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Cover: Mauve Stinger *Pelagiala noctiluca* by Swaathi Na. Medium used is soft pastels and gelly roll.

INTRODUCTION

Camera trapping has been proved to be an effective method in monitoring elusive and nocturnal species along with population estimation of naturally marked individuals using spatially explicit capture-recapture models (Karanth & Nichols 1998; Harihar et al. 2014). Alternatively, for indistinguishable individuals of species such as ungulates, bears, and other small mammals; generally photo capture rate (photographs/ trapping effort) has been widely used to estimate the relative abundance (Datta et al. 2008; Sathyakumar et al. 2011; Palei et al. 2015, 2016, 2021; Debata & Swain 2018; Dhendup et al. 2019; Ahmed et al. 2021). Although the use of relative abundance index (RAI) generated from camera trap encounter rates is controversial as it gets biased with animal body mass and study design (Sollmann et al. 2013), there are examples of a linear relationship between RAI and abundance, estimation, especially of cryptic species (Karanth et al. 1998; Datta et al. 2008; Rovero & Marshall 2008; Rovero & Marshall 2009; Jenks et al. 2011; Gonthier et al. 2013; Lahker et al. 2018). In the Papikonda hills, northern Eastern Ghats, 23 mammal species were recorded during camera trap survey (Aditya & Ganesh 2017). In Odisha several mammalian studies were reported; (Tiwari et al. 2002) first compiled 37 species of mammals from Chandaka-Dampara Wildlife Sanctuary. Ramakrishna et al. (2006) reported 55 species of mammals from Similipal Biosphere Reserve encompassing the Similipal Wildlife Sanctuary and Similipal Tiger Reserve. Mohapatra et al. (2009, 2012, 2013) reported 36 species of mammals from different hill forests of southern Odisha, 43 species from Kotgarh Wildlife Sanctuary, and 47 species from several sacred groves in Sundargarh District. Murmu et al. (2013) also reported 23 species of mammals of Kuldiha Wildlife Sanctuary, and 42 species of mammals from Hadagarh Wildlife Sanctuary. Recently, (Debata & Swain 2020) surveyed the mammalian fauna of an urban-influenced zone of Chandaka-Dampara Wildlife Sanctuary using camera traps and reported 14 species of mammals. Debata et al. (2018) also reported 20 species of mammals of Kuldiha Wildlife Sanctuary. Palei et al. (2020) reported 22 species of mammals of Sunabeda Wildlife Sanctuary. Palei et al. (2021) reported 19 species of mammals from Hadagarh Wildlife Sanctuary. In the present study we carried out a camera trap survey in the tropical dry deciduous forest of Debrigarh Wildlife Sanctuary and provide the first photographic evidence and updated checklist of mammals in the Sanctuary.

MATERIALS AND METHODS

Study area

The Debrigarh Wildlife Sanctuary (DWS) is located between the latitudes 21.5570°N and the longitudes 83.6461°E (Image 1). The division shares its boundaries with Chhattisgarh State. DWS covers 346.91 km² and is dominated by tropical dry-deciduous forests, northern tropical dry-deciduous, and dry-mixed deciduous forests (Champion & Seth 1968). The mean daily temperatures in winters range from 8–20 °C and in summers from 28–48 °C. The average annual rainfall of the sanctuary and the nearby areas varies from 1,000–1,450 mm. Most villagers in the sanctuary are tribal, and their activities inside the forest are grazing livestock and collection of forest products (e.g., fodder for livestock, non-timber forest products).

As per (Champion & Seth 1968) classification, both the reserved forests of this Sanctuary come under the northern tropical dry deciduous forests under, dry mixed deciduous forests, and bamboo brakes. Sal *Shorea robusta* is the main species in both the forest blocks containing dry deciduous vegetation and it occurs in pure patches to occasional mixed patches in miscellaneous vegetation in the division. Vegetation on hill slopes and upper portions is predominantly miscellaneous consisting of a high proportion of Dhaura *Anogeissus latifolia*, Moi *Lannea coromandelica*, Salai *Boswellia serrata*, Karada *Cleistanth uscollinus*, and Barabakulia *Dalbergia aniculata*. However, Sal, which is the principal species, still constitutes a major proportion of the crop as compared to the miscellaneous species but undoubtedly its survival and status, particularly regeneration status, has deteriorated over the years due to excessive biotic interferences and soil erosion. Bamboos occur in almost all parts of the sanctuary over extensive areas of forests. The species of bamboo covering large tracts of hills is *Dendrocalamus strictus* Salia bamboo throughout the sanctuary.

We first carried out an extensive reconnaissance survey in three wildlife forest ranges within Hirakud Wildlife Range, Kamgaon Wildlife Range, and Lakhanpur Wildlife Range of DWS. During the survey, signs of carnivores, viz., scats, pug-marks, claw marks, scraps, and scent marks, were recorded and geo-referenced using a geographical positioning system (GPS).

Camera positioning

We conducted a camera trapping survey from 25 August 2018–29 December 2019: first phase (43 camera trap stations), second phase (40 camera trap stations),

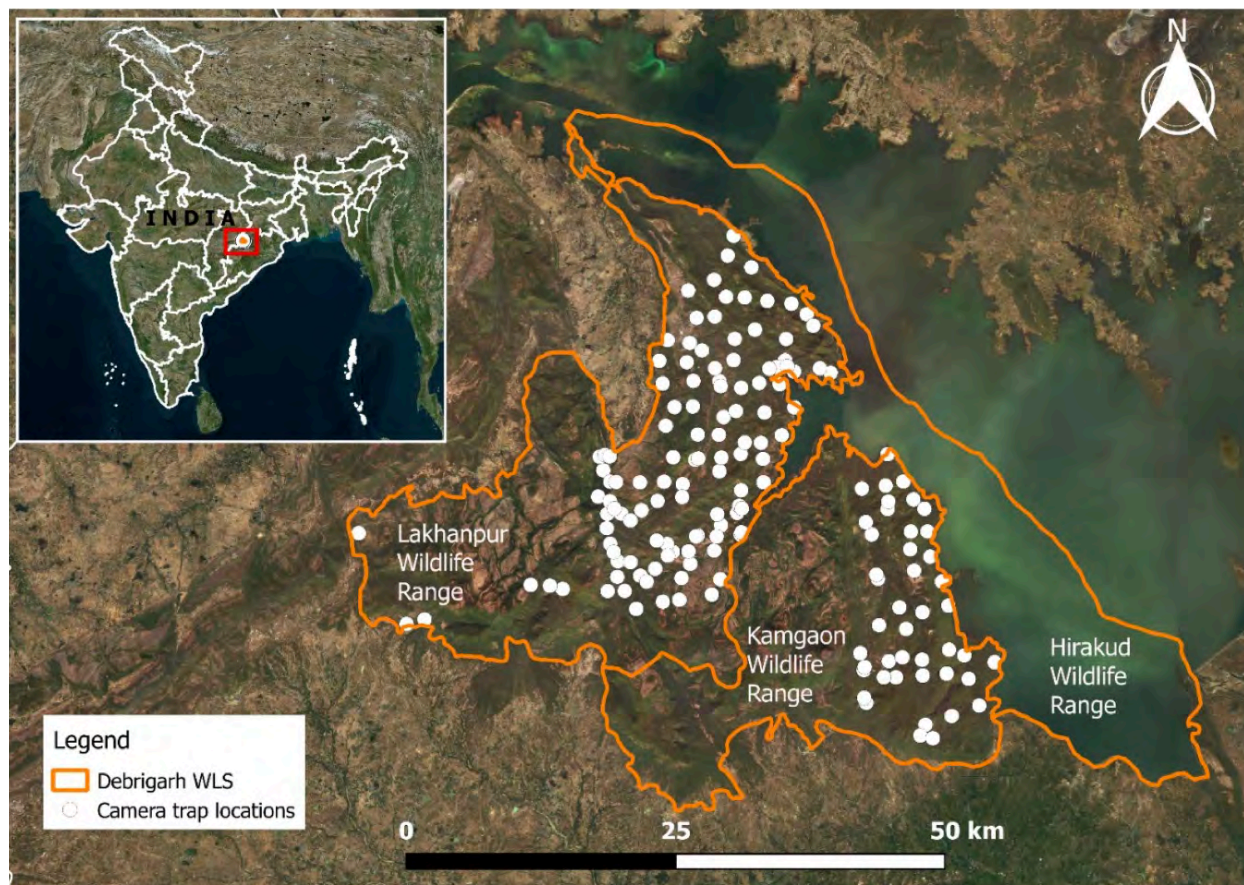


Image 1. Study area showing locations of camera traps in the Debrigarh Wildlife Sanctuary, western Odisha.

and third phase (40 camera trap stations) covering the three ranges of Hirakud, Kamgaon, and Lakhanpur Wildlife Ranges of DWS (Image 1). A total of 123 camera trap stations were established in the study area (Image 1). Most suitable camera trap stations were selected based on frequently used by the wildlife (e.g., along trails, forest roads, near stream beds, and around water holes). At each camera trap station, a pair of automated motion-triggered digital camera-traps (Cuddeback Model C1; Non Typical, Inc., Green Bay, WI) was placed on both sides of the roads, facing each other, placed around 30–40 cm above the ground without using lure or bait. Camera-trap placement at trails optimizes the capture of large as well as small animals. Cameras were checked every week to replace the batteries and memory cards and to ensure their proper functioning. Total sampling effort was calculated as the sum of the effective days across all stations that each camera was functioning (Boitani & Powell 2012). We considered photos separated by at least 30 min as independent events (Ohashi et al. 2013; Guo et al. 2017).

Data on large and medium sized mammals, human

trafficking, and livestock including date, time, year, and behavior were collated from camera trap photographs. Relative abundance index (RAI) was calculated as $RAI = A/N \times 100$

Where A is the total number of independent detections of a species by all cameras and N is the total number of camera trap days by all the cameras throughout the study area following (Jenks et al. 2011). All animals captured (photographed) in the camera traps were identified to the species level and the time and date of the capture (inbuilt in the camera) were noted. Consequently, each photo was rated as a dependent or independent event. All camera trap pictures were screened for the presence of animals and all data was entered in an Office ACCESS 2010 database. Identification of the animals was done using the field guide (Menon 2014). We assessed species' conservation significance on a global and national level according to the threat categories assigned in the IUCN Red List (IUCN 2017).

RESULTS

A total of 123 locations of camera trapping effort over 3,150 trap nights with 2,767 photographs were captured; 1,304 photographs of mammals belonging to 13 families and 27 species were recorded in the study area. Table 2 shows all identified species (common and scientific names), the total number of pictures obtained, the RAI for each species as well as the total number of locations where each species was photographed (Image 4–30). Out of all the photographs, recorded during the study period, the of majority of 49% ($n = 1,304$) were wildlife, and mostly herbivorous mammals 30% ($n = 794$) followed by carnivore mammals 13% ($n = 341$), omnivore mammals 6% ($n = 169$), birds 5% ($n = 130$), and the remaining photographs were anthropogenic from the movement of livestock, feral dogs, and human traffic 46% ($n = 1,242$) (Figure 2).

Besides that, camera traps also captured 10 bird species including the Indian Pea Fowl (RAI = 1.49, 46 locations) followed by Red Jungle Fowl (RAI = 1.21, 15 locations), and the Booted Eagle & Black-necked Ibis, which were the minimum photographed species (RAI = 0.16, each 2 locations). Concerning large mammals, *Panthera pardus* represented high relative abundance (RAI = 5.68, 45 locations) among the Sloth Bear *Melursus ursinus* (RAI = 4.13, 55 locations), and the Wild Boar *Sus*

scrofa (RAI = 3.81, 54 locations). Indian Pangolin *Manis crassicaudata* (RAI = 0.06, 2 locations) was represented by a relatively low abundance in the study area (Figure 1).

Among all the anthropogenic activity the highest activity inside the sanctuary, were livestock, human traffic, and feral dogs (RAI = 24.63) followed by forest department staff (RAI = 13.58) and poachers were the minimum photographed species (RAI = 0.76) (Figure 1). Detailed information on the species RAI of mammals and various anthropogenic activities throughout the sampling areas is given in (Table 1).

DISCUSSION

The Debrigarh Wildlife Sanctuary is home to 15 species of mammals represented by (Nayak 2016). Our study confirmed that of the 27 mammalian species recorded during the camera tap survey, carnivore species were the most common at each study site followed by herbivores. Only two species of medium-sized carnivores were found in our study, Jungle Cat *Felis chaus*, and Rusty-spotted Cat *Prionailurus rubiginosus*. But according to the camera trap survey in DWS there are 12 more species recorded (Dhole, Rusty-spotted Cat, Jungle Cat, Striped Hyena, Indian Fox, Jackal, Ruddy

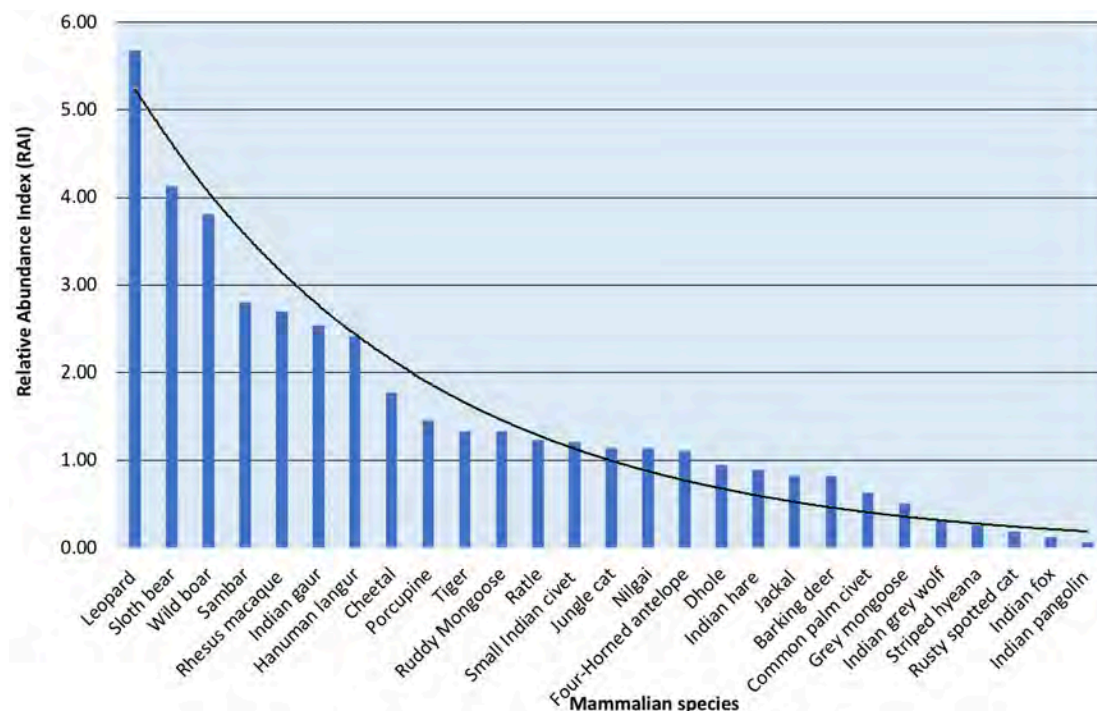


Figure 1. Relative abundance index (RAI) of different mammals in Debrigarh Wildlife Sanctuary.

Table 1. Comparative relative abundance index (RAI) of different wildlife species and others based on camera trap photographs in Debrigarh Wildlife Sanctuary during the field work with their current IUCN Red List status and type of encounter.

	Common name	Families	Scientific name	WPA Status	IUCN Status	N Camera trap stations with occurrence	%	Total Photo Captured	RAI
	Mammals								
1	Tiger	Felidae	<i>Panthera tigris</i>	Schedule-I	EN	12	9.52	42	1.33
2	Leopard	Felidae	<i>Panthera pardus</i>	Schedule-I	EN	45	35.71	179	5.68
3	Rusty-spotted Cat	Felidae	<i>Prionailurus rubiginosus</i>	Schedule-I	EN	4	3.17	6	0.19
4	Jungle Cat	Felidae	<i>Felis chaus</i>	Schedule-II	LC	25	19.84	36	1.14
5	Dhole	Canidae	<i>Canis alpinus</i>	Schedule-I	EN	10	7.94	30	0.95
6	Indian Grey Wolf	Canidae	<i>Cuon lupus</i>	Schedule-I	LC	8	6.35	10	0.32
7	Jackal	Canidae	<i>Canis aureus</i>	Schedule-II	LC	9	7.14	26	0.83
8	Striped Hyaena	Hyaenidae	<i>Hyaena hyaena</i>	Schedule-III	NT	5	3.97	8	0.25
9	Indian Fox	Canidae	<i>Vulpes bengalensis</i>	Schedule-II	LC	2	1.59	4	0.13
10	Small Indian Civet	Viverridae	<i>Viverricula indica</i>	Schedule-II	LC	20	15.87	38	1.21
11	Common Palm Civet	Viverridae	<i>Paradoxurus hemaphroditus</i>	Schedule-II	LC	12	9.52	20	0.63
12	Sloth Bear	Ursidae	<i>Melursus ursinus</i>	Schedule-I	EN	55	43.65	130	4.13
13	Wild Boar	Suidae	<i>Sus scrofa</i>	Schedule-III	LC	54	42.86	120	3.81
14	Porcupine	Hystricidae	<i>Hystrix indica</i>	Schedule-IV	LC	40	31.75	46	1.46
15	Ratel	Mustelidae	<i>Mellivora capensis</i>	Schedule-I	LC	18	14.29	39	1.24
16	Rhesus Macaque	Cercopithecidae	<i>Macaca mulatta</i>	Schedule-II	LC	34	26.98	85	2.70
17	Hanuman Langur	Cercopithecidae	<i>Semnopithecus entellus</i>	Schedule-II	LC	52	41.27	76	2.41
18	Indian Gaur	Bovidae	<i>Bos gaurus</i>	Schedule-I	VU	30	23.81	88	2.79
19	Nilgai	Bovidae	<i>Boselaphus tragocamelus</i>	Schedule-III	LC	8	6.35	36	1.14
20	Four-Horned Antelope	Bovidae	<i>Tetracerous quadricornis</i>	Schedule-I	EN	61	48.41	35	1.11
21	Sambar	Cervidae	<i>Rusa unicolor</i>	Schedule-III	VU	46	36.51	80	2.54
22	Barking Deer	Cervidae	<i>Muntiacus muntjak</i>	Schedule-III	LC	16	12.70	26	0.83
23	Cheetal	Cervidae	<i>Axis axis</i>	Schedule-III	LC	28	22.22	56	1.78
24	Indian Hare	Leporidae	<i>Lepus nigricollis</i>	Schedule-IV	LC	19	15.08	28	0.89
25	Indian Pangolin	Manidae	<i>Manis crassicaudata</i>	Schedule-I	NT	2	1.59	2	0.06
26	Grey Mongoose	Herpestidae	<i>Herpestes edwardsii</i>	Schedule-II	LC	8	6.35	16	0.51
27	Ruddy Mongoose	Herpestidae	<i>Herpestes smithii</i>	Schedule-II	LC	15	11.90	42	1.33
	Birds								
28	Crested Serpent Eagle	Accipitridae	<i>Spilornis cheela</i>	Schedule-IV	LC	2	1.59	2	0.06
29	Indian Pea Fowl	Phasianidae	<i>Pavo cristatus</i>	Schedule-I	LC	46	36.51	47	1.49
30	Red Jungle Fowl	Phasianidae	<i>Gallus gallus</i>	Schedule-IV	LC	15	11.90	38	1.21
31	Painted Spurfowl	Phasianidae	<i>Galloperdix lunulata</i>	Schedule-IV	LC	2	1.59	4	0.13
32	Black Napped Ibis	Threskiornithidae	<i>Pseudibis papillosa</i>	Schedule-IV	LC	2	1.59	5	0.16
33	Lesser Adjutant	Ciconiidae	<i>Leptoptilos javanicus</i>	Schedule-IV	VU	1	0.79	2	0.06
34	Grey Francolin	Phasianidae	<i>Francolinus pondicerianus</i>	Schedule-IV	LC	5	3.97	12	0.38
35	Brown Fish Owl	Strigidae	<i>Ketupa zeylonensis</i>	Schedule-IV	LC	8	6.35	1	0.03
36	Jungle Babbler	Leiothrichidae	<i>Argya striata</i>	Schedule-IV	LC	5	3.97	14	0.44
37	Booted Eagle	Accipitridae	<i>Hieraetus pennatus</i>	Schedule-IV	LC	2	1.59	5	0.16
	Reptiles								
38	Monitor Lizard	Varanidae	<i>Varanus bengalensis</i>	Schedule-I	LC	2	1.59	2	0.06

	Common name	Families	Scientific name	WPA Status	IUCN Status	N Camera trap stations with occurrence	%	Total Photo Captured	RAI
	Human traffic and livestock								
39	Forest department staff					62	49.21	260	8.25
40	Department vehicle					48	38.10	168	5.33
41	Private vehicle of villagers					36	28.57	186	5.90
42	Villagers					28	22.22	154	4.89
43	Poachers					12	9.52	24	0.76
44	Cattle, goat and buffalo					64	50.79	328	10.41
45	Feral dog					35	27.78	108	3.43

EN—Endangered | NT—Near Threatened | VU—Vulnerable | LC—Least Concern | RAI—Relative abundance index | IUCN—International Union for Conservation of Nature | WPA—Wildlife Protection Act.

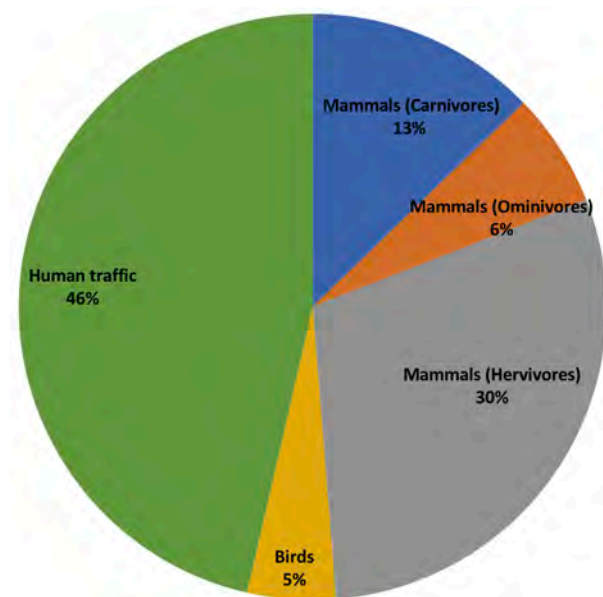


Figure 2. Different wildlife species and others activities based on camera trap photographs captured in Debrigarh Wildlife Sanctuary during the field work.

Mongoose, Small Indian Civet, Indian Pangolin, Rhesus Macaque, Barking Deer, and Ratel). As per the elephant census of 2017 there are 20 elephants recorded in the sanctuary (Palei et al. 2017) but there was no photo capture during the camera trap survey.

A small area of the sanctuary was sampled and one female tiger was photo captured (Jhala et al. 2020) from Lakhanpur Wildlife Range, and also in Kamgaon Wildlife Range of DWS during its movement. This movement was subsequently found within the sanctuary in August 2018 and photo captured in Mundamahul, Chowrasimal, Jhagadabehera, Khajuria, and Damodarpada. Among all the species, the Indian Grey Wolf *Canis lupus*, Dhole

Cuon alpinus, Jackal *Canis aureus*, Striped Hyena *Hyaena hyena*, and Indian Fox *Vulpes bengalensis* were the less frequently photo-captured in the study area. Indian Gaur and Sambar were the most common ungulate species, while leopards were the most common carnivore species. Rusty-spotted Cat, Dhole, Hyena, Indian Fox, Indian Pangolin, Rattle, and Chowsingha were photo captured for the first time in the camera traps survey.

Feral dogs were common prey animals occurring abundantly in the sanctuary area. However, the feral dogs were detected in a few locations 35 (27.78%) out of 126 locations in the study areas and is unlikely to have any significant effect on forest mammals. Relative abundance index of livestock was higher than any other species photo-captured in the sanctuary and is indicative of the high level of human traffic and movement of livestock (RAI = 24.63; Table 1) disturbance in the sanctuary. The presence of domestic animals can have a detrimental effect on distribution and assemblage of wild animal communities and account for detections under anthropogenic disturbance in DWS, much less than in Kuldiha Wildlife Sanctuary, Sunabeda Wildlife Sanctuary, and Similipal Tiger Reserve (Palei et al. 2015, 2020; Debata & Swain 2018). Many human trails, paths, and traps were found across the study area indicating that the local people regularly go for fishing in Hirakud reservoir adjacent to the sanctuary area. It may be assumed that probably other small mammalian species which were present in the sanctuary have not been captured by the camera traps. Biotic pressure (especially non timber forest product (NTFP) collection, livestock grazing, and fishing in the Hirakud Reservoir by the local community round the year) in the forest reduces resource availability in DWS.

In conclusion, the DWS could be an important habitat

and source population for mammals in western Odisha, because of abundant prey, lack of disturbance, and good habitat connectivity with the central India landscape. Certainly, further research is needed to learn about animal diversity and distribution patterns throughout the sanctuary. This study highlights the rich potential of the sanctuary in relation to the mammalian diversity in Debrigarh Wildlife Sanctuary.

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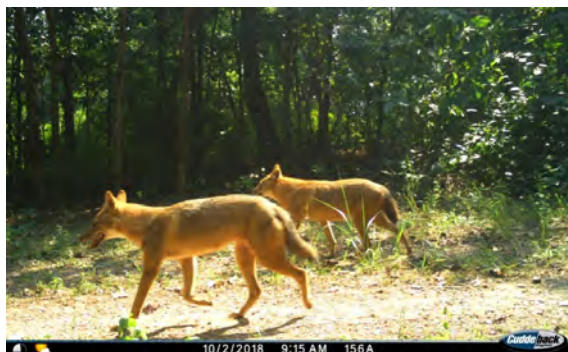
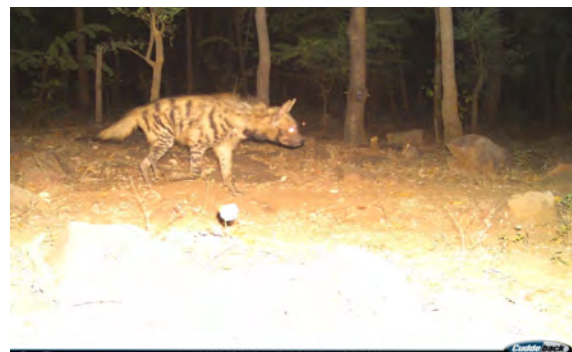
Image 2. *Panthera tigris*Image 3. *Panthera pardus*Image 4. *Prionailurus rubiginosus*Image 5. *Felis chaus*Image 6. *Canis lupus*Image 7. *Cuon alpinus*Image 8. *Canis aureus*Image 9. *Hyaena hyaena*



Image 10. *Melursus ursinus*

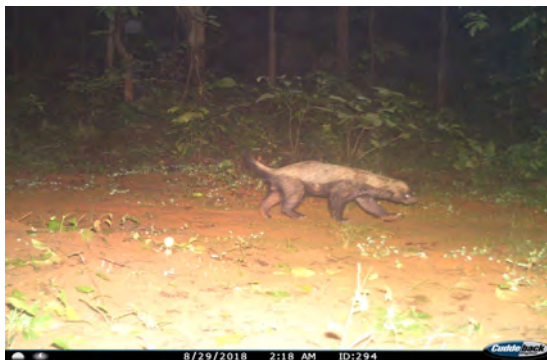


Image 11. *Mellivora capensis*



Image 12. *Bos gaurus*



Image 13. *Boselaphus tragocamelus*



Image 14. *Rusa unicolor*



Image 15. *Axis axis*



Image 16. *Tetracerus quadricornis*



Image 17. *Muntiacus muntjak*

Image 18. *Semnopithecus entellus*Image 19. *Macaca mulatta*Image 20. *Sus scrofa*Image 21. *Hystrix indica*Image 22. *Paradoxurus hemaphroditus*Image 23. *Viverricula indica*Image 24. *Herpestes edwardsii*Image 25. *Herpestes smithii*



Image 26. *Manis crassicaudata*



Image 27. *Lepus nigricollis*



Image 28. *Vulpes bengalensis*



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