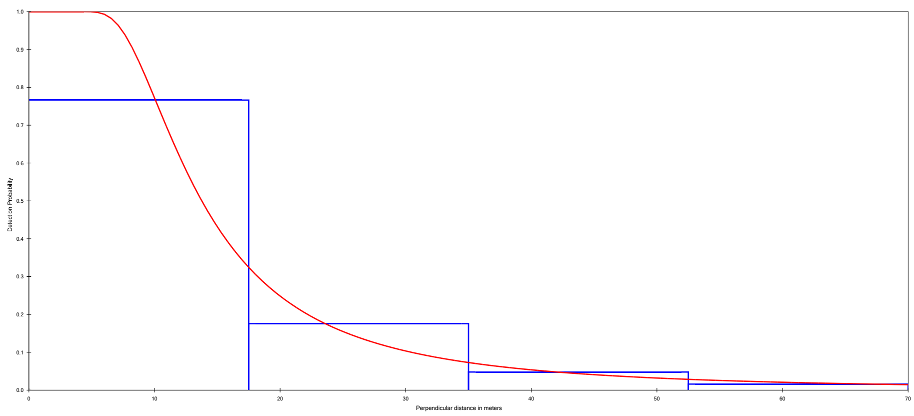


Figure 3.1.12. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- hazard rate (cosine adjustment) in DISTANCE analysis for population density estimation of hare during May 2024 (goodness of fit X^2- p= 0.66, number of observations-39)*

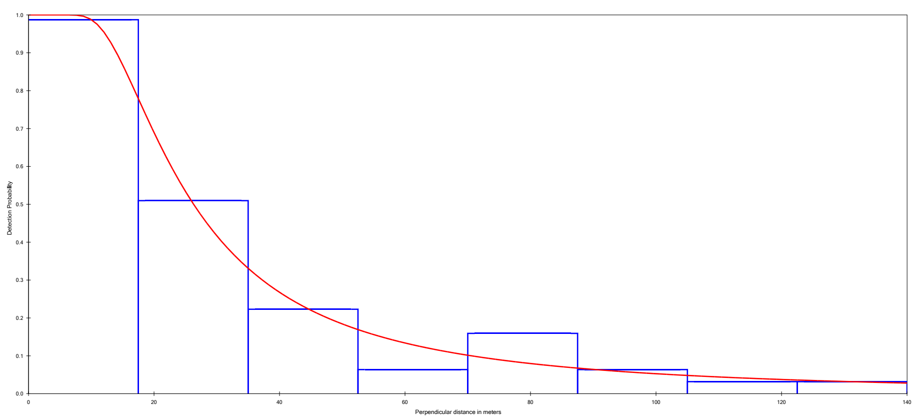


Figure 3.1.13. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- hazard rate (simple polynomial adjustment) in DISTANCE analysis for population density estimation of peafowl during May 2024 (goodness of fit X^2- p= 0.64, number of observations-24)*

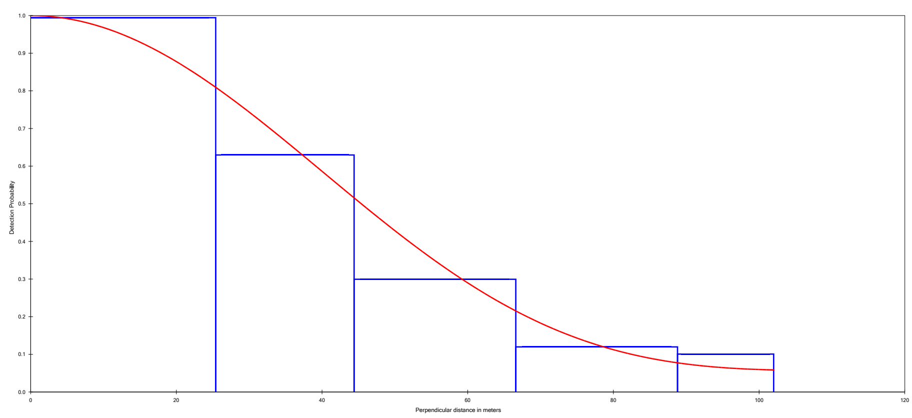


Figure 3.1.14. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- uniform (cosine polynomial adjustment) in DISTANCE analysis for population density estimation of wild pig during May 2024 (goodness of fit X^2- p= 0.79, number of observations-20)*

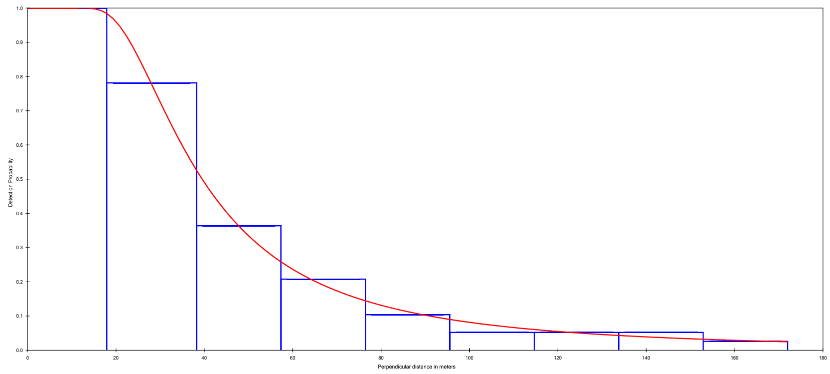


Figure 3.1.15. Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- hazard rate (cosine adjustment) in DISTANCE analysis for population density estimation of grey langur during May 2024 (goodness of fit X^2- p= 0.99, number of observations-54)

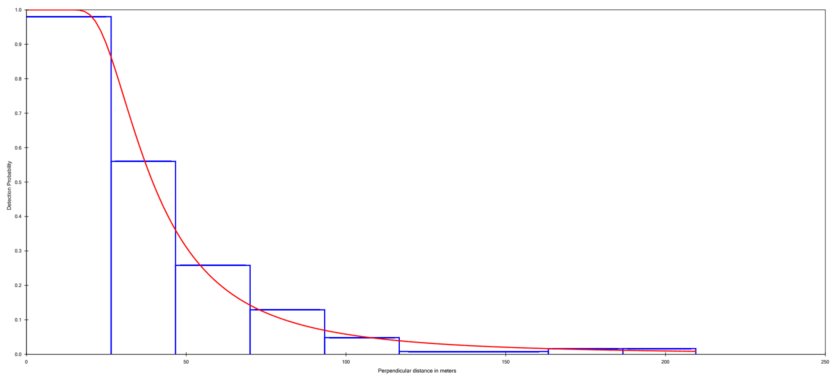


Figure 3.1.16. Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- hazard rate (simple polynomial adjustment) in DISTANCE analysis for population density estimation of domestic/feral cattle in May 2024 (goodness of fit X^2- p= 0.76, number of observations- 42/5)

Image 3.1.4. Peafowl in Kuno National Park © Sumit Patel

3.1.1. Relative Abundance Index and spatial distribution of prey in the erstwhile Wildlife Sanctuary area of Kuno National Park

The capture-mark-recapture method is commonly used to estimate carnivore populations, but not for species that do not have distinct individual markings (Carbone *et al.* 2001). Consequently, we employed the relative abundance index (RAI) as a surrogate for abundance in such cases (Carbone *et al.* 2001; O'Brien *et al.* 2003). Relative abundance indices are used to describe the spatial distribution and abundance of species, based on the assumption that these indices scale have a linear relationship with actual abundance (Güthlin *et al.* 2014). The RAI was calculated as the total number of independent photographs divided by the effort, multiplied by 100. The RAI is expected to increase with higher animal density (O'Brien *et al.* 2003). An independent photo-capture event was defined as one occurring more than 10 minutes after the previous photo-capture (Carbone *et al.* 2001; O'Brien *et al.* 2003). The details of camera trap sampling conducted in the erstwhile WLS area of Kuno NP during 2023 is described in section 6.1. Maps were generated based on the RAI at each camera trap to depict the spatial distribution of the photo-captured species.

Table 3.1.5. *Relative Abundance Index (RAI) of prey species obtained during camera trap survey conducted in the erstwhile Wildlife Sanctuary area of Kuno National Park during 2023*

Species	No. of photo-captures	No. of independent events	RAI
Peafowl	5004	1320	44.81
Chital	13663	972	32.99
Indian hare	1022	682	23.15
Wild pig	1492	514	17.45
Porcupine	319	235	7.98
Sambar	480	186	6.31
Grey langur	1729	118	4.01
Nilgai	1528	65	2.21
Chowsingha	107	15	0.51
Monitor lizard	44	20	0.68
Chinkara	3	1	0.03

Image 3.1.5. *Black-naped hare in Kuno National Park © Parul Sen*

Image 3.1.6. *Nilgai bulls in Kuno National Park © Prateek Sharma*

Image 3.1.7. *Indian porcupine in Kuno National Park © WII (Project Cheetah)*

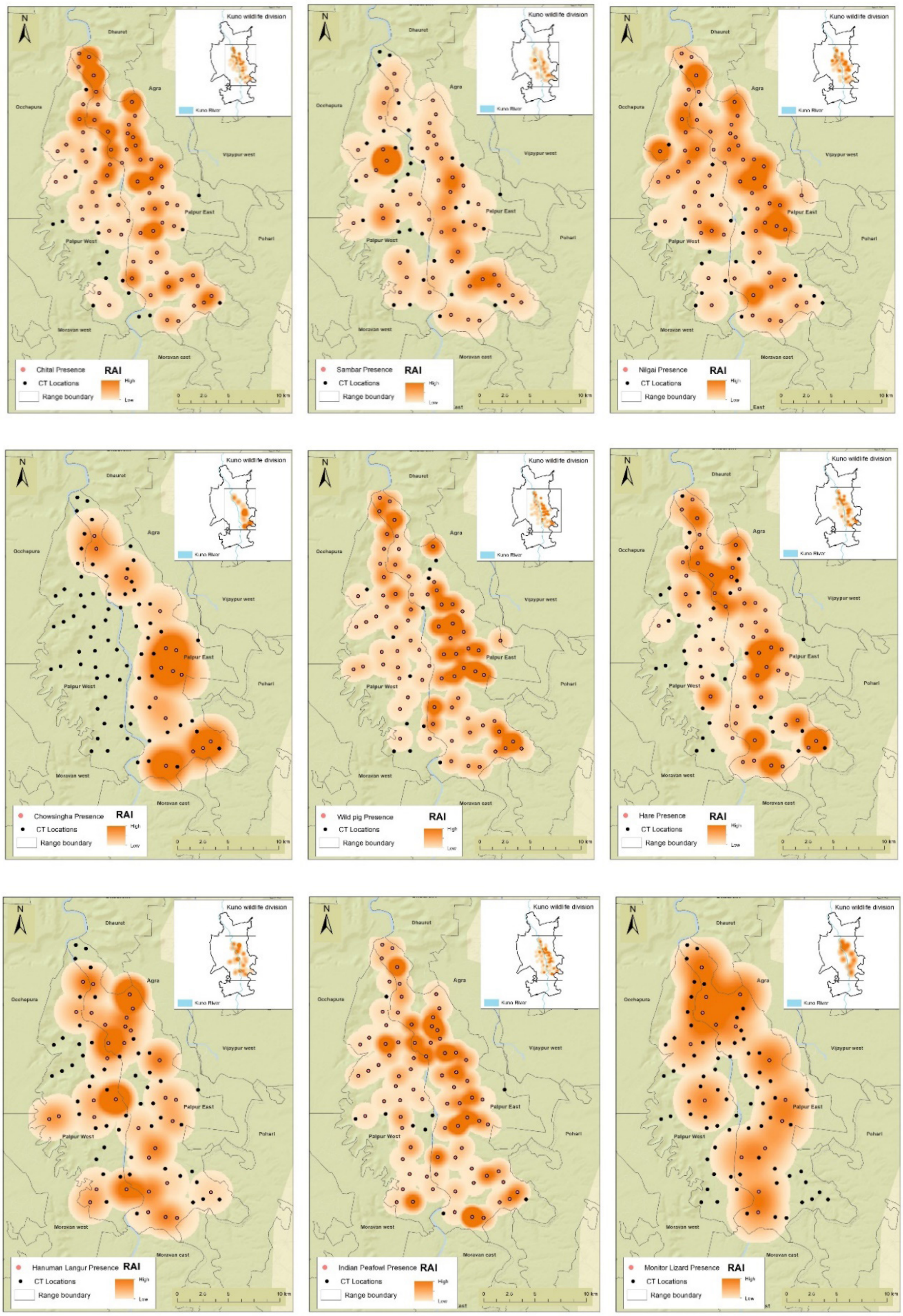


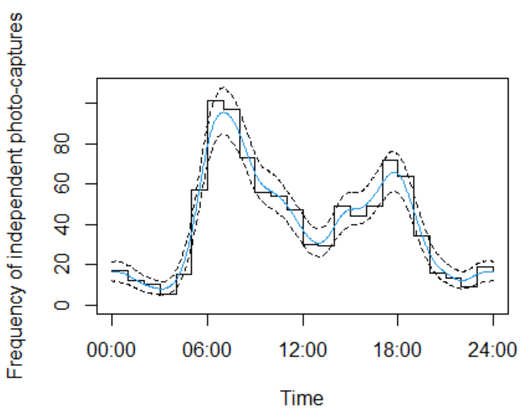
Figure 3.1.17. *Spatial distribution of prey species obtained from camera trap sampling conducted in the erstwhile Wildlife Sanctuary area of Kuno National Park. Chital, sambar and nilgai (top row L-R), chowsingha, wild pig and hare (middle row L-R),grey langur, peafowl and monitor lizard (bottom row L-R)*

Image 3.1.8. Chowsingha in Kuno National Park © WII (Project Cheetah)

3.1.2. Activity pattern of prey species in the erstwhile Wildlife Sanctuary area of Kuno National Park

The time of each independent photo-capture of the study species obtained from camera traps was extracted to understand the temporal activity pattern of prey species. This information was used to generate activity curves using the 'overlap' package in R. The 'overlap' package applies a kernel density function to model activity curves based on the species' independent photo-captures across time intervals (Meredith and Ridout 2014).

Chital, nilgai, and peafowl were active most of the day with peaks during mornings and evenings. Chital and nilgai also showed some amount of activity at night. Sambar and hare were mostly active at night with peaks in late evenings and early mornings. Wild pigs showed some amount of activity during the entire 24-hour period with peaks in the evenings and early mornings. Langur was active only during the daytime, whereas chowsingha was active mostly during the daytime with peak activity at noon and some activity during the night.



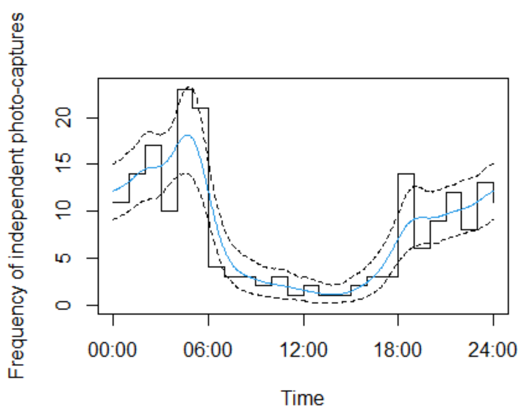


Figure 3.1.18. Activity patterns of chital (left) and sambar (right) in the erstwhile Wildlife Sanctuary area of Kuno National Park

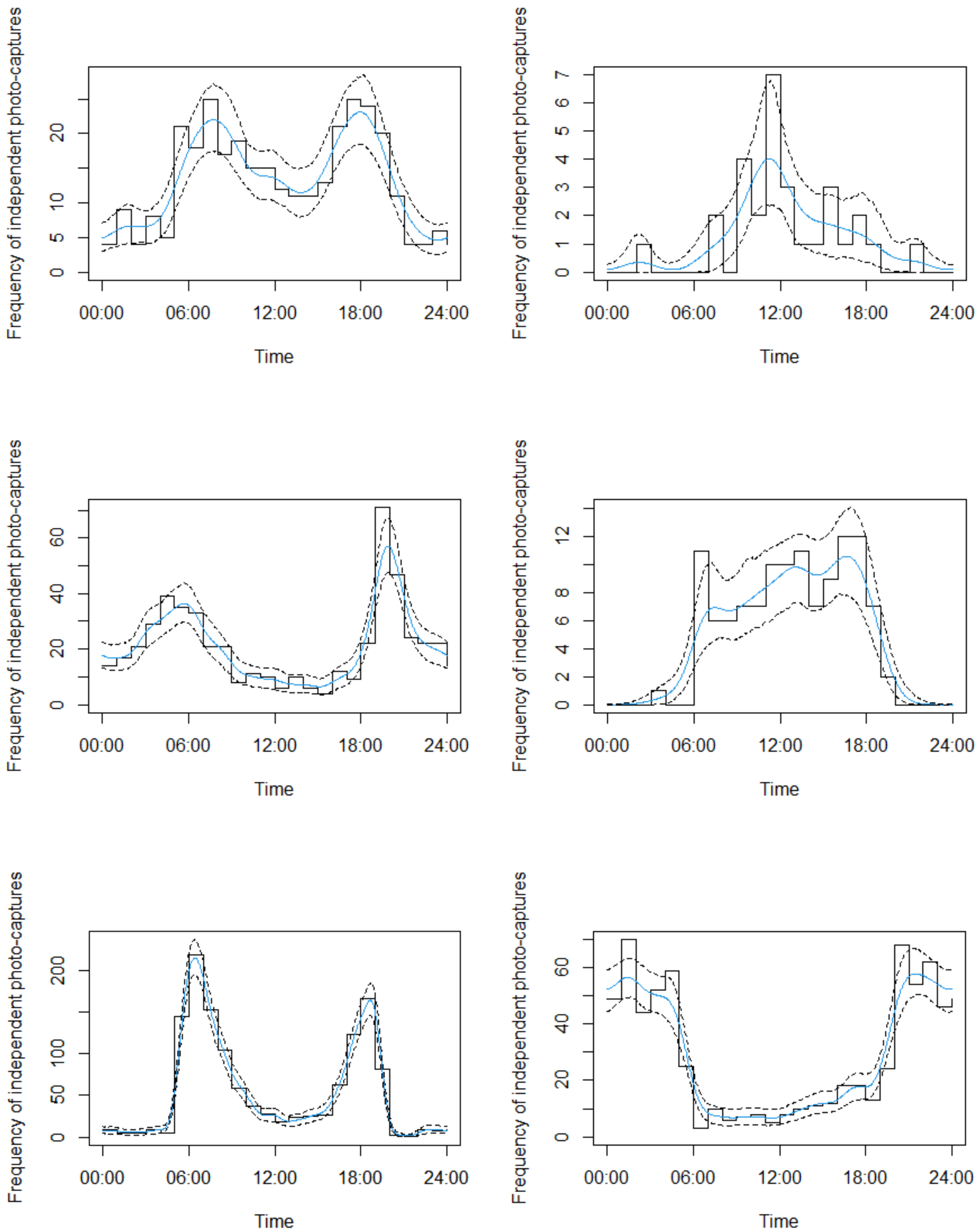


__Figure 3.1.19.__ Activity patterns of nilgai and chowsingha (L-R top row), wild pig and grey langur (L-R middle row), peafowl and hare (L-R bottom row) in the erstwhile Wildlife Sanctuary area of Kuno National Park

__Image 3.1.9.__ Grey langur in Kuno National Park © WII (Project Cheetah)

3.2. Monitoring of prey in Kuno National Park

As part of examining the dynamics of ecosystem functioning and the response of prey species such as understanding the spatial and behavioural response of chital to cheetah introduction, animals were radio-collared using AWT Ultra High-Frequency (UHF) and Very High-Frequency (VHF) devices with the help of veterinarians and forest department staff. As chital are the primary prey as well as the most abundant prey species in Kuno, it is crucial to investigate the various aspects of their ecology in addition to monitoring their population status. A total of eight female chitals were radio-collared (4 UHF and 4 VHF) to understand their behaviour, habitat use, movement patterns, and resource use, out of which, three were predated by leopards.

__Image 3.1.10.__ Male chitals with velvet antlers © Deb Ranjan Laha

©Nikunj Vasava

3.2.1. Home range and movement of chital in Kuno National Park

A home range refers to the geographic area occupied by an animal or group of animals over a specific period, typically encompassing their usual living space and areas they regularly visit. It represents the spatial extent of an organism's activities, including resting, foraging, mating, etc. The home range of chital varies depending on habitat type, resource availability, and population density. The home range of chital varies from 0.5 km^2 to 1.2 km^2 for females and up to 2.5 km^2 for males in forested areas (Mishra 1982, Johnsingh 1983). In some semi-arid areas with lower resource availability, chital home ranges can expand to larger areas due to the need for greater foraging grounds (Khan 1994). The data reported here is preliminary and would require additional information over time to comprehensively understand the prey-predator interactions.

Home range was estimated using the locations obtained from the animals deployed with UHF collars and from daily monitoring of VHF collared chitals by using minimum convex polygon (MCP) and kernel density estimator (KDE). R package adehabitatHR was used for home range analysis (Calenge 2006). An MCP is estimated by working out the smallest polygon including all the locations where an individual has been recorded. MCPs provide information on the total area that an individual uses. Utilization distribution from animal locations using the kernel method was also used for home range estimation (Worton 1989).

Home ranges (100% MCP) of adult female chitals varied from 0.4 km^2 to 13.43 km^2, whereas for sub- adult females, it was 0.83 km^2 to 0.95 km^2. Using 95% KDE, the home range of adult female chital was found to range between 0.98 km^2 to 10.63 km^2. The average daily distance moved by adult female chitals ranged from 0.41(0.09SE) km to 2.48 (0.08SE) km.

Table 3.2.1. *Home ranges of radio-collared chital in Kuno National Park*

Animal (Tag ID & Type)	Age & Sex	100% MCP Area (km^2)	95% KDE Area (km^2)	Average daily movement (km)	Days
Chital 1 (VHF)	Adult Female	1.05	3.21	-	362
Chital 2 (VHF)	Sub-Adult Female	0.83	-	-	483
Chital 3 (VHF)	Sub-Adult Female	0.95	-	-	475
Chital 4 (VHF)	Adult Female	0.40	-	-	398
Chital 5 (UHF 6805)	Adult Female	9.34	3.51	1.93(0.04SE)	421
Chital 6 (UHF 6800)	Adult Female	10.98	6.21	2.09(0.05SE)	233
Chital 7 (UHF 6803)	Adult Female	0.80	0.98	0.41(0.09SE)	75
Chital 8 (UHF 6798)	Adult Female	13.43	10.63	2.48(0.08SE)	109

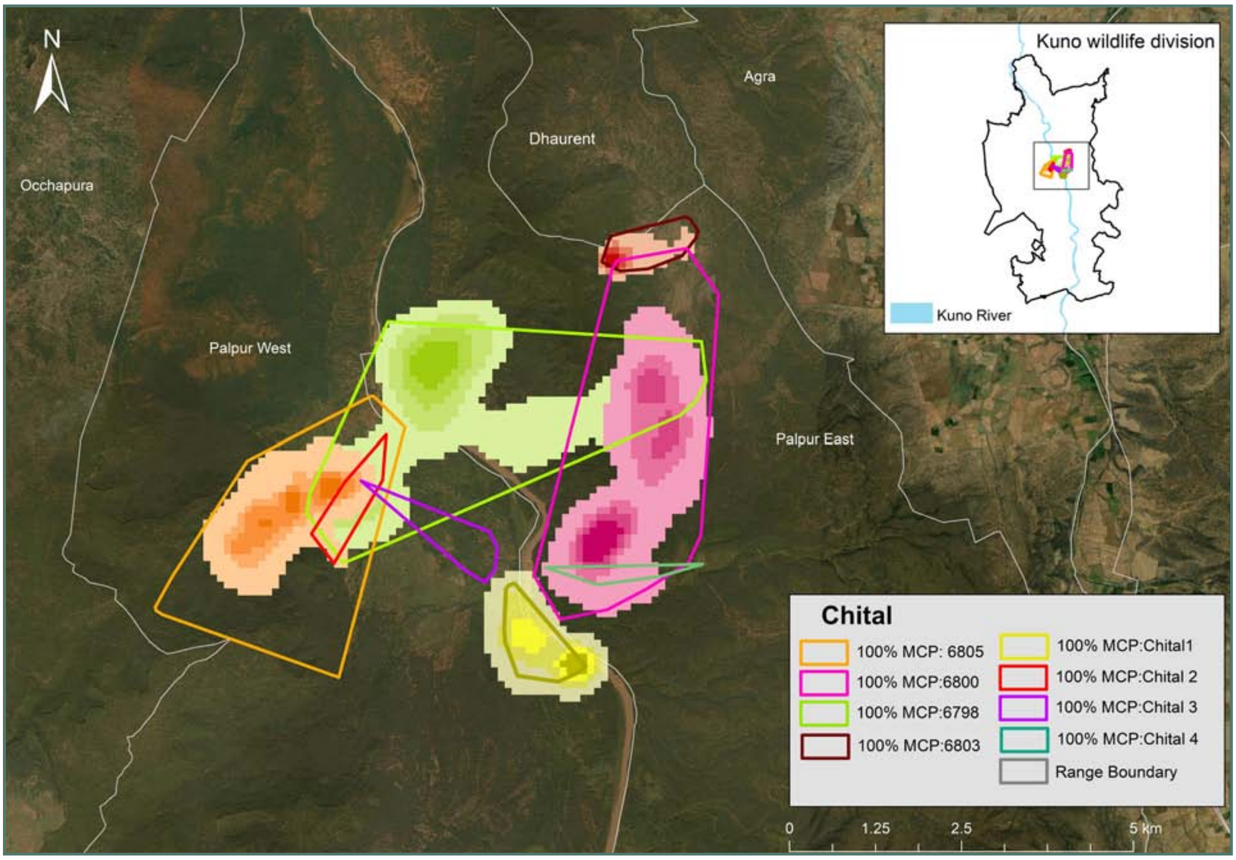


Figure 3.2.1. Home ranges (100% MCP and 95%KDE) of eight radio-collared chitals in Kuno Wildlife Division

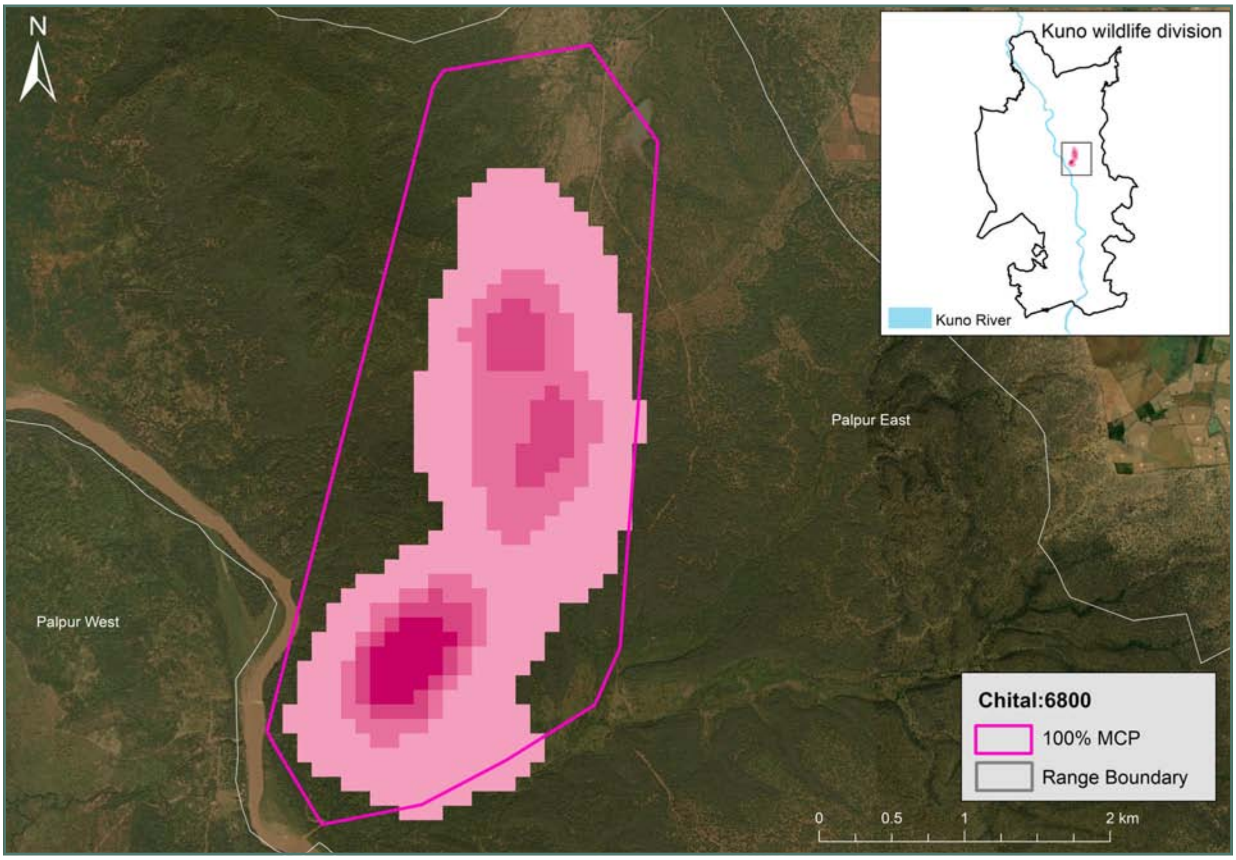


Figure 3.2.2. Home ranges (100% MCP and 95%KDE) of radio-collared chital adult female (id. 6800) in Kuno Wildlife Division

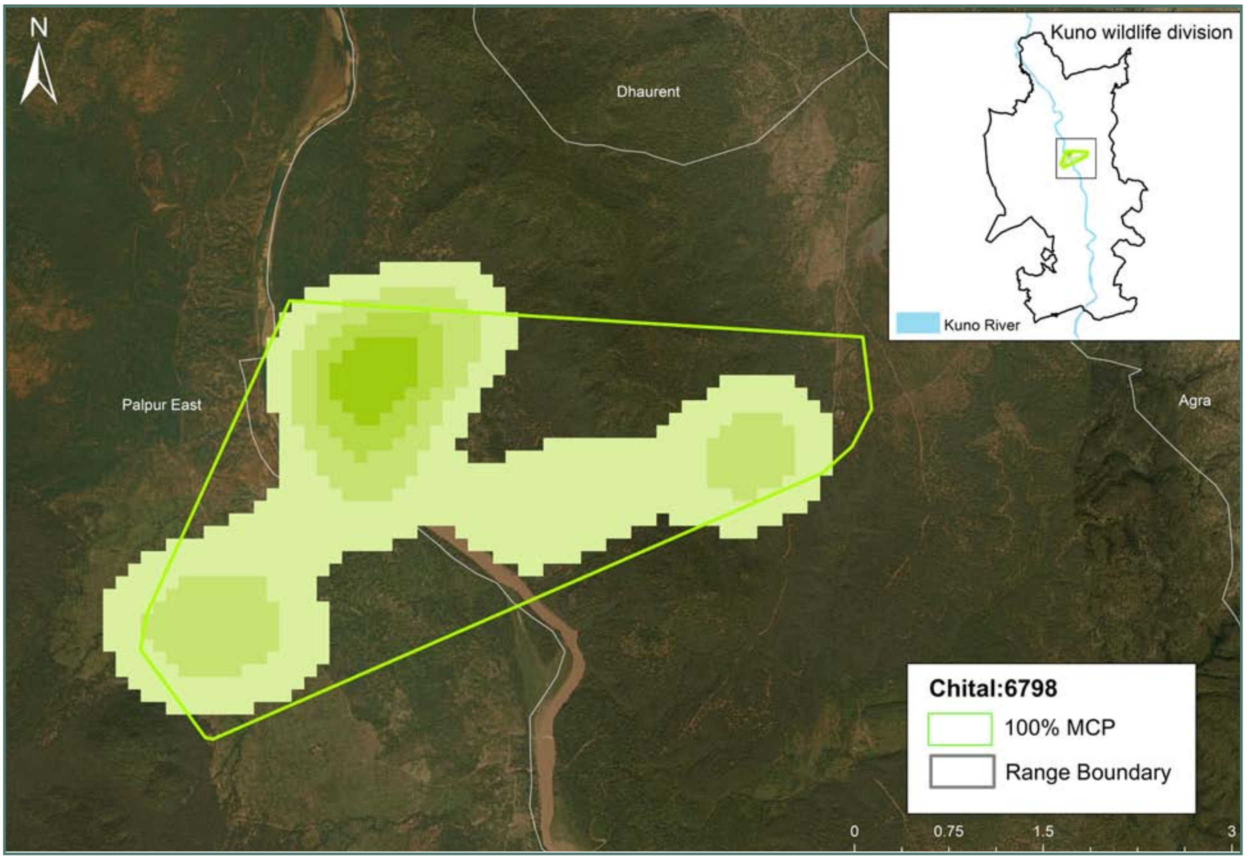


Figure 3.2.3. *Home ranges (100% MCP and 95%KDE) of radio-collared chital adult female (id. 6798) in Kuno Wildlife Division*

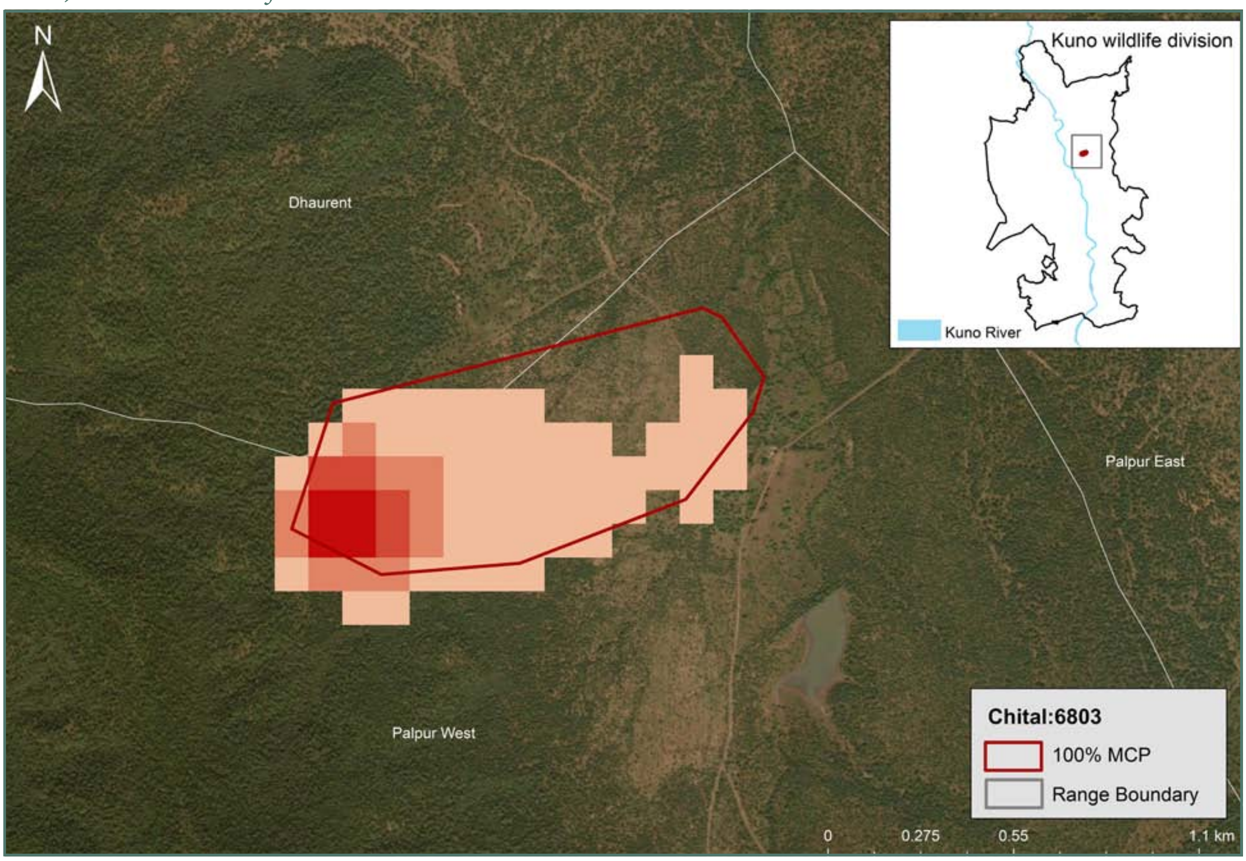


Figure 3.2.4. *Home ranges (100% MCP and 95%KDE) of radio-collared chital adult female (id. 6803) in Kuno Wildlife Division*

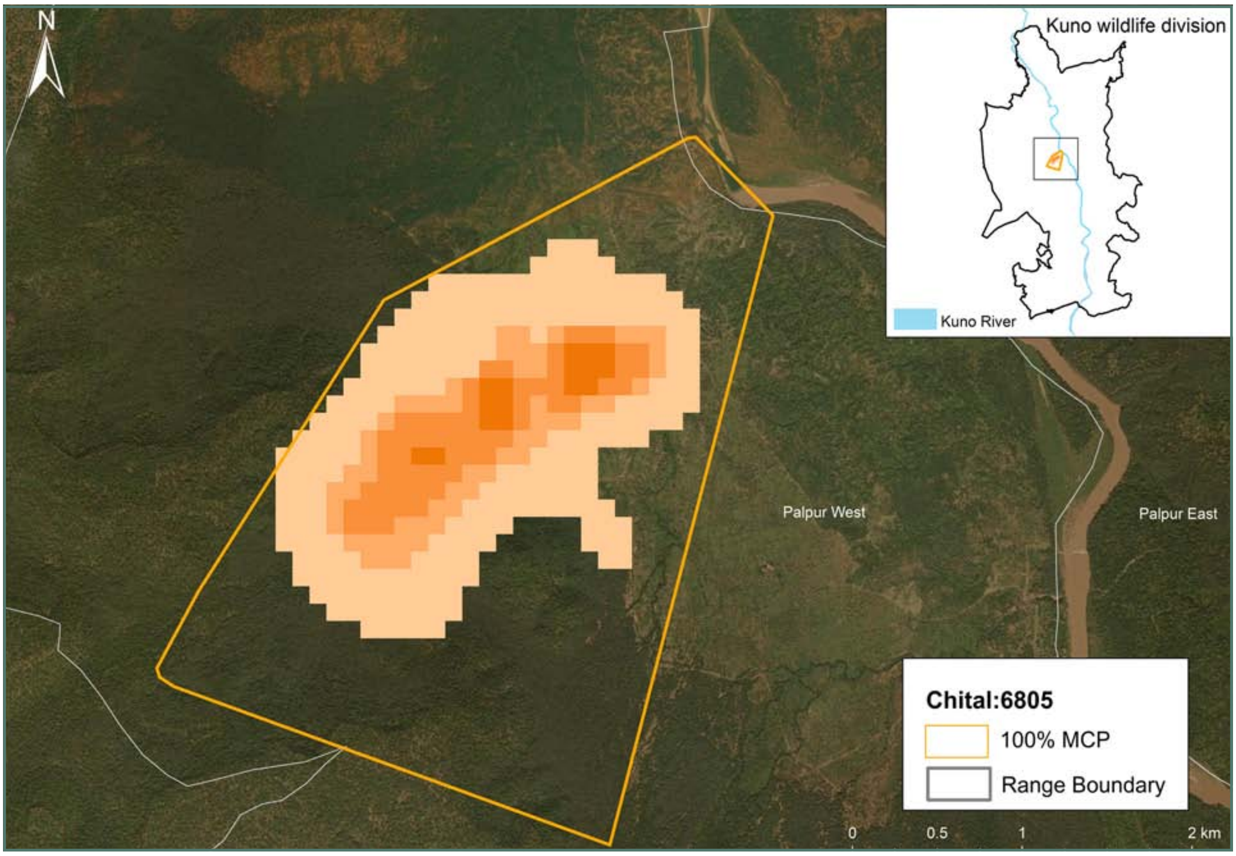


Figure 3.2.5. *Home ranges (100% MCP and 95%KDE) of radio-collared chital adult female (id. 6805) in Kuno Wildlife Division*

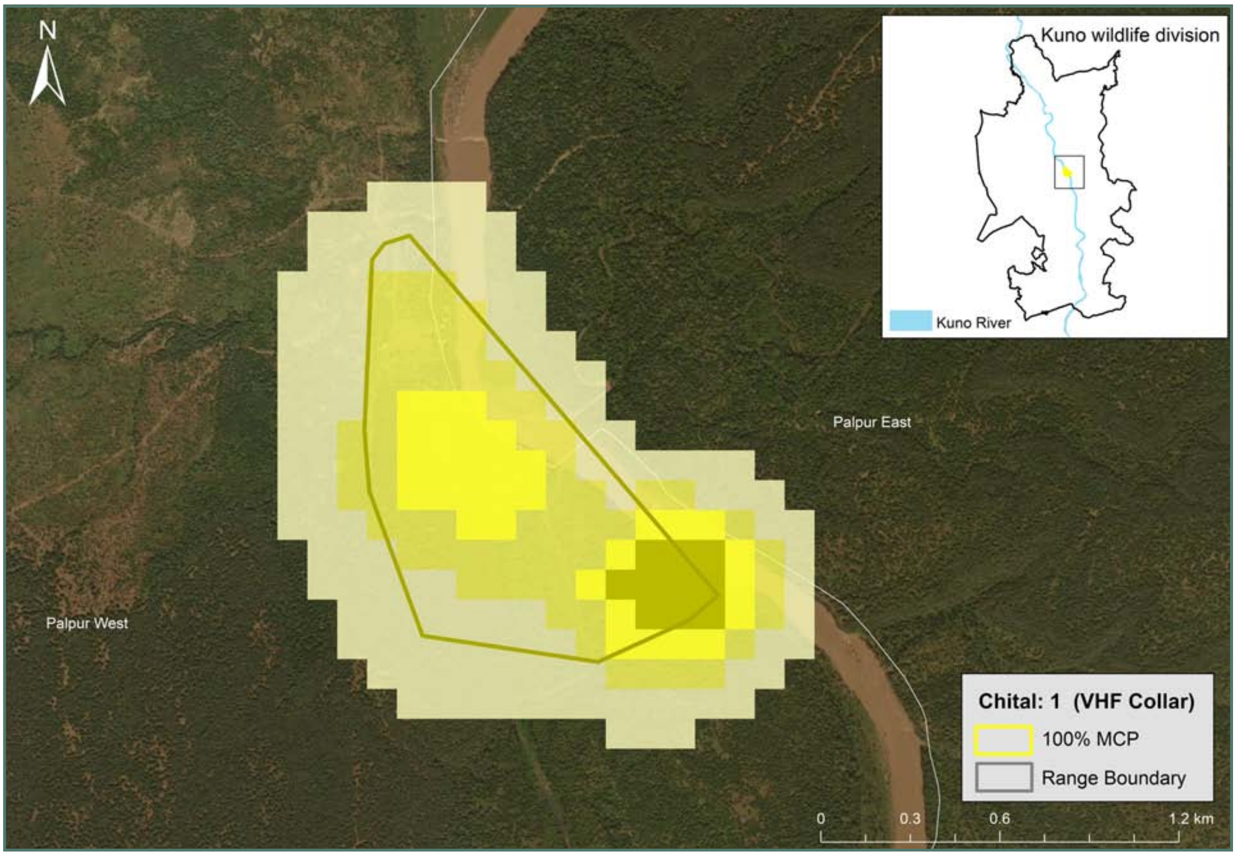


Figure 3.2.6. *Home range (100% MCP & 95%KDE) of radio-collared chital adult female (VHF1) in Kuno Wildlife Division*

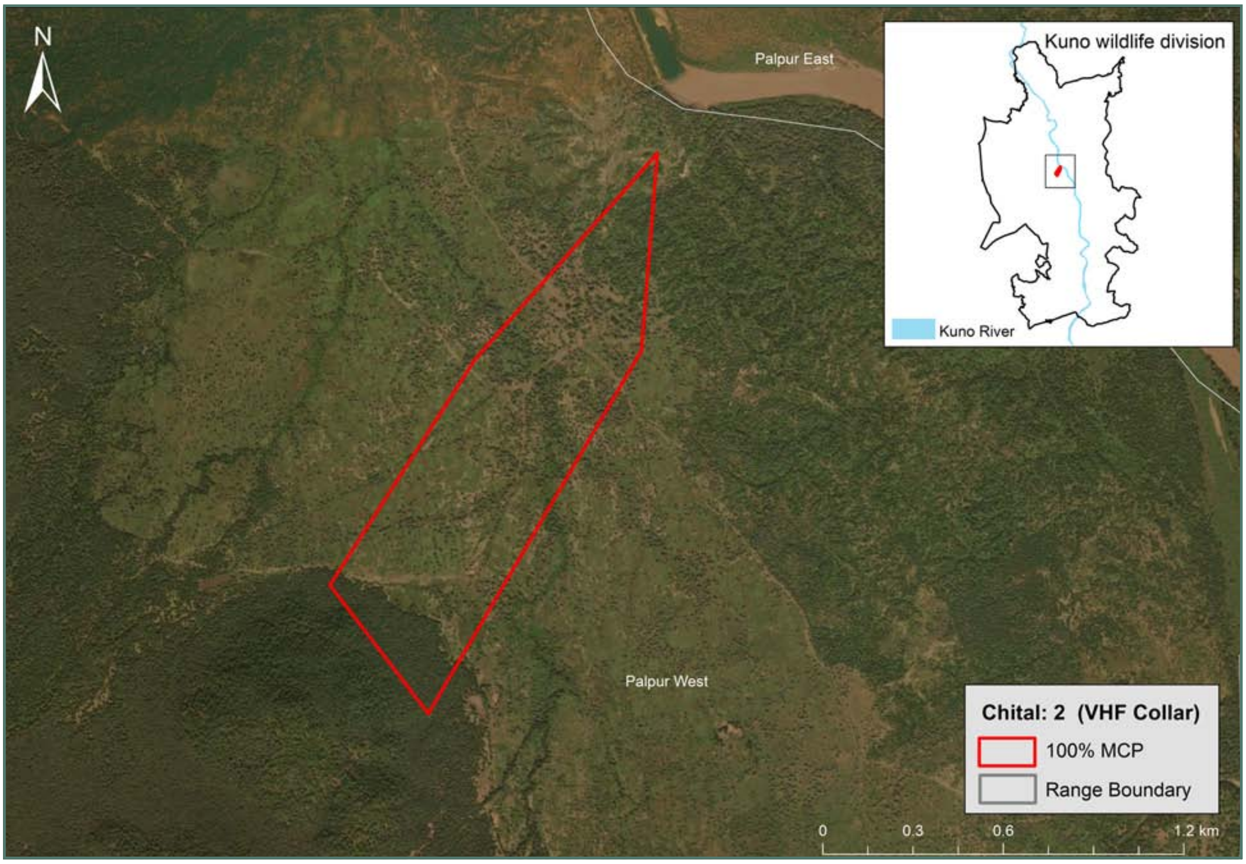


Figure 3.2.7. *Home range (100% MCP) of radio-collared chital sub-adult female (VHF2) in Kuno Wildlife Division*

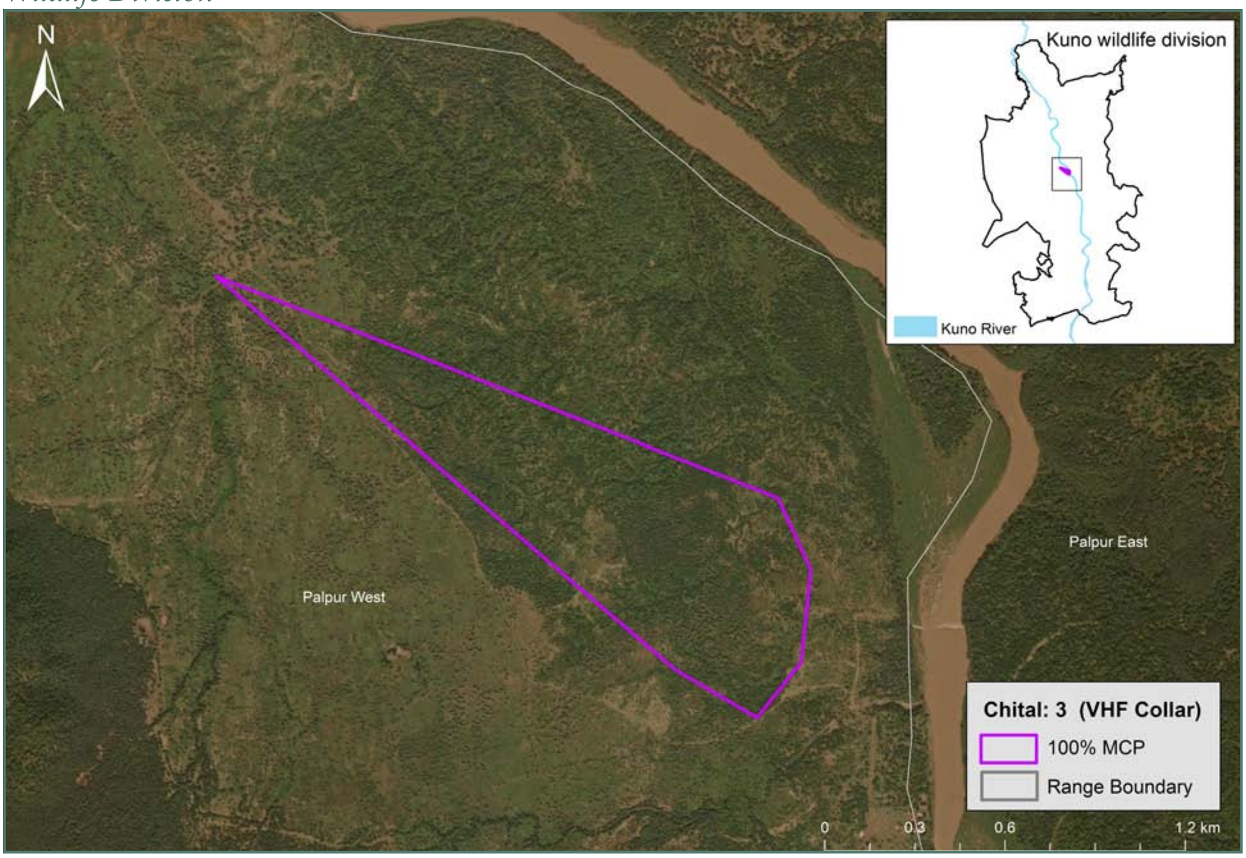


Figure 3.2.8. *Home range (100% MCP) of radio-collared chital sub-adult female (VHF3) in Kuno Wildlife Division*

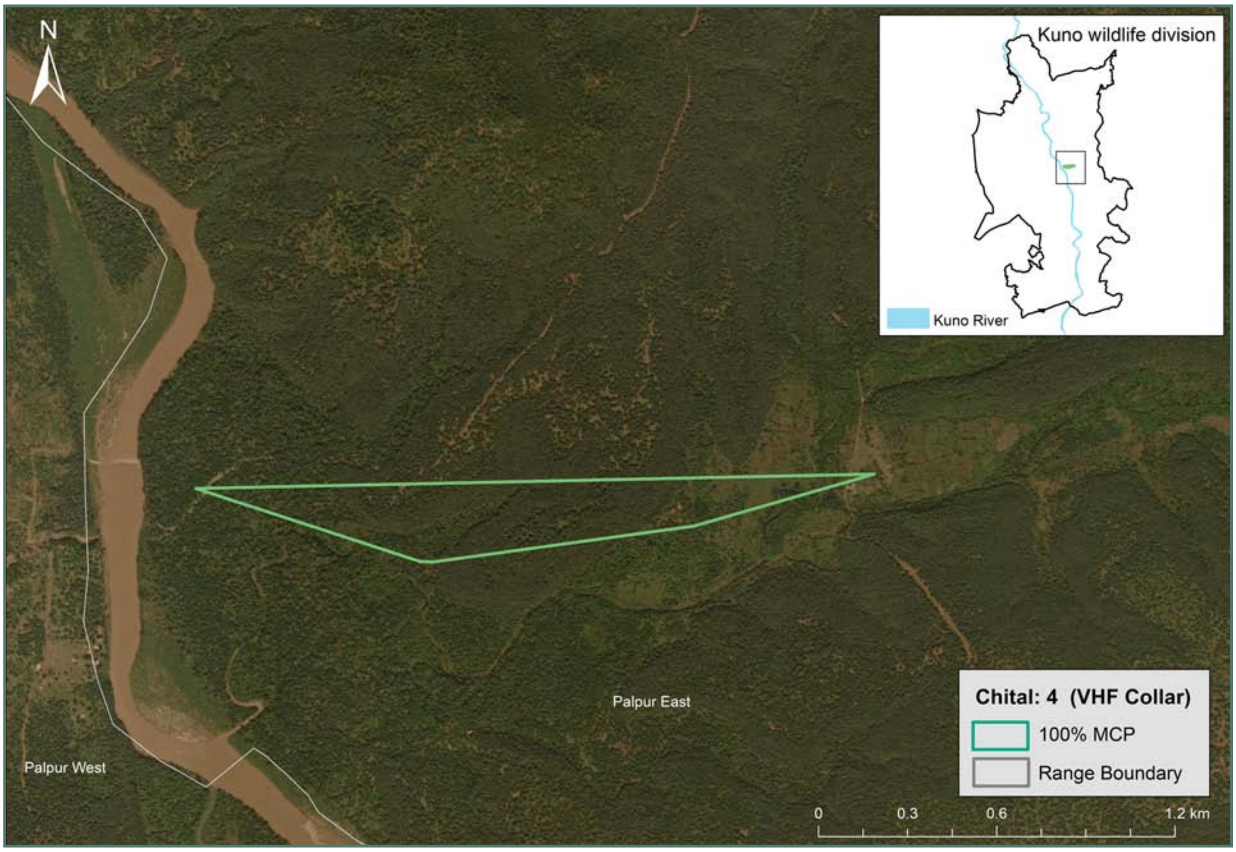


Figure 3.2.9. Home range (100% MCP) of radio-collared chital adult female (VHF4) in Kuno Wildlife Division

3.2.2. Habitat selection of radio-collared chital in Kuno National Park

Resource Selection Function (RSF) was used to calculate habitat preferences of radio-collared chital in Kuno NP based on the use of available resources. RSF evaluates the probability that a particular habitat feature (e.g., class value categories) influences the likelihood of the species using a specific area (Manly *et al.* 2007). RSF applies logistic regression by comparing the characteristics of regions that are used to those that are available but not used (Johnson *et al.* 2006). In R, the amt package was used to generate RSF models by using logistic regression with data from radio-collared individuals to investigate habitat selection (Signer *et al.* 2019). The LULC classes used for analysis are grassland, dhonk forest, riverine, miscellaneous dry deciduous, areas adjacent to water bodies, human habitation, and agriculture.

Second-order habitat selection was assessed across seasons for each of the individuals presently collared and active. We employed selection ratios to assess habitat selection at the home-range level, as these ratios indicate the likelihood of a resource being used relative to its availability. For second-order habitat selection, we compared the proportion of each LULC (land use/land cover) type available at the 100% MCP (Minimum Convex Polygon) scale with the proportion of locations selected within individual home ranges. We calculated species-specific selection ratios through Ivlev's index for each LULC class using the R package adehabitatHS. Ivlev's index Ei for habitat 'i' is calculated using the formula: Ei = (ui - ai)/(ui + ai), where 'ui' represents the proportion of satellite locations in habitat 'i' (habitat utilized) by the species, and 'ai' represents the proportion of habitat 'i' available in the study area. For habitat selection, ratios range from -1 to +1 scale; -1 denotes strong avoidance for that habitat class, and +1 denotes strong preference for that habitat class. All analyses were done in R Studio version 4.3.2. This analysis was conducted for four adult females deployed with UHF radio collars and one female with VHF radio collar.

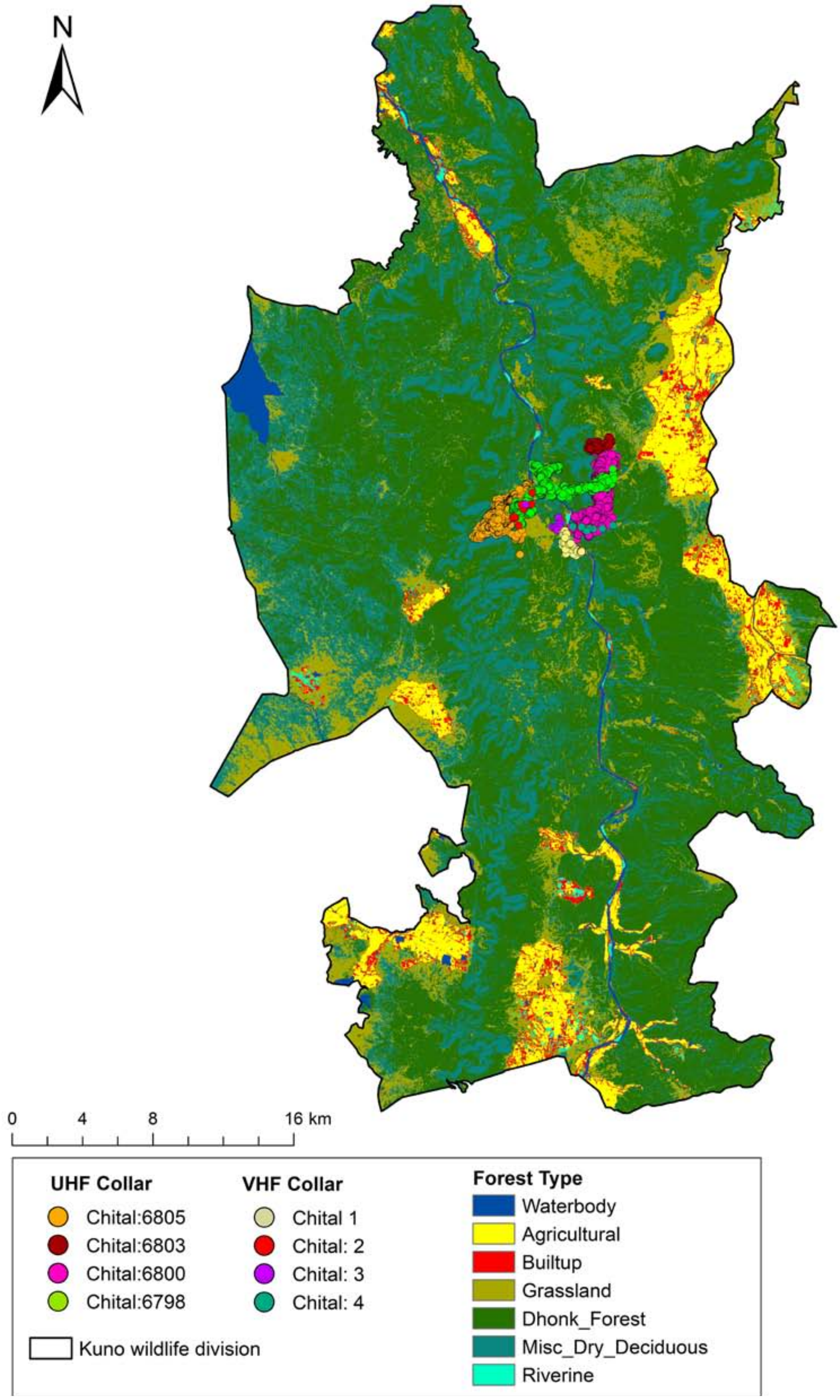
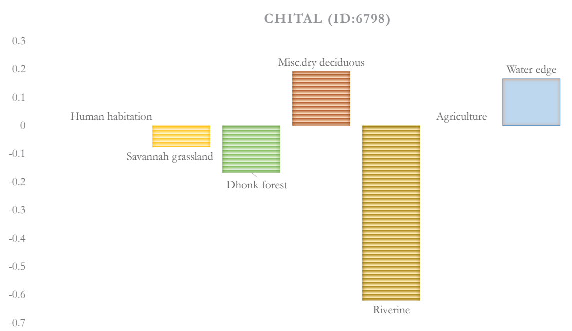


***Figure 3.2.10.** Locations of radio-collared chital overlaid on the forest type map of Kuno Wildlife Division*

Chital adult females as a whole selected savannah grassland habitat the most followed by miscellaneous dry forest and dhonk forest based on resource selection function. Individually, based on Ivlev's index two adult females selected dhonk forest, whereas miscellaneous dry deciduous and savannah grassland patches were selected by one adult female chital each.

Figure 3.2.11. Habitat selection of radio-collared chital in Kuno National Park using the Resource Selection Function, error bars depict standard errors



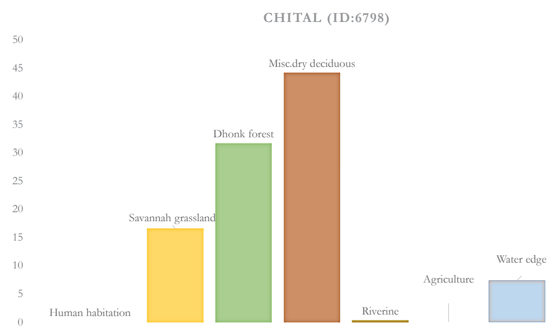
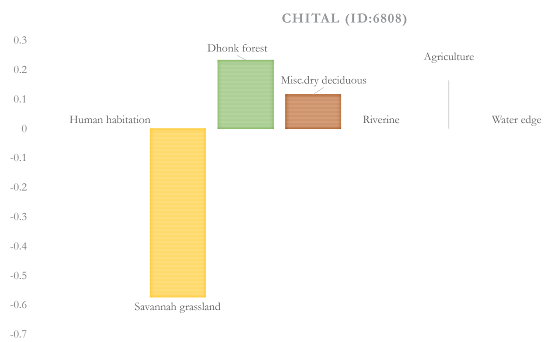


Figure 3.2.12. Habitat selection of radio-collared chital (id.6798) adult female using Ivlev's index (left) and percentage of locations in each habitat type (right)



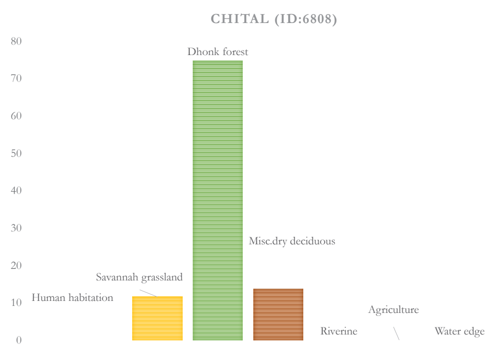


Figure 3.2.13. Habitat selection of radio-collared chital (id.6808) adult female using Ivlev's index (left) and perentage of locations in each habitat type (right)

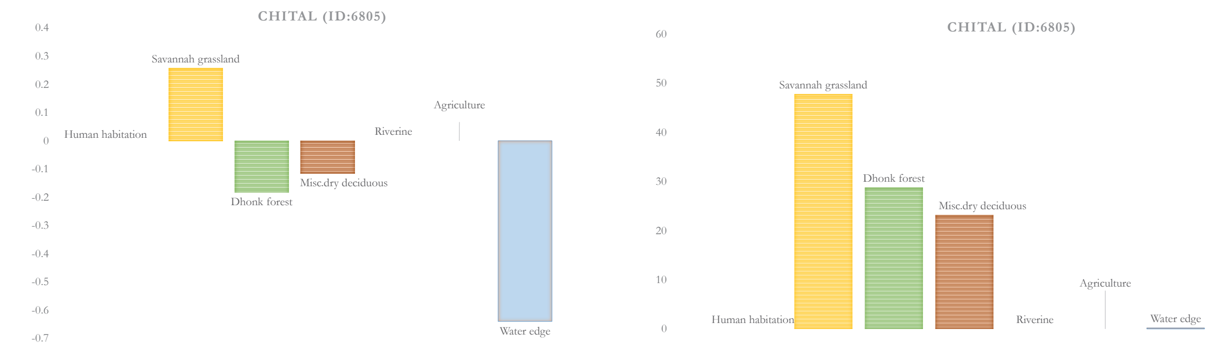


Figure 3.2.14. *Habitat selection of radio-collared chital (id.6805) adult female using Ivlev's index (left) and percentage of locations in each habitat type (right)*

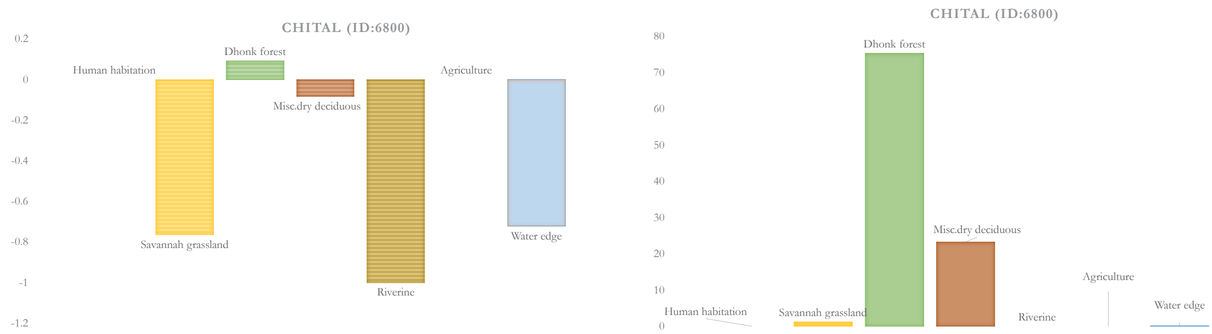


Figure 3.2.15. *Habitat selection of radio-collared chital (id.6800) adult female using Ivlev's index (left) and percentage of locations in each habitat type (right)*

Image 3.2.1. *Monitoring of radio-collared chital in Kuno National Park © Moulik Sarkar*

3.3. Prey assessment in Gandhi Sagar Wildlife Sanctuary

Line transect method using distance sampling to assess prey populations in Gandhi Sagar WLS was conducted during December 2023-January 2024. A total of 82 line transects (39 temporal and 43 spatial replicates) were walked in Gandhi Sagar East and West ranges with a total effort of 320 km surveyed by foot. Among these, temporal replicates were walked thrice, and spatial replicates were sampled once. Chinkara and nilgai were the most sighted wild prey species, followed by wild pig, chital, hare, peafowl, and grey langur. Additionally, observations of domestic animals such as cattle, buffalo, camel, and goat from the nearby villages were also recorded during the sampling.

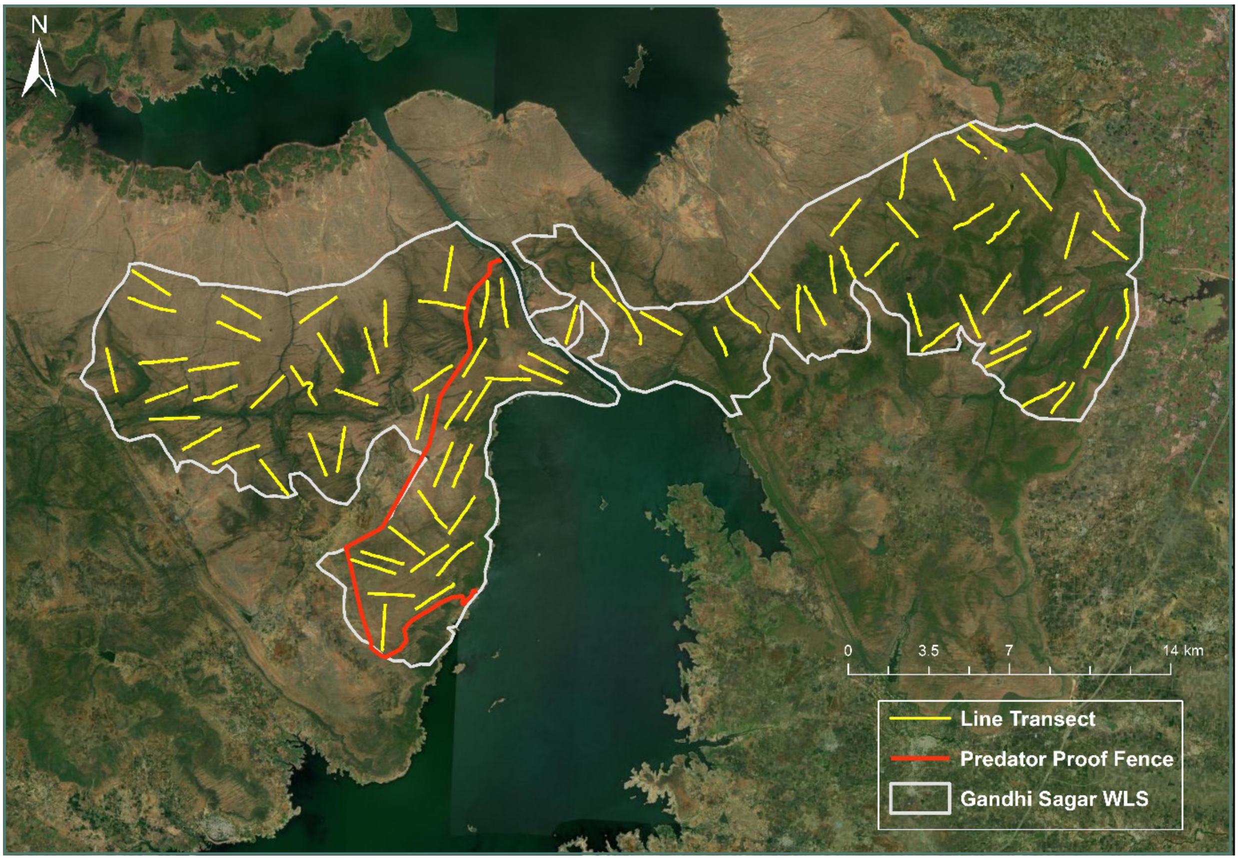


Figure 3.3.1. Layout of line transects surveyed based on distance sampling to assess the status of prey in Gandhi Sagar Wildlife Sanctuary

The East and West ranges of the Gandhi Sagar WLS are separated by the deep gorge of Chambal River as well as the reservoir of the dam, and animals have very minimal chances of crossing to the other side. Within the West range, an area of ~64 km^2 is fenced with predator proofing for release of cheetah.

Therefore, data analysis was carried out by post-stratification using the global detection to estimate the densities of chinkara, nilgai, hare, buffalo, and cattle across three distinct areas: inside fenced area in the West Range (Area~60 km^2), outside the fenced area (Area~120 km^2) in the West Range and entire East Range (Area~180 km^2) of the Sanctuary.

Table 3.3.1. *Species wise encounter detected during the line transect based distance sampling in Gandhi Sagar Wildlife Sanctuary*

	Fenced – Gandhi Sagar West Range (Area- 60 km²)		Outside – Gandhi Sagar West Range (Area~120 km²)		Gandhi Sagar East Range (Area~180 km²)	
Effort (km)	72		104		144	
Species	No of observations -Groups (individuals)	Encounter rate per km -Groups (individuals)	No of observations -Groups (individuals)	Encounter rate per km -Groups (individuals	No of observations -Groups (individuals)	Encounter rate per km -Groups (individuals)
Chinkara	37 (131)	0.51 (1.82)	11 (15)	0.11 (0.14)	23 (99)	0.16 (0.69)
Nilgai	36 (63)	0.50 (0.88)	31 (79)	0.3 (0.76)	47 (90)	0.33 (0.63)
Hare	4 (4)	0.06 (0.06)	6 (6)	0.06 (0.06)	24 (24)	0.17 (0.17)
Peafowl	0	0	4 (8)	0.04 (0.08)	6 (20)	0.04 (0.14)
Wild pig	2 (35)	0.03 (0.49)	7 (87)	0.07 (0.84)	1 (10)	0.01 (0.07)
Chital	1 (5)	0.01 (0.07)	2 (5)	0.02 (0.05)	0	0
Grey langur	0	0	1 (1)	0.01 (0.01)	0	0
Buffalo	19 (116)	0.26 (1.61)	12 (80)	0.12 (0.77)	21 (102)	0.15 (0.71)
Cattle	34 (304)	0.47 (4.22)	32 (242)	0.31 (2.33)	25 (232)	0.17 (1.61)
Goat	0	0	1 (6)	0.01 (0.06)	1 (28)	0.01 (0.19)

The density of animals inside the fenced area was found to be higher. Livestock density was the highest inside (as well as outside) the fenced area followed by chinkara, nilgai, and hare in West Range. As the survey was carried out when certain parts of the fence were incomplete and livestock were sent inside for grazing early mornings by the local people and therefore encountered during the time of sampling, whereas, outside the fenced area, livestock would be driven towards the forest later in the day as it was winter. Increased patrolling and security within and adjacent to the fence was more during the broad daylight hours.

In the West Range, the density estimate of chinkara inside the fenced area was 7.38(2.00SE) animals per km² and 0.5(0.19SE) animals per km² outside the fenced area. The estimated population of chinkara is ~443 animals inside the fenced area (~60 km²). The density estimate of nilgai inside the fenced area was 4.35(1.17SE) animals per km², whereas outside the fenced area, it was found to be 4.05(1.36SE) animals per km². The estimated population of nilgai is ~260 animals inside the fenced area. One-fourth of the nilgai encountered inside the fenced area during sampling consisted of calves. The density estimates of chinkara, nilgai, and hare were 3.33(1.33SE), 2.86(0.63SE), and 5.71(1.64SE) animals per km² respectively in the East Range. The total population of chinkara in the East Range was estimated to be 600 animals.

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Table 3.3.2. Summary of prey densities in Gandhi Sagar Wildlife Sanctuary obtained from line transect based distance sampling the fenced area in Gandhi Sagar West Range (Area- 60 km²), outside the fenced area in Gandhi Sagar West Range (Area~120 km²) and Gandhi Sagar East Range (Area~180 km²)

Species	Area	Density (SE) per km²	CV of Density (%)	MCS (SE)	ESW in m	Model	Adjustment key	Estimated population
Chinkara	Fenced-GSW	7.38(2.00)	27.15	3.54(0.4)	138.02	Half normal	Cosine	443
	Outside-GSW	0.5(0.19)	39.4	1.36(0.2)				60
	GSE	3.33(1.33)	40.11	4.30(0.63)				600
Nilgai	Fenced-GSW	4.35(1.17)	27.05	1.75(0.2)	91.77	Half normal	Cosine	261
	Outside-GSW	4.05(1.36)	33.54	2.5(0.42)				486
	GSE	2.86(0.63)	22.26	1.9(0.24)				515
Hare	Fenced-GSW	1.90(0.92)	48.55	1	14.6	Half normal	Cosine	114
	Outside-GSW	1.97(1.04)	52.93	1				237
	GSE	5.71(1.64)	28.84	1				1028
Large livestock	Fenced-GSW	28.39(8.43)	29.7	7.92(1.28)	120.89	Half normal	Cosine	1704
	Outside-GSW	14.76(5.54)	37.58	7.41(1.34)				1772
	GSE	8.70(2.37)	27.28	7.26(0.99)				1566

SE- Standard Error, CV- Coefficient of Variation, MCS- Mean Cluster Size, ESW- Effective Strip Width
GSW- Gandhi Sagar West Range, GSE- Gandhi Sagar East Range

Image 3.3.1. *Chinkaras in the open savannah of Gandhi Sagar Wildife Sanctuary © Moulik Sarkar*

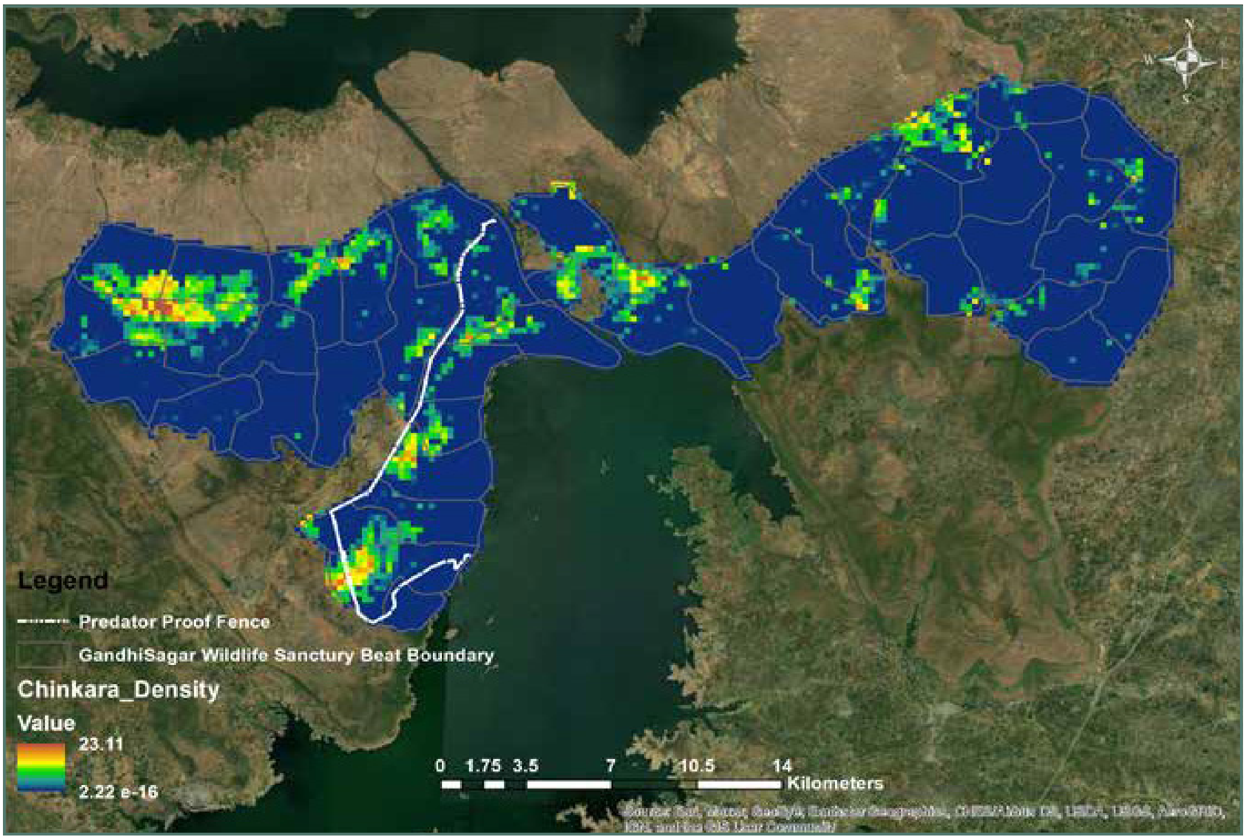

Figure 3.3.2. *Distribution of chinkara in Gandhi Sagar Wildlife Sanctuary based on distance sampling using density surface modelling*

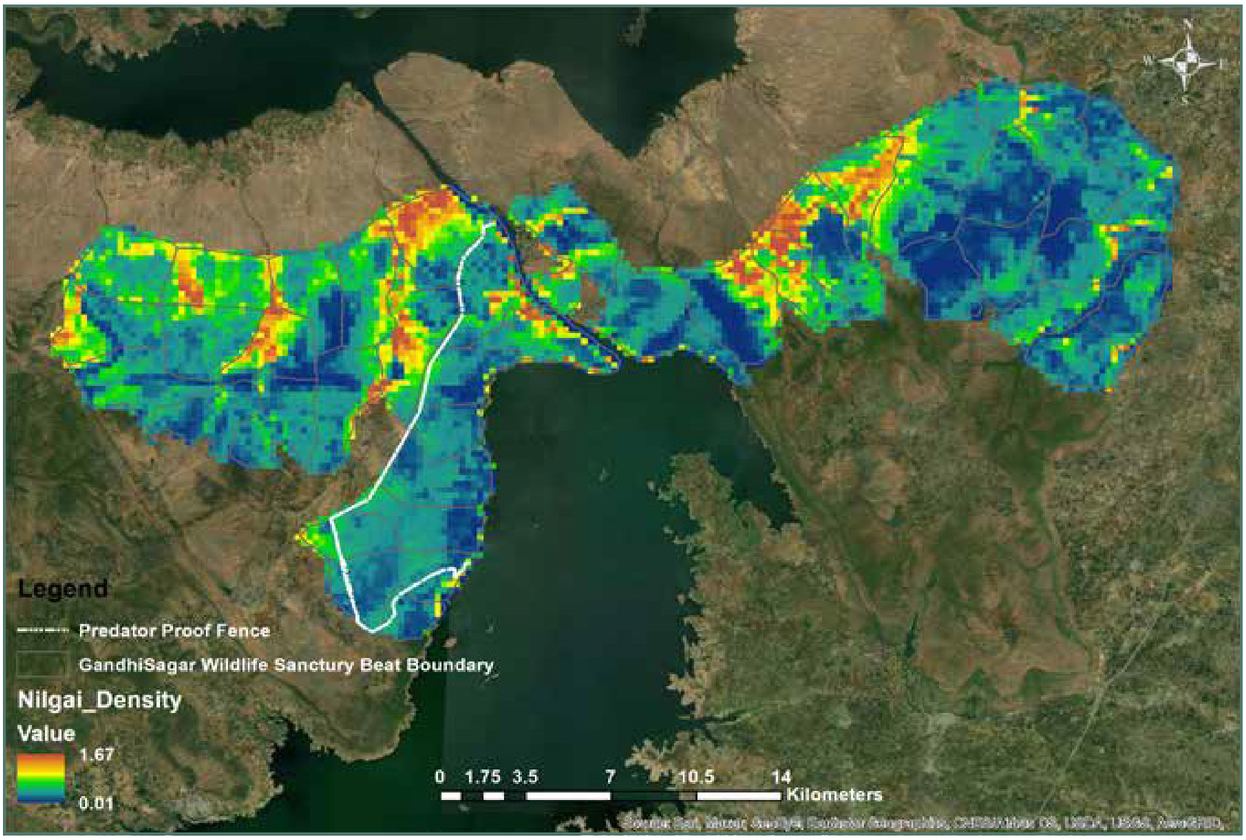

Figure 3.3.3. *Distribution of nilgai in Gandhi Sagar Wildlife Sanctuary based on distance sampling using density surface modelling*

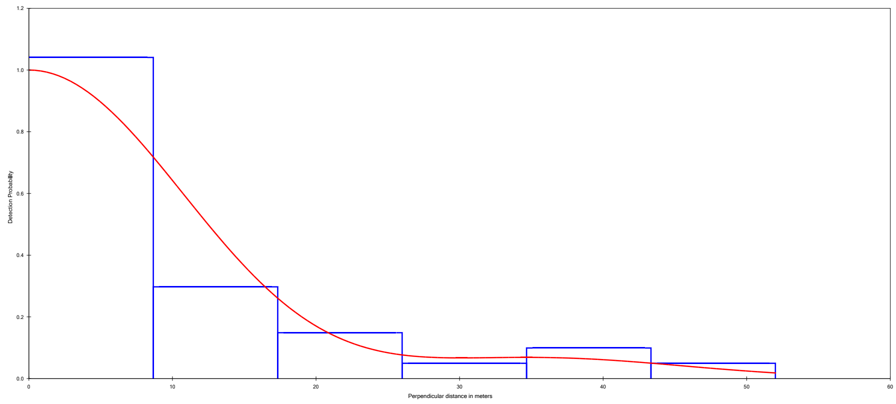

Figure 3.3.4. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- half normal (cosine adjustment) in DISTANCE analysis for population density estimation of chinkara in December 2023-January 2024 (goodness of fit X^2- p= 0.95, number of observations-71)*

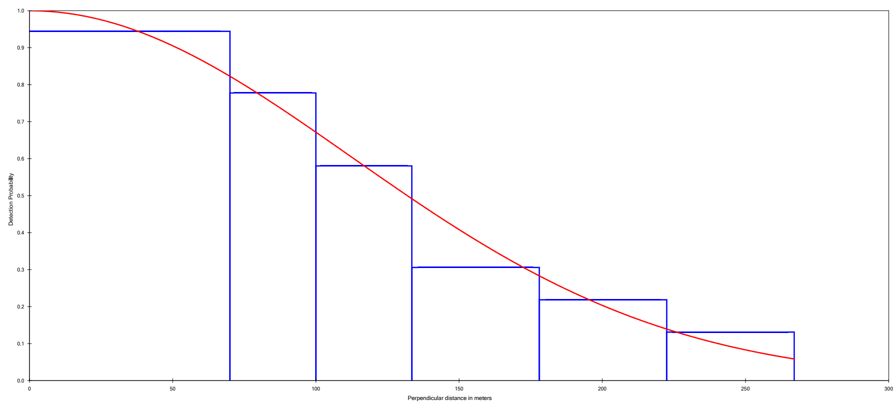

Figure 3.3.5. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- half normal (cosine adjustment) in DISTANCE analysis for population density estimation of nilgai in December 2023-January 2024 (goodness of fit X^2- p= 0.81, number of observations-114)*

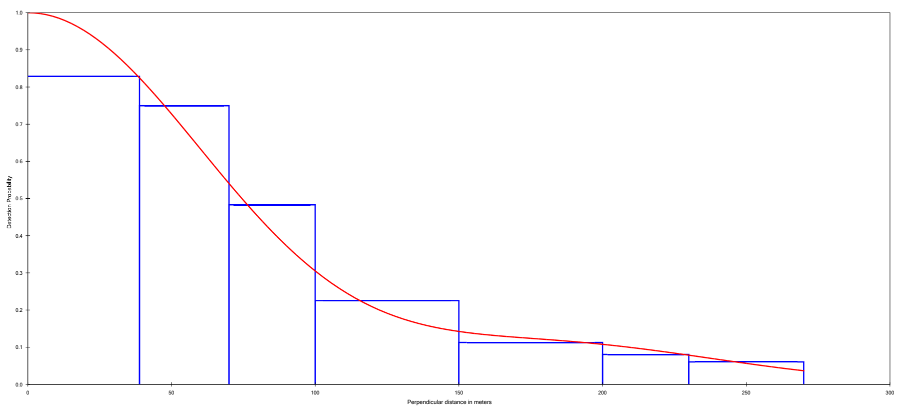

Figure 3.3.6. *Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- half normal (cosine adjustment) in DISTANCE analysis for population density estimation of hare in December 2023-January 2024 (goodness of fit X^2- p= 0.47, number of observations-34)*

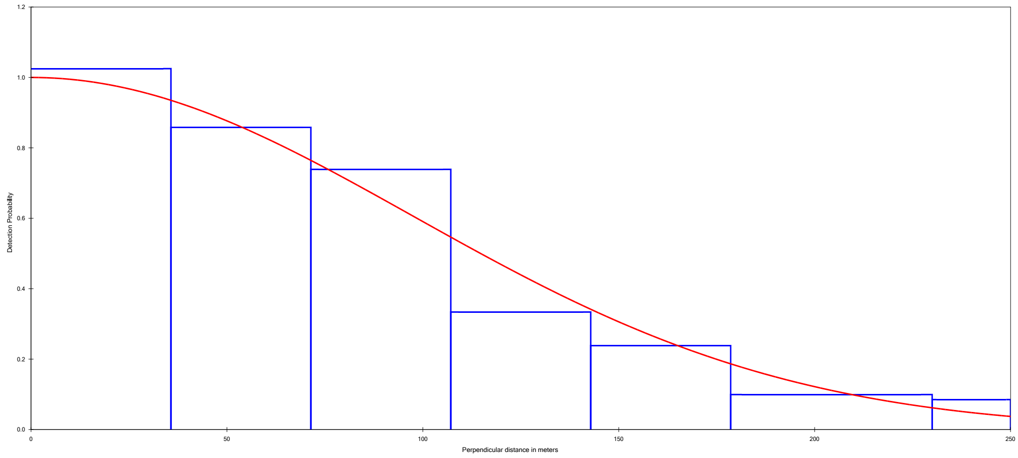

***Figure 3.3.7**. Detection function curve overlaid on the histogram of observed distances obtained from the best fit model- half normal (cosine adjustment) in DISTANCE analysis for population density estimation of large livestock in December 2023-January 2024 (goodness of fit X^2- p= 0.78, number of observations- 143)*

***Image 3.3.2.** Nilgai female with calf in Gandhi Sagar Wildlife Sanctuary © Moulik Sarkar*

4.

Monitoring of cheetahs in Kuno National Park

4.1. Adaptations, predation strategy and prey selection by the cheetah

Cheetahs, renowned for their status as apex coursing predators, employ a distinctive suite of anatomical adaptations to facilitate their unparalleled hunting techniques. Central to their hunting strategy is their utilization of high-speed pursuit, culminating in suffocation as the primary method of catching prey (Caro 1994). Foremost among their adaptations is the unique morphology of their claws characterized by a specialized semi-retractile modification. This adaptation enhances their ability to maintain traction on varied terrain during rapid pursuits, crucial for successful hunts in diverse environments (Hayward *et al.* 2009). The robust and sharply curved dewclaw is of particular significance, situated on the forepaw's first digit. This structure functions as a pivotal tool for ensnaring prey during high-velocity pursuits, disrupting their balance by tripping them and facilitating capture (Mills 2014). Furthermore, the cheetah's slender physique confers distinct advantages, notably in reducing overall mass and augmenting acceleration capabilities. This streamlined form optimizes their efficiency in traversing landscapes with rapidity, a testament to the evolutionary refinement of their hunting strategy. Elongated hind limbs further contribute to their locomotive prowess, enabling extended stride lengths that serve to amplify accelerative forces (Hudson 2012).

Integral to the cheetah's pursuit dynamics is the presence of a long, muscular tail, pivotal for maintaining equilibrium during high-speed chases (Wilson 2013). This appendage acts as a stabilizing force, counteracting the forces exerted by rapid changes in direction and velocity. Additionally, during bursts of speed, enlarged nasal passages facilitate heightened rates of air intake accommodated by large lungs, optimizing respiratory efficiency to sustain prolonged exertion. The cheetah's prowess as a consummate predator is underpinned by a suite of specialized anatomical adaptations tailored to the demands of high-speed pursuits. Through the interplay of claw morphology, body structure, and respiratory physiology, these magnificent felines epitomize the pinnacle of evolutionary ingenuity in the pursuit of prey.

Cheetahs exhibit a distinct preference for prey within the small to medium size range, with a particular focus on species such as gazelles, impalas, springboks, and young wildebeests inhabiting the African savannah (Mills *et al.* 2004). These target species typically display body masses ranging from 20 to 80 kilograms (44 to 176 pounds), representing optimal prey for the cheetah's hunting strategy. Central to the cheetah's hunting technique is its tremendous surge of speed, a trait leveraged to close the distance with prey rapidly and effectuate capture. Unlike their counterparts among the stalking predators, cheetahs avoid prolonged stealth in favor of sudden bursts of acceleration, catching prey unawares before initiating a high-speed pursuit. Upon securing a kill, cheetahs exhibit a behavior characterized by expedited consumption, minimizing the risk of scavenger interference from co-predators such as hyenas, leopards, and lions. This reluctance to hold on to the kills distinguishes cheetahs from other carnivores, underscoring their preference for efficiency and expediency in prey consumption.

***Image 4.1**. Cheetah in Kuno National Park © Yash Deshpande*

4.2. Predation by cheetah in Kuno

Continuous monitoring of all the cheetahs in Kuno was carried out to comprehensively understand their predation patterns, both within the soft-release (acclimatization) boma and in free-ranging habitat. Their predation events were monitored daily and kills recorded were noted in a standard datasheet where the age, gender, and species killed were noted down with habitat, respective dates, and time of observations. The reported predation rate was derived from documented instances of actual predation events; however, it is important to acknowledge the potential existence of undetected predation events due to various factors that may elude detection by the field team such as carcasses of small prey, removal by scavengers etc. Other than two individuals (one male Pawan and one female Veera) which were released into free-ranging conditions during mid-December 2023, all the other cheetahs were either inside the soft-release enclosures or in quarantine bomas. The soft-release bomas are regularly supplemented with chital. The data provided is from September 2023 to July 2024.

Cheetahs predated on a variety of prey species including Indian hare, chital, sambar, chowsingha, chinkara, blackbuck, and nilgai. The detected kill rate of cheetahs ranged from 4.00 -7.91 days per kill inside the soft-release enclosure and 3.96 - 4.63 days per kill in free-ranging conditions. The relatively higher kill rate observed in a few cheetahs was due to the high probability of missing some kills, particularly kills of smaller prey and its remains not being detected or disposal of the remains by other predators/scavengers. The larger duration between kills were observed in the case of coalition males and a solitary female, in which the latter chiefly predated on young chital (in both the cases, chances of prey consumption/carcass disappearance is faster/higher). In free-ranging conditions, the predation rate of the male cheetah was higher than the female, whereas it was mostly the opposite in the soft-release enclosure. However, this smaller duration between kills was primarily by the three female cheetahs who littered cubs. The main prey available for cheetahs are chital and the same was also observed in cheetah predation data.

Table 4.2.1. *Monthly detected number of cheetah kills in Kuno (September 2023-July 2024)*

Sl No	Animal	Sex	Number of detected kills											Total
			Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	
1	Pawan	M	1	2	5	5	8*	8*	13*	9*	4*	4*	6*	65
2	Veera	F	Q	2	6	4	5*	4*	8*	6*	5*	6*	Q	46
3	Asha	F	Q	2	4	5	11	14	7	NA	2	NA	2	47
4	Gamini	F	1	4	6	9	10	9	4	3	NA	NA	NA	46
5	Nabha	F	4	NA	NA	NA	2	NA	NA	NA	NA	NA	NA	6
6	Jwala	F	Q	3	2	4	11	11	7	NA	NA	NA	NA	38
7	Dheera	F	1	3	4	3	5	5	5	5	4	4	3	42
8	Nirva	F	Q	Q	Q	Q	5	5	7	5	NA	2	3	27
9	Agni	M	4	5	3	4	Q	4	5	4	1	1	2	33
10	Vaayu	M	3	5	4	4	Q	4	5	4	1	1	2	33
11	Gaurav	M	2	2	NA	3	1	Q	Q	1	3	Q	1	13
12	Shaurya	M	2	2	NA	2	1#	-	-	-	-	-	-	7
13	Prabhas	M	2	4	3	4	6	5	5	11	1	Q	Q	41
14	Pavak	M	1	3	4	6	6	5	5	11	1	4	1	47

*M- Male, F- Female, *- Free-ranging, Q-Quarantine, NA- Not Available, #-Deceased*

Table 4.2.2. Prey species killed by cheetah in Kuno (December 2022-July 2024)

Animal(s)	Sex	Soft-release enclosure				Free-ranging								
		Chital	Sambar	Nilgai	Hare	Chital	Sambar	Nilgai	Chowsingha	Chinkara	Blackbuck	Hare	Cattle	Goat
Pawan	M	Yes	Yes			Yes	Yes	Yes	Yes		Yes		Yes	Yes
Veera	F	Yes				Yes		Yes	Yes				Yes	Yes
Asha	F	Yes		Yes		Yes			Yes	Yes		Yes		
Gamini	F	Yes				Yes								
Nabha	F	Yes			Yes									
Jwala	F	Yes												
Dheera	F	Yes	Yes											
Nirva	F	Yes			Yes	Yes								
Agni & Vaayu	M	Yes		Yes		Yes								
Prabhas & Pavak	M	Yes												
Gaurav & Shaurya	M	Yes		Yes		Yes	Yes	Yes						

Table 4.2.3. Detected kill rate of cheetahs from September 2023 to July 2024

Animal(s)	Sex	Kill rate (days per kill)	
		Inside soft-release enclosure	Free-ranging
Pawan	M	5.42	3.96
Veera	F	7.91	4.63
Asha	F	4	NA
Gamini	F	4.33	NA
Nabha	F	NA#	NA
Jwala	F	4.26	NA
Dheera	F	6.86	NA
Nirva	F	4.48	NA
Agni & Vaayu	M	6.74	NA
Prabhas & Pavak	M	5.87	NA
Gaurav & Shaurya	M	NA#	NA

M- Male, F- Female, #-Mostly supplemented, NA- Not Available

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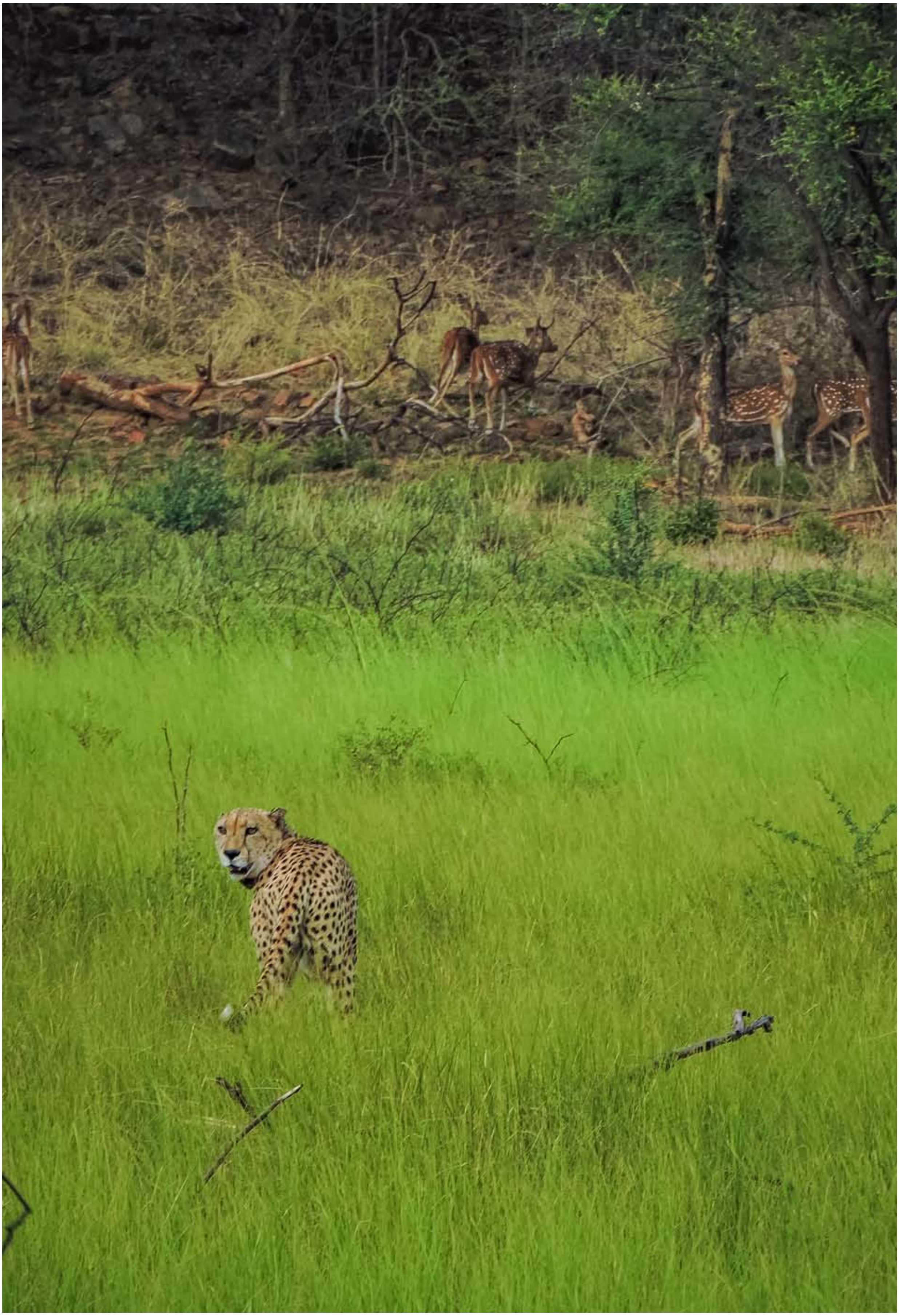

Image 4.2.1. *Cheetah stalking chital in Kuno National Park © Moulik Sarkar*

4.2.1. Pattern of chital predation by cheetahs

A total of 350 kills of chital were detected from September 2023- July 2024, wherein 305 kills of chitals were detected inside the soft-release enclosure. Among the chitals killed by cheetahs, the predation of female chitals was double the proportion of male kills. The majority of chital killed by the cheetahs were adults. Most of the successful hunts of chital took place in the mixed forest followed by the dhonk forest. Cheetah male coalitions and females predated more on chital females. A similar pattern was also observed in kills of the solitary male, however, the proportion of kills whose sex could not be identified was higher. The solitary male cheetah predated more on young chitals, whereas cheetah females and male coalitions predated more on adult chitals.

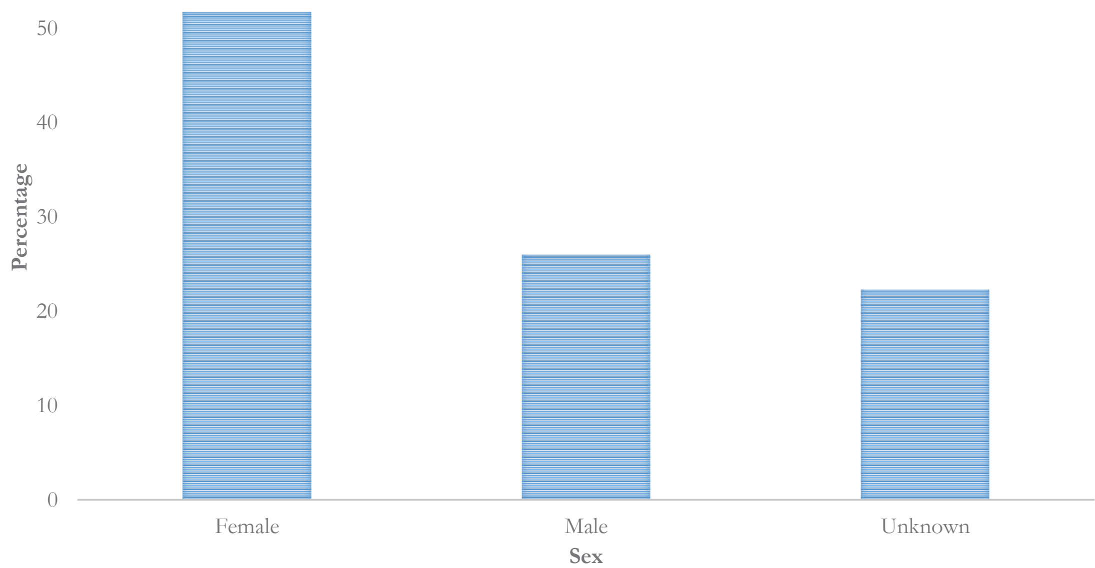

Figure 4.2.1. Sex of chital predated by cheetahs in Kuno

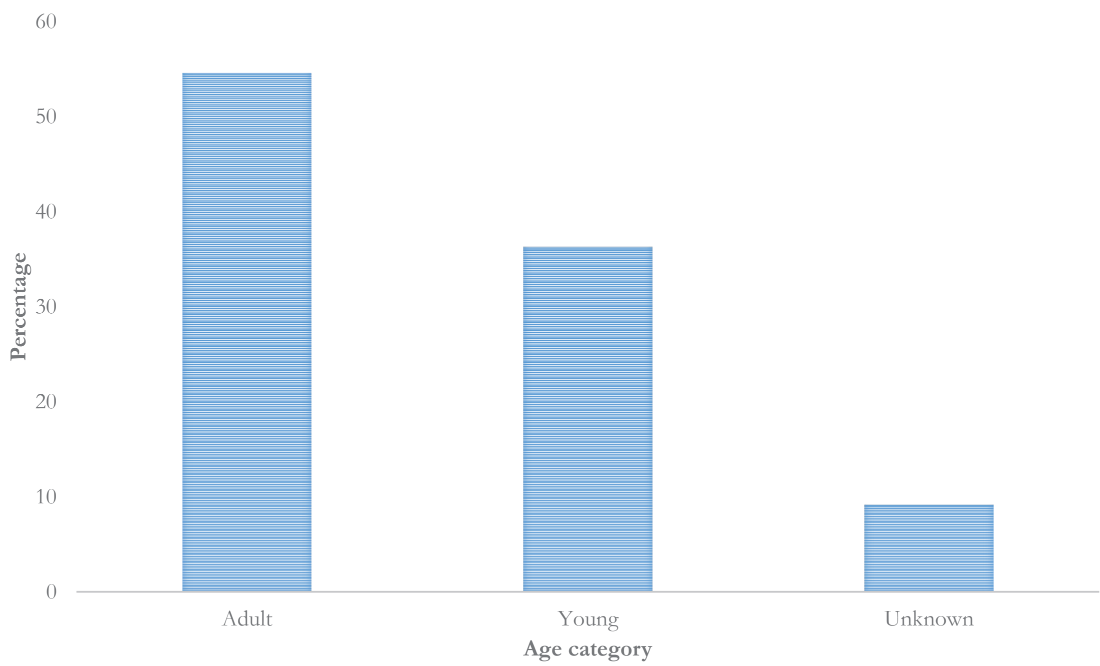

Figure 4.2.2. Age category of chital predated by cheetahs in Kuno

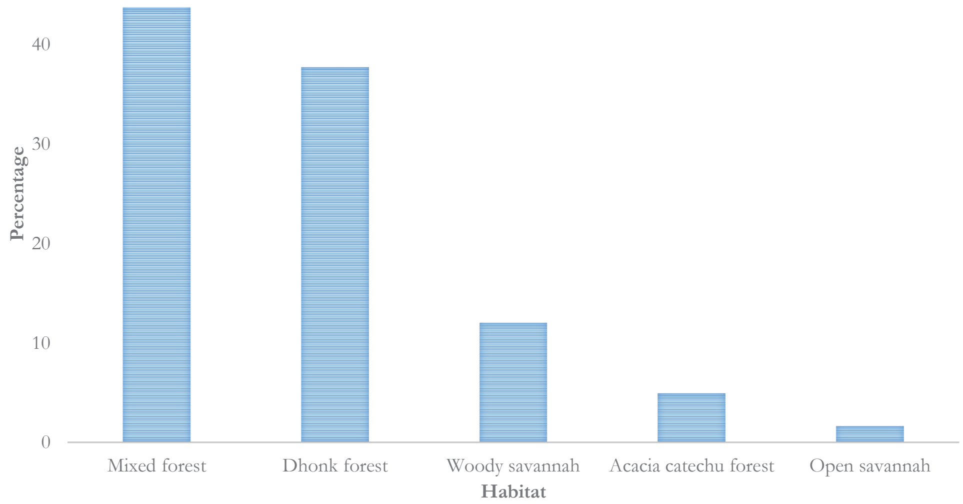

***Figure 4.2.3.** Chital predation by cheetahs in various habitats of Kuno*

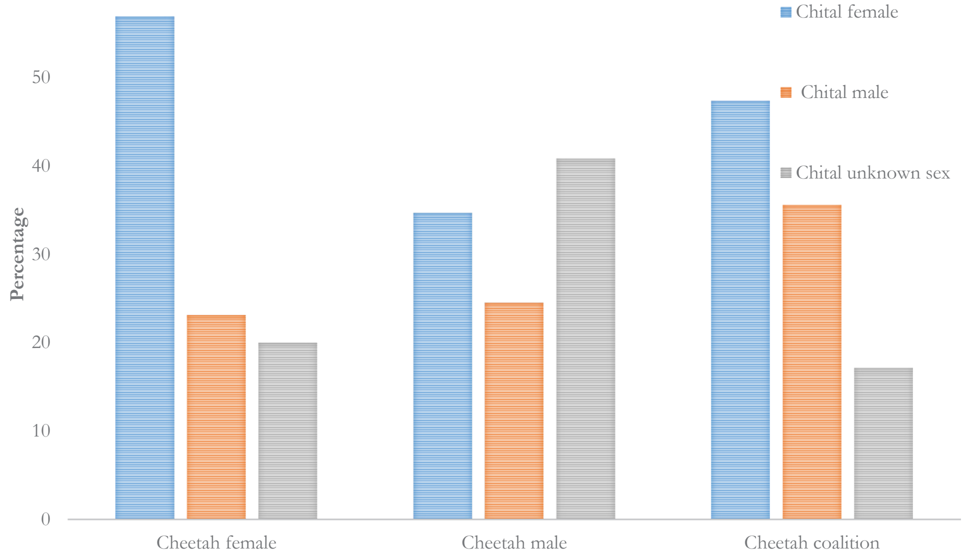

Figure 4.2.4. Sex of chital predated by cheetah social unit

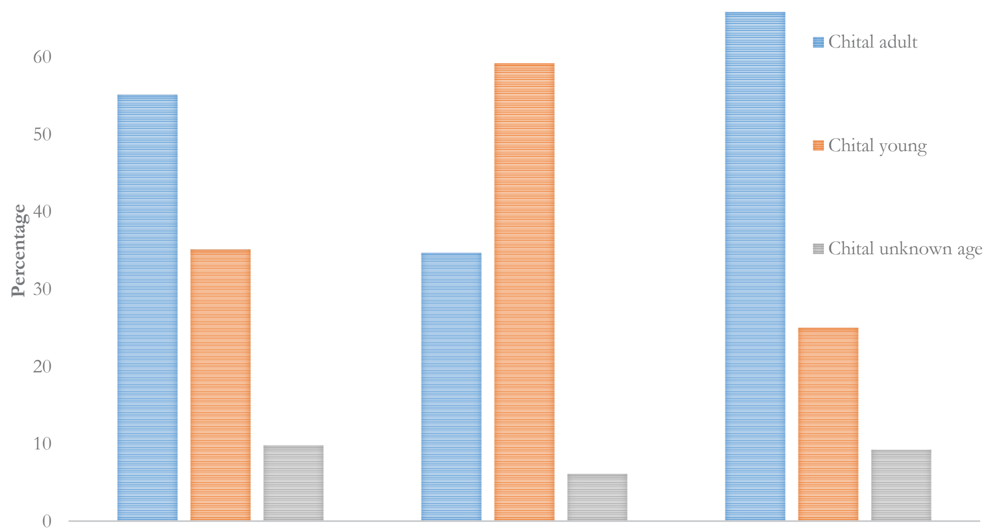

***Figure 4.2.5.** Age category of chital predated by cheetah social unit*

Image 4.2.2. *Cheetah with chital kill in Kuno National Park © Prateek Sharma*

Image 4.2.3. *Tracking of cheetahs in Kuno National Park © Yash Deshpande*

4.2.2. Predation by cheetah social units

The details of the prey killed by each of the cheetah social units (male coalition, male and female) from September 2023 onwards are discussed in detail below.

4.2.2.1. Predation by male coalition Prabhas and Pavak

The male coalition partners Prabhas and Pavak shared a soft-release boma from September 2023 onwards. Only chitals were predated by Prabhas and Pavak and the detected kill rate was 5.87 days per kill. Most of the detected kills (38) were made as a coalition, however, a few kills were also made individually (Prabhas-3 kills, Pavak-8 kills and Pavak with cheetah female Gamini-1 kill). Both males and females of chitals were predated equally by the coalition. Among the kills made by Prabhas and Pavak as a coalition, the majority (79%) of them were adult chitals (Figure 4.2.2.1). In cases of individual kills, mostly females and young were predated. An almost equal number of kills made by the coalition were in mixed forest and dhonk forest.

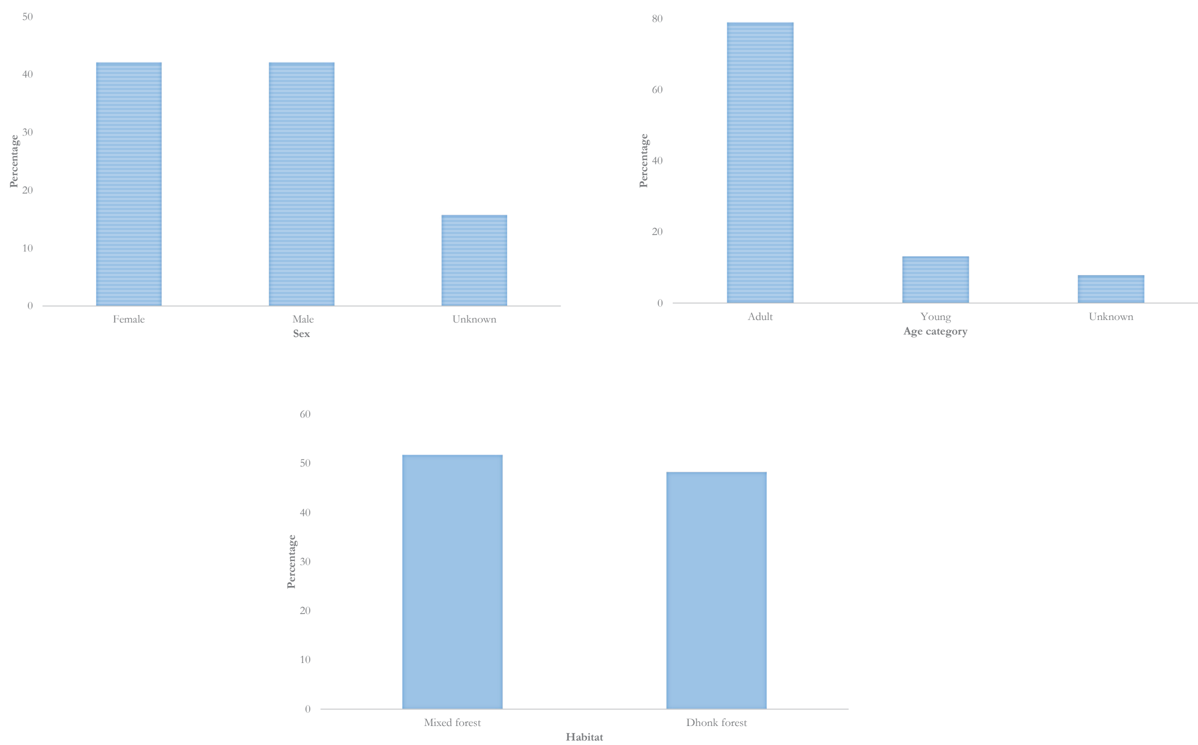

Figure 4.2.2.1. *Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah male coalition Prabhas and Pavak within the soft-release boma*

4.2.2.2. Predation by female cheetah Jwala

Jwala is a four year-old female kept inside the soft-release boma and the information on her kills is till April 2024, after which she gave birth to four cubs, and monitoring was regulated to reduce disturbances. All the detected kills (38) made by Jwala were of chital and the detected kill rate was 4.26 days per kill. A higher percentage of female chital (45%) were predated compared to males (32%). The sex of almost one-fourth of the kills couldn't be identified. Adult chital among the kills were 58%, whereas 37% were young. Maximum kills were made in woody savannah, followed by open savannah.

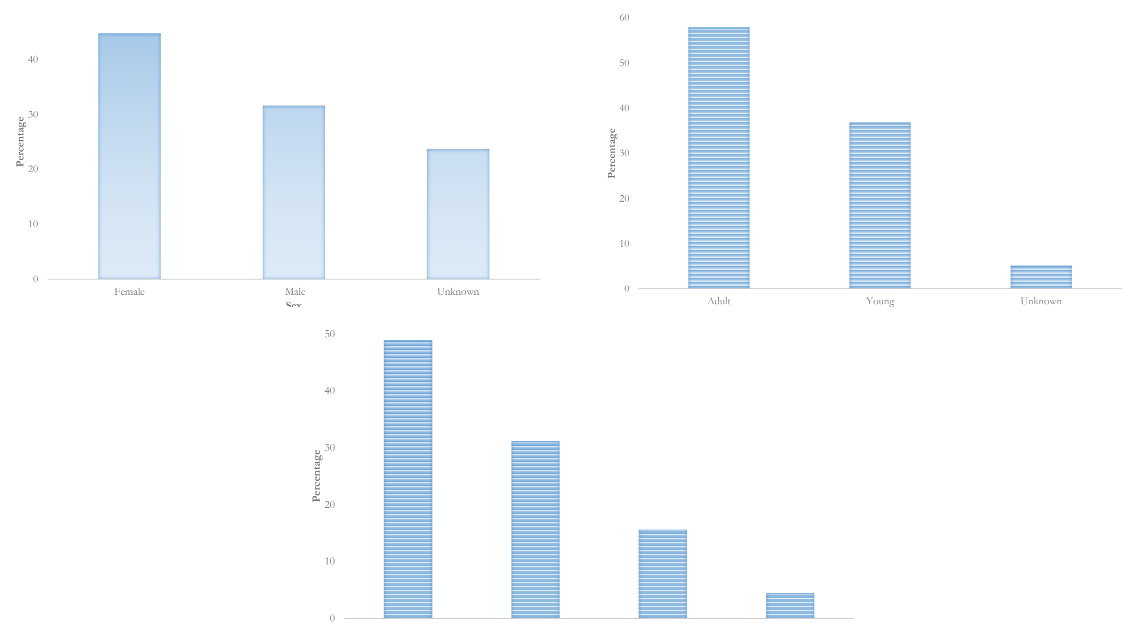

Figure 4.2.2.2. *Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah female Jwala within the soft-release boma*

4.2.2.3. Predation by female cheetah Dheera

Dheera is a seven year-old female housed inside the soft-release enclosure. A total of 42 chital kills were observed during the reporting period and the detected kill rate was 6.86 days per kill. Dheera's kills comprised almost equal proportions of females (48%) and males (43%). Among the detected kills, the majority (67%) were adults. Dheera was observed to predate more in the mixed forest habitats within the boma.

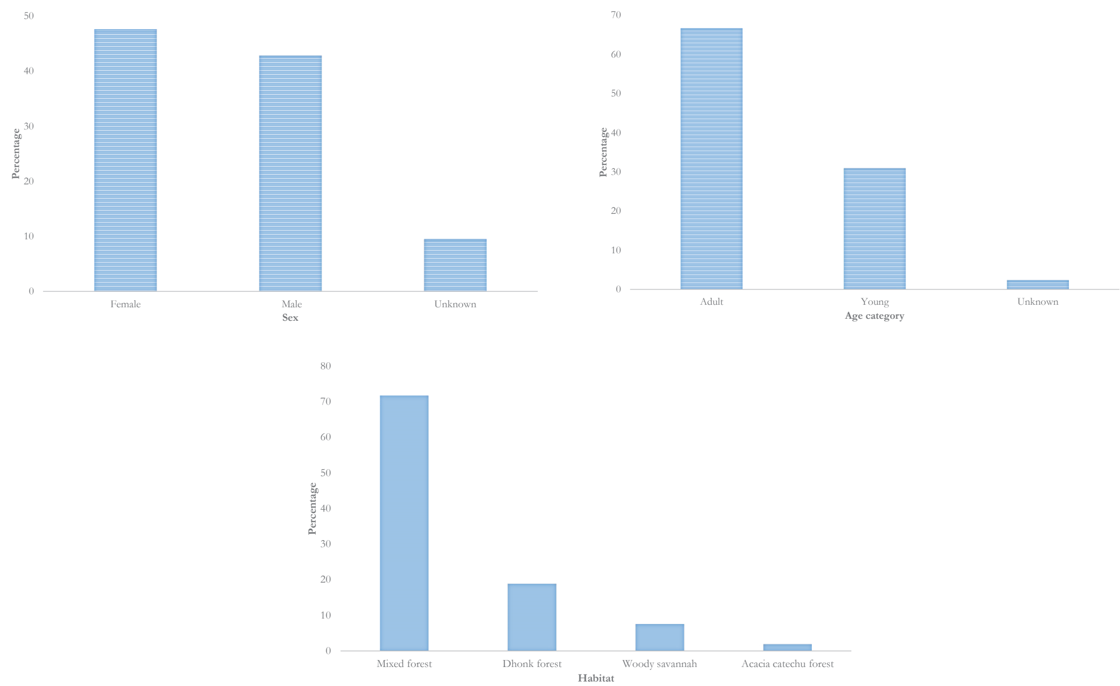

Figure 4.2.2.3. *Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah female Dheera within the soft-release boma*

4.2.2.4. Predation by male cheetah coalition Agni and Vayu

The coalition males Agni and Vayu were housed in the large soft-release boma and observed predating together (33 kills) except in a few cases (Agni-2 kills and Vayu- 2 kills). Chital was the main prey species hunted by the coalition with one instance of predation on adult female nilgai and the detected kill rate was 6.74 days per kill. The coalition males were observed to predate more on female chital. About 48% of the prey killed were adults. Most of the kills were made in dhonk forest (51%) followed by mixed forest (46%).

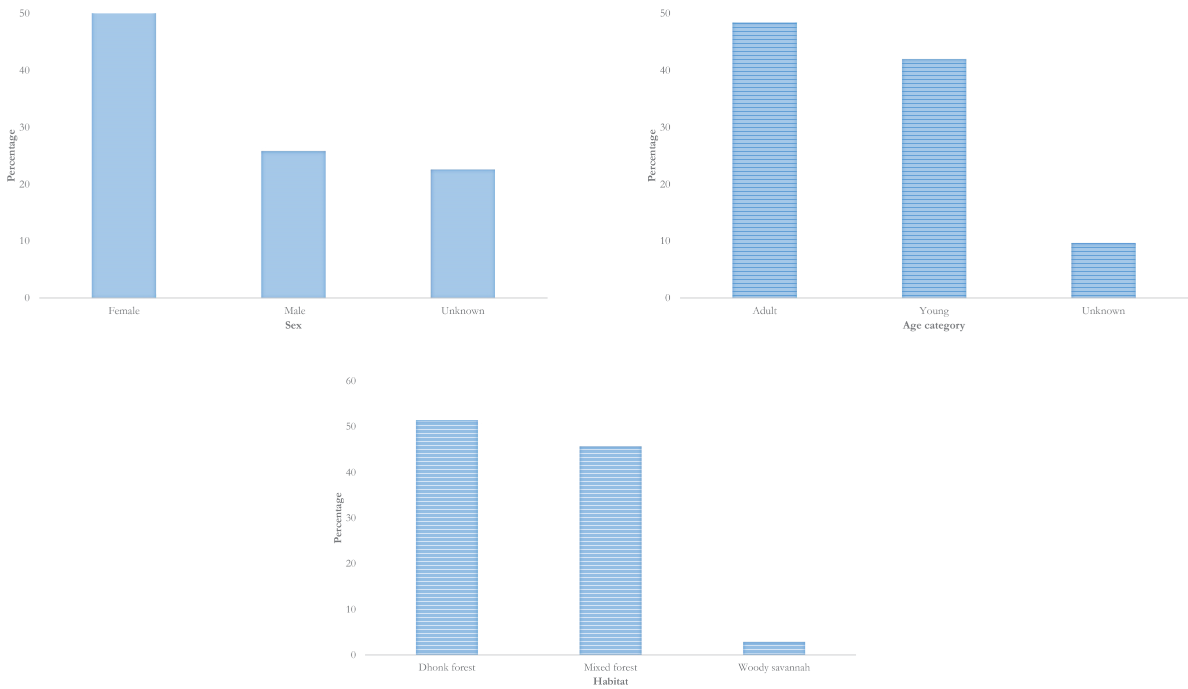

Figure 4.2.2.4. Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah male coalition Agni and Vayu within the soft-release boma

4.2.2.5. Predation by female cheetah Gamini

Gamini is an adult female cheetah housed in the soft-release enclosure and was observed to predate only on chital. A total of 46 kills were detected during the reporting period and the detected kill rate was 4.33 days per kill. The majority of the kills were female chital (63%) compared to male chital (17%). About 52% of the chital were adults and 37% were of young. 67% of the kills were made in dhonk forest, 25% were in mixed forest and 8% were in woody savannah.

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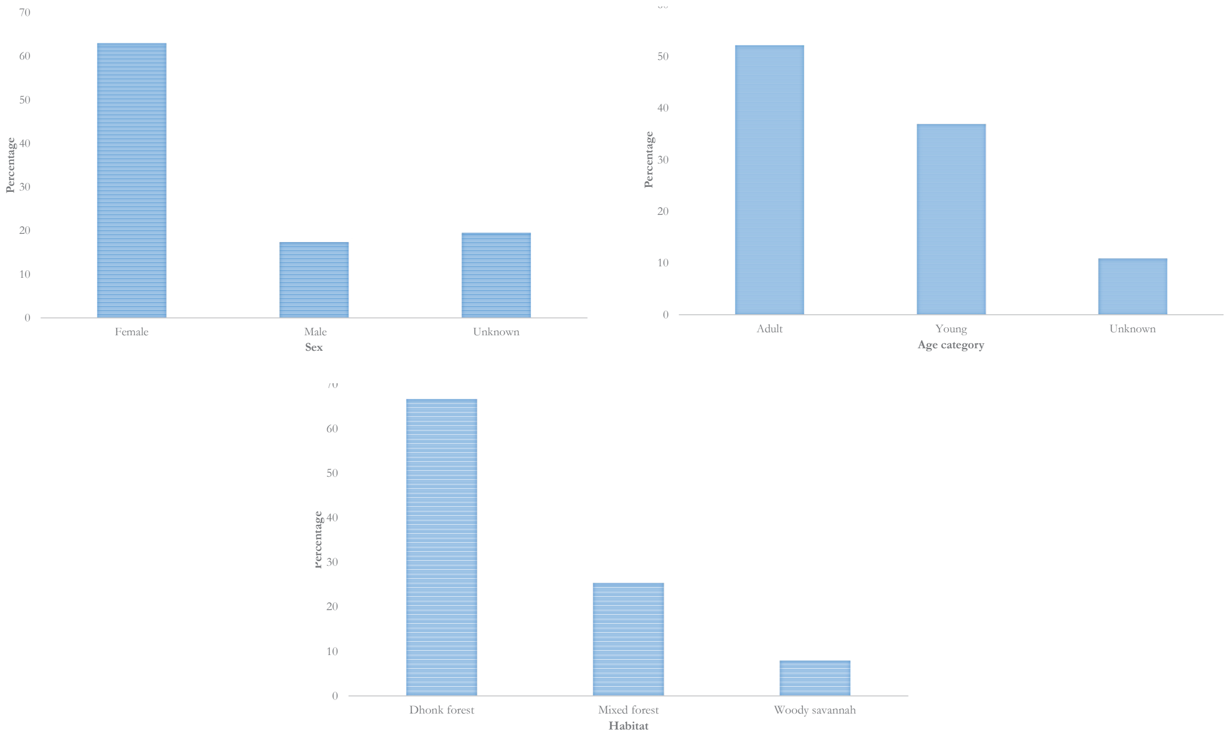

Figure 4.2.2.5. Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah female Gamini within the soft-release boma

4.2.2.6. Predation by female cheetah Nirva

Nirva is a female cheetah approximately six years old kept in the soft-release enclosure and was observed to prey mostly on chital with one predation event on a hare. A total of 27 kills were detected in the soft-release enclosure and the detected kill rate was 4.48 days per kill. The majority of the kills (67%) were of female chital. She was observed to almost equally predate on adult (48%) and young (44%) chital. About 61% of the predations were observed in mixed forest followed by dhonk forest (39%).

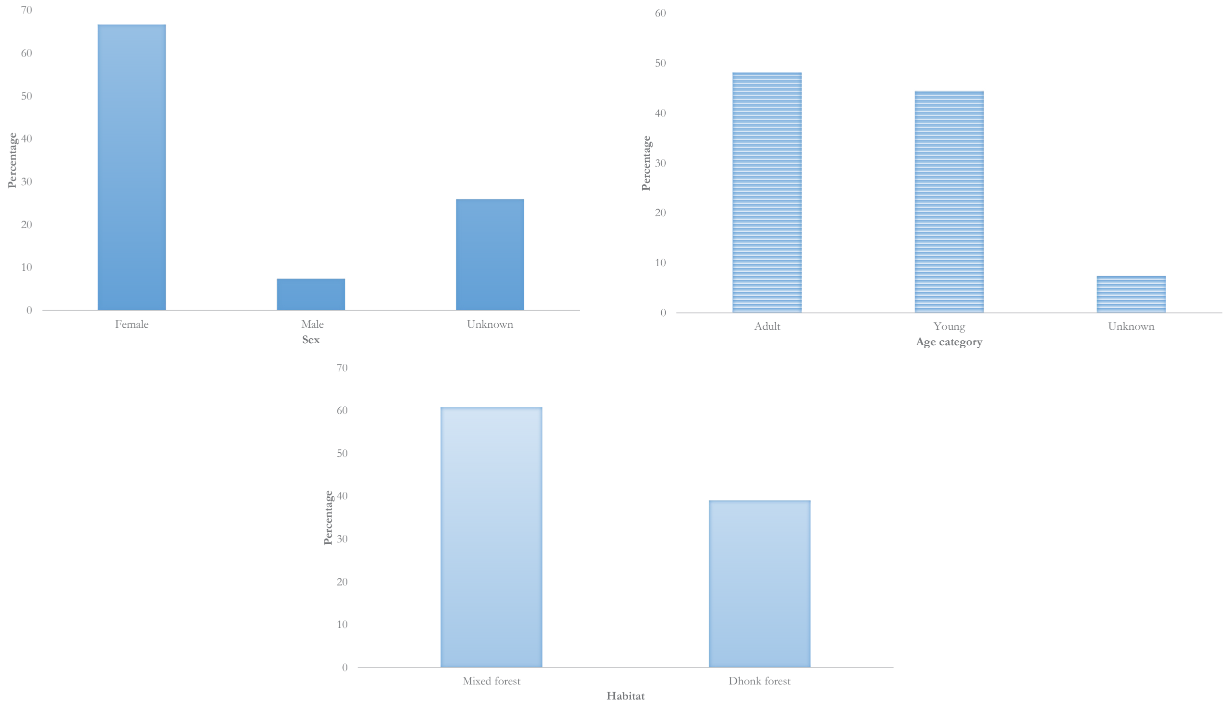

Figure 4.2.2.6. Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah female Nirva within the soft-release boma

4.2.2.7. Predation by female cheetah Nabha

Nabha is a seven year old female cheetah housed inside the soft-release enclosure and most of the time, supplemented with meat. However, a few kills (six) were made between September 2023 and January 2024. She was observed to predate mostly on female chital (71%). The majority of her kills (71%) comprised of young chital. About half the kills were made in woody savannah habitats within the soft-release boma.

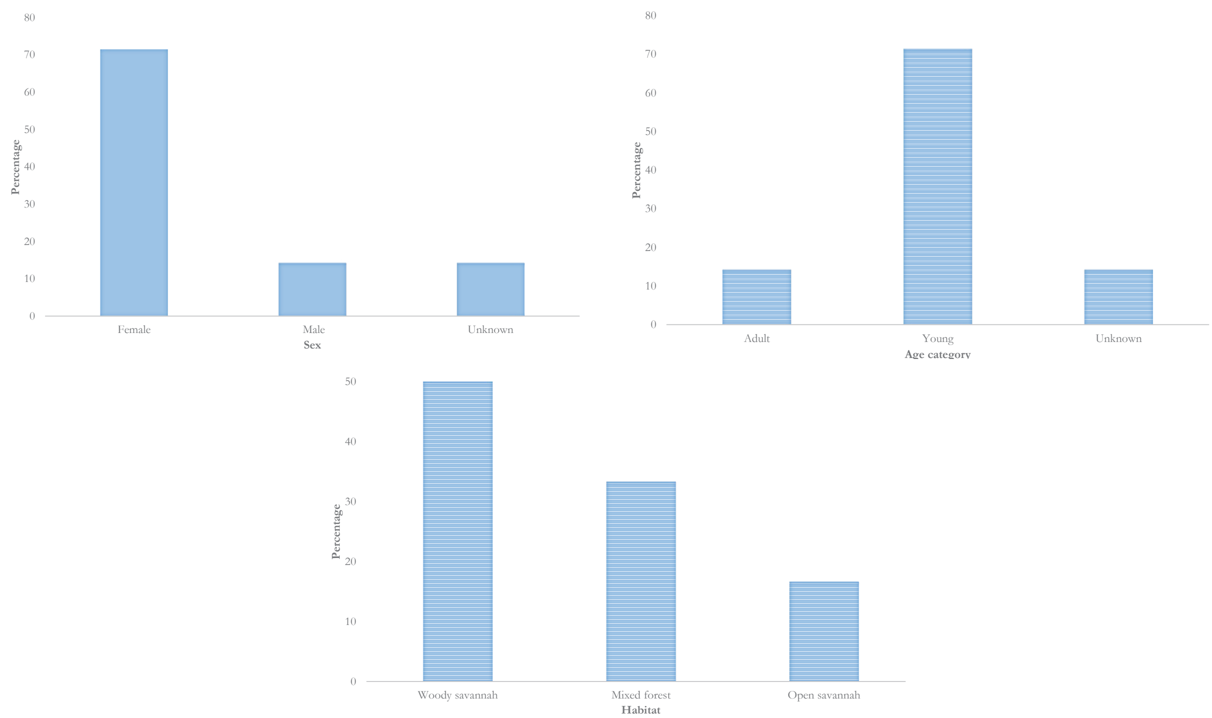

Figure 4.2.2.7. Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah female Nabha within the soft-release boma

4.2.2.8. Predation by cheetah male coalition Gaurav and Shaurya

Shaurya and Gaurav were male coalition partners of approximately seven years old. In January 2024, Shaurya died due to health complications and Gaurav was shifted into the quarantine boma. The information on predation by the coalition provided here is up to that period. Other than one instance of predation on nilgai, all the other kills were of chital. They were observed to predate slightly more on female chital. Most of the kills were of adult chital (71%). About 75% of the kills by the coalition was made in open savannah habitat.

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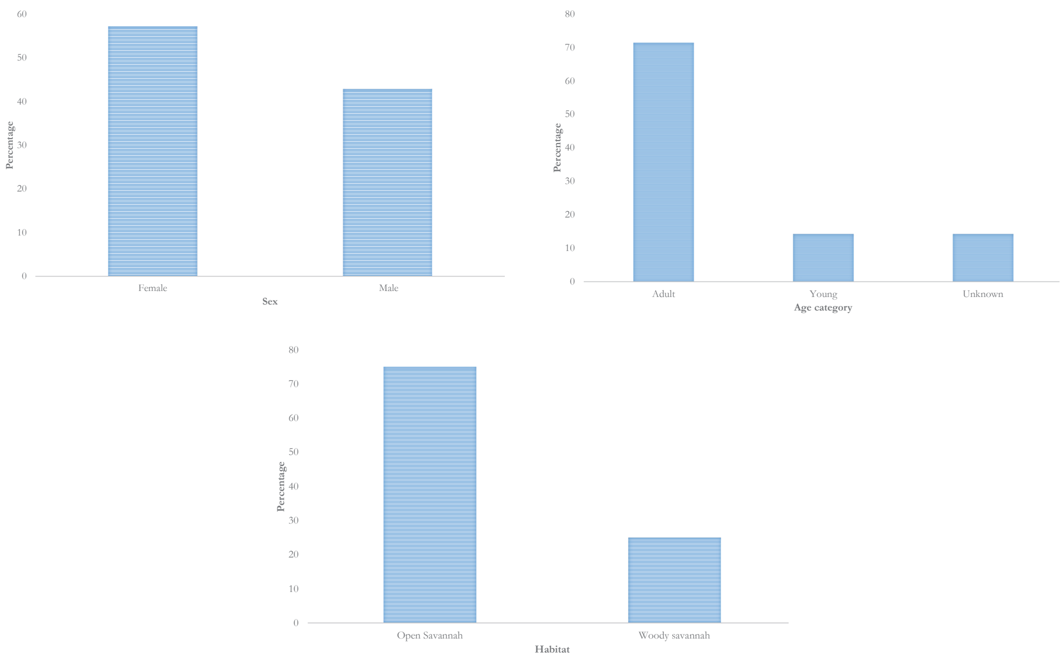

Figure 4.2.2.8. *Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah male coalition Gaurav and Shaurya within the soft-release boma*

4.2.2.9. Predation by female cheetah Asha

Asha is a female cheetah housed in a soft-release enclosure. The information provided on the kills is till the end of March 2024 during which she gave birth to cubs and monitoring was regulated to minimize disturbance. Only chital was predated and a total of 43 kills were made with a kill rate of 4 days per kill. Most of the kills (64%) were of female chital. Adult animals (62%) were predated more compared to young (30%). The majority of the predations were made in mixed forest.

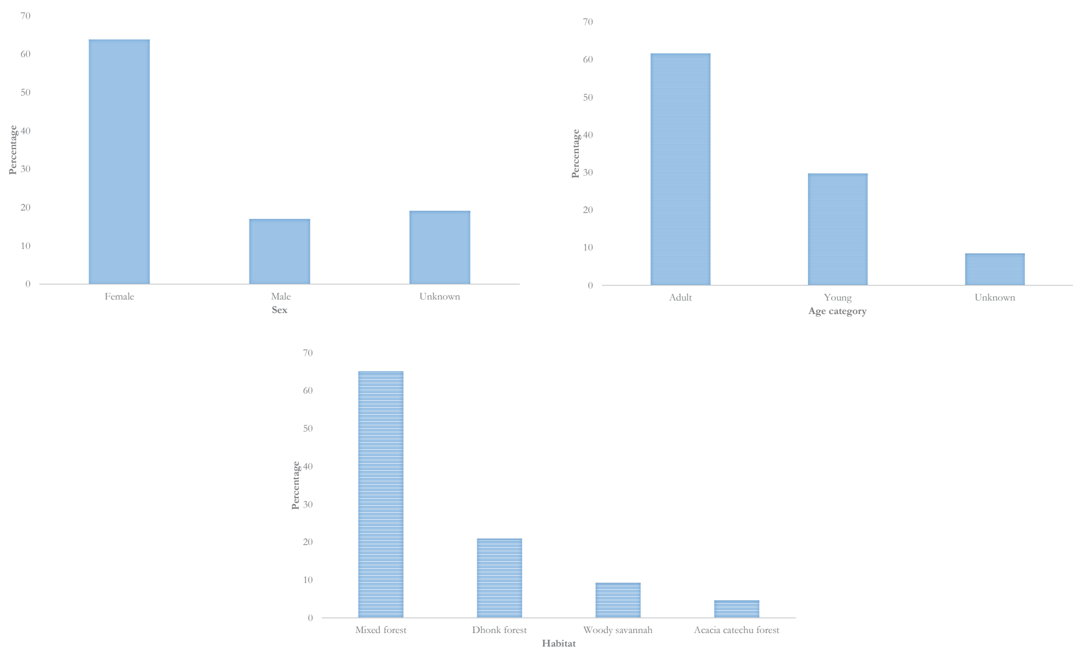

Figure 4.2.2.9. *Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah female Asha within the soft-release boma*

Image 4.2.4. Monitoring of cheetah predation in Kuno National Park © Shivang Mehta team/ WII (Project Cheetah)

4.2.2.10. Predation by male cheetah Pawan

Pawan is an adult male cheetah about six years old and was released into free-ranging environment on 21 December 2023. Since then, he has been observed predating on multiple herbivore species found in the Kuno landscape, including domestic livestock such as cattle and goats. The detected kill rate was observed to be 3.96 days per kill. Pawan predated mostly on chital (71%) followed by domestic goats, sambar, chowsingha, nilgai, and domestic cattle (4%). Pawan was observed to predate more on chital young (48%) compared to adults (19%). About 4% of total predation was also contributed by chowsingha. Female chitals were predated more than males. The majority of the predation by Pawan was observed in mixed forest habitats (43%) followed by woody savannah habitats (22%) and dhonk forest (13%).

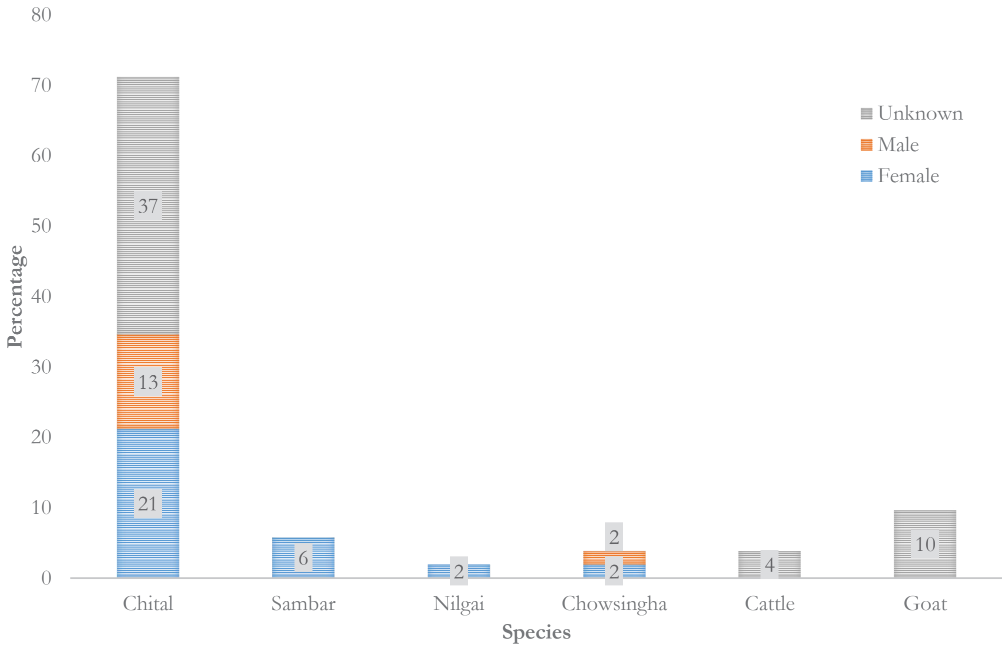

Figure 4.2.2.10.1. Sex of various prey species predated by cheetah male Pawan in free-ranging environment

Inside the soft-release enclosure, only chital were predated by Pawan and the detected kill rate was 5.42 days per kill. A slightly higher proportion of female kills (50%) were observed than male kills (42%). Adult chital were predated more than young. The majority of the predation was observed in dhonk forest. Pawan spent eight months in free-ranging conditions after being released out of the soft-release enclosure.

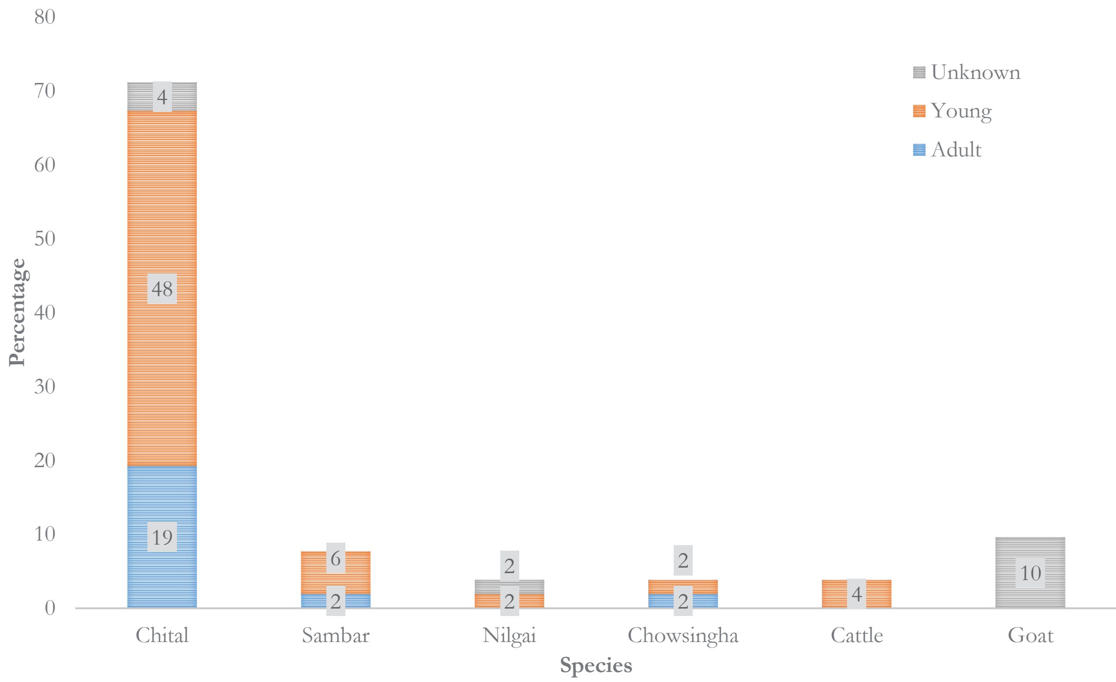

Figure 4.2.2.10.2. Predation on different age classes of prey species by cheetah male Pawan in free-ranging environment

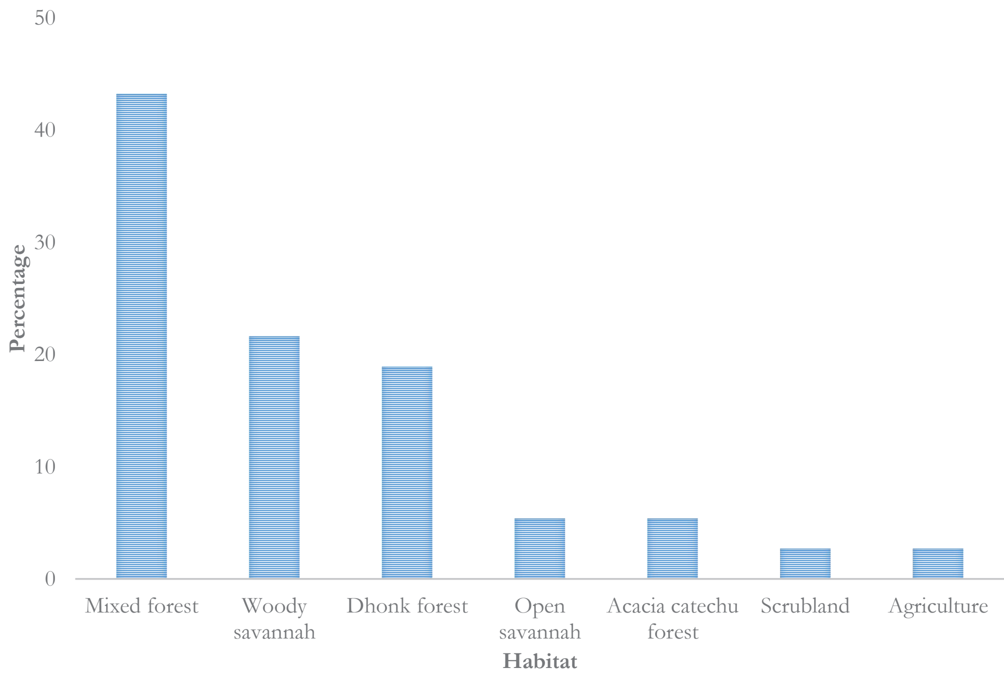

Figure 4.2.2.10.3. Predation by cheetah male Pawan in various habitat types in free-ranging environment

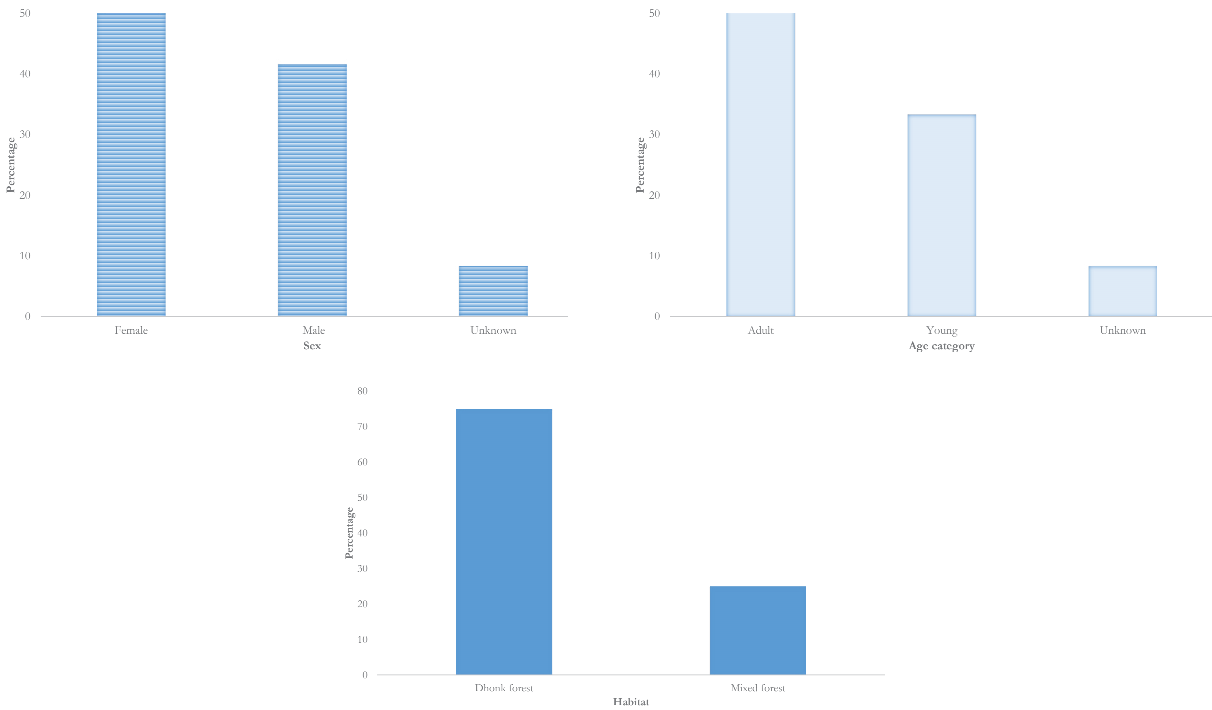

Figure 4.2.2.10.4. Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah male Pawan within the soft-release boma

4.2.2.11. Predation by female cheetah Veera

Veera is a female cheetah of approximately six years old and was released into free-ranging conditions on 20 December 2023. A total of 38 kills were made and the kill rate was 4.63 days per kill. Domestic goat (59%) was the major prey followed by chital, nilgai, chowsingha, and cattle calf. Among chital kills, young were observed to be predated more, whereas, in kills of nilgai and cattle, only young were predated. Almost one-third of the total predations were in mixed forest (31%) followed by scrubland and agricultural patches. Before release into free-ranging conditions, inside the soft-release enclosure, only chitals were predated and the majority (73%) of them were females. The proportion of detected kills of both adult and young chital were the same. The kill rate inside the soft-release enclosure was 7.91 days per kill and half of the predation events were in mixed forest.

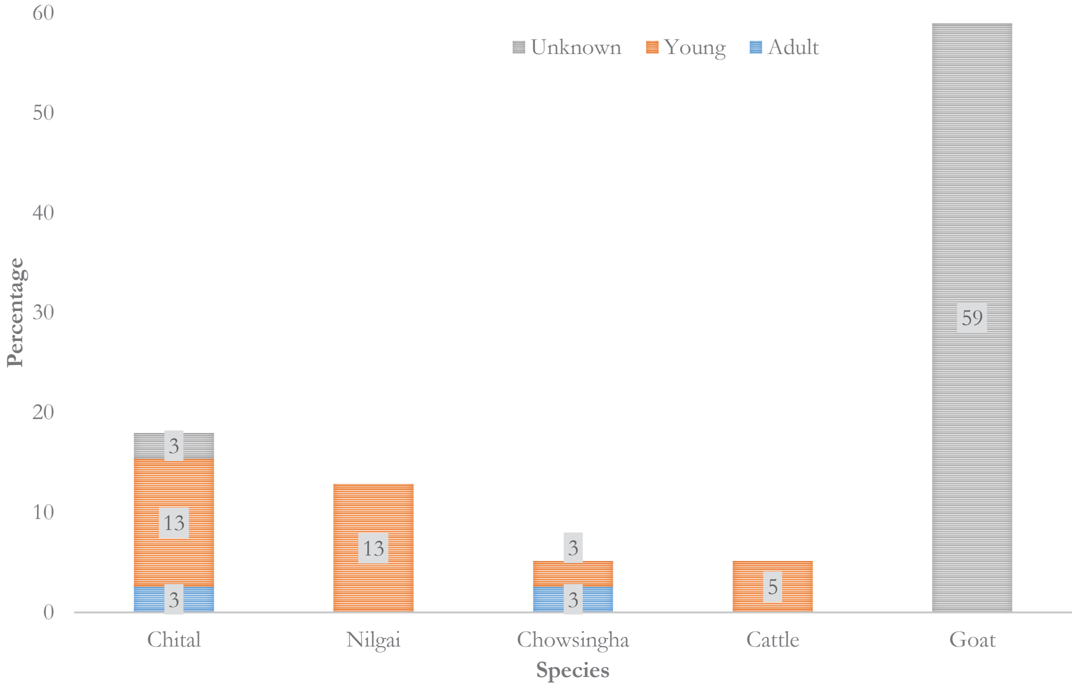

__Figure 4.2.2.11.1.__ Predation on different age classes of various prey species by cheetah female Veera in free-ranging environment

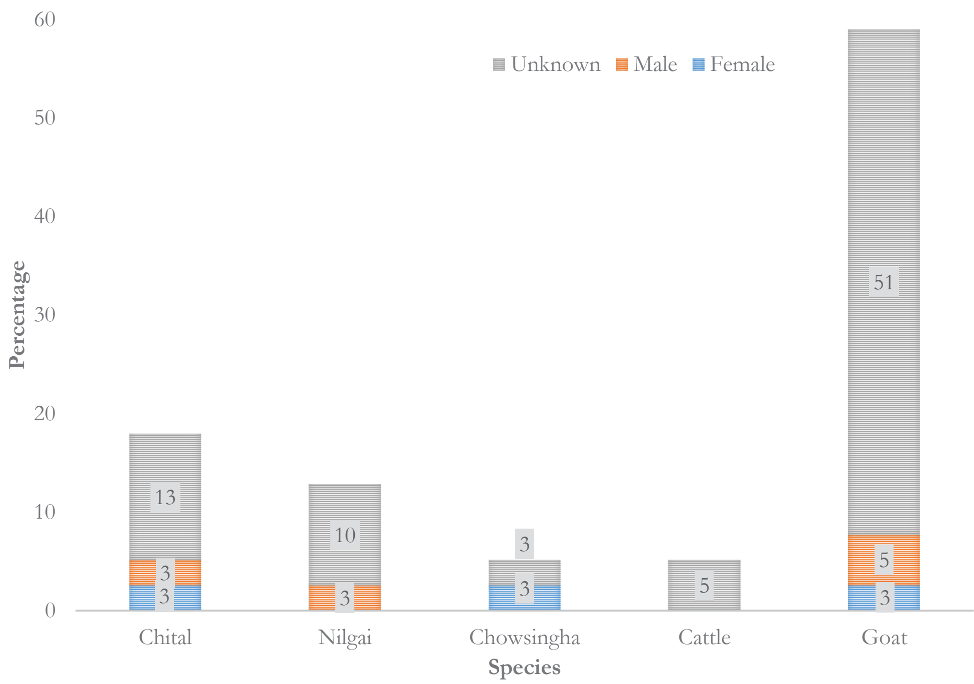

__Figure 4.2.2.11.2.__ Sex of various prey species predated by cheetah female Veera in free-ranging environment

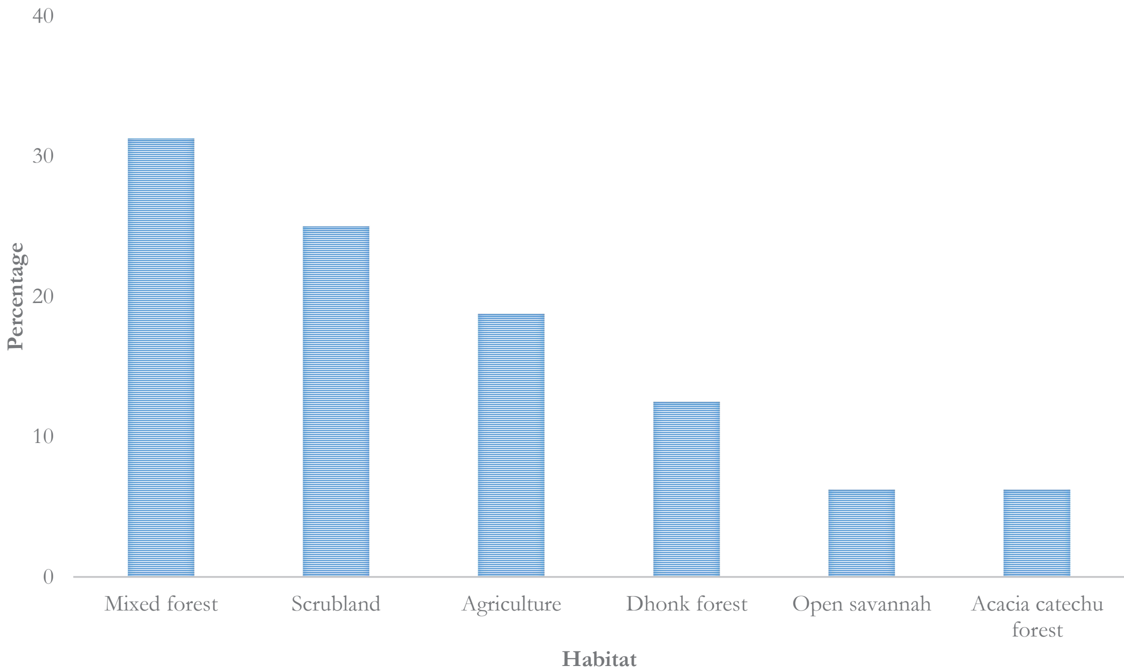

Figure 4.2.2.11.3. *Predation of different prey species in different habitat types by cheetah female Veera in free-ranging environment*

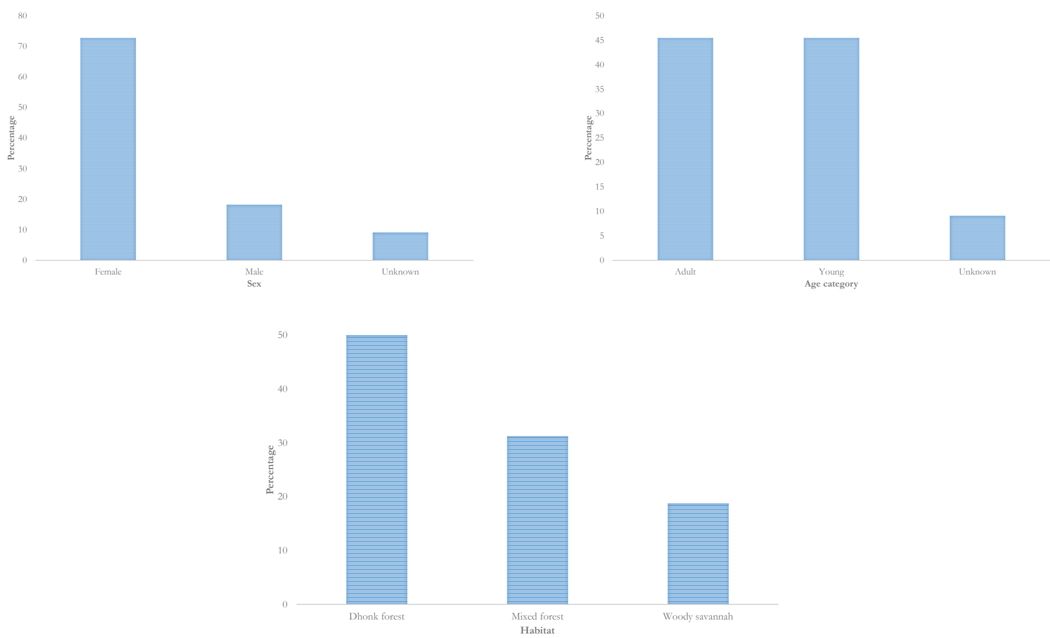

Figure 4.2.2.11.4. *Sex (top left) and age category (top right) of prey species predated in different habitat types (bottom) by cheetah female Veera within the soft-release boma*

4.3. Home range and movement of free-ranging cheetahs

Two cheetahs, Veera (female) and Pawan (male) were released in free-ranging environment during December 2023. All the cheetahs translocated to India were deployed with satellite collars manufactured by African Wildlife Telemetry (AWT), equipped with both VHF (Very High Frequency) and UHF (Ultra High Frequency) transmitters for ground tracking and data retrieval via specialized receivers. The logging frequency of data was tailored to the specific monitoring needs of each individual. Remote data retrieval is facilitated through the online interface provided by AWT. Trained personnel from the M.P. Forest Department and researchers from the WII continuously monitored the released cheetahs. Observations were carried out at a safe distance from the animals to minimize distraction and continue with their natural behavior. Both individuals ventured over considerable distances across the landscape. In a couple of instances, veterinary intervention was required to safely capture and transport these individuals back into the National Park.

Image 4.3. *Cheetah scent marking in Kuno National Park © Prateek Sharma*

Movement pathways and home ranges of individual cheetahs were delineated using the Minimum Convex Polygon (MCP) method within the ArcMap software environment. Average daily movement and Kernel Density estimation (KDE) method of home ranges of wild-released cheetahs were calculated using the R package adehabitatHR (Calenge 2006). The analysis revealed an average daily movement of 5.82 km (0.57SE) for Veera (175 days) and 4.75 km (0.36SE) for Pawan (209 days). Furthermore, home range sizes of individual cheetahs were assessed using the 100%MCP and 95%KDE methods, spanning areas of 7430.19 km^2 and 5275.76 km^2 for Veera and 1876.79 km^2 and 817.59 km^2 for Pawan respectively.

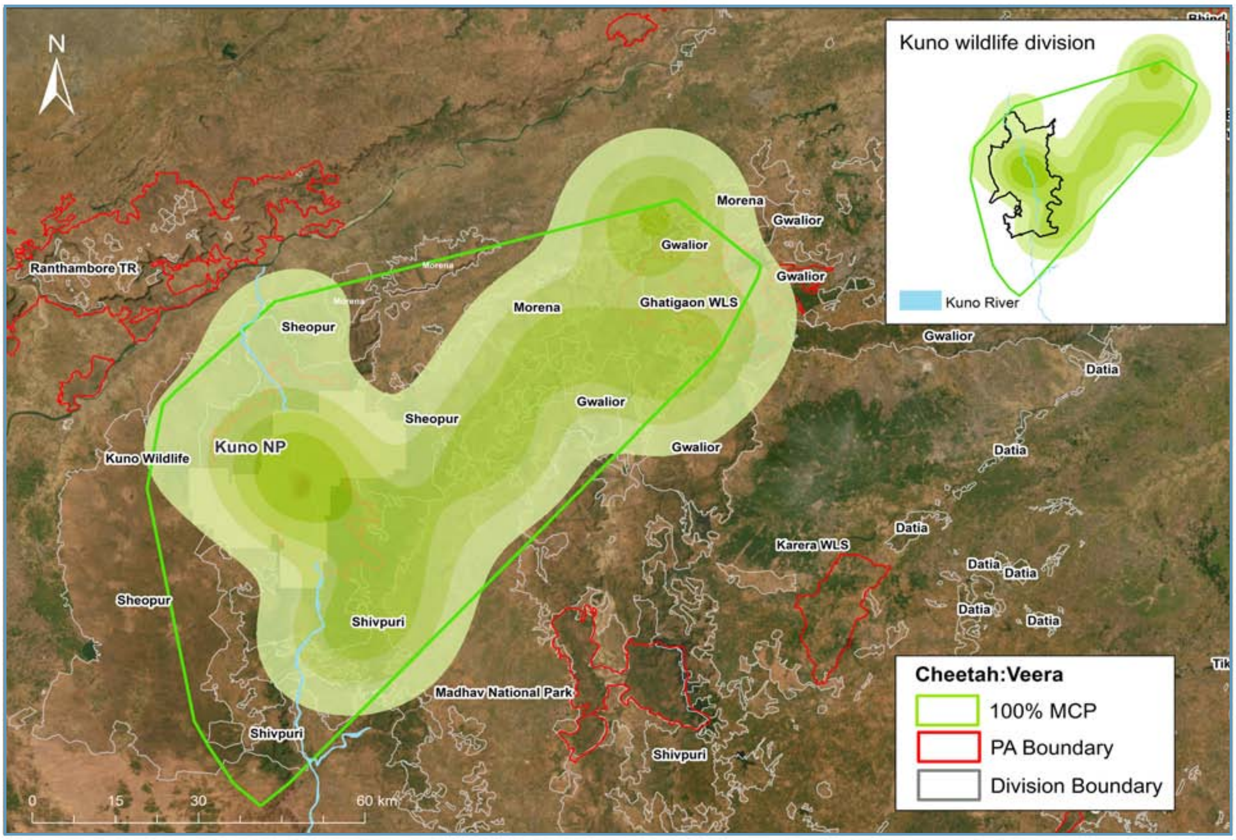

Figure 4.3.1. Home range (100% MCP and 95% KDE) of cheetah female Veera

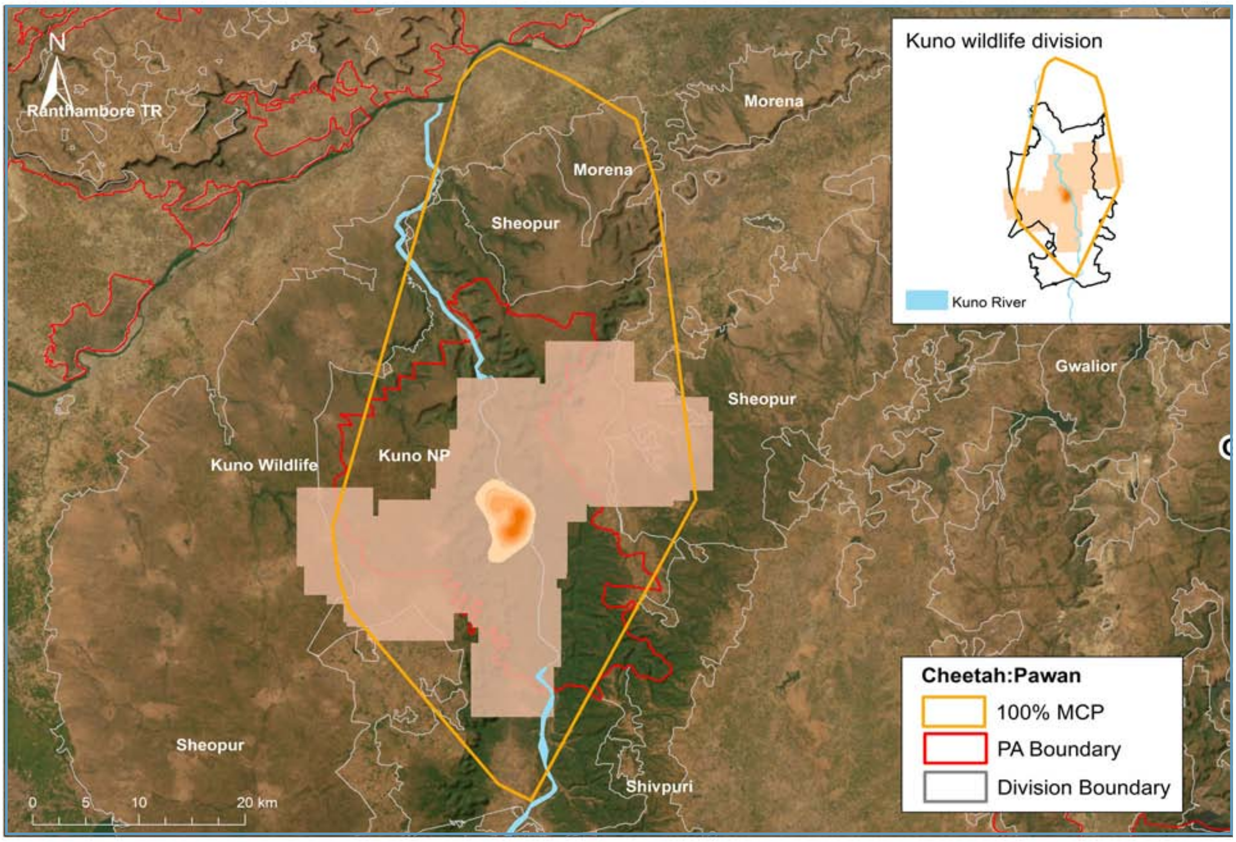

Figure 4.3.2. Home range (100% MCP and 95% KDE) of cheetah male Pawan

4.3.1 Movement behaviour of free-ranging cheetahs

Understanding the movement behavior of free-ranging cheetahs is essential for insights into their habitat preferences, resource utilization, and spatial ecology. Moreover, by tracking the movements of carnivores, important habitat features, core areas, and corridors crucial for their survival and long-term persistence can be identified (Cagnacci *et al.* 2010, Doherty *et al.* 2016). This information is fundamental for habitat management, species conservation, and landscape planning initiatives aimed at maintaining viable cheetah populations in the larger landscape (Broekhuis *et al.* 2013, Hebblewhite & Merrill 2008). A preliminary investigation was carried out to understand the specific movement patterns of the two free-ranging cheetahs in the landscape. For this, movements of the free-ranging cheetahs were categorized into three states (1) Resting, which is characterized by short bouts of intense activity interspersed with longer stationary periods usually related to resting (2) Area-restricted movement, in which localized movements within a defined area, typically associated with foraging or territorial behavior, and (3) Long-distance exploration/dispersal, which is characterised by long-distance directional movement of the individuals with fewer turnings in their movement path related to exploratory movement or dispersal.

Image 4.3.1. *Cheetah on the banks of River Kuno © Moulik Sarkar*

The above classes of different movement states in the free-ranging environment were correlated with the daily ambient temperature and how changes in the ambient temperature influence the animals to change from one state to another. Since, ambient temperature affects their thermoregulatory behaviors, such as seeking shade or water to cool down in hot weather or sunning themselves to warm up in cooler conditions. Moreover, in hot weather, they may avoid open areas and move in the cooler hours of the day or seek out cooler, shaded habitats to rest and minimize heat stress thereby influencing movements in a landscape. All three states of their movement behaviour are plotted in different colour codes (Figure 4.3.1.1). Package moveHMM (Michelot *et al.* 2016) was used to construct the movement models in R (R core team 2023).

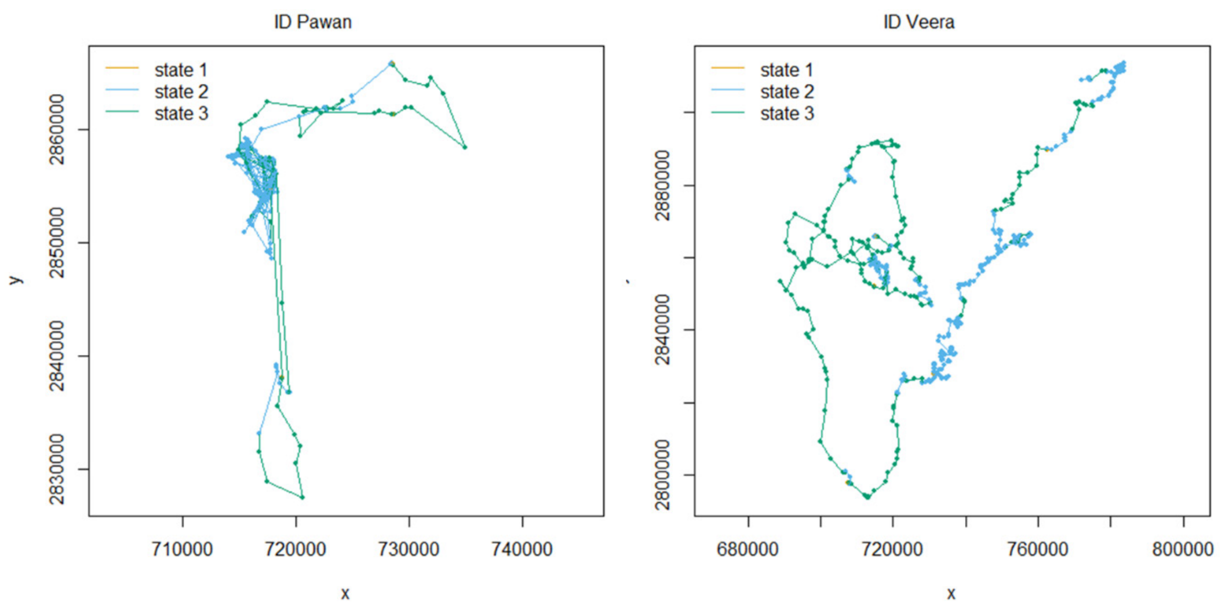

Figure 4.3.1.2a. *Movement states of male cheetah Pawan and female cheetah Veera's path in the landscape where state 1 is resting, state 2 is area restricted movements and state 3 is long distance exploration/dispersal*

The transition probabilities of the different movement states were then estimated to see how animals change the three movement states in response to ambient temperatures. It indicates the likelihood of an animal transitioning from one state to another. It was observed that animals avoided long-distance exploration/dispersal (changing from state 1 to state 3) during the high-temperature periods of the day, however the probability of an animal changing its state from resting to area restricted movement increases with increasing ambient temperature. Further, that also coincides with the high human activity periods in free-ranging environment of the human dominated landscape beyond the Protected Area. Hence, during this time period, animals most likely confined themselves in restricted areas and had shorter displacements and localized exploratory movements (Figure 4.3.1.2a). Similarly, figure 4.3.1.2b shows the probabilities of the different states changing with respect to the ambient temperature.

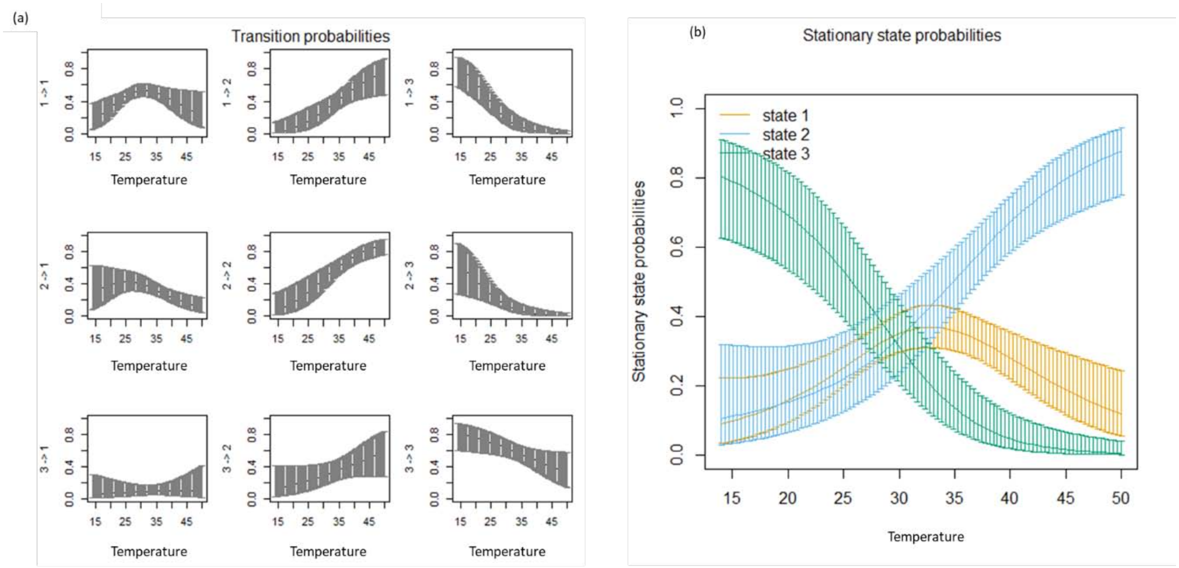

Figure 4.3.1.2.b (a) Probabilities of transitioning from one movement state to another among the free-ranging cheetahs, (b) Stationary state probabilities of movement changes with temperature

The above descriptions of the movement states of free-ranging cheetahs in Kuno are just preliminary insights into their movement ecology. However, there's more to understand about the eco-geographic factors influencing their movement in the landscape, as well as their interactions with humans and at trophic levels. Movement analysis of the cheetahs can be used as an effective tool to mitigate negative interactions with humans, as understanding where and when carnivores move in relation to human-dominated landscapes will enable devising effective strategies to mitigate human-wildlife conflict, enhance coexistence, and promote sustainable land use practices (Treves & Karanth 2003, Zimmermann *et al.* 2020). Further, by examining cheetah's movements in relation to prey distribution and availability in the landscape, the impacts of predators on prey populations, community structure, and ecosystem functioning can be assessed (Estes *et al.* 2011, Terborgh *et al.* 2001). This knowledge will be crucial for understanding the impact of the cheetahs on the ecosystem functioning of the Kuno landscape and maintaining ecosystem integrity (Palomares *et al.* 2011, Prugh *et al.* 2009).

© Shivang Mehta team/ WII (Project Cheetah)

4.4. Habitat selection by free-ranging cheetah in Kuno Wildlife Division

Using the Resource Selection Function as described in section 3.2.2., based on the locations obtained from two radio-collared free-ranging cheetahs, it was observed that the animals selected savannah grassland habitat. Individually, male cheetah selected savannah grassland patches followed by areas next to water bodies such as ponds, whereas female cheetah selected savannah grassland patches followed by dhonk forest and riverine areas. However, the highest proportion of locations of both animals was from dhonk forest. This information is only limited to the habitats within the boundary of Kuno Wildlife Division, but the animals have moved beyond these areas.

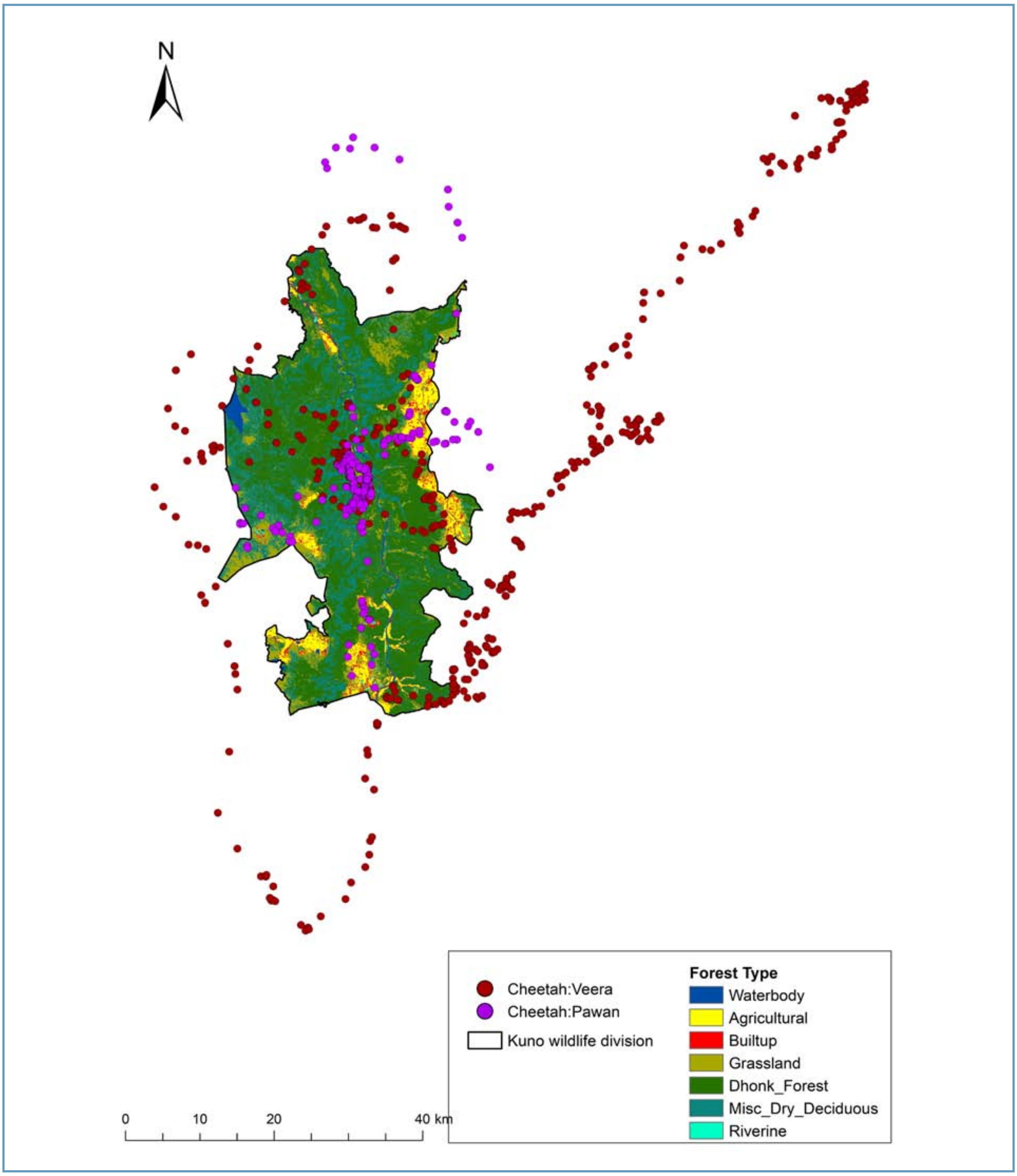

Figure 4.4.1. Locations of two radio-collared free-ranging cheetahs overlaid on the forest type map of Kuno Wildlife Division

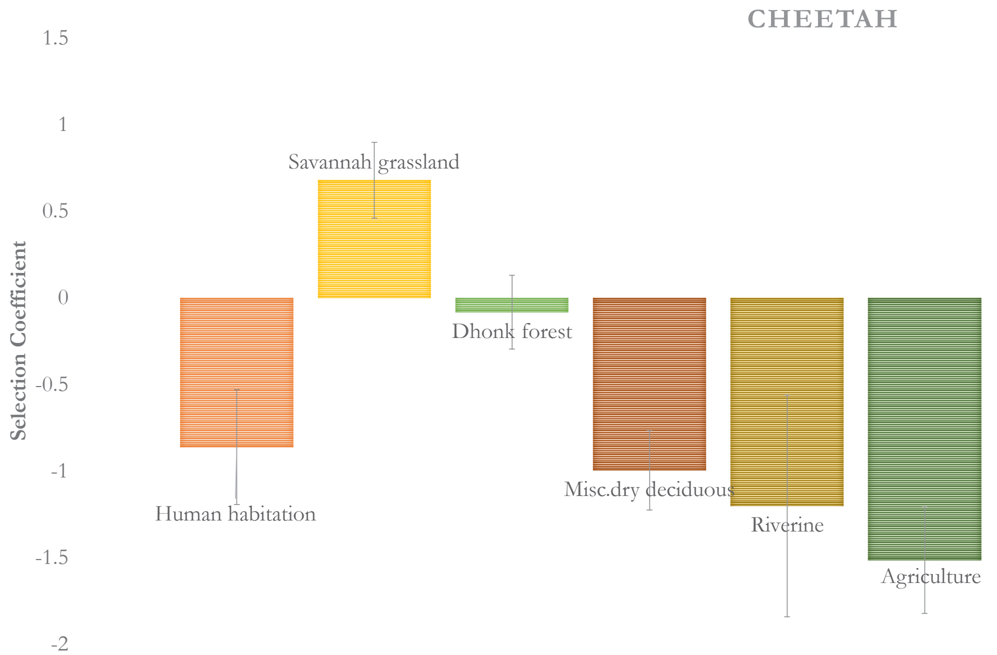

Figure 4.4.2. *Habitat selection of radio-collared free-ranging cheetahs in Kuno Wildlife Division using Resource Selection Function, error bars depict standard errors*

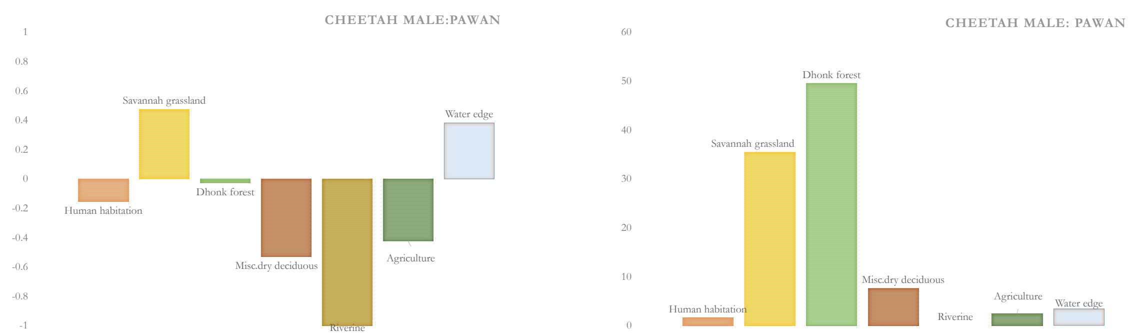

Figure 4.4.3. *Habitat selection of radio-collared free-ranging cheetah adult male (Pawan) using Ivlev's index (left) and percentage of locations in each habitat type (right)*

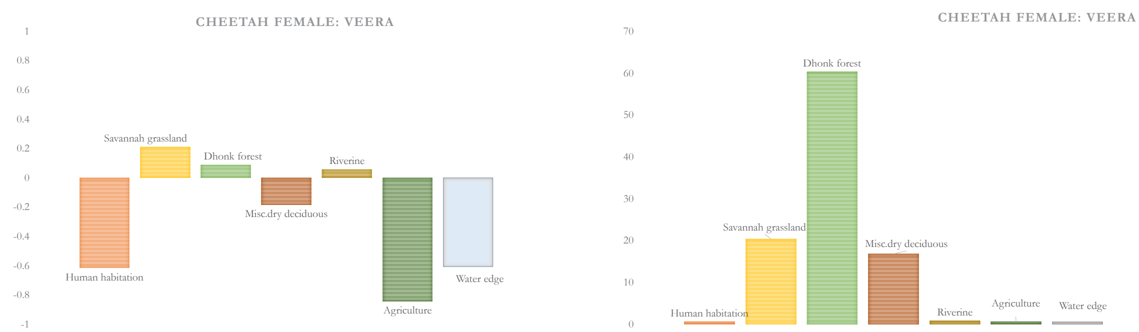

Figure 4.4.4. *Habitat selection of radio-collared free-ranging cheetah adult female (Veera) using Ivlev's index (left) and percentage of locations in each habitat type (right)*

Image 4.4.1. *Cheetah in the miscellaneous dry deciduous forest of Kuno National Park © Moulik Sarkar*

5. Management of cheetahs in Kuno National Park

5.1. Veterinary care and management of cheetahs in Kuno National Park

The complexity of cheetah veterinary care, coupled with the broader challenges of wildlife reintroductions/conservation translocations, necessitates constant veterinary interventions to ensure the biological and ecological well-being of founder animals and the long-term success of reintroduction programs (Karesh and Cook 1995, Kock *et al.* 2007, Colburn *et al.* 2018). Cheetahs, while sharing many characteristics with other felids, possess unique adaptations that complicate their veterinary management (Tordiffe 2017, Braud *et al.* 2019). They are particularly susceptible to stress-induced ailments, a vulnerability that exceeds that of other species (Tordiffe 2017, Terio *et al.* 2018). This heightened susceptibility, often linked to their limited genetic diversity, has been documented in numerous studies (O'Brien *et al.* 1985, Franklin 2014, Brown *et al.* 2023). Consequently, managing cheetah populations effectively demands comprehensive veterinary care and husbandry to maintain a healthy and resilient founder cheetah population.

To ensure ongoing veterinary support for the project, the NTCA, in collaboration with the WII and Kuno NP administration, has made concerted efforts to establish a robust veterinary infrastructure capable of meeting all project requirements (NTCA *et al.* 2023). Currently, Kuno benefits from the dedicated services of four full-time veterinarians—one from NTCA, two from the Madhya Pradesh Forest Department, and one from the WII. Additionally, an upgraded veterinary facility has been established within the park, meeting international standards. A panel of international experts and specialists from countries where cheetahs are native is also being consulted on a case-by-case basis to further enhance the quality of care (NTCA *et al.* 2023).

The veterinary team's primary responsibility at Kuno is to ensure the overall health and well-being of the cheetahs, while also safeguarding the welfare of the existing species in the habitat. The tasks encompass a range of activities, including conducting thorough disease diagnostics to identify and manage potential health issues, performing necropsy examinations to investigate causes of mortality, and implementing preventive and prophylactic measures to protect the cheetahs and the native species. In addition to these crucial tasks, the veterinary team is also actively involved in ensuring the physical, behavioral, and nutritional well-being of founder cheetah stock in Kuno. This involves monitoring their physical health through routine monitoring, observing their behavior to detect any signs of stress or maladaptation, and ensuring the availability of an adequate diet that meets their nutritional needs, all of which are aimed at ensuring the cheetahs successfully adapt and integrate into their new environment in Kuno.

The activities undertaken to achieve these goals are further elaborated in this section, highlighting the comprehensive approach required to support the long-term success of the cheetah introduction program in India.

5.1.1. Capture and immobilization of cheetahs in Kuno

Chemical immobilization of free-ranging wildlife inherently carries risks, including the potential for adverse effects and mortality (Muliya *et al.* 2016). Field immobilization of cheetahs particularly presents significant challenges due to their unique physiological characteristics, making them particularly susceptible to complications such as hyperthermia, hypoxemia, capture myopathy, and even death (Braud *et al.* 2019). Despite these challenges, managing introduced animals in unconfined environments, such as the current project in Kuno, often necessitates the capture and chemical immobilization of individuals for various purposes, including shifting, deployment of radio collars, sample collection, health examinations, prophylaxis, and treatment.

To minimize stress and reduce the risk of adverse outcomes, it is imperative to adhere to established protocols. This includes careful selection and administration of appropriate drugs, minimizing handling time, and continuously evaluating and refining immobilization techniques as necessary (Semjonov *et al.* 2019). In line with this, the veterinary team in Kuno has been strictly following a predefined protocol, prioritizing the safety and well-being of the animals above all else. Traditionally, mortality rates have been used as a metric to assess the negative impacts of wildlife capture. Notably, in Kuno, there have been no reported instances of capture-related morbidity or mortality among the cheetahs, even after conducting more than 90 chemical immobilizations. This outcome underscores the importance of following best practices and maintaining a high standard of care during the immobilization process, ultimately contributing to the successful management and conservation of the species in India.

Image 5.1. *A cheetah being examined post chemical immobilization in Kuno National Park © Shivang Mehta team/WII (Project Cheetah)*

5.1.2. Post-Release Veterinary Monitoring, Care and Management of Cheetahs in Kuno

The management of free-ranging cheetahs in Kuno is a highly coordinated and continuous effort that involves comprehensive round-the-clock supervision of each cheetah by a dedicated monitoring team (NTCA *et al.* 2023). Each cheetah is equipped with a radio collar, which allows for remote monitoring of their movement patterns, as well as ground tracking and routine physical observation, to ensure their overall health and well-being. The monitoring team is meticulous in observing and documenting the cheetahs' activities and reports the findings daily through a well-structured hierarchical communication channel. This robust monitoring protocol has enabled proactive management and veterinary interventions when cheetahs are found in unfavourable environments or distress.

For instance, if a released cheetah ventured beyond Kuno NP and was found in human-dominated areas, the veterinary team was quickly notified through the said communication channel. The veterinary team would then intervene to safely capture and release the cheetah within the Kuno NP boundary. This approach not only helped reinforce the cheetah's natural homing instinct but also mitigated risks to both the cheetah and nearby human populations and their livestock, thereby preventing potential conflicts. Four such interventions were carried out during the reporting period, details of which are presented in Table 5.1.1.

Table 5.1.1. *Relocation interventions undertaken for free-ranging cheetahs in Kuno*

S. No.	Cheetah ID	Sex	Date	Capture Site	Release Site
1	Agni	Male	25-12-2023	Baran (Rajasthan)	Kuno NP
2	Veera	Female	18-04-2024	Joura (Madhya Pradesh)	Kuno NP
3	Pawan	Male	04-05-2024	Karoli (Rajasthan)	Kuno NP
4	Veera	Female	13-06-2024	Mohana (Madhya Pradesh)	Kuno NP

The regular monitoring protocols also allow the veterinary team to assess individual cheetahs' nutritional status and determine if intervention is necessary. In situations where a released cheetah failed to make a successful kill for an extended period, typically exceeding 5-6 days, the veterinary team intervened by providing supplementary feeding. This crucial support helps meet the released cheetahs' nutritional needs while they adapt and integrate into their new environment. This intervention not only ensures that the cheetahs remain healthy but also aids in their overall adaptation process. Furthermore, it supports a smoother transition into the wild by reducing the stress associated with extended periods of unsuccessful predation in novel habitats.

5.1.3. Veterinary interventions for health complications of cheetahs in Kuno

The primary goal of Project Cheetah is to establish a sustainable metapopulation of cheetahs in India, with Kuno being the first introduction site (Jhala *et al.* 2021). To ensure the success of the project, it is vital to prioritize the health and welfare of each cheetah, especially the founder individuals in Kuno. In addition to diligent monitoring, in some cases, direct human intervention and veterinary care is required to address any health issues that arise. While these interventions, at times necessitate placement of affected cheetah individuals under extended periods of captive care, the ultimate goal is to eventually release them into free-ranging environment being fully fit, functional, and capable of sustaining themselves independently.

© *Madhya Pradesh Forest Department*

5.1.4. Cheetah mortalities and necropsy examinations in Kuno

Similar to global cheetah reintroduction efforts, the Cheetah project in Kuno has also encountered several mortalities, which are an inherent aspect of reintroduction/conservation translocation programs as well as natural populations (Buk *et al.* 2018, Sievert *et al.* 2022). To identify underlying pathology and to ensure transparency in the process, each deceased cheetah underwent necropsy procedures in line with NTCA's guidelines. These procedures were conducted by the in-house veterinary team, with the involvement of external experts from veterinary universities or nearby zoological parks. Samples from every mortality instance were also sent to the School of Wildlife Forensic and Health (SWFH), an independent unit of the Nanaji Deshmukh Veterinary Science University (NDVSU) in Jabalpur, M.P., following the existing policies of the M.P. Forest Department for confirmatory diagnosis.

Since the inception of Project Cheetah, out of the 20 cheetahs imported from Southern Africa and Namibia, eight animals (40% in 2 years) have died, either during the acclimatization period in larger bomas or in free-ranging conditions. Additionally, five out of 17 cubs born in India have died, resulting in 29 % cub mortality rate during the reporting period. Details of cheetah mortality events in Kuno, with causes for each, are tabulated below.

Table 5.1.2. Cheetah mortality events documented in Kuno since the initiation of the project

S. No.	Cheetah ID/ Origin	Gender	Date of mortality	Age at mortality	Cause of mortality
1	Sasha/ Namibia	Female	27-03-2023	4 years 10 months	Renal insufficiency
2	Uday/ South Africa	Male	23-04-2023	6 years 2 months	Trauma/neurological ailment
3	Daksha/ South Africa	Female	09-05-2023	3 years 1 month	Intraspecific aggression (Mortality during mating attempt by the male coalition)
4	Jwala Cub 1/ India	Male	23-05-2023	2 months	Insufficient maternal care (first ever litter of the dam), dehydration, and heat stroke
5	Jwala Cub 2/ India	Female	23-05-2023	2 months	
6	Jwala Cub 3/ India	Female	23-05-2023	2 months	
7	Tejas/ South Africa	Male	11-07-2023	5 years 5 months	Tick infestation, scratch wound resulting in septicaemia
8	Suraj/ South Africa	Male	14-07-2023	3 years 1 month	Tick infestation, scratch wound resulting in septicaemia
9	Dhatri/ Namibia	Female	02-08-2023	3 years, 3 months	Tick infestation, scratch wound resulting in septicaemia
10	Shaurya/ Namibia	Male	15-01-2024	7 years	Unknown
11	Gamini Cub 1/ India	Female	04-06-2024	3 months	Runt, malnutrition
12	Gamini Cub 2/ India	Female	05-08-2024	5 months	Fall from a height, fracture to spinal vertebrae, paraplegia.
13	Pawan/ Namibia	Male	27-08-2024	6 years	Yet to be ascertained

5.1.5. Breeding status of cheetahs in Kuno

The success of any wildlife reintroduction/conservation translocation program is ultimately measured by the ability of the founder population to establish itself, grow, and become self-sustaining in its new environment (Armstrong and Seddon 2008, van Wieren 2012). A critical indicator of this success is the breeding and reproduction by the founder stock. Breeding usually signifies that the animals have adapted well to the new environment, are healthy, and are able to meet their basic ecological needs (Brittas *et al.* 1992, Sarrazin and Barbault 1996). While the primary objective of Project Cheetah is to establish a viable metapopulation of cheetahs in India, initially by introducing a healthy founder stock from Africa, the program also aims to sustain this population through natural breeding at the introduction sites over time. This approach is crucial to ensuring the long-term survival and stability of the cheetah metapopulation in the Indian environment.

In the case of cheetahs, successful breeding is especially significant due to the species' vulnerable status and the challenges associated with their reproduction. Cheetah breeding is notoriously challenging due to several factors, including their low genetic diversity, which leads to reduced fertility and increased vulnerability to diseases (Marker *et al.* 2018, Crosier *et al.* 2022). Cheetahs also have a complex mating system, where females are solitary and only seek out males during estrous, making successful breeding less frequent (Tommasi *et al.* 2021). For example, in captivity, even with intensive management, cheetah breeding success rates remain low worldwide (Marker and O'Brien 1989, Caro 1993, Marker-Kraus and Grisham 1993). Additionally, stress-related complications can affect reproductive health, further complicating breeding efforts. These challenges underscore the importance of carefully managed breeding initiatives to maintain and grow the cheetah population, especially in conservation translocation projects such as Project Cheetah in India.

In light of the above, a Standard Operating Procedure (SOP) was developed under the aegis of NTCA, outlining the essential criteria, actions, and precautions to be followed at the field level in the cheetah release sites when managing pre- and post-breeding situations in cheetahs in India. The SOP includes guidelines for monitoring mating individuals, pregnant and lactating females, neonatal care, and the supervision of cubs born in the wild (Appendix I). Additionally, the SOP provides protocols for addressing health and veterinary management of orphaned, abandoned, or injured cheetah cubs if any, at release sites across India.

To ensure the survival and well-being of the founder population, mating instances in Kuno were meticulously managed within large, specially designed acclimatization enclosures. Genetically unrelated male and female cheetahs were housed in the same enclosure for a short duration under close supervision, with considerations given to factors such as reproductive status, age, health, and genetic compatibility of each pair. Behavioral cues and natural instincts were also particularly observed to assess the readiness and willingness of each pair. Although initial interactions were managed to facilitate mating, the subsequent mating activities and birthing processes occurred naturally. After confirming the mating events, the cheetah pairs were separated, and the females were kept in large acclimatization bomas with minimal disturbance.

Methods to ascertain pregnancy in cheetahs in Kuno included visual examinations, as well as physical examination, and ultrasonography when feasible. Visual examinations identified signs such as well-developed mammary glands and an enlarged abdomen, observable when the cheetah was walking, sitting, or lying down during advanced pregnancy. Routine visual assessments also detected changes in body shape and behavior indicative of pregnancy. Ultrasonography, when performed, allowed for the visualization of developing foetuses within the cheetah's womb, providing crucial insights into the stage of pregnancy and the health of the unborn cubs. These field practices enabled veterinarians and the management to deliver appropriate care for pregnant cheetahs and prepare for the arrival of new cubs.

Throughout the gestation period, which typically lasts around 90 to 95 days, pregnant cheetahs received comprehensive care and attention. Regular visual monitoring sessions were conducted by the veterinary team to track the pregnancy progress. The large acclimatizing enclosures in Kuno, wherein the pregnant cheetahs were housed is a natural environment with adequate natural prey, thus creating a self-sustaining, safe, stress-free setting that supported the cheetah's instincts and behaviours, while also ensuring privacy for the expectant mothers. During the advanced pregnancy stage, human disturbances were minimized to facilitate a stress-free denning and birthing process.

Kuno NP has witnessed four breeding events so far, with three latest instances of females engaging in hunting and nursing their cubs independently. Veterinarians monitored the process closely, intervening only as necessary to ensure the safety and well-being of both the nursing mothers and their cubs. Notably, a female cheetah named Jwala has produced two litters, while two other females, Asha and Gamini, have each given birth to one litter (Table 5.1.3). The fact that cheetahs have been able to reproduce in Kuno so early on in the project is a strong indication that the habitat conditions are suitable for their survival. This early success suggests that the reintroduction efforts are progressing well and that the environment in Kuno is conducive to supporting a stable and thriving cheetah population.

***Table 5.1.3.** Breeding details of cheetahs in Kuno*

Female	Mate	Date of birth	Number of cubs at birth	Number of surviving cubs
Jwala	Shaurya	28/03/2024	4	1
Asha	Pawan	03/01/2024	3	3
Jwala	Pawan	23/01/2024	4	4
Gamini	Pavak	10/03/2024	6	4

Birthing or parturition in each female cheetah was initially confirmed through satellite telemetry data (clustering of locations occur at parturition site as females tend to stay put at the site for first couple of days) or through visual observation. Once confirmed, restrictions on vehicular and monitoring team movement in the vicinity of the den were promptly enforced, with access limited only to the veterinary team to ensure the health and well-being of the mother and cubs. Within the first week after parturition, the veterinary team also inspected the den site to evaluate litter size and cub survival. Dens were checked by one or two personnel while the female was away hunting, as confirmed by radio-telemetry. The cubs typically opened their eyes around 10 days after birth. Following this period, they were physically examined and weighed by the veterinarians to assess their health. This examination was also carried out while the female was away hunting. All cubs were handled gently, swiftly, and minimally, using gloves and other personal protective equipment (PPE) to prevent the transmission of pathogens and minimize human scent. The graphical representation of weight gain recorded over time in one of the litters, is provided below.

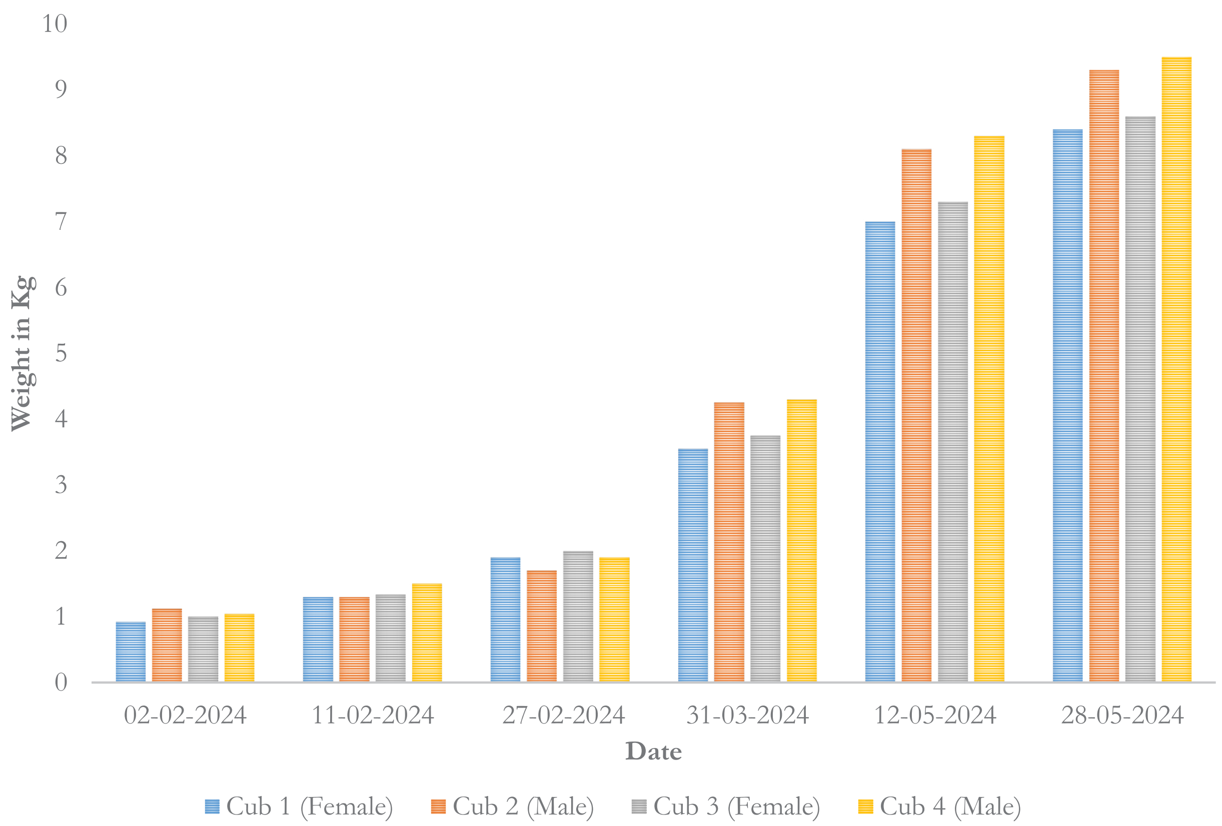

***Figure 5.1.1.** Body weights at various points in time, of cubs littered by female cheetah Jwala*

Currently, there are 12 cheetah cubs in Kuno, each under the care of their respective mothers in the fenced natural environment. The veterinary team regularly monitors both females and cubs to ensure adequate nutrition and health. Intervention is only considered when absolutely necessary, due to either maternal neglect or health issues, and may include supplemental feeding and veterinary care. Since the primary goal is to eventually release these cubs into free-ranging conditions with their mothers in a fit, functional, and self-sustaining condition, interventions that might lead to human dependence or imprinting are kept to a minimum.

Image 5.1.5. *Cheetah cubs in Kuno National Park © Sumit Patel*

5.1.6. Miscellaneous veterinary activities in Kuno

In addition to veterinary interventions for cheetahs, the veterinary team at Kuno also assists with various other activities, including the capture and collaring of co-predators and prey, and the augmentation of prey from adjacent Protected Areas.

As part of the project, the WII was granted permission to conduct radio-collaring and telemetry studies on 10 leopards (vide File.No.1-38/2021 WL, dated 11/11/2021), 10 striped hyenas (vide File.No.1644/2021/10-2, dated 08/10/2021), 10 jungle cats, 25 golden jackals & 15 chital (vide File No. WL/Management/139-C/1005, dated 28/12/2022). These studies aim to explore variations in the movement ecology and spatial habitat utilization of co-predators and prey in relation to the introduction of cheetahs. Under the initiative, the veterinary team has assisted in capturing and radio-collaring of 9 leopards, 8 chital, 5 jungle cats, 4 striped hyenas, and 2 golden jackals since August 2022, details of which are tabulated below.

© Shivang Mehta team/ WII (Project Cheetah)

Table 5.1.4. *Details of animals radio-collared in Kuno National Park*

No.	Species collared	Sex	Age group	Date of collaring	Current status of the collar/animal
1	Leopard	Male	Adult	23-09-2022	Not Active
2	Leopard	Male	Old	25-09-2022	Found dead - senility; collar retrieved
3	Leopard	Male	Sub-Adult	17-10-2022	Not Active
4	Leopard	Female	Sub-Adult	12-11-2022	Not Active
5	Leopard	Male	Sub-Adult	10-12-2022	Active
6	Leopard	Female	Sub-Adult	31-12-2022	Collar dropped; retrieved
7	Leopard	Female	Adult	09-04-2023	Collar dropped; retrieved
8	Leopard	Male	Old	29-04-2023	Active
9	Leopard	Male	Adult	19-11-2023	Active
1	Chital	Female	Adult	26-01-2023	Dead
2	Chital	Female	Sub-Adult	28-01-2023	Active
3	Chital	Female	Sub-Adult	29-01-2023	Not Active
4	Chital	Female	Adult	05-02-2023	Active
5	Chital	Female	Adult	20-03-2023	Dead
6	Chital	Female	Adult	10-10-2023	Active
7	Chital	Female	Adult	12-10-2023	Predated by leopard; collar retrieved
8	Chital	Female	Adult	29-02-2024	Active
1	Jungle cat	Male	Juvenile	16-03-2023	Dead
2	Jungle cat	Female	Adult	12-04-2023	Dead
3	Jungle cat	Male	Sub-Adult	16-04-2023	Active
4	Jungle cat	Male	Adult	27-02-2024	Active
5	Jungle cat	Male	Sub-Adult	16-04-2024	Active
1	Hyena	Male	Sub-Adult	21-11-2023	Active
2	Hyena	Male	Sub-Adult	03-05-2023	Not Active
3	Hyena	Female	Young	13-12-2023	Predated; Not Active
4	Hyena	Male	Sub-Adult	09-04-2023	Active
1	Jackal	Male	Sub-Adult	22-10-2023	Active
2	Jackal	Male	Adult	23-11-2023	Active

5.2. Management interventions in Kuno National Park

5.2.1. Capture and transportation of cheetahs (Pawan, Veera & Agni) which wandered close to human habitation and out of State boundary

Whenever any cheetah ventured into human habitation or crossed state boundaries, immediate capture operations were conducted to ensure the safety of the animals. Often, cheetah wandered beyond the boundaries of Kuno Wildlife Division into human-dominated areas. A rapid response team comprising forest department officials, veterinarians, and trackers immediately responded and reached near the cheetah's location. The operation was safely carried out by immobilizing the cheetah to capture and transport the animal back inside the boundary of Kuno NP. Once immobilized, the cheetah was transported by a vehicle with proper facilities to minimize stress and potential injury. Throughout the process, the veterinarians closely monitored the animal and ensured its well-being.

Agni and Pawan both crossed the State boundary into Rajasthan State from where they were safely captured and relocated back to the PA. After release, Veera wandered mostly in the territorial forests and later was captured near Gwalior and safely shifted back to Kuno. After a successful capture operation, the cheetah was relocated to a suitable environment within the PA boundaries or as needed, released into quarantine boma or inside the soft-release enclosure.

Image 5.2.1. *Kuno National Park team during the capture operation of cheetah which had crossed the interstate boundary © Uttam Sharma*

5.2.2. Treatment of Mukhi, the first Indian-born female cheetah cub for complete diaphyseal fracture at the proximal third of the humerus bone of the right forelimb

Mukhi, the first Indian-born female cheetah cub, suffered a diaphyseal fracture at the proximal third of the humerus bone in the right forelimb. The veterinarian team opted for non-surgical treatment due to her young age and the nature of the fracture to minimize risks and promote natural healing. The team performed precise procedures to align and stabilize the fractured bone. To facilitate optimal recovery, Mukhi was kept in a feeding chamber to limit mobility to prevent any displacement or aggravation of the fracture. Comprehensive care was provided during confinement which included necessary medications to manage pain and reduce any inflammation. After treatment, physical therapy was initiated to restore range of motions, strength, and functionality to the shoulder and forelimb. The combination of precise alignment, restricted movement, supportive care, and rehabilitation program contributed to Mukhi's successful recovery.

© Moulik Sarkar

Image 5.2.2. *Treatment being administered to the cheetah cub for right forelimb fracture by the veterinary team in Kuno National Park © Uttam Sharma*

5.2.3. Treatment of two severely dehydrated cheetahs during the summer of 2024

During the intense summer heat in 2024, the weather posed a significant challenge to cheetahs. Prabhas (adult male cheetah) and Nabha (adult female cheetah) were dehydrated due to prolonged exposure to heat. They both showed signs of dehydration including extreme fatigue, lethargy, and unsteady gait. Recognizing the urgency of the situation, the veterinary team initiated treatment by administering intravenous fluids to restore hydration and electrolyte balance in their body. To further support their recovery, the cheetahs were shifted into specialized quarantine bomas fitted with a mist system to regulate their body temperatures. Nutritional support was also provided to aid their recovery which included a diet rich in essential vitamins and minerals to rebuild their strength and address any deficiencies caused by dehydration. The veterinary team closely monitored their progress throughout the recovery process, ensuring the well-being of the animals. This timely intervention and comprehensive care, allowed both Prabhas and Nabha to fully recover, showing no long-term effect of dehydration.

5.2.4. Application of anti-ectoparasitic medicine with good effects before the start of rains

Ahead of the rainy season, the veterinary team administered Bravecto, a highly effective anti-ectoparasitic medicine, to all the cheetahs to protect them from parasites. This treatment was delivered either orally or injected through the darting technique, depending on the needs of each cheetah. This intervention addressed the threat of parasites that typically flourish in the warm, humid, and moist conditions brought on by the monsoon rains. By ensuring that the cheetahs were treated before the onset of parasite proliferation, the team significantly lowered the risk of infestations such as tick or flea outbreaks, which could have led to life-threatening infections.

5.2.5. Successful management of interactions between male and female cheetahs in a planned way with the successful organisation of mating provided and subsequent administration of proper veterinary care and support to gravid females and mother & cubs

Cheetahs were closely monitored twice daily, allowing field staff to promptly report when females enter their oestrus cycle, as indicated by observable behavioral changes. To facilitate natural mating behaviours while minimising stress and aggression, males with whom the females showed greater comfort were also carefully monitored. When the females were receptive to the male's approach, gates of their respective soft-release enclosures were opened, allowing males and females to interact in a controlled environment under close observation.

A team of veterinarians and researchers continuously monitored the mating process to ensure it proceeded without heightened aggression and fights. Following successful mating, gravid females underwent regular health assessments to track pregnancy progress, and potential complications were identified. A nutritional diet was also maintained to meet the increased needs of pregnant females, and human interactions were minimized during this period to reduce stress and provide an optimal environment for gestation. Post-parturition, mothers and their cubs were kept in a secluded area to minimise disturbances, and veterinary teams ensured proper lactation, nursing, and cubs' well-being.

5.2.6. Rehabilitation efforts for female cheetah cub Mukhi

Mukhi, is a female cub who is one of the first cheetah cubs born on Indian soil. As she was abandoned by the mother, rehabilitation of this cub started immediately. After initial nurture and care, Mukhi was relocated to a quarantine boma (a space of 50m×30m) continuously monitored by veterinarians and caretakers primarily focusing on the animal's health and proper nutrition. A veterinary team visited the boma twice daily, once in the morning and in the afternoon, to conduct thorough health checkups, monitor for injuries, and assess for any signs of parasitic infections. The team was also in charge of her nutritional intake, ensuring the right balance of nutrients to support her growth and development was administered during this critical stage.

A fractured right forelimb and injury required intensive treatment and rehabilitation over a period of one and a half months, during which the veterinary team worked diligently to ensure full recovery. Subsequently, small live prey species, such as hares, were introduced into the boma to stimulate hunting instincts and help develop skills necessary to catch and kill prey independently.

5.2.7. Proper monitoring of each cheetah, whether inside the enclosure or out in the wild including going out of the boundaries of Kuno NP or district or State, and timely detection of any problem the cheetah is facing

Cheetahs were regularly monitored twice a day by the tracking team comprising of WII researchers and forest department staff inside the enclosures, and a team of forest department staff along with trackers monitored round the clock in free-ranging conditions. This monitoring process extended beyond Kuno NP extensively and in a few instances, cheetahs crossed district or State boundaries. Such monitoring protocol was essential for the timely detection of any health issues, injuries, or potential threats, such as conflict situations or poaching, that a cheetah might encounter in these diverse landscapes. The veterinary teams were equipped with the proper gear to promptly address any problems identified through continuous surveillance, including on-site medical treatment, detailed health assessments, or emergency interventions in case the cheetah is found in a risky situation, particularly in human-dominated areas. By maintaining continuous monitoring, veterinarians and management authorities implemented rapid response strategies to prevent minor issues from becoming a severe health crisis.

© Shivang Mehta/Team WII (Project Cheetah)

Image 5.2.7. Veterinary examination of cheetah in Kuno National Park © Parul Sen

5.2.8. Habitat Management in Kuno National Park

1. Minimal fire incidents in National Park and no fire incident close to cheetah enclosure in the last two years.

2. Summer preparation inside soft-release enclosure to make them conducive for cheetahs

3. Supplementation of prey inside enclosures for cheetah

4. For improving chital density in the NP, a chital breeding enclosure of area 80 ha at Taal in Occhapura Range has been constructed and chitals have been kept inside it.

5. General protection of the whole area especially where cheetahs are kept or moving.

6. Habitat improvement work done:

a. Total grass land area: 12,870 ha

b. Grassland development and habitat improvement works such as weed eradication, brushwood removal etc. were taken up in more than 5000 ha in the last 2 years.

Image 5.2.8.1. *Grassland management in Kuno National Park © Madhya Pradesh Forest Department*

Table 5.2.1. *Habitat management activities in Kuno National Park*

Activity	Financial Year			
1.Weed eradication (Parthenium, Lantana etc) 2. Brushwood removal	2021-22	2022-23	2023-24	2024-25
Total Area	1471 ha	4698 ha	6675 ha	967.35 ha (till July 2024)

7. Development of new water sources along with maintaining old sources were taken up on a large scale. In the last 2 years, 51 small and big ponds have been constructed. A new water lifting facility from Kuno River at a place named Bared in Palpur West Range, was created in which water is lifted from river using 15 HP solar pump, stored in a water tank of 100,000 litres capacity and then pushed using 7.5 HP solar pump to three ponds spread over 5 km using 4-inch pipe line. It led to availability of water throughout the summer in these three ponds which used to be dry earlier.

Image 5.2.8.2. *Shade nets tethered inside the cheetah soft-release enclosure during summer © Uttam Sharma*

8. Similarly, an additional 4 km long network of pipelines was laid in addition to the existing 8 km network of pipelines for enclosures. Water was lifted from Kuno River at two places at Palpur by installing two solar pumps (capacity 5KV & 15KV). Through this network of 12 km long pipelines, water was distributed as far as 5 km away from the river. An additional diesel pump was also kept in reserve in case of emergency when water had to be supplied during the night and cloudy weather. Water was not only supplied to saucers and guzzlers but also to identified and marked dry streams (Nalas) inside soft-release enclosures. This lifted water not only created an additional water source but also helped leaf growth on trees along the stream banks, making the area a lot cooler. These cool places were preferred throughout the summer by the cheetahs, especially mothers with cubs, which protected them from the scorching heat.

9. Upgradation of roads for improving patrolling: with nearly 52 km in the year 2023-24 and about 80 km taken up during 2024.

10. A 5-member delegation visited Gandhi Sagar WLS and Kuno NP from 24th to 26th April 2024 and consisted of officers from the Government of South Africa. Additionally, a 6 member Kenyan delegation visited Gandhi Sagar WLS and Kuno NP from 20th to 23rd May 2024. The delegation consisted of officers from the Kenyan Wildlife Service.

Image 5.2.8.3. *Visit of South African delegation to Kuno National Park © Uttam Sharma*

Both the delegations were briefed about the Project Cheetah, its progress and achievements in Kuno NP, preparations made for introduction of cheetahs in Gandhi Sagar WLS and given a tour of the area to apprise them of the current situation. This visit was part of a broader initiative focused on wildlife conservation and the introduction of cheetahs to the region. Kuno NP has been at the forefront of efforts to establish cheetah population in India after their extinction in the country more than 70 years ago.

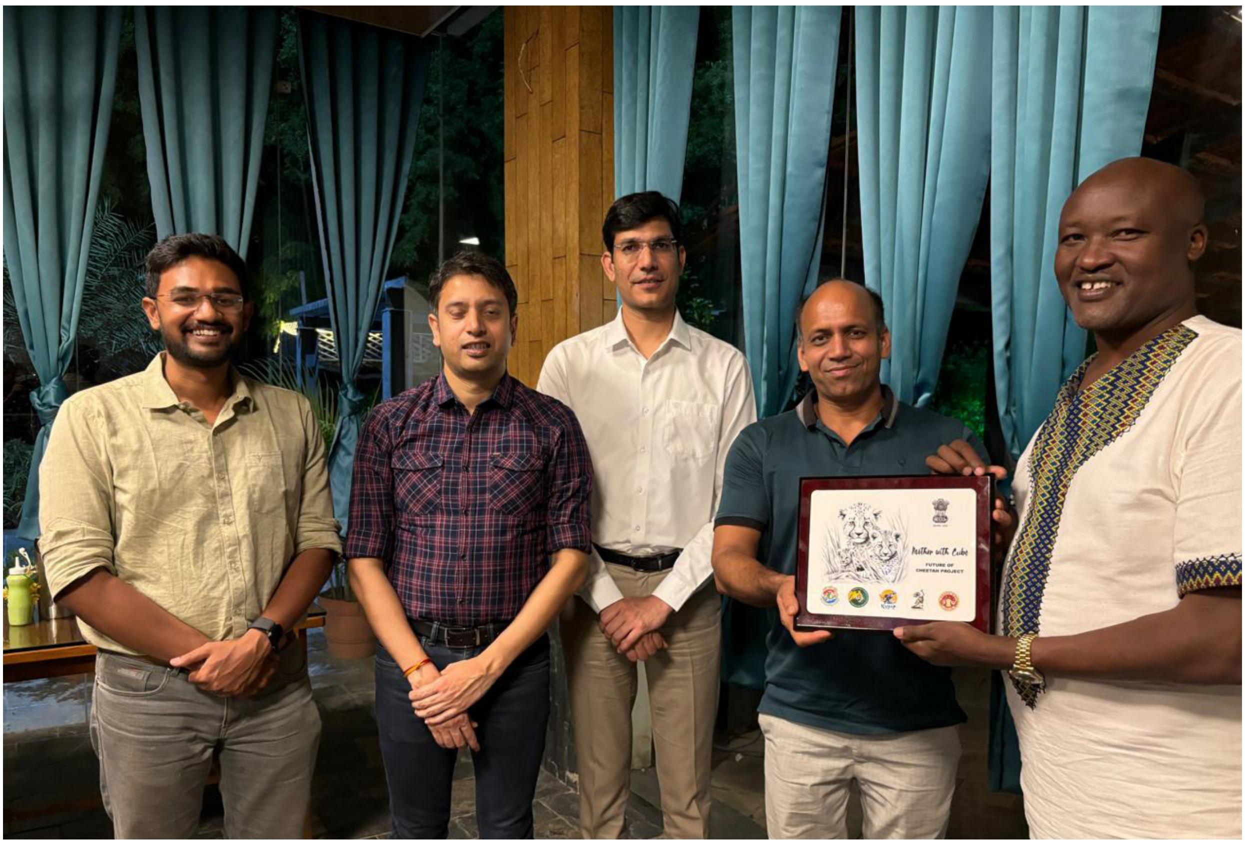

Image 5.2.8.4. *Visit of Kenyan delegation to Kuno National Park © Uttam Sharma*

5.3. Veterinary contributions to Project Cheetah in Gandhi Sagar Wildlife Sanctuary

Historical experiences in species introductions worldwide, coupled with recent insights from Kuno, emphasize the need for a prolonged and dedicated commitment in every facet of the project for success. However, acknowledging that all attempts can face susceptibility to failure, often due to veterinary reasons, underscores the importance of careful planning. Hence, a well-equipped veterinary facility is being established in Gandhi Sagar WLS before initiating cheetah release. Simultaneously, ongoing efforts are being implemented to upgrade the facility to international standards, ensuring long-term sustainability. Additional veterinary activities undertaken so far in Gandhi Sagar, in preparation for cheetah arrival are elaborated below.

5.3.1. Identification and placement of a veterinary team in Gandhi Sagar Wildlife Sanctuary

A veterinary team, composed of veterinarians from the NTCA, the M.P. Forest Department, and the WII will be stationed in Gandhi Sagar. This team will oversee and facilitate the establishment of a comprehensive veterinary facility for cheetahs. Additionally, they will be responsible for ensuring the health and welfare of all animals, including the introduced cheetahs and sympatric species in Gandhi Sagar, before, during, and after introduction. The team will manage intervention procedures such as capture, immobilization, treatment, and prophylaxis. Furthermore, provisions will be made for new veterinarians to undergo basic hands-on training in cheetah veterinary management, initially at Kuno and subsequently at advanced cheetah management facilities abroad. A panel of national and international veterinary experts will be established to provide specific guidance to the team regarding the veterinary care, management, and husbandry of cheetahs. This guidance will apply to both quarantine and later free-ranging conditions, ensuring comprehensive and informed care for the cheetahs at all stages of the project.

5.3.2. Disease Risk Analysis for Gandhi Sagar Wildlife Sanctuary

During conservation introductions, the management of health risks, both communicable and noncommunicable, are extremely important to maximise the survival of translocated animals and to minimise the risk of introducing a novel health hazard to the destination country (Miller 2007, Sainsbury *et al.* 2012, Sainsbury and Vaughan-Higgins 2012). To analyse and manage the possible outcomes of situations involving health risks in projects like this, a process known as Disease Risk Analysis (DRA) has been adopted by the World Organisation for Animal Health & International Union for Conservation of Nature (OIE & IUCN 2014). The objective of this process is to identify all possible health risks of concern while providing an evidence-based analysis of the said risks to the cheetahs translocated from source countries to reserves in India. In addition, the prevention of alien disease introduction to the recipient area and native fauna is also considered.

A comprehensive list of potential hazards has already been compiled through a systematic scientific literature search as part of the "Disease Risk Analysis for Introduction of Cheetahs (A*cinonyx jubatus*) to India," conducted during earlier cheetah translocations to Kuno (Tordiffe *et al.* 2021). Building upon this foundation and drawing from previous experiences in Kuno, a site-specific DRA will be compiled for Gandhi Sagar WLS in preparation for the cheetah introduction. Initiatives undertaken to gather the following information, enhance the DRA process at the proposed field site are as follows:

A. Seroprevalence of major carnivore diseases in Gandhi Sagar WLS: Biological sampling for the said exercise is being carried out in conjunction with capture and radio-telemetry operations of co-predators by the WII team. So far, biological samples from 12 leopards have been collected for kit based seroprevalence studies. Additional efforts are underway to increase the sampling size spanning multiple species.

B. Seroprevalence of major diseases in feral/domestic animals in the vicinity of Gandhi Sagar WLS: Biological sampling for the said exercise is being carried out in conjunction with feral animal vaccination by the WII team, whereas population control drive is to be carried out by M.P. Forest Department. Samples from 50 dogs have been collected, covering all the major villages adjacent to the cheetah release site for kit-based seroprevalence studies.
C. Prevalence of non-communicable risks in the Gandhi Sagar landscape: Said exercise will be carried out using landscape-level information available with the M.P. Forest Department, complemented with field observations and environmental/ecological modeling which are being conducted by the WII team for the project.

Following the collation of the above data, a comprehensive document will be released, containing information on the evaluation and classification of the level of risk associated with each identified hazard, risk management measures to mitigate the same, and protocols for the operationalization of risk management measures. Identified risks will also be communicated to relevant experts and stakeholders, to enhance the quality of analysis and ensure the effective implementation of the developed protocols.

5.3.3. Leopard capture and relocation efforts from cheetah release enclosure

To ensure the safety of translocated cheetahs within the fenced area, the NTCA, WII, and M.P. Forest Department have initiated capturing leopards and shifting them outside the fenced cheetah release area. This operation is being carried out under the permissions granted vide letter number [Letter No./Prabandh/W.L./01-C/3884].

The capture methods employed by the teams are humane, safe and adhere to established wildlife management protocols to minimize stress and injury to the animals. Leopards are being captured using humane foot snares or walkthrough capture cages. These methods are designed to ensure safe and secure handling of the animals, minimizing any potential harm during the capture process. A total of 11 leopards were captured and shifted outside.

Image 5.3.3. *Leopard radio-collaring in Gandhi Sagar Wildlife Sanctuary © Sanath Muliya*

Table 5.3.3. *Details of leopard capturing exercise carried out in Gandhi Sagar Wildlife Sanctuary*

S No	Animal id	Date of capture	Age-sex classification	Collared/not
1	GSM 1	11-05-2024	Adult male	Collared
2	GSM 2	21-05-2024	Adult male	Collared
3	GSM 3	23-05-2024	Adult male	Collared
4	GSM 4	25-07-2024	Adult male	Collared
5	GSM 5	10-08-2024	Adult male	Not collared
6	GSF 1	08-05-2024	Sub-adult female	Collared
7	GSF 2	10-05-2024	Adult female	Collared
8	GSF 3	24-07-2024	Sub-adult female	Not collared
9	GSF 4	24-07-2024	Adult female	Not collared
10	GSM 6	12-08-2024	Adult male	Collared
11	GSF 5	12-08-2024	Sub-adult female	Not collared

5.4. Preparations for cheetah introduction in Gandhi Sagar Wildlife Sanctuary

Long-term commitment of resources and personnel have been obtained from the Central and State Governments with endorsement from the Union Government of India and State Government of M.P. for successful implementation of the Project. The construction of predator-proof solar-powered electric fence for cheetah release (Area~ 64 km^2) of 28 km length, enclosures with adequate prey and free from competing large predators (similar to the outer fence) in Gandhi Sagar WLS was completed along with the preparation of quarantine bomas by the M.P. Forest Department. Associated management issues of the Park were addressed by the State Forest Department based on the technical recommendations of WII from additional financial support from the Central Government provided by the NTCA. Additionally, grassland restoration, removal of invasive plants, and other habitat management activities are regular activities of the Forest Department. Habitat assessments, ungulate, and carnivore population assessments were carried out with the collaborative efforts of the WII and the Forest Department. Awareness and outreach campaigns were conducted to sensitize local communities by the M.P. Forest Department. Involvement of local people in ongoing construction and habitat development work was undertaken across the entire Sanctuary to garner community support and to provide them with employment locally.

Image 5.4.1. *Predator-proof fenced area of ~64 km^2 for release of cheetah in Gandhi Sagar Wildlife Sanctuary © Madhya Pradesh Forest Department*

5.4.1. Park/Habitat Management

For grassland management inside the enclosure area, it is proposed to start an eradication program of *L. camara* & *P. juliflora* to increase the available grassland area. Proposals for the eradication of these species and the development of grasslands are regularly sent under various Annual Plan of Operations (APOs). During the year from September 2023 to September 2024, ~870 ha area was treated under various budget heads. The work which has been taken under grassland development includes eradication of *L. camara* & *P. juliflora* with other weeds (*Senna tora* and *Ocimum gratissimum*), soil and moisture conservation works such as clearing of loose boulders and brushwood, check dams on small streams and construction of percolation tanks. After uprooting the weeds, grass seeds were sprayed in the vacant area resulting in increase of grassland area available for ungulate prey.

The fenced area for cheetah release has a sufficient number of water sources. In addition to existing water sources, an additional 25 HP solar water pump has been installed at the Kunamata site to make water available for wildlife during hot summers as well as to maintain moisture in grassland areas to sustain green grass around the year.

Image 5.4.2. *Solar powered predator-proof fence for cheetah release in Gandhi Sagar Wildlife Sanctuary © Madhya Pradesh Forest Department*

Image 5.4.3. *Quarantine bomas (predator proofed and solar powered) for cheetahs in Gandhi Sagar Wildlife Sanctuary © Madhya Pradesh Forest Department*

5.4.2. Veterinary infrastructure

An old dormitory building at Rampura pathar area inside the fenced area for cheetah release has been renovated and modified for use as a veterinary hospital. Some of the necessary animal rescue equipment have been procured. Procurement of basic surgery and veterinary equipment is in process. As instructed by the Steering Committee of Project Cheetah, six quarantine bomas and two treatment bomas of size 30m×50m have been constructed at Rampura pathar. These quarantine bomas have been equipped with water saucers, mounds, feeding and treatment chambers with cages as well as natural and artificial shade. For 24×7 monitoring of the cheetahs inside, the six quarantine bomas are equipped with two PTZ cameras of high resolution and six stilt cameras (one in each boma) including the construction of two robust watchtowers for visual monitoring by forest department staff/WII researchers. A full-fledged monitoring room with a minimum backup capacity of 30 days at the Eco-center in Rampura pathar is in operational condition.

5.4.3. Prey base augmentation work

As part of the augmentation of ungulate prey in Gandhi Sagar WLS, the State government has given sanction for the translocation of 1250 chitals from various PAs in M.P. Till now, 387 chitals have been translocated to increase the prey base in the fenced area for cheetah. Three predator-proof ungulate prey breeding enclosures of sizes- 90 ha, 50 ha, and 50 ha at Khemla, Golabavdi, and Karanpura respectively were constructed. Currently, there are 79 chitals in the Karanpura enclosure and there are 42 chitals in the Khemla enclosure. Fawns have been born in herds in both enclosures.

5.4.4. Capture and shifting out of leopard from the fenced area for cheetah release

As recommended by the cheetah action plan to minimize the competition for prey and to minimize the conflict between cheetahs with leopards, work for shifting leopards from the fenced area for cheetahs is in progress under the supervision of a veterinarian from NTCA and researchers from WII. Till August 2024, 11 leopards have been captured and shifted out of the area.

5.4.5. Dog vaccination and biological sampling

As a part of the cheetah project to analyse the prevailing diseases in the area, work has been initiated for the biological sampling of dogs and their vaccination under the guidance of a wildlife veterinarian from WII. Biological samples have been collected from 50 dogs in the periphery area of the Sanctuary and they have been vaccinated.

5.4.6. Action plan for the introduction of cheetah in Gandhi Sagar Wildlife Sanctuary

Based on the IUCN guidelines for reintroductions and conservation translocations and learnings from Kuno experience, an action plan for introduction of cheetah in Gandhi Sagar WLS was prepared. Various aspects of introduction such as site assessment and preparation, organizational commitments, founder stock, veterinary interventions, disease and health management, post-release monitoring, research and management including co-predators, prey, and habitat; capacity building, community participation, ecotourism, publicity and media management, landscape management, project review, and monitoring were elaborated upon.

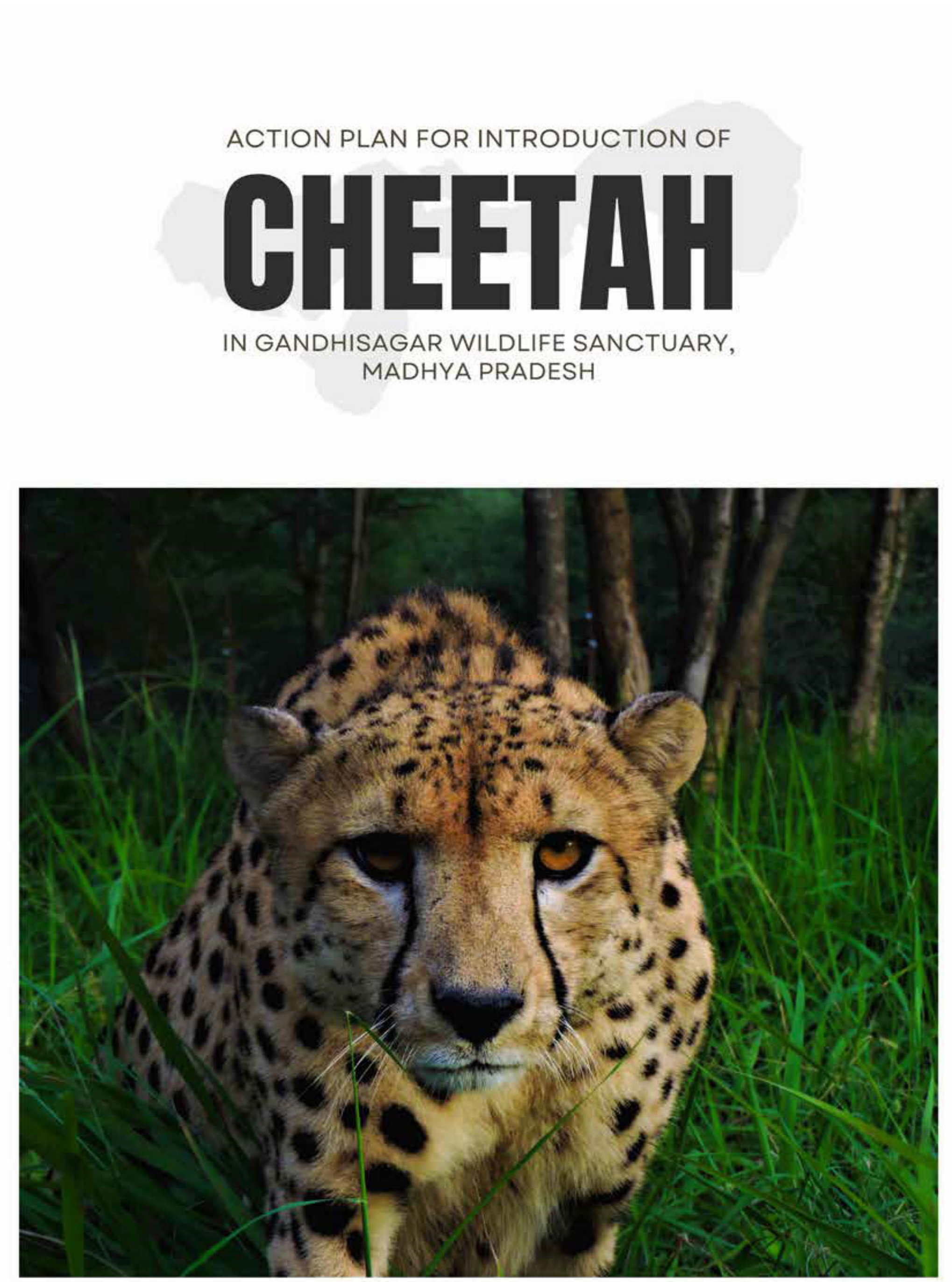

Image 5.4.6. *Action plan for introduction of cheetah in Gandhi Sagar Wildlife Sanctuary*

5.5. Preliminary hormonal assessment of cheetahs in Kuno National Park

Currently, predatory carnivores within the families Felidae, Canidae, and Ursidae are among the most threatened species globally (Cardillo *et al.* 2006, Schipper *et al.* 2008, Ceballos *et al.* 2005). Habitat destruction, hunting, and human-animal conflict are among the most significant pressures facing these large carnivores (Morrison *et al.* 2007). Ensuing this, reintroductions and conservation translocations of large carnivores have been recognised as an effective strategy to conserve threatened species and restore ecosystem functions (Kock *et al.* 2010, IUCN/SSC 2013). It is now largely accepted that the number of wildlife translocation initiatives is likely to intensify in the near future, as attempts are increasingly being made to conserve many critical species amid human-caused environmental changes (Sainsbury and Vaughan-Higgins 2012). Nutritional and other forms of physiological stress can significantly impact the reproductive capacity and susceptibility to parasite/disease outbreaks in translocated wildlife populations (Romero *et al.* 2004, Wikelski *et al.* 2006, Charmandari *et al.* 2005, Busch *et al.* 2009). Quantifying population-level differences in physiological and nutritional stress is thus critical to understanding how these pressures take their toll on the health and reproduction of translocated or reintroduced large carnivores. The relative immediacy of these measures also makes them ideal for identifying mitigation strategies and assessing the success of their implementation for conservation and management (Millspaugh *et al.* 2004, Keay *et al.* 2006).

Exposure to natural or human-induced disturbances has generally had two different kinds of impact on wildlife: (i) direct impacts such as population decline due to poaching or hunting (Schipper *et al.* 2008) and (ii) indirect impacts from increased disturbances, including habitat loss, inadequate food resources and conflict. Each of these pressures tends to be impacted by life history and mediated by elevated psychological as well as nutritional stress, and associated reduced reproductive capacity (Millspaugh *et al.* 2004, Keay *et al.* 2006, Wingfield *et al.* 1997). For an animal to survive and dwell successfully, it must respond to environmental cues via physiological or behavioural adaptations (Friend 1980). To cope with external stressful conditions and to maintain homeostasis of the individual, the body elicits an endocrine response involving elevated levels of glucocorticoids as a coping mechanism (Möstl and Palme 2002). A stressful situation or event cannot always be said to have a negative impact on physiological processes (Moberg 2000), however, the continuity of stressful events and associated elevated levels of glucocorticoids (cortisol and corticosterone) can be detrimental to fitness (Munck *et al.* 1984) and fecundity of the animal (Liptrap 1993). Also, it may lead to severe behavioural disturbances in the animal ultimately leading to a decline in survivorship.

Stress hormones work to attain homeostasis under adverse conditions and it is important to understand or determine the best way to bring the animal back to homeostasis. The action of glucocorticoids enables the release of glucose to provide energy and halts the other energy-consuming physiological processes like reproduction and immune response. Such a temporary withdrawal of energy is favorable to the survival of the animal in case of acute stress, but if the stressful situation is prolonged, the body starts to deplete all stored energy (fat reservoirs, muscle, and glycogen) (Asterita 1985, Broom and Johnson 1993). Reproductive capacity decreases and overall animal health declines due to depleted energy and increased susceptibility to diseases. Any chronic perturbation in the habitat of animals will be reflected as behavioural changes, suppressed reproduction rate, stunted growth, and loss of body mass. All these phenotypes are exhibited in later stages during the course of stress. It is therefore crucial to identify the causes and effects at the earliest to correct or minimize the duration of the stressful event. This becomes particularly important when dealing with the conservation of threatened animals and it is crucial to keep in mind the overall health of animals (behaviour, reproduction, and diet). In recent times, impacts of environmental disturbance on resource use have been particularly pervasive for wild animal populations.

Accessing preferred resources may become very stressful for animals when the disturbance is high and may even become inaccessible or avoided. Monitoring the associated nutritional and other forms of physiological stress, as well as reduced reproductive capacity provides an ideal approach to link such impacts (Monfort *et al.* 1998, von der Ohe *et al.* 2004, Van Meter *et al.* 2009, Wasser *et al.* 1983).

An abundance of studies indicate detrimental effects of physiological stress (both psychological and nutritional) on immunosuppression, reduced disease resistance, and reproductive capacity (Keay *et al.* 2006, Monfort *et al.* 1998, Van Meter *et al.* 2009, Wasser *et al.* 1983). Non-invasive measures of stress and nutrition can now be coupled with resource selection measures, providing a powerful approach that links the impacts of environmental pressures to animal well-being.

Understanding the reproductive physiology of cheetahs along with physiological stress (both psychological and nutritional) is critical for successful conservation efforts, particularly in reintroduction/conservation translocation programs. Reproductive hormones play a pivotal role in regulating sexual development, estrous cycles, spermatogenesis, and overall reproductive health in both males and females (Senger 2012). As reproduction is key to species survival and hormones drive this process, understanding the basic reproductive endocrinology of felids is vital for their conservation and management (Brown 2011). By assessing the reproductive status of cheetahs through a comprehensive analysis of key hormonal markers, valuable insights can be gained into their overall health and well-being. Estrogen & progesterone are primary female reproductive hormones and evaluating these can provide information on ovarian activity, ovulation timing, and potential pregnancy status in females (Brown *et al.* 1996). Similarly, in males, testosterone is the major endocrine variable to objectify testicular activity and thus reproductive function in males. It is also involved in the development and function of male reproductive physiology and sex-related behavior. Monitoring testosterone levels in males is a powerful tool to assess the gonadal status of males (Pribbenow *et al.* 2016). Interestingly, mammals (both male & female) do produce small amounts of each other's primary sex hormones (Andersen *et al.* 2006, Maggiolini *et al.* 1999), suggesting additional physiological roles beyond reproduction. However, this area remains understudied, presenting a unique opportunity for studying reintroduced/translocated populations in India.

By analyzing these key reproductive hormones, a deeper understanding of the cheetah's reproductive physiology can be gained and thus contribute valuable information for their long-term conservation. Identifying optimal breeding windows and potential fertility issues in both males and females will be vital for successful breeding programs and reintroduction/conservation translocation efforts (Ganswindt *et al.* 2012).These highly accessible measures provide relatively immediate physiological indices that reflect how disturbances are impacting population growth over time (Millspaugh *et al.* 2004, Keay *et al.* 2006, Wingfield *et al.* 1997). Such information can also be very useful in understanding individual/ population responses of reintroduced/translocated animals and help in developing appropriate management decisions regarding their health. Standard observations and long-term demographic changes are logistically difficult to employ in the wild, and live-capture based methods can be risky if not conducted appropriately and necessarily infrequent. Faecal sample collection has the benefit of allowing extraordinary sample access in a manner that does not confound stress measures when compared with wildlife capture for blood withdrawal. Faecal hormone (Velloso *et al.* 1998, Wasser *et al.* 2000) measures are also better integrated over time, with each sample reflecting the cumulative stress and parasites experienced by the animal during prior exposures.

The "Project Cheetah," is a transcontinental initiative to introduce African cheetahs into India, offers a unique opportunity to closely monitor the physiological patterns of individual animals in a conservation introduction/translocation program. The project also allows for comprehensive monitoring of the cheetah population's physiology from its inception, providing a deeper understanding of various physiological parameters such as stress, nutrition, and reproductive cycles, which may have or will influence cheetah survival and reproduction at the introduction sites. Alongside traditional ecological data (e.g., prey density, habitat conditions, disturbance factors), physiological and dietary data are expected to provide essential management insights for the introduced/translocated population. This chapter provides updates on the progress and activities undertaken to understand the cheetah physiology component of the project.

The main objectives of this investigation are:

- Standardization & quantification of Corticosterone (GC), Triiodothyronine (T3), and reproductive (progesterone, testosterone, and 17β-estradiol) hormones of cheetahs in Kuno NP through non-invasive approaches.

- Preliminary comparative analysis of these hormone measures in individual cheetahs at various stages of the project, i.e. translocation, quarantine, and release.

5.5.1. Sample Collection & Processing

After translocation, all cheetahs were first shifted to quarantine bomas (QB) from crates (C), and then to larger bomas (LB) as part of a soft-release approach. The monitoring team has collected a total of 164 scat samples in a staggered manner from these individuals between September 2022 and February 2024. The samples were collected in a sterile manner to reduce any possible cross-contamination, and stored in butter paper inside airtight zip-lock bags. After field collection, the samples were stored at -20°C at the field station, Kuno NP. Later, they were transferred to the Wildlife Endocrinology Facility at WII, Dehradun for further processing and analysis. Two samples out of 164 samples were excluded from the processing due to unidentified gender.

Image 5.5.1. Cheetah in transportation crate © Cheetah Conservation Fund

Image 5.5.2. *Cheetah in quarantine boma © Moulk Sarkar*

Image 5.5.3. *Cheetah in soft-release boma © Moulk Sarkar*

5.5.1.1. Drying & Sieving

Frozen fecal samples (n=162) were removed from the freezer and allowed to thaw overnight. The thawed samples were pulverized and placed in disposable aluminum trays. To remove moisture, the samples were dried in an oven (Promax Heating Oven- Techno Engineer, Dehradun) at 50°C for 72 hours. The dried samples (n=162) were further pulverized and then sieved through a fine mesh to separate the fecal powder from any remaining coarse materials (such as bones and hair) from their diet. The resulting, well-homogenized fecal powder was used for hormone extractions.

5.5.1.2. Hormone metabolite extraction

0.1 grams of fecal powder from each sample was weighed and ashed individually in a muffle furnace (model NSW-101, NSW, New Delhi, India) at 450°C for 1.5 hours. The weight of the sample was measured again to determine the amount of inorganic matter (IOM). Following a previous study (Patel *et al.* 2021), samples with < 80% IOM were used for hormone assays. Each dried fecal powder sample (n=160) was thoroughly mixed, and 0.1 grams was weighed for hormone extraction. The extraction procedure involved suspending the weighed powder in 10 ml of 70% ethanol solution and vortexing it for 30 minutes. This was followed by centrifugation at 2200 rpm for 20 minutes (Wasser *et al.* 2010, Mondol *et al.* 2020). The hormone extracts were collected in 2ml cryochill vials (1:10 dilution) and stored at -20^{o}C in the freezer until assays.

5.5.1.3. Enzyme Immunoassay (EIA)

EIA or enzyme immunoassay is a powerful technique for quantifying and detecting different macromolecules such as antibodies, peptides, hormones, proteins, etc. The target macromolecule or antigen immobilized on a microtiter plate competes with conjugates (enzyme-labeled antigens) for binding sites on polyclonal antibodies. The detection requires the incubation of appropriate substrate with the reporter enzyme and the production of a measurable product. The standardization (Figure 5.5.2 to 5.5.6) and quantification of all five hormones were done using the commercially available EIA kits for corticosterone (#ISWE007), triiodothyronine (#K056-H5), progesterone (#ISWE003), 17β-estradiol (#ISWE008) & testosterone (#ISWE001) using the collected fecal samples (n=160). During assays, sample extracts were air-dried inside an incubator (Promax Bacteriological Incubator, Techno Engineer, Dehradun) and re-suspended in assay buffer (AB) as per required dilutions. Each sample (n=160) was assayed in duplicate using respective kit protocols and the optical density was measured at 450 nm using an ELISA plate reader (#EPOCH2, Agilent Technologies, California, USA). Hormone metabolite concentration was interpolated using four parametric logistic curve (4PLC) regression functions of GraphPad Prism version 8 (GraphPad Software, California, USA). Cross-reactivities of respective antibodies are listed in Table 5.5.1. Inter and intra coefficient of variation was calculated for the assays (Table 5.5.1).

5.5.1.4. Standardization (Parallelism & Accuracy)

Parallelism was analyzed by running serial dilutions of the pooled samples (N=7;♂=3,♀=4) in assay buffer provided in each kit (Arbor Assays, USA). This test determined the dilution for a sample at 50% binding, which is the most accurate portion of the curve for measuring hormones. Accuracy was tested by spiking a set of hormone standards for each hormone assay with a pooled sample at a dilution of 50% binding, as indicated by the parallelism curve (Figure 5.5.2-5.5.6). Results were plotted as regression lines using observed and expected concentrations from accuracy tests to show that faecal components were not interfering with assay accuracy at the tested dilution. (Table 5.5.1).

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***Table 5.5.1.** Details for fecal hormone assay of cheetah*

Hormone	Dilution	Slope (R^2)	Inter-Assay CV	Intra-Assay CV	Cross -reactivities
Corticosterone	1:1280	1.02 (0.9)	NA	4.5	100% with corticosterone, 12.30% with Desoxycorticosterone, 2.30% with Tetrahydrocorticosterone and <1% with Aldosterone, Cortisol, Progesterone, Dexamethasone, Corticosterone-21-Hemisuccinate, Cortisone and Estradiol
Triiodothyronine	1:40	1.09 (0.9)	3.98	4.09	100% with T3, 0.88% with thyroxine, and less than 0.1% with reverse T3 (3,3',5'-Triiodo-L-thyronine)
Progesterone	1:200	1.02 (0.9)	4.36	4.12	100% with Progesterone, 172% with 3β-hydroxy-progesterone, 188% with 3α-hydroxy progesterone, 147% with 11α-hydroxy progesterone, 2.7% with 11β-hydroxy-progesterone, 7% with 5- α-hydroprogesterone, 5.9% with Pregnenolone, & less than 1% with Corticosterone & Androstenedione
17β-estradiol	1:80	0.97 (0.9)	NA	4.05	100% with 17β-Estradiol, & less than 1% with Estrone, 17α-Estradiol, 17α-Ethynylestradiol, Estrone sulfate, Progesterone, Testosterone, 5α-dihydroprogesterone, cortisol, corticosterone.
Testosterone	1:160	0.90 (0.9)	NA	3.46	100% with Testosterone, 56.8% with 5a-Dihydrotestosterone, 2.34% with 11-Ketotestosterone, & less than 1% with Androstendione, Androsterone, DHEA, Cholesterol, 17β-Estradiol, Progesterone, Pregnenolone, Hydrocortisone, Cholic Acid, Cholic Derivatives, Aldosterone, Cortisol, Corticosterone, Cortisone

5.5.2. Analysis of samples

To assess the extent of IOM presence, the faecal samples were categorized into five intervals of increasing percentage of IOM as 0-20%, 20-40%, 40-60%, 60-80%, and 80-100 % (Figure 5.5.1). Skewness and kurtosis for all the data sets, and log-transformed concentration values were checked before conducting statistical analyses. These analyses, along with the following statistical tests, were conducted in PAST 4.03 Software.

To evaluate faecal corticosterone metabolite (fGCM) level differences in translocated cheetah population, all the cheetah samples were divided into three groups based on where they were housed: crate (C) (n=6;♂=4,♀=2) during transport, quarantine bomas (QB) (n=84;♂=40,♀=44), and larger bomas (LB) (n=45;♂=9,♀=36). A statistical test (one-way ANOVA with subsequent post hoc Tukey's HSD test) was used for the comparison to ascertain any differences in stress levels (fGCM) between the locations. Stress hormone levels among different sexes within each housing category were compared using the T-test. Triiodothyronine (FT3M) data was analyzed following the same approach. Individual female fT3M levels were compared to check for any differences in the nutritional levels.

For the reproductive hormones, fecal estrogen metabolite (fE2M) and fecal progesterone metabolite (fP4M) levels in all female cheetahs (n=10) were checked. One-way ANOVA (with subsequent post hoc Tukey's HSD test) was used to assess variations in fP4M and fE2M levels across all the female cheetahs sampled during this period. Unfortunately, fecal samples for some male individuals were not available, and therefore, individual faecal testosterone metabolite (fTM) levels were not assessed for males. For a cumulative assessment between all the reproductive hormones, the faecal samples were further categorized into different sexes (males: 64; females: 96). T-test was used to compare fTM, fP4M, and fE2M levels between the sexes. To assess overall fluctuations in these hormones, each hormone data was categorized sex-wise. One-way ANOVA (with subsequent post hoc Tukey's HSD test) was used to identify any significant variations across them.

For a better understanding of the different reproductive phases, baseline range values for all three reproductive hormones in females were calculated through an iterative process in which values greater than M+2SD were excluded for fP4M & fTM and values greater than the M+1.5SD were excluded for fE2M (Brown *et al.* 1996, Arora *et al.* 2023) to exclude outliers. All reproductive hormone data were classified into two categories: above baseline (>B) and below baseline (<B). Subsequently, a T-test was performed for each of the three hormones to determine significant differences between the two categories.

For a better understanding of the different reproductive phases, baseline range values for all three reproductive hormones in females were calculated through an iterative process in which values greater than M+2SD were excluded for fP4M & fTM and values greater than the M+1.5SD were excluded for fE2M (Brown et al. 1996, Arora *et al.* 2023) to exclude outliers. All reproductive hormone data were classified into two categories: above baseline (>B) and below baseline (<B). Subsequently, a T-test was performed for each of the three hormones to determine significant differences between the two categories.

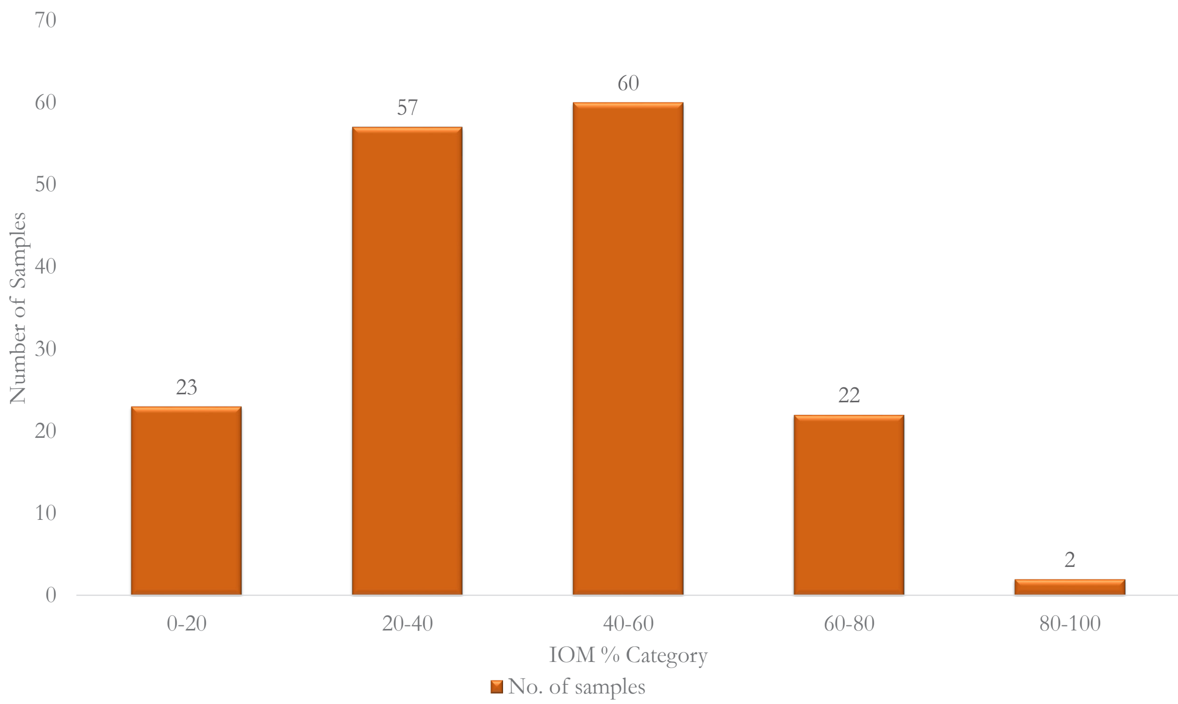

Figure 5.5.1. *Categorization of cheetah faecal samples on the basis of IOM %*

5.5.3. Results

5.5.3.1. Standardization (Parallelism & Accuracy)

Parallelism and accuracy studies of the targeted hormones indicated that reliable measurement of all fecal hormone metabolites across their ranges of concentration was being carried out. Eight dilutions were used for the corticosterone (GC) assay (1:10-1:1280), seven for the triiodothyronine (T3) (1:10-1:640), six for progesterone (P4) (1:40-1:1280), five for 17β-estradiol (E2) (1:10-1:160), and seven for testosterone (T) (1:10-1:640). This test determined the dilution for a sample at 50% binding, which is the most desirable for measuring hormones. Accuracy was tested by spiking a set of hormone standards for each hormone assay with a pooled sample at a dilution of 50% binding, as indicated by the parallelism curve (Figure 5.5.2-5.5.6). The slopes produced ranged from 0.90 to 1.09 depending on hormones, illustrating that fecal extracts did not interfere with their measurement precisions (Table 5.5.1). The inter-assay coefficient of variation (CV) ranged from 3.98 to 4.36 and intra-assay coefficient of variation (CV) ranged from 3.46 to 4.5, depending on the assay (Table 5.5.1).

Corticosterone

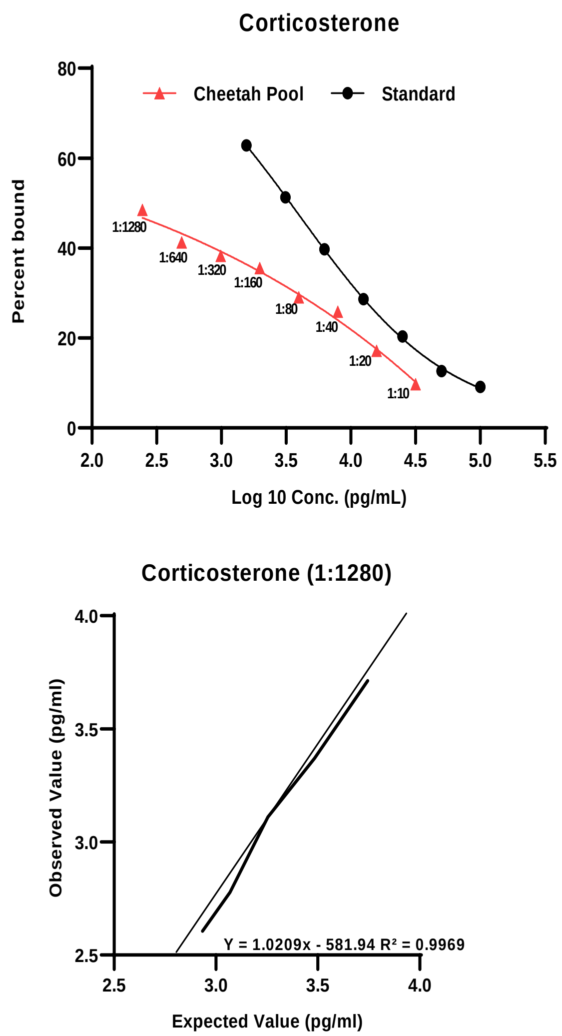

Figure 5.5.2. *Parallelism (top) and accuracy (bottom) results for corticosterone using a serially diluted pool of cheetah faecal extracts*

Triiodothyronine

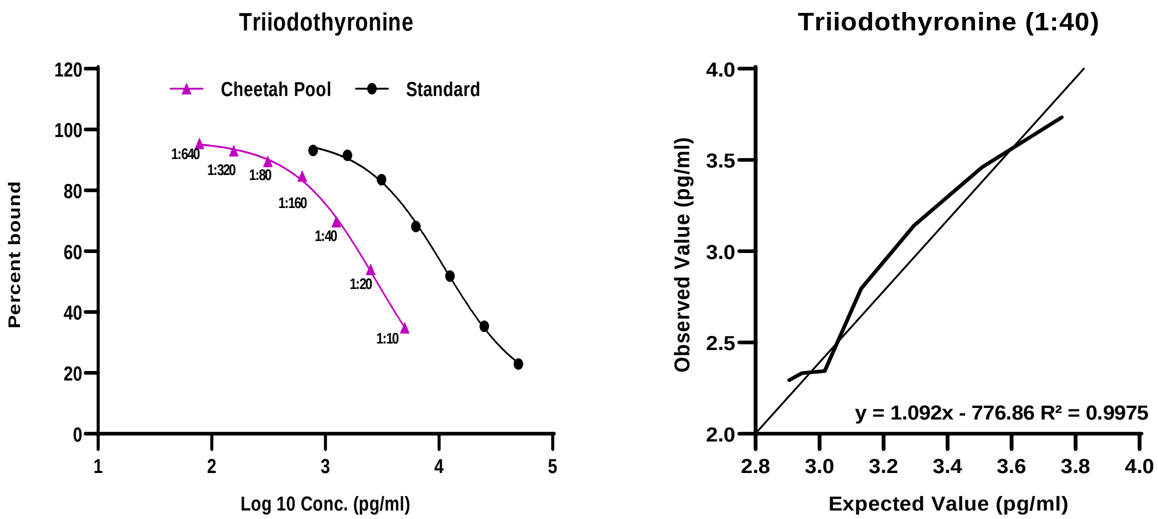

Figure 5.5.3. *Parallelism (left) and accuracy (right) results for triiodothyronine using a serially diluted pool of cheetah faecal extracts*

Progesterone

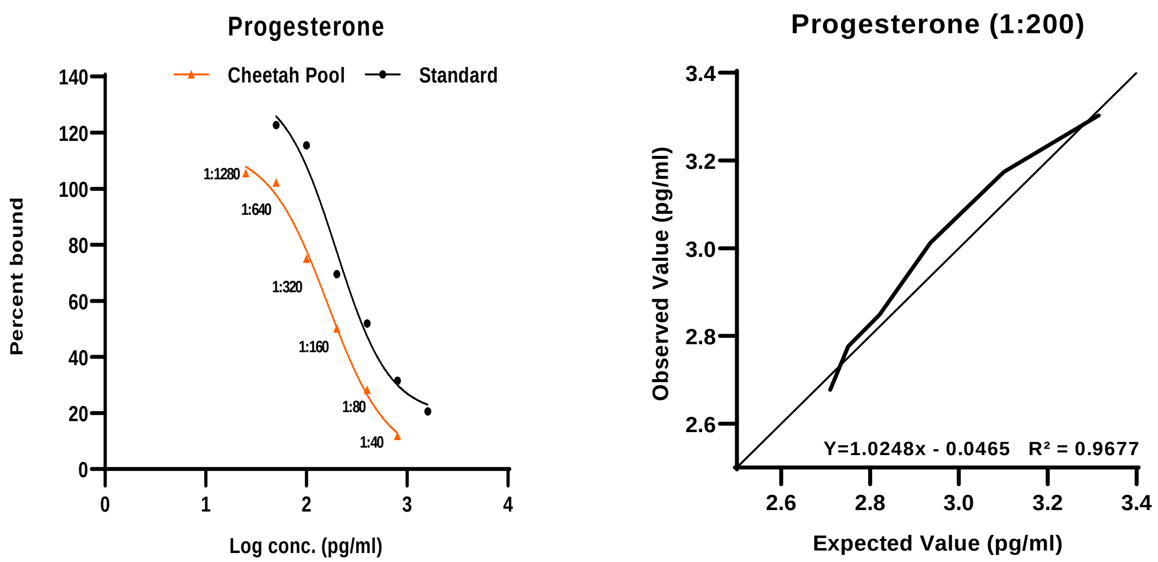

Figure 5.5.4. *Parallelism (left) and accuracy (right) results for progesterone using a serially diluted pool of cheetah faecal extracts*

17β-estradiol

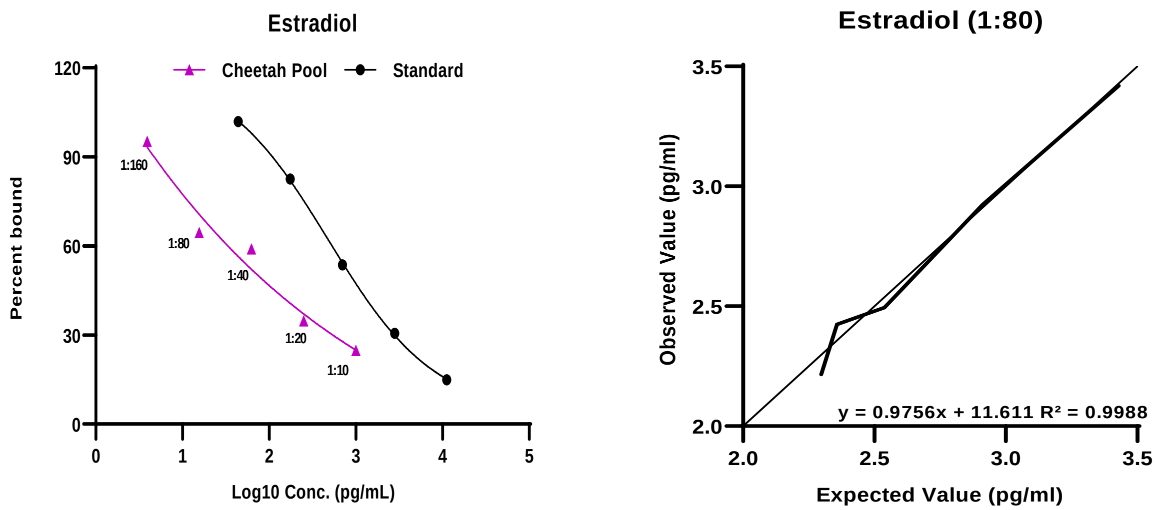

__Figure 5.5.5.__ Parallelism (left) and accuracy (right) results for 17β-estradiol using a serially diluted pool of cheetah faecal extracts

Testosterone

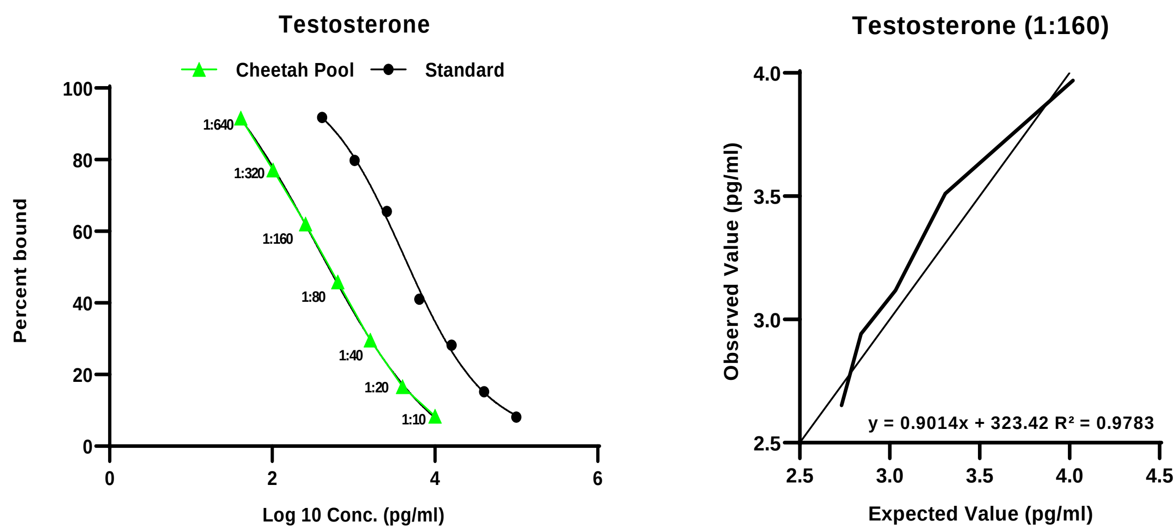

__Figure 5.5.6.__ Parallelism (left) and accuracy (right) results for testosterone using a serially diluted pool of cheetah faecal extracts

5.5.3.2. Comparative analysis

The samples from all three groups: C, QB, and LB showed significant variations in stress hormone (fGCM) levels (p-value = 0.0002, Figure 5.5.7a). Cheetahs in crates had lower fGCM levels compared to those in QB (p-value=0.02) and LB (p-value=0.0005). Further, fGCM level of cheetahs in LB did not vary significantly with cheetahs in QB (p-value > 0.05).

For fT3M, the test also showed significant differences (p-value < 0.0001, Figure 5.5.7b) in all groups (C, QB, and LB). Moreover, fT3M levels of cheetahs in C & QB were higher than those in LB (p-value=0.0007; p-value= <0.0001), most likely because they were systematically well-fed before transportation and quarantine compared to those in LB. No differences were observed in fT3M levels in C and QB (p-value=0.85).

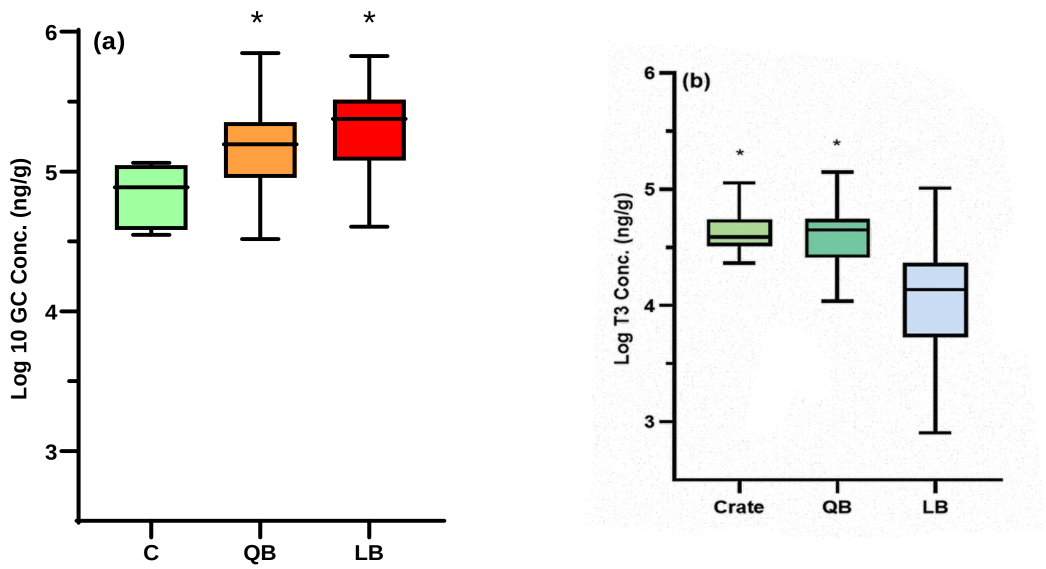

*Figure 5.5.7. (a) Comparison of fGCM among all three categories (C=6, QB=84, LB=45), (b) Comparison of fT3M among all three categories (C=6, QB=84, LB=45), * indicates significant differences*

Cheetahs in C showed no significant difference in fGCM levels between males and females (p-value = 0.962). However, in both the QB and LB groups, fGCM levels differed significantly between the sexes (p-value = 0.01 for QB and p-value = 0.02 for LB). Interestingly, in both quarantine bomas and larger bomas, females had higher fGCM levels compared to males (Figure 5.5.8).

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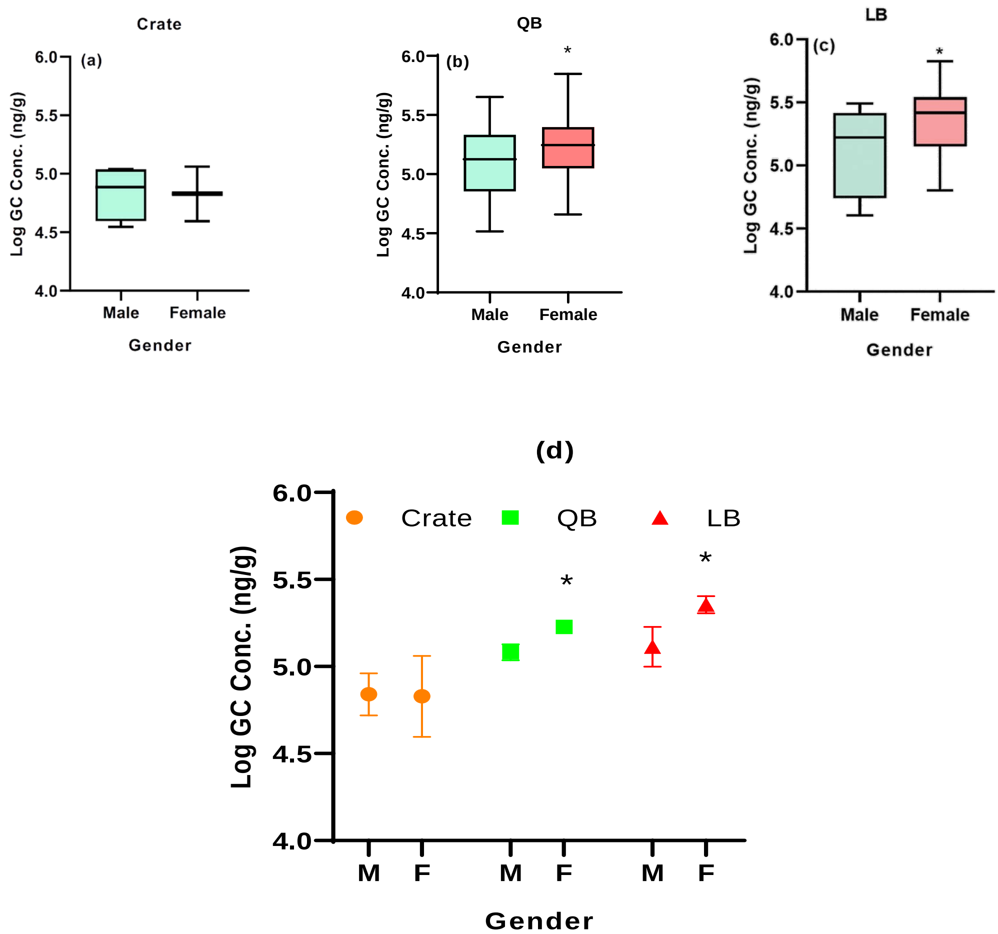

*__Figure 5.5.8.__ (a) Pairwise comparison of fGCM levels of male (n=4) and female (n=2) samples of crate (n=6), (b) Pairwise comparison of fGCM levels of male (40) and female (44) samples of QB (n=84), (c) Pairwise comparison of fGCM levels of male (n=9) and female (n=36) samples of LB (n=45), (d) Plot showing cumulative difference in male and female fGCM levels in all three locations (C, QB, LB), * indicates significant differences*

There were no significant differences in fT3M levels between male and female cheetahs in any of the housing locations i.e. C (p= 0.68), QB (p= 0.54), and LB (p= 0.38) (Figure 5.5.9).

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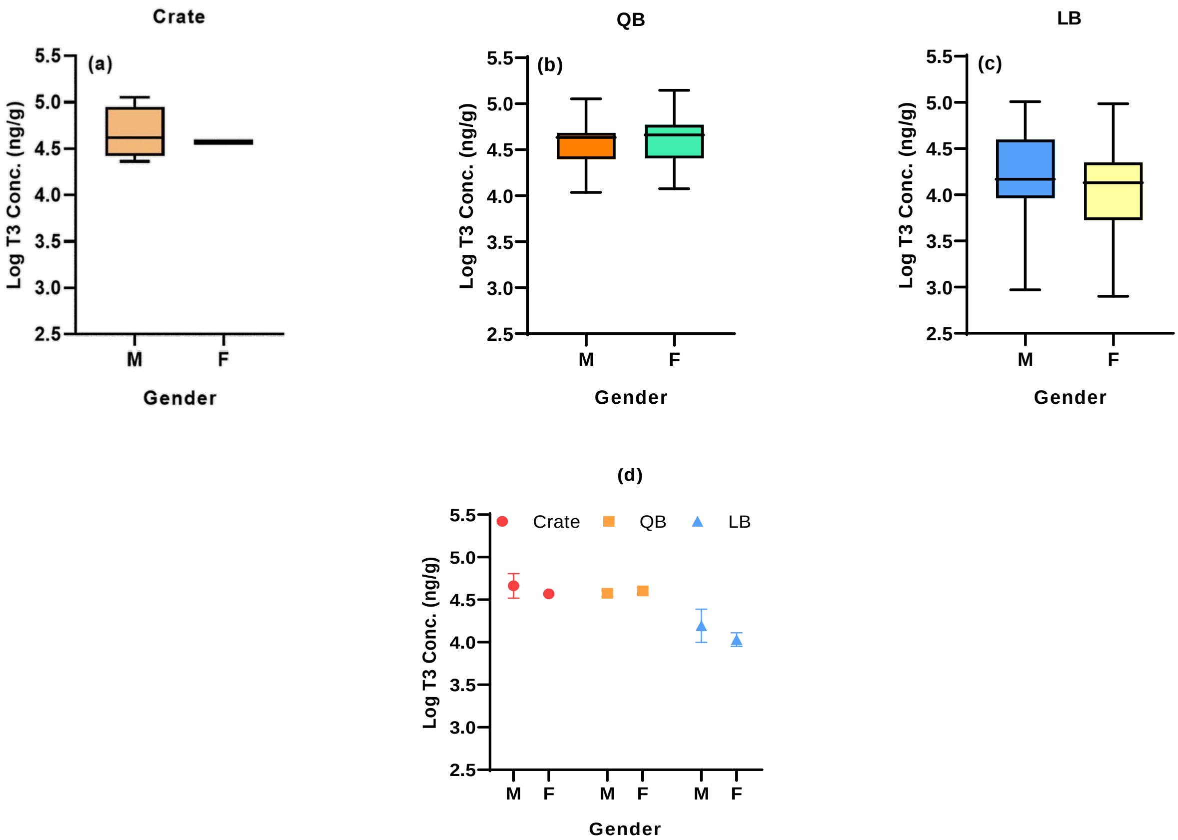


__Figure 5.5.9.__ (a) Pairwise comparison of fT3M levels of male (n=4) and female (n=2) samples of crate (n=6), (b) Pairwise comparison of fT3M levels of male (40) and female (44) samples of QB (n=84), (c) Pairwise comparison of fT3M levels of male (n=9) and female (n=36) samples of LB (n=45), (d) Plot showing cumulative difference in male and female fT3M levels in all three locations (C, QB, LB)

Statistically significant difference ($p < 0.0001$) in fT3M levels between individual females was observed, however, post-hoc pairwise comparisons indicated that only one female cheetah (Dheera) exhibited a significant variation in fT3M levels compared to all other individuals ($p < 0.05$) (Figure 5.5.10). This suggests that while overall fT3M levels differed among females, the majority of the variation was attributable to a single individual.

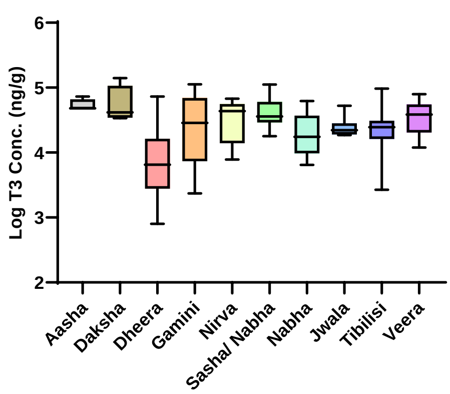


__Figure 5.5.10.__ Individual analysis of fT3M level of female cheetahs

There was no significant difference in all three reproductive hormones between males and females: p-value = 0.06 for fTM, p-value = 0.2 for fP4M, p-value = 0.12 for fE2M (Figure 5.5.11).

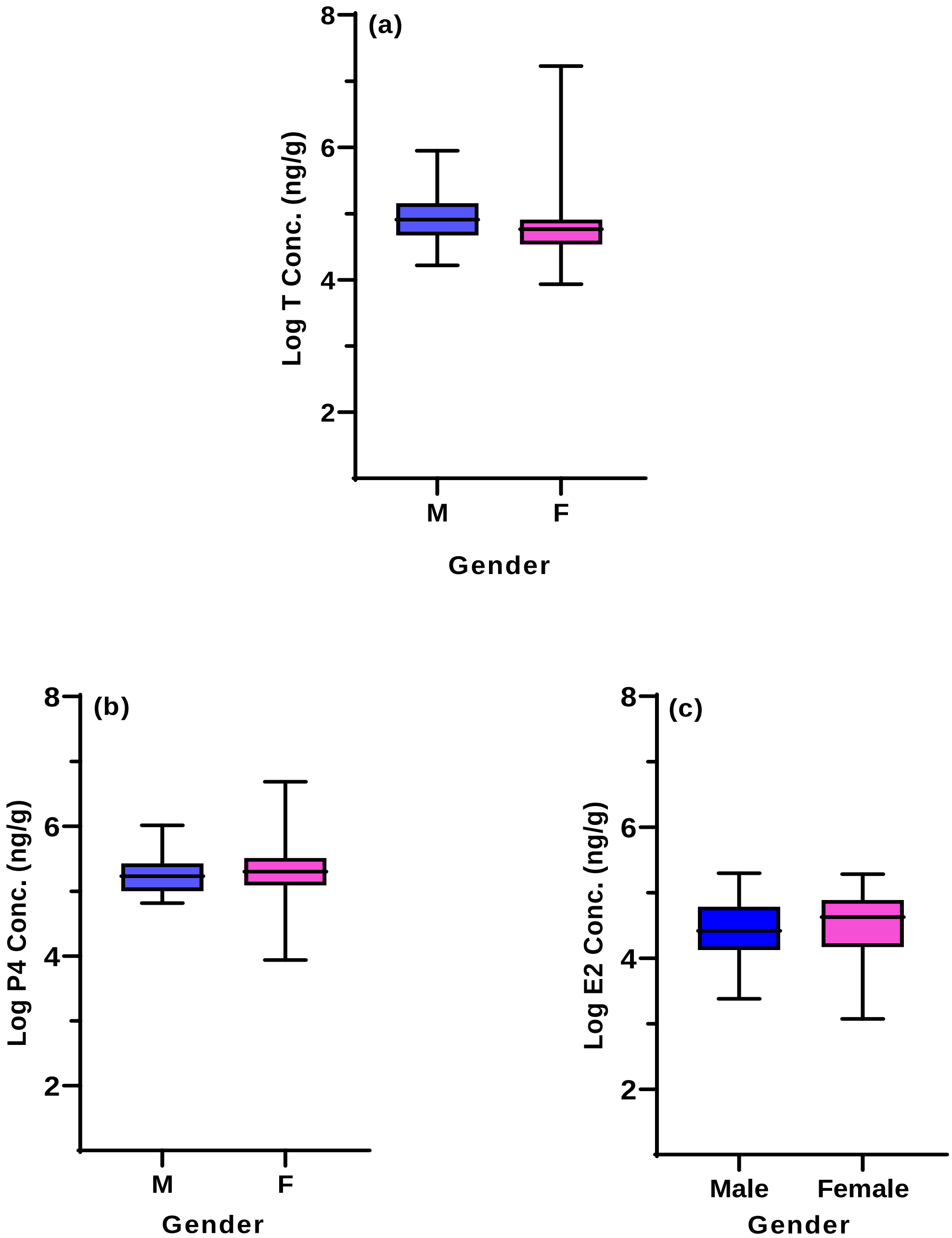


Figure 5.5.11. *(a) Comparative analysis of both male and female fTM levels, (b) Comparative analysis of both male and female fP4M levels, (c) Comparative analysis of both male and female fE2M levels*

Analysis revealed statistically significant variations (p = 0.007 for fP4M, Figure 5.5.12a; p < 0.0001 for fE2M, Figure 5.5.12b) in overall female cheetah fP4M and fE2M levels. However, post-hoc pairwise comparisons identified limited individual differences. For fP4M, only Gamini exhibited a significant difference compared to Veera (p = 0.016). Similarly, for fE2M, significant differences were found only between Jwala and Dheera (p = 0.04) and Veera with both Dheera (p < 0.0001) and Nabha (p = 0.006). These findings suggest that while overall hormone levels differed, substantial variation was concentrated within a small subset of cheetah females.

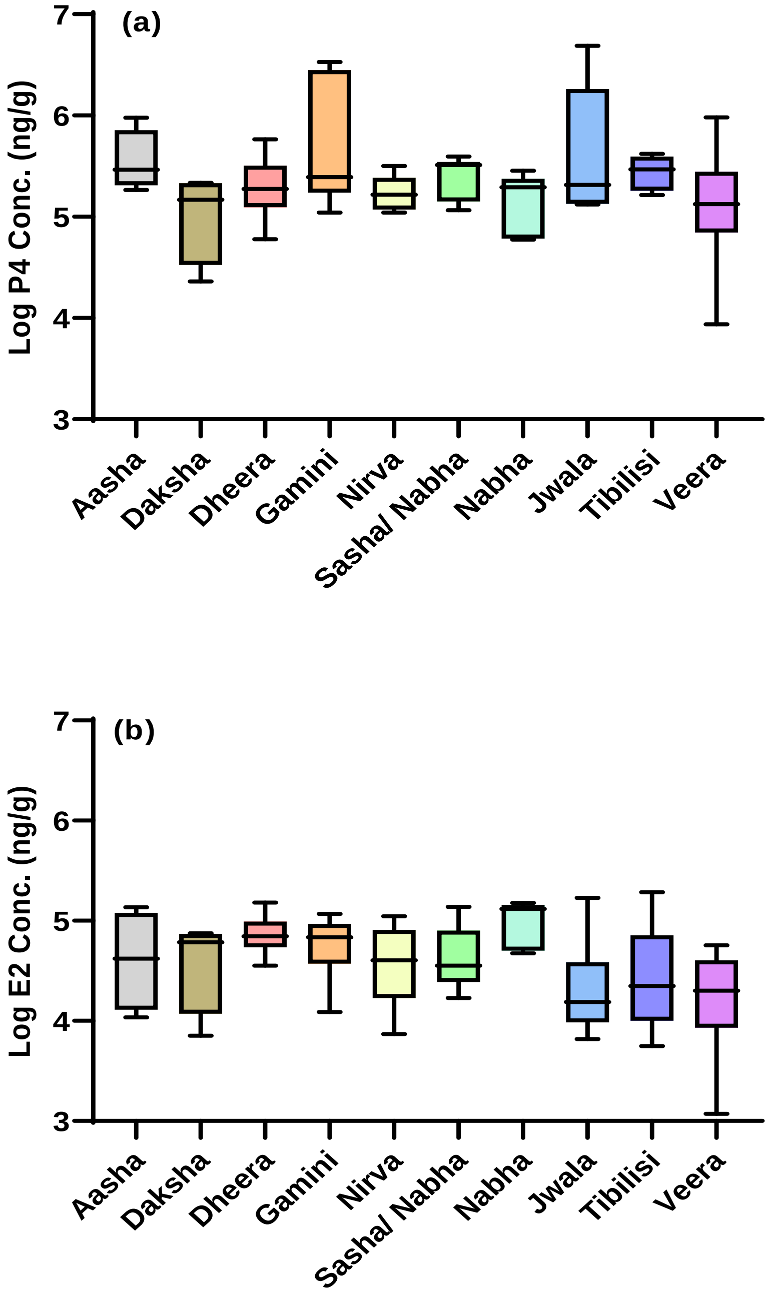
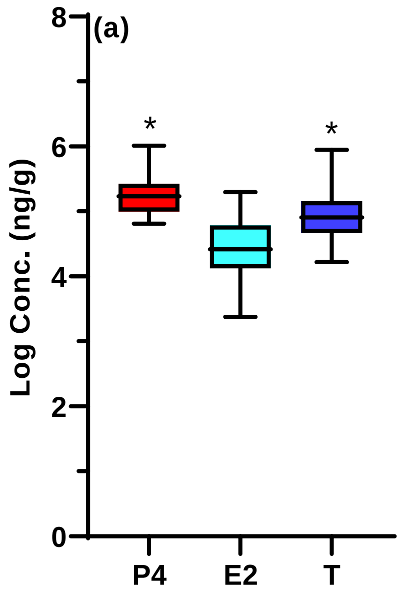


Figure 5.5.12. *(a) Individual analysis of fP4M level of female cheetahs, (b) Individual analysis of fE2M level of female cheetahs*

Significant differences in the levels of all three reproductive hormones (fP4M, fE2M & fTM) (p-value < 0.0001) in males were observed. As expected, males had higher fTM levels compared to fE2M levels (p<0.0001). Interestingly, in males, the fP4M levels were higher than both fTM levels (p<0.0001) and fE2M levels (<0.0001) (Figure 5.5.13a).



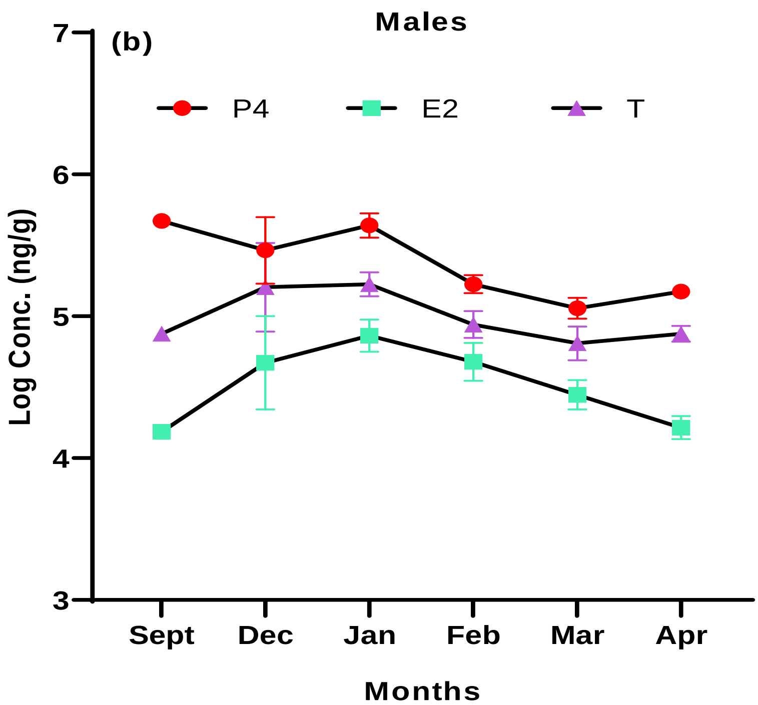
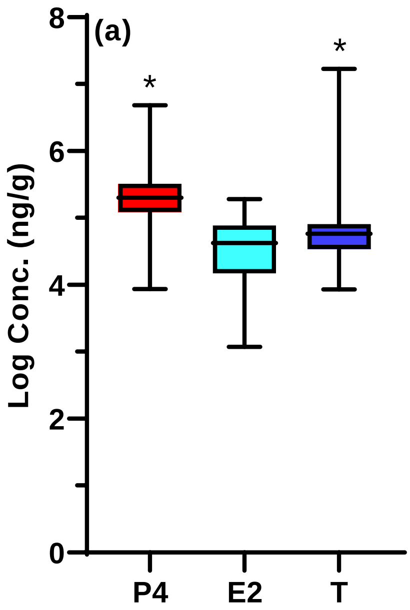


Figure 5.5.13. *(a) Pairwise comparison of fP4M, fE2M and fTM levels in males, (b) Month wise illustration of all three reproductive hormones in males, * indicates significant differences*

Similar to males, significant differences in the levels of all three reproductive hormones (fP4M, fE2M & fTM) (p-value < 0.0001) in females was found. High fP4M levels in females as compared to fE2M (p-value < 0.0001) and fTM levels (p-value < 0.0001) was observed. High fE2M levels in comparison with fTM was expected, but a surprisingly opposite pattern (p=0.0001) (Figure 5.5.14a) was seen.



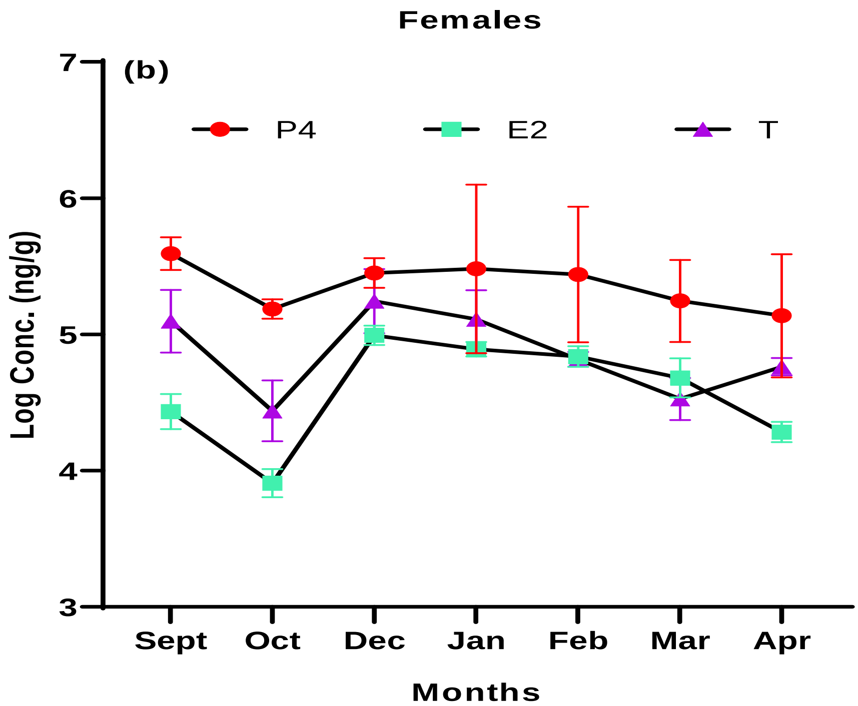


Figure 5.5.14. *(a) Pairwise comparison of fP4M, fE2M and fTM levels in females, (b) Month wise illustration of all three reproductive hormones in females, * indicates significant differences*

For all three reproductive hormones in females (fP4M, fE2M & fTM), significant differences between above and below the baselines values (p=<0.0001) were found (Figure 5.5.15). The significant difference in progesterone concentrations among females is likely to be observed due to possible pseudo-pregnant state in females as witnessed in other felids (Koester *et al.* 2022, Graham *et al.* 1995).

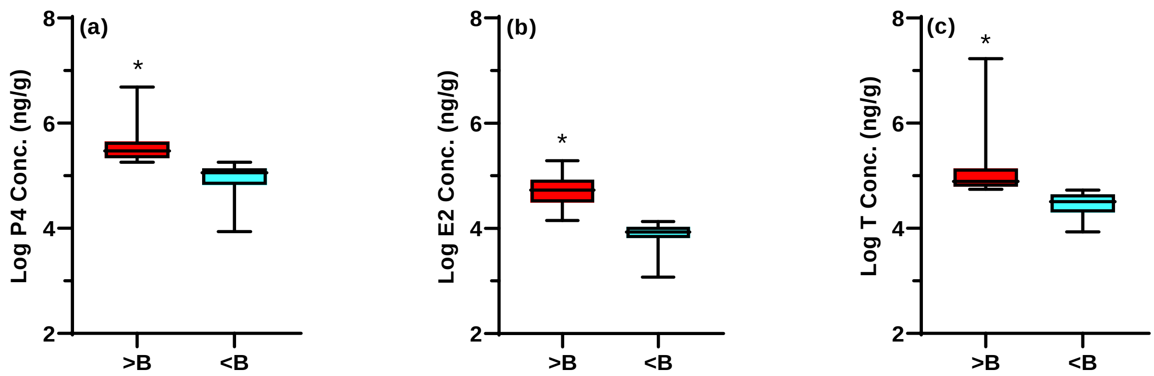


Figure 5.5.15. *(a) Pairwise comparison of above (n=56) and below (n=40) baseline levels of fP4M, (b) Pairwise comparison of above (n=55) and below (n=41) baseline levels of fE2M, (c) Pairwise comparison of above (n=54) and below (n=42) baseline levels of fTM, * indicates significant differences*

5.5.4. Discussion

This component envisions to support the ongoing cheetah monitoring effort by using a non-invasive approach to ascertain the physiological health of the translocated animals and establish a regular monitoring protocol to assess their physiological and reproductive health. Using the fecal samples collected from the field, standardizations of all five target hormones have been completed and generation of comparable datasets has been achieved so far (GC, T3, P4, T, and E2). Some of the salient physiological understanding from the results are:

a) The fGCM values were significantly lower in the crates, i.e. during transportation compared to quarantine and larger bomas, which was contrary to expectations. A plausible explanation for this is the administration of a long-acting tranquilizer (Water-based perphenazine, effects can last from 1 to 11 days post-administration) to the cheetahs prior to transportation as a stress management measure (Huber *et al.* 2001). The higher fGCM values in quarantine and larger bomas can be interpreted as a result of coping mechanisms in a completely new environment. Nonetheless, more systematic stress monitoring for the animals that are still in larger bomas and the ones being released in the wild would give better clarity about their stress levels.

b) The initial data also indicate that females have higher fGCM levels than males, suggesting that females might be more sensitive to stress than males in both quarantine and larger bomas. While the results are preliminary, more sampling and data points can help the management to give proper attention to this issue in the future.

c) As expected, cheetahs during their tenure in the quarantine bomas were observed to be nutritionally better than the other situations, possibly due to sufficient food provisioning during this period. It would be important to generate longitudinal data on this aspect of dietary requirements from this population. It was encouraging to see no differences in nutritional status between the sexes.

d) For the reproductive hormones, baseline values for all three target hormones have been established which would help in investigating their reproductive status through non-invasive approaches in the future. As expected, males averaged higher fTM levels than fE2M levels. However, the unexpectedly high fP4M levels in males and fTM levels in females require further investigation with a larger sample size. Female samples could be clearly separated into lower and higher progesterone levels. In this regard, a more systematic, gender-specific sampling in the field (due to the cheetah's unique physiology) would be greatly beneficial to categorize the animals into different reproductive stages.

This component of the project provides valuable insights into the physiological state of the cheetahs in Kuno. The established methods for hormone measurement will be crucial for monitoring their health post-release into free-ranging conditions. Further understanding the impact of location, sex, and seasonal effects on hormone levels can significantly aid in cheetah conservation efforts. Systematic sampling (both spatial and temporal/seasonal) and tracking hormone levels over time will provide a critical evaluation of the success of the program and address future management policies. Moreover, this study serves as a model to understand the impacts of environmental stressors on large carnivores, ultimately aiding in the development of effective mitigation approaches in other species.

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5.6. Overview of cheetah genetics

The cheetah (*Acinonyx jubatus*), once present across vast regions in Africa, the Middle East, and India, is currently found in sub-Saharan Africa, with a critically endangered population surviving in Iran (Durant *et al.* 2017). Studies have identified four (Durant *et al.* 2023) to five subspecies of cheetah (Prost *et al.* 2022) based on geography and genetic differences: *A. j. jubatus* in Southern Africa, *A. j. soemmeringii* in Northeast Africa, *A. j. hecki* in Northwest Africa, *A. j. venaticus* in Asia, and *A. j. raineyi* in East Africa. Among these, *A. j. hecki* and *A. j. venaticus* are critically endangered, with only a handful of individuals remaining in the wild (Prost *et al.* 2022, Smithers 1975). While there is a significant lack of information for the West African subspecies (Schmidt-Küntzel *et al.* 2018). According to IUCN assessment, there are four subspecies of cheetah viz., *A. j. jubatus* in Southern and Eastern Africa, *A. j. soemmeringii* in Northeast Africa, *A. j. hecki* in Northwest Africa, and *A. j. venaticus* in Asia. However, the authors note that further genetic examination is warranted (Durant *et al.* 2023).

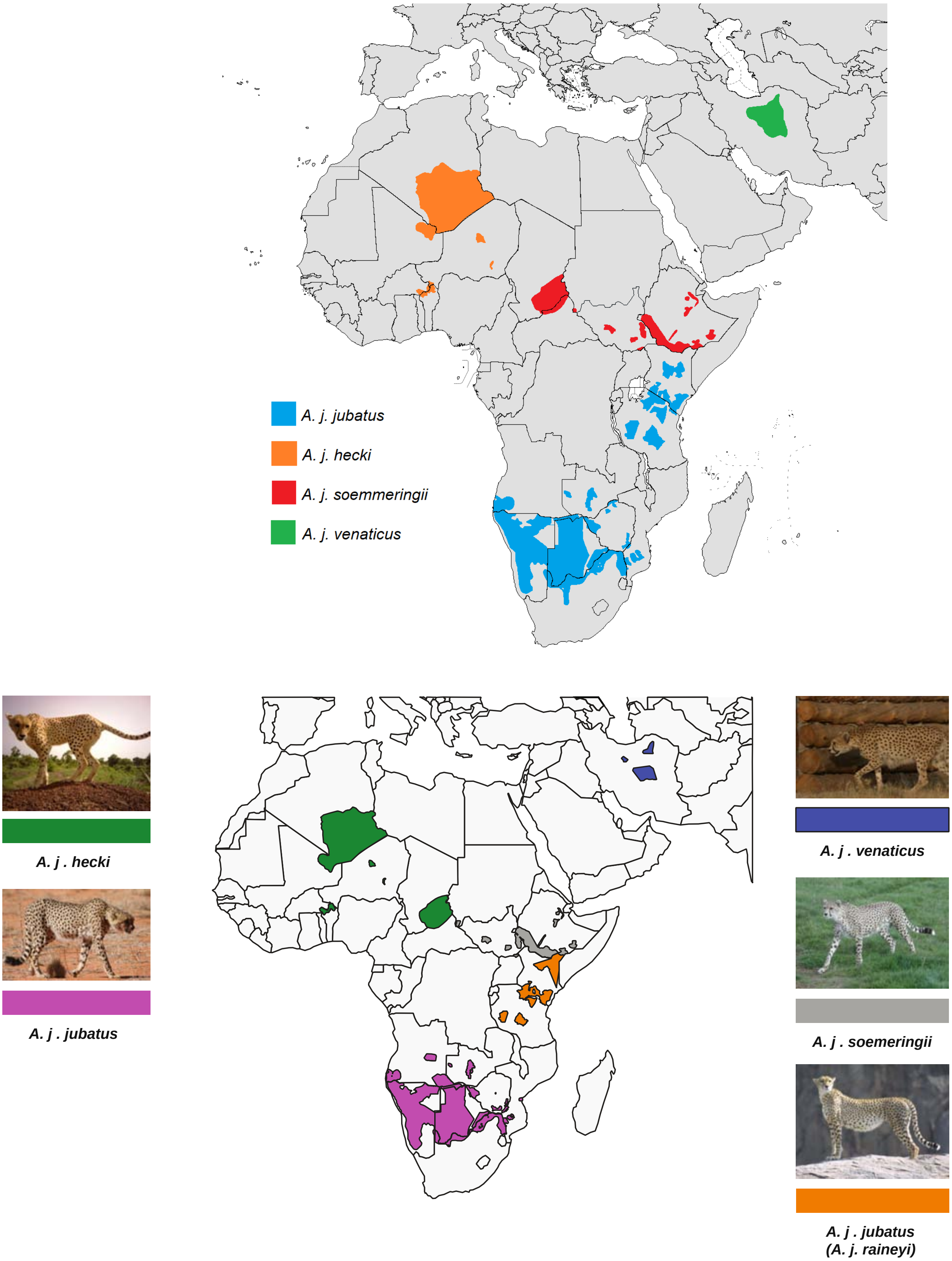


Figure 5.6. *The cheetah subspecies – four (top) according to IUCN (Durant et al. 2023) and five according to Prost et al. 2022 (bottom - map reproduced from the publication) distributed across Africa and Iran.*

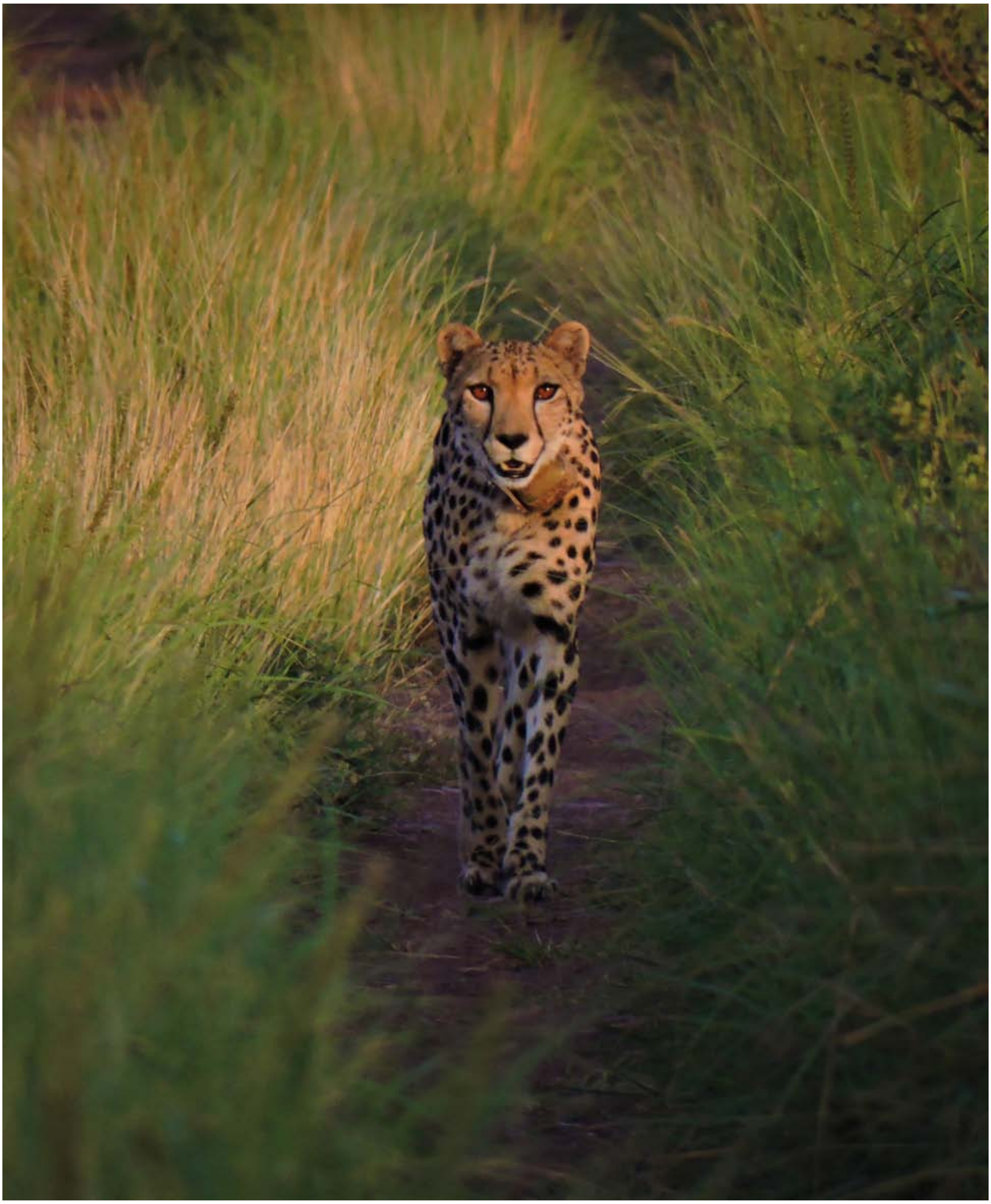
Research indicates that the Asiatic cheetah is the most genetically distinct subspecies, having diverged from the African cheetahs (A. j. jubatus) around 6,500 years ago representing the earliest split within the species (O'Brien *et al.* 2017). Genetic distance (F_{ST}) estimates further support this, showing a greater genetic distance between the Asiatic and African subspecies compared to the differences among African subspecies, highlighting the substantial genetic divergence between them (Charruau *et al.* 2011).

Cheetahs have faced severe genetic bottlenecks in their evolutionary history, particularly around 10,000 to 12,000 years ago, during the Pleistocene megafaunal extinction. This event drastically reduced the global cheetah population, leading to the low genetic diversity observed in the species today (Castro-Prieto *et al.* 2012, Dobrynin *et al.* 2015, Driscoll *et al.* 2002, Menotti-Raymond & O'brient 1993a). In more recent times, habitat loss due to agriculture, human-wildlife conflict, and hunting has fragmented cheetah populations, contributing further to their decline and reducing connectivity between isolated groups (Durant *et al.* 2017, Maxwell *et al.* 2016, Ripple *et al.* 2014).

As a result, modern cheetah populations exhibit very low genetic variability. Studies have shown that cheetahs are homozygous across much of their genome, leading to issues such as inbreeding depression, low sperm viability, and increased disease susceptibility (Dobrynin *et al.* 2015). Cheetahs have some of the lowest genetic diversity of any large carnivore. They exhibit low heterozygosity and genetic uniformity across many loci, in contrast to the genetic variability seen in other big cats like tigers and leopards (Charruau *et al.* 2011, Dobrynin *et al.* 2015, Driscoll *et al.* 2002, Menotti-Raymond & O'brient 1993a, 1993b; O'Brien *et al.* 1985 & 2017). The genetic similarity among cheetahs is so pronounced that they can accept skin grafts from unrelated individuals without immune rejection, a rare occurrence among vertebrates, largely due to the low diversity of genes responsible for immune response (O'Brien *et al.* 1985).

The Major Histocompatibility Complex (MHC) genes, which are highly polymorphic and crucial for immune function, play a key role in recognizing and presenting pathogens to immune cells. MHC gene diversity is essential for a population's ability to combat a wide range of pathogens. Because of their role in disease resistance and adaptive immunity, MHC genes are critical markers in conservation biology (Klein *et al.* 2007, Sommer 2005, Ujvari & Belov 2011). However, in cheetahs, the diversity of MHC genes is significantly reduced, making them more vulnerable to diseases and environmental changes (Castro-Prieto *et al.* 2011 & 2012, Heinrich *et al.* 2017). This vulnerability was evident during a fatal coronavirus outbreak in captive African cheetahs at Winston Safari Park in the early 1980s. The virus caused a mortality rate of 60% within three years, with an 85% mortality rate in cubs—significantly higher than the 5% to 10% mortality rate in domestic cats (Schmidt-Küntzel *et al.* 2018, Wilkerson *et al.* 2004). Despite their low genetic diversity, cheetah populations recovered by the 19th century and have shown no signs of major disease outbreaks in the wild, suggesting a remarkable ability to survive and thrive (Schmidt-Küntzel *et al.* 2018). Some studies have discussed topics like positive selection that might be helping the cheetah to get rid of deleterious alleles from the species (Dobrynin *et al.* 2015, Hedrick & Garcia-Dorado 2016), while other indicates that cheetahs have some good signs of innate immunity that compensates for their low immune diversity (Heinrich *et al.* 2017). However, this resilience does not guarantee future survival, as the lack of diversity limits the cheetah's ability to adapt to significant environmental changes or pathogenic pressures.

Modern genetic and genomic tools are vital for cheetah conservation and the ongoing monitoring of introduced individuals in India. Using whole-genome sequencing, a detailed insight into the genetic health of populations will be obtained, and to monitor and identify viral and bacterial diseases, RT-PCR will be useful. Another aspect of molecular monitoring is to understand the diversity of microorganisms present in the environment which helps warn us of the potential measures to be taken for safeguarding the populations. For future monitoring, non-invasive techniques using fecal DNA analysis will help in select disease monitoring, and monitoring of diet, without the need for physical capture, reducing stress on the animals and providing valuable data for conservation management. Regular genomic monitoring can help track and mitigate the uncertainties associated with low genetic diversity and immunity and assess potential risks of disease transmission. This approach is essential for guiding management decisions to establish a healthy founder population in India.



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6.

Co-predators status and monitoring

To understand the overall dynamics of cheetah introduction on a plethora of carnivores in Kuno, population monitoring, movement, spatial and temporal interactions using methods such as camera trap sampling and radio-collaring of certain species have been carried out. The advancement of spatial capture-recapture techniques using camera traps has improved the accuracy and precision of density estimation by incorporating the spatial coordinates of animal photo-captures (Jhala *et al.* 2020). The camera trap surveys were conducted in the erstwhile WLS area of Kuno NP and Gandhi Sagar WLS according to the protocol used in All India Tiger Estimation to estimate densities of naturally marked carnivore species, relative abundance index and activity patterns of all carnivores. A pair of camera traps were deployed within a 2 km^2 grid on either side of animal trails and roads. Spacing of <1 km was maintained between adjacent camera trap locations.


Image 6.1. *Camera trap survey in Kuno National Park © Kesha Patel (left) & Moulik Sarkar (right)*

6.1. Population assessment of co-predators in Kuno National Park

A camera trap survey was carried out from June 2023 to September 2023 in Kuno NP. A total of 88 locations were sampled within the erstwhile WLS area to obtain photo-captures of carnivores (Figure 6.1.1). The total effort involved 2946 camera days.

6.1.1. Leopard population estimation

The data obtained from camera trap sampling was geo-tagged and images were segregated species wise. The segregated images of leopards were further processed for individual identification based on rosette patterns on the animals using the HotSpotter software (Crall *et al.* 2013). The software utilizes pattern-recognition algorithms to compare images of leopards and identifies recurring individuals by analyzing the arrangement of rosettes. The identified individual leopard images were thoroughly checked to avoid double counting of any individual.

A total of 1,788 leopard images were photo-captured in Kuno NP during the sampling period. From these photographs, 504 images representing 92 individually identified adult leopards were selected for further analysis using spatially explicit capture-recapture (SECR) models (Efford *et al.* 2004). Using sex-specific heterogeneity model in SECR, the estimated density of leopards in Palpur East and West Ranges (the erstwhile Kuno WLS) was found to be 27.05(2.9SE) per 100 km².

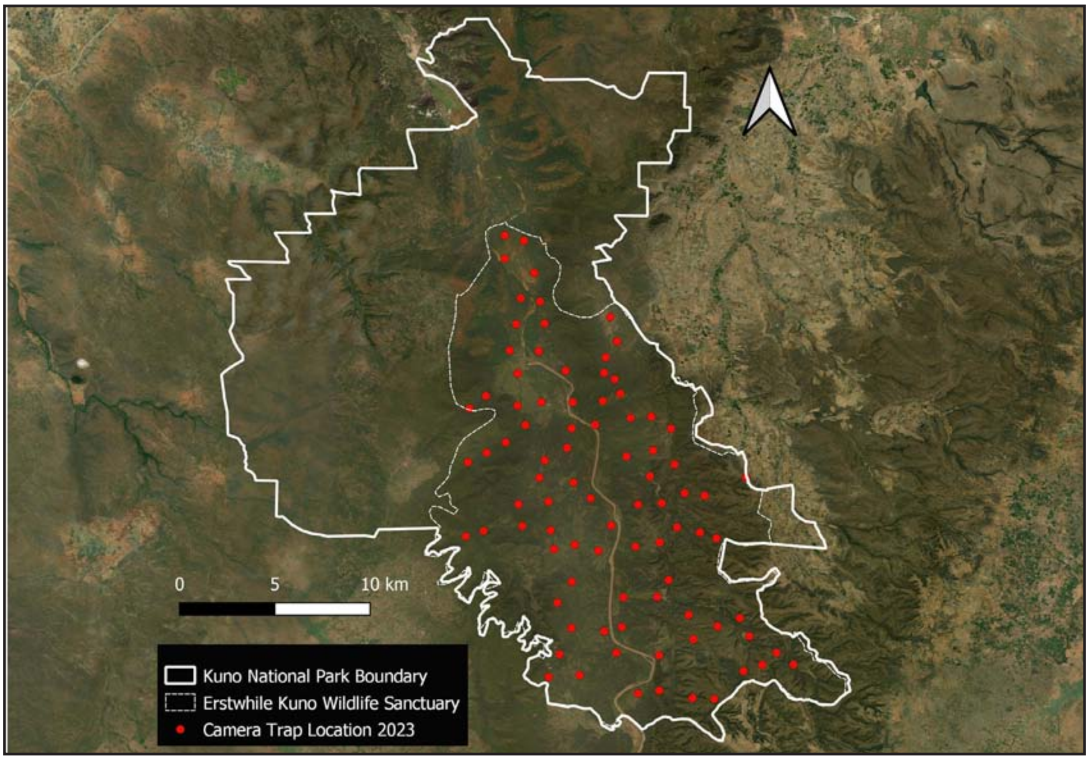

Figure 6.1.1. *Location of camera traps deployed in the erstwhile Wildlife Sanctuary area of Kuno National Park to assess the status of large mammalian predators*

Table 6.1.1.1. *Summary of SECR analysis results for density of leopards in the erstwhile Wildlife Sanctuary area of Kuno National Park*

Parameters	Year 2023
Number of camera trap locations	88
Sampled Area	350 km²
Effort	2956 camera trap days
No. of Individuals (M(t+1))	92
Density	27.04(2.89 SE) individuals per 100 km²
95 % Confidence Interval	21.94 - 33.34
g0 (Male & Female)	0.083 & 0.073
Sigma (Male & Female)	1397.71(46.44 SE) & 810.35(43.26 SE)
Pmix (Male & Female)	30.14 & 69.85

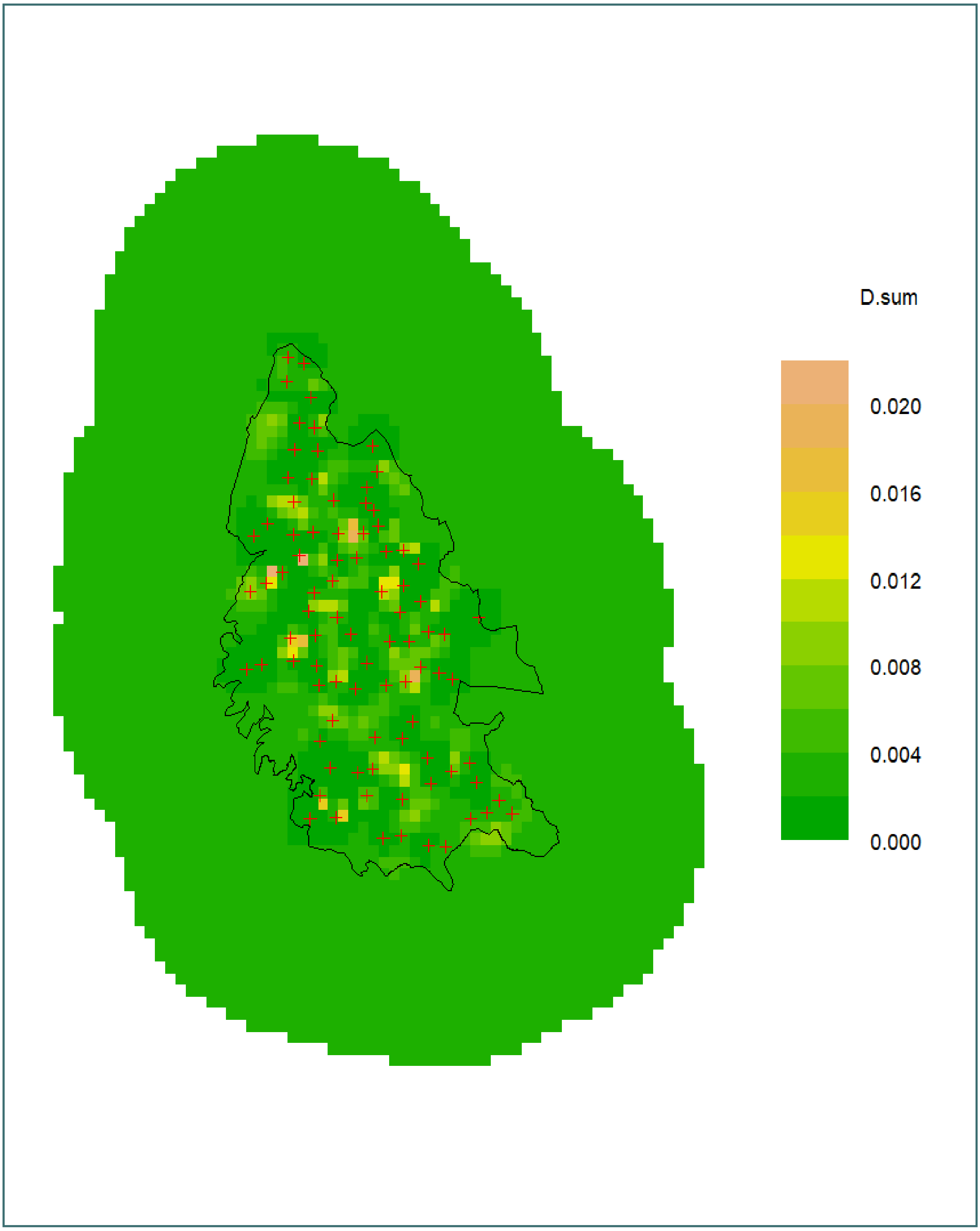

Figure 6.1.1.2. *Distribution of leopards in the erstwhile Wildlife Sanctuary area of Kuno National Park in 2023 obtained from spatially explicit capture recapture using camera traps (denoted as +)*

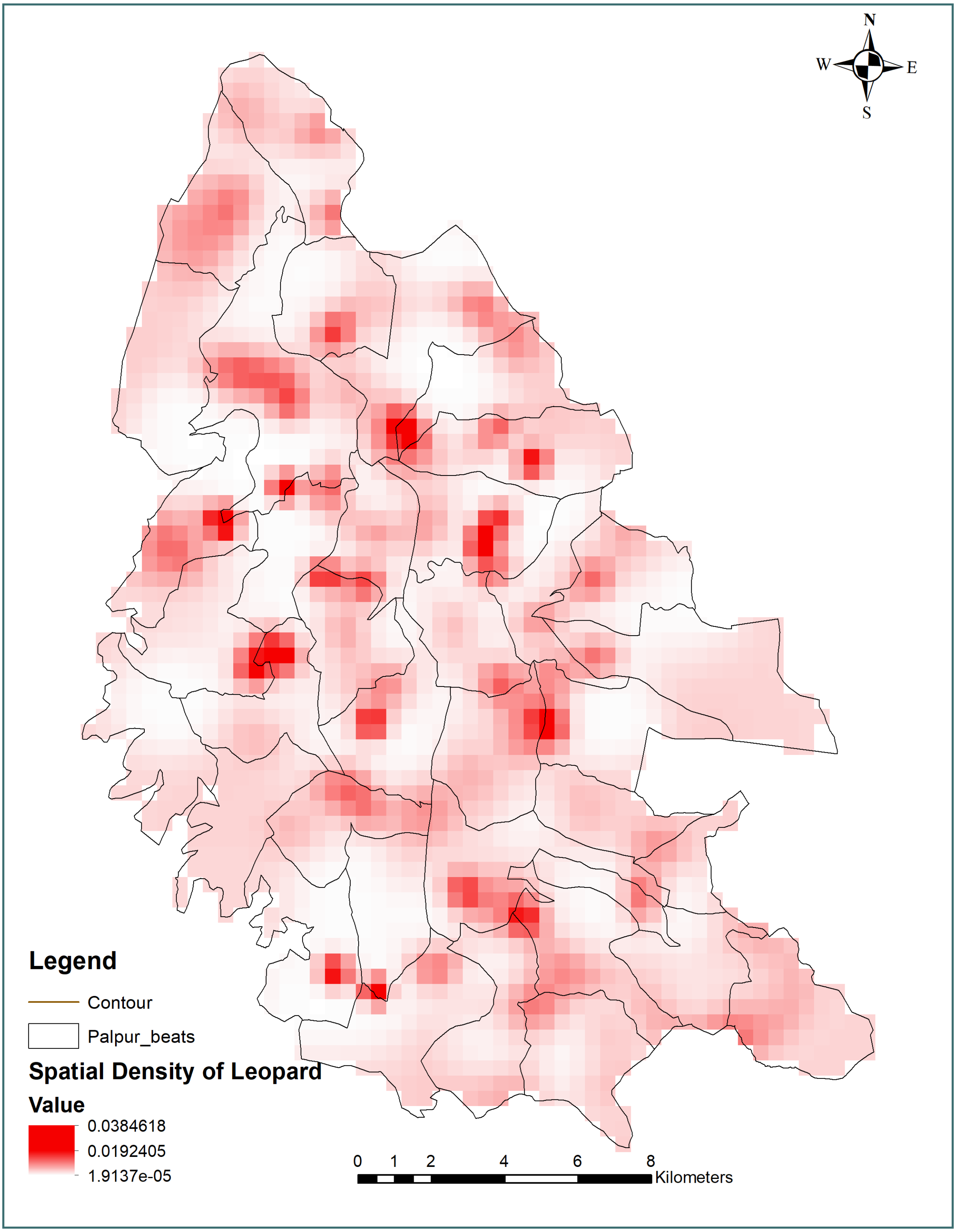

Figure 6.1.1.3. Spatial density (per hectare) of leopards obtained from camera trap sampling using SECR in the erstwhile Wildlife Sanctuary area of Kuno National Park

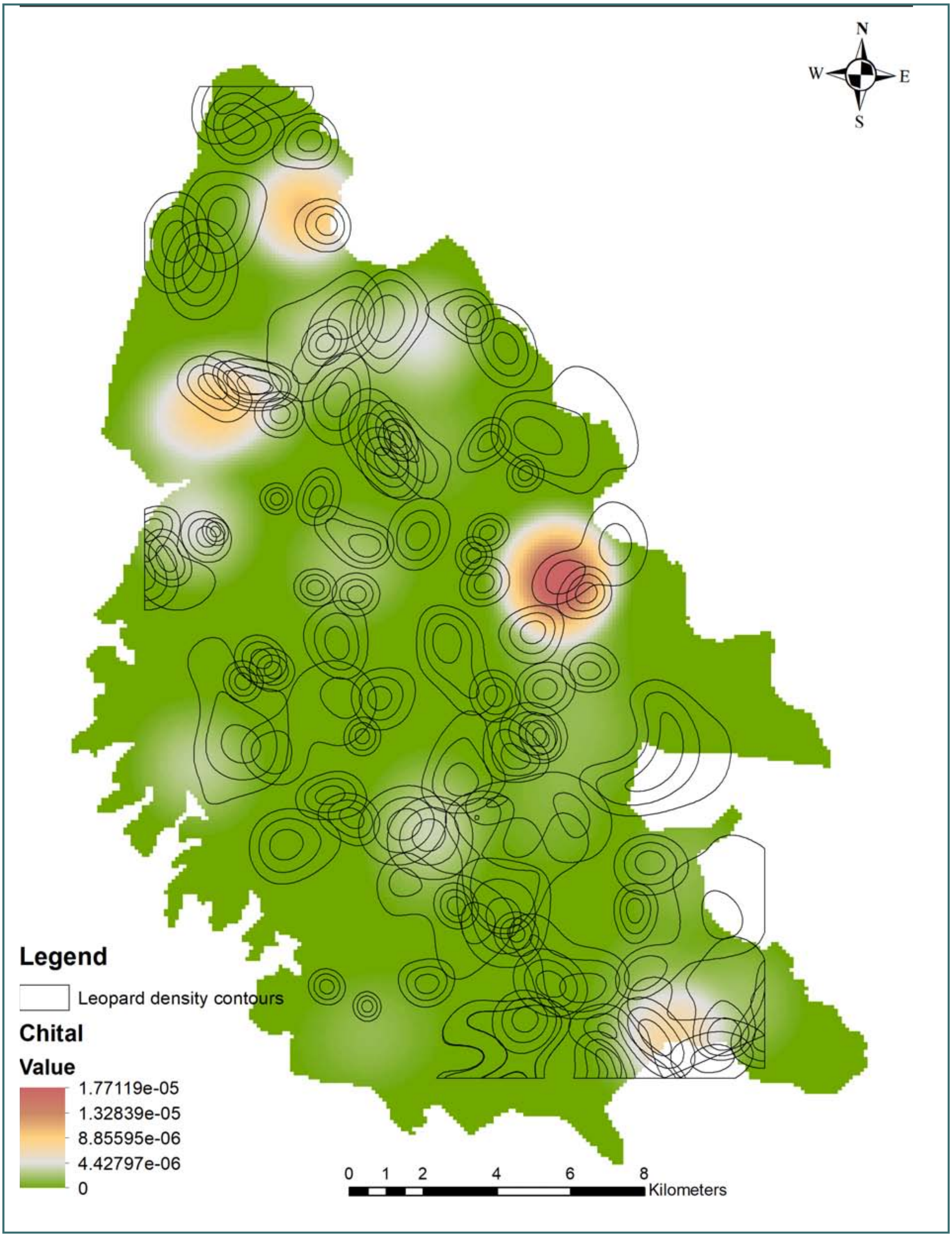

__Figure 6.1.1.4.__ Map of leopard density contours obtained from camera trap sampling using SECR overlapped on chital detections on line transects in the erstwhile Wildlife Sanctuary area of Kuno National Park

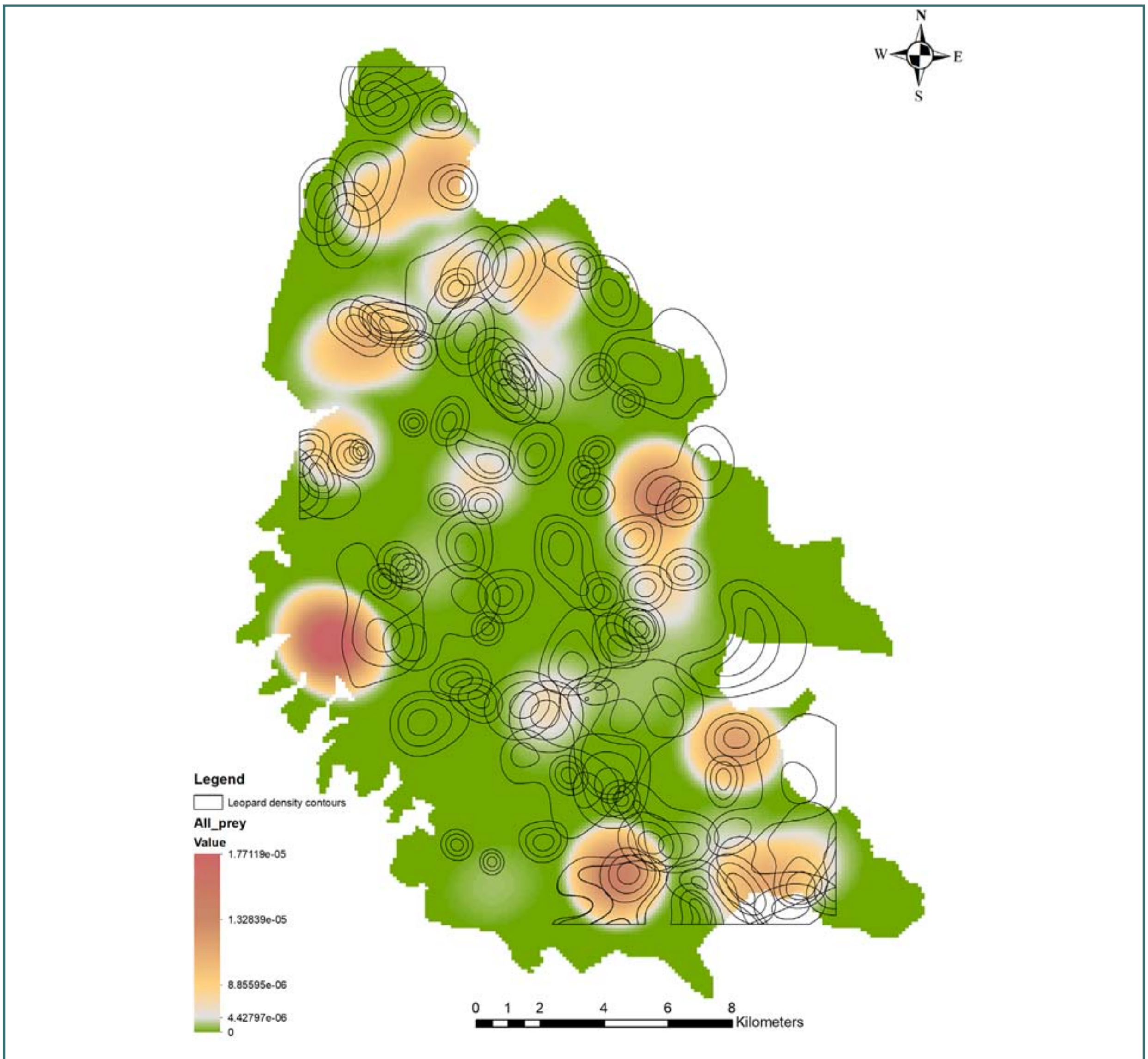

Figure 6.1.1.5. *Map of leopard density contours obtained from camera trap sampling using SECR overlapped on all prey detections on line transects in the erstwhile Wildlife Sanctuary area of Kuno National Park*

6.1.2. Striped hyena population estimation

The individual striped hyenas were identified from images collected during the camera trap survey in Kuno by visually examining the markings on the pelage of the hind limbs, forelimbs, and forequarters (Schaller 1967; Karanth 1995; Singh 2008). To avoid double counting of any individual, multiple observers cross-checked individual images thoroughly. During 2021, a sampling effort of 2695 trap nights yielded 495 independent photo-captures of 74 unique striped hyenas, which included 17 females, 22 males, and 35 individuals whose sex could not be determined. For this analysis, a habitat mask was not applied because the habitat of Kuno NP and the surrounding area is fairly homogeneous, and striped hyenas have broad habitat tolerance. The estimated density of striped hyena during 2021 was 13.35(1.6SE) individuals per 100 km^2.

In 2023, from a sampling effort of 2956 trap nights, 53 unique striped hyenas were identified from 405 independent photo-captures. The estimated density of striped hyena in 2023 was 9.84(1.38SE) individuals per 100 km^2.

Image 6.1.2. Striped hyena in Kuno National Park © WII (Project Cheetah)

Table 6.1.2. Summary of SECR analysis results for striped hyena density in the the erstwhile Wildlife Sanctuary area of Kuno National Park

Parameters	Year 2021	Year 2023
Number of camera trap locations	86	88
Sampled Area	350 km^2	350 km^2
Effort (camera trap days)	2695	2956
No. of Individuals (M (t+1))	74	53
Density (individuals per 100 km^2)	13.35(1.6 SE)	9.84(1.38 SE)
95 % Confidence Interval	10.55-16.89	7.48-12.95
g0 (Male & Female)	0.030 & 0.059	0.058 & 0.058
Sigma (Male & Female)	2950.3 (152.37 SE) & 1671.5 (72.90 SE)	2505.8(104.59 SE) & 1507.6 (71.60 SE)
P mix (Male & Female)	46 & 53	40.51 & 59.48

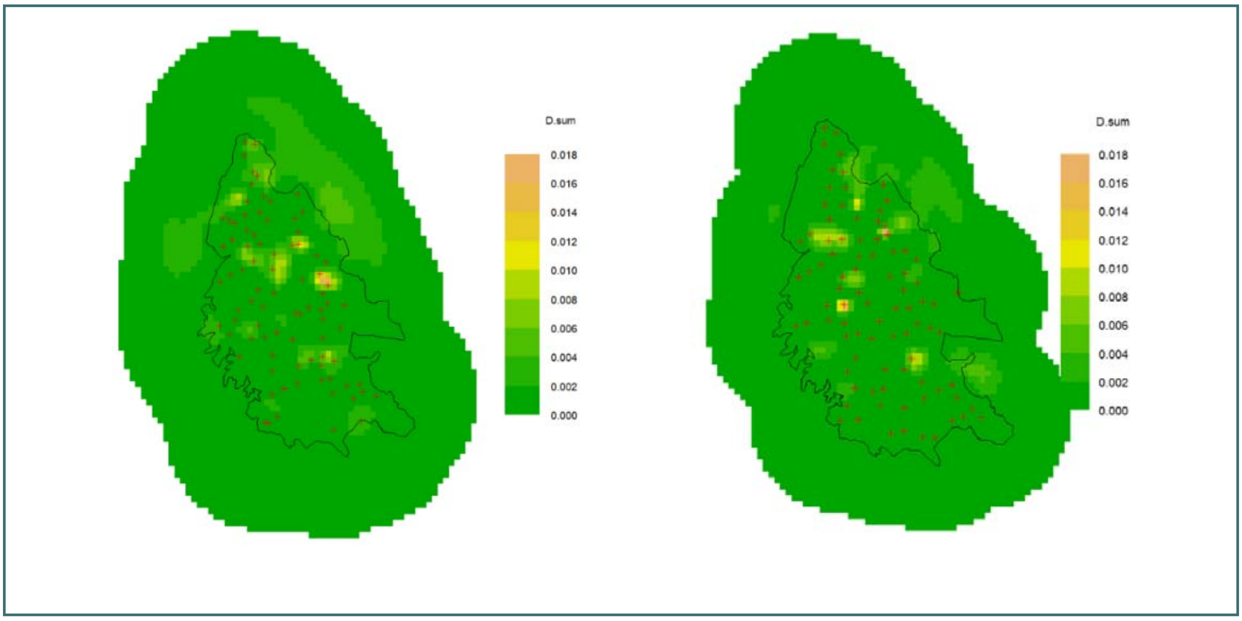

Figure 6.1.2. *Distribution of striped hyenas in the erstwhile Wildlife Sanctuary area of Kuno National Park during 2021 (left) & 2023 (right) obtained from spatially explicit capture recapture using camera traps (denoted as +)*

6.1.3. Relative Abundance Index of mammalian carnivores and their spatial distribution in Kuno National Park

Based on photo captures obtained from camera trap sampling conducted during 2023, RAI values were calculated as described in section 3.1.1. Maps were generated for each species using RAI values at every camera trap location.

Table 6.1.3. *Relative Abundance Index (RAI) of mammalian carnivores obtained during camera trap survey conducted in the erstwhile Wildlife Sanctuary area of Kuno National Park during 2023*

S No.	Species	No. of photo-captures	No. of independent events	RAI
1	Leopard	1788	625	21.22
2	Striped hyena	945	585	19.86
3	Golden jackal	514	311	10.56
4	Sloth bear	434	237	8.04
5	Jungle cat	350	226	7.67
6	Honey badger/ Ratel	187	89	3.02
7	Small Indian civet	68	63	2.14
8	Common palm civet	24	22	0.75
9	Indian fox	20	15	0.51
10	Grey mongoose	41	11	0.37
11	Ruddy mongoose	19	11	0.37
12	Tiger	13	5	0.17
13	Rusty-spotted cat	2	2	0.07

Image 6.1.3. *Sloth bear in Kuno National Park © WII (Project Cheetah)*

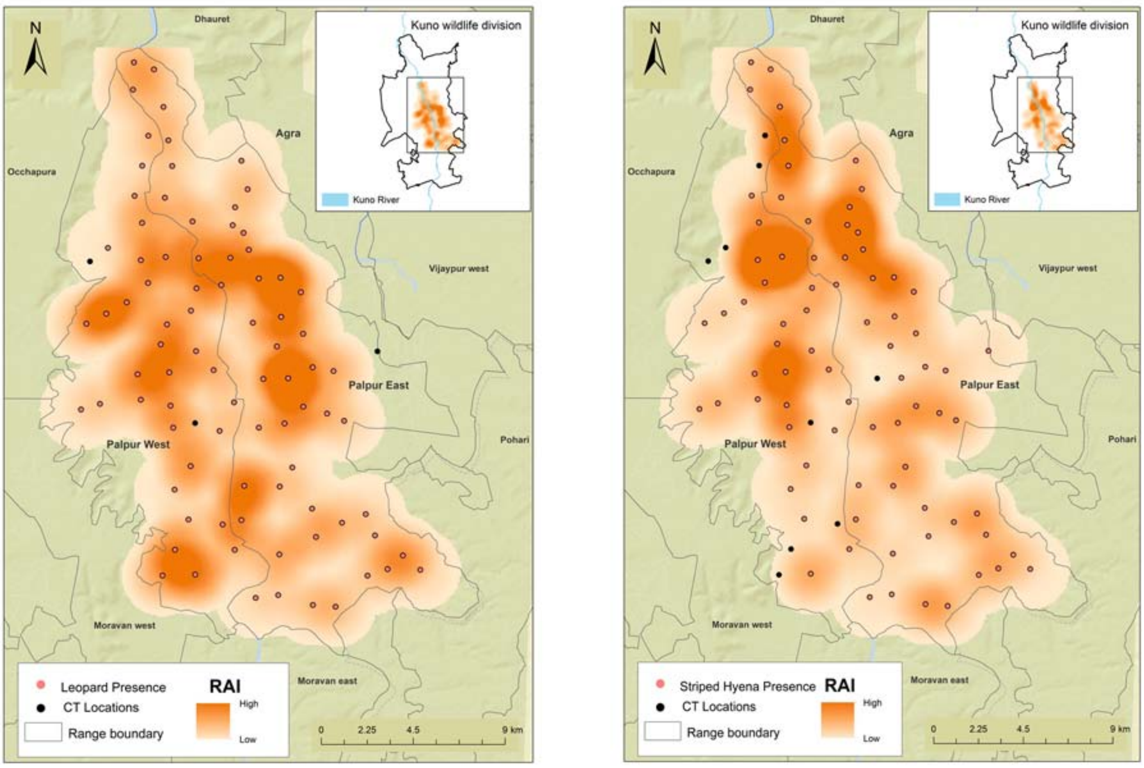

Figure 6.1.3.1. *Spatial distribution of leopard (left) and striped hyena (right) in the erstwhile Wildlife Sanctuary area of Kuno National Park*

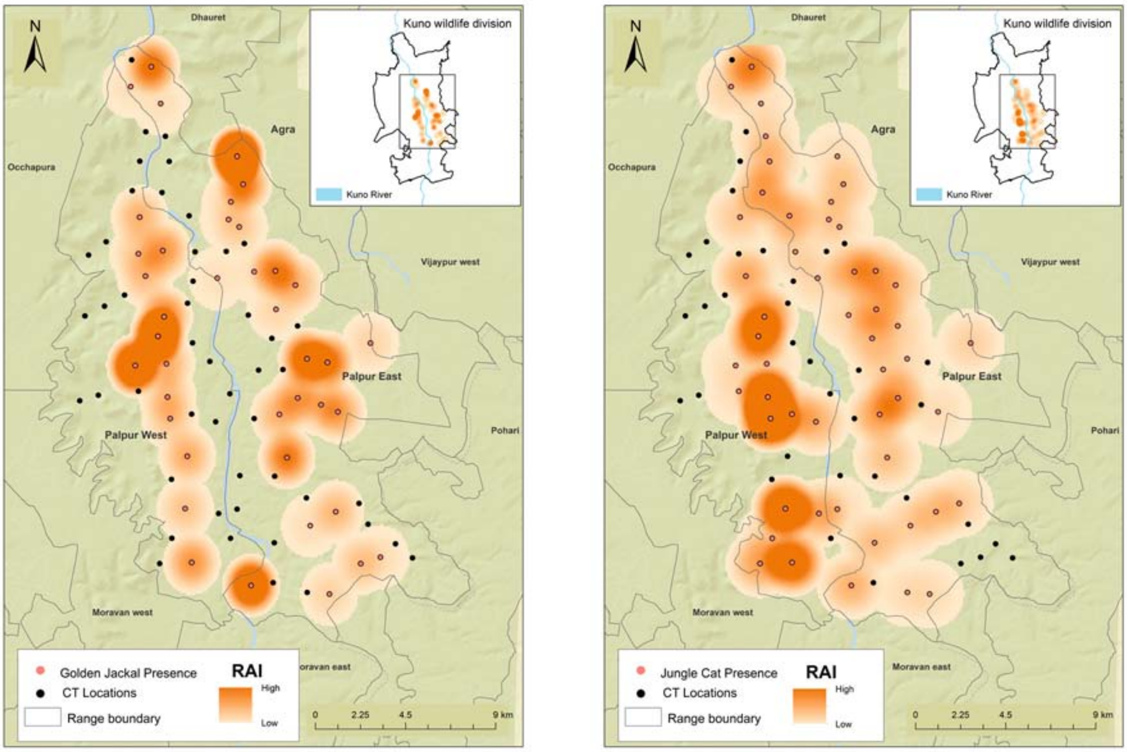

Figure 6.1.3.2. *Spatial distribution of golden jackal (left) and jungle cat (right) in the erstwhile Wildlife Sanctuary area of Kuno National Park*

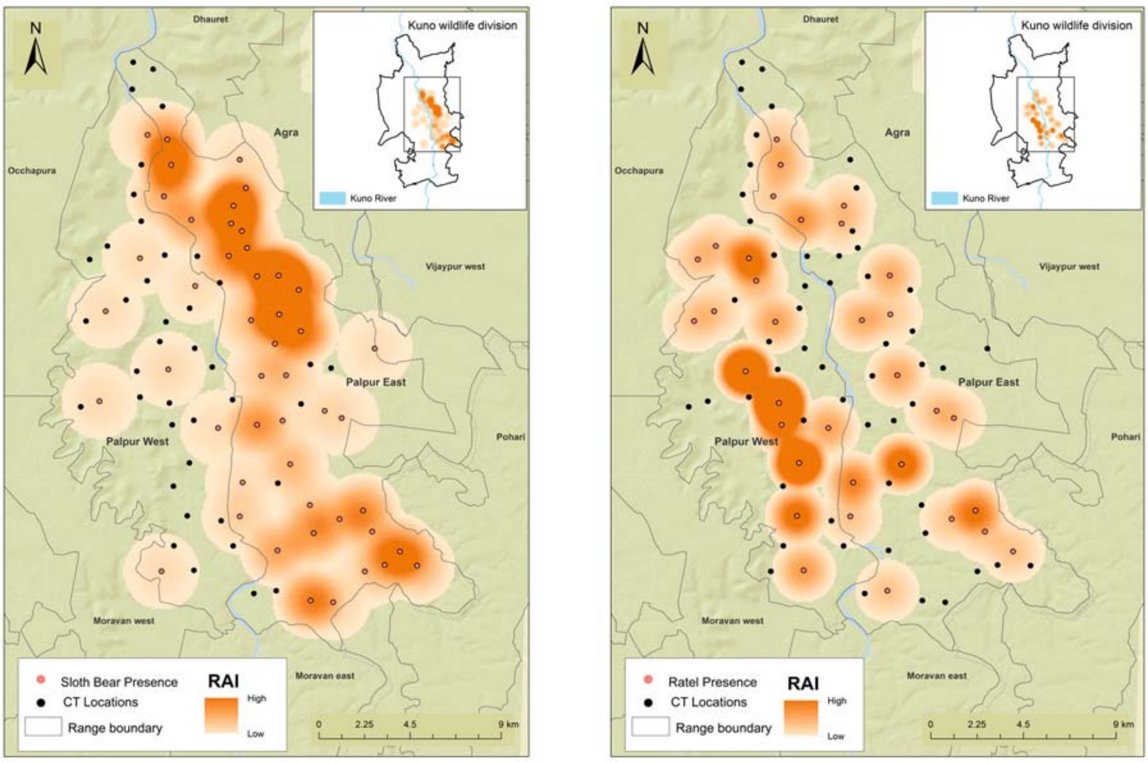

Figure 6.1.3.3. *Spatial distribution of sloth bear (left) and ratel (right) in the erstwhile Wildlife Sanctuary area of Kuno National Park*

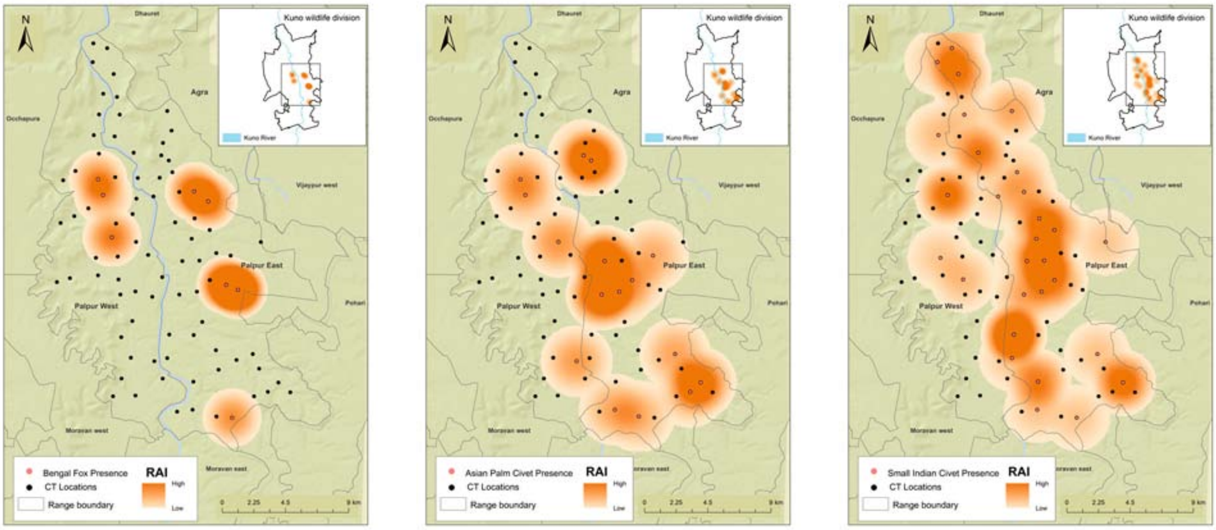

Figure 6.1.3.4. Spatial distribution of Indian fox (left), Asian palm civet (middle) and small Indian civet (right) in the erstwhile Wildlife Sanctuary area of Kuno National Park

6.1.4. Activity pattern of carnivores in the erstwhile Wildlife Sanctuary area of Kuno National Park

Based on the time of each independent photo-capture similar to calculating RAI values of the study species obtained from camera traps, activity curves were generated as described in section 3.1.2.

6.1.4.1. Activity pattern of leopards in erstwhile Wildlife Sanctuary area of Kuno National Park

There was a stark difference in temporal activity patterns of leopards between the summer and monsoon seasons. Leopards exhibited primarily nocturnal and crepuscular activity in the summer season. While their activity peaked during early morning (5-6 AM) and evening (6-7 PM), they also showed relatively high activity during the night. However, a completely reverse pattern was observed in the monsoon season, when leopards were more active during the day between 6 AM and 10 AM followed by a sudden decrease in activity during the afternoon and a sharp rise in activity again after 3 PM. Their activity pattern in monsoon depicts a shift to primarily diurnal behavior.

Image 6.1.4. Ratel in Kuno National Park © WII (Project Cheetah)

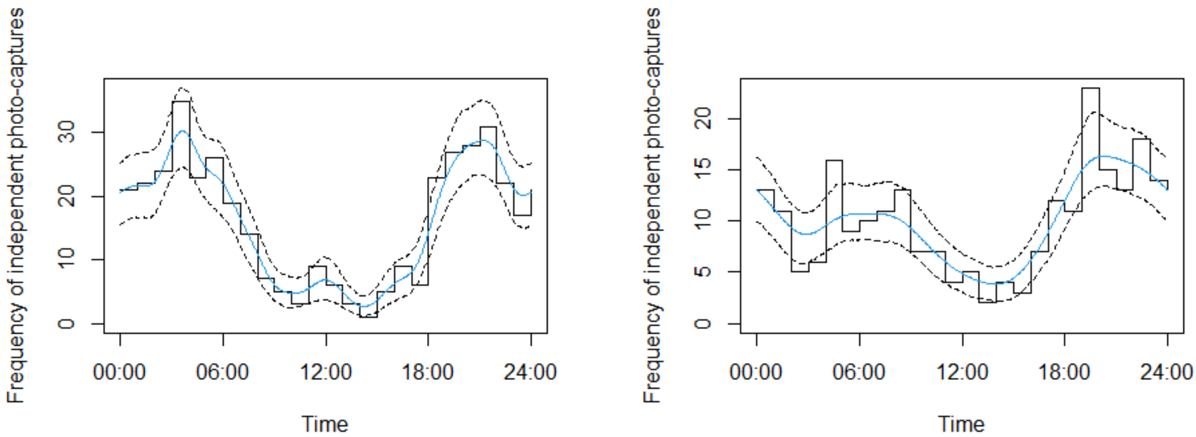

Figure 6.1.4.1. *Temporal activity pattern of leopards in the summer season- Palpur East Range (left) and monsoon season- Palpur West Range (right)*

6.1.4.2. Activity pattern of other carnivores in the erstwhile Wildlife Sanctuary area of Kuno National Park

The daily activity patterns of hyenas and bears were predominantly nocturnal, with hardly any activity during the day. The activity typically began around sunset and subsided during early morning hours. Golden jackals and jungle cats were exhibiting activity all around the 24-hour period with a peak around midnight. Ratel, Indian fox, common palm civet, and small Indian civet were mostly active at night, whereas grey mongoose was most active in the early mornings and their activity continued during the day into early evenings.

Image 6.1.5*. Rusty-spotted cat in Kuno National Park © WII (Project Cheetah)*

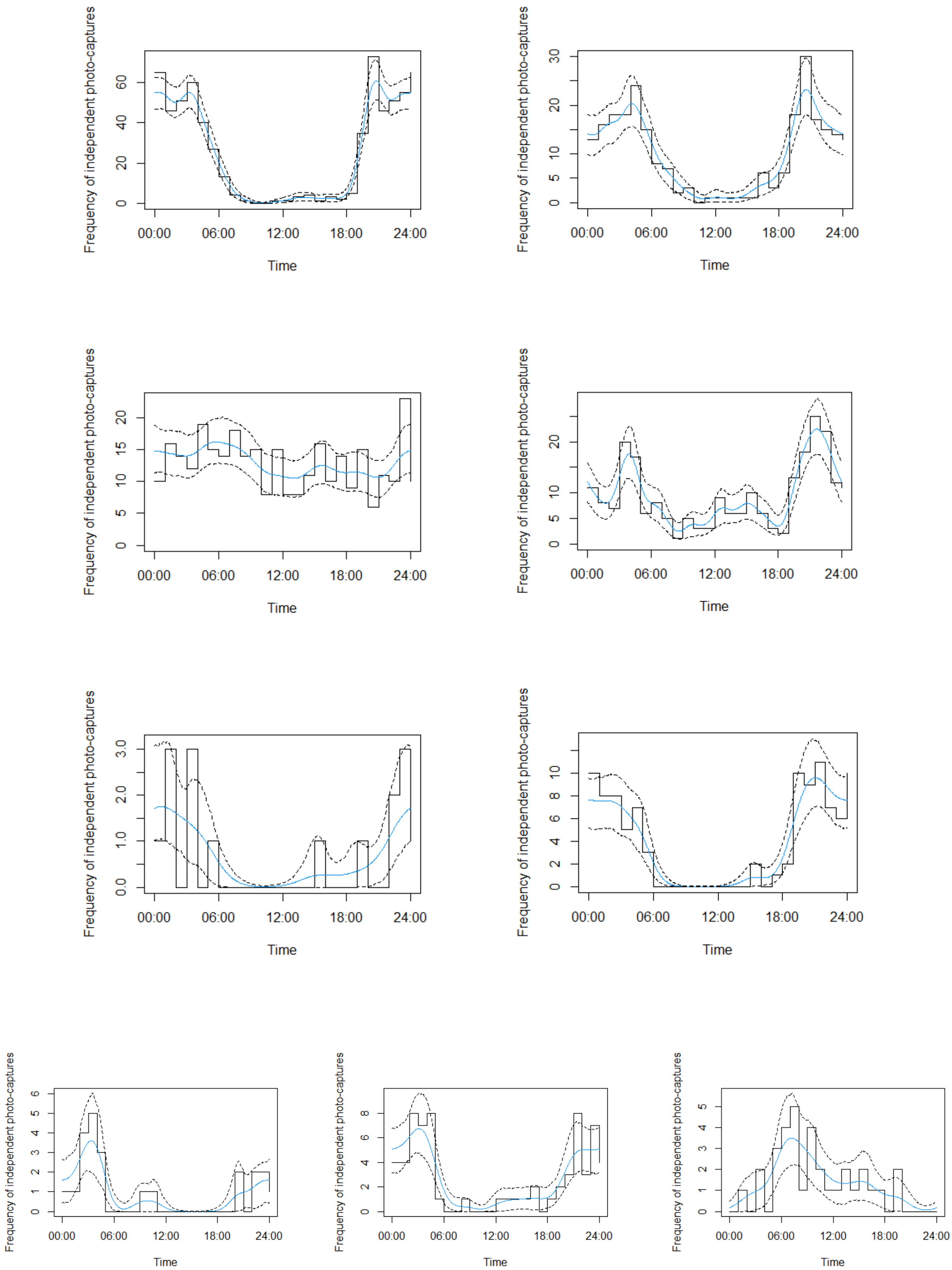

Figure 6.1.4.2. *Temporal activity patterns of striped hyena, sloth bear (top row L-R), golden jackal, jungle cat (second row L-R), Indian fox, ratel (third row L-R), common palm civet, small Indian civet, grey mongoose (bottom row L-R) in the erstwhile Wildlife Sanctuary area of Kuno National Park*

6.2. Home range and habitat use of leopard, striped hyena, golden jackal, and jungle cat in Kuno National Park

6.2.1. Movement and home range of leopards in Kuno Wildlife Division

Leopards are apex predators, exerting top-down control on herbivore populations. They play a crucial role in regulating prey populations through predation (Chamaille-Jammes *et al.* 2019). Being generalists in their diet preference, leopards prey on a wide variety of ungulate species (Edgaonkar and Chellam 2002) and thus help maintain ecological balance. This regulation of prey populations has cascading effects on the ecosystem, influencing habitat quality and resource availability for other species (Gandiwa 2013). The predatory pressure exerted by leopards may cause indirect effects on vegetation dynamics (Ford *et al.* 2014). By controlling herbivore populations, leopards mitigate the impact of overgrazing, thereby promoting plant diversity and maintaining its structure and composition (Ford & Goheen 2015). This influence extends beyond direct predation to shaping habitat suitability for a myriad of species, including small mammals, birds, and insects. Thus, leopards indirectly contribute to maintaining the health and stability of ecological communities.

The presence of leopards in an ecosystem affects the behavior and distribution of mesopredators like jackals and smaller felids through competitive interactions or direct predation pressure (Prugh *et al.* 2009). This regulatory role helps sustain a balance among predator and prey populations, essential for preserving species diversity. Monitoring leopard populations and their behavior is important to assess ecosystem health. They serve as indicators of ecosystem integrity (Tshabalala *et al.* 2021). Changes in leopard abundance or distribution can signal shifts in habitat quality, prey availability, or human disturbance levels (Mondal *et al.* 2013). Therefore, conservation efforts aimed at preserving leopard populations have broader implications for ecosystem management and biodiversity conservation.

Research suggests that leopards can pose a significant predation threat to cheetahs, particularly on cubs and sub-adults. Research by Palomares & Caro (1999), listed high predation rates on cheetah cubs by large carnivores including leopards. They found that large co-predators accounted for a significant proportion of cheetah cub mortality, with an estimated 68% of cheetah cubs falling victim to combined predation by lions, spotted hyenas, and leopards. This predation pressure on cheetah cubs can have significant implications on population dynamics, as mortality rates during early life stages can affect population growth and recruitment (Durant 2000, Laurenson 1995). Sub-adult cheetahs also face considerable predation risk from leopards. These findings highlight the vulnerability of young cheetahs to predation by co-predators during the transitional phase from dependence on their mother to independence (Laurenson 1995). While adult cheetahs are less vulnerable to predation compared to cubs and sub-adults, leopards can still pose a threat to adult cheetah individuals, particularly in areas of high leopard density or where prey availability is limited (Durant 1998).

Leopards and cheetahs in Kuno would occupy overlapping ranges and habitats, leading to competition for resources such as prey and territory. Intense competition for similar prey can lead to reduced food availability for cheetahs, affecting their nutritional condition and reproductive success (Durant 1998). Competition for territory can restrict the distribution and range expansion of cheetah populations, limiting their access to suitable habitats and dispersal opportunities. In areas with high leopard densities and scarce prey resources, competition between leopards and cheetahs may intensify, potentially affecting cheetah survival and reproductive success (Durant 1998).

Cheetahs exhibit various behavioral responses to cope with resource competition with leopards. One adaptation is the selection of different hunting strategies or prey preferences to minimize direct competition with leopards. Additionally, cheetahs adjust their ranging patterns and habitat use to avoid areas of high leopard density or activity (Durant 1998). Studies have shown that cheetahs exhibit spatial avoidance behaviors, such as selecting habitat patches with lower occurrence of large co-predators or shifting their activity patterns to the time periods when competing co-predators are less active (Durant 2000). These behavioral adaptations may enable cheetahs to minimize direct encounters with leopards and reduce the risk of competition or predation. Resource competition between cheetahs and leopards can have complex and multifaceted effects on cheetah populations, influencing their behavior, distribution, and survival. Understanding the dynamics of competition and predation between these two species is crucial for informing conservation strategies aimed at mitigating threats and promoting the long-term viability of cheetah populations in shared landscapes.

6.2.1.1. Capturing and radio-collaring of leopards

For radio-collaring of leopards, walk-through cages of dimensions 2.9m×0.8m×1m were deployed to humanely capture the animals. In contrast to the traditional cages used for capturing leopards, these double-door cages are see-through as a double layer of mesh wires was used as the outer layer to confine the captured leopard. These wires helped in minimizing injuries to the captured animal as they provided the required elasticity without compromising its strength. Various baits were used to lure leopards into the cage. After setting up in the presence of veterinarians and forest department staff, the active cages were monitored regularly following a strict protocol to ensure minimum delay in response, following any successful capture.

Image 6.2.1. *Humane capture using walk-through cage (left) © WII (Project Cheetah), and radio-collaring of leopard (right) © Kesha Patel*

In the event of successful leopard capture, the captured individual was cautiously approached in an open vehicle and the mixture of drugs was delivered remotely using either Dan-Inject or Pneu-Dart projectors by a team of veterinarians. For immobilization, a combination of Ketamine, Xylazine, and Medetomidine was used. Drug dosages were based on animal body weight, age, and sex. After successful immobilization, the individual was managed by veterinarians(s) in the presence of forest department staff following strict veterinary procedures such as regular monitoring of vitals, morphometric measurements, sample collection, deployment of satellite collar, revival of the animal and monitoring of the animal (6-hour period) post revival while maintaining adequate distance using on-ground tracking equipment. AWT (African Wildlife Telemetry) satellite collars were deployed and programmed to take GPS fixes at an interval of every 3 hours. The collared leopards were monitored and tracked remotely using AWT's online user interface.

6.2.1.2. Home range size and movement of radio-collared leopards in Kuno Wildlife Division

A total of six leopards were radio-collared in Kuno NP, which includes 2 females and 4 males.

Based on the data obtained from radio telemetry, the female leopard home range (100% MCP) size (16.18-58.54 km^2) was found to be much smaller as compared to the male leopard (35.63-1505.43 km^2). The home range of the sub-adult female was almost four times larger as compared to the home range of the adult female. The sub-adult female had once ventured inside the cheetah enclosure in the Palpur West Range. The animal was captured and released into the Palpur east range of Kuno NP ~25 km away from the enclosure to deter her from entering the enclosure again. Another marked deviation in home-range size was of the sub-adult male leopard L2 (255.42 km^2). This can be attributed to the fact that the animal was still in its dispersing phase for an initial period of six months after collaring. However, upon later inspection of its GPS data, showed that this individual had established its territory on the eastern edge of the National Park and now operates within a much smaller area.

The latest collared individual L6 an adult male has demonstrated an exceptionally large home range size (1505.43 km^2). The GPS data obtained so far has shown that this individual has ventured across the length and breadth of Kuno NP, never remaining in a particular area for long. Based on its movement pattern it can be deduced that the individual hasn't yet established a home range. A marked reduction in home range size can be expected once the individual establishes its territory. The average daily distance moved by the males ranged from 1.76(0.09SE) to 3.51(0.19SE) km, whereas females ranged from 1.93(0.22SE) to 2.98(0.17SE) km.

Table 6.2.1.2. *Home range sizes of radio-collared leopards in Kuno Wildlife Division*

Animal ID (Collar ID)	Age category & Sex	100% MCP (km^2)	95%KDE (km^2)	50%KDE (km^2)	Average daily distance moved (km)	Days
Leopard 1 (6310)	Adult Male	35.63	10.45	3.11	1.76(0.09SE)	388
Leopard 2 (6303)	Sub-adult Male	255.42	51.73	7.36	2.71(0.12SE)	461
Leopard 3 (6316)	Adult Female	16.18	20.02	5.50	2.98(0.17SE)	116
Leopard 4 (6317)	Sub-adult Female	58.54	83.50	8.06	1.93(0.22SE)	59
Leopard 5 (6315)	Adult Male	81.48	17.77	2.91	3.48(0.23SE)	322
Leopard 6 (6226)	Adult Male	1505.43	1694.45	25.57	3.51(0.19SE)	118

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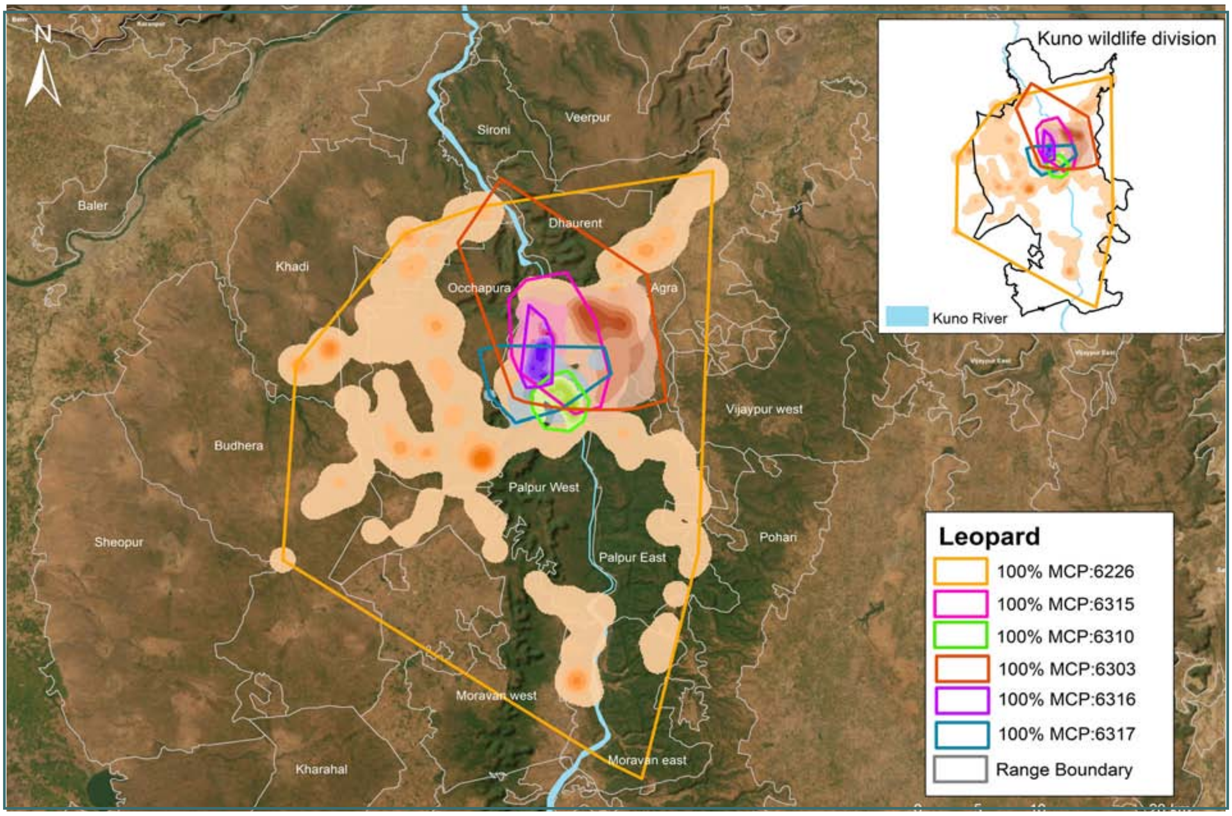


Figure 6.2.1.2. *Home ranges (100% MCP and 95%KDE) of six radio-collared leopards in Kuno Wildlife Division*

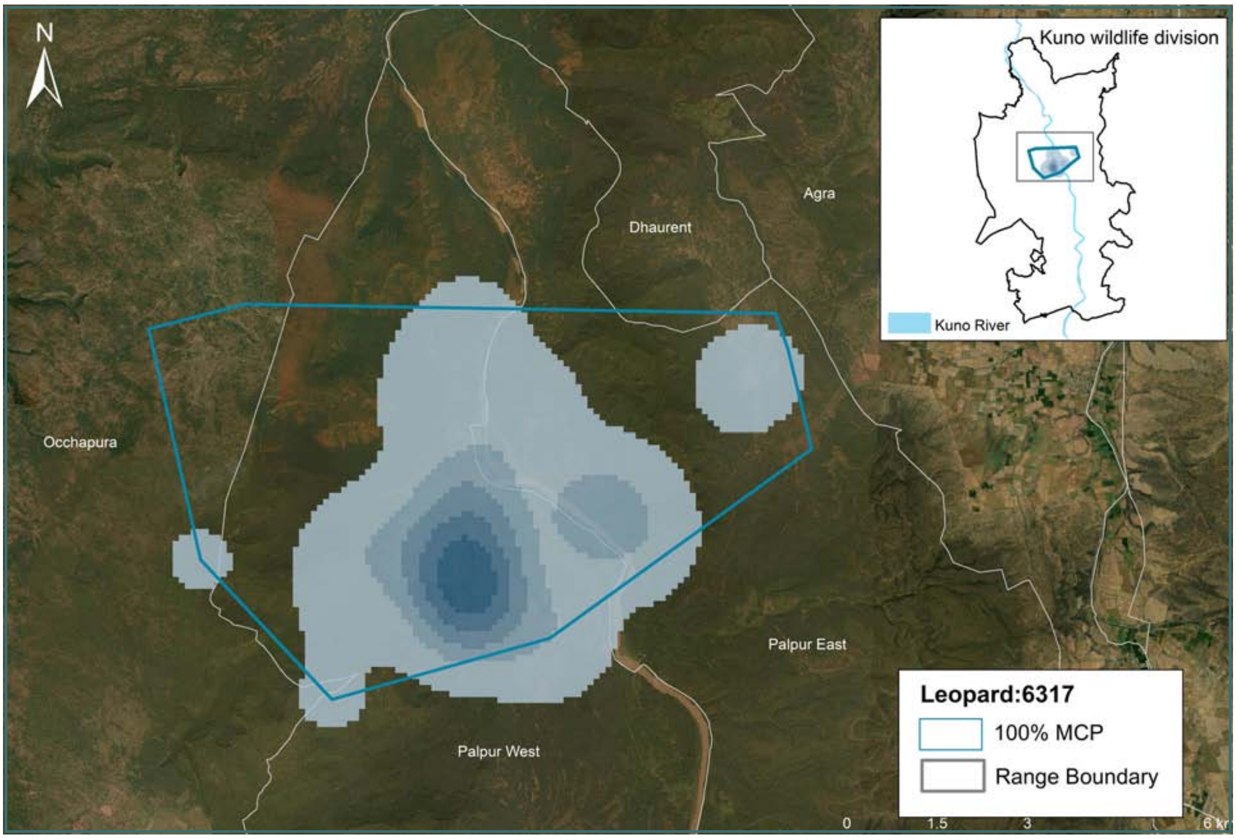


Figure 6.2.1.3. *Home range (100% MCP and 95%KDE) of radio-collared leopard sub-adult female (id.6317) in Kuno Wildlife Division*

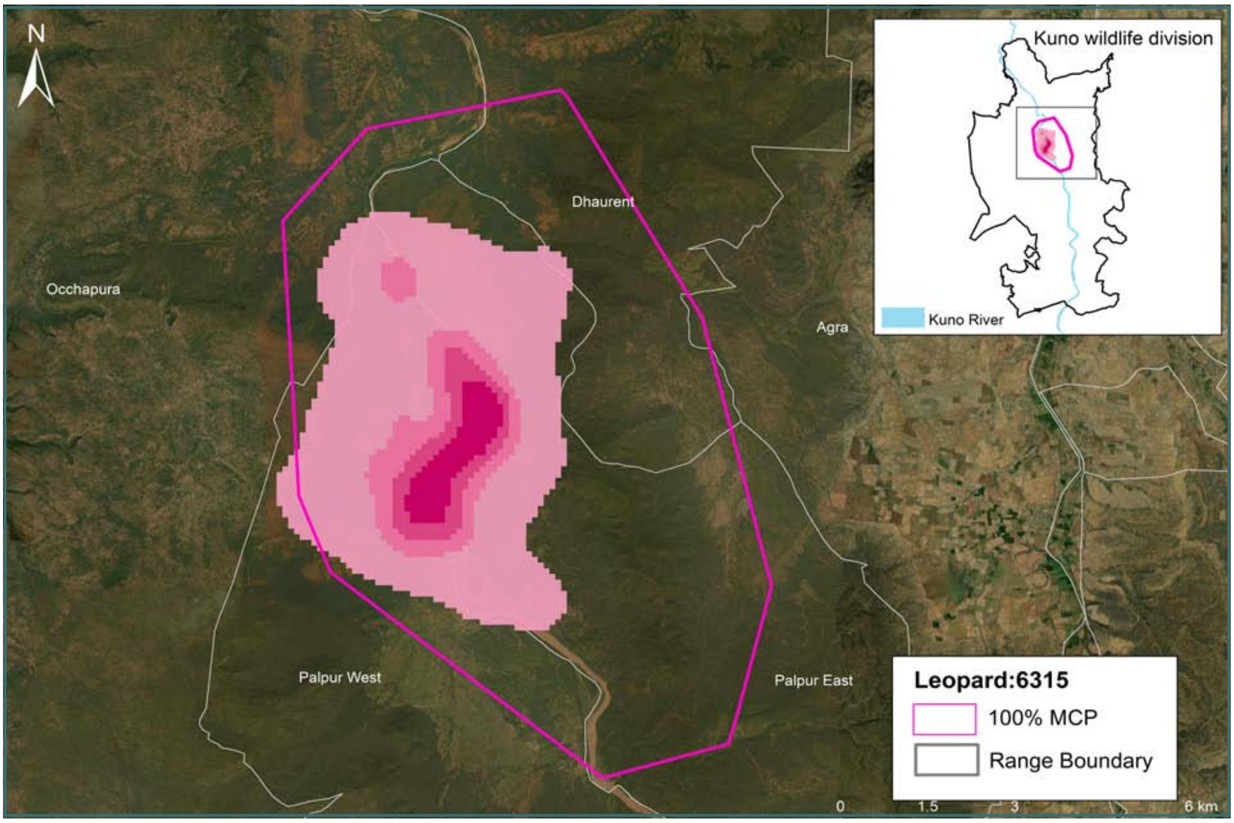


Figure 6.2.1.4. *Home range (100% MCP and 95%KDE) of radio-collared leopard adult male (id.6315) in Kuno Wildlife Division*

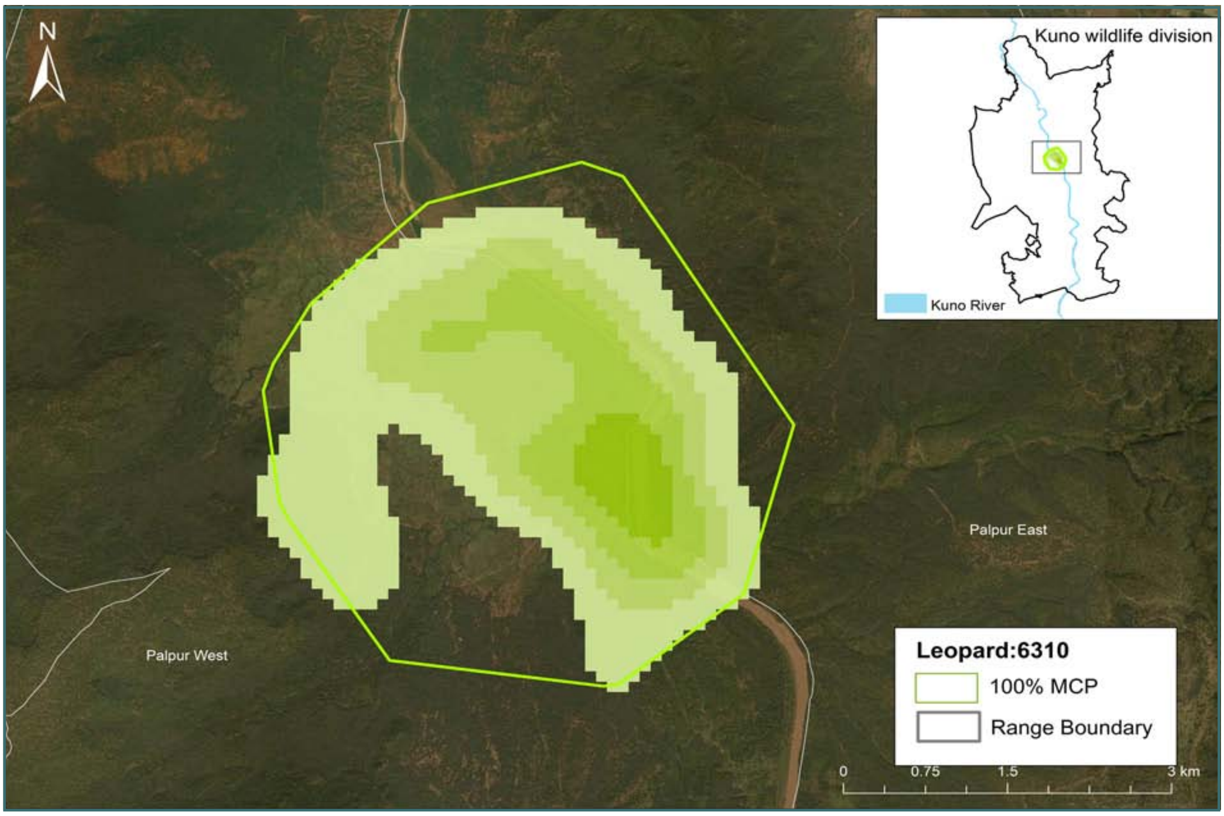


Figure 6.2.1.5. *Home range (100% MCP and 95%KDE) of radio-collared leopard adult male (id.6310) in Kuno Wildlife Division*

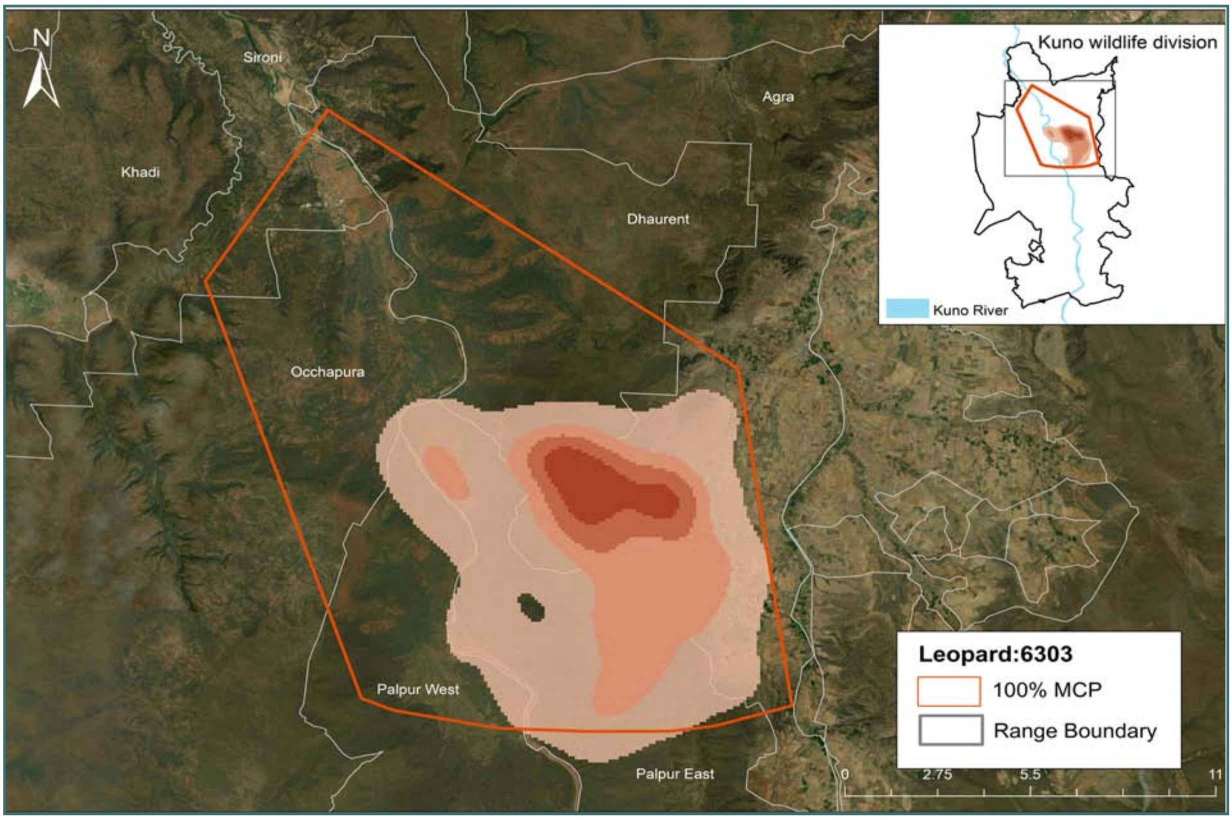


Figure 6.2.1.6. *Home range (100% MCP and 95%KDE) of radio-collared leopard sub-adult male (id.6303) in Kuno Wildlife Division*

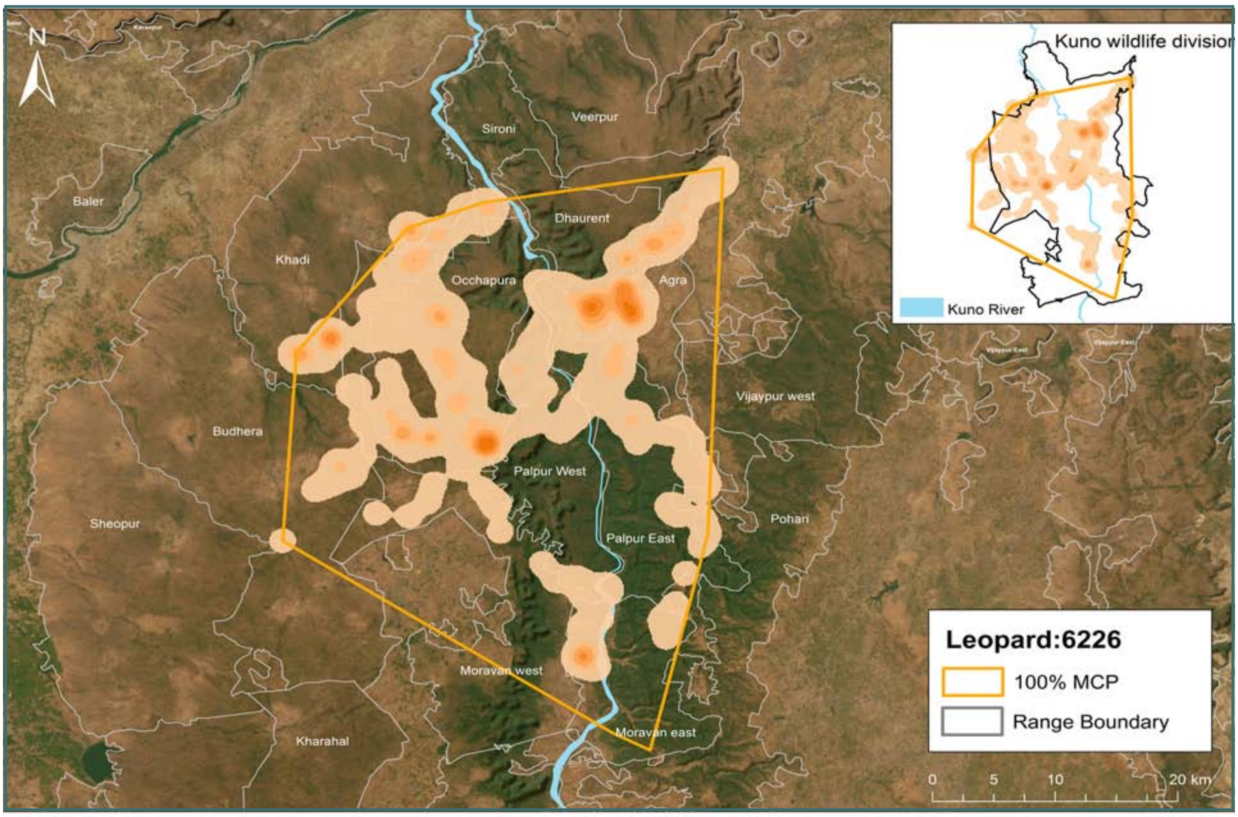


Figure 6.2.1.7. *Home range (100% MCP and 95%KDE) of radio-collared leopard adult male (id.6226) in and around Kuno Wildlife Division*

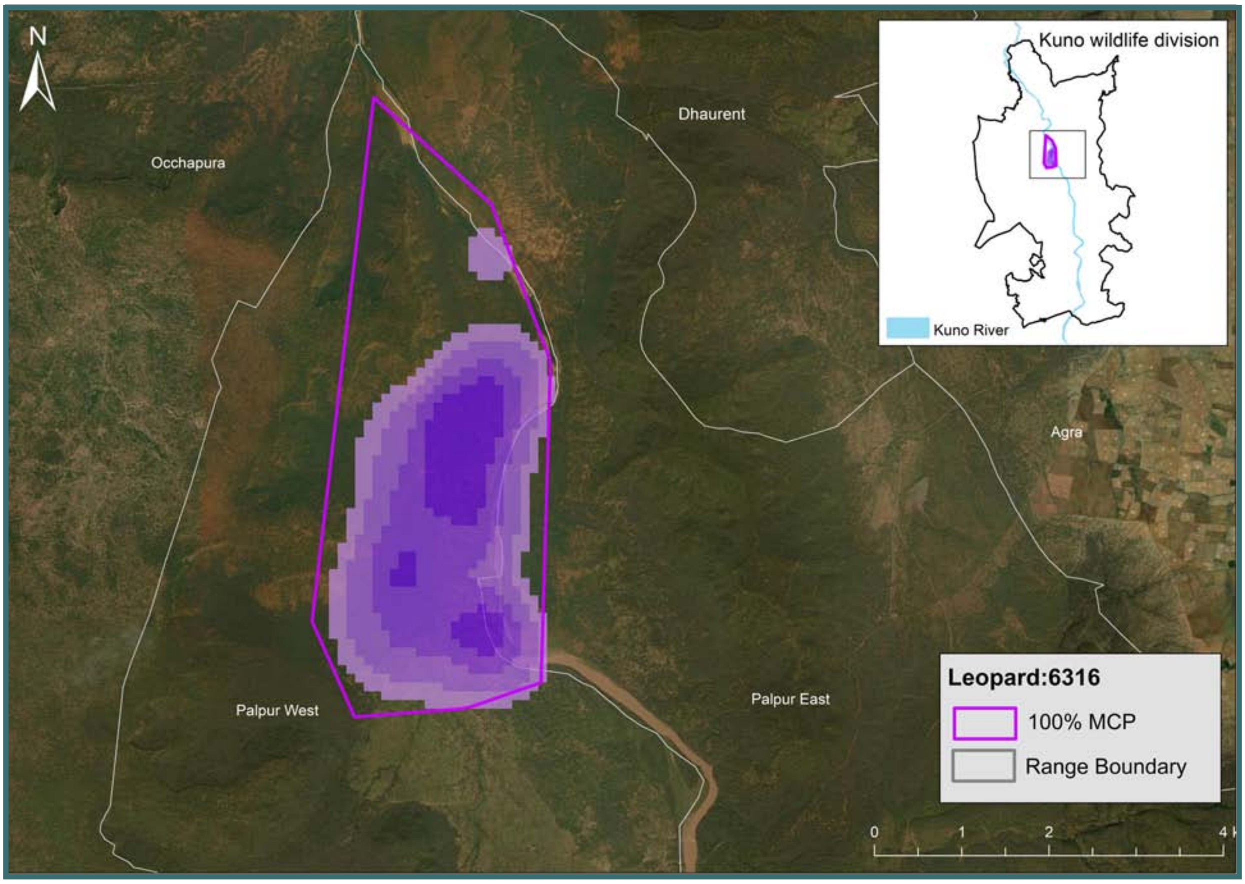


Figure 6.2.1.8. Home range (100% MCP and 95%KDE) of radio-collared leopard adult female (id.6316) in Kuno Wildlife Division

6.2.2. Habitat selection of the radio- collared leopards in Kuno Wildlife Division

Resource Selection Function (RSF) was used to calculate habitat preferences of radio- collared leopards in Kuno Wildlife Division based on the use of available habitats. Additionally, Ivlev's index was used to assess the second-order habitat selection of the individuals for each LULC class (grassland, dhonk forest, riverine, miscellaneous dry deciduous, water bodies, human habitation/ built up, and agriculture). The methods are described in section 3.2.2.

Overall, leopards selected riverine patches compared to other habitat types as seen from the results of resource selection function analysis. Based on Ivlev's index for individual leopards, one sub-adult male and one sub-adult female selected grassland habitat more over other habitats. Among the three adult males, one adult male selected dhonk forest and the proportion of locations of another adult male were higher in dhonk forest, whereas the third male selected riverine habitat more than other habitats. The adult female selected savannah grassland patches, although a higher proportion of locations were from dhonk forest.

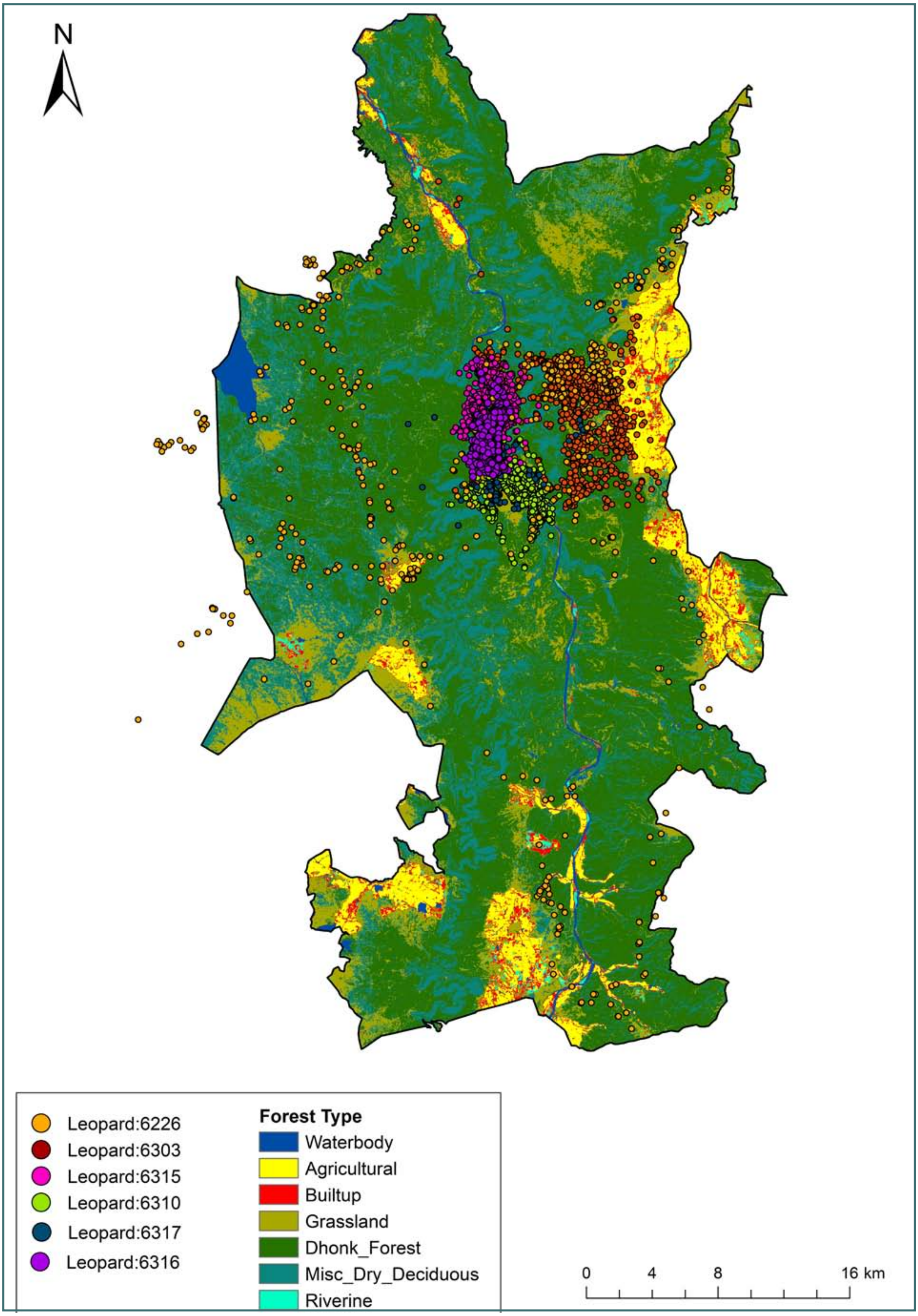


Figure 6.2.2.1. *Locations of radio-collared leopards overlaid on the forest type map of Kuno Wildlife Division*

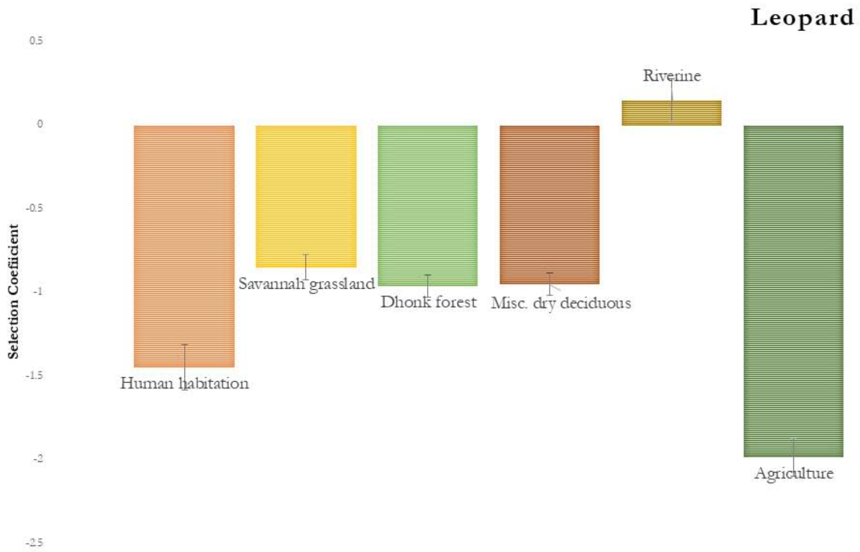
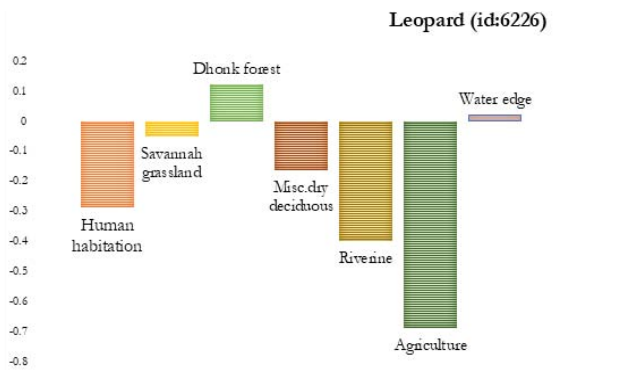


__Figure 6.2.2.2.__ Habitat selection of radio-collared leopards in Kuno Wildlife Division using the Resource Selection Function, error bars depict standard errors



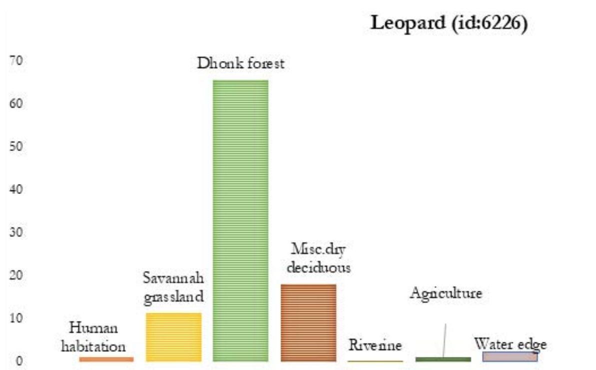
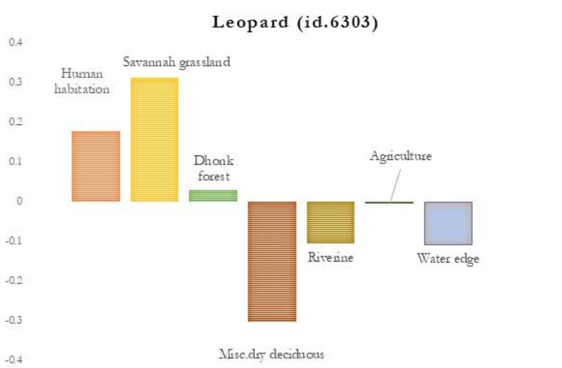


__Figure 6.2.2.3.__ Habitat selection of radio-collared leopard adult male (id. 6226) using Ivlev's index (left) and percentage of locations in each habitat type (right)



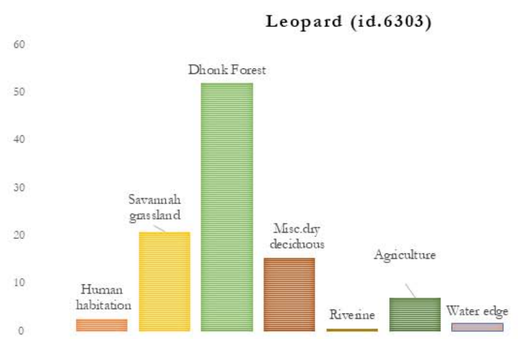


__Figure 6.2.2.4.__ Habitat selection of radio-collared leopard sub-adult male (id. 6303) using Ivlev's index (left) and percentage of locations in each habitat type (right)

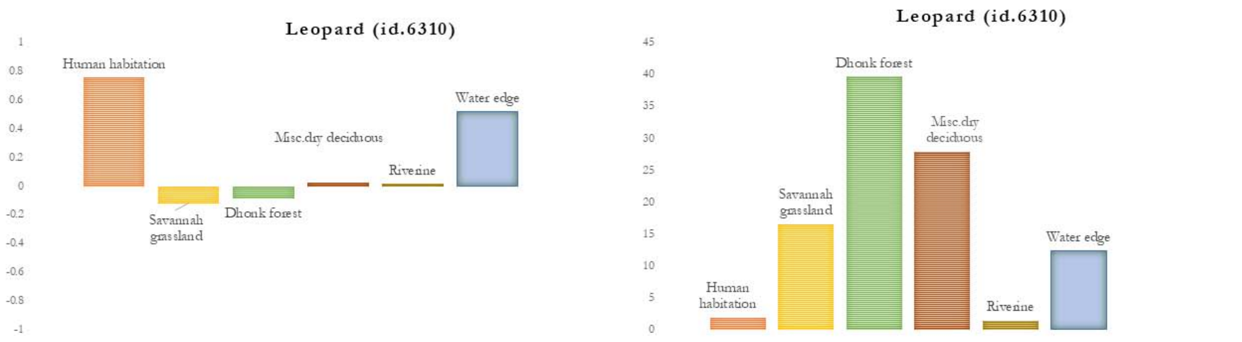


Figure 6.2.2.5. Habitat selection of radio-collared leopard adult male (id. 6310) using Ivlev's index (left) and percentage of locations in each habitat type (right)

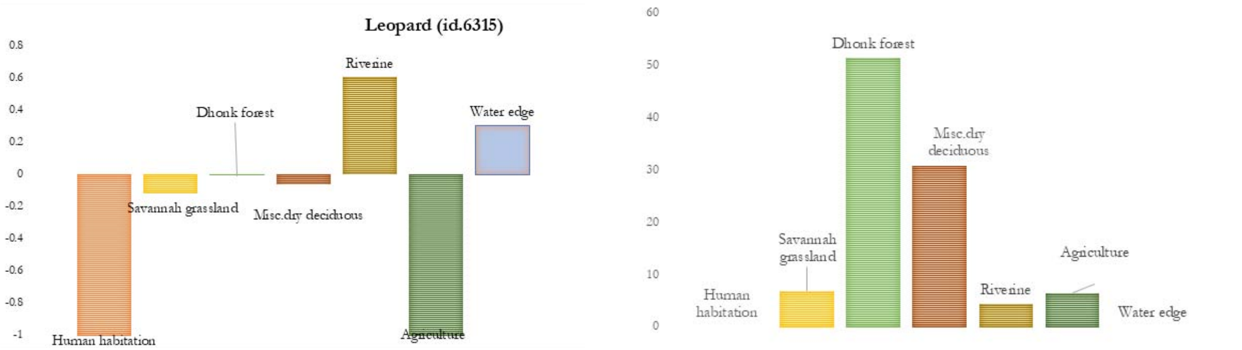


Figure 6.2.2.6. Habitat selection of radio-collared leopard adult male (id. 6315) using Ivlev's index (left) and percentage of locations in each habitat type (right)

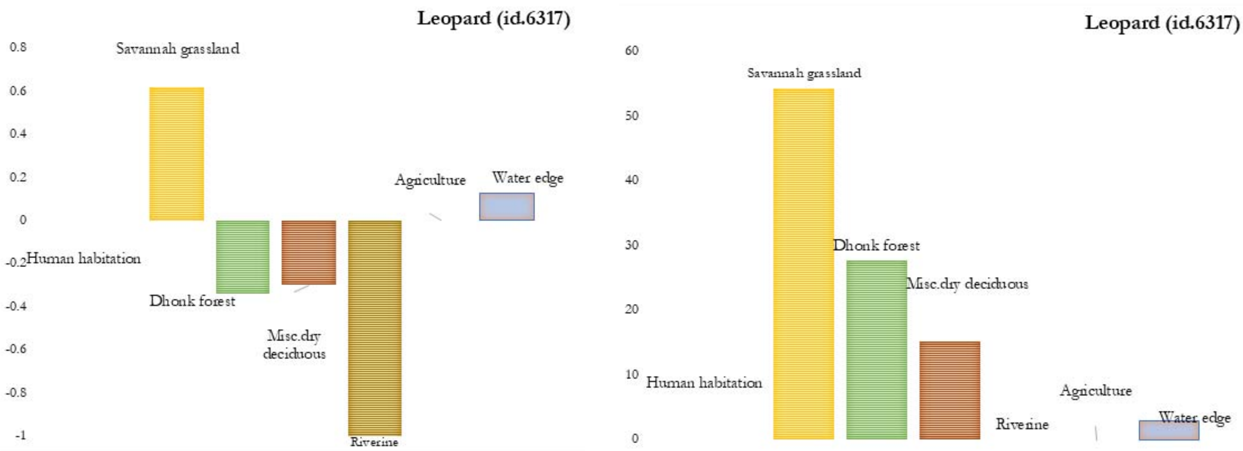


Figure 6.2.2.7. Habitat selection of radio-collared leopard sub-adult female (id. 6317) using Ivlev's index (left) and percentage of locations in each habitat type (right)

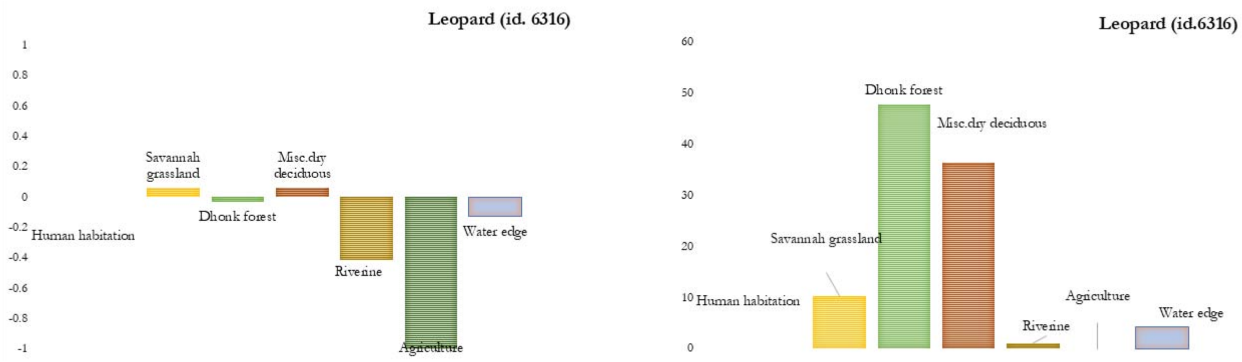


Figure 6.2.2.8. Habitat selection of radio-collared leopard adult female (id. 6316) using Ivlev's index (left) and percentage of locations in each habitat type (right)

6.2.3. Movement and home range of striped hyenas in Kuno Wildlife Division

Scavengers are a diverse group of organisms that have developed specialized traits to utilize an unconventional food source—carrion, or the remains of dead animals. This adaptation enables them to occupy ecological niches that other animals either cannot or choose not to inhabit. There are three main ecosystem services that scavengers offer (Beasley *et al.* 2015). First, they enhance the stability of the food webs by an increase in connectivity (Rooney *et al.* 2006, Wilson and Wolkovich 2011). Second, scavengers have the ability to disperse nutrients both within and across the borders of an ecosystem (Helfield and Naiman 2001, Huijbers et al. 2013). Third, and maybe most direct benefit to humans, is sanitary benefits associated with the removal of carcasses from the environment and preventing disease outbreaks. By removing animal remains from the environment before they decompose, scavengers reduce the resources available to bacteria (Kaden *et al.* 2003), thereby preventing the spread of diseases that could otherwise disrupt local food webs and pose risks to human health and the economy.

Hyenas play a crucial role in the ecosystem primarily as scavengers. Of the four species of hyenas found in the world, only striped hyena occurs in India. With a dog-like appearance, striped hyenas are large, solitary carnivores (Califf *et al.* 2020) that inhabit arid and semi-arid landscapes across East Africa and South Asia (Akash *et al.* 2021). Striped hyenas are recognized as facultative scavengers that share habitats with other carnivores, including tigers, leopards, and golden jackals (Panda *et al.* 2023). They opportunistically feed on the remains of animals killed by larger carnivores and discarded carcasses of domestic livestock. By recycling significant amounts of organic waste (Panda *et al.* 2023), striped hyenas contribute to ecosystem services, such as waste removal, which help prevent disease transmission and nature's direct contribution to humans. As a result, disease control and waste management rank among the most important regulatory and maintenance ecosystem services (Costanza *et al.* 1996).

Studying the interactions between striped hyenas and their co-predators such as cheetah and leopard in Kuno is crucial to understanding the resource partitioning (dietary, spatial, and temporal), habitat use, movement patterns, and population dynamics as their interactions can influence predator communities and have a domino effect on the entire food chain (Moleon *et al.* 2014, Allen *et al.* 2015). At the temporal level, the objective focuses on investigating whether there is a partitioning of activity times between striped hyenas and co-predators like cheetahs and leopards. Such partitioning, if present, could help explain how these species coexist despite competing for limited resources (Hayward 2006).

6.2.3.1. Capturing and radio-collaring of striped hyenas

Trapping sites in Kuno NP were selected either in areas where hyenas are frequently photo-captured by camera traps or in areas where frequent sightings or signs of hyenas were encountered. Striped hyenas were captured using humane leg-hold traps with various kinds of bait to lure the animals. Coil spring traps are made of steel components padded with rubber to prevent injury to animals and powered by compact coil springs. After being baited and set with the help of veterinarians in the presence of forest department staff, the trap floors were lined with black tape and a layer of thick, dead grass. Since hyenas are olfactory foragers (Woodmansee *et al.* 1991), bait was dragged around the intended capture sites to form scent trails. The trapping site was checked every couple of hours in order to reduce the response time if an animal was caught, minimise the chance of animal escape, and to avoid by-catch.

Image 6.2.3. *Radio-collaring of striped hyena in Kuno National Park © Srikrishna Kukkemane*

The first male striped hyena (Id: 6309) in Kuno NP was captured and collared after 180 hrs of trapping effort on 5th May 2023 using a leg hold trap. Subsequently, a sub-adult male hyena (Id: 6307) on 21st November 2023 after 240 hrs of trapping effort, and a young male hyena (Id: 6225) on 9th April 2024 with 72 hrs of trapping effort. Immobilizations of all the captured hyenas were performed by a team of veterinarians in the presence of forest department staff. Hyenas were immobilized with a combination of Zoletile 100, Butorphenol, and Medetomidine hydrochloride.

During each capture, blood samples and ectoparasites were collected by veterinarians for future studies on disease profiling and genetics. Morphometric data, tooth measurements, and reproductive and lactation status were recorded for each individual. Based on this data, each hyena was assigned to an age class determined by body measurements, weight, and tooth wear. Photographs were taken of each hyena's body profile (to document stripe patterns), dentition, and genitals. All the captured hyenas were fitted with IR-SAT (Iridium satellite) collars. The collared animals were then reversed with Atipamezole and released after complete recovery.

Currently, two radio-collars are active. The radio-collars were set to transmit the location every 3 hrs at night and every 4 hrs during the day time. The monitoring team regularly tracked their movement, health condition and recorded habitat parameters of the locations where they sighted the collared individual. One mortality of a collard hyena occurred during the study period. The carcass of the young collared female hyena (Id-6784) was found with most of her lower body consumed, after tracking by the monitoring team when the collar had stopped transmitting data for a couple of days. The upper body of the female was missing along with the collar. The thoroughness of carcass consumption makes it likely that she was predated by a leopard.

***Table 6.2.3.1.** The details of radio-collared striped hyenas in Kuno National Park*

Hyena Id	Collar Type	Date of collaring	Trap effort (hr)	Collar status
Id:6309	IR-SAT	3 May 2023	180	Not Active
Id:6307	IR-SAT	21 November 2023	240	Active
Id:6784	IR-SAT	13 December 2023	180	Not Active
Id:6225	IR-SAT	9 April 2024	72	Active

***6.2.3.2.** Home range of radio-collared striped hyenas in Kuno Wildlife Division*

Home ranges (100%MCP) sizes of the radio-collared hyenas varied from 22.39 km^2 for a young animal to 103.68 km^2 of a sub-adult male. The home range sizes using 95%KDE and 100% MCP methods are listed in Table 6.2.3.2. The average daily distance moved by the animals ranged from 4.49(0.5SE) to 8.69(0.4SE) km.

***Table 6.2.3.2.** Home range sizes and average daily movement of radio-collared striped hyenas in Kuno Wildlife Division*

Tag-ID/ Type	Age category & Sex	100% MCP area (km^2)	95% KDE area (km^2)	50% KDE area (km^2)	Average daily distance (km)	Days
IR-SAT 6309	Adult Male	91.81	31.15	3.40	4.49(0.50SE)	366
IR-SAT 6307	Sub-adult Male	103.68	65.49	22.64	8.69(0.40SE)	166
IR-SAT 6225	Young (6-7 months)	22.39	15.59	2.58	6.17(0.45SE)	72

© Shivang Mehta/Team WII (Project Cheetah)

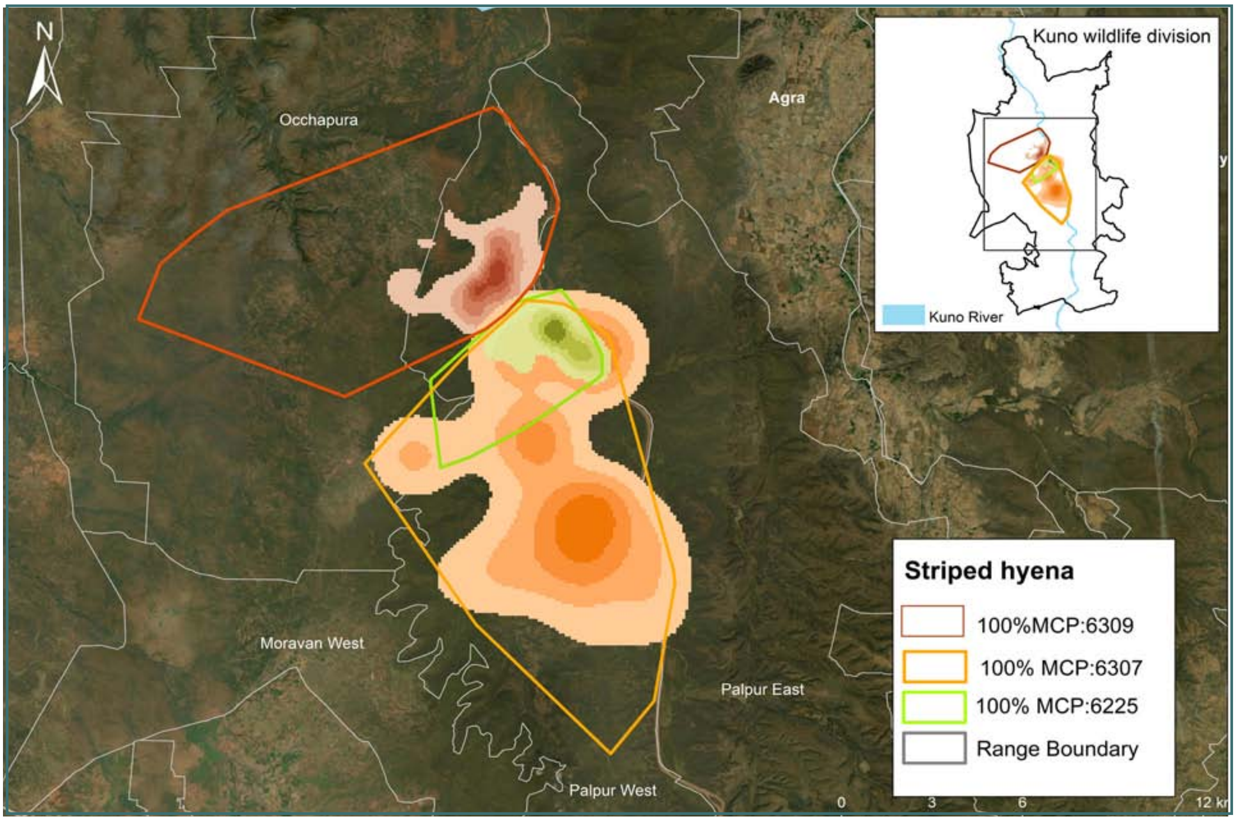


Figure 6.2.3.2.1. Home range (100%MCP & 95% KDE) of radio-collared striped hyenas in Kuno Wildlife Division

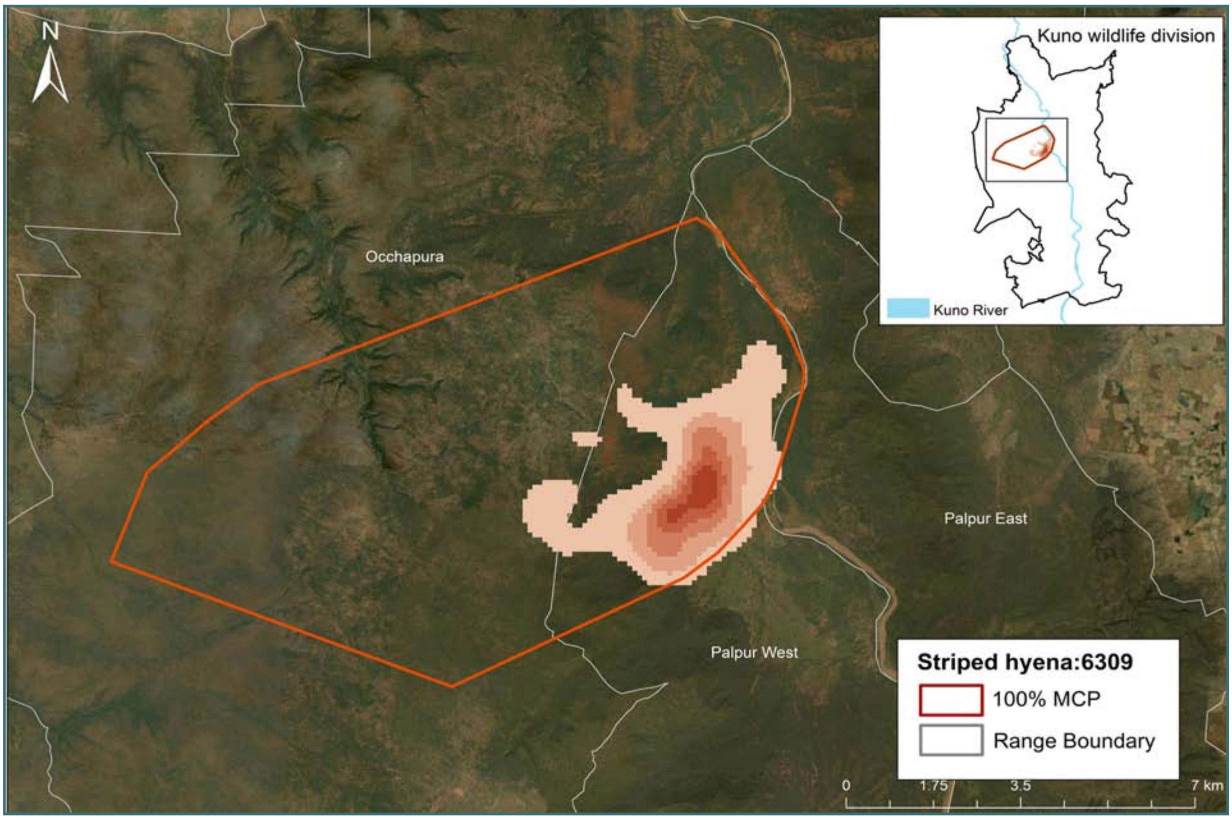


Figure 6.2.3.2.2. Home range (100%MCP & 95% KDE) of radio-collared striped hyena adult male (id.6309) in Kuno Wildlife Division

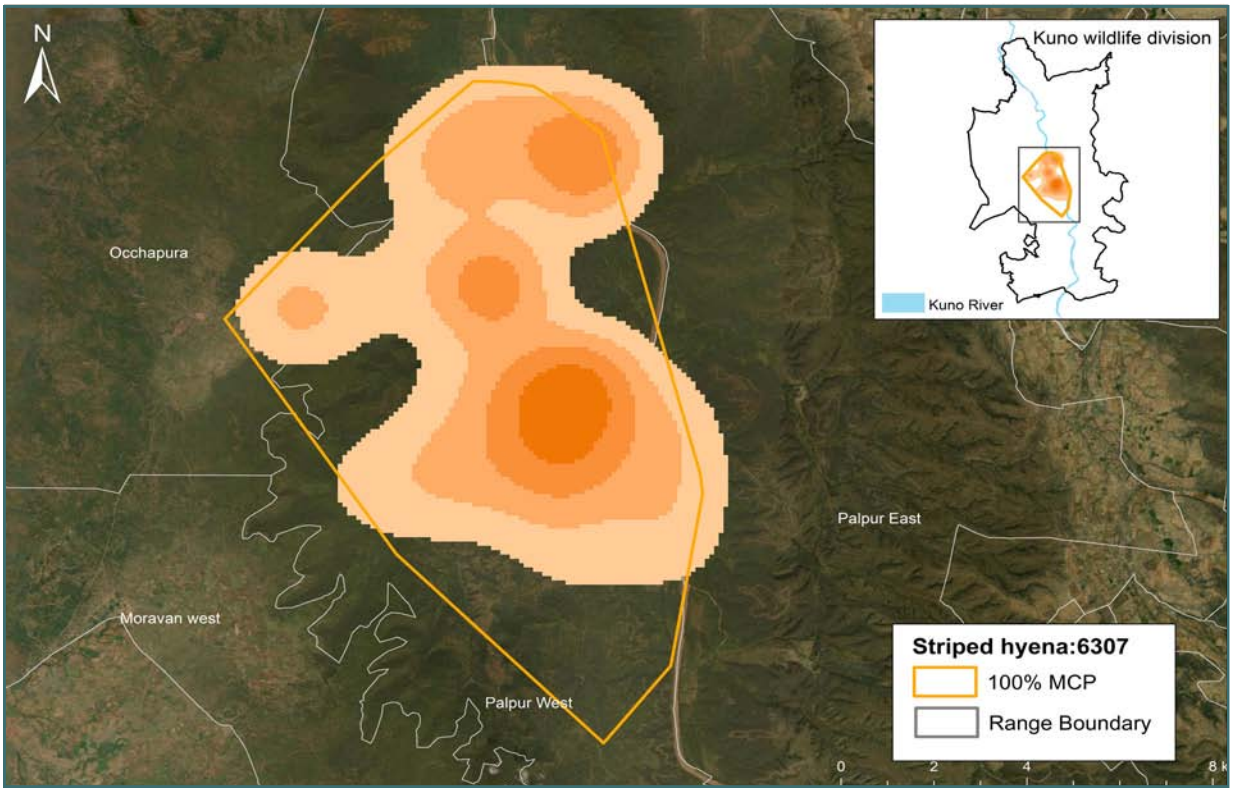


Figure 6.2.3.2.3. *Home range (100%MCP & 95% KDE) of radio-collared striped hyena sub-adult male (id. 6307) in Kuno Wildlife Division*

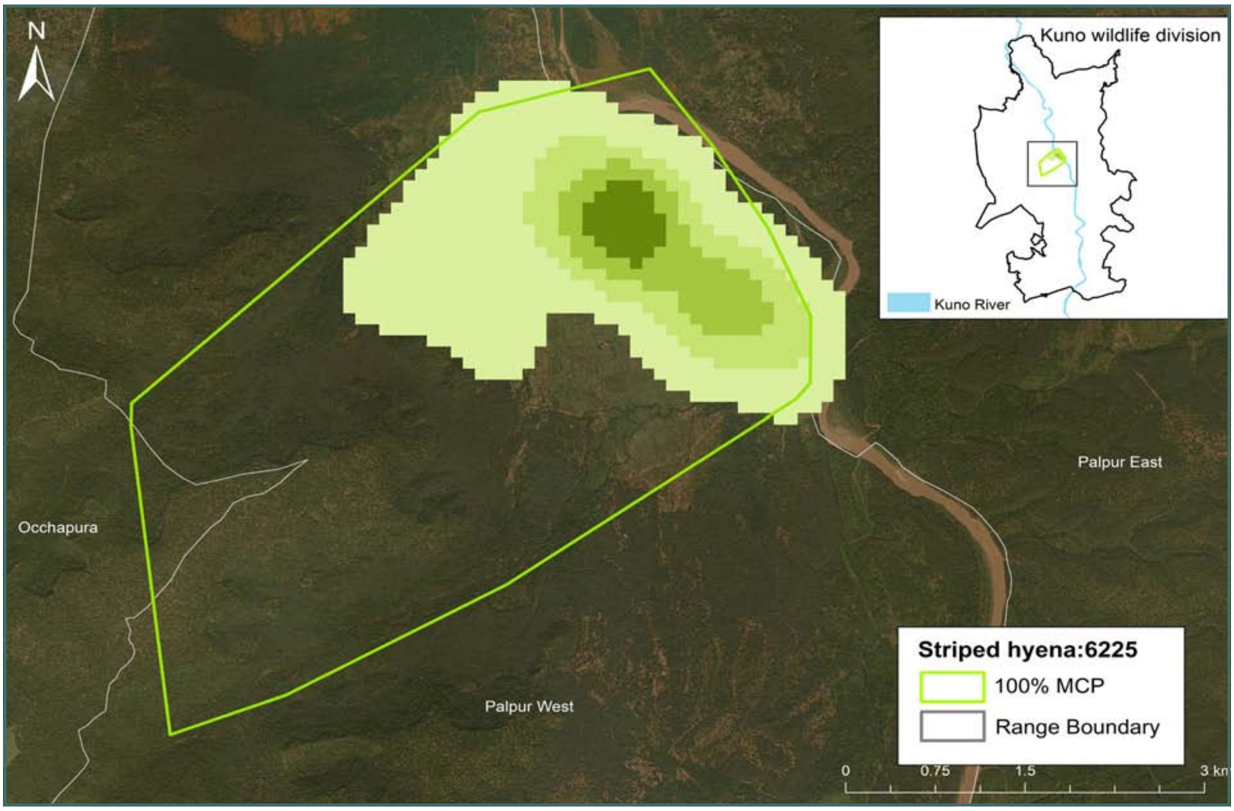


Figure 6.2.3.2.4. *Home range (100%MCP & 95% KDE) of radio-collared young striped hyena (id. 6225) in Kuno Wildlife Division*

6.2.4. Habitat selection of radio- collared striped hyenas in Kuno Wildlife Division

As described in section 3.2.2., Resource Selection Function (RSF) was used to calculate habitat preferences of radio- collared striped hyenas in Kuno Wildlife Division based on the use of available habitats. Additionally, Ivlev's index was used to assess the second-order habitat selection of the individuals for each LULC class (grassland, dhonk forest, riverine, miscellaneous dry deciduous, water bodies, built up/human habitation, and agriculture).

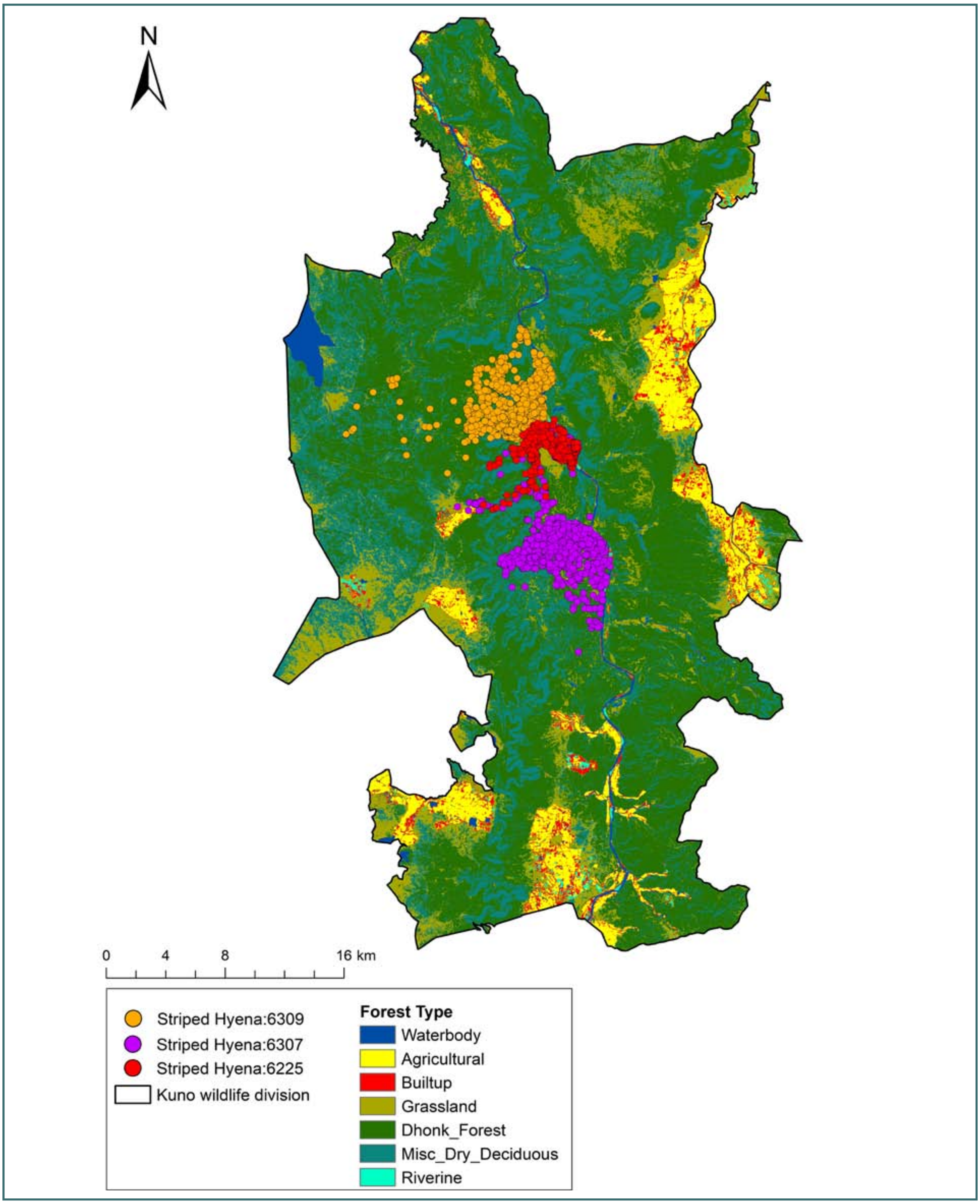


Figure 6.2.4.1. Locations of radio-collared striped hyenas overlaid on the forest type map of Kuno Wildlife Division

Using RSF, striped hyenas were observed to highly select riverine patches over other habitat types. Based on Ivlev's index, within its home range, each striped hyena consistently selected riverine patches. However, the proportionality of locations obtained was higher in savannah grassland patches for two individuals, whereas, for the adult male, it was higher in the dhonk forest.

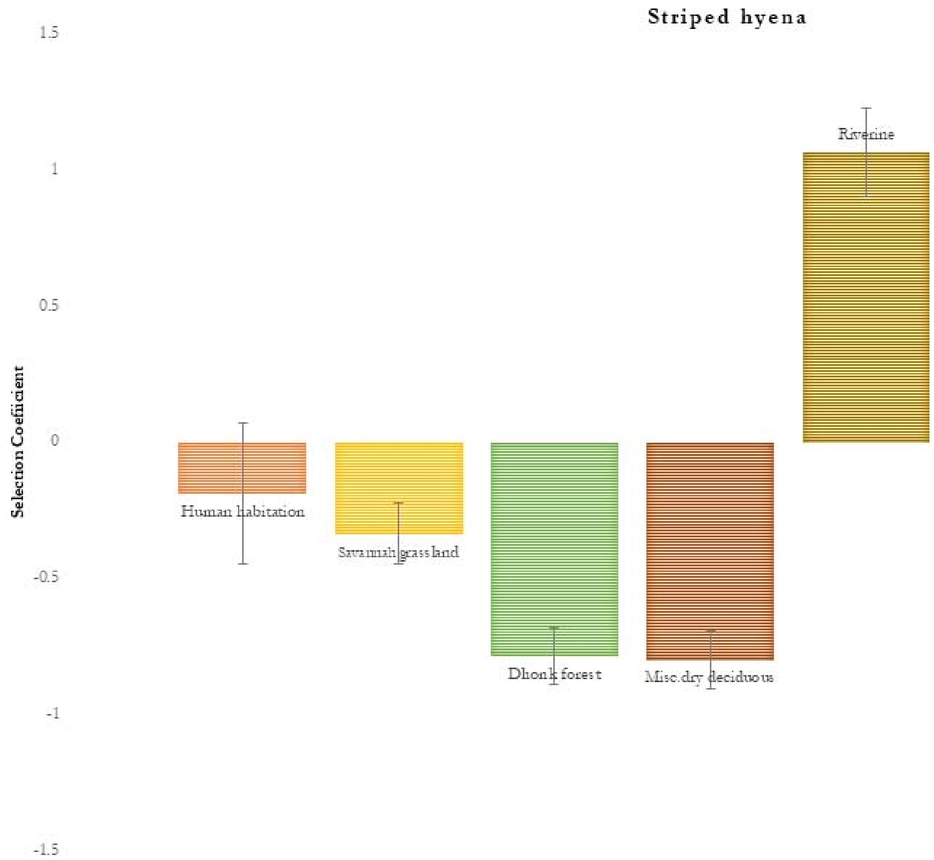


***Figure 6.2.4.2**. Habitat selection of radio-collared striped hyenas in Kuno Wildlife Division using the Resource Selection Function, error bars depict standard errors*

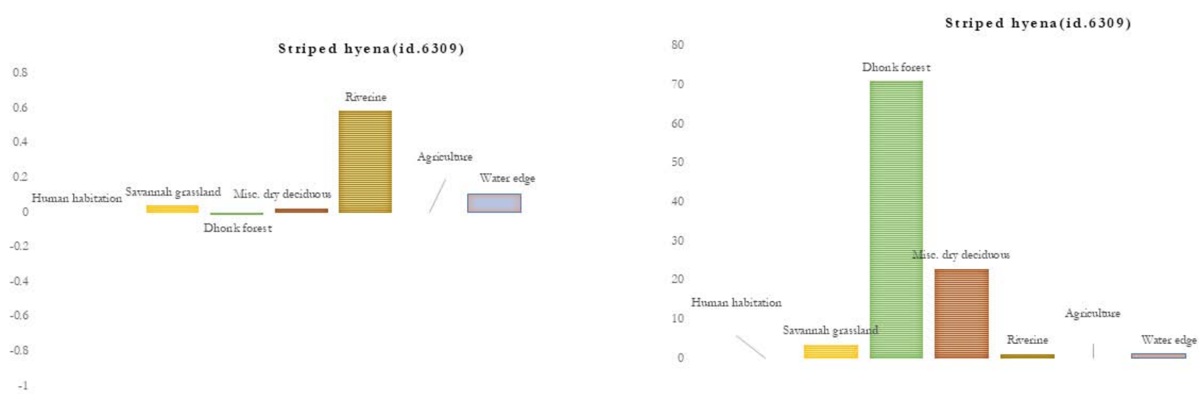


***Figure 6.2.4.3.** Habitat selection of radio-collared striped hyena (6309) adult male using Ivlev's index (left) and percentage of locations in each habitat type (right)*

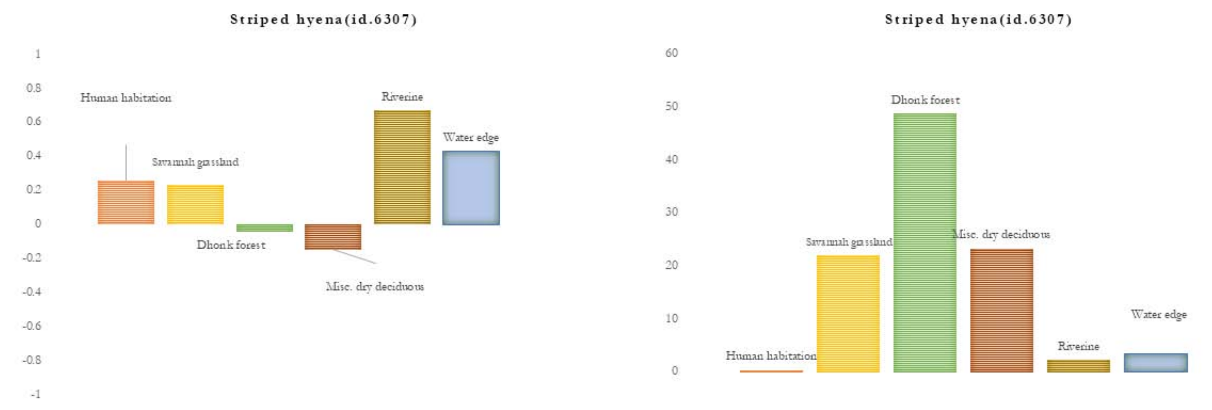


__Figure 6.2.4.3.__ Habitat selection of radio-collared striped hyena (6307) sub-adult male using Ivlev's index (left) and percentage of locations in each habitat type (right)

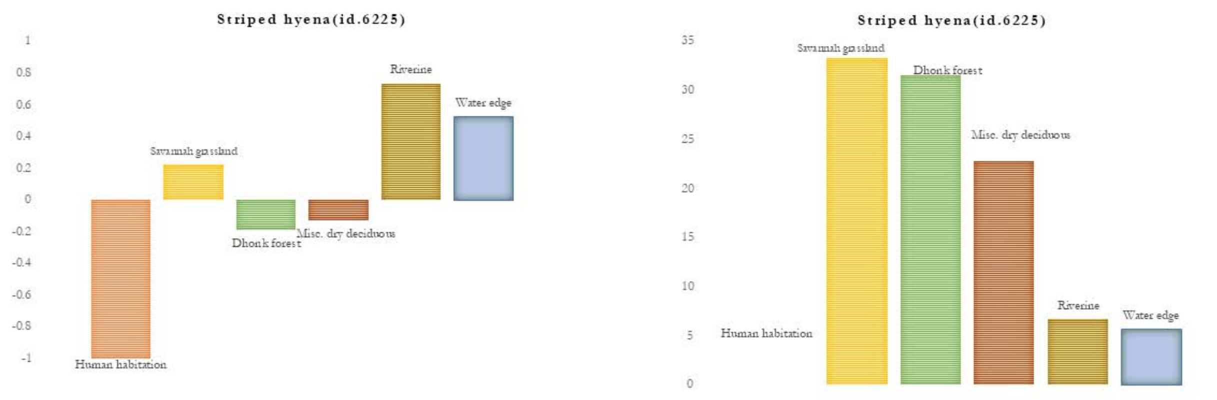


__Figure 6.2.4.4.__ Habitat selection of radio-collared striped hyena (6225) young male using Ivlev's index (left) and percentage of locations in each habitat type (right)

6.2.5. Ecological importance of small carnivores

Often overlooked, small carnivores play a significant role in "middle-out" ecosystem dynamics (Bandyopadhyay *et al.* 2024, Marneweck *et al.* 2022), primarily by modulating prey and plant populations (Nagy-Reis *et al.* 2017). As secondary consumers, they exert a distinct top-down influence on herbivory, initiating trophic cascades at both species and community levels (Polis *et al.* 2000). Their presence contributes to the maintenance of ecosystem health indirectly by safeguarding critical habitats and ecotones (Jachowski *et al.* 2020), and by promoting economic stability in agro-pastoral systems through pest control and mitigation of vector-borne diseases (Mukherjee *et al.* 2004, Hofmeester *et al.* 2017). Furthermore, small carnivores occupying intermediate trophic levels may serve as sentinels, influencing various ecological processes such as landscape connectivity, seed dispersal, gene flow (Salom Pérez, 2019), disease dynamics affecting human health (Jachowski *et al.* 2020), management of non-native species, and bioaccumulation (Peterson *et al.* 2021).

India's Open-Natural Ecosystems have witnessed profound qualitative and quantitative degradation compared to other ecotypes in the sub-continent (Ranjitsinh & Jhala 2010). It is imperative to prioritize the conservation of these degraded grasslands and scrubland habitats. Government initiatives like Project Cheetah (Jhala *et al.* 2021) are crucial steps towards addressing research gaps in the long term. Assessing the abundance, density, and space-use patterns of meso-carnivores in protected reserves, particularly along gradients of human and large carnivore influence, is essential for the epistemological understanding required to safeguard these natural habitats.

6.2.5.1. Movement and home range of golden jackal

The golden jackal is a generalist predator and occurs across most of its range with medium to high densities seen in places with plenty of food and cover (Jhala and Moehlman 2013). They are omnivorous and opportunistic foragers (Temu, Nahonyo and Moehlman 2018) and in addition to hunting, they subsist by scavenging (Sheldon 1992). They feed primarily on rodents, birds as well as fruits (Mukherjee *et al.* 2004). In India, they often wander into human habitations at night to feed on human subsidies, or scavenge on livestock carcasses (Jhala and Moehlman 2008). As facultative scavengers, they play a significant role in the removal of considerable amounts of discarded animal waste and potential crop pests in urban ecosystems (Ćirović, Penezić & Krofel 2016). They have flexible social systems (Macdonald 1979) and vary according to the availability of food (Chourasia *et al.* 2012). Golden jackals are facultative cooperative hunters and often hunt prey larger than their body size (Moehlman 1986). They are not strictly territorial (Aiyadurai 2001) and their home range sizes range from 3 to 30 km² (Aiyadurai and Jhala, 2006). The changes in the agro-pastoral system over the last 25-30 years have contributed to a significant decline in the jackal population (Negi 2014). The diseases and competition from feral dogs are considerable concerns for the jackal population in India (Jhala, Qureshi & Yadav 2021). The assessment of abundance, movement ecology, food habits, habitat use, and factors influencing the den site selection of golden jackal will provide valuable insights, which is essential for effective management and conservation of the species.

Image 6.2.4. *A golden jackal and a cheetah in Kuno National Park ©Moulik Sarkar*

6.2.5.1.1 Capturing and radio-collaring of golden jackals

In order to humanely capture and radio-collar golden jackals, two types of traps were deployed: padded foothold traps and double door walk through cage. These traps were set up at locations of frequent direct sightings or photo-captured in the camera traps. Baits such as chicken waste and opportunistic carcasses helped in attracting targeted species to the trap. These traps were monitored every 2-3 hours. The immobilization of individuals (n=2) was carried out by a team of proficient veterinarians by using a combination of meditomedine and zolotil for the procedure. The animals were fitted with GPS (UHF) collars from African Wildlife Tracking, which weighed between 2 - 4% of their body weight. The collars were provided with a cotton insert designed to act as a "drop-off" device at the completion of the study. This feature enabled the collars to be collected at their last known GPS locations. The age of the individuals was determined by examining teeth wear and their sex was documented. During the process, a thorough health examination of the animals was conducted, and their morphometric details were recorded. A reversal drug was administered to ensure full recovery from effects of anesthesia. The GPS (UHF) collars were programmed to record GPS locations every three hours during the telemetry period.

6.2.5.1.2. Monitoring of radio-collared golden jackal

The radio-collared animals were visually monitored on a regular basis, and environmental parameters were recorded whenever they were sighted. These parameters included broad habitat type, micro-habitat, weather conditions, terrain type and the nearest source of water. The GPS locations were downloaded using AWT transceiver. The data collection began in October 2023 and is still ongoing and both the radio-collars are active.

6.2.5.1.3. Home range and average daily movement of radio-collared golden jackal

The home-range sizes of the golden jackals using kernel density estimates (95% and 50% KDE) and 100% and 95% Minimum Convex Polygon (MCP) methods and average daily distance moved are provided in the Table 6.2.5.1.3.

Table 6.2.5.1.3. *Home range sizes and average daily movement of radio-collared golden jackals in the Kuno Wildlife Division*

Animal Tag ID &Type	Age category & Sex	100%MCP Area (km²)	95%KDE Area (km²)	50%KDE Area (km²)	Average daily distance moved (km)	Days
Golden Jackal UHF 6790 (GPS)	Sub-adult Male	0.37	0.21	0.1	0.89(0.07SE)	84
Golden Jackal UHF 6792 (GPS)	Adult Male	66.13	6.31	0.19	4.54(0.20SE)	176

©Moulik Sarkar

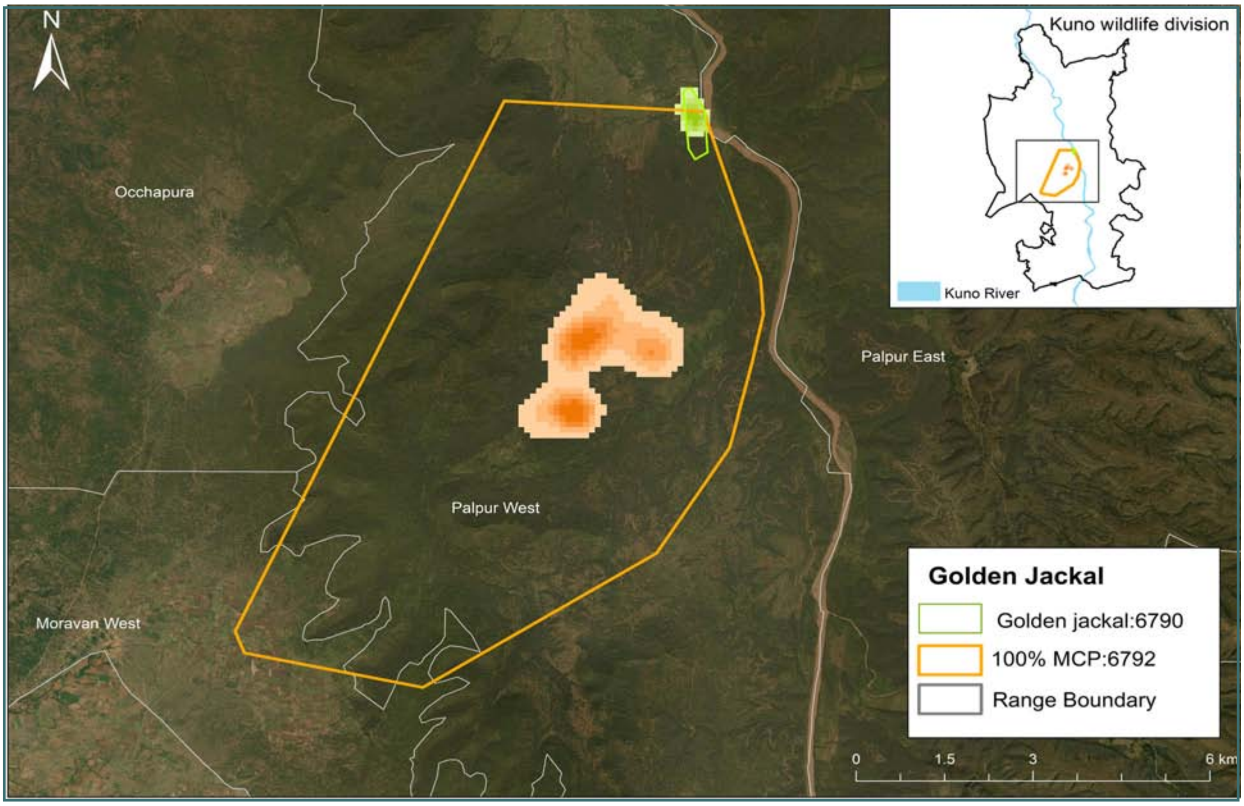


Figure 6.2.5.1.3.1. *Home range (100%MCP and 95% KDE) of radio-collared golden jackals in Kuno Wildlife Division*

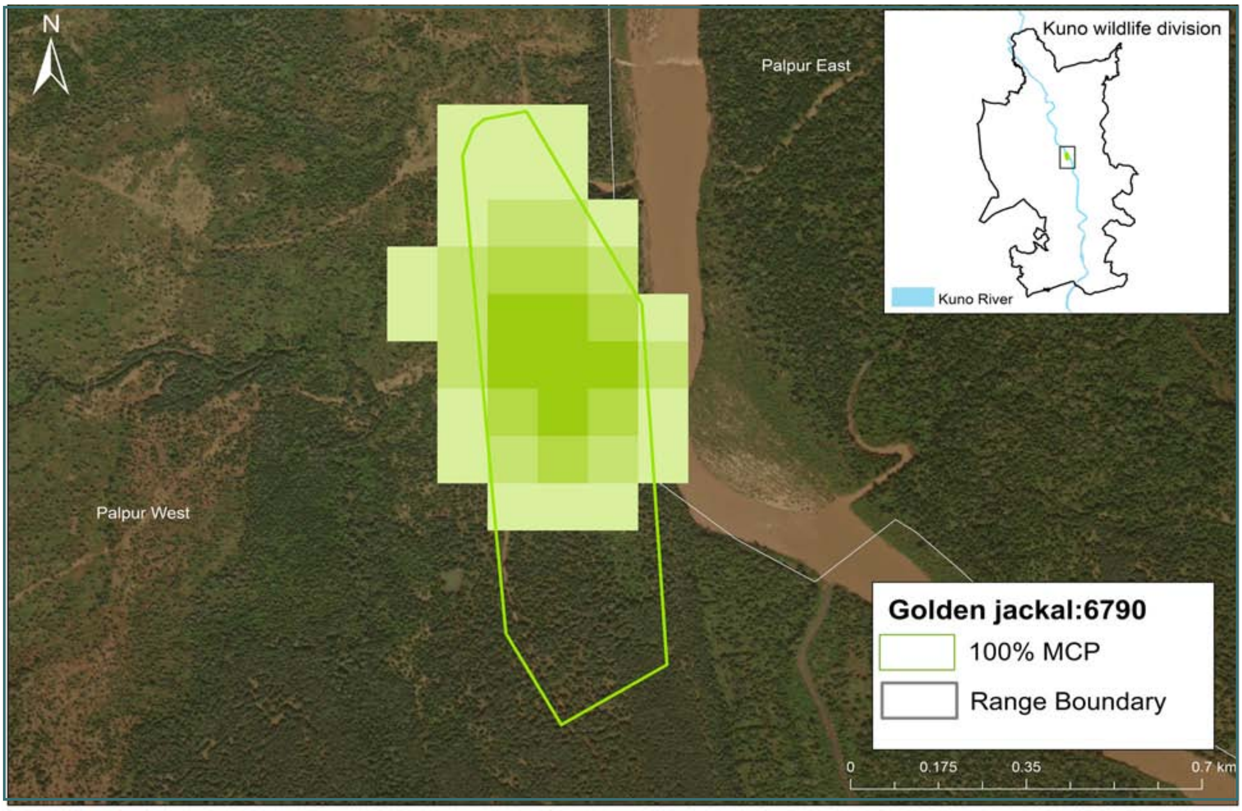


Figure 6.2.5.1.3.2. *Home range (100%MCP & 95% KDE) of radio-collared golden jackal sub-adult male (id. 6790) in Kuno Wildlife Division*

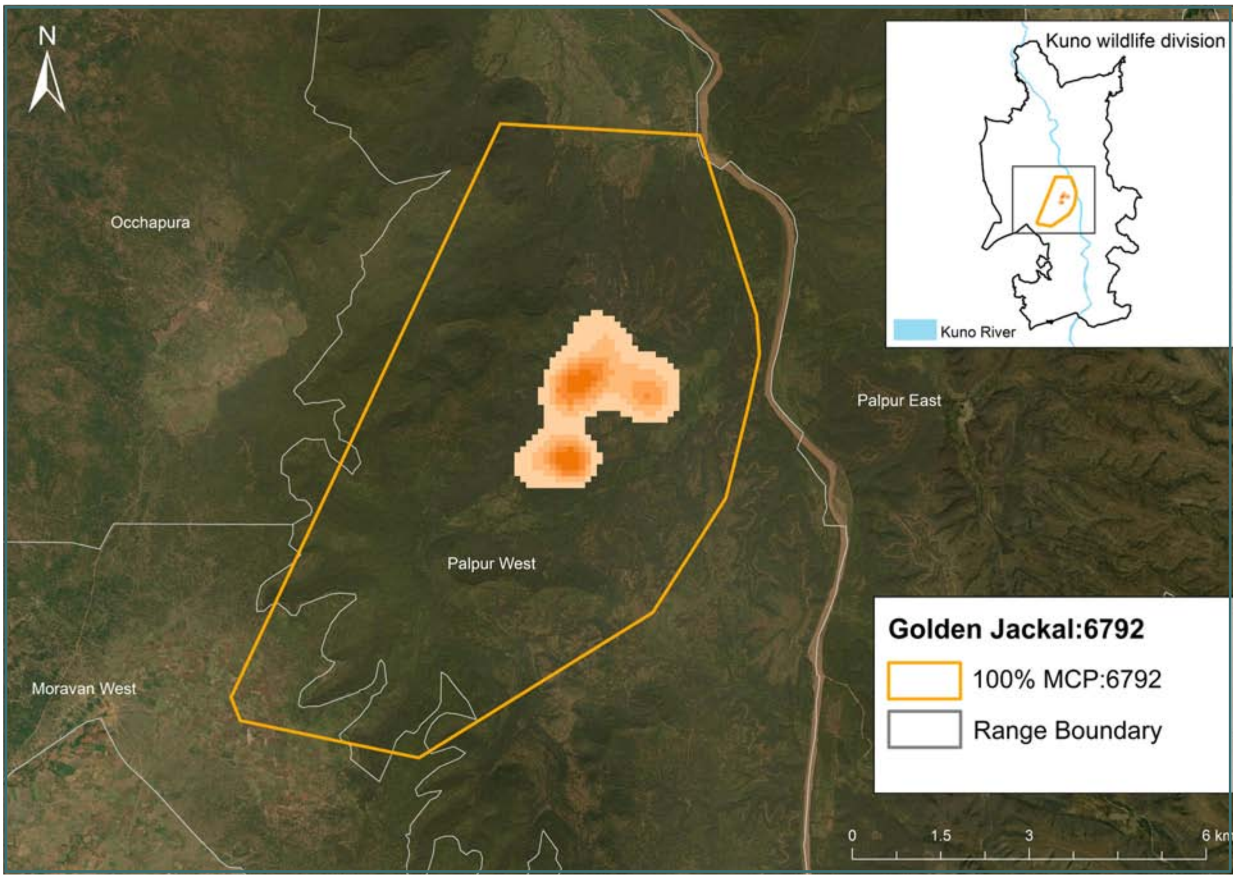


Figure 6.2.5.1.3.3. Home range (100%MCP & 95% KDE) of radio-collared golden jackal adult male (id. 6792) in Kuno Wildlife Division

6.2.5.2. Habitat selection of radio-collared golden jackal in Kuno Wildlife Division

Two thousand and forty-one GPS locations of two radio-collared golden jackals obtained at various time intervals during the day were analyzed to investigate their habitat use pattern. The locations were plotted on Land Use and Land Cover (LULC) map of the study area. Habitat utilization by radio-collared jackals was estimated using the Resource Selection Function (RSF) and Ivlev's index. The 100% MCP (Minimum Convex Polygon) of each individual was calculated, and the proportion of different habitat types within each home range was compared to the proportion of those habitat types available in the study area. Habitat selection for the individual was measured with Ivlev's index using R packages adehabitatHS. Habitat selection ratios range from -1 to +1, indicating the degree of preference or avoidance for a habitat class. A value of -1 signifies strong avoidance of that habitat class, while a value of +1 denotes strong preference.

Based on the Resource Selection Function, it was found that golden jackals selected areas next to human habitation which in the context of the National Park is the patrolling camp of the forest department. These animals were collared near these camps, owing to which their area of use highly overlaps with the area of the camp. Proportionality of locations show high use of dhonk forest by the adult male.

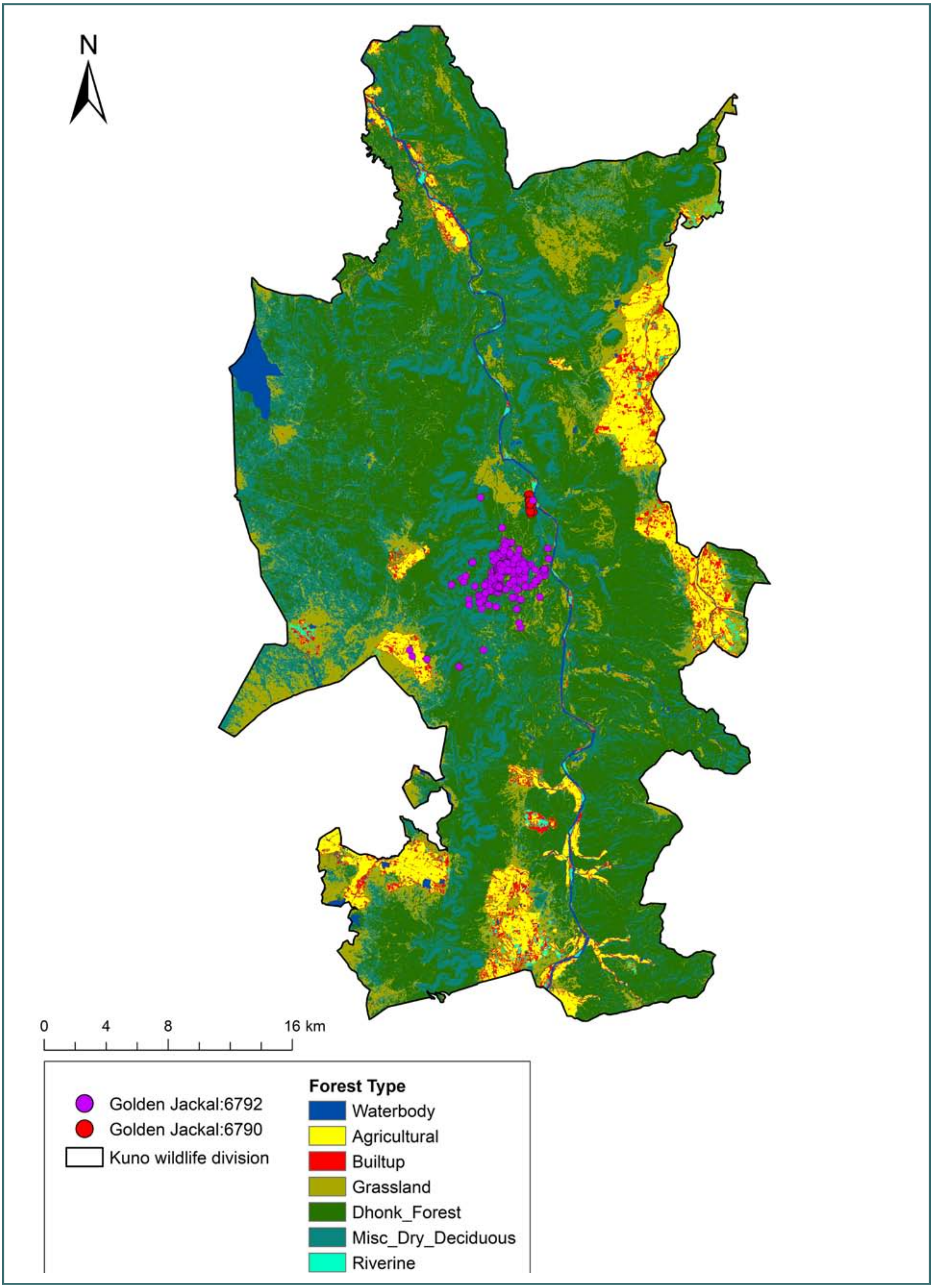


***Figure 6.2.5.2.1**. Locations of radio-collared golden jackals overlaid on the forest type map of Kuno Wildlife Division*

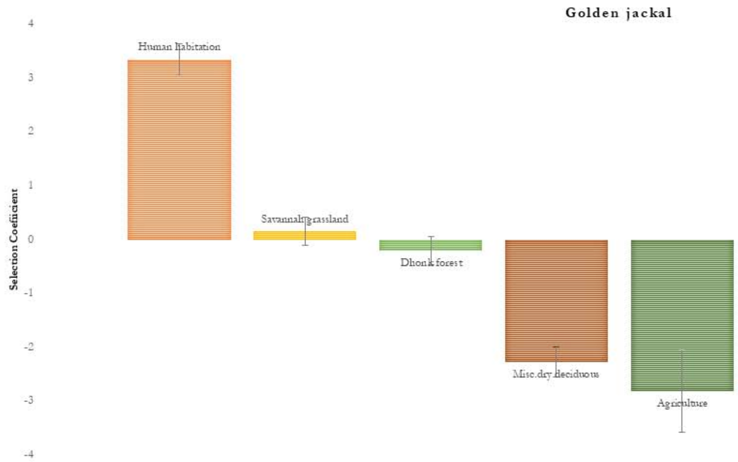


Figure 6.2.5.2.2. *Habitat selection of radio-collared golden jackals in Kuno Wildlife Division using the Resource Selection Function, human habitation is patrolling camp of the forest department and error bars depict standard errors*

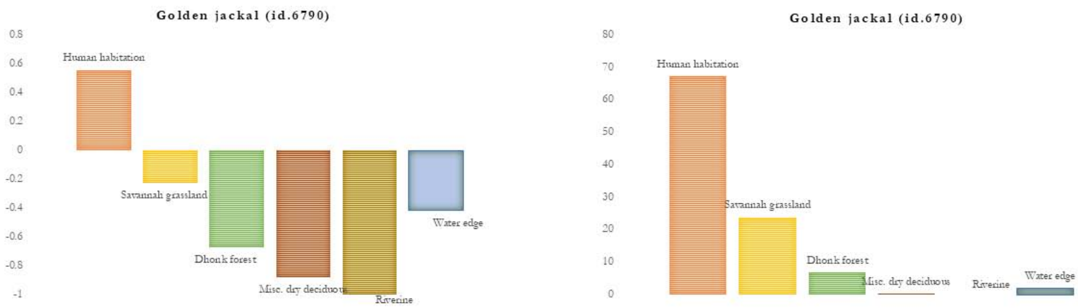


Figure 6.2.5.2.3. *Habitat selection of radio-collared golden jackal sub-adult male (id. 6790) using Ivlev's index (left) and percentage of locations in each habitat type (right), human habitation is pa-trolling camp of the forest department*

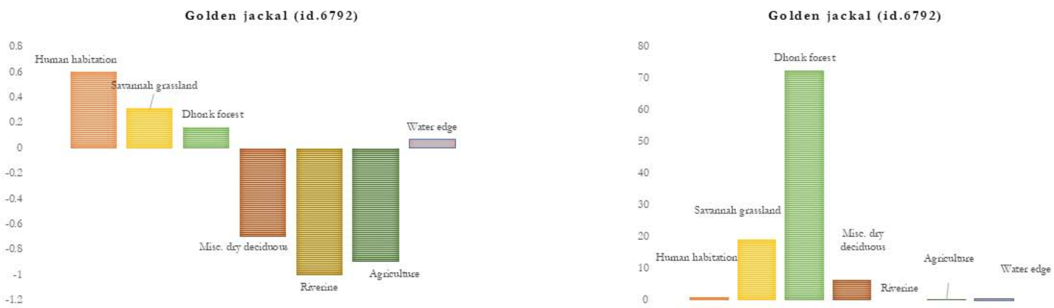


Figure 6.2.5.2.4. *Habitat selection of radio-collared golden jackal adult male (id. 6792) using Ivlev's index (left) and percentage of locations in each habitat type (right), human habitation is patrolling camp of the forest department*

6.2.5.3. Capturing, radio-collaring, and home ranges of jungle cats

Jungle cats were humanely captured using a combination of cage traps and padded foothold traps, with traps being monitored visually every 2 to 3 hours. Visual and olfactory lures, such as chicken legs, stuffed animals, feathers, gland scents, urine, and blood, enhanced capture efficiency. Immobilization of individuals (n=3, adult males) was performed by experienced veterinarians in the presence of forest department staff using a combination of ketamine, medetomidine, and butorphanol or alternative formulations as available. Animals were fitted with GPS (UHF) collars (Africa Wildlife Tracking), weighing between 2% and 4% of their body weight. The collars were equipped with a cotton insert designed to act as a "drop-off" device at the conclusion of the study, enabling collection based on the last known GPS locations. These marking methods are commonly accepted in wild mammal research. Age and body-mass index were estimated by examining teeth wear and collecting morphometric data from all captured animals. Following full recovery from anesthesia, all animals were released into the wild. GPS (UHF) collars were programmed to record location data every 3 hours during the telemetry period.

The total trapping effort amounted to 447 trap nights, with three out of four UHF collars actively collecting data. Data collection began in March 2023 and continues to be ongoing. Habitat data, including visual sightings and den sites, were collected following the protocol of Jhala *et al.* (2017).

Image 6.2.5. *Radio-collaring of jungle cat in Kuno National Park © Moulik Sarkar*

Home range size (100% MCP) of male jungle cats ranged from 4.45 to 16.45 km^2. The latter is of a sub-adult male. The average daily distances moved ranged from a minimum of 1.8(0.3SE) km to a maximum of 2.62(0.8SE) km.

Table 6.2.5.3. *Home range of radio-collared jungle cats in Kuno Wildlife Division*

Animal &TagID/ Type	Age category & Sex	100%MCP Area (km^2)	95%KDE Area (km^2)	50% KDE Area (km^2)	Average daily distance moved (km)	Days
Jungle Cat UHF 6795 (GPS)	Adult male	4.87	2.61	0.64	1.87(0.3SE)	366
Jungle Cat UHF 6793 (GPS)	Adult male	6.35	3.66	0.49	2.62(0.8SE)	183
Jungle Cat UHF 6791 (GPS)	Sub-adult male	16.45	7.9	0.5	1.8(0.3SE)	251
Jungle Cat UHF 6794 (GPS)	Adult male	4.45	2.62	0.43	1.8(0.4SE)	125

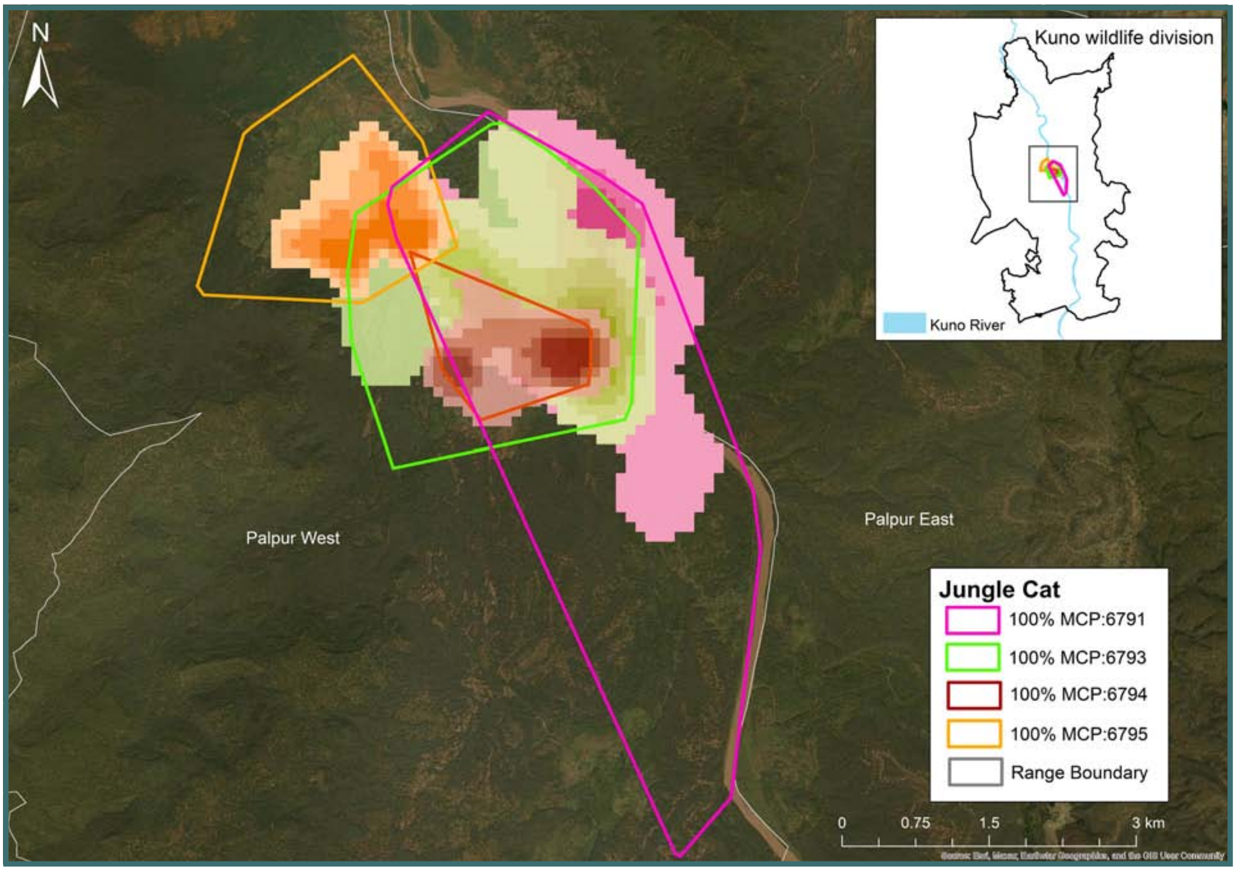


Figure 6.2.5.3.1. *Home ranges (100% MCP & 95%KDE) of radio-collared jungle cats in Kuno Wildlife Division*

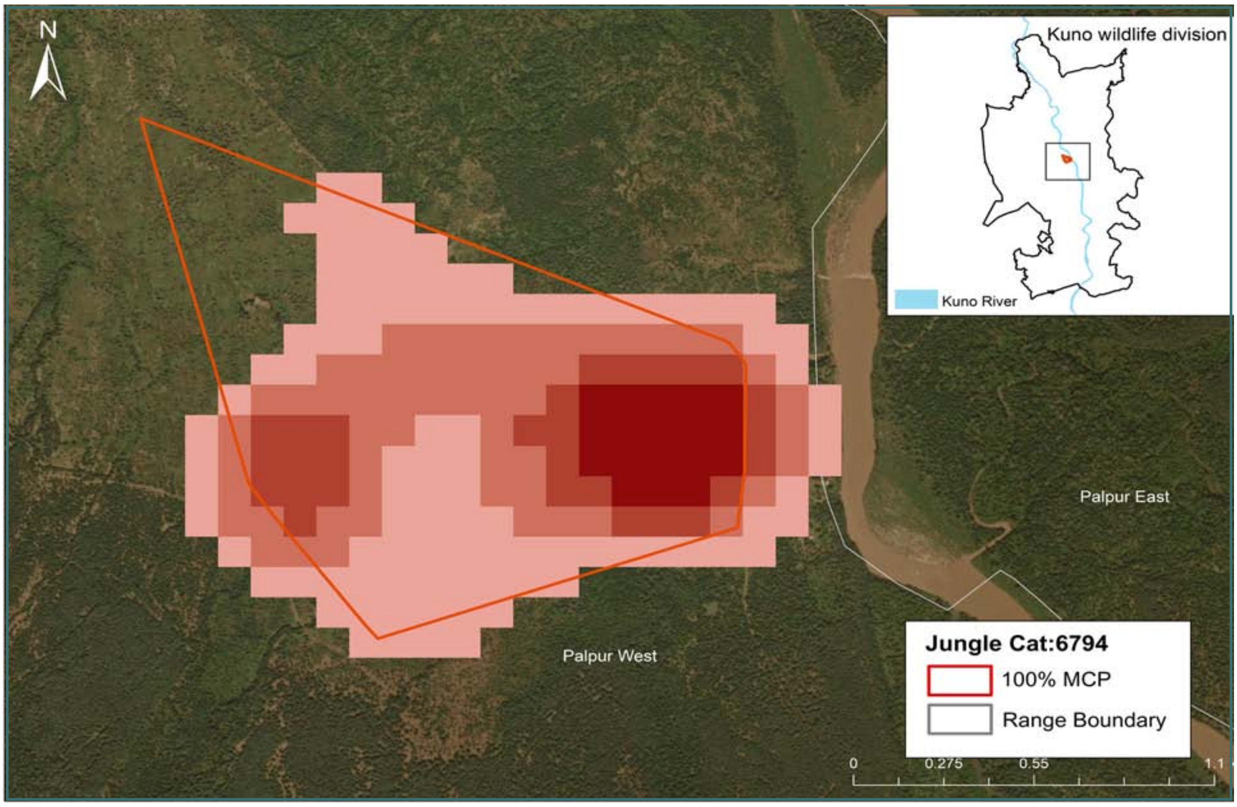


Figure 6.2.5.3.2. *Home range (100%MCP & 95% KDE) of radio-collared jungle cat adult male (id. 6794) in Kuno Wildlife Division*

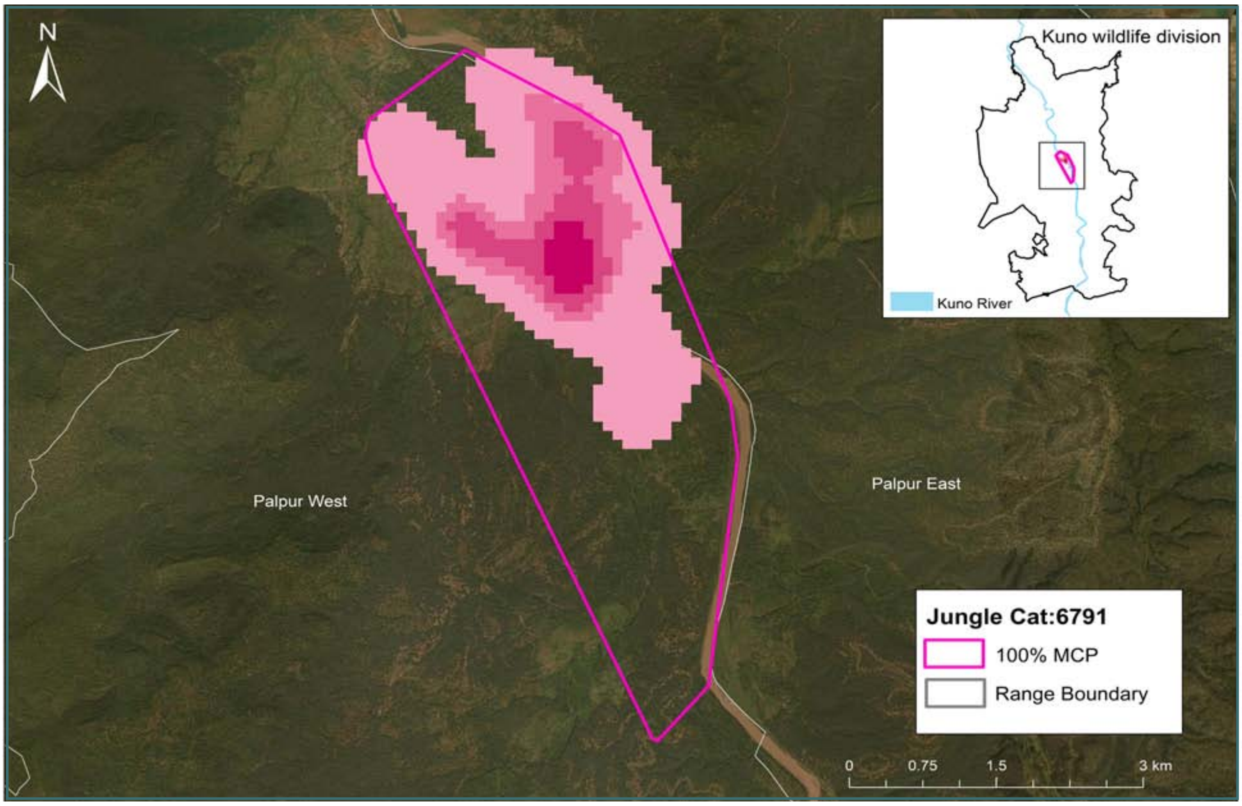


Figure 6.2.5.3.3. *Home range (100%MCP & 95% KDE) of radio-collared jungle cat (id. 6791) in Kuno Wildlife Division*

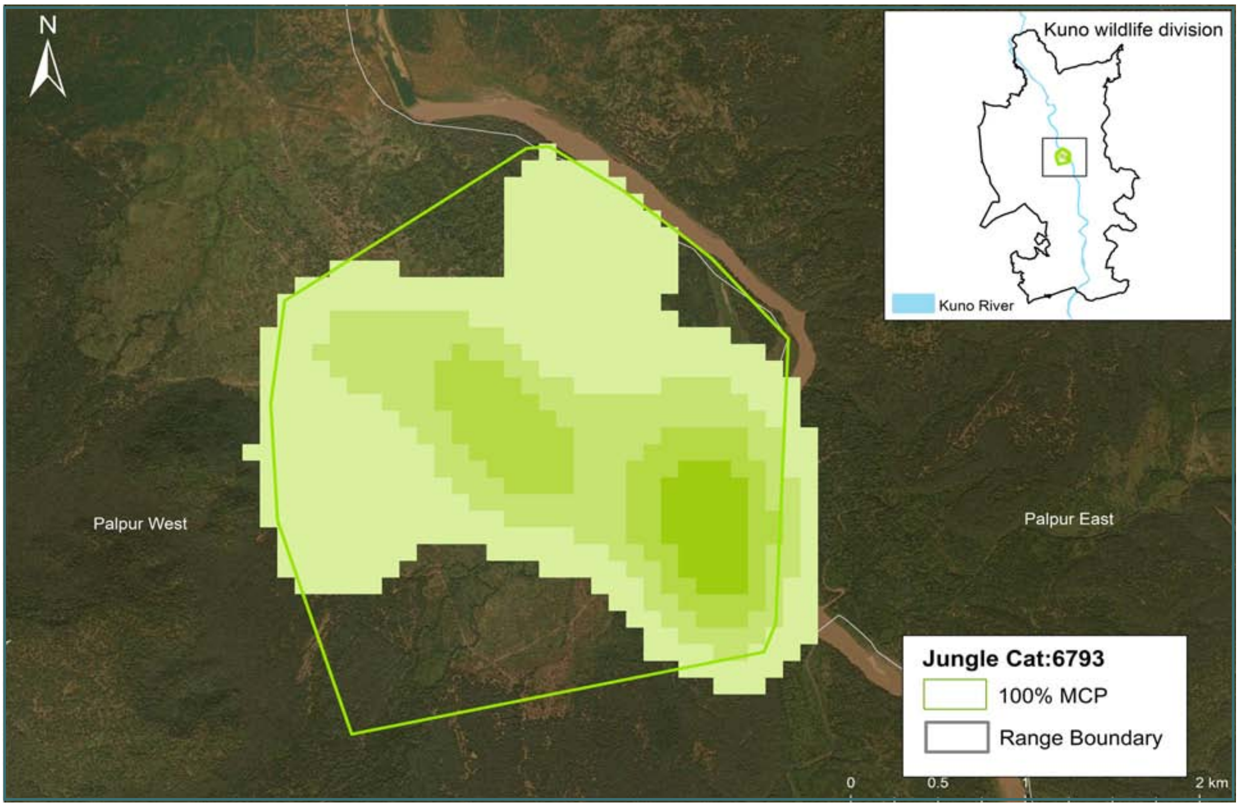


Figure 6.2.5.3.4. *Home range (100%MCP & 95% KDE) of radio-collared jungle cat (id. 6793) in Kuno Wildlife Division*

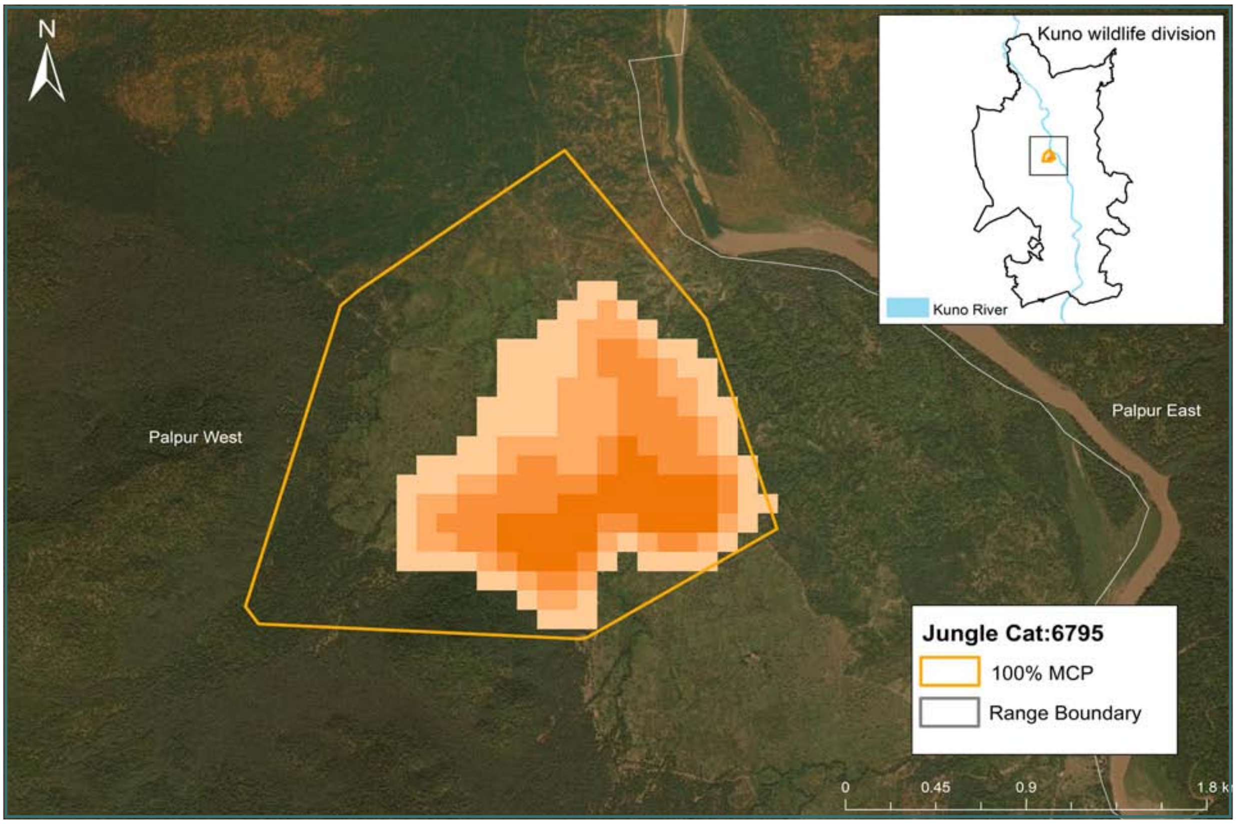


Figure 6.2.5.3.5. Home range (100%MCP & 95% KDE) of radio-collared jungle cat (id. 6795) in Kuno Wildlife Division

6.2.5.4. Habitat selection of the radio-collared jungle cats in Kuno Wildlife Division

Using the Resource Selection Function (RSF), the habitat selection of radio-collared jungle cats based on locations from available habitats in Kuno Wildlife Division was assessed. Further, for individual preference, Ivlev's index was used to assess second-order habitat selection for each LULC class as described in earlier section 3.2.2.

Jungle cats selected human habitation (patrolling camps) and savannah grassland patches inside Kuno NP. Three individuals were regularly visiting and staying in the premises of the forest department monitoring/protection camp in Palpur owing to which a high number of locations were obtained from the campsite. This probably has biased the preliminary results obtained here and additional data over time would reveal a better representation of habitat selection by jungle cats. One individual selected areas close to water followed by savannah savannah grassland patches. However, the proportion of locations was the highest in grassland for all the individuals.

Image 6.2.5.1. *Jungle cat in Kuno National Park © Parul Sen*

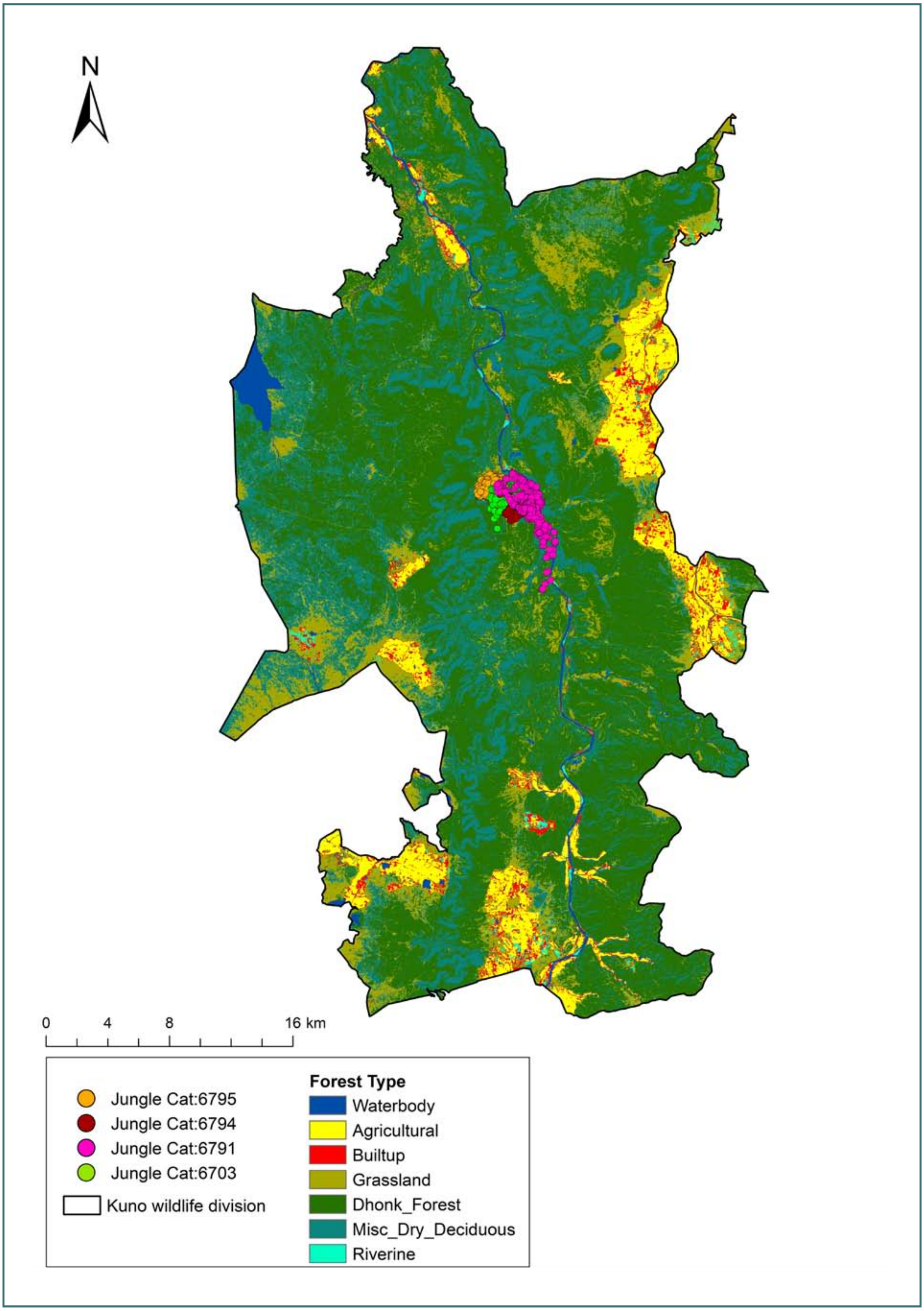


Figure 6.2.5.4.1. *Locations of radio-collared jungle cats overlaid on the forest type map of Kuno Wildlife Division*

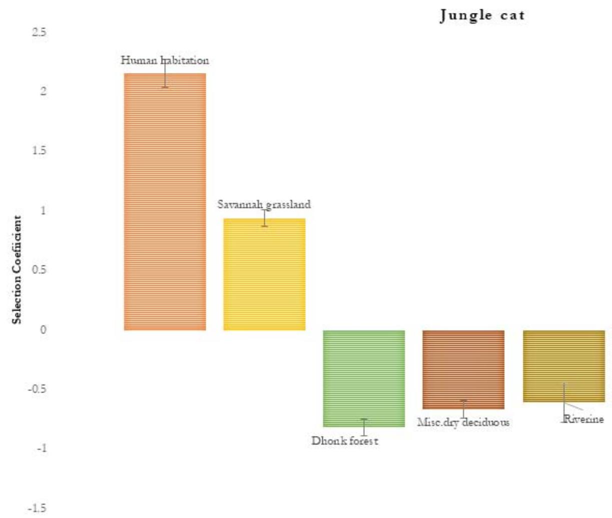


__Figure 6.2.5.4.2.__ Habitat selection of radio-collared jungle cats in Kuno Wildlife Division using the Resource Selection Function, human habitation is the patrolling camp of the forest department and error bars depict standard errors

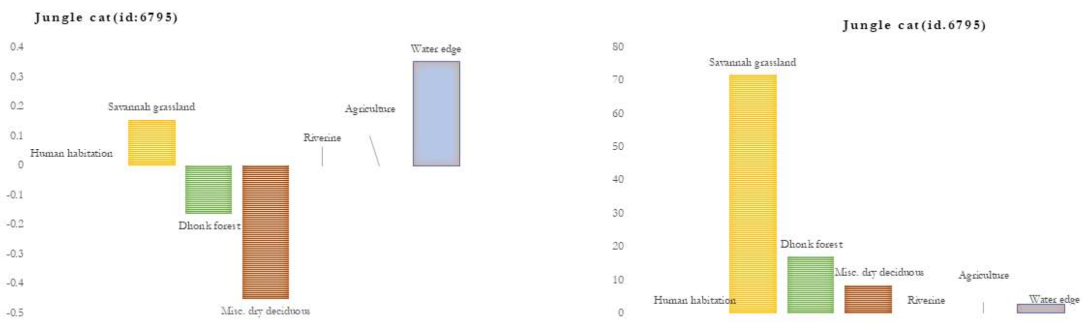
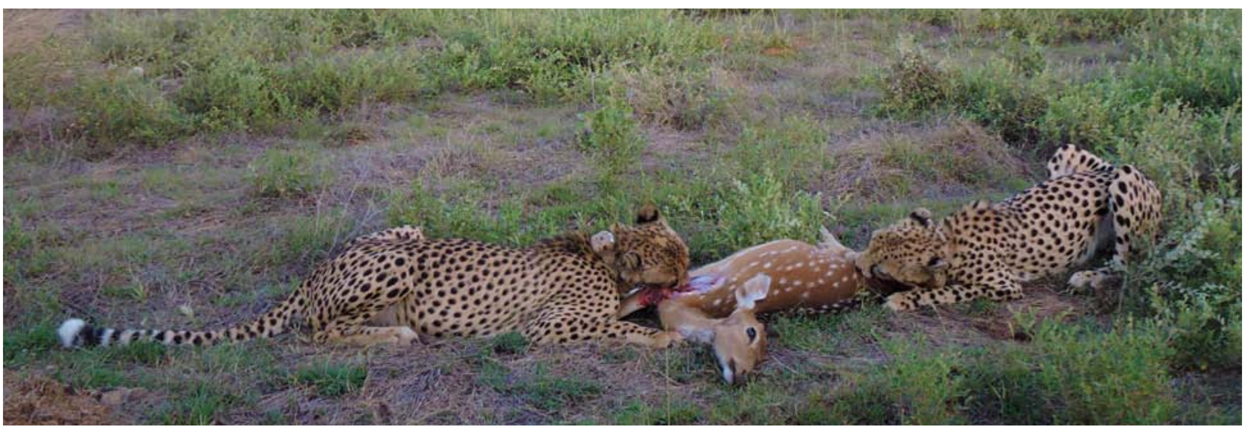


__Figure 6.2.5.4.3.__ Habitat selection of radio-collared jungle cat adult male (UHF ID 6795) using Ivlev's index (left) and percentage of locations in each habitat type (right), human habitation is the patrolling camp of the forest department



© Moulik Sarkar

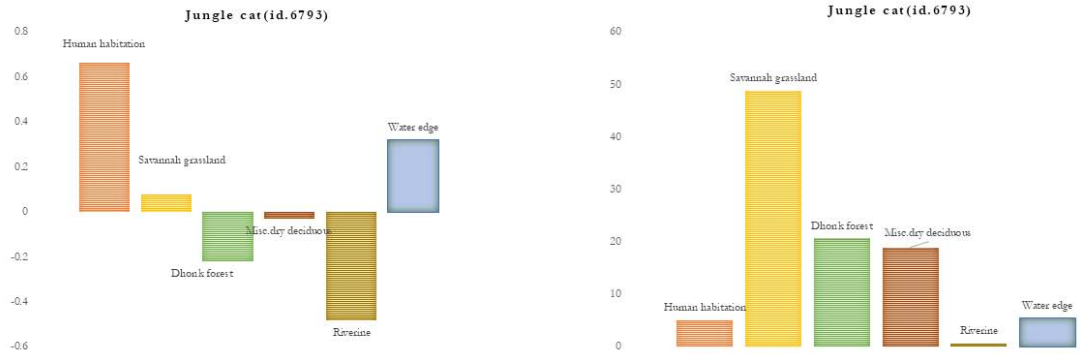


Figure 6.2.5.4.4. *Habitat selection of radio-collared jungle cat adult male (UHF ID 6793) using Ivlev's index (left) and percentage of locations in each habitat type (right) , human habitation is the patrolling camp of the forest department*

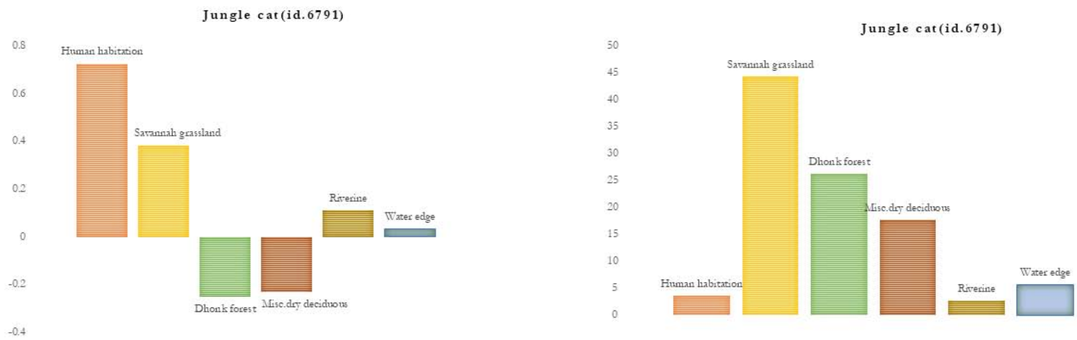


Figure 6.2.5.4.5. *Habitat selection of radio-collared jungle cat sub-adult male (UHF ID 6791) using Ivlev's index (left) and percentage of locations in each habitat type (right), human habitation is the patrolling camp of the forest department*

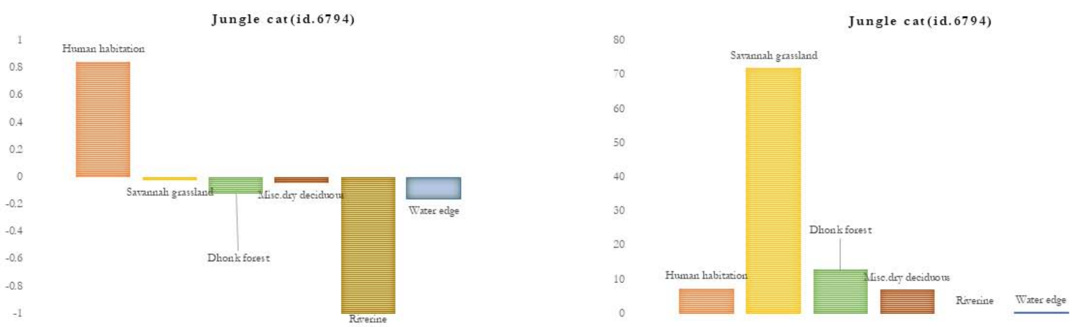


Figure 6.2.5.4.6. *Habitat selection of radio-collared jungle cat adult male (UHF ID 6794) using Ivlev's index (left) and percentage of locations in each habitat type (right), human habitation is the patrolling camp of the forest department*

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6.3. Population assessment of co-predators in Gandhi Sagar Wildlife Sanctuary

In Gandhi Sagar WLS, a camera trap survey was carried out from October 2023 to January 2024. A total of 161 locations were sampled in the WLS area to obtain photo-captures of carnivores (Figure 6.3.1.). The total effort involved 7042 camera days.

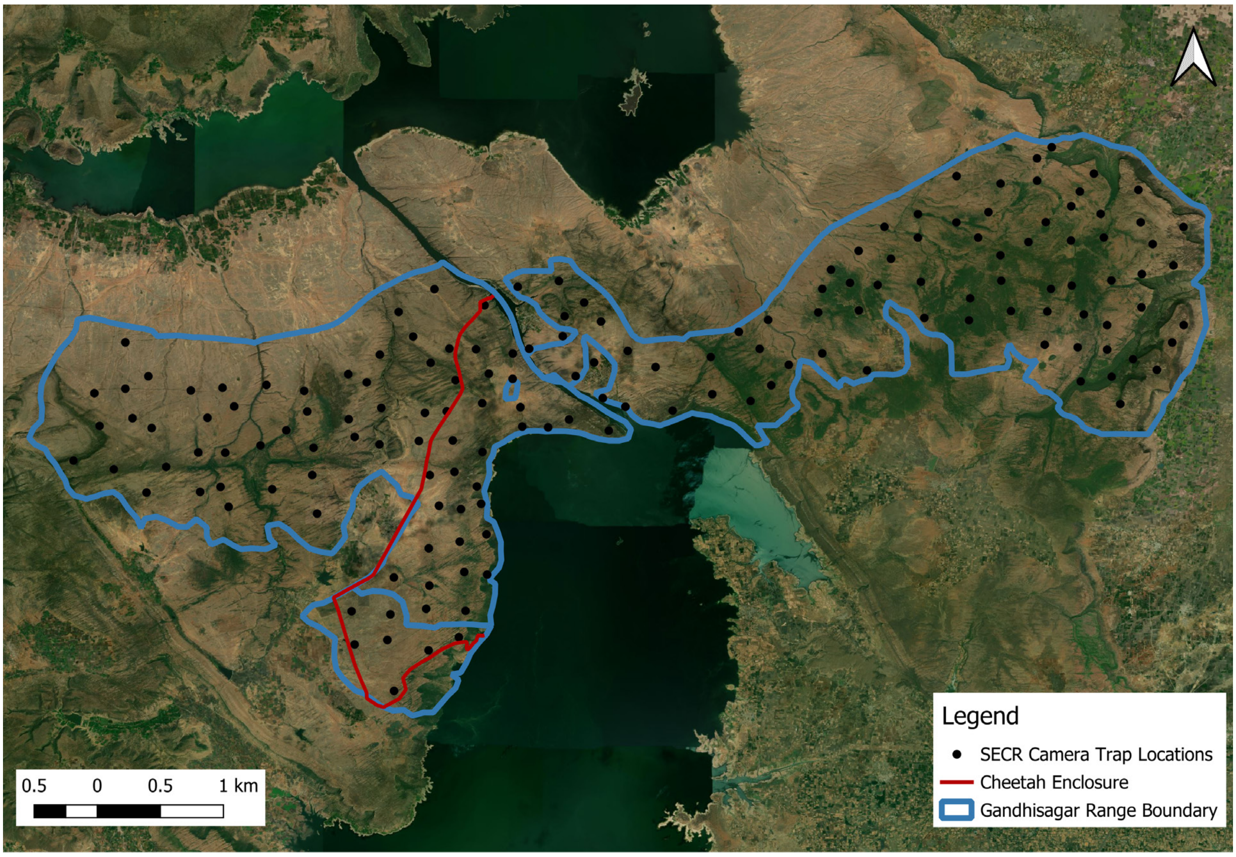

Figure 6.3.1. *Locations of camera traps deployed in Gandhi Sagar Wildlife Sanctuary to assess status of large mammalian predators*

A total of 122 individual leopards were identified from Gandhi Sagar East and West Ranges, out of which 68 unique individuals were identified from the West Range (160 km^2 sampled area) and 54 were identified from the East Range (128 km^2 sampled area) of the Sanctuary. There were no common individuals in the data obtained from the two Ranges, as the river between them poses a major barrier and therefore, the density was estimated separately. A habitat mask was used to remove the non-habitat areas such as the reservoir of the dam. The density of leopards in the West Range was 27.6(3.3SE) individuals per 100 km^2, while in the East Range it was 16.4(2.3SE) individuals per 100 km^2.

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Table 6.3.1. *Summary of SECR analysis results for density of leopards in Gandhi Sagar Wildlife Sanctuary*

Parameters	Gandhi Sagar West Range 2023-24	Gandhi Sagar East Range 2023-24
Number of camera trap locations	80	81
Sampled Area (km^2)	160	128 km^2
Effort (camera trap days)	3630	3412
No. of Individuals ($M_{(t+1)}$)	68	54
Density (individuals per 100 km^2)	27.6(3.3SE)	16.4(2.3SE)
g0 (Male & Female)	0.030 & 0.053	0.024 & 0.037
Sigma (Male & Female)	1841.25m(94.51SE) & 1038.37m(40.64SE)	2741.53m(158.44SE) & 1138.84m(70.19SE)
P_{mix} (Male & Female)	29.39 & 70.6	29.1 & 70.8
95 % Confidence Interval	21.7- 35.1	12.5- 21.6

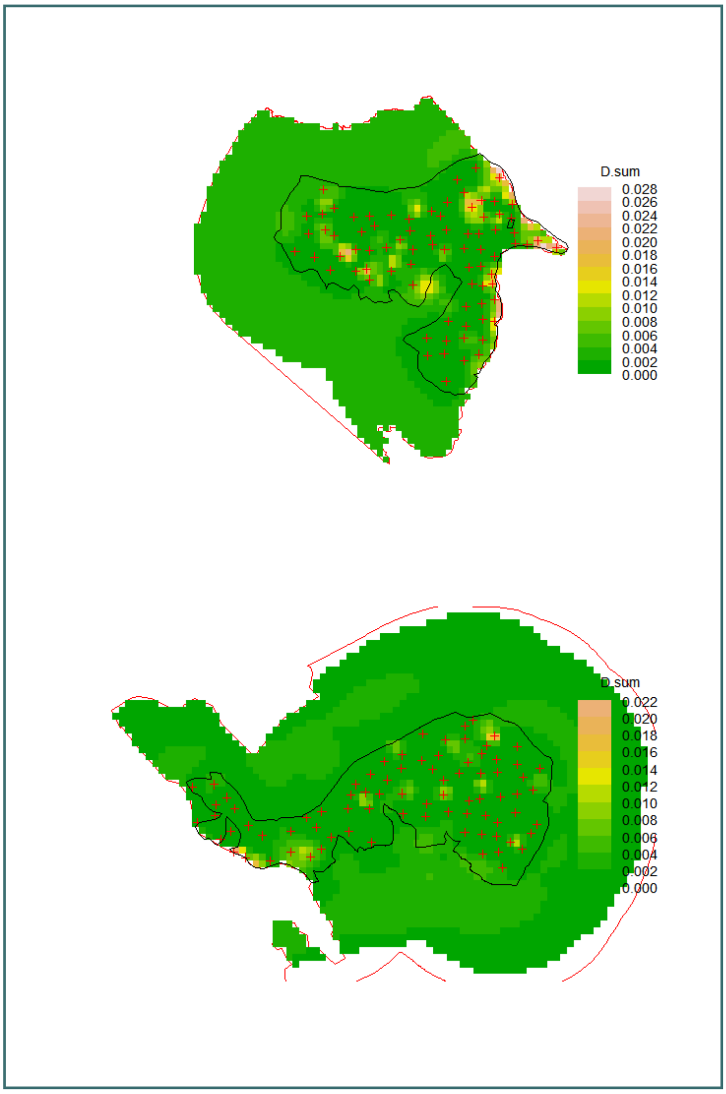

Figure 6.3.2. *Distribution of leopards in the West (top) and the East Ranges (bottom) of Gandhi Sagar Wildlife Sanctuary obtained from spatially explicit capture recapture using camera traps (denoted as +)*

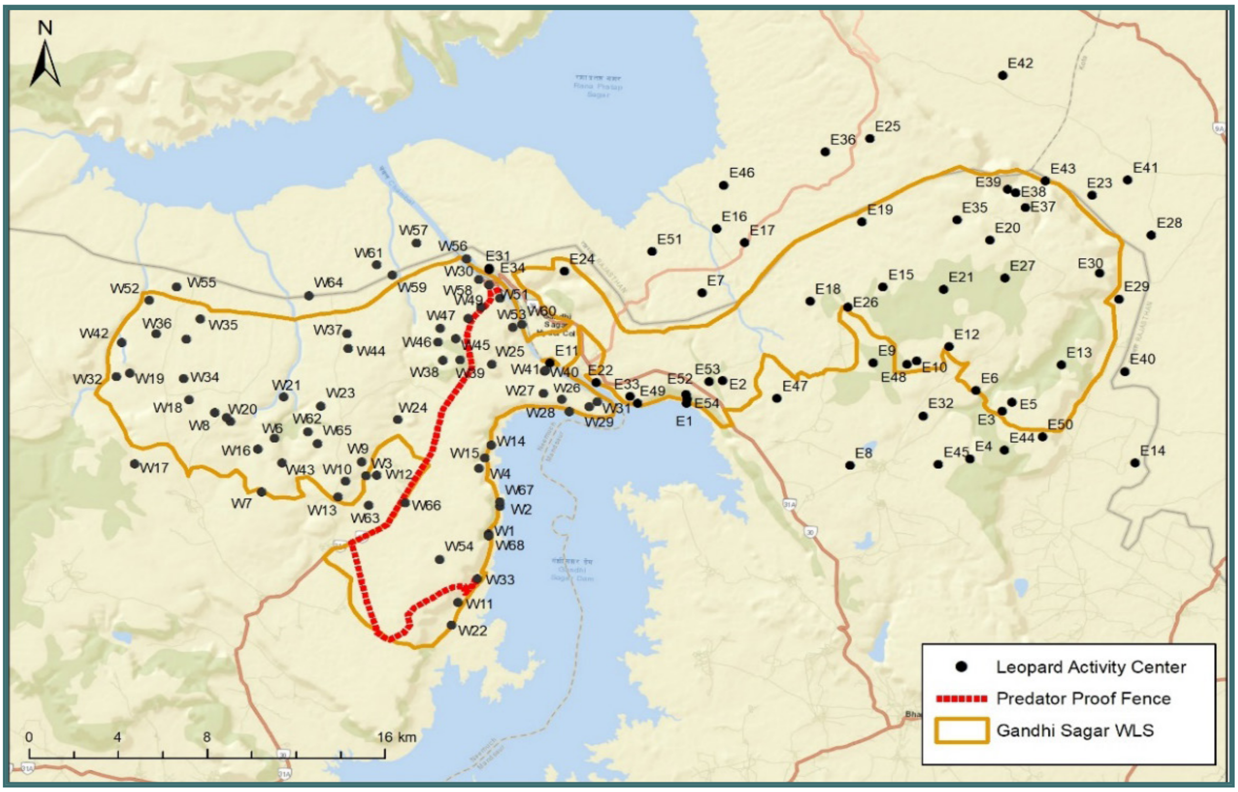

Figure 6.3.3. Activity centres of leopards in the West (68 individuals) and East (54 individuals) Ranges of Gandhi Sagar Wildlife Sanctuary obtained from spatially explicit capture recapture using camera trap sampling

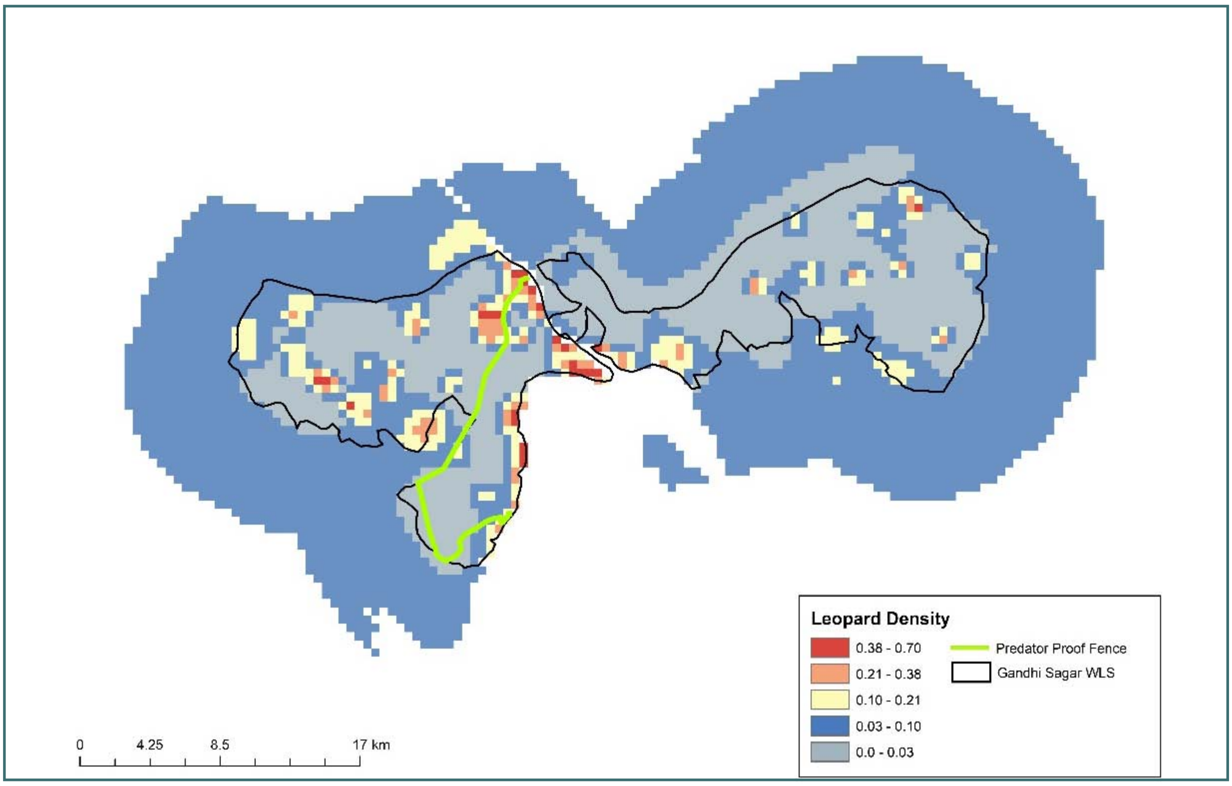

Figure 6.3.4. Spatial density (per hectare) of leopards obtained from spatially explicit capture recapture using camera trap survey in Gandhi Sagar Wildlife Sanctuary

6.4. Home range and movement of leopards in Gandhi Sagar Wildlife Sanctuary

Using the methods described in section 3.2.1., four leopards (2 males and 2 females) were humanely captured and radio-collared in Gandhi Sagar WLS by a team of veterinarians assisted by forest department staff and WII researchers. The home ranges (100%MCP) of male leopards ranged from 73.68 to 198.40 km^2 and for female leopards it was found to be 102.08 to 837.19 km^2. The average daily distance of radio-collared leopards ranged from a minimum of 4.02(0.36SE) of a female to 4.74(1.51SE) of a male leopard.

Table 6.4.1. Home ranges of radio-collared leopards in Gandhi Sagar Wildlife Sanctuary

Animal	Tag ID/ Type	Sex	100% MCP Area(km^2)	95% KDE Area(km^2)	50% KDE Area(km^2)	Average Daily Distance moved (km)
Leopard1	IR_SAT 8040	Female	837.19	544.5	52.35	4.02(0.36SE)
Leopard2	IR_SAT 8038	Female	102.08	73.51	13.87	4.32(0.29SE)
Leopard3	IR_SAT 8029	Male	198.40	233.46	35.89	4.74(1.51SE)
Leopard4	IR_SAT 8039	Male	73.68	104.82	16.59	4.42(0.3SE)

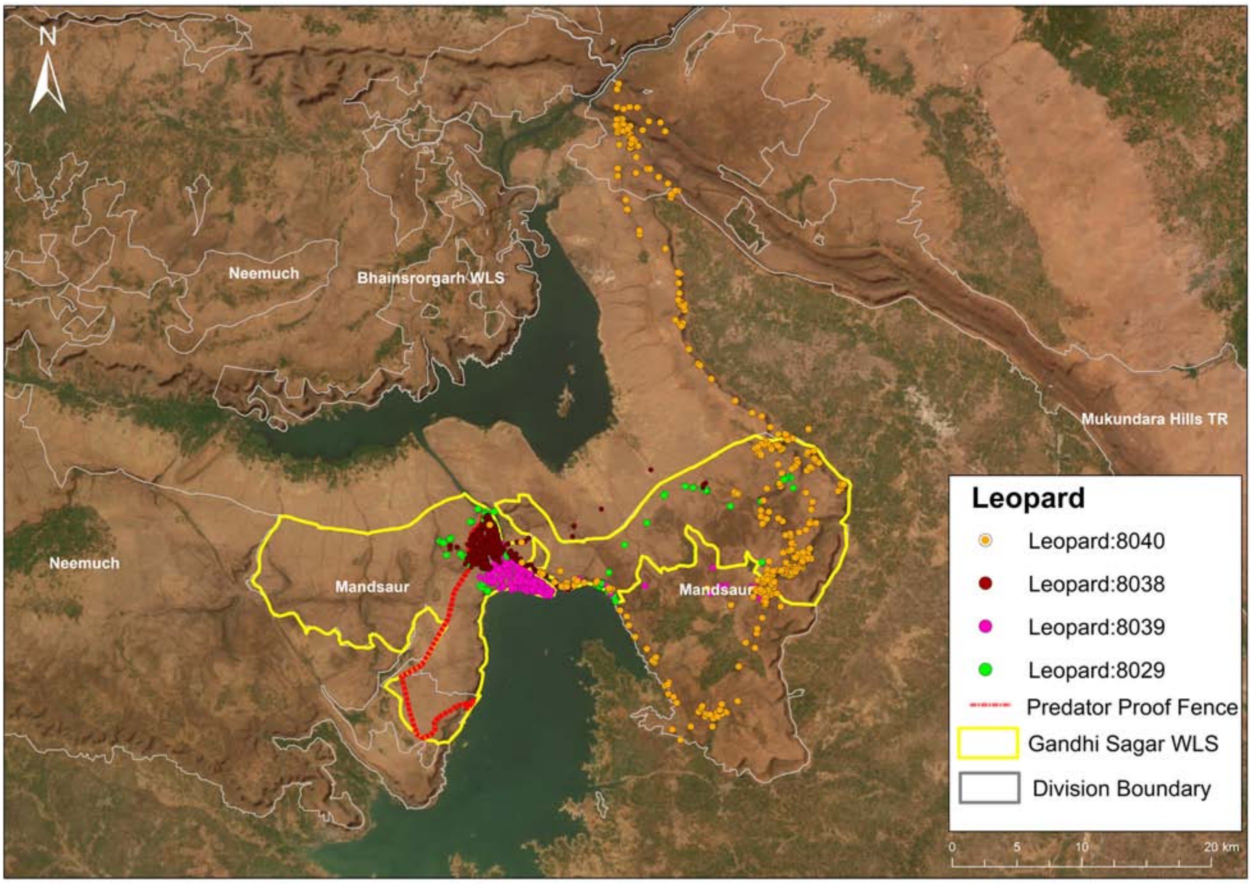

Figure 6.4.1. Locations of radio-collared leopards in Gandhi Sagar Wildlife Sanctuary

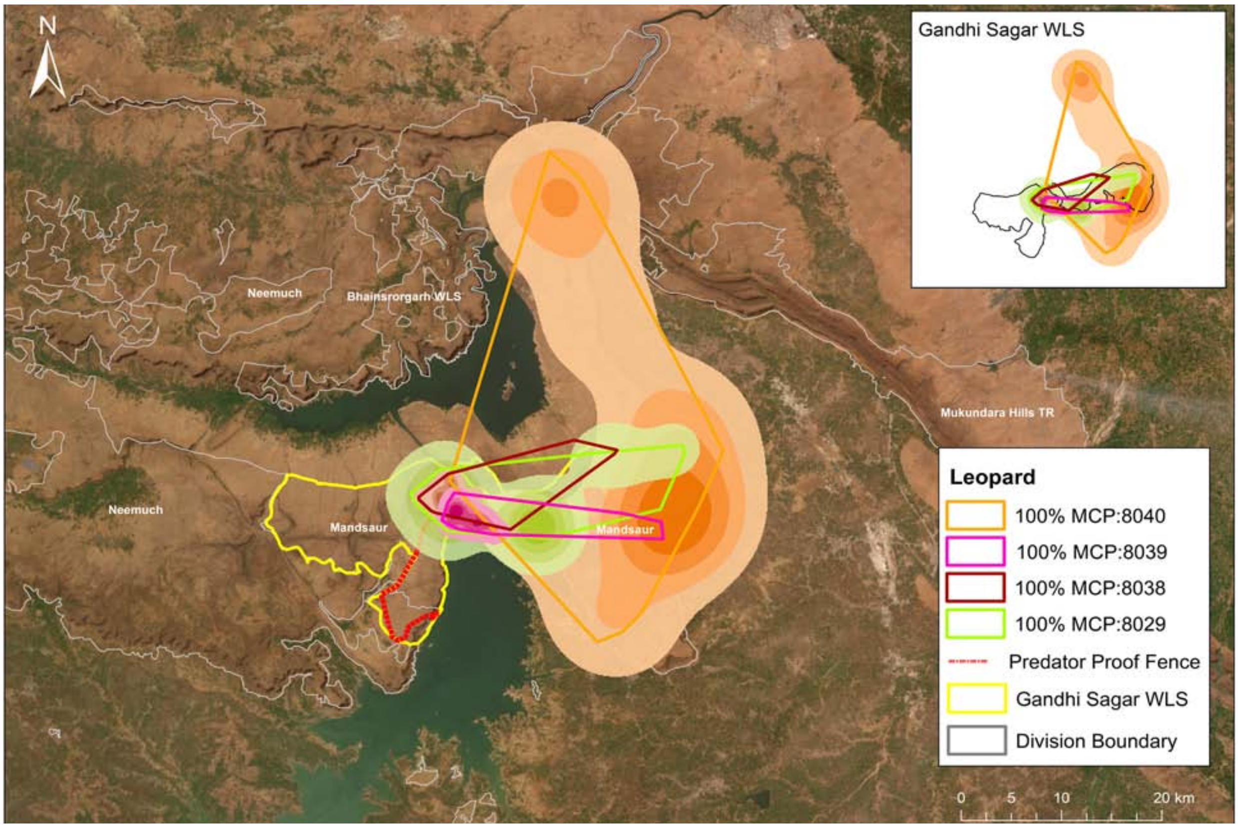

Figure 6.4.2. *Home ranges (100% MCP & 95%KDE) of radio-collared leopards in Gandhi Sagar Wildlife Sanctuary*

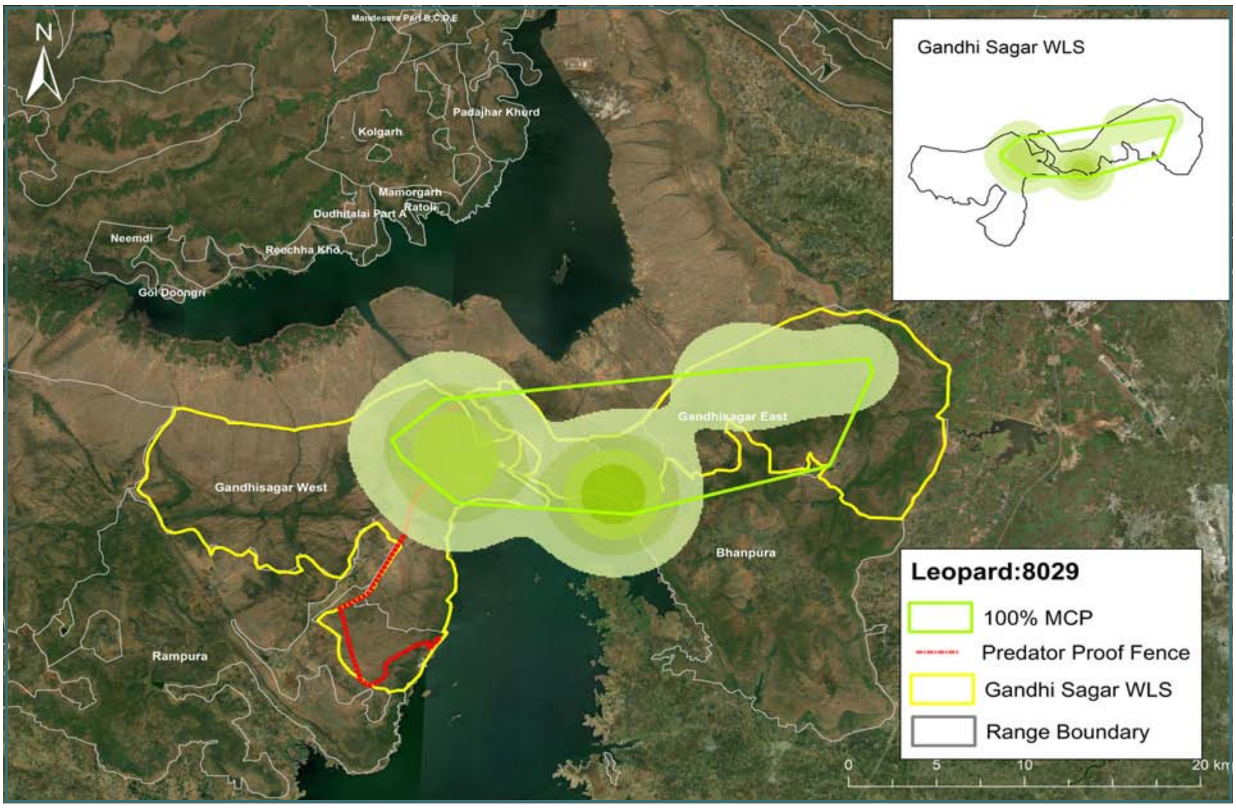

Figure 6.4.3. *Home range (100% MCP & 95%KDE) of radio-collared leopard (id.8029) in Gandhi Sagar Wildlife Sanctuary*

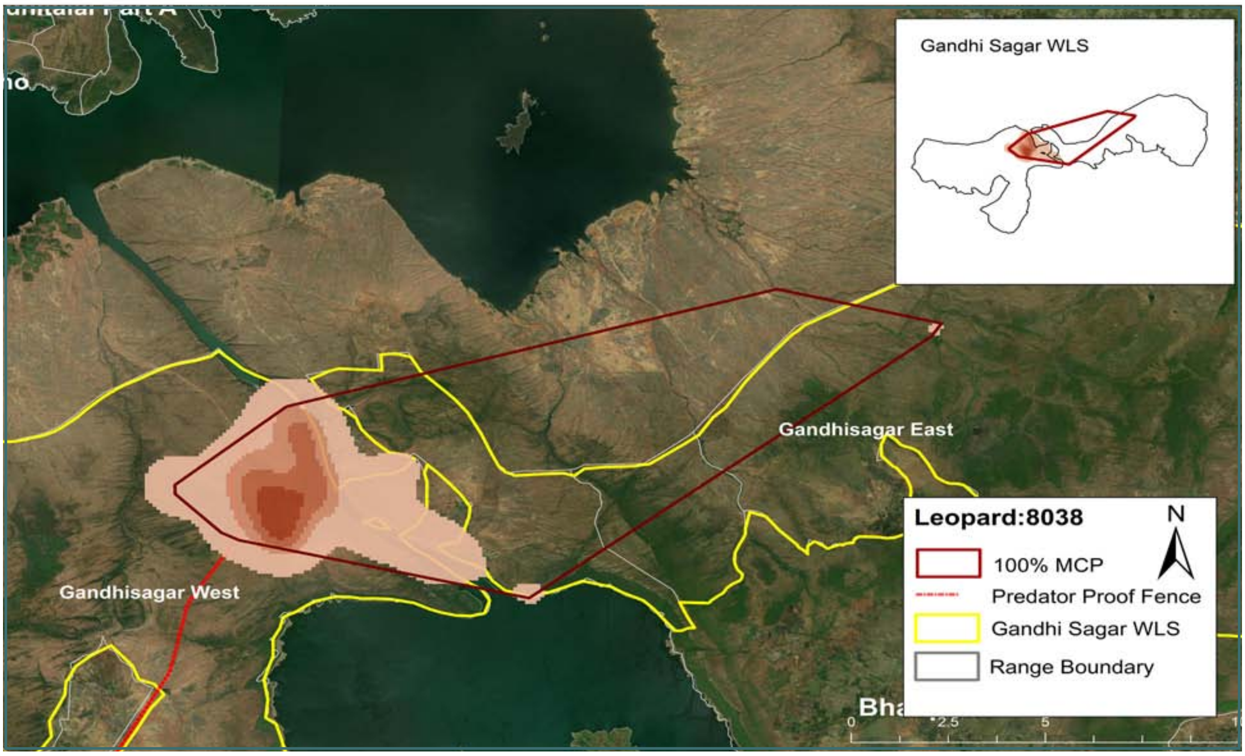

__Figure 6.4.4.__ Home range (100% MCP & 95%KDE) of radio-collared leopard (id.8038) in Gandhi Sagar Wildlife Sanctuary

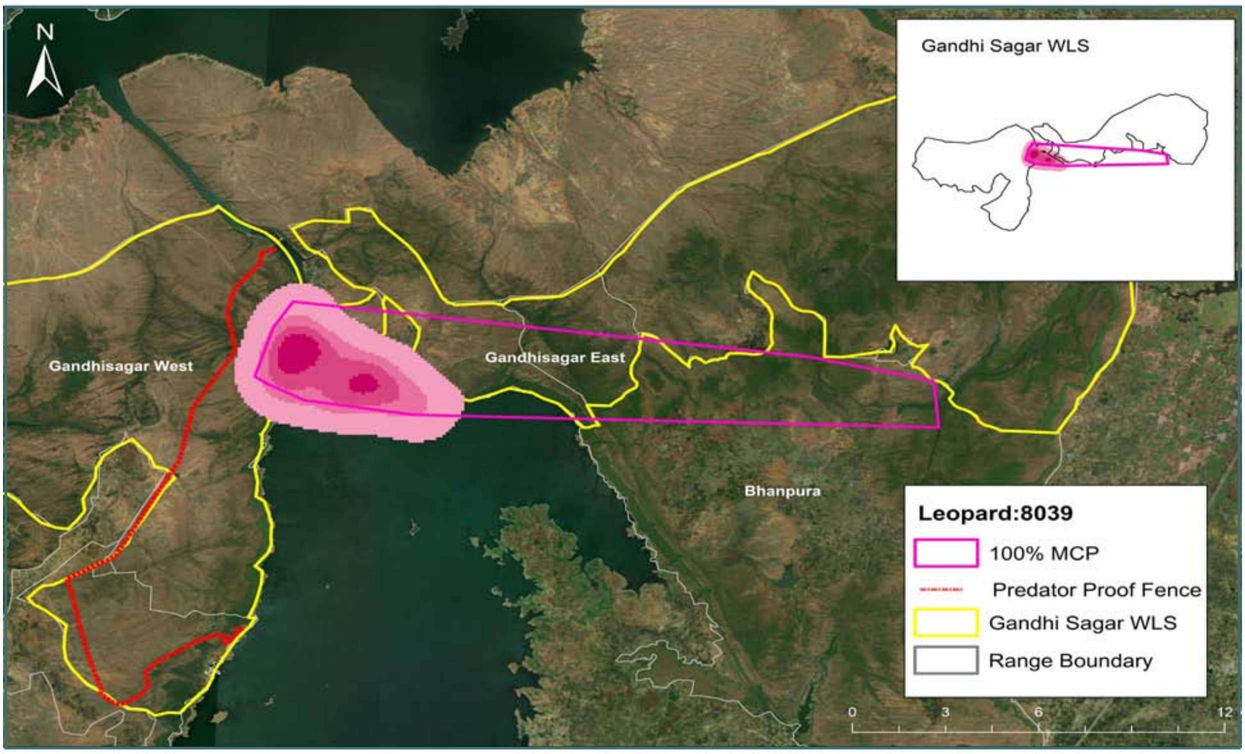

__Figure 6.4.5.__ Home range (100% MCP & 95%KDE) of radio-collared leopard (id.8039) in Gandhi Sagar Wildlife Sanctuary

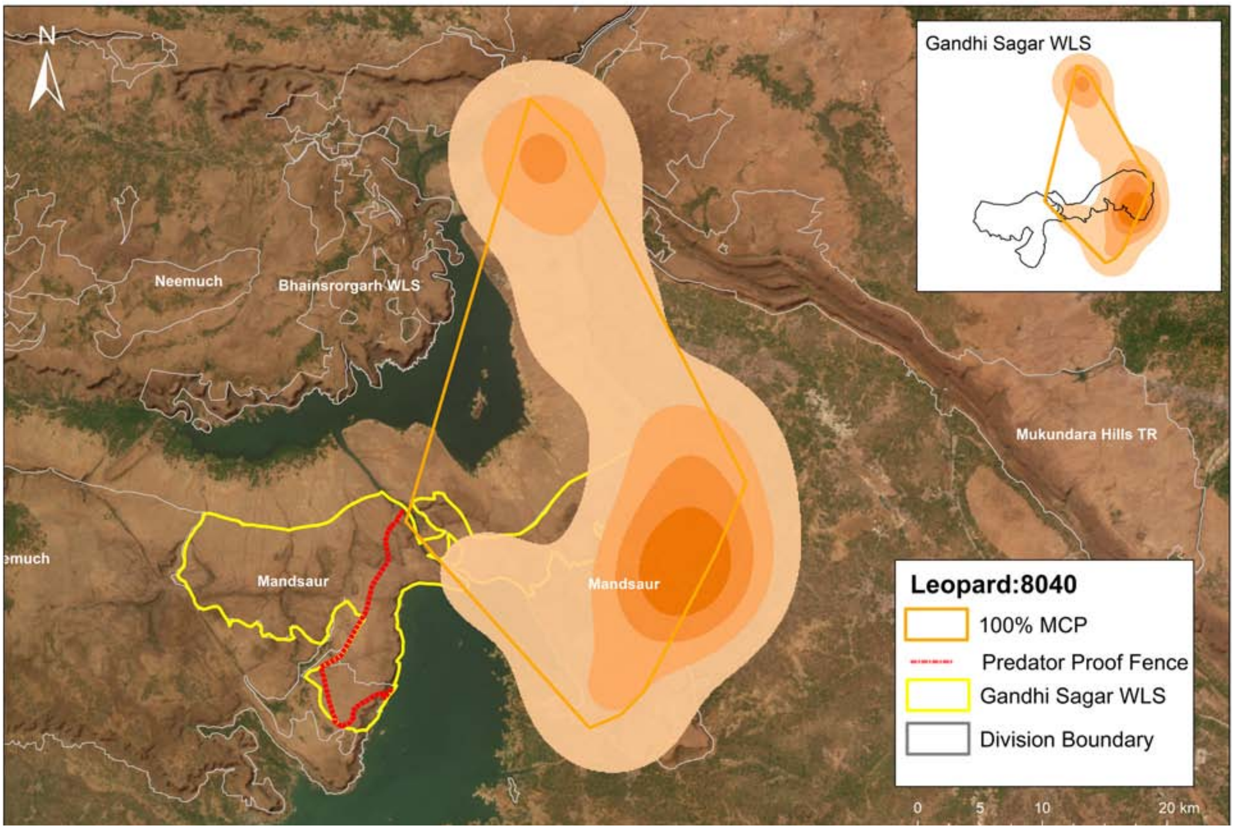

Figure 6.4.6. *Home range (100% MCP & 95%KDE) of radio-collared leopard (id.8040) in Gandhi Sagar Wildlife Sanctuary*

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7.

Management of ungulate prey in Kuno National Park and Gandhi Sagar Wildlife Sanctuary

The current population of chital in Kuno NP, which is the primary prey for cheetahs and leopards, is about 6700 animals. The population density of leopards in the Kuno is quite high with 27.04(2.9SE) animals per 100 km^2; whereas the population of prey (chital) has declined from 23.43(4.67SE) animals per km^2 in 2021 (Jhala *et al.* 2021) to 17.5(3.39SE) animals per km^2 in 2024. One leopard or cheetah would hunt a chital-sized animal every four days on average. To sustain one cheetah or a leopard, 260 prey animals are required annually based on Keith's equation, N=K/(--1) (Fuller, 1983) where K is the annual ungulate kill per predator (one kill every 4 days for leopard/cheetah) and λ is the annual finite rate of increase for ungulate population (1.35 for chital). The current population of 91 leopards and 12 adult cheetahs would require ~ 23,660 prey animals and ~ 3,120 respectively. With the current population of chital (6700) and other prey (~1000 ungulates), there is a huge deficit of prey in Kuno NP.

In light of this, prey (initially chital) augmentation has to be carried out immediately in Kuno. At least 1500 chital have to be brought to Kuno to increase the ungulate prey base. Additionally, it is necessary to maintain chital populations in predator-proof enclosures to ensure a consistent supply of prey. These breeding enclosures for chital have to be established along productive areas adjacent to Kuno River valley such as Nayagaon and Khaloi areas inside the NP on priority to permit their population recovery. The population of other ungulates is currently very low and their growth rate is also slow. The growth rate of chital, a more gregarious compared to other ungulates, in the past, was recorded to be high, which makes it an appropriate species for augmentation. To enable ungulate prey recovery in the wild in Kuno NP, grassland patches have to be managed to increase their productivity by promoting the growth of palatable species through the reduction of woody species as well as the uprooting of *Ziziphus nummularia* shrub and *Desmostachya bipinnata* grass. Further, blackbuck translocation into Kuno through mass capture from agriculture fields has to be initiated.

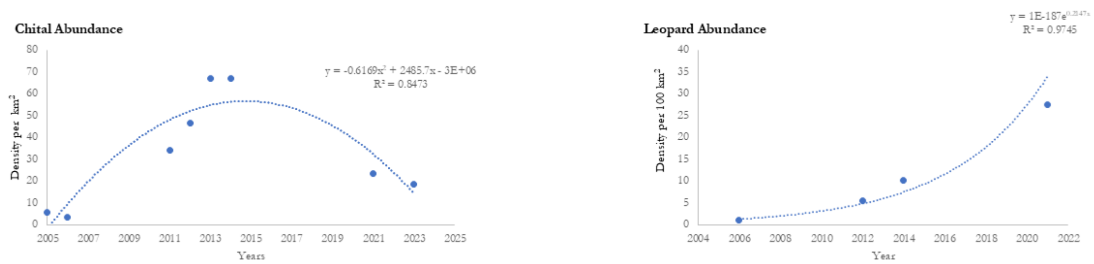

Figure 7.1. *Population of chital (left) and leopard (right) over the years from 2005 onwards in Kuno*

Breeding in chital takes place throughout the year with localized peaks. Males produce sperm throughout the year, however, levels of testosterone decline during the antler development. In case of females, oestrus cycles are regular, lasting three weeks each. Regardless of their size, males without antlers or in velvet are subordinate to males with hard antlers. The age of sexual maturity in females is two years, whereas it is two and a half years for males. The gestation period is seven and a half months. After the birth of fawn (usually one), females can conceive again two weeks to four months later. The weaning age of fawns is about four months.

In areas such as Kuno, where chital densities can go up to 40-60 animals per km^2 in the wild, one predator-proof enclosure size of 1 km^2 can accommodate an initial (founder) population of 30 individuals. Based on chital breeding ecology, the composition of animals inside the enclosure would have to be female-biased with 24 adult females and six males. As for the males, it would be preferable to include two dominant adult males, two subordinate males, and two sub-adult males. Restricted mating is advisable for synchronous fawning during peak breeding season (which is usually summer). As the scenario is in captive conditions with unlimited resources and no threat of predators, if all females breed and 24 fawns are born and a conservative estimate of two-thirds survive, there will be an addition of at least 16 animals annually. Under such settings, for initially breeding ~100 chitals annually, at least six predator-proof enclosures have to be constructed at various locations, as suggested above preferably along the productive habitats of Kuno River valley.

Image 7.1. *Chital herd in Kuno National Park © Sumit Patel*

In the case of blackbucks, females become sexually mature at the age of eight months, but mating starts at around two years. Males mature at the age of one-and-a-half years. Mating takes place throughout the year. Two peaks have been observed in India: from August to October and from

March to April. The gestation period lasts for five-six months, after which a single calf is born. As in the case of chital, captive breeding of blackbuck can also follow a similar procedure and population growth. The predator-proof enclosures for blackbuck breeding have to be located in open areas such as on plateau top in Kuno NP or possibly areas in territorial divisions on the eastern and south-eastern side of the PA.

In Gandhi Sagar WLS, an area of ~64 km^2 with predator-proof fencing is being prepared for the release of six to eight cheetahs. All the leopards in this area are being captured and shifted outside the fence area. The prey requirement for six to eight cheetahs is 1500- 2000 ungulates annually using Keith's equation. Chinkara is the most abundant ungulate in the area. The population density of chinkara and nilgai inside the fenced area is 7.38(2.00SE) animals per km^2 and 4.35(1.17SE) animals per km^2 respectively. The current availability of prey in the area is about 520 animals comprised of chinkara with 440 animals and 80 nilgai (one-fourth of nilgai population comprised of calves). The deficit of prey in the fenced area is about 1500 animals. The habitat of Gandhi Sagar WLS is not suitable for chital, and efforts towards prey augmentation and captive breeding with chinkara and blackbuck would be more appropriate. Three predator-proof enclosures (Area-90ha., 50ha. and 50 ha.) for captive breeding of ungulate prey have been prepared inside the fenced area for cheetah release.

Image 7.2. *Blackbuck on the outskirts of Kuno Wildlife Division © Bipin C.M.*

8.

Outreach, awareness and capacity building

Since no landscape-level conservation program can be sustained without the help of local communities, it is critical to involve these communities especially those whose livelihoods may be affected by the project. To achieve the same, the confidence of local communities has to be won through various livelihood, outreach & awareness programs. Through awareness programs, the communities are being made aware that the cheetahs are not a threat to human lives and that any damage to livestock will be compensated effectively and immediately. At the same time, there is a need to strengthen and diversify the means of livelihood for local communities and reduce their dependence on the PA for grazing and other resources. While incentivising the local communities is important for their participation in the project, there is also a need for a strong protection regime for the safety of cheetahs and their habitat.

Image 8.1.1. *Hon'ble Minister of Environment and Forest & Climate Change, Government of India felicitating cheetah mitras from villages around Kuno National Park © Uttam Sharma*

8.1. Outreach activities conducted in Kuno National Park

Continuous engagement by organising awareness programs was carried out in villages around Kuno NP

- Cheetah Mitra Sammelan was held on 26th Feb 2024 and the distribution of cycles to all cheetah Mitra

- Massive awareness program organised on 17/09/2023 on the first anniversary of cheetah introduction in India

- Celebration of International cheetah day by organising different programs involving villagers

Anubhuti camps in which one-day awareness camps were conducted in the forest area for local communities for sensitizing local people

- 19 camps (16 govt & 3 private schools) were organized

- Around 2500 students and more than 100 teachers participated

Nature guide training was organized for 34 guides from local communities

Two NGOs namely The Corbett Foundation and The Last Wilderness Foundation have been engaged in spreading awareness and working with people living around Kuno NP. Along with them, the forest department is working closely with Sahariya and Mogiya tribes in providing them basic facilities and livelihood options such as sewing/tailoring training with distribution of sewing machines to trainees (20 beneficiaries), masonry training (5 beneficiaries), educational support to 28 students, distribution of solar home lighting (4 villages- 255 beneficiaries) and energy-efficient stoves (15 beneficiaries), setting-up of small grocery shop and creation of drinking water facility in one village.

Image 8.1.2. *Interactions with local communities in villages around Kuno National Park © Uttam Sharma*

Image 8.1.3. *Provision of livelihood options to local people around Kuno National Park © Uttam Sharma*

Image 8.1.4. *Visit of Hon'ble Forest Minister of Madhya Pradesh to Kuno National Park © Uttam Sharma*

Image 8.1.5. *First anniversary of cheetah introduction in India held at Sesaipura village on the vicinity of Kuno National Park © Uttam Sharma*

Image 8.1.6. *Wildlife Institute of India team at the first anniversary of cheetah introduction in India held at Sesaipura village on the vicinity of Kuno National Park © Kesha Patel*

8.2. Outreach activities conducted in Gandhi Sagar Wildlife Sanctuary

To create awareness and sensitization about the forests and biodiversity among the local community members, particularly children living around the WLS, and to make people aware of the need to protect forests various programs were carried out. The Gandhi Sagar WLS in collaboration with NGO Last Wilderness Foundation has started outreach awareness activities in and around the Sanctuary. The activities include the celebration of Wildlife Week, International Cheetah Day, and International Tiger Day in all Primary, Middle, High, and Higher Secondary schools. Regular meetings with Eco-development committee members making them aware of the project, engagement of local people in ongoing habitat development works, employing locals for Suraksha shramik and other works.

Gandhi Sagar WLS in collaboration with NGO Last Wilderness Foundation till now has covered 12 villages (15 schools) and completed 30 outreach awareness programs in and around the Sanctuary. To make people aware of the introduction of cheetah in Gandhi Sagar on the occasion of Republic Day, a cheetah awareness tableau was taken out at the district headquarters in Mandsaur and a cheetah awareness exhibition stall set up at the Neemuch district headquarters during the HCM program.

As a part of the regular ANUBHUTI program of the state forest department around 480 students of high and higher secondary schools (through 04 events with 120 students in each) situated in the vicinity of Gandhi Sagar have been given exposure visits to the forest area with full day awareness program on cheetah introduction in Gandhi Sagar WLS.

8.3. MSTrIPES training workshops for field staff of Kuno Wildlife Division and Gandhi Sagar WLS

To train the field staff on techniques of ecological monitoring and patrolling, MSTrIPES workshops were conducted twice in Kuno Wildlife Division and Gandhi Sagar WLS by teams from WII. During the training workshops held for a period of three days each, 78 field staff of Kuno and 25 field staff of Gandhi Sagar WLS participated in various technical and field sessions related to protocols and methods, data collection and collation, use of recording equipment and mobile application required for ecological monitoring and patrolling. In Kuno, the workshops were held during the months of November 2023 and February 2024, whereas in Gandhi Sagar, they were conducted during October and December 2023.

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Image 8.2. *Outreach activities conducted in villages adjoining Gandhi Sagar Wildlife Sanctuary © Madhya Pradesh Forest Department*

Image 8.3.1. *MSTrIPES training workshop in Gandhi Sagar Wildlife Sanctuary © Deb Ranjan Laha*

Image 8.3.2. *MSTrIPES training workshop in Kuno National Park © Manish Singanjude*

9.

Conclusion and way forward

The endeavour to establish viable cheetah metapopulation in India has achieved a few milestones such as the addition of 12 cubs to the founder stock in Kuno. However, natural mortalities of a few cheetahs occurred during the last one year. The project has completed two years and as prescribed by the Action Plan for the introduction of cheetahs in India, would require annual supplementation of cheetahs from source countries (Jhala *et al.* 2021). As a part of the metapopulation management of cheetahs, preparation of Gandhi Sagar WLS as the next site for the release of cheetahs is underway and expected to receive animals as soon as adequate requirements of infrastructure and prey are completed.

Due to the high number of leopards in Kuno, the current population of chital is not adequate to sustain the current large carnivore population for very long in Kuno. This would require immediate augmentation of ungulate prey such as chital and blackbuck as well as captive breeding of these ungulates in predator-proof enclosures (prey nurseries) at multiple locations inside Kuno NP at conducive sites as per the requirement of the species. Additionally, augmentation of ungulates such as chital and blackbuck have to be regularly carried out until they reach the level of self-sustenance. However, care must be taken to ensure that the source populations in PAs where these animals are translocated from are not endangered due to this translocation.

Image 9.1. *Cheetah mother and cub in Kuno National Park © Madhya Pradesh Forest Department*

The area outside Kuno NP in Kuno Wildlife Division covering an area of 1235 km^2 has to be prioritized for habitat management and protection to allow recovery of prey and habitat within the next three to five years. The landscape outside Kuno has contiguous forested habitat spanning an area of about 6800 km^2 wherein an area of over 3200 km^2 has high potential for cheetah occupancy. Over a period of the next ten years, this contiguous forested habitat has to be managed for habitat and prey recovery expanding outwards from Kuno Wildlife Division parallelly in multiple sites in phases. Additionally, this area spread across the states of M.P. and Rajasthan has to be brought under a unified administrative, legal, financial, and management framework as part of the Kuno cheetah landscape.

In the first phase at Gandhi Sagar WLS, a maximum of four to five cheetahs can be released into a fenced area providing them an opportunity to establish a breeding population. Augmentation and captive breeding of ungulate prey similar to Kuno including chinkara has to be taken up on a priority basis. The habitat around the fenced area in the PA and the surrounding areas is being restored in phases and subsequently, after ecological restoration and prey recovery, cheetahs will be released into free-ranging conditions in the Gandhi Sagar landscape. In the next five years, Gandhi Sagar WLS requires various management interventions for habitat and prey recovery for the release of cheetahs outside the fenced area. The landscape outside Gandhi Sagar WLS forms a large contiguous habitat of vast savannah, grassland and open woodlands of ~2500 km^2 area has immense potential as cheetah habitat in the states of M.P. and Rajasthan. Securing this landscape as a transboundary management unit over the next 10-15 years can be ensured with efforts towards conservation and sustainable management as suggested for the Kuno landscape.

Habitat restoration in these landscapes with measures such as grassland management including deterring the growth of woody species, eradication of plant invasive species, promoting the growth of native forage species to facilitate ungulate recovery, vehicular traffic regulation in wildlife-rich areas, water management to ensure availability of surface water at appropriate distances during lean seasons, supervision of NTFP collection and strategy to mitigate fire incidences. Along with the execution of these actions in the whole region, a smart monitoring system such as MSTrIPES has to be implemented to understand the effectiveness of the management interventions and improved upon if required in an adaptive framework.

The importance of outreach and awareness programs in wildlife conservation as a continuous activity targeting diverse stakeholders, most importantly the local communities can't be stressed enough. A pro-cheetah/conservation outline has to be chalked out for the entire region to ensure regular and systematic dissemination and publicity. As the area is large, elected public representatives and media play an important role in shaping people's opinions far and wide, and hence, it becomes crucial to engage these representatives/agencies as part of the outreach mechanism. Pro-conservation campaigns, nature awareness programs, veterinary initiatives for livestock, government schemes that promote environment conservation/ecotourism/wildlife tolerance, and tangible benefits of cheetah conservation through enhanced livelihood options have to be incorporated into the narrative of outreach and awareness programs.

Individual cheetah populations with a carrying capacity of over 25 individuals with appropriate augmentation and management have a higher chance of persistence over the long term as per the population habitat viability model analysis (Jhala *et al.* 2021). Within the PA, after incorporating natural mortality, births, annual supplementation, and with about 5% growth rate in the founder population, the cheetah population should reach the carrying capacity level in approximately 15 years only if adequate prey is available. To reach the landscape carrying capacity after the restoration of the habitat, for a population size of 25-30 cheetahs, the time required would be anywhere between 30-40 years depending on survival, recruitment, and supplementation.

The combined areas of Kuno and Gandhi Sagar landscapes forming the larger cheetah metapopulation landscape under the umbrella of Project cheetah in the long term (within the next 25 years) would effectively serve towards the goal of establishing the first viable cheetah metapopulation in India. Cheetahs would be allowed to populate the larger landscape only after securing the potential habitats sufficiently restored in the area, necessary prey base such as medium-sized ungulates adequately enhanced, and risks to both cheetahs and prey survival are minimized. However, such enactments demand time and they must not hamper the immediate objective of establishing cheetah populations first inside the Protected Areas and simultaneously adequate restoration efforts at the landscape level. Instead, they would be simultaneous with the management of cheetah introduction inside Kuno NP and Gandhi Sagar WLS. One of the long-term goals of Project Cheetah is to establish a metapopulation of cheetahs in the interstate Kuno-Gandhi Sagar landscape of 60-70 individuals after restorative measures, prey availability, and scientific management are effectively in place. The strong political will and the proficient government machinery that ensured cheetahs were brought back to India would have to play a crucial role in facilitating interstate cooperation for the management of large landscapes to guarantee that cheetah populations survive and thrive in India.

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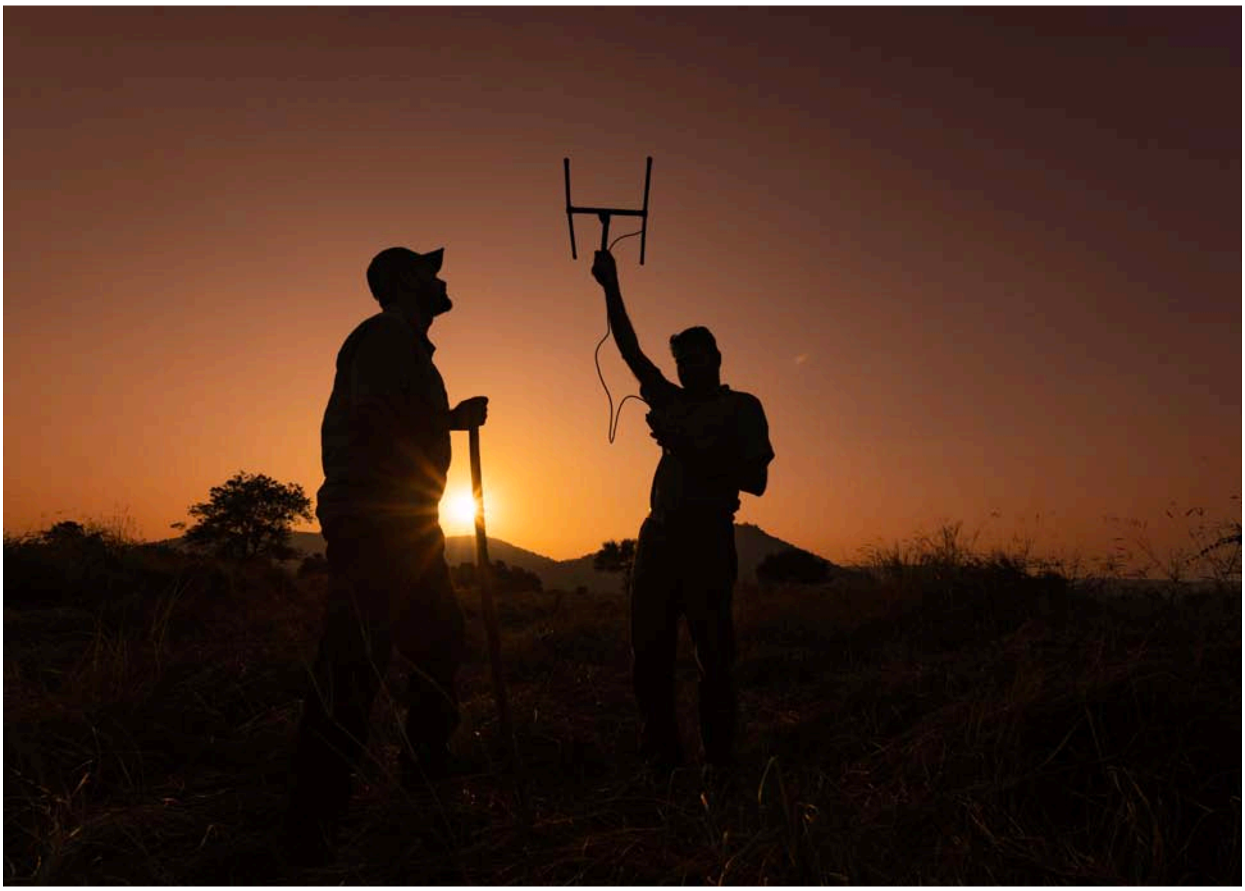

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APPENDIX - I

STANDARD OPERATING PROCEDURE

TO DEAL WITH NURSING CHEETAH FEMALES, NEONATAL CARE AND ORPHANED/ ABANDONED/INJURED CHEETAH CUBS AT CHEETAH INTRODUCTION SITES IN INDIA

NATIONAL TIGER CONSERVATION AUTHORITY (NTCA)

THE MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE (MOEFCC), GOVERNMENT OF INDIA

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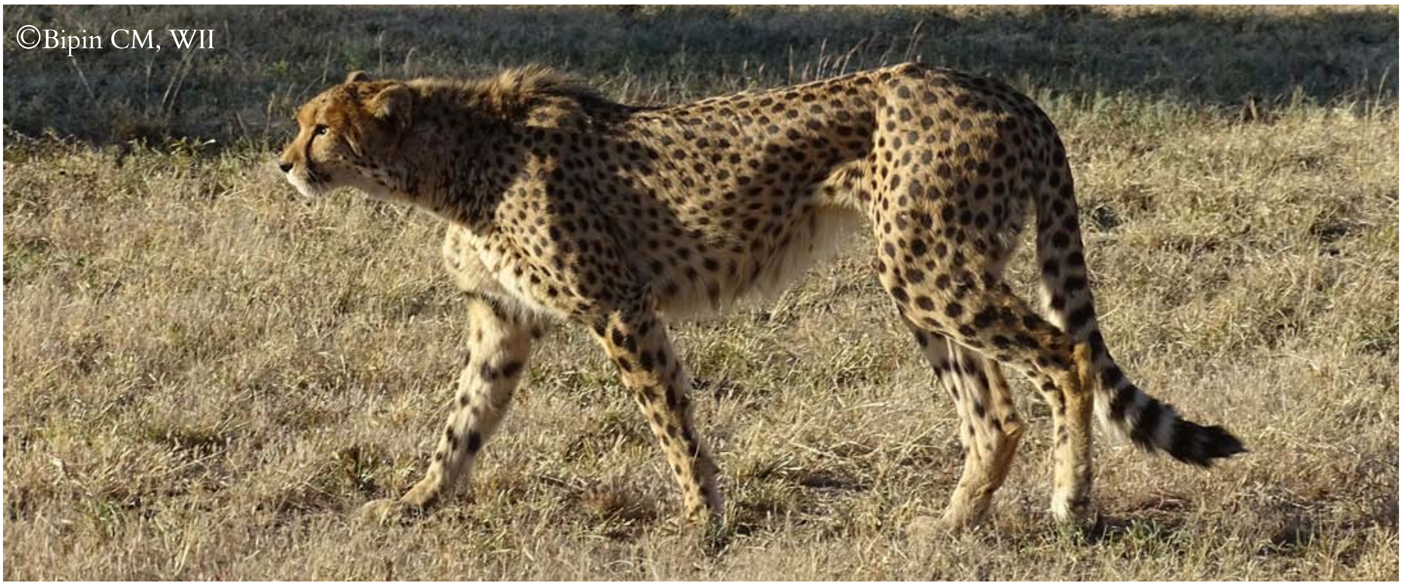

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NATIONAL TIGER CONSERVATION AUTHORITY (NTCA)

THE MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE (MOEFCC), GOVERNMENT OF INDIA

STANDARD OPERATING PROCEDURE TO DEAL WITH NURSING CHEETAH FEMALES, NEONATAL CARE AND ORPHANED/ABANDONED/INJURED CHEETAH CUBS AT CHEETAH INTRODUCTION SITES IN INDIA

1. Title

Standard operating procedure to deal with nursing cheetah females, neonatal care and orphaned/ abandoned/ injured cheetah cubs at cheetah introduction sites in India.

2. Subject

Dealing with pre and post breeding situations in introduced cheetahs in India, including monitoring of pregnant/ lactating females, neonatal care and monitoring of cubs born and in circumstances requiring health/ veterinary management of orphaned, abandoned or injured cheetah cubs at cheetah introduction sites in India.

3. Purpose

The primary objective of the Project Cheetah is to establish a viable metapopulation of cheetahs (*Acinonyx jubatus*) in India. This is to be achieved initially through introduction of healthy founder stock from Africa and later sustained through naturally breeding cheetah population at the introduction sites. Therefore, ensuring the welfare of each individual cheetah, particularly breeding females and cubs born in India, is crucial for the project's success. This not only necessitates vigilant monitoring of pregnant/ lactating females and their cubs with utmost caution, but also human interventions and veterinary care would also be necessary in some circumstances. For example, though it is imperative to have naturally bred and wild raised cheetah cubs, there may be occasions where it becomes necessary to hand-rear cheetah cubs due to various factors such as maternal abandonment, health issues, or other unforeseen circumstances. This document outlines protocols for appropriate monitoring, veterinary care, and husbandry in such scenarios, while prioritizing, minimal disruption to the natural cheetah behaviour, its health as well as well-being and safeguarding the health concerns of field staff involved in such operations.

The purpose of rehabilitation of sick, injured, orphaned and abandoned animals is to eventually release them into free ranging environment as fully fit and self-sustaining functional individuals. To understand the success of rehabilitation, techniques employed must be accurately documented, replicable and tested. The process of rehabilitation needs to be meticulously planned and organized with regard to habituation and behaviour development in captivity, as these developments can affect subsequent behavioural responses. Some of the steps required in cheetah rehabilitation before release into the wild are stimulation, hunting training, de-humanizing and predator avoidance programme etc. These steps require specific insights by experts involved in cheetah rehabilitation to develop appropriate training protocols and approaches specifically catering to the needs of the cheetahs. Prior to release into the wild, cheetahs need to be certified for adequate health and ensure diseases are not transmitted into wild populations, appropriate blood investigations and molecular testing needs to be carried out.

4. Short Summary

This Standard Operating Procedure (SOP) outlines the essential criteria, actions, and precautions to be followed at the field level in cheetah introduction sites when managing pre and post-breeding situations in cheetahs introduced in India.

5. Scope

The SOP applies to all cheetah introduction sites and field formations with cheetah presence in India.

6. Responsibilities

For Protected Areas (National Park/ Wildlife Sanctuary), the concerned Protected Area manager would be responsible. In the case of other areas (revenue land/ Conservation Reserve/ Community Reserve/ Village/ Township) the Wildlife Warden, as per the Wildlife (Protection) Act, 1972, or Divisional Forest Officer (DFO)/ Deputy Conservator of Forests (DCF) under whose jurisdiction the area falls, would be responsible. The overall responsibility at the State level would rest with the Chief Wildlife Warden of the concerned State. The Cheetah Steering Committee, constituted by the Ministry of Environment, Forests, and Climate Change, Government of India in conjunction with the National Tiger Conservation Authority (NTCA), Government of India will be responsible for issuing specific advisories based on individual circumstances when deemed necessary.

7. Circumstances Covered Under the SOP

a. Presence of pregnant cheetah female at cheetah introduction sites and/ or adjacent areas (Reserve Forest, Revenue land, Conservation Reserve, etc.).

b. Confirmation of cub birth (parturition) in cheetah female/ nursing cheetah female at cheetah introduction sites and/ or adjacent areas.

c. Circumstances necessitating hand rearing of cheetah cubs due to orphaning ensuing mortality of mother (poaching/ inter or intra species negative interaction/ other natural causes) or abandonment by the mother or incapacitation of mother due to injury/ illness (natural or other causes); cubs with in-born incapacitation; weak cheetah cubs/ runt and injured/ sick cheetah cubs.

To comprehend the intricacies that could precipitate in above situations and to facilitate decision-making process, essential knowledge of reproductive ecology and breeding behaviour in cheetahs is a prerequisite. A concise summary of this is provided as **Annexure I**. Additional literature listed below may be referred for a more comprehensive understanding of the subject.

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8. Suggested Field Actions

a. At the outset, constitution of an Action Committee (herein after referred as the Committee) for technical guidance, monitoring and routine, as under -

i. Field Director/ Protected Area Manager/ Division Forest Officer I/C-Member Convener
ii. Nominee of the NTCA,
iii. Nominee from Cheetah Steering Committee,
iv. Nominee from Wildlife Institute of India (WII), and
v. A team of field veterinarians (at least one each from NTCA, cheetah introduction site, and the WII).

Note : An international expert with experience in cheetah care/husbandry maybe consulted in case necessary (in consultation with the NTCA).

b. Based on the available history with the resident veterinarian(s) and the insights provided by field monitoring team(s), clearly outlining the current situation at hand.

c. Communicating the latest situation to the above committee and outlining a precise action plan based on the inputs/ suggestions received.

d. In case of suspected pregnancy in cheetah female, confirmatory examination (visual, physical or ultrasound based) to be conducted by the resident veterinarian(s). Detailed protocol in this regard is placed as **Annexure II**- *Protocols for Pre-partum Management of Pregnant Cheetah at Cheetah Introduction Sites.*

e. In case of confirmed pregnancy in cheetah female, initiating round the clock non-intrusive field monitoring. Detailed protocol on watch and ward in such scenarios is placed as **Annexure II** - *Protocols for Pre-partum Management of Pregnant Cheetah at Cheetah Introduction Sites.*

f. If situation warrants capture and thorough physical examination of pregnant cheetah female, the same may be carried out until advanced pregnancy period (>10 days of parturition) using chemical immobilization. Detailed protocol in this regard, including safe drug combinations, dosages and specific considerations, is placed as **Annexure II**- *Protocols for Pre-partum Management of Pregnant Cheetah at Cheetah Introduction Sites.*

g. Birth of cheetah cub(s) (denning) can occur either in enclosed/ protected environment (larger acclimatisation enclosures) or in free ranging conditions, with each warranting different approaches. Detailed protocol to deal with both is placed as **Annexure III**- *Protocols for Post-partum Management of Pregnant Cheetah and Cubs at Cheetah Introduction Sites.*

h. Upon confirmation of birthing/ parturition, whether in a protected environment or free-ranging conditions, the den site should be located using telemetry data or visual observation. Restrictions on vehicular and human movement in the den vicinity should be promptly implemented and access to the area should be limited only to the veterinary team to ensure health and well-being of the mother and cubs. Detailed protocol in this regard is placed as **Annexure III** - *Protocols for Post-partum Management of Pregnant Cheetah and Cubs at Cheetah Introduction Sites.*

i. Circumstances involving orphaning/ abandonment/ or illness in cheetah cubs should be immediately intervened with, keeping the Committee outlined in para 8(a) informed. The underlying issue should be immediately assessed and if deemed necessary, cheetah cub(s) should immediately be brought under human care. Cheetah cubs under 60 days of age can be easily handled with physical restraint. Older cubs however may warrant chemical immobilization. Detailed protocol in this regard, including safe drug combinations and dosages is placed in **Annexure IV**- *Protocols for Dealing with Orphaning/ Abandonment/ or Illness in Cheetah Cubs at Cheetah Introduction Sites.*

j. Cheetah cub(s) under circumstances detailed in para 8 (i) should be closely examined by the field veterinary team and the findings should be communicated to the Committee constituted as suggested at para 8 (a) to make recommendations with respect to following objectives:
i. Managing the cheetah cub(s)/ mother 'in-situ', if cubs are old enough and treatable in the field or still under mothers' care.
ii. Temporarily managing the cheetah cub(s) 'ex-situ', providing neonatal care or hand-rearing or veterinary interventions with the ultimate goal of rehabilitating them into natural, free-ranging conditions.
iii. Permanently housing cheetah cub(s) with congenital incapacitation, lasting deformities/ injuries, or untreatable illness in 'ex-situ' setup/ dedicated cheetah captive care facility.
iv. Rehabilitation of hand-reared cheetah cubs into free ranging conditions.

k. Neonatal care and hand rearing of cheetah cubs is a specialized field, involving the provision of dedicated care, nutrition, and socialization to ensure the cubs' well-being and successful development. However, it is crucial to strike a balance and minimize human imprinting, as the ultimate aim is for these cheetahs to exhibit natural behaviours and thrive independently in free ranging conditions. Protocol to be followed in this regard, including feeding regimens, husbandry, veterinary care, prophylaxis, socialization, training and rehabilitation are placed as **Annexure IV-** *Protocols for Dealing with Orphaning/ Abandonment/ or Illness in Cheetah Cubs at Cheetah Introduction Sites* and **Annexure V-** *Captive Care and Cub(s) Rearing Infrastructure Prototype at Cheetah Introduction Sites.* Additionally, the *guidance notes in Standard Operating Procedure to Deal with Orphaned/Abandoned Tiger Cubs and Old/Injured Tigers in the Wild* by NTCA with descriptions and precautions about habituation, conditioning, critical distance and imprinting appropriate for cheetahs is placed as **Appendix I.**

l. A designated representative from the NTCA/Cheetah Steering Committee/ Forest Department/ WII should communicate with the media (when necessary) to ensure accurate information is disseminated regarding the management interventions during circumstances covered under the SOP. Sensationalism or misinformation can result in additional rumour mongering as well as negatively impact the morale of the field personnel and the project as a whole.

m. The Member Secretary (MS) - NTCA and Chief Wildlife Warden of the concerned state, in consultation with the committee outlined in paragraph 8(a) will be responsible for taking the ultimate decision on circumstances warranting human interventions.

n. It is imperative to have dedicated captive care and cub(s) rearing infrastructure at each cheetah introduction sites. These include holding enclosures designed to cater to the behavioural and nutritional requirements of cheetahs, as well as a neonatal care setup, with readily available emergency medications and necessary equipment that would be required in hand rearing process.

***Note:** Recent advances in management/ healthcare/ drugs/ medicines shall be prudently taken into account wherever necessary based on established recommendations while cheetah are managed under Project Cheetah in multiple landscapes.*

ANNEXURE I

REPRODUCTIVE ECOLOGY AND BREEDING BEHAVIOUR OF CHEETAHS

I.1. Reproductive Ecology

Southern African Cheetah females exhibit a non-seasonal breeding behaviour in their native home ranges, indicating that sexually mature females in wild are typically either pregnant, lactating, or raising young (Laurenson *et al.,* 1992; Wachter *et al.,* 2011). Current literature suggests that captive cheetah females reach physiological puberty between 25—30 months of age (Maly *et al.,* 2015). Nevertheless, it is essential for a female to display receptiveness and breeding behaviour before allowing successful copulation by male(s). This age range aligns with information from free-ranging females, who presumably conceive shortly after puberty and have their first litter at an average age of 29 months (Crosier *et al.,* 2017). Male cheetahs in the wild typically delay reproduction until reaching prime adulthood, which occurs between 48 to 96 months of age when they are capable of acquiring and defending territories from conspecifics (Caro, 1994).

Females exhibit polyoestrous behaviour, with a typical estrous cycle lasting two weeks, during which the receptive period varies from one (01) to six (06) days (Brown *et al.,* 1996). However, captivity and other stressors can alter the cycle length and receptive period, with some captive females exhibiting cycle lengths ranging from five (05) to 30 days (Brown *et al.,* 1996; Crosier *et al.,* 2017). In quarantine or captive conditions, the co-habitation of unrelated female cheetahs in pairs can lead to suppressed ovarian cyclicity, likely due to stress-related factors, particularly among subordinate individuals (Jurke *et al.,* 1997; Wielebnowski and Brown, 1998; Wielebnowski *et al.,* 2002). Separating unrelated females with fence lines has however been shown to re-initiate ovarian activity in previously suppressed individuals. They also resume cyclicity quickly when a litter is lost (Laurenson *et al.*, 1992).Unlike many other felid species, behavioural signs of estrous are difficult to detect in female cheetahs and require considerable observation and field

Image 1. *Spray urinating and frequent rolling may be overt indications of behavioural estrous in cheetah females © Bradford-Wright, 2013*

experience (Wielebnowski, 1999). Receptive females spray urinates on bushes, trees, and rocks and often undertake extensive movement during the period. Other overt signs of behavioural estrous include frequent rolling, rubbing, sniffing, vocalizing, and increased tolerance or affection toward male cheetahs in the vicinity (Wielebnowski and Brown, 1998).

(A)

(B)

Image 2. *(A) Cheetah mating pair in Kuno National Park © Sanath Muliya, NTCA, (B) Cheetah male courting behaviour of display © Bradford-Wright, 2013*

I.2. Mating Behaviour

When a male cheetah detects the scent markings of a female in estrous, it begins calling out with a series of yelps or stutter calling (Eaton, 1974; Bradford-Wright, 2013). Following the female's trail, the male exhibits signs such as salivation, penis exposure, and sniffing. Meanwhile, the female displays behaviours such as tail swishing, rolling, and spray urinating in close proximity to the male or a coalition (Bradford-Wright, 2013).

As they approach each other, the mating pair stands side by side facing opposite directions, orienting their heads to sniff each other's genitals. This is followed by immediate copulation or circling each other before copulation (Eaton, 1974). Copulation typically lasts less than a minute. The female solicits copulation by crouching down and the male approaches from behind. The male sometimes maintains a hold on the female's nape while mating by biting her nape region. Mounting occurs when the male cheetah lifts its front legs off the ground and brings them to rest on the back of the female cheetah. This behaviour may occur when the female is standing but typically occurs when the female is lying upright on the ground with all four legs semi-tucked under her body, a posture known as lordosis (Bradford-Wright, 2013). Following individual mating instances, the female immediately throws off the male and starts rolling vigorously from side to side. Male in turn hisses/ exhibits flehmen response. These behaviours consistently indicate successful copulation, as documented in facilities that have successfully bred cheetahs abroad (Frank and Saffoe, 2005; Ziegler-Meeks, 2009) and also observed in breeding cheetahs at Kuno.

(A)

(B)

Image 3. *(A) Mating with female in lordosis, (B) Female immediately throwing off the male after completion of mating as observed in Kuno National Park © Sanath Muliya, NTCA*

The mating pair typically stay together for a few days and mate several more times during this period, averaging three (03) to five (05) times per day. The male will stay close to her, following and sniffing the ground where she has been, until the female is not receptive anymore and leaves the male. Cheetahs exhibit a polygynous mating system where one male can mate with multiple females (Crosier *et al.,* 2017). Additionally, a female cheetah may mate with more than one male during her receptive period. Since several follicles mature simultaneously in female cheetahs, the same litter can have cubs from different fathers if the female mated with multiple males during estrous (Gottelli *et al.,* 2007; Crosier *et al.,* 2017). Multiple paternities are rare from males of the same coalition as the dominant male in the social group tends to get priority in mating (Mills and Mills, 2017). Nonetheless, most coalition members do share mating with same females.

I.3. Pre-partum and Parturition and Post-partum Behaviour

Indications of pregnancy in cheetah may include an increase in appetite and weight and during the third trimester, nipple development and visible relatively bulged belly (Ziegler-Meeks, 2009). Following a gestation period of three (03) months, female cheetahs give birth to litters of up to six (06) cubs (Gottelli *et al.,* 2007; Crosier *et al.,* 2017).

Birth takes place in bushy patches of vegetation, tall grass, or rock cavities, chosen for the protection they provide for the cubs (Sievert, 2020). Since all the introduced cheetahs in India are radio-collared, den site can precisely be identified post parturition as females tend to stay-put in same location for two (02)- three (03) days and then develop a star patterned movement (exploring different directions, but always returning to the same location). Following parturition, the female will immediately eat the afterbirth by delicately removing the foetal membrane with her teeth (Cheetah outreach, 2015). Mothers with newly emerged cubs spend a greater proportion of the day observing their surroundings and are more vigilant; these activities decline as cubs grow older. Cheetah cubs are born altricial (requiring significant parental care) and remain in the den for 51-65 days (Laurenson, 1993). Cubs open their eyes between four (04) and 14 days (average 10 days) and start crawling in about two (02) to three (03) days and walk at three (03) weeks of age.

Image 4. *A pregnant cheetah female in its third trimester with visibly bulged belly in Kuno. © Sanath Muliya, NTCA*

Image 5. *One week-old cheetah cubs kept hidden by female in thick grass cover in Kuno. © Sanath Muliya, NTCA*

During the first six (06) - seven (07) weeks of age, the female cheetah keeps her cubs hidden and nurses them in dense vegetation to avoid detection or predation. The mother may frequently change den sites, carrying one cub at a time by the nape of the neck for various reasons, including preventing smells from accumulating and attracting predators, or to move closer to concentrations of prey so she doesn't have to travel far to hunt. Lactation in cheetah females typically continues for several months; cubs are entirely dependent on milk until around 2 months of age (Caro, 1994; Mills *et al.,* 2017). By 4 months old, mothers cease nursing as the cubs have typically developed the ability to consume solid food (Caro, 1994; Mills *et al.,* 2017). Nursing is avoided by employing behaviours such as covering their nipples with hind legs, rolling onto their bellies, or sitting up (Caro, 1994; Mills *et al.,* 2017).

At 6 weeks of age, the cubs start to follow their mother, but they return to their den by the end of the day until about 8 weeks. After 8 weeks, they continuously follow her, settling down for the night wherever they are (Cheetah outreach, 2015). From 6 weeks to 3 or 4 months is the most vulnerable period for cubs, with predation and starvation being the primary causes of death. Cubs are most susceptible to predation while still in the den or when left alone for extended periods while their mother hunts. Young cubs exhibit a notable failure to recognize danger and react to other carnivores typically scattering when their mother runs. Mothers with young cubs that have exited the den exhibit heightened vigilance, detecting predators at greater distances (Caro, 1994). This heightened vigilance may manifest as stalking, chasing, slapping, or attempts to bite predators or large herbivores (Laurenson, 1994). A cheetah mother will aggressively confront smaller predators and may even confront hyenas and leopards threatening her cubs to provide them with an opportunity to escape. However, when approached by humans or large predators, she can only simulate charges and vocalize without actual physical attacks (Cheetah outreach, 2015). By the age of 5 or 6 months, cubs become more aware of predators' presence and respond by either remaining still or running directly away from danger instead of scattering. They can usually outrun most carnivores except other cheetahs. In the event of separation, the female reunites with her cubs by emitting chirping calls, a bird-like sound that may deceive other predators (Cheetah outreach, 2015).

Female cheetahs remain with their cubs until they are approximately 18 months old, during which they teach vital survival skills such as predation and predator avoidance (Caro, 1994). Play behaviour in cubs during the period is also believed to serve as training for future survival and propagation (Caro, 1987, 1995). Four categories of play behaviour have been distinguished in cheetah cubs: locomotor play, primarily seen in very young cubs, possibly enhancing their evasion skills against predators; noncontact social play, which includes crouching and stalking family members, necessary skillsets for successful hunting; contact social play; and object play (Caro, 1995). The last two categories are mainly observed in older cubs and object play entails the mother capturing and releasing live prey for the cubs to refine their hunting abilities (Caro and Hauser, 1992).

Once independent, adolescents usually remain in a sibling group for up to another six months after separation from mother. Female siblings may stick together for a few additional weeks before becoming solitary and establishing separate, albeit largely overlapping, home ranges proximal to their natal territory (Caro, 1994; Frame, 1984; Marker *et al.,* 2008). In contrast, male siblings frequently establish coalitions, maintaining lifelong bonds, and disperse to settle away from their natal range (Caro, 1994; Caro and Kelly, 2001). Solitary males from a litter, if any, may choose to remain solitary or join other solitary males or a coalition (Caro, 1994; Mills *et al.,* 2017). In cheetahs, paternal involvement in offspring rearing is absent, leaving the responsibility of parental care solely to females. Examining maternal-offspring interactions provides valuable insights into the life history decisions of female cheetahs, including the allocation of time towards weaning, vigilance, predator defence, teaching hunting skills, and determining the timing of offspring separation.

Image 6. *Female cheetah with her two week old cubs at den site in Kuno National Park © Onkar Anchal, MPFD*

I.4. Nutritional Requirements of Cheetah during Pre- and Post-partum period

The nutrition of both mother and cubs is initially interlinked, as maternal nutrition and body stores play a crucial role in providing nourishment for foetal growth and development during gestation (lasting 90-95 days) and are equally important during the nursing period of cubs (0-4 months old) (Caro, 1994). In the wild, cubs also rely on their mothers for the supplementation of prey during the weaning process, which typically begins at approximately 5 weeks of age, and continue to depend on maternal provisioning post-weaning until they become independent hunters (12-18 months old). During late pregnancy and lactation, energy expenditure in female cheetahs can increase up to two to five-fold due to activities such as predator avoidance, searching for water and food, and securing safe places for cubs (Laurenson, 1995a). Cheetah cubs develop more quickly than young of any other large felid, gaining about 45 grams of weight daily (Cheetah outreach, 2015). In the wild, maternal food intake exceeding 1.5 kg per day is necessary to maintain adequate milk production for cub growth, while cub growth decreased when maternal intake fell below 1.5 kg per day, with no added benefit observed with higher intake levels (up to 5 kg per day) (Laurenson, 1995b). To sustain higher intake levels, cheetahs adjust their diet by hunting and targeting larger prey, which in turn increases the proportion of large prey killed (Cooper *et al.,* 2007); lactating female cheetahs consume 65-97% more food compared to non-reproductive females.

Image 7. *Two week old cheetah cubs at den site in Kuno National Park ©Onkar Anchal, MPFD*

Image 8. *Male cheetah coalition in Kuno © Moulik Sarkar, WII*

ANNEXURE II

PROTOCOLS FOR PRE-PARTUM MANAGEMENT OF PREGNANT CHEETAH AT CHEETAH INTRODUCTION SITES

II.1. General Considerations

• All introduced cheetahs in India are equipped with radio collars and are regularly tracked by dedicated field teams on a daily basis. This meticulous monitoring allows for close observation of each cheetah, including documenting their hunting activities, interactions with other individuals, and instances of successful mating.

• These occurrences should be carefully recorded, and such females should consistently be visually assessed for signs of pregnancy, such as increased appetite, weight gain, nipple development, and a visibly swollen abdomen, beginning as early as the second month after mating. Pregnancy can however be difficult to confirm, especially during the first trimester and if the female is bulkier or carrying a small litter.

• A day-to-day record of activities and kills made by suspected pregnant females should be maintained through unobtrusive monitoring, with bi-weekly supervisory checks by veterinarians and weekly checks by the concerned authority of Park Management.

• Pregnant cheetahs have substantially increased nutritional requirements. If the pregnancy occurs within fenced area or larger acclimatizing boma, adequate prey base should always be maintained through frequent prey supplementation to aid in successful hunts.

• In free-ranging cheetahs, pregnant females will have ample prey available. Nonetheless, in case of prolonged fasting bouts (> 5 days) or presence of pregnant females in an area with lower prey density, dressed meat may be supplemented after thorough review of the situation.

• In drier areas/ months, adequate arrangements for multiple water source shall be additionally made/ installed in areas harbouring pregnant females.

• While monitoring is essential, it is important to strike a balance to avoid too much human presence around such cheetahs, so as to prevent undue stress.

• In fenced areas, restrictions to non-essential personnel shall be strictly enforced.

• In free-ranging environments, areas that are known to harbour pregnant females should be restricted from tourist access.

Image 9. *Radio-collared cheetah on a chital kill in Kuno © Moulik Sarkar, WII*

II.2. Capture and Chemical Immobilization and Health Care

• Pregnant cheetahs with sufficient prey availability typically do not require any veterinary interventions or nutritional supplements. Nonetheless, decision on the same shall be taken on case-by-case basis in due consultation with the committee outlined in paragraph 8(a).
• Capturing and handling of pregnant or suspected pregnant cheetah females should only be conducted when absolutely essential.
• Instances such as replacing radio collars with depleted batteries to maintain uninterrupted monitoring, veterinary interventions for treating injuries or illnesses, and confirming pregnancies in suspected cases within free-ranging or wild settings may unavoidably require capture.
• The MS-NTCA and Chief Wildlife Warden of the concerned state, in consultation with the committee outlined in paragraph 8(a) will be responsible for taking the ultimate decision on circumstances warranting capturing of pregnant females.
• If situation warrants, capture and thorough physical examination of pregnant female may be carried out in early to advanced pregnancy period (>10 days of parturition date) by chemical immobilization by qualified personnel using following drug combination:

Ketamine-Medetomidine-butorphanol combinations at dose rate of 3 mg/kg, 0.04 mg/kg and 0.2 mg/kg respectively, reversed with atipamezole at 4X medetomidine dose. This combination has proven to be safe in pregnant cheetahs in Kuno National Park.

• ***Any combinations with tiletamine and zolazepam should especially be avoided in pregnant females*** as safety of the drugs in these cases are unclear.
• The administration of veterinary medicines, particularly those contraindicated during pregnancy such as dewormers, must be completely avoided.
• Under no circumstances should physical restraint or cage capturing techniques be employed with pregnant females to prevent unnecessary stress and complications.
• If circumstances necessitate the capture of pregnant females, it is imperative that the team from the NTCA and Kuno National Park, who possess expertise in handling cheetahs, be invariably engaged.

II.3. Ex-situ Management of Pregnant Females

• If situation warrants prolonged veterinary interventions in pregnant female, it should be immediately shifted to the quarantine/ treatment facility after due certification from on-site veterinarian(s) and in due consultation with the committee outlined in paragraph 8(a).
• Transportation of capture site to quarantine/ treatment facility shall be carried out with utmost precautions, during cooler periods of the day, utilizing appropriate cheetah crates and in the presence of onsite veterinarian(s).
• The quarantine/ treatment facility selected for holding pregnant females shall be in an isolated section, devoid of other cheetahs and frequent human presence.
• A machan or raised platform should be constructed with adequate concealment measures adjacent to quarantine/ treatment facility to allow for continuous monitoring of these cheetahs without disrupting their natural behaviours or causing unnecessary stress.
• Due to the significant stress that captivity can impose on pregnant females, their time in captivity should be curtailed to the absolute minimum necessary period.
• Since provision to natural prey is not feasible in captivity, adequate dressed meat shall be provided until release into wild. Said meat shall be procured from a certified vendor and subjected to thorough examination by onsite veterinarians before feeding.
• Feeding should be carried out by providing a large meal (15 — 20 kg) every third or fourth day during the period, mimicking the natural feed starvation cycle. Under no circumstances should daily feeding be carried out, as cheetahs are very prone to gastrointestinal disorders

(A) (B)

Image 10. *Appropriate crate for long distance transport of cheetahs; (A) Wooden crate & (B) Metal crate used in Kuno. © Moulik Sarkar, WII* arising out of such unnatural feeding regimen.

• The holding enclosures containing pregnant females should be regularly cleaned of excreta and leftover meat to prevent the buildup of pathogens. However, housekeeping activities in such enclosures should be kept brief to minimize stress on the pregnant cheetahs.

• The onsite veterinarian(s) shall record all the observations in well-defined formats with respect to feeding, health and well-being, including veterinary interventions and husbandry activities that were carried out.

• Said records shall be monitored by the Deputy Director and the Field Director on regular basis and communicated to the committee outlined in paragraph 8(a) for necessary recommendations.

• External veterinary expertise shall be availed on case-by case basis whenever necessary, in due consultation with the committee outlined in paragraph 8(a).

• The MS- NTCA and the Chief Wildlife Warden of the concerned state, in consultation with onsite veterinarian(s) and the committee outlined in paragraph 8(a) will be responsible for taking the ultimate decision regarding such cheetah on either extending captivity or release back to wild.

Image 11. *A treatment enclosure in Kuno for short-term holding of cheetah. © Moulik Sarkar, WII*

II.4. Watch and Ward of Pregnant Females

• The on-site veterinary team should visit the pregnant females, at least once a day for visual health examination.

• The dedicated field monitoring teams already established at each cheetah introduction site will also be responsible for the surveillance and care of pregnant females.

• The field monitoring staff shall be well versed in normal behaviour of the cheetahs to notice any deviance and sensitive to wild carnivore behaviour. This is especially with respect to appearance, gait and feeding habit of individual animals.

• Training on above aspects shall routinely be imparted on field monitoring staff by the onsite veterinarians and WII research team.

• In wild conditions, the staff shall ensure that no domestic livestock including stray dogs are present in the vicinity of pregnant females.

• The staff shall record all the observations in well-defined formats with respect to hunting, inter-species interactions, behavioural and health parameters.

• The staff shall be equipped with wireless sets to communicate any exigency/ change from routine.

• The staff shall promptly communicate to the onsite veterinary team of any irregularities or even the slightest suspicion of ill health immediately.

• The following records shall be maintained which shall be monitored by the Range Forest Officer in their entirety. Test check of records shall be carried out by the concerned authority of the Park management every month during field visits/ surprise checks

a. General Appearance and Belly Scores
b. Habitat Interventions
c. Feeding Pattern/ Release of Prey
d. Maintenance Activities
e. Reporting/ Wireless register

ANNEXURE III

PROTOCOLS FOR POST-PARTUM MANAGEMENT OF PREGNANT CHEETAH AND CUBS AT CHEETAH INTRODUCTION SITES

III.1. General Considerations

• All introduced cheetahs in India are equipped with radio collars and are regularly tracked by dedicated field teams on a daily basis. This meticulous monitoring allows for close observation of each cheetah, including successful parturition/ cub births.
• The frequency of locations communicated by the radio-collar should be kept at one-hour interval, starting at least five days before the anticipated parturition date and continuing until at least four (04) to six (06) weeks after birth.
• Upon confirmation of parturition, the den site shall be promptly located using telemetry data or visual monitoring. After parturition, den sites can be accurately identified as females typically remain stationary in the same location for two (02) to three (03) days around the birth date. Subsequently, they exhibit a pattern of movement resembling a star shape, as observed in telemetry data, wherein movement is in various directions but consistently returning to the initial location.
• Den information shall only be securely shared with essential field personnel responsible for monitoring the cheetah female.
• Restrictions on vehicular access and excessive human movement in the den vicinity shall promptly be implemented.
• Den sites should be inspected by veterinary team within the first weeks of denning to evaluate litter size and cub survival. Checking dens can be performed by one or two persons while the female is away hunting, which can be confirmed through radio-telemetry. It is essential to refrain from handling cubs during this period to minimize disturbance to the denning process.
• A day-to-day record of activities and kills made by nursing females should be maintained through unobtrusive monitoring, with daily supervisory checks by veterinarians and weekly checks by the concerned authority of Park Management.
• The cubs typically open their eyes around 10 days after birth. After this period, they shall be physically examined by the veterinarian(s) and weighed to assess their health and well-being. This examination should occur while the cheetah female is away hunting, as previously mentioned. Handling should be done gently, swiftly, and minimally, with the use of gloves and other personal protective equipment (PPE) to prevent the transmission of pathogens and minimize the transfer of human scent.
• This process should be repeated with periodic checks whenever opportunities arise until the cheetah cubs reach approximately one month/ three (03) to four (04) weeks of age. Regular monitoring during this critical period helps ensure the proper development and care of the cheetah cubs.
• By the sixth week of age, the cheetah cubs will become increasingly mobile, making them difficult to catch as they scurry upon approach. Therefore, handling should be strictly avoided unless absolutely necessary for prophylaxis or treatment purposes. It is crucial to minimize human intervention and allow the cubs to continue their development and adaptation to their environment without undue disturbance.
• Between six (06) to eight (08) weeks of age, cubs begin venturing out of the den site accompanied by their mother. To ensure the well-being of both the mother and cubs, concealed trail cameras shall be set up along probable trails and around the den vicinity. This allows for continuous monitoring of the mother and cubs without direct human interference, providing valuable insights into their health and behaviour.
• Routine monitoring by the veterinary team should also persist during the aforementioned period until 18 months of age, allowing for visual observation of the cubs with their mother whenever opportunities arise. This ongoing monitoring ensures that any potential health issues or concerns be addressed promptly.
• In free-ranging cheetahs, nursing females will always have ample prey available. Nonetheless, in case of prolonged unsuccessful hunts or frequent encounter of female with belly score less than two (02), dressed meat shall be supplemented as and when necessary.

Image 12. *A cheetah cub being weighed in field conditions at Kuno. © Sumit Patel, WII*

Image 13. *Watchful female cheetah nursing her two week old cubs at den site in Kuno National Park © Onkar Anchal, MPFD*

Image 14. *Female cheetah feeding on supplemented carcass with her two month old cubs in Kuno National Park ©Sanath Muliya, NTCA*

III.2. Specific Considerations

Births of cheetah cubs (denning) can take place either in fenced areas/ larger acclimatization enclosures or in free-ranging conditions. While general considerations apply to both scenarios, each situation warrants specific considerations as outlined below:

III.2.1. Fenced Areas/ Larger Acclimatization Enclosures

• Similar to pregnant cheetahs, nursing mothers have substantially increased nutritional requirements. If the birthing occurs within fenced area or larger acclimatizing boma, ad libitum prey base should always be maintained through frequent prey supplementation to aid in successful hunts.

• Though fenced areas are relatively large, they will have limited availability of space, provision for adequate spots with denning area, shade, vegetation and water source shall be created well in advance to the parturition dates.

• Alternatively, cheetahs may be relocated to adjacent

or different fenced areas/ acclimatization enclosures where these requirements are naturally available.
• Fences shall regularly be checked for breaches or intrusion by large predators.
• Since fenced areas provide some sort of protection from predators, the watch and ward shall be limited to periodic observation by veterinary team as elaborated under general considerations above.
• Contingency plans for emergencies such as adverse weather, forest fire, etc shall be laid down in writing.
• Presence of cheetah male(s) shall be avoided in adjacent fenced or larger acclimatization enclosures.
• While enclosures or bomas are typically designed to be predator-proof, smaller carnivores such as foxes, jungle cats, or scavengers like wild pigs may still inhabit them. It is essential to promptly remove these potential threats from birthing enclosures well before parturition to prevent cub predation events.

III.2.2. Free-Ranging Conditions

• In the wild, cheetah females and their cubs face numerous threats to their survival, with predation from other carnivores being the primary challenge. Cub mortalities or emergencies in such conditions are expected to be extremely high due to the harsh realities of the natural environment.
• This in turn necessitates enhanced monitoring, protection measures, preparedness, and contingency plans to effectively address and mitigate such emergencies.
• In addition to veterinary monitoring, round-the-clock non-intrusive presence of a field monitoring team in the vicinity but not too close shall be ensured to offer protection to the den site. This continuous presence serves as a deterrent to potential threats and provides an additional layer of security for the cubs when mother is away hunting.
• Non-intrusive observation techniques, such as trail cameras or field installable solar powered remote monitoring, to minimize disturbances to the natural behaviour of the animals.
• Pregnant cheetah females typically avoid human-dominated areas for denning. However, if a situation arises where a mother cheetah is found far away from the Protected Area during last trimester, she shall be promptly relocated to a suitable Protected Area well in advance of the parturition dates.
• In free-ranging conditions, nursing cheetah females will always have ample prey available. Nonetheless, in case of prolonged unsuccessful hunts or frequent encounter of female with belly score below two, dressed meat shall be supplemented as and when necessary.
• A field veterinary unit shall be on standby at all times to intervene promptly in case of any emergent situations. This ensures rapid response and effective management of any medical or health-related issues that may very well arise in free ranging condition.

III.3. Capture and Chemical Immobilization and Health Care of Pregnant Cheetahs

• Nursing cheetahs with sufficient prey availability typically do not require any veterinary interventions or nutritional supplements. Nonetheless, decision on the same shall be taken on case-by-case basis in due consultation with the committee outlined in paragraph 8(a).
• Capturing and handling of nursing cheetah females and her cub(s) should only be conducted when absolutely essential.
• Instances such as veterinary interventions for treating injuries or illnesses, administration of prophylaxis, etc. within free-ranging or wild settings may unavoidably require capture.
• The MS-NTCA and the Chief Wildlife Warden of the concerned state, in consultation with the committee outlined in paragraph 8(a) will be responsible for approving of these operations.
• If situation warrants capture and thorough physical examination of nursing cheetah female, it should be carried out by chemical immobilization by qualified personnel using either of the following drug combination,
Ketamine-Medetomidine-butorphanol combinations at dose rate of 3 mg/kg, 0.04 mg/kg and 0.2 mg/kg respectively, reversed with atipamezole at 4X medetomidine dose.
OR
T***iletamine-Zolazepam and Medetomidine combination at dose rate of 30 — 25 mg (total dose) + 2 mg (total dose), respectively, reversed with atipamezole at 4X medetomidine dose.***
•The procedure of capture by chemical immobilization and thorough physical examination of nursing cheetah female shall be carried out with utmost care and precaution.
• Whenever a nursing mother cheetah is immobilized, particularly in wild conditions, it is crucial to also capture and secure the cubs in crates until the mother is reversed out of anesthesia, so as to ensure their safety.
• Cheetah cubs below two (02) months of age can easily be captured using physical restraint.
• Cubs above two (02) months of age shall be captured using chemical immobilization by qualified personnel if situation warrants, using either of the following drug combination:
Ketamine-Medetomidine-butorphanol combinations at dose rate of 3 mg/kg, 0.04 mg/kg and 0.2 mg/kg respectively, reversed with atipamezole at 4X medetomidine dose.
OR
Tiletamine-Zolazepam and Medetomidine combination at dose rate of 30 — 25 mg (total dose) + 2 mg (total dose), respectively, reversed with atipamezole at 4X medetomidine dose.
• During both the above scenarios, capture and handling process shall be gentle, swift, and minimal to avoid undue stress to the cheetah cubs and possible maternal rejection due to human scent. Once the cubs are crated, disturbance, activities and noise around the crates shall also be kept minimal.
• Cheetah cub(s) shall be subjected to appropriate prophylaxis measures as tabulated below.
• If circumstances necessitate the capture of nursing cheetah females or cubs, the veterinary team from the NTCA, Kuno NP and WII, who possess expertise in han-

Measure	Drug/ Vaccine	Schedule	Note
Vaccination	Rhinotracheitis-Calci-Panleukopaenia-Chlamydia Psittaci Vaccine	First dose at 06-07 weeks of age. Booster at 09 — 10 weeks of age Yearly annual booster	• Non adjuvanted and killed vaccine such as TruFel™ HC2PCh or Fel-O-Vac to be used. • Live attenuated or inactivated vaccines should be completely avoided. • Vaccine to be administered subcutaneously
	Rabies vaccine	First dose at 04 months of age. Booster at 01 year age Yearly annual booster	• Non adjuvanted recombinant vaccines such as PUREVAX Feline Rabies Vaccine to be used. • Vaccine to be administered subcutaneously
Deworming	Pyrantel pamoate	First dose at 06 weeks, repeated after a month, and every 03 months until adulthood.	• To be administered orally at dose tare of 3-5 mg/kg
External parasiticidal	Fluralaner	Above 06 months of age, single application effective for 04 months	• To be used judiciously, preferably during monsoon/ post monsoon/ humid weather. • To be administered topically or orally

Image 15. *Monitoring cheetah cubs with trail cameras in Kuno National Park © MPFD and WII*

dling cheetahs, shall be invariably involved.

III.4. Ex-situ Management of Nursing Cheetah Females and Cubs

• If situation warrants prolonged veterinary interventions in nursing female, it should be immediately shifted to the quarantine/treatment facility along with all the cubs after due certification from on-site veterinarian(s) and in due consultation the committee outlined in paragraph 8(a).

• Protocols as described above for ex-situ management of pregnant female shall also be applicable here, with following additional considerations.
• Transportation from capture site to quarantine/ treatment facility shall be carried out with utmost precautions, during cooler periods of the day, utilizing appropriate cheetah crates and in the presence of onsite veterinarian(s).
• Cheetah cub(s) and mother shall be transported in separate crates to avoid injury to cubs during the process.
• The quarantine/ treatment facility selected for holding such females shall be in an isolated section, devoid of other cheetahs and frequent human presence. Fencing of said enclosure should also be covered with green shade netting to provide secluded environment.
• The holding enclosures containing nursing females and cubs should be regularly cleaned of excreta and leftover meat to prevent the build-up of pathogens. However, housekeeping activities in such enclosures should be kept absolutely brief, with one or two persons involved. This needs to be carried out on feeding days.
• The MS-NTCA and the Chief Wildlife Warden of the concerned state, in consultation with onsite veterinarian(s) and the committee outlined in paragraph 8(a) will be responsible for taking the ultimate decision on either extending captivity or release of such cheetah back to wild.

Image 16. *Female cheetah resting with her two month old cubs in Kuno National Park © Sanath Muliya, NTCA*

ANNEXURE IV

PROTOCOLS FOR DEALING WITH ORPHANING/ ABANDONMENT/ OR ILLNESS IN CHEETAH CUBS AT CHEETAH INTRODUCTION SITES

IV.1. General Considerations

• All introduced cheetahs in India are fitted with radio collars and are meticulously tracked by dedicated field teams on a daily basis. This rigorous monitoring, combined with the protocols outlined in **Annexures II & III,** facilitates close observation of each cheetah, including instances of orphaning, abandonment, or illness in cheetah cubs.
In cases where the mother is still alive, every effort should be made to reunite the cubs with her and support natural parenting behaviour.
• Circumstances such as orphaning due to mortality or incapacitation of the mother caused by injury, illness (natural or otherwise), abandonment, cubs with in-born incapacitation, weak cheetah cubs, runts, and injured or sick cheetah cubs will inevitably necessitate hand-raising and human interventions for the survival and well-being of the cubs.
• Before being brought under human care, cub(s) should undergo on-site evaluation by the veterinary team to assess for health problems, hydration status, and congenital defects. The findings of this evaluation should be promptly communicated to the field director, who will then relay the information to the committee outlined in paragraph 8(a).
• The MS-NTCA and Chief Wildlife Warden of the concerned state, in consultation with the committee outlined in paragraph 8(a) will be responsible for taking the ultimate decision on circumstances warranting neonatal care and hand raising of cheetah cubs.
• Before attempting transportation for neonatal care or hand-rearing, necessary veterinary intervention, including on-site health stabilization, should be carried out to ensure the well-being of the cubs. Additionally, a field veterinary unit equipped with necessary emergency medication shall accompany the veterinary team at all times to intervene promptly in case of emergent situations, ensuring the safety and health of the cubs during transportation and subsequent care.
• When situation warrants, cheetah cubs below two (02) months of age shall be captured using physical restraint. Cubs above two (02) months of age shall be captured using chemical immobilization by qualified personnel as described in **Annexure III.**
• Transportation from capture site to hand rearing/ treatment facility shall be carried out with utmost precautions, during cooler periods of the day, utilizing appropriate cheetah cub crates and in the presence of onsite veterinarian(s).
• To prevent exposure to infectious diseases, handling of cub(s) should always be carried out while wearing proper personal protective equipment, including gloves, gowns, masks, and boots.
• Neonatal care and hand rearing shall be carried out with the utmost caution, providing dedicated care, appropriate nutrition, and socialization to ensure the well-being and successful development of the cubs.
• During above interventions, every effort should be made to minimize human imprinting, as the ultimate goal is for these cheetahs to exhibit natural behaviours and thrive independently in free-ranging habitats. This involves minimizing unnecessary human interaction and providing secluded and safe environment, ensuring that the cubs retain their natural instincts and behaviours to increase their chances of successful integration into the wild.

IV.2. Consideration for Neonatal Care in Cheetah Cubs

Cheetah cubs are born altricial, meaning they are relatively underdeveloped at birth and require significant parental care, especially during the initial days of life. Cubs that have not received sufficient colostrum, the first milk produced by the mother, are more susceptible to infectious diseases due to their decreased immunity resulting from the failure of passive transfer of antibodies. A large percentage of hand-reared cubs in captive setups abroad have been observed to die before reaching 30 days of age due to these reasons, highlighting the criticalities involved in neonatal care and management of cheetah cubs. The following specific considerations shall thus be followed to maximize their welfare and chances of survival:
• To prevent exposure to infectious diseases, neonatal care should be conducted in an isolated room by qualified veterinarian(s) only, who are equipped with appropriate personal protective equipment.
• The room designated for neonatal care should be temperature-controlled to ensure optimal conditions for the health and well-being of the cheetah cubs. Ideally, it should also be equipped with a veterinary incubator.
• The room designated for neonatal care should be equipped with a foot dip at the entrance to prevent the spread of pathogens, along with adequate sanitary facilities to maintain cleanliness and hygiene standards.
• Neonates should be placed in a disinfected incubator set to a temperature range of 85-90°F or in a clean box lined with fresh towels over a heating pad, with an adjustable heat lamp positioned above. This practice is especially crucial for cubs less than 10 days old to ensure that they remain within the appropriate temperature range at all times, supporting their physiological needs and promoting their health and well-being.
• The routine neonatal examination should include monitoring of body temperature (normal range 98-100° F) and weight (normal range 350-500g), along with other necessary vital parameters.
• If cubs have not suckled (in cases of maternal abandonment/ death immediately after parturition), a plas-

ma transfusion from the mother (if alive) or another cheetah shall be carried out. Plasma shall be obtained by centrifugation of freshly drawn blood for 10 minutes at 1,000-2,000 x g using a refrigerated centrifuge.
• Plasma shall be given to the cubs subcutaneously or by mouth at rate of up to 10% of cubs body weight, every two (02)-three (03) days for the first one (01)—two (02) weeks.
• Adequate provisions shall be made to ensure the availability of clean bottles and nipples for every feeding of the neonatal cheetah cubs.
• After each use, used bottles should be thoroughly disinfected and rinsed well, and then sterilized (autoclaved) on a daily basis.
• Commercially available kitten feeding bottles, equipped with slow-flow (preemie) nipples, are recommended for feeding neonates, as they are suitable for their delicate feeding requirements and help minimize the risk of overfeeding or aspiration.
• Feeding in neonates shall be carried out only when they are in stable, alert and responsive state. Force feeding while sleeping or unresponsive state should be totally avoided.
• The initial feeding attempt for neonatal cheetah cubs should always be with 5% dextrose in water. This is done to evaluate the suckle response of the cubs. If the suckling reflex is strong and the cubs demonstrate an ability to nurse effectively, further feeding can then be initiated using an appropriate milk formula or replacer.
• Neonates shall be nursed with commercially available Kitten Milk Replacers (KMR: Royal Canin® Baby Cat Milk, Beaphar® Lactol Kitten Milk, Bio PetActive KMR etc. are readily available in India). Alternatively, freshly milked goat milk (with dilutions suggested below) may also be used (previously used in successfully hand raising a cheetah cub in Kuno).
• Feeding with the above formulations should begin with a dilution of 25% liquid KMR/ sterilized goat milk and 75% Oral Rehydrating Solution (ORS)/ Pedialyte. There should be at least three (03) feedings at this strength before increasing to a 50:50 ratio. The 50:50 ratio should be fed for a minimum of 48 hours before further increasing to a 75:25 ratio.
• If diarrhoea occurs after changing the concentrations as stated above, the concentration of the milk formula should be reverted to the previous dilution until stools appear solidified. This approach helps ensure that the cheetah cubs receive the appropriate balance of nutrients and hydration while minimizing the risk of gastrointestinal upset.
• While using commercially available KMR, lact-aid or any other commercially available supplements with combination of prebiotics, enzymes, and probiotics (e.g. Gutwell®) shall be added to aid in digestion.
• Neonates should be bottle fed every 2 hours until 2 weeks of age (roughly around 10 — 11 feedings per day)
• The average growth rate in a healthy hand-reared cheetah cub averages 48 g/ day and amount of formula per feeding shall always be determined by cub's weight.
• Amount of milk formula shall start around 10%—12% of body weight per day and is gradually increased to 15%—20%. If problem such as indigestion or diarrhoea persists, amount may be reverted back to earlier percentages.
• For ease of understanding, following example is being provided:
For a cub weighing 500g at birth, the total milk formula requirement per day is 60ml (at 12%), followed by gradual rise to 100ml (at 20%) over first couple of days. The said amount is divided into 10 - 11 feedings per day until two (02) weeks of age: Thus 05 — 06 ml/feeding of milk formula shall initially be provided and gradually raised to 09 — 10 ml/feeding, fed every 02 hours until 02 weeks of age. As weight increases, amount shall also be increased as per above calculations.
• Overfeeding (quantity more than mentioned above) shall be avoided at all times even if cubs appear hungry after above feedings. In such instances, ORS may be supplemented to calm the cubs.
• By the third week, number of feeding per day shall further be decreased to 07 — 08 feedings per day, while keeping the amount fed at around 20% of the body weight/day.
• To determine the amount and strength of the milk formula to be provided, the cheetah cubs should be weighed at the same time every day, preferably early in the morning after defecation and urination.
• This consistent weighing schedule helps ensure accurate monitoring of the cubs' growth and nutritional needs, allowing for daily adjustments to the milk formula as necessary.
• Since neonates often do not urinate or defecate on their own, they require stimulation to achieve these. This involves gently massaging around the anal and genital area with a warm water swab to stimulate the natural elimination reflex. Said procedure needs to be carried out consistently before weighing, as well as before and after every feeding.
• Any other illness or situations warranting additional veterinary interventions shall be made on case-by-case bases in due consultation with the committee outlined in paragraph 8(a).

IV.3. Consideration for Hand Rearing and Ex-situ Care in Cheetah Cubs

• After reaching one month of age, cheetah cubs shall be shifted to a nursery area equipped with adequate access to appropriate environmental stimuli and social interactions essential for their physical and behavioural development.
• Adequate arrangements shall be made to ensure a smooth transition, including appropriate facilities and protocols for the transfer process.
• This may involve considerations such acclimatization to the new environment, and continued monitoring and care by qualified veterinary personnel to support the cub(s) development and well-being in the nursery enclosure.
• The nursery area should be meticulously designed to closely mimic natural habitat conditions, while also prioritizing the safety and well-being of the cheetah cubs.
• Nursery area should provide opportunities for natural

behaviours, such as exploration, climbing, and hiding, while also ensuring that potential hazards are minimized. Features such as varied terrain, vegetation, hiding spots, and enrichment activities should be incorporated to promote physical and mental stimulation.

• Careful consideration shall also be given to enclosure design to prevent escape and minimize stress for the cubs.

• Throughout the nursery period, it is crucial to provide nursery-reared cheetahs with sufficient age-appropriate enrichment.

• A suitable surrogate may be provided to simulate the maternal body, so as to provide comfort and stimulation for the cheetah cubs. A stuffed animal can serve this purpose effectively, but any surrogate should be selected with the following criteria in mind:

o Durable fake fur that is not easily pulled free and ingested.

o Absence of buttons, strings, or other ornamentation that might be pulled free and ingested by the cubs.o The surrogate should be completely washable to maintain cleanliness and hygiene standards.

• Additionally, cheetah cub(s) shall be provided with a soft bedding/ nest or hiding spot with the above relevant criteria to ensure their comfort and security in nursery area.

• As the cubs become more capable of moving and start to explore their environment, a selection of suitable toys shall be introduced.

• These toys should be routinely inspected for safety and rotated to provide variety and novelty, stimulating the cubs(s) curiosity and development.

• Additionally, items such as browse and wood shall be included in the enclosure gradually as age advances to offer natural enrichment opportunities. These materials allow the cubs to engage in natural behaviours such as chewing and scratching, promoting physical and mental stimulation.

(A)

(B)

Image 17. *Cheetah cub provided with (A) Surrogate © Ziegler—Meeks, 2009 & (B) Soft bed to ensure comfort © Sanath Muliya, NTCA*

• Balanced nutrition is essential for cheetah cubs to prevent deficiencies and nutritional disorders throughout their growth phase and into adulthood. Therefore, a diet plan shall be formulated while considering the recommendations placed below.

• Meat-based foods shall be added at 03 weeks of age and if doing well, cooked meat is added to the diet, followed by raw meat, around 04—05 weeks of age. Cubs shall then be gradually weaned from milk replacer by 06—07 weeks of age.

• Diet fed to cub(s), especially supplemented meat, can vary significantly in vitamin and mineral content, predisposing cheetahs to nutritional disease, such as metabolic bone disease. Thus, diet should be carefully evaluated, particularly in growing cheetahs, to ensure that they not only meet dietary recommendations for felids, but also that circulating levels of nutrients are adequate.

• While chicken meat can be suitable initially, red meat from goat or buffalo shall be provided as they grow. Red meat provides essential nutrients and proteins necessary for the healthy development of cheetah cubs, while mimicking their natural diet more closely.

• Additional vitamin and mineral supplements shall also be provided periodically to avoid deficiencies and nutritional disorders.

• Recommended feeding schedule for cheetah cubs is as follows (Adopted from Ziegler-Meeks, 2009 and Colburn *et al.,* 2018 and learnings from Kuno).

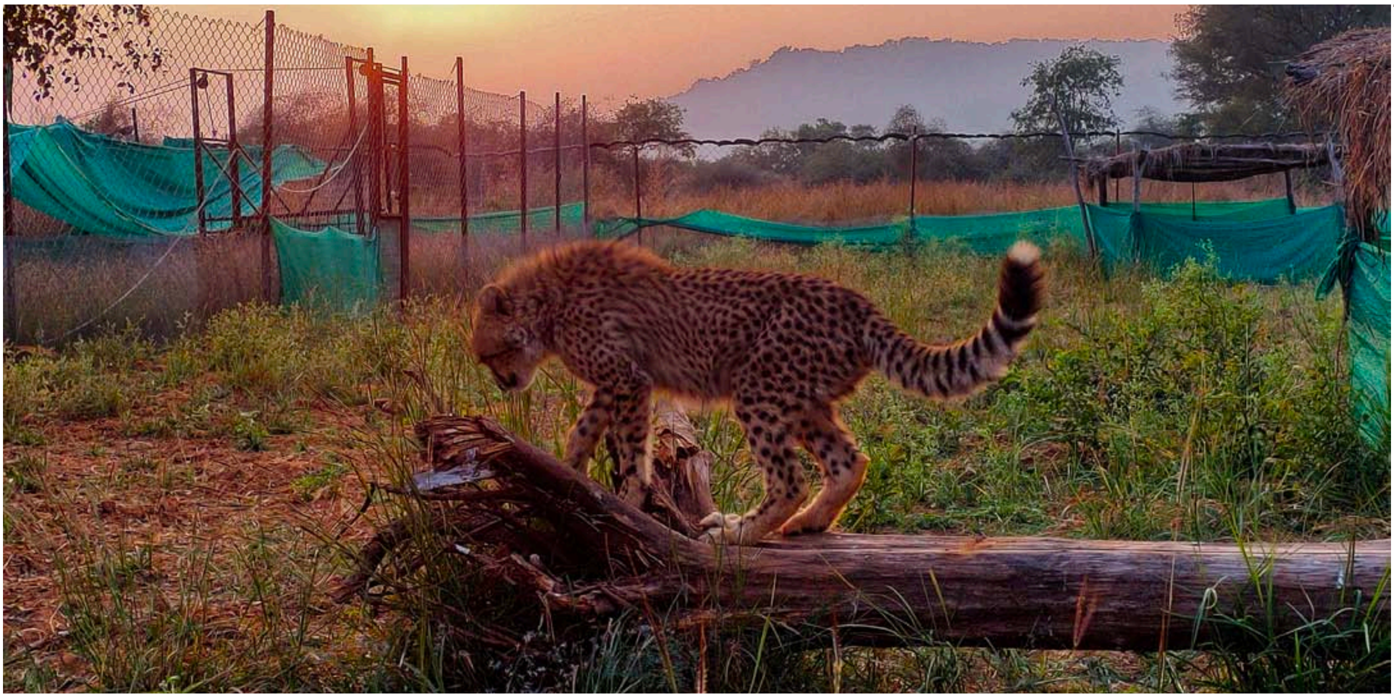

Image 18. *A fallen tree provided to hand-raised cub as enrichment in Kuno. © Moulik Sarkar, WII*

Age	Feeding Schedule
Week 03	Milk formula divided into 08 feedings per day
Week 04	Milk formula divided into 08 feedings per day Gradually introduce small quantities of cooked meat (chicken or goat) along with the formula, while keeping the total feeding volume still at 20% body weight
Week 05	05 feedings of milk formula/day, decreasing to 03 days by the end of the week. Continue weaning onto meat Meat shall be cooked 75% for 3 days, 50% for 03 days, then raw meat shall be fed
Week 06	Boneless meat chunks with added essential vitamin-mineral supplements, divided over 05 meals per day
Week 07 — 15	Boneless meat chunk with added essential vitamin-mineral supplements, divided over 05 meals per day Over time, gradually introduce pieces of meat with larger bones that are large enough to prevent swallowing but still provide dental benefits and additional nutrients
04 — 08 months	Large meat pieces on bone divided over 03 meals per day until 05 months and 02 meals per day thereafter
Above 08 months — 01 year	Large meat pieces once a day
01 year and above	Single, large enough chunk of red meat, every alternate day Consuming a single substantial portion of red meat every other day or two is imperative to replicate the feeding-starvation cycle crucial for preserving typical gut health in cheetahs

• Cheetah cub(s) shall also be subjected to appropriate prophylaxis measures as described in **Annexure III.**
• In addition to the veterinary team, a select group of committed caretakers shall be chosen from the field staff. These individuals will undergo regular training and sensitization sessions conducted by onsite veterinarians, with valuable insights provided by the experienced veterinary team in Kuno.
• The designated caretakers will be responsible for various tasks including feeding, caring for, and managing the nursery enclosures, as well as maintaining cleanliness and hygiene standards within those areas by following the enclosure cleaning protocols described in **Annexure III.**
• Meticulous daily record keeping plays a crucial role when hand rearing cheetah cubs. These data will be valuable for comparative study and early detection of medical problems.
• Developmental data such as weight, eyes and ears opening, dental status and locomotion as well as appetite, vitality, stool and urine production shall thus be promptly be noted.
• The onsite veterinarian(s) shall record all the above in well-defined formats. Said records shall be monitored by the Deputy Director and the Field Director on regular basis and communicated to the committee outlined in paragraph 8(a) for necessary recommendations.
• Effective communication between caretakers and the veterinarians should also be ensured and, concerns or changes if any shall promptly be discussed with onsite veterinarian(s).
• Exceptional caution must be exercised to prevent imprinting, a learning process in which the cub(s) forms a deep attachment to a specific object or person(s) during its critical developmental phase. This emphasis is crucial as the ultimate goal for these cubs is to be successfully rehabilitated into the wild.
• Any other illness or situations warranting additional veterinary interventions shall be made on case-by-case bases in due consultation with the committee outlined in paragraph 8(a).
• External veterinary expertise shall be availed on case-by case basis whenever necessary, in due consultation with the committee outlined in paragraph 8(a).
• The MS- NTCA and the Chief Wildlife Warden of the concerned state, in consultation with onsite veterinarian(s) and the committee outlined in paragraph 8(a) will be responsible for taking the ultimate decision regarding rehabilitation and release of such cheetah cubs into the wild in future or to place them in permanent captive cheetah care facility. IV.4. Considerations for Rehabilitation of Captive Reared Cheetah Cubs into Wild and Free-Ranging Conditions
• Before considering the captive reared cheetah cubs for the rehabilitation process in free- ranging conditions, the health, behaviour, and natural instincts of the cheetah cubs shall be thoroughly assessed. Additionally, ensure that they are physically fit and free from any health issues that could hinder their rehabilitation process.
• If found fit, cheetah cubs shall gradually be introduced to a controlled natural environment, such as a large enclosure designed to mimic their future habitat. Cubs shall be allowed to explore and familiarize themselves with natural elements like vegetation, terrain, and climate.
• Activities that stimulate hunting instincts should also be initiated, such as providing smaller live prey for the cubs to chase and catch. Further, encourage natural hunting behaviours through these interactive plays and simulated hunting scenarios.
• Human interaction should be limited to prevent imprinting and to ensure the cubs maintain a healthy fear of humans. Caretakers especially should minimize direct contact and use techniques that maintain a respectful distance from the cubs being prepped for rehabilitation into the wild.
• Essential survival skills, including hunting techniques, territory marking, and predator avoidance, should be imparted by providing protected access to experienced individuals or surrogate adult cheetahs if available and with careful consideration.
• Protected interactions (over fencing or by keeping in adjacent enclosures) with other cheetahs should be followed to promote socialization and the development of natural social structures.
• Bonding with sibling(s) shall be encouraged if available, or compatible cheetah companions introduced to foster social skills.
• Cheetah cub(s) should gradually be transitioned to a larger, more expansive natural habitat as they demonstrate proficiency in hunting and survival skills.
• While male sibling(s) should always be moved together, female(s) above 18 months of age should be moved into solitary enclosures to mimic natural social structure.
• Monitor and promptly record their adaptation to the new environment while providing support as needed during the adjustment period.
• Progress during the period should be communicated promptly to the committee outlined in paragraph 8(a) to aid in the decision-making process.
• Once the cheetahs exhibit self-sufficiency and readiness, facilitate their release into protected wild areas where they have the opportunity to thrive.
• External expertise during the entire process shall be availed whenever necessary, in due consultation with the committee outlined in paragraph 8(a).
• Based on progress, the MS-NTCA and the Chief Wildlife Warden of the concerned state, in consultation with onsite veterinarian(s) and the committee outlined in paragraph 8(a), will be responsible for making the ultimate decision regarding rehabilitation of such cheetahs into wild and free ranging conditions.
• Post release of cheetahs into wild and free ranging conditions, progress, behaviour, and health of the individuals shall be continuously monitored. Continued support, such as supplementary feeding, if necessary, shall be provided while allowing the cheetahs to maintain their independence in the wild.
• The process of their integration into the wild population shall be rigorously monitored to ensure their long-term success.
• To enhance endeavours such as rehabilitation of captive reared cheetahs into the wild and free ranging conditions as well as grasp the scientific insights and methodologies involved in introduction of cheetahs in India, researchers from the Wildlife Institute of India (Project Cheetah) will

play a pivotal role. Documenting and periodically disseminating insights gained from the entire process to the committee outlined in paragraph 8(a) will inform future captive management strategies and improve the efficacy of rehabilitation initiatives.

Image 19. *One year old hand reared cheetah cub in large enclosure in Kuno National Park © Sanath Muliya, NTCA*

ANNEXURE V

CAPTIVE CARE AND CUB(S) REARING INFRASTRUCTURE PROTOTYPE AT CHEETAH INTRODUCTION SITES

V.1. General Considerations

Given their unique anatomy, physiology, and vulnerability to illnesses in captive settings, managing cheetahs presents significant challenges. Effectively caring for these animals within enclosures hinges upon a thorough comprehension of their physical, physiological, behavioural and clinical management requirements. This entails not only recognizing their distinctive needs but also implementing appropriate protocols to address them, thereby ensuring their well-being and longevity in captivity. A facility for captive cheetah care should thus be meticulously designed to function as a secure containment structure, ensuring the safety and well-being of the animals during both short-term and long-term stays. It should encompass distinct units such as holding enclosures, feeding chambers, transfer areas, shelter spaces, water sources, and corridors, all tailored to fulfil the fundamental requirements of cheetahs under human supervision.

The holding facility constructed within Kuno National Park for captive care of cheetahs have a rectangular configuration measuring 55 × 30 meters. They include a holding space of 50 × 30 meters, along with a corridor area measuring 30 × 05 meters. This corridor is subdivided into a kraal area measuring 20 × 05 meters and a feeding chamber measuring 10 × 05 meters, equipped with a double-sided cage as depicted below.

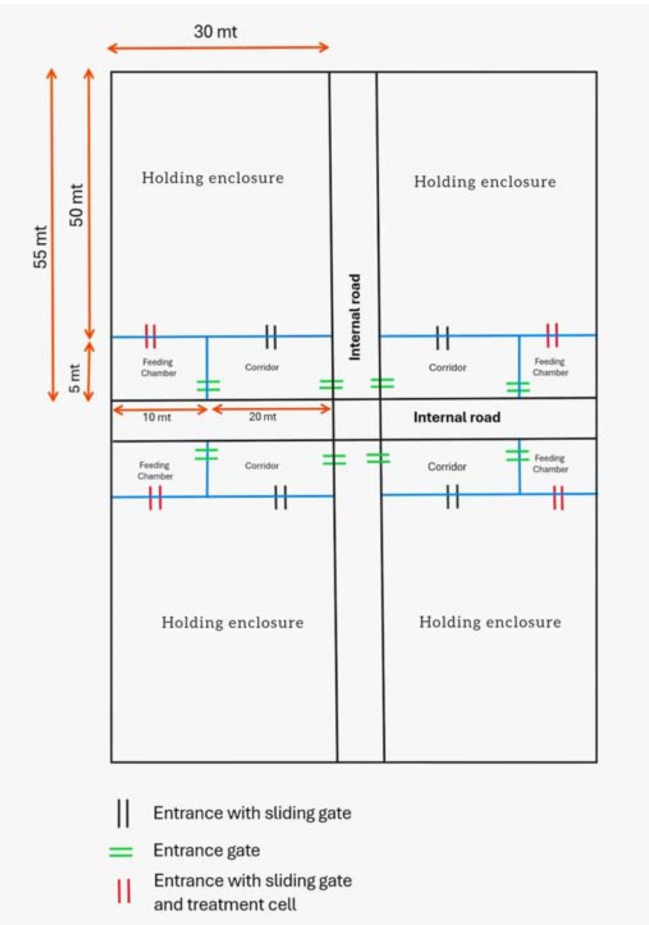

__Figure 1.__ Diagram of holding facility for captive care of cheetahs,

__Image 20.__ Aerial view of the holding facility for captive care of cheetahs in Kuno National Park © Amritanshu Singh, MPFD

Key requirements of the Captive Care Enclosure:

• **Enclosure Location:** The enclosure site must be carefully chosen, ideally in a secluded area away from high human activity. It should provide ample space and incorporate multiple holding areas to accommodate the needs of cheetahs. Sturdy fencing surrounding the enclosure is essential to prevent any escape attempts and guarantee the safety of both the mother cheetah and her cubs.

• **Bedding and Nesting Materials:** The enclosure should provide soft and cushiony materials such as grasses, hay, and straw to create a warm and cozy environment reminiscent of the cheetah's natural habitat. This ensures the comfort and well-being of both the mother and her cubs.

• **Temperature Control Facility:** Considering the dry and hot climate of Indian summers, the enclosure must incorporate temperature control measures. This could include ambient shading structures, both natural and artificial, as well as sprinkler systems to regulate temperature fluctuations and maintain a comfortable environment for the cubs.

• **Feeding Area:** Proper nutrition is vital for the healthy growth and development of the cubs. The enclosure should be equipped with dedicated feeding stations, especially if the mother is with the cubs, or areas where nutritious food can be provided in a naturalistic manner.

• **Regular Health Examination and Veterinary Care:** The enclosure should be easily accessible to veterinary staff for regular health check-ups and medical interventions if necessary, ensuring the ongoing well-being of the cheetahs.

• **Enrichment and Stimulation:** To foster the social and cognitive development of the cubs and manage stress, the enclosure should provide opportunities for natural enrichment and mental stimulation. This could include features such as running spaces, climbing structures, and wooden logs to encourage natural behaviours.

• **Security and Monitoring:** Surveillance cameras and monitoring systems should be installed to observe the cheetahs without causing disturbance. Additionally, the enclosure should be secured with locks and alarms to prevent unauthorized access and ensure the safety of the animals.

Image 21. *Male cheetah coalition patrolling their territory © Bipin C M, WII*

APPENDIX 1

“GUIDANCE NOTES

1. Habituation

Habituation is a learning process where animals ‘learn’ not to respond to certain stimuli which have proved ‘harmless’ or of ‘no consequence’. It is a common phenomenon and plays an important role in selection of habitats and inter -specific relationships between wild animals. Thus, a wild animal, it placed new surroundings, may initially exhibit fear but would subsequently lose the fear owing to habituation. Further, congenial habituation may also result in positive response in such animals. Thus, during in-situ rearing of cubs repeated familiarization with human beings or objects may result in strong habitation making ‘wilding’ difficult.

2. Conditioning

It is a behavioural response which is acquired by an organism through experience, usually through the association of a stimulus with a reward. If the said stimulus is associated with a rewarding experience, it results in a ‘positive reinforcement’. On the other hand, ‘negative reinforcement’ takes place if the stimulus results in a ‘painful’ experience to the animal. Thus, in the process of in-situ rearing association of sounds (opening of enclosure gates, sound of vehicle movement etc.) with the availability of food would result in conditioning to such stimuli which would hamper wilding.

3. Critical distance (wilding/rewilding)

‘Critical distance’ may be understood as the minimum distance to an unfamiliar/strange object tolerated by wild animal. Violation of this distance would elicit a response which may result in fleeing of the wild animal from the site or attack by the wild animal on the object. Such a critical distance in the context of human —beings is non-existing in domesticated animals. In the wilding process of cubs reared under in-situ conditions, it is extremely important to restore the behaviour relating to critical distance (wilding) by ensuring complete seclusion from human -beings and their associates (unobtrusive monitoring).

4. Imprinting

This is a process of learning wherein an animal recognizes and becomes attached to a particular object in its early life (critical time). The critical time of imprinting may vary from few hours to several days, soon after birth depending on the species. In the wilding process of cubs, this social attachment requires to be carefully avoided.”

Source- *Guidance Notes in Standard Operating Procedure to Deal with Orphaned/Abandoned Tiger Cubs and Old/Injured Tigers in the Wild*

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