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Short Communication

New record of two established populations of *Lepomis cyanellus* Rafinesque (1819) (Centrarchidae) from the state of Querétaro, Central Mexico

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Introduction

Invasive exotic species have long been considered one of the mayor threats to freshwater systems and species loss in Central Mexico (Lyons et al., 1998; Mercado-Silva et al., 2006; Domínguez-Domínguez et al., 2008). One of these exotics is the green sunfish, *Lepomis cyanellus* Rafinesque (1819), originally found in the central region of the United States, southern Canada and Mexico's northwest region, on the Atlantic slope in the Río Bravo basin (Miller, 2005).

Lepomis cyanellus has been introduced in more than 30 US states (Page and Burr, 1991), as well as overseas (Welcomme, 1988; Ma et al., 2003; Halos et al., 2004; Soes et al., 2011; Froese and Pauly, 2014). It was mainly introduced as forage for black bass (*Micropterus dolomieu*), for sport fishing and aquaculture (Dill and Cordone, 1997; USGS, 2013), where it has had a negative impact on native fish, other vertebrates and aquatic macro-invertebrates (Hayes and Jennings, 1986; Karp and Tyus, 1990; Rosen et al., 1995; Lohr and Fausch, 1996; Dudley and Matter, 2000; Olden and Poff, 2005; CABI, 2014).

The economical use of *L. cyanellus* has favored their translocation to several reservoirs in northeast Mexico, where it has shown a great capacity to disperse, colonize and become established in the lotic systems that feed these reservoirs (Ruiz-Campos et al., 2014). For the central region of Mexico, its presence has been mentioned in lotic systems of the Lerma basin in the state of Guanajuato (Mercado-Silva et al., 2009), however no scientific records exist at present. One specimen of *L. cyanellus* was reported previously for the Santa Catarina Reservoir in the state of Querétaro (Díaz Pardo, 1998), but there is no information on the length, sex or maturation stage of the specimen. We report here for the first time the presence of two well-established populations of *L. cyanellus* from Presa del Carmen and Quiotillos, both in the state of Querétaro. This also represents a range extension of this species in Mexico.

Material and methods

During a project on temporal variation of fish communities in lotic systems in the Lerma-Chapala and Pánuco River basins we captured 14 *L. cyanellus* specimens on 26 June 2014, in the Arroyo Grande stream, near the discharge site of the Presa del Carmen reservoir, located near Santa María de los Baños, in the municipality of El Marqués (20°48′35.86″N; 100°18′30.40″E); an additional six specimens were captured near the discharge site of the Quiotillos Reservoir in the municipality of Amealco de Bonfil (20°18′06.5″N, 100°09′03.7″O), both in the state of Querétaro (Fig. 1). Backpack electrofishing was used (maximum potency 600 W; 120 volts, 60 Hz, 20.8 amp). The specimens were identified as *L. cyanellus* Rafinesque based on the taxonomic criteria of Miller (2005), preserved in 70% ethyl alcohol, and deposited in the Ichthyologic collection 'Dr. Edmundo Díaz Pardo' of the Natural Science Faculty, Universidad Autónoma de Querétaro. All specimens were weighed (scale accuracy 0.01 g), measured (caliper accuracy 1 mm) and sexed after preservation. The maturation phase of each individual was assigned based on the macroscopic features proposed by Brown-Peterson et al. (2011).

Results

For the Presa del Carmen sample, the standard length (SL) of *L. cyanellus* was 104 ± 31 mm and the mean weight 150 ± 8 g. For the Quiotillos sample, the SL was 92 ± 19 mm and the weight 22 ± 12.61 g. In both locations, we found specimens of both sexes in all phases of maturation (Table 1).

The non-native species, *Heterandria bimaculata* Heckel (1848) was also present in Presa del Carmen. Their co-occurrence seems to be rare, because the introduction source for this Central American species is different from that of *L. cyanellus*. The presence of *H. bimaculata* is probably due to inadvertent introductions from the aquaria trade. A total of 36 specimens of both sexes and in all phases of maturation were collected. The SL was 41 ± 9 mm and mean weight 1.56 ± 1.29 g. The native species, *Goodea atripinnis* Jordan (1880), was also collected in the same locality.

Habitat characteristics of both sampling areas were: 1.2 ± 0.1 m maximum depth, water flow lower than 0.1 $m \cdot s^{-1}$ and water temperature 22.1 ± 2°C at time of

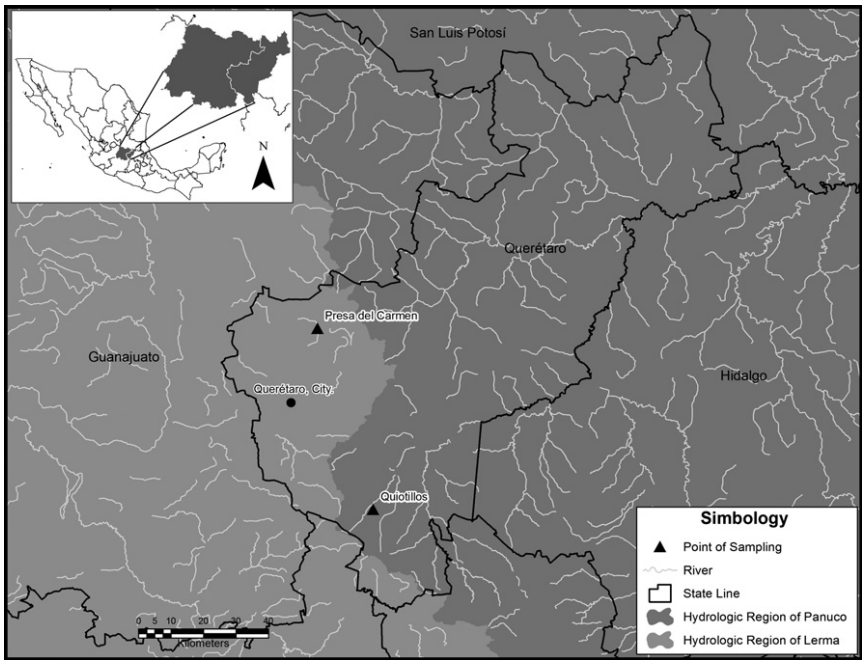

Fig. 1. Sampling sites of Lepomis cyanellus in the state of Querétaro, Central Mexico.

Table 1
Standard length and weight for all maturation phases of *Lepomis cyanellus* captured in Presa del Carmen (14 individuals) and Quiotillos (six individuals), respectively

Site	Maturation phase	NI	SLR	SL	WR	W
PC	Immature	6	65–79	69 ± 5	8.1–15.9	10.86 ± 3.93
	Developing	5	97–135	109 ± 14	34.5–102.3	62.58 ± 23.11
	Spawning-capable	2	110–145	128 ± 25	50.2–143.8	97 ± 66.19
	Regressing	1	150	150	150.9	150.9
QT	Developing	1	69	69	8	8
	Spawning-capable	4	81–113	92 ± 15	15.5–37.5	9.17 ± 10.68
	Regressing	1	115	115	38	38

PC, Presa del Carmen; QT, Quiotillos; NI, Number of individuals; SLR, Standard Length Range (mm); SL, Standard Length (mm ± SD); WR, Weight Range (g); W, Weight (g ± SD).

capture. Fish were captured in pools having a heterogeneous substrate (aquatic plants, roots, rocks, hollows) and rocky bottom, with the surrounding riparian vegetation consisting of secondary growth and urban-crop land use at both sites.

Discussion

The presence of *L. cyanellus* in both locations reflects a history of an increase in introductions of exotic fish species in Mexico, particularly during the last decades of the 20th Century (Mendoza and Koleff, 2014). The Ley General de Pesca y Acuacultura Sustentable (General Law of Sustainable Fishing and Acuaculture) in Mexico makes it possible to grant permits to introduce non-native species in freshwater bodies with no previous risk studies (Ortiz Monasterio, 2014). Basically, anyone can introduce exotic species without permission and suffer no legal consequences. This has facilitated the spread of several invasive species, such as *L. cyanellus*, in various freshwater bodies within Mexico.

The presence of reproductive adults with such short lengths (92–153 mm SL) was unexpected when compared to the size of adults (305 mm SL) reported by Scott and Crossman (1973) in Kansas, U.S. This is consistent with those presented by Carlander (1977), who reported adults maturing between minimum lengths of 45 and 66 mm SL for the U.S. and Canada. Mean water temperature in both locations (22.1 ± 2°C) is above the minimum necessary (18°C) to stimulate gonadal maturation (rapid gametogenesis) in this species (Kaya and Hasler, 1972), which could explain the presence of developing and spawning adults.

Negative effects caused by invasive species begin with the establishment of a population (Lockwood et al., 2007), the result of a successful reproduction (Copp et al., 2005), and evidenced by the presence of fish of different sizes and gonadal maturity stages, as was found at our two sites. For this reason, this new record of established *L. cyanellus* populations represents an important risk factor to the native aquatic biota, which can lead to further ecosystem degradation.

The introduction of *L. cyanellus* outside its natural range of distribution is cause for concern, given its negative impact records (decline of native populations and local

extinctions) in many freshwater systems (CABI, 2014). In the present case, the effect of this fish on the local species diversity and ecosystem function in both streams is unknown. Also unknown is in how many other water bodies in the region *L. cyanellus* is present and whether it dispersed from other lotic systems or was via one or several deliberate introductions.

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