Check List the journal of biodiversity data
NOTES ON GEOGRAPHIC DISTRIBUTION

First record of *Lebiasina boruca* (Bussing, 1967) (Characiformes, Lebiasinidae) from Panama: a range extension

Andrés E. Fraiz-Toma[1], Arturo Angulo[2, 3], Arturo Dominici-Arosemena[4, 6, 7], Sergio Othón-Chirú[4], Miguel Agames-Pérez[4], Antonio Clemente[5], Emiliano Montoya-Sanchez[2, 3]

1 MarAlliance, Ciudad de Panamá, Panamá
2 Escuela de Biología, Museo de Zoología/Centro de Investigación en Biodiversidad y Ecología Tropical (CIBET) and Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), Universidad de Costa Rica. 11501–2060, San Pedro de Montes de Oca, San José, Costa Rica
3 ICtioCR, Laboratorio de Ictiología, Museo de Zoología, Universidad de Costa Rica. 11501–2060, San Pedro de Montes de Oca, San José, Costa Rica
4 Universidad Marítima Internacional de Panamá (UMIP), Apartado 0843-03561, Ciudad de Panamá, Panamá
5 Asociación Nacional para la Conservación de la Naturaleza (ANCON), Ciudad de Panamá, Panamá
6 Sistema Nacional de Investigación (SNI), Panamá
7 Instituto Smithsonian de Investigaciones Tropicales (STRI), Balboa, Ancón, Panamá

Corresponding author: Andrés E. Fraiz-Toma (andres@maralliance.org)

Abstract. We report the first peer-reviewed record of *Lebiasina boruca* (Bussing, 1967) (Characiformes, Lebiasinidae) from Panama. Specimens were collected in lowland streams of the Escarrea and Chico river basins, Chiriquí Province, on the Pacific slope in western Panama. This record extends the known distribution of the species southeastward from southern Costa Rica and fills a distributional gap within the Chiriquí ichthyological province. The finding improves our current knowledge on the biogeography of Central American freshwater fishes and highlights the importance of surveys in relatively poorly studied transboundary drainages.

Keywords. Biogeography, Central America, Chiriquí, distribution, freshwater fish

Fraiz-Toma AE, Angulo A, Dominici-Arosemena A, Othón-Chirú S, Agames-Pérez M, Clemente A, Montoya-Sanchez E (2026) First record of *Lebiasina boruca* (Bussing, 1967) (Characiformes, Lebiasinidae) from Panama: a range extension. Check List 22 (5): 810–818. https://doi.org/10.15560/22.5.810

Introduction

The family Lebiasinidae (order Characiformes) currently includes 75 valid species distributed primarily in South America, with a smaller number occurring in Central America (Weitzman and Weitzman 2003; Fricke et al. 2026). Within this lineage, the subfamily Lebiasininae, currently represented by 27 valid species (Fricke et al. 2026), is characterised by its ecological affinity for headwaters and fast-flowing lotic environments, although certain species exhibit considerable plastic traits that allow them to colonise lowland streams and secondary tributaries (Weitzman and Weitzman 2003; Netto-Ferreira et al. 2011). Species of *Lebiasina* Cuvier & Valenciennes, 1847 in Central America show a discontinuous distribution, occurring in isolated drainages along the isthmus. This spatial isolation reflects historical processes of tectonic isolation, landscape evolution, and inter-drainage river captures (Weitzman and Weitzman 2003; Smith and Bermingham 2005).

In Panama, the family Lebiasinidae has historically been represented by only two species of *Lebiasina*: *L. panamensis* (Gill, 1877) and *L. festae* (Boulenger, 1899). Both species have been documented from several drainages in eastern and central Panama, with records extending westward to the Capira region on the Pacific slope (Loftin 1965; González-Gutiérrez 2021; Garcés and García 2007, 2023). Available records and taxonomic compilations (Eschmeyer 1998; Fricke et al. 2026) indicate that no species of *Lebiasina* have been reported between central Panama and southern Costa Rica (Loftin 1965; Weitzman and Weitzman 2003; González-Gutiérrez 2021).

West of this perceived distributional gap, on the Pacific slope of Costa Rica, Bussing (1967) originally described *Piabucina boruca*, subsequently assigned to the genus *Lebiasina* based on modern taxonomic reviews and systematic checklists (Angulo et al. 2013; Angulo 2021; Fricke et al. 2026). Subsequent surveys reported *L. boruca* from several Pacific-slope drainages in southern Costa Rica, including

OPEN ACCESS

Academic editor: Victor De Brito
Received: 15 June 2026
Accepted: 20 August 2026
Published: 14 September 2026

Copyright © The authors.
This is an open-access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0)

the Tusubres river basin (Angulo et al. 2015), the Grande de Térraba basin (Rojas and Rodríguez 2008), and the transboundary Coto river basin (Angulo et al. 2020). Given the proximity and environmental similarity of Pacific-slope drainages in southern Costa Rica and western Panama, the absence of records of *L. boruca* from Panama was unexpected. The Pacific-slope drainages of southern Costa Rica and western Panama belong to the Chiriquí ichthyological province, a region characterized by strong faunal affinities and a shared geological history (Smith and Bermingham 2005). No ecological barrier is known that would explain this distribution pattern.

Here, we report the first confirmed record of *L. boruca* from Panama, based on voucher material and photographic records obtained from the Escarrea and Chico river basins in Chiriquí Province. This record extends the known distribution of the species into western Panama and confirms its occurrence within the Panamanian portion of the Chiriquí ichthyological province. The finding also highlights the value of additional ichthyological surveys in small and poorly sampled drainages of western Panama.

Study area

The study area is in the westernmost region of the Republic of Panama, within Chiriquí Province, on the Pacific slope (Figure 1). Biogeographically, this region belongs to the Chiriquí ichthyological province (Smith and Bermingham 2005), an ecoregion characterised by high freshwater fish endemism and strong faunal affinities with the Pacific slope of Costa Rica. Field surveys and observations were carried out in lowland tributaries of two major hydrological networks: the Escarrea river basin [basin no. 104, *sensu* IMHPA (2021)] and the Chico river basin (including the Piedra river drainage) [basin no. 106, *sensu* IMHPA (2021)]. These river systems originate in the southern foothills of the Cordillera de Talamanca and flow southward across coastal alluvial plains before draining into the Gulf of Chiriquí

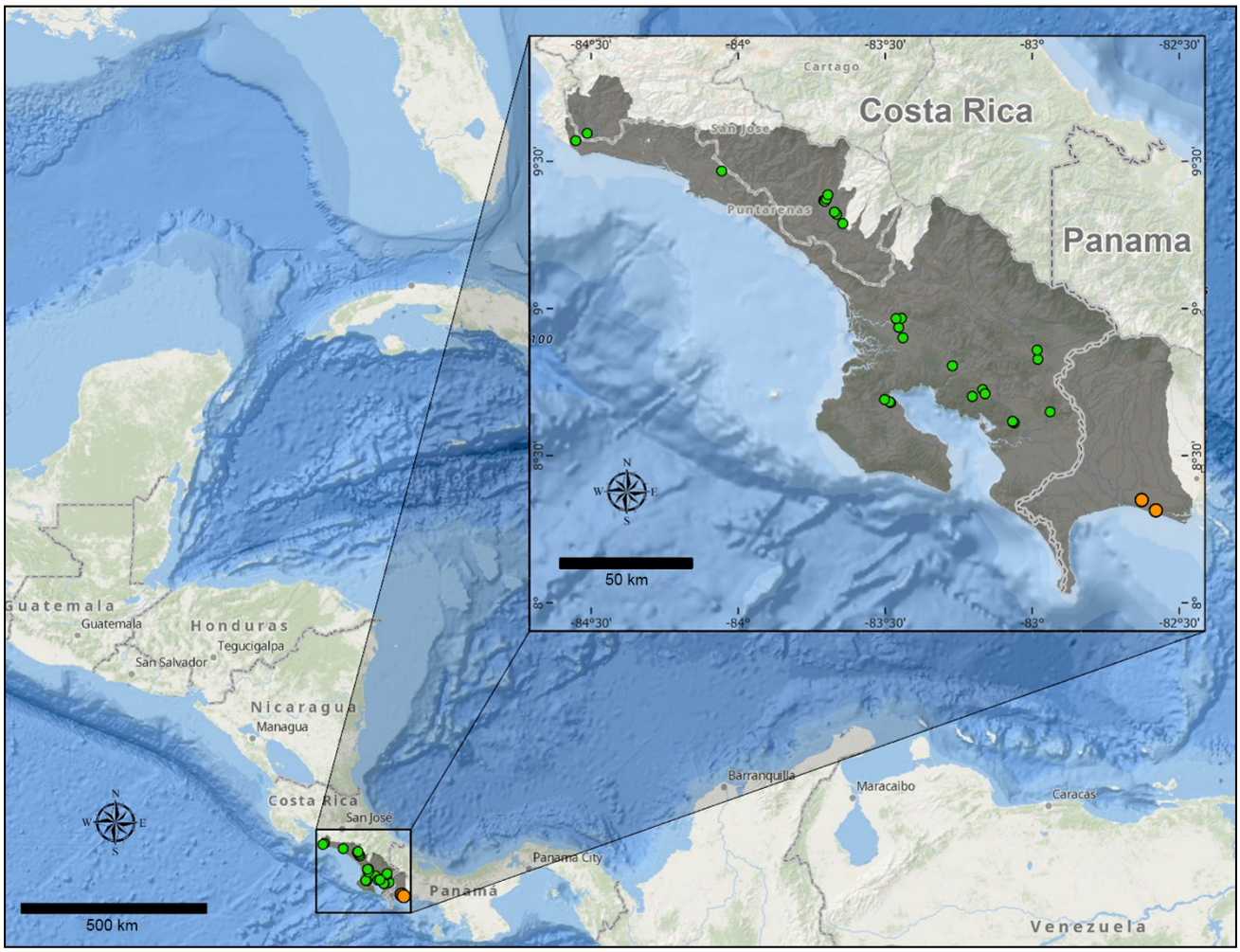


Figure 1. Updated geographic distribution map of *Lebiasina boruca* in Lower Mesoamerica, showing historical records derived from museum collections and GBIF data (green circles), and the new occurrence localities in the Escarrea and Chico river basins, Chiriquí Province, western Panama (orange circles).

in the Pacific Ocean. Within this region, the terrain is predominantly lowland, characterised by gentle slopes and floodplains associated with extensive regional development.

According to the Köppen climate classification (Köppen 1931), the climate of the area is a tropical monsoon, characterised by consistently high temperatures and strong seasonality in precipitation (Köppen 1931; Marshall 2007). This pronounced rainy season heavily modulates local stream discharge and drives seasonal connectivity among aquatic habitats. The specific sampling and observation sites are situated within small, shallow, low-order streams at low elevations. These habitats typically feature slow-to-moderate water velocity, a substrate complex predominantly composed of gravel, sand, and accumulated leaf litter, and varying degrees of secondary riparian vegetation canopy that provides partial shading.

The landscape surrounding these aquatic systems has been heavily modified by human activity. Land use in the district of Alanje is dominated by intensive agriculture and cattle ranching, with major crops including rice, sugarcane, watermelon, and other seasonal products; this widespread cultivation has led to the extensive modification of natural vegetation and native riparian zones (Jaén et al. 2016). As a direct result of these intensive agricultural practices, the area is recognised as one of the regions with the highest levels of nitrogen fertilizer application in Panama, which significantly influences soil and freshwater nutrient dynamics (Morales-Saldaña et al. 2026). Notably, no portion of the study area lies within a legally protected area.

Methods

Sampling and field procedures. Fieldwork was conducted in March 2021 and April 2025, during daylight hours using a targeted, active-search approach focused on habitats where lebiasinids are commonly found. Sampling effort was systematically focused on specific microhabitats known to be preferred by lebiasinid fishes, including shallow littoral stream margins, slow-flowing backwaters, seasonal marginal pools, and microhabitats characterised by dense submerged vegetation and accumulated leaf litter (Bussing 1967; Angulo et al. 2020). Conversely, deep main river channels were intentionally excluded from the sampling design. Fish specimens were captured along shallow channels and stream banks using a small cast net (10 mm mesh size) and fine-mesh hand nets. All capture sites were immediately georeferenced using a handheld GPS unit set to the WGS84 datum. Because the primary objective of this study was strictly to confirm the geographic occurrence of the target species rather than to evaluate community composition, ecological structure, or relative abundance, most captured individuals were released alive at their exact collection points after field identification.

Voucher material and documentation. Captured individuals were placed in field containers, examined live, and digitally photographed in high resolution to document diagnostic in-life colouration and pigmentation patterns. To provide formal physical evidence of the record in the Escarrea river basin, one representative specimen was selected as a physical voucher, euthanised following standard ethical guidelines for ichthyological research (Jenkins et al. 2014), and preserved directly in 70% ethanol. This voucher specimen was formally curated and deposited in the fish collection of the Museo de Biología Marina y Limnología "Luis Howell Rivero" at the Universidad de Panamá (MBML), Panama City, Panama, under the catalogue number MBML 2144.

Its presence in the Chico river basin was documented through a photographic record showing the species' diagnostic coloration pattern.

Morphometrics and comparative material examined. Counts and measurements followed Fink and Weitzman (1974) and Menezes and Weitzman (1990). All morphometric measurements were taken point-to-point on the left side of the specimens whenever possible, using dial callipers with a precision of 0.1 mm. Standard length (SL) is presented in millimetres (mm), whereas all other measurements are expressed as proportions of SL, except for subunits of the head, which are presented as proportions of head length (HL).

In addition to the voucher material supporting the new country record, comparative museum specimens from the fish collection of the Universidad de Costa Rica (UCR) were examined for taxonomic verification and morphological comparison. This comparative material included 10 specimens of *L. boruca* [UCR 114-6 (4 specimens), UCR 0108-9 (5 specimens), and UCR 3083-1 (1 specimen)] and two specimens of *L. panamensis* (UCR 1547-1). The morphometric and meristic data compiled from both the new records and the comparative material are summarised in Table 1.

Distribution mapping. An updated distribution map for *L. boruca* (Figure 1) was generated using ArcGIS Pro software v. 3.6 (Esri 2026). The map was constructed by integrating the newly compiled

Table 1. Morphometric and meristic data of the voucher specimen of *Lebiasina boruca* (MBML 2144) from Panama and comparative material of *L. boruca* and *L. panamensis*.

Morphometric and meristic data	*L. boruca*			*L. panamensis*	
	MBML 2144	UCR 0114-6, 0108-9, 3083-1 (*n* = 10)		UCR 1547-1 (*n* = 2)	
		Min.	Max.	Min.	Max.
Standard length	52.20	56.46	124.66	59.02	64.20
Depth at dorsal-fin origin	26.81	22.39	27.25	21.19	21.47
Snout to anal-fin origin	83.14	75.31	80.45	75.18	75.80
Snout to pelvic-fin origin	58.04	51.74	57.10	51.15	51.97
Snout to dorsal-fin origin	59.00	55.22	58.23	54.43	54.75
Dorsal-fin origin to caudal-fin base	46.16	42.88	46.83	44.51	48.17
Dorsal-fin length	16.09	15.95	23.14	19.4	19.40
Dorsal-fin base	9.960	6.47	10.23	8.67	9.33
Adipose-fin to caudal peduncle	8.620	7.84	13.64	9.23	12.92
Caudal-peduncle length	11.49	12.25	15.49	12.00	17.09
Caudal-peduncle depth	13.02	10.79	14.52	8.70	10.63
Anal-fin length	15.13	16.83	22.43	18.55	18.70
Anal-fin base	11.11	10.12	12.92	10.38	11.13
Pelvic- to anal-fin origin	24.13	19.19	24.88	18.89	19.81
Pelvic-fin length	16.28	12.79	16.59	13.99	15.07
Pectoral to pelvic-fin origin	29.31	23.33	29.55	24.06	26.68
Pectoral-fin length	17.81	15.61	19.59	15.9	15.94
Snout to pectoral-fin origin	24.52	22.03	25.77	24.08	24.46
Bony head length	26.81	24.56	27.27	25.61	26.02
Head width	59.28	57.87	66.19	49.66	53.91
Horizontal eye diameter	26.42	17.51	26.55	25.55	25.66
Distance snout tip to eye	22.85	19.44	26.89	25.55	25.72
Interorbital distance	43.57	36.65	44.29	31.87	35.48
Lower jaw length	19.28	19.35	26.56	22.8	25.26
Upper jaw length	14.28	14.05	19.37	17.05	19.11
Gill rakers on first gill arch	27	26	29	22	25
Dorsal-fin rays	ii, 8	ii, 8	ii, 8	ii, 7	ii, 8
Pectoral-fin rays	i, 13	i, 13	i, 14	i, 12	i, 12
Pelvic-fin rays	i, 7	i,7	i, 7	i, 7	i, 7
Anal-fin rays	iii, 8	iii, 8	iii, 9	iii, 9	iii, 9
Caudal-fin procurrent rays	i, 17, i	i, 17, i	i, 17, i	i, 17, i	i, 17, i
Lateral line scales	28	28	30	28	30
Predorsal scales	13	12	14	13	13
Longitudinal rows of scales between dorsal and pelvic fins	7	7	7	7	7
Circumpeduncular scales	13	13	13	13	13

georeferenced field data from this study with historical occurrence records across Lower Mesoamerica. Historical distribution data were gathered from georeferenced ichthyological material deposited in the UCR fish collection and supplemented with verified digital records retrieved from the Global Biodiversity Information Facility repository (GBIF 2026). Spatial visualisation, geoprocessing, and final map rendering were performed using ArcGIS.

Results

***Lebiasina boruca* (Bussing, 1967)**

Figure 2

New records. PANAMA — Chiriquí • Chico river basin, Guasimo stream; 08°18′48.52″N, 082°34′46.02″W; 4 m a.s.l.; 20 Mar. 2021; Fraiz-Toma, A.E. obs.; cast net (10 mm mesh); 1 spec. • Escarrea river basin, Palmilla stream; 08°20′56.30″N, 082°37′39.76″W; 10 m a.s.l.; 12 Apr. 2025; Fraiz-Toma, A.E., Brenes, R. leg.; cast net (10 mm mesh); 1 spec., 52.2 mm SL, MBML 2144.

Identification. The Panamanian specimens possess an elongated and robust body, characteristically subcylindrical anteriorly from the snout to the dorsal-fin origin and progressively compressed toward the caudal peduncle. The dorsal profile is slightly convex from the snout tip to the occipital region, nearly straight or weakly arched from the nape to the insertion of the dorsal fin, and gently sloping along the dorsal-fin base toward the caudal peduncle. The ventral profile is moderately convex from the lower jaw to the insertion of the pelvic fins, and relatively straight or flattened from that point to the anal-fin origin. The head is wide, robust, and moderately depressed. In the dorsal view, the snout is short and rounded. The mouth is terminal and slightly oblique. The maxilla is short, posteriorly



Figure 2. *Lebiasina boruca*. **A.** Lateral view in-life of the voucher specimen MBML 2144 (52.2 mm SL) from Alanje District, Chiriquí Province, Panama. **B.** Lateral view of the same voucher specimen, alcohol-preserved. **C, D.** Lateral view in-life of the specimen from the Chico river basin, Chiriquí Province, Panama. Scale bars: 2 cm.

extending to just reach the vertical line through the anterior margin of the orbit. The eyes are moderate in size and positioned dorsolateral on the anterior half of the head. The interorbital space is wide and slightly convex.

The dorsal-fin origin is situated on the posterior half of the body and located distinctly behind the vertical line through the pelvic-fin insertion; its distal margin is rounded. The pectoral fins are short, rounded, and inserted low (ventrolaterally) on the body. The pelvic fins are relatively small, and their tips do not reach the anal-fin origin. The anal-fin origin is positioned far back on the caudal region of the body. The adipose fin is small but well developed, dorsally positioned over the posterior branched rays of the anal fin. The caudal fin is slightly emarginated, with conspicuously rounded upper and lower lobes.

In life (Figure 2A, C, D), the ground colour of the body is silvery, with a dark-brown dorsal median surface and abruptly paler sides. The pelvic and anal fins are bright red, whereas the adipose fin is yellow, and the dorsal and caudal fins are pale-dusky orange. In alcohol-preserved material, the ground colour of the body changes to a light brown, with the dorsal median surface remaining dark brown and the sides becoming abruptly paler. Three distinctive longitudinal rows of bright orange-to-red spots are present on the scales along the flanks, forming a characteristic dotted pattern. In alcohol-preserved material, these reddish-orange markings completely fade. No dark mid-lateral stripe or markings of any kind are present at the caudal-fin base. The median fins are uniformly dusky, with the distal border of the anal fin being slightly darker than the rest of the fin.

Remarks. The Panamanian specimens were identified as *L. boruca* based on a combination of diagnostic morphometric, meristic (Table 1), and/or colour pattern characters (Figure 2A, C, D) that align completely with the original description by Bussing (1967) and subsequent taxonomic revisions/descriptions (e.g. Angulo et al. 2020). *Lebiasina boruca* can be clearly distinguished from its regional congener, *L. panamensis*, by its significantly higher count of gill rakers on the first arch (26–29, including 27 in MBML 2144, vs. 22–25 in *L. panamensis*). Morphologically, *L. boruca* exhibits a greater distance from the snout to the pelvic-fin origin (51.74–58.04% SL vs. 51.15–51.97% SL in *L. panamensis*) and a distinctly wider head in mature specimens (head width 57.87–66.19% HL vs. 49.66–53.91% HL in *L. panamensis*).

Furthermore, colour patterns provide an unambiguous diagnosis to differentiate *L. boruca* from Central American congeners. This species is readily distinguished by the complete absence of a well-defined dark lateral band along the body axis (which is either entirely absent or represented only by two indistinct, pale longitudinal bands) and of dark spots or pigmentation at the caudal-fin base at all stages of development. In contrast, both *L. panamensis* and *L. festae* possess a prominent, well-defined dark mid-lateral stripe running continuously along the body and distinctive dark pigmentation or a conspicuous spot at the caudal-fin base, which is particularly well developed in juvenile individuals. An updated identification key to the Panamanian species of *Lebiasina*, based on Meek and Hildebrand (1916), is presented below.

Dichotomous key to the identification of the Central American (Costa Rica and Panama) species of *Lebiasina*

1a. Dark lateral band absent or represented only by two indistinct pale longitudinal bands; markings absent from the caudal-fin base at all ages; adults with a high total gill raker count on the first arch (26–29); greater predorsal distance (55.0–60.7% of SL) ..... ***L. boruca***

1b. Well-defined dark lateral band present along the body; caudal-fin base usually with a dark spot or pigmentation (especially in juveniles); adults with a lower total gill raker count on the first arch (21–25); shorter predorsal distance (usually <56% of SL) **2**

2a. Distinct dark humeral spot separate (unconnected) from the lateral band; lateral band located primarily below the midline of the side; caudal spot usually absent or inconspicuous; maxillary reaching slightly past the anterior margin of the eye; dorsal-fin origin midway between the posterior margin of the opercle and the origin of the adipose fin ..... ***L. festae***

2b. Humeral spot usually integrated with or connected to the beginning of the lateral band; lateral band extending along the midline of the body; conspicuous triangular spot present at the caudal-fin base; maxillary reaching the middle of the eye; dorsal-fin origin midway between the posterior margin of the preopercle and the origin of the adipose fin ..... ***L. panamensis***

Discussion

The discovery of *L. boruca* in the Escarrea and Chico river basins represents the first formal record of this species for the Republic of Panama, extending its known geographic range approximately 48–55 km southeastward from the nearest verified localities in the transboundary Coto River basin in southern Costa Rica (Angulo et al. 2020). Prior to this study, *L. boruca* was considered a regional endemic restricted entirely to the Pacific slope of Costa Rica, spanning from the Tusubres river basin in the northwest to the Coto river drainage near the international border (Bussing 1967; Angulo et al. 2015, 2020; Angulo 2021). By documenting its occurrence within the administrative boundaries of Chiriquí Province, Panama, this study eliminates a long-standing distributional gap for the subfamily Lebiasininae along the coastal lowlands of Lower Mesoamerica.

The historical absence of *L. boruca* from previous extensive ichthyological inventories in Chiriquí Province (e.g. Goodyear et al. 1976; Briceño and Martínez 1986; Goodyear and Montenegro 1987; Garcés 2016) may be partly attributed to methodological and spatial sampling biases. Nevertheless, Netto-Ferreira (2010) reported four specimens from Panama as examined material: ANSP 151023 (77.9–92.7 mm SL), collected from a stream 29 km south of the Inter-American Highway along the Canoas–Puerto Armuelles Road, Chiriquí Province (08°19′09.6″N, 082°49′34.0″W), on 28 January 1983 by D. Fromm and D. Weber. Netto-Ferreira (2010) also included northwestern Panama within the distribution of *L. boruca*. However, this record appeared only in an unpublished doctoral thesis and had not been formally discussed in the peer-reviewed literature. The historical ANSP material, together with the records reported herein and the species' occurrence in neighbouring southern Costa Rica,

supports the interpretation of *L. boruca* as a native but previously under-documented component of Panama's freshwater ichthyofauna, rather than as an introduced species. Because MBML 2144 was preserved directly in ethanol, it may also be suitable for future molecular analyses to further evaluate its taxonomic identification. Nevertheless, the limited number of records does not allow us to determine whether the species is broadly established, naturally rare, or locally threatened in Panama. Additional targeted surveys are therefore needed to assess its distribution, abundance, population status, and potential threats. Past ichthyological efforts in western Panama heavily prioritised the main channels of major river systems, which are characterised by deeper waters, higher water velocities, and open substrates. However, lebiasinids are highly specialised, cryptic fishes that exhibit an ecological preference for primary and secondary low-order streams, low-velocity littoral margins, shallow backwaters, and seasonal marginal pools with dense accumulations of leaf litter and submerged riparian structures (Bussing 1967, 1987, 1998; Weitzman and Weitzman 2003; González-Gutiérrez 2021). Because these minor, peripheral aquatic habitats were consistently bypassed or under-sampled in historical surveys, populations of *L. boruca* probably remained undetected. This suggests that some low-order streams in western Panama remain insufficiently sampled.

The occurrence of the species in an agriculturally modified landscape also warrants further assessment. Intensive agriculture, livestock ranching, riparian clearing, and agrochemical runoff may affect freshwater habitats in western Chiriquí (Jaén et al. 2016; Morales-Saldaña et al. 2026). Because the known localities are outside legally protected areas, targeted monitoring is needed to evaluate the species' distribution, habitat requirements, and conservation status in Panama.

Acknowledgements

We gratefully acknowledge MarAlliance for its continued support of scientific research and conservation initiatives in Panama, which contributed to the development of this manuscript. Facultad de Ciencias del Mar of the Universidad Marítima Internacional de Panamá and the Museo de Zoología of the Universidad de Costa Rica provided laboratory facilities, equipment, and materials necessary for the morphometric analyses of examined specimens and the processing of biological samples. Special thanks are extended to Ricardo Brenes for his interest in the freshwater fishes of Chiriquí and to Alexander Rojas for his valuable support of fisheries-related work in Chiriquí.

Additional information

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

Fish handling and specimen preservation followed accepted ethical practices for ichthyological research. One specimen was euthanised and preserved as a voucher specimen to document the occurrence of the species in Panama. The voucher specimen was deposited in the Museo de Biología Marina y Limnología "Luis Howell Rivero" (MBML), Universidad de Panamá.

Use of artificial intelligence (AI)

The authors accept full responsibility for the content of the manuscript, including the disclosure of any use of AI. No AI tools were used in the preparation of this manuscript.

Funding

This study was supported by research projects C1125 and B6773-23, funded by the Vicerrectoría de Investigación of the University of Costa Rica through the Centro de Investigación en Ciencias del Mar y Limnología (CIMAR) and the Centro de Investigación en Biodiversidad y Ecología Tropical (CIBET). Additional funding was provided by MarAlliance through internal funds and by UMIP through research funds from the Faculty of Marine Sciences

Author contributions

Conceptualization: AFT, AA. Data curation: AA, EMS, SOC, MAP. Formal analysis: AFT, AA, ADA, EMS, SOC, MAP, AC. Funding acquisition: AFT, AA, ADA. Investigation: AFT, AA. Methodology: AFT, AA. Resources: AFT, AA, ADA. Supervision: AFT, AA, ADA. Visualization: AC, AFT, AA. Project administration: AFT. Software: AC, AA. Validation: AA, ADA. Writing – original draft: AFT. Writing – review and editing: AFT, AA, ADA.

Author ORCID iDs
Andrés Emiliano Fraiz-Toma https://orcid.org/0000-0001-5677-5292
Arturo Angulo https://orcid.org/0000-0002-4587-1446
Arturo Dominici-Arosemena https://orcid.org/0000-0002-2467-4814
Sergio Othón-Chirú https://orcid.org/0009-0003-4602-784X
Miguel Ramón Agames Pérez https://orcid.org/0009-0006-1257-6543
Antonio Clemente https://orcid.org/0000-0002-6505-9076
Emiliano Montoya-Sanchez https://orcid.org/0009-0006-1794-8940

Data availability
All data that support the findings of this study are available in the main text.

References

Angulo A (2021) New records and range extensions to the Costa Rican freshwater fish fauna, with an updated checklist. Zootaxa 5083: 1–72. https://doi.org/10.11646/zootaxa.5083.1.1

Angulo A, Garita-Alvarado CA, Bussing WA, López MI (2013) Annotated checklist of the freshwater fishes of continental and insular Costa Rica: additions and nomenclatural revisions. Check List 9: 987–1019. https://doi.org/10.15560/9.5.987

Angulo A, Molina-Arias A, Murase A, Miyazaki Y, Bussing WA, López M (2015) Fishes from the Tusubres river basin, Pacific coast, Costa Rica: checklist, identification key and photographic album. Check List 11: 1666. https://doi.org/10.15560/11.3.1666

Angulo A, San Gil-León J, Oviedo-Soto A, Abarca-Odio JI, Umaña-Villalobos G (2020) The fishes from the Coto river basin, Pacific coast, Costa Rica. Check List 16: 345–365. https://doi.org/10.15560/16.2.345

Briceño J, Martínez JA (1986) Ictiofauna del río Chiriquí. In: Hernández D, D'Croz L (Eds.) Evaluación ecológica del río Chiriquí en relación a la construcción de la represa hidroeléctrica Edwin Fábrega. Informe Técnico, IRHE–Universidad de Panamá, Panamá, Panama, 41–56.

Bussing WA (1967) New species and new records of Costa Rican freshwater fishes with a tentative list of species. Revista de Biología Tropical 14: 205–249.

Bussing WA (1987) Peces de las aguas continentales de Costa Rica / Freshwater fishes of Costa Rica. Editorial Universidad de Costa Rica, San José, Costa Rica, 271 pp.

Bussing WA (1998) Peces de las aguas continentales de Costa Rica / Freshwater fishes of Costa Rica. Editorial Universidad de Costa Rica, San José, Costa Rica, 468 pp.

Cuvier G, Valenciennes A (1847) Histoire naturelle des poissons. Tome dix-neuvième. Suite du livre dix-neuvième. Brochets ou Lucioïdes. Livre vingtième. De quelques familles de Malacoptérygiens, intermédiaires entre les Brochets et les Clupes. Bertrand, Paris, France, xix + 544 pp., pls. 554–590.

Eschmeyer WN (1998) Catalog of fishes. Special Publication of the Center for Biodiversity Research and Information 1(1–3). California Academy of Sciences, San Francisco, USA, 2905 pp.

Esri (2026) ArcGIS Pro. https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview. Accessed on: 2026-6-10.

Fink WL, Weitzman SH (1974) The so-called cheirodontin fishes of Central America with descriptions of two new species (Pisces: Characidae). Smithsonian Contributions to Zoology 172: 1–46. https://doi.org/10.5479/si.00810282.172

Fricke R, Eschmeyer WN, Van der Laan R (2026) Eschmeyer's catalog of fishes: genera, species, references. California Academy of Sciences. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. Accessed on: 2026-6-17.

Garcés HA (2016) Distribución de los peces de agua dulce del río Está, provincia de Chiriquí, Panamá. Puente Biológico 8: 1–12.

Garcés HA, García J (2007) Inventario ictiológico en la cuenca del río Balsas, Parque Nacional Darién, Panamá. Tecnociencia 9: 23–40.

Garcés HA, García J (2023) Distribución de los peces de agua dulce del Parque Nacional Darién y áreas de influencia. Tecnociencia 25: 45–62.

GBIF (2026) GBIF occurrence download. https://doi.org/10.15468/dl.e7huvm. Accessed on: 2026-6-8.

González-Gutiérrez R (2021) Elementos de los peces dulceacuícolas de Panamá. Ed. Rigoberto González Gutiérrez, Panamá, Panama, 290 pp.

Goodyear RH, Montenegro E (1987) Los peces del río Caldera, Chiriquí, República de Panamá: distribución y abundancia relativa. Informe Técnico. Centro Regional Universitario de Chiriquí, Universidad de Panamá, David, Panama. https://biota.wordpress.com/2007/07/10/los-peces-del-rio-caldera-chiriqui-republica-de-panama/?utm_source=chatgpt.com. Accessed on: 2026-3-8.

Goodyear R, Martínez V, Del Rosario JB (1976) Los peces del río Chiriquí y afluentes principales. Biota Panamá, Universidad de Panamá, Panamá, Panamá. https://biota.wordpress.com/2008/04/25/los-peces-del-rio-chiriqui-y-afluentes-principales/?utm_source=chatgpt.com. Accessed on: 2026-3-8.

IMHPA (Instituto de Meteorología e Hidrología de Panamá) (2021) Cuencas hidrográficas de Panamá. https://www.imhpa.gob.pa/es/cuencas-hidrograficas-panama. Accessed on: 2026-6-9.

Jaén AJ, Samaniego L, Villarreal Á (2016) Aspectos socioeconómicos y factores que limitan la producción de sandía en Alanje y Progreso, Chiriquí, Panamá. Tecnociencia 18: 45–60.

Jenkins JA, Bart HL Jr, Bowker JD, Bowser PR, MacMillan JR, Nickum JG, Rachlin JW, Rose JD, Sorensen PW, Warkentine BE, Whitledge GW (2014) Guidelines for the use of fishes in research. American Fisheries Society, Bethesda, Maryland, United States, 90 pp. https://doi.org/10.47886/9781934874394

Köppen W (1931) Grundriß der Klimakunde. W. de Gruyter, Berlin, Germany, 388 pp. https://doi.org/10.1515/9783111667751

Loftin HG (1965) The geographical distribution of freshwater fishes in Panama. PhD thesis, Florida State University, Tallahassee, USA, 245 pp.

Marshall JS (2007) The geomorphology and physiographic provinces of Central America. In: Bundschuh J, Alvarado GE (Eds.) Central America: geology, resources and hazards. Taylor & Francis, London, United Kingdom, 75–121.

Meek, SE, Hildebrand SF (1916) The fishes of the fresh waters of Panama. Field Museum of Natural History (Publication 191), Zoological Series 10 (15): 217–374. https://doi.org/10.5962/bhl.title.13853

Menezes NA, Weitzman SH (1990) Two new species of *Mimagoniates* (Teleostei: Characidae: Glandulocaudinae), their phylogeny and biogeography and a key to the gladulocaudin fishes of Brazil and Paraguay. Proceedings of the Biological Society of Washington 102: 380–426.

Morales-Saldaña JM, Guzman HM, Leung B (2026) Assessing the drivers of nitrogen fertilizer application in Panama to support sustainable nutrient management. Journal of Environmental Management 397: 128371. https://doi.org/10.1016/j.jenvman.2025.128371

Netto-Ferreira AL (2010) Revisão taxonômica e relações interespecíficas de Lebiasininae (Ostariophysi: Characiformes: Lebiasinidae). PhD thesis, Instituto de Biociências, Universidade de São Paulo, São Paulo, Brazil, xix + 460 pp.

Netto-Ferreira AL, Oyakawa OT, Zuanon J, Nolasco JC (2011) *Lebiasina yepezi*, a new Lebiasininae (Characiformes: Lebiasinidae) from the Serra Parima-Tapirapecó mountains. Neotropical Ichthyology 9: 767–775. https://doi.org/10.1590/S1679-62252011000400008

Rojas JRR, Rodríguez O (2008) Diversidad y abundancia ictiofaunística del río Grande de Térraba, sur de Costa Rica. Revista de Biología Tropical 56: 235–248.

Smith SA, Bermingham E (2005) The biogeography of lower Mesoamerican freshwater fishes. Journal of Biogeography 32: 1835–1854. https://doi.org/10.1111/j.1365-2699.2005.01370.x

Weitzman M, Weitzman SH (2003) Lebiasinidae. In: Reis RE, Kullander SO, Ferraris CJ Jr (Eds.) Checklist of the freshwater fishes of South and Central America. EDIPUCRS, Porto Alegre, Brazil, 241–251.