

Building evidence for conservation globally

Journal of Threatened Taxa



Open Access

10.11609/jott.2024.16.4.25019-25118

www.threatenedtaxa.org

26 April 2024 (Online & Print)

16(4): 25019-25118

ISSN 0974-7907 (Online)

ISSN 0974-7893 (Print)



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

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

Host
Zoo Outreach Organization
www.zooreach.org

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

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 641006, India

Deputy Chief Editor

Dr. Neelesh Dahanukar

Noida, Uttar Pradesh, India

Managing Editor

Mr. B. Ravichandran, WILD/ZOO, Coimbatore, Tamil Nadu 641006, 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 641006, India

Dr. B.A. Daniel, ZOO/WILD, Coimbatore, Tamil Nadu 641006, 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, Mavinhalla 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. Ilangovan, 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 2020–2022

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

Dr. Kiran Ramchandra Ranadive, Annasaheb Magar Mahavidyalaya, Maharashtra, 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, Department of Plant and Soil Science, Texas Tech University, Lubbock, Texas, USA.

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 Baños, 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. A.G. Pandurangan, Thiruvananthapuram, Kerala, India

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

Dr. Kannan C.S. Warriar, 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. Ghate, Modern College, Pune, India

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

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: A gravid praying mantis just before she laid her ootheca—digital art on procreate. © Aakanksha Komanduri.



Aquatic insects as bioindicators of stream water quality - a seasonal analysis on Western Ghats river, Muthirapuzha, in central Kerala, India

M. Harinagaraj¹ , Leenamma Joseph² & V.S. Josekumar³

¹⁻³Department of Zoology, Mar Ivanios College (Autonomous), Nalanchira, Thiruvananthapuram, Kerala 695015, India.

¹harinagura@gmail.com (corresponding author), ²leenamma.joseph@mic.ac.in, ³vsjosekumar@gmail.com

Abstract: This study was conducted to assess the water quality of Muthirapuzha River, Idukki using aquatic insects as bioindicators. Insects were collected on a seasonal basis from February 2014 to January 2015 from 12 sampling stations. Insects were sampled using standard collection methods and were identified up to family level. A total of 3,278 individuals belonging to seven orders and 37 families were collected during the study period. The greatest number of taxa was represented by order Ephemeroptera during monsoon (27%) and post-monsoon (25%), while Diptera (22.7%) dominated the pre-monsoon season. Shannon-Weiner diversity index, Simpson dominance index, and Margalef's richness index was highest at post-monsoon. The EPT score in Muthirapuzha was for normal waters, however, pre-monsoon values were lowest, indicating pollution load during this period. Hilsenhoff's family biotic index (HFBI) was used to estimate the status of organic pollution along the river based on representative families of aquatic entomofauna; values were highest at pre-monsoon season. The overall organic water quality level in the Muthirapuzha was good to fair based on this study.

Keywords: Biomonitoring, diversity indices, EPT scores, Hilsenhoff's family biotic index, macro-invertebrates, Margalef's richness index, Munnar, Muthirapuzha River, Periyar River, Shannon Weiner diversity index, Simpson dominance index.

Editor: R. Ramanibai, University of Madras, Chennai, India.

Date of publication: 26 April 2024 (online & print)

Citation: Harinagaraj, M., L. Joseph & V.S. Josekumar (2024). Aquatic insects as bioindicators of stream water quality - a seasonal analysis on Western Ghats river, Muthirapuzha, in central Kerala, India. *Journal of Threatened Taxa* 16(4): 25082–25088. <https://doi.org/10.11609/jott.7690.16.4.25082-25088>

Copyright: © Harinagaraj et al. 2024. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: The Higher Education Department, Government of Kerala, Thiruvananthapuram.

Competing interests: The authors declare no competing interests.

Author details: DR. M. HARINAGARAJ was a research scholar in Zoology of Mar Ivanios College, Thiruvananthapuram worked on macroinvertebrates of Western Ghats, pursuing studies on fresh water monitoring system. DR LEENAMMA JOSEPH is a retired associate professor of Zoology, Mar Ivanios College (Autonomous). She studied on aquatic insect fauna as well as reproductive biology of insect pest. DR V.S. JOSEKUMAR is retired associate professor of Zoology, Mar Ivanios College Thiruvananthapuram, formerly associate professor of Biology, ArbaMinch University Ethiopia. His research interest is in fresh water aquatic macroinvertebrates and biodiversity conservation.

Author contributions: MH—data collection and manuscripts preparation. LJ—correction of manuscripts, language check. VSJ—conceptual support, Identification of macroinvertebrates, correction of final draft.

Acknowledgements: Financial assistance from Govt. of Kerala to Harinagaraj M is gratefully acknowledged. Authors are thankful to the Mar Ivanios College administrations for the library and laboratory support.



INTRODUCTION

Rivers provide fresh water for agricultural, industrial and domestic needs (Ridoutt et al. 2010; Sunil et al. 2010) that can create enormous environmental pressures, including pollution leading to deteriorated water quality adversely affecting aquatic life (Kamboj & Kamboj 2019; Sinha et al. 2020). Biological communities provide a faithful reflection of environmental conditions, since they are continually exposed to them (Rosenberg & Resh 1993). Water quality changes are directly reflected by aquatic fauna, which can be assessed to measure the health of their ecosystems (Mulani et al. 2009; Saxena & Singh 2020). This approach is widely exploited as a reliable technique for assessing point and non-point sources of pollution of water bodies via biomonitoring protocols. Benthic macroinvertebrates representing different visible aquatic phyla exhibit a relatively wide range of response to chemical and physical water quality stressors like pH, temperature, dissolved oxygen, organic pollutants, heavy metals and sediments that can serve as a biological indicator of water pollution (Marzelai et al. 2008). Latha & Thanga (2010) identified macroinvertebrates as useful bioindicators in estuaries. Stream insect communities were suggested for aquatic biomonitoring protocol by Morse et al. (1994) and Subramanian & Sivaramkrishnan (2005). Diversity of aquatic insects is relatively easy to measure for assessing the health status of streams, and many biomonitoring studies are reported from southern Indian rivers (Sheeba & Ramanujan 2009; Priyanka & Prasad 2014). Stream entomofauna were targeted in Killi Ar, an urban river of Trivandrum corporation area, to assess the pollution status of the stream (Dinesh et al. 2017).

Many tools are employed in biological monitoring to assess the quality of water resources (Buss et al. 2003). The effective use of these tools leads to a better understanding of aquatic organisms that influence on biotic index results, and occurrence of bioindicators (Czerniawska-Kusza 2005). Distribution of bioindicator taxa is influenced by hydrological characteristics, nutrient supply, substrate type, predation pressure and natural or anthropogenic disturbances, in addition to variation in water quality, that makes these biotic indices important tools for evaluate the health of water ecosystems (Silveira et al. 2004). Comparative analyses of biotic indices are now available to determine which index best reflects ecosystem health (Gonçalves & Menezes 2011). William Hilsenhoff formulated family-level (Hilsenhoff 1988) versions of a biotic index, and tabulated interpretive criteria based on known sensitivities of arthropod taxa

to organic enrichment (i.e., sewage pollution). This has been widely used in to characterize the health of freshwater streams (Reynoldson & Metcalfe-Smith 1992; Hu et al. 2007).

The river Periyar, the longest river in Kerala State (PWD 1974; CESS 1984) is considered to be the life line of central Kerala. Muthirapuzha River, the major tributary of the Periyar, forms the main drainage system south of Anamudi. This river is the major water resource of five panchayath in Devikulam Taluk of Idukki District. The Muthirapuzha watershed includes Kannan Devan Tea plantations along with Eravikulam National Park, and forms the highest watershed of the Western Ghats. Munnar Township, one of major tourist destinations in Kerala, extends along the banks of this stream. Thus this river is experiencing active anthropogenic pressure chiefly due to tourism and agricultural activities. In this study we undertook a rapid assessment of the status of this river utilizing a biomonitoring protocol targeting aquatic insects as bioindicators for stream water quality.

MATERIALS AND METHODS

Study area

The Muthirapuzha is located at 10.172–9.951 °N & 77.077–76.983 °E (Figure 1). It originates from Umayala near Anamudi Peak and flows through Deikulam, Munnar, Pallivasal, Vellathooval and Konnathadi panchayths of Devikulam and Udumbanchola of Idukki District, and joins the Periyar River at Panamkutti, covering a distance of 34 km.

Macroinvertebrate analysis

Macroinvertebrates were sampled once every four months from February 2014 to January 2015 at twelve selected stations on the Muthirapuzha to capture seasonal variations. A D-frame aquatic net (0.5 mm mesh) was used to collect benthic organisms present in a 10 m² area (Hellawell 1986). After each jab and sweep, the net was rinsed in a sieve bucket (250 µm mesh) to collect all the macroinvertebrates. Samples were washed, separated through three sieves (2 mm, 1 mm, and 0.3 mm), transferred to glass bottles after labeling and preserved in 5% formalin in the field immediately after each collection. Each animal was then brush picked, preserved in 4% formalin, sorted and identified in the laboratory according to Edmondson (1992) and Pennak (1978). Aquatic insects were counted and identified using a stereo microscope (Headz-HD600D) with the help of standard keys (McCafferty 1983; Morse et al. 1994

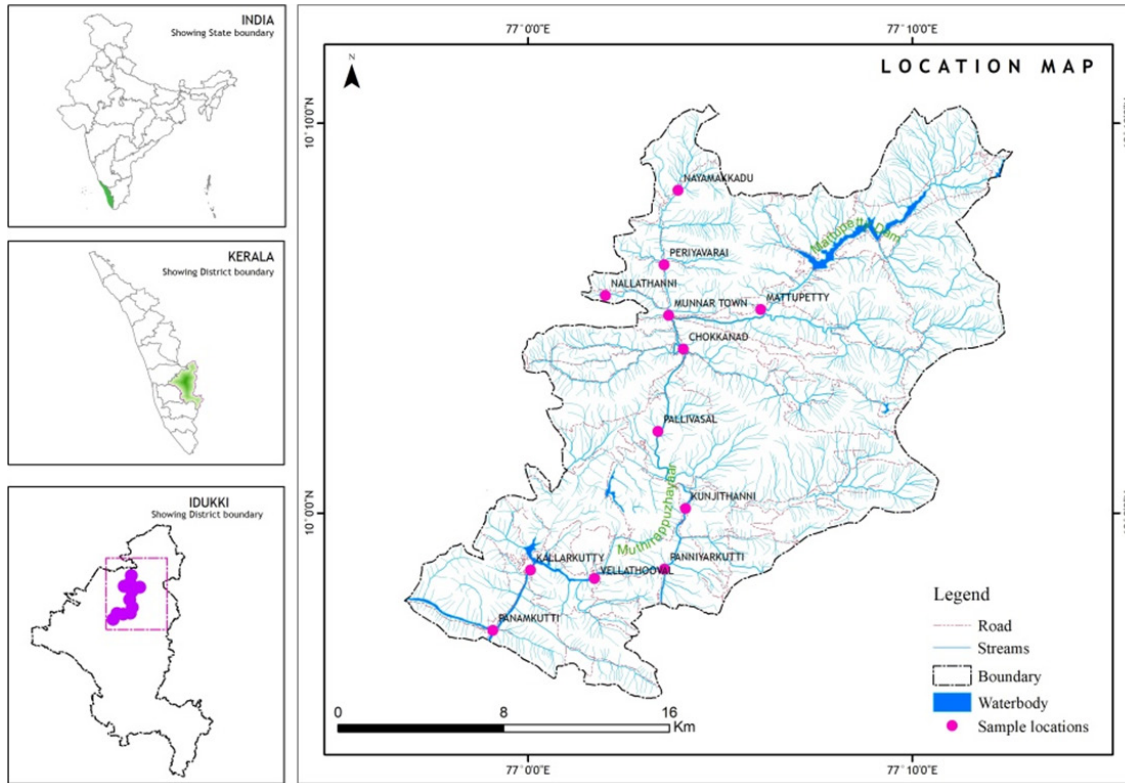


Figure 1. Sampling stations of river Muthirapuzha.

& Yong & Yule 2004) up to the family level. Taxonomic indices used for analyses of aquatic insects include Shannon-Weiner diversity index, Simpson dominance index, Margalef richness index (Shannon & Weiner 1963; Simpson 1949; Margalef 1958; Pielou 1966) and Hilsenhoff’s Family Biotic Index (HFBI) (Hilsenhoff 1988) to estimate the level of organic pollution. Biodiversity indices were calculated using PAST ver. 1.34 software (Hammer et al. 2005).

RESULTS AND DISCUSSION

The present study identified 55 taxa represented by 37 families belonging to eight orders among the 3,278 total aquatic insects collected during the study period in pre-monsoon, monsoon, and post-monsoon seasons. Table 1 shows the overall numbers of insects collected during the sampling period. The number of individuals found in the pre-monsoon season was 1,313, 270 in monsoon, and 1,695 post monsoon. The greatest numbers of taxa were represented by order Ephemeroptera in monsoon (27%) and post-monsoon (25%), while Diptera (22.7%) dominated in pre-monsoon. The overall analysis of aquatic insects indicated that the most abundant taxa

were Ephemeroptera (22%), followed by, Odonata (18.5%), Diptera (18%), Trichoptera (11%), Hemiptera (10%), Coleoptera (9.7%), and Plecoptera (7.9%) (Figure 2).

The biological indices of aquatic insects computed for 12 sampling sites are represented in Table 2, 3, & 4. Shannon-Weiner diversity index for pre monsoon season ranged between 3.807–3.211 and were found to be maximum at station 2 and minimum at station 10. During monsoon it was highest at station 1 (3.266) and lower index value was reported in station 10 (2.306). Shannon-Weiner diversity index was varying between 3.752 and 3.428; these values are represented in stations 1 and 10, respectively. Simpson dominance index also showed similar relation and varied from 0.974 to 0.943 in pre-monsoon. Maximum dominance index was found in station 2 and minimum in station 10. Index values were between 0.956 to 0.879 in monsoon and 0.972 to 0.948 in post- monsoon seasons. Margalef’s richness index showed comparatively low value in monsoon season and the lowest value (2.954) was identified from station 6, Chokkanadu which is an urbanized site and higher (7.452) in station 1, Nayamakkadu near the origin of stream. Richness index was higher in pre-monsoon and post-monsoon seasons compared to monsoon. In

Table 1. Aquatic insects collected from river Muthirapuzha over different seasons (2014–15).

ORDER	FAMILY	PRM*	MON**	POM***
Diptera	Simuliidae	33	2	39
	Chironomidae	155	10	129
	Culicidae	68	20	52
	Tipulidae	42	5	38
Hemiptera	Nepidae	20	3	16
	Velliidae	19	3	19
	Hydrometridae	9	7	26
	Belostomatidae	12	2	27
	Gerridae	85	13	66
Ephemeroptera	Ephemeridae	34	9	53
	Heptageniidae	24	11	68
	Leptohyphidae	64	14	108
	Caenidae	94	16	110
	Ephemerellidae	18	3	25
	Baetidae	27	20	63
Plecoptera	Perlidae	94	14	151
Odonata	Coenagrionidae	114	3	125
	Chlorocyphidae	24	3	31
Odonata	Eupaeidae	25	2	25
	Calopterygidae	17	0	17
	Lestidae	7	2	13
	Platystictidae	13	0	15
	Cordullidae	7	0	7
Megaloptera	Gomphidae	43	6	39
	Aeshnidae	22	5	43
	Corydalidae	17	4	30
Trichoptera	Helicopsychidae	27	8	47
	Hydropsychidae	11	15	46
	Glossosomatidae	18	1	26
	Polycentropodidae	6	4	21
	Leptoceridae	21	31	80
Coleoptera	Haliplidae	10	7	17
	Hydrophilidae	68	11	55
	Gyrinidae	14	12	33
	Dytiscidae	51	4	35

PRM*—Pre-monsoon | MON**—Monsoon | POM***—Post-monsoon

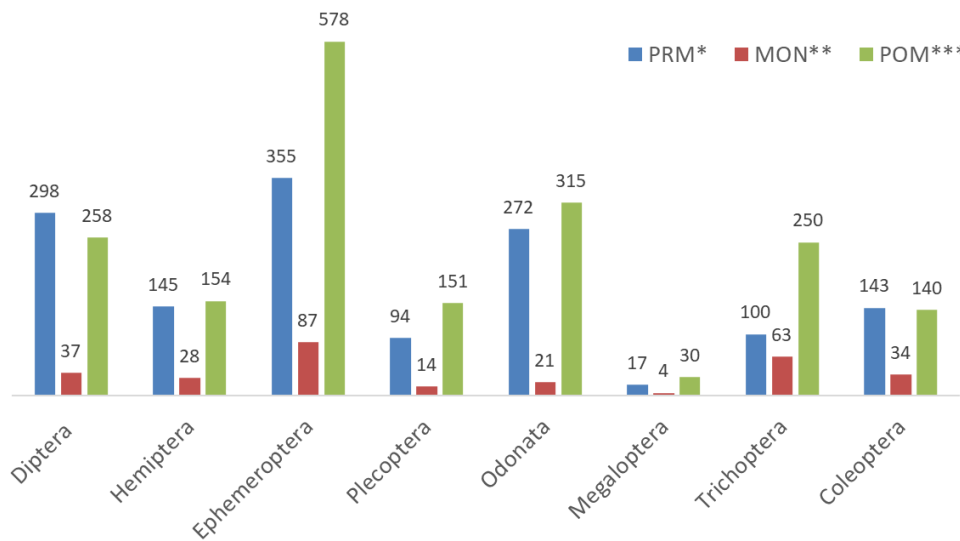


Figure 2. Aquatic insects collected from river Muthirapuzha during 2014–15.

pre-monsoon the maximum Margalef richness index was found in station 2 (10.98) and minimum in station 11 (7.015). In post-monsoon season the richness index varied from 10.08 to 7.856, respectively from station 2 and station 9. Highest taxonomic indices were observed in post-monsoon season.

Among aquatic insects, Ephemeroptera, Plecoptera, and Trichoptera (EPT) have a great role in low and

medium order stony cobble streams. The percentage of EPT in river Muthirapuzha during the study period was represented in Table 5. These organisms are sensitive to environmental perturbations and occur in clean and well oxygenated waters. Therefore, EPT assemblages are frequently considered to be good indicators of water quality (Rosenberg & Resh 1992; Priyanka & Prasad 2014), EPT is widely used for the measure of health of

Table 2. Biodiversity indices of aquatic insects in pre-monsoon season (2014–15).

Stations	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Taxa_S	46	53	50	48	43	39	39	37	32	33	31	30
Individuals	132	114	128	151	149	135	100	114	81	77	72	60
Simpson_1-D	0.969	0.974	0.968	0.956	0.954	0.947	0.962	0.964	0.956	0.949	0.955	0.953
Shannon_H	3.647	3.807	3.652	3.49	3.369	3.261	3.451	3.452	3.298	3.211	3.242	3.223
Margalef	9.216	10.98	10.1	9.368	8.393	7.747	8.252	7.601	7.054	7.367	7.015	7.083

Table 3. Biodiversity indices of aquatic insects in monsoon season (2014–15).

Stations	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Taxa_S	30	23	23	15	12	9	14	14	12	12	12	12
Individuals	49	33	30	22	19	15	18	22	17	21	20	18
Simpson_1-D	0.956	0.949	0.951	0.922	0.903	0.871	0.92	0.905	0.899	0.879	0.89	0.901
Shannon_H	3.266	3.061	3.078	2.626	2.406	2.119	2.582	2.5	2.395	2.306	2.346	2.399
Margalef	7.452	6.292	6.468	4.529	3.736	2.954	4.498	4.206	3.883	3.613	3.672	3.806

Table 4. Biodiversity indices of aquatic insects in post-monsoon season (2014–15).

Stations	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Taxa_S	55	55	52	48	45	41	44	42	38	41	40	41
Individuals	228	212	182	170	141	147	118	105	111	102	90	89
Simpson_1-D	0.972	0.966	0.965	0.971	0.953	0.959	0.958	0.956	0.948	0.96	0.955	0.957
Shannon_H	3.752	3.668	3.649	3.683	3.402	3.416	3.486	3.434	3.248	3.481	3.409	3.42
Margalef	9.946	10.08	9.8	9.151	8.891	8.015	9.013	8.81	7.856	8.649	8.667	8.911

fresh water ecosystem (Wallace & Jackson 1996).

In this study the percentage of EPT was very high in sampling stations 1, 2, & 3 in three sampling seasons. But it was gradually decreased in the middle and lower streams of river Muthirapuzha. Especially the middle sampling sites representing Munnar Township and nearby inhabited area exhibit a very low percentage of EPT level. This clearly indicates that the water quality was badly affected by pollution related activities at this stretch of river. The percentage of EPT in lower stream varied from station to station which means that each sampling stations were under different types of pollution stress mainly due to anthropogenic and tourism related activities along the river, Muthirapuzha. The overall mean percentage of EPT score indicated that the pre-monsoon season was polluted in nature compared to the other two seasons (Figure 3)

Hilsenhoff family biotic index (HFBI) is one of the most effective bio monitoring tool in stream ecology and is used to assess the level of organic pollution in water bodies (Hilsenhoff 1988). HFBI of river Muthirapuzha

(Table 6) categorizes the water quality based on the families identified from 12 stations along this river. Water quality grade according to HFBI index is shown in table 7. HFBI indicated that the water quality varies in each sampling station ranging from excellent to fairly poor and the degree of organic pollution was comparatively low in Muthirapuzha. Based on this study the water of Muthirapuzha could be classified into four categories using the HFBI, 'excellent', 'very good', 'good', and 'fair'. The HFBI values were higher in pre-monsoon and lower during monsoon seasons indicating the organic loading during pre-monsoon.

When classifying water quality during monsoon, the HFBI index gave scores of 'excellent' to 'good', however, station 11 was under some organic pollution (Table 6) otherwise the overall water quality was very good during this period. During post-monsoon season the HFBI ranged 3.78–5.34 which indicated the water quality in between very well to fair (Table 6). Station 5, 6, 8, 11, & 12 came under 'fairly substantial pollution likely' (Table 7) during this season. Finally in pre-monsoon HFBI

Table 5. Percentage of EPT in river Muthirapuzha (2014–15).

Stations	PRM*	MON**	POM***
1 - Nayamakkadu	42.73	33.84	46.18
2 - Periyavarai	45.74	47.61	48.56
3 - Mattupetty	46.05	30.61	45.56
4 - Nallathanni	22.7	15.21	28.78
5 - Munnar Town	20.68	15.55	23.78
6 - Chokkanadu	15.95	21.42	27.21
7 - Pallivasal	27.78	54.57	36.87
8 - Kunjithanni	31.13	44.82	39.59
9 - Panniyarkutti	27.47	32.14	42.95
10 - Vellathooval	24.09	55.17	36.71
11- Kallarkutti	29.67	24.32	41.07
12 - Panamkutti	25	56.1	46.28
Mean	29.91	35.93	38.62

PRM*—Pre-monsoon | MON**—Monsoon | POM***—Post-monsoon

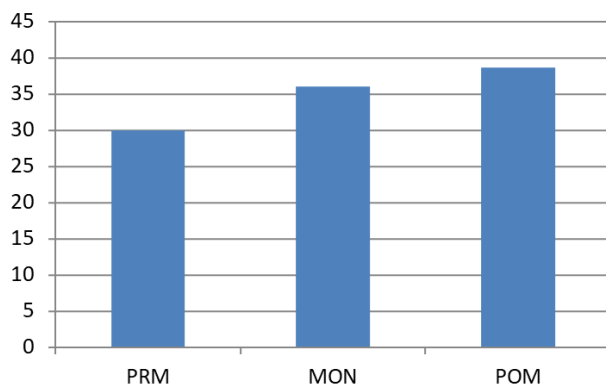


Figure 3. Mean percentage of EPT in river Muthirapuzha (2014–15).

Table 6. Hilsenhoff family biotic index of river Muthirapuzha (2014–15).

Stations	PRM	MON	POM
S1 (Nayamakkadu)	3.78	3.22	3.99
S2 (periyavarai)	4.33	3.45	3.78
S3 (Mattupetty)	4.51	3.37	4.12
S4 (Nallathanni)	5.29	3.57	4.34
S5 (Munnar Town)	5.75	3.8	5.19
S6 (Chokkanadu)	5.8	3.78	5.34
S7 (Pallivasal)	5.21	3.6	4.92
S8 (Kunjithanni)	5.33	4.18	5.13
S9 (Panniyarkutti)	5.3	4.23	4.83
S10 (Vellathooval)	4.82	4.4	5.04
S11 (Kallarkutti)	5.12	4.54	4.61
S12 (Panamkutti)	5.41	3.38	4.94

PRM*—Pre-monsoon | MON**—Monsoon | POM***—Post-monsoon

Table 7. Hilsenhoff family biotic index for water quality grades.

HFBI	Water quality	Degree of organic pollution
0.00–3.75	Excellent	Organic Pollution Unlikely
3.76–4.25	Very Good	Possible Slight Organic Pollution
4.26–5.00	Good	Some Organic Pollution Probable
5.01–5.75	Fair	Fairly Substantial Pollution Likely
5.76–6.50	Fairly Poor	Substantial Pollution Likely
6.51–7.25	Poor	Very Substantial Pollution Likely
7.26–10.00	Very Poor	Severe Organic Pollution Likely

was comparatively higher with the other two seasons; the water quality values come under the categories of ‘very good’ to ‘fairly poor’. Sampling stations 5 and 6 reported ‘substantial pollution likely’ (Table 6, 7) during this period. It may be noted that these sampling stations are representing the Munnar township segment of the stream. ‘Poor’ and ‘very poor’ water qualities were not reported at any sampling stations during the course of sampling period.

According to the HFBI, overall water quality was very good in monsoon, good in post monsoon and fair in pre-monsoon seasons (Figure 3). Though the sampling points were located within populated area except the first three, the HFBI did not reflect obvious anthropogenic pressure on this river. Munnar Township and some small towns are located in the middle and lower reaches of river Muthirapuzha, which reported ‘fairly poor’ status of water at these stretches but the overall water quality falls between very good to fair scale of HFBI. Present study shows a temporal variation in bioassessment of Muthirapuzha River that influence the judgment of the sites. Studies shows temporal variations in bioassessment based on benthic macroinvertebrates (Linke et al. 2001; Nukeri et al. 2021). Substrate heterogeneity as well as land use changes are generally the determinants of the macroinvertebrate distribution along streams (Semwal & Mishra 2019). Spatio-seasonal flux of benthic macroinvertebrate assemblages as indicators of water quality in a coastal basin of southern Chile was assessed by applying HFBI (Fierro et al. 2012). River Muthirapuzha seems sensitive to anthropogenic activities due to tourism as indicated by the macroinvertebrate community based biotic index.

CONCLUSION

River Muthirapuzha one of the major tributary of river Periyar, a mountain stream originated and flow

through the higher elevations of Western Ghats. There are 33 small and large streams contribute water to river Muthirapuzha at various stretches. The taxonomic indices of aquatic insects collected from this river established a clear view of level of stream health. The season-wise analysis of taxonomic indices indicated that the water quality was good on monsoon season and comparatively higher pollution in other two seasons. The EPT scores indicated average water quality in the river, except at the middle stream sampling sites, the anthropogenic pressure due to tourism activities affects the water quality in this area. The study identified the water quality of the river Muthirapuzha varied seasonally at every sampling station, and the overall water quality was good based on HFBI category, although pollution load was evident in pre-monsoon season.

REFERENCES

- Buss, D.F., D.F. Baptista, M.P. Silveira, J.L. Nessimian & L.F.M. Dorville (2002). Influence of water chemistry and environmental quality on the macroinvertebrate assemblages in a river basin in south-east Brazil. *Hydrobiologia* 481: 125–136. <https://doi.org/10.1007/s10750-005-1255-5>
- CESS (1984). *Resource Atlas of Kerala*. Centre for Earth Science Studies.
- Czerniawska-Kusza, I. (2005). Comparing modified biological monitoring working party score system and several biological indices based on macroinvertebrates for water-quality assessment. *Limnologica* 35: 169–176. <https://doi.org/10.1016/j.limno.2005.05.003>
- Dinesh, V., J. Leenamma & V.S. Josekumar (2017). Dependence of upstream entomofauna to water quality in a semi-urbanized river (Killi Ar), south Kerala, India. *Journal of Aquatic Biology & Fisheries* 5: 96–106.
- Fierro, P.B., M. Carlos, Maritza Peña-Cortés, T. Fernando, H. Jaime & V.C. Enrique (2012). Benthic macroinvertebrate assemblages as indicators of water quality applying a modified biotic index in a spatio-seasonal context in a coastal basin of southern Chile. *Revista de Biología Marina y Oceanografía* 47(1): 23–33. <https://doi.org/10.4067/S0718-19572012000100003>
- Gonçalves, F.B. & M. S. de Menezes (2011). A comparative analysis of biotic indices that use macro invertebrates to assess water quality in a coastal river of Paraná state, southern Brazil. *Biota Neotropica* 11(4): 27–36. <https://doi.org/10.1590/S1676-06032011000400002>
- Hammer, Ø., D.A.T. Harper & P.D. Ryan (2005). PAST: palaeontological statistics, ver. 1.34. Paleontological Museum, University of Oslo, Norway.
- Hellawell, J.M. (1986). Biological Indicators of Freshwater Pollution and Environmental Management. *Pollution Monitoring Series*, 546 pp.
- Hilsenhoff, W.L. (1988). Rapid field assessment of organic pollution with a family-level biotic index. *Journal of the North American Benthological Society* 7(1): 65–68.
- Hu, T.-J., H.-W. Wang & H.-Y. Lee (2007). Assessment of environmental conditions of Nan-Shih stream in Taiwan. *Ecological Indicators* 7: 430–441. <https://doi.org/10.1016/j.ecolind.2006.04.003>
- Kamboj, N. & V. Kamboj (2019). Water quality assessment using overall index of pollution in riverbed-mining area of Ganga-River Haridwar, India. *Water Science* 33(1): 65–74. <https://doi.org/10.1080/11104929.2019.1626631>
- Latha, C. & V.S.G. Thanga (2010). Choice of bioindicator species for estuaries of South Kerala: an approach based on macroinvertebrate. *The Ecoscan* 4(4): 285–289.
- Margalef, D.R. (1958). Information Theory in Ecology. *General Systems* 3: 36–71.
- Marziali, L., V. Lencioni, P. Parenti & B. Rossaro (2008). Benthic macroinvertebrates as water quality indicators in Italian lakes. *Boletim do Museu Municipal do Funchal (Historia Natural)* 13: 51–59.
- McCafferty, W.P. (1983). Aquatic entomology: the fishermen's and ecologists illustrated guide to insects and their relatives. *Jones and Bartlett Learning*, New York, 448 pp.
- Morse, J.C., L. Yang & L. Tian (1994). Aquatic insects of China useful for monitoring water quality (13) Hohai University Press, 570 pp.
- Mulani, S.K., M.B. Mule & S.U. Patil (2009). Studies on water quality and zooplankton community of the Panchganga river in Kolhapur city. *Journal of Environmental Biology* 30(3): 455–459.
- Nukeri, S., A. Addo-Bediako & M.B. Kekana (2021). Macroinvertebrates assemblages in the Spekboom River of the Olifants River System, South Africa. *African Journal of Ecology* 59(1): 320–325.
- Pennak, R.W. (1978). *Freshwater invertebrates of the United States*, 2nd ed. John Wiley & Sons, New York, 803 pp.
- Pielou, E.C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology* 13(2): 131–144.
- Priyanka, G.L. & G. Prasad (2014). Diversity of aquatic insects (Ephemeroptera, Plecoptera and Trichoptera) in Kallar Stream. *Journal of Aquatic Biology and Fisheries* 2: 493–499.
- PWD (1974). Water Resources of Kerala. Public Works Department, Govt. of Kerala, Trivandrum, 130 pp.
- Reynoldson, T.B. & J.L. Metcalfe-Smith (1992). An overview of the assessment of aquatic ecosystem health using benthic invertebrates. *Journal of Aquatic Ecosystem Stress and Recovery (Formerly Journal of Aquatic Ecosystem Health)* 1(4): 295–308.
- Ridoutt, B.G. (2010). A revised approach to water foot printing to make transparent the impacts of consumption and production on global freshwater scarcity. *Global Environmental Change* 20: 113–120. <https://doi.org/10.1016/j.gloenvcha.2009.08.003>
- Rosenberg, D.M. and V.H. Resh (1992). Freshwater bio monitoring using individual organisms, populations, and species assemblages of benthic macro-invertebrates. Chapman & Hall, New York, USA, 40-158.
- Semwal, V.P. & A.S. Mishra (2019). The distributional pattern of benthic macroinvertebrates in a spring-fed foothill tributary of the Ganga River, western Himalaya, India. *Journal of Threatened Taxa* 11(12): 14511–14517. <https://doi.org/10.11609/jott.4648.11.12.14511-14517>
- Shannon, C.E. & W. Weaver (1963). The mathematical communication of Communication. University of Illinois Press, Urbana, 117.
- Sheeba, S. & N. Ramanujan (2009). Macroinvertebrate fauna of Ithikkara River. *Journal of Industrial Pollution Control* 25(2): 151–154.
- Silveira, M.P., J.F. Queiroz & R.C. Boeira (2004). Protocolo de coleta e preparação de amostras de macroinvertebrados bentônicos em riachos. Embrapa, Jaguariúna. Comunicado Técnico 19. <http://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/14553>
- Simpson, E.H. (1949). Measurement of diversity. *Nature* 163: 688.
- Sinha, R., S. Das & T. Ghosh (2020). Pollution and its consequences at Ganga Sagar mass bathing in India. *Environment, Development and Sustainability* 22: 1413–1430. <https://doi.org/10.1007/s10668-018-0255-3>
- Subramanian, K.A. & K.G. Sivaramkrishnan (2005). Habitat and microhabitat distribution of stream insect communities of the Western Ghats. *Current Science* 89(6): 976–987
- Sunil, C.R., K. Somashekar & B.C. Nagaraja (2010). Riparian vegetation assessment of Cauvery River Basin of South India. *Environmental Monitoring and Assessment* 170: 545–553. <https://doi.org/10.1007/s10661-009-1256-3>
- Yong, H.S. & C.M. Yule (2004). Freshwater invertebrates of the Malaysian region. Academy of Sciences Malaysia, 861 pp.

Mr. Jatishwor Singh Irungbam, Biology Centre CAS, Branišovská, Czech Republic.
Dr. Ian J. Kitching, Natural History Museum, Cromwell Road, UK
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, Taleigão Plateau, Goa, India
Dr. S.R. Ganesh, Chennai Snake Park, Chennai, Tamil Nadu, India
Dr. Himansu Sekhar Das, Terrestrial & Marine Biodiversity, Abu Dhabi, UAE

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

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, SACON, 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 Sundev, 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. P.A. Azeez, Coimbatore, Tamil Nadu, India

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, SACON, 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, SACON, 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 2021–2023

Due to pausivity of space, the list of reviewers for 2021–2023 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.

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



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)

April 2024 | Vol. 16 | No. 4 | Pages: 25019–25118

Date of Publication: 26 April 2024 (Online & Print)

DOI: 10.11609/jott.2024.16.4.25019-25118

Articles

Mitochondrial CO1 gene haplotype diversity of Sumatran Tiger *Panthera tigris sumatrae* (Pocock, 1929) (Mammalia: Carnivora: Felidae)

– Ashrifurrahman, Saruedi Simamora, Rusdian Ritonga, Wilson Novarino, Djong Hon Tjong, Rizaldi, Syaifullah & Dewi Imelda Roesma, Pp. 25019–25028

The population trend of the largest breeding colony of the Indian Swiftlet *Aerodramus unicolor*: is it on the verge of extinction?

– Dhanusha Kawalkar & Shirish S. Manchi, Pp. 25029–25039

DNA barcoding reveals a new population of the threatened Atlantic Forest frog *Sphaenorhynchus canga*

– Diego J. Santana, André Yves, Elvis A. Pereira, Priscila S. Carvalho, Lucio M.C. Lima, Henrique C. Costa & Donald B. Shepard, Pp. 25040–25048

Ecological values of Ourkiss wetland (Oum El Bouaghi province - Algeria), an overview of waterbirds diversity and richness

– Ryadh Aissaoui & Mouslim Bara, Pp. 25049–25056

Elliptic Fourier analysis of leaf shape of *Callicarpa pedunculata* and *Callicarpa rubella* (Lamiaceae)

– Jennifer S. Danila & Grecebio Jonathan D. Alejandro, Pp. 25057–25068

Communications

Checklist and comparison of the bird diversity from the Himachal Pradesh Agricultural University, India

– Praveen Kumar, Bharti Parmar & Pardeep Kumar, Pp. 25069–25081

Aquatic insects as bioindicators of stream water quality - a seasonal analysis on Western Ghats river, Muthirapuzha, in central Kerala, India

– M. Harinagaraj, Leenamma Joseph & V.S. Josekumar, Pp. 25082–25088

Short Communications

New distribution record of *Alstonia sebusii* (Van Heurck & Müll. Arg.) Monach. from Manipur, India

– Kazhuhrii Eshuo, Pp. 25089–25093

New distribution record of fungi *Mycena chlorophos* (Berk. & M.A.Curtis) Sacc. (Mycenaceae) from the Konkan region of Maharashtra, India

– Yogesh Koli, Umesh Pawar, Mangesh Mangaonkar, Pravin Sawant & Gurunath Kadam, Pp. 25094–25100

Notes

Potential first record of parrotfish *Scarus zufar* (Randall & Hoover, 1995) (Actinopterygii: Labriformes: Scaridae) from Indian waters, at Netrani Island, Karnataka, India

– Farai Divan-Patel, Abhishek Jamalabad, Venkatesh Charloo & Jeremy Josh, Pp. 25101–25102

First record of the phoretic association between *Pediculaster* sp. (Pygmephoridae) mites and *Musca crassirostris* (Muscidae) flies in India

– Ramandeep Achint & Devinder Singh, Pp. 25103–25106

Uniyala multibracteata (Gamble) H. Rob. & Skvarla (Asteraceae: Vernoniae): notes on its identity and rediscovery

– Reshma Raju, Joby Joseph, K.S. Divya, Chethana Badekar & Jomy Augustine, Pp. 25107–25110

Addition of two wild jasmines (*Jasminum caudatum* and *J. grandiflorum*) to Sikkim Himalaya, India

– Pramod Rai & Prakash Limboo, Pp. 25111–25113

Extended distribution of *Ceropegia bhatii* S.R. Yadav & Shendage (Apocynaceae)—an endemic plant from Haveri District, Karnataka, India

– Ningaraj S. Mankanur & K. Kotresha, Pp. 25114–25116

Response

Small Paa Frog and Marbled Cascade Frog are not endemic to Nepal: a response to Tachamo-Shah et al. 2023

– Chandramani Aryal, Pp. 25117–25118

Publisher & Host



Threatened Taxa