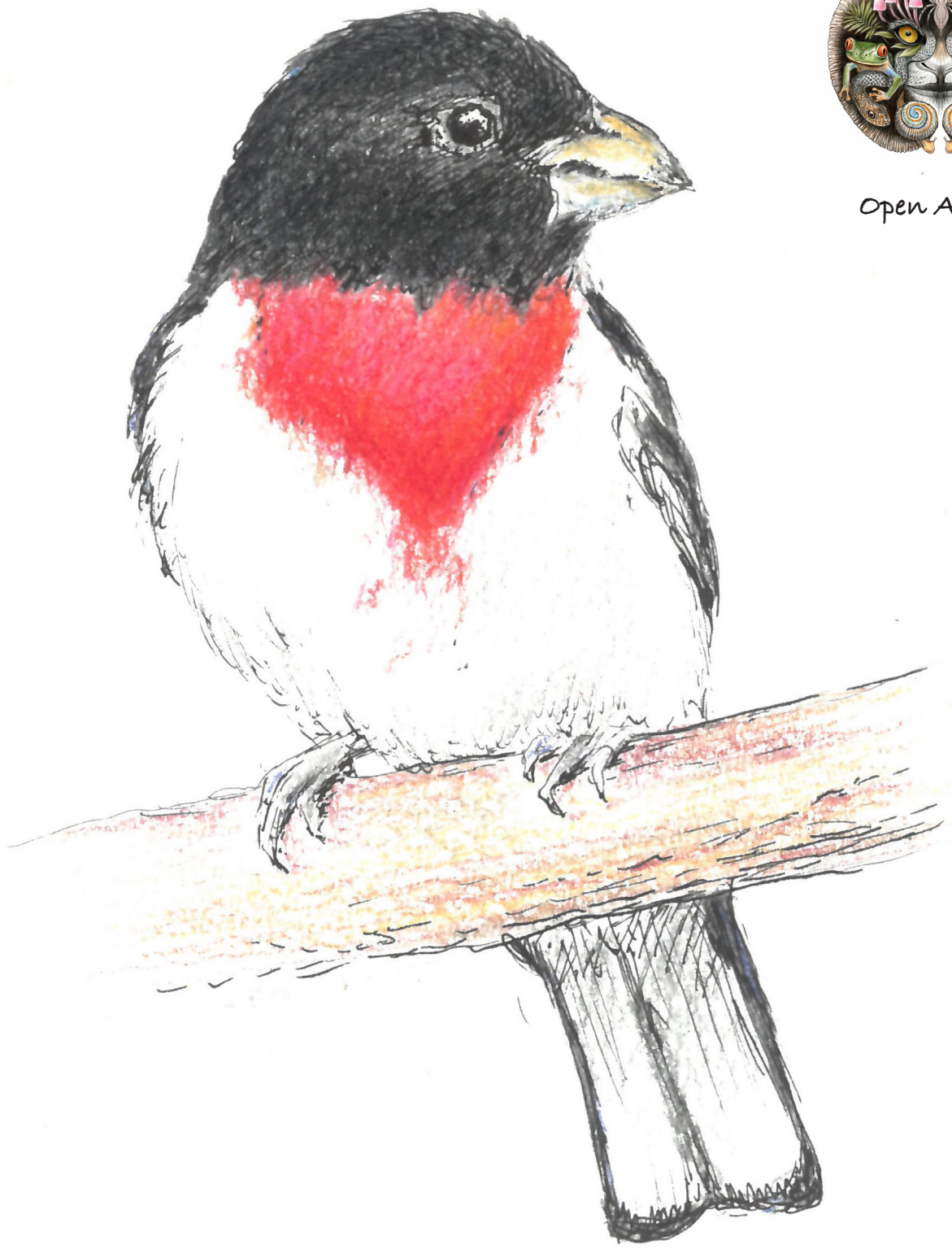
Building evidence for conservation globally

Journal of Threatened Taxa

10.11609/jott.2024.16.5.25119-25282
www.threatenedtaxa.org

26 May 2024 (Online & Print)
16(5): 25119–25282
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

Open Access



ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

For Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scope
For Article Submission Guidelines, visit https://threatenedtaxa.org/index.php/JoTT/about/submissions
For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/policies_various

continued on the back inside cover

Cover: Rose-breasted Grosbeak *Pheucticus ludovicianus*, pen & ink with colour pencil. © Lucille Betti-Nash.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 May 2024 | 16(5): 25129–25136

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.8898.16.5.25129-25136

#8898 | Received 02 January 2024 | Final received 15 March 2024 | Finally accepted 05 April 2024

OPEN ACCESS

ARTICLE

Small Wild Cats Special Series

Diet of Rusty-spotted Cat *Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831) (Mammalia: Carnivora: Felidae) in Sanjay Gandhi National Park, Mumbai, India

Shomita Mukherjee [1], Arati Ramdas Gawari [2], Kartik Pillai [3], Pankaj Koparde [4], P.V. Karunakaran [5] & Nayan Khanolkar [6]

[1,5] Sálim Ali Centre for Ornithology and Natural History, Anaikatty, Coimbatore, Tamil Nadu 641108, India.
[2] Post Barav, Shivneri Fort Road, Junnar, Pune, Maharashtra 410502, India.
[3] Nav Krushnai CHS-HSG, New Ayre Road, Dombivli (East), Maharashtra 421201, India.
[4] Department of Environmental Studies, Dr. Vishwanath Karad MIT World Peace University, Kothrud, Pune, Maharashtra, 411038, India.
[6] B11, Om co.op society, Devil chowk, Shastri Nagar, Dombivli west, Thane, Maharashtra 421202, India
[1] shomita.sacon@wii.gov.in (corresponding author), [2] aratiarg@gmail.com, [3] pillai.kartik439@gmail.com,
[4] pankaj.koparde@mitwpu.edu.in, [5] karunakaran.pv@gmail.com, [6] nayankhanolkar@gmail.com

Abstract: The 103.68 km^2 Sanjay Gandhi National Park (SGNP), Mumbai, exists amidst human densities that figure among the highest in the world. The rich biodiversity of SGNP includes the Rusty-spotted Cat *Prionailurus rubiginosus*, endemic to India, Sri Lanka, and Nepal, and categorised as 'Near Threatened' on the IUCN Red List. Little is known about its ecology and the dynamics of its coexistence with the other small carnivores in SGNP. We conducted a study with citizen volunteers to explore the diet of the Rusty-spotted Cat and other sympatric small carnivores in SGNP and in the adjoining human-dominated areas of Yeur village, Shivaji Nagar, Dahisar Quarry, and Aarey Milk Colony. After initial training, the volunteers collected scat samples from all forest ranges in SGNP and the surrounding areas outside, following defined protocols. Seventy-eight scat samples were analysed for species assignments using standardised molecular techniques, felid-specific primers, and DNA sequencing, and 24 were identified as of the Rusty-spotted Cat. The contents of the samples were examined under a microscope to identify prey remains. Results were presented as the mean number of scat samples containing remains of specific taxa with 95% Confidence Intervals. Diet estimated from 22 Rusty-spotted Cat scat samples and 52 samples of other small carnivores revealed rodents to be the major prey of the entire group. However, a higher proportion of Rusty-spotted Cat scat samples had remains of rodents (95%) and reptiles (6%) as compared to samples of other small carnivores, i.e., 79% with rodent remains and none with remains of reptiles. On the other hand, a lower proportion of Rusty-spotted Cat scat samples had remains of insects (14%), plant matter (9%), and birds (5%) than samples of other small carnivores (40% plant matter, 38% insects, 17% birds). Our results highlight the role of small carnivores, especially Rusty-spotted Cat in regulatory services through pest control.

Keywords: Ecosystem services, molecular tools, rodent prey, scat analysis, small carnivores.

Editor: Angie Appel, Wild Cat Network, Germany. **Date of publication:** 26 May 2024 (online & print)

Citation: Mukherjee, S., A.R. Gawari, K. Pillai, P. Koparde, P.V. Karunakaran & N. Khanolkar (2024). Diet of Rusty-spotted Cat *Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831) (Mammalia: Carnivora: Felidae) in Sanjay Gandhi National Park, Mumbai, India. *Journal of Threatened Taxa* 16(5): 25129–25136. https://doi.org/10.11609/jott.8898.16.5.25129-25136

Funding: Maharashtra Forest Department, (Ref: O.N. Room-3/Project/2229/Year 2016-17; O.N. Room-8/V.P./Research/Ch 01-B/2596/Year 2017-18; O.N. Room-8/V.P./Research/Ch 01-B/Year 2018-19).

Competing interests: The authors declare no competing interests.

Author details: See end of this article.

Author contribution: SM, NK and PVK conceptualised the study. PK, ARG, KP, SM and PVK analysed and mapped the samples. SM wrote the manuscript. PVK, PK and NK reviewed and edited the manuscript.

Acknowledgements: We thank the Maharashtra Forest Department and the entire staff of Sanjay Gandhi National Park for funding the project and for the support extended throughout the study period. We are grateful to the former and current directors, as well as all faculty and staff of SACON for their support during the project period. We are obliged to Robin V.V. and members of IISER Tirupati for supporting the molecular analysis in their laboratory facilities. We thank Nandini Rajamani for the discussions and support during the analysis, and much appreciate the effort of all reviewers. Their comments helped significantly to improve the manuscript.

INTRODUCTION

Small carnivores have demonstrated their value in controlling pests, drawing attention to the larger effort required to monitor their responses to changes in their environment, in order to effectively plan their conservation (Marneweck et al. 2021; Bandyopadhyay et al. 2024). Further, Marneweck et al. (2022) argue that small carnivores are an ideal group to study for understanding the effects of global change due to their higher diversity, intermediate trophic position, wider ecological niches, and higher reproductive rates than of large carnivores.

Sanjay Gandhi National Park (SGNP), spread over an area of 103.68 km^2, is unique in being located within one of the world's most densely populated cities and is popularly referred to as the lungs of Mumbai (Everard 2019). However, the protected area faces severe threats from human encroachments and rapid development along its boundary (Zérah & Landy 2013; Shinde 2017; Engineer 2018). Although several studies on various taxa have been undertaken in SGNP, the Leopard *Panthera pardus* has received most research attention, largely due to severe conflict issues (Munde & Limaye 2013; Surve et al. 2022). Eight other carnivore species have been reported in SGNP, including the Rusty-spotted Cat *Prionailurus rubiginosus* and Jungle Cat *Felis chaus,* Small Indian Civet *Viverricula indica*, Asian Palm Civet *Paradoxurus hermaphroditus*, Indian Grey Mongoose *Herpestes edwardsii*, Ruddy Mongoose *Herpestes smithii*, Golden Jackal *Canis aureus* and Striped Hyena *Hyaena hyaena* (Surve et al. 2015; Mukherjee et al. 2020). All these species are placed in Schedule I of the Wildlife (Protection) Amendment Act, 2022. Among these, the Rusty-spotted Cat is a species of conservation priority in India and SGNP, as the larger part of its relatively restricted global distribution falls within the country (Munde & Limaye 2013; Mukherjee et al. 2016a).

The Rusty-spotted Cat is categorised as 'Near Threatened' on the IUCN Red List, and is endemic to India, Sri Lanka, and Nepal (Mukherjee et al. 2016a). It is the smallest member of the cat family, weighing 2 kg on average (Pocock 1939; Nowell & Jackson 1996; Sunquist & Sunquist 2002). Based on preliminary information on habitat requirements, a population decline of up to 25% is predicted in the next decade, largely due to habitat loss associated with large-scale expansion of agriculture, development and urbanisation (Mukherjee et al. 2016a; Sharma & Dhakad 2020). Some observations on the cat suggest that it largely feeds on small mammals (Patel 2006; Athreya 2010; Langle 2019). Although SGNP has a captive breeding facility for the Rusty-spotted Cat, there is very little information available on its ecology within SGNP. The same applies to all the other small carnivores with only sporadic reports from by-catch data on camera traps placed for the Leopard.

Dietary studies can provide useful insights into several aspects of small carnivore ecology, e.g., community dynamics, competition, and niche spaces, and provide information on ecosystem services and functioning (McNab 2002; Ćirović et al. 2016; Everard 2019; Müller et al. 2022). A reason for this low volume of information on small carnivores is perhaps the difficulty in studying their ecology, especially diet and behaviour due to their largely cryptic habits. With molecular techniques, these aspects can now be explored through non-invasive means (Piggott & Taylor 2003). Available literature on the diet of some small cats suggests that rodents form the major prey of the Jungle Cat (Mukherjee et al. 2004; Majumdar et al. 2011), of the Leopard Cat *Prionailurus bengalensis* (Rabinowitz 1990; Grassman et al. 2005; Rajaratnam et al. 2007; Shezad et al. 2012; Lorica & Heany 2013, Parchizadeh et al. 2023) and of the Caracal *Caracal caracal* (Mukherjee et al. 2004; Braczkowski et al. 2012). In contrast, viverrids and herpestids feed largely on insects and plant matter (Su & Sale 2007; Kalle et al. 2012; Akrim et al. 2023).

We involved citizen volunteers in our research and exposed them to the scientific methods used in studying the diets of small carnivores (Mukherjee et al. 2021). In this paper, we present results from our study on the diets of Rusty-spotted Cat and other co-occurring small carnivores in SGNP and the adjoining areas in Yeur village, Shivaji Nagar, Dahisar Quarry, and Aarey Milk Colony.

Study area

SGNP is credited with providing several ecosystem services, including provisioning of water to the metropolis, recreation to tourists who visit daily and supporting services for maintaining biodiversity (Everard 2019) (Figure 1). Tulshi and Vihar lakes are located within SGNP and provision part of the city's water requirements; several streams and rivers flow through SGNP and into the Arabian Sea (Munde & Limaye 2013).

Due to its proximity to the coastal region, SGNP experiences a mean humidity of 75% (Munde & Limaye 2013). The southwest monsoon occurs from June to September with an average of 2,000 mm of rain (Munde & Limaye 2013). The mean annual temperature is 27 °C, occasionally soaring up to 40 °C, and January is generally the coolest month with a mean minimum temperature

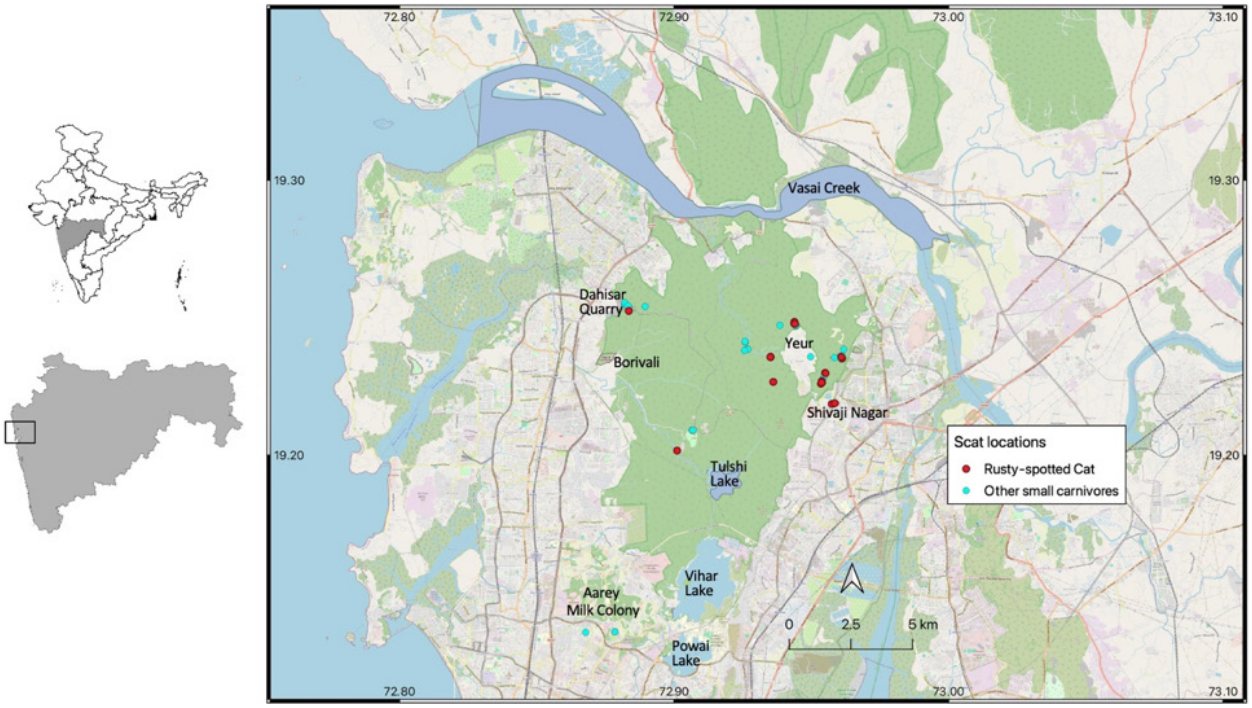


Figure 1. Locations of scat samples of the Rusty-spotted Cat and small carnivores in Sanjay Gandhi National Park and adjoining areas.

of 19 °C (Munde & Limaye 2013).

The major forest types in SGNP are Southern Moist Teak-bearing, Southern Moist Mixed Deciduous, Mangrove Scrub, and Western Subtropical Hill forests (Champion & Seth 1968). SGNP falls within the 5A-Malabar Plains Biogeographic Zone (Rogers et al. 2002).

The faunal diversity list of SGNP includes 172 species of butterflies, 50 species of herpetofauna, 286 species of birds, and around 43 mammalian species (Kasambe 2012). Apart from the Leopard and smaller carnivores, mammals occurring in SGNP include Sambar *Rusa unicolor*, Chital *Axis axis*, Southern Red Muntjac *Muntiacus muntjac*, Indian Chevrotain *Moschiola indica,* Wild Pig *Sus scrofa*, Northern Plains Gray Langur *Semnopithecus entellus*, Bonnet Macaque *Macaca radiata,* Rhesus Macaque *M. mullata*, Black-naped Hare *Lepus nigricolis*, Indian Crested Porcupine *Hystrix indica*, palm squirrels *Funambulus* and several species of murid rodents (Edgaonkar & Chellam 1998; Pradhan 2002; Surve et al. 2015). Due to numerous human settlements within SGNP, several domestic mammals are also present, including Domestic Dog *Canis familiaris*, Domestic Cat *Felis catus*, Goat *Capra hircus*, Water Buffalo *Bubalus bubalis* and Cattle *Bos taurus* (Surve et al. 2015).

MATERIALS AND METHODS

In March and April 2017, volunteers from Mumbai were trained in field techniques which included locating and collecting scats, using field instruments and software such as hand-held GPS, mobile phone applications for marking coordinates and uploading data, monitoring water bodies and streams, camera trapping, and the basics of GIS applications (Mukherjee et al. 2021). Soon after the training, from 16 April 2017 to 15 May 2018, volunteers formed three groups, one for each of the three Forest Ranges closest to their residences and visited various locations within SGNP to collect scat samples. Each group had a team leader who prepared a schedule for sampling, which was restricted to weekends and holidays. Each team comprised two to four volunteers who walked trails within the Forest Range and collected scat samples following a specific protocol. Only intact samples were collected. Once a scat was located, it was photographed along with a labelled vial with the date, geographic coordinates and sample number, a scale and GPS unit or android phone with the geo-coordinates visible, placed next to it. This photograph, along with the names of members of the sampling team, date, time, name of the Forest Range, and geographic coordinates were uploaded onto the android application Epicollect 5 (Aanenson et al. 2009),

which could be accessed by the investigators.

The scat samples were shipped to the Indian Institute of Science Education and Research (IISER) Tirupati for further analysis. Due to the large number of scat samples collected and the limited time to analyse them, they were initially assigned to cats because of their compact shape that is segmented and with tapering ends (Chame 2003) and based on personal observations by the first author. A small portion of the samples that was most intact and smooth, and visually assigned to cats, was kept aside for molecular analysis and assignment to a predator species. These samples were weighed and analysed for diet remains. Prey remains such as teeth, bones, feathers and other undigested matter were observed under a microscope. The percentage of samples containing specific prey remains was determined (Klare et al. 2011). Data were analysed using R version 3.2.3 (R Development Core Team 2016), package "boot" version 1.3–24 (Canty & Ripley 2019). Sub-samples equalling original sample sizes (n=22 for Rusty-spotted Cat and n=52 for other unidentified small carnivores) were analysed using non-parametric bootstrap analysis with 6,000 simulations. Results were presented as the mean number of scat samples containing remains of specific taxa with basic 95% Confidence Intervals.

We used a commercially available stool DNA extraction kit from HiMedia Laboratories following the manufacturer's protocols, with a control in each set of extractions to detect any contamination. We targeted the 16s rRNA region of the mitochondrial DNA for assigning the samples to predators, using primers designed by Mukherjee et al. (2016b). The primers amplified a region of 200 bp and their sequences were as follows:
Felid16srRNA Forward: 5' AATTGACCTTCCCGTGAAGA 3'
Felid16srRNA Reverse: 5' TCCGACTGGTTAGTCTAGAT 3'

The T_m of both primers was 58 °C, and we used an annealing temperature of 50 °C in the Polymerase Chain Reaction (PCR) programme. PCR reactions were set up in volumes of 20 µl with a PCR Master Mix (MM) (Origin Diagnostics, Kerala). Bovine Serum Albumin (BSA) (Sigma-Aldrich) was added to the reactions for better results. The volumes and concentrations of the reagents used were as follows: 5 ml of MM, 2 µl of 2 mM primers, 2µl of 4 mg BSA, 7 µl of Mili-Q water, and 4 µl of DNA extract. Specifications of the PCR program used were initiation at 94 °C for 10 minutes, denaturation at 94 °C for 30 seconds, amplification at 50 °C for 45 seconds, elongation at 72 °C for 50 seconds, and final elongation 72 °C for 10 seconds. The 2nd, 3rd and 4th steps were repeated for 59 cycles.

We used UV-treated hoods and had PCR negative controls to detect any contamination during the PCR stage.

We viewed the PCR products through gel electrophoresis on a 2% agarose gel (HiMedia laboratories) with Orange G loading dye from Sigma-Aldrich and GelRedTM DNA stain (Life Technologies, India). We loaded a 100 bp ladder (HiMedia laboratories) along with the PCR products as reference. The PCR products that amplified with the felid primers were sent to Chromgene Biotech Private Limited for forward and reverse reaction sequencing. We used Chromas version 2.6.5 (Technelysium Pty Ltd.) to view and clean sequences, and then used the BLAST analysis (Basic Local Alignment Search Tool) on NCBI (McGinnis & Madden 2004) for identifying species. We aligned sequences using ClustalW in MEGA 6.0 (Tamura et al. 2013) for alignments. For sequences that were identified as Rusty-spotted Cat, we constructed a Neighbour Joining phylogenetic tree in MEGA 6.0 (Tamura et al. 2013), rooted with members of the genus *Felis* (Domestic Cat, Accession Number: AF006453.1; Afro-Asiatic Wildcat *F. lybica*, Accession Number: AF006395.1; Jungle Cat, Accession Number: AF006393.1). We also included Leopard Cat *P. bengalensis* (Accession Number: AF006437.1), Fishing Cat *P. viverrinus* (Accession Number: AF006451.1) and an existing sequence of Rusty-spotted Cat (Accession Number: NC_028304.1) to depict the accuracy of the assignments. All existing sequences were obtained from NCBI (Clark et al. 2016). We mapped the locations of Rusty-spotted Cat and other small carnivore scat samples used in the diet analysis using QGIS Version 2.8.2-Wien (QGIS 2015).

RESULTS

Over approximately five months, 126 scat samples were collected in Yeur, Tulshi and Borivali Forest Ranges within SGNP and surrounding areas in Yeur village, Shivaji Nagar, Dahisar Quarry and Aarey Milk Colony (Figure 1). From these, 78 were visually assigned to small cats based on their shape. These 78 were subjected to DNA analysis, of which 30 samples (38%) gave positive results with the felid primers and were sent for sequencing. Results from BLAST revealed that 24 of these were of Rusty-spotted Cat, comprising 20 from Yeur Range, two from Shivaji Nagar, and one each from Tulshi Range and Dahisar Quarry area. Five were not of felids but most similar to mongoose species. One scat did not generate a good enough sequence for assignment. The average weight of Rusty-spotted Cat scat was 4 g (range: 1.2–16.5

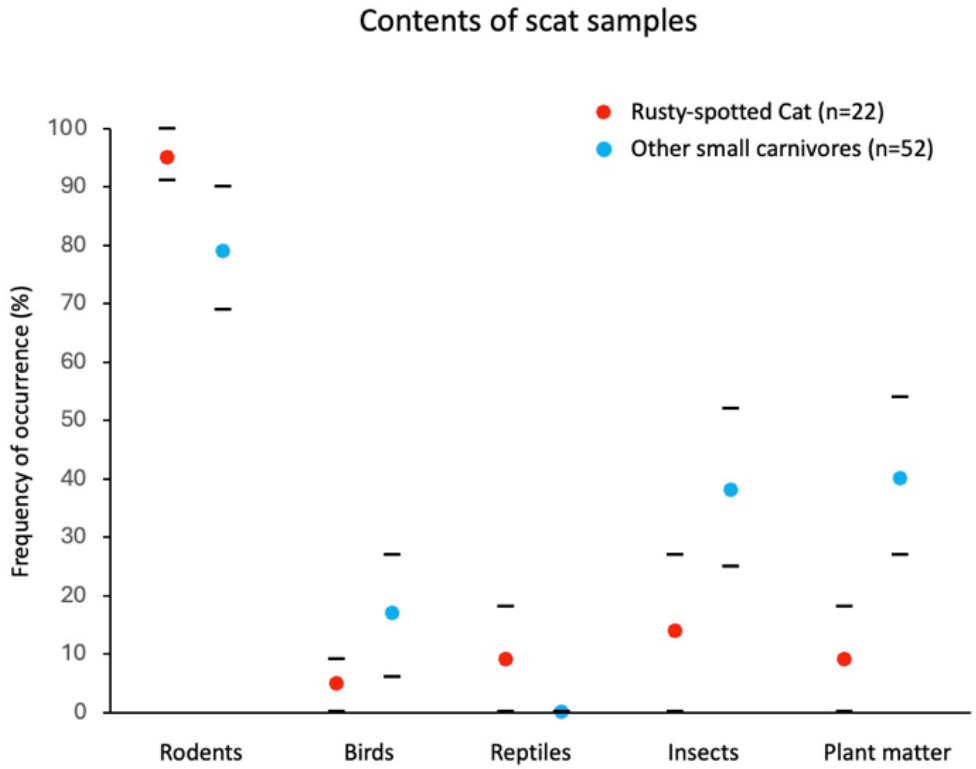


Figure 2. Diet of Rusty-spotted Cat and other small carnivores in SGNP showing bootstrap means with confidence Intervals.

g). No Jungle Cat scat was reported through molecular analysis.

Seventy-four scat samples with discernible food remains were analysed for diet and showed a predominance of rodent remains (Figure 2). Of the 24 scat samples assigned to Rusty-spotted Cat, two from Yeur Range had no identifiable remains and were not included in the diet analysis. The phylogeny of the sequences supported the BLAST results of assignments to Rusty-spotted Cat (Figure 3). A comparison of diets revealed a higher presence of rodents in the diet of the Rusty-spotted Cat (Table 1).

We presume that the rodents consumed by the Rusty-spotted Cat belong to the *Mus* genus, based on size and morphological characteristics of rodent molars found in the sample (Image 1).

Table 1. Mean percentage frequency of prey items in scat of Rusty-spotted Cat and other unidentified small carnivores from Sanjay Gandhi National Park and surrounding areas in Mumbai, India, with bootstrap 95% confidence intervals (CI)

Prey	Rusty-spotted Cat (n = 22) Mean (%), (95% CI)	Other small carnivores (n = 52) Mean (%), (95% CI)
Rodents	95, (91–100)	79, (69–90)
Birds	5, (0–27)	17, (6–27)
Reptiles	6, (4–18)	0
Insects	14, (0–27)	38, (25–52)
Plant matter	9, (0–18)	40, (27–54)

DISCUSSION

Our study is the first to involve citizen volunteers in sampling scat of small carnivores in India and to systematically document Rusty-spotted Cat diet. Our results of murid rodents forming the predominant diet of the Rusty-spotted Cat corroborate earlier observations (Patel 2006; Athreya 2010; Langle 2019). Systematic studies on the diets of other small cat species in varied habitats reiterate the role of small cats as rodent control agents and highlight their ecosystem services (Rabinowitz 1990; Mukherjee et al. 2004; Grassman et al. 2005; Rajaratnam et al. 2007; Majumdar et al. 2011; Braczkowski et al. 2012; Shezad et al. 2012; Lorica & Heany 2013, Mukherjee et al. 2016b; Parchizadeh et al. 2023).

In contrast, the diets of the other small carnivores show a much higher proportion of insects and plant matter than consumed by the Rusty-spotted Cat. This is in

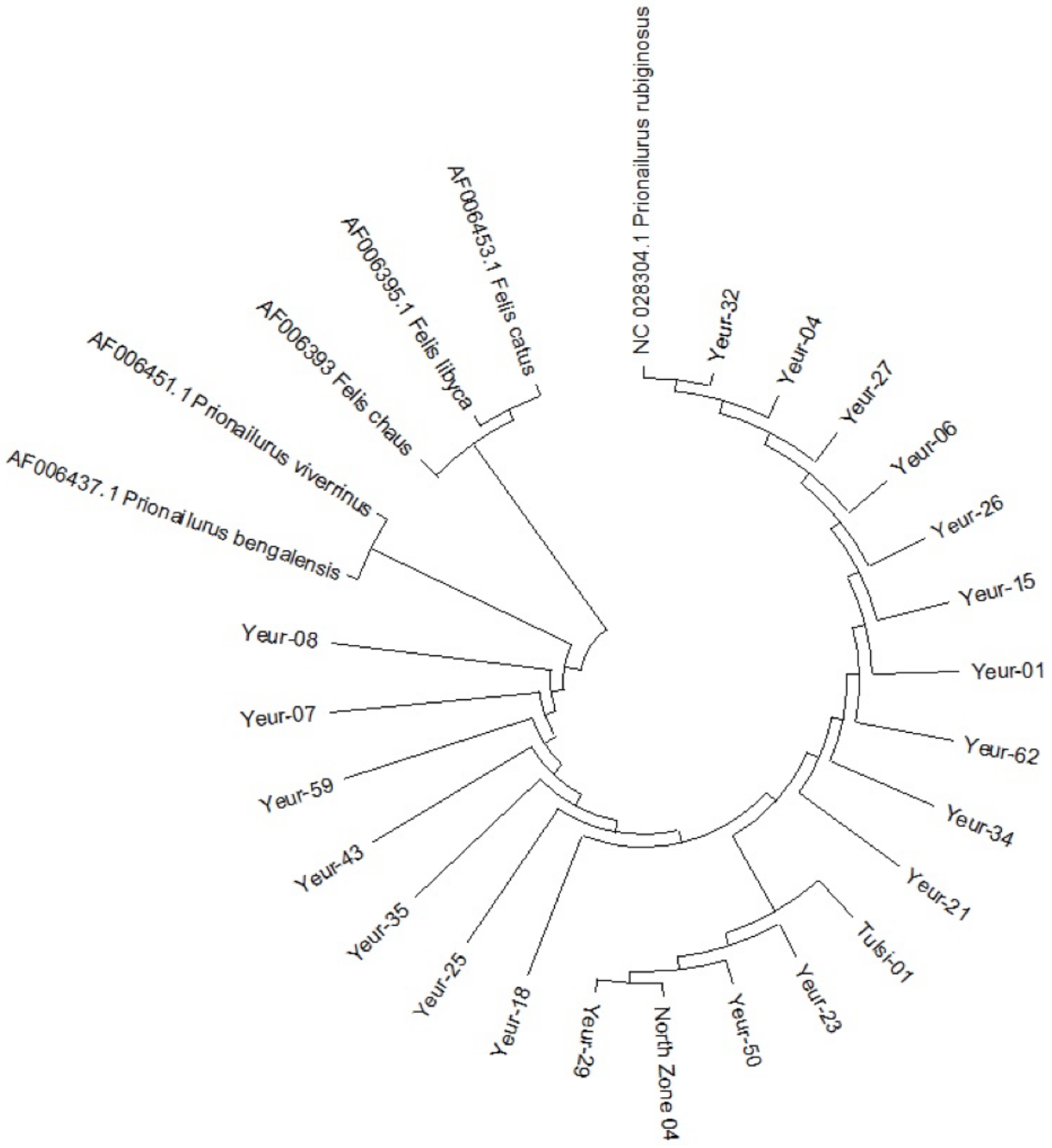


Figure 3. Neighbour Joining Tree of Rusty-spotted Cat 16s rRNA mitochondrial DNA sequences from scat samples used for diet analysis.

line with existing information (Su & Sale 2007; Kalle et al. 2012; Akrim et al. 2023).

Future studies can focus on standardising primers for other carnivore species, identifying the prey remains in scat with greater precision through Next Generation Sequencing work, quantifying diets and estimating prey abundance for more precise and meaningful results (Mukherjee et al. 2004; Klare et al. 2011; Shezad et al. 2012).

Visual assignment of scat had an error of more than 60%, where scat samples of other carnivores were assigned to small cats. The primers designed for detecting felids gave an error of 17%, where five mongoose scat samples were amplified, an error that was noticed after sequencing. Based on these, we recommend using PCR amplification followed by sequencing for assigning scat to species for obtaining reliable results. Further, there is a possibility of false negatives where the primers

Image 1. Rodent dentition found in a scat sample of Rusty-spotted Cat identified as *Mus* sp., scale: 1 mm. © Arati Gawari & Kartik Pillai.

did not amplify small cat DNA, and some scat samples could have erroneously been placed in the unidentified carnivore group, biasing the diet results. In the future, this can be addressed by using additional primer sets designed on other regions of the DNA (Liu et al. 2023).

Studies conducted in other parts of the country had a larger proportion of 47–67% of scat assigned to felids using molecular tools (Mukherjee et al. 2010, 2016b), whereas only 38% in the current study in SGNP were detected as being felid scat. This can either be attributed to the poorer condition of the scat samples during collection or smaller populations of small cats in SGNP. A drawback of this study was that most scat samples were collected in the Yeur Range, which could reflect the possible unequal effort put in by volunteer teams, since each team was assigned to a specific forest range and adjoining areas outside.

A report by Everard (2019) listing the potential ecosystem services of SGNP includes possible regulatory services by predators that can be hampered by habitat destruction. The results of our project highlight the importance of generating information on such services, especially around the fringes and outside the perimeter of SGNP. We also found scat near human habitation outside the boundary in Yeur and Dahisar Quarry, though most of the sampling was restricted within SGNP. Unlike the Leopard, small carnivores do not pose a threat to human lives, so the conflict with humans is unidirectional where developmental activities are directly responsible for habitat loss.

REFERENCES

Akrim, F., T. Mahmood, J.L. Belant, M.S. Nadeem, S. Qasim, T. Dhendup, H. Fatima, S.A. Bukhari, A. Aslam, H. Younis, A. Rafique, Z.A. Subhani, S.A. Hashmi & N. Munawar (2023). Niche partitioning by sympatric civets in the Himalayan foothills of Pakistan. *PeerJ* 11: e14741. https://doi.org/10.7717/peerj.14741

Athreya, V. (2010). Rusty-spotted Cat more common than we think? *Cat News* 53: 27.

Bandyopadhyay, K., K. Banerjee, M.V. Mazzamuto, S. Koley, J.L. Koprowski, Q. Qureshi & Y. Jhala (2024). Review of small cat ecology and status within India. *Mammal Review: Early View.* https://doi.org/10.1111/mam.12348

Braczkowski, A., L. Watson, D. Coulson, J. Lucas, B. Peiser & M. Rossi (2012). The diet of Caracal, *Caracal caracal*, in two areas of the southern Cape, South Africa as determined by scat analysis. *South African Journal of Wildlife Research* 42(2): 111–116. https://doi.org/10.3957/056.042.0205

Canty, A. & B. Ripley (2019). boot: Bootstrap R (S-Plus) Functions. R package version 1.3-24. https://CRAN.R-project.org/package=boot

Chame, M. (2003). Terrestrial mammal feces: a morphometric summary and description. *Memórias do Instituto Oswaldo Cruz* 98: 71–94. https://doi.org/10.1590/S0074-02762003000900014

Champion, H.G. & S.K. Seth (1968). *A Revised Survey of the Forest Types of India*. Natraj Publishers, Dehradun, 404 pp.

Ćirović, D., A. Penezić & M. Krofel (2016). Jackals as cleaners: ecosystem services provided by a mesocarnivore in human-dominated landscapes. *Biological Conservation* 199: 51–55. https://doi.org/10.1016/j.biocon.2016.04.027

Clark, K., I. Karsch-Mizrachi, D.J. Lipman, J. Ostell & E.W. Sayers (2016). GenBank. *Nucleic Acids Research* 44(D1): D67–72. https://doi.org/10.1093/nar/gkv1276

Edgaonkar, A. & R. Chellam (1998). A preliminary study on the ecology of the Leopard (*Panthera pardus fusca*) in the Sanjay Gandhi National Park, Maharashtra. RR-98/002. Wildlife Institute of India, Dehradun, 33pp.

Engineer, T. (2018). Mumbai may soon lose Sanjay Gandhi National Park. Mumbai Mirror, 6 February 2018. https://mumbaimirror.indiatimes.com/mumbai/cover-story/park-in-peril/articleshow/62773396.cms. Accessed 20 February 2020.

Everard, M. (2019). Report of the developing payment of ecosystem services mechanisms for Sanjay Gandhi National Park – A revenue generating model. Sanjay Gandhi National Park, Govt. of Maharashtra; Wildlife and We Protection Foundation, Mumbai, 97 pp.

Grassman, L.I., M.E. Tewes, N.J. Silvy & K. Kreetiyutanont (2005). Spatial organization and diet of the Leopard Cat (*Prionailurus bengalensis*) in north-central Thailand. *Journal of Zoology* 266(1): 45–54. https://doi.org/10.1017/S095283690500659X

Kalle, R., T. Ramesh, K. Sankar & Q. Qureshi (2012). Diet of mongoose in Mudumalai Tiger Reserve, southern India. *Journal of Scientific Transactions in Environment and Technovation* 6: 44–51.

Kasambe R. (2012). Butterfly fauna of the Sanjay Gandhi National Park and Mumbai. *Bionotes* 14(3): 76–80.

Klare, U., Kamler, J. F. & D.W. Macdonald (2011). A comparison and critique of different scat-analysis methods for determining carnivore diet. *Mammal Review* 41(4): 294–312.

Langle, P.R. (2019). *Prionailurus rubiginosus* (Carnivora: Felidae). *Mammalian Species* 51(986): 155–162. https://doi.org/10.1093/mspecies/sez020

Liu, H., D. Wang, C. Zhang, T. Pu, L. Xiong, F. Wei & Y. Hu (2023). Development of short-target primers for species identification in biological studies of Carnivora. *Ecology and Evolution* 13(5): e10135.

https://doi.org/10.1002/ece3.10135

Lorica, M.R.P. & L.R. Heaney (2013). Survival of a native mammalian carnivore, the Leopard Cat *Prionailurus bengalensis* Kerr, 1792 (Carnivora: Felidae), in an agricultural landscape on an oceanic Philippine island. *Journal of Threatened Taxa* 5(10): 4451–4460. https://doi.org/10.11609/JoTT.o3352.4451-60

Marneweck, C., A.R. Butler, L.C. Gigliotti, S.N. Harris, A.J. Jensen, M. Muthersbaugh, B.A. Newman, E.A. Saldo, K. Shute, K.L. Titus & S.W. Yu (2021). Shining the spotlight on small mammalian carnivores: global status and threats. *Biological Conservation* 255: 109005. https://doi.org/10.1016/j.biocon.2021.109005

Marneweck, C.J., B.L. Allen, A.R. Butler, E. Do Linh San, S.N. Harris, A.J. Jensen, E.A. Saldo, M.J. Somers, K. Titus, M. Muthersbaugh & A. Vanak (2022). Middle-out ecology: small carnivores as sentinels of global change. *Mammal Review* 52(4): 471–479. https://doi.org/10.1111/mam.12300

McGinnis, S. & T.L. Madden (2004). BLAST: at the core of a powerful and diverse set of sequence analysis tools. *Nucleic Acids Research* 32(Web Server issue): W20–W25. https://doi.org/10.1093/nar/gkh435

McNab, B.K. (2002). *The Physiological Ecology of Vertebrates: A View From Energetics*. Cornell University Press, New York, 576 pp.

Mukherjee, S., S.P. Goyal, A.J.T. Johnsingh & M.R.P.L. Pitman (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. *Journal of Zoology* 262(4): 405–411. https://doi.org/10.1017/S0952836903004783

Mukherjee, S., C.N. Ashalakshmi, C. Home & U. Ramakrishnan (2010). A PCR-RFLP technique to identify Indian felids and canids from scats. *BMC Research Notes* 3: 159. https://www.biomedcentral.com/1756-0500/3/159

Mukherjee, S., J.W. Duckworth, A. Silva, A. Appel & A. Kittle (2016a). *Prionailurus rubiginosus*. The IUCN Red List of Threatened Species 2016: e.T18149A50662471. Downloaded on 21 April 2021. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T18149A50662471.en

Mukherjee, S., R. Athreya, P.V. Karunakaran & P. Choudhary (2016b). Ecological species sorting in relation to habitat structure in the small cat guild of Eaglenest Wildlife Sanctuary, Arunachal Pradesh. Technical Report, No. PR-182. Sálim Ali Centre for Ornithology and Natural History, Coimbatore, Tamil Nadu, 52 pp.

Mukherjee, S., P.V. Karunakaran & N. Khanolkar (2020). Survey for small cats in Sanjay Gandhi National Park, Mumbai. Technical Report No. PR204. Sálim Ali Centre for Ornithology and Natural History, Coimbatore, Tamil Nadu, 36 pp.

Müller, L., W.D. Briers-Louw, R. Amin, C.S. Lochner & A.J. Leslie (2022). Carnivore coexistence facilitated by spatial and dietary partitioning and fine-scale behavioural avoidance in a semi-arid ecosystem. *Journal of Zoology* 317(2): 114–128. https://doi.org/10.1111/jzo.12964

Munde, P.N. & S. Limaye (2013). Management Plan for Sanjay Gandhi National Park, Borivali, Mumbai for the period 2013–14 to 2022–23. Forest Department, Government of Maharashtra, 35 pp.

Nowell, K. & P. Jackson (eds.) (1996). Rusty-spotted cat, *Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831), pp. 72–74. In: *Wild Cats: Status Survey and Conservation Action Plan*, Vol. 382. IUCN SSC Cat Specialist Group, Gland, 383 pp.

Parchizadeh, J., S.L. Schooler, M.A. Adibi, M.G. Arias, S. Rezaei & J.L. Belant (2023). A review of Caracal and Jungle Cat diets across their geographical ranges during 1842–2021. *Ecology and Evolution* 13(5): e10130. https://doi.org/10.1002/ece3.10130

Patel, K. (2006). Observations of Rusty-spotted Cat in eastern Gujarat. *Cat News* 45: 27–28.

Piggott, M.P. & A.C. Taylor (2003). Remote collection of animal DNA and its applications in conservation management and understanding the population biology of rare and cryptic species. *Wildlife Research* 30(1): 1–13. https://doi.org/10.1071/WR02077

Pocock, R.I. (1939). Family Felidae, pp. 191–330 in: The Fauna of British India, including Ceylon and Burma: Mammalia, Volume 1, Primates and Carnivora. Taylor & Francis, London, 572 pp.

Pradhan, M.S. (2002). Common vertebrate species of Sanjay Gandhi National Park, Borivali, Mumbai, Fauna of Conservation Area Series: 12: (1-5). Zoological Survey Of India, Kolkata, 56 pp.

QGIS (2015). QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.org

R Development Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available online at https://www.R-project.org

Rabinowitz, A.R. (1990). Notes on the behaviour and movements of Leopard Cats, *Felis bengalensis*, in a dry tropical forest mosaic in Thailand. *Biotropica* 22(4): 397–403. https://doi.org/10.2307/2388557

Sharma, S.K. & M. Dhakad (2020). The Rusty-spotted Cat *Prionailurus rubiginosus* (I. Geoffroy Saint-Hillaire, 1831) (Mammalia: Carnivora: Felidae) in Rajasthan, India – a compilation of two decades. *Journal of Threatened Taxa* 12(16): 17213–17221. https://doi.org/10.11609/jott.6064.12.16.17213-17221

Shehzad W., T. Riaz, M.A. Nawaz, C. Miquel & C. Poillot (2012). Carnivore diet analysis based next generation sequencing: application to the Leopard Cat (*Prionailurus bengalensis*) in Pakistan. *Molecular Ecology* 21(8): 1951–1965. https://doi.org/10.1111/j.1365-294X.2011.05424.x

Shinde, R. (2017). Aarey Milk Colony, Mumbai as Forest Territory. A Status Report. Xplore – *The Xavier's Research Journal* 8(3): 80–95.

Su, S. & J. Sale (2007). Niche differentiation between Common Palm Civet *Paradoxurus hermaphroditus* and Small Indian Civet *Viverricula indica* in regenerating degraded forest, Myanmar. *Small Carnivore Conservation* 36: 30–34.

Sunquist, M. & F. Sunquist (2002). Rusty-spotted Cat *Prionailurus rubiginosus* (Geoffroy, 1831), pp. 237–240. In: *Wild Cats of the World*. University of Chicago Press, Chicago, Illinois, 462 pp.

Surve, N., S. Sathyakumar, K. Sankar & V. Athreya (2015). Ecology of Leopard in Sanjay Gandhi National Park, Maharashtra, with special reference to its abundance, prey selection and food habits. Mumbai, India, Maharashtra Forest Department, 29 pp.

Surve, N., S. Sathyakumar, K. Sankar, D. Jathana, V. Gupta & V. Athreya (2022). Leopards in the City: The Tale of Sanjay Gandhi National Park and Tungareshwar Wildlife Sanctuary, Two Protected Areas in and Adjacent to Mumbai, India. *Frontiers in Conservation Science* 3: 787031. https://doi.org/10.3389/fcosc.2022.787031

Tamura K., G. Stecher, D. Peterson, A. Filipski & S. Kumar (2013). MEGA6: molecular evolutionary genetics analysis version 6.0. *Molecular Biology and Evolution* 30(12): 2725–2729. https://doi.org/10.1093/molbev/mst197

Technelysium Pty Ltd (2018). Chromas 2.6.6. Technelysium Pty Ltd, South Brisbane, Australia. https://technelysium.com.au/wp/chromas

Zérah, M.H. & F. Landy (2013). Nature and urban citizenship redefined: The case of the National Park in Mumbai. *Geoforum* 46: 25–33. https://doi.org/10.1016/j.geoforum.2012.11.027

Author details: Shomita Mukherjee is a senior principal scientist at the Sálim Ali Centre for Ornithology and Natural History at Coimbatore, Tamil Nadu in the Division of Conservation Biology. Her current work focuses on the ecology of small cats. Arati Gawari completed her master's dissertation on this project from VP.M's B.N. Bandodkar College of Science, Thane. Kartik Pillai is a B.Tech Biotechnology graduate and is currently working as a Naturalist for Exotic Hospitality Pvt. Ltd, Nagpur in Tathastu Resorts at Pench National Park, Madhya Pradesh. Pankaj Koparde is currently an assistant professor with the Department of Environmental Studies, MIT-WPU Pune. His core expertise is in subjects such as aquatic ecology, urban ecology, biogeography, biodiversity informatics, and science communication. He primarily works on owls and dragonflies. P.V. Karunakaran is a landscape ecologist working as a senior principal scientist at Sálim Ali Centre for Ornithology and Natural History (SACON). His current areas of research include conservation and management of natural resources, protected area management, community participation in biodiversity conservation, plant taxonomy and GIS and Remote Sensing. Nayan Khanolkar is an educator, naturalist and wildlife photographer. His current assignments include documenting urban leopards, participating in citizen science programs and teaching photography at various colleges across Maharashtra.

Journal of Threatened Taxa is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64

Print copies of the Journal are available at cost. Write to:
The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org

Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

May 2024 | Vol. 16 | No. 5 | Pages: 25119–25282
Date of Publication: 26 May 2024 (Online & Print)
DOI: 10.11609/jott.2024.16.5.25119-25282

Publisher & Host

WILD zoo reach
Zoo Outreach Organisation

Threatened Taxa