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Range extension for *Lacantunia enigmatica* Rodiles-Hernández, Hendrickson & Lundberg, 2005 (Siluriformes, Lacantuniidae) in the Usumacinta river basin, Guatemala

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Abstract
The Lacantun Catfish, *Lacantunia enigmatica*, is reported for the first time in the Usumacinta river basin in Guatemala. Two specimens were collected in the Usumacinta tributaries Río La Pasión and Río Negro, which are characterized by seasonally fast-flowing deep channels and high fluctuations in water-level. We present a map with new records, and a brief description, and images of the specimens collected.

Key words
Central America, endemic species, Lacantun Catfish, Usumacinta ichthyological province.

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Introduction

The Lacantun Catfish or madre juil, *Lacantunia enigmatica* Rodiles-Hernández, Hendrickson & Lundberg, 2005, is endemic to the Usumacinta river basin. It belongs to the monotypic family Lacantuniidae, which is part of a "multi-family clade of African freshwater catfishes" that diverged during the mid-Eocene (Lundberg et al. 2007). Historically, *L. enigmatica* has been found in habitats such as deep river channels, rocky pools with strong eddy currents, and stream mouths in the Río Lacantún, part of the Usumacinta river basin, Mexico (Fig. 1) (Rodiles-Hernández et al. 2005). However, *L. enigmatica* is a seldom-collected species (Lozano-Vilano et al. 2007), and no other published locations have been reported to our knowledge. In Mexico, it is listed as a conservation priority by the Secretariat of Environment and Natural Resources (known as SEMARNAT by its Spanish acronym), because of its endemic status, few known specimens, and lack of conservation assessment (SEMARNAT 2015). However, it is not included in the IUCN Red List (IUCN 2017).

The Usumacinta river basin is divided between Guatemala and Mexico, with 58% of the basin in northwestern Guatemala and 42% of the basin in Mexico (March and Fernández 2003). Together with the Grijalva river basin, this region forms the Grijalva-Usumacinta area of endemism, which has at least 57 endemic fish

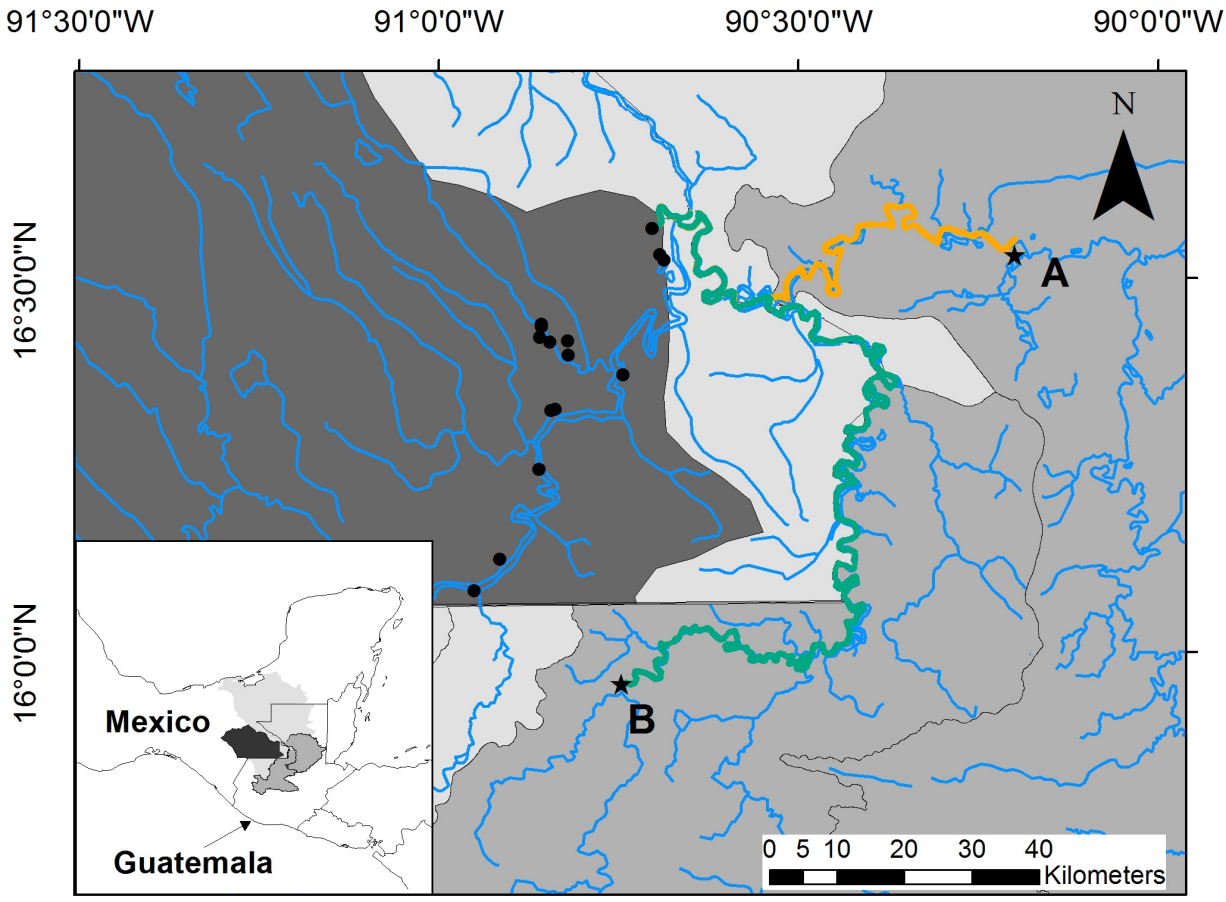

Figure 1. Distribution of *Lacantunia enigmatica* in the Usumacinta river basin. Black stars indicate the new locations reported at (A) Río La Pasión and (B) Río Negro. Black dots indicate previous location reported by Rodiles-Hernández et al. (2005). Orange and green lines represent the distance from the nearest point Arroyo Caribe, Río Lacantun, Mexico to the new localities. The Usumacinta river basin is represented in grey: the Lacantun River subbasin is represented in dark grey, the Río La Pasión subbasin (upper area) and Río Negro subbasin (bottom) are represented in middle grey, the light grey area indicates the lower Usumacinta basin.

species (Matamoros et al. 2015). However, many species reported in this area of endemism have not yet been reported from the poorly sampled upper Usumacinta in Guatemala, but they could also occur there. The upper Usumacinta basin is within different categories of protected areas in Guatemala and Mexico, with differing management regimes. However, the basin's unique fishes are at risk in both countries from threats such as habitat loss, disruption of the ecosystem dynamics, introduction of non-native species (Willink et al. 2000, Amador-del Ángel and Wakida-Kusunoki 2014, Barrientos et al. 2018, Soria-Barreto et al. 2018), and extraction of natural resources (Schwartz 1990).

We present 2 new localities for *L. enigmatica* in the upper Usumacinta river basin, in Guatemala. This discovery highlights the need for research in the Usumacinta river basin to clarify the geographic ranges of its endemic fish species (e.g. *Pseudoxiphophorus cataractae* (Rosen, 1979), *P. obliquus* (Rosen, 1979), *Maskaheros argenteus* (Allgayer, 1991), and *Wajpamheros nourissati* (Allgayer, 1989)).

Methods

We carried out an ichthyological survey in the upper Usumacinta river basin in Guatemala between January and March 2016. The survey included 20 locations in lotic and lentic ecosystems within the tributaries Río San Pedro, Río La Pasión, and Río Negro (also known as Chixoy or Salinas), in the departments of Petén, Quiche, and Alta Verapaz. Fish were collected using complementary fishing gears appropriate for each habitat type. Streams were sampled with backpack electrofishing gear (Samus SUM725) and a 2 m × 8 m seine. Deep river channels were sampled with 20 mm mesh size cast nets. We also interviewed fishermen and fishmongers in local markets, because their area of work encompasses deep channels that we were not able to sample with our fishing gear.

The collection of specimens and tissue samples was done following the Guidelines for the Use of Fishes in Research by the American Fisheries Society (Use of Fishes in Research Committee 2014). The specimens were photographed and measured in the field and were preserved in a solution of 10% formalin and later transferred to a solution of 70% ethanol. All the specimens collected were accompanied by tissue samples preserved in 70% ethanol for subsequent DNA analysis. We measured the specimens with a measuring tape and electronic caliper, following Rodiles-Hernández et al.

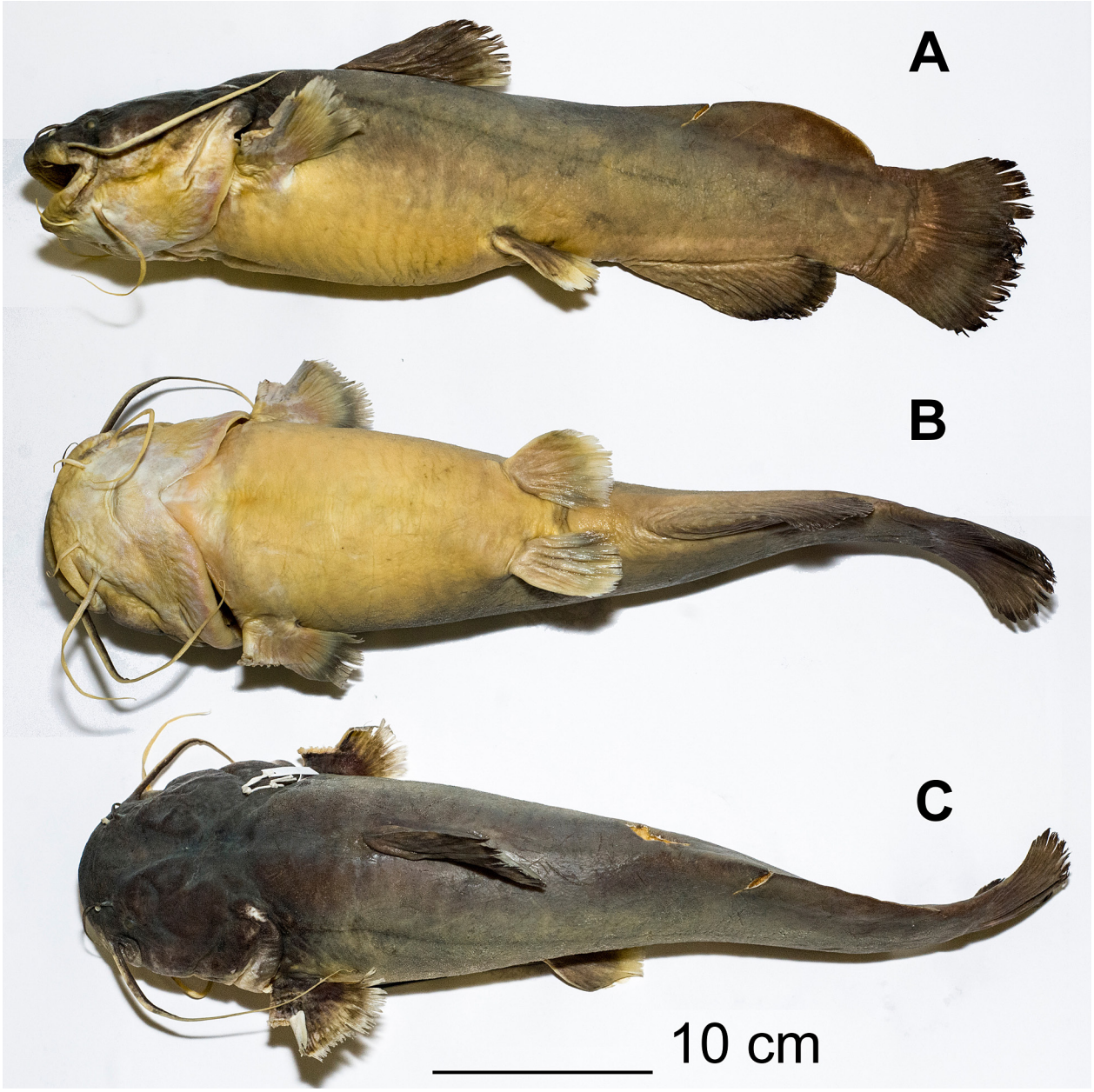

Figure 2. *Lacantunia enigmatica*. **A.** Robust body in lateral view. **B.** Ventral view. **C.** Dorsal view. USAC 2421, 370.0 mm SL.

(2005). The collection permit used in this project was granted by the Consejo Nacional de Areas Protegidas (CONAP No. 14/2015). The specimens were register in the ichthyological collections of El Colegio de la Frontera Sur, San Cristóbal (ECOSC), and the University of San Carlos de Guatemala (USAC).

Results

New records. ECOSC 12608, 1 adult female, 372.0 mm SL, Guatemala, Quiché Department, Playa Grande, Ixcán, Río Negro tributary, 15°59.18′ N, 090°46.89′ W; 180 m elev.; Rocio Rodiles-Hernández, Christian Barrientos, & Yasmín Quintana collectors, 18 March 2016. USAC 2421, 1 adult, 370.0 mm SL, Guatemala, El Petén Department, Sayaxché, Río La Pasión tributary, 16°31.76′ N, 090°11.41′ W; 125 m elev.; Rocio Rodiles-Hernández, Christian Barrientos, & Yasmín Quintana collectors, 17 March 2016.

Identification We identified specimens as *L. enigmatica* by their robust body and brown color when fresh (Fig. 2A). Additional characters used were: the truncated caudal fin with rounded corners (Fig. 2A); the maxillary barbel inserted above the lip remote from the corner of mouth (Fig. 2B, C); widely separated nostrils (Fig. 2C); nasal barbels present on anterior rim of posterior nostrils (Fig. 2C); upper lip lacking accessory folds parallel to premaxillary teeth; dorsal-fin soft rays from 8 to 10 and 6 pelvic rays (Rodiles-Hernández et al. 2005). Morphometric characters are described for the specimen collected from the Río La Pasión and compared with the holotype and 10 paratypes (Table 1). The specimen collected in Río Negro was 372.0 mm SL and identified to be a mature female with oocytes present. However, we did not conduct all the metrics on this last specimen because it was eviscerated by the fishermen before we

Table 1. Measurements for *Lacantunia enigmatica* collected in Río La Pasión (Catalog number USAC 2421).

Measurement	Holotype (mm) ECOSC 3859	Paratypes range (*n*=10)*	USAC 2421 (mm)
Standard length	427.0	223.0–427.0	370.0
Prepectoral length	153.0	333.0–455.0	80.0
Predorsal length	109.0	225.0–339.0	126.0
Head length, bony	110.0	246.0–313.0	82.0
Head length, gill membrane	116.0	255.0–336.0	93.0
Head depth at eye	45.0	80.0–130.0	48.0
Head depth at occiput	54.0	94.0–161.0	63.0
Body depth at dorsal-fin origin	82.0	146.0–221.0	83.0
Posterior cleithral process	21.0	46.0–81.0	23.0
Caudal peduncle depth	43.0	95.0–140.0	55.0
Snout length	42.0	94.0–121.0	30.0
Eye diameter, horizontal	8.0	17.0–30.0	7.0
Eye diameter, vertical	7.0	15.0–28.0	6.0
Eye to posterior nostril	8.0	16.0–26.0	10.0
Bony interorbital	57.0	125.0–168.0	51.0
Eye to posterior margin of bony opercle	66.0	143.0–205.0	55.0
Snout to anterior nostril	10.0	21.0–34.0	10.0
Width between anterior nares	42.0	87.0–114.0	34.0
Width between posterior nares	44.0	92.0–128.0	36.0
Anterior to posterior nares distance	5.0	10.0–17.0	4.0
Gape width	72.0	164.0–234.0	70.0
Premaxillary width	32.0	60.0–99.0	54.5
Lowe jaw to gular fold	28.0	57.0–69.0	26.0
Maxillary barbel length	120.0	279.0–462.0	127.0
Nasal barbel length	38.0	86.0–157.0	50.0
Outer mental barbel length	72.0	169.0–332.0	85.0
Inner mental barbel length	26.0	61.0–103.0	23.0
Width between inner mental barbel	31.0	68.0–96.0	29.0
Width between outer mental barbel	52.0	121.0–185.0	51.0
Posterior margin of bony opercle to dorsal-fin origin	59.0	127.0–167.0	49.0
Dorsal-spine length, bony	11.0	26.0–57.0	15.0
Dorsal-spine length, entire	54.0	119.0–179.0	47.0
Longest (4th) dorsal-fin ray	60.0	130.0–202.0	44.0
Dorsal-fin base	53.0	111.0–167.0	48.0
Dorsal-fin end to adipose-fin origin	100.0	135.0–262.0	69.0
Adipose-fin length	99.0	232.0–370.0	108.0
Adipose-fin height	15.0	31.0–55.0	21.0
Pectoral-spine length, bony	29.0	60.0–108.0	19.0
Pectoral-spine length, entire	57.0	132.0–179.0	38.0
Longest (2nd) pectoral-fin ray	65.0	145.0–215.0	43.0
Width at pectoral-spine insertions	100.0	219.0–278.0	86.0
Longest (3rd) pelvic-fin ray	51.0	16.0–170.0	41.0
Width between pelvic-fin insertions	50.0	105.0–151.0	43.0
Anal-fin to pelvic-fin origins	123.0	261.0–417.0	167.0
Pectoral-fin to pelvic-fin origins	77.0	146.0–252.0	109.0
Anal-fin height	51.0	112.0–175.0	44.0
Anal fin to anus	40.0	67.0–141. 0	31.0
Urogenital papilla to anal fin	32.0	57.0–116.0	40.0
Caudal peduncle length	52.0	116.0–178.0	45.0
Anal-fin base	81.0	173.0–249.0	74.0
Adipose-fin end to middle caudal-fin rays	31.0	67.0–99.0	30.0
Length of middle caudal-fin rays	50.0	117.0–199.0	50.0
Dorsal-fin to pectoral-fin origins	87.0	198.0–260.0	78.0
Dorsal-fin to pelvic-fin origins	105.0	218.0–300.0	99.0
Dorsal-fin end to pectoral-fin origin	122.0	263.0–386.0	107.0
Dorsal-fin end to pelvic-fin origin	74.0	152.0–208.0	75.0
Dorsal-fin end to anal-fin origin	115.0	249.0–352.0	102.0
Adipose-fin to pelvic-fin origins	110.0	195.0–305.0	85.0
Adipose-fin to anal-fin origins	71.0	143.0–188.0	63.0
Adipose-fin origin to anal-fin end	88.0	206.0–312.0	104.0
Adipose-fin end to anal-fin origin	124.0	268.0–377.0	114.0
Adipose-fin to anal-fin ends	53.0	119.0–161.0	52.0

* Paratypes with standard length in mm and other measurements expressed in thousandths of standard length (Rodiles-Hernández et al. 2005).

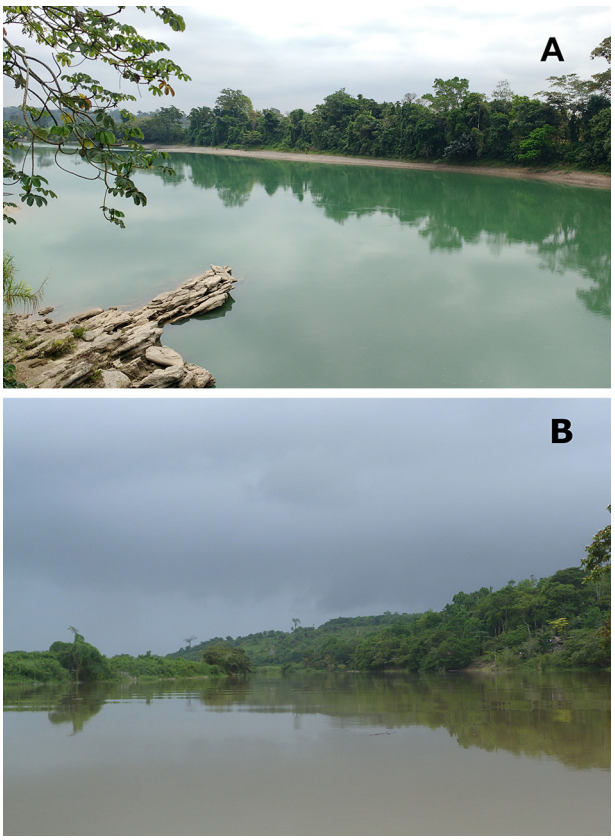

Figure 3. Landscape view of the new locations reported in Guatemala. **A**. Río Negro, Ixcán, and **B.** Río La Pasión, Sayaxché.

had access to it. Also, it was deformed due to the evisceration and handling during storage.

We collected the specimens from fish markets next to the Río Negro (Figs 1, 3A) and Río La Pasión tributaries (Figs 1, 3B) where they were caught by fishermen. The Río Negro tributary has a surface area of 12,150 km^2 with turquoise-colored river channels, sulfur springs, and dam infrastructure. The Río La Pasion tributary has a surface area of 35,854 km^2 with deep channels and trophic levels ranging from mesotrophic to eutrophic (Ixquiac 2016). Both rivers are surrounded by dense urban areas and are subject to artisanal fisheries.

Discussion

According to our findings, *L. enigmatica* occurs in the headwaters of the Usumacinta River in Guatemala, including the Río Negro and Río La Pasión tributaries. Historically, *L. enigmatica* was found in the Río Lacantún, Mexico. These new reports expand the range of this species by approximately 240 km to the Río Negro and 126 km to the Río La Pasión from the nearest point in Arroyo Caribe in Río Lacantún, Mexico, following the course of the river. The localities reported here are at 180 m (Río Negro) and 125 m (Río La Pasión) above sea level, which is consistent with historical records of *L. enigmatica* in Río Lacantún and its tributaries of Río Chajulillo, Río Tzendales, and Rio Lacanjá (Rodiles-Hernández et al. 2005, http://www.fishnet2.net/) where it is known to occupy an elevation range between 100 and 450 m (Rodiles-Hernández et al. 1999). The Usumacinta River (1,000 km in length) is within the Grijalva-Usumacinta area of endemism (Miller 1966, Matamoros et al. 2015), and thus, many endemic species have potential distribution among the many tributaries within the upper and lower basin. Many generalist or detritivorous species have a broad distribution in the Usumacinta (e.g. *Astyanax* spp., *Vieja bifasciata* (Steindachner, 1864), and *Thorichthys pasionis* (Rivas, 1962)), and we therefore suggest that *L. enigmatica* could be present in the lowlands of the Xacibal and Ixcán tributaries in the upper Usumacinta basin, especially given their connectivity to and distance from the species' type locality in Río Lacantun. The Xacibal and Ixcán subbasins could contain important microhabitats for many endemic species; however, a lack of exploration and ichthyological survey work in this area makes it difficult to evaluate for management decisions. There has been only sporadic research in the last 60 years (Quintana et al. 2016).

Previous research shows that *L. enigmatica* inhabits rocky stretches and deep pools with eddies (Rodiles-Hernández et al. 2005). However, the new localities reported here are deep river channels with high water-level fluctuations and vary from mesotrophic to eutrophic. Although the upper and middle Usumacinta river basin contains similar habitat types, Río La Pasión and Río Negro (Fig. 3A, B) do not have the typical rocky pools or eddies, which are preferred by this species, such as those found in the Río Lacantún subbasin and its tributaries. These findings suggest that the range of potential habitats for *L. enigmatica* may be greater than previously thought.

The uncertainty about the occurrence of *L. enigmatica* in the Usumacinta river basin can be explained by the cryptic nature of this species and the lack of ichthyological studies in the upper basin (Velázquez-Velázquez et al. 2016, Soria-Barreto et al. 2018). Moreover, most of the previous studies are biased by location access and/or sampling gear, as usually happens with biodiversity surveys (Boakes et al 2010, Wehi et al. 2012). For example, *L. enigmatica* was not captured with electrofishing, cast net, or seine, but we found the specimens by interviewing local fishers and fish sellers. The interviews allowed us to collect data from gear used (i.e. gillnets) and the habitat fished. We also observed that compared with other catfishes (i.e. *Ictalurus meridionalis* (Günther 1864), *Rhamdia* spp., *Cathorops* spp., *Potamarius* spp.), *L. enigmatica* is uncommon in the local fisheries, as we only observed 2 specimens in March, which corresponds to the dry season in the region (Instituto Nacional de vulcanología, meteorología e hidrología 2018). Other studies also reported low abundandes of *L. enigmatica* in the Río Lacantun (Lozano-Vilano et al. 2007), which supports making this species a high priority for conservation (Velázquez-Veláquez et al. 2016).

The discovery of the family Lacantuniidae and *L. enigmatica* is one of the most important recent findings

in the field of ichthyology, as it is common to describe new species but not new families that are "enigmatic" in origin (Lozano-Vilano et al. 2007). The occurrence of *L. enigmatica* in the upper Usumacinta basin continues highlighting the richness and endemism of fish species along the complex mosaic of habitats existing there. The Usumacinta basin harbours 172 species (Soria-Barreto et al. 2018), and has, in combination with the Grijalva basin, 58 endemic species (e.g. *Kihnichthys ufermanni* (Allgayer 2002), *Maskaheros argenteus* (Allgayer 1991), *Wajpamheros nourissati* (Allgayer, 1989), and *Rheoheros lentiginosus* (Steindachner, 1864)) (Matamoros et al. 2015, Soria-Barreto et al. 2018). However, several threats are present in the basin, such as impoundment, land use changes, pollution, invasive species, and unregulated fisheries, which might contribute to the imperilment of native fishes, including population decrease or displacement (Willink et al. 2000, Amador-del Ángel and Wakida-Kusunoki 2014, Barrientos et al. 2018, Mendoza-Carranza et al. 2018). In agreement with Mexican regulations for the protection of *L. enigmatica*, Guatemalan authorities should consider giving it special protected status.

Although the north Guatemalan ichthyofauna is considered well explored (Valdez-Moreno et al. 2005), Central American freshwater ecosystems are considered as only moderately known as compared to other world regions (Abell et al. 2008). Conducting more research in the upper Usumacinta basin, especially the areas less explored such as the Xacibal and Ixcán subbasins will be beneficial to increase our knowledge of species distribution, existent microhabitats, and potential threats to the basin and its biodiversity. Additionally, there is a need for assessment of conservation needs for this endemic region.

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Authors' Contributions

YQ collected specimens, and wrote and revised the manuscript; CB collected specimens and revised the manuscript; RRH: collected and identified the specimens, and revised the manuscript.

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