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FIRST RECORD OF THE NON-NATIVE PACU, *PIARACTUS BRACHYPOMUS*, IN LAGO PETÉN-ITZÁ, GUATEMALA, CENTRAL AMERICA

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ABSTRACT

We documented the first record of the non-native species *Piaractus brachypomus* (Characiformes: Serrasalminidae) in Lago Petén-Itzá, Petén, Guatemala. One brined specimen was donated by a local fisherman in San Benito, El Petén. The captured specimen was reportedly collected in the southern basin of the lake. We used the mitochondrial gene cytochrome oxidase I (COI) to validate identity of the specimen. We hypothesize that the local aquarium trade is the most likely source of introduction of the non-native Pacu in Lago Petén-Itzá.

RESUMEN

Documentamos el primer registro de la especie no nativa *Piaractus brachypomus* (Characiformes: Serrasalminidae) en el lago Petén Itzá, Petén, Guatemala. Un espécimen colectado en la cuenca sur del lago por pescadores locales de San Benito, Petén nos fue donado. La identificación a nivel de especie fue realizada utilizando el gen mitocondrial citocromo oxidasa I (COI). Hipotetizamos que individuos provenientes de acuarios ornamentales son la fuente más plausible de la introducción del pez no nativo Pacu en el lago Petén Itzá.

KEY WORDS: Serrasalminidae, Northern Central America, Exotic, Petén Lake district

INTRODUCTION

The family Serrasalminidae (Characiformes) is a group of freshwater fishes containing 94 recognized species (Eschmeyer and Fong 2017). These fishes, commonly known as pacus and piranhas, are native to South America and possess a wide range of feeding strategies from predatory piscivory, fin and scale biting, to omnivory (e.g., invertebrates, leaves, algae, fruits, and seeds; Goulding 1980; Winemiller 1989; Correa et al. 2007). Differences in trophic guilds have been associated with differences in morphological characters related to alimentation such as tooth shape and number (Goulding 1980; Ortí et al. 2008).

The genus *Piaractus* (family Serrasalminidae) contains two species: *P. brachypomus*, distributed in the Orinoco and Amazon river basins across Argentina, Bolivia, Brazil, Colombia, Peru, and Venezuela (Eschmeyer et al. 2017), and *P. mesopotamicus*, which

occurs in the Paraguay-Parana river basin in Argentina, Bolivia, Brazil, Paraguay, and Uruguay (Eschmeyer et al. 2017). Both species are highly valued in the global aquarium (Nico et al. 2017) and aquaculture industries (Singh 2014; Ramos-Valladão et al. 2016) and consequently have been introduced outside their native range (e.g., Europe, United States of America, Southeast Asia, India and Colombia; Howells 2001; Cagauan 2007; Leunda 2010; Čaleta et al. 2011; Restrepo-Santa Maria and Alvarez-León 2013; Correa et al. 2014).

Lago Petén-Itzá is a lake located in the karstic region of El Petén in northern Guatemala (Curtis et al. 1998; Brenner et al. 2002; Anselmetti et al. 2006). The lake, located in an endorheic basin, is some 100 km² in area and can be divided into two major zones: the northern basin, which is up to 160 meters deep and the shallower southern basin that reaches only 50 meters (Fig. 1; Anselmetti et al. 2006). Twenty-two native (Brenner et al. 2002; Barrientos 2015)

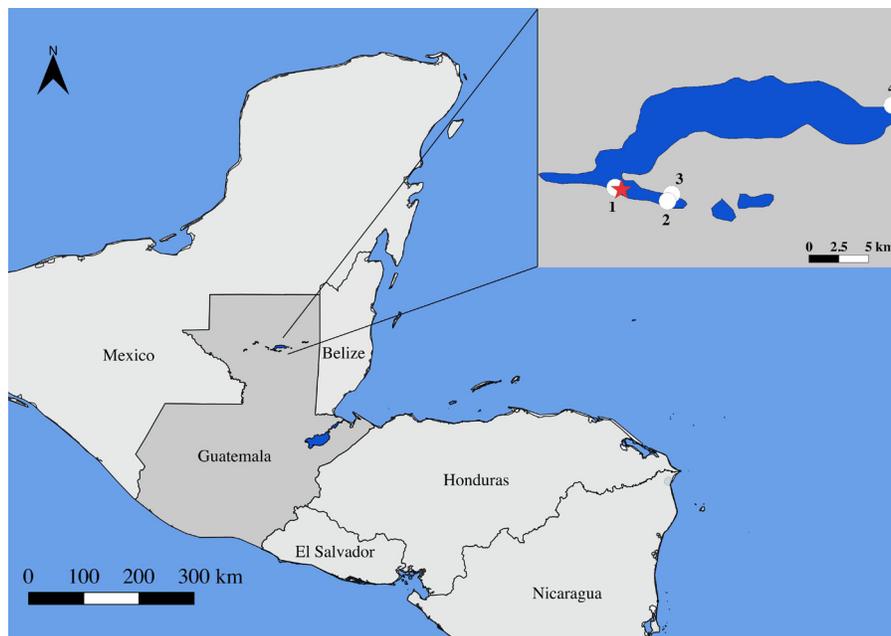


Figure 1: Location of Lago Petén-Itzá in northern Guatemala. Sampling localities (white dots) are: San Benito (1), Aereopuerto (2), Petencito (3), and El Remate (4). The red star corresponds to the approximate area where the fisherman collected the initial specimen of *P. brachypomus* (FMNH 131894), as well as the area where the other two Pacus were caught and reported by local fisherman.

and two non-native species of freshwater fishes (*Oreochromis niloticus* and *Pterygoplichthys* sp.) are reported from the lake (Barrientos 2015). We document the presence of introduced *Piaractus brachypomus* (Serrasalminidae) in Northern Guatemala.

MATERIALS AND METHODS

Fieldwork – During a recent trip to Lago Petén-Itzá, fishermen in the southern basin of the lake commented to the authors (DJE and CDM) they had recently caught a type of fish that they had never before observed. One of the fish was brined and preserved (salted) by a fisherman and donated to the authors (Fig. 2). The specimen was washed to eliminate the salt and tissue samples of muscle were preserved in 95% ethanol. The specimen was formalin fixed and deposited in the Collection of Fishes at The Field Museum of Natural History (FMNH 131894).

On the 4th and 5th of March 2017, we conducted six sampling (collecting) events in Lago Petén-Itzá at four localities: three in the southern basin and one in the northern basin (Fig. 1). Collecting events were conducted during the morning, afternoon, and night using three collection methods (cast net, seine, and gillnets). Cast net and seine were each used for two hours per locality while gillnets (300m in length) were set at noon and at dawn for three hours and checked every hour (Table 1).

One of the main sources of introduction reported for non-native species is the release of ornamental/aquarium fishes (Duggan et al. 2006; Cagauan 2007; Nico et al. 2017). We visited three pet stores selling ornamental fishes around the vicinity of the lake, one of which sold juvenile *Piaractus* resembling the species collected by the fisherman. We obtained an individual, euthanized it, and removed the right pectoral fin and stored it in 95% ethanol for molecular analysis (Fig. 3). The voucher specimen was preserved in 10% formalin (FMNH 131895).

Molecular analysis – Whole genomic DNA was extracted from the two tissue samples using a Qiagen DNeasy Tissue kit. The mitochondrial cytochrome oxidase I gene (COI) was amplified and sequenced in both forward and reverse directions using the primers BOL-F and BOL-R (Ward et al. 2005) via polymerase chain reaction (PCR) in 25 μ L reactions. The PCR protocols follow Ward et al. (2005). Amplification products were visualized on a 1% agarose gel, purified with ExoSAP-IT, and sequenced on an ABI 3730 in the Pritzker Laboratory for Molecular Systematics and Evolution at The Field Museum of Natural History. Sequences for the two pacu specimens were compared with sequences on GenBank using the BLAST algorithm (Altschul et al. 1990; Johnson et al. 2008).

Table 1: Collecting events in Lago Petén-Itzá with three different methods: cast net (C), seine (S), and gillnets (G). Sampling localities: San Benito (1), Aereopuerto (2), Petencito (3), and El Remate (4).

Sampling locality	Morning	Afternoon	Night
1	C,S		G
2		C,S,G	G
3		C,S,G	
4	C,S		



Figure 2: Specimen of *Piaractus brachypomus*, collected by fishermen in Lago Petén-Itzá (FMNH 131894).

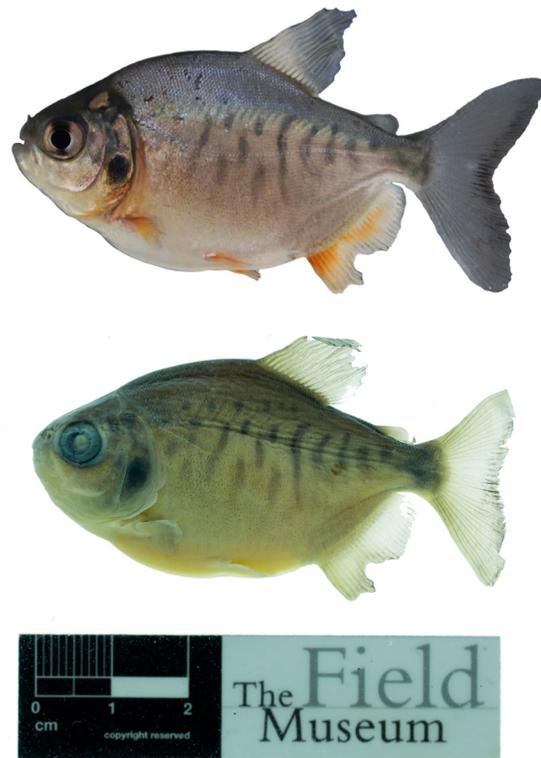


Figure 3: Specimen of *Piaractus brachypomus* (FMNH 131895) purchased from pet store in Santa Elena, Peten near Lago Petén-Itzá showing live coloration (A) and coloration after preservation (B).

RESULTS AND DISCUSSION

During our fieldwork, we collected a total of 14 species of native freshwater fishes in Lago Petén-Itzá (Table 2), but did not collect a single specimen of *Piaractus brachypomus*. Approximately a month after our field expedition, a fisherman caught two additional pacu individuals according to a local Guatemalan newspaper (Escobar 2017). These individuals were collected in the southern basin of Lago Petén-Itzá (Fig. 1); the same region where the initial specimen reported here was collected, and where we conducted our sampling efforts.

Table 2: Species collected in Lago Petén-Itzá during fieldwork 4-5 March 2017.

Family	Genus species
Atherinopsidae	<i>Atherinella alvarezii</i>
Characidae	<i>Astyanax aeneus</i>
	<i>Hyphessobrycon compressus</i>
Heptateridae	<i>Rhamdia guatemalensis</i>
Poeciliidae	<i>Poecilia mexicana</i>
	<i>Gambusia sexradiata</i>
	<i>Gambusia yucatanana</i>
Cichlidae	<i>Thorichthys affinis</i>
	<i>Mayaheros urophthalmus</i>
	<i>Vieja melanura</i>
	<i>Petenia splendida</i>
	<i>Parachromis friedrichsthalii</i>
	<i>Trichromis salvini</i>
	<i>Cribroheros robertsoni</i>

Two rows of teeth in the premaxilla are diagnostic of the family Serrasalminidae (Ortí et al. 2008; Thompson et al. 2014). Poor preservation of the donated specimen from the fisherman made examination of morphological characters difficult. However, we identified two rows of teeth on the premaxilla of FMNH 131894. COI sequence data for the two pacu specimens were 632 base pairs in length and identical (GenBank accession number MG754202 for FMNH 131894 and MG754201 for FMNH 131895). Based on Blast matches, the sequences were identical to sequences of *P. brachypomus* from the Orinoco River archived in GenBank (Escobar L. et al. 2015).

Since there are no records of members of Serrasalminidae being used for aquaculture in Guatemala (OSPESCA 2012, FAO 2014), we do not consider this as a likely source of introduction of the specimen collected in Lago Petén-Itzá. A more plausible source is the aquarium trade (Duggan et al. 2006) around the lake. Lago Petén-Itzá is a popular tourist destination, with many hotels and restaurants. Some of these establishments possess artificial ponds that sometimes contain non-native species (Barrientos 2015), making them a potential source of introduction through accidental escape during severe weather or intentional release (Duggan et al. 2006).

There were differences in the size (standard length) of the specimen of *P. brachypomus* collected by the fishermen and the fishes we observed in the aquarium trade in the area surrounding the lake (Figs. 2-3). Pacus for sale were juveniles (Fig. 3), but fishes of similar size to the specimen caught by fisherman were observed on display in a pet store. The difference in size and the two additional records of this species in Lago Petén-Itzá (Escobar 2017) suggests that all the specimens were released/escaped at a smaller size and grew in the lake.

CONCLUSIONS

Effects of introductions of non-native species in ecosystems

can have severe ecological impacts such as displacement, competitive exclusion, and extirpation of native species (Mooney and Cleland 2001). *Piaractus brachypomus* occupies a unique trophic guild (fruits/seeds) in its natural range. However, Correa et al. (2014) indicate that an established population of the *P. brachypomus* in Papua New Guinea has drastically changed their diet from fruits and seeds to piscivory (likely carrion and not predation) and aquatic vegetation. This dietary plasticity towards aquatic vegetation is a potential threat to native species in Lago Petén-Itzá, where fishes possess a strong relationship with the littoral zone and aquatic vegetation that provides critical habitat for reproduction and growth (Barrientos and Allen 2008; Barrientos 2015). A potential shift in the diet of an introduced population of this species could have negative effects on the lake's native biodiversity. This shift could also have a direct impact on the artisanal fisheries of the lake, which typically target cichlids (e.g., *Petenia splendida*, *Mayaheros urophthalmus*, *Vieja melanura*, *Parachromis friedrichsthalii*; Barrientos 2015; Quintana 2015). These cichlids use aquatic vegetation in Lago Petén-Itzá for food and shelter (Barrientos 2015).

There is currently no evidence that *P. brachypomus* has an established population in Lago Petén-Itzá (e.g., no records of breeding individuals in the lake); however, there has not been a direct effort to intensively sample the shore and areas with vegetation. Nevertheless, the evidence presented here clearly documents the introduction of this species in Lago Petén-Itzá. We conclude that this introduction is in its early stages, and based on the invasive potential for this species (Correa et al. 2014) and others (e.g., *Pterygoplichthys* spp.) in the region (Kihn et al. 2006; Wakida-Kusunoki et al. 2006; Wakida-Kusunoki and Amador-del-Angel 2008; Barrientos 2015; Wakida-Kusunoki et al. 2016), we suggest there is an urgent need to evaluate the extent of these introduced populations and eradicate them from the lake.

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