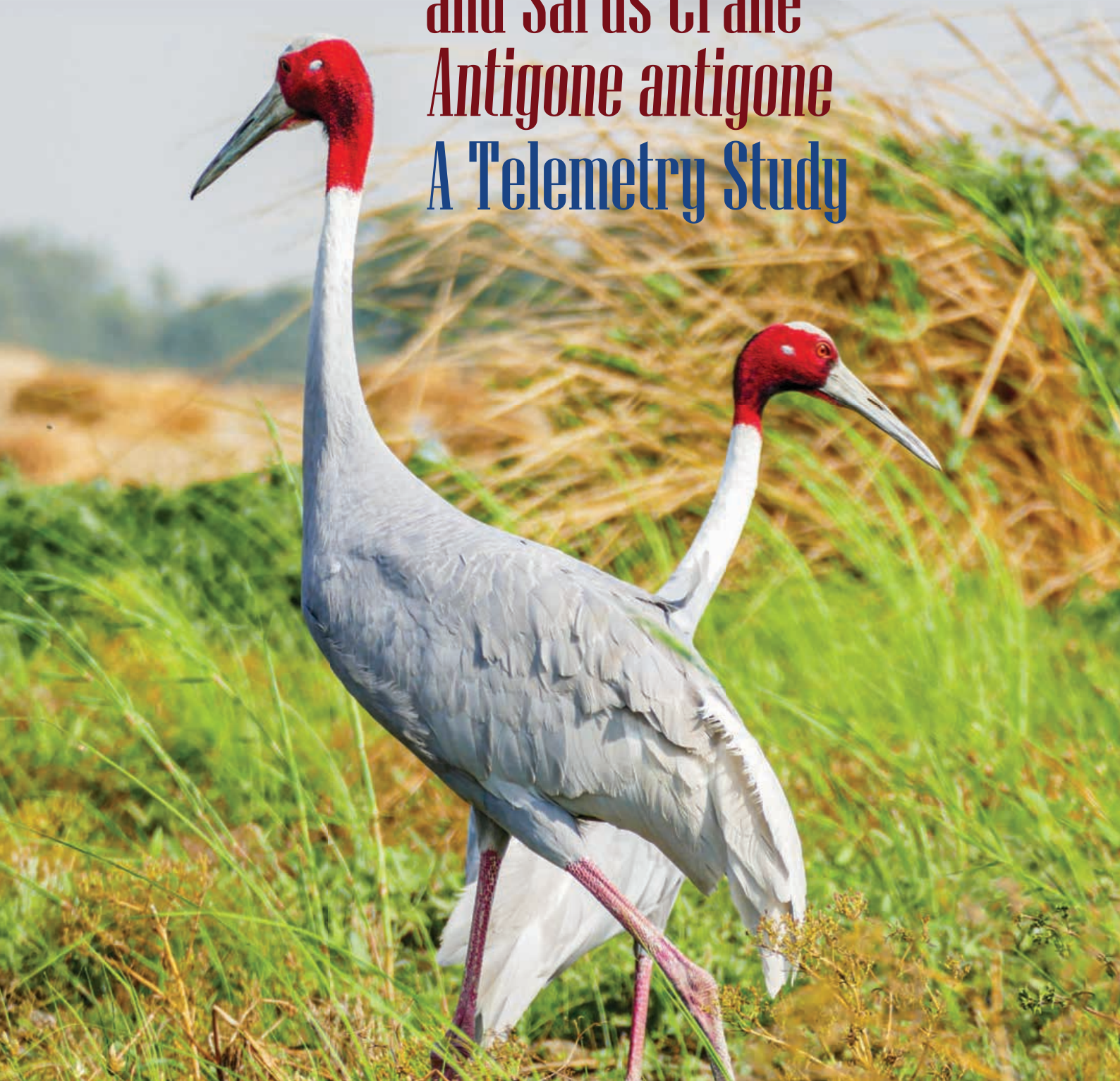
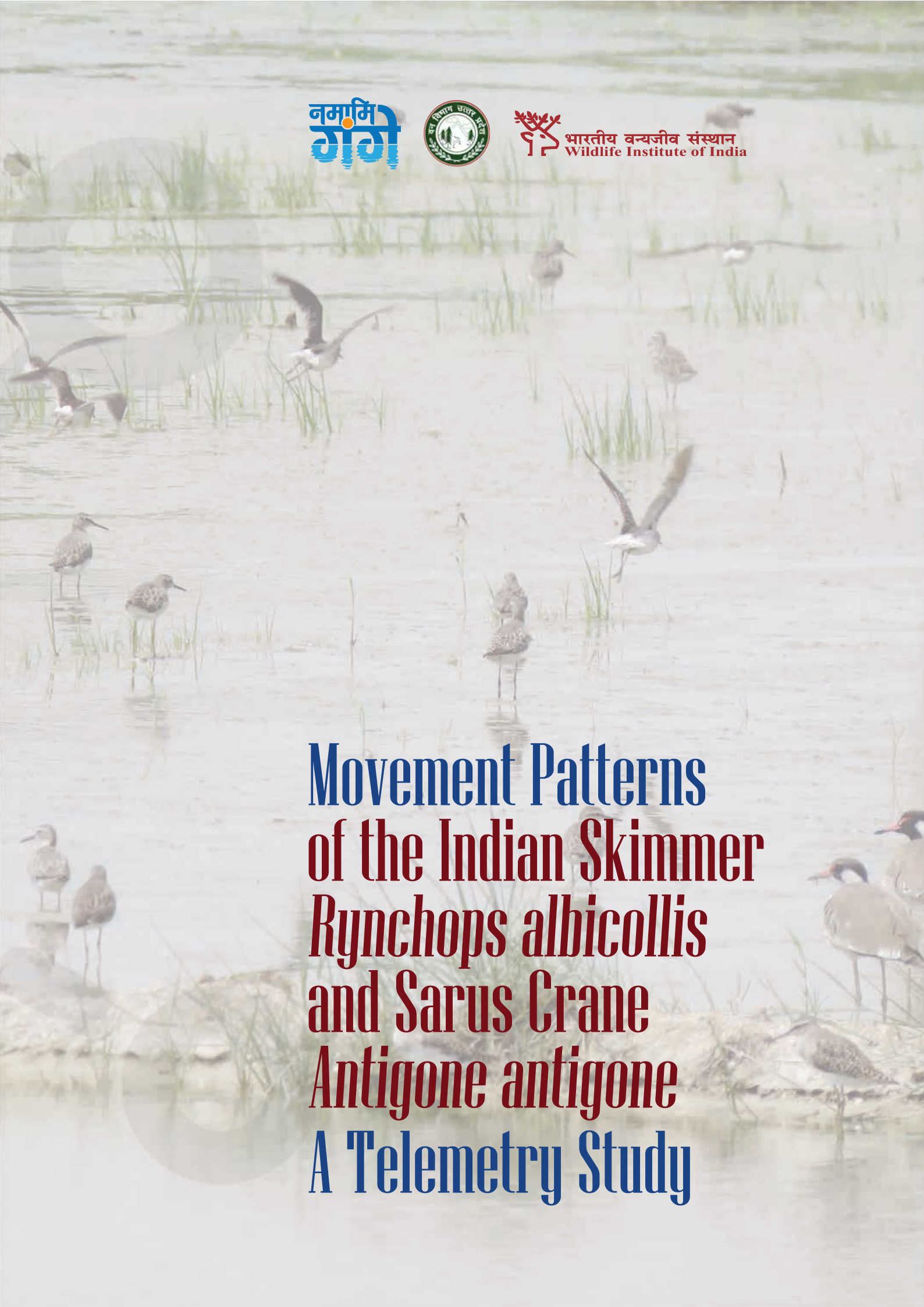
भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Movement Patterns of the Indian Skimmer *Rynchops albicollis* and Sarus Crane *Antigone antigone* A Telemetry Study





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This document is an output of the Project Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga sponsored by the National Mission for Clean Ganga, Ministry of Jal Shakti, Government of India, New Delhi.

Citation

WII-GACMC (2023). Movement Patterns of the Indian Skimmer (*Rynchops albicollis*) and Sarus Crane (*Antigone antigone*): A Telemetry Study. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehra Dun, India. Pp 26

Movement Patterns of the Indian Skimmer (*Rynchops albicollis*) and Sarus Crane (*Antigone antigone*): A Telemetry Study

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ACKNOWLEDGEMENTS

MINISTRY OF JAL SHAKTI

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CONTENTS

INTRODUCTION

The National Mission for Clean Ganga (NMCG) was constituted by the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD&GR) to ensure effective abatement of pollution and rejuvenation of the river Ganga by adopting a river basin approach to promote inter-sectoral co-ordination for comprehensive planning and management; and maintain minimum ecological flows in the river Ganga with the aim of ensuring water quality and environmentally sustainable development. Subsequently, the NMCG entrusted the Wildlife Institute of India (WII) toidentify priority stretches and develop a science-based restoration plan of the Ganga River and its tributaries. The first Phase of the project was started in 2017 and extended further as Phase II in 2019 for Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga. The objective of the project is science-based aquatic species conservation and maintenance of ecosystem services in the Ganga River basin, including ecological monitoring of species and their habitats. During the first phase of the study boat-based surveys were conducted to document the biodiversity and determine the status and distribution of various taxa such as crocodylians, freshwater turtles, aquatic mammals and waterbirds including river nesting birds. Extending it further to determine the species' habitat use, migration pattern and conservation statustwo species the Indian Skimmer (*Rynchops albicollis*) and Sarus Crane (*Antigone antigone*) were considered for telemetry study. Indian Skimmer and Sarus crane are two of the five conservation priority species along with River tern, River lapwing and Black-bellied tern, under the project owing to their threatened status.

Satellite telemetry is important for studying different aspects including behavioural, physiological and environmental. It helps experts find details of an animal's location that further elaborate the broad aspects of animal ecology, including resource use, home range, dispersal, and population dynamics (Cagnacci et al., 2010). Telemetry is widely utilized to understand the movement patterns and habitat selection of various species. Since its first use in 1963 for studying on rabbits (*Sylvilagus floridanus*), striped skunks (*Mephitis mephitis*), and raccoons (Procyon lotor), telemetry techniques have undergone remarkable advancements, transitioning from low-range VHF transmitters to satellite transmitters (Cochran, WW, 1963; Habib et al., 2014). Moreover, the accessibility of Argos data, along with enhanced data quality and reductions in transmitter size and weight, have rendered telemetry-based wildlife research increasingly feasible,for small and wide-ranging animals ranging from beesto crocodylians (Sivakumar et al., 2010; Fuller & Howey, 1995; Kaczensky & Walzer, 2010). The weight of transmitters, which previously posed a significant challenge to the widespread adoption of telemetry in wildlife science, has been substantially reduced from bulky attachment devices to tiny PTTs weighing as little as 2 grams (Fancy et al., 1988; Iverson et al., 2023).The development of advanced low-weight transmitter made it possible in most of the studies (>70%) to deploy transmitters with less than three percent weight of the individual following standard transmitter-to-animal body weight ratio. Additionally, modern PTT tags offer remote data access and retrieval, eliminating the need for physical retrieval to access data. The advancement of telemetry techniques, deployed transmitters consistently achieved a success rate of more than 86% in data retrieval (Iverson et al., 2023).

Movement Patterns of the Indian Skimmer *Rynchops albicollis* and Sarus Crane *Antigone antigone* : A Telemetry Study

STUDY AREA

Based on the previous information on the distribution and abundance of Indian skimmer and Sarus crane, the Upper Ganga Ramsar site situated within the middle stretch of the Ganga River was identified as the ideal location for capturing and deploying transmitters.

The Upper Ganga Ramsar site is 85 km stretch of the Ganga River between Brijghat to Narora designated as a Ramsar Site (Site No.: 1574, India) in 2005. This shallow stretch with intermittent deep pools harbours rich biodiversity, including 82 species of fish, 12 species of freshwater turtles, gharial (*Gavialis gangeticus*), mugger (*Crocodylus palustris*), 100 species of waterbirds and Gangetic dolphin (*Platanista gangetica*). The site is the home to more than a hundred of bird species, including River tern, Indian Skimmer and Oriental darter. This stretch is bounded by the Amroha, Hapur, Sambhal and Bulandshahr districts of Uttar Pradesh (Dey et al., 2021; Khan, 2013).

The adjoining wetlands along the Ganga River were also surveyed to find the Sarus crane flocks for transmitter deploymentin the Aligarh, Etah, Hathras, Etwah, Mainpuri, Kannauj, and Hardoi districts. The Sarsai Nawar wetland in Etawah was deemed ideal for the capture of Sarus Craneowingits accessibility and large number of Sarus in the wetland. The Sarsai Nawar wetland is a permanent rainfed marshy wetland of 161 hectares around 80 km away from the Ganga Riversituated near Etawah-Bewar road in the Etawah District of Uttar Pradesh.The wetland . The wetland was designated as a Ramsar Site or wetland of International Importance (Site No. 2411, India) in September 2019. The site derived its name Sarsai from the word 'Sarus' as it supports a large number of Sarus cranes, hosting the largest flock in the region. During the survey conducted prior to transmitter deployment, a total of 80 individuals and 15 nests were observed (Figure 1).

Figure 1. Transmitter deployment sites

Movement Patterns of the Indian Skimmer *Rynchops albicollis* and Sarus Crane *Antigone antigone* : A Telemetry Study

STUDY SPECIES

INDIAN SKIMMER

Indian Skimmer is the only skimmer reported from India out of three species of skimmer found globally. The skimmers belong to the genus Rynchops of the family Laridae and show characteristic feeding behaviour by skimming water with their shorter upper and larger lower mandible (Birdlife International, 2023). These tern-like birds have characteristic pointed wings, mainly blackish brown above and white below, and are easily identified by a pied plumage and knife-like orange-yellow bill. It is a piscivorous bird that generally feeds on small fish (Ali & Reply, 1978).

The species is mainly found on larger, sandy, lowland rivers, around lakes and adjacent marshes. During the non-breeding season, its distribution extends up to the estuaries and coasts. It is a colonial nesting bird that selects large, exposed sand-bars and islands, exposed sufficiently above the water level to avoid flooding the nests and surrounded by water channels with sufficient depth that does not allow terrestrial predators to reach nesting sites (Debata et al.,2019; Shaikh, 2020). The breeding populations of the skimmer are confined to the Ganga, Yamuna, Chambal, Son and Mahanadi rivers in India (eBird, 2020; Debata et al., 2019; Dilawar & Shama, 2016; Ankit et al., 2018; Rajguru, 2017; Shaikh & Mendis, 2019).

Indian skimmers are found only in India, Nepal, and Bangladesh, with a significant proportion of the wintering population in the Padma-Meghna delta in Bandladesh (Das, 2021). It is a rare visitor to Nepal. The species is showing a declining trend, with current population estimates of around 2,450-2,900 mature individuals. The current declining population trends have resulted in a global population decline of more than 20% in the last 10 years (two generations). Therefore, the species has been listed under the 'Endangered' category of the IUCN RedList of threatened species (BirdLife International, 2017).

The bird is an island nesting bird and its primary threats include alteration in water level and cultivation. Low water levels during the nesting season increase easy access to eggs by terrestrial predators (Debata et al., 2019; Shaikh, 2020). The release of access water from the barrage and dams causes flooding of the nesting colonies, which results in the destruction of eggs and nests (Rajguru, 2017). Stochastic weather events, such as heavy pre-monsoon showers, storms, etc., also known to destroy nesting colonies (Debata et al., 2019; Shaikh, 2020). Sand mining also impacts the establishment of nesting habitats and leaves a long-term impact on the nest site selection of the bird (Das, 2015; Debata et al., 2019; Shaikh et al., 2018).

Indian Skimmers serve as an indicator species for the health of riverine ecosystems in South Asia. Their presence and breeding success in habitats like the National Chambal Sanctuary and the Gagna River can reflect the quality of the riverine ecosystem, including factors like water availability, prey abundance, and habitat suitability. By monitoring the population trends and breeding success of Indian Skimmers, conservationists and researchers can gain insights into the overall health of the river systems where these birds reside. Declines in Indian Skimmer populations may indicate environmental threats such as habitat loss, water pollution, or disturbances in the ecosystem (Sundar, 2004).

Movement Patterns of the Indian Skimmer *Rynchops albicollis* and Sarus Crane *Antigone antigone* : A Telemetry Study

SARUS CRANE

The Sarus crane, the world's tallest flying bird, belongs to the family Gruidae, which contains 15 species of global cranes. It has three distinct and separate populations viz., *Grus Antigone antigone, Grus antigone sharpie* and *Grus antigone gilli*, residing in subtropical areas of the northern Indian subcontinent, tropical regions of southeast Asia, and northeastern parts of Australia, respectively. The Indian subcontinental population of the species resides in north India and Nepal, along with Pakistan and Bangladesh (BirdLife International, 2023). The largest congregations of the species lie in Uttar Pradesh. The Sarus cranes have recently extirpated from Thailand and the Philippines (Sundar, 2008).

The Indian Sarus prefers open wet and dry grasslands, marshes, pools, and agricultural fields (Archibald et al., 2003). Indian Sarus cranes are being driven to use suboptimal rice fields as breeding grounds due to the degradation and destruction of their natural wetland habitats (Sundar, 2009). In India and Nepal, Breeding pairs maintain distinct territories throughout the year in areas with sufficient water year-round. However, the non-breeding cranes generally form flocks and use larger wetlands as roosting sites. Sarus cranes are resident birds and do not show seasonal movement except for some restricted movement driven by water availability. During the summer months between April and June, large flocks of birds gathered along the rivers, lakes and remaining wetlands (Mukherjee et al., 1999). No regular or seasonal migration of the species has been reported so far (Archibald et al., 2003).

It is an omnivore species with versatile foraging behaviour. It generally feeds upon small animals ranging from bird eggs, insects, and rodents to reptiles. They also feed on terrestrial and aquatic plant tubers, roots and bulbs. They also eat grass seeds and green vegetation (BirdLife International, 2023).

The clutch size of the Sarus crane ranges between one and two eggs per clutch (Meine & Archibald, 1996; Sunder, 2009). The flock size of the Indian Sarus Crane depends upon the availability of the wetland and congregates to form large flocks during summer due to the availability of wetlands and reduction in its size (Sundar, 2009).

The species has been listed as Vulnerable under the IUCN RedList of Threatened Species as It is believed to have seen a rapid population decline, which is expected to continue because of significant loss in the quality and extent of wetlands and the effects of pollutants. The current population estimate of the Sarus crane is about 8,000-10,000 individuals in India and 19,000-22,000 globally. Degradation and loss of wetlands due to drainage and land use changes and indiscriminate use of pesticides are the major causes of the population decline (BirdLife International, 2023). The species is being driven to use less-than-ideal rice fields in India as breeding grounds due to the degradation and destruction of its natural wetland habitat (Sundar, 2009).

Movement Patterns of the Indian Skimmer *Rynchops albicollis* and Sarus Crane *Antigone antigone* : A Telemetry Study

TRANSMITTERS

Previous studies have used the transmitters to determine the movement pattern and home ranges of threatened bird species such as the Whooping crane, Black vulture, Turkey vulture, American woodcock, Amur falcon, Black-tailed godwit, Gull-billed tern Black-tailed godwit and Red knot etc.

Table 1. Different telemetry-based studies and their success using PTT and GSM transmitters

Study	Species	Satellite transmitter	Specification
Harrel et al. (2013)	Whooping crane	Weight - 70 70gm	Dimension - 9.7 cm (length) × 3.84 cm (width) × 2.54 cm (height)
			Solar strip size - 4.5 cm × 1.2 cm
			Antenna - 8.51 cm
Byrne et al. (2017)	Black Vulture and Turkey Vulture	GSM20-70 70gm	Dimension - 9.7 cm (length) × 3.84 cm (width) × 2.54 cm (height)
			Weight - 70 g
			Solar strip size - 4.5 cm × 1.2 cm
			Antenna - 8.51 cm
Moore et al. (2021)	American woodcock	Solar 5g PTT	Dimension - 2.46 cm (length) × 1.52 cm (width) × 0.81 cm (height)
			Weight - 5 g
			Solar strip size -2.35 cm x 1.40 cm
			Antenna - 21.59 cm
Meyburg et al. (2017)	Amur falcon	Solar 5g PTT	
Verhoeven et al. (2022)	Black-tailed godwit	Solar 5g PTT	
Goodenough et al. (2019)	Gull-billed tern	Solar 5g PTT	
Kok et al. (2020)	Red knot	Solar 2g PTT	Dimension - 2.0 cm (length) × 1.0 cm (width) × 0.7 cm (height)
			Weight - 2 g
			Antenna - 21.59 cm
Tengeres et al. (2020)		Solar 2g PTT	Dimension - 2.03 cm (length) × 1.17 cm (width) × 0.84 cm (height)
			Weight - 2 g
			Antenna - 21.59 cm

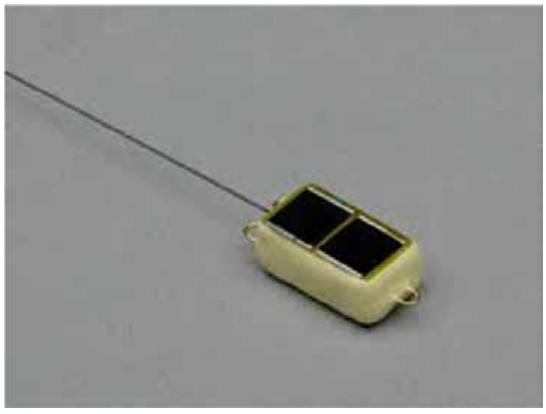
Based on the different telemetry studies and their success rate (Table 1), Solar 5g PTT and GSM 45g transmitters were selected to deploy on the Indian Skimmer and Sarus crane, respectively.

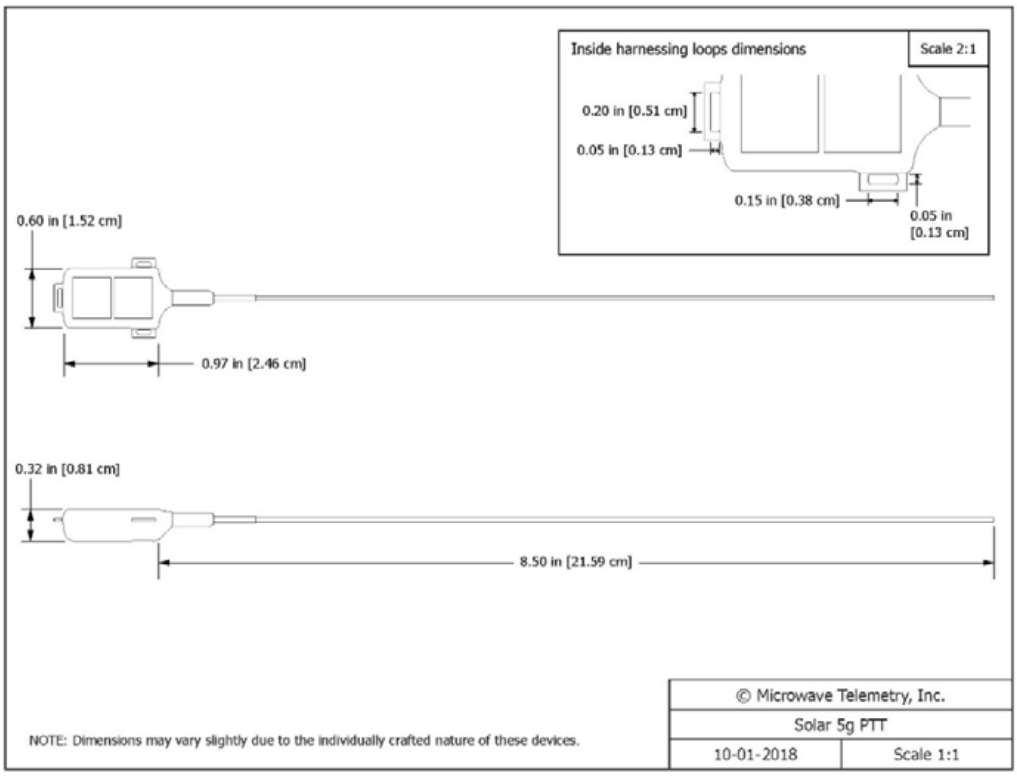
	Mounting place	Success Rate (functional/ deployed
	Backpack	87% (62/71)
	Backpack	85% (17/20)
	Backpack	75% (40/53)
	Backpack	100% (7/7)
	Backpack	100% (45/45)
	Backpack	90% (11/20)
	Backpack	100% (1/1)
	Backpack	80% (8/10)

MICROWAVE SOLAR 5g PTT

The Solar 5g PTT includes sensors to measure temperature, battery voltage, and activity (optional), with each parameter relayed to Argos on three of every four transmissions. The transmitters are equipped with solar-powered rechargeable batteries with microprocessor-controlled power management. The key characteristics of the transmitter are as follows:

- **Operating frequency:** 401.650 MHz ±36 kHz
- **Power output:** 200 mW output is standard†
- **Output impedance:** 50 ohms
- **Modulation tri-phase PSK:** ±1.1 Rad ±0.1 Rad
- **Quiescent current:** <3 ?A
- **Spurious emissions:** -45 dB
- **Transmission interval:** 60 seconds
- **Supply voltage:** 3.6-4 volts
- **Operating temperature range:** -5-45°C
- Physical Specifications
- **Dimensions:** Length 2.46 cm x Width 1.52 cm x Height 0.81 cm
- **Weight:** ~4.5-5 grams
- **Antenna:** Hard nylon-coated flexible stranded marine-grade stainless steel, 21.59 cm long, protruding from the back edge of the transmitter.
- Microelectronics are encapsulated in epoxy resin to minimize weight and create a durable, long-lasting form.





ORNITELLA 40g GSM

OrniTrack-L40 - leg-mount solar-powered GPS-GSM tracker selected for Sarus Cranes. It was a leg-mount transmitter especially designed to attach to the tibia of cranes. Key features of this transmitter include its strong and waterproof build with an internal antenna. It is a compact device of 64×35×32 mm in size, weighing around 40g. The transmitter is equipped with a solar-powered Lithium-Polymer battery. The key characteristics of the transmitter are as follows:

- **Size of OrniTrack-L40:** dimensions 64×35×32 mm, inner diameter 19mm, weight ~40 g
- **GPS receiver:** high sensitivity 99 channel module
- **GSM transceiver:** 3G hexaband 800/850/900/1800/1900/2100 or 4G LTE-M or 4G LTE-Cat1
- **Internal battery:** Lithium-polymer with under and over-charge protection
- A fully charged battery is sufficient for logging 1,000 positions without additional recharge (under optimal GPS satellite view and not exceeding 20 GPRS data upload sessions in good network coverage)
- **Solar charger:** 3 high-efficiency (22%) solar panels
- **GPS logging intervals:** from 1 second to 48 hours
- **Data storage:** 128 MB capable of storing nearly 2,000,000 records
- **Data upload:** via GSM/3G network
- **GSM connection interval:** from 10 minutes to 192 hours
- SMS message with 10 GPS positions when GSM network is not available
- Logged data are stored in memory if GSM network is unavailable
- **Geofences:** 2 zones with separate sets of parameters. Zones defined by user by multiple rectangles (up to 10 per zone)
- High frequency (up to 50 Hz) sensor (accelerometer, magnetometer, temperature, light intensity) data collection on a separate schedule
- Day & night sensing
- **Operational temperature:** from -20 to +60 °C

- **Control:** user remotely controls GPS & GSM schedules, night-time GPS hibernation and geofence settings via an online control panel
- **Main data record:** UTC date & time, GPS position, GPS altitude, speed, direction, HDOP, battery voltage, battery charging current, instant acceleration (3 axes), temperature, magnetic field strength (3 axes)

TESTING OF TRANSMITTERS

All four transmitters were kept in sunlight for a few days to check the battery life and for other functions before deployment on the birds. All transmitters were found to be working properly under test conditions, and data for the test duration was retrieved.

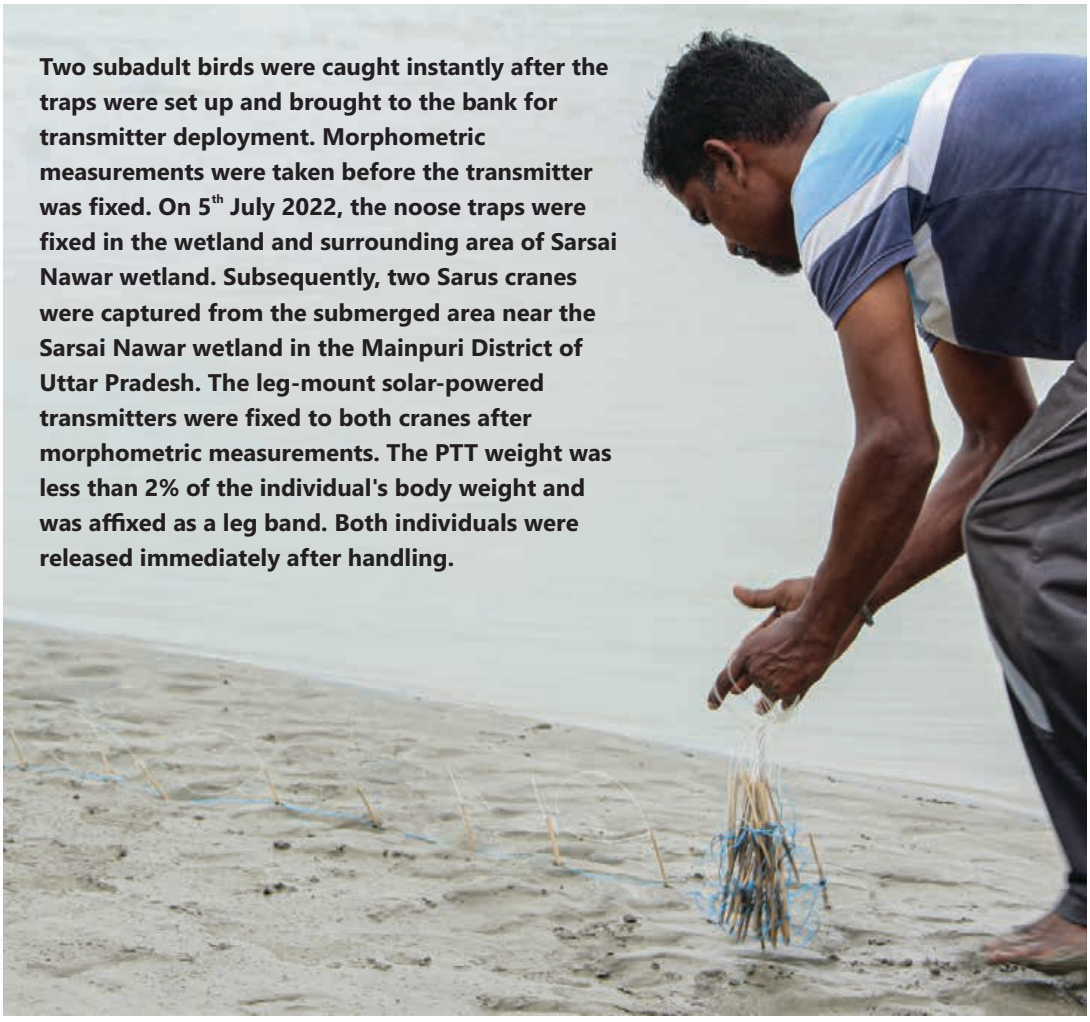
CAPTURE AND TAGGING

PERMISSIONS

The permit to capture and tag the birds were obtained from the Chief Wild Life Warden of Uttar Pradesh (Vide Letter No. 2158/23-2-12 (G) Dated 8th March 2021; Annexure I). Indian Skimmer and Sarus crane are protected species under the Wild Life (Protection) Act 1972. Therefore, permission for capture and tagging was

TRAPPING OF BIRDS

On 20th June 2022, during the pre-capture survey between Brijghat and Narora, a flock of around 20 Indian skimmers was observed near Upstream of Anupshahr in the Bulandshahr district of Uttar Pradesh. This site was selected for the trapping of individuals using noose traps made up of mono-filament nylon twine. The traps were fixed on the partially emerged river island covered with sparse grasses.



Two subadult birds were caught instantly after the traps were set up and brought to the bank for transmitter deployment. Morphometric measurements were taken before the transmitter was fixed. On 5th July 2022, the noose traps were fixed in the wetland and surrounding area of Sarsai Nawar wetland. Subsequently, two Sarus cranes were captured from the submerged area near the Sarsai Nawar wetland in the Mainpuri District of Uttar Pradesh. The leg-mount solar-powered transmitters were fixed to both cranes after morphometric measurements. The PTT weight was less than 2% of the individual's body weight and was affixed as a leg band. Both individuals were released immediately after handling.

Professional trappers with over 20 years of experience were hired to capture the birds. All precautions were taken to ensure the safe capture and release of the birds, and the entire process was finished within a minimum time frame. All essential tools, gears and items such as Super glue, Super cold spray, Stain remover sprays, measuring scales, Digital Vernier calliper, Digital Weighing scale, Surgical tool set, Mounting pad, Eye-protecting wares, Face mask, Hand Gloves, Apron, etc. were used during capture, morphometric measurements and tagging.

MORPHOMETRIC MEASUREMENTS

Detailed morphometric measurements of captured birds were done before fitting transmitters. The body weight of the birds was measured to the nearest 5 g with an electronic balance. A steel ruler with a zero stop was used to measure the length of the wings by flattening and straightening the closed wing as much as possible and then measuring from the proximal end of the carpometacarpus to the tip of the longest primary. For tarsus length, the bird's foot was bent at the inter-tarsal joint, and its extreme bending points were measured up to the nearest 0.5 mm using a digital calliper. The bill length was measured up to 0.5 mm with a digital calliper. For Indian skimmers, the length of the lower and upper mandibles was also measured to the nearest 0.5 mm using the digital calliper (Tables 2&3).

Table 2. Morphometric details of Indian Skimmer

Sr. No.	Tag Id	Age class	Upper mandible (mm)	Lower mandible (mm)	Tarsus length (mm)	Part wing span (mm)	Whole wing span (mm)	Body weight (g)
Is1	197622	Juvenile	52.8	64.2	25.2	329	970	240
IS2	197623	Juvenile	52.0	63.6	25.0	332	990	245

Table 3. Morphometric details of Sarus crane (*Antigone antigone*), captured in Sarsai Wetland, Uttar Pradesh, India

Sr. No.	Tag Id	Age class	Sex	Bill length (mm)	Bill depth (mm)	Tarsus length (mm)	Tarsus diameter (mm)	Wing span-Part (mm)	Wing span-Whole (mm)	Body weight (g)
SC1	194074	Adult	Male	162.6	41.8	330	16.63	610	2600	6950
SC2	194075	Adult	Female	157.0	35.4	285	15.75	580	2000	5975

RESULTS

INDIAN SKIMMER

The transmitters with serial numbers197622 and 197623 were deployed on two juvenile Indian skimmers on 20th July 2022. Both transmitters started sending locations soon after the deployment. Transmitters with serial numbers 197622 (IS1) stopped sending signals after 25 days of working for unknown reasons. However, the transmitter with serial number 19763 (IS2) worked for 346 days. A total of 730 and 1883 satellite passes were received by IS1 and IS2, respectively.

Argos assigned classes to each location based on their accuracy (radius of error). All received locations fall within the classes 0,1,2,3, A, and Z. High-accuracy location classes between 0 and 3 were selected for home range estimation (Figure 2). Maximum locations (27%) were received under location class 0, followed by Location class 1 (24.2%). No locations were received under the G or Z class.

Class	Type	Estimated error*		Number of messages received per satellite pass	
		Least Squares	Kalman Filter	Least Squares	Kalman Filter
G	GPS	< 100m		1 message or more	
3	Argos	< 250m		4 messages or more	
2	Argos	250m < < 500m		4 messages or more	
1	Argos	500m < < 1500m		4 messages or more	
0*	Argos	> 1500m		4 messages or more	
A	Argos	No accuracy estimation	Unbounded accuracy estimation	3 messages	
B	Argos	No accuracy estimation	Unbounded accuracy estimation	messages	1 or 2 messages
Z	Argos	Invalid location (available only for Service Plus/Auxiliary Location Processing)			

Figure 2. Argos location classes with the estimated error

IS1 shows a movement of 1,557 km during its deployment period, and its movement was restricted to the nearby areas of the deployment site. The movement of IS2 was 47,861 km along the Ganga and Ghaghara rivers, starting from Bulandshahr district to Nijum Dwip of Sundarbans in Bangladesh, with an estimated home range of 3,27,281 km^2. The Kernel density estimate shows two core areas of activity. The upper core area of the activity was between July 2022 and Oct 2022, followed by a downstream of the Ganga and Ghaghara rivers. The lower core area of activity falls in the Sundarbans area of Bangladesh between December 2022 and May 2023 (Figure 3).

During the movement, the Indian skimmer moved eastwards along the Ganga and Ghaghara rivers. The average daily movement of the Indian skimmer I was 47.0+3.01 km, and the Indian skimmer II was 33.89+1.01 km. The average monthly distance covered by IS2 was 1907.8 +27.78 km. The maximum

distance (3225 km) was covered in March 2023, followed by April 2023 (3008 km), November 2022 (2742 km) and January 2023 (2359 km). The least distance was covered in July 2022 (203 km) and August 2022 (1047 km) (Figure 4).

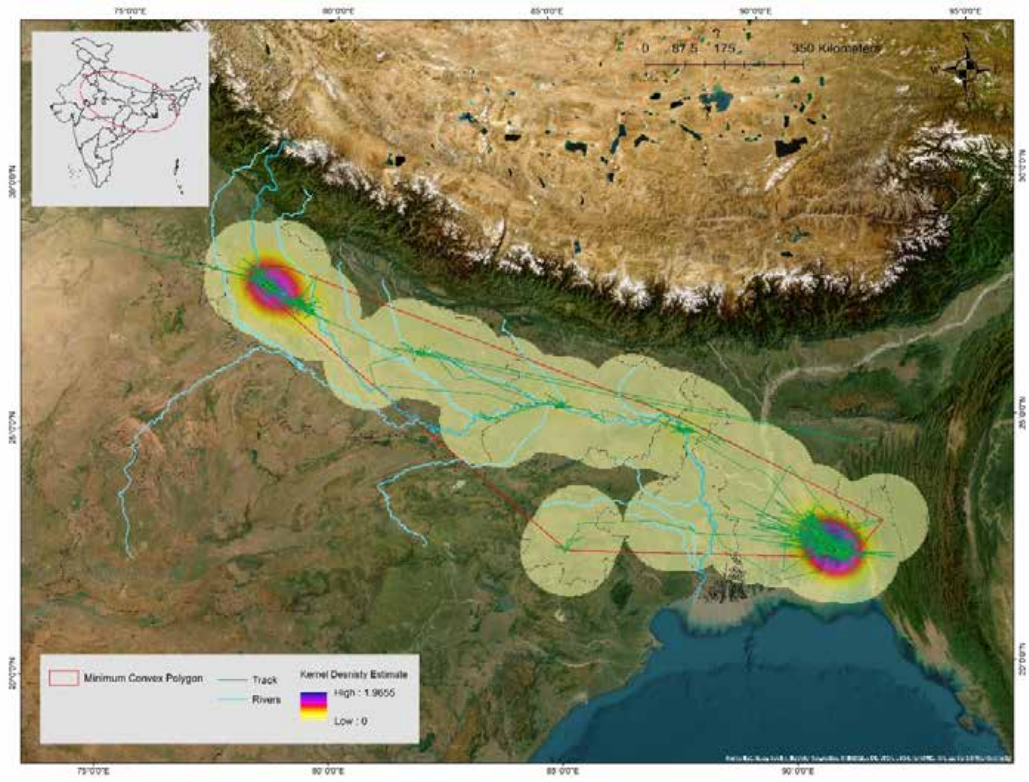


Figure 3. Movement, (Full form) MCP and Kernel Density estimate of the Indian skimmer

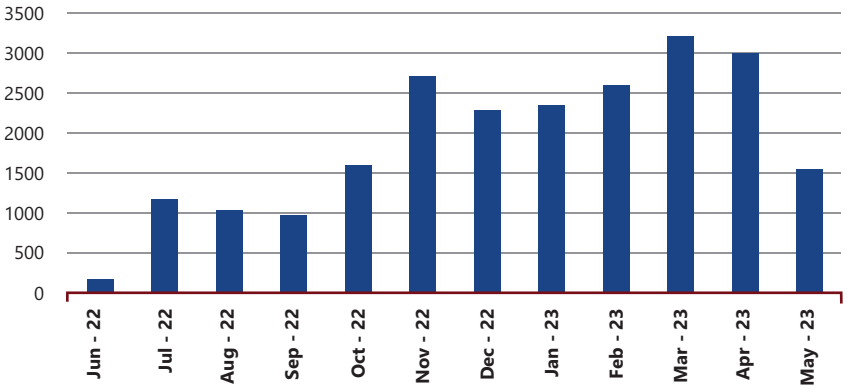


Figure 4. Month-wise distance covered by the Indian skimmer II

SARUS CRANE

Both transmitters start working soon after the deployment. On 5th July 2022, a Transmitter with serial number 194074 was deployed on a male (Sc1), and a Transmitter with serial number 194075 was deployed on a female (SC2). The SC1 and SC2 transmitters worked for 402 and 369 days and received 8,762 and 17,823 locations, respectively. Both transmitters gave all the locations using 3 to 19 GPS satellites.

Transmitters worked at ambient temperatures ranging between 30^{0}C and 48^{0}C, with an average temperature of 32.6^{0}C. The maximum speed for SC1 was 60 km/h, and SC2 was 74 km/h.We constructed the Minimum Convex Polygon (MCP) to calculate the home range of the individuals. The home range of SC1 was 286 km^2, and SC2 was 321 km^2. The total movement of the SC1 was 2,004 km, and SC2 was 922 km within their respective home ranges. Both individuals share a 30 Km^2 home range with each other (Figure 5).

We calculated the monthly and daily movement patterns of Common Cranes using the Tracking Analyst tool in ArcGIS. The monthly distance travelled across all months was calculated by segregating the location fixed into months. The average daily movement of the Sarus Crane I was (mean ± SD) 4.0 ± 0.02 km, and Sarus Crane II was 57.69 ± 4.22 km. The maximum distance SC I covered was in February 2023 (300 km), followed by April 2023 (241 km), and March 2023 (204 km). The least distance was covered in August 2023 (25 km), December 2022 (67 km) and July 2022 (81 km) (Figure 6).

The maximum distance SC I covered was in February 2023 (217 km), followed by December 2022 (159 km) and July 2022 (157 km). The least distance was covered in September 2022 (13 km), October 2022 (12 km) and August 2023 (12 km) (Figure 7).

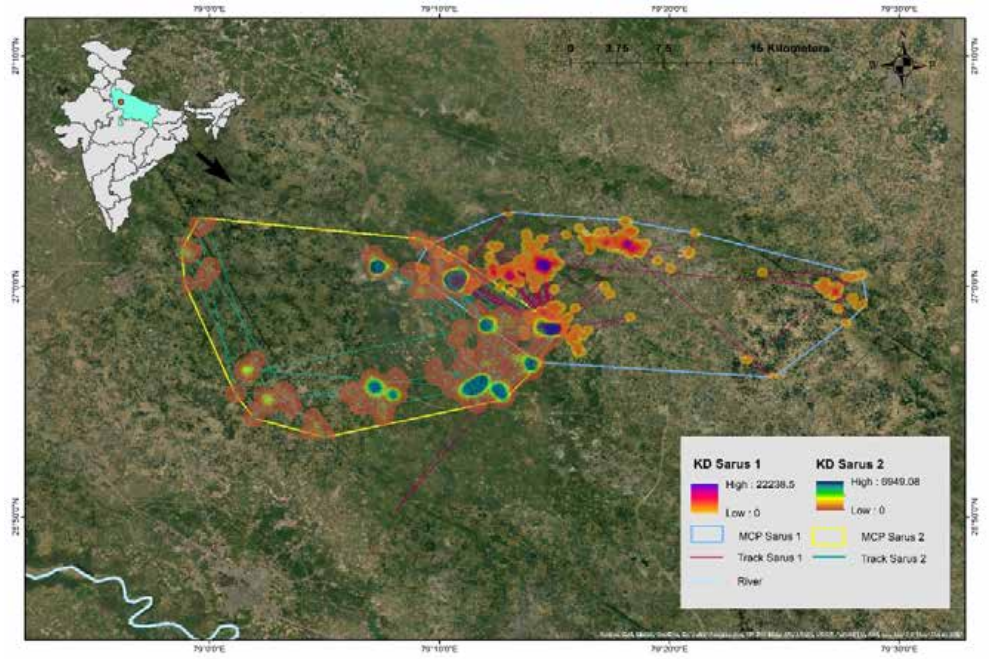


Figure 5. Movement, Minimum Convex Polygon (MCP) and Kernel Density estimate of the Sarus crane

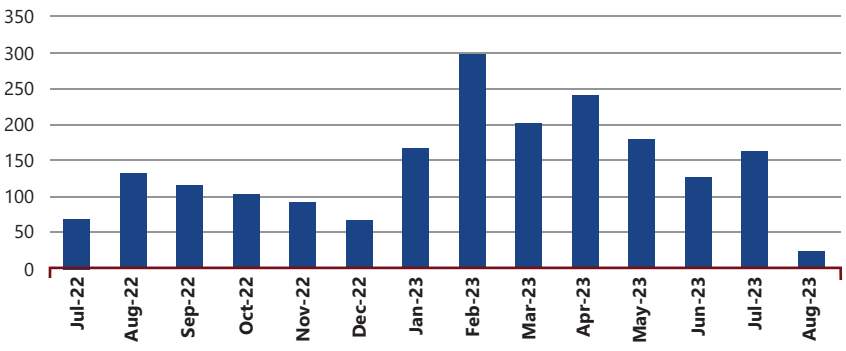


Figure 6. Month-wise distance covered by the Sarus Crane I

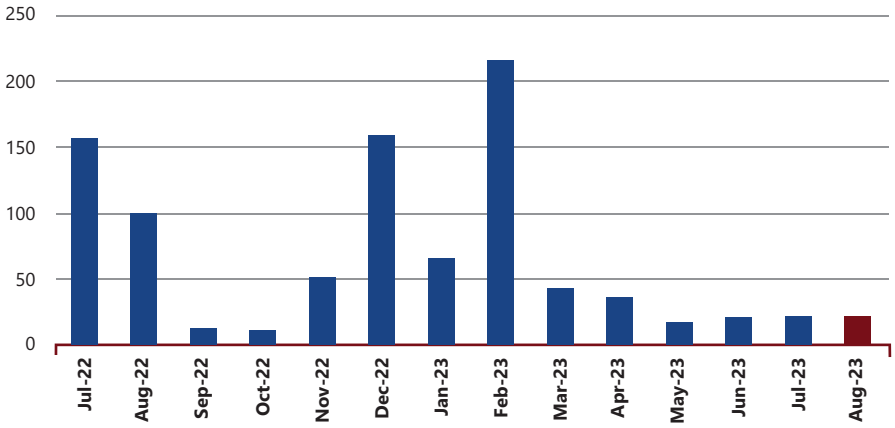


Figure 7. Month-wise distance covered by the Sarus Crane I

The Land Use Land Cover of the area was classified into six broad categories, namely Built-up, Crops, Sand, Barren land, Scrub and Water, based on the Land Use Land Cover images of 2015-16 (NRSC, 2019). Based on the location points received from Sarus cranes I & II, the most used habitat class was found to be crops (>70%), followed by scrub areas with grasslands (Figure 6).It is also evident from previous studies that the Sarus crane depends upon the crop fields, especially paddy crops, for breeding and foraging along with natural waterbodies (Gopi, 2011; Mukherjee, 2002).

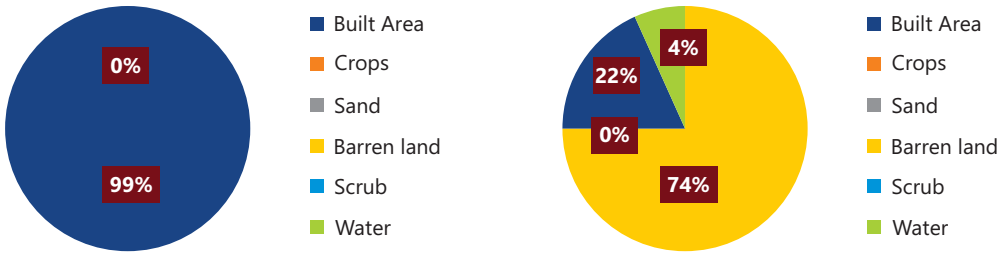


Figure 8. Habitat use of the Sarus Crane I & II

DISCUSSION

The breeding record of the Indian skimmer has been confined to the Chambal, Yamuna, Son, Mahanadi, Ganga rivers and Tawa reservoir only. However, the non-breeding population of Indian skimmers has been reported from a comparatively wide range in the Indian sub-continent (Shaikh et al., 2018; Dilawar & Sharma, 2016; Mital et al., 2019; Debata et al., 2018; Jha, 2015; Rahmani, 2012).The Indian skimmer is known to move within the Indian subcontinent from National Chambal Sanctuary in the Western India to eastward up to Sundreban in Bangladesh. However, its movement patterns were unclear except for a few resighting of tagged individuals (Shaikh et al., 2021). It was the first telemetry-based study of the Indian skimmer.

The study showed new insights into its movement pattern. Our study revealed that the Indian skimmer moves from the riverine habits of the Upper Gangetic Plains to the Sundarbans in Bangladesh. During this study, several new riverine habitats of the species were revealed those were previously unknown, including the Ghaghara River, the Lower stretch of the Ganga River near Patna and the Farakka Barrage. The individuals moved up to the North Koel River in the Jharkhand. The species moved downward along the Ganga and Ghaghara Rivers and finally settled in the Sundarbans areas of Bangladesh. Sundarbans of Bangladesh are known for their largest congregation of non-breeding skimmers (Das et al., 2021).The Indian Skimmer exhibits specific habitat preferences for breeding and foraging. During the breeding season, it is known to frequent larger, sandy, slow-flowing lowland rivers, lakes, and marshes . They are colonial breeders and typically lay their eggs on exposed sandbars and islands. The foraging habitat includes estuaries and coastal areas during the non-breeding season. They are specialized feeders that use their unique bill to skim the water surface for fish, their primary food source. Habitat use of Indian Skimmers is closely linked to the availability of suitable nesting sites, access to food sources, and factors that influence nesting success, such as water levels in rivers. Understanding of the habitat use of the species is crucial for its effective conservation planning. Conservation efforts for the species should focus on protecting its preferred habitats, ensuring the availability of suitable nesting sites, and addressing threats such as habitat degradation, human disturbance, and pollution (Debata et. al., 2017).

Sarus cranes are residential birds that do not move seasonally, and their local movement is governed by water availability (Archibald et al., 2003).The home range of cranes is affected by numerous factors, including the availability of food, habitat conditions, breeding season and weather conditions (Ivy et al., 2015). Sarus cranes are a resident species in this region ,inhabiting seasonally flooded wetlands and crop field. We also observed similar habits in our study. The movement of both individuals was restricted to less than 350 km^2 throughout the year. The Sarus crane predominantly uses agricultural areas as their nesting and feeding sites. Sarus cranes prefer wide-open landscapes with mosaics of wetlands and fields. They prefer wet crops such as paddy. Sarus cranes are rarely found in forested areas (Sundar et al., 2000). Our study also proved that the Sarus cranesprefer non-forested areas dominated bya mosaic of paddy crops and wetlands.

Further studies are imperative to comprehensively understand the ecological dynamics of the Sarus crane and Indian skimmer. Increasing the number of tagged individuals can significantly enhance our understanding of their behaviors, movements, and habitat preferences. By tracking a larger sample size of individuals equipped with transmitters, deeper insights into their ranging patterns, migration routes, and interactions with their environment can be understand efficiently. This expanded data set would enable more robust conservation strategies tailored to the specific needs of these species, helping to safeguard their populations and preserve their habitats effectively.

Detailed study of these species would enhance our scientific knowledge and will also lay a crucial foundation for the development of effective conservation strategies aimed at preserving the habitats and populations of these iconic bird species.

Movement Patterns of the Indian Skimmer *Rynchops albicollis* and Sarus Crane *Antigone antigone* : A Telemetry Study

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ANNEXURE I

OFFICE OF THE PRINCIPAL CHIEF CONSERVATOR OF FOREST WILDLIFE, UP, LUCKNOW

No. 2158 /23-2-12 (G) Lucknow dated March 08 2021

Permission for investigating the movement ecology of birds using satellite telemetry and bird ringing under the project "Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga" under National Mission for Clean Ganga, Government of India – reg.

Under the provisions of Sec 12(b) & 28 of the Wildlife (Protection) Act, 1972, (as amended) the permission is hereby granted to Director Wildlife Institute Dehradun of India to for investigating the movement ecology of birds using satellite telemetry and bird ringing under the project "Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga" under National Mission for Clean Ganga, Government of India in Uttar Pradesh.

List of Birds whose capture is permitted

S.No.	Species	Number of Individuals to be fitted with satellite tags	Number of Individuals to be fitted with colour bands
1	Sarus Crane Antigone antigone	2	0
2	Indian Skimmer Rynchops albicollis	10	50
3	Black–bellied Tern Sterna acuticauda	5	50
4	River Lapwing Vanellus duvaucelii	0	50
5	River Tern Sterna aurantia	0	50

This permission is subject to the following conditions:-

1- The permit holder should be well versed with the provisions of Wildlife (Protection) Act, 1972 and all subsequent amendments and rules therein and will ensure that no rules are transgressed in the conduct of their work of study.
2- The permit holder will attach a list of bonafide persons associated with this research project and will also inform the concerned Divisional Forest Officer along with their identity cards.
3- Before entering the area, permit holder will inform the concerned Divisional Forest Officer.
4- The permit holder will have to pay all charges as required as per rules.
5- Three hard bound copies of every report, publication and literature originating from the above research will have to be supplied free of charge to this office along with a soft copy of each.
6- After the completion of project work, the Wildlife Institute Dehradun will be required to present the outcome of the project through Power point presentation in the office of the Chief Wildlife Warden, UP.
7- The Permit holder will maintain a register in which all birds caught showing thier species, date and place of the capture as well as disposal of the birds swowing thier species, date and place of release will be systematically recorded. This register will have to be produecd for examination by the undersigned or his representative on demad.
8- Department of Forest & Wildlife UP should be duly acknowledged in all research papers and publication coming out of above studies.
9- The Forest Department will be not responsible for any loss of life or property or injury that may be sustained during the conduct of their work.
10- If the research project involves foreign partner/Foreign collaboration/foreign funding, the requisite permission from Biodiversity Board will have to be taken under Biodiversity Act 2002.
11- The applicants will ensure to make presentations about their research work before local officers and staff and also undertake measures for capacity building of field staff as required.

12- Protected area manager will ensure the instruction of UP Gov. & Higher Officer regarding COVID-19 pandemics, the concerned Division Forest Officer will allow the field work, only if, the activities are permitted under COVID-19 directives.

13- The permit will be valid from March, 2021 to February, 2024.

(Pawan Kumar Sharma)
Principal Chief Conservator of Forest/
Chief Wildlife Warden,
Uttar Pradesh, Lucknow

No. 2159 **/ of dated**

Copy-. to Director Wildlife Sciences, Wildlife Institute of India, Dehradun to reference to his Letter dated 17.02.2021 for information and necessary action.

Copy- to Chief conservator of Forests, Ruhailkhand Zone, Bareilly, Meerut, Kanpur Mandol, Kanpur, South Zone Prayagraj, Mirzapur Mondal, Mirzapur & Eastern Zone, Gorakhpur for information and necessary action.

Copy- to Divisional Forest Officer, Bijnor, Hapur, Bulandshahar, Meerut, Mujaffar Nagar, Farrukkhabad, Kannauj, Etawah, Kanpur Nagar, Kanpur Dehat, Unnao, Fatehpur, Prayagraj, Varanasi, Gazipur, Azamgarh, Mou, Mirzapur, Mainpuri & Ballia for information and necessary action.

(Pawan Kumar Sharma)
Principal Chief Conservator of Forest/
Chief Wildlife Warden,
Uttar Pradesh, Lucknow

NMCG

National Mission for Clean Ganga,
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