



Open Access

200





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 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, FNAPsyRamanna 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, Mavinahalli PO, Nilgiris, Tamil Nadu 643223, India

Dr. Martin FisherSenior 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 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, Kuvenpu University, Shimoga, Karnataka, India
Dr. K.R. Sridhar, Mangalore University, Mangalagangotri, 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, 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 Ranjan Housing Society, Pune, Maharashtra, India
Prof. A.J. Solomon Raju, Andhra University, Visakhapatnam, India
Dr. Manda 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. Nobile, 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. Navendu Page, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, India
Dr. Kannan C.S. Warrier, 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, Ilandduon, North Wales, LL30 1UP
Dr. Hemant V. Ghate, 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, UKFor Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scopeFor 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: Pseudo-flying animals and wind-dependent seed & spore dispersers – made with digital painting in Krita. © Melito Prinson Pinto



Range extension of *Isthmoheros tuyrensis*, a threatened species of fish (Cichlidae) in Panama: including new ecological and morphological data

Arturo Dominici-Arosemena¹ , Arturo Angulo² , Haydee Osorio-Ugarte³ , Quiriatjaryn Ortega-Samaniego⁴ , Andrés Fraiz⁵ , Arminda Guerrel⁶ , Edgar Araúz⁷ , Jennyfer Montiel⁸ , Beatriz Medina⁹ , Yehudi Rodríguez-Arriatti¹⁰ , Yessenia González¹¹ , Javier Pardo¹² , Karly Urriola¹³ & Adrián Ramos-Merchante¹⁴

^{1,6,9,10,11,13} Universidad Marítima Internacional de Panamá (UMIP), Facultad de Ciencias del Mar, Apartado 0843-03561, Ciudad de Panamá, República de Panamá.

² Museo de Zoología, Centro de Investigación en Biodiversidad y Ecología Tropical (CIBET), Universidad de Costa Rica (UCR) 11501-2060, San Pedro de Montes de Oca, San José, Costa Rica.

³ Universidad Tecnológica de Panamá (UTP), Apartado 0819-07219, El Dorado, Ciudad de Panamá.

⁴ Instituto Universitario de Investigación de Ingeniería del Agua y Medio Ambiente Universidad Politécnica de Valencia, Camino de Vera S/N Valencia 46022 España.

⁵ Ministerio de Ambiente de Panamá, Dirección Regional de Panamá Oeste, Avenida de las Américas, La Chorrera, República de Panamá.

⁵ Wetlands International, Latinoamérica y el Caribe Apartado Postal 0819-03717, Ciudad de Panamá, República de Panamá.

^{7,12} Universidad de Panamá (UP). Apartado 0824 Estafeta Universitaria, Ciudad de Panamá, República de Panamá.

⁸ Universidad Autónoma de Chiriquí (UNACHI), El Cabrero, Ciudad de David, Provincia de Chiriquí, República de Panamá.

¹⁴ Facultad de Ciencias Experimentales, Departamento de Ciencias Integradas, Universidad de Huelva, Campus Universitario El Carmen, Avda. Andalucía s/n, 21071 Huelva, España.

¹ adominici@umip.ac.pa (corresponding author), ² arturo.angulosibaja@ucr.ac.cr, ³ haydee.osorio@utp.ac.pa, ⁴ quiorsa@doctor.upv.es,

⁵ andres.fraiz@wetlands.org, ⁶ arminda.guerrel@umip.ac.pa, ⁷ edgar.arauza@up.ac.pa, ⁸ jennyfer.montiel@unachi.ac.pa,

⁹ bmedina@umip.ac.pa, ¹⁰ yrodriguez@umip.ac.pa, ¹¹ ygonzalez@umip.ac.pa, ¹² javier.pardo@up.ac.pa, ¹³ karriola@umip.ac.pa,

¹⁴ adrian.ramos@ciecemaha.uhu.es

Editor: Topiltzin Contreras MacBeath, Universidad Autónoma del estado de Morelos, Cuernavaca, México. **Date of publication:** 26 February 2023 (online & print)

Citation: Dominici-Arosemena, A., A. Angulo, H. Osorio-Ugarte, Q. Ortega-Samaniego, A. Fraiz, A. Guerrel, E. Araúz, J. Montiel, B. Medina, Y. Rodríguez-Arriatti, Y. González, J. Pardo, K. Urriola & A. Ramos-Merchante (2023). Range extension of *Isthmoheros tuyrensis*, a threatened species of fish (Cichlidae) in Panama: including new ecological and morphological data. *Journal of Threatened Taxa* 15(2): 22611–22622. <https://doi.org/10.11609/jott.7950.15.2.22611-22622>

Copyright: © Dominici-Arosemena et al. 2023. 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: Grant IOMA-19-008 from the Panama National Secretary of Science and Technology (SENACYT).

Competing interests: The authors declare no competing interests.

Abstract, Keywords, Spanish abstract, Author details, Author contributions & Acknowledgements: See end of this article.



UNIVERSIDAD
DE
COSTA
RICA



REPÚBLICA DE PANAMÁ
GOBIERNO NACIONAL
MINISTERIO DE AMBIENTE



Wetlands
INTERNATIONAL



Universidad
de Huelva



SENACYT
Secretaría Nacional de Ciencia, Tecnología e Innovación

INTRODUCTION

Cichlids dispersed to northern Central America (from South America) early in the Cenozoic, long before the Plio-Pleistocene rise of the Isthmus of Panama (IOP; Matamoros et al. 2015). Currently, there is a relatively low species diversity and a limited number of cases of endemism within the Cichlidae in southern Central America. This is especially evident in the Pacific Slope of Eastern Panama (PSEP), as compared to the western side of Panama (which borders Costa Rica) and the rest of Central America, including Mexico (Matamoros et al. 2015). The PSEP includes 13 major river drainages starting from the west side of the Panama Canal (Comité de Alto Nivel de Seguridad Hídrica 2016) and is recognized within the Chocó Biogeographical Region (Matamoros et al. 2015).

Only two endemic species of cichlids have been documented in the PSEP, particularly in the Darien and Bayano River tributaries (Comité de Alto Nivel de Seguridad Hídrica, 2016). One of these is *Darienheros calobrensis* and the other is *Isthmoheros tuyrensis*, both recognized in monotypic genera (Rican et al. 2016). *Isthmoheros tuyrensis*, commonly known as “Aviente” in Spanish (González-Gutiérrez 2021), has been reported in both the Tuíra & Bayano river basins, in the Balsas & Urugantíco rivers within Darien National Park, as well as in the Mamatí river (Lyons 2020). It has been described as a detritivore with a lentic postcranial morphology (Rican et al. 2016).

Isthmoheros tuyrensis was previously classified in the genus *Vieja* (Kullander 2003; Garcés & García 2007; McMahan 2010; McMahan et al. 2015), however, Rican et al. (2016) concluded that *Vieja* is actually part of the herichthysine clade, while *Isthmoheros* is an amphiphilopine, more closely related to other middle American genera such as *Amatitlania*, *Amphilophus*, and *Parachromis*, among others. Moreover, Rican et al. (2016) stated that *Isthmoheros* has its sister genus on the opposite side of the Isthmus in western Panamá and southeastern Costa Rica (i.e., *Talamancaheros*), which also present a detritivore cranial morphology and a lentic postcranial morphology with an obscure breeding coloration (vs. a scraping cranial and a lotic postcranial morphology with a white and black breeding coloration). Moreover, despite some ecomorphological differences, both *Isthmoheros* and *Talamancaheros* share a similar semi-herbivorous diet, based in tooth morphology (Conkel 1993), and they are separated, according to Rican et al. (2016), by a long-isolated monophyletic lineage within the amphiphilopines, being the sister clade

of the aforementioned *Darienheros* plus *Panamius* (Matamoros et al. 2015; Rican et al. 2016).

Isthmoheros tuyrensis faces several threats due to the increased spread of human activities in the eastern region of Panama; mainly due to the expansion of the urban footprint of the Panama City, originating from the Pacific entrance of the Panama Canal. Information on distribution and ecology of *I. tuyrensis* in the Eastern side of the IOP is relatively scarce and only a few comparative studies on ecomorphology have been done from collections in the Bayano River tributaries and the Darien region (Rican et al. 2016). Moreover, river basins towards the west of Panama (i.e., in the Panama District), have been relatively under sampled for freshwater fish species in general, including a lack of information on the distribution of endemic cichlids such as *I. tuyrensis*.

In this paper we report a new distribution range extension for *I. tuyrensis* in the Panama City area. This record is presented after conducting seasonal surveys in three river basins of the region. A morphological description of specimens is included as taxonomical validation for this new range extension. Moreover, our survey locations give us an idea of the potential barriers and distribution limits leading to the possible threat of extirpation of the species in this area, in particular from heavy pollution towards the west of Panama. Finally, we also provide and discuss data on several environmental parameters as a reference for the species' habitat condition in this region. This information will be relevant for future taxonomic and conservation studies, contributing to a better understanding on the biology of the species.

MATERIALS AND METHODS

Study Area

Although this paper is focused on specimens collected only in the Pacora river basin, the sampling effort was part of a broader study between September 2020–May 2021 in three rivers in the District of Panama: Matasnillo, Juan Díaz, and Pacora (Figure 1). All these rivers drain to the Pacific Ocean via the Bay of Panama and experience different levels of degradation due to human activities. These rivers are surrounded by commercial, industrial, and residential land, with an estimated of 1,098,068 people residing in an area of 191 km² (i.e., 540 inhabitants/km²) (Municipio de Panamá 2019). Pressures such as water diversion, extraction of sand & gravel, polluted runoff from nearby agricultural & livestock production, improper use of soils, sanitary

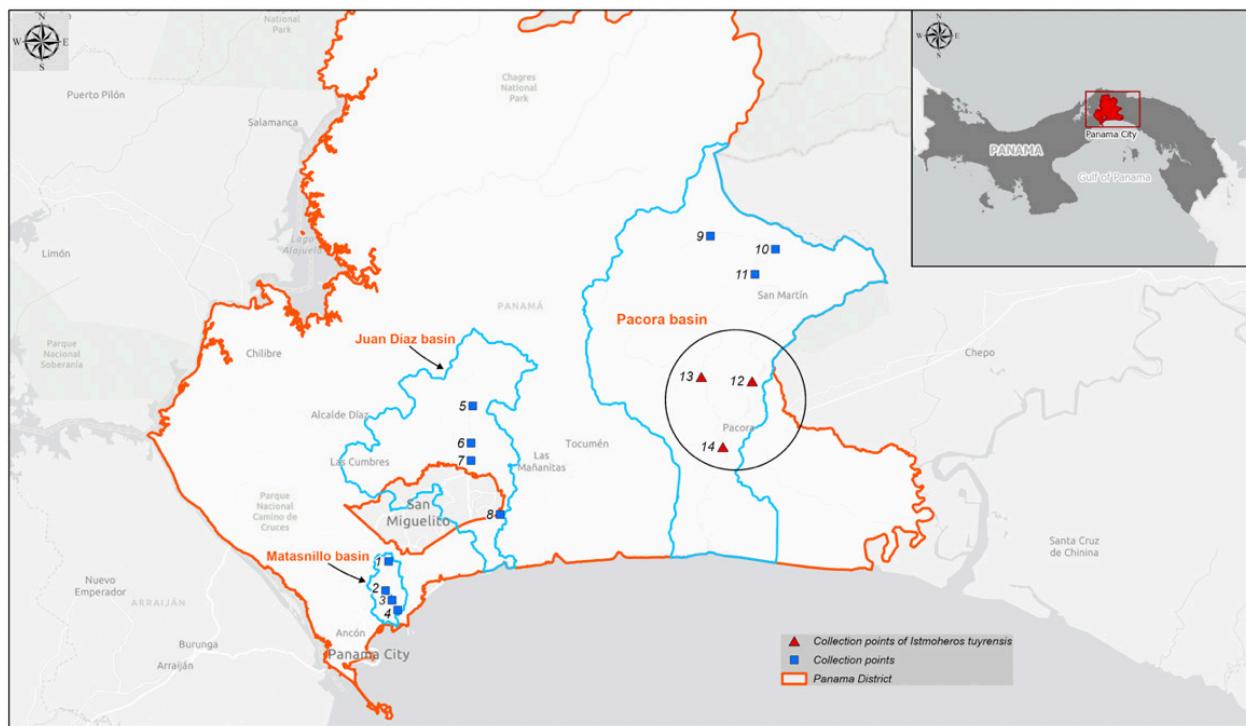


Figure 1. The three sampled basins and localities in the Panama District area (Panama City), specific locations where *I. tuyrensis* was collected are pointed out.

landfills, urban development near drainage areas, sedimentation resulting from deforestation, and untreated sewage affect these three rivers. Moreover, previous reports suggest that these impacts are higher in the city's western side (ANAM 2009).

The Matasnillo River is the main tributary of river basin No. 142 (between Caimito and Juan Díaz River) and is located in the center of Panama City. It is 6 km long, with an annual precipitation of 1,500 l/m², and a 33 m³/s flow. The whole basin, divided by the Panama Canal to the west, has an area of 137 km² and according to the last Panama census of population in 2010 has an estimated of 1,013,714 inhabitants. Both the Arraiján District at the west side of the Panama Canal and the main river at the city center are extremely channelized with little vegetation (Comité de Alto Nivel de Seguridad Hídrica, 2016). Compounding these threats are several sites where sewage tanks occupy river and stream easements, in parallel, the uncontrolled urban development hinders sewage infrastructure maintenance and repairs; this is a critical problem for many urban rivers in the Republic of Panama (MINSA 2019).

The Juan Díaz basin (basin No. 144) includes some of the largest rivers in the east side of the city. The basin is 351 km² & 22.5 km long, with an annual precipitation of 3,000 l/m² & flow of 5.1 m³/s, and an estimated of

868,401 inhabitants (Comité de Alto Nivel de Seguridad Hídrica 2016). To date, the biodiversity of this basin has not been well studied and there is a lack of awareness regarding the area's natural capital, although recent studies have highlighted its importance and relevance at the ecosystem level (Charris-Palacios 2020). Moreover, there are several high-income housing projects currently planned in the basin, which threaten these natural areas and are faced with opposition from local communities, which depend on drinking water from the river (Ruiz 2018). The upper basin is also used by some local communities as a tourist attraction.

The Pacora River basin (basin No. 146) is 368 km² & 48 km long, with 2,750 l/m² in annual precipitation, an average flow rate of 11.1 m³/s, and about 253,131 inhabitants (Comité de Alto Nivel de Seguridad Hídrica 2016). Although the Pacora River faces many of the same threats from expanding urbanization from the east, it also hosts some of the most important natural features (including beaches, pools, waterfalls, and forested areas) in the city. These attractions are connected to the city by a relatively good road network and are enjoyed predominantly by the local communities in addition to in-country tourists. The ecotourism potential of this area is recognized by the local government in the Panama City Resilience Strategy (Municipio de Panamá

2019), which recommends promoting the river's natural ecosystems and biodiversity, along with training tour guides, as a potential income generation activity for local communities. In addition, the Pacora River is a source of drinking water (after treatment in nearby plants), although it's not the sole water source for the urbanized area (García-Armuelles 2020).

Sampling effort at the three explored rivers

Fish sampling was conducted in the three river basins in a one-week period per season, including August–September (rainy season) 2020, February–March (dry season), and April (transition season) 2021. A total of 13 sampling sites were selected from the upper, middle, and lower river basins (Figure 1). At each site, depending on the riparian river structure, physiography, and river length & width, we selected a representative 100-m long transect. Fish were sampled in each transect using an Electro fisher (Halltech, HT-2000, 2020) for 45 minutes, according to the methodology described by Barbour et al. (1999), with voltage limits to 250 volts for areas with high conductivity ($>300 \mu\text{S}/\text{cm}$) and 750 volts for water with moderate to low conductivity (100–300 $\mu\text{S}/\text{cm}$). Since saltwater intrusion limits the use of electrical devices, we also employed a 213 cm long cast net with 1 cm mesh width, utilizing random throws for 30 minutes at each 100 m long transect.

Testing of water quality and physical parameters were carried out mostly using a multi parameter device (YSI Professional Plus 2015). The basic parameter data presented here include water temperature, pH, dissolved oxygen, and conductivity. Water samples were also collected in each locality to test for nitrate and fecal coliform levels. Samples were analyzed by a local laboratory (Ambitek Service Inc). River width was measured using a metric tape, depth with a limnometric rod, and flow with a current meter (Global Water BA1100 Model Fp111 Probe 3.7–6', 2017). Forest condition was assessed according to Munné et al. (2003) including qualitative in situ observations of gallery forest (as coverage percentages) within the upper, middle and lower sections on each river with 50 m long transects measuring on each side of the main riverbed.

Matasnillo River

Four fixed monitoring stations were established for repeated sampling in this basin during all seasons, one in the upper basin, one in the middle basin, and two in the lower basin. A single 100 m long section, due to the narrow river width, was sampled at each locality, totaling 400 m of sampling per season. This means that a

total of 1,200 m were sampled during a total of 540 min (9 h), with heavy limitations due to saltwater intrusion, mainly in the lower basin. The river condition's regarding obstructive garbage, such as metal wires and cement structures, in addition to heavy pollution from sewage disposal, made it impossible to use a cast net in this river basin.

Juan Díaz River

Three fixed monitoring stations were established for repeated sampling in this basin during the rainy season and in-between seasons. During the dry season, an additional site located on the upper basin, inaccessible during the rainy season, was sampled. At all localities (one in the upper basin, one in the middle basin, and one in the lower basin), two 100 m long sections were sampled, totaling 600 m sampled during the rainy season, 600 m between seasons, and 800 m during the dry season. Grouping all the sections monitored during the three seasons using electrofishing, a total of 2,000 m were sampled for 900 min (15 h). For cast net sampling, we spent a total of 600 min (10 h) in this basin across all seasons.

Pacora River

Surveys were conducted in this basin in five fixed monitoring stations during the rainy season and the transition season. Due to the inclusion of one site that was unreachable in other seasons, six stations were monitored during the dry season. At all localities (one in the upper basin, one in the middle basin, and one in the lower basin), two 100 m long sections were sampled. For the rainy and transition seasons we completed a total of 1,000 m sampled; during the dry season a total of 1,200 m were sampled with electrofishing. Considering all the sections monitored during the three seasons, we had a total of 3,200 m sampled for 1,440 min (24 h). For cast net sampling we spent a total of 960 min (16 h).

For practical purposes, this paper is focused on the localities where specimens of *I. tuyrensis* were found (Tables 1 & 2).

Species identification and morphological assessment

For the identification of the species collected we consulted the specialized literature (e.g., Bussing 1998; Gonzalez 2021), including revisionary works and the original description of the species known to occur in the sampled area after Matamoros et al. (2015) and Rican et al. (2016). Specimens identified as *I. tuyrensis* were retained (both preserved and alive), photographed, and measured (see Table 3) according to McMahan et al.

Table 1. Collection localities, season, collecting methods and number of individuals of *Isthmoheros tuyrensis* found in the Pacora River.

Site number	Elevation (m)	Basin / Season*	Method	Ind	Size (cm)	Weight (g)
12	40	M/T	Cast net	1	16.0	63
13	52	M/R	Electrofishing	1	8.1	10
13	52	M/T	Electrofishing	1	8.1	10
14	20	L/T	Cast net	2	8.1	10

*M—Middle Basin | L—Lower Basin | R—Rainy Season | T—Transition Season | Ind—Number of individuals collected

Table 2. Average Physical Parameters in the Pacora River, Panama City.

Parameter	Units	Average	Minimum	Maximum	SD
Temperature	°C	27.9	23.0	31.6*	2.14
PH	-	7.73	7.01	8.5	0.28
Conductivity	µS/cm	166.5	124.4	207.7**	21.83
DO	%	7.90	6.11	9.93	1.03
TDS	mg/L	87.04	2.8***	206.2	44.83
Nitrate	Mg/L N-NO ₃	1.87	0.5	5.2****	1.53
Fecal Coliform	MPM/100 mL	1897	63	7701****	3126
Flow	Meters/second	0.29	0	2.44	0.40
Width	M	22.47	6	53.6	9.30
Depth	Cm	39.08	0.8	100	27.76
Forest Condition	%	53	20	90*****	28.31

*Dry and transitional season, middle and lower basin | ** Transitional season, lower basin | *** Rainy season, middle basin | **** Rainy season, lower basin | ***** Upper basin.

(2015) and Rican et al. (2016). Counts (see Table 3) were done on preserved specimens according to Rican et al. (2016). Comparative morphometric and meristic data was obtained from the literature (McMahan et al. 2015; Rican et al. 2016).

RESULTS

Fish diversity

From a total of 9,259 fish specimens found in the sampled period, including 21 families, 40 genera, and 43 species (data under analysis for further publication), there were only two species of native cichlids. The most abundant species, with a total of 374 individuals, was the Chogorro (*Andinoacara coeruleopunctatus*). Of these 374 specimens, 134 were collected in Juan Díaz and 240 in Pacora, with zero individuals in Matasnillo.

On the other side, only five specimens of *I. tuyrensis* were collected (see morphological details/data below), all in the Pacora River (Table 1). Of these five specimens, two were found in the middle basin and captured with

electrofishing (Figure 1, Site 13, Table 1), one was collected during the rainy and the other in the transition season; a third specimen was found at a middle basin (Figure 1, Site 12, Table 1), during the transition season; and the last two specimens were captured in the lower basin (Figure 1, Site 14, Table 1), during the transition season. These last three specimens (Sites 12 and 14) were captured using cast net.

At the time of this writing, three specimens of *I. tuyrensis* are preserved and housed at the “Dr. Luis Howell Rivero” Museum at the Center of Marine Biology and Limnology (CCML) in the University of Panama, Catalogue number MBML No 2151; while the two other specimens are maintained alive in an aquarium located in the International Maritime University of Panama’s laboratory, in the Faculty of Marine Sciences. Pictures of one preserved specimen are provided in Images 1–2. Live specimens of *I. tuyrensis* are illustrated in Images 3–5.

Two exotic species of cichlids were also collected during our study. A total of 426 individuals of the Nile Tilapia (*Oreochromis niloticus*) were captured, 423

in Juan Díaz, 3 in Pacora, and zero in Matasnillo. A single specimen of the Jaguar Guapote (*Parachromis managuensis*), which is native from Honduras, Nicaragua, and Costa Rica, was found in the Juan Díaz river.

Species identification (*I. tuyrensis*) and morphological assessment

Identification of fishes as *I. tuyrensis*, comprising a new record for the Pacora river, was based on the following combination of distinctive characteristics which separate it from the other cichlid species occurring in the southern portion of Central America: body relatively robust and wide; second lower lip missing; teeth conical, without second cusp, but with tip labiolingually flattened; lateral line scales 31–32; anal fin spines 6–7; and coloration pattern (body grayish-green to greenish-brown, with 8–9 lateral black blotches, and several longitudinal series of small dark spots on the sides and fins). Complementary morphometric and meristic data for the species, based on three specimens measured, and analyzed, is provided in Table 3.

Environmental parameters at the sampled localities

The results for the environmental analysis are restricted to the Pacora River, since it is the only river where *I. tuyrensis* was found. The physiochemical and physical parameters are detailed in Table 2.

Physicochemical parameters

Temperature averaged 27.9 °C, with maximum values in the dry season. The average pH was 7.73, with a maximum of 8.5 and similar values across all seasons. Conductivity showed high variation with higher values in the lower basin. Dissolved oxygen averaged 7.90%, with relatively low variation and maximum values in the upper basin. Nitrate levels showed an average of 1.87, increasing in the middle and lower basins during the rainy season. Fecal Coliform concentration showed higher values in the localities at the middle and lower portion of the basin, increasing during the rainy season (Table 2).

Physical parameters

Water flow averaged 0.29 m/s; with a range from 0 (no current) –2.44 m/s. River depth and width showed strong variation across sampled localities, both increasing during the rainy season. Forest coverage tended to increase towards the middle and upper basins, with a maximum of 90% coverage in the upper basin and an average of 53% along the entire basin (Table 2).

Table 3. Morphometric and meristic data of individuals of *I. tuyrensis* found in the Pacora River. Head measurements are expressed as percentages of the head length; body measurements are expressed as percentages of the standard length.

Measurement/Count	N1	N2	N3
Total length (cm)	10.51	10.12	19.47
Standard length (cm)	8.10	8.10	16.00
Head length (cm)	2.69	2.40	4.69
Snout length	27.43	25.54	26.08
Mouth length	16.43	19.85	19.09
Eye diameter	29.33	27.23	25.00
Post-ocular length	42.35	46.15	42.74
Head depth	106.57	120.00	130.11
Predorsal length	31.51	32.28	29.18
Prepectoral length	33.70	30.78	31.07
Pectoral length	28.24	27.95	30.60
Prepelvic length	35.67	30.59	35.96
Pelvic length	25.35	29.63	28.23
Preanal length	64.71	67.40	64.12
Dorsal fin base	55.31	56.48	59.07
Dorsal fin height	11.29	13.29	12.93
Anal fin base	24.26	25.02	24.05
Body depth	47.25	50.59	51.03
Caudal peduncle length	11.41	12.10	12.22
Caudal peduncle depth	14.06	15.34	14.91
Dorsal fin elements	XVI, 10	XVII, 10	XVII, 11
Pectoral fin elements	14	13	14
Anal fin elements	VII, 7	VI, 8	VI, 7
Lateral line scales	32	31	32

DISCUSSION

Species distribution and environmental limitations

Toward the western-most range limit for *I. tuyrensis*, Loftin (1965) reported its presence almost 6 km east from the town of Pacora (not the river basin), near the Señora River, which drains to the Bayano River. Our findings report, for the first time, the presence of this species in the Pacora River basin, about 20 km in a straight line from previously known localities in Central Panama. This finding raises questions about the possible past distribution of the species in other rivers in Central/Western Panama, given there is no previous records of the species in the rivers of Panama City.

In the neighboring Juan Díaz river, not a single specimen of *I. tuyrensis* was found during the three sampled seasons, although another native and even two others exotic (more generalist and less sensitive to



Image 1. Preserved specimen of *I. tuyrensis*, right side, 16 cm, collected at the Prison La Joya (Site #12) on transition season in May 2021, picture from 3 July 2021. © Javier Pardo, UP.



Image 2. Preserved specimen of *I. tuyrensis*, left side, 16 cm, collected at the Prision La Joya (Site # 12) on transition season in May 2021, picture from 3 July 2021. © Javier Pardo, UP.



Image 3. Live individual of *I. tuyrensis*, 15 cm, kept at the UMIP Aquarium, collected at the Restaurante Cabobre (Site # 13) in May 2021, picture from 13 December 2021. © Jafet Santos, UMIP.



Image 4. Same live individual of Image 4 kept at the UMIP Aquarium, 18 cm, picture from 21 March 2022. © Javier Pardo, UP.



Image 5. The two live individuals collected at the Restaurante Cabobre (Site # 13) keep at the UMIP Aquarium, 18 cm and 10 cm, picture from 21 March 2022. © Javier Pardo, UP.

environmental changes/disturbances) cichlid species were found. This river (Juan Díaz) is surrounded by densely populated areas at its middle and lower portions and is currently undergoing a rapid urbanization process. is most likely an unsuitable habitat for *I. tuyrensis*, although that does not mean that this species was not present in this river before 1970 when the uncontrolled urbanization started (Municipio de Panamá 2019). Both Juan Díaz and Pacora Rivers drain to the Panama Bay Ramsar Site (Kaufmann 2012; Suman 2014), however *I. tuyrensis* is not reported in any study in the area; moreover, in the past, only 9 individuals were found in surveys on the Darien Province in rivers such as Balsas, near the Colombian border (Garcés & García 2007). Unfortunately, this Ramsar Site does not include the middle river basin and covers little freshwater habitat, even though watersheds can be considered wetlands according to the Ramsar technical classification (Ramsar Convention Secretariat 2016).

Conservation issues

Some conservation issues, mainly related to the agricultural-urban expansion, habitat loss, and pollution, that are affecting negatively the current conservation and populational status and distribution of *I. tuyrensis* are discussed below.

Agricultural-urban expansion vs. habitat loss

A study of land uses in the Pacora River basin conducted by Rodríguez-Martínez (2019) discusses transitions of land type measured though Geographic Information Systems (GIS) via three classifications—deforestation, gain or loss of agricultural land, and expansion of the urban footprint; with a variation trend between the periods corresponding to the years 1992, 2000, 2009, and 2019. The transition that presented the greatest magnitude of variation was deforestation, with the greatest loss between 2009 and 2019 (4,996.4 ha). These results indicate that the most significant transition that occurred was the transformation of forest land into pasture for livestock, with losses of 3,031.7 ha, 1,991.6 ha, and 3,466.9 ha, respectively, in the three periods assessed. Another significant change presented in the study is the growth of the urban footprint, which went from 259.6 ha in 1992, to 642.2 ha in 2000, to 2,412.0 ha in 2019; a tenfold increase in less than 30 years. A management plan proposal for the Pacora River basin developed by PREVDA (2008) states that the basin is (in addition) exposed to a series of climate risks and extreme events ranging from heavy rainfall and floods to some periods of drought. Moreover, we observed

that the river was blocked in multiple areas by local communities, especially during dry season, in order to create swimming areas. Currently there are no studies at this basin addressing the impact of the aforementioned factors, as well as of the deforestation due to livestock increasing, on the water availability, hydrological capacity, and biodiversity.

The impact from pollution

Regardless of the habitat connectivity and of their ability to survive in estuarine areas (as we found some specimens in the lower Pacora basin). Our surveys indicated that the Pacora River has an average pH of 7.7, with maximum values of 8.5, pointing to relatively alkaline waters with significant mineral input and less accumulation of organic material (Nilsson & Renfölt 2008). The presence of anthropogenic impacts from agricultural activity and urban sewage in some areas can contribute to denitrification, which may cause an increase of pH levels (He et al. 2017). On the other hand, our nitrate values showed an average value of 1.87 mg NO₃-N/l, with a maximum of 5.2 mg NO₃-N/l; little surprising was the fact that we did not find individuals of *I. tuyrensis* in localities with the highest nitrate values (Table 1 & Table 2). Although no information is available on nitrate toxicity for *I. tuyrensis* or for any of its close relatives, some studies have found that many freshwater fishes can exhibit increased mortality with nitrate levels between 1.1 and 4.5 mg NO₃-N/l (Camargo et al. 2005).

Many studies, on the other hand, have considered the agricultural leaching as the major factor driving the increase of conductivity and dissolved solids. For instance, in the geographically proximate region of the Costa Rican Pacific, Pérez-Castillo & Rodríguez (2008) incorporated the conductivity variable in their analyses of water quality in lagoons of the Palo Verde National Park, considering it an indicator for inorganic fertilizer presence and poor water quality. They established a 250 µS/cm maximum value for uncontaminated waters and a value of 1,500 µS/cm for heavily polluted waters. In other studies, specifically the Rincón River basin, also in the Costa Rican Pacific region, Beita-Sandí & Barahona-Palomo (2010) determined that average conductivity was 161.8 µS/cm, with a range from 92.7 µS/cm up to 249.6 µS/cm, thus, suggesting the area to be free of marine influence since none of the records exceeded 45.2 µS/cm (Villegas-Arguedas 2011). For the Pacora River, our minimum conductivity values were 124.4 µS/cm, with an average of 166.5 µS/cm, and tended to be higher in the middle and lower basin. This may be a product of the cumulative impact of agricultural activities from the

upper to the lower sections of the basin.

Moreover, Beita-Sandí & Barahona-Palomo (2010) found that the conductivity range in natural fresh waters in some Pacific Rivers in Costa Rica varied between 10 $\mu\text{S}/\text{cm}$ & 350 $\mu\text{S}/\text{cm}$, while in areas with marine influence the values varied between 125 $\mu\text{S}/\text{cm}$ & 2,200 $\mu\text{S}/\text{cm}$. We consider our conductivity and other pollution indicators discussed here to be high in the lower section of Pacora River, leading us to infer that the river, in addition to those discussed above, also has a marked marine influence. However, since higher conductivity values were obtained from collection localities near urbanized areas, we cannot conclude that these values are a natural characteristic of this river.

Although we used different voltage settings, electrofishing was probably affected in some cases by the high conductivity; on the other hand, in the lower & middle basin most collections were done using cast nets. More studies are necessary to confirm if *I. tuyrensis* prefer particular conditions at proximity with estuaries as occur in other cichlid genera (e.g., *Vieja*; Bussing 1998). Moreover, several studies mention that some fish can prefer aquatic habitats with specific requirements such as elevated values of water conductivity, but this can vary among species (Vieira & Tejerina; Garro 2020). The few individuals of *I. tuyrensis* that we found in our study were collected in sites in the middle and lower river sections with intermediate to relatively high conductivity values. Thus, there is a possibility that these conductivity values are negatively affecting the population status of the species since they may be due to anthropogenic activities.

Authors including Mondal & Bath (2020) have found that conductivity and total dissolved solids affect negatively the water quality conditions; thus, tolerant species, particularly those peripheral and with broader distributions on the whole basin (which does not seem to be the case of *I. tuyrensis*), are able to survive on high conductivity values. The same authors also stated that increased total dissolved solids and conductivity is related to reduced species richness and diversity of freshwater fish in tropical river basins. The same review concludes that an increase of nutrient contents in the water leads to an increase in primary productivity and persistence of periphyton feeding fishes, producing excessive algal growth, increased sediments, and an imbalanced food chain, which, again, seems not to be the case for *I. tuyrensis* a detritivorous species (Rican et al. 2016).

Since the bacteria *Escherichia coli* is predominant in sewage; we consider that fecal pollution may represents

a potential threat to *I. tuyrensis*. A study by Guzmán et al. (2004) where *E. coli* concentration was determined in digestive tracts and muscles of two species of fishes (*Jenynsia multidentata* and *Bryconamericus iberi*) sampled at the same sites, showed higher concentrations of the bacteria in *J. multidentata* than in *B. iberi*, thus indicating that the former species is more sensitive to the accumulation of the bacteria. Moreover, these authors concluded that increased bacteria concentration compromises the immunological system of these fish. Although we found no specific information for cichlids and considering that *E. coli* (measured by us as fecal coliform) is present in variable concentrations in all the sampled localities, we can conclude that *I. tuyrensis* is a sensitive species, since it was not found in the most polluted rivers (e.g., Juan Díaz;). On the other hand, no other cichlids were found in the nearby and heavily polluted Matasnillo river, which can provide us information on the tolerance levels of the species of this family to the fecal pollution.

Conservation measures

Habitat conditions and the permanence of this endemic species in the PSEP is not guaranteed if measures are not taken to control agricultural and urban footprint expansions. The Pacora River has a population of one of the only two endemic species of cichlids from this region, which is struggling to survive after its possible disappearance from nearby rivers toward the west. In terms of planning and environmental policies, recent management plans are non-existent except for an expired initiative that proposed integral management for the basin more than 10 years ago (PREVDA 2008). There are multiple threats to the Pacora river, and this species, posed by increased water demand for livestock, crops and industry, including the extraction of gravel, sand, and of non-metallic minerals directly from the river. These factors affect the biophysical and social components of the river basin where local communities, mostly living in poverty, are fighting for the right to healthy rivers, and ecosystems (Espinoza 2021).

Freshwater fishes are among the most threatened groups of species on the planet (Lacy et al. 2017). They have persisted for decades in tropical river basins and their ecological/environmental and socio-economical value is probably not fully understood by human communities, particularly in urban cities. As in other countries (see Lacy et al. 2017), neither local Panamanian stakeholders nor governments consider freshwater fishes to be a priority group in their Environmental Impact Assessment processes. We hope that this study can begin raising

awareness for riverine fishes and particularly for members of the Cichlidae. Panama's central and local governments should monitor biological indicators in its rivers and set priorities such as connecting the sewage system to the Juan Díaz Treatment Plant and increase sewage treatment capacity, instead of depositing sewage directly to the river (MINSA 2019; Municipality of Panama 2019). We also recommend training local tourist guides for eastern rivers such as Pacora, including the recognition of their unique and local biodiversity. Finally, actions outlined in the Panama City Resilience Strategy should be implemented within the next 10 years, according to existing regulations (Municipio de Panamá 2019).

Other functional and taxonomical aspects

Previous studies on *I. tuyrensis* noted the preference of this species for slow-moving waters. However, for the Pacora River, particularly at the lower basin, current velocity is relatively high. This is typical from rivers in this region of Panama, which is characterized by steep profiles and a shorter distance to the coast. This contrast, for example with the Bayano & Darien Rivers, in particular the Tuyra & Balsas rivers, where freshwater wetland ecosystems include lagoons with aquatic plants adapted to intermittent flooding (Ibáñez & Flores 2021).

Regarding the morphological data, despite our specimen count is scarce due to the low population densities of the species, the information provided here agree with the morphometric and meristic information published by previous authors (e.g., Kullander 2003; Rican et al. 2016); moreover, this study adds new and relevant information on the morphology of *I. tuyrensis*, contributing to its further diagnosis and characterization. This information could be relevant for taxonomic and descriptive studies, as well as in applied ecology research. Finally, our data provided limited information in terms of size classes, since four specimens measured about 8 cm and the maximum size reported was 16 cm. In this regard, previous authors (Kullander 2003; Rican et al. 2016) reported a maximum size of 23.5 cm for the species.

GENERAL CONCLUSIONS

The distribution limit for *I. tuyrensis* towards the west side of the PSEP is extended with our findings as the previous westernmost reports are limited to the Chichebre and Señora Rivers in the Bayano River basin (Lyons 2020). Most rivers of Panama City, such as the

Juan Díaz, are heavily polluted and this could prevent or limit the presence of this species, which, based on our data, can be considered as sensitive to pollution. For the Matasnillo River, pollution and deforestation are even higher; moreover, this river shows high marine influence and conductivity values that exceeds 400 $\mu\text{s}/\text{cm}$ in most sites. These issues (pollution, deforestation, river salinization, among others) call for the urgent implementation of restoration, conservation, and sanitation programs for all these rivers. This includes updating and implementing 1—the Pacora River Management Plan, buffering the spread of new urbanizations in the basin and 2—the Territorial Ordination Plan for the Panama City, which has already been developed, but is pending approval (IDOM SUMA CONTRANS 2017).

Although our study expands the geographic range of *I. tuyrensis* and furthers biological understanding of the species, it does not alter the fact that this species is listed as Vulnerable and likely to become endangered based on the criteria of the IUCN Endangered Species Red List. The relatively few known populations of this species (less than 10, based on Lyons 2020, including the new reported in this study) as herein discussed, are exposed to several threats including deforestation, agricultural expansion, mining activities, and road infrastructure development among others, not only on the central and western portion of the country but also within the Darien Region (Lyons 2020; Arcia-Jaramillo 2022). As we pointed out, this species is virtually lacking any effective protection along their distribution range, even in the eastern portion of the country (Arcia-Jaramillo 2022).

REFERENCES

- Arcia-Jaramillo (2022). Parque Darién, joya natural bajo constante amenaza. *Diario La Prensa*. <https://www.prensa.com/sociedad/parque-darien-joya-natural-bajo-constante-amenaza/>
- Beita-Sandí, W. & M. Barahona-Palomo (2010). Físico-química de las aguas superficiales de la cuenca del río Rincón, Península de Osa, Costa Rica. *Cuadernos de Investigación UNED* 2(2): 157–179.
- Camargo, J.A., A. Alonso & A. Salamanca (2005). Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates. *Chemosphere* 58: 1255–1267.
- Charris-Palacios, A. (2020). Las dos caras del río Juan Díaz. *Periódico En Segundos*. <https://ensegundos.com.pa/2020/08/30/las-dos-caras-del-rio-juan-diaz/>
- Comité de Alto Nivel de Seguridad Hídrica (2016). Plan Nacional de Seguridad Hídrica 2015-2050: Agua Para Todos, *Gobierno de la República de Panamá* 168 pp. <https://www.undp.org/es/panama/publications/plan-nacional-de-seguridad-h%C3%A9drica-2015-2050-agua-para-todos>
- Conkel, D. (1993). *Cichlids of North and Central America*. TFH Publications, 191 pp.
- Espinoza, T. (2021). Comunidad teme afectaciones al río Pacora por posible extracción de arena *TVN Noticias Website*. <https://www.tvn->

- 2.com/contenido_exclusivo/Comunidad_afectaciones-Rio-Pacora-extraccion-contaminacion_0_5927407260.html
- Garcés, H.A. & J. García (2007).** Inventario ictiológico en la cuenca del Río Balsas, Parque Nacional Darién, Panamá *Tecnociencia* 9(2): 45–57.
- García-Armuelles, L. (2020).** IDAAN sectorizará Pacora. *Periódico La Estrella de Panamá*. <https://www.laestrella.com.pa/nacional/200325/realizan-sectorizacion-planta-centenario-pacora>
- González-Gutiérrez, R. (2021).** *Elementos de los peces dulceacuícolas de Panamá*. First personal Edition by González-Gutiérrez R. 290 pp.
- Guzmán, M.C., M. de los Angeles Bistoni, L.M. Tamagnini & R.D. González (2004).** Recovery of *Escherichia coli* in fresh water fish, *Jenynsia multidentata* and *Bryconamericus iheringi*. *Water Research* 38(9): 2368–2374.
- Ibáñez, A. & R. Flores (2021).** *Phyllanthus fluitans* (Phyllanthaceae): a new record of an aquatic plant for the flora of Panama/*Phyllanthus fluitans* (Phyllanthaceae): un nuevo registro de planta acuática para la flora de Panamá. *Acta Botánica Mexicana* (128): 1G–1G. <https://doi.org/10.21829/abm128.2021.1767>
- IDOM SUMA COTRANS (2017).** Plan Estratégico Distrital, Política Locales y Plan Local de Ordenamiento Territorial del Distrito de Panamá", en base a la adjudicación de la Licitación por Mejor Valor №.2016-5-76-0-08-LV-008821. <https://plandistritalpanama.com/>
- Kaufmann, K. (2012).** *Nuestros Humedales, Nuestro Futuro: Plan de Conservación para los Humedales de la Bahía de Panamá* (Our Wetlands, Our Future: Conservation Plan for the Panama Bay Wetlands). Sociedad Audubon de Panamá/Panama Audubon Society, 70 pp.
- Kullander, S.O. (2003).** Cichlidae (Cichlids), pp. 605–654. In: Reis, R.E., S.O. Kullander & C.J. Ferraris Jr. (eds.). *Checklist of the Freshwater Fishes of South and Central America*. Porto Alegre: EDIPUCRS, Brasil.
- Lacy, S., F. Meza & P. Marquet (2017).** Can environmental impact assessments alone conserve freshwater fish biota? Review of the Chilean experience. *Environmental Impact Assessment Review*. 63: 87–94. <https://doi.org/10.1016/j.eiar.2016.12.006>
- Loftin, H.G. (1965).** The geographical distribution of freshwater fishes in Panama. *PhD Thesis, The Florida State University*, 278 pp
- Lyons, T.J. (2020).** *Isthmoheros tuyrensis*. The IUCN Red List of Threatened Species 2020: e.T152306277A152306353. Accessed on 21 May 2022. <https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T152306277A152306353.en>
- Matamoros, W.A., C.D. McMahan, P. Chakrabarty, J.S. Albert & J.F. Schaefer (2015).** Derivation of the freshwater fish fauna of Central America revisited: Myers' hypothesis in the twenty-first century. *Cladistics* 31(2): 177–188. <https://doi.org/10.1111/cla.12081>
- McMahan, C.D., A.D. Geheber & K.R. Piller (2010).** Molecular systematics of the enigmatic Middle American genus *Vieja* (Teleostei: Cichlidae). *Molecular Phylogenetics and Evolution* 57: 1293–1300.
- McMahan, C.D., W.A. Matamoros, K.R. Piller & P. Chakrabarty (2015).** Taxonomy and systematics of the herichthysins (Cichlidae: Tribe Heroini), with the description of eight new Middle American Genera. *Zootaxa* 3999(2): 211–234. <https://doi.org/10.11646/zootaxa.3999.2.3>
- Ministerio de Salud - Programa Saneamiento Panamá - MINSA (2019).** La Contaminación del Río Matasnillo por Aguas Residuales Programa Saneamiento Panamá <https://saneamientodepanama.gob.pa/la-contaminacion-del-rio-matasnillo-por-aguas-residuales/>
- Munné, A., N. Prat, C. Solá, N. Bonada & M. Rieradevall (2003).** A simple field method for assessing the ecological quality of riparian habitat in rivers and streams: QBR index. *Aquatic Conservation: Marine and Freshwater Ecosystems* 13(2): 147–163. <https://doi.org/10.1002/aqc.529>
- Municipio de Panamá (2019).** Acuerdo Municipal Número 7 del 15 de enero 2019. Por el cual se Adopts la Estrategia de Resiliencia para la Ciudad de Panamá. Gaceta Oficial No. 28710-B, 1-190. https://www.gacetaoficial.gob.pa/pdfTemp/28710_B/71387.pdf
- Nilsson, C. & B.M. Renöfält (2008).** Linking flow regime and water quality in rivers: a challenge to adaptive catchment management. *Ecology and Society* 13: 18.
- Pérez-Castillo, A. & A. Rodríguez (2008).** Índice fisicoquímico de la calidad de agua para el manejo de lagunas tropicales de inundación. *Revista de Biología Tropical* 56(4): 1905–1918.
- Programa Regional de Reducción de la Vulnerabilidad y Degradación Ambiental-PREVDA (2008).** Formulación del plan estratégico para el manejo integrado de la cuenca del río Pacora. Panamá. Comisión Europea-SICA, 123 pp.
- Ramsar Convention Secretariat (2016).** An Introduction to the Convention on Wetlands (previously The Ramsar Convention Manual). Ramsar Handbook 5th Edition Sub-series I: Handbook 1 International Cooperation on Wetlands, 110 pp.
- Rican, O., L. Pialek, K. Dragova & J. Novak (2016).** Diversity and evolution of the Middle American cichlid fishes (Teleostei: Cichlidae) with revised classification. *Vertebrate Zoology* 66(1): 3–102.
- Rodríguez-Martínez, O.A. (2019).** *Evaluación de escenarios de intervención para la implementación de buenas prácticas de manejo en la cuenca del río Pacora, Panamá*. Master's Thesis, Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Costa Rica, 91 pp
- Ruiz, L.M. (2018).** Panamá: Moradores de La Primavera se organizan para enfrentar proyecto urbanístico. *Radiotemblor*. <https://www.radiotemblor.org/panama-moradores-de-la-primavera-se-organizan-para-enfrentar-proyecto-urbanistico-audio-foto/#:~:text=Moradores%20de%20la%20comunidad%20de,costo%20de%20partida%20de%2024150%2C000>
- Suman, D. (2014).** Panama Bay Wetlands: Case Study of a Threatened Ecosystem. *Water Resources and Wetlands* 366–371.
- Vieira, T.B. & F.L. Tejerina-Garro (2020).** Relationships between environmental conditions and fish assemblages in tropical savanna headwater streams. *Scientific Reports* 10(1): 1–12. <https://doi.org/10.1038/s41598-020-59207-9>
- Villegas-Arguedas, J.C. (2011).** Relación entre la diversidad de ictiofauna y la calidad del agua en ríos con diferente grado de afectación por diques y canales en la zona sur de Costa Rica. Master's Thesis in Natural Resource Management and Protection. Universidad Estatal a Distancia – UNED, Costa Rica, 126 pp.



Abstract: There are two endemic species of Cichlidae in southern Central America, both found in the Pacific Slope of Eastern Panama (PSEP). One is *Isthmoheros tuyrensis*, which until now was presumed to be distributed in the Darién Province and the Bayano River basin. Information on distribution and ecology of *I. tuyrensis* is relatively scarce. In this investigation we report a new range extension for the species and provide additional morphological and ecological data. Fish were sampled using electrofishing and cast nets, in three river basins of the Panama District (Matasnillo, Juan Díaz, and Pacora) from August–September (rainy season) of 2020, February–March (dry season), and April (transition season) of 2021. Fish diversity, water quality, and physical parameters were gathered within the upper, middle, and lower portions of the three basins. This study focused on the localities where specimens of *I. tuyrensis* were found (i.e., Pacora river basin). The presence of the species in localities with significant anthropogenic threats results in a potential barrier for distribution, along with the possibility of extirpation due to heavy pollution – in particular from the rivers on the western side of Panama City. In addition, we note an increase in urban threat from the east of the city due to expanded development and agricultural activities. *I. tuyrensis*, the virtually unknown “Aveinte” in Spanish or the “Isthmian Hero”, is listed as Vulnerable by the International Union for Conservation of Nature (IUCN’s) Red List and inhabits some river basins lacking effective protection, being the only endemic fish species located in an urban basin in the Pacific of Mesoamerica. The information on distribution, morphology, and ecology provided here will contribute to a better understanding of the species’ biology and will aid the creation and implementation of management and conservation measures.

Keywords: Agriculture, Central American ichthyofauna, conservation actions, Eastern Panama, endemism, pollution, urban expansion.

Resumen: Existen dos casos de endemismo de cíclidos en el Sur de Centroamérica, i.e., en la Vertiente Pacífico del Este de Panamá. Una de estas especies es *I. tuyrensis*, cuya distribución conocida incluye los ríos de la Provincia de Darién y el Río Bayano. La información sobre distribución y ecología de *I. tuyrensis* es, no obstante, relativamente escasa. En esta contribución reportamos una extensión en el rango de distribución conocido para la especie, así como datos morfológicos y ecológicos adicionales. Se realizaron muestreos ictiológicos utilizando electropesca y atarrayas, en tres ríos del Distrito de Panamá (Ciudad de Panamá: Matasnillo, Juan Díaz y Pacora) entre agosto y septiembre (estación lluviosa) de 2020, febrero y marzo (estación seca) y abril (transición entre estación seca y lluviosa) de 2021. Se recopilaron datos sobre diversidad de peces y parámetros físicos y de calidad del agua en las zonas alta, media y baja de las tres cuencas. Este reporte se enfoca, no obstante, en la única zona en donde se encontraron ejemplares de la especie endémica mencionada (i.e., Pacora). La frecuencia de los censos frente a las amenazas muestra una posible barrera de distribución con posibilidad de extirpación, debido a la fuerte contaminación en los ríos, hacia el Oeste de la Ciudad de Panamá, acompañada de amenazas producto de la expansión urbana y las actividades agrícolas en el Distrito de Panamá. *I. tuyrensis*, el desconocido “Aveinte” o el “Héroe del Istmo”, es una especie catalogada como vulnerable en la Lista Roja de Especies en Peligro de la UICN que habita en una zona que carece de protección efectiva; siendo la única especie de pez endémica ubicada en una cuenca urbana en el Pacífico de Mesoamérica. La información sobre distribución, morfología y ecología aquí provista se espera que contribuya a un mejor conocimiento y entendimiento de la biología de la especie, así como a la creación y promoción de medidas de manejo y conservación.

Acknowledgments: The data collected for this study was part of an interinstitutional and interdisciplinary project (IOMA-19-008: “Environmental impact of multistressors in aquatic ecosystems of the metropolitan area of Panama”) funded by the Panama National Secretary of Science and Technology (SENACYT). The Funding source had no role in study design, data collection, interpretation of results or manuscript writing. Logistical and technical support was provided by the Panama City Municipality (Luis Norato, Paola Samaniego & Edwin García). Resource administration and technical coordination was conducted by the Wetlands International Regional Office. The International Maritime University of Panama (UMIP) contributed with logistic, sampling storage and processing space, as well as equipment and technical personnel. We thank the Panama Ministry of Environment (MiAmbiente, Environmental Performance Direction, Miguel Flores) for their additional contributions with transportation and technical personnel (MiAmbiente, Environmental Performance Direction, Veraguas Province, Leonel Rivera), along with the scientific permits to conduct this research. This full-length report is the result of the implementation of Panama District/City River monitoring actions stated in the Panama City Resilience Strategy (Municipio de Panamá 2019) for the determination of biological water quality indicators related to fishes and invertebrates. UMIP Research Associate Isaac Pearlman contribute with the English language reviewing of this publication.

Author details: A.DOMINICI-AROSEMENA is a Panamanian Biologist, Professor & Director of the School of Marine and Environmental Resources at the Faculty of Marine Sciences at the International Maritime University Panama (UMIP). He’s scientific work is focused on study the Ecology and Biogeography of Neotropical fishes along with the biodiversity assessments of Wetlands Ecosystems. A. ANGULO is a Costa Rican Ichthyologist with extensive experience in field inventories and museographic work in the Neotropics. He is Professor, Researcher and Curator of the Fish Collection at the University of Costa Rica (UCR). H. OSORIO-UGARTE is a Hydrologist, Civil Engineer and Researcher in Water Resources at the Faculty of Civil Engineering at the Technological University of Panama (UTP), she is in charge of the Geographic Information System and Director of the Urban Water and Forest Hydrology Research Group. Q. ORTEGA-SAMANIEGO is a Biologist specialized in Marine Biology, Limnology and Environmental Management. Currently she is a Panama Ministry of Environment collaborator and a doctoral student in the Water and Environmental Engineering Program at the Polytechnic University of Valencia, Spain. Her research is based on environmental impacts on aquatic ecosystems, with emphasis on the biotic component. A. FRAIZ is a Biologist specialized in Environmental Management with more than 15 years of experience in Coastal Management projects, he’s research is focused on primary production, restoration of coastal ecosystems, coastal erosion, management and aquaculture. Currently he is a Technical Officer at the Wetlands International Foundation. A. GUERREL is currently a student a obtaining the Degree of Marine Biologist at UMIP, her thesis is focused on river plankton as indicator of water quality. E. ARAUZ is a Biologist, specialist in wildlife management and conservation, he currently works at the Natura Foundation in the management of environmental projects, and in research projects in the Wetlands International Foundation. He also is a professor of Biology and Ecology at the School of Biology at the University of Panama. J. MONTIEL is currently a student a obtaining the Degree in Environmental Sciences and Natural Resources at the Autonomous University of Chiriquí and is a pioneer in the implementation of the QBR index (riverine forest index) in Panama. B. MEDINA is a Biologist, Professor and specialist in Environmental Management and Marine Resources Development and Protection. She currently works as the Dean of the Faculty of Marine Sciences at UMIP. Y. RODRÍGUEZ-ARRIATTI is a Biologist specialized in Coastal Resources Management, Fisheries and Elasmobranchs. She is conducting research related to ichthyological resources that are part of the bycatch for various fisheries, as well as the compilation of a collection of otoliths for future studies of age structure and as reference material for analysis of stomach contents. Y. GONZALEZ is a specialist in Phyto-genetic Resources, Biotechnology and Biodiversity Conservation. She served as the Panama National Director of Protected Areas and Wildlife. Currently she is Academic Coordinator, Professor and Researcher in the Faculty of Marine Sciences at UMIP. J. PARDO is currently a student a obtaining the Degree in Marine Biology and Limnology at the University of Panama. He worked on long-term water quality monitoring projects and the restoration of mangroves in the Bay of Panama. He is a land and underwater photographer that works for environmental education in panels and conferences national and international. K. URRIOLA is a Biologist, researcher and Professor at UMIP specialized in Environmental Management and cetaceans. A. RAMOS-MERCHANTE has a PhD in Biology and a Bachelor of Environmental Sciences, he has dedicated his professional career to the conservation and management of continental aquatic environments through projects that apply the Water Framework Directive (DMA) and Monitoring Networks of the State of Quality of Hydrographic Basins. He is specialized in the monitoring of macroinvertebrates, aquatic macrophytes, continental ichthyofauna and riparian forest management.

Author contributions: Arturo Dominici-Arosemena- 1) Conceptualization, 2) Field Data collection, 3) Manuscript writing, 4) Acquisition of funds, 5) Project Administration & Coordination at UMIP 6) live animals management in the UMIP aquarium Arturo Angulo-Sibaja- 1) Conceptualization, 2) Morphometrical Analysis, 3) Manuscript writing, Haydé Osorio- 1) Conceptualization, 2) Maps, 3) Hydrological Information, Quiriatjaryn Ortega- 1) Conceptualization, 2) Field Data collection, 3) Acquisition of funds, 5) Project Administration & Coordination, Andrés Fraiz- 1) Conceptualization 2) Field data collection 3) Acquisition of funds 4) Project Administration & Coordination in Wetlands International, Arminda Guerrel-1) Field Data Collection 2) Environmental data management 3) field assistant 4) Lab assistant, Edgar Araúz- 1) Conceptualization 2) Data collection 3) Lab assistant 4) Project Coordination in Wetlands International, Jennyfer Montiel- 1) Forest condition data, 2) field assistant Beatriz Medina- 1) Project Administration & Coordination at UMIP 2) Field data collection ,Yehudi Rodríguez-Arratti- 1) Support for fieldwork coordination, 2) Field data collection, 3) live animals management at UMIP aquarium, Yessenia González- 1) Project Coordination at UMIP 2) Field data collection 3) Lab assistant, Javier Pardo-1) Photographic Material 2) Field Data collection, Karly Uriola-1) Support fieldwork coordination at UMIP, 2) Field Data collection, Adrián Ramos-Merchanter 1) Methodology , 2) Team Training in the Panama City Rivers, for fish collecting methods & Data Interpretation.

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. Karen 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 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. Karen 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. Chandrashekher 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. Biju, 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 Jayopal, 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 Inskip, Bishop Auckland Co., Durham, UK
Dr. Tim Inskip, 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, 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, Budhanilkantha Municipality, Kathmandu, Nepal
Dr. Susan Cheyne, Borneo Nature Foundation International, Palangkaraya, 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 Helleni 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. Bharat Baviskar, Wild-CER, Nagpur, Maharashtra 440013, India

Reviewers 2019–2021

Due to paucity 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.

Print copies of the Journal are available at cost. Write to:

The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org

Journal of Threatened Taxa 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

Communications

Sunda Clouded Leopard *Neofelis diardi* (Cuvier, 1823) (Mammalia: Carnivora: Felidae) occupancy in Borneo: results of a pilot vehicle spotlight transect survey

– Jephth Sompud, Sze Lue Kee, Kurtis Jai-Chyi Pei, Paul Liau, Collin Goh & Anthony J. Giordano, Pp. 22559–22566

On the occurrence of Eurasian Otter *Lutra lutra* (Carnivora: Mustelidae) in Neeru stream of Chenab catchment, Jammu & Kashmir, India

– Dinesh Singh, Anil Thakar & Neeraj Sharma, Pp. 22567–22573

Distribution of avifauna on twenty-one islands of the Gulf of Mannar Biosphere Reserve, India

– H. Byju, N. Raveendran & S. Ravichandran, Pp. 22574–22585

Habitats of House Sparrow *Passer domesticus* (Linnaeus, 1758) in Rameswaram Island, Tamil Nadu, India

– M. Pandian, Pp. 22586–22596

Seasonal diversity and dietary guild structure of birds in two Vindhyan gorge forests of Rajasthan, India

– Ashvini Kumar Joshi, Pp. 22597–22605

Differential kleptoparasitic interactions of Himalayan Vulture *Gyps himalayensis* with conspecifics and heterospecifics during various stages of breeding

– Hameem Mushtaq Wani, Pp. 22606–22610

Range extension of *Isthmoheros tuyrensis*, a threatened species of fish (Cichlidae) in Panama: including new ecological and morphological data

– Arturo Dominici-Arosemena, Arturo Angulo, Haydee Osorio-Ugarte, Quiriatjaryn Ortega-Samaniego, Andrés Fraiz, Arminda Guerrel, Edgar Araúz, Jennyfer Montiel, Beatriz Medina, Yehudi Rodríguez-Arriatti, Yesenia González, Javier Pardo, Karly Urriola & Adrián Ramos-Merchante, Pp. 22611–22622

Tadpole morphology of Jerdon's Narrow-mouthed Frog *Uperodon montanus* (Jerdon, 1853) with a range and elevation extension report from Western Ghats, India

– Amit Hegde, Girish Kadadevaru & K.P. Dinesh, Pp. 22623–22631

An annotated checklist of the economically important family of moths (Lepidoptera: Heterocera: Noctuidae) of the northern Western Ghats, India, with notes on their type species, diversity, distribution, host plants, and an unusual new faunistic record

– Aparna Sureshchandra Kalawate, Prachee Surwade & S.N. Pawara, Pp. 22632–22653

Report of a tussock moth genus *Maeoproctis* (Lepidoptera: Erebidae: Lymantriinae: Nygmiaini) from India

– Gagan Preet Kour Bali & Amritpal Singh Kaleka, Pp. 22654–22660

Butterflies of Silent Valley National Park and its environs, Western Ghats of Kerala, India

– Kalesh Sadasivan, P.C. Sujitha, Toms Augustine, Edayillam Kunhikrishnan, Vinayan P. Nair, M. Divin Murukesh & Baiju Kochunarayanan, Pp. 22661–22676

Notes on morphology and bionomics of *Urolabida histrionica* (Westwood) (Heteroptera: Urostylididae) from Assam, India

– Sachin Ranade & Hemant V. Ghate, Pp. 22677–22685

Andromonoecy functional through heterostyly and large carpenter bees as principal pollinators in *Solanum carolinense* L. (Solanaceae)

– Suvarna Raju Palathoti & Aluri Jacob Solomon Raju, Pp. 22686–22694

An inventory of endemic and near endemic angiosperm flora of Biligiri Rangaswamy Temple Tiger Reserve, peninsular India

– J. Jayanthi, Pp. 22695–22717

Multidimensional time-lapse of a relict species *Canarium strictum* Roxb. from a sacred landscape in Pune District, India

– Mukul Mahabaleshwar, Nivedita Ghayal, Supriya Mahabaleshwar & Vinaya Ghate, Pp. 22718–22725

Rediscovery of *Sewardiella tuberifera* Kash., a long-lost monotypic endemic Indian liverwort

– Sapana Pant, S.D. Tewari, Prachi Joshi, Manisha Bhandari & Richa Arya, Pp. 22726–22730

Physcomitrium eurystomum Sendtn. (Funariaceae: Bryophyta) and *Splachnobryum obtusum* (Brid.) Müll. Hal. (Splachnobryaceae: Bryophyta), two rare moss species from the Western Ghats of Kerala

– C. Nair Manju, P.M. Vineesha, B. Mufeed & K.P. Rajesh, Pp. 22731–22736

Short Communications

First record of the Great Seahorse *Hippocampus kelloggi* Jordan & Snyder, 1901 (Actinopterygii: Syngnathiformes: Syngnathidae) from the northwestern coast of Bay of Bengal

– Anil Kumar Behera, Biswajit Mahari & Amrit Kumar Mishra, Pp. 22737–22740

Schoenoplectiella erecta (Poir.) Lye ssp. *raynalii* (Schuyler) Beentje (Cyperaceae) – a new record to India from Ossudu Bird Sanctuary, Villupuram District, Tamil Nadu

– Chandrasegrane Pradeep, Paneerselvam Umamaheswari, Natesan Balachandran & Raphael Mathevet, Pp. 22741–22745

Notes

Status of the Sumatran Striped Rabbit *Nesolagus netscheri* in Isau-Isau Wildlife Reserve, South Sumatra Province, Indonesia

– Arum Setiawan, Muhammad Iqbal, Octavia Susilowati, Doni Setiawan, Martialis Puspito Khristy Maharsi & Indra Yustian, Pp. 22746–22748

Photographic record of the butterfly ray *Gymnura cf. poecilura* (Myliobatiformes: Gymnuridae) from the Bhagirathi-Hooghly River in West Bengal, eastern India

– Priyankar Chakraborty, Pp. 22749–22751

First report of the fairyfly *Schizophagma mitai* Triapitsyn (Hymenoptera: Mymaridae) from India with notes on *S. indica* Rehmat & Anis

– Anandhan Rameshkumar, Nazurius Anand, Sayan Sardar & Sarfrazul Islam Kazmi, Pp. 22752–22756

Occurrence of *Ranunculus sceleratus* L. (Ranunculaceae) from the Nilgiri District, Tamil Nadu, India

– J. Shashikanth, S. Mugendhiran & Digvijay Verma, Pp. 22757–22760

First report of *Meliola panici* on *Ottochloa nodosa* (Kunth) Dandy (Poaceae)

– Gopinathan Nair Gokul & Jacob Thomas, Pp. 22761–22763

New record of an usneoid lichen *Usnea hirta* (L.) Weber ex F.H.Wigg. from India

– K.S. Vinayaka, Archana R. Mesta & N. Rajeshwari, Pp. 22764–22766

On the occurrence of two species of rare cyanobacterial genus *Petalonema* M.J.Berkeley ex Wolle, 1887 (Cyanophyceae: Nostocales: Scytonemataceae) from eastern Himalaya, India

– Jai Prakash Keshri, Narendra Nath Koley & Jay Mal, Pp. 22767–22770

Publisher & Host

