

Building evidence for conservation globally

Journal of Threatened Taxa

10.11609/jott.2023.15.1.22355-22558

www.threatenedtaxa.org

26 January 2023 (Online & Print)

15(1): 22355-22558

ISSN 0974-7907 (Online)

ISSN 0974-7893 (Print)

Open Access





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

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

Host
Zoo Outreach Organization
www.zooreach.org

43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641035, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

EDITORS

Founder & Chief Editor

Dr. Sanjay Molur

Wildlife Information Liaison Development (WILD) Society & Zoo Outreach Organization (ZOO),
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641035, India

Deputy Chief Editor

Dr. Neelesh Dahanukar

Noida, Uttar Pradesh, India

Managing Editor

Mr. B. Ravichandran, WILD/ZOO, Coimbatore, India

Associate Editors

Dr. Mandar Paingankar, Government Science College Gadchiroli, Maharashtra 442605, India

Dr. Ulrike Streicher, Wildlife Veterinarian, Eugene, Oregon, USA

Ms. Priyanka Iyer, ZOO/WILD, Coimbatore, Tamil Nadu 641035, India

Dr. B.A. Daniel, ZOO/WILD, Coimbatore, Tamil Nadu 641035, India

Editorial Board

Dr. Russel Mittermeier

Executive Vice Chair, Conservation International, Arlington, Virginia 22202, USA

Prof. Mewa Singh Ph.D., FASc, FNA, FNAsc, FNAPsy

Ramanna Fellow and Life-Long Distinguished Professor, Biopsychology Laboratory, and
Institute of Excellence, University of Mysore, Mysuru, Karnataka 570006, India; Honorary
Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; and Adjunct
Professor, National Institute of Advanced Studies, Bangalore

Stephen D. Nash

Scientific Illustrator, Conservation International, Dept. of Anatomical Sciences, Health Sciences
Center, T-8, Room 045, Stony Brook University, Stony Brook, NY 11794-8081, USA

Dr. Fred Pluthero

Toronto, Canada

Dr. Priya Davidar

Sigur Nature Trust, Chadapatti, Mavinahalla PO, Nilgiris, Tamil Nadu 643223, India

Dr. Martin Fisher

Senior Associate Professor, Battcock Centre for Experimental Astrophysics, Cavendish
Laboratory, JJ Thomson Avenue, Cambridge CB3 0HE, UK

Dr. John Fellowes

Honorary Assistant Professor, The Kadoorie Institute, 8/F, T.T. Tsui Building, The University of
Hong Kong, Pokfulam Road, Hong Kong

Prof. Dr. Mirco Solé

Universidade Estadual de Santa Cruz, Departamento de Ciências Biológicas, Vice-coordenador
do Programa de Pós-Graduação em Zoologia, Rodovia Ilhéus/Itabuna, Km 16 (45662-000)
Salobrinho, Ilhéus - Bahia - Brasil

Dr. Rajeev Raghavan

Professor of Taxonomy, Kerala University of Fisheries & Ocean Studies, Kochi, Kerala, India

English Editors

Mrs. Mira Bhojwani, Pune, India

Dr. Fred Pluthero, Toronto, Canada

Mr. P. Ilangoan, Chennai, India

Ms. Sindhura Stothra Bhashyam, Hyderabad, India

Web Development

Mrs. Latha G. Ravikumar, ZOO/WILD, Coimbatore, India

Typesetting

Mrs. Radhika, ZOO, Coimbatore, India

Mrs. Geetha, ZOO, Coimbatore India

Fundraising/Communications

Mrs. Payal B. Molur, Coimbatore, India

Subject Editors 2019–2021

Fungi

Dr. B. Shivaraju, Bengaluru, Karnataka, India

Dr. R.K. Verma, Tropical Forest Research Institute, Jabalpur, India

Dr. Vatsavaya S. Raju, Kakatiya University, Warangal, Andhra Pradesh, India

Dr. M. Krishnappa, Jnana Sahyadri, Kuvempu University, Shimoga, Karnataka, India

Dr. K.R. Sridhar, Mangalore University, Mangalagangothri, Mangalore, Karnataka, India

Dr. Gunjan Biswas, Vidyasagar University, Midnapore, West Bengal, India

Plants

Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India

Dr. N.P. Balakrishnan, Ret. Joint Director, BSI, Coimbatore, India

Dr. Shonil Bhagwat, Open University and University of Oxford, UK

Prof. D.J. Bhat, Retd. Professor, Goa University, Goa, India

Dr. Ferdinando Boero, Università del Salento, Lecce, Italy

Dr. Dale R. Calder, Royal Ontario Museum, Toronto, Ontario, Canada

Dr. Cleofas Cervancia, Univ. of Philippines Los Baños College Laguna, Philippines

Dr. F.B. Vincent Florens, University of Mauritius, Mauritius

Dr. Merlin Franco, Curtin University, Malaysia

Dr. V. Irudayaraj, St. Xavier's College, Palayamkottai, Tamil Nadu, India

Dr. B.S. Kholia, Botanical Survey of India, Gangtok, Sikkim, India

Dr. Pankaj Kumar, Kadoorie Farm and Botanic Garden Corporation, Hong Kong S.A.R., China

Dr. V. Sampath Kumar, Botanical Survey of India, Howrah, West Bengal, India

Dr. A.J. Solomon Raju, Andhra University, Visakhapatnam, India

Dr. Vijayasankar Raman, University of Mississippi, USA

Dr. B. Ravi Prasad Rao, Sri Krishnadevaraya University, Anantpur, India

Dr. K. Ravikumar, FRLHT, Bengaluru, Karnataka, India

Dr. Aparna Watve, Pune, Maharashtra, India

Dr. Qiang Liu, Xishuangbanna Tropical Botanical Garden, Yunnan, China

Dr. Noor Azhar Mohamed Shazili, Universiti Malaysia Terengganu, Kuala Terengganu, Malaysia

Dr. M.K. Vasudeva Rao, Shiv Ranjani Housing Society, Pune, Maharashtra, India

Prof. A.J. Solomon Raju, Andhra University, Visakhapatnam, India

Dr. Mandar Datar, Agharkar Research Institute, Pune, Maharashtra, India

Dr. M.K. Janarthanam, Goa University, Goa, India

Dr. K. Karthigeyan, Botanical Survey of India, India

Dr. Errol Vela, University of Montpellier, Montpellier, France

Dr. P. Lakshminarasimhan, Botanical Survey of India, Howrah, India

Dr. Larry R. Noblick, Montgomery Botanical Center, Miami, USA

Dr. K. Haridasan, Pallavur, Palakkad District, Kerala, India

Dr. Analinda Manila-Fajard, University of the Philippines Los Banos, Laguna, Philippines

Dr. P.A. Sinu, Central University of Kerala, Kasaragod, Kerala, India

Dr. Afroz Alam, Banasthali Vidyapith (accredited A grade by NAAC), Rajasthan, India

Dr. K.P. Rajesh, Zamorin's Guruvayurappan College, GA College PO, Kozhikode, Kerala, India

Dr. David E. Boufford, Harvard University Herbaria, Cambridge, MA 02138-2020, USA

Dr. Ritesh Kumar Choudhary, Agharkar Research Institute, Pune, Maharashtra, India

Dr. Navendu Page, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, India

Dr. Kannan C.S. Warrior, Institute of Forest Genetics and Tree Breeding, Tamil Nadu, India

Invertebrates

Dr. R.K. Avasthi, Rohtak University, Haryana, India

Dr. D.B. Bastawade, Maharashtra, India

Dr. Partha Pratim Bhattacharjee, Tripura University, Suryamaninagar, India

Dr. Kailash Chandra, Zoological Survey of India, Jabalpur, Madhya Pradesh, India

Dr. Ansie Dippenaar-Schoeman, University of Pretoria, Queenswood, South Africa

Dr. Rory Dow, National Museum of Natural History Naturalis, The Netherlands

Dr. Brian Fisher, California Academy of Sciences, USA

Dr. Richard Gallon, Llandudno, North Wales, LL30 1UP

Dr. Hemant V. Ghatge, Modern College, Pune, India

Dr. M. Monwar Hossain, Jahangirnagar University, Dhaka, Bangladesh

Mr. Jatishwor Singh Irungbam, Biology Centre CAS, Branišovská, Czech Republic.

Dr. Ian J. Kitching, Natural History Museum, Cromwell Road, UK

For Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scope

For Article Submission Guidelines, visit <https://threatenedtaxa.org/index.php/JoTT/about/submissions>

For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/policies_various

continued on the back inside cover

Cover: Whale Shark *Rhincodon typus* and Reef - made with poster colours. © P. Kritika.



INTRODUCTION

Sambar *Rusa unicorn* is native to India, Pakistan, Sri Lanka, Philippines, southern China, Taiwan, Malaysia, Borneo, Sumatra, and Java (Wilson & Mittermeier 2011). In India the distribution range extends east along the southern Himalaya and south throughout the Deccan peninsula. Sambar are abundant in the southern states of Karnataka, Tamil Nadu, and Kerala (Sridhar et al. 2008; Timmins 2015). In other central and east Indian states, Sambar is considered very rare, and the distribution is patchy and declining due to severe hunting pressure, insurgency, and habitat destruction (Timmins 2015). Sambar have disappeared from Sikkim and Tripura (Khan & Johnsingh 2015).

Ungulates play an important role in maintaining the ecosystem by influencing vegetation structure (Augustine & McNaughton 1998; Bagchi & Ritchie 2010). They also play a major role in maintaining prey-predator relations. Sambar is known to be a preferred prey of tiger, throughout its range (Karanth & Sunquist 1992; Karanth & Nichols 2000; Ramesh et al. 2009). Tiger Estimation Report (2019) reported 2,967 tigers in India among which a maximum of 526 tigers are present in Madhya Pradesh (Jhala et al. 2018). Such population of tigers needs a good prey base and population estimation is key for managing the population of prey species. The Sambar and Chital *Axis axis* together form the bulk of the prey base for all large carnivores of the Indian subcontinent such as the Tiger, the Asiatic Lion, the Leopard, and the Dhole (Devidar 1974; Johnsingh 1983; Bhatnagar 1991; Venkataraman 1995). Sambar contributes the most to the prey biomass and is considered a keystone species in Pench Tiger Reserve (Venkataraman 1995).

Information on specific habitat requirements is important for conservation, and governing species habitat use including aspect, slope, food availability, vegetation cover, food availability, vegetation cover, terrain, and cover against extremes of weather and other biotic pressures. Conservation of species requires a good understanding of the habitat requirements and careful monitoring of populations (Yoccoz et al. 2001; Acharya 2007). Understanding population trends and habitat use is crucial for implementation of conservation actions.

The study aims to evaluate the density and population structure of Sambar and the factors affecting its distribution in different seasons within Pench Tiger Reserve (PTR), Madhya Pradesh, India. This study will update knowledge on the abundance and habitat use of Sambar in PTR. The present study will be useful for

the managers and policymakers for conservation of the species and its habitat throughout its distribution range.

MATERIAL AND METHODS

Study Area

The Pench Tiger Reserve, Madhya Pradesh, India is one of the important protected areas of the Satpura-Maikal ranges of the central Indian Landscape. The area was declared as the 19th tiger reserve of India in 1992. PTR comprises a sanctuary and national park, covering an area of 757.85 km² (21.6200° latitude and 79.2125° longitude) at an altitude of 425–600 m (Figure 1). The terrain is gently undulating comprising seasonally flowing streams and nullahs. The Pench River, from which this tiger reserve is named, runs through the reserve over a length of 24 km bisecting it into two halves.

The tiger reserve has four seasons: Summer (March–June), Monsoon (July–August), Post-monsoon (September–November), and Winter (December–February). The temperature ranges from 4° C in peak winter to 45° C in the peak summer. The PTR receives an average annual rainfall of 1,300 mm. The PTR is a dry deciduous forest dominated by *Tectona grandis*, *Boswellia serrata*, *Anogeissus latifolia*, *Sterculia urens*, and *Gardenia latifolia*. Tiger *Panthera tigris*, Leopard *Panthera pardus*, Dhole *Cuon alpinus*, Jungle Cat *Felis chaus*, Small Indian Civet *Viverricula indica*, Striped Hyena *Hyaena hyaena*, Sloth Bear *Melursus ursinus*, Golden Jackal *Canis aureus*, and Common Palm Civet *Paradoxurus hermaphroditus* are the carnivore species of the reserve. Herbivores, apart from Sambar, include Chital, Gaur *Bos gaurus*, Nilgai *Boselaphus tragocamelus*, Barking Deer *Muntiacus muntjac*, and Chowsingha *Tetracerus quadricornis*.

Methods

Distance sampling was used to study the population density of Sambar in PTR. A total of 15 line transects of 2-km length were traversed morning and evening. The study area was divided into five different habitats on the basis of vegetation composition, and the transects were set to cover all the five habitats and three transects were laid in each one, i.e., Bamboo forest, Grassland, Mixed forest, Teak forest, and Teak mixed forest.

Two seasons were selected to reduce the bias in data collection: Summer and Winter. Eight monitorings were made on each transect in summer and winter, 0600–0900 h and 1600–1800 h. The direct sightings of

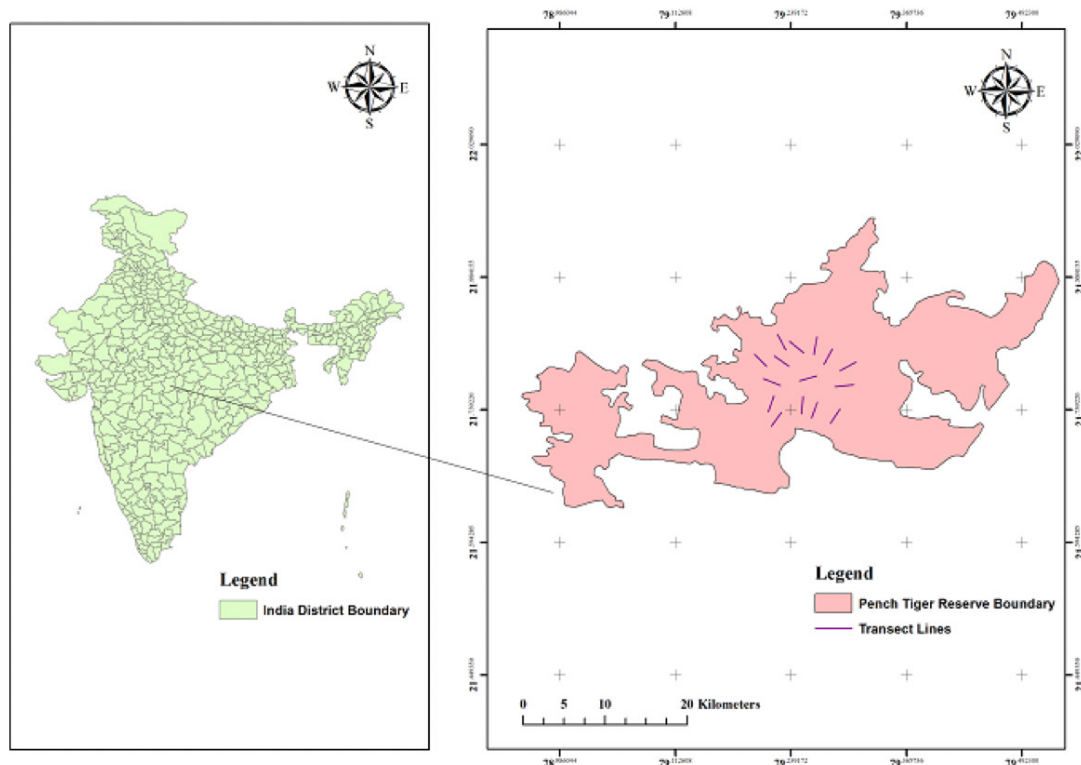


Figure 1. Map of the study area with location of transects.

Sambar were recorded. During the field survey a total of 1,232km efforts were given while traversing the transects.

To assess the habitat utilization pattern, indirect data were also collected. Ten-meter radius circular plots were laid on all of the 15 transects at an interval of 200 m from one another. The tree species present were counted within each plot. Five-meter circular plots were laid to assess shrub cover and 1-m quadrats for grasses and herbs. Pellet groups are another indicator of the presence of a species in a given habitat. For assessing the habitat utilization pattern of Sambar, along with the vegetation data, data on Sambar pellet groups were also collected.

On each sampling plot, canopy cover was measured at four different points, using a mirror of 25 x 25 cm divided into 100 equal grid squares. The mirror was held horizontally at 1.25 m above ground level, and grid squares covered by more than 50% tree foliage were counted. Percentage canopy cover for each sampling plot was calculated from these counts. Shrub cover, grass cover and herb cover was also measured for each plot in different seasons through ocular estimation.

Data analysis

Line transect data collected were analyzed using DISTANCE 7.0. The distribution of the data was firstly examined by assigning very small cut-off points to the distance intervals during the curve fitting. After choosing convenient cut-off points for the distance intervals, the best key function (with the appropriate adjustment term, where necessary) was selected using the criterion of lowest AIC (Akaike information criteria).

Age classification of Sambar followed Schaller (1967), Sankar (1994), and Sankar et al. (2001). Data on group size and composition were analyzed following Schaller (1967) and Johnsingh (1983). Mean group size was estimated by taking the average of different group sightings, and group size was classified into different class intervals for better explanation between different seasons.

Analysis of indirect evidence such as pellet groups was organized in a simple habitat matrix in order to investigate the habitat selection at macro level. The pallet group density was calculated using following formula:

$$\text{Density / ha} = (\text{Number of pallet groups / Area}) \times 10000.$$

Species diversity and richness were calculated by using modified version of "SPECDIVER BAS" (Ludwing & Reynolds 1988), a module of software STASTICAL

ECOLOGY written in BASIC.

One-way ANOVA was used to test significant differences in mean pellet group density in different habitats in different seasons using the computer program SPSS 6.1 (Norusis 1994).

To understand the habitat selection at micro level, principal component analysis (PCA) was performed to avoid confounding highly correlated variables. All the quantitative data in the matrix were transformed using log and arcsine transformation and transformed data were standardized by calculating the mean and standard deviation of each column of data matrix.

Factor analysis was used to reduce the dimensionality of different habitat variables. The first two factors were used for interpretation as these explained maximum variations in the data set. Before using PCA most of the auto-correlated variables were dropped. As habitat selection analysis concentrated on 30 variables around different sampling plots in different season, were recorded out of which different variables in different seasons were used for PCA, and factor scores were saved. Utilized and available plots were plotted in two dimension space defined by PCI, and PCII. All the extracted factors with eigen values of more than one were saved and used for logistic regression analysis. In logistic regression, the principal component was then used as candidate variables in logistic regression model with forward step-wise entry.

RESULTS

Population density and abundance of Sambar

During the winter season, a total of 80 sightings were observed, while in summer 113 sightings were observed (sightings for both years were pooled). The long distance sightings were truncated to reduce the bias. A total number of detection of Sambar was 80 in winter, and 113 in summer were used to estimate density. Half-normal cosine model was selected for both winter and summer season as best fit estimator. The effective strip width for winter season was (23.7 ± 3.45) m whereas for summer season it was (18.7 ± 2.34) m. The estimated density of Sambar was $6.93 (\pm 1.69) \text{ km}^{-2}$ in winter 2014, $4.27 (\pm 1.05) \text{ km}^{-2}$ in winter 2015 and $3.36 (\pm 0.71) \text{ km}^{-2}$ for overall winter season. Summer density was $10.2 (\pm 2.58) \text{ km}^{-2}$ in 2013, $15.7 (\pm 4.88) \text{ km}^{-2}$ in 2014, $8.53 (\pm 2.48) \text{ km}^{-2}$ in 2015 and $4.06 (\pm 0.74) \text{ km}^{-2}$ for summer overall (Table 1). Group density of Sambar in different seasons are also shown in Table 1.

Mean pellet group density of Sambar during post

monsoon, summer and winter season were maximum $(100.8 \pm 101, 89.8 \pm 88, 98.2 \pm 94)$, respectively, in Teak forest, teak mixed forest, & bamboo forest and minimum $(30.78 \pm 37.85, 50.24 \pm 62.78, 53.07 \pm 65.20)$ in teak mixed, grassland, & teak mixed forest, respectively. Analysis of two way ANOVA shows significance differences in mean pellet group density in different habitat in different seasons [$F_{8, 1043} = 3.706, \eta^2 (166748.3), P < 0.05$]. Post hoc test shows that mean pellet group density of Sambar in grassland and teak forest were found significantly different with each other. It also shows that mean pellet group density of Sambar shows significant differences between post monsoon season and winter season. The group density $\pm$ SE was highest in Teak forest (1.22 ± 0.24) followed by Mixed forest, (0.54 ± 0.14) , Grassland (0.50 ± 0.12) , Teak mixed (0.33 ± 0.07) , and Bamboo forest (0.27 ± 0.06) (Table 5).

Age and sex structure of Sambar

Adult males (AM) and adult females (AF) were observed more (31% and 53%, respectively) in winter than in summer (27% and 48%, respectively). Observations of yearlings (Y) were (15%) in summer and (10%) in winter. The sex ratio was found biased towards females. In winter, out of 165 individuals, the AF:AM sex ratio was 100:59, and AF:Y 100:18. In summer out of 341 individuals, the AF:AM ratio was 100:56 and AF:Y 100:32. The mean group size $\pm$ SE of Sambar, during winter was $2.08 (\pm 0.11)$ and in summer $3.15 (\pm 0.18)$.

Factors affecting the selection of habitats by Sambar in different seasons

For Sambar during post monsoon season, there were 15 variables that had correlation coefficient above 0.80 therefore, these variables were removed from the analysis for avoiding multicollinearity (Table 2). The first two principal components accounted for 26.52% of the variation on data set. The first principle component (PC 1) was highly positively correlated with herb diversity ($r = 0.84$), herb density ($r = 0.79$), and tree diversity ($r = 0.70$). The second PC 2 was highly positively correlated with grass diversity ($r = 0.88$) and grass density ($r = 0.86$). Figure 2 indicates a relationship between the use of PC 1 and PC 2 in the selection of habitat by Sambar during the post-monsoon. Our analyses showed a clear shift in habitat use in response to the increased use of low to medium grass diversity and grass density and medium to high herb diversity, herb density, and tree diversity. Overall, the logistic regression model had an efficiency of 97.40% correct classification of cases that identified tree density, as a key predictor of Sambar habitat use

Table 1. Sambar Densities (Individuals/km²) in Pench Tiger Reserve, Madhya Pradesh, during winter and summer seasons (2013 to 2015).

Years/Seasons	Winter				Summer			
	2013	2014	2015	Pooled	2013	2014	2015	Pooled
Total effort (km)	NA	272	240	512	240	240	240	720
Total Observations	NA	48	32	80	27	41	45	113
Truncated at (m)	50				45			
Observation after Truncation	NA	48	32	78	27	41	40	104
Density $\pm$ SE/km ²	NA	6.93 $\pm$ 1.69	4.27 $\pm$ 1.05	3.36 $\pm$ 0.71	10.21 $\pm$ 2.58	15.73 $\pm$ 4.88	8.53 $\pm$ 2.48	4.06 $\pm$ 0.74
Group Density $\pm$ SE/ km ²	NA	2.46 $\pm$ 0.57	2.17 $\pm$ 0.51	1.60 $\pm$ 0.32	2.17 $\pm$ 0.48	3.43 $\pm$ 0.97	2.99 $\pm$ 0.82	1.28 $\pm$ 0.22
Mean Group Size $\pm$ SE	2.08 $\pm$ 0.11				3.15 $\pm$ 0.18			
Effective Strip Width $\pm$ SE (m)	23.66 $\pm$ 3.45				18.67 $\pm$ 2.34			
A value	201.68				213.34			
Model+ Adjustment term	Half-normal Cosine				Half-normal Cosine			

Table 2. Principal component analysis of Sambar pellet group during post-monsoon season.

Variables	PC I	PC II	PC III
Bear Ground	0.0331	0.107829	0.105539
Grass Density	0.027686	0.868578	-0.136
Grass Diversity	0.136071	0.883648	-0.06249
Herb Cover	-0.03474	0.262041	0.084252
Herb Density	0.799433	-0.12273	0.133806
Herb Diversity	0.840358	0.278337	0.011688
Sapling Density	0.248571	0.018811	0.109222
Sapling Diversity	0.005983	0.06579	-0.0031
Shrub Cover	-0.36659	-0.01112	0.660385
Seedling Density	0.095794	-0.0226	0.079414
Seedling Diversity	0.101087	0.134554	0.063229
Shrub Diversity	0.12455	-0.04253	0.77041
Shrub Density	0.186455	-0.15938	0.777779
Tree Density	-0.02252	0.295619	0.346735
Tree Diversity	0.701757	0.086988	-0.04878
% of Variance by each component	14.17153	12.35785	12.25404
Cumulative Variance	14.17153	26.52938	38.78343

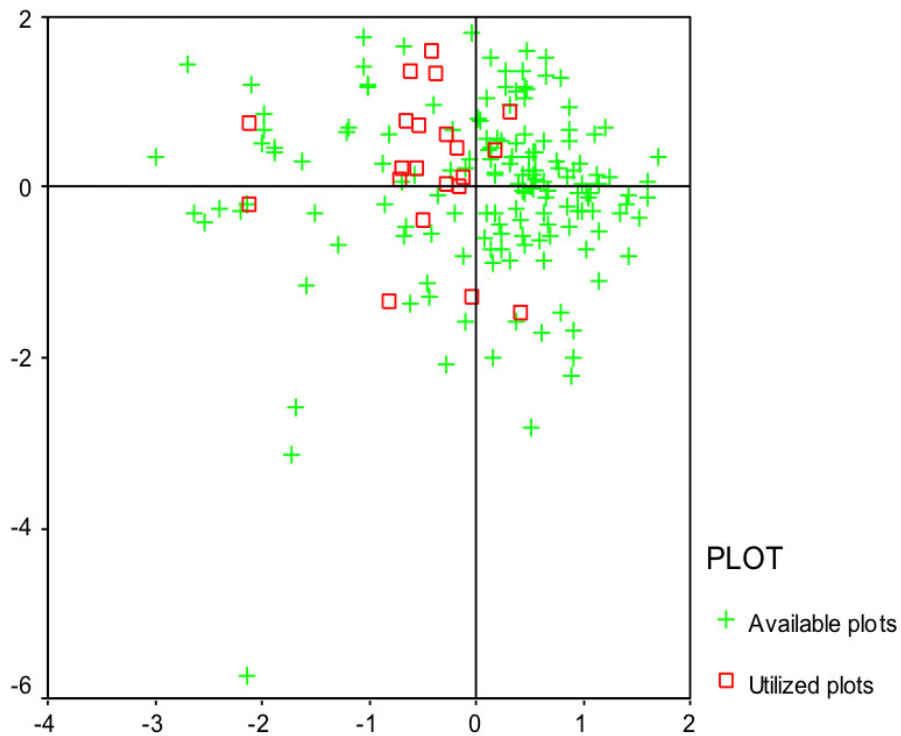
in the post-monsoon season. During summer, 11 out of 30 variables were selected from data collected from 519 sampling plots (Table 3). The first two principal components accounted for 41.31% of the variation. The first principle component (PC 1) was highly positively correlated with grass density ($r = 0.83$), herb density ($r = 0.74$), weathered stone ($r = 0.54$) and negatively correlated with litter ($r = -0.82$). The second principle component (PC 2) was highly positively correlated with herb cover (%) ($r = 0.76$) and and negatively correlated

Table 3. Principal component analysis of Sambar pellet group during the summer season.

Variables	PC I	PC II	PC III
Grass Density	0.83167	0.275057	0.010902
Herb Cover	0.207257	0.698108	0.041515
Herb %	0.317452	0.768572	0.048339
Herb Density	0.747446	0.401299	0.053116
Herb Diversity	0.25406	0.449724	0.400123
Litter	-0.82924	-0.04759	0.018185
Rock	0.25652	-0.61443	0.028021
Seedling Density	-0.00611	-0.04101	0.892497
Seedling Diversity	-0.0352	0.089607	0.872159
Tree Cover	-0.0003	-0.05004	-0.09414
Weathered Stone	0.542355	-0.35789	-0.03183
% of Variance by each component	22.79538	18.51902	15.77547
Cumulative Variance	22.79538	41.31441	57.08987

with rocks ($r = -0.61$). During summer the distribution of available and utilized plots in relation to first and second component is shown in Figure 3. The graph shows that during summer Sambar preferred the area with low to high herb cover % and and medium to high grass density, herb density and weathered stone and on the other hand avoiding rock and litter. The logistic regression model had an efficiency of 66.28% correct classification of available and used plots by Sambar during summer. According to this model, herb diversity was the most important predictor for Sambar's habitat selection.

During winter, 12 variables from 350 sampling plots of 30 variables were selected (Table 4). The first two principal components accounted for 33.32% of



Grass diversity, grass density

Figure 2. Ordination of available and utilized plots for Sambar during post-monsoon season in Pench Tiger Reserve.

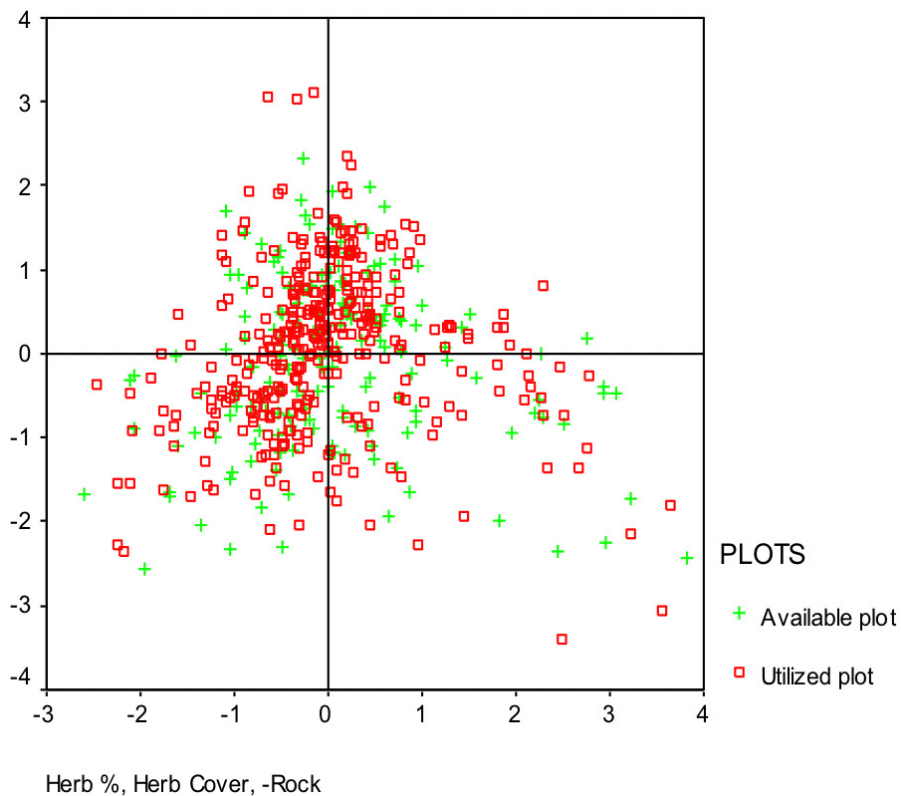


Figure 3. Ordination of available and utilized plots for Sambar during the summer season in Pench Tiger Reserve.

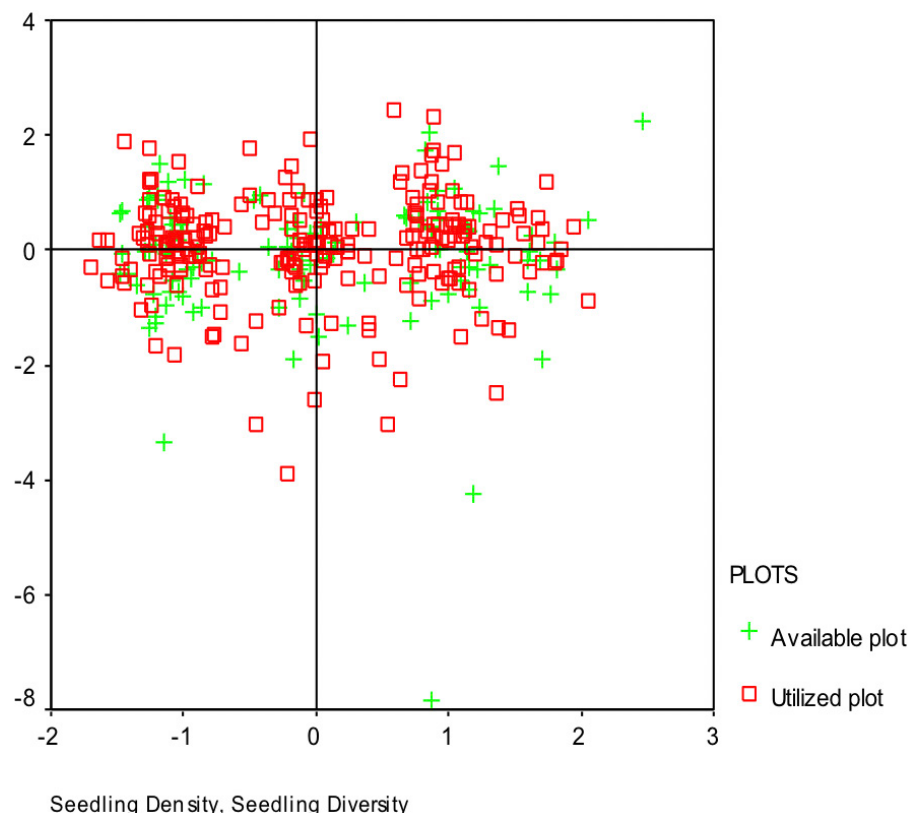


Figure 4. Ordination of available and utilized plots for Sambar during the winter season in Pench Tiger Reserve.

Table 4. Principal component analysis of Sambar pellet group during the winter season.

Variables	PC I	PC II	PC III
Grass Density	0.617863	-0.04698	-0.27626
Grass Diversity	0.525874	0.300114	-0.19871
Herb Cover	0.651132	-0.01108	0.147166
Herb Density	0.674319	0.013231	0.116658
Herb Diversity	0.62023	0.166813	0.171585
Rock	-0.53704	0.072539	0.282335
Sapling Density	0.090378	0.061656	-0.08938
Seedling Density	-0.01843	0.890214	0.110038
Seedling Diversity	0.090306	0.878828	0.016763
Shrub Diversity	0.054001	-0.10344	0.854835
Shrub Density	0.005772	0.232585	0.779192
Tree Cover	-0.08705	-0.05413	0.171437
% of Variance by each component	18.64389	14.68341	13.73232
Cumulative Variance	18.64389	33.3273	47.05962

the variation. The first principle component (PC 1) was positively correlated with herb density ($r = 0.67$), herb cover ($r = 0.65$), herb diversity ($r = 0.62$), & grass density ($r = 0.61$) and negatively correlated with rocks

Table 5. Seasonal variation in density of Sambar in different habitats of Pench Tiger reserve, Madhya Pradesh (2013 to 2015).

Habitat	Sambar (Density $\pm$ SD)		
	Post monsoon	Summer	Winter
Bamboo Forest (n=180)	45.64 $\pm$ 51.34	69.70 $\pm$ 83.63	98.19 $\pm$ 94.59
Grassland	41.40 $\pm$ 45.15	50.24 $\pm$ 62.78	61.04 $\pm$ 78.29
Mixed (n=180 in PNP & n=144 in PMS)	64.85 $\pm$ 66.56	65.89 $\pm$ 69.94	82.51 $\pm$ 82.67
Teak Forest (n=180)	100.84 $\pm$ 101.77	72.54 $\pm$ 65.28	80.67 $\pm$ 78.55
Teak-mixed (n=180)	30.78 $\pm$ 37.85	89.87 $\pm$ 88.36	53.07 $\pm$ 65.20

PNP—Pench national Park | PMS—Pench Mowgli Sanctuary.

($r = -0.53$). The second principle component (PC 2) was highly positively correlated with seedling density ($r = 0.89$), seedling diversity ($r = 0.87$). For Sambar during winter season the distribution of available and utilized plots in relation to first and second component is shown in Figure 4. The graph shows that during winter season Sambar preferred the area with low to medium seedling density and seedling diversity and medium herb density, herb cover, herb diversity, grass density and avoiding rocks. The logistic regression model had an efficiency

of 66.57% correct classification of available and used plots by Sambar during winter season. According to this model, sapling density was the most important predictor for Sambar's habitat selection.

DISCUSSION

Sambar density is showing a declining trend in the last two decades in PTR. During 1995–2000 Sambar density was reported to be 9.6 animals/km² (Karanth & Nichols 2000). Sambar favours dense forest patches as well as hilly terrain (Biswas & Sankar 2002; Kushwaha et al. 2004) and a similar trend was observed in the present study. Our results show that Sambar prefers the teak dominated habitat with hilly terrain and dense forest during winter and summer, and feeding results also confirm the same as Sambar utilizes *Tectona grandis* less than the availability in both seasons (Ilyas 2015). Most of the sightings were around water holes. Studies conducted in different parts of India suggest the Sambar tend to concentrate their activity around these waterholes (Ilyas 2001; Biswas & Sankar 2002; Kushwaha et al. 2004). Being a deer that prefers relatively dense forest, distribution pattern of Sambar was found to be clumped type with highest pellet group recorded in Teak forest. Studies on a variety of other ungulates have also shown clumped type distribution patterns due to the availability of food resources (Adhikari & Khadka 2009). The Chital density in PTR was reported to be 31.48 ($\pm$ 3.47) in winter and 39.99 ($\pm$ 2.73 during summer), 8–9 times higher than Sambar density (Ilyas 2015). The increased population of chital may also be one of the reasons for the clumped distribution of Sambar, to avoid competition. The overabundant population of Spotted Deer in PTR is a major concern for the management point of view, and translocation of chital to unoccupied areas outside PTR could resolve the issue to some extent for Sambar (Ilyas 2015).

Schaller (1967) and Eisenberg & Lockhart (1972) reported that Sambar does not remain in permanent social groups. In PTR, the observed Sambar male:female ratio was 0.59:1 in winter and 0.56:1 in summer. The observed low male ratio might be due to selective predation by tiger on male Sambar as reported in other studies (Schaller 1967; Johnsingh 1983; Karanth & Sunquist 1992). Sambar male:female sex ratio of the present study can be compared with Gir—0.5:1 (Khan et al 1996), Wilpattu—1.2:1 (Eisenberg & Lockhart 1972), Ranthambore—0.83:1 (Bagchi et al. 2003), and Florida—0.73:1 (Flynn et al. 1990). In Sambar, group size is generally small, numbering fewer than six individuals

(Schaller 1967). The characteristic social unit in Sambar is one hind and one fawn or one hind, one yearling, and one fawn (Schaller 1967; Downes 1982). In the present study group size of 1–5 individuals was recorded throughout the year, as was also reported in Mudumalai (Ramesh 2010).

Habitat studies provide crucial information about the ecological requirements of a species or community. Habitats of animals have been studied for long. From the days of Aristotle (344 BCE) where man learnt about habitat use by animals due to innate curiosity to today's times when understanding ecological relationships (Morisson et al. 1992), conservation of natural resources (e.g. Soule 1986), and management of areas with specific requirements (e.g. Fox et al. 1988; Rahmani 1989) have made it mandatory to understand habitat requirements of different species. Increasing habitat loss causes a significant increase in extinction risk among many species, especially habitat specialists (Rahmani 1989; Birdlife International 2001; Mallon 2003; Norris & Harper 2003). While it is important to assess the habitat usage, it is equally important to conduct studies addressing the pattern of usage. It is assumed that high quality resources will be selected more than low quality ones and use may change with availability when the latter is not uniform (Manly et al. 1993).

Unoccupied habitat with little selection cannot be assumed to provide low fitness potential. Although effects of habitat cover, landscape structure and spatial variables on abundance of birds has been reported (Heikkinen et al. 2004), fitness potential of habitat cannot be assumed to vary with habitat selection and a gradient in observed density does not necessarily indicate a gradient in habitat quality (Hobbs & Hanley 1990). The approaches used in the present study for collecting data on habitat use reduced chances of collecting insufficient or biased data. Ungulates defecate at a particular rate, which varies between species, but is usually constant within species (Marques et al. 2001; Laing et al. 2003). Using pellets as indirect evidence of presence have their understandable strengths, but also have some challenges. Although the issue of detectability is reduced to a great extent when areas were combed thoroughly for faecal matter, disintegration rate and site selection pose concerns (Marques et al. 2001; Laing et al. 2003).

In the present study most of the pellet groups of Sambar were recorded from hilly terrain with Teak dominated forest type. The study shows that Sambar avoid dense forest which is also supported by Imam (2014). This, however, is contrary to the studies

conducted by Ramesh et al. (2012) and Khushwaha et al. (2014). Findings of factorial analysis state that density and diversity of trees and herbs were the most important factors for their habitat preference which is significantly supported by logistic regression analysis. These findings are similar to the study conducted by Khushwaha et al. (2004). Water is an important resource, particularly in hot temperatures. Sambar, being an animal of hilly terrain, reduce energy expenditure by restricting their home ranges around the water resources in summer. In certain occasions they rush into a water body to avoid predation (Yahya 2014), often unsuccessfully. Our study also shows a similar trend. It is also supported by studies conducted by Johnsingh (1983), Eisenberg & Lockhart (1972), and Imam (2014). The study area consists tropical dry and tropical moist deciduous forests, so that covering of the ground with leaf litter is common during summer. Sambar avoids habitats covered with high amount of litter as they contain very few plant materials to be utilized as food. In the present study similar results were recorded, where Sambar avoids litters in summer. The rocks do not provide any protection from predators, high temperature and forage. This has resulted in a decrease of suitable habitat for this habitat specialist species. The woodland contains climax stage species with interspersed shrubs was the most preferred habitat type and favourable for its grazing and browsing requirement throughout the year.

Ungulates in general and Sambar in specific are a good indicator of the health of the forest. Their population structure should be assessed at temporal and spatial levels at different landscapes. The Pench Tiger Reserve is one of the best managed tiger reserve and contains a very good prey base for the thriving tiger population. For effective Sambar conservation a large undulating tract of undisturbed habitat is required. Such tracts should have protection from poaching as poachers prefer Sambar as it provides more meat. At the global level Sambar population has declined and in peninsular Malaysia Sambar has lost more than 50% of its historical range. (Kawanishi et al. 2014). In India also Sambar has disappeared from Sikkim, Tripura and many other places, which is an alarming condition for the managers (Khan & Johnsingh 2015). The government as well as NGOs involved in conservation should pay special attention to Sambar conservation. Sambar is not only ecologically important for the ecosystem but is also a main prey for tigers. We also recommend IUCN Red List authorities to review the Red List category of Sambar, presently listed as 'Vulnerable' (Timmins et al. 2015). If Sambar continue to disappear from other areas, then

soon it may be included in the Endangered category.

REFERENCES

- Acharya, B.B. (2007). The ecology of the dhole or Asiatic wild dog (*Cuon alpinus*) in Pench tiger reserve, Madhya Pradesh. PhD Thesis, Saurashtra University, Rajkot, Gujarat, 132 pp.
- Adhikari S. & A. Khadka (2009). Study on relative abundance and distribution of Tiger prey base (ungulates) in Kanha corridor, Bardia national park Kathmandu University *Journal of Science Engineering and Technology* 5:121–135.
- Augustine, D.J. & S.J. McNaughton (1998). Ungulate effects on the functional species composition of plant communities: herbivore selectivity and plant tolerance. *Journal of Wildlife Management* 62: 1165–1183.
- Bagchi S., S.P. Goyal & K. Sankar (2008). Habitat separation among ungulates in dry tropical forest of Ranthambhore national park, Rajasthan. *Tropical Ecology* 44 (2): 175–181.
- Bagchi S., S.P. Goyal & K. Sankar (2003). Prey abundance and prey selection by Tigers (*Panthera tigris*) in a semi-arid, dry-deciduous forest in western India. *Journal of Zoology* 260: 285–290.
- Bagchi S. & M. Ritchie (2010). Herbivore effects on above- and belowground plant production and soil nitrogen availability in the trans-Himalayas shrub-steppes. *Oecologia* 164: 1075–1080.
- Bhatnagar, Y. (1991). Habitat preference of Sambar (*Cervus unicolor*) in Rajaji National Park. MSc Dissertation, Saurashtra University, Rajkot, 51 pp.
- Birdlife International (2001). *Threatened Birds of Asia: The Birdlife International Red Data Book*. Cambridge, UK, 32 pp.
- Biswas, S. & K. Sankar (2002). Prey abundance and food habit of tigers (*Panthera tigris*) in Pench National Park, Madhya Pradesh, India. *Journal of Zoology* 256: 411.
- Buckland, S.T., D.R. Anderson, K.P. Burnham & J.L. Laake (1993). *Distance sampling: estimating abundance of biological populations*. Chapman and Hall, New York, 446 pp.
- Carbone, C. & J.L. Gittleman (2002). A common rule for the scaling of carnivore density. *Science* 295: 2273–2276.
- Davidar, E.R.C. (1974). Observation at the dens of the dhole or Indian wild dog (*Cuon alpinus*). *Journal of the Bombay Natural History Society* 71: 183–187.
- Dinerstein, E. (1979). An ecological survey of the Royal Karnaia Bardia Wildlife Reserve, Nepal. Part II. Habitat/animal interaction *Biological Conservation* 16: 265–300.
- Downes, M. (1983). *The Forest Deer Project (1982)*. Australian Deer Foundation Ltd. Melbourne, Australia, xx + 190 pp.
- Eisenberg, J.F. & M. Lockhart (1972). An ecological reconnaissance of Wilpattu National Park, Ceylon. *Smithsonian Contributions to Zoology* 101: 1–118.
- Flynn, L.B., S.M. Shea, & J.C. Lewis (1990). Marchinton RL. Population, status, health, and habitat use, pp. 63–96. In: *Ecology of Sambar deer on St. Vincent National Wildlife Refuge, Florida*. Bull No. 25 Tall timber research station, Tallahassee, Florida, 107 pp.
- Fox, J.L., S.P. Sinha, R. Chundawat & P.K. Das (1988). A field survey of snow leopard presence and habitat use in northwestern India, pp. 99–111. In: Freeman, H. (ed.). *Proceedings of the Fifth International Snow Leopard Symposium*. International Snow Leopard Trust, Bellevue, Washington and Wildlife Institute of India, Dehradun, India.
- Heikkinen, R.K., M. Luoto, R. Virkkala & K. Rainio (2004). Effects of habitat cover, landscape structure and spatial variables on the abundance of birds in an agricultural forest mosaic. *Journal of Applied Ecology* 41: 824–835.
- Hobbs, N.T. & T.A. Hanley (1990). Habitat evaluation: do use/availability data reflect carrying capacity? *Journal of Wildlife Management* 54: 515–522.
- Ilyas, O. (2015). *Conservation status and ecology of ungulates*

- in Pench Tiger Reserve M.P. with special reference to resource partitioning. Aligarh Muslim University, Aligarh, SERB-DST Funded Final Technical Report. 2015. (Unpublished Report)
- Imam, E. (2014).** Habitat suitability model for Sambar (*Rusa unicorn*): A remote sensing and GIS approach. Proceeding of National Seminar on Remote sensing and Environment. Jadhavpur University, Kolkata.
- Imam, E., S.P.S. Kushwaha & A. Singh (2009).** Evaluation of suitable tiger habitat in Chandoli National Park India using Multiple logistic regression, *Ecological Modelling* 220: 3621–3629.
- Jhala, Y.V., Q. Qureshi & A.K. Nayak (2019).** Status of tigers, co-predators and prey in India 2018. Summary Report. National Tiger Conservation Authority, Government of India, New Delhi, and Wildlife Institute of India, Dehradun. TR No./2019/05.
- Johnsingh, A.J.T. (1983).** Large mammalian prey-predators in Bandipur. *Journal of the Bombay Natural History Society* 80(1): 1–57.
- Karanth, K.U. & J.D. Nichols (2000).** Ecological status and conservation of tigers in India. Centre for Wildlife Studies, Bangalore, India, 124 pp.
- Karanth, K.U. & M.E. Sunquist (1992).** Population structure, density and biomass of large herbivores in the tropical forests of Nagarhole, India. *Journal of Tropical Ecology* 8: 21–35.
- Kawanishi, K., D.M. Rayan, M.T. Gulmul & C.R. Shepherd (2014).** Extinction process of the sambar in Peninsular Malaysia. *DSG Newsletter* 26: 48–59.
- Khan, J.A., R. Chellum & A.J.T. Johnsingh (1996).** Group size and age-sex composition of three major ungulate species in Gir Lion Sanctuary, Gujarat, India. *Journal of the Bombay Natural History Society* 92: 295–302.
- Khan, J.A. & A.J.T. Johnsingh (2015).** Sambar, pp. 223–241. In: Johnsingh, A.J.T. & N. Manjerekar (eds.). *Mammals of South Asia, Vol 2*. University Press (India) Private Ltd., 739 pp.
- Kushwaha S.P.S., A. Khan, B. Habib, A. Quadri & A. Singh (2004).** Evaluation of Sambar and muntjac habitats using geostatistical modelling. *Current Science* 86(10): 390–1400.
- Kushwaha, S.P.S., S. Nandy & M. Gupta (2014).** Growing stock and woody biomass assessment in Asola-Bhatti Wildlife Sanctuary, Delhi, India. *Environmental Monitoring and Assessment* 186(9): 5911–5920.
- Laake, J.L., S.T. Buckland, D.R. Anderson & K.P. Burnham (1993).** *DISTANCE User's Guide, Version 2.0*. Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, Colorado, USA
- Laing, S.E., S.T. Buckland, R.W. Burn, D. Lambie & A. Amphlett (2003).** Dung and nest surveys: estimating decay rates. *Journal of Applied Ecology* 40: 1102–1111.
- Mallon, D.P. (2003).** *Tetracerus quadricornis* In: IUCN (2006). Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 28 November 2006.
- Manly, B.F., L.L. McDonald & D.L. Thomas (1993).** *Resource Selection by Animals: Statistical Design and Analysis for Field Studies*. Chapman and Hall, London, 221 pp.
- Marques, T.A., L. Thomas, S.W. Martin, D.K. Mellinger, J.A. Ward, J. David, D.J. Moretti, D. Harris & P.L. Tyack (2013).** Estimating animal population density using passive acoustics. *Biol. Rev. Camb. Philos. Soc.* 88(2): 287–309.
- Marques, F.F.C., S.T. Buckland, D. Goffin, C.E. Dixon, D.L. Borchers, B.A. Mayle & A.J. Peace (2001).** Estimating deer abundance from line transect surveys of dung: sika deer in southern Scotland. *Journal of Applied Ecology* 38: 349–363
- McFarland, D. (1981).** *The Oxford Companion to Animal Behaviour*. Oxford University Press, UK, 672 pp.
- Morrison, M.L., B.G. Marcot, & R.W. Mannan (1992).** *Wildlife-Habitat relationships: concepts and applications*. The University of Wisconsin Press, Madison, WI, 343 pp.
- Norris, K. & N. Harper (2003).** Extinction processes in hot spots of avian biodiversity and the targeting of the pre-emptive conservation action. *Proceedings of the Royal Society London* 271: 123–130.
- Odum, H.T. (1996).** *Environmental Accounting*. Energy and Environmental Decision Making. John Wiley and Sons, New York, 384 pp.
- Rahmani, A.R. (1989).** The Great Indian Bustard: Final Report. Bombay Natural History Society, Mumbai, India, 234 pp.
- Ramesh, T., K. Sankar, V. Snehalatha & Q. Qureshi (2009).** Food habits and prey selection of tiger and leopard in Mudumalai Tiger Reserve, Tamil Nadu, India. *Journal of Scientific Transactions in Environment and Technovation* 2(3): 170–181.
- Ramesh, T. (2010).** Prey Selection and Food habits of large carnivores (Tiger, Leopard and Dhole) in Mudumalai Tiger Reserve, Western Ghats, India. PhD Thesis, Saurashtra University, Gujarat, India, 178 pp. <https://doi.org/10.20894/STET.116.002.003.010>
- Ramesh, T., K. Sankar, Q. Qureshi & R. Kalle (2012).** Group size, sex and age composition of Chital (*Axis axis*) and Sambar (*Rusa unicorn*) in a deciduous habitat of Western Ghats. *Mammalian Biology* 77: 53–59.
- Sankar K, Q. Qureshi, M.K. Pasha & G. Areendran (2000).** Ecology of Gaur (*Bos gaurus*) in Pench Tiger Reserve, Madhya Pradesh, Wildlife Institute of India, Dehradun, 27 pp.
- Schaller, G.B. (1967).** *The Deer and the Tiger*. The University of Chicago Press, 384 pp.
- Shukla, R. (1990).** An ecological study of interactions between wild animals and vegetation in Pench Sanctuary and environs. PhD Thesis. Dept. of Botany, Harisingh Gaur Vishwavidyalaya, Sagar, India.
- Soule, M.E. (1986).** *Conservation Biology: The Science of Scarcity and Diversity*. Sinauer, Sunderland, 584 pp.
- Sridhar, M., N. Sridhar & M. Chandrashekhar (2008).** Bacterial biomass as feed for rearing of *Panaeus indicus* (H. Milne Edwards) larvae. *Indian Journal of Animal Nutrition* 5: 25–30.
- Timmins, R.K., B. Kawanishi, A. Gimán, B. Lynam, R. Chan, R. Steinmetz, Sagar, H. Baral & K.N. Samba (2015).** *Rusa unicorn*. The IUCN Red List of Threatened Species 2015:e.T41790A85628124. <https://doi.org/10.2305/IUCN.UK.2015-2>
- Venkataraman, A., B.R. Arumugam & R. Sukumar (1995).** The foraging ecology of Dhole (*Cuon alpinus*) in Mudumalai Sanctuary, southern India. *Journal of Zoology* 237: 543–561.
- Wilson, D.E. (2011).** Mittermeier RA *Handbook of Mammals of the World - Vol 2*. Hoofed Mammals. Lynx Editions, Barcelona, 886 pp.
- Yahya, H.S.A. (2014).** Observations on killings of Sambar (*Rusa unicorn*) by wild dog in Periyar Tiger Reserve Kerala India. *DSG Newsletter* 26: 31–36.
- Zar, J.H. (1984).** *Bio statistical analysis*. Prentice-Hall Inc., New Jersey, 818 pp.

Dr. George Mathew, Kerala Forest Research Institute, Peechi, India
 Dr. John Noyes, Natural History Museum, London, UK
 Dr. Albert G. Orr, Griffith University, Nathan, Australia
 Dr. Sameer Padhye, Katholieke Universiteit Leuven, Belgium
 Dr. Nancy van der Poorten, Toronto, Canada
 Dr. Kareen Schnabel, NIWA, Wellington, New Zealand
 Dr. R.M. Sharma, (Retd.) Scientist, Zoological Survey of India, Pune, India
 Dr. Manju Siliwal, WILD, Coimbatore, Tamil Nadu, India
 Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India
 Dr. K.A. Subramanian, Zoological Survey of India, New Alipore, Kolkata, India
 Dr. P.M. Sureshan, Zoological Survey of India, Kozhikode, Kerala, India
 Dr. R. Varatharajan, Manipur University, Imphal, Manipur, India
 Dr. Eduard Vives, Museu de Ciències Naturals de Barcelona, Terrassa, Spain
 Dr. James Young, Hong Kong Lepidopterists' Society, Hong Kong
 Dr. R. Sundararaj, Institute of Wood Science & Technology, Bengaluru, India
 Dr. M. Nithyanandan, Environmental Department, La Ala Al Kuwait Real Estate. Co. K.S.C., Kuwait
 Dr. Himender Bharti, Punjabi University, Punjab, India
 Mr. Purnendu Roy, London, UK
 Dr. Saito Motoki, The Butterfly Society of Japan, Tokyo, Japan
 Dr. Sanjay Sondhi, TITLI TRUST, Kalpavriksh, Dehradun, India
 Dr. Nguyen Thi Phuong Lien, Vietnam Academy of Science and Technology, Hanoi, Vietnam
 Dr. Nitin Kulkarni, Tropical Research Institute, Jabalpur, India
 Dr. Robin Wen Jiang Ngiam, National Parks Board, Singapore
 Dr. Lionel Monod, Natural History Museum of Geneva, Genève, Switzerland.
 Dr. Asheesh Shivam, Nehru Gram Bharti University, Allahabad, India
 Dr. Rosana Moreira da Rocha, Universidade Federal do Paraná, Curitiba, Brasil
 Dr. Kurt R. Arnold, North Dakota State University, Saxony, Germany
 Dr. James M. Carpenter, American Museum of Natural History, New York, USA
 Dr. David M. Claborn, Missouri State University, Springfield, USA
 Dr. Kareen Schnabel, Marine Biologist, Wellington, New Zealand
 Dr. Amazonas Chagas Júnior, Universidade Federal de Mato Grosso, Cuiabá, Brasil
 Mr. Monsoon Jyoti Gogoi, Assam University, Silchar, Assam, India
 Dr. Heo Chong Chin, Universiti Teknologi MARA (UiTM), Selangor, Malaysia
 Dr. R.J. Shiel, University of Adelaide, SA 5005, Australia
 Dr. Siddharth Kulkarni, The George Washington University, Washington, USA
 Dr. Priyadarsanan Dharma Rajan, ATREE, Bengaluru, India
 Dr. Phil Alderslade, CSIRO Marine And Atmospheric Research, Hobart, Australia
 Dr. John E.N. Veron, Coral Reef Research, Townsville, Australia
 Dr. Daniel Whitmore, State Museum of Natural History Stuttgart, Rosenstein, Germany.
 Dr. Yu-Feng Hsu, National Taiwan Normal University, Taipei City, Taiwan
 Dr. Keith V. Wolfe, Antioch, California, USA
 Dr. Siddharth Kulkarni, The Hormiga Lab, The George Washington University, Washington, D.C., USA
 Dr. Tomas Ditrich, Faculty of Education, University of South Bohemia in Ceske Budejovice, Czech Republic
 Dr. Mihaly Foldvari, Natural History Museum, University of Oslo, Norway
 Dr. V.P. Uniyal, Wildlife Institute of India, Dehradun, Uttarakhand 248001, India
 Dr. John T.D. Caleb, Zoological Survey of India, Kolkata, West Bengal, India
 Dr. Priyadarsanan Dharma Rajan, Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Bangalore, Karnataka, India

Fishes

Dr. Neelesh Dahanukar, IISER, Pune, Maharashtra, India
 Dr. Topiltzin Contreras MacBeath, Universidad Autónoma del estado de Morelos, México
 Dr. Heok Hee Ng, National University of Singapore, Science Drive, Singapore
 Dr. Rajeev Raghavan, St. Albert's College, Kochi, Kerala, India
 Dr. Robert D. Sluka, Chiltern Gateway Project, A Rocha UK, Southall, Middlesex, UK
 Dr. E. Vivekanandan, Central Marine Fisheries Research Institute, Chennai, India
 Dr. Davor Zanella, University of Zagreb, Zagreb, Croatia
 Dr. A. Biju Kumar, University of Kerala, Thiruvananthapuram, Kerala, India
 Dr. Akhilesh K.V., ICAR-Central Marine Fisheries Research Institute, Mumbai Research Centre, Mumbai, Maharashtra, India
 Dr. J.A. Johnson, Wildlife Institute of India, Dehradun, Uttarakhand, India
 Dr. R. Ravinesh, Gujarat Institute of Desert Ecology, Gujarat, India

Amphibians

Dr. Sushil K. Dutta, Indian Institute of Science, Bengaluru, Karnataka, India
 Dr. Annemarie Ohler, Muséum national d'Histoire naturelle, Paris, France

Reptiles

Dr. Gernot Vogel, Heidelberg, Germany
 Dr. Raju Vyas, Vadodara, Gujarat, India
 Dr. Pritpal S. Soorae, Environment Agency, Abu Dhabi, UAE.
 Prof. Dr. Wayne J. Fuller, Near East University, Mersin, Turkey
 Prof. Chandrashekhar U. Rivonker, Goa University, Taleigao Plateau, Goa, India
 Dr. S.R. Ganesh, Chennai Snake Park, Chennai, Tamil Nadu, India
 Dr. Himansu Sekhar Das, Terrestrial & Marine Biodiversity, Abu Dhabi, UAE

Birds

Dr. Hem Sagar Baral, Charles Sturt University, NSW Australia
 Mr. H. Byju, Coimbatore, Tamil Nadu, India
 Dr. Chris Bowden, Royal Society for the Protection of Birds, Sandy, UK
 Dr. Priya Davidar, Pondicherry University, Kalapet, Puducherry, India
 Dr. J.W. Duckworth, IUCN SSC, Bath, UK
 Dr. Rajah Jayapal, SAGON, Coimbatore, Tamil Nadu, India
 Dr. Rajiv S. Kalsi, M.L.N. College, Yamuna Nagar, Haryana, India
 Dr. V. Santharam, Rishi Valley Education Centre, Chittoor Dt., Andhra Pradesh, India
 Dr. S. Balachandran, Bombay Natural History Society, Mumbai, India
 Mr. J. Praveen, Bengaluru, India
 Dr. C. Srinivasulu, Osmania University, Hyderabad, India
 Dr. K.S. Gopi Sundar, International Crane Foundation, Baraboo, USA
 Dr. Gombobaatar Sunde, Professor of Ornithology, Ulaanbaatar, Mongolia
 Prof. Reuven Yosef, International Birding & Research Centre, Eilat, Israel
 Dr. Taej Mundkur, Wetlands International, Wageningen, The Netherlands
 Dr. Carol Inskipp, Bishop Auckland Co., Durham, UK
 Dr. Tim Inskipp, Bishop Auckland Co., Durham, UK
 Dr. V. Gokula, National College, Tiruchirappalli, Tamil Nadu, India
 Dr. Arkady Lelej, Russian Academy of Sciences, Vladivostok, Russia
 Dr. Simon Dowell, Science Director, Chester Zoo, UK
 Dr. Mário Gabriel Santiago dos Santos, Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, Vila Real, Portugal
 Dr. Grant Connette, Smithsonian Institution, Royal, VA, USA
 Dr. M. Zafar-ul Islam, Prince Saud Al Faisal Wildlife Research Center, Taif, Saudi Arabia

Mammals

Dr. Giovanni Amori, CNR - Institute of Ecosystem Studies, Rome, Italy
 Dr. Anwaruddin Chowdhury, Guwahati, India
 Dr. David Mallon, Zoological Society of London, UK
 Dr. Shomita Mukherjee, SAGON, Coimbatore, Tamil Nadu, India
 Dr. Angie Appel, Wild Cat Network, Germany
 Dr. P.O. Nameer, Kerala Agricultural University, Thrissur, Kerala, India
 Dr. Ian Redmond, UNEP Convention on Migratory Species, Lansdown, UK
 Dr. Heidi S. Riddle, Riddle's Elephant and Wildlife Sanctuary, Arkansas, USA
 Dr. Karin Schwartz, George Mason University, Fairfax, Virginia.
 Dr. Lala A.K. Singh, Bhubaneswar, Orissa, India
 Dr. Mewa Singh, Mysore University, Mysore, India
 Dr. Paul Racey, University of Exeter, Devon, UK
 Dr. Honnavalli N. Kumara, SAGON, Anaikatty P.O., Coimbatore, Tamil Nadu, India
 Dr. Nishith Dharaiya, HNG University, Patan, Gujarat, India
 Dr. Spartaco Gippoliti, Socio Onorario Società Italiana per la Storia della Fauna "Giuseppe Altobello", Rome, Italy
 Dr. Justus Joshua, Green Future Foundation, Tiruchirappalli, Tamil Nadu, India
 Dr. H. Raghuram, The American College, Madurai, Tamil Nadu, India
 Dr. Paul Bates, Harison Institute, Kent, UK
 Dr. Jim Sanderson, Small Wild Cat Conservation Foundation, Hartford, USA
 Dr. Dan Challender, University of Kent, Canterbury, UK
 Dr. David Mallon, Manchester Metropolitan University, Derbyshire, UK
 Dr. Brian L. Cypher, California State University-Stanislaus, Bakersfield, CA
 Dr. S.S. Talmale, Zoological Survey of India, Pune, Maharashtra, India
 Prof. Karan Bahadur Shah, Budhanilakantha Municipality, Kathmandu, Nepal
 Dr. Susan Cheyne, Borneo Nature Foundation International, Palangkaraja, Indonesia
 Dr. Hemanta Kafley, Wildlife Sciences, Tarleton State University, Texas, USA

Other Disciplines

Dr. Aniruddha Belsare, Columbia MO 65203, USA (Veterinary)
 Dr. Mandar S. Paingankar, University of Pune, Pune, Maharashtra, India (Molecular)
 Dr. Jack Tordoff, Critical Ecosystem Partnership Fund, Arlington, USA (Communities)
 Dr. Ulrike Streicher, University of Oregon, Eugene, USA (Veterinary)
 Dr. Hari Balasubramanian, EcoAdvisors, Nova Scotia, Canada (Communities)
 Dr. Rayanna Hellem Santos Bezerra, Universidade Federal de Sergipe, São Cristóvão, Brazil
 Dr. Jamie R. Wood, Landcare Research, Canterbury, New Zealand
 Dr. Wendy Collinson-Jonker, Endangered Wildlife Trust, Gauteng, South Africa
 Dr. Rajeshkumar G. Jani, Anand Agricultural University, Anand, Gujarat, India
 Dr. O.N. Tiwari, Senior Scientist, ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India
 Dr. L.D. Singla, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India
 Dr. Rupika S. Rajakaruna, University of Peradeniya, Peradeniya, Sri Lanka
 Dr. Bahar Baviskar, Wild-CER, Nagpur, Maharashtra 440013, India

Reviewers 2019–2021

Due to pausity of space, the list of reviewers for 2018–2020 is available online.

The opinions expressed by the authors do not reflect the views of the Journal of Threatened Taxa, Wildlife Information Liaison Development Society, Zoo Outreach Organization, or any of the partners. The journal, the publisher, the host, and the partners are not responsible for the accuracy of the political boundaries shown in the maps by the authors.

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

NAAS rating (India) 5.64

Print copies of the Journal are available at cost. Write to:
 The Managing Editor, JoTT,
 c/o Wildlife Information Liaison Development Society,
 43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
 Tamil Nadu 641035, India
 ravi@threatenedtaxa.org



www.threatenedtaxa.org

OPEN ACCESS



The Journal of Threatened Taxa (JoTT) is dedicated to building evidence for conservation globally by publishing peer-reviewed articles online every month at a reasonably rapid rate at www.threatenedtaxa.org. All articles published in JoTT are registered under [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/) unless otherwise mentioned. JoTT allows unrestricted use, reproduction, and distribution of articles in any medium by providing adequate credit to the author(s) and the source of publication.

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

January 2023 | Vol. 15 | No. 1 | Pages: 22355–22558

Date of Publication: 26 January 2023 (Online & Print)

DOI: 10.11609/jott.2023.15.1.22355-22558

Communications

Asiatic Black Bear *Ursus thibetanus* attacks in Kashmir Valley, India

– Aaliya Mir, Shanmugavelu Swaminathan, Rashid Y. Naqash, Thomas Sharp & Attur Shanmugam Arun, Pp. 22355–22363

Food habits of the Red Fox *Vulpes vulpes* (Mammalia: Carnivora: Canidae) in Dachigam National Park of the Kashmir Himalaya, India

– Kulsum Ahmad Bhat, Bilal A. Bhat, Bashir A. Ganai, Aamir Majeed, Naziya Khurshid & Muniza Manzoor, Pp. 22364–22370

Status distribution and factors affecting the habitat selection by Sambar Deer *Rusa unicolor* in Pench Tiger Reserve, Madhya Pradesh, India

– Abdul Haleem & Orus Ilyas, Pp. 22371–22380

Assessing illegal trade networks of two species of pangolins through a questionnaire survey in Nepal

– Nikita Phuyal, Bipana Maiya Sadadev, Reeta Khulal, Rashmi Bhatt, Santosh Bajagain, Nirjala Raut & Bijaya Dhami, Pp. 22381–22391

First occurrence record of Indian Roundleaf Bat *Hipposideros lankadiva* in Rajasthan, India

– Dharmendra Khandal, Dau Lal Bohra & Shyamkant S. Talmale, Pp. 22392–22398

Food availability and food selectivity of Sri Lanka Grey Hornbill *Ocyrceros gingalensis* Shaw, 1811 in Mihintale Sanctuary, Sri Lanka

– Iresha Wijerathne, Pavithra Panduwawala & Sriyani Wickramasinghe, Pp. 22399–22409

Conservation significance of Changaram wetlands - a key wintering site for migratory shorebirds and other waterbirds in the western coast of Kerala, India

– Jasmine Anand, H. Byju, Aymen Nefla, S. Abhijith, Omer R Reshi & K.M. Aarif, Pp. 22410–22418

Long-term monitoring of pelicans in National Chambal Sanctuary, India

– Lala A.K. Singh & Rishikesh Sharma, Pp. 22419–22429

A checklist of avifauna of Mangalore University, Karnataka, India

– K. Maxim Rodrigues, K. Vineeth Kumar, Vivek Hasyagar, M.C. Prashantha Krishna & Deepak Naik, Pp. 22430–22439

Biology of *Bhutanitis ludlowi* Gabriel, 1942 (Lepidoptera: Papilionidae) Bumdeling Wildlife Sanctuary, Bhutan

– Tshering Dendup, Namgay Shacha, Karma Tempa & Tez Bdr Ghalley, Pp. 22440–22447

Biodiversity of butterflies (Lepidoptera: Rhopalocera) in the protected landscape of Nandhour, Uttarakhand, India

– Hem Chandra, Manoj Kumar Arya & Aman Verma, Pp. 22448–22470

A comparison of four sampling techniques for assessing species richness of adult odonates at riverbanks

– Apeksha Darshetkar, Ankur Patwardhan & Pankaj Koparde, Pp. 22471–22478

Floristic diversity of native wild ornamental plants of Aravalli Hill Range: a case study from district Rewari, Haryana, India

– Pradeep Bansal, Amrender Singh Rao, Surender Singh Yadav, M.S. Bhandoria & S.S. Dash, Pp. 22479–22493

Flowering and fruiting of Tape Seagrass *Enhalus acoroides* (L.f.) Royle from the Andaman Islands: observations from inflorescence buds to dehiscent fruits

– Swapnali Gole, Sivakumar Kuppusamy, Himansu Das & Jeyaraj Antony Johnson, Pp. 22494–22500

Short Communications

Status of Swamp Deer *Rucervus duvaucelii duvaucelii* (G. Cuvier, 1823) in grassland-wetland habitats in Dudhwa Tiger Reserve, India

– Sankarshan Rastogi, Ashish Bista, Sanjay Kumar Pathak, Pranav Chanchani & Mudit Gupta, Pp. 22501–22504

First photographic evidence of Indian Pangolin *Manis crassicaudata* Geoffroy, 1803 (Mammalia: Pholidota: Manidae), in Colonel Sher Jung National Park, Himachal Pradesh, India

– Nidhi Singh, Urjit Bhatt, Saurav Chaudhary & Salvador Lyngdoh, Pp. 22505–22509

The Marine Otter *Lontra felina* (Molina, 1782) (Mammalia: Carnivora: Mustelidae) along the marine protected areas in Peru

– José Pizarro-Neyra, Pp. 22510–22514

First record of the genus *Acropyga* Roger, 1862 (Hymenoptera: Formicidae: Formicinae) in Kerala, India

– Merin Elizabeth George & Gopalan Prasad, Pp. 22515–22521

First report of a coreid bug *Aurelianus yunnananus* Xiong, 1987 (Hemiptera: Heteroptera: Coreidae) from India

– Hemant V. Ghate, Pratik Pansare & Rahul Lodh, Pp. 22522–22527

First record of the long-horned beetle *Niphona fuscatrix* (Fabricius, 1792) (Coleoptera: Cerambycidae: Lamiinae) from the Western Ghats, India

– Yogesh K. Mane, Priyanka B. Patil & Sunil M. Gaikwad, Pp. 22528–22532

Incidence of *Clinostomum complanatum* (Trematoda: Clinostomidae) in *Trichogaster fasciata* (Actinopterygii: Osphronemidae), the first report from Deepor Beel, Assam, India

– Bobita Bordoloi & Arup Kumar Hazarika, Pp. 22533–22537

Sauromatum horsfieldii (Araceae): a new addition to the flora of Manipur, northeastern India

– Kazuhrii Eshuo & Adani Lokho, Pp. 22538–22542

Rhynchostegiella menadensis (Sande Lac.) E.B. Bartram and *R. scabriseta* (Schwagr.) Broth.: two new records of mosses (Brachytheciaceae: Bryophyta) for peninsular India

– V.K. Rajilesh, C.N. Manju & R. Prakashkumar, Pp. 22543–22547

Notes

Installation of hot boxes for conservation in the last nursery roost of Greater Horseshoe Bats *Rhinolophus ferrumequinum* in Austria

– Lukas Zangl, Alexander Gutstein, Wolfgang Paill, Edmund Weiss & Peter Sackl, Pp. 22548–22550

New prey record of giant ladybird beetle *Anisolemnia dilatata* (Fabricius) (Coccinellidae: Coleoptera) feeding on Som Plant Aphid *Aiceona* sp.

– Suprakash Pal, Biwash Gurung, Ponnusamy Natarajan & Partha Sarathi Medda, Pp. 22551–22555

Book Review

Book Review - Under the Feet of Living Things

Editors — Aparajita Datta, Rohan Arthur & T.R. Shankar Raman

– Review by Melito Prinson Pinto, Pp. 22556–22558

Publisher & Host

