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THE INVASIVE ARMORED SUCKERMOUTH CATFISH *PTERYGOPLICHTHYS PARDALIS* (SILURIFORMES: LORICARIIDAE) AS PART OF THE DIET OF THE DOUBLE-CRESTED CORMORANT *PHALACROCORAX AURITUS* (PHALACROCORACIDAE) IN TWO TROPICAL REGIONS OF MEXICO

EL PEZ BAGRE INVASIVO *PTERYGOPLICHTHYS PARDALIS* (SILURIFORMES: LORICARIIDAE) COMO PARTE DE LA DIETA DEL CORMORAN *PHALACROCORAX AURITUS* (PHALACROCORACIDAE) EN DOS REGIONES TROPICALES DE MÉXICO

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ABSTRACT

The armored suckermouth catfish *Pterygoplichthys pardalis* (Castelnau 1855) is an invasive fish species in several regions in Mexico, including the fluvial lagoon systems of the state of Campeche in southeastern and in Mazatlán, Sinaloa in northwestern of the country. Although several studies have mentioned the negative impacts of this invasive fish in the aquatic environment, few reports exist about the natural predators that may help to control these fish populations. In this study, we investigate the feeding predation by double-crested cormorants *Phalacrocorax auritus* (Lesson, 1831) on *P. pardalis* in the Palizada River, southeast of the Gulf of Mexico, and in the the Laguna del Camarón in northwestern Mexico. The evidence of feeding found in stomach contents of these birds indicates that feeding habits might being adapted to changes in the resident fish community after the introduction of armored suckermouth invasive catfish to this new aquatic environments, with the birds exploiting a new food source as a component of their diet.

Keywords: birds – invasive species – diet – biological control – Pacific – Gulf of Mexico – Mexico

RESUMEN

El bagre *Pterygoplichthys pardalis* (Castelnau 1855) es una especie de pez invasivo en varias regiones de México, incluidos los sistemas de lagunas fluviales del estado de Campeche en el sureste y en Mazatlán, Sinaloa, en el noroeste de este país. Aunque varios estudios han mencionado los impactos negativos de este pez invasor en el medio acuático, existen pocos informes sobre los depredadores naturales que pueden ayudar a controlar estas poblaciones de peces. En este estudio, investigamos la depredación por alimentación de peces *P. pardalis* por cormoranes de doble cresta *Phalacrocorax auritus* (Lesson, 1831) en el río Palizada, al sureste del Golfo de México y la laguna del Camarón en el noroeste de México. La evidencia de alimentación encontrada en el contenido estomacal de estas aves puede indicar que los hábitos de alimentación podría adaptarse a los cambios en la comunidad de peces residentes después de la introducción del bagre invasivo a estos nuevos ambientes acuáticos y las aves están explotando una nueva fuente de alimento como componente de su dieta.

Palabras clave: aves - especies invasoras - dieta - control biológico - Pacífico - Golfo de México - México

INTRODUCCIÓN

The armored suckermouth catfish *Pterygoplichthys pardalis* (Castelnau 1855) (Loricariidae) is native to Amazon River basin of Brazil and Peru (Burgess, 1989). This fish was reported as an invasive species in Mexico since the 1990s (Guzmán & Barragán, 1997) and is currently distributed in several regions of the country (Castillo-Capitán *et al.,* 2014). The impacts of its introduction include reduction of commercial fish species, alteration of fish population structure, disruption of aquatic food chains, competition with native species regarding reproduction and feeding, mortality of threatened coastal birds and changes in aquatic plant communities (Bunkley-Williams *et al.* 1994; Wakida-Kusunoki *et al.,* 2007; Zworykin & Budaev, 2013). Although several studies have mentioned the negative impacts of this invader in the aquatic environment (Hossain *et al*., 2018), few reports exist about the natural predators that may help to control these fish populations in the receipt environment (Nico, 2010; Toro-Ramirez *et al*., 2014; Ríos-Muñoz, 2015).

The aim of the present study was to describe that the armored suckermouth fish *P. pardalis* is part of the diet of the double-crested cormorant *Phalacrocorax auritus* (Lesson, 1831) in freshwater systems of two regions of Mexico (the Palizada del Este River, southeastern- Mexico and Camaron Lagoon or ¨Laguna del Camaron", northwestern- Mexico) where this invasive fish reaches high densities (Wakida-Kusunoki *et al.,* 2007). This study contributes to knowledge of alternative fish eating bird species that could potentially help to reduce the populations of invasive fish species through their consumption.

MATERIALS AND METHODS

Fifteen stomach content of *P. auritus* individuals were analyzed and *in vivo* observations of feeding behavior was recorded using a Nikon camera. Birds were obtained (from June 2013 to March 2015) from ´the Palizada del Este´ river system, Campeche (southeastern Mexico) (18º23'39" N–91º47'02" W). Birds specimens were sacrificed by decapitation to ensure a fast dead, which is according to Mexican laws (NOM-033-ZOO-1995) and were transported in individual plastic bags in a cool box to the El Carmen Research Unit. Moreover, in the ´Laguna del Camaron´, Sinaloa, (northwestern Mexico) (23°14'16"N–106°26'28"W) (Fig. 1). Evident *in vivo* observations showed the eating behavior of *P. auritus* was conducted in March 2016. The stomach of each bird was removed and the food content was identified (Fig. 2). Fish identification was performed in accordance with Page & Robins (2006). Complete fish recovered were measured (total length, mm) and weighed (g).

RESULTS

From the total examined stomachs, seven of them were empty and six contained identifiable contents (Table 1). *Pterygoplichthys pardalis* was found in over 40% of birds examined in which prey were recognizable. Six entire fish and twenty-three fragments were identified (Fig. 2); two of the fish had asize of~250 mm and in four fish it ranging from 150.to - 170 mm. The weight ranged from 69.to 130 g. In the Laguna del Camaron, individuals of *P. auritus* were observed feeding during the day (around 10:00 am) on *P. pardalis* individuals (Fig. 3).

DISCUSSION

Non-native fish have been found in the diet of fish-eating birds (including Phalacrocoracidae species) and others native piscivorous animals, in both Europe and North America (Johnson *et al*., 2010). In the present study *P. pardalis* is reported as part of the diet of cormorant *P. auritus* in two Mexican regions. This may be due to its

opportunist feeding habits depending on the species of fish that are available (Neuman *et al.*, 1997), as well as to the substantial increment of the densities of *P. pardalis* in the study areas. This suggests that populations of *P. pardalis* in the zone could be higher in relation to other local fish species. In accordance with Wakida-Kusunoki & Amador-del Angel (2011) introduced *Pterygoplichthys* species have become more abundant relative to native fish species, representing up to 41% of the total catch. The high densities and swimming behavior (buoyancy and aerial respiration) of these invasive fish possibly make them an ideal forage base for native piscivorous birds with the potential to influence resident's predator behavior.

This loricariid fish species has also been found to be a main dietary item of piscivorous fishes such as *Centropomus undecimalis* (Bloch, 1792), *C. poeyi* Chávez, 1961 and *Megalops atlanticus* Valenciennes, 1847, two top predators in the Palizada River (Toro-Ramírez *et al.,* 2014; Wakida-Kusunoki & Toro-Ramírez, 2016). Also, in a study conducted in Thailand where it was demonstrated that the bagrid catfish *Hemibagrus wyckioides* (Fang & Chaux, 1949) and the marbled sleeper *Oxyeleotris marmorata* (Bleeker, 1852) were potential predators of juvenile *P. pardalis* (0.6–10 cm total length [TL]) (Chaichana & Jongphadungkiet, 2012). In the southeastern Mexico the only report of predation of armored suckermouth invasive catfish by native fish eating birds was the report elaborated by Rios-Muñoz (2015) who observed that the Neotropic cormorant *P. brasilianus* (Gmelin, 1789) was feeding on juvenile fish *Pterygoplichthys*. In northwestern Mexico this is the first time that a predator of *P. pardalis* is documented, in this case *P. auritus*.

In other regions outside Mexico (such as Florida, USA), it has also been reported to *P. auritus* feeding on juvenile *P. disjunctivus* (Nico, 2010). The evidence of consumption of *P. pardalis* by cormorants indicate that these native predators have adapted to changes in the fish community after the introduction of this invasive catfish and are exploiting this new food resource as a component of this diet. Nevertheless, additional field investigation about the cormorant populations and the revision of more stomach content is needed to determine the capacity of the cormorant as a potential predator of this invasive fish.

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Table 1. Data summary on the abundance of *Pterygoplichthys pardalis* on stomach contents of the double-crested Cormorant *Phalacrocorax auritus* at Palizada River, Campeche during the period 2013-2015.

L (mm)	CD	NBE	TNSI	NSW	TNF
910	20 -06- 2013	1	1	0	1
830	10 -11- 2013	2	2	1	1
960	12 -02- 2014	3	3	2	2
960	24 -04- 2014	3	3	1	1
990	29 -01- 2015	3	3	1	1
850	10 -03- 2015	3	3	1	1

L, Bird length; CD, Collection date; NBE, Number of birds examined; TNSI, Total number stomachs w/ identifiable contents; NSW, Number stomachs w/ *P. pardalis* (proportion of total); TNF, Total number fish (*P. pardalis*).

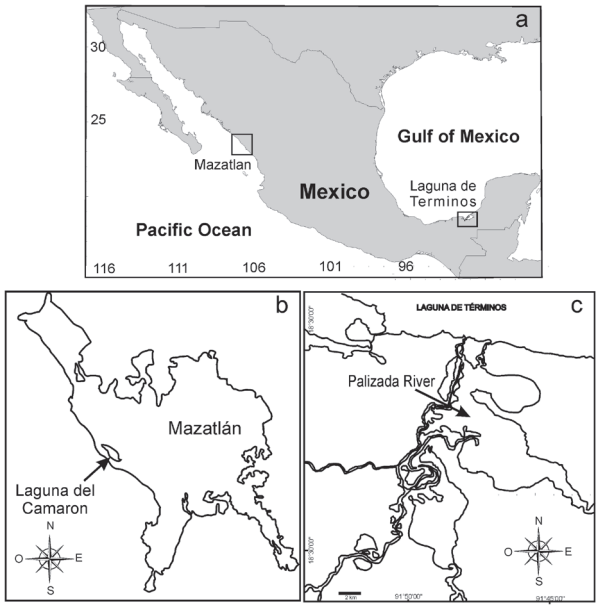

Figure 1. a) Location of the study areas in Mexico. b) The Shrimp Lagoon (Laguna del Camaron) Mazatlan, Sinaloa (northwestern Mexico) and c) Palizada River, Campeche (southwestern Mexico).

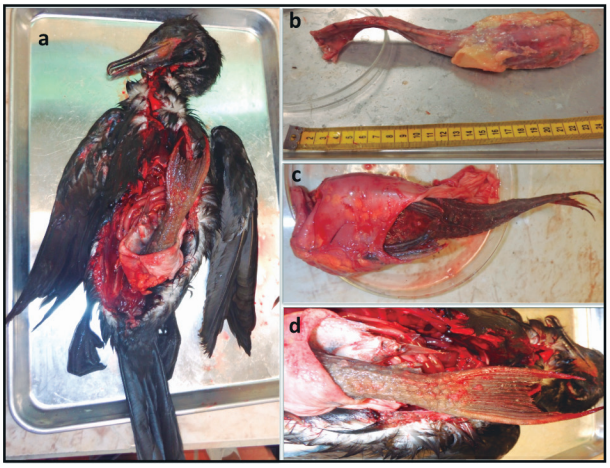

Figure 2. *Pterygoplichthys pardalis* found in the stomach of the double-crested Cormorant *Phalacrocorax auritus* from Palizada River, Campeche, Mexico. a) Specimen of *P. auritus* dissected. b) A stomach completely occupied with a *P. pardalis* individual. c) *P. pardalis* semi-digested and d) strongly digested.

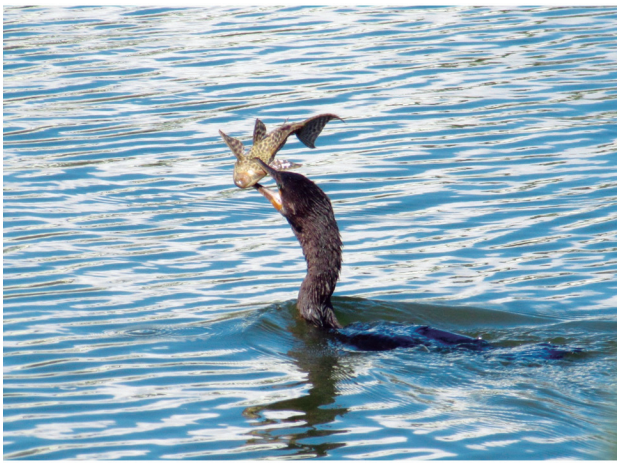

Figure 3. The double-crested cormorant catching an armored suckermouth catfish *P. pardalis* at the Shrimp Lagoon, Sinaloa, Mexico. (Picture taken by Santos-Guzmán S. in March 2016).

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