BioInvasions Records (2021) Volume 10, Issue 3: 691–700

Rapid Communication

First records of a non-native spotted raphael catfish *Agamyxis pectinifrons* (Cope, 1870) (Siluriformes: Doradidae) in the floodplain of the Grijalva basin

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Citation: Álvarez-Pliego N, Garrido-Mora A, Sánchez AJ, Salcedo MA, Florido R (2021) First records of a non-native spotted raphael catfish *Agamyxis pectinifrons* (Cope, 1870) (Siluriformes: Doradidae) in the floodplain of the Grijalva basin. *BioInvasions Records* 10(3): 691–700, https://doi.org/10.3391/bir.2021.10.3.19

Received: 17 November 2020
Accepted: 26 May 2021
Published: 23 July 2021

Handling editor: Luciano Santos
Thematic editor: Michal Janáč

Abstract

These are the first records of the spotted raphael catfish *Agamyxis pectinifrons* in a Mexican basin. Three adult specimens, two female and one undetermined, were collected in the floodplain of the Grijalva river near the Metropolitan Zone of Villahermosa. The presence of catfish is likely due to releases by aquarists. Whether this non-native catfish is able to settle and spread in the floodplain of the Grijalva basin is uncertain. If established, this detection will indicate another step in continuous increase in non-native catfish species in Mesoamerican basins dominated originally by native cichlid and poeciliid species.

Key words: Usumacinta province, ornamental fish, alien, invasive species, wetlands

Introduction

The introduction of non-native fish into Mexico for ornamental fish markets has had a negative effect, since several of these species have become invasive and have replaced the native ichthyofauna, decreased beta diversity, and affected ecosystems (Contreras-Balderas and Escalante 1984; Contreras-Macbeath et al. 1998; Cucherousset and Olden 2011; Álvarez-Pliego et al. 2015; Espinosa-Pérez and Ramírez 2015; Mendoza et al. 2015). A number of South American Siluriformes species, known mostly as armoured and thorny catfishes (families Locariidae and Doradidae), have been commercialized as ornamental species, since the aquarium market found their anatomical characteristics attractive (Arce et al. 2013; Guzmán-Maldonado and Lasso 2014; Mendoza et al. 2015; PlanetCatfish 2020). Their mismanagement, however, has caused them to be introduced into a great variety of aquatic systems, and some species have become invasive due to a favorable combination of biological traits and environmental factors (Williams and Meffe 1998). For example, the worldwide invasion of the suckermouth armoured catfish (*Pterygoplichthys* spp.) has been very successful (Orfinger and Gooding 2018). In the case of southeastern Mexico,

this invasive fish has spread to and colonized most of the limnetic and oligohaline environments located in the low reaches of the Grijalva-Usumacinta basin and the rivers adjacent to Laguna de Términos (Wakida-Kusunoki and Amador-del Ángel 2011; Álvarez-Pliego et al. 2015; Sánchez et al. 2015a, 2019; Soria-Barreto et al. 2018), affecting aquatic organisms, ecosystems and fisheries (Lienart et al. 2013; Mendoza-Carranza et al. 2018; Orfinger and Gooding 2018). Thus, the introduction of non-native catfish into this region is considered highly risky for the local ecosystems, habitats and species, particularly in the case of the Protected Natural Areas (CONAP 2011; USGS 2020).

The spotted raphael catfish *Agamyxis pectinifrons* (Cope, 1870) is a small species that reaches less than 15 cm of maximum standard length (Birindelli and de Sousa 2018). It is classified in the Doradidae family, and is known as "thorny catfish" or "talking catfish" as it produces sounds through the air bladder, the parapophysis of the fourth vertebra, known as the Mullerian ramus (Birindelli et al. 2009). It also presents one row of mediolateral scutes, each scute with a single posteriorly oriented spine, three pairs of barbels and a strong cephalic shield (Birindelli 2014; Birindelli and de Sousa 2018).

Agamyxis pectinifrons is endemic to the Amazon basin (Ferraris 2007; Correa et al. 2008; Arce et al. 2013; Birindelli and de Sousa 2018). It is morphologically very similar to *Agamyxis albomaculata* (Peters, 1877) that is found throughout the Orinoco river basin (Birindelli and de Sousa 2018). The latter species is also used as an ornamental fish, although there are no data on its introduction into other countries. Among other features, both species differ from other Doradidae in that they have a heart-shaped air bladder and a posterior end with small diverticula: four to six diverticula in *A. pectinifrons* and three diverticula in *A. albomaculatus* (Birindelli et al. 2009; de Sousa 2010). The introduction of the spotted raphael catfish has already been reported for South Laguna Madre, Texas, USA (Witmer and Fuller 2011; Fuller 2020), and among the non-native fauna of Guatemala (CONAP 2011), although its settlement or possible invasion in North America and Mesoamerica have not been documented yet (Fuller 2020).

This report presents the first records of *A. pectinifrons* in the floodplain of the Grijalva basin, southern Gulf of Mexico. Sightings of this species in the area have been frequent, according to fishermen, but it is currently unknown whether it has spread to other drainage areas of this basin. However, it is expected that its reproductive biology and distribution associated with structured habitats are similar to those of other Doradidae (Breder and Rosen 1966; Cordiviola et al. 2009; Wright 2009), and at the same time different from those of the suckermouth armored catfish, whose biological and management attributes have favored its invasiveness (Williams and Meffe 1998; Sánchez et al. 2015a; Orfinger and Gooding 2018;

Liang et al. 2020). Thus, the possible establishment of *A. pectinifrons* is uncertain, since it is as yet unknown how its ecological characteristics and life strategies affect direct and indirect predation interactions with native or previously introduced species, and how they may stop or favor its dispersion at different time scales (Contreras-Balderas and Escalante 1984; Olden et al. 2006; Liang et al. 2020). For this reason, taking appropriate eradication measures cannot be postponed.

Materials and methods

Study area

The sampling and sighting sites of the spotted raphael catfish are located in the Grijalva River basin, where the La Sierra and Chilapa rivers flow and their surface drainage areas merge with the Grijalva River (INEGI 2013; Sánchez et al. 2015b).

The sampling sites were located in the La Sierra River (C1; two specimens) and the Cuhy Lagoon (C2; one specimen), both situated just south of the Metropolitan Area of Villahermosa. The five sighting sites were the Zapote River (S1) near the town of Coronel Traconís, the Chilapa River (S2) near the towns of Ismate and Chilapilla, and three sites in the Grijalva River (S3, S4, and S5) near the towns of Aztlán, Acachapan-Colmena and in the El Vigia Lagoon (Supplementary material Table S1). Both collecting sites lie within the polygon of the Metropolitan Area of Villahermosa (Figure 1). The polygon formed by the collecting and sighting sites forms an area of approximately 190 km^2 (Figure 1). All the sightings and the specimens caught were carried out by fishermen of the Federación de Cooperativas Pesqueras Acuícolas y Permisionarias de Tabasco S.C. de R.L. de C.V. (acronyms used for commercial societies, where S.C. is Civil Society, R.L. is Limited Responsibility, and C.V. is Variable Capital).

On September 17th, 2020, Jorge Marin, a fisherman of Las Gaviotas cooperative, collected two specimens with a gill net on a low-energy sandy shoal at the head of a river bend. In addition, on December 6th, 2020, the fisherman Lorenzo Alcudia, from the same cooperative, collected one specimen. Fish were identified following the taxonomic keys of de Sousa (2010), van der Sleen and Albert (2018) and Birindelli and de Sousa (2018), and a paper published by Birindelli et al. (2009). The three specimens were preserved in 10% formaldehyde, photographed and measured for 19 morphometric and meristic traits (Table 1). Specimens 1 and 3 (Table 1) were weighed and dissected in order to 1) examine the stomach contents, 2) observe the morphology of the air bladder and corroborate identity (Birindelli et al. 2009; de Sousa 2010), and 3) determine the sex and state of gonadal maturity (*sensu* Núñez and Duponchele 2009). The gonads were measured with a digital caliper, weighed on a digital scale and preserved in 4% formaldehyde. The specimens were placed in the Colección Nacional

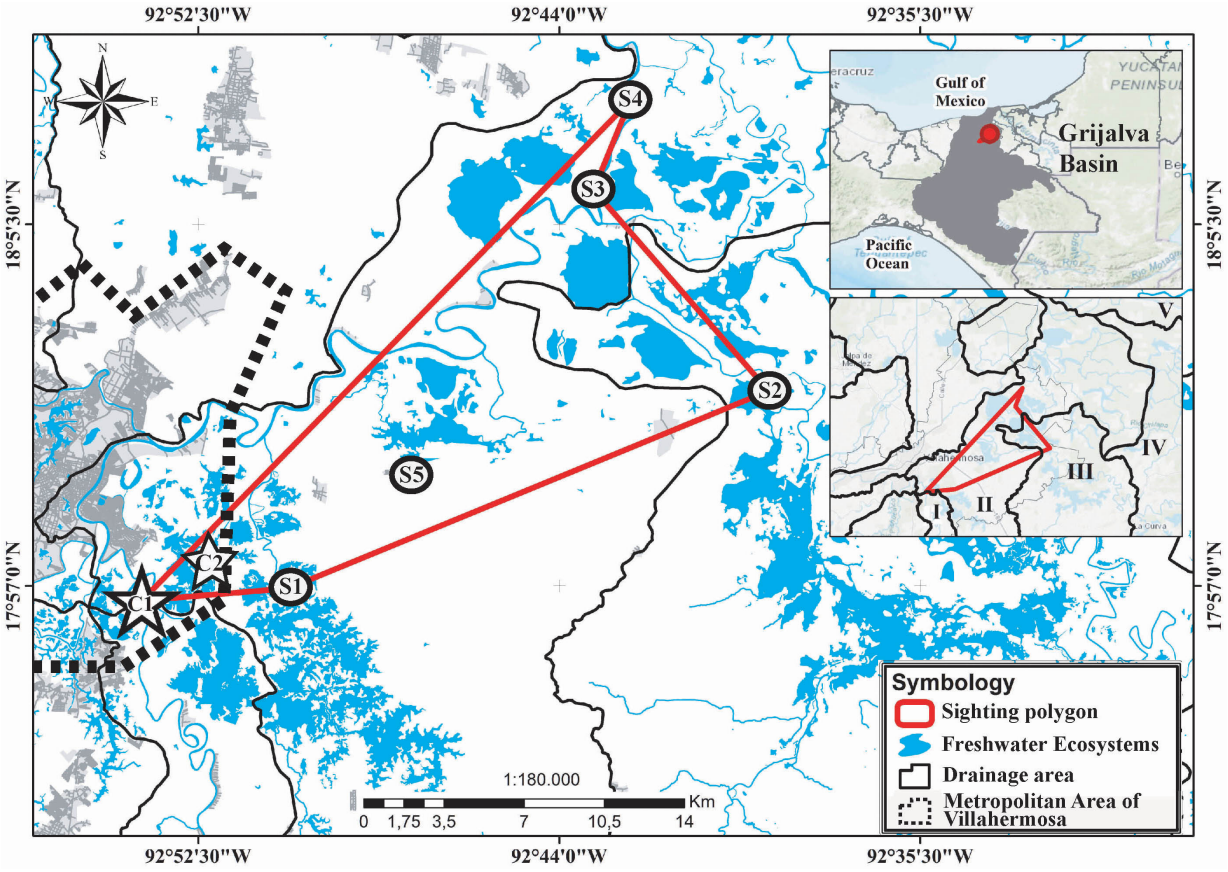

Figure 1. *Agamyxis pectinifrons* records and sightings polygon in the Grijalva river basin. C = collected, S = sightings. Drainage areas: I La Sierra River, II Grijalva River, III Chilapa River, IV Chilapilla River, V Usumacinta River. Modified from SIATL (INEGI 2013).

Table 1. Morphometric and meristic traits of the three *Agamyxis pectinifrons* specimens captured in the La Sierra River, Grijalva River basin. Morphometric measurements are expressed in millimeters.

	La Sierra River		El Cuhy Lagoon
	Specimen 1	Specimen 2	Specimen 3
Total length	172	147	170
Standard length	145	122	142
Predorsal length	67	52	59
Preanal length	101	89	102
Head length	41	40	41
Interorbital distance	19	17	18
Mouth width	19	18	19
Maxillary barbel length	57	56	49
External mental barbel length	52	48	45
Internal mental barbel length	22	31	24
Body depth	51	44	49
Dorsal fin to adipose fin distance	34	28	32
Caudal-peduncle depth	14	12	14
Adipose fin to anal fin depth	27	26	21
Dorsal fin (spines, rays)	II, 6	II, 5	II, 5
Anal fin (spines, rays)	II, 8	II, 9	II, 7
Pelvic fin (spines, rays)	I, 6	I, 6	I, 5
Pectoral fin (spines, rays)	I, 5	I, 5	I, 5
Number of lateral bony plates	27	28	27

de Peces, Instituto de Biología, UNAM, for safekeeping, each with a CNPE-IBUNAM 23799 catalogue number.

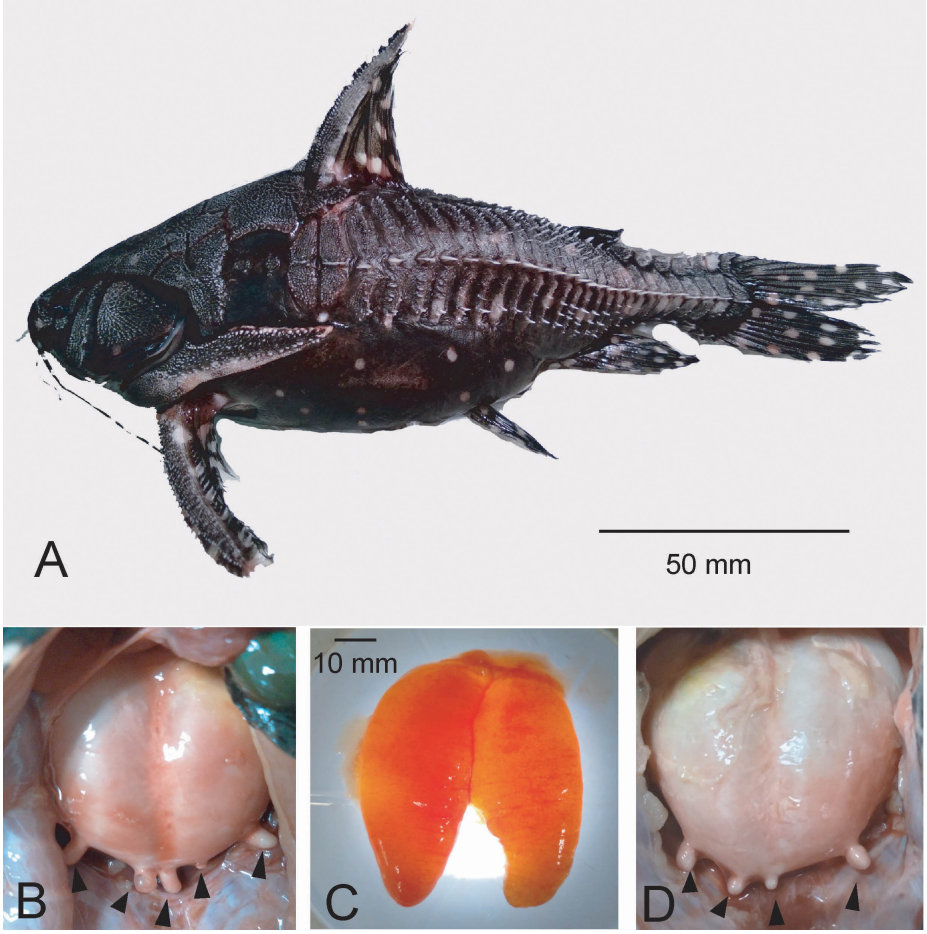

Figure 2. *Agamyxis pectinifrons* specimens collected in the La Sierra River, Grijalva River basin: A) 145 mm SL female; B) air bladder with five terminal diverticula at the posterior end ▲; C) female gonad in advanced developmental stage (CNPE-IBUNAM 23799); D) 142 mm SL female air bladder with four terminal diverticula at the posterior end ▲. Photographs by Álvarez-Pliego.

Searches through the scientific literature were carried out in order to corroborate that this is the first report on the introduction of the spotted raphael catfish into aquatic ecosystems of Mexico. Sources included Redalyc (www.redalyc.org), and ScienceDirect (www.sciencedirect.com) with the keywords "Doradidae", "*Agamixys*", "spotted raphael catfish", "North America" and "Mesoamerican". Records of *Agamixys* spp. were consulted in the FishNet2 data bases (www.fishnet2.net) that include the data base of the Colección Nacional de Peces-IBUNAM, the Global Biodiversity Information Facility (www.gbif.org), and the Sistema de Información sobre Especies Invasoras (CONABIO 2020).

Results

The three specimens were identified as *Agamyxis pectinifrons* (Figure 2A). The identification was based on and verified by 19 morphometric and meristic traits (Table 1), particularly the presence of an air bladder with four and five terminal diverticula at the posterior end (Figure 2B, D) and the pigmentation pattern which coincided in the three specimens that measured from 122 to 145 mm standard length (SL). The specimens present

27 to 28 lateral bony scutes covering the upper half of the sides of the body, starting below the second dorsal spine and ending where the caudal fin begins. Each bony scute bears a robust backward-directed medial thorn and a smaller thorn at the side. These thorns increase in number and size from scutes 12 to 20, decreasing after that. The space between the first dorsal fin and the adipose fin is smooth, while six to seven plates (i.e. procurrent rays) lie between the adipose fin and the start of the caudal fin, as well as between the anal fin and the start of the caudal fin. The posterior cleithral process extends to the lower section of the third lateral scute, and the maxillary barbels extend almost to the distal section of the posterior cleithral process. The specimens are brown with rounded spots throughout the body, and the fins are yellow. The spots on the ventral region are small (< 5 mm) and most are separated more than 10 mm on average.

The 145 mm SL and 127.1 g specimen was identified as a female. Its gonads were orange and occupied a large area of its visceral cavity, weighed 12.5 g and measured 55 mm (Figure 2C). Oocytes were visible to the naked eye and were homogeneous in size (± 1 mm). These characteristics correspond to annual spawners in a state of advanced maturation with vitellogenic oocytes. The 142 mm SL and 127.6 g specimen was also a female. Its gonads weighed 3.8 g, but its state of maturity could not be determined. No stomach content was found in both specimens.

Discussion

Agamyxis pectinifrons is a demersal fish that is commercialized as an ornamental species through removal from its natural environment (Guzmán-Maldonado and Lasso 2014; PlanetCatfish 2020). Knowledge of this species is scant. In captivity it survives in temperatures of 22–26 °C, pH 5.5–7.5 and hardness 18–357 ppm. It is nocturnal, hides in hollows or buries itself in sand during the day, while the juveniles may take refuge among the aquatic vegetation (Birindelli and de Sousa 2018; PlanetCatfish 2020; Seriously Fish 2020). In its natural distribution area, it is associated with free-floating macrophytes and flooded tropical forests during the high water level season (Correa et al. 2008).

The reproductive biology of the spotted raphael catfish is unknown, although it may be similar to that of other Doradidae. For example, in species of the genus *Platydoras*, the female is more robust than the male, fertilization is external, they form nests and exhibit paternal care (Breder and Rosen 1966; Cordiviola et al. 2009). *Agamyxis pectinifrons* has been recorded as omnivorous with a preference for invertebrates, while the adults may eat small fish (Birindelli and de Sousa 2018; PlanetCatfish 2020; Seriously Fish 2020), although the dissected specimen had no stomach content. Local fishermen have reported a numbness of the hands after handling the fish, coinciding with Wright (2009) who stated that at least one third of the Siluriformes (among them the Doradidae) are toxic or poisonous.

The available biological information on this species and other Doradidae indicates that the limnetic environments, tropical temperature (Table S1), and types of habitats (free-floating macrophytes and flooded forest) present in the Grijalva basin offer the spotted raphael catfish environmental conditions similar to those found in its natural distribution area (Correa et al. 2008). These environmental similarities support the possibility of raising the hypothesis that the establishment of this catfish might be possible, although in a different scenario from that of the suckermouth armored catfish. The lack of previous biological knowledge on *A. pectinifrons* represents a disadvantage in estimating the time required for a possible pre-adaptation that may include the displacement or elimination of a native species with similar ecological characteristics and life histories, as some authors have mentioned (Contreras-Balderas and Escalante 1984; Olden et al. 2006; Liang et al. 2020). Thus, further studies are necessary, as Fuller (2020) stated.

Considering that the Siluriforms are a dominant group in South America (van der Sleen and Albert 2018), the presence of this catfish in the Grijalva basin is considered highly risky for Mesoamerica (Orfinger and Gooding 2018; Lardizabal et al. 2020). For example, a list of non-native fish species of Guatemala reported 101 species of the Callichthydae, Doradidae, and Loricariidae families, of which 80 are considered a great threat to aquatic organisms and ecosystems (CONAP 2011). Likewise, 22 species of armored catfish have been recorded in the USA, of which 10 have already caused negative effects to the environment and other native species. In addition, Mexico has an unsustainable ornamental fish market that has commercialized around 368 freshwater species, among which 17 non-native species are considered highly risky (Mendoza et al. 2015). In this context, the implementation of initiatives for preventing and controlling non-native species, organized in 2009 (Comité Asesor Nacional sobre Especies Invasoras 2010), has been insufficient to regulate the practices of marketing and releasing of non-native species into ecosystems.

In particular, the presence of scutes with poisonous thorns (Wright 2009; Birindelli 2014) in the spotted raphael catfish could increase its abundance by reducing predation mortality as in the case of *Pterygoplichthys* spp. (Hoover et al. 2014; Orfinger and Gooding 2018). Moreover, these morphological traits have caused damage to fishing nets and economic losses to fishermen, as has been reported for *Pterygoplichthys* spp. in the Grijalva and Usumancinta basins (Ríos-Muñoz 2015; Mendoza-Carranza et al. 2018). Finally, the spotted raphael catfish is an omnivorous species (Birindelli and de Sousa 2018) similar to other invasive fish such as *Oreochromis* spp. (CONABIO 2020) that compete directly and indirectly for food resources with aquatic invertebrates and small-bodied fish (Hoover et al. 2017) such as the native and dominant Poecilids in the Grijalva Basin (Sánchez et al. 2019). Scarce information on the natural history of the

spotted raphael catfish represents an opportunity to increase knowledge of its reproductive and trophic biology in order to understand the direct and indirect effects of the potential predation on native species.

This study recommends increasing biological knowledge of non-native species, together with a socio-environmental eradication program through an extensive community monitoring in the floodplain of the Grijalva basin, in order to prevent a possible biological homogenization phenomenon (Villéger et al. 2015) through a potential future dominance of non-native catfish species in Mesoamerica, in place of that of native cichlid and poeciliid species.

Acknowledgements

We would like to thank Sergio Ramos Isidro, president of the Federación de Cooperativas Pesqueras Acuícolas y Permisionarias de Tabasco S.C. de R.L. de C.V., Andrea Raz-Guzmán, PhD., UNAM, for editorial services and the translation into English, and Ana Belen Rodríguez-Guadarrama for the preparation of the map. The manuscript was substantially improved by the suggestions of three anonymous reviewers.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Location and environmental characteristics of the *Agamyxis pectinifrons* collection and sighting sites in the Grijalva floodplain.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2021/Supplements/BIR_2021_Alvarez-Pliego_Sanchez_SupplementaryMaterial.xlsx