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Cover: Emperor Tamarin *Saguinus imperator*: a look into a better world through the mustache lens – mixed media illustration. © Maya Santhanakrishnan.

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ARTICLE

Empirical evidence of Tiger *Panthera tigris* (Mammalia: Carnivora: Felidae) dispersal towards south from Similipal Tiger Reserve to Kuldiha Wildlife Sanctuary: potential implications for its conservation in the Greater Similipal Landscape

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Abstract: India has achieved a rare global conservation success by doubling its Tiger *Panthera tigris* number since 2006. However, in India's east-central states of Odisha, Chhattisgarh, and Jharkhand the tiger numbers are declining. The tiger population in Odisha is largely confined to Similipal Tiger Reserve which represents the only known breeding population of a genetically unique wild melanistic form. We report a first empirically confirmed tiger dispersal event towards the south between Similipal Tiger Reserve and adjacent Kuldiha Wildlife Sanctuary as part of our intensive monitoring exercise conducted from 2019–2022. This evidence-based dispersal event confirms tiger presence in Kuldiha after 11 recent years and urges strong support for tiger conservation in the Greater Similipal Landscape. In order to ensure long-term tiger presence in this landscape, we suggest more rigorous management interventions like habitat restoration and management, prey recovery, intensive protection measures, conflict management, and creation of inviolate space.

Keywords: Eastern Ghats Landscape, east-central tiger population, functional corridor, habitat integrity, Hadgarh Wildlife Sanctuary, human-tiger conflict mitigation, melanistic tiger population, metapopulation dynamics, prey recovery, systematic camera-trapping

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INTRODUCTION

The Tiger *Panthera tigris* is an endangered large carnivore (Goodrich et al. 2022) that exemplifies conservation efforts worldwide. India has achieved a rare conservation achievement by implementing a strong 50-year conservation program (MoEF&CC 2023). The tiger numbers got more than doubled from a population estimate of 1411 (1165–1675) in 2006 to 3682 (3439–3925) in 2022 (Jhala et al. 2008; Qureshi et al. 2023). However, the future of these tiger populations depends on careful management of the remaining forested habitats, where they are expected to face challenges from rapid urbanisation, increasing human density, expanding agriculture and associated infrastructure development and economic growth (Gubbi et al. 2016). In the Indian scenario, it is even more important as majority of the extant protected areas (PAs) are fragmented and all the tiger landscapes of the country have not experienced similar levels of population recovery. For example, the Central-India and Eastern Ghat landscapes currently retains ~40% of India's wild tiger population inside largely fragmented wildlife habitats (Jhala et al. 2020). This landscape has experienced substantial increase in tiger abundance from 2014 to 2022, except in the east-central states of Odisha, Chhattisgarh, and Jharkhand (Jhala et al. 2021; Qureshi et al. 2023). The small, isolated tiger populations of this landscape currently face various ecological, demographic, and genetic challenges (Seidensticker 2016).

The tiger population in Odisha, in particular, is of specific conservation interest as they represent a genetically unique lineage of melanistic form in the wild (Singh 1999; Kolipakam et al. 2019; Sagar et al. 2021). Similipal Tiger Reserve (STR- 2750 km^2 area) in Odisha currently reports the only known breeding population of the melanistic wild tigers globally (Rathore et al. 2021) and has been identified as one of the 42 source populations of tigers in Asia (Walston et al. 2010). Historically, tigers were found across STR along with surrounding PA's of Kuldiha Wildlife Sanctuary (KWS- 272.75 km^2 area), Hadagarh Wildlife Sanctuary (HWS- 191.40 km^2 area) and in Satkosia Tiger Reserve (SkTR- 963 km^2 area). However, the tigers have gone locally extinct from KWS (the last Tiger died in 2009- Panda 2019), HWS (the last Tiger died in 2014), and SkTR (Qureshi et al. 2023). An intensive camera-trap based study conducted over a duration of eight months in 2013 failed to report tiger presence in KWS (Debata & Swain 2018), making STR as the only hope for this unique population as well as in the east-central landscape.

Such recent events of local extinctions and declining tiger occupancy (between 2006–2022) (Qureshi et al. 2023) demands appropriate long-term conservation strategies through landscape-level approaches to ensure future tiger survival. The expansion of tiger occupancy along with ensured connectivity between the remnant habitats is critical for their future persistence in this landscape. Here, we present empirical evidence of a tiger dispersal from STR to KWS and discuss potential measures to be undertaken for increasing tiger occupancy in Greater Similipal (Similipal-Hadagarh-Kuldiha) Landscape.

MATERIAL AND METHODS

Study Area

The study was conducted across STR and KWS, located within the Deccan Peninsula Biogeographic Zone (Rodgers & Panwar 1988). Both areas feature tropical moist deciduous, tropical dry deciduous, and tropical semi-evergreen forest types (Champion & Seth 1968). The major large carnivores include Tigers, Leopards *Panthera pardus*, Indian Wolves *Canis lupus*, Asiatic Wild Dogs *Cuon alpinus*, Sloth Bears *Melursus ursinus*, and Striped Hyenas *Hyaena hyaena*. The ungulate prey community consists of Chital *Axis axis*, Sambar *Rusa unicolor*, Gaur *Bos gaurus*, Northern Red Muntjac *Muntiacus vaginalis*, Indian Chevrotain *Moschiola indica*, Four-horned Antelope *Tetracerus quadricornis*, and Wild Boar *Sus scrofa*. The Asiatic Elephant *Elephas maximus* is also present in both protected areas (Nayak 2014; Panda 2019).

STR and KWS are connected by two corridors along the northern and southern parts of the Salandi reservoir (Nayak 2014; Menon et al. 2017; Figure 1). The Similipal-Kuldiha corridor traverses the northern part of the Salandi reservoir along HWS and connects to a thin strip of reserve forest (ranging 0.3–2 km in width). This region is part of a proposed elephant corridor and contains six densely populated villages (Nayak 2014; Menon et al. 2017) and 97 temporarily defunct stone quarries. The forest has experienced encroachment pressures from nearby villages, posing a significant conservation challenge (Menon et al. 2017; Panda 2019)

Camera Trapping

As part of an ongoing tiger assessment program, 1,526 motion sensor camera-trap stations were placed and systematically monitored in STR from 2019 to

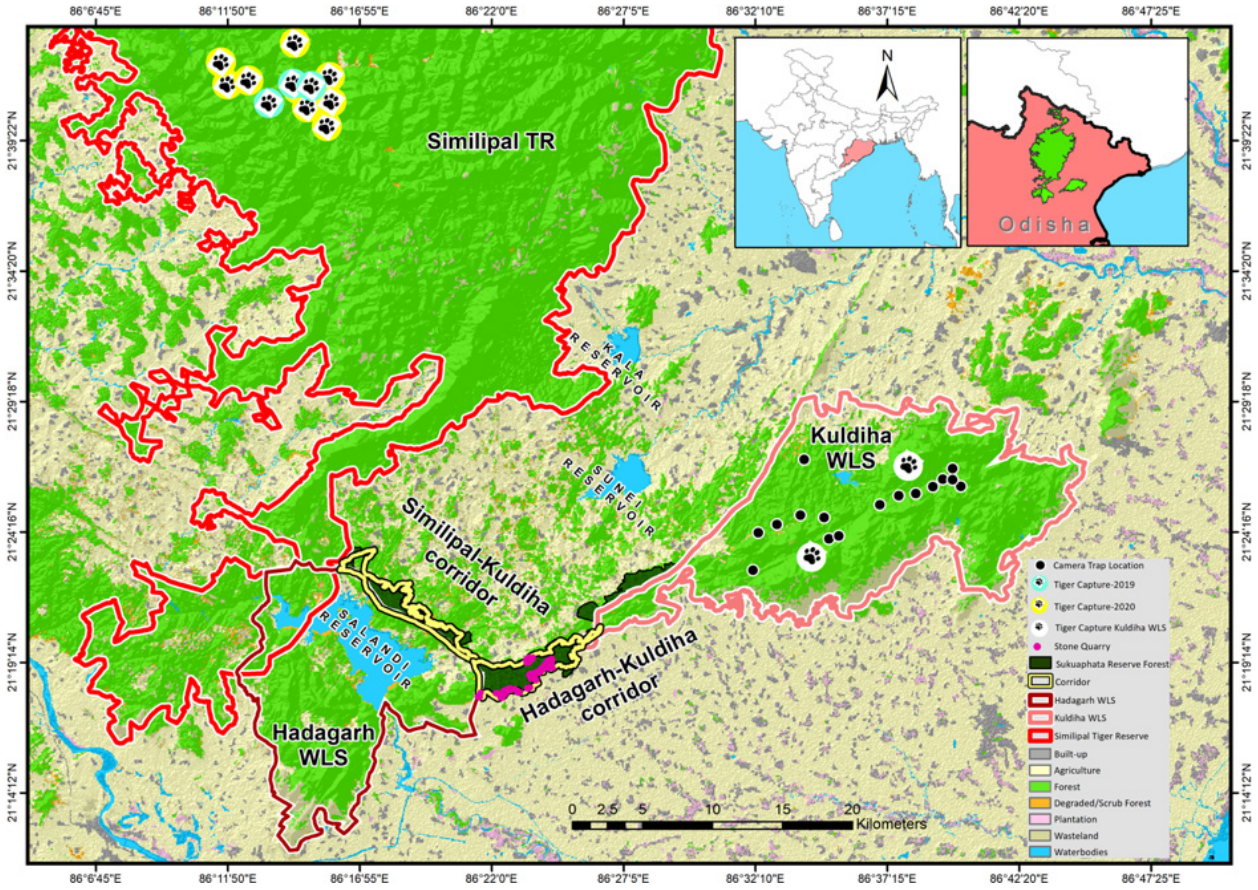

Figure 1. Map of Similipal-Hadagarh-Kuldiha protected area complex along with the biological corridors and the Tiger (T21) photo-capture locations in the years 2019, and 2020 in STR and 2021–2022 in KWS.

2022. Camera trapping was conducted in the entire core of STR following the national guideline of a 2 km^2 grid design to cover the intensive study area (NTCA-WII 2018). All the digitally stamped (with date and time of capture inforamtion) tiger photographs were identified and seperated out from the entire data set. The individual tiger identification was performed by using the software ExtractCompare (Hiby et al. 2009). Genetalia and secondary sexual characters (such as nipples for females) were used to ascertain the gender of the individual tigers in the four-year dataset.

Initially, KWS was not part of this monitoring effort, as no tiger signs were recorded here over last decade (Panda 2019). During December 2021, local department officials reported presence of possible tiger pugmarks in KWS and immediately a monitoring exercise was planned. An intensive large carnivore sign survey was conducted across KWS based on the reports from the ground staff members. Eighteen sites (forest roads, animal trails and trail junctions etc.) were selected with high potential of tiger presence for deploying camera-traps. Subsequently, single-sided camera traps were placed in all these sites from 22 December 2021 to 27 January 2022. The cameras were kept active throughout the day and regularly monitored. The tiger photos captured in these cameras were compared with the available tiger photograph repository from STR (Rathore et al. 2021) using ExtractCompare (Hiby et al. 2009). The results were further validated by three independent trained personnel. The age-class category assessments was conducted by using all earlier camera-trap records of the individual following Sadhu et al. (2017).

RESULTS

Two tiger images were obtained from all the camera traps deployed in KWS (Image 1c,d). The images were captured on 24 December 2021 and 8 January 2022, respectively. Both images were ascertained to be from one young-adult male tiger, which later matched with a cub (named as T21, Image 1a) earlier photographed

Image 1. Images of tiger (T21): a—photo-captured as a cub in 2019 | b—juvenile in 2020 in STR | c—Right flank | d—and left flank of T21 photo-captured in KWS in 2021–2022.

in UBK range of STR in 2019. T21 was photographed till September 2020 in the same range (Image 1b) before finally photo-captured in KWS in 2021. This dispersal event confirmed tiger presence in KWS after 11 years and indicates the possibility of an active corridor between these two PAs, where STR can be considered as the source and KWS as a sink habitat.

DISCUSSION

The STR tiger population has experienced a recent population increase from 12 ± 1 individuals in 2018 (Jhala et al. 2020) to 20 ± 2.47 individuals in 2022 (Qureshi et al. 2023). We feel that the recent tiger dispersal is possibly driven by the displacement of young individuals from STR to KWS as a result of the increase in tiger numbers. It is important to point out that although the growth of human habitation and mining activities in this space has ecologically separated Kuldiha from Similipal, but tiger movement link exists through Hadgarh WS. Our results provide empirical evidence of tiger dispersal to this protected area, which was earlier suggested by Singh (2021). If such a rise is continued then more such events can be anticipated across the Greater Similipal Landscape, and therefore appropriate steps towards managing this region need to be planned.

PAs connected through corridors in a metapopulation framework are currently the foundation for contemporary tiger conservation initiatives (Seidensticker 2016). Considering the evolutionary importance of the STR Tiger population, their demographic and genetic challenges, and isolated habitats, maintaining the integrity of the larger Similipal-Hadagarh-Kuldiha complex will be extremely critical. Firstly, urgent management attention is warranted toward habitat restoration of both the Similipal-Kuldiha and Hadagarh-Kuldiha corridors. One of the most effective ways to achieve this would be to include HWS, KWS, and the reserve forests (RF) in this corridor within a potential revised STR boundary, where the added areas could become part of the extended buffer area of STR, where a synchronized management

plan can be implemented. Further, adequate attention towards prey recovery throughout the entire region is required, where habitat management efforts aimed at increasing large ungulate densities would be beneficial for potential tiger recovery as the relative abundance of prey species is very low in KWS (Debata & Swain 2018) and HWS (Palei et al. 2021). The prey density estimation exercises should be conducted regularly in KWS and HWS to track ungulate biomass availability. Illegal hunting/poaching of ungulate prey has been reported in KWS (Panda 2019) and thus intensive monitoring of their population and protection measures will be crucial for tiger recovery. In this regard, implementation of regular anti-poaching patrolling using MSTriPES (Monitoring System of Tigers- Intensive Protection and Ecological Status; https://www.project-tiger.in/) would be essential. Similarly, government-supported incentivized voluntary human settlement relocation programs will improve the habitat productivity for ungulates and would play a vital role in successful tiger repopulation in KWS and HWS. Further, attention and necessary planning towards addressing potential human-tiger negative interactions is also needed. There are 12 villages within KWS with a human population of 17,000 and a large population of livestock (Panda 2019). Considering the fragmented nature of this area and such high human presence surrounding the PAs, increasing human-tiger interactions can be expected in the near future. Tigers are known to traverse through agricultural landscapes (Habib et al. 2021), often leading to such conflict situations. For conflict mitigation, active management efforts like timely compensation plans, participatory management efforts, etc., need to be in place to reduce any chances of retaliatory tiger deaths.

It is important to point out that our data is suggestive of this active corridor between STR and KWS, as no direct evidence was available to prove tiger use of these corridors. We suggest regular monitoring and assessment programs through intensive field surveys and camera-trapping approaches to assess the prey diversity, density, habitat use, and movement patterns across KWS, HWS, and the corridor regions.

The tiger populations in the east-central region of the central-India and Eastern Ghat landscape are facing adverse impacts from various human interventions across their habitats. The STR tigers are showing encouraging dispersal signatures with surrounding habitats. We believe that the dispersal event presented in this paper should be used to prepare an appropriate and focused management plan aiming at maintaining the source-sink population dynamics thereby assisting in long-term persistence of this evolutionary unique tiger lineage in Kuldiha and Hadgarh sanctuaries.

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