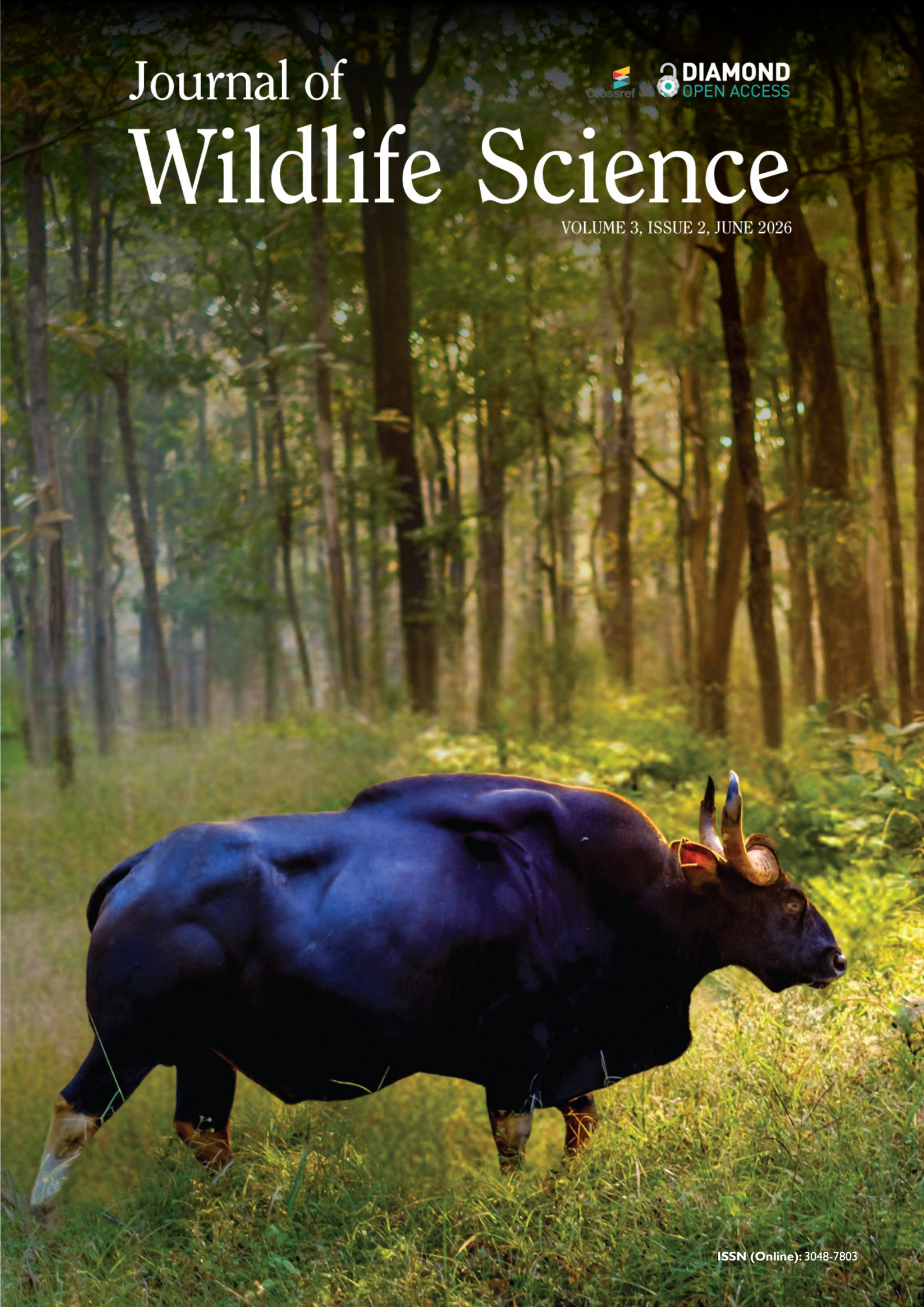
Journal of Wildlife Science

VOLUME 3, ISSUE 2, JUNE 2026



ISSN (Online): 3048-7803

Journal of Wildlife Science

Editors

Editor-in-Chief
Mewa Singh *University of Mysore, Mysuru, India*

Managing Editor
Bilal Habib *Wildlife Institute of India, Dehradun, India.*

Associate Managing Editor
Vishnupriya Kolipakam *Wildlife Institute of India, Dehradun, India.*

Academic Editors

A. B. Srivastava *(Former) Nanaji Deshmukh Veterinary Science University, Jabalpur, India.*
Abhijit Das *Wildlife Institute of India, Dehradun, India.*
Advait Edgaonkar *Indian Institute of Forest Management, Bhopal, Madhya Pradesh.*
Ajay Gaur *Centre for Cellular & Molecular Biology, Hyderabad, India.*
Akanksha Saxena *Wildlife Institute of India, Dehradun, India.*
Aleksandr Semjonov *Clinical operations, Estonian University of Life Sciences.*
Amit Kumar *Wildlife Institute of India, Dehradun, India.*
Amiya Kumar Sahoo *ICAR-Central Inland Fisheries Research Institute, Kolkata, India.*
Anand Krishnan *Jawaharlal Nehru Centre for Advanced Scientific Research.*
Anuradha Bhat *Indian Institute of Science Education and Research, Kolkata, India.*
Ashish David *Indian Institute of Forest Management, Bhopal, India.*
Ashish Jha *Wildlife Institute of India, Dehradun, India.*
Aashna Sharma *University of Washington, Seattle, Washington, USA.*
Bitapi C. Sinha *(Former) Wildlife Institute of India, Dehradun, India.*
Bivash Pandav *Wildlife Institute of India, Dehradun, India.*
Chandra Prakash Kala *Indian Institute of Forest Management, Bhopal, Madhya Pradesh.*
Cobus Raath *Wildlife Pharmaceuticals, South Africa.*
Diwakar Sharma *The World Bank & United Nations Development Programme, India.*
G. Umapathy *Centre for Cellular and Molecular Biology, Hyderabad, India.*
Gautam Talukdar *Wildlife Institute of India, Dehradun, India.*
Gopi G.V. *Wildlife Institute of India, Dehradun, India.*
Hema Somanathan *Evolutionary Ecology, Insect & Pollination Ecology, IISER Thiruvananthapuram.*
H. N. Kumara *Salim Ali Centre for Ornithology and Natural History, Coimbatore, India.*
H.V. Girisha *Wildlife Crime Control Bureau (WCCB), New Delhi, India.*
Himender Bharti *Punjabi University, Patiala.*
Indranil Mondal *AI Dash, Bengaluru, India.*
J.A. Johnson *Wildlife Institute of India, Dehradun, India.*
K. Sivakumar *Pondicherry University, Pondicherry, India.*
Kristy Deiner *ETH Zürich Universitätstrasse 16, 8092 Zürich, Switzerland.*
Manjari Jain *Department of Biological Sciences, IISER Mohali.*
Manoj Nair *Forest Department, Government of Odisha, Bhubaneshwar, India.*
Mark Auliya *Leibniz Institute for the Analysis of Biodiversity Change, Germany.*
Manavi Sharma *Ashoka University, Sonepat, Haryana.*
Meghna Agarwala *Associate Professor of Environmental Studies, Ashoka University.*
Navendu Page *Thackeray Wildlife Foundation, Mumbai, India.*
Nishant Kumar *National Centre for Biological Sciences, TIFR, Bengaluru & THINKPAWS.*
P. K. Malik *(Former) Wildlife Institute of India, Dehradun, India.*
P. Pramod *Salim Ali Centre for Ornithology and Natural History, Coimbatore, India.*
P. R. Arun *Salim Ali Centre for Ornithology and Natural History, Coimbatore, India.*
Parag Nigam *Wildlife Institute of India, Dehradun, India.*
Punyasloke Bhadury *Indian Institute of Science Education and Research, Kolkata, India.*
Qamar Qureshi *(Former) Wildlife Institute of India, Dehradun, India.*
R. J. Ranjit Daniels *Care Earth Trust, Chennai, India.*
R. Suresh Kumar *Wildlife Institute of India, Dehradun, India.*
Rajapandian Kangaraj *Kasetsart University, Bangkok.*
Ruchi Badola *Wildlife Institute of India, Dehradun, India.*
S.A. Hussain *Wildlife Institute of India, Dehradun, India.*
S. K. Gupta *Wildlife Institute of India, Dehradun, India.*
S. Sathyakumar *(Former) Wildlife Institute of India, Dehradun, India.*
Samrat Mondol *Wildlife Institute of India, Dehradun, India.*
Shivani Krishna *Ashoka University, Sonepat, Haryana.*
Shomita Mukherjee *Salim Ali Centre for Ornithology & Natural History, Coimbatore, India.*
Sumit Dookia *Guru Gobind Singh Indraprastha University, Delhi, India.*
Surendra P. Goyal *Wildlife Institute of India, Dehradun, India.*
Sushma Reddy *Bell Museum of Natural History, University of Minnesota.*
Sutirtha Dutta *Wildlife Institute of India, Dehradun, India.*
Tapajit Bhattacharya *Durgapur Government College, Paschim Bardhaman, India.*
T.N.C. Vidya *Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru.*
Uma Ramakrishnan *National Centre for Biological Sciences, TIFR, Bengaluru.*
V. B. Mathur *Warner College of Natural Resources, USA.*
Vidyadhar Atkore *Salim Ali Centre for Ornithology and Natural History, Coimbatore, India.*
Vinita Gowda *Indian Institute of Science Education and Research, Bhopal, India.*
Werner Kaumanns *German Primate Center and Curator of Primates, Cologne Zoo, Germany.*
Yogesh Dubey *Indian Institute of Forest Management, Bhopal, India.*

Advisory Board

Secretary	Director General of Forests & Special Secretary	Add. Director General of Forests (Wildlife)	Dr. G. S. Bhardwaj	Dr. Ruchi Badola
Ministry of Environment, Forest & Climate Change, Govt. of India	*Ministry of Environment, Forest & Climate Change, Govt. of India*	*Ministry of Environment, Forest & Climate Change, Govt. of India*	*Director, Wildlife Institute of India*	*Dean, Wildlife Institute of India*

Editorial Staff

Shivam Shrotriya, *Assistant Managing Editor*
Kashish Sherdia, *Typesetter*
Hanok Stephen, *Website Designer*

Published By: Wildlife Institute of India https://wii.gov.in/ **Published On:** 05 July 2026

Publisher's disclaimer: The Publisher, Journal of Wildlife Science (JWLS) or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this journal. All claims expressed in articles published in JWLS are solely those of the authors and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in the research published in JWLS or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

Open Access and Copyright: All articles published by JWLS are fully open access, meaning they are immediately and freely available to read, download, and share. All articles are published under the terms of a Creative Commons license (CC BY 4.0), allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Copyright for any research article published by JWLS is retained by the author(s).

Contact Information: For inquiries regarding submissions, editorial policies, or other matters related to JWLS, please contact:
Journal of Wildlife Science, Wildlife Institute of India,
PO Box # 18, Chandrabani, Dehradun – 248001 INDIA
Email: info@jwls.in

ISSN (Online): 3048-7803 **DOI (Volume 3, Issue 2):** https://doi.org/10.63033/JWLS.GGED8795

Cover Image: An adult male Indian Gaur (*Bos gaurus*) in Kanha Tiger Reserve. Gaur, a vital megaherbivore, helps sustain India's forest ecosystems. © Subharanjan Sen

About the Journal

The Journal of Wildlife Science (JWLS) is dedicated to advancing wildlife science and conservation through rigorous, evidence-based research across taxa and ecosystems. The journal operates on a diamond open-access model, meaning neither authors nor readers incur fees for accessing or publishing in JWLS. In a departure from the traditional pay-to-publish or pay-to-read models, our mission is to foster open and free access to high-quality, peer-reviewed interdisciplinary research in wildlife science, conservation, and management. We provide an inclusive, author-friendly platform welcoming original articles, reviews, commentaries, policy briefs, and novel paper types like Methods Papers, Natural History Notes, and Academic Practices in Wildlife Science. Our unique peer review approach emphasises constructive mentorship between authors and reviewers to elevate quality while fostering a collaborative research community.

JWLS is a quarterly publication with an online-first feature (publishing online as soon as the article is accepted). Therefore, the authors can submit their latest findings, insights, and perspectives for publishing in JWLS at any time.

Aim and Scope

The journal does not categorise research based on taxonomic groups, allowing authors working on any wildlife taxa, ecological communities, or ecosystems to submit their work under a relevant theme.
https://jwls.in/author-guidelines.

Submission Guidelines

Authors interested in submitting their work to JWLS are encouraged to review the updated submission guidelines at https://jwls.in/author-guidelines.

Manuscripts should be submitted online through our submission system (https://www.editorialmanager.com/jwls/), and all submissions will undergo rigorous peer review.

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Content

Obituary

1. *Shri H. S. Panwar (1937–2026)*
Visionary Conservationist, Institution Builder, and Founder Director of the Wildlife Institute of India
Vinod B. Mathur 44

Research Articles

2. *Occurrence of the lesser-known endemic Rhinolophidae species in the caves of the Andaman Islands, India: insights from a rapid survey*
Dhanusha Kawalkar, Shirish S Manchi, Avimanyu J Mukherjee, Rima Sadhukhan, Pooja R Patil 46

3. *Efficacy and schedule of Ivermectin in vivo against naturally acquired infestation of Sarcoptes scabiei on wild red foxes (Vulpes vulpes) treated in a controlled veterinary / clinical rehabilitation environment*
Ryan Fox 53

4. *Community Perceptions and Social Feasibility for Gaur (Bos gaurus gaurus) Reintroduction in Nagarjunasagar-Srisailam Tiger Reserve, Andhra Pradesh*
Ritesh Vishwakarma, Arun Kumar Gorati, Swati Chandola, Habeeba Fathima, Anukul Nath, Samrat Mondol, Bilal Habib, Ajaya Kumar Naik, B.N.N. Murthy, Vignesh Appavu G., Parag Nigam 62

Short Communications

5. *Clinical recovery from multidrug-resistant bacterial infection in a suppurative wound of a Royal Bengal Tiger using linezolid*
Anik Dutt, Tishita Sen Ape, Md. Sarwar Uddin, Md. Shahadat Hossain Suvo, Shuvo Singha, Md. Mizanur Rahman 73

Natural History Notes

6. *First record of true vivipary in Eragrostiella bifaria var. walkeri (Poaceae: Chloridoideae, Tripogoninae) under cultivated conditions, and a brief note on its taxonomy*
Shahid Nawaz Khwaja Bhai Landge & Alok Lamuel Gude 79

7. *Opportunistic Frugivory of Small Indian Mongoose (Urva auropunctata) in an Agricultural Field, Uttarakhand, India*
Shrey Dandriyal, Nitesh Goswami, Piyush Sharma, Ashutosh Singh Rana 83

8. *An unusual rusty coloration of an Indian Crested Porcupine Hystrix indica*
Sumanas Koulagi, Madhushri Mudke, Shashank C L, Ashish Jha 87

ISSN (Online): 3048-7803

JWLS

Volume 3 Issue 2 (June 2026)

TYPE Obituary

Shri H. S. Panwar (1937–2026)
Visionary Conservationist, Institution Builder, and Founder Director of the Wildlife Institute of India

Vinod B. Mathur[1,2]

[1]Former Director, Wildlife Institute of India
[2]Former Chairperson, National Biodiversity Authority

*CORRESPONDENCE
Vinod B. Mathur
✉ vbm.ddn@gmail.com

RECEIVED 02 June 2026
ACCEPTED 04 June 2026
ONLINE EARLY 04 June 2026
PUBLISHED 05 July 2026

CITATION
Mathur V. B. (2026). Shri H. S. Panwar (1937–2026) Visionary Conservationist, Institution Builder, and Founder Director of the Wildlife Institute of India. *Journal of Wildlife Science,* 3(2), 44-45. https://doi.org/10.63033/JWLS.RUER7788

COPYRIGHT
© 2026 Mathur. This is an open-access article, immediately and freely available to read, download, and share. The information contained in this article is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0),allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited in accordance with accepted academic practice. Copyright is retained by the author(s).

PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001 INDIA

PUBLISHER'S NOTE
The Publisher, Journal of Wildlife Science or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this article. All claims expressed in this article are solely those of the author(s) and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in this article or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

The Indian conservation community lost one of its most distinguished pioneers with the passing of Shri H. S. Panwar on 29 May 2026. A recipient of the Padma Bhushan, former Director of Project Tiger, architect of modern protected area management in India, and Founder Director of the Wildlife Institute of India (WII), Shri Panwar leaves behind a legacy that has profoundly shaped wildlife conservation, protected area management, and conservation capacity building in India and beyond.



Shri H. S. Panwar
22.03.1937 - 29.05.2026

Shri Panwar belonged to a generation of conservation leaders who combined vision with action. At a time when wildlife conservation was still emerging as a national priority, he played a pivotal role in establishing scientific approaches to protected area management and strengthening institutional frameworks for biodiversity conservation. His contributions extended from field-level species recovery and habitat management to national policy, institution building, and international conservation cooperation.

Among his most celebrated achievements was the recovery of the hard-ground barasingha in Kanha National Park, Madhya Pradesh. When the species had declined to critically low numbers, Shri Panwar championed an integrated conservation strategy involving habitat restoration, scientific management, and community engagement. The remarkable recovery of the species stands today as one of India's greatest conservation success stories and remains a lasting testament to his foresight and commitment.

As Director of Project Tiger, he provided leadership during a crucial phase in the evolution of India's flagship conservation programme. His efforts helped strengthen the foundations upon which India's globally acclaimed tiger conservation success has since been built. He understood that effective wildlife conservation required not only protected areas and policies but also capable institutions and skilled professionals.

It is perhaps in institution building that Shri Panwar's legacy shines most enduringly. As the Founder Director of the Wildlife Institute of India, he laid the intellectual, professional, and ethical foundations of what has become one of the world's leading institutions dedicated to wildlife research, conservation training, and capacity development. The Institute that he nurtured in its formative years continues to influence generations of wildlife managers, scientists, researchers, and conservation practitioners across India and many other countries.

For those fortunate enough to work with him, Shri Panwar was much more than an accomplished conservation leader. He was an inspiring mentor who invested deeply in people. He believed in identifying potential, empowering young professionals, and encouraging them to take responsibility. Many conservation leaders of today trace important milestones in their professional journeys to the confidence and opportunities he provided during their formative years.

I had the privilege of knowing Shri Panwar for nearly four decades. My association with him began in the mid-1980s when he selected me, a young Indian Forest Service officer, to join the Wildlife Institute of India. Looking back, that decision became one of the defining turning points of my professional career. He not only provided opportunities but also instilled values that shaped my approach to conservation, leadership, and public service.

I was later fortunate to work closely with him once again in Sri Lanka, where he headed a UNDP-GEF programme aimed at strengthening the capacity of protected area professionals. These years revealed yet another dimension of his personality. Despite his international stature and numerous achievements, he remained remarkably humble, approachable, and generous with his time and wisdom. His leadership style was characterised by quiet confidence, intellectual rigour, and unwavering integrity.

One conversation with Shri Panwar remains deeply etched in my memory. Fascinated by his extraordinary ability to pursue multiple ambitious goals simultaneously and deliver results of exceptional quality, I once asked him the secret of his success. His reply was simple yet profound: "Set impossible targets and then pursue them relentlessly. Success will be yours." Over the years, I came to realise that this was not merely advice; it was the philosophy by which he lived his life. Every major achievement of his distinguished career reflected this conviction. It was also a lesson that inspired and guided many of his students and colleagues, including myself.

The true measure of Shri Panwar's life lies not only in the awards he received or the positions he held, but also in the institutions he built, the species he helped conserve, the protected areas he strengthened, and the countless individuals he mentored. His influence continues to be reflected in India's conservation landscape and in the work of generations of professionals who benefited from his guidance and vision.

As we mourn his passing, we also celebrate a life of extraordinary purpose and service. The forests he helped protect, the wildlife populations he helped recover, the institutions he established, and the conservation ethic he championed will continue to inspire future generations.

Shri H.S. Panwar was not merely a conservationist; he was a nation-builder in the truest sense of the term. His vision transformed Indian wildlife conservation, and his legacy will endure for decades to come.

May his noble soul rest in eternal peace.

 https://doi.org/10.63033/JWLS.RUER7788

ISSN (Online): 3048-7803

JWLS

Volume 3, Issue 2 (June 2026)

TYPE Research Article

Occurrence of the lesser-known endemic *Rhinolophidae species* in the caves of the Andaman Islands, India: insights from a rapid survey

Dhanusha Kawalkar[1], Shirish S Manchi[1]*, Avimanyu J Mukherjee[1], Rima Sadhukhan[1], Pooja R Patil[1]

[1] Sálim Ali Centre for Ornithology and Natural History (South India Centre of Wildlife Institute of India), Anaikatty (P.O), Coimbatore - 641 108, Tamil Nadu, India

EDITED BY
Abhijit Das
Wildlife Institute of India, Dehradun, India.

*CORRESPONDENCE
Shirish S Manchi
ediblenest@gmail.com

RECEIVED 01 November 2025
ACCEPTED 16 May 2026
PUBLISHED 05 July 2026

CITATION
Kawalkar, D., Manchi, S. S., Mukherjee, A. J., Sadhukhan, R., Patil, P. R. (2026). Occurrence of the lesser-known endemic *Rhinolophidae species* in the caves of the Andaman Islands, India: insights from a rapid survey. *Journal of Wildlife Science,* 3(2), 46-52. https://doi.org/10.63033/JWLS.PJQJ6487

FUNDING
The Habitats Trust (Conservation grant 2023).

COPYRIGHT
© 2026 Kawalkar, Manchi, Mukherjee, Sadhukhan, Patil. This is an open-access article, immediately and freely available to read, download, and share. The information contained in this article is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited in accordance with accepted academic practice. Copyright is retained by the author(s).

PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001
INDIA

PUBLISHER'S NOTE
The Publisher, Journal of Wildlife Science or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this article. All claims expressed in this article are solely those of the author(s) and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in this article or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

Abstract

The Andaman and Nicobar Islands host a unique diversity of cave-dwelling bat species, most of which remain understudied. We conducted a rapid assessment of the two lesser-known endemic Rhinolophidae bat species (*Rhinolophus andamanensis* and *Rhinolophus cognatus*) in 13 limestone caves in the North and Middle Andaman Islands (Baratang Island (n=5), Interview Island (n=4), and Chalis-Ek, North Andaman Island (n=4). We used passive acoustic recorders to document the occurrence of Rhinolophidae bats, sampling one cave at a time, from February 22, 2025, to March 4, 2025. After identifying the presence of each species in different caves, we performed a joint probability test followed by the chi-square test to confirm the results. Of the 13 study caves, at the three locations, five were exclusively occupied by *R. andamanensis*, two were occupied by *R. cognatus*, and both species were detected in six caves. The joint probability test indicated mutual exclusivity between both species and suggests thorough surveys for their population and distribution across the Andaman Islands. Based on the literature and the number of colonies detected, we estimate that the maximum population of *R. cognatus* can be about 400 individuals in 8 caves. It is the first focused survey, identifying caves harbouring the populations of the endemic and endangered *R. cognatus*. The study recommends prioritising the identified caves, strategising and initiating science-based conservation efforts for protecting the Threatened endemic *R. cognatus* and the subterranean cave habitats in the Andaman Islands.

Keywords: Bat conservation, cave-dwelling bats, cave prioritisation, island endemics, *Rhinolophus cognatus*

Introduction

Bats are among the most gregarious mammals, with diverse species roosting communally (Kelm *et al.*, 2021). The diurnal roosts of bats, such as tree cavities, rock crevices, abandoned buildings and caves, serve as resting places that shelter them from predation and extreme weather conditions (Kunz *et al.*, 2003). The communal roosts provide numerous benefits, including transfer of information, such as, food sources, roost sites, and other resources (Gager, 2019), interspecific social bonding, fitness benefits (Ancillotto *et al.*, 2015), and active predator deterrence (Knörnschild & Tschapka, 2012). These communal roosts are termed positive associations in cases where species pairs (or larger sets) occur at the same sites more often than expected by chance. On the other hand, negative associations or segregations or mutual exclusions occur when species tend to avoid one another (they are found at the same sites less often than expected by chance). Both these associations are collectively referred to as 'deviating', in the sense that they do not conform to random expectations (Pitta *et al.*, 2012). Several mixed-species roosts of bats are documented, deriving benefits from aggregation (Rodríguez-Durán, 1998; Korad, 2014; Barros & Bernard, 2023). Not many bat species, especially from the Rhinolophidae family, co-occur with their congenerics (Jiang *et al.*, 2008) and members of another genus, such as Hipposideridae (Struebig *et al.*, 2009). While ecologists have long focused on the coexistence of sympatric species (Jiang *et al.*, 2008), detailed information is lacking on species-specific roost selection, particularly among species in tropical communities (Kelm *et al.*, 2021). Islands in the tropics represent some of the most vulnerable ecosystems (Jones *et al.*, 2009). Given the natural fragility of these habitats, island biodiversity has been severely impacted both historically and presently by anthropogenic disturbances. According to Jones *et al.* (2009), bats form a major component of island biodiversity and are often the only native island mammals, playing critical roles in the terrestrial ecosystem for seed dispersal, pollination and also in the subterranean cave ecosystems for energy input (in the form of guano, and prey base). Despite the apparent importance of bats to island ecosystem functioning, little is known about the global distribution and status of island bat populations (IUCN, 2025).

The Andaman and Nicobar Islands (A&N Is) are rich in biodiversity, with 32 endemic mammal species and subspecies (Department of Environment & Forests, Andaman & Nicobar Administration 2026). Aul *et al.* (2014) documented 25 bat species across 13 genera in the A&N Is. Recently, Srinivasulu *et al.* (2017) reported a similar number of species along with the newly identified species Nicobar leaf-nosed bat (*Hipposideros ater*, Douangboubpha *et al.*, 2011) and Guillen's tube-nosed bat (*Murina guilleni*; Soisook *et al.*, 2013). Many of these species are cave-dwelling, occupying a vital ecological niche within island ecosystems. Additionally, the island flying fox (*Pteropus hypomelanus*) is widespread across the Andaman and Nicobar Islands, and several other regions of South-east Asia (Indonesia, Malaysia, Thailand, Vietnam); the Andaman Horseshoe Bat (*Rhinolophus cognatus*), and Homfray's Horseshoe Bat (*Rhinolophus andamanensis*) are endemic to the Andaman Islands. The Nicobar flying fox (*Pteropus faunulus*) and Nicobar leaf-nosed bat (*Hipposideros nicobarule*) are endemic to the Nicobar Islands (Chaturvedi, 1979; Menon, 2023). Given the high endemism and ecological sensitivity of island systems, cave-dwelling bats are crucial for the overall health of both island and cave ecosystems (Tanalgo *et al.*, 2022).

The only Rhinolophid bats known from the Andaman Islands are the endemic *Rhinolophus andamanensis* and *Rhinolophus cognatus*. *R. cognatus* is an Endangered species (IUCN, 2016) and is known to occur at a few locations in the Andaman Islands (Bates & Harrison, 1997; Aul, 2014). Based on surveys by Srinivasulu *et al.* (2017), their population ranges between 50 -200 individuals and is currently declining (Aul & Chakravarty, 2016). The *R. andamanensis* was misidentified as intermediate horseshoe bat (*R. affinis*) because of the morphological similarities. However, recently Srinivasulu *et al.* (2019), based on its taxonomic distinctiveness, recognised *R. andamanensis* as a separate species.

In the islands, *R. andamanensis* occurs with *R. cognatus*, diadem leaf-nosed bat (*Hipposideros diadema masoni*), Andersen's leaf-nosed bat (*H. gentilis*), grand roundleaf bat (*H. grandis*), and Horsfield's bat (*Myotis horsfieldii*). While the distribution of these species across the islands is documented to some extent (Aul *et al.*, 2014; Srinivasulu *et al.*, 2017), no studies have focused on identifying species-specific colony sites. Since *R. cognatus*, being an endemic and Endangered, is a priority species as part of the ongoing efforts to understand and conserve the lesser-known, overlooked subterranean cave habitats. Hence, we attempted to understand the occurrence of bats in the caves of the North and Middle Andaman Islands, with special emphasis on the endemic species. As both the Rhinolophidae members are endemic and only broad distribution information is available (Srinivasulu *et al.*, 2019), the present document is focused on discussing the initial findings regarding earlier unknown cave-wise occurrence of these species in our study area. The findings also contribute to identifying caves for conservation prioritisation.

Materials and methods

We conducted this rapid survey at three sites: Baratang Island, Chalis-Ek on North Andaman Island, and Interview Island in the North and Middle Andaman Islands district of the A&N Is (06° 45′ 9" N; 13° 41′ 9" N; 92° 12′ 9" E; 93° 57′ 9" E; Fig. 1). Baratang Island (12° 05′ N, 92° 45′ E), which has more than 175 caves within 0.77 km^2 between Wraffter's Creek (also mentioned as Rafter's Creek) and Naya Dera, possesses the largest known cave complex of the A&N Is. (Sankaran, 2001; Manchi & Sankaran, 2014; Mane *et al.*, 2019). Chalis-Ek, in North Andaman, as the vernacular name suggests, is believed to have 41 caves; however, only 30 caves have been explored on this limestone hillock (Manchi & Sankaran, 2009). Interview Island, the only identified simple carbonate island in the Andaman and Nicobar Islands (Kawalkar & Manchi, 2020), comprises 34 known caves (Manchi & Sankaran, 2014). Most caves at all three sites are protected between January and June to conserve the edible-nest swiftlet (*Aerodramus fuciphagus*).

The study was conducted from 22nd February 2025 to 4th March 2025 in randomly selected caves (n=13) accessible at all three sites (Baratang Island = 5, Interview Island = 4, and Chalis-Ek = 4). We used passive acoustic recorders (AudioMoth; ver. 1.10) to detect the presence of various bat species in the study caves, sampling one site at a time. Based on the known acoustics characters of *R. cognatus* and *R. andamanensis* (Srinivasulu *et al.*, 2017), we configured the Audiomoth with a sample rate of 250kHz and medium gain. The calls were recorded from 1800 hours to 0600 hours, with a 5min sleep and a 10min recording cycle to maintain a balance between data resolution, battery life and storage efficiency. The use of this duty cycle allowed for adequate temporal coverage of bat activity patterns without requiring excessive battery use or data redundancy. It was also chosen for optimal conditions, such as high humidity and temperature in caves, where frequent battery replacements are impossible. Once the bat calls were recorded, we used Kaleidoscope (5.6.8) to cluster the data. Raven Pro (Ver. 1.6) was used to analyse calls, extract the robust parameters (Frequency of Maximum Energy, FMAXE Srinivasulu *et al.*, 2025), prepare spectrogram (Fig. 2) required for scientific documentation and evidence generation. Some calls were subjected to Doppler shift compensation. Following Srinivasulu *et al.* (2017), only the pulses with a good signal-to-noise ratio were selected for identification. We used the joint probability (Zohuri *et al.*, 2022) test to calculate the independent probabilities of occurrence for *R. cognatus* and *R. andamanensis*, as well as their co-occurrence at the cave level. The following formulae 1&2 were used to estimate the probability of occurrence for both Species A (*R. andamanensis*) and B (*R. cognatus*) exclusively;

$$\frac{\text{(Number of caves occupied by only species A)}}{\text{(Total caves surveyed)}} \quad \text{(Formula 1)}$$

$$\frac{\text{(Number of caves occupied by only species B)}}{\text{(Total caves surveyed)}} \quad \text{(Formula 2)}$$

Probability of occurrence of both P(A) and P(B) together;

$$P(A \cap B) = \frac{\text{(Number of caves occupied by both species)}}{\text{(Total caves surveyed)}} \quad \text{(Formula 3)}$$

Probability of occurrence of both P(A) and P(B) independently, then,

$$P(A) \times P(B) \quad \text{(Formula 4)}$$

We used the chi-square test to confirm the results of the probability test. All the analyses were conducted using R ver. 4.6.0 in R Studio ver. 2024 12.1 .

Results

We encountered at least one Rhinolophidae species in all 13 randomly surveyed caves (Table 1). The FMAXE and call duration were measured from high-quality calls and used as key acoustic features for species identification. For *R. cognatus*, FMAXE ranges between 85.26 to 92.35 kHz, with a mean of 89.43±1.71 kHz, and call duration varied from 40.66 to 59.06 ms (Mean±SD: 50.86±6.45 ms). For *R. andamanensis*, FMAXE varied from 56.64 to 58.74 kHz, with a mean of 57.70±0.56 kHz, and call duration varied from 35.24 to 50.40 ms (Mean±SD 43.46±5.16 ms).

Of these, five caves were exclusively occupied by *R. andamanensis* (Fig. 3a), and two were occupied by *R. cognatus* (Fig. 3b). Both species were encountered sharing six caves. We conducted the Joint Probability Test to further understand the relative occurrence of these two endemic species.

Following the formulas 1-4, the probabilities of occurrence of the species:

$P(A) = (5)/(13) = 0.38$, $P(B) = (2)/(13) = 0.15$,

$P(A \cap B) = 6/13 = 0.46$ $P(A) \times P(B) = 0.38 \times 0.15 = 0.057$

 https://doi.org/10.63033/JWLS.PJQJ6487

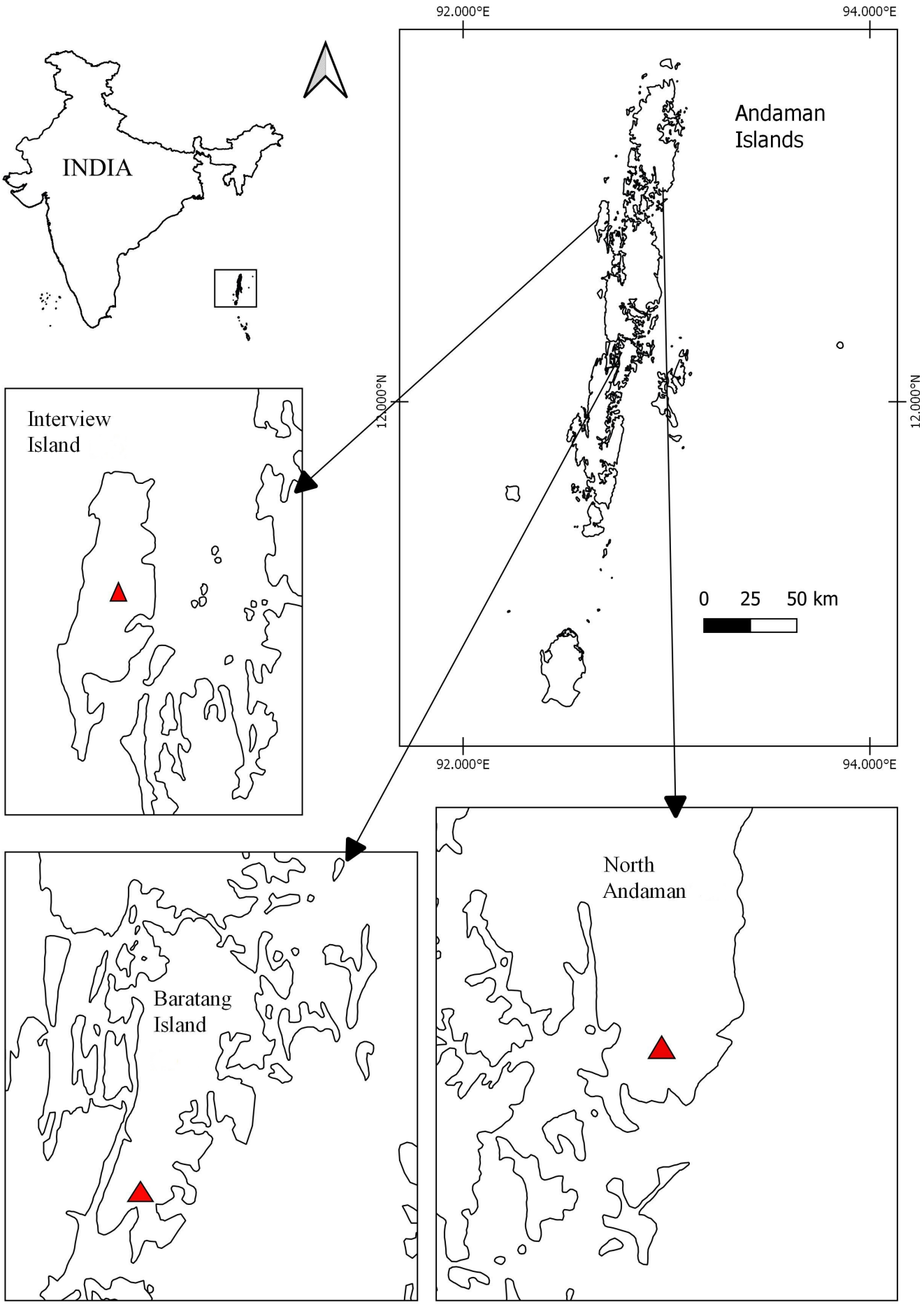


Figure 1. The geographical location of the Chalis-Ek, Interview and Baratang Islands

 https://doi.org/10.63033/JWLS.PJQJ6487

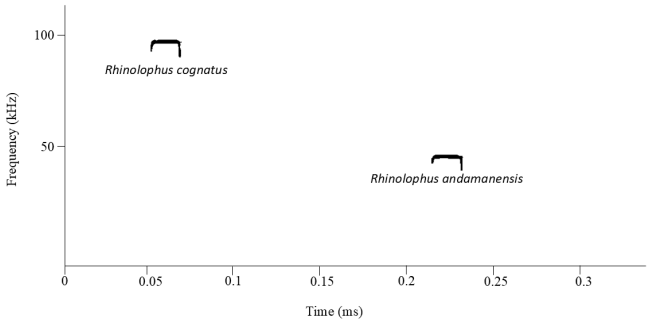


Figure 2. Spectrograms of (A) *R. andamanensis* (FMAXE range: 56.64 - 58.74 kHz, call duration- 35.24 - 50.40 ms) and (B) *R. cognatus* used for the identification of the species (FMAXE range: 85.26 - 92.35 kHz, call duration: 40.66 - 59.06 ms)

Table 1. Presence-absence data of Homfray's Horseshoe Bat (*Rhinolophus andamanensis*) and Andaman Horseshoe Bat (*Rhinolophus cognatus*) in different sampling locations in Andaman & Nicobar Islands.; the presence is denoted by ✓ and the absence is denoted by × , and the Cave IDs are given by the initials of the island names and number of the cave that is being sampled. (IN- Interview Island; CE- Chalis-EK; BT- Baratang Island)

S. No.	Cave ID	*R. andamanensis*	*R. cognatus*
1	IN 1	✓	✓
2	IN 2	×	✓
3	IN 3	✓	✓
4	IN 4	✓	✓
5	CE 1	✓	✓
6	CE 2	✓	✓
7	CE 3	✓	×
8	CE 4	✓	×
9	BT1	×	✓
10	BT2	✓	✓
11	BT3	✓	×
12	BT4	✓	×
13	BT5	✓	×

The output of the Joint Probability Test, P(A∩B) > P(A)xP(B), depicts that the congeneric species A (*R. andamanensis*) and species B (*R. cognatus*) do occur in the same caves. The Chi-square test, conducted to ratify the finding, further confirmed that the occurrence of these sympatric species is independent of each other and their occurrence in the same cave is by chance (p>0.05).

Following the estimate of Aul (2003) that *R. cognatus* colonies do not grow more than 50 individuals, we estimate the eight caves identified with the colonies can hold a maximum of 400 individuals (50×8=400) in the study caves.

Discussion

Globally, 28% of caves exhibit high bat diversity and are significantly threatened (Tanalgo *et al.*, 2022). Of the 16 cave-dwelling bats known from the Andaman Islands (Srinivasulu *et al.* 2017), the *R. cognatus* is listed in the Endangered category of the IUCN Red List due to its limited population with a declining trend (Aul & Chakravarty, 2016). The species is also among the seven most nationally important bat species listed in Schedule-I of Indian Wild Life (Protection) Amendment Act,



Figure 3. Photographic documentation of the (a) Homfray's Horseshoe Bat (*R. andamanensis*) in the Interview Island, (b) Andaman Horseshoe Bat (*R. cognatus*). The individual was found in one of the caves of the Baratang Island during the study. The photographs display distinct morphological characters. A Horse-shoe shaped nose leaf structure with three mental grooves and a pointed lancet, B Bifid structure of sella, C Pinna with a prominent antitragus in the front

2022. The roosting sites of this endemic and Endangered species and threats to this endemic species are unknown. The species is known to occur with the another endemic congeneric *R. andamanensis* which is considered relatively common compared to other cave-dwelling bat species in the Andaman Islands (Aul *et al.*, 2014). During the present study, of the 13, eight caves were identified harbouring populations of *R. cognatus*. Of these six caves, sheltering populations of *R. cognatus* were also occupied by *R. andamanensis*. The data further unveiled that the probability of occurrence of these congeneric Rhinolophus species (*R. cognatus* and *R. andamanensis*) is 46% and is mutually exclusive. This segregation indicates the randomness of their occurrence in the same cave.

Since, *R. andamanensis* is common in the islands, its presence can be attributed to its generalist characteristics (Furey *et al.*, 2020), such as roosting in available caves or caverns (Rodríguez-Durán, 2009). Species within genera often share similar roosting behaviours (Rodríguez-Durán, 2009), which may explain the co-occurrence of *R. andamanensis* and *R. cognatus* in six caves. This pattern is comparable to the concept known as "paradox of the plankton" (Hutchinson, 1978), which proposes that ecologically similar species can coexist within homogeneous environments due to temporal variation and subtle niche differentiation. In cave systems, such coexistence may be facilitated by differences in call frequencies, morphology, and roosting microhabitat, allowing both species to occupy the same caves with minimal competition. Salsamendi *et al.* (2012) documented that congeneric species coexist in the same roost, a pattern also observed in R. pearsoni and *R. affinis* by Jiang *et al.* (2008). In various studies (Jiang *et al.* 2008; Ashrafi *et al.*, 2011; Salsamendi *et al.*, 2012), it has been observed that bat species co-occur when there is low or no dietary overlap or niche separation. Detailed studies on *R. andamanensis* and *R. cognatus* can enhance our understanding of their trophic ecology and foraging habits. According to Scheffer & Van Nes (2006), various mechanisms such as predation, population dynamics, environmental

 https://doi.org/10.63033/JWLS.PJQJ6487

variability, and disturbances help prevent competitive exclusion. Therefore, thorough investigations of both species, their habitat selection, and their interactions can aid in understanding the dynamics of co-occurrence or co-existence of the congeneric *R. cognatus* and *R. andamanensis*. As there have been no species-focused attempts to estimate population sizes and habitat requirements for *R. cognatus*, discussing the selection of caves or habitats by *R. cognatus* is currently challenging.

During 2013-14, R. Chakravarty (pers. obs.) did not encounter the *R. cognatus* around the previously known roosting locations in North Andaman, Interview Island, and Little Andaman (Aul, 2003). Furthermore, R. Chakravarty stated that this may be attributed to seasonality. Based on these observations, Aul & Chakravarty (2016) concluded that there is a declining trend in the species' subpopulations. Unlike Aul & Chakravarty (2016), the present study detected the *R. cognatus* populations in all four caves surveyed on Interview Island and in two out of four caves surveyed on North Andaman Island (*i.e.*, Chalis-Ek). These variations in population detection may be attributed to the limited survey efforts during previous studies. Considering the variations in the population detection and estimation, there is a dire need to conduct a thorough survey of the population status and distribution across the Andaman Islands to devise conservation plans for this endangered and island-endemic species.

Srinivasulu *et al.* (2017) estimated the presence of *R. cognatus* population to be 50-200 individuals. Aul (2003) studied population of *R. cognatus* in the Andaman Islands by mist-netting at cave openings. *R. cognatus* colonies generally do not exceed 50 individuals. Taking this estimation into consideration, we estimated that the population of *R. cognatus* in our study caves could not be more than 400 individuals. However, as the roosting caves of the endemic *R. cognatus* and *R. andamanensis* are known, further detailed surveys can provide clarity on the population status of these species in the study sites.

Island-dwelling bats are increasingly threatened by various stochastic events, periods of limited resource availability and increasing anthropogenic activities (Pedersen *et al.*, 2009, Willig *et al.*, 2009). According to Conenna *et al.* (2017), basic knowledge about ecological features and taxonomy is mostly lacking for Island Endemic Bats (IEBs), which in turn affects the establishment of conservation priorities (Wiles & Brooke, 2009). As Aul & Chakravarty (2016) mentioned, this is true for the *R. cognatus*. Aul (2003) suspected the disturbance from the illegal harvesting of the cave-dwelling edible-nest swiftlet's nest as the only known threat. Presently, the illegal harvesting of edible nests from more than 200 caves at all three study sites has been completely stopped since the year 2000 by protecting these caves as part of the ongoing edible-nest swiftlet conservation program (Manchi & Sankaran, 2014; Manchi *et al.*, 2022). Hence, we can conclude that the only known threat to the *R. cognatus* from the illegal harvesting of the cave-dwelling edible-nest swiftlet's nest does not exist anymore. Nevertheless, the ecological or other anthropogenic threats to the species were never identified and need to be documented and managed before the species faces any further negative change in its population status. Recognising the urgency recently, the species was included in the Schedule-I (the highest priority species list) of the Wild Life (Protection) Amendment Act, 2022. On the contrary, recently, a cave on Baratang Island was converted into a show cave, with significant modifications inside. This is a growing threat to species like *R. cognatus* and many other known and unknown cave-dwelling animals in the islands. Hence, the conservation efforts for the endemic and endangered *R. cognatus* and the island's cave habitats are critical.

Globally, subterranean habitats are overlooked (Wynne *et al.*, 2021), and the situation in India is even worse, with limited published materials on the conservation prioritization (Biswas, 2022; Saikia *et al.*, 2023; Kawalkar *et al.*, 2024; Kawalkar & Manchi, 2025). This indicates that we still lack significant knowledge regarding this least-explored priority habitat and the fauna living in it. The present study is the first focused survey to identify the colonies of the endemic Rhinolophidae species, including the endangered *R. cognatus*, in the Andaman Islands. This study is part of ongoing efforts to conserve subterranean habitats in the Andaman Islands; we will continue to identify more colonies of the species and the potential threats to it. Furthermore, it is recommended that science-based conservation efforts be strategised and initiated for the species throughout its distribution range across the Andaman Islands.

Acknowledgment

We thank the Habitats Trust for funding the ongoing "Conserving the Overlooked Subterranean Cave Habitat: A Sustainability Approach" project, under which the present study was conducted. We are equally grateful to the Department of Environment and Forests, Andaman and Nicobar Islands, for the permissions and support. The study would have been impossible without the field assistance of Justin Sumit Kumar, Santial Toppo, and all the swiftlet protectors.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

DATA AVAILABILITY

Data is available from the corresponding author on request.

AUTHOR CONTRIBUTIONS

DK- Conceptualization, Methodology, Formal analysis, Validation, Writing – original draft, review & editing; MSS- Conceptualization, Methodology, Funding acquisition, Project administration, Resources, Investigation, Validation, Writing – original draft, review & editing; AM- Data curation, Formal analysis, Visualization, Software, Writing – original draft, review & editing; RS- Data curation, PP- Data curation.

References

Ancillotto, L., Allegrini, C., Serangeli, T., Jones, G. & Russo, D. (2015). Sociality across species: spatial proximity of newborn bats promotes heterospecific social bonding. *Behavioral Ecology*, 26(1), 293–299. https://doi.org/10.1093/beheco/aru193

Ashrafi, S., Beck, A., Rutishauser, M., Arlettaz, R. & Bontadina, F. (2011). Trophic niche partitioning of cryptic species of long-eared bats in Switzerland: implications for conservation. *European Journal of Wildlife Research*, 57, 843–849. https://doi.org/10.1007/s10344-010-0493-3

Aul, B. (2003). *The status and distribution of bats in Andaman and Little Andaman Islands.* Andaman and Nicobar Islands Environmental Team Technical Report. Madras Crocodile Bank Trust, Mamallapuram, India.

Aul, B. & Chakravarty, R. (2016). *Rhinolophus cognatus. IUCN Red List of Threatened Species 2016*: e.T19533A21981807. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T19533A21981807.en

Aul, B., Bates, P. J. J., Harrison, D. L. & Marimuthu, G. (2014). Diversity, distribution and status of bats on the Andaman and Nicobar Islands, India. *Oryx*, 48(2), 204–212. https://doi.org/10.1017/S0030605312000646

Barros, J. S. & Bernard, E. (2023). Species richness, occurrence and rarity of bats in Brazilian caves. *Austral Ecology*, 48(8), 2144–2170. https://doi.org/10.1111/aec.13453

Bates, P. J. J. & Harrison, D. L. (1997). *Bats of the Indian Subcontinent*. Harrison Zoological Museum Publication, Sevenoaks, Kent.

Biswas, J. (2022). *Cave Science: Insights from the Indian Subcontinent.* National Cave Research and Protection Organization, India. ISBN: 978-81-939423-0-7.

Chaturvedi, Y. (1979). Mammals of the Andamans and Nicobars: Their Zoogeography and Faunal Affinity. *Records of the Zoological Survey of India*, 77, 127–139. https://doi.org/10.26515/rzsi/v77/i1-4/1979/161849

Conenna, I., Rocha, R., Russo, D. & Cabeza, M. (2017). Insular bats and research effort: a review of global patterns and priorities. *Mammal Review*, 47(3), 169–182. https://doi.org/10.1111/mam.12090

Department of Environment & Forests, Andaman & Nicobar Administration (2026). Mammals. https://forest.and.nic.in/WebPages/mammals.html (Accessed on 20 June 2026)

Douangboubpha, B., Bumrungsri, S., Soisook, P., Murray, S.W., Puechmaille, S.J., Satasook, C., Bu, S.S.H., Harrison, D.L. & Bates, P.J.J. (2010). A taxonomic review of Hipposideros halophyllus, with Additional Information on *H. ater* and *H. cineraceus* (Chiroptera: Hipposideridae) from Thailand and Myanmar. *Acta Chiropterologica*, 12(1), 29-50. https://doi.org/10.3161/150811010X504572

Furey, N., Walston, J., Kingston, T. & Hutson, A. M. (2020). *Rhinolophus affinis. The IUCN Red List of Threatened Species 2020*: e. T19522A21982358. https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T19522A21982358.en (Accessed on 12 August 2025).

Gager, Y. (2019). Information transfer about food as a reason for sociality in bats. *Mammal Review*, 49(2), 113–120. https://doi.org/10.1111/mam.12146

Hutchinson, G. E. (1978). *An introduction to population ecology (Vol. 260).* Yale University Press, New Haven.

IUCN. (2025). *The IUCN Red List of Threatened Species.* Version 2025-2. https://www.iucnredlist.org. Accessed on [13th April 2025].

Jiang, T., Feng, J., Sun, K. & Wang, J. (2008). Coexistence of two sympatric and morphologically similar bat species *Rhinolophus affinis* and *Rhinolophus pearsoni*. *Progress in Natural Science*, 18(5), 523–532. https://doi.org/10.1016/j.pnsc.2007.12.005

Jones, K. E., Mickleburgh, S. P., Sechrest, W., Walsh, A. L., Fleming, T. H. & Racey, P. A. (2009). *Global overview of the conservation of island bats: importance, challenges and opportunities.* In: Fleming, T. H. & Racey, P. A. (eds.), Island Bats: Evolution, Ecology and Conservation, 496–530. University of Chicago Press, Chicago, Illinois, USA.

Kawalkar, D. & Manchi, S. (2020). Coastal caves on the Interview Island of Andaman Islands, India. *Carbonates and Evaporites*, 35(4), 111. https://doi.org/10.1007/s13146-020-00626-5

Kawalkar, D., Manchi, S., Parab, R. & Lad, P. (2024). First report of a freshwater turtle species as a permanent resident of a cave. *The Herpetological Bulletin*, 167, 34–36. https://doi.org/10.33256/hb167.3436

Kawalkar, D. & Manchi, S. (2025). Habitat selection theory and cave-dwelling birds: The corollary. *Raffles Bulletin of Zoology*, 73, 220–232. https://doi.org/10.26107/RBZ-2025-0016

Kelm, D. H., Toelch, U. & Jones, M. M. (2021). Mixed-species groups in bats: non-random roost associations and roost selection in neotropical understory bats. *Frontiers in Zoology*, 18, 1–12. https://doi.org/10.1186/s12983-021-00418-2

Knörnschild, M. & Tschapka, M. (2012). Predator mobbing behaviour in the greater spear-nosed bat, *Phyllostomus hastatus*. *Chiroptera Neotropical*, 18(2), 1132–1135.

Korad, V. S. (2014). Studies on diversity, distribution, and conservation of the bat fauna in Maharashtra State, India. Taprobanica: *The Journal of Asian Biodiversity*, 6(1), 1–13. https://doi.org/10.4038/tapro.v6i1.7155

Kunz, T. H., Lumsden, L. F. & Fenton, M. B. (2003). *Ecology of cavity and foliage roosting bats.* In: Kunz, T. H. & Fenton, M. B. (eds.), Bat Ecology. University of Chicago Press, Chicago, Illinois, USA. pp. 3–89.

Manchi, S. & Sankaran, R. (2009). Predators of swiftlets and their nests in the Andaman Islands. *Indian Birds*, 5, 118–120.

Manchi, S. & Sankaran, R. (2014). Protection of the white-nest swiftlet *Aerodramus fuciphagus* in the Andaman Islands, India: an assessment. *Oryx*, 48(2), 213–217. https://doi.org/10.1017/S0030605311000603

Manchi, S., Kawalkar, D., Gurjarpadhye, P., Dhamorikar, A. & Jena, S. K. (2022). I*n-situ and ex-situ conservation of endemic Andaman Edible-nest Swiftlet in the Andaman and Nicobar Islands.* Sálim Ali Centre for Ornithology and Natural History, Coimbatore, India. p. 104.

Mane, A. M., Prabakaran, N. & Manchi, S. S. (2019). Floral diversity, composition, and recruitment on the karstland of Baratang Island, India. *Ecological Complexity*, 37, 47–54. https://doi.org/10.1016/j.ecocom.2018.11.002

Menon, V. (2023). *Indian Mammals: A Field Guide. Hachette India.*

Pederson, S. C., Kwiecinski, G. G., Larsen, P. L., Morton, M. N., Adams, R. A., Genoways, H. H. & Swier, V. J. (2009). *Bats of Montserrat: population fluctuation in response to hurricanes and volcanoes, 1978–2005.* In: Fleming, T. H. & Racey, P. A. (eds.), Island Bats: Evolution, Ecology and Conservation. University of Chicago Press, Chicago, Illinois, USA. pp. 302–340.

Pitta, E., Giokas, S. & Sfenthourakis, S. (2012). Significant pairwise co-occurrence patterns are not the rule in the majority of biotic communities. *Diversity*, 4(2), 179–193. https://doi.org/10.3390/d4020179

Rodríguez-Durán, A. (1998). Non-random aggregations and distribution of cave-dwelling bats in Puerto Rico. *Journal of Mammalogy*, 79(1), 141–146. https://doi.org/10.2307/1382848

Rodríguez-Durán, A. (2009). *Bat assemblages in the West Indies: the role of caves.* In: Fleming, T. H. & Racey, P. A. (eds.), Island Bats: Ecology, Evolution and Conservation. University of Chicago Press, Chicago, Illinois, USA. pp. 265–280.

Salsamendi, E., Garin, I., Arostegui, I., Goiti, U. & Aihartza, J. (2012). What mechanism of niche segregation allows the coexistence of sympatric sibling rhinolophid bats? *Frontiers in Zoology*, 9, 30. https://doi.org/10.1186/1742-9994-9-30.

Sankaran, R. (2001). The status and conservation of the Edible-nest Swiftlet Collocalia fuciphaga in the Andaman and Nicobar Islands. *Biological Conservation*, 97, 283–294. https://doi.org/10.1016/S0006-3207(00)00124-5

Saikia, U., Daly, B.K., Manuel, R. (2023) Caves as priority area for conservation of the lesser known mammalian fauna of Meghalaya, North-eastern India. *Current Science*, 124 (9), 1021-1022. https://www.currentscience.ac.in/Volumes/124/09/1021.pdf

Scheffer, M. & van Nes, E. H. (2006). Self-organized similarity: the evolutionary emergence of groups of similar species. *Proceedings of the National Academy of Sciences*, 103(16), 6230–6235. https://doi.org/10.1073/pnas.0508024103

Soisook, P., Karapan, S., Satasook, C. & Bates, P. J. J. (2013). A new species of Murina (Mammalia: Chiroptera: Vespertilionidae) from peninsular Thailand. *Zootaxa*, 3746, 567–579. http://dx.doi.org/10.11646/zootaxa.3746.4.4

Srinivasulu, C., Srinivasulu, A., Srinivasulu, B., Gopi, A., Dar, T. H., Bates, P. J., Rossiter, S. J. & Jones, G. (2017). Recent surveys of bats from the Andaman Islands, India: diversity, distribution, and echolocation characteristics. *Acta Chiropterologica*, 19(2), 419–437. https://doi.org/10.3161/15081109ACC2017.19.2.018

Srinivasulu, C., Srinivasulu, A., Srinivasulu, B. & Jones, G. (2019). Integrated approaches to identifying cryptic bat species in areas of high endemism: the case of *Rhinolophus andamanensis* in the Andaman Islands. *PLoS One*, 14(10), e0213562. https://doi.org/10.1371/journal.pone.0213562

Srinivasulu, A., Srinivasulu, C., Srinivasulu, B., Senapathi, D. & González-Suárez, M. (2025). Bat echolocation in South Asia. *Journal of Threatened Taxa*, 17(11): 27897–27931. https://doi.org/10.11609/jott.9550.17.11.27897-27931

Struebig, M. J., Kingston, T., Zubaid, A., Le Comber, S. C., Mohd-Adnan, A., Turner, A., Kelly, J., Bożek, M. & Rossiter, S. J. (2009). Conservation importance of limestone karst outcrops for Palaeotropical bats in a fragmented landscape. *Biological Conservation*, 142(10), 2089–2096. https://doi.org/10.1016/j.biocon.2009.04.005

Tanalgo, K. C., Oliveira, H. F. & Hughes, A. C. (2022). Mapping global conservation priorities and habitat vulnerabilities for cave-dwelling bats in a changing world. *Science of the Total Environment*, 843, 156909. https://doi.org/10.1016/j.scitotenv.2022.156909

Wiles, G. J. & Brooke, A. P. (2009). *Conservation threats to bats in the tropical islands and insular Southeast Asia.* In: Fleming, T. H. & Racey, P. A. (eds.), Island Bats: Ecology, Evolution and Conservation, pp. 405–459. University of Chicago Press, Chicago, Illinois, USA. pp. 405–459.

Willig, M. R., Lyons, S. K., Stevens, R. D., Kunz, T. & Parsons, S. (2009). *Spatial methods for the macroecological study of bats.* In: Kunz, T. H. & Parsons, S. (eds.), Ecological and Behavioral Methods for the Study of Bats (2nd ed.). Johns Hopkins University Press, Baltimore, MD.

Wynne, J. J., Howarth, F. G., Mammola, S., Ferreira, R. L., Cardoso, P., Di Lorenzo, T., Galassi, D. M. P., Medellin, R. A., Miller, B. W. *et al.* (2021). A conservation roadmap for the subterranean biome. *Conservation Letters*, 14(5), e12834. https://doi.org/10.1111/conl.12834

Zohuri, B., Mossavar-Rahmani, F. & Behgounia, F. (2022). *Predictive analytics.* In: Zohuri, B. (ed.), Knowledge is Power in Four Dimensions: Models to Forecast Future Paradigm, pp. 573–637. Academic Press. pp. 573–637. ISBN: 978-0-323-95112-8 https://doi.org/10.1016/C2021-0-02583-9

ISSN (Online): 3048-7803

JWLS

Volume 3, Issue 2 (June 2026)

TYPE Research Article

Efficacy and schedule of Ivermectin in vivo against naturally acquired infestation of *Sarcoptes scabiei* on wild red foxes (*Vulpes vulpes*) treated in a controlled veterinary / clinical rehabilitation environment

Ryan Fox[1]*

[1] The Fox Hospital, Red Fox Rehabilitation Clinic, United Kingdom

EDITED BY
Pradeep Kumar Malik
Wildlife Institute of India, Dehradun, India.

*CORRESPONDENCE
Ryan Fox
researchpapers@thefoxhospital.org

RECEIVED 30 March 2026
ACCEPTED 31 May 2026
PUBLISHED 05 July 2026

CITATION
Fox, R. (2026). Efficacy and schedule of Ivermectin in vivo against naturally acquired infestation of *Sarcoptes scabiei* on wild red foxes (*Vulpes vulpes*) treated in a controlled veterinary / clinical rehabilitation environment. *Journal of Wildlife Science,* 3(2), 53-61.
https://doi.org/10.63033/JWLS.WIOO2051

COPYRIGHT
© 2026 Fox. This is an open-access article, immediately and freely available to read, download, and share. The information contained in this article is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited in accordance with accepted academic practice. Copyright is retained by the author(s).

PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001
INDIA

PUBLISHER'S NOTE
The Publisher, Journal of Wildlife Science or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this article. All claims expressed in this article are solely those of the author(s) and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in this article or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

Abstract

Ivermectin is widely used in the treatment of veterinary and human endoparasites and ectoparasites. Ivermectin is administered to red foxes with *Sarcoptes scabiei* mite infestation, killing the mites once sufficient concentrations are reached provided the mites have a sufficiently developed CNS and are not in one of three life cycle molt periods. There does not appear to be a consensus on the optimal frequency of ivermectin administration despite many wildlife studies, and this study shows that molt period and co-morbidities may be significant factors in the efficacy of ivermectin in vivo on red foxes in real world rehabilitation care scenarios.

Analyses for the presence of mange mites were performed on 3,420 skin samples, from a total of 111 rescued wild red foxes (*Vulpes vulpes*) from 2020 to 2021. Most of the foxes had crusted scabies, and all had co-morbidities, as is common and almost guaranteed in naturally infected wild red foxes. This report was based upon widely recognised dose rates of ivermectin 1% by sub-cutaneous (s.c.) injection between 200–400 µg/kg (0.02–0.04mL/kg), which was given at 7 -day intervals following skin scrapings and confirmation of *Sarcoptes scabiei*. Many patients were deemed in such poor condition upon rescue, precluding doubling the dose, especially since red foxes seem to be particularly susceptible to hepatic diseases. All patients presented with co-morbidities, additional investigations and treatments were carried out on the patients for their respective injuries, indications and conditions, including traumatic injuries, nutritional deficiencies, organ disease, and co-parasitism. Details of co-morbidities beyond their relevance to ivermectin efficacy are not reported here. Patients were stabilised and their overall condition and injuries treated and improved first before addressing the mange infestation to reduce the potential of any adverse reactions to medication.

Among the 111 red foxes, it was found that there is a potential need for up to nine treatments at 7-day intervals to effectively eradicate *Sarcoptes scabiei* fully, in a controlled, clinical environment. Nine patients required nine treatments before results showed no evidence of infestation, 25 patients required eight treatments, 22 patients required seven treatments, 31 patients required six treatments, and 24 patients required five treatments. The minimum acceptable amount of treatments was found to be five treatments, 7-days apart, and this was on patients with little to no clinical signs of mites or lesions but suspected based on the author's experience with early warning signs and subsequently confirmed through skin scrapings. This suggested strongly that any less than five treatments could result in patients being released back to the wild still infested, particularly if skin scrapings are not done as a routine procedure during the treatment and prior to wild release. Two simulated models illustrated different mites and how the molting period can potentially affect treatment.

Red foxes required up to nine single doses given at 7-day intervals to eradicate naturally caused infection, likely due to mite life cycle, molting periods, and mating frequency and the patients being in a weakened state initially reducing their ability to fight off disease, with five doses, instead of two, being the minimum before the infection was confirmed to be eradicated. It was also clear that delaying treatment for the mites was necessary to ensure the best chance of survival based on other indications and severely compromised immune systems of most patients. Patients would need to be in care or being treated for their underlying conditions alongside the scabies for around 8-12 weeks minimum, with a suggested 16-20 weeks on some more serious patients to avoid releasing back to the wild population with untreated conditions and/or a potential of re-infestation of mites causing post-release decline.

Keywords: Co-morbidities, fluralaner, ivermectin resistance, mange, mites, molting, retrospective studies, treatment outcome, wildlife rehabilitation, wildlife disease.

Introduction

Red foxes (*Vulpes vulpes*) are known to suffer particularly in urban areas from mange, most commonly *Sarcoptes scabiei* (Scott *et al.,* 2020; Soulsbury *et al.*, 2007). However, the author has found through treating a large number of red fox patients that the underlying causes are most linked to malnutrition (mineral, nutrient, vitamin and/or amino acid deficiencies) and/or acidosis, particularly with a heavy parasite burden, which red foxes with mange commonly experience. Poor and insufficient diet through decimation of natural habitats or prey poisoned by pest control substances leading to secondary toxicity, diminished body condition through infected wounds often caused by bite wounds of cats or other foxes or open fractures and subsequent infected wounds leading to an inability to hunt effectively and a subsequently a poorly operating immune system eventually leading to a heavy parasite burden are common root causes (Fox R., unpub. data). In rural environments, this seems to be much less, likely due to various factors including but not limited to more natural and uncontaminated prey, lack of human-caused obstacles or hazardous environment and larger open space reducing the potential for territory issues (Fox R., unpub. data).

Ivermectin is commonly prescribed to treat both internal and external parasitic infections, including *Sarcoptes scabiei* infections. Shortly after it became available, reports of resistance to ivermectin have become widespread (Furnival-Adams *et al.* 2024, Laing *et al.* 2017, Shoop 1993). In the veterinary world, ivermectin resistance is now a concern in cases of roundworm infection in horses, cattle, and sheep, as well as canine heartworm infections (Kaplan 2004). However, reports of ivermectin resistance in human and livestock parasites have been limited and contentious to date (Crump & Ōmura 2011).

There are a number of studies pertaining to different dose schedules and ivermectin efficacy, and they appear to vary significantly in results from single dose and double dose in vitro (Mounsey *et al.* 2017) to 7 doses recommended by the U.S Centers for Disease Control and Prevention (CDC 2023) and U.K. National Health Service (NHS 2024). However, there does not appear to be a consensus on the optimal frequency of ivermectin administration.

The present study aimed to understand the efficacy of different dose schedules to standardise the ivermectin administration protocol for red foxes infected by *Sarcoptes scabiei* in the wild. The study involved, the red foxes, in vivo, in a rehab/rescue environment and in clinical best-case conditions, suggesting the accuracy to be potentially as close to ideal real-world conditions as possible.

In this study, the author refers mostly to crusted scabies since wild foxes were generally not reported by members of the public until they were advanced in their condition and already crusting. However, it was still noted that on suspicion of molting periods or possible biofilm protection, there did appear to be some ivermectin resistance based on the skin scraping results each time, resulting in a need for further doses, where the minimum amount of doses required was still above those stated in other studies.

Sarcoptes scabiei mite has three life cycle molt periods (between larvae and protonymph, protonymph and tritonymph or tritonymph and adult). Life cycle molting periods affect the efficacy of ivermectin. A study was conducted by Feng *et al.* (2023) demonstrated that "*molting Sarcoptes mites are less susceptible to ivermectin than active mites. As a consequence, mites may survive after two doses of ivermectin given 7 days apart due not only to hatching eggs but also to the resistance of mites during their molting process. [Their] results provide insight into the optimal therapeutic regimens for scabies and highlight the need for further research on the molting process of Sarcoptes mites, where one third of mites survive the administration of ivermectin during a molting stage*".

While scabies has been observed in human patients with seemingly normal immune response, it should be noted that in red foxes, particularly adults, as demonstrated in (Supplementary Table S1), co-morbidities existed in each patient and it is the opinion of the author that there was in every case an underlying condition that appeared to have led to a reduced immune response and unnatural bodily terrain leading to the infestation of the mange mites suggesting strongly that mange is not a primary concern and instead a condition contracted and infested only once the fox was severely immunocompromised. The author notes that in his experience the exception to this appears to be only in newborns and young cubs still nursing from their already infected mother, since *Sarcoptes scabiei* is spread through direct contact, and the cubs then appear to become malnourished and lacking in vital nutrients *via* poor mother's milk quality, leading to further decline. In the case of this report, usually either a declined immunoresponse leading to a chronic or acute parasite burden, a poorly functioning lymphatic system, previously untreated open infected wounds leading to a suspected infection of the blood, severe malnutrition and/or serious lack of essential minerals, vitamins, amino acids and nutrients due to environmental factors. The author has recognised patterns over the course of many hundreds of red fox patients treated hands-on, spanning multiple years (Fox, R., unpub. data).

Methods

A total of 111 wild red foxes (*Vulpes vulpes*) were rescued from 2020 to 2021, showing clinical signs and indications of decline, injury and/or mange suspicion, reported by members of the public and subsequently rescued and brought into a clinical veterinary environment for treatment. All samples were obtained as part of the standard protocol during healing therapies on rescued patients with the goal of healing and releasing them back to the wild where possible.

Skin samples from the patients were taken during the standard triage procedure within the first hour of rescue. Each time skin samples were taken by skin scrapes, a little mineral oil was placed on 3 microscope slides as well as a drop of mineral oil on the area of skin about to be sampled/scraped, then skin scrapings were carried out using a sterile size 10 scalpel blade per patient dipped in a little mineral oil (liquid paraffin) to help adhere mites and/or eggs to the blade, per patient on 3–4 areas of the body (including lesion areas, common areas on red foxes or suspected areas where it was not obvious in early stage patients. Where patients had a significant thick crust, a mineral oil-dipped dull scalpel blade or small medical spatula was used to get a sample from under the crust, with care taken to not cause the patient any pain, harm or stress. Skin was scraped on each occasion until capillary ooze was obtained to ensure removal of the epidermis where mites burrow. Skin samples from each area were then placed onto their individual microscope slides with cover slips, labelled according to the patient where necessary and the skin area sampled and examined under compound microscopy at 4x and 10x objective to identify the presence of infection (Figure 1). After samples were taken each patient was placed into isolation in either a veterinary stainless steel or polypropylene industry standard clinical veterinary kennel and remained for the duration of their treatment to avoid any cross contamination where their clinical environment could be disinfected multiple times per day as necessary to maximise the potential for the fastest healing and reduce or eliminate any possibility of environmental reinfection, with disposable incontinence pads changed frequently each day, each patient quarantined and isolated from others with no materials in kennel that could harbour any eggs, larvae or mites and in each case and each interaction, long arm length gloves and nitrile over-gloves and disposable aprons disposed of between patients and with every interaction eliminating any cross contamination. Cleaning of kennels was done using F10SCXD Veterinary Disinfectant rated for various bacteria, fungi, moulds, viruses, micro organisms and spores, and Safe4 veterinary biocide disinfectant. Another reason patients

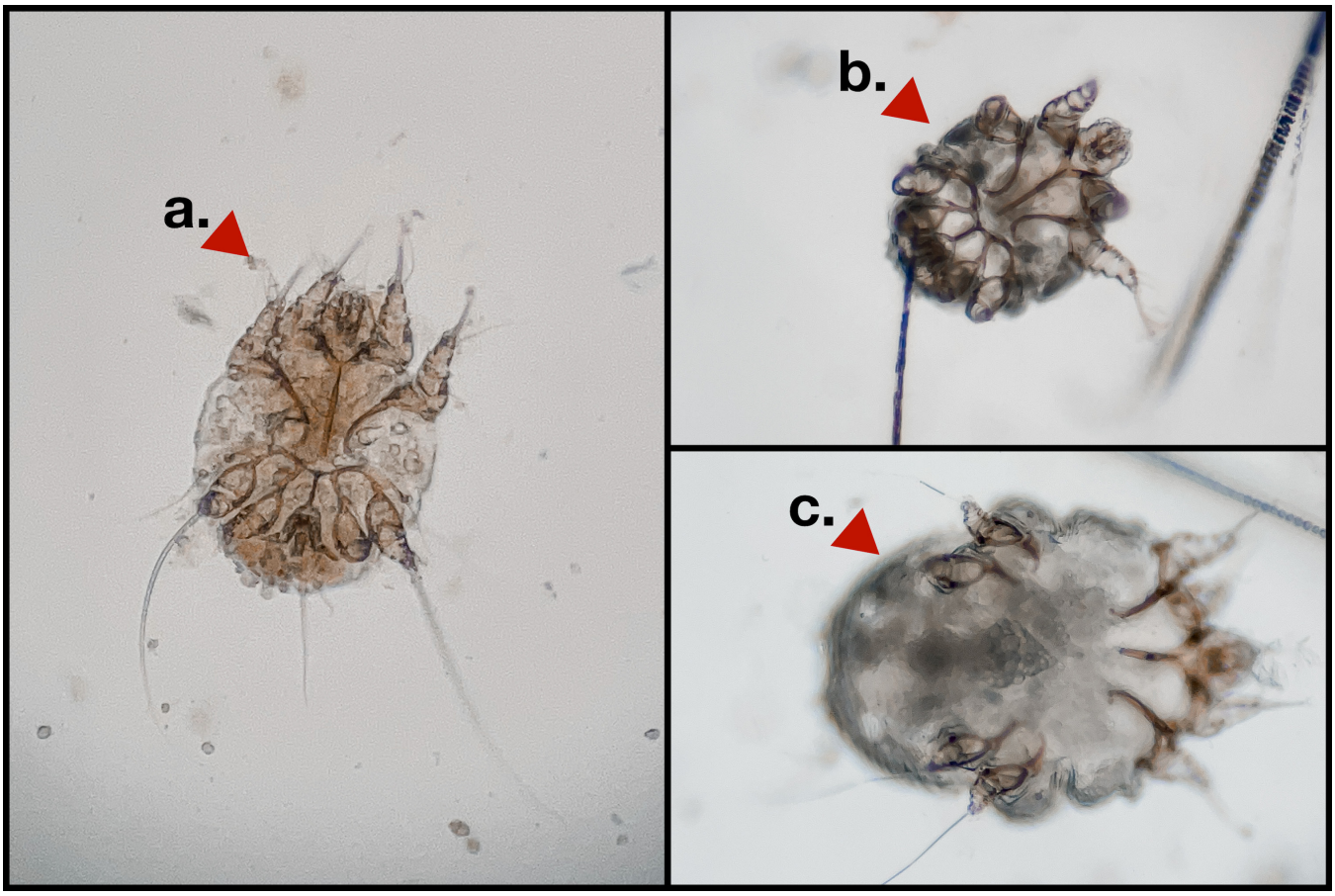


Figure 1. *Sarcoptes scabiei*, skin scraping samples, red foxes (*Vulpes vulpes*). a) ventral surface of an adult male *Sarcoptes scabiei*. b) ventral surface of a *Sarcoptes scabiei* protonymph. c) ventral surface of a pregnant adult female *Sarcoptes scabiei*.

were placed into an environment capable of being disinfected multiple times per day and not into environments with hay, wood shavings, or similar and in outdoor enclosures during treatment was due to the potential for mites to fall off the host and reattach onto new hosts within 24 to 36 hours, as demonstrated by Arlian *et al.* (1984).

Samples were taken on the initial triage day to confirm infection and again on each day of treatment, prior to treatment. The author is aware of an amended schedule which has also been implemented and recommended by the CDC following a study on ivermectin resistance (Currie *et al.* 2004). Due to the poor condition each patient came in at the point of rescue and the risk of adverse reaction to the medication it was decided to not administer on day 2 and 9 according to that schedule, although the author is aware it can be beneficial in otherwise healthier more stable patients. Ivermectin was administered on treatment days (depending on the patient and their skin scraping result) 1, 8, 15, 22, 29, and for those still showing active infection, treatment was extended accordingly on a per patient basis and administered according to results on days 36, 43, 50, 57, 64 and 71 where necessary. It is recognised that red foxes being wild animals and their specific behaviour are known to exhibit the masking of health conditions or injuries until late stage, therefore by the time they are rescued they are often very advanced and significantly declined in their condition(s), as such they are at much greater risk of adverse reaction to pharmaceutical medications with known adverse reactions or ingredients that are likely to cause an adverse reaction or exacerbate existing symptoms, particularly on patients with a compromised lymphatic system and/or eliminatory organ problem where the elimination of toxins or foreign compounds need to be metabolised or eliminated *via* those routes. The author is aware that the BSAVA Small Animals Formulary 10th Edition Part A (the then current edition at the time of treatment of all patients) stated 200µg/kg (0.02mL/kg), q2wks for 4-6 weeks. (Allerton *et al.* 2020, Chitty *et al.* 2020). The author is also aware of various other therapies and medications shown to be effective against *Sarcoptes scabiei* (Bernigaud *et al.* 2016, 2018, Mounsey *et al.* 2017), none of which were used in the patients listed on this specific study and it should be noted that different protocols are used for different patients depending on their condition, other indications, stage of illness and other factors. For this study, the only patients listed are those where only ivermectin was used for the mange symptoms; any other therapies used, which were mostly nutritional and hydration based, were not known to have any contraindications with ivermectin. The volume of mites was not determined at any point throughout each patient's treatment, as this would have been both impractical and unnecessarily invasive to attempt to determine — one of the important factors during the patients' rehabilitation was comfort and providing a stress free environment for recovery, merely the presence of clinical evidence of infestation was sufficient. The 7-day intervals between ivermectin administration were followed so as not to overload the already immunocompromised patients, since, in the author's experience, usually when foxes are admitted to rehabilitation care with mange, they are often quite advanced and significantly sick with co-morbidities.

While skin samples were taken upon initial triage to confirm infection (see "First Triage" column in Supplementary Table S1), treatment for mange itself was not started immediately due to each patient's other indications and their compromised immune system as the priority was to heal the patients effectively and safely and not cause any unnecessary potential of medication induced shock or adding any toxic ingredients to a patient struggling to eliminate additional toxins through a poorly functioning lymphatic system and eliminatory organs, factoring in the potential adverse reaction to early administration of pharmaceutical drugs where contraindications and adverse reactions are known. For this reason, treatment was started

once patient's overall condition was stable, (recorded in Supplementary Table S1 as "Day 1"), referring to Day 1 of ivermectin treatment, administered sub-cutaneous by injection of POM-V ivermectin 1% injectable w/v solution (in this case 'Noromectin' or 'Ivomec') as a single dose rate for confirmed presence of *Sarcoptes scabiei* of 200µg/kg (0.02mL/kg), Q7days until confirmation of eradication by way of two consecutive negative microscopy examined skin scraping results on multiple lesion sites or previously infected sites on the body. The plasma half-life of ivermectin varies depending on the dose, formulation, and regimen.

After the first triage, the time between said triage on the day of patient intake to the first day of ivermectin administration depended upon the stability of the patient, which ranged anywhere from around 3–6 weeks. In most cases, the patient was bathed after the initial skin samples were taken during first triage, to ease their skin condition somewhat and reduce the potential for infected wounds, and then bathed a second time usually up to 7 days later, as a follow up using mild cruelty-free dog shampoo which all patients tolerated well. The author has found this to be the best method of hygiene for the patients and has been shown to improve patient comfort. Stress-induced or restraint-induced myopathy has not been observed in stable patients. In fact, red foxes tolerate treatment well in the right environment, provided the carer understands red fox behaviour and is experienced in interpreting it as well as providing the right environment for recovery. Red foxes when handled safely and correctly simply muzzle and correct manual handling by hand generally in most cases leads them to be quite submissive, particularly when immunosuppressed or significantly sick or injured, even masking pain which can be challenging for veterinary professionals with little to no prior experience with red foxes. With that said the author has not seen any instances in capture myopathy in any red fox patient thus far. The author is aware that a number of organisations choose to instead attempt to regularly massage vegetable based oils (such as off the shelf supermarket seed oils) into the infected and dirty skin of red fox patients in an attempt to loosen the crust, the author has found this to be unnecessarily stressful, messy, unhygienic and not as effective as simply bathing with shampoos on up to two occasions. It is recognised by the author that mange in red foxes is usually a much later symptom of the result of other indications, and as such mange appears to be the least of the patients' concerns when they are at the stage of rescue. The author has found over 7 years at the time of writing that red fox patients brought in with natural infections of mange mites were chronically or acutely immunocompromised and/or injured, suggesting the underlying conditions preceded and likely led to the mite infestation. The author has no records of a patient treated for mange without other co-morbidities, of higher treatment priority. The age and stage of the mange mites infestation further indicated that the mites infestation were relatively younger than other conditions indicated by all patients. It has, therefore, been necessary to address the more serious, acute or chronic indications first to improve survival and recovery, and delay treatment against the mange mites until the patient is more stable. All patients in this study had compromised immune systems, likely to have declined them enough to create an environment suitable for sarcoptes mites and other parasites to later develop, survive and thrive in and on the patient, with the various defense mechanisms of the body otherwise unable to destroy and remove the live and dead parasites effectively.

Bodily locations of samples:
Method of sample was the same for each patient, a scalpel skin scraping taken at three sites on each patient, and examined under microscopy.

Adult patients were sampled from 3 sites on their body. Juvenile cubs were sampled from four. The same sites were sampled on each patient throughout to ensure consistency. The sites on the body at which the patients were sampled were as follows:

Adult red foxes:
Sample site 1
an obvious significant skin lesion site indicated on the patient.

Sample site 2
a second, different obvious significant skin lesion site indicated on the patient.

Sample site 3
base of the tail at the joining of the sacrum and caudal vertebrae area, a common site for skin parasites to fester.;

Juvenile red foxes: Same as adults, plus;
Sample site 4
on juveniles, samples were taken as per the adults and in addition from the head region, where possible the muzzle, forehead and behind ears - common areas for nursing and young cubs to contract mites by proxy during suckling from an infected vixen, which is usually how the very young end up with mange mites initially.

Simulated models of mite life cycle and ivermectin administration
To contextualise the in vivo findings of this study, I developed two simulated models theoretically visualising how mite life cycle stage and molt period timing might interact with ivermectin administration schedule. Each model follows the reproductive trajectory of a single female mite and her progeny across successive ivermectin doses, demonstrating how molt-period resistance could extend the number of treatments required for full eradication. The models are not predictive but are intended as visual representations to support interpretation of the treatment outcome data. The simulated models make the following assumptions:

(a) that the Mite Developmental Stages & Time Lengths are similar to those shown by Arlian & Vyszenski-Moher (1988) as summarised in Table 1.

(b) that ivermectin is administered by sub-cutaneous injection, once per 7-day interval, until confirmation of eradication of infection (in this case for up to 9 weeks);

(c) that ivermectin kills all three mites on the 3 egg timelines shown at the relevant point where no molting period is present on that day, (although, in reality, mites of different ages may vary), or;

(d) that at least one third of mites survive ivermectin administration on the individual 3 egg birth timeline where ivermectin administration coincides with any mite(s) who happen to be in any of the molt periods.

(e) that molt periods provide resistance to the ivermectin due to the possibility of protection from the cuticle (Arlian & Vyszenski-Moher 1988) since we know there is resistance to the medication, and there are three molt periods in the life cycle from egg to adult, therefore, 3 potential periods of time that approximately one third of the mites may resist and survive the ivermectin. Since mites lay approximately 2 to 3 eggs per day, this assumes a potential minimum 1-in-3 survival rate of the mite if, on the day of ivermectin administration, any of the mites are at one of the three molting stages.

(f) that at least one of the mites on each 3-egg timeline is female and reaches mating age and is able to lay eggs, and at least one mating age capable male is present for mating, bearing in mind this shows only the lifetime of a single original mite and the possibility of multiple mites present increases the chances and likelihood of this to a realistic assumption exponentially.

(g) that rescues who opt for ivermectin may do so due to the cost for one 50mL bottle of ivermectin capable of treating a

potential of at least 23 to 46 patients (if we assume a dose of 200-400µg/kg (0.02-0.04mL/kg) for the average adult weight of a fox patient at 6kg, assuming 9 doses in total over 9 weeks at 7 day intervals) comparable to a single tablet containing fluralaner, afoxolaner or sarolaner or a similar based tablet capable of treating one patient in one hit, making ivermectin potentially approximately 23 to 46 times more cost effective than one tablet, albeit more labour intensive, yet potentially 'safer'.

(h) that ivermectin has been chosen as a result of the indications of the fox patients requiring a milder, safer medication to prevent the possibility of medication-induced shock or toxicity or further damage to the patient based on known adverse reactions of other common medications.

(i) that the commonly used homoeopathic remedies commonly suggested for foxes with suspected mange by most fox rescues in the UK (and subsequently repeated by many members of the public on various online social media platforms) are ineffective, failing to address any of the patient's indications (Supplementary Table 1) common to new intake foxes with confirmed *Sarcoptes scabiei* mites.

Results

A total of 3420 skin scrapings were taken from 111 patients over the course of their respective treatment schedules (Figure 2, Supplementary Table S1). Where a skin scrape was positive for infection, eggs, larvae or any stage of mite, it was followed up with a dose of ivermectin. Supplementary Table S1 enlists each individual patient, their indications upon intake, initial triage and the minimum number of doses of Ivermectin 1% injectable w/v solution required for each individual patient, found to range between five and nine doses (given as one dose per 7-day interval).

Simulated Model

While the results of this study are based on actual samples and real in vivo data, the simulated models (Figures 3 & 4) show a very basic theoretical visual on how this can potentially occur since we know from the study by Feng *et al.* (2023) that there is potential for up to a third of mites surviving ivermectin due to molt period. The simulated models demonstrate this showing two different scenario examples of a single female mite life, mating and birth cycle, with subsequent life, mating and birth cycles of offspring in conjunction with ivermectin administration. The first model (Figure 3) follows a young female mite, having only had a potential opportunity to mate once, laying three eggs a day for four days before perishing from ivermectin exposure, with the resulting mites from those matings not surviving beyond three treatments of ivermectin but able to lay eggs before death and those resulting mites able to mate and lay eggs, but not survive beyond three further treatments. This example demonstrates that even for a young single mite that only managed to mate once and only give birth for four days, the host still required nine doses of ivermectin at one dose per 7-day intervals, due to molt periods and administration days coinciding with those molt periods. The second model (Figure 4) follows an older female mite, able to have mated and subsequently lay eggs for 19 days in a row, three eggs per day, and despite those hatched eggs and the resulting mites being able to reproduce multiple times yet the host only required six doses of ivermectin at one dose per 7-day interval to eradicate the entire bloodline based on the timing of the administration of the ivermectin and the fortunate timing of the molt periods on the original mite and subsequent offspring.

Table 1. Simulated model *Sarcoptes scabiei* mite life stages and time durations

Development Stage	Length of Time
Egg	2.08~2.21 days
Larvae	3.22~4.20 days, including 1~23 hour molt
Molt Stage 1 from larvae to Protonymph	1-23 hours in the final stages of the above 3.22~4.20 days
Protonymph	2.33-3.40 days, including 3-30 hour molt
Molt Stage 2 from Proto-nymph to Tritonymph	3-30 hours in the final stages of the above 2.33~3.40 days
Tritonymph	2~3.42 days, including 3-30 hour molt
Molt Stage 3 from Tritomyph to Adult Mite	3-30 hours in the final stages of the above 2~3.42 days
Adult Mite	1 to 2 months

The purpose of these simulated cycles was to demonstrate the variation in the need for dose schedule length based on known and theoretical yet plausible outcomes with in vivo infections.

This shows that the timing of ivermectin treatment and molt periods are a significant factor in the number of doses required due to molt period ivermectin resistance and the mites' potential one-third survival rates previously observed (Feng *et al.* 2023).

Effective doses and schedule

In all cases, in each patient, it was found that stabilising the patient and treatment of the co-morbidities was a higher priority over the *Sarcoptes scabiei* infection. Once treatment was started for the *Sarcoptes scabiei* infestation, the minimum doses were found to be between 5 and 9 doses (given as one dose per 7- day interval). The *Sarcoptes scabiei* resistance to ivermectin during any of the three life cycle molting processes is a likely factor. Ivermectin as a milder medication over a longer schedule was preferred over a single dose of other medication with higher toxicity risk, which did not pose a problem since the co-morbidities all required a long schedule to treat and recover from and all of the patients tolerated the captivity well since a comfortable environment was provided and patients were supervised by a care provider with experience in red fox behaviour, body language and medical care.

It was not clear during this study whether the non-responsiveness of some patients to some doses was due to resistance or due to other operational factors. It was not possible to determine with certainty whether the life cycle of the mites and the molting period resistance was a factor or whether biofilms in general came into play. All environmental factors were the same across all patients, although co-morbidities differed across many of the patients (other than juvenile siblings rescued together), and it is unclear whether there were any patient-specific biochemical factors in relation to their other indications having an effect on the ivermectin efficacy. I can only speculate the possibility of the mite molting periods playing a role, given that patients with the same or similar indications had different reactions, including same-age siblings (juveniles rescued together at similar stages of infection, for example).

While there have been a variety of treatment methods published for wildlife, there still appears to be a lack of consensus, particularly with red foxes (Rowe *et al.* 2019).

Other Findings:

While not part of this report, all adult red foxes in this study were found to have lungworm eggs (*Eucoleus aerophilus* and/or *Eucoleus boehmi*) in each of their faecal floats under microscopy, all of whom were asymptomatic and separately treated accordingly prior to release back to the wild.

Clinical significance:

Red foxes usually mask injury and health conditions incredibly

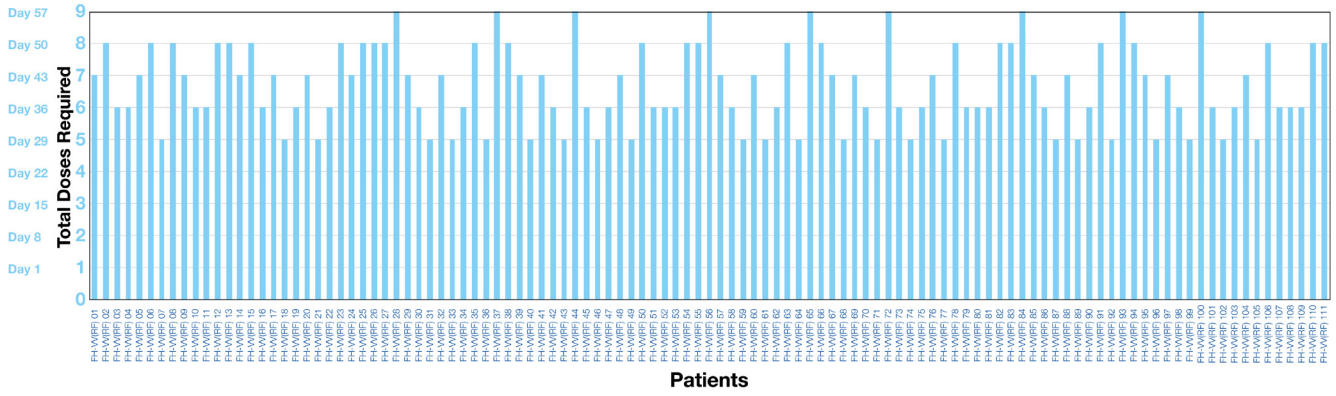


Figure 2. Summary of the number of doses of ivermectin 1% injectable w/v solution required for each individual patient to eradicate the infestation of *Sarcoptes scabiei*, ranging between 5 and 9 doses (given as one dose per 7-day interval).

well until extremely advanced and often signs of slow decline can be almost undetectable until final stages, sometimes within days, hours or minutes of death. This means a fox may seem fine, even with extreme injuries or conditions, until hours or minutes before passing away due to their natural survival instincts. Experience with and knowledge of the species behaviour and body language, or consulting with those who have, is essential to effectively treating and diagnosing. This can also be a reason foxes are not rescued until advanced stages of indications are obvious.

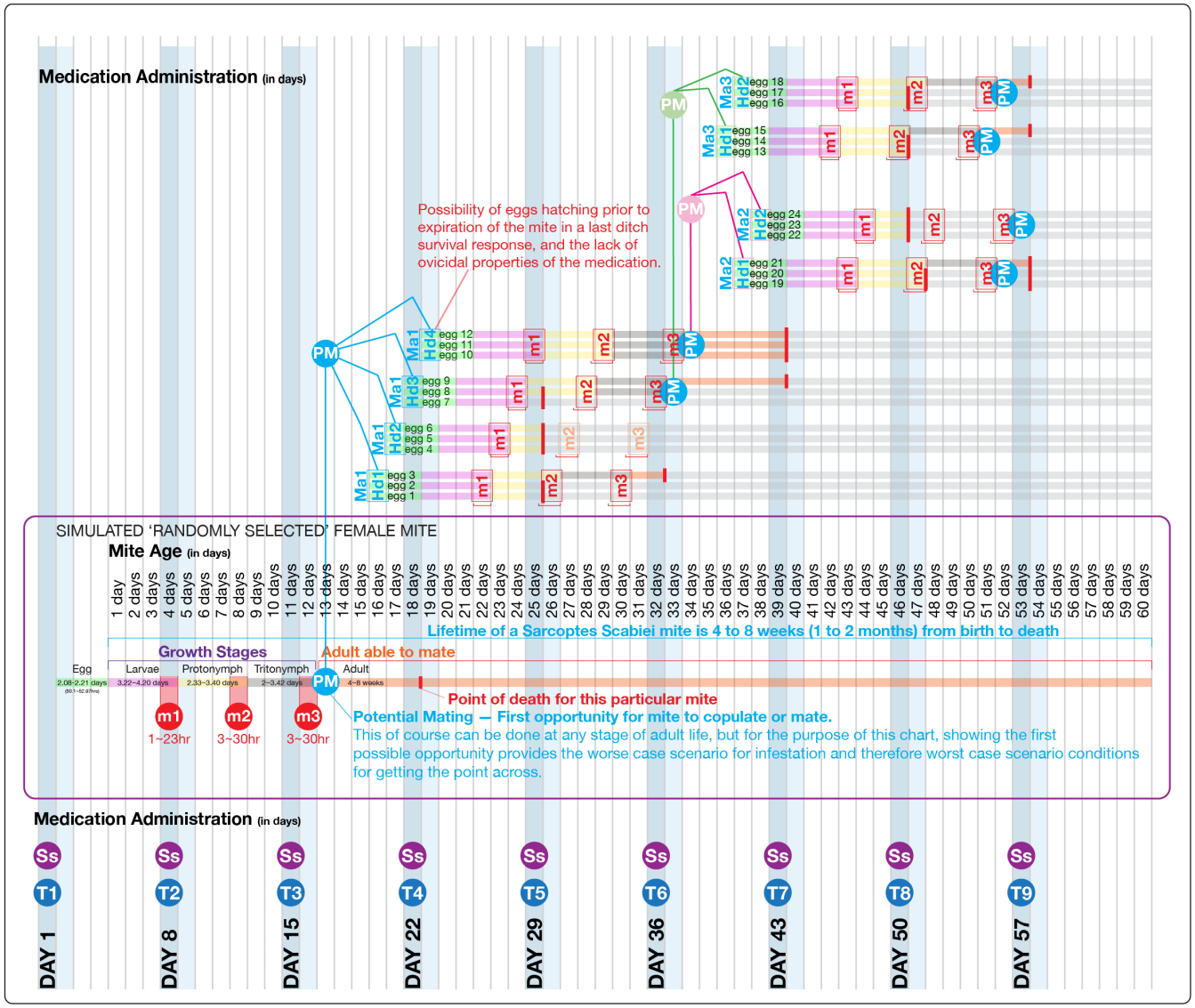
Discussion

While ivermectin remains a common treatment, studies on newer drugs such as isoxazolines may have superior efficacy and a single-dose regimen due to longer half- life and coverage for the entire mite life cycle, and to avoid repeated handling. As this was a retrospecific case series, where patient records were selected retrospectively, the qualifying criteria for patients discussed in this paper were those being administered ivermectin specifically; therefore, a comparative study was not carried out, and those administered isoxazolines or other remedies instead were not included. It should be noted, however, that the condition red foxes come into care in these cases is usually at an advanced stage. By the time foxes are able to be seen or captured for treatment, it is usually because they have become weak, desperate, and finally showing signs of distress and disease. Red foxes are remarkably resilient acting on natural instincts for survival. They are well known among those who hold expertise in their behaviour, lifestyle and medical treatments to mask pain and medical conditions with almost absolute mastery. By the time a red fox shows symptoms, they are usually unable to mask these any longer, which means patients like these usually need to be considered urgent cases. Red foxes are not like companion animals, who may show symptoms very early on. In the cases discussed above, this means the patients were already advanced in their inability to filter out toxic loads efficiently, and so their elimination pathways were a priority area of concern and of higher priority than the *Sarcoptes scabiei* infection. Many of the foxes in these presented cases had a very guarded prognosis upon intake, so lessening toxic shock potential or further toxin intake was a consideration. For this reason, isoxazolines were not administered as the patients required long-term care for their comorbidities, as is often the case with *Sarcoptes scabiei* red fox patients. Even if isoxazolines are chosen, many of the comorbidities they have take many weeks to rectify effectively regardless of avoiding relapse after release back to the wild.

Given this, it is suggested that caution may be warranted if choosing isoxazolines due to the potential additional toxic load and the initial temporarily retarded elimination pathways, considering that comorbidities noted in many of the patients included renal, hepatic and lymphatic drainage indications with anaemia. If choosing this classification of treatment, delaying their use would be suggested, which in some cases may negate one of their main benefits of single use, particularly as some rescue centres may appear to choose them for the purpose of reducing captivity time. To the author's knowledge, from own experience and discussions with other rehabilitators over the years, isoxazolines or other pharmaceutical or synthetic drugs may potentially cause suspected toxin-related adverse reactions or potentially fatal results if given too early, which the author has witnessed in early cases leading to a change in regimen and schedule.

In many cases, the author finds success in choosing to carry out cleaning of the patient's skin upon intake by bathing while following handling caution such as the use of effective muzzle, proper handling without the need of bite gloves (full arm-length gloves with nitrile over gloves and disposable apron are usually sufficient and provide effective dexterity and safe handling), and the use of a veterinary tub table with a quiet warm free flowing shower attachment nozzle. A mild flea, tick and anti-fungal shampoo was used in these specific cases to address any potential topical bacterial and fungal presence. This seems to be sufficient. In some cases, a second bathing is followed up one or two weeks later on a case-by-case basis and depending on the patient's behaviour and personality as they recover and as the skin improves with sloughing of crust and dead skin. Red foxes have a very dense double coat, so this bathing helps provide a less favourable environment for any stage of the mite life cycle.

Many foxes in cases like these where they are significantly immunocompromised are accepting of the treatment through weakness and almost limp or unreactive (as opposed to patients with minor ailment who are still able to be naturally full defensive), making this process in the first few hours of rescue fairly straight forward. No lasting mental or physical adverse effects were shown in any of the patients bathed. Some may choose to administer natural or pharmaceutical methods surrounding bacterial infection of the skin, the author has found oral pharmaceutical antibiotics to be mostly unnecessary unless there are clear indications and confirmation of specific bacterial overgrowth on wounds (such as those who came into care with bite wounds), and is assessed on a case-by-case basis. In this paper, the patients without wounds relating to other injuries were not administered pharmaceutical antibiotics, in favour of preserving the gut microbiome to aid healing. Due to the bathing stage, the author saw nothing to indicate that antibiotics were required throughout the entire treatment schedule for those admitted without infected wounds unrelated to the *Sarcoptes scabiei* infection (such as animal bites).



Key

- Day Markers - One vertical line increment = 1 day (24 hour period)
- 3 potential lifelines of 3 separate eggs and therefore 3 separate life span potentials for 3 individual mites. Point of death for the respective mite from the medication.
- Ss — Skin scrapings performed
- Ivermectin Administered on this day
- Ivermectin half-life within 12-18 hours after administration, becoming less effective.
- Tn — Treatment No. — Ivermectin Administered on this day. Ivermectin Given Sub-cutaneous (s.c.) - Treatment No. (T1 = Treatment 1, T9 = Treatment 9), etc. Half-Life, 2 days. Most effective within first few hours.
- m1 — Molt Period 1; (1~23 hours). Larvae to Protonymph. Ivermectin Resistance.
- m2 — Molt Period 2; (3~30 hours). Protonymph to Tritonymph. Ivermectin Resistance.
- m3 — Molt Period 3; (3~30 hours). Tritonymph to Adult. Ivermectin Resistance.
- PM — Potential Mating, and its respective mating number.
- Man Hdn — Hatch day, and t's related Mating event— day on which an egg hatches after a Potential Mating

- T1 — Treatment No. 1 — Original simulated mite. Dose ineffective - Ivermectin non-ovicidal.
- T2 — Treatment No. 2 — Original simulated mite. Dose potentially 33% ineffective - Molt period. 1/3rd of mite survival.
- T3 — Treatment No. 3 — Original simulated mite. Dose potentially 33% ineffective - Molt period. 1/3rd of mites survival.
- T4 — Treatment No. 4 — Original simulated mite. Dose effective - Mite perished, but had opportunity to mate and lay up to 9 eggs. Ineffective on newly birthed eggs, non-ovicidal. All egg survival.
- T5 — Treatment No. 5 — Newly birthed eggs 1–12 from Original mite. Dose potentially effective against new mite larvae 1–6. Dose ineffective against new mite larvae 7–12.
- T6 — Treatment No. 6 — Birthed mites 7–12. Dose potentially 33% ineffective - Molt period. Mite survival. Mites 9–12 potential opportunity to mate.
- T7 — Treatment No. 7 — Birthed mites 13–24. Dose ineffective - Mites 13–15 under-developed CNS. Ineffective on newly birthed eggs 16–24, non-ovicidal. All egg survival.
- T8 — Treatment No. 8 — Birthed mites 13–24. Dose potentially 33% ineffective against mites 13–18, and 19–21, Molt period. Dose effective against mites 22–24, Mites perished.
- T9 — Treatment No. 9 — Birthed mites. Dose effective against all remaining selected mites.
- Important Note: This only factors one starter mite and her subsequent offspring. An infected patient would likely be infested with many more mite at different life stages, exponentially

Figure 3. Simulated model of a young female mite that mated once and laid 3 eggs/day for 4 days before dying from ivermectin. Resulting offspring survived up to 3 treatments, mating and laying eggs before death; their offspring similarly did not survive beyond 3 further treatments. Despite originating from a single, short-lived female, the host still required 9 ivermectin doses at 7-day intervals to eradicate the infestation, owing to molt periods coinciding with administration days. (To download high resolution, click here)

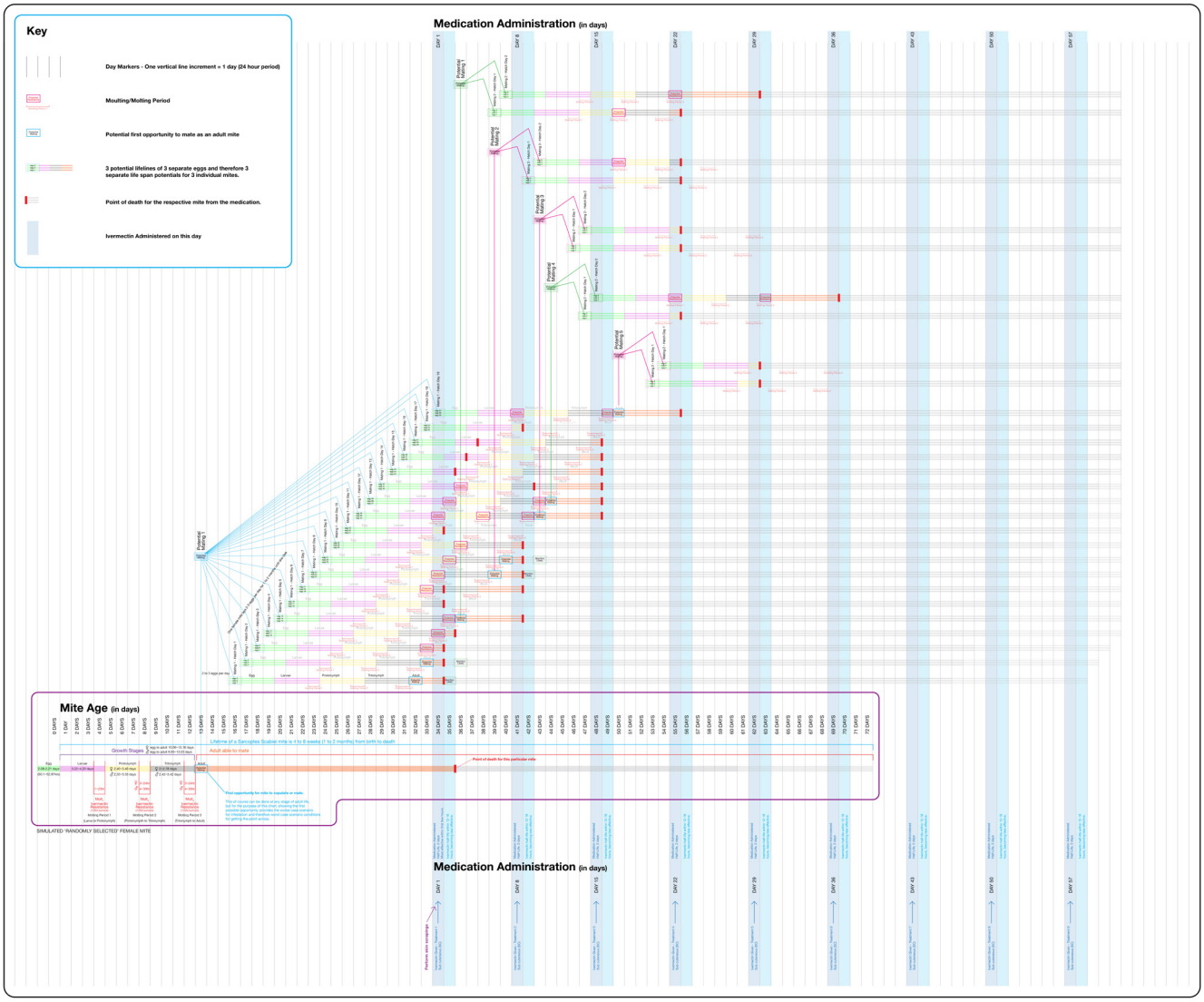


Figure 4. Simulated model of an older female mite (cf. Fig 2.) that laid 3 eggs/day for 19 consecutive days, with resulting offspring reproducing multiple times. Despite greater reproductive output than Fig 2., the host required only 6 ivermectin doses at 7-day intervals to eradicate the theoretical bloodline, owing to favourable timing of administration relative to molt periods in the original mite and her offspring.
(To download high resolution, click here)

Recommendations on red fox rescue

It is the author's opinion through treating a large number of patients like this over the years (Fox, R., unpub. data) that the treatment of *Sarcoptes scabiei* in the wild population of red foxes, through rescue organisations should be treated as a secondary issue and the primary issues, such as malnutrition and/or wounds rectified as a priority with the mange treated once the patient is stable and improved somewhat and their elimination pathways are functioning optimally, with full confirmation by skin scrapings (not assumptions) to confirm complete eradication of the mange, and healing of other co-morbidities (which could be between 6–10 weeks or longer before releasing back to the wild to increase chances of survival and reduce possibility of reinfection upon release. It would also be prudent to factor in the original reason for rescue and indications of the patient which regards to whether it is best practice to releasing the fox back to the exact location or to soft release carefully and effectively to another area abundant with natural resources and prey without disrupting the balance in that area, on the basis of a patient coming in with severe malnutrition and whether it would be wise to release back to an area clearly lacking in natural resources or where they may have been pushed away from available food (particularly in heavily populated urban environments with competitive resource guarding by other wildlife or red foxes) or in an area that has a known problem for mange suffering foxes. The author believes it is the responsibility of any organisation rescuing and/or rehabilitating red foxes with a view to release back to the wild upon healthy recovery to make sufficient efforts to survey the area and ensure survival chances rather than a quick turnaround of patients and releasing them to the same location for convenience. It should be noted that in the author's experience of personal hands-on care with many foxes of different indications, red foxes generally tolerate both short and long-term veterinary captivity during treatment so long as the right enclosure, regimen and calm, supervised environment are provided, and the carers respect and understand fox-specific behaviour and body language.

TO DOWNLOAD SUPPLEMENTARY MATERIAL, CLICK **HERE.**

Acknowledgment

The author thanks Dr Kwint HNE, Dr Giurgiu RS, Dr Klocek M, Dr Hamilton CV, and RVN's Williams C, Horsnell MA, Newman GN, Klein NE, and Berwick L for assistance in triage/examination of a small number of the patients in this manuscript, and Dr Lategan J and Hill DJ for kind support and assistance.

CONFLICT OF INTEREST

Ryan Fox is the founder of The Fox Hospital, where the patients were treated; however, the treatment was carried out as part of standard routine care at the charity and not for commercial purposes, so there was no financial gain, with the manuscript being written retrospectively from previous records simply reporting patient findings.

DATA AVAILABILITY

All data underlying the results, including tables and figures, are available as part of the article, and no additional source data are required.

AUTHOR CONTRIBUTIONS

Conceptualisation: RF.
Sample gathering, Data Curation and Formal Analysis: RF.
Investigation, Methodology and Project administration: RF.
Writing — original draft and preparation: RF.
Writing — review: RF.

References

Arlian, L. G. & Vyszenski-Moher, D. L. (1988). Life cycle of *Sarcoptes scabiei* var. *canis. The Journal of Parasitology*, 74(3), 427–430. https://doi.org/10.2307/3282050

Arlian, L. G., Runyan, R. A., Achar, S. & Estes, S. A. (1984). Survival and infectivity of *Sarcoptes scabiei* var. *canis* and var. *hominis*. *Journal of the American Academy of Dermatology*, 11(2 Part 1), 210–215. https://doi.org/10.1016/S0190-9622(84)70151-4

Allerton, F., Batchelor, D., Bexfield, N., Chan, D. L., Featherstone, H., Frowde, P., Helm, J., Hodgkiss-Geere, H., Kent, A. *et al.* (2020). BSAVA Small Animal Formulary (10th ed., Part A: Canine and Feline). *BSAVA*. pp. 6–7, 164–165, 172–173, 216, 369.

Bernigaud, C., Fang, F., Fischer, K., Lespine, A., Aho, L. S., Dreau, D., Kelly, A., Sutra, J. F., Moreau, F. *et al.* (2016). Preclinical Study of Single-Dose Moxidectin, a New Oral Treatment for Scabies: Efficacy, Safety, and Pharmacokinetics Compared to Two-Dose Ivermectin in a Porcine Model. *PLoS Neglected Tropical Diseases*, 10(10), e0005030. https://doi.org/10.1371/journal.pntd.0005030

Bernigaud, C., Fang, F., Fischer, K., Lespine, A., Aho, L. S., Mullins, A. J., Tecle, B., Kelly, A., Sutra, J. F. *et al.* (2018). Efficacy and Pharmacokinetics Evaluation of a Single Oral Dose of Afoxolaner against *Sarcoptes scabiei* in the Porcine Scabies Model for Human Infestation. Antimicrobial Agents and Chemotherapy, 62(9), e02334-17. https://doi.org/10.1128/aac.02334-17

CDC (2023). *Clinical Care of Scabies*. U.S. Centers for Disease Control and Prevention. https://www.cdc.gov/scabies/hcp/clinical-care/index.html [February 2025]

Chitty, J., Hedley, J., Saunders, R., Hildgoose, W. H. & Wissink-Argilaga, N. (2020). BSAVA Small Animal Formulary (10th ed., Part B: Exotic Pets). *BSAVA*. pp. 169–170.

Crump, A. & Ōmura, S. (2011). Ivermectin, "wonder drug" from Japan: the human use perspective. *Proceedings of the Japan Academy, Series B*, 87(2), 13–28. https://doi.org/10.2183/pjab.87.13

Currie, B. J., Harumal, P., McKinnon, M. & Walton, S. F. (2004). First documentation of in vivo and in vitro ivermectin resistance in *Sarcoptes scabiei*. *Clinical Infectious Diseases*, 39(1), e8–e12. https://doi.org/10.1086/421776

Feng, S., Shi, M., Yin, Z., Di, W., Guillot, J. & Fang, F. (2023). Can Ivermectin kill *Sarcoptes scabiei* during the molting process? *PLoS Neglected Tropical Diseases*, 17(5), e0011337. https://doi.org/10.1371/journal.pntd.0011337

Furnival-Adams, J., Kiuru, C., Sagna, A. B., Mouline, K., Maia, M. & Chaccour, C. (2024). Ivermectin resistance mechanisms in ectoparasites: a scoping review. *Parasitology Research*, 123(5), 221. https://doi.org/10.1007/s00436-024-08223-z

Kaplan, R. M. (2004). Drug resistance in nematodes of veterinary importance: a status report. *Trends in Parasitology*, 20(10), 477–481. https://doi.org/10.1016/j.pt.2004.08.001

Laing, R., Gillan, V. & Devaney, E. (2017). Ivermectin—Old Drug, New Tricks? *Trends in Parasitology*, 33(6), 463–472. https://doi.org/10.1016/j.pt.2017.02.004

Mounsey, K. E., Walton, S. F., Innes, A., Cash-Deans, S. & McCarthy, J. S. (2017). In Vitro Efficacy of Moxidectin versus Ivermectin against *Sarcoptes scabiei*. *Antimicrobial Agents and Chemotherapy*, 61(8), e00381-17. https://doi.org/10.1128/AAC.00381-17

NHS (2024). *Clinical Guideline: Scabies Therapeutic Management, Acute & Primary Care.* National Health Service. https://rightdecisions.scot.nhs.uk/media/q3cnc1dq/1179-scabies-therapeutic-management-acute-primary-care-v1.pdf [February 2025]

Rowe, M. L., Whiteley, P. L. & Carver, S. (2019). The treatment of sarcoptic mange in wildlife: a systematic review. *Parasites & Vectors*, 12(1), 99. https://doi.org/10.1186/s13071-019-3340-z

Scott, D. M., Baker, R., Tomlinson, A., Berg, M. J., Charman, N. & Tolhurst, B. A. (2020). Spatial distribution of sarcoptic mange (*Sarcoptes scabiei*) in urban foxes (*Vulpes vulpes*) in Great Britain as determined by citizen science. *Urban Ecosystems* 23, 1127–1140. https://doi.org/10.1007/s11252-020-00985-5

Shoop, W. L. (1993). Ivermectin resistance. *Parasitology Today*, 9(5), 154–159. https://doi.org/10.1016/0169-4758(93)90136-4

Soulsbury, C. D., Iossa, G., Baker, P. J., Cole, N. C., Funk, S.M. & Harris, S. (2007). The impact of sarcoptic mange Sarcoptes scabiei on the British fox *Vulpes vulpes* population. *Mammal Review*, 37, 278-296. https://doi.org/10.1111/j.1365-2907.2007.00100.x

ISSN (Online): 3048-7803

JWLS

Volume 3 Issue 2 (June 2026)

TYPE Research Article

Community Perceptions and Social Feasibility for Gaur (*Bos gaurus gaurus*) Reintroduction in Nagarjunasagar-Srisailam Tiger Reserve, Andhra Pradesh

Ritesh Vishwakarma[1,2], Arun Kumar Gorati[1,2], Swati Chandola[1], Habeeba Fathima[1], Anukul Nath[1], Samrat Mondol[1,2], Bilal Habib[1,2], Ajaya Kumar Naik[3], B.N.N. Murthy[3], Vignesh Appavu G.[3], Parag Nigam[1,2,*]

[1]Wildlife Institute of India, Chandrabani Road, Dehradun, Uttarakhand, 248001
[2]Academy of Scientific and Innovative Research, Kamla Nehru Nagar, Ghaziabad, Uttar Pradesh, 201002
[3]Andhra Pradesh Forest Department, Aranya Bhavan, Guntur, Andhra Pradesh, 522503

EDITED BY
Shivam Shrotriya
Wildlife Institute of India, Dehradun, India.

*CORRESPONDENCE
Parag Nigam
nigamp@wii.gov.in

RECEIVED 16 May 2025
ACCEPTED 17 June 2026
PUBLISHED 05 July 2026

CITATION
Vishwakarma, R., Gorati, A. K., Chandola, S., Fathima, H., Nath, A., Mondol, S., Habib, B., Naik, A. K., Murthy, B. N. N., Appavu, G. V., Nigam, P. (2026). Community Perceptions and Social Feasibility for Gaur (*Bos gaurus gaurus*) Reintroduction in Nagarjunasagar-Srisailam Tiger Reserve, Andhra Pradesh. *Journal of Wildlife Science,* 3(2), 62-72.
https://doi.org/10.63033/JWLS.PDNP5891

FUNDING
This work was supported by the Andhra Pradesh Forest Department

COPYRIGHT
© 2026 Vishwakarma, Gorati, Chandola, Fathima, Nath, Mondol, Habib, Naik, Murthy, Appavu, Nigam. This is an open-access article, immediately and freely available to read, download, and share. The information contained in this article is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited in accordance with accepted academic practice. Copyright is retained by the author(s).

PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001
INDIA

PUBLISHER'S NOTE
The Publisher, Journal of Wildlife Science or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this article. All claims expressed in this article are solely those of the author(s) and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in this article or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

Abstract

Understanding the human dimension is essential for effective wildlife conservation management. It is especially important to identify the extent of support for conservation translocation of species involved in human-animal conflict among local communities, particularly those dependent on the forests within the translocation region. The reintroduction of megaherbivores into their historical habitats to restore biodiversity and ecological functions is an emerging topic of interest. In this study, we assessed the social feasibility of gaur (*Bos gaurus gaurus*) reintroduction in the Nagarjunasagar Srisailam Tiger Reserve (NSTR), Andhra Pradesh, India. The study focused on community perceptions, current socio-economic conditions, and perceived risks associated with the prospective reintroduction of gaur. We conducted a semi-structured voluntary questionnaire survey of 109 personnel representing distinct households residing in 22 villages within the core and buffer zones of the NSTR. Data were analyzed using logistic regression models to examine possible influences on public attitudes toward gaur reintroduction. The results indicate that occupation, resource dependency, and fear of potential harm influenced current attitudes. Although 52% of respondents reported no fear of encounters with gaurs, concerns about crop damage and limited access to forests were common among the forest-dependent households. Approximately three-quarters (75%) of respondents were aware of conservation action, with 83% noting that wildlife populations have increased over time. Younger participants and larger households displayed a more positive stance towards gaur reintroduction; however, fear and potential loss remained major deterrents. This study highlights the need for targeted awareness campaigns, effective conflict mitigation measures, and conservation-based approaches that engage the community to increase acceptance of gaur reintroduction in NSTR.

Keywords: Community perspectives, conservation translocation, crop depredation, human-wildlife conflict, megaherbivore, protected area management.

Introduction

The accelerating decline of large terrestrial mammals poses profound ecological consequences, as more species vanish from their historic ranges (Ceballos *et al.*, 2005). Among these, megaherbivores such as elephants, rhinos, and gaur play a crucial role as ecological architects, profoundly impacting vegetation structure, nutrient cycling, predator-prey dynamics, and trophic interactions while affecting the composition and dynamics of ungulate communities (Owen-Smith, 1988; Fritz *et al.*, 2002; Mondanaro *et al.*, 2017). Their presence supports ecological balance, while their decline has been closely associated with significant disruptions in ecosystem processes, underscoring their role in maintaining environmental stability (Berzaghi *et al.*, 2022). Despite their ecological significance, mega herbivores face threats from hunting, competition with livestock, and land-use change, including habitat loss, human encroachment, cultivation, and deforestation (Ripple *et al.*, 2015). By the end of the 20th century, 84 of the 175 species of large herbivores were classified as Critically Endangered, Endangered or Vulnerable (IUCN 2002).

To combat these losses, reintroducing species to their historical ranges is an increasingly recognized conservation method that promotes population recovery and strengthens entire ecosystems (Godet *et al.*, 2018; Novak *et al.*, 2021; Fischer & Lindenmayer 2000; IUCN/SSC, 2013). Such reintroductions involve relocating animals bred in captivity or from existing wild populations to regions where they have

gone extinct (Seddon *et al.*, 2007). Some examples of successful conservation relocations from around the world include Père David's deer (*Elaphurus davidianus*) in Poyang Lake National Wetland Park, China (Jiang *et al.*, 2000), and the restoration of white rhinoceroses (*Ceratotherium simum*) in Kruger National Park (Cromsigt *et al.*, 2014). The red-rumped agouti (*Dasyprocta leporina*) has been reintroduced in Rio de Janeiro, Brazil's Tijuca National Park. European bison (*Bison bonasus*) are being brought back to Romania's Vanatori Neamt Nature Park (Soorae *et al.*, 2021). Successful relocations in India include tiger (*Panthera tigris*) in Sariska Tiger Reserve (Sankar *et al.*, 2013) and gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve (BTR) and Sanjay Tiger Reserve (Nigam *et al.*, 2019; 2024a).

However, not all reintroduction efforts succeed, often due to a lack of social and political considerations, including insufficient support for conservation goals from local communities (Griffith *et al.*, 1989). Although wildlife relocations have become a frequently applied tool in conservation over the past 25 years, few studies evaluate the social dimensions that often influence their success (Seddon *et al.*, 2016; Brichieri-Colombi *et al.*, 2016). Recognizing these challenges, contemporary conservation strategies increasingly incorporate social feasibility assessments to ensure that reintroduction plans align with community interests and mitigate potential conflicts (Seddon *et al.*, 2016; Brichieri-Colombi *et al.*, 2016).

Social feasibility refers to the extent to which local attitudes, values, and beliefs align with conservation objectives, and it relies on the community's ability to recognize potential benefits while creating solutions for perceived and actual challenges (Reading & Kellert 1993; Redpath *et al.*, 2013). Concerns such as fear of livestock depredation, economic loss, inadequate compensation for wildlife–related losses, personal safety, and restricted access to forest resources can build resistance to management and conservation initiatives (Allendorf *et al.*, 2006; Talukdar & Gupta, 2014). Intangible factors, such as anxiety and perceived threats associated with the presence of large carnivores and megaherbivores, frequently contribute to negative public perceptions of species reintroduction efforts (Hiroyasu *et al.*, 2019; LeFlore *et al.*, 2020). However, when local communities recognize tangible benefits from forests and wildlife such as enhanced ecosystem services, improved livelihoods, increased biodiversity, and opportunities for ecotourism, their attitudes toward conservation initiatives, including species reintroductions, tend to become more favorable (Williams *et al.*, 2002; Lindsey *et al.*, 2005; Lamichhane *et al.*, 2018; Sakurai *et al.*, 2020).

Understanding social dynamics becomes especially important when reintroducing species that have declined in the past (Nigam *et al.* 2014; Nigam *et al.* 2024a & b). The gaur, one of India's iconic megaherbivores, was historically present across diverse forested landscapes. Owing to habitat degradation, poaching, and changing land-use patterns, the species have become locally extinct in several areas, including Sanjay Tiger Reserve, Bandhavgarh Tiger Reserve, Kanger Valley National Park, and Thattekad Wildlife Sanctuary (Sankar *et al.*, 2001). Historical records, such as the 19th-century Imperial Gazetteer of India (Hunter, 1886), mention that the forests of Nagarjuna Srisailam Tiger Reserve (NSTR) once harbored viable gaur populations. However, decades of habitat loss and hunting pressure have rendered the species locally extinct in NSTR.

This study was conducted as part of the Gaur Reintroduction Plan for NSTR aimed at reintroducing and restoring the gaur population within NSTR. We conducted a social feasibility assessment for the reintroduction of gaur to NSTR to answer two questions: (1) How do local communities perceive the reintroduction of gaur? (2) What factors shape community attitudes toward the reintroduction of gaur in NSTR?

Materials and Methods

Study Area

The study was conducted in Nagarjunasagar Srisailam Tiger Reserve, Andhra Pradesh, India (Figure 1). The reserve is known as India's largest tiger reserve, spanning 3727.82 km^2 (NSTR - Tiger Conservation Plan, 2013-2023). The area is characterized by hilly terrain, plateaus, ridges and valleys that host tropical dry deciduous and tropical moist deciduous forests with bamboo and grasslands dispersed throughout (Qureshi *et al.*, 2023; Yadav *et al.*, 2023). The tiger reserve is hosted along the Nallamala range and fed by the river Krishna along the northern border for a 130 km stretch. The region receives an average annual rainfall of 676 mm, primarily from the southwest monsoon. Temperatures range from 16°C to 46°C, with perennial streams and springs such as Palanka Waterfall and Gundlakamma River (Yadav *et al.*, 2023). Within the reserve, 3,285 people live across 10 villages in the core and 12 in the buffer, primarily belonging to Chenchu, Lambadi, Yadava, and Vaddera communities (NSTR - Tiger Conservation Plan, 2013-2023).

Social Survey

A questionnaire survey was conducted to assess social feasibility in NSTR. A structured questionnaire (Supplementary S1) was developed, drawing on the frameworks proposed by Vasudeva *et al.* (2021), Gillingham & Lee (2003), Bhattacherjee (2012), and Karanth & Ranganathan (2018). The survey included both closed and open-ended questions to evaluate knowledge levels and opinions on the reintroduction of the species in forests where the communities reside and are dependent. A reconnaissance survey was conducted from May to July 2024 to understand the socio-economic status, livestock practices, non-timber forest produce (NTFP) usage, and community perceptions toward wildlife conservation. The survey was conducted over 20 days across 22 villages situated within the core and buffer zones of NSTR. A total of 109 individuals, each from a different family, were interviewed; the survey represented approximately 3.3% of the resident population. The survey was conducted by two trained interviewers familiar with the local language and each interview lasted approximately 20–25 minutes. Participants were initially selected randomly within each village (Vodouhê *et al.*, 2010; Hariohay *et al.*, 2018; Karanth & Ranganathan, 2018), and the snowball sampling method was adopted to further recruit additional willing participants from the same village (Parker *et al.*, 2019). Respondents were stratified into six categories: farmers, government employees, private sector employees, bamboo collectors/artisans, self-employed individuals, and unemployed individuals. This stratification aimed to capture diverse socio-economic perspectives within the region. Interviewers were proficient in both the local language and English, facilitating effective communication. Verbal consent was obtained from all participants, and no incentives were provided, adhering to the ethical standards.

Variables of perception

Variables such as age, gender, education, household size, and the economic status of communities living in proximity to forested areas have been identified as influencing forest use and, in turn, the relationship with the forest and wildlife. (Williams *et al.*, 2002; Ericsson & Heberlein, 2003; Meadow *et al.*, 2005; Ogra & Badola, 2008; Badola *et al.*, 2012; Karanth & Ranganathan, 2018; Hiroyasu *et al.*, 2019; Vasudeva *et al.*, 2021). A total of 15 independent variables were selected and grouped into four broad categories that could help understand possible drivers influencing people's behavior towards wildlife conservation and gaur reintroduction. The categories included (1) Socio-Economic Values, (2) Sense of Forest and Ecosystem Values, (3) Perception of Gaur Reintroduction, and (4) Losses and Fear from Wildlife (Table 1).

The values of response variables ranged from 0 to 1, 0 indicating the lowest level of well-being and 1 indicating the highest level.

 https://doi.org/10.63033/JWLS.PDNP5891

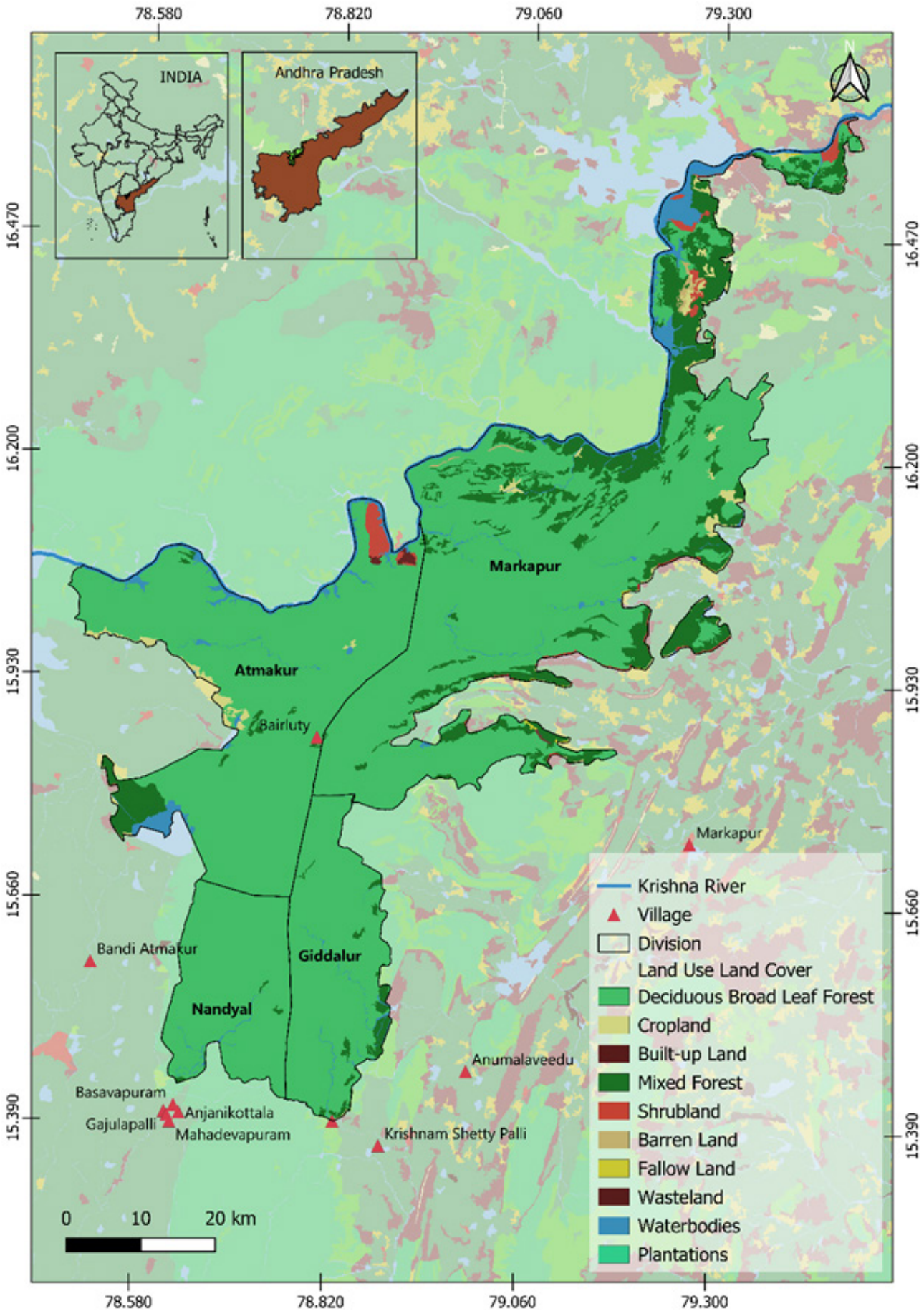


Figure 1. Relocation of gaur (*Bos gaurus gaurus*) is proposed in Nagarjunasagar Srisailam Tiger Reserve, Andhra Pradesh, India

 https://doi.org/10.63033/JWLS.PDNP5891

In addition to quantitative data, respondents were also asked for their opinions on whether the gaur should be reintroduced into the NSTR (Table 1). Their answers were grouped into three broad categories: 'Approval' or 'Disapproval', and 'Unsure / No response' for unclear responses, and instances where no response was given. Responses to the question of gaur reintroduction were categorized into three broad groups: positive, negative, and neutral. For logistic regression analysis, neutral or unclear responses were excluded so that the dependent variable represented clear approval (1) or disapproval (0) for gaur reintroduction in NSTR.

Data Preparation

Initially, the dataset was examined to identify any missing or inconsistent data points. Descriptive statistics were computed for each variable to assess the distributional characteristics. The analysis involved calculating descriptive statistics to understand patterns in livestock ownership, land use, forest resource use, and human-wildlife interactions. Categorical data, such as livestock types, land utilisation, and employment activities, were summarized using percentages and frequency counts (Creswell & Creswell, 2017). Reports of crop damage by specific wildlife species were quantified, and the proportion of affected households was calculated. Attitudes toward conservation and gaur reintroduction were analysed by grouping responses into categories supportive, neutral, or opposing and determining the percentage distribution. Additionally, qualitative responses about potential risks and benefits of reintroduction were reviewed to identify recurring themes through content analysis.

Construction of Composite Indices

To reduce the complexity associated with multiple related variables and to represent broader socio-economic dimensions, composite indices were developed by aggregating conceptually related variables, a common practice in social feasibility studies (Dewi *et al.*, 2005; Soman & Anitha, 2020; Vasudeva *et al.*, 2021). Specifically, four indices were constructed: the Economic Status

Table 1. Four broad categories of variables used in logistic regression models to predict the attitude of people towards gaur reintroduction in NSTR, prepared following Vasudeva *et al.* (2021)

Category	Variable	Data Scale	Description and Response Type
SOCIO-ECONOMIC VALUES	Gender (GEN)	Categorical	Gender of the Respondent: Classified into two categories – Male and Female.
	Age group (AGE)	Categorical	Age of the Respondent: Divided into four age groups – 0-18, 19-30, 31-40, and above 40 years.
	Education (EDU)	Categorical	Educational Level at the Time of Interview: Four categories – Illiterate, Primary (1-5 years of schooling), Secondary (6-10 years), and Higher Education (11th standard and above).
	Family Size (FAM)	Ratio	Household Size: The number of family members residing in one physical household structure.
	Occupation (OCC)	Categorical	Occupation of the Respondent: The primary employment or livelihood activity of the respondent.
	Economic Status Index (ESI)	Ratio	Economic Status Index: A composite index reflecting the economic standing of households based on income, assets (*e.g.*, property, livestock), and type of housing, ranging from 0 (low) to 1 (high).
	Government Scheme Beneficiaries (GSB)	Ratio	Government Scheme Beneficiaries: The total number of government programs or schemes from which the household was receiving benefits at the time of the survey.
SENSE OF FOREST AND ECOSYSTEM VALUES	Resource Dependence Index (RDI)	Ratio	Resource Dependency Index: An index measuring the extent of household reliance on forest resources, such as firewood, fodder, and non-timber products, ranging from 0 (low) to 1 (high).
	Income Dependence Index (IDI)	Ratio	Income Dependency Index: An index indicating household dependence on income-generating activities related to forests and forest resources, ranging from 0 (low) to 1 (high).
	Access to clean cooking (LPG)	Categorical	LPG Usage: The use of liquefied petroleum gas for cooking or heating, considered only for households actively refilling LPG cylinders at the time of the interview. Two categories – Yes and No.
	Sense of Ecosystem Services of Forest (FECO)	Ratio	The ability of respondents to identify and acknowledge various benefits derived from forests, based on a set of predetermined ecosystem services.
PERCEPTION OF GAUR REINTRODUCTION	Approval for reintroduction (APOR)	Categorical	Respondents' stance on the reintroduction of gaur, categorized into four levels – Approve, Not Approve, Unsure, and No Response.
	Knowledge of gaur (KOG)	Categorical	Prior Knowledge of Gaur: Whether the respondent had prior awareness of the gaur species. Two categories – Yes and No.
LOSSES AND FEAR DUE TO WILDLIFE	Losses experienced (LOSS)	Ratio	Experience of Wildlife-Induced Losses: The cumulative number of loss experiences due to wildlife, including human-wildlife conflict, crop damage, and livestock depredation.
	Fear for human life upon gaur release (FOGR)	Categorical	Safety Concerns Post-Reintroduction: Concerns regarding personal safety or threats to human life following the potential reintroduction of gaur, classified as Yes or No.

 https://doi.org/10.63033/JWLS.PDNP5891

Index (ESI), Forest Dependency Index (FDI), Income Dependency Index (IDI), and Resource Dependency Index (RDI) (Table 1). The indices were calculated by combining related variables into cohesive categories following the approach described by Vasudeva *et al.* (2021). For the Forest Dependency Index (FDI), variables such as forest usage frequency, types of forest resources utilized, and the extent of reliance on forest resources were combined to provide a comprehensive measure of forest dependency. Similarly, the Income Dependency Index (IDI) incorporated variables such as income from forest-based activities, percentage of income derived from forest resources, bamboo cutting and artistry, and income stability to assess economic reliance on forest resources. For the Resource Dependency Index (RDI), factors such as access to forest resources, frequency of resource extraction (NTFP collection), and types of resources accessed were aggregated to quantify resource dependency. The selection and combination of variables into these indices were guided by their thematic relevance and conceptual similarity while maintaining internal consistency (Vasudeva *et al.*, 2021).

Correlation Analysis

Following the development of composite indices and the normality assessment of data (Shapiro & Wilk 1965), Pearson's correlation coefficients were calculated to determine the strength and direction of relationships between the independent variables (Supplementary 1). This step aimed to identify multicollinearity and potential redundant variables that could distort the logistic regression model. Variables exhibiting correlation coefficients above 0.7 were flagged for further scrutiny, and in cases of high multicollinearity, one of the correlated variables was excluded based on theoretical relevance and statistical significance. The use of composite indices also helped streamline highly related variables by representing multiple dimensions within a single explanatory variable, thereby reducing redundancy in the final model.

Chi-square test

A Chi-square test was conducted to determine the statistical significance of associations between independent variables (such as age, gender, education, occupation, resource dependency, experience of loss, and conservation experience) and the two dependent variables (awareness of gaur and attitudes toward its reintroduction), with a null hypothesis set to no significant relationship between knowledge about the gaur and perspectives on its reintroduction. The tests were performed at a 95% confidence level. The analysis was done in R Software version 4.2.4 (Posit Team, 2024).

Logistic Regression Analysis

The logistic regression model (Hosmer *et al.*, 2013) was used using the GLM function in R Software version 4.2.4 (R Core Team, 2024). The binary logistic regression model was structured as follows:

$$\text{logit}(P) = \ln(P/(1-P)) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta i Xi$$

where P represents the probability of a respondent being supportive of gaur reintroduction, Xi are the independent variables, and βi are the corresponding coefficients.

Model Selection

A binary logistic regression model was used to assess the factors influencing the support or opposition to the reintroduction of the gaur. In this model, the dependent variable was binary, with a response of either 1 (approval) or 0 (disapproval) regarding the reintroduction. The model used 15 independent variables (as described in Table 1), which included socio-economic, demographic, and resource dependency indicators, encompassing socio-demographic characteristics, resource dependency, and prior experiences of loss due to wildlife.

Four different logistic regression models were constructed using various combinations of predictor variables (Table 4). The Akaike Information Criterion (AIC) was used as the primary criterion for model selection (Akaike, 1974; Burnham & Anderson, 2004), to identify the most parsimonious model that effectively balances goodness-of-fit and model complexity. Models with lower AIC values were considered optimal, indicating a better trade-off between model fit and the number of predictors included.

A probability threshold of $p < 0.05$ was applied to classify variables as statistically significant (Fisher, 1925). Variables with p-values less than 0.05 were identified as significantly reliable predictors of support for reintroduction, whereas those with p-values equal to or greater than 0.05 were non-significant (Cohen, 1994).

Results

General Socio-demographic profile

Of the 109 respondents, 77.06% were male, and all belonged to rural, forest-dependent communities near NSTR. Major occupations included bamboo craftsmanship (31.19%), private sector jobs (20.75%), agriculture (21.1%), and firewood collection (13%). Most followed a non-vegetarian diet (95.2%) and lived in Pakka houses (67.92%). Educational attainment was low, with over half (54.13%) reporting no formal education. While 86.79% had access to LPG, many still relied partly or fully on firewood for cooking (Table 2).

Livestock ownership was low with 76.6% of households owning no livestock. Very small percentages owned cows, buffalo, or fowl. Around 65% utilized forest resources in timber, bamboo, and NTFP. Among the 21.69% of respondents who reported wildlife-related losses, 66.67% attributed the damage primarily to wild boar, occasionally in combination with chital or sambar, and at times with bears (33%) and leopards (18.51%). Awareness of conservation measures among respondents was high at 75%, with 83% believing that wildlife populations have increased since their childhood. Although only one respondent had seen a gaur during childhood, many cited having knowledge of them second-hand. When queried about the prospect of reintroducing gaur into the area, 52% of respondents expressed that there were no fears, while 24.5% expressed concern, and the remainder were indifferent. Those who supported reintroducing gaur stated ecological benefits, while those opposed expressed fear of limited access to forests and crop damage (Table 3).

Overall Perception Towards Gaur Reintroduction in NSTR

Knowledge about gaur was significantly associated with age ($\chi^2 = 5.083$, $p = 0.04$), occupation ($\chi^2 = 14.072$, $p = 0.002$), and experiences of wildlife-induced losses ($\chi^2 = 12.744$, $p = 0.0003$). These findings suggest that older individuals, certain occupational groups, and those who had experienced wildlife-related losses were more likely to have knowledge of the species. No significant associations were observed with gender, education, resource dependency, or perceived importance of forests (Table 3).

Support for gaur reintroduction was significantly associated with occupation ($\chi^2 = 17.995$, $p = 0.0004$), resource dependency ($\chi^2 = 14.297$, $p = 0.0001$), sense of forest importance ($\chi^2 = 9.803$, $p = 0.001$), and wildlife loss experiences ($\chi^2 = 13.037$, $p = 0.0003$). Respondents more dependent on forest resources and those who had experienced losses were less supportive of reintroduction. No significant associations were found with age, gender, or education, though gender and education showed weak significance ($p = 0.063$ and $p = 0.064$, respectively) (Table 3).

Factors Influencing Gaur Reintroduction in NSTR

Socio-Economic Values: Logistic regression analysis provided insights into socio-economic determinants influencing approval of gaur reintroduction. Age group 3 (31- 40 years) showed a negative relationship with approval ($\beta = -0.5847$, $p < 0.05$),

 https://doi.org/10.63033/JWLS.PDNP5891

Table 2. Socio-demographic profile of the respondents of household survey in Nagarjunasagar Srisailam Tiger Reserve, Andhra Pradesh, India.

Total Respondents	**N=109**
GENDER	Male = 84 (77.06%)
	Female = 25 (22.91%)
EDUCATION	Illiterate = 59 (54.128%)
	Primary = 34 (31.192%)
	Secondary = 9 (8.256%)
	University = 7 (6.422%)
OCCUPATION	Government employee = 4 (3.669%)
	Private job = 15 (13.761)
	Private (CBET) = 3 (2.752%)
	Driver = 6 (5.504%)
	Regular labor = 4 (3.669%)
	Agriculture = 23 (21.1%)
	Bamboo artisan = 34 (31.192%)
	Menial job = 1 (0.917%)
	Self-employed = 9 (8.256%)
	Unemployed = 9 (8.256%)
	Other = 1 (0.917%)
MEAN FAMILY SIZE	4.28 individuals
LAND HOLDERS	24.77%

suggesting individuals in this cohort were less likely to support the initiative. Larger family sizes positively correlated with approval ($\beta = 0.3055$, $p < 0.05$), potentially indicating greater openness among households with more members to environmental changes. Access to government schemes was a significant predictor of approval ($\beta = 1.032$, $p < 0.05$), pointing to the role of institutional support in shaping public opinion. Economic well-being, however, did not emerge as a significant variable ($\beta = 1.2929$, $p > 0.05$) (Table 4).

Forest and Ecosystem Values

The second model offered insights into how perceptions of forest and ecosystem services influenced approval of reintroduction. The intercept ($\beta = 1.0362$, $p < 0.05$) established a positive baseline. Interestingly, the sense of ecosystem services (FECO) negatively influenced approval ($\beta = -3.4491$, $p < 0.05$), suggesting that those who highly valued ecosystem services might fear introducing a large herbivore such as gaur. Neither income dependence ($\beta = -0.6273$, $p > 0.05$) nor resource dependence ($\beta = 1.5315$, $p > 0.05$) was statistically significant, suggesting these factors exerted less sway in shaping opinion within this model's framework (Table 4).

Perception of Gaur Reintroduction

In this model, the intercept ($\beta = 0.0274$, $p > 0.05$) indicated neutrality in perception. Knowledge of the gaur (KOG) showed a marginally significant positive effect ($\beta = 0.7936$, $p < 0.05$), suggesting that greater awareness of the species might improve public opinion of its reintroduction, implying that informed populations are more likely to accept ecological interventions (Table 4).

Loss and Fear due to Wildlife

Loss and fear emerged as a significant variable in the fourth model. The intercept ($\beta = 1.4378$, $p < 0.01$) suggested strong baseline approval. However, fear of the gaur's impact on human life (FOGR) significantly reduced approval likelihood ($\beta = -2.5001$, $p < 0.01$). Contrary to expectations, actual reported losses ($\beta = -0.032$, $p > 0.05$) did not significantly shape perceptions, indicating that perceived fear may outweigh evidence-based experiences in driving opinion (Table 4).

Table 3. Summary Statistics of χ^2 test to determine the relationship between the dependent variables 'Support for gaur reintroduction in NSTR' and 'knowledge about the gaur'

Variable	**Support for gaur reintroduction in NSTR[4]**				**Knowledge about the gaur[5]**			
	n	**df**	**χ^2**	**p**	**n**	**df**	**χ^2**	**p**
Age	109	2	0.828	0.660	109	2	5.083	0.04*
Gender		2	5.503	0.063		2	1.180	0.554
Occupation		3	17.995	0.0004**		3	14.072	0.002**
Education		1	3.424	0.064		1	0	1
Resource dependency[1]		1	14.297	0.0001**		1	1.907	0.167
Sense of Forest Importance[2]		1	9.803	0.001**		1	0	1
Loss experiences due to wildlife[3]			13.037	0.0003**		1	12.744	0.0003**

*p<0.05, **p<0.005
n= Number of samples; df= degree of freedom; χ^2 = Statistic calculated with chi-square test.
1Dependency on forest resources: binary (Yes/No)
[2]Sence of importance of forest: binary (Yes/No)
[3]Loss experiences due to wildlife: binary (Yes/No)
[4]Support for gaur reintroduction in NSTR: Supportive or Non-supportive

Discussions

The interactions of socio-economic factors with conservation support have been recognized widely. Both Bennett *et al.* (2017) and Kansky & Knight (2014) found economic stability, household characteristics, and trust in government authorities to be likely influences on community attitudes towards wildlife reintroductions. In NSTR, this was clearly tangible, with larger households showing greater approval for gaur reintroduction. Households with larger household sizes may be positioned for greater income prospects and collective decision-making which could lead to a more favorable trajectory towards projects for conservation. Additionally, access to and use of government services and welfare schemes were reported as important

Table 4. Significant variables predicting the attitude of local households towards gaur reintroduction in NSTR (Category vis models using logistic binomial regression)

Significant predictor variables	Estimate (β)	Std. error	Z value	Pr(>|z|)	Significance level
MODEL 1 SOCIO-ECONOMIC VALUES					
(INTERCEPT)	-3.017	1.9015	-1.59	0.11259	
AGE GROUP (AGE)-3	-0.5847	0.2905	-2.01	0.04414	*
ECONOMIC STATUS INDEX (ESI)	1.2929	0.8938	1.446	0.14805	
FAMILY SIZE (FAM)	0.3055	0.1106	2.762	0.00574	**
GOVERNMENT SCHEME BENEFICIARIES (GSB)	1.032	0.3932	2.625	0.00867	**
AIC (FINAL MODEL)	133.88				
AIC (INITIAL MODEL)	135.43				
MODEL 2: SENSE OF FOREST AND ECOSYSTEM VALUES					
(INTERCEPT)	1.0362	0.3771	2.748	0.006	**
FECO	-3.4491	1.5998	-2.16	0.0311	*
IDI	-0.6273	0.4466	-1.41	0.1601	
RDI	1.5315	1.4933	1.026	0.3051	
AIC (FINAL MODEL)	143.95				
AIC (INITIAL MODEL)	145.79				
MODEL 3: PERCEPTION OF GAUR REINTRODUCTION					
(INTERCEPT)	0.0274	0.2341	0.117	0.9068	
KNOWLEDGE ON GAUR (KOG)	0.7936	0.4309	1.841	0.0455	*
AIC (FINAL MODEL)	149.5				
AIC (INITIAL MODEL)	151.03				
MODEL 4: LOSS AND FEAR DUE TO WILDLIFE					
(INTERCEPT)	1.4378	0.37496	3.834	0.00013	***
LOSS	-0.032	0.57715	-0.06	0.95574	
FOGR	-2.5001	0.4663	-5.36	8.25E-08	***
AIC (FINAL MODEL)	120.32				
AIC (INITIAL MODEL)	152.8				

*Significance code: 0 '***' 0.001 '**' 0.01 '*'*

determinants of support for conservation. Redpath *et al.* (2013) and Oldekop *et al.* (2016) observed that communities that have greater access to institutional resources will tend to have more favorable attitudes toward conservation. In NSTR, respondents who were more aware of government schemes expressed stronger approval for the reintroduction of gaur, which indicates that institutional facilitation, perceived or not, can alleviate some of the hesitation regarding likely losses associated with wildlife. This finding emphasizes integrating strategic conservation practice with broader socio-economic development efforts, similar to various conservation landscapes observed globally (Brooks *et al.*, 2012).

Several respondents were clearly in favor of introducing the gaur to the forest, in part with an understanding of potential aesthetic and ecological value. Comments such as "It is good to have animals in the forest" and "A species should stay in its forest" convey a positive attitude concerning restoring the fauna in NSTR. Other comments addressed the aesthetic and ecological values of reintroduction, highlighting that it would "add aesthetic value to the forest" or that it could help with biodiversity restoration and increase tiger numbers. Clearly in sync with broader conservation efforts, these perspectives also hint at some segment of the community recognizing the ecological value of reintroducing gaur, which is consistent with earlier studies showing community support as an essential factor for reintroduction (Bennett *et al.*, 2017). These kinds of perspectives are also relevant because they suggest potential ways to build community engagement and conservation awareness.

Another important influence on community thinking about gaur reintroduction was dependence on forests. Communities dependent on forest resources often view conservation projects as a threat to their resource-dependent way of life (Infield & Namara, 2001; Berkes, 2004). In NSTR, concerns regarding limited access to the forest and stricter rules emerged as clear themes, particularly that residents would not be able to continue to collect firewood, graze cattle, or collect medicinal plants after gaur reintroduction. Similarly, in the Satkosia Tiger Reserve, a tiger translocation program was impeded by concerns about restricted access and resource dependence, as residents feared they would lose access to limited forest resources, and they expressed concerns about resource extraction restrictions surmounting the wildlife reintroduction approval process (Vasudeva *et al.*, 2021). Redpath *et al.* (2015) pinpoint the importance of addressing perceived resource restrictions, as ongoing perceived losses of access to resources could lead to heightened negativity toward conservation and prompt considerations of alternative approaches to developing sustainable resource management and compensatory mechanisms.

 https://doi.org/10.63033/JWLS.PDNP5891

Community perceptions of gaur reintroduction had a small positive relationship to public support, but this relationship was only marginally significant. This was similar to findings in Taiwan, where Best & Pei (2020) showed that communities with greater awareness of leopard cat conservation were more supportive, and that younger, educated individuals were particularly supportive. Although many respondents in NSTR had limited direct experience of gaur, previous generations of the family often passed on anecdotal information. Dickman (2010) notes that a lack of direct encounters with a species can create misconceptions, making targeted awareness campaigns necessary. Barua *et al.* (2013) and Madden & McQuinn (2014) state that the use of participatory meetings, workshops, and storytelling is a way to address these gaps in information and promote informed support for conservation actions.

Fear emerged as a significant deterrent to community support for gaur reintroduction, with concerns centered around crop damage and human-wildlife conflict. Such fears are not unfounded, as previous wildlife interactions in NSTR have left lasting impressions on residents, shaping their attitudes toward new conservation projects. In extended contexts, fear of large carnivores has been a dominant factor influencing support for conservation. Bombieri *et al.* (2023) documented that bold brown bears in human-modified landscapes often triggered heightened public fears, leading to conflict and retaliatory actions. Similarly, Jansson *et al.* (2024) observed that lions in multi-use landscapes in Tanzania strategically altered their movements to avoid human encounters, suggesting that minimizing the potential for conflict is a critical component of coexistence strategies. Interestingly, in NSTR, the perceived loss of resources, such as income or access to land, was less significant than the overarching sense of fear and uncertainty. Kansky *et al.* (2014) argue that fear often carries more weight than anticipated financial losses in shaping community attitudes. Therefore, effective conflict mitigation strategies, such as early-warning systems, compensation schemes for livestock losses, and proactive community engagement, are essential for fostering acceptance (Bruskotter *et al.*, 2014; Slagle *et al.*, 2012).

The fear of crop destruction was a strong factor in NSTR, with respondents expressing their view as "gaur would cause major damage to the crops". This fear resonates with existing literature showing that human-wildlife conflict, particularly in agricultural settings, is a significant barrier to reintroduction project adoption (Kansky & Knight, 2014; Redpath *et al.*, 2013). The perception of economic costs was also talked about fairly frequently, with respondents suggesting that the reintroduction of gaur could create restrictions on forest use and provide fewer resources. Phrases like "It will reduce our visits to the forest for livelihood" demonstrated fear that economic stability would be impacted by more wildlife use in the area. Although it was also interesting to note that some people believed that gaur could also help support tourism development, saying "This can help to promote tourism" and "It will positively impact the forest and hence the economic activity", thus suggesting a somewhat dual perception of economic impacts.

Taken together, these findings provide a comprehensive understanding of how socio-economic, perceptual, and emotive factors influence community attitudes toward the reintroduction of gaur in NSTR. Understanding social and economic realities that shape communities' thinking about species conservation initiatives is important for the success of these initiatives and for ecological factors. This study in sync with other global and local studies, adds to greater depth and underscores the need for holistic approaches to wildlife reintroduction. The assessment of social feasibility is not simply advantageous but necessary for the success of conservation translocation initiatives. The IUCN, in its Guidelines for Reintroductions and Other Conservation Translocations, highlights that feasibility assessments should not only focus on biological and ecological aspects of a translocation but also on social context, community engagement, and potential future conflicts (IUCN/SSC, 2013; Seddon *et al.*, 2014; Brichieri-Colombi & Moehrenschlager, 2016). These guidelines recommend an integrated approach that weighs conservation-related benefits and the social cost and risks involved in conservation plans, regardless of how they are formulated (IUCN/SSC, 2013; Redpath *et al.*, 2013; Bennett *et al.*, 2017).

Despite clearly written guidelines, many translocation projects have neglected social aspects, leading to significant difficulties during implementation. A review of 550 projects indicated that social feasibility assessments were often incomplete or limited in scope, resulting in unresolved controversies and community opposition that ultimately led to ineffective project outcomes (Miller *et al.*, 2014; Soorae, 2018; Teixeira *et al.*, 2007). The lack of consideration for social aspects has been a recurring feature of many failed conservation activities, especially in projects involving larger mammals and human-wildlife conflict (Dickman, 2010; Kansky & Knight, 2014; Nyhus, 2016).The present findings therefore reinforce the importance of incorporating social feasibility assessments into conservation planning and demonstrate that community perceptions, institutional support, livelihood concerns, and conflict-related fears are integral components of successful wildlife reintroductions

Conclusion

The success of gaur reintroduction in NSTR does not completely rely on ecological approaches but also on socio-economic and perceptual dimensions. Park managers, along with conservation efforts, should focus on engaging and building trust with forest-dependent communities, ensuring socio-economic stability, implementing welfare programs, and raising awareness of human-wildlife interactions through outreach and mitigation. Further deploying targeted, participatory awareness campaigns, such as community meetings, workshops, and storytelling, to bridge information gaps within local communities and highlight the gaur's aesthetic and ecological value. Also, integrating tangible benefits may alleviate hesitation, build goodwill, and strengthen trust. Providing a holistic approach that combines ecologically restorative use with community development leads to constant dialogue and ownership by the specific community - this amalgamation will allow for conservation models that are not only ecologically sound, but socially inclusive and place-based. Ultimately, the success of these actions will depend on how well they engage with the needs and perceptions of local communities and how they incorporate long-term benefits for both communities and wildlife.

TO DOWNLOAD SUPPLEMENTARY MATERIAL, CLICK **HERE.**

Acknowledgment

This study was conducted as part of a collaborative initiative between the Andhra Pradesh Forest Department and the Wildlife Institute of India, with the support of the Nagarjuna Sagar Srisailam Tiger Reserve (NSTR), Andhra Pradesh. The authors extend their sincere appreciation to the NSTR field staff for their invaluable assistance during data collection. Special thanks are also extended to Ms. Shanti Priya Pandey, Ms. Tanya Gupta, Mr. V. Saibaba, Mr. Anurag Meena, and Mr. Y. V. Narsimha Rao for their significant contributions and support throughout the study.

CONFLICT OF INTEREST

Samrat Mondol, Bilal Habib & Parag Nigam hold editorial positions at the Journal of Wildlife Science. However, none of them participated in the peer review process of this article except as authors. The authors declare that they have no competing interests.

DATA AVAILABILITY

The study contains sensitive household information, including personal details, which cannot be publicly shared. All relevant data generated during the study are provided within the article and its supplementary materials. Please contact the corresponding author at nigamp@wii.gov.in to obtain access to the dataset and associated documentation.

AUTHOR CONTRIBUTIONS

RV: data collection, formal analysis, visualization, writing—original draft.
AKG: data collection and analysis.
SC: data collection.
HF: review and editing.
AN: formal analysis, methodology, and writing—review and editing.
SM: supervision, writing—review and editing.
BH: supervision, writing—review and editing.
AKN: funding acquisition, permission acquisition, resources.
BNNM: funding acquisition, resources.
VAG: permission acquisition, resources.
PN: funding acquisition, investigation, resources, supervision, and review and editing.

ETHICS STATEMENT

The authors confirm that all procedures involved in this study adhered to the ethical guidelines established by the relevant national and institutional bodies, including the IUCN/SSC (2013) reintroduction guidelines and the Wildlife Institute of India under the Ministry of Environment, Forest, and Climate Change, Government of India. The research also complied with the Code of Conduct for contributors to the Journal. The interview methodology followed the IUCN/SSC (2013) guidelines, and informed consent was obtained from all participants for the use of the data collected. Participant anonymity has been maintained to ensure confidentiality.

ORIGINALITY STATEMENT

We, the authors, confirm that the manuscript submitted is our original research work. The content is not derived from other studies or the published work of the authors. We confirm that all the sources have been properly acknowledged and cited. We also understand that the journal conducts plagiarism checks, and we agree to provide additional clarification if the index exceeds 15% as required during the peer-reviewed process.

References

Akaike, H. (1974). A new look at the statistical model identification problem. *IEEE Transactions on Automatic Control*, 19(6), 716. https://doi.org/10.1109/TAC.1974.1100705

Allendorf, T., Swe, K. K., Oo, T., Htut, Y. E., Aung, M., Allendorf, K., Hayek, L., Leimgruber, P. & Wemmer, C. (2006). Community attitudes toward three protected areas in Upper Myanmar (Burma). *Environmental Conservation*, 33(4), 344-352. https://doi.org/10.1017/S0376892906003389

Badola, R., Barthwal, S. & Hussain, S. A. (2012). Attitudes of local communities towards conservation of mangrove forests: A case study from the east coast of India. *Estuarine, Coastal and Shelf Science*, 96, 188-196. https://doi.org/10.1016/j.ecss.2011.11.016

Barua, M., Bhagwat, S. A. & Jadhav, S. (2013). The hidden dimensions of human–wildlife conflict: Health impacts, opportunity and transaction costs. *Biological conservation*, 157, 309-316. https://doi.org/10.1016/j.biocon.2012.07.014

Bennett, N. J., Roth, R., Klain, S. C., Chan, K. M., Clark, D. A., Cullman, G., Epstein, G., Nelsom, M. P., Stedman, R. *et al.* (2017). Mainstreaming the social sciences in conservation. *Conservation Biology*, 31(1), 56-66. https://doi.org/10.1111/cobi.12788

Berkes, F. (2004). Rethinking community-based conservation. *Conservation biology*, 18(3), 621-630. https://doi.org/10.1111/j.1523-1739.2004.00077.x

Berzaghi, F. & Awasthi, B. (2022). MegaFeed: Global database of megaherbivores' feeding preferences. *bioRxiv*, 2022-09. https://doi.org/10.1101/2022.09.23.509174

Best, I., & Pei, K. J.-C. (2020). Factors influencing local attitudes towards the conservation of leopard cats *Prionailurus bengalensis* in rural Taiwan. *Oryx*, 54(6), 866–872. https://doi:10.1017/S0030605318000984

Bhattacherjee, A. (2012). *Social science research: Principles, methods, and practices.* University of South Florida.

Bombieri, G., Penteriani, V., Almasieh, K., Ambarlı, H., Ashrafzadeh, M. R., Das, C. S., Dharaiya, N., Hoogesteijn, R., Hoogesteijn, A. *et al.* (2023). A worldwide perspective on large carnivore attacks on humans. *PLoS Biology*, 21(1), e3001946. https://doi.org/10.1371/journal.pbio.3001946

Brichieri-Colombi, T. A. & Moehrenschlager, A. (2016). Alignment of threat, effort, and perceived success in North American conservation translocations. *Conservation Biology*, 30(6), 1159-1172. https://doi.org/10.1111/cobi.12743

Brooks, J. S., Waylen, K. A. & Borgerhoff Mulder, M. (2012). How national context, project design, and local community characteristics influence success in community-based conservation projects. *Proceedings of the National Academy of Sciences*, 109(52), 21265-21270. https://doi.org/10.1073/pnas.1207141110

Bruskotter, J. T., Vucetich, J. A., Enzler, S., Treves, A. & Nelson, M. P. (2014). Removing protections for wolves and the future of the US Endangered Species Act (1973). *Conservation Letters*, 7(4), 401-407. https://doi.org/10.1111/conl.12081

Burnham, K. P. & Anderson, D. R. (2004). Multimodel inference: understanding AIC and BIC in model selection. *Sociological Methods & Research*, 33(2), 261-304. https://doi.org/10.1177/0049124104268644

Ceballos, G., Ehrlich, P. R., Soberón, J., Salazar, I. & Fay, J. P. (2005). Global mammal conservation: what must we manage? *Science*, 309(5734), 603-607. https://doi.org/10.1126/science.1114015

Cohen, J. (1994). The earth is round (p< .05). *American psychologist*, 49(12), 997. https://doi.org/10.1037/0003-066X.49.12.997

Creswell, J. W. & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Cromsigt, J. P. & Te Beest, M. (2014). Restoration of a megaherbivore: landscape-level impacts of white rhinoceros in Kruger National Park, South Africa. *Journal of Ecology*, 102(3), 566-575. https://doi.org/10.1111/1365-2745.12218

Dewi, S., Belcher, B. & Puntodewo, A. (2005). Village economic opportunity, forest dependence, and rural livelihoods in East Kalimantan, Indonesia. *World development*, 33(9), 1419-1434. https://doi.org/10.1016/j.worlddev.2004.10.006

Dickman, A. J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal conservation*, 13(5), 458-466. https://doi.org/10.1111/j.1469-1795.2010.00368.x

Ericsson, G. & Heberlein, T. A. (2003). Attitudes of hunters, locals, and the general public in Sweden now that the wolves are back. *Biological conservation*, 111(2), 149-159. https://doi.org/10.1016/S0006-3207(02)00258-6

Fischer, J. & Lindenmayer, D. B. (2000). An assessment of the published results of animal relocations. *Biological conservation*, 96(1), 1-11. https://doi.org/10.1016/S0006-3207(00)00048-3

Fisher, R. A. (1925). Theory of statistical estimation. *Mathematical Proceedings of the Cambridge Philosophical Society*, 22(5), 700-725. https://doi.org/10.1017/S0305004100009580

Fritz, H., Duncan, P., Gordon, I. J. & Illius, A. W. (2002). Megaherbivores influence trophic guilds structure in African ungulate communities. *Oecologia*, 131, 620-625. https://doi.org/10.1007/s00442-002-0919-3

Gillingham, S. & Lee, P. C. (2003). People and protected areas: a study of local perceptions of wildlife crop-damage conflict in an area bordering the Selous Game Reserve, Tanzania. *Oryx*, 37(3), 316-325. https://doi.org/10.1017/S0030605303000577

Godet, L. & Devictor, V. (2018). What conservation does. *Trends in ecology & evolution*, 33(10), 720-730. https://doi.org/10.1016/j.tree.2018.07.004

Griffith, B., Scott, J. M., Carpenter, J. W. & Reed, C. (1989). Translocation as a species conservation tool: status and strategy. *Science*, 245(4917), 477-480. https://doi.org/10.1126/science.245.4917.477

Hariohay, K. M., Fyumagwa, R. D., Kideghesho, J. R., & Røskaft, E. (2018). Awareness and attitudes of local people toward wildlife conservation in the Rungwa Game Reserve in Central Tanzania. *Human dimensions of wildlife*, 23(6), 503-514. https://doi.org/10.1080/10871209.2018.1494866

Hiroyasu, E. H., Miljanich, C. P., & Anderson, S. E. (2019). Drivers of support: The case of species reintroductions with an ill-informed public. *Human Dimensions of Wildlife*, 24(5), 401-417. https://doi.org/10.1080/10871209.2019.1622055

Hosmer Jr, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied logistic regression*. John Wiley & Sons.

Hunter, W. W. (ed.). (1886). *The imperial gazetteer of India: Vol. VII (II).* Oxford at the Clarendon Press

Infield, M. & Namara, A. (2001). Community attitudes and behaviour towards conservation: an assessment of a community conservation programme around Lake Mburo National Park, Uganda. *Oryx*, 35(1), 48-60. https://doi.org/10.1046/j.1365-3008.2001.00151.x

International Union for Conservation of Nature (IUCN). (2002). 2002 IUCN Red List of Threatened Species. IUCN. https://www.redlist.org

IUCN/SSC (2013). *Guidelines for reintroductions and other conservation translocations.* Gland Switz Camb UK IUCNSSC Re-Introd Spec Group, 57.

Jansson, I., Parsons, A. W., Singh, N. J., Faust, L., Kissui, B. M., Mjingo, E. E., Sandström, C. & Spong, G. (2024). Coexistence from a lion's perspective: Movements and habitat selection by African lions (Panthera leo) across a multi-use landscape. *PLoS One*, 19(10), e0311178. https://doi.org/10.1371/journal.pone.0311178

Jiang, Z., Yu, C., Feng, Z., Zhang, L., Xia, J., Ding, Y. & Lindsay, N. (2000). *Reintroduction and recovery of Père David's deer in China.* Wildlife Society Bulletin, 681-687.

Kansky, R. & Knight, A. T. (2014). Key factors driving attitudes towards large mammals in conflict with humans. *Biological Conservation*, 179, 93-105. https://doi.org/10.1016/j.biocon.2014.09.008

Kansky, R., Kidd, M. & Knight, A. T. (2014). Meta-analysis of attitudes toward damage-causing mammalian wildlife. *Conservation Biology*, 28(4), 924-938. https://doi.org/10.1111/cobi.12275

Karanth, K. K., & Ranganathan, P. (2018). Assessing human–wildlife interactions in a forest settlement in Sathyamangalam and Mudumalai Tiger Reserves. *Tropical Conservation Science*, 11, 1940082918802758. https://doi.org/10.1177/1940082918802758

Lamichhane, B. R., Persoon, G. A., Leirs, H., Poudel, S., Subedi, N., Pokheral, C. P., Bhattarai, S., Thapaliya, B. P. & De Iongh, H. H. (2018). Spatio-temporal patterns of attacks on human and economic losses from wildlife in Chitwan National Park, Nepal. *PLoS One*, 13(4), e0195373. https://doi.org/10.1371/journal.pone.0195373

LeFlore, E. G., Fuller, T. K., Tomeletso, M., Dimbindo, T. C., & Stein, A. B. (2020). Human dimensions of human–lion conflict: a pre-and post-assessment of a lion conservation programme in the Okavango Delta, Botswana. *Environmental Conservation*, 47(3), 182-189. https://doi.org/10.1017/S0376892920000120

Lindsey, P. A., Du Toit, J. T., & Mills, M. G. L. (2005). Attitudes of ranchers towards African wild dogs Lycaon pictus: conservation implications on private land. *Biological Conservation*, 125(1), 113-121. https://doi.org/10.1016/j.biocon.2005.03.015

Madden, F., & McQuinn, B. (2014). Conservation's blind spot: The case for conflict transformation in wildlife conservation. *Biological Conservation*, 178, 97-106. https://doi.org/10.1016/j.biocon.2014.07.015

Meadow, R., Reading, R. P., Phillips, M., Mehringer, M., & Miller, B. J. (2005). *The influence of persuasive arguments on public attitudes toward a proposed wolf restoration in the southern Rockies.* Wildlife Society Bulletin, 33(1), 154-163. https://doi.org/10.2193/0091-7648(2005)33[154:TIOPAO]2.0.CO;2

Miller, K. A., Bell, T. P., & Germano, J. M. (2014). Understanding publication bias in reintroduction biology by assessing translocations of New Zealand's herpetofauna. *Conservation Biology*, 28(4), 1045-1056. https://doi.org/10.1111/cobi.12254

Mondanaro, A., Castiglione, S., Melchionna, M., Di Febbraro, M., Vitagliano, G., Serio, C., Vero, V. A., Carotenuto, F. & Raia, P. (2017). Living with the elephant in the room: Top-down control in Eurasian large mammal diversity over the last 22 million years. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 485, 956-962. https://doi.org/10.1016/j.palaeo.2017.08.021

Nigam, P., Habib, B., Vishwakarma, R. & Joshi, A. K. (2019). *Annual report on monitoring reintroduced gaur (Bos gaurus gaurus) in Bandhavgarh Tiger Reserve, Madhya Pradesh, Phase II, extension.* Wildlife Institute of India, Dehradun, India.

Nigam, P., Sankar, K., Cooper, D., Carlisle, L. & Pabla, H. S. (2014). *Capture and translocation of gaur (Bos gaurus) in India*. In: Melletti, M. & Burton, J. (eds.). Ecology, evolution and behaviour of wild cattle. Cambridge University Press, Cambridge, United Kingdom, 393-402. https://doi.org/10.1017/CBO9781139568098.025

Nigam, P., Vishwakarma, R., Bhandari, B., Habib, B., Sen, S., Singh, S. K., Krishnamurthy, L., Dubey, A. K. & Chauhan, J. S. (2024a). *Revival of the gaur in Sanjay Tiger Reserve, Madhya Pradesh.* Technical Report No. 2024/19. Wildlife Institute of India, Dehradun, India.

Nigam, P., Vishwakarma, R., Gorati, A. K., Chandola, S., Nath, A., Habib, B., Mondol, S., Appavu, G. V. & Murthy, B. N. N. (2024b). *A pilot study on feasibility assessment of gaur for reintroduction in Nagarjunasagar Srisailam Tiger Reserve, Andhra Pradesh.* Technical Report No. 2024/20. Wildlife Institute of India, Dehradun, India.

Novak, B. J., Phelan, R., & Weber, M. (2021). U.S. conservation translocations: Over a century of intended consequences. *Conservation Science and Practice*, 3, e394. https://doi.org/10.1111/csp2.394

Nyhus, P. J. (2016). Human–wildlife conflict and coexistence. *Annual review of environment and resources*, 41(1), 143-171. https://doi.org/10.1146/annurev-environ-110615-085634

Ogra, M. & Badola, R. (2008). Compensating human–wildlife conflict in protected area communities: ground-level perspectives from Uttarakhand, India. *Human Ecology*, 36, 717-729. https://doi.org/10.1007/s10745-008-9189-y

Oldekop, J. A., Holmes, G., Harris, W. E., & Evans, K. L. (2016). A global assessment of the social and conservation outcomes of protected areas. *Conservation Biology*, 30(1), 133-141. https://doi.org/10.1111/cobi.12568

Owen-Smith, R. N. (1988). *Megaherbivores: the influence of very large body size on ecology.* Cambridge University Press. https://doi.org/10.1017/CBO9780511565441

Parker, C., Scott, S. & Geddes, A. (2019). *Snowball sampling*. SAGE research methods foundations.

Posit Team. (2024). RStudio: Integrated Development Environment for R (Version 2024.04 or newer) [Computer software]. Posit Software, PBC. http://www.posit.co/

Qureshi, Q., Jhala, Y. V., Yadav, S. P. & Mallick, A. (2023). *Status of tigers, co-predators and prey in India, 2022.* National Tiger Conservation Authority, Government of India, New Delhi, and Wildlife Institute of India, Dehradun.

Reading, R. P. & Kellert, S. R. (1993). Attitudes toward a proposed reintroduction of black-footed ferrets (*Mustela nigripes*). *Conservation Biology*, 7(3), 569-580. https://doi.org/10.1046/j.1523-1739.1993.07030569.x

Redpath, S. M., Bhatia, S. & Young, J. (2015). Tilting at wildlife: reconsidering human–wildlife conflict. *Oryx*, 49(2), 222-225. https://doi.org/10.1017/S0030605314000799

Redpath, S. M., Young, J., Evely, A., Adams, W. M., Sutherland, W. J., Whitehouse, A., Amar, A., Lamber, R. A. *et al.* (2013). Understanding and managing conservation conflicts. *Trends in ecology & evolution*, 28(2), 100-109. https://doi.org/10.1016/j.tree.2012.08.021

Ripple, W. J., Newsome, T. M., Wolf, C., Dirzo, R., Everatt, K. T., Galetti, M., Hayward, M. W., Kerley, G. I. H., Levi, T. *et al.* (2015). Collapse of the world's largest herbivores. *Science advances*, 1(4), e1400103. https://doi.org/10.1126/sciadv.1400103

Sakurai, R., Tsunoda, H., Enari, H., Siemer, W. F., Uehara, T., & Stedman, R. C. (2020). Factors affecting attitudes toward reintroduction of wolves in Japan. *Global Ecology and Conservation*, 22, e01036. https://doi.org/10.1016/j.gecco.2020.e01036

Sankar, K., Pabla, H. S., Patil, C. K., Nigam, P., Qureshi, Q., Navaneethan, B., Manjreakar, M. Virkar, P. S. & Mondal, K. (2013). Home range, habitat use and food habits of re-introduced gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Central India. *Tropical Conservation Science*, 6(1), 50-69. https://doi.org/10.1177/194008291300600108

Sankar, K., Qureshi, Q., Pasha, M. K. S. & Areendran, G. (2001). *Ecology of gaur (Bos gaurus) in Pench Tiger Reserve, Madhya Pradesh.* Final report, Wildlife Institute of India, Dehra Dun. pp. 1-124.

Seddon, P. J. & Armstrong, D. P. (2016). *Reintroduction and other conservation translocations: history and future developments. In: David S. Jachowski, D. S, Millspaugh, J. J., Angermeier, P. L. & Slotow, R. (eds.).* Reintroduction of fish and wildlife populations. University of California Press. pp. 7-28. https://doi.org/10.1525/9780520960381-004

Seddon, P. J., Armstrong, D. P. & Maloney, R. F. (2007). Developing the science of reintroduction biology. *Conservation biology*, 21(2), 303-312. https://doi.org/10.1525/9780520960381-004

Seddon, P. J., Griffiths, C. J., Soorae, P. S. & Armstrong, D. P. (2014). Reversing defaunation: restoring species in a changing world. *Science*, 345(6195), 406-412. https://doi.org/10.1126/science.1251818

Shapiro, S. S. & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, 52(3-4), 591-611. https://doi.org/10.1093/biomet/52.3-4.591

Slagle, K. M., Bruskotter, J. T. & Wilson, R. S. (2012). The role of affect in public support and opposition to wolf management. *Human Dimensions of Wildlife*, 17(1), 44-57. https://doi.org/10.1080/10871209.2012.633237

Soman, D. & Anitha, V. (2020). Community dependence on the natural resources of Parambikulam Tiger Reserve, Kerala, India. *Trees, Forests and People*, 2, 100014. https://doi.org/10.1016/j.tfp.2020.100014

Soorae, P. S. (ed.). (2018). *Global reintroduction perspectives, 2018: Case studies from around the globe*. IUCN-International Union for Conservation of Nature and Natural Resources.

Soorae, P. S. (Ed.). (2021). *Global conservation translocation perspectives, 2021: Case studies from around the globe*. IUCN SSC Conservation Translocation Specialist Group, Environment Agency & Calgary Zoo.

Talukdar, S. & Gupta, A. (2014). Medicinal plants used by the Bodo community of Chakrashila Wildlife Sanctuary, Assam, India. *Indian Journal of Applied Research*, 4(2). https://doi.org/10.15373/2249555X/FEB2014/13

Teixeira, C. P., De Azevedo, C. S., Mendl, M., Cipreste, C. F. & Young, R. J. (2007). Revisiting translocation and reintroduction programmes: the importance of considering stress. *Animal behaviour*, 73(1), 1-13. https://doi.org/10.1016/j.anbehav.2006.06.002

Vasudeva, V., Ramasamy, P., Pal, R. S., Behera, G., Karat, P. R. & Krishnamurthy, R. (2021). Factors influencing people's response toward tiger translocation in Satkosia Tiger Reserve, Eastern India. *Frontiers in Conservation Science*, 2, 664897. https://doi.org/10.3389/fcosc.2021.664897

Vodouhê, F. G., Coulibaly, O., Adégbidi, A. & Sinsin, B. (2010). Community perception of biodiversity conservation within protected areas in Benin. *Forest Policy and Economics*, 12(7), 505-512. https://doi.org/10.1016/j.forpol.2010.06.008

Williams, B. K., Nichols, J. D. & Conroy, M. J. (2002). *Analysis and management of animal populations.* Academic Press.

Yadav, S. P., Tiwari, V. R., Mallick, A., Garawad, R., Talukdar, G., Sultan, S., Ansari, N. A., Banerjee, K. & Das, A. (2023). *Management Effectiveness Evaluation of Tiger Reserves in India, Fifth Cycle, 2022*. Wildlife Institute of India, Dehradun and National Tiger Conservation Authority, Government of India.

ISSN (Online): 3048-7803

JWLS

Volume 3 Issue 2 (June 2026)

TYPE Short Communication

Clinical recovery from multidrug-resistant bacterial infection in a suppurative wound of a Royal Bengal Tiger using linezolid

Anik Dutta[1,2]*, Tishita Sen Ape[1,2], Md. Sarwar Uddin[3], Md. Shahadat Hossain Suvo[3], Shuvo Singha[2,4], Md. Mizanur Rahman[1,2]

[1]Department of Medicine and Surgery, Chattogram Veterinary and Animal Sciences University, Khulshi, Chattogram, Bangladesh.
[2]Udder Health Bangladesh, Chattogram, Bangladesh.
[3]Chattogram zoo, Foy's Lake Approach Rd, Akbar shah (Pahartali), Chattogram 4202, Bangladesh.
[4]Programme for Emerging Infections, Infectious Diseases Division, The International Centre for Diarrhoeal Disease Research (icddr,b), Dhaka 1212, Bangladesh.

EDITED BY
Pradeep Kumar Malik
Wildlife Institute of India, Dehradun, India.

*CORRESPONDENCE
Anik Dutta
anik3291@my.cvasu.ac.bd

RECEIVED 11 May 2026
ACCEPTED 26 May 2026
PUBLISHED 05 July 2026

CITATION
Dutta, A., Ape, T. S., Uddin, M. S., Suvo, M. S. H., Singha, S., Rahman, M. M. (2026). Clinical recovery from multidrug-resistant bacterial infection in a suppurative wound of a Royal Bengal Tiger using linezolid. *Journal of Wildlife Science,* 3(2), 73-78. https://doi.org/10.63033/JWLS.OWCW2196

COPYRIGHT
© 2026 Dutta, Ape, Uddin, Suvo, Singha, Rahman. This is an open-access article, immediately and freely available to read, download, and share. The information contained in this article is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited in accordance with accepted academic practice. Copyright is retained by the author(s).

PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001 INDIA

PUBLISHER'S NOTE
The Publisher, Journal of Wildlife Science or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this article. All claims expressed in this article are solely those of the author(s) and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in this article or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

Abstract

Antimicrobial resistance (AMR) poses a critical threat to both human and animal health, with indiscriminate and excessive antibiotic use in livestock and captive wildlife contributing to its rapid emergence. This case report describes a clinical case of treatment failure due to multidrug-resistant bacteria in a captive tiger (*Panthera tigris*) at Chattogram Zoo, Bangladesh. An adult tiger was injured in a fight, leading to a wound on the shoulder region. Initial treatment with flucloxacillin (10 mg/kg, intramuscularly [IM], for 13 days) failed to yield improvement. Subsequent bacteriological culture and antimicrobial susceptibility (AMS) testing revealed flucloxacillin resistance. The animal was then treated sequentially with cefazolin (20 mg/kg IM, 13 days) and ciprofloxacin (15 mg/kg IM, 10 days), both of which were identified as susceptible in vitro; however, neither resulted in clinical recovery. The administration of linezolid (600 mg orally, every 12 hours for 15 days) led to complete wound healing. This case highlights the clinical challenges posed by AMR in captive wild animals and underscores the necessity of prompt culture-guided therapy and prudent antibiotic use in zoological settings.

Keywords: Antimicrobial susceptibility, captive animal, cefazolin, flucloxacillin, treatment failure, wildlife disease.

Introduction

The tiger (*Panthera tigris*) is the largest cat species, and it is native to Asia (Maharjan *et al.*, 2024). In taxonomical classification, it belongs to the order Carnivora within the family Felidae (Wild Cat Family, 2024). There are nine subspecies of tiger in the world; six of these subspecies are endangered, and the remaining three are extinct (Wilting *et al.*, 2015). The endangered six subspecies are the Bengal (*P. t. tigris*), Indo-Chinese (*P. t. corbetti*), South China (*P. t. amoyensis*), Siberian (*P. t. altaica*), Malayan (P. t. jacksoni), and Sumatran (P. t. sumatrae) tigers. The extinct three subspecies are the Caspian tiger (*P. t. virgata*), the Javan tiger (*P. t. sondaica*), and the Bali tiger (*P. t. balica*) (Liu *et al.*, 2018). The Bengal Tiger is a living subspecies native to Asia, most commonly found in Bangladesh, India, Nepal, and Bhutan (Goodrich *et al.,* 2022). The Bengal tiger is listed as an endangered subspecies according to the IUCN Red List of Threatened Species (IUCN 2021). According to the last census conducted in 2024, the number of Royal Bengal Tigers living in the Sundarbans is 125 (Bangladesh Forest Department 2024), which represents about 5.0%-6.25% of the entire wild Bengal tiger population in the world. Zoos provide conservation support for endangered species, playing a vital role in the conservation of the tiger population (Christie 2010).

Antimicrobial resistance (AMR) has become a major global threat to humans, animals, and plants (WHO 2023). A major driver of antimicrobial resistance (AMR) in animals is the prophylactic use of antimicrobials for disease prevention or growth promotion. Subtherapeutic doses of antimicrobials are also responsible for the emergence of resistant bacterial strains (Van Boeckel *et al.*, 2015). Antibiotic-resistant bacteria (ARB) and antibiotic residues may transfer into wild animals through various routes, such as food/ meat, and the environment. Manure of the food-producing animals used in the land acts as a reservoir of resistant bacteria and antibiotic residues; these spread

into the wild animal population (Libisch *et al.*, 2020). Food-producing animals, especially poultry, may be an important source of antibiotic-resistant bacteria due to the extensive use of antibiotics, including third-generation antibiotics, in industrial farming (Alam *et al.*, 2023; de Been *et al.*, 2014). Thus, chicken meat when supplied as a diet can transfer AMR to the tigers in captive conditions (Shousha *et al.*, 2015). In captive conditions, tigers are fed raw meat diets consisting of broiler meat, beef, whole poultry, or rabbit carcass (Dotterweich & Lacie, 2020). These types of feed ingredients can transfer AMR to tigers in captive conditions. In captivity, tigers remain in close contact with humans, who can transfer AMR bacteria from humans to animals as well (Xue *et al.*, 2016). In Bangladesh, most of the AMR research mainly focused on livestock, poultry, and humans, but there is a limited number of studies on evidence-based treatment of captive wildlife like tiger that are victims of AMR bacteria. This case report aims to analyse therapeutic challenges, AMR patterns and clinical management of a persistent MDR wound infection in a Royal Bengal Tiger.

Materials and Methods

Case history and clinical examination

The Chattogram Zoo, Bangladesh currently houses 19 Royal Bengal tigers in two separate enclosures segregated by sex. The zoo is managed by a team of two on- site veterinarians, and they are responsible for animal health, medical care and nutrition. The tigers are routinely fed raw meat, including chicken and beef, at an allotted amount that is determined by veterinarians. On 8 April 2024, a wound was detected on shoulder of a 3.1-year-old female tiger, which was presumed to have resulted from intraspecific fighting (Figure 1). Notably, this tiger had experienced a similar fighting-related injury the previous year, which had successfully healed following treatment with the antibiotic ceftriaxone. In the current incident, she was treated with flucloxacillin at a dose of 10 mg/kg body weight, administered at 8-hour intervals for 13 consecutive days. However, the tiger did not respond to this therapeutic regimen.

Laboratory Test

- *Sample collection, transportation and preservation*

For the bacteriological culture and antimicrobial susceptibility test (AST), sterile swab samples were collected from the wound of the tiger for three consecutive days following the failure of antibiotic therapy. The first sample was obtained on the 19th day of postinfection, after completing a 13-day course of flucloxacillin. The infection did not subside, so the second sample was collected on the 35th day after the failure of recovery of a 13-day course of cefazolin, and the final sample was collected on the 45th day after finishing a 10-day course of ciprofloxacin. A sterile cotton bud was gently rubbed on the wound area and then dissolved in 3 mL of 0.9% NaCl that was contained in the 10mL falcon tube (Scenesafe, UK). The marked falcon tube was placed in an icebox that maintained a temperature of 4°C and carried to the Udder Health Bangladesh (UHB) lab, where it was maintained at 4°C until the bacterial culture.



Figure 1. Wound present on the shoulder region of the tiger

- *Bacteriological culture and antimicrobial susceptibility*

The collected sample was inoculated on blood agar supplemented with 5% bovine blood, MacConkey agar, and incubated for 24 hours at 37 °C. Presumptive identification of bacteria was done based on cultural characteristics on blood agar, which was identified as gram-positive bacteria and growth on blood agar and MacConkey agar was identified as both gram-negative and gram-positive bacteria, as follows by Singha (Singha *et al.*, 2024). Antimicrobial susceptibility tests were performed using the Kirby–Bauer disc diffusion method according to the Clinical and Laboratory Standards Institute (CLSI) (Humphries *et al.*, 2021). A total of 17 antibiotic discs were used in AMS test including Amoxicillin+Clavulanic Acid (20µg+10µg), Ampicillin (10 µg), Ceftriaxone (30 µg), Ciprofloxacin (5 µg), Clindamycin (2 µg), Cefazolin (30 µg), Gentamicin (10 µg), Cefotaxime (5 µg), Ceftazidime (10 µg), Linezolid (30 µg), Vancomycin (30 µg), Cefoxitin (30 µg), Oxacillin (1 µg), Erythromycin (15 µg), Penicillin (0.6 µg), Sulfamethoxazole + Trimethoprim (23.75 µg+1.25 µg), and Tetracycline (30 µg). The results of the AMS tests were interpreted according to the criteria established by CLSI guidelines (Humphries *et al.*, 2021) as susceptible, intermediate, and resistant (Table 1). Resistant to at least one agent of three or more antimicrobial categories, determined as MDR bacteria.

Treatment Strategy

Following the injury, the tiger was initially treated with flucloxacillin at a dosage of 10 mg/kg body weight, administered intramuscularly at 8-hour intervals for 10 consecutive days (Table 2). However, no clinical improvement was observed. Subsequently, bacteriological isolation and AMS testing were conducted. The AMS test results revealed resistance to clindamycin and ceftriaxone, whereas cefazolin was found to be effective. Based on these findings, the tiger was treated with cefazolin (Inj. Zolibac 1 g®, manufactured by Square Pharmaceuticals PLC, Bangladesh) at 20 mg/kg body weight, administered intramuscularly at 8-hour intervals for 13 consecutive days, but remained ineffective. Further, the AMS test result showed that the sensitive antibiotic was ciprofloxacin. Then the antibiotic ciprofloxacin (Inj. Ciprocin 50 mL®, manufactured by Square Pharmaceuticals PLC, Bangladesh) was provided at 15 mg/kg body weight intramuscularly in 8-hour intervals for 10 days. But when it did not work, another AMS test was conducted. AMS test results indicated that the antibiotics linezolid and vancomycin were sensitive. After these tests, the tiger was treated with the antibiotic linezolid (Tab. Linzolid-600 mg®, manufactured by Incepta Pharmaceuticals Limited, Bangladesh), using one tablet (600 mg) at 12-hour intervals orally for 15 days. After this medication, the tiger fully recovered.

Results and Discussion

The current case report was considered to describe the antibacterials used to treat the injured tiger. The current study identified a multidrug-resistant bacterial infection in the wound of the Royal Bengal Tiger. The result of consecutive culture and AST revealed that the responsible bacteria showed

Table 1. Summary of the antimicrobial susceptibility and resistance profiles of suspected bacteria over time, and key findings reflect the presence of multidrug-resistant (MDR) bacteria.

Date	Tested antibiotics[1]	Sensitive antibiotics [2]	Resistant antibiotics[3]	Suspected Bacterial Type[4]
28/04/24	Cefazolin, Clindamycin, Ceftriaxone Vancomycin	Cefazolin, Vancomycin (intermediate)	Clindamycin, Ceftriaxone	Gram Positive, Gram Negative
15/05/24	Amoxycillin+Clavulanic acid, Ceftriaxone, Ciprofloxacin, Gentamycin,Cefotaxime, Ceftazidime, Ampicillin	Ciprofloxacin	Amoxycillin+Clavulanic acid, Ceftriaxone, Gentamycin, Cefotaxime, Ceftazidime, Ampicillin	Gram Positive
26/05/24	Ampicillin, Cefoxitin, Erythromycin, Ciprofloxacin, Amoxycillin+Clavulanic acid, Penicillin, Gentamycin, Linezolid, Vancomycin	Linezolid, Vancomycin	Ampicillin, Cefoxitin, Erythromycin, Ciprofloxacin, Amoxycillin+Clavulanic acid, Penicillin, Gentamycin	Gram Positive, Gram Negative

[1] AST were performed against these listed antibiotics by following CLSI guidelines
[2]Antibiotics shown efficacy to effectively kill or inhibit microorganism on AST
[3]Antimicrobials to which microorganism shows resistance on AST
[4]The presumptive bacterial identification based on the growth on blood agar and MacConkey agar

resistance to multiple classes of antimicrobials like tetracyclines, penicillins, aminoglycosides, and exhibited susceptibility to the third-generation cephalosporins, fluoroquinolones, and Oxazolidinones. Focused on these findings, the therapeutic regimen was strategically changed at each stage to promote gradual healing of the wound and complete clinical recovery of the tiger. To the best of our knowledge, this is the first documented report of the successful management of a MDR wound infection in a Royal Bengal Tiger with linezolid. The necessity to require a critical last-line antibiotic like linezolid for wound management underscores the growing and serious threat of antimicrobial resistance in captive wild animals and the severe depletion of viable therapeutic options. Linezolid is a well- established antibiotic in human medicine, but its application to large wild felids has not been reported previously.

In this current case, microbiological investigation was limited to phenotypic bacterial isolation and AST, but species-level identification could not be performed due to limitations of advanced diagnostic infrastructure during case management. Advanced molecular diagnostic techniques, including 16s rRNA gene sequencing and MALDI-TOF mass spectrometry, may provide precise species-level identification and should be considered in future investigations of MDR infection cases in wildlife species (Seng *et al.*, 2009; Woo *et al.*, 2008).

Initially, following the injury, the tiger was treated with flucloxacillin. It is a narrow-spectrum, beta-lactamase-resistant penicillin (Kennard *et al.*, 2019). Recently, the use of the antibiotic flucloxacillin has increased for treatment purposes, and this overuse can develop antimicrobial resistance (Francis *et al.*, 2016). After the use of flucloxacillin, the tiger did not recover, possibly in response to the invasion by antimicrobial-resistant bacteria.

When flucloxacillin didn't work, then the AMS test was conducted, and it showed that the Cefazolin was sensitive in-vitro. Cefazolin is a first-generation antibiotic in the group of cephalosporins (Kirby *et al.*, 1973). Then Cefazolin was administered at 20 mg/kg body weight intramuscularly for 13 days, but the wound did not heal. In a study, cefazolin showed less effectiveness against some strains of Staphylococcus aureus (Weis *et al.*, 2019). Methicillin-susceptible Staphylococcus aureus (MSSA) strains can produce type A beta-lactamase; these are responsible for the failure of cefazolin (Nannini *et al.*, 2009).

Further in-vitro AMS tests identified Ciprofloxacin as a sensitive antibiotic. Based on the veterinarian's advice, Ciprofloxacin at 15 mg/kg body weight at 8-hour intervals intramuscularly was used for 10 days. Ciprofloxacin is an antibiotic in the group of fluoroquinolones, and it is effective against gram-positive and gram-negative bacteria and also against methicillin-resistant Staphylococcus aureus (MRSA) and Pseudomonas aeruginosa (Terp & Rybak, 1987). However, it remained ineffective. Further AMS tests showed that the antibiotic ciprofloxacin became resistant, but it was sensitive previously. Due to improper use of this antibiotic, it might have developed resistance, which arises when the treatment disturbs the susceptible bacteria and selectively allows adapted or mutated strains to survive, expand, and spread to others (Habboush & Guzman N, 2025).

In the final AMS test, the result indicated the sensitive antibiotic was linezolid. Linezolid is a synthetic antibiotic in the class of oxazolidinones. It is highly effective against gram-positive bacteria and indicated for the treatment of skin infections (Azzouz & Preuss, 2024). It acts by binding to the 23S rRNA component of the 50S ribosomal subunit, thereby blocking formation of the 70S initiation complex essential for bacterial protein synthesis (Shinabarger *et al.*, 1997). This distinct mechanism confers no cross-resistance with other antibiotic classes (Falagas *et al.*, 2008). It is found to be highly sensitive to the methicillin-resistant Staphylococcus aureus or Streptococcus pyogenes that are responsible for the skin infection. It is also effective against vancomycin-resistant enterococci (Hashemian *et al.*, 2018). Then linezolid was prescribed at a dose of 600 mg at 12-hour intervals for 15 days. After this treatment, the tiger recovered (Figure 2). This outcome illustrates a critical, growing problem of multidrug-resistant (MDR) infection in captive wildlife. This case gives strong reasoning for evidence-based treatment decisions and a need for AMR surveillance in the captive wildlife interface.

This study is constrained by some limitations of a single-case nature, the absence of bacterial specification, and the lack of pharmacokinetic data for linezolid in tigers. Future investigation should focus on bacterial specification, increased sample size with collaborations, and pharmacokinetic evaluations to validate therapeutic application in tigers.

 https://doi.org/10.63033/JWLS.OWCW2196

Table 2. Chronological therapeutic interventions, adjustment of antimicrobials and other supportive therapies guided by sequential culture and antimicrobial susceptibility test results.

Before CS Test						
Date	**Groups of Drug**	**Generic name**	**Trade name**	**Route**	**Dosage**	**Duration**
8/04/24	Antibacterial	Flucloxacillin Sodium	Inj. Fluclox 500mg	i/m	10 mg/kg (8 hours interval)	13 days
	Anthelmintic	Ivermectin	Inj. A-mectin Vet 5ml	i/m	2 ml	Single dose
Along with that as supplement from 10-04-24	Immunostimulant	Pidotimod	Tab. Pidonex 800mg	PO	1tab (SID)	10 days
	Anti-inflammatory	Hydrocortisone Acetate	Cream. Topicort	Topically	SID	10 days
After CS Test						
After 1st test (28-04-24)	Antibacterial	Cefazolin Sodium	Inj Zolibac -1 gm	i/m	1gm (8 hours interval)	13 days
After 2nd test (15-05-24)	Antibacterial	Ciprofloxacin	Inj Ciprocin -50 ml	i/m	15 mg/kg IM (8-hour interval)	10 days
	Proton pump inhibitor	Pantoprazole Sodium	Tab Pantonix 20	PO	1+0+1	10 days
After 3rd test (26-05-24)	Antibacterial	Linezolid	Tab Linzolid-600mg	PO	1+0+1 (12 hours interval)	15 days
	Proton pump inhibitor	Pantoprazole Sodium	Tab Pantonix 20	PO	1+0+1	15 days
	Nutritional supplement	Multivitamin and Multimineral	Syp. Zovia GOLD-100 ml	PO with feed	4 tsp	15 days



Figure 2. The tiger's wound recovered following treatment with the antibiotic linezolid.

Conclusion

This case highlights the emergence of antimicrobial resistance in a captive Bengal tiger, demonstrated by the failure of response to several antibiotic therapies. It emphasises the need for prudent antibiotic use, proper antimicrobial stewardship, and safe feeding practices in zoo animals to reduce the risk of treatment failure and curb the spread of resistant pathogens. This study indicates that evidence-based treatment decisions would be an effective pathway for management of captive wildlife, and surveillance is needed to assess the AMR in the wildlife-human-environment interface to understand the transmission of AMR bacterial strains. To elucidate resistant development and dissemination, further investigation is warranted. This evaluation should include assessing the feed, personnel and environmental samples to identify specific AMR genes and trace their potential transmission pathways.

Acknowledgment

The authors would like to thank the veterinarian at the Chattogram Zoo for their assistance during sample collection and the Udder Health Bangladesh lab for their funding and logistic support during fieldwork and laboratory tests.

CONFLICT OF INTEREST

The authors declare no competing interests.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

Anik Dutta: Investigation, Data curation, Data visualization, Writing- original draft. Tishita Sen Ape: Laboratory analysis, Data visualization, Writing-review and editing. Md. Sarwar Uddin: Investigation, Sample collection. Md. Shahadat Hossain Suvo: Sample collection, Writing-review and editing. Shuvo Singha: Supervision, Writing-review and editing. Md. Mizanur Rahman: Writing- review and editing. All authors read and approved the final manuscript.

ETHICAL APPROVAL

Permit to handle the tiger was issued by the Ethics Committee of Chattogram Veterinary and Animal Sciences University (CVASU) under permit number CVASU/Dir(R&E) EC/2025/952/6.

USE OF GENERATIVE AI

The authors used ChatGPT (OpenAI, GPT-5.5) for grammatical improvement and language editing during the preparation of this manuscript. The authors thoroughly reviewed and edited the content generated and take full responsibility for the content of the publication.

References

Alam, G. S., Hassan, M. M., Ahaduzzaman, M., Nath, C., Dutta, P., Khanom, H., Khan, S. A., Pasha, M. R., Islam, A. *et al.* (2023). Molecular Detection of Tetracycline-Resistant Genes in Multi-Drug-Resistant Escherichia coli Isolated from Broiler Meat in Bangladesh. *Antibiotics*, 12(2). https://doi.org/10.3390/antibiotics12020418

Azzouz, A. & Preuss, C. V. (2024). *Linezolid*. In: StatPearls [Internet]. StatPearls Publishing, Treasure Island (FL). https://www.ncbi.nlm.nih.gov/sites/books/NBK539793/

Bangladesh Forest Department (2024). *Statue of Tigers in the Sundarbans of Bangladesh I 1.* Bangladesh Forest Department, Ministry of Environment, Forest and Climate Change, Government of the People's Republic of Bangladesh. https://bforest.portal.gov.bd/sites/default/files/files/bforest.portal.gov.bd/page/2df7f2df_fa89_453f_8058_7efa3bd806f1/2024-10-08-16-54-b980bccfac92f65a091dcdb97b76f8dc.pdf

Christie, S. (2010). *Why Keep Tigers in Zoos? In: Tilson, R. & Nyhus, P. J. (eds.). Tigers of the World: The Science, Politics and Conservation of Panthera Tigris, Second edition.* Academic Press. pp. 205–214. https://doi.org/10.1016/B978-0-8155-1570-8.00015-3

de Been, M., Lanza, V. F., de Toro, M., Scharringa, J., Dohmen, W., Du, Y., Hu, J., Lei, Y., Li, N. *et al.* (2014). Dissemination of Cephalosporin Resistance Genes between Escherichia coli Strains from Farm Animals and Humans by Specific Plasmid Lineages. *PLoS Genetics*, 10(12), e1004776. https://doi.org/10.1371/journal.pgen.1004776

Dotterweich, L. (2020). *A Feast Fit for a [Tiger] King.* American Feed Industry Association. https://www.afia.org/news/afia-blog/a-feast-fit-for-a-tiger-king/ [Accessed on 10 May 2026]

Falagas, M. E., Siempos, I. I. & Vardakas, K. Z. (2008). Linezolid versus glycopeptide or β-lactam for treatment of Gram-positive bacterial infections: meta-analysis of randomised controlled trials. *The Lancet Infectious Diseases*, 8(1), 53–66. https://doi.org/10.1016/S1473-3099(07)70312-2

Francis, N. A., Hood, K., Lyons, R. & Butler, C. C. (2016). Understanding flucloxacillin prescribing trends and treatment non-response in UK primary care: A Clinical Practice Research Datalink (CPRD) study. *Journal of Antimicrobial Chemotherapy*, 71(7), 2037–2046. https://doi.org/10.1093/jac/dkw084

Goodrich, J., Wibisono, H., Miquelle, D., Lynam, A. J., Sanderson, E., Chapman, S., Gray, T. N. E., Chanchani, P. & Harihar, A. (2022). *Panthera tigris. The IUCN Red List of Threatened Species 2022: e. T15955A214862019.* https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T15955A214862019.en . Accessed on 25 June 2026.

Habboush, Y. & Guzman, N. (2025). *Antibiotic Resistance.* In: StatPearls [Internet]. StatPearls Publishing, Treasure Island (FL). https://www.ncbi.nlm.nih.gov/books/NBK513277/StatPearls.

Hashemian, S. M. R., Farhadi, T. & Ganjparvar, M. (2018). Linezolid: a review of its properties, function, and use in critical care. *Drug Design, Development and Therapy*, 12, 1759–1767. https://doi.org/10.2147/DDDT.S164515

Humphries, R., Bobenchik, A. M., Hindler, J. A. & Schuetz, A. N. (2021). Overview of Changes to the Clinical and Laboratory Standards Institute Performance Standards for Antimicrobial Susceptibility Testing, M100, 31st Edition. *Journal of Clinical Microbiology*, 59, jcm.00213-21. https://doi.org/10.1128/jcm.00213-21

IUCN. (2021). The IUCN Red List of Threatened Species. https://www.iucnredlist.org

Kennard, L., Rutkowski, K., Siew, L. Q. C., Nakonechna, A., Sargur, R., Egner, W., Shrimpton, A., Mirakian, R. & Wagner, A. (2019). Flucloxacillin Hypersensitivity: Patient Outcomes in a Multicenter Retrospective Study. *Journal of Allergy and Clinical Immunology: In Practice*, 7(7), 2212-2217.e1. https://doi.org/10.1016/j.jaip.2019.03.018

Kirby, W. M. M., Regamey, C. & Kirby, M. M. (1973). Pharmacokinetics of Cefazolin Compared with Four Other Cephalosporins. *The Journal of Infectious Diseases* 128(Supplement_2), S341–S346. https://doi.org/10.1093/infdis/128.Supplement_2.S341

Libisch, B., Keresztény, T., Kerényi, Z., Kocsis, R., Sipos, R., Papp, P. P. & Olasz, F. (2020). Metagenomic analysis of acquired antibiotic resistance determinants in the gut microbiota of wild boars (*Sus scrofa*) - preliminary results. *Journal of Veterinary Research (Poland)*, 64(1), 111–118. https://doi.org/10.2478/jvetres-2020-0015

Liu, Y. C., Sun, X., Driscoll, C., Miquelle, D. G., Xu, X., Martelli, P., Uphyrkina, O., Smith, J. L. D., O'Brien, S. J. & Luo, S. J. (2018). Genome-Wide Evolutionary Analysis of Natural History and Adaptation in the World's Tigers. *Current Biology*, 28(23), 3840-3849.e6. https://doi.org/10.1016/j.cub.2018.09.019

Maharjan, A., Maraseni, T., Allen, B. L. & Apan, A. (2024). A systematic literature review: Trends and current state of research on Bengal tiger (*Panthera tigris tigris*), 2010–2022. *Biodiversity and Conservation*, 33(6–7), 1871–1894. https://doi.org/10.1007/s10531-024-02856-3

Nannini, E. C., Stryjewski, M. E., Singh, K. V., Bourgogne, A., Rude, T. H., Corey, G. R., Fowler, V. G. & Murray, B. E. (2009). Inoculum effect with cefazolin among clinical isolates of methicillin-susceptible Staphylococcus aureus: Frequency and possible cause of cefazolin treatment failure. *Antimicrobial Agents and Chemotherapy*, 53(8), 3437–3441. https://doi.org/10.1128/AAC.00317-09

Seng, P., Drancourt, M., Gouriet, F., La Scola, B., Fournier, P.-E., Rolain, J. M. & Raoult, D. (2009). Ongoing Revolution in Bacteriology: Routine Identification of Bacteria by Matrix-Assisted Laser Desorption Ionization Time-of-Flight Mass Spectrometry. *Clinical Infectious Diseases*, 49(4), 543–551. https://doi.org/10.1086/600885

Shinabarger, D. L., Marotti, K. R., Murray, R. W., Lin, A. H., Melchior, E. P., Swaney, S. M., Dunyak, D. S., Demyan, W. F. & Buysse, J. M. (1997). Mechanism of action of oxazolidinones: effects of linezolid and eperezolid on translation reactions. *Antimicrobial Agents and Chemotherapy*, 41(10), 2132–2136. https://doi.org/10.1128/AAC.41.10.2132

Shousha, A., Awaiwanont, N., Sofka, D., Smulders, F. J. M., Paulsen, P., Szostak, M. P., Humphrey, T. & Hilbert, F. (2015). Bacteriophages isolated from chicken meat and the horizontal transfer of antimicrobial resistance genes. *Applied and Environmental Microbiology*, 81(14), 4600–4606. https://doi.org/10.1128/AEM.00872-15

Singha, S., Koop, G., Rahman, M. M., Ceciliani, F., Addis, M. F., Howlader, M. M. R., Hossain, M. K., Piccinini, R., Locatelli, C. *et al.* (2024). Pathogen group-specific risk factors for intramammary infection in water buffalo. *PLoS One*, 20(10), e0334533. https://doi.org/10.1371/journal.pone.0299929

Terp, D. K. & Rybak, M. J. (1987). Ciprofloxacin. *Drug Intelligence & Clinical Pharmacy*, 21(7-8), 568-574 https://doi.org/10.1177/1060028087021007-801

Van Boeckel, T. P., Brower, C., Gilbert, M., Grenfell, B. T., Levin, S. A., Robinson, T. P., Teillant, A. & Laxminarayan, R. (2015). Global trends in antimicrobial use in food animals. *Proceedings of the National Academy of Sciences of the United States of America*, 112(18), 5649–5654. https://doi.org/10.1073/pnas.1503141112

Weis, S., Kesselmeier, M., Davis, J. S., Morris, A. M., Lee, S., Scherag, A., Hagel, S. & Pletz, M. W. (2019). Cefazolin versus anti-staphylococcal penicillins for the treatment of patients with Staphylococcus aureus bacteraemia. In *Clinical Microbiology and Infection*, 25 (7), pp. 818–827. https://doi.org/10.1016/j.cmi.2019.03.010

WHO (2023). Antimicrobial Resistance. https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance [Accessed on 10 May 2026]

Wild Cat Family. (2024). 2024 Wild Cat List by Lineage. https://www.wildcatfamily.com/wp-content/uploads/2024/11/2024-11-Wild-Cat-List-by-Lineage.pdf [Accessed on 10 May 2026]

Wilting, A., Courtiol, A., Christiansen, P., Niedballa, J., Scharf, A. K., Orlando, L., Balkenhol, N., Hofer, H., Kramer-Schadt, S. *et al.* (2015). Planning tiger recovery: Understanding intraspecific variation for effective conservation. *Science Advances*, 1(5). https://doi.org/10.1126/sciadv.1400175

Woo, P. C. Y., Lau, S. K. P., Teng, J. L. L., Tse, H. & Yuen, K. Y. (2008). Then and now: Use of 16S rDNA gene sequencing for bacterial identification and discovery of novel bacteria in clinical microbiology laboratories. In *Clinical Microbiology and Infection*, 14(10), 908–934. https://doi.org/10.1111/j.1469-0691.2008.02070.x

Xue, Y., Chen, J., Hua, Y., Zhang, W., Liu, S. & Liu, D. (2016). Antimicrobial Resistance and Resistance Gene Determinants in Clinical Escherichia coli from a Captive Population of Amur Tiger in China. *Pakistan Journal of Zoology*, 48(4), 1155-1159. http://zsp.com.pk/pdf48/1155-1159%20(34)%20PJZ-2306-15%2027-4-16%20Antimicrobial%20Resistance%20and%20Resistance%20Gene%20Deter_.pdf

ISSN (Online): 3048-7803

JWLS

Volume 3 Issue 2 (June 2026)

TYPE Natural History Note

First record of true vivipary in *Eragrostiella bifaria* var. *walkeri* (Poaceae: Chloridoideae, Tripogoninae) under cultivated conditions, and a brief note on its taxonomy

Shahid Nawaz Khwaja Bhai Landge[1]*, Alok Lamuel Gude[2]

[1]The Blatter Herbarium (BLAT), St. Xavier's College (Empowered Autonomous Institute), Mumbai, 400001 India

[2]Department of Botany, St. Xavier's College (Empowered Autonomous Institute), Mumbai, 400001 India

EDITED BY
Navendu Page
Thackeray Wildlife Foundation

*CORRESPONDENCE
Shahid Nawaz Khwaja Bhai Landge
shahidnawaz.landge@xaviers.edu

RECEIVED 07 January 2026
ACCEPTED 20 April 2026
PUBLISHED 05 July 2026

CITATION
Landge, S. N. K. B. & Gude, A. L. (2026). First record of true vivipary in *Eragrostiella bifaria* var. *walkeri* (Poaceae: Chloridoideae, Tripogoninae) under cultivated conditions, and a brief note on its taxonomy. *Journal of Wildlife Science,* 3(2), 79-82.
https://doi.org/10.63033/JWLS.OQBW9095

COPYRIGHT
© 2026 Langde & Gude. This is an open-access article, immediately and freely available to read, download, and share. The information contained in this article is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited in accordance with accepted academic practice. Copyright is retained by the author(s).

PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001 INDIA

PUBLISHER'S NOTE
The Publisher, Journal of Wildlife Science or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this article. All claims expressed in this article are solely those of the author(s) and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in this article or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

Abstract

This study documents the accidental emergence of viviparous spikelets in *Eragrostiella bifaria* var. *walkeri* observed during a controlled cultivation trial. This phenomenon constitutes the first record of vivipary for the genus *Eragrostiella*. A detailed morphological description of this rare taxon is provided, accompanied by photo plates to aid in precise identification. We discuss the potential environmental and physiological factors that may have triggered this rare event under cultivated conditions, speculating on its biological significance as an acute survival mechanism.

Keywords: Asexual reproduction, endemic plant, gramineae, grass anatomy, India.

The genus *Eragrostiella* Bor historically segregated from *Eragrostis* due to its solitary spike inflorescence bearing secund spikelets, contrasting with the panicle of the latter. Phylogenetically, *Eragrostiella* is considered sister to the *Tripogonella* clade (Peterson *et al.*, 2016). *Eragrostiella* is characterised by its multiflowered spikelets and exaristate lemma, a feature that reliably distinguishes it from the closely related genera *Tripogon* Roem. & Schult. and *Tripogonella* P.M. Peterson & Romasch., both of which possess a distinctly aristate lemma. The genus consists of six species distributed across the old-world tropics and subtropics, with five species and two varieties known to occur in India (Lazarides, 1976).

Eragrostiella bifaria var. *walkeri* thrives in the dry, rocky habitats (characterised by sandstone and quartzite substrates) of Andhra Pradesh, South India. Despite inhabiting these xeric conditions, vivipary has not been documented in its wild populations. Gandikota hills, a geologically unique and botanically underexplored region, harbours unique grass flora in South India (Landge *et al.*, 2026).

In its native habitats in Gandikota hills, Kadapa district of Andhra Pradesh, *Eragrostiella bifaria* var. *walkeri* exhibits notably robust growth forms, attaining a height of up to 90 cm (3 feet) (Figure 1). This impressive stature alone allows for easy distinction from its congeners such as, *E. brachyphylla* (Stapf) Bor, *E. bifaria* var. *bifaria* (Vahl) Bor and *E. nardoides* (Trin.) Bor. The inflorescence in var. *walkeri* is typically long and drooping, often measuring up to 40 cm in length. The leaves are evenly distributed on the culms; they are long, flat and drooping, and may reach up to 50 cm long. The lowest leaves clearly exceed the base of the inflorescence. Culms can be 2–4 nodded. The spikelets are generally whitish, occasionally displaying a purple tinge on the glumes, lemma apices, and submarginal sides. The spikelet floret count can be exceptionally high, often reaching 50 to 60 per spikelet.

The remarkable numerical superiority observed in the plant habit (height), inflorescence length, and spikelet floret number far exceeds the recorded extremes for any other taxa within the genus *Eragrostiella*. However, Lazarides (1976), viewing this taxon within the broader circumscription of E. bifaria, reduced its taxonomic rank to a variety. This treatment may be justified to some extent, as there is a paucity of qualitative characteristics currently available to support its segregation as a distinct species. To resolve this taxonomic uncertainty and confirm its appropriate rank, a molecular phylogenetic approach is strongly recommended.

In the present study, we report the occurrence of true vivipary in the inflorescence of *Eragrostiella bifaria* var. *walkeri* under controlled cultivated conditions. This observation is significant as it constitutes the first published record of true vivipary for the genus *Eragrostiella* and for the entire subtribe Tripogoninae. This finding warrants further investigation into the genetic potential and environmental triggers for vivipary within this taxonomically important group.



Figure 1. Habitats and habit of *Eragrostiella bifaria* var. *walkeri* in Gandikota hill, Kadapa [Cuddapah] district, Andhra Pradesh, India. (Captured on 21 December 2019 by Mr. Shahid Nawaz).

True vivipary is defined as the precocious germination of the embryo into small, separable plantlets while the developing structures remain attached to the mother plant (Goebel, 1905; Arber, 1965; Beetle, 1980; Vega & de Agrasar, 2006). These plantlets subsequently detach and fall to the ground; however, they often exhibit reduced reproductive potential, either remaining strictly vegetative or perishing. Vivipary is sometimes confused with vegetative proliferation (also termed pseudovivipary). Pseudovivipary is distinct because it involves asexual growth and the direct conversion of floral buds into vegetative plantlets, rather than the germination of a sexually produced embryo (Vega & de Agrasar, 2006).

In grasses, vivipary is considered an adaptation to severe climatic conditions, such as alpine, mountain, and arid regions (Tzelev, 1989). Vivipary has been documented across various grass genera, including *Agrostis* L., *Poa* L., *Eleusine* Gaertn., *Sesleria* Scop, *Avena* L., *Bromus* L., *Festuca* Tourn. ex L., *Deschampsia* P. Beauv., *Panicum* L., *Phleum* L., *Setaria* P. Beauv., and *Zea* L. The causal factors are complex, ranging from genetic influences (*e.g.*, hybridization, polyploidy) to adverse environmental stressors (*e.g.*, hormonal imbalance or fluctuation) (Beetle, 1980).

The grass *Eragrostiella bifaria* var. *walkeri*, an Indo-Ceylon disjunct taxon, is consistently observed thriving in dry, rocky areas (sandstone and quartzite) (Figure 1) within Andhra Pradesh, South India, confirming its remarkable desiccation tolerance and resurrection potential. In similar habitats, two more endemic grass taxa are found, *viz.*, *Parahyparrhenia bellariensis* (Hack.) Clayton and *Chrysopogon velutinus* (Hook.f.) Bor, more details on them can be found in Landge & Shinde (2021, 2022, 2023).

An extremely desiccated tuft of the grass was collected from Gandikota Fort hill, Andhra Pradesh, on 21 December 2019, and subsequently planted under controlled cultivated conditions at the grass experimental set-up at St. Xavier's College (Empowered Autonomous Institute), Mumbai, India. The first flowering appeared approximately six months later, in late June 2020, coinciding with the onset of the monsoon in India. Based on the characters such as robust habit, long inflorescence, four nodes on the culms, and leaf blades reaching the base of the inflorescence, the grass was identified using Bor (1960) and Lazarides (1976) as a match for *Eragrostiella walkeri* (now considered as *E. bifaria* var. *walkeri*).

In the same cultivated tuft, after the initial rigorous flowering subsided, accidental emergence of viviparous spikelets was observed in the inflorescence during the first week of October of the same year. The proliferated spikelet possessing a germinated caryopsis was studied under a stereo zoom microscope at Blatter Herbarium (BLAT) to understand its morphology and definitively confirm the occurrence of true vivipary, ruling out pseudovivipary.

Crucially, no instances of vivipary were recorded in natural populations in the wild, suggesting this phenomenon may be a stress-induced response triggered by the specific cultivated conditions (*e.g.*, increased moisture availability) following severe desiccation.

The collected viviparous voucher specimen of *Eragrostiella bifaria* var. *walkeri* has been processed for herbarium preparation and deposited at the Blatter Herbarium (BLAT) for future study.

The viviparously proliferated spikelet was found situated below the middle of the spike (Figure 2). It was confirmed to possess a caryopsis, which rapidly germinated inside the floret. The viviparous spikelet measured up to 0.8 cm in length and consisted of well-developed sheaths, blades up to 25 mm, and a ciliate ligule. Notably, a small portion of a root, emerging from within the lower floret, was visible towards the rachis near the lower involucral glume (Figure 3).

Since the phenomenon of vivipary was not observed in the wild population of *Eragrostiella bifaria* var. *walkeri*, it prompts a consideration of the factors that triggered its emergence under controlled conditions. This rare event, which was not witnessed in any subsequent years after its first emergence, suggests a highly specific or acute environmental stimulus.

Perhaps the sudden change in environmental conditions, specifically the shift from the extremely desiccated wild state to the moisture-rich, cultivated environment, played a role. This change, particularly following the initial recovery and flowering, may have stimulated a survival mechanism in the species. Whether it is due to an acute, stress-induced survival instinct activated by the unusual habitat changes under cultivation is not known.

Morphological description, taxonomy and distribution of *Eragrostiella bifaria* var. *walkeri*

Eragrostiella bifaria* var. *walkeri (Stapf) Lazarides, Contr. Herb. Austral. **22**: 7 (1976). – *Eragrostis walkeri* Stapf in Trim. Handb. Fl. Ceylon **298**. (1900). – *Eragrostiella walkeri* (Stapf) Bor in Ind. Forest. **66**: 270 (1940b). **Type**: SRI LANKA [CEYLON]. Walker s.n. [C.P. 60 pro parte on the label] (K000245121–lecto-type, designated by Lazarides (1994).

Robust, 30–90 cm high, densely tufted, geniculately ascending, glabrous, un-branched, perennial herb. Culms very slender, terete, bases studded with disintegrating fibrous sheaths, striated, glabrous, nodes 2–4, swollen and glabrous. Sheath shorter than the internode, scabrous, striated, terete, somewhat

 https://doi.org/10.63033/JWLS.OQBW9095

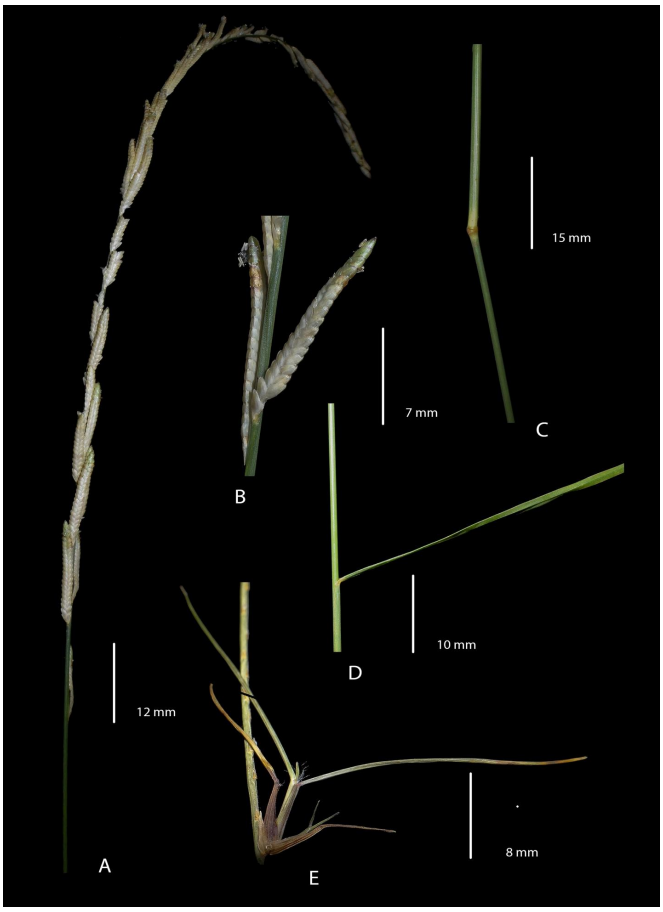


Figure 2. Morphology of *Eragrostiella bifaria* var. *walkeri* (Stapf) Lazarides with viviparous spikelet. A. Spicate inflorescence. B. Normal Spikelets. C. Node and geniculate culm. D. Leaf. E. Viviparous spikelet. (Captured on 5th October 2020 by Mr. Shahid Nawaz).

tightly clasping the culm, except near the mouth and little below, 6.0–8.0 cm in length. Ligule 0.8–2.0 mm long, ciliolate to ciliate. Blades sub-auriculate (thin, hyaline, membranous, glabrous extension of the margin of sheath), flat (becoming dry and convolute on maturity), striated, scaberulous and puberulous on intercostal spaces, linear long with attenuate to filiform apices 12–40 × 0.1–0.2 cm; basal leaves longer than their upper cauline counterparts, drooping, drying and somewhat curling at the tips on maturity; leaves reaching fairly above the base of the spike. Inflorescence a spike, up to 35 cm in length, remarkably curling and slightly drooping. Rachis very slender, serrulate on the edges. Spikelets sessile, distinctly white, multi-flowered (up to 50 florets), laterally compressed, linear long, 1.3 × 0.2 (–1.5) cm, biseriately secund, disposed alternately on a rhachis. Lower and the uppermost spikelets are smaller than those below and a little above the middle on the rhachis. Lower glume ovate adjacent to rhachis (adaxial), thin, hyaline, chartaceous, glabrous, 1-nerved, dorsally keeled, keel scabrous (somewhat pectinate in the lower two-third), apex sub-acute, slightly obtuse, 1.3 × 1.5 mm. Upper glume, sub-hyaline, fragile, chartaceous, 1-nerved, dorsally keeled, tip acute, slightly pectinate on the keel, linear-oblong 1.5 × 1.5 mm.

Floret: Lemma (lower two florets in the spikelets are barren) hyaline, membranous, glabrous, 3-nerved, margins broad, apex retuse or obtuse tinged with purple, broadly ovate, 2.5 × 2 mm; palea slightly shorter to its lemma, hyaline, obovate-spatulate, 2-keeled, ciliolate on the winged-keel, margin inflexed, broader at the base and tapering upwards, depressed between the keels, apex acute, broadly ovate. Stamens 3, anthers 0.8–1.1 mm in length. Lodicules turgid, in a pair at the base of the ovary, clavellate, slightly tridentate, ca. 0.3 mm. Ovary green, 0.25–0.3 mm in length, tipped with a tubercle protuberance (0.01 mm).

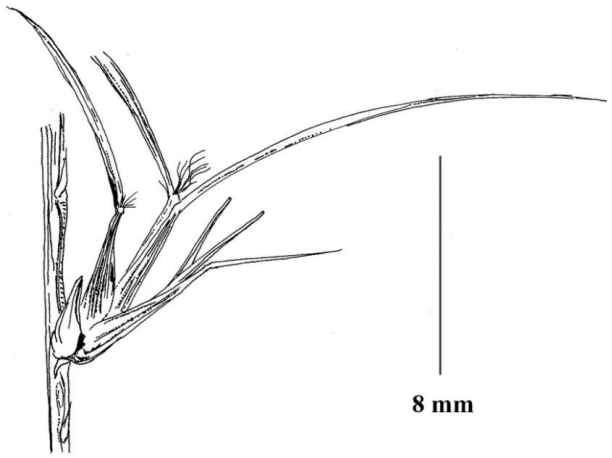


Figure 3. Illustration of the viviparous spikelet in *Eragrostiella bifaria* var. *walkeri* (Stapf) Lazarides. (Illustrated in October 2020 by Mr. Shahid Nawaz).

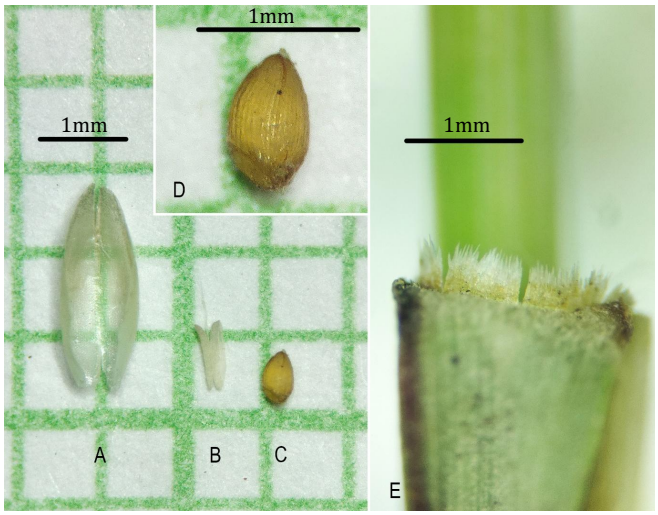


Figure 4. Lemma, stamen, caryopsis and ligule of *Eragrostiella bifaria* var. *walkeri*. A. Lemma. B. Anther. C. Caryopsis. D. Close-up of caryopsis. E. Ligule. Scale bar: 1 mm (A, B, C, D, and E). (Captured on 5th October 2020 by Mr. Shahid Nawaz).

Caryopsis, globose-ellipsoid, striate, finely reticulate, reddish brown, 0.7–0.8 mm, embryo laterally wedged, half of the seed.

Habitat & Distribution: In the dry, quartzite and sandstone rocky habitats, growing in meager soil accumulation through rocky crevices. This species is distributed in South India (Karnataka, Andhra Pradesh, Telangana and Tamil Nadu) and Sri Lanka. (Bor, 1940 & 1960; Lazarides, 1976; Kabeer & Nair 2009; Thoiba, 2018; Lakshminarasimhan *et al.*, 2019).

Flowering and fruiting: June–January.

Taxonomic Notes: This particular taxon can be easily distinguished based on combinations of characters such as, the robust habit, wider tufts, culms 2-4 nodded, drooping inflorescences, higher number of florets per spikelet (up to 60 florets), whitish spikelets, lower leaf blades long, initially broad and wide open, and glaucous in appearance, reaching the base of the inflorescence and sometimes also exceeding it (Figures. 2-4).

 https://doi.org/10.63033/JWLS.OQBW9095

Acknowledgment

The lead author (SNKBL) expresses his sincere gratitude to his family for their financial support during his research in South India. We also thank the management of St. Xavier's College (Empowered Autonomous Institute), Mumbai, for providing the laboratory and infrastructure facilities necessary to conduct the experimental work.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

DATA AVAILABILITY

All the data available to authors have been provided in the paper.

AUTHOR CONTRIBUTIONS

SNKBL collected the plant specimens from the wild, designed the experimental work, captured the field and experimental photography, and prepared the original manuscript draft. ALG reviewed the original draft and provided critical comments and valuable suggestions during manuscript preparation.

References

Arber, A. (1965). *The Gramineae: A Study of Cereal, Bamboo, and Grass.* J. Cramer-Weinheim, New York.

Beetle, A. A. (1980). Vivipary, proliferation, and phyllody in grasses. *Journal of Range Management.* 33(4), 256–261. https://doi.org/10.2307/3898068

Bor, N. L. (1940). Three new genera of Indian Grasses. *Indian Forester,* 66, 267–272.

Bor, N. L. (1960). *The grasses of Burma, Ceylon, India & Pakistan*. Pergamon Press, London.

Goebel, K. (1905). *Organography of Plants, Especially of the Archegoniatae and Spermophyta, Part II.* Clarendon Press, Oxford.

Kabeer, A. K. A. & Nair, V. J. (2009). *Grasses of Tamil Nadu*. Botanical Survey of India Publication, Kolkata. pp. 131.

Lakshminarasimhan, P., Dash, S. S., Singh, P., Singh, N. P., Vasudeva, R. M. K. & Rao, P.S.N. 2019. *Flora of Karnataka (Monocotyledons). Vol. 3.* Botanical Survey of India Publication, Kolkata. pp. 645.

Landge, S. N. & Shinde, R. D. (2021). Rediscovery of *Parahyparrhenia bellariensis* (Poaceae: Andropogoneae): a presumed extinct grass from Andhra Pradesh, India. *Phytotaxa*, 497 (2), 147–156. https://doi.org/10.11646/phytotaxa.497.2.7

Landge, S. N. & Shinde, R. D. (2022). A taxonomic revision of the genus *Parahyparrhenia* (Poaceae: Andropogoneae) in India and review of African and Thai species. *Phytotaxa*, 541 (3), 247–260. https://doi.org/10.11646/phytotaxa.541.3.4

Landge, S. N. & Shinde, R. D. (2023). On the identity and distribution of *Chrysopogon velutinus* (Poaceae: Andropogoneae) and its taxonomic comparison with allied species in India. *Phytotaxa*, 612 (1), 046–056. https://doi.org/10.11646/phytotaxa.612.1.3

Landge, S. N., Chandran, M., Gude, A. L. & Shinde, R. D. (2026). *Tripogon fibrosissimus* (Poaceae: Chloridoideae: Tripogoninae): a new species from the Grand Canyon of India. *Phytotaxa*, 739 (2), 213–226. https://doi.org/10.11646/phytotaxa.739.2.5

Lazarides, M. (1976). The genus *Eragrostiella Bor* (Poaceae, Eragrostideae). Contributions from the Herbarium Australiense 22, 1–7. https://doi.org/10.1071/HA76011

Lazarides, M. (1994). *Eragrostiella Bor. Eragrostis Wolf, Leptochloa P. Beauv., Tripogon Roem. & Schult.* In: Dassanayake, M. D., Fosberg, F. R. & Clayton, W. D. (eds.). A revised handbook to the flora of Ceylon. Vol. 8. Amerind Publishing Co. Pvt. Ltd., New Delhi, pp.199–229.

Peterson, P. M., Romaschenko, K. & Herrera, A. Y. (2016). A molecular phylogeny and classification of the *Cynodonteae* (Poaceae: Chloridoideae) with four new genera: Orthacanthus, Triplasiella, Tripogonella, and Zaqiqah; three new subtribes: Dactylocteniinae, Orininae, and Zaqiqahinae; and a subgeneric classification of Distichlis. *Taxon*, 65 (6), 1263–1287. https://doi.org/10.12705/656.4

Thoiba, K. (2018). *Taxonomic studies on Eragrostidineae (Poaceae: Chloridoideae: Eragrostideae) in Peninsular India*. Ph.D Thesis, University of Calicut

Tzvelev, N. N. (1989). The system of grasses (Poaceae) and their evolution. *Botanical Review*, 55 (3), 141–204. https://doi.org/10.1007/BF02858328

Vega, A. S. & De Agrasar, Z. E. R. (2006). Vivipary and pseudovivipary in the Poaceae, including the first record of pseudovivipary in *Digitaria* (Panicoideae: Paniceae). *South African Journal of Botany*, 72 (4), 559–564. https://doi.org/10.1016/j.sajb.2006.03.012

ISSN (Online): 3048-7803

JWLS

Volume 3 Issue 2 (June 2026)

TYPE Natural History Note

Opportunistic Frugivory of Small Indian Mongoose (*Urva auropunctata*) in an Agricultural Field, Uttarakhand, India

Shrey Dandriyal[1]*, Nitesh Goswami[1], Piyush Sharma[2], Ashutosh Singh Rana[2]

[1]Wildlife Institute of India, Dehradun, Uttarakhand, India, 248001
[2]Gurukul Kangri (Deemed to be University), Haridwar, Uttarakhand, India, 249404

EDITED BY
Vidyadhar Atkore
Salim Ali Centre for Ornithology and Natural History, Coimbatore, Tamil Nadu.

*CORRESPONDENCE
Shrey Dandriyal
shreydandriyal@gmail.com

RECEIVED 25 February 2026
ACCEPTED 31 May 2026
PUBLISHED 05 July 2026

CITATION
Dandriyal, S., Goswami, N., Sharma, P., Rana, A. S. (2026). Opportunistic Frugivory of Small Indian Mongoose (*Urva auropunctata*) in an Agricultural Field, Uttarakhand, India. *Journal of Wildlife Science,* 3(2), 83-86.
https://doi.org/10.63033/JWLS.CRVE5590

COPYRIGHT
© 2026 Dandriyal, Goswami, Sharma, Rana. This is an open-access article, immediately and freely available to read, download, and share. The information contained in this article is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited in accordance with accepted academic practice. Copyright is retained by the author(s).

PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001 INDIA

PUBLISHER'S NOTE
The Publisher, Journal of Wildlife Science or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this article. All claims expressed in this article are solely those of the author(s) and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in this article or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

Abstract

The Small Indian Mongoose (*Urva auropunctata*) is considered a diurnal mesocarnivore, characterized by a flexible diet in both wild and domestic environments. Despite being carnivores with primarily insectivorous diet, incorporating small vertebrates and eggs, they occasionally include plant material and fruits in their diet. On 19th July 2024 in an agricultural area near Dehradun, Uttarakhand, it was noticed that two *Urva auropunctata* were interacting with a fallen mango (*Mangifera indica*) fruit, which had probably been opened by a bird earlier.

One of them fled away immediately after noticing the observer, while the other continued to feed on the exposed pulp for about 34 seconds before moving away from the spot. The second mongoose only consumed the soft pulp of that opened mango, demonstrating opportunistic exploitation of seasonally available fruit resources. Short behavioral records like this contribute to understanding how the species uses readily available food resources and adapts to changing environments.

Keywords: Agricultural field, frugivory, foraging ecology, mesocarnivore, peri-urban.

The Small Indian Mongoose (*Urva auropunctata*) is an opportunistic omnivore, native to the Middle East and the Indian sub-continent, with its distribution spanning between Iraq and Myanmar, including Iran, Pakistan, Northern India, Nepal, and Bangladesh (Gilchrist *et al.* 2009, as cited in Louppe *et al.* 2020). It was introduced to multiple areas throughout the globe between the late 19th and early 20th century such as the Caribbean in 1870-1872, Hawaii in 1882, Fiji in 1883, the South American continent and various islands of the Mascarenes in 1900, and in a few Japanese and Croatian islands in 1910 (Louppe *et al.* 2020). These introductions were mainly done to achieve biological control to reduce the population of rats in sugar cane plantations (Berentsen *et al.* 2018) and to control the population of dangerous snakes (IUCN GISD 2024). The introduction of mongoose has caused drastic effects on the native biodiversity in the introduced areas, causing the decline and extinction of native mammals, birds, reptiles and amphibians (IUCN GISD 2024).

The taxonomic history of the Small Indian Mongoose, now identified as *Urva auropunctata*, has undergone significant revision to distinguish it from closely related species. While historically classified as Herpestes auropunctatus and was long considered conspecific with the Javan Mongoose (*Urva javanica*) under the name *Herpestes javanicus* (Veron *et al.* 2007, as cited in Louppe *et al.* 2020; Veron & Jennings 2017). However, molecular phylogenetic studies have established that both these taxa are different species (Patou *et al.* 2009; Veron & Jennings 2017), though older literature often mentions both of them as a single species under the name *H. javanicus*. In this paper, we have used the name *U. auropunctata* to align with contemporary classifications.

The Small Indian Mongoose is an opportunistic omnivore with a diverse diet that includes insects, snakes, rodents, birds, fruits, tubers and berries, and may occasionally scavenge (Feldhamer *et al.* 1999; Gilchrist *et al.* 2009). In agricultural landscapes, the species plays a significant role in controlling pest populations (Mahmood & Nadeem 2011), while in Sialkot district, animals comprised 58% of the diet with plants making up 8%, and insects were consumed more heavily during summer (Mahmood & Adil 2017).

In a study of the Potohar plateau in north-western Pakistan, it was discovered that an omnivorous diet was the most common, consisting of mammals (66% by volume), with the mongoose adapting to coexist with human habitation (Mahmood

& Nadeem 2011). A closer examination of *U. auropunctata* diet revealed seasonal dietary plasticity in the state of Gujarat, India, in which the primary insect diet in summers changed to 64.6% plant matter and 35.6% insects during the winters (Dabholkar & Devkar 2020). Such food flexibility is probably a contributing factor to the survival of the mongoose in a variety of habitats and environments. In this paper, we present an opportunistic observation of frugivory by the species, *U. auropunctata*, feeding on cultivated mango (*Mangifera indica*) fruit in a peri-urban agricultural setting, in Uttarakhand, and thus contribute to natural-history information of the species in its native habitat on the Indian subcontinent.

Observation details

On 19th July 2024, the authors observed two Small Indian Mongooses feeding on a fallen mango fruit in an agriculture field adjacent to mango orchards near Dehradun, Uttarakhand, India (30.289322° N, 78.025837° E) at 07:38h in the morning (Figure 1). The site is a peri-urban agricultural landscape with mixed cultivation including mango trees, interspersed with patches of grass and shrub cover. One of the two animals instantly withdrew into a high grass cover when it noticed the presence of the observer. The second mongoose kept feeding on the naked pulp of a fallen mango fruit on the ground. The mango seemed to have been opened somewhere previously, probably by a bird, and the inner pulp was soft. The mongoose fed upon this bare pulp and ate the soft material of the fruit without trying to move or to manipulate the fruit. The feeding behavior was also found to be concentrated and intentional as the animal stayed at the fruit throughout the observation. The immediate location did not have any other animals or people during the observation. The mongoose stopped feeding and left the fruit after about 34 seconds of feeding. The images were photographed through video recording (Figure 2).

Our observation documents the opportunistic consumption of a fallen mango fruit by *Urva auropunctata* in a peri-urban agricultural area during the peak mango season in northern India. The short feeding time (about 34 seconds) and the fact that the mongoose consumed a fruit that seemed to have been opened by another animal indicate incidental feeding on a ready food source and not frugivorous feeding. The fact that there were two individuals with, different reactions to human presence, suggests individual differences in behavior or adaptation to anthropogenic disruptions.

The consumption of mango aligns with documented dietary flexibility of this species as an opportunistic predator from other parts of its native range, where seasonal shifts in diet composition have been recorded (Dabholkar & Devkar 2020; Mahmood & Adil 2017). We observed in July, when the mangoes are in abundance as fallen fruits in the agricultural fields around Dehradun, which is a seasonal food source that mongooses seem to take advantage of and exploit opportunistically. The extent to which this type of fruit consumption is a small supplement or a larger seasonal food item in the mango-growing areas would have to be systematically studied by the use of techniques like fecal analysis during and out of the fruiting season.

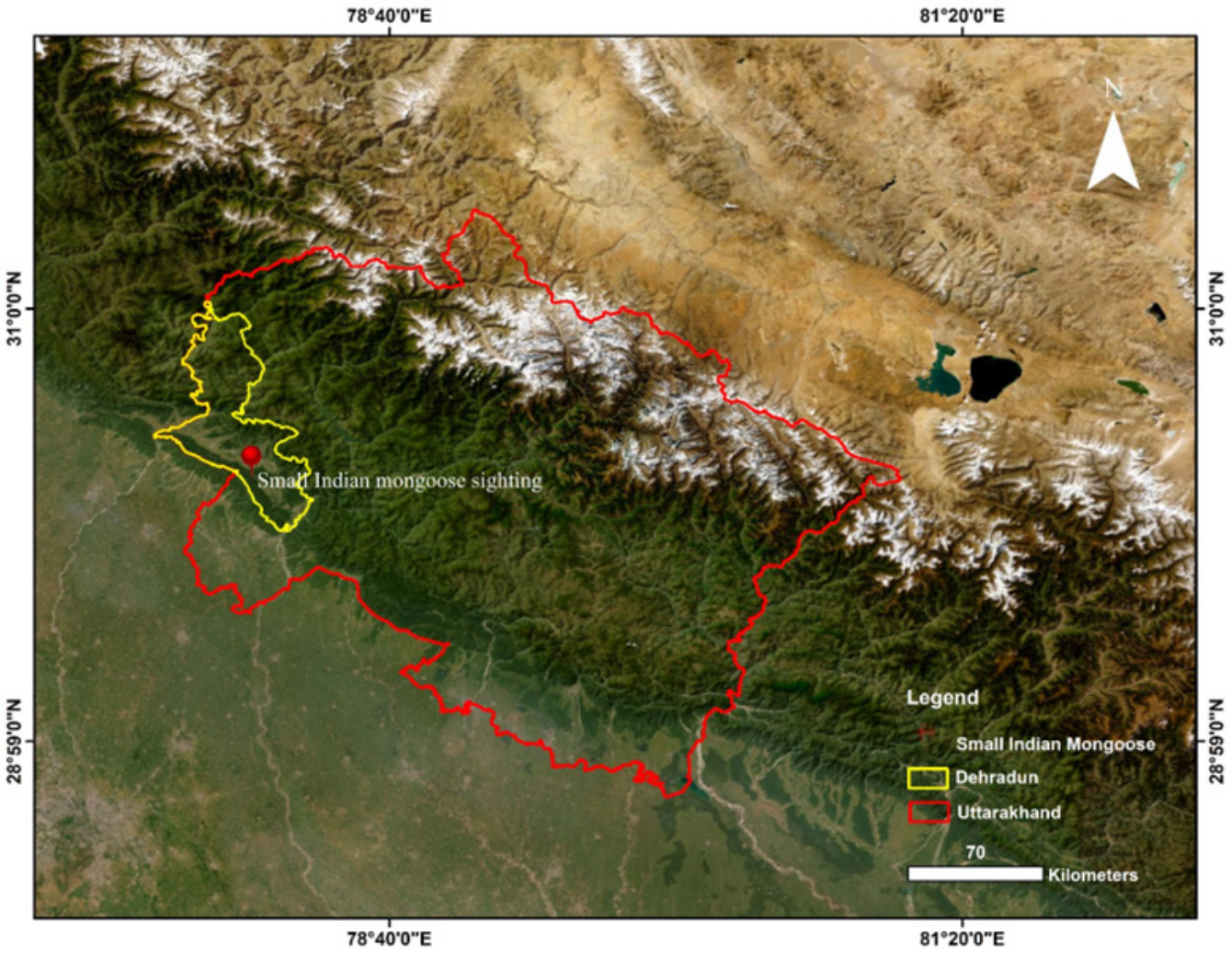


Figure 1. Geographic location of the site of observation

 https://doi.org/10.63033/JWLS.CRVE5590



Figure 2. Opportunistic frugivory by *Urva auropunctata* in Uttarakhand, India. The image displays a single individual consuming the pulp of a fallen mango (*Mangifera indica*) on 19th July 2024, 07:38 h. Note the previous damage to the fruit skin, likely caused by an avian species, which facilitated access. (To watch the full video, click here)

Observation of mongooses feeding on mangoes suggests potential dietary plasticity and highlights their ability to exploit opportunistic food resources. In human-modified landscapes, *i.e.*, areas with waste dumps, drainage channels, and fruit-bearing trees, these animals effectively exploit available resources. The location close to a high-traffic road like NH-72, especially during the high season of mango, helps in facilitating opportunistic frugivory. The observation occurred in a farm field near the mango orchards, which is a reflection of the species' recorded capacity to be able to inhabit human-altered environments (Baldwin *et al.* 1952, as cited in Louppe *et al.* 2020).

In such landscapes, mongooses may come across both their natural food sources and anthropogenic food sources like cultivated fruits. The partial opening of the mango by another animal, likely an avian frugivore, may facilitate access for ground-foraging mongooses that might not otherwise break intact mango skin. This observation suggests that mongooses may be more likely to scavenge fruits that have already been opened by other animals rather than actively seeking and opening intact fallen fruits. Further observations are needed to test this.

It should be noted that the above interpretations are based on a single anecdotal observation of 34 seconds and therefore remain speculative.

Although there is a substantial amount of research on *U. auropunctata* in the regions where it has become an invasive species, ecological observations in the native range are relatively few (Dabholkar & Devkar 2020). Such short natural history notes add to the background information on resource utilization and behavioral ecology of the species in its native range. Further studies that use camera traps in agricultural environments and a series of dietary studies in various seasons and areas would assist in understanding the scope and importance of fruit feeding in the range of the species, especially in regions where there is extensive farming of mango and other fruit crops.

Acknowledgment

We sincerely thank Dr. Harshvardhan Singh Rathore, Gargi Roy Chaudhary, and Rajat Singh Rana for their kind encouragement in documenting this observation, and the Wildlife Institute of India for their Institutional support.

CONFLICT OF INTEREST

The authors declare no competing interests.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

Shrey Dandriyal conceived the observation, conducted the field observation, collected the data, prepared the figures, wrote the original manuscript, and revised the manuscript. Nitesh Goswami reviewed and edited the manuscript. Piyush Sharma contributed to manuscript writing and reference compilation and verification. Ashutosh Singh Rana contributed to manuscript writing and prepared the study-area map.

ETHICAL APPROVAL

This was an opportunistic, non-invasive observation with no handling, capture, or disturbance of animals. The observation was conducted at a distance that did not alter the natural behavior of the animals. No permits were required for this observational study.

References

Baldwin, P. H., Schwartz, C. W. & Schwartz, E. R. (1952). Life History and Economic Status of the Mongoose in Hawaii. *Journal of Mammalogy*, 33(3), 335–356. https://doi.org/10.2307/1375771

Berentsen, A. R., Pitt, W. C., & Sugihara, R. T. (2018). *Ecology of the Small Indian Mongoose (Herpestes auropunctatus) in North America.* In: W. C. Pitt, J. C. Beasley, & G. W. Witmer (eds.), Ecology and Management of Terrestrial Vertebrate Invasive Species in the United States. CRC Press, pp.17-42. https://doi.org/10.1201/9781315157078-12

Dabholkar, Y. & Devkar, R. V. (2020). Diurnal activity and diet of Small Indian Mongoose *Urva auropunctata* on the outskirts of Vadodara, Gujarat, India. *Small Carnivore Conservation*, 58, e58002.

Feldhamer, G. A., Drickamer, L. C., Vessey, S. H. & Merritt, J. F. (1999). *Mammalogy: Adaptation, Diversity, and Ecology*. The McGraw-Hill, Boston, USA. pp. 511–543.

Gilchrist, J., Jennings, A. P., Veron, G. & Cavallini, P. (2009). Family Herpestidae (mongooses). In: Wilson, D. E. & Mittermeier, R. A. (eds.), *Handbook of the Mammals of the World. Volume 1: Carnivores.* Lynx Edicions, Barcelona, Spain, pp. 262–328.

Global Invasive Species Database (2024). *Species profile: Herpestes javanicus.* http://www.iucngisd.org/gisd/speciesname/Herpestes+javanicus [Accessed on 3 January 2026].

Louppe, V., Leroy, B., Herrel, A. & Veron, G. (2020). *The globally invasive small Indian mongoose Urva auropunctata is likely to spread with climate change.* Scientific Reports, 10, 7461. https://doi.org/10.1038/s41598-020-64502-6

Mahmood, T. & Adil, A. (2017). Diet composition of small Indian mongoose (*Herpestes javanicus*) varies seasonally in its native range. Animal Biology, 67(1), 69–80. https://doi.org/10.1163/15707563-00002516

Mahmood, T. & Nadeem, M. S. (2011). Population estimates, habitat preference and the diet of Small Indian Mongoose (*Herpestes javanicus*) in Potohar Plateau, Pakistan. *Pakistan Journal of Zoology*, 43(1), 103–111.

Patou, M.-L., McLenachan, P. A., Morley, C. G., Couloux, A., Jennings, A. P., & Veron, G. (2009). Molecular phylogeny of the Herpestidae (Mammalia, Carnivora) with a special emphasis on the Asian Herpestes. *Molecular Phylogenetics and Evolution*, 53(1), 69-80. https://doi.org/10.1016/j.ympev.2009.05.038

Veron, G. & Jennings, A. P. (2017). Javan mongoose or small Indian mongoose—who is where? *Mammalian Biology*, 87, 62–70. https://doi.org/10.1016/j.mambio.2017.05.006

Veron, G., Patou, M. L., Pothet, G., Simberloff, D. & Jennings, A. P. (2007). Systematic status and biogeography of the Javan and small Indian mongooses (Herpestidae, Carnivora). *Zoologica Scripta*, 36(1), 1–10. https://doi.org/10.1111/j.1463-6409.2006.00261.x

ISSN (Online): 3048-7803

JWLS

Volume 3 Issue 2 (June 2026)

TYPE Natural History Note

An unusual rusty coloration of an Indian Crested Porcupine *Hystrix indica*

Sumanas Koulagi[1], Madhushri Mudke[1], Shashank C L[1] , Ashish Jha[2]*

[1]Janapada Seva Trust, Melukote, India
[2]Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, 248001

EDITED BY
Govindhaswamy Umapathy
Centre for Cellular and Molecular Biology, Hyderabad, India.

*CORRESPONDENCE
Ashish Jha
ashishjha@wii.gov.in

RECEIVED 17 November 2025
ACCEPTED 31 May 2026
PUBLISHED 05 July 2026

CITATION
Koulagi, S., Mudke, M., Shashank, C. L., Jha, A. (2026). An unusual rusty coloration of an Indian Crested Porcupine *Hystrix indica*. *Journal of Wildlife Science*, 3(2), 87-92.
https://doi.org/10.63033/JWLS.OGVI4185

FUNDING
The logistic support during the camera trapping exercise was provided by the Janapada Seva Trust, Melukote.

COPYRIGHT
© 2026 Koulagi, Mudke, Shashank, Jha. This is an open-access article, immediately and freely available to read, download, and share. The information contained in this article is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), allowing for unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited in accordance with accepted academic practice. Copyright is retained by the author(s).

PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001 INDIA

PUBLISHER'S NOTE
The Publisher, Journal of Wildlife Science or Editors cannot be held responsible for any errors or consequences arising from the use of the information contained in this article. All claims expressed in this article are solely those of the author(s) and do not necessarily represent those of their affiliated organisations or those of the publisher, the editors and the reviewers. Any product that may be evaluated or used in this article or claim made by its manufacturer is not guaranteed or endorsed by the publisher.

Abstract

The Indian Crested Porcupine (*Hystrix indica*) is a widespread species across India, generally exhibiting a distinctive pattern of alternating black and white bands on quills. Here, we report photographic evidence of an unusual red morph of *H. indica* recorded through camera traps in the Melukote region, Karnataka, southern India. Over a 50-night survey (150 trap-nights across three cameras) from September to November 2025, 564 images documenting 12 vertebrate species were obtained, including two individuals of the red morph and several naturally shed reddish-orange quills. Semi-structured interviews and discussions with forest personnel, researchers, hunters, and residents confirmed that the red morph, locally termed Kemmulla (usual morph porcupine is called 'Karimulla'), is known but rare, with only a few encounters reported over the past two decades. Based on our observations and literature review, we evaluate five potential explanations for this coloration: soil or tannin staining, diet, age, environmental factors, and natural polymorphism. The evidence supports the latter, suggesting that the red morph likely represents a rare, genetically encoded color variant of *H. indica*. Further molecular and ecological studies are needed to determine its genetic basis, distribution, and frequency within Indian porcupine populations.

Keywords: Camera trap, color morph, erythrism, Karnataka, Melukote wildlife sanctuary, natural polymorphism

Introduction

The Indian crested porcupine (*Hystrix indica* Kerr, 1792; Wilson *et al.*, 2016) is among the largest rodents in India, distributed throughout the country except in the extreme north, northeast, and the Himalayan regions (Gurung & Singh, 1998). It is easily recognized by its coat of modified hairs forming spines or quills, each typically ornamented with alternating black or deep brown and white bands (Prater, 1971). The species is considered monotypic, with no recognized subspecies (Prater, 1971).

Occasional reports describe individuals exhibiting atypical coloration, including quills with a distinct rusty-red or orange hue (Prater, 1971; Menon, 2014). This reddish morph has been noted mainly from southern India, particularly the Mysore, Coimbatore, and Kerala hill ranges, and possibly central India (Prater, 1971; Menon, 2014). Most other regional field guides do not mention this color morph (Mallick & Bahuguna, 2010; Choudhury, 2016). It appears to be a rare morph, with few publicly available photographs. One image from Tadoba (Maharashtra) is published in Menon (2014). Anecdotal accounts suggest that reddish individuals may be smaller in size, that the intensity of their color may fade in captivity or with poor health, and that local communities recognize a distinctive odor from their burrows (Prater, 1971). Menon (2014) proposed that coloration could be diet- or habitat-related, though this has not yet been empirically tested in *Hystrix indica*.

Porcupines are primarily herbivorous, consuming roots, tubers, fruits, bark, and occasionally bones, which may provide minerals influencing quill formation (Khan *et al.*, 2022). Since porcupine quills are composed of keratin and pigmented through melanin and related compounds, nutritional factors such as carotenoids and minerals could theoretically affect their pigmentation, as observed in other keratin-based structures like feathers and hair (Roze, 1989; Inayah *et al.*, 2020).

Studies on other porcupine taxa provide insight into color variation as a form of genetic or pigment aberration. For example, in the North American porcupine (*Erethizon dorsatum*), one report documented isabellinism, a genetic condition resulting in pale yellowish to reddish coloration due to partial melanin loss (Jung & Jantunen, 2015). Similarly, in South American *Coendou* species, albinism and pigmentation anomalies have been recorded, including individuals with yellowish or white quills, red eyes, and pink extremities (Ramos *et al.*, 2024). Though porcupines and hedgehogs are not closely related, analogous rusty morphs are known in African pygmy hedgehogs (*Atelerix albiventris*), such as the "Cinnicot" variety, arising from selective pigment expression. These examples suggest that while reddish or rusty morphs are rare in *Hystrix indica*, color variation among porcupines can occur due to a combination of genetic mutations, environmental influences, or dietary factors (Roze, 1989; Inayah *et al.*, 2020). Nonetheless, direct studies on pigmentation mechanisms in porcupines are lacking, and reports of the red morph in India remain largely anecdotal (Prater, 1971; Menon, 2014).

Here we report one such incidence of an unusually reddish porcupine captured through randomly placed camera traps in the Melukote region, Karnataka, India, and discuss potential causes.

Methods

Study Area

This study was carried out at Melukote (12.6626 °N, 76.6486 °E) in Pandavapura Taluk, Mandya District, Karnataka, India (Figure 1). The region forms part of the semi-arid landscape of the southern Deccan Plateau, situated at an elevation of approximately 900 m above sea level. It is characterized by a mosaic of scrub forests, rocky outcrops, and dry deciduous vegetation interspersed with agricultural lands and tanks and falls within the Melukote Wildlife Sanctuary buffer, supporting a rich assemblage of dry-zone fauna. Melukote is also culturally significant, housing the historic Cheluvanarayana Swamy Temple complex and associated sacred groves, which contribute to local biodiversity conservation (Bhagwat & Rutte, 2006). The climate is tropical semi-arid, with mean annual rainfall of around 700–800 mm, largely received during the southwest monsoon (June–September).

Camera trapping

We established three motion-activated infrared camera traps (K&F Concept, model KF35.086; 4K video, 32 MP still images, 0.2 s trigger speed, 100° detection angle, 940 nm low-glow IR LEDs, IP67 waterproof rating) to monitor wildlife presence and activity patterns in and around Melukote, India. Cameras were mounted ca. 30–40 cm above ground and programmed to record 10-second videos with a 2-second interval between triggers. The camera traps were deployed for a total of 50 days and nights, from 21st September 2025 to 11th November 2025.

Semi-structured Interviews

In addition to camera trapping surveys, we conducted semi-structured interviews to assess local knowledge of the unusual reddish morph of *Hystrix indica*. Because porcupines are nocturnal and rarely observed by the general public, individuals most likely to have encountered this morph, like local hunters and personnel from the regional forest department, were identified as key informants. Participants were selected using a snowball sampling approach, whereby initial informants referred others with relevant experience (Biernacki & Waldorf, 1981).

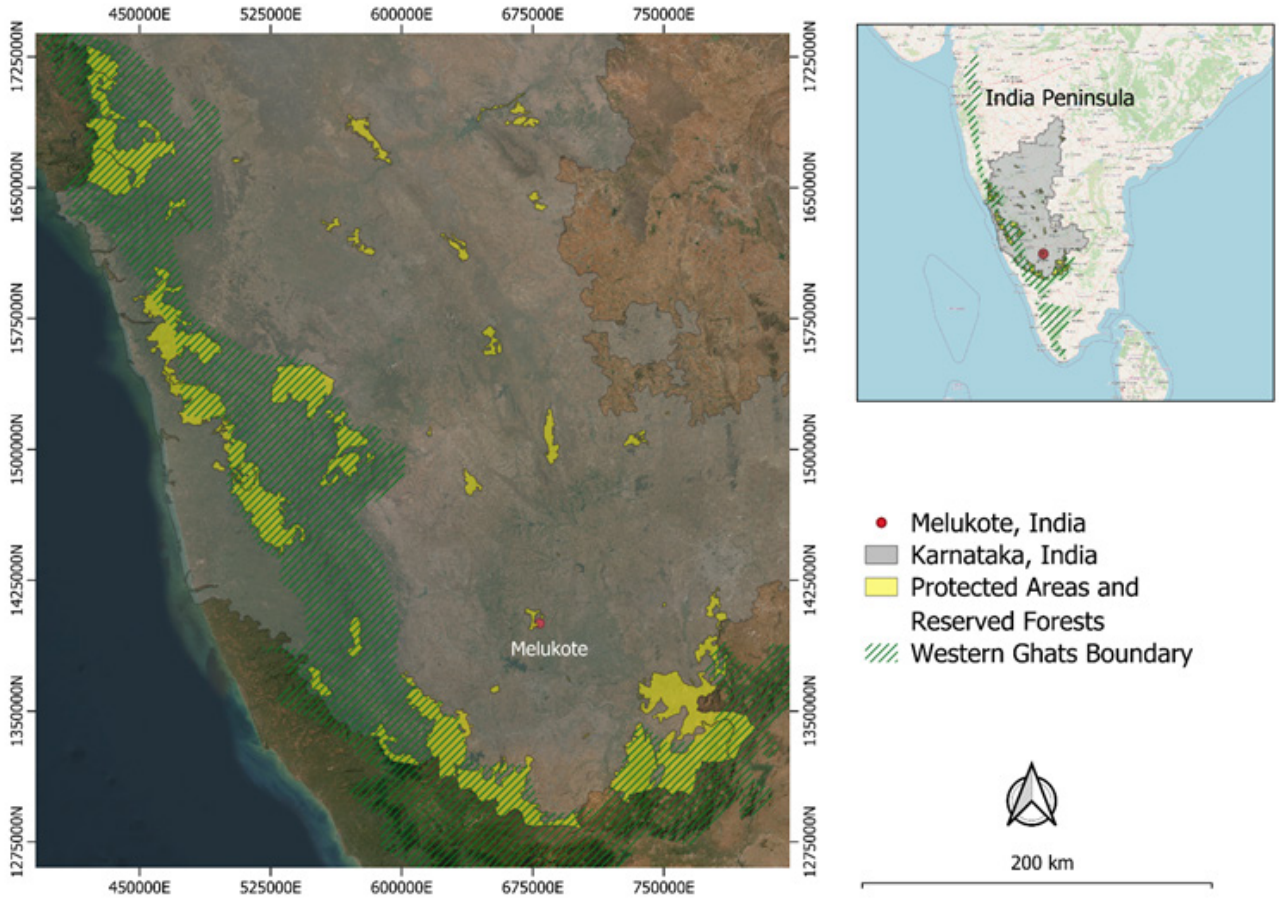


Figure 1. Location of the study area in southern India showing the position of Melukote (12.6626° N, 76.6486° E) in Mandya District, Karnataka, India.

 https://doi.org/10.63033/JWLS.OGVI4185

Before each interview, the purpose of the study was explained to participants, and oral informed consent was obtained. A total of nine interviews were conducted, including five local hunters (four aged approximately 60–70 years and one approximately 40 years old, each with two to three decades of experience in the region) and four officials from the local forest department. All interviews were conducted in the local Kannada language.

Semi-structured interviews were chosen to allow flexibility for participants to introduce additional observations while enabling the interviewer to explore predefined themes (Cohen *et al.*, 2007). During the interviews, photographs of the unusually red porcupines were shown to participants, who were asked about local names, frequency of sightings, and any observed morphological or behavioural differences relative to the typical morph. Interviews lasted approximately 10–20 minutes, depending on the depth of responses.

In addition to interview data, we reviewed publicly available photographic records of *H. indica* on iNaturalist (inaturalist.org) and the India Biodiversity Portal (indiabiodiversity.org) to identify further evidence of similar colour morphs. Additionally, we consulted ecologists regarding the presence of red porcupines in their respective study regions.

Results

Over the 50-days period (150 trap-nights across three cameras), a total of 564 images were recorded, documenting 12 vertebrate species, including mammals, birds, and reptiles (Table 1). On 9th October 2025, two individuals of an unusual reddish morph of the Indian Crested porcupine (*Hystrix indica*) were photographed at a burrow at around 11 AM (Figure 2a–c). It had rained that early morning, which could have flooded the burrow, making the porcupines come out during the day hours. Four images of the typical morph were also obtained at a nearby site, ca. 500 m away, but during the night hours (Figure 2d). A road kill of a typical morph was also recovered from the region during the study period.

Table 1. Species recorded from camera traps in the Melukote region, Karnataka, over 50 nights, with corresponding IUCN Red List status.

S. No.	Category (Class / Order / Family)	Common name	Scientific name	IUCN status
1	Aves / Galliformes / Phasianidae	Painted Spurfowl	*Galloperdix lunulata*	Least Concern
2	Reptilia / Squamata / Varanidae	Bengal Monitor lizard	*Varanus bengalensis*	Near Threatened
3	Mammalia / Artiodactyla / Suidae	Wild Boar	*Sus scrofa*	Least Concern
4	Aves / Passeriformes / Turdidae	Orange-headed Thrush	*Geokichla citrina*	Least Concern
5	Mammalia / Rodentia / Hystricidae	Indian Crested Porcupine (including red ones)	*Hystrix indica*	Least Concern
6	Mammalia / Pholidota / Manidae	Indian Pangolin	*Manis crassicaudata*	Endangered
7	Aves / Passeriformes / Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	Least Concern
8	Mammalia / Carnivora / Herpestidae	Ruddy Mongoose	*Urva (Herpestes) smithii*	Least Concern
9	Mammalia / Rodentia / Muridae	Gerbil spp. (likely Indian gerbil)	*Tatera indica (probable; record listed as "Gerbil spp.")*	Least Concern
10	Mammalia / Rodentia / Sciuridae	Squirrel (likely Indian palm squirrel)	*Funambulus palmarum (likely)*	Least Concern
11	Mammalia / Lagomorpha / Leporidae	Black-naped Hare	*Lepus nigricollis*	Least Concern
12	Reptilia / Squamata / Pythonidae	Indian Rock Python	*Python molurus*	Near Threatened

The red morph differs from the typical form in that the usual white quill bands are replaced by bright rusty-red or orange bands, while the black bands remain dark. The camera trap data and local interviews yielded both photographic and anecdotal evidence for an unusual reddish morph of *Hystrix indica* in the Melukote region.

Local Knowledge

To assess local awareness of the red morph, semi-structured interviews were conducted with forest personnel, local hunters, and community members. Across all interviews with local hunters (n = 5), informants consistently described the red morph ('*Kemmulla*') as rare, recalling only 2–4 encounters over the past two decades. All respondents indicated no size or weight difference compared to the typical morph ('*Karimulla*'). Our interview data affirmed the local rarity of the red morph 'Kemmulla' relative to the usual 'Karimulla' porcupines and two separate names for the typical and red morph. From the surveys, capture frequency appears extremely low; hunters reported only two confirmed captures of the red morph porcupines over ~15 years, and another hunter reported four sightings in the last 20 years. Local forest department officials reported that they have not observed the red morph in the region, either through direct sightings or during their

 https://doi.org/10.63033/JWLS.OGVI4185



Figure 2. The photograph panel shows camera trap images of various species captured during our exercise. a) the red morph Indian Crested Porcupine (*Hystrix indica*) at its burrow, b) a pair of the red morph porcupine showing with erect quills, c) night time image of likely the same red morph porcupine pair at the burrow, d) night time image of a normal morph porcupine at another location. The following animals were photographed at the porcupine burrow site: e) Indian hare (*Lepus nigricollis*), f) Ruddy Mongoose (*Urva smithii*), g) Indian monitor (*Varanus bengalensis*), h) a painted spurfowl (*Galloperdix lunulata*) pair, i) unidentified *Gerbil* spp. j) An Indian pangolin (*Manis crassicaudata*) was photographed at one of the three camera trap sites.

camera-trapping exercises. These accounts, combined with our photographic records, suggest that the red morph is a rare but locally recognized variant of *H. indica* in southern India.

Discussion

This study documents photographic and physical evidence of a rare reddish morph of *Hystrix indica* in southern India, a form that appears to be locally recognized but poorly documented scientifically. Besides the image from Tadoba, Maharashtra (Menon, 2014), we found another camera trap image of a similar red morph porcupine from the Melagiri Hills, Tamil Nadu, captured in August 2011, uploaded on both iNaturalist (observation ID: 78215724) and India Biodiversity Portal (observation ID: 324945). Additionally, a camera-trap image of *H. indica* exhibiting an orangish tinge on its quills was obtained by the Hyderabad Tiger Conservation Society in the Nagarjunasagar-Srisailam Tiger Reserve (Imran Siddiqui, pers. comm.).

Although the species is common and widely distributed, most available camera trap records, often illuminated by infrared or flash, do not accurately reflect true coloration, which may have led to underreporting of this morph. In our study too, the night image of red morph porcupines (Figure 2c) looks indistinguishable from the usual morph (Figure 2d). The actual frequency and distribution of red individuals are therefore likely underestimated.

We propose five possible explanations for the reddish coloration observed in the Melukote individuals and evaluate each below.

1. Pigmentation from external sources such as soil or tannins
Some species derive coloration from environmental staining. For example, bearded vultures (*Gypaetus barbatus*) intentionally bathe in ferruginous waters rich in iron oxides, acquiring a reddish hue (Margalida *et al.*, 2019), while elephants coat themselves in mud for thermoregulation and parasite defense (Mole *et al.*, 2016). Similarly, tannin-rich water from decomposing vegetation can impart reddish tones. However, in this study, several other species, including a mongoose, python, and monitor lizard, used the same burrow system and displayed normal coloration. This strongly suggests that soil or tannin-based pigmentation or any external dye is not the cause.

2. Dietary influences
Dietary composition, particularly amino acid and micronutrient content, can influence coat pigmentation in mammals. Dogs consuming food with reduced phenylalanine, tyrosine, and copper exhibit lighter or less red coats (Watson *et al.*, 2017). However, both normal and red morph porcupines were recorded within the same locality, implying shared foraging resources. Without evidence of dietary segregation, this explanation appears unlikely.

3. Age-related variation
In several mammalian taxa, juvenile coloration differs from adult pelage (*e.g.*, in felids and suids). No ontogenetic color variation has been described in Hystrix. The red individuals recorded here were adult-sized, suggesting that the observed coloration is not age-related.

4. Environmental effects
Environmental gradients can sometimes influence pelage coloration. For instance, rodents tend to show darker or redder hues in warm or humid regions (Cerezer *et al.*, 2024). However, both normal and red morphs were observed in the same locality, indicating that local environmental factors do not explain this variation.

5. Natural polymorphism
Aberrant pigmentation and color polymorphisms such as melanism, leucism, and erythrism occur in many mammals, for example, golden jackal (*Canis aureus*) (Samson *et al.*, 2024) and leopard (*Panthera pardus*) (Pirie *et al.*, 2016). These arise from genetic mutations affecting melanin synthesis (Fuentes *et al.*, 2024). The occurrence of reddish porcupines reported from multiple regions and over several decades suggests that this is not a random, isolated mutation but rather a rare, naturally occurring color morph within *H. indica* populations.

In mammals, pigmentation is primarily governed by the relative production of eumelanin (black or brown pigments) and pheomelanin (red or yellow pigments), regulated by a conserved set of melanogenesis genes (Bennett & Lamoreux, 2003; Hoekstra, 2006). The melanocortin-1 receptor (MC1R) plays a central role in this pathway, with reduced or altered MC1R signaling commonly associated with erythristic or reddish phenotypes across diverse mammalian taxa (Mundy, 2005). Other genes, including ASIP (Agouti Signaling Protein), which antagonizes MC1R, and TYRP1 (Tyrosinase-Related Protein 1), which influences eumelanin synthesis and stability, are also known to produce reddish, diluted, or modified banding patterns in mammalian hair and other keratinous structures when mutated or differentially regulated (Bennett & Lamoreux, 2003; Hubbard *et al.*, 2010). Variation in these genes can result in partial suppression of eumelanin while retaining pheomelanin expression, yielding rusty-red or orange coloration without complete depigmentation.

Taken together, the evidence best supports the hypothesis that the red coloration represents a genetically based polymorphism rather than environmental or dietary staining. Further work combining genetic sampling, morphometric comparison, and systematic camera trapping across regions will be necessary to assess the true distribution, frequency, and heritability of this morph. Investigating potential behavioral or olfactory differences, as historically noted by Prater (1971), may also yield insights into whether color variation in *H. indica* has ecological or reproductive significance.

Acknowledgment

We thank Amoghavarsha M for assisting in securing the camera traps, and to Preetham C. S. and Archana Khyadi for their help in identifying and setting them up at appropriate locations. We are also grateful to Kabalayya and Suresh for sharing details about the red morph and facilitating interactions with locals formerly involved in hunting, which provided valuable insights. We thank Imran Siddiqui for sharing camera trap image of a probable red morph *H. indica*.

CONFLICT OF INTEREST

Ashish Jha is an academic editor at the Journal of Wildlife Science. However, he did not participate in the peer review process of this article except as author. The authors declare that they have no competing interests.

DATA AVAILABILITY

Camera trap images used in this study have been provided in the manuscript.

AUTHOR CONTRIBUTIONS

Conceptualisation, Data curation, Funding acquisition, Investigation: SK and SCL; Formal analysis, Validation, Visualization, Writing – original draft: MM and AJ; Writing – review & editing: SK, MM, and AJ.

References

Bennett, D. C. & Lamoreux, M. L. (2003). The Color Loci of Mice – A Genetic Century. *Pigment Cell Research*, 16(4), 333–344. https://doi.org/10.1034/j.1600-0749.2003.00067.x

Biernacki, P. & Waldorf, D. (1981). Snowball Sampling: Problems and Techniques of Chain Referral Sampling. *Sociological Methods & Research*, 10(2), 141–163. https://doi.org/10.1177/004912418101000205

Bhagwat, S. A. & Rutte, C. (2006). Sacred groves: potential for biodiversity management. *Frontiers in Ecology and the Environment*, 4(10), 519–524. https://doi.org/10.1890/1540-9295(2006)4[519:SGPFBM]2.0.CO;2

Cerezer, F. O., Campos, A. B., Dambros, C. S., Maestri, R., Bubadué, J. M. & Cáceres, N. C. (2024). Rodents show darker and redder coloration in warm and rainy environments. *Global Ecology and Biogeography*, 33(3), 426–438. https://doi.org/10.1111/geb.13802

Choudhury, A. (2016). *The Mammals of India: A Systematic and Cartographic Review.* Gibbon Books & The Rhino Foundation, Guwahati, India.

Cohen, L., Manion, L. & Morrison, K. (2007). *Research Methods in Education.* 6th Edition. Routledge, London. pp.1-656. https://doi.org/10.4324/9780203029053

Fuentes, R., Castillo, M., Moreno, R., Quintero-Arrieta, H., Pérez, E., Araúz, J., Añino, Y., Murcia-Moreno, D., Valdés, R. *et al.* (2024). Report of coloration anomalies in mammals from Panama. *Neotropical Biology and Conservation*, 19(3), 333–345. https://doi.org/10.3897/neotropical.19.e125890

Gurung, K. K. & Singh, R. (1998). *Field Guide to the Mammals of the Indian Subcontinent: Where to Watch Mammals in India, Nepal, Bhutan, Bangladesh, Sri Lanka and Pakistan* (Ap Natural World). Academic Press, San Diego. pp.1-150. ISBN-10: 0123093503, ISBN-13: 978-0123093509.

Hoekstra, H. E. (2006). Genetics, development and evolution of adaptive pigmentation in vertebrates. *Heredity*, 97(3), 222–234. https://doi.org/10.1038/sj.hdy.6800861

Hubbard, J. K., Uy, J. A. C., Hauber, M. E., Hoekstra, H. E. & Safran, R. J. (2010). Vertebrate pigmentation: from underlying genes to adaptive function. *Trends in Genetics*, 26, 231–239. https://doi.org/10.1016/j.tig.2010.02.002

Inayah, N., Farida, W.R., & Purwaningsih, E. (2020). Microstructure of Quills in Sunda Porcupine *Hystrix javanica* (F. Cuvier, 1823). *Jurnal Biologi Indonesia*. 16 (1): 81 – 88. https://doi.org/10.47349/jbi/16012020/81

Jung, T. S., & Jantunen, J. (2015). Unusual Coloration of a North American Porcupine (*Erethizon dorsatum*). *Northwestern Naturalist* 96(1), 99-100. https://doi.org/10.1898/NWN14-24.1

Khan, M. B., Irshad, N., Ahmed, B., Khan, M. R., Minhas, R. A., Ali, U., Mahmood, M., Muhammad, A., Sheikh, A. A. & Ashraf, N. (2022). Food habits of Indian Crested Porcupine (*Hystrix indica* Kerr, 1792) in district Bagh, Azad Jammu and Kashmir. *Brazilian Journal of Biology*, 82, e243063. https://doi.org/10.1590/1519-6984.243063

Mallick, J. K. & Bahuguna, N. C. (2010). *Handbook of the Mammals of South Asia.* Natraj Publishers, New Delhi.

Margalida, A., Braun, M. S., Negro, J. J., Schulze-Hagen, K. & Wink, M. (2019). Cosmetic colouring by Bearded Vultures *Gypaetus barbatus*: still no evidence for an antibacterial function. *PeerJ*, 7, e6783. https://doi.org/10.7717/peerj.6783

Menon, V. (2014). *Indian Mammals: A Field Guide.* Hachette India, Gurgaon.

Mole, M. A., Rodrigues D'Áraujo, D., van Aarde, R. J., Mitchell, D. & Fuller, A. (2016). Coping with heat: behavioural and physiological responses of savanna elephants in their natural habitat. *Conservation Physiology*, 4(1), cow044. https://doi.org/10.1093/conphys/cow044

Mundy, N. I. (2005). *A window on the genetics of evolution: MC1R and the evolution of colour variation in natural populations.* Proceedings of the Royal Society B: Biological Sciences, 272(1573), 1633–1640. https://doi.org/10.1098/rspb.2005.3112

Pirie, T., Thomas, R. & Fellowes, M. (2016). Erythristic leopards *Panthera pardus* in South Africa. *Bothalia*, 46(1), 1–5. https://doi.org/10.4102/abc.v46i1.2034

Prater, S. H. (1971). *The Book of Indian Animals, 3rd Edition.* Bombay Natural History Society, Wheldon & Wesley Ltd, Mumbai. pp.1-347.

Ramos, M. L. A., Brito, J., Burneo, S. F. & Tirira, D. (2024). Albinism in the Quichua Porcupine (*Coendou quichua* Thomas, 1899) from Ecuador. *Therya Notes*, 5(2), 214–218. https://doi.org/10.12933/therya_notes-24-176

Roze, U. (1989). *The North American Porcupine.* Smithsonian Institution Press, Washington, D.C.

Samson, A., Jabamalainathan, L. P., Natarajan, M., Kumaresan, T. & Govindaraj, N. Y. (2024). First known case of erythrism in the Golden Jackal *Canis aureus* in South India. *Journal of the Bombay Natural History Society*, 121(3). https://doi.org/10.17087/jbnhs/2024/v121/170731

Watson, A., Le Verger, L., Guiot, A.-L., Feugier, A. & Biourge, V. (2017). Nutritional components can influence hair coat colouration in white dogs. *Journal of Applied Animal Nutrition*, 5, e5. https://www.cambridge.org/core/journals/journal-of-applied-animal-nutrition/article/nutritional-components-can-influence-hair-coat-colouration-in-white-dogs/82EFDAA1C05DA9D9B369961F4937FA7E

Wilson, D. E., Lacher Jr., T. E., Mittermeier, R. A. & Don, C. (2016). *Hystricidae.* In: Plazi.org Taxonomic Treatments Database. Checklist dataset. https://doi.org/10.15468/dzf4sq (Accessed on 26 October 2025).

JWLS

JOURNAL OF WILDLIFE SCIENCE

Interdisciplinary Journal of Wildlife Research, Conservation and Management

Contact Information:

Journal of Wildlife Science
Wildlife Institute of India,
PO Box # 18, Chandrabani,
Dehradun – 248001 INDIA
Email: info@jwls.in

https://jwls.in

Crossref

DIAMOND OPEN ACCESS

भारतीय वन्यजीव संस्थान
Wildlife Institute of India