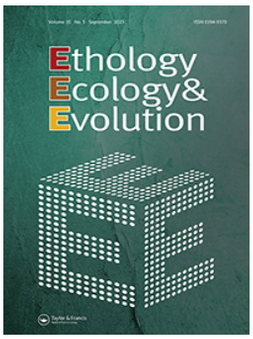

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Jungle cat (*Felis chaus*) in farmlands: potential benefits of coexistence and human-wildlife conflicts in West Bengal, India

Santanu Mahato [1,2,*], Tanmoy Ghosh[3], Shuvra K. Sinha [4], Kranti Yardi [1] and Erach Bharucha [1]

[1]*Bharati Vidyapeeth Institute of Environment Education and Research (BVIEER), Bharati Vidyapeeth (Deemed to be University), Pune, India*
[2]*Biopsychology Laboratory and Institution of Excellence, University of Mysore, Mysuru, India*
[3]*Belun Biodiversity Research Centre, Katwa, Purba Bardhaman, India*
[4]*Department of Zoology, Sreegopal Banerjee College, Hooghly, India*

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Human-wildlife coexistence has increasingly been known for providing diverse ecological services to humans. However, the global repercussions of the Anthropocene epoch have changed the status and future of human-wildlife relationships. In this paper, we shed light on the significance of a positive attitude towards sharing space with animals in identifying and managing both conflict and ecological aspects of human-wildlife interactions in an agrarian landscape. We tried to understand how interactions between meso-carnivores like jungle cats (*Felis chaus*) and humans influence their survival in dense human populations. We evaluate the abundance and habitat use by jungle cats seasonally and diet, as well as their interactions with farmers in West Bengal, India. The mean encounter rate of jungle cats was assessed and used as a proxy for their abundance. Using a combination of direct sign surveys, we found that the habitat preference and seasonal distribution of jungle cats were influenced by the change in seasons with respect to different habitats. Our results indicate that jungle cats were more associated with human settlements during the monsoon. Scat analysis revealed the dominance of rodents in the diets of jungle cats. This activity helps to control the rodent population from destroying crops. However, our interactions with farmers showed their negative attitude towards the species due to the instances of livestock (poultry birds) depredation. We suggest that, more interdisciplinary researches are required to address how affectively socioeconomic structures shape up positive human-wildlife interaction. Planning and implementation of conservation education programmes are also necessary to help people for understanding the economic and ecological benefits provided by jungle cats and other wide-ranging carnivores.

KEY WORDS: agrarian landscape, *Felis chaus*, ecosystem services, abundance, habitat use, co-existence, farmers' perceptions.

*Corresponding author: Santanu Mahato, Biopsychology Laboratory, Institution of Excellence, University of Mysore, Mysuru, Karnataka 570006, India (E-mail: santanumahato94@gmail.com).

INTRODUCTION

Humans have altered land cover and biodiversity on a local and global scale through the cumulative, progressive and unlawful pressure of adaptive constraints (Low et al. 2019). Several threats are posed to the native wildlife species by these land-use patterns to achieve specific goals. This negatively effects the inhabiting population of species as well as the ecosystem as a whole (Foley et al. 2005; Mooney et al. 2009; Kumara et al. 2022). A rapid change in land-use patterns in the anthropogenic landscape is responsible for species extinction (Ellis et al. 2010; Otto 2018) where agricultural practices combined with other human activities are hazardous for wildlife (Cushman 2006; Martinuzzi et al. 2015). Living in proximity to human settlements is one of the reasons for the population alteration of native wild species (Díaz et al. 2019). These incidents result in a wide range of negative interaction between humans and wildlife due to the competition for overlapping resources.

Besides, certain animal populations face major challenges in coping with the changing environments in various landscapes (Messmer 2009; Marchini & Crawshaw 2015). For example, the biodiversity of the sacred groves near farmlands in India, remains undisturbed and helps in conserving diverse plant and animal species. Unfortunately, they were disrupted and their population started declining at a faster rate due to increasing anthropogenic activities (Mishra et al. 2004; Manna et al. 2017). The growing human dependence on natural resources as well as the destruction of wildlife habitats have resulted in conflicts between humans and wildlife. According to studies, nearly 90% of India currently experiences these types of human-wildlife conflict issues (Choudhury 2004; Karanth et al. 2013; Anand & Radhakrishna 2017; Mishra et al. 2020a). It is important to address the threats to the local biodiversity and develop an approach that involves community participation in conservation. This will help us to understand the ecological role of wildlife in a better way. Many more comparative studies are required to determine how the existence of wildlife in human-dominated landscapes benefits humans by providing diverse ecosystem services, as there is a lack of such investigations (Sillero-Zubiri & Laurenson 2001; Nyhus 2016). As most of the wild animal populations are distributed beyond the protected areas, it is necessary to shift conservation priority from a protected area-centric way to an anthropogenic landscape-centric way (Athreya et al. 2013).

Agricultural practice is one of the drivers of land-use patterns in the modern world (Etter et al. 2006; Mottet et al. 2006; Munteanu et al. 2014). For thousands of years, farmlands have been increasing in size for the production of large amount of crops. Currently, farmlands cover 38% of the global land surface (Ramankutty et al. 2008) and these expansions and intensifications pose major threats to wild species. Thus, animals which inhabit outside of protected areas frequently come into contact with anthropogenic landscapes and struggle to survive in such altered habitats. For example, macaque monkeys like bonnet macaque (*Macaca radiata*) and rhesus macaque (*Macaca mulatta*) can easily cope with such environments due to their behavioural flexibility (Jaman & Huffman 2013; Mangalam & Singh 2013). On the other hand, Asian elephants (*Elephas maximus*) have become environmental refugees and are struggling for coexistence in a human-dominated landscape (Kumar & Singh 2010; Mahato & Pal 2021; Nayak & Swain 2022). Furthermore, vulnerable carnivore species such as leopards (*Panthera pardus*) find the high density of domestic animals in human-dominated landscapes as a rich potential prey source (Athreya et al. 2013). Whereas Palei et al. (2018) expressed concern that agriculture, intensive

fishing and aquaculture practices have become highly vulnerable to fishing cats (*Prionailurus viverrinus*). In this context, it is crucial to understand the ecological relationship between farmland and other living forms in the ecosystem. This relationship can be determined by various food chains involved in human-wildlife commensalism, such as the consumption of rodents by small carnivores (Capizzi et al. 1995; Mukherjee et al. 2004; Ćirović et al. 2016) or the food-niche pattern of barn owls (*Tyto alba*) in pest control implications (Kross et al. 2016; Horváth et al. 2018). The presence of certain wildlife in the human-dominated landscape controls crop pests and may offer economic benefits to farmers. However, farmers do not always perceive the fact that how much quantity of grains are getting damaged by rodents because of their limitations of visualising it.

We recently conducted a case study on jungle cats ("least concern" in the IUCN Red List) which may act as an effective biological pest control agent. Jungle cats are widespread in India, where the persecution of species is not on a large scale like some traded species. However, the indiscriminate killing of jungle cats in rural areas of West Bengal under the name of ritualistic hunting festivals, commonly known as "Shikar Utsav" in Bengali (such as "Falharini Kali Puja") needs prior attention (Bhattacharya et al. 2019; HEAL 2020), where this study was conducted. Thus, hunting pressure and a decrease in human-wildlife tolerance levels result in the depletion of widespread and adaptable species such as the jungle cat in farmlands (Duckworth et al. 2005). In this context, a study on its occurrence, preferences in habitat selection and relative abundance may be important. In addition, jungle cats potentially suffer from conflicts and persecution, although their presence may bring benefit to humans since they may act as pest control agents. On the contrary, local people have a biased negative perception because they may think that this cat is responsible for all the killings of their domestic livestock (poultry birds). Therefore, establishing baseline documentation on the effect of jungle cats on rodent control in farmlands and disseminating this information among farmers can change their agonistic attitudes towards the animal. Thus, this study is important because it can support the management of the persistence of this animal in such anthropogenic landscapes. We chose a primarily agrarian landscape for the present study. Here we tried to focus on the following objectives:

(1) To understand the abundance and diet of jungle cats.
(2) To understand the habitat utilisation of jungle cats on seasonal basis.
(3) To understand the perception of farmers about the presence of jungle cats in their farmlands.

METHODS

Study area

We conducted our study in Nabagram, with an area of 33.63 km^2 in the Purba Bardhaman district of West Bengal, India. The survey was carried out between November 2016 and October 2017. The study area lies between 88°3'–88°7"E and 23°38"–23°43'N (Fig. 1). The summer is extremely warm and lasts from March to June. The monsoons (July–October) receive most of the rainfall with an annual average of 1400 mm, and winter prevails between November and February. The maximum temperature ranges between 35 and 40 °C and the minimum temperature varies between 8 and 13 °C. The area is characterised by four major habitats: human settlements (HH) and farmlands (AG), in addition to

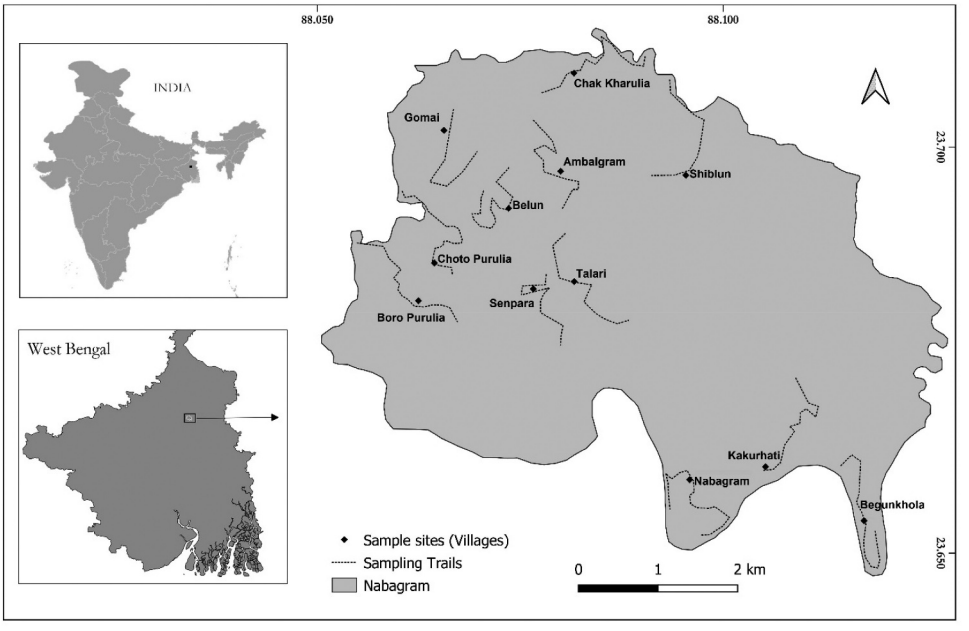

Fig. 1. — Location of the study site, Nabagram, in the Purba Bardhaman district of the state of West Bengal, India.

small patches of vegetation (FP) and grass fields (GS). Farmland covers 87.7% of the study area, with "Kharif" rice, "Rabi" rice, and potato being the major crops. Jungle cats are the only wild cat species found with other carnivores living in the study area, like golden jackal (*Canis aureus*), small Indian civet (*Viverricula indica*), grey mongoose (*Herpestes edwardsii*) and small Indian mongoose (*H. auropunctatus*) (S. Mahato, T. Ghosh pers. obs.).

Field survey, data collection and analysis

Abundance estimation. Surveys were carried out the whole day to record both the diurnal and nocturnal activities of jungle cats. The line transect method of sampling was used to record the detection of jungle cats. A total of 12 transect walks were laid, with a minimum distance of 500 m between each of the 12 sampling sites to estimate the detection frequency (Fig. 1). For each trail, the length was specified at about 500 m for each of the four habitats so that the proportion of length remained the same (Table 1). The average length of each trail was 2.08 km based on the landscape. A single day (24 hr) was divided into four time slots: morning (6:01 am–12:00 pm), afternoon (12:01 pm–6:00 pm), evening (6:01 pm–12:00 am) and night (12:01 am–6:00 am). In each time slot, two replicated walks were made at a speed of 1 km per hour. Thus, eight replicated walks were done on each trail for all 4 time slots in each season, covering a total distance of 16.64 km. And, repeated walks in 3 seasons gave a total of 24 replicates which covered 49.92 km for each trail. Thus, the total distance covered in all 3 seasons was 599.04 km.

During the trail walk, every sighting of the animal (irrespective of whether it was the same individual) was recorded to estimate the encounter rate. We used the following formula to calculate the encounter rate (ER), generally considered an index of relative abundance (Seber 1982; Southwood & Henderson 2009):

$$\text{ER} = \frac{TS}{TL} \text{per km}$$

where *TS* is the total number of sightings in each season or habitat and *TL* is the total length of eight replicates of the respective habitat on a trail.

Details of the sampling effort by observers are shown in Table 1. The sighting data was also used to indicate the presence of the species and to estimate the relative encounter rates of the species in different habitats. At night, when an animal was spotted with the shining of eyes, it was identified by an infrared night vision full spectrum camcorder and camera. We used headlamps and hand torches, both covered with red cellophane paper to reduce the disturbance of spot lights (Charles-Dominique 1977; Radhakrishna & Singh 2002). The abundance was presented as an encounter rate (animal detections/km). Detections of jungle cats were used for analysis and to draw a comparison between different seasons of summer (March–June), monsoon (July–October) and winter (November–February). Statistical test like one-way ANOVA was used to study the intensity of habitat use for every season, and two-way ANOVA was used to investigate the effect of different habitats and seasons on sightings of jungle cats.

Diet. Scat analysis is the most commonly used method for determining the diet of terrestrial carnivores (Klare et al. 2011). The scat analysis of jungle cats was shown to be reliable in determining their diet (Mukherjee et al. 2004; Majumder et al. 2011). The scats of jungle cats were searched within 10 m breadth on each side while walking. Scat samples were collected in each habitat area based on the colour, size, and diameter of the scats (Shrestha & Basnet 2005; Vanak & Mukherjee 2008). Three scats were kept as standards, which had been observed and

Table 1.

The detection rates of jungle cats at the various sampling sites in the study area.

No	Sampling sites	Trail lengths (km)	Habitat covered in each trail (km)				Detections (/km)				
			HH	AG	GS	FP	HH	AG	GS	FP	Overall
1	Ambalgram	2.09	0.52	0.56	0.49	0.52	2.24	2.24	1.80	2.31	2.15
2	Boro Purulia	2.05	0.54	0.49	0.50	0.52	3.97	2.28	1.68	3.03	2.74
3	Begunkhola	1.99	0.60	0.45	0.48	0.47	2.91	2.24	2.10	1.61	2.22
4	Belun	2.10	0.55	0.53	0.49	0.53	1.43	3.04	4.98	4.72	3.54
5	Chak Kharulia	2.03	0.47	0.51	0.55	0.51	1.52	1.13	2.43	2.97	2.01
6	Choto Purulia	2.01	0.51	0.54	0.52	0.45	2.20	2.16	1.21	3.82	2.35
7	Gomai	2.01	0.52	0.53	0.44	0.53	1.61	1.82	1.70	1.82	1.74
8	Kakurhati	2.31	0.65	0.61	0.48	0.57	1.15	1.30	3.10	3.02	2.14
9	Nabagram	2.15	0.55	0.57	0.51	0.52	0.99	1.76	1.72	2.15	1.66
10	Senpara	1.99	0.52	0.58	0.43	0.47	1.29	2.17	2.80	1.79	2.01
11	Shiblun	2.01	0.54	0.52	0.44	0.52	1.54	1.86	2.49	2.18	2.02
12	Talari	2.24	0.62	0.61	0.53	0.48	1.94	1.38	2.74	1.91	1.99
	Mean	2.08	0.54	0.54	0.49	0.51	1.90	1.95	2.40	2.61	2.21
	SE	0.03	0.02	0.01	0.01	0.01	0.24	0.15	0.29	0.27	0.24

HH = human settlements; AG = farmlands; GS = grass fields; FP = small patches of vegetation.

collected after defaecation by jungle cats in the field. Firstly, collected scats were sundried to prevent fungal contamination and dried in the laboratory for 48 hr at a temperature of 60 °C. The scats were thoroughly washed under tap water to remove residues and mucus, and then sieved through a fine-mesh. Then, the prey contents were segregated into hairs, teeth and bone parts of vertebrates, invertebrates and other plant materials (Singh et al. 2016). Hair and prey remains were also compared under the microscope with reference slides of birds and other body parts of rodents available in the laboratory. The prey species were identified on the basis of dentition and compared with photographs and descriptions (Patnaik et al. 2008; Talmale & Pradhan 2009).

Perception of farmers towards jungle cats. Semi-structured interviews were conducted to understand the perceptions of local people about the jungle cat. A total of 240 people were interviewed from 12 villages (20 people in each village) in the study area. A questionnaire was prepared which comprised questions mainly focused on human-animal interactions, the ecosystem services of jungle cats and threats to their population (Appendix). Various graphic representations were made to show the responses related to wild animals existing in the study area (Figs 2–4).

RESULTS

During the study, a total of 1318 sightings occurred. The overall average of encounter rate of the jungle cat was $2.21 \pm 0.24_{SE}$ individuals per km (Table 1). The encounter rate of the jungle cat was higher at night ($4.53 \pm 0.73_{SE}$) than during the day ($2.12 \pm 0.60_{SE}$). The highest encounter rate was observed from Belun village ($3.54 \pm 0.75_{SE}$). The average of encounter rate in small patches of vegetation, grass fields, farmlands, and human settlements was 2.61, 2.40, 1.85, and 1.90, respectively. A homogenous subset ($P = 0.134$) was formed by the mean sighting rate of 3 different seasons. We found no significant difference in mean detection of jungle cats by habitat types ($F_{3,44} = 2.05$, $P = 0.11$) and by seasons ($F_{2,45} = 1.88$, $P = 0.16$). There was a strong association between habitats and seasons ($F_{6,132} = 10.94$, $P = 0.001$) indicating that the jungle cats preferred habitats according to different seasons (Table 2). The post hoc tests for pair-wise comparisons among seasons revealed that the jungle cat significantly preferred human settlements in monsoon, farmlands in winter and grass fields

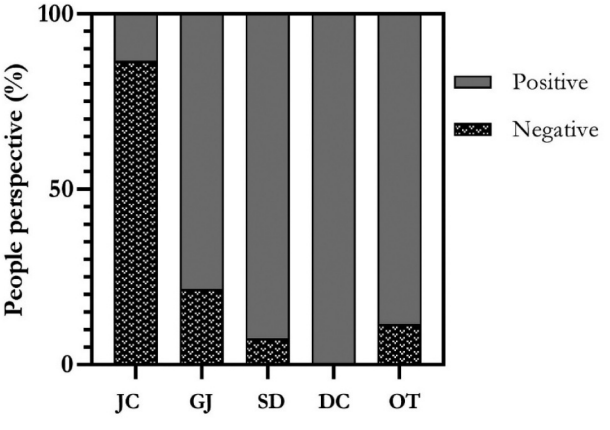

Fig. 2. — People's responses to the animals suspected of killing their poultry (JC = jungle cat; GJ = golden jackal; SD = street dog; DC = domestic cat; OT = others).

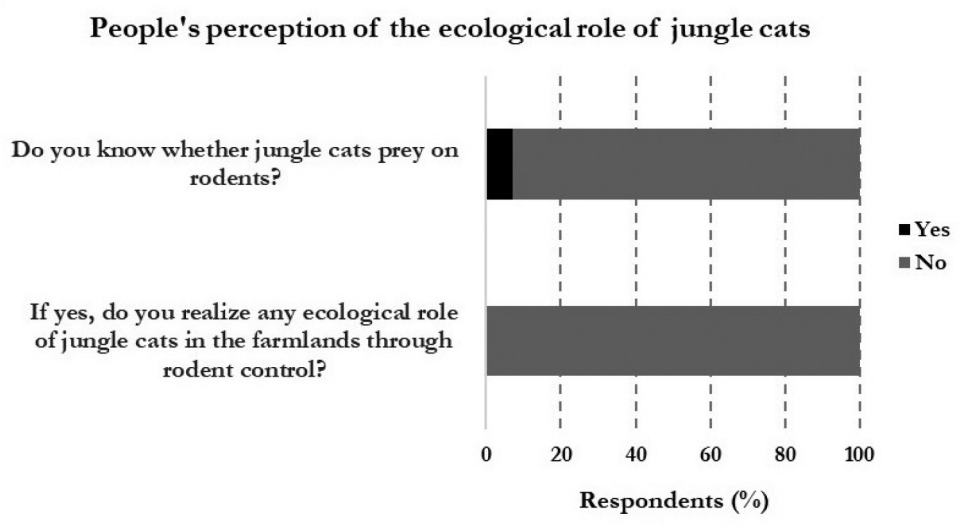

Fig. 3. — People's perception of the ecological role of jungle cats through rodent control in the farmlands.

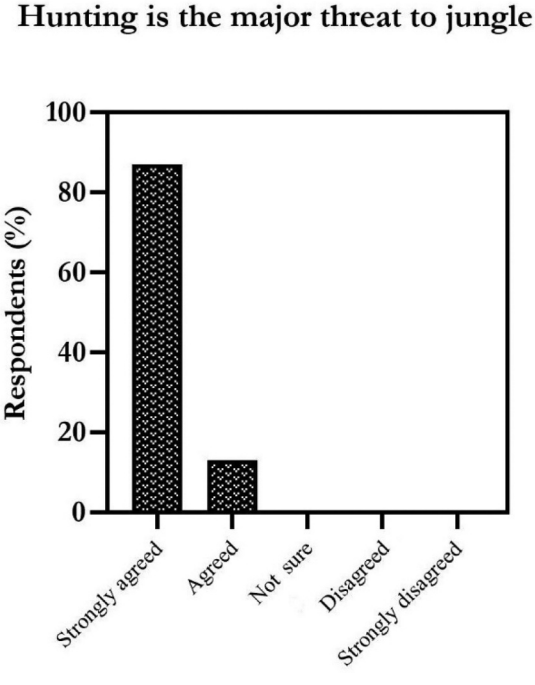

Fig. 4. — People's perception of hunting as the most serious threat to jungle cats.

Table 2.

The mean detections of jungle cats per km in various habitats and the interaction between the seasons within a habitat in the study area.

Habitat	Seasons	Mean (/km)	SE	95% Confidence interval for mean		Minimum	Maximum	*F* (df1, df2)	*P* value
				Lower bound	Upper bound				
HH	Winter	0.84	0.18	0.44	1.23	0.00	2.20	16.20 (2, 33)	< 0.001
	Summer	0.99	0.17	0.62	1.36	0.23	1.93		
	Monsoon	3.87	0.69	2.35	5.40	0.96	9.81		
AG	Winter	3.15	0.43	2.21	4.09	0.49	5.04	11.03 (2, 33)	< 0.001
	Summer	1.95	0.43	1.01	2.89	0.41	4.92		
	Monsoon	0.75	0.17	0.38	1.11	0.00	2.11		
GS	Winter	1.77	0.31	1.07	2.46	0.24	3.87	6.01 (2, 33)	< 0.006
	Summer	3.67	0.67	2.18	5.15	0.48	9.28		
	Monsoon	1.76	0.22	1.27	2.25	0.57	3.10		
FP	Winter	1.88	0.24	1.35	2.42	0.00	3.10	2.72 (2, 33)	< 0.08
	Summer	3.32	0.61	1.98	4.65	0.52	7.31		
	Monsoon	2.63	0.38	1.80	3.46	0.54	4.47		

HH = human settlements; AG = farmlands; GS = grass fields; FP = small patches of vegetation. The relation in mean value of detections sampled were not statistically significance ($P > 0.05$).

in summer than in the other seasons. It suggests that there was no preference for seasons in small patches of vegetation by jungle cats.

The analysis of scats (n = 55) revealed that rodents contributed 65.4% (n = 36) of the diet of jungle cats (Table 3). Other remains like birds consisted of ducks and poultry (21.8%, n = 12) and insect remains comprised of the legs and wing carapaces

Table 3.

The frequency of occurrence of various food items in the diet of the jungle cat, as well as a comparison with two previous studies in India.

	Frequency of occurrence (%)		
Studies & number of scats (n)	Mukherjee et al. (2004) (n = 69)	Majumder et al. (2011) (n = 85)	Present study (n = 55)
Habitat type	Tropical dry deciduous and tropical thorn forest	Tropical dry deciduous and tropical moist deciduous forests	Gangetic plain mostly agricultural land, with human habitation
Population density or abundance	NA	NA	Encounter rate of $2.21 \pm 0.24_{SE}$/km
Food items: Mammals	94	–	–
• Rodents	73	63.6	65.4
• Langur *Semnopithecus entellus*	–	1	–
• Hare *Lepus nigricollis*	–	11.1	–
• Wild ungulates	12	–	–
• Chital *Axis axis*	–	6.1	–
• Sambar *Rusa unicolor*	–	2	–
• Wild pig *Sus scrofa*	–	1	–
• Cattle	–	–	–
Birds	42	7.1	21.8
Reptiles	26	8.1	–
Amphibians	–	–	7.2
Invertebrates	23	–	45.4
Plant materials	19	–	14.5
Others (synthetic non-food materials like plastic, papers)	9	–	–

such as crickets (45.4%, n = 25). There were also plant materials (14.5%, n = 8) and amphibian remains (7.2%, n = 4).

Most of the interviewed people (83%) were dependent on agriculture for their livelihoods. The majority of households had poultry (97%), out of which 90% of households reported depredation of poultry by jungle cats and three to four poultry birds were killed each year on average. Most of the people (86.66%) suspected that jungle cats were responsible for the death of their poultry as compared to the other probable predators, such as golden jackal (21.66%) and dogs (7.5%) (Fig. 2). It is noteworthy that many respondents reported that poultry birds were caught by other villagers, but the usual blame was placed on jungle cats. We asked people whether they knew that "jungle cats feed on rodents". Surprisingly, 93% of the respondents were unaware that jungle cats eat rodents. Although, the remaining respondents (7%) were aware, they were unable to realise or quantify any economic role of this animal through rodent control in the farmlands (Fig. 3). All of the respondents agreed (87% strongly agreed, 13% agreed) that the major threat to jungle cats was hunting using snares, bows and arrows (Fig. 4).

DISCUSSION

This study was conducted in a human-dominated landscape inhabited by jungle cats. The results show that the mean encounter rate of jungle cats was $2.21 \pm 0.24_{SE}$ individuals per km which differed in each habitat seasonally. Scat analysis showed the dominance of rodents in their diet.

It is well known that jungle cats live in various habitats ranging from plain land to the Himalayas (Gray et al. 2016; Noor et al. 2017), including tropical dry deciduous forest, thorn scrub forest and wetlands (Mukherjee et al. 2010; Chatterjee et al. 2020; Mishra et al. 2020b). Our findings provide an insight of how they are living alongside human in the same habitat. The movement patterns of jungle cats varied seasonally from natural habitats to human settlements. A high encounter rate was found in human settlements in the monsoon season when the farmlands were filled with rain water. During that season, these cats usually visit the human settlements in search of rodents, but very often they come into close contact with another unwanted animal — poultry birds (Choudhury & Ghorai 2022). Most of the people were unaware of the fact that jungle cats primarily feed on rodents. Apart from that, they also have a false perception that jungle cats kill poultry birds. Additionally, all of the respondents agreed that hunting is the primary threat to the survival of the species. Hence, people's perceptions are somewhat negative, which is affecting the population of jungle cats in the area. There are certain studies which show that jungle cats play an important role in limiting the rodent population (Mukherjee et al. 2004; Majumder et al. 2011).

In the recent past, the feeding ecology of jungle cats has been estimated in several regions across India (Mukherjee et al. 2004; Majumder et al. 2011). The data of scat analysis from this study was compared with two previous works (Table 3). Results revealed that the dominance of rodents in the diets of jungle cats remains similar as compared in the protected forest areas to the agrarian landscape. Scat analysis found that rodents dominated the diet of jungle cats (65.4%), which is consistent with the other two studies such as 73% in Sariska Tiger Reserve and 63.6% in Pench Tiger Reserve. The presence of a diverse range of food items in the diet of jungle cats in different landscapes with highly variable resource availability indicates the

opportunistic feeding behaviour of jungle cats and their adaptability to various habitats (Table 3). In this study, the birds were recorded as an important component in the diet of the jungle cats (21.8%), which is comparable to studies conducted across India, ranging from 7.1% in Pench Tiger Reserve to 42% in Sariska Tiger Reserve.

An increasing population of rodents in farmlands causes massive loss of crops in Asia (Singleton 2003; Stenseth et al. 2003; Brown et al. 2007; Singleton et al. 2010). The current study area is located in the Gangetic plain of West Bengal, where crop damage is estimated to be 33.75 kg per hectare, or ₹ 675 per hectare (at a local market price of ₹ 20) using a simple bioenergetics model (Sultana & Jaeger 1992; Chattopadhyay et al. 2010). Following this estimation, the total wheat loss for farmlands in the current study area (2948.4 ha) would then be ₹ 19,90,170. The loss of food grains by rodents in India is estimated to be between 2.4 and 26 million tons per year. Statistically, it is estimated that six rats are eating one man's food on a daily basis (IGMRI – Rodent pests n.d.). Jungle cats eat three to five rodents per day and that makes 1095 to 1825 rodents per year (Mukherjee et al. 2004). Thus, they keep rodent populations under control in farmlands, which helps farmers to save money by keeping the pest population under control and reducing the loss of crops.

This study reveals perceptions of farmers about how jungle cats are coexisting with them. This species is one of the apex and predominant meso-predators in the area. A healthy population of jungle cats will be able to coexist in the agrarian landscape along with high resource availability and the absence of other major predators or competitors (Singh et al. 2016). Rodents are the primary prey base for jungle cats in the farmlands, and so this helps in controlling their populations. However, most people overlook the hunting activities of jungle cats because they are less tolerant to this feline species. Even, farmers did not perceive the ecosystem services that jungle cats provide in the farmlands. This study shows diet of jungle cat includes a minimal amount of poultry birds and a maximum amount of rodents as food. This information may help to change the perception of farmers in a positive way, thereby potentially limiting the rodent population. Besides, a long-term study overcoming relevant limitations can be done with respect to the biomass of both rodents and jungle cats to necessitate broad quantification of the loss of poultry as well as a demonstration of the consumed species.

Conservation actions are required to be taken to assist people in making better animal husbandry. This may also lower the risk of predation, which may lead to fewer conflicts. At the same time, degraded lands may be transformed into grassland and forest patches, which will provide a suitable habitat for jungle cats and other species. This may be achieved by promoting conservation education programmes and raising awareness among local people. As a result of this approach, these village areas can become biodiversity hotspots for the local area. Awareness workshops for high school and college students may be the most effective way to collect baseline data on community perceptions of human-dominated landscapes (Bhattacharya et al. 2019; Kamil et al. 2020). Individual or organisational efforts can influence people's attitudes towards wildlife, and we can implement the same in other areas to enhance people's perceptions of coexistence and community conservation. It will contribute to the spread of community-based conservation approaches by involving students directly in their localities so that they can positively influence and motivate local people about the conservation of wildlife.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

AUTHOR CONTRIBUTION

S. Mahato conceived and designed the study, accomplished the survey and completed the data collection. T. Ghosh and S.K. Sinha contributed to data collection, and helped to prepare the Appendix. S. Mahato analysed the data and wrote the manuscript. K. Yardi and E. Bharucha supervised the study and revised the manuscript and provided support for the discussion of the results. All authors read and approved the final version of the manuscript.

ORCID

Santanu Mahato http://orcid.org/0000-0003-4453-4859
Shuvra K. Sinha http://orcid.org/0000-0002-2408-7441
Kranti Yardi http://orcid.org/0000-0001-8636-7820
Erach Bharucha http://orcid.org/0000-0003-1035-4585

REFERENCES

Anand S, Radhakrishna S. 2017. Investigating trends in human-wildlife conflict: is conflict escalation real or imagined? J Asia Pac Biodivers. 10(2):154–161. doi:10.1016/j.japb.2017.02.003

Athreya V, Odden M, Linnell JD, Krishnaswamy J, Karanth U, Hayward M. 2013. Big cats in our backyards: persistence of large carnivores in a human dominated landscape in India. PLoS ONE. 8(3):e57872. doi:10.1371/journal.pone.0057872

Bhattacharya S, Zia SZ, Mahato S, Gangwar RK, Singh N, Auliya M, Koch A. 2019. Report on the Awareness Workshops "Perceptions of Wildlife Conservation of Today's Youth in West Bengal, India, with a Focus on Monitor Lizards". Biawak. 13:94–100.

Brown PR, Huth NI, Banks PB, Singleton GR. 2007. Relationship between abundance of rodents and damage to agricultural crops. Agric Ecosyst Environ. 120(2–4):405–415. doi:10.1016/j.agee.2006.10.016

Capizzi D, Luiselli L, Capula M, Rugiero L. 1995. Feeding habits of a Mediterranean community of snakes in relation to prey availability. Rev Ecol. 50(4):353–363. doi:10.3406/revec.1995.2183

Charles-Dominique P. 1977. Ecology and behaviour of nocturnal primates: prosimians of equatorial West Africa. New York (NY): Columbia University Press.
Chatterjee N, Nigam P, Habib B. 2020. Population density and habitat use of two sympatric small cats in a central Indian reserve. PLoS ONE. 15(6):e0233569. doi:10.1371/journal.pone.0233569
Chattopadhyay D, Madhu NR, Manna CK. 2010. Burrowing pattern and damage caused by the rodent pest, Indian house rat (*Rattus rattus*) in the Gangetic and Non Gangetic plain of West Bengal, India. Univ J Zool. 28:57–60. doi:10.3329/ujzru.v28i0.5288
Choudhury A. 2004. Human–elephant conflicts in Northeast India. Hum Dimens Wildl. 9 (4):261–270. doi:10.1080/10871200490505693
Choudhury T, Ghorai N. 2022. Jungle cat (*Felis chaus* Schreber 1777) – a victim of false blame? A case study in Gomai, Katwa, West Bengal, India. Eco Environ Cons. 28(1):342–346. doi:10.53550/EEC.2022.v28i01.050
Ćirović D, Penezić A, Krofel M. 2016. Jackals as cleaners: ecosystem services provided by a mesocarnivore in human-dominated landscapes. Biol Conserv. 199:51–55. doi:10.1016/j.biocon.2016.04.027
Cushman SA. 2006. Effects of habitat loss and fragmentation on amphibians: a review and prospectus. Biol Conserv. 128(2):231–240. doi:10.1016/j.biocon.2005.09.031
Díaz S, Settele J, Brondízio ES, Ngo HT, Agard J, Arneth A, Balvanera P, Brauman KA, Butchart SH, Chan KM, et al. 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. Science. 366(6471):eaax3100. doi:10.1126/science.aax3100
Duckworth JW, Poole CM, Tizard RJ, Walston JL, Timmins RJ. 2005. The jungle cat *Felis chaus* in Indochina: a threatened population of a widespread and adaptable species. Biodivers Conserv. 14(5):1263–1280. doi:10.1007/s10531-004-1653-4
Ellis EC, Klein Goldewijk K, Siebert S, Lightman D, Ramankutty N. 2010. Anthropogenic transformation of the biomes, 1700 to 2000. Glob Ecol Biogeogr. 19(5):589–606. doi:10.1111/j.1466-8238.2010.00540.x
Etter A, McAlpine C, Wilson K, Phinn S, Possingham H. 2006. Regional patterns of agricultural land use and deforestation in Colombia. Agric Ecosyst Environ. 114(2–4):369–386. doi:10.1016/j.agee.2005.11.013
Foley JA, DeFries R, Asner GP, Barford C, Bonan G, Carpenter SR, Chapin FS, Coe MT, Daily GC, Gibbs HK, et al. 2005. Global consequences of land use. Science. 309 (5734):570–574. doi:10.1126/science.1111772
Gray TNE, Timmins RJ, Jathana D, Duckworth JW, Baral H, Mukherjee S. 2016. *Felis chaus*. The IUCN Red List of Threatened Species 2016:e.T8540A50651463. [Accessed 28 Jan 2017].
[HEAL] Human & Environment Alliance League. 2020. Hunting festivals of West Bengal — an untold story of wildlife massacre. Conservation India. Available from: https://www.conservationindia.org/articles/hunting-festivals-of-west-bengal-an-untold-storyof-wildlife-massacre. [Accessed 21 Jan 2022].
Horváth A, Morvai A, Horváth GF. 2018. Food-niche pattern of the Barn Owl (*Tyto alba*) in intensively cultivated agricultural landscape. Ornis Hung. 26(1):27–40. doi:10.1515/orhu-2018-0002
[IGMRI] Indian Grain Storage Management and Research Institute. n.d. Rodent pest. Hapur (India): Government of India. Available from: https://igmri.dfpd.gov.in/igmri/rodent-pests. [Accessed 25 Nov 2020].
Jaman M, Huffman MA. 2013. The effect of urban and rural habitats and resource type on activity budgets of commensal rhesus macaques (*Macaca mulatta*) in Bangladesh. Primates. 54(1):49–59. doi:10.1007/s10329-012-0330-6
Kamil PI, Susianto H, Purwandana D, Ariefiandy A. 2020. Anthropomorphic and factual approaches in Komodo dragon conservation awareness program for elementary school students: initial study. Appl Environ Educ Commun. 19(3):225–237. doi:10.1080/1533015X.2019.1582374

Karanth KK, Gopalaswamy AM, Prasad PK, Dasgupta S. 2013. Patterns of human–wildlife conflicts and compensation: insights from Western Ghats protected areas. Biol Conserv. 166:175–185. doi:10.1016/j.biocon.2013.06.027

Klare U, Kamler JF, Macdonald DW. 2011. A comparison and critique of different scat-analysis methods for determining carnivore diet. Mamm Rev. 41(4):294–312. doi:10.1111/j.1365-2907.2011.00183.x

Kross SM, Bourbour RP, Martinico BL. 2016. Agricultural land use, barn owl diet, and vertebrate pest control implications. Agric Ecosyst Environ. 223:167–174. doi:10.1016/j.agee.2016.03.002

Kumar MA, Singh M. 2010. Behavior of Asian elephant (*Elephas maximus*) in a land-use mosaic: conservation implications for human-elephant coexistence in the Anamalai hills, India. Wildl Biol Pract. 6(2):69–80. doi:10.2461/wbp.2010.6.6

Kumara HN, Babu S, Rao GB, Mahato S, Bhattacharya M, Rao NVR, Tamiliniyan D, Parengal H, Deepak D, Balakrishnan A, Bilaskar M. 2022. Responses of birds and mammals to long-established wind farms in India. Sci Rep. 12(1):1–15. doi:10.1038/s41598-022-05159-1

Low FM, Gluckman PD, Hanson MA. 2019. Niche modification, human cultural evolution and the Anthropocene. Trends Ecol Evol. 34(10):883–885. doi:10.1016/j.tree.2019.07.005

Mahato S, Pal A. 2021. Struggle for coexistence: effect of the Anthropocene on non-human life forms. In: Mandal B, editor. PEEPAL. West Bengal (India): Sonamukhi College; p. 145–161.

Majumder A, Sankar K, Qureshi Q, Basu S. 2011. Food habits and temporal activity patterns of the Golden jackal *Canis aureus* and the Jungle cat *Felis chaus* in Pench Tiger Reserve, Madhya Pradesh. J Threat Taxa. 3(11):2221–2225. doi:10.11609/JoTT.o2713.2221-5

Mangalam M, Singh M. 2013. Flexibility in food extraction techniques in urban free-ranging bonnet macaques, *Macaca radiata*. PLoS ONE. 8(12):e85497. doi:10.1371/journal.pone.0085497

Manna S, Manna S, Ghora TK, Roy A. 2017. Sacred grove as remnant forest: a vegetation analysis. Biodivers J. 18(3):899–908. doi:10.13057/biodiv/d180306

Marchini S, Crawshaw PG Jr. 2015. Human–wildlife conflicts in Brazil: a fast-growing issue. Hum Dimens Wildl. 20(4):323–328. doi:10.1080/10871209.2015.1004145

Martinuzzi S, Withey JC, Pidgeon AM, Plantinga AJ, McKerrow AJ, Williams SG, Helmers DP, Radeloff VC. 2015. Future land-use scenarios and the loss of wildlife habitats in the southeastern United States. Ecol Appl. 25(1):160–171. doi:10.1890/13-2078.1

Messmer TA. 2009. Human–wildlife conflicts: emerging challenges and opportunities. Hum–Wild Conflicts. 3:10–17.

Mishra BP, Tripathi OP, Tripathi RS, Pandey HN. 2004. Effects of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, northeast India. Biodivers Conserv. 13(2):421–436. doi:10.1023/B:BIOC.0000006509.31571.a0

Mishra PS, Kumara HN, Thiyagesan K, Singh M, Velankar AD, Pal A. 2020a. Chaos in coexistence: perceptions of farmers towards long-tailed macaques (*Macaca fascicularis umbrosus*) related to crop loss on Great Nicobar Island. Primate Conserv. 34:175–183.

Mishra R, Gautam B, Shah SK, Subedi N, Pokheral CP, Lamichhane BR. 2020b. Opportunistic records of jungle cat (*Felis chaus*) and their activity pattern in Koshi Tappu Wildlife Reserve, Nepal. Nepal J Zool. 4(1):50–55. doi:10.3126/njz.v4i1.30673

Mooney H, Larigauderie A, Cesario M, Elmquist T, Hoegh-Guldberg O, Lavorel S, Mace GM, Palmer M, Scholes R, Yahara T. 2009. Biodiversity, climate change, and ecosystem services. Curr Opin Environ Sustain. 1(1):46–54. doi:10.1016/j.cosust.2009.07.006

Mottet A, Ladet S, Coqué N, Gibon A. 2006. Agricultural land-use change and its drivers in mountain landscapes: a case study in the Pyrenees. Agric Ecosyst Environ. 114(2–4):296–310. doi:10.1016/j.agee.2005.11.017

Mukherjee S, Goyal SP, Johnsingh AJT, Pitman MRPL. 2004. The importance of rodents in the diet of jungle cat (*Felis chaus*), caracal (*Caracal caracal*) and golden jackal (*Canis aureus*) in Sariska Tiger Reserve, Rajasthan, India. J Zool. 262(4):405–411. doi:10.1017/S0952836903004783

Mukherjee S, Krishnan A, Tamma K, Home C, Joseph S, Das A, Ramakrishnan U, Ramakrishnan U. 2010. Ecology driving genetic variation: a comparative phylogeography of jungle cat (*Felis chaus*) and leopard cat (*Prionailurus bengalensis*) in India. PLoS ONE. 5 (10):e13724. doi:10.1371/journal.pone.0013724

Munteanu C, Kuemmerle T, Boltiziar M, Butsic V, Gimmi U, Halada L, Kaim D, Király G, Konkoly-Gyuró É, Kozak J, et al. 2014. Forest and agricultural land change in the Carpathian region—a meta-analysis of long-term patterns and drivers of change. Land Use Policy. 38:685–697. doi:10.1016/j.landusepol.2014.01.012

Nayak M, Swain PK. 2022. From fear to festivity: Multi-stakeholder perspectives on human-elephant conflict and coexistence in India. J Public Affairs. 22(2):e2496. doi:10.1002/pa.2496

Noor A, Mir ZR, Veeraswami GG, Habib B. 2017. Activity patterns and spatial co-occurrence of sympatric mammals in the moist temperate forest of the Kashmir Himalaya, India. Folia Zool. 66(4):231–241. doi:10.25225/fozo.v66.i4.a4.2017

Nyhus PJ. 2016. Human–wildlife conflict and coexistence. Annu Rev Environ Resour. 41:143–171. doi:10.1146/annurev-environ-110615-085634

Otto SP. 2018. Adaptation, speciation and extinction in the Anthropocene. Proc R Soc Lond B. 285(1891):20182047. doi:10.1098/rspb.2018.2047

Palei HS, Das UP, Debata S. 2018. The vulnerable fishing cat *Prionailurus viverrinus* in Odisha, eastern India: status and conservation implications. Zool Ecol. 28(2):69–74. doi:10.1080/21658005.2018.1468646

Patnaik R, Badam GL, Murty MLK. 2008. Additional vertebrate remains from one of the Late Pleistocene—Holocene Kurnool Caves (Muchchatla Chintamanu Gavi) of South India. Quat Int. 192(1):43–51. doi:10.1016/j.quaint.2007.06.018

Radhakrishna S, Singh M. 2002. Social behaviour of the slender loris (*Loris tardigradus lydekkerianus*). Folia Primatol. 73(4):181–196. doi:10.1159/000065426

Ramankutty N, Evan AT, Monfreda C, Foley JA. 2008. Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000. Global Biogeochem Cycles. 22(1): GB1003. doi:10.1029/2007GB002952

Seber GAF. 1982. The estimation of animal abundance and related parameters. New York (NY): MacMillan Press.

Shrestha B, Basnet K. 2005. Indirect methods of identifying mammals: a case study from Shivapuri National Park, Nepal. Ecoprint Int J Ecol. 12:43–58. doi:10.3126/eco.v12i0.3196

Sillero-Zubiri C, Laurenson MK. 2001. Interactions between carnivores and local communities: conflict or co-existence? Conservation Biology Series. Cambridge (UK): Cambridge University Press; p. 282–312.

Singh A, Mukherjee A, Dookia S, Kumara HN. 2016. High resource availability and lack of competition have increased population of a meso-carnivore—a case study of golden jackal in Keoladeo National Park, India. Mamm Res. 61(3):209–219. doi:10.1007/s13364-016-0267-z

Singleton G. 2003. Impacts of rodents on rice production in Asia. IRRI Discussion Paper Series No 45. Los Baños (Philippines): International Rice Research Institute.

Singleton GR, Belmain S, Brown PR, Aplin K, Htwe NM. 2010. Impacts of rodent outbreaks on food security in Asia. Wildl Res. 37(5):355–359. doi:10.1071/WR10084

Southwood TRE, Henderson PA. 2009. Ecological methods. New York (NY): John Wiley & Sons.

Stenseth NC, Leirs H, Skonhoft A, Davis SA, Pech RP, Andreassen HP, Singleton GR, Lima M, Machang'u RS, Makundi RH, et al. 2003. Mice, rats, and people: the bio-economics of agricultural rodent pests. Front Ecol Environ. 1(7):367–375. doi:10.1890/1540-9295(2003)001[0367:MRAPTB]2.0.CO;2

Sultana P, Jaeger MM 1992. Control strategies to reduce preharvest rat damage in Bangladesh. In: Borrecco J, Marsh R, editors. Proceedings of the Fifteenth Vertebrate Pest Conference 1992. Davis (CA): University of California; p. 261–267.

Talmale SS, Pradhan MS. 2009. Identification of some small mammal species through owl pellet analysis. Kolkata (India): Zoological Survey of India.

Vanak AT, Mukherjee S. 2008. Identification of scat of Indian fox, jungle cat and golden jackal based on morphometrics. J Bombay Nat Hist Soc. 105:212.

APPENDIX

Human-animal interactions	
1	Do you have any poultry birds?
2	Is there any incidence of poultry birds killed? (Yes/No)
2a	If yes, how many birds killed every year?
3	Which animal do you suspect more? (jungle cat/golden jackal/dog/domestic cat or others)
Ecological role of jungle cat	
4	Do you know whether jungle cats prey on rodents? (Yes/No)
4a	If yes, do you realise any ecological role of jungle cats in the farmlands through rodent control?
Threats	
5	Have you ever seen or heard that local people or tribal people killing jungle cats in your area? (Yes/No)
5a	If yes, why do they kill jungle cat?
6	"Hunting is the major threat to jungle cats" – Do you agree? (Strongly agree/Agree/Not sure/Disagree/Strongly disagree)