Presence of the Amazon sailfin catfish, Pterygoplichthys pardalis (Castelnau, 1855) (Pisces: Loricariidae), in the Shatt al-Arab River, Basrah, Iraq

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RESEARCH ARTICLE

Presence of the Amazon sailfin catfish, *Pterygoplichthys pardalis* (Castelnau, 1855) (Pisces: Loricariidae), in the Shatt al-Arab River, Basrah, Iraq

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Abstract

This paper documents the first record of the Amazon sailfin catfish, *Pterygoplichthys pardalis* (Castelnau, 1855) (Pisces: Loricariidae), in the natural waters of the Shatt al-Arab River, Basrah, Iraq, as a result of aquarium trade activities in the country. The length-weight relationships and condition factors of 175 specimens of *P. pardalis*, collected in 2017 in the Shatt al-Arab, were calculated. The studied population of *P. pardalis* showed an allometric growth, where the regression line slope b = 2.548±0.038 and the intercept a = 0.041±0.005. The average condition factor (K) was 8.802±4.208. All 175 specimens had mature gonads and the sample was dominated by females, which had eggs as large as 3.7 mm diameter in the ovaries. Fecundity varied from 2,400 to 19,245 eggs per brood. Fourty-one food items were recognised in the stomach contents, broadly categorised as follows: Algae, Crustacea, insect larvae and pupae, meiofauna, fish, fish eggs, and fish larvae. Suggestions for future studies are given, so as to correlate reproduction and diet with water level and seasonality.

Keywords: aquarium trade, condition factor, length-weight relationship, reproduction, stomach contents.

Zusammenfassung

Dieser Artikel dokumentiert den ersten Nachweis des Leopard-Segelschilderwelses, *Pterygoplichthys pardalis* (Castelnau, 1855) (Pisces: Loricariidae) in den natürlichen Gewässern des Shatt al-Arab, Basrah, Irak, als Ergebnis von Aquarienhandel in diesem Land. Die Längen-Gewichts-Verhältnisse und Konditionsfaktoren von im Jahr 2017 gesammelten 175 Exemplaren von *P. pardalis* aus dem Shatt al-Arab wurden berechnet. Die untersuchte Population von *P. pardalis* zeigte ein allometrisches Wachstum, wobei die Steigung der Regressionslinie b = 2,548±0,038 und der Achsenabschnitt a = 0,041±0,005 betrug. Der Konditionsfaktor (K) betrug im Durchschnitt 8,802±4,208. Alle 175 Exemplare hatten ausgereifte Gonaden und die Probe wurde von Weibchen dominiert, die Eier mit einem Durchmesser von bis zu 3,7 mm in den Eierstöcken aufwiesen. Die Fruchtbarkeit schwankte zwischen 2.400 und 19.245 Eiern pro Brut. Im Mageninhalt wurden einundvierzig Nahrungsbestandteile erkannt, die sich grob in die folgenden Kategorien einteilen lassen: Algen, Krustentiere, Insektenlarven und -puppen, Meiofauna, Fische, Fischeier und Fischlarven. Es werden Vorschläge für künftige Untersuchungen gemacht, um die Fortpflanzung und die Ernährung mit dem Wasserstand und der Jahreszeit zu korrelieren.

Introduction

The main causes of the dispersal of exotic fish species are aquaculture, through incorrect release of specimens, and aquariums, through improper disposal. These are responsible for the introduction of ornamental and economically important fish species into new environments (Chavez et al. 2006).

Members of the family Loricariidae, the largest family within the order Siluriformes with 80 genera and over 700 species, are characterised by their suckermouths and armoured bodies. Their natural distribution is confined to South America and Panama (Ferraris 2007), but the aquarium trade has dispersed them all over the world (Hoover et al. 2004). They are now reported in North and Central America and the Pacific Islands (Hoover et al. 2004), Southeast Asia (Page & Robins 2006; Chavez et al. 2006; Levin et al. 2008; Chaichana & Jongphadungkiet 2012; Panase et al. 2018), Japan (Nakabo 2002), Europe (Orfinger & Goodding 2018), and Turkey (Özdilek 2007). The Amazon sailfin catfish, *Pterygoplichthys pardalis*, has been reported from Bangladesh (Hossain et al. 2018), India (Sinha et al. 2010), Indonesia (Page & Robins 2006), Malaysia (Samat et al. 2005), the Philippines (Agasen 2050), Singapore (Tan et al. 2003), Puerto Rico (Grana 2007), Brazil (Weber 2003), and Peru (Ortega & Vari 1986). In the Middle East, it had so far been reported in Israel only (Golani & Snovsky 2013).

Pterygoplichthys pardalis (Castelnau, 1855) is a voracious algal feeder, which for that reason has been adopted by aquarists as a tank cleaner. Potential ecological hazards have resulted from such feeding habits, such as overgrazing of benthic algae (Chavez et al. 2006), competition with native species (Nico & Martin 2001), alteration of substrates and interruption of benthic communities (Hoover et al. 2004), and destruction of river banks through burrowing, though they have not yet been reported from lakes (Bunkley-Williams et al. 1994).

The present study reports on the presence of the Amazon sailfin catfish in the Shatt al-Arab River at Basrah, Iraq, where 175 individuals of *P. pardalis* were collected in 2017. This is the first record of this species from the freshwater system of Iraq in general and from the Shatt al-Arab River in particular.

Fig. 1. Map showing the locality of collection (arrow) of *Pterygoplichthys pardalis* (Castelnau, 1855) in the Shatt al-Arab River, Basrah, southern Iraq.

Material and methods

Study area

The Shatt al-Arab River, which originates from the convergence of the Tigris and Euphrates rivers, is the main surface water source in lower Mesopotamia and serves around three million people, the majority of which live in the city of Basrah (Mahmood & Feachem 1987). The river is widely used for human consumption, agricultural, trade and industrial activities, transportation, electric power plants, and recreation. This river suffered from a massive regression in water quality related to the decline in rates of discharge from the Tigris and Euphrates rivers (Al-Mahmood et al. 2015) as a result of several hydrological constructions in the riparian countries (Partow 2001) and of the diversion of the Karun River into Iranian territory (Hameed & Aljorany 2011). The average rate of discharge in the upper part of the Shatt al-Arab River declined from 207 m^3/s in 1977–1978 to 60 m^3/s in 2014 (Alaidani 2014). The decrease of freshwater inflow into the estuary has allowed saltwater to intrude about 80 km upstream from the river mouth (Abdullah et al. 2016). The water salinity reaches 28‰ in the mid-region of the river, whereas it reaches up to 30‰ in the lower reaches of the river at Fao city (Al-Tawash et al. 2013; Hameed et al. 2013; Yaseen 2016). A decrease of river discharge into an estuary may lead to an increase in tidal range and wave celerity, with consequent increase in salinity levels (Cai et al. 2011).

Fish specimens

One hundred and seventy-five (175) specimens of *P. pardalis* were collected in the Shatt al-Arab River south of Basrah city, Iraq (30°28′55.14″N 47°56′26.76″E) (Fig. 1). The specimens were caught on December 3rd, 2017 by fishing hobbyists using hooks and lines, and identified according to Armbruster & Page (2006). The specimens were dead when handed over to the second author for identification. The nomenclature follows Eschmeyer et al. (2018).

Statistical analyses

The specimens were blotted dry to remove excess water before being weighed to the nearest gram using a Sartorius electronic weighing scale (Entris 2202-1S). Length-weight relationships were calculated using the formula $W = aL^b$ (Zar 1984), where W = weight of the fish in grams, L = total length of the fish in millimetres, a = intercept showing the rate of change of weight with length, and b = weight at unit length.

The degree of well-being or relative robustness of the fish was expressed by a “coefficient of condition” (also known as condition factor or length-weight factor) and represented by the letter ‘K’ when the fish is measured and weighed, as in the following formula:

$$K = 100W/L^3$$

Where W = weight of the fish in grams and L = total length of the fish in millimetres.

A microscopic examination of the gonads was performed to determine the sex of the specimens. The gonadosomatic index (GSI) was calculated as a ratio of gonad weight to weight of the individual, according to the equation given by Nikolsky (1963).

Ovaries were dissected from fresh, mature females, weighed to the nearest 0.1 g and kept in Gilson’s fluid (Bagenal 1978). Fecundity was determined by a combination of gravimetric and volumetric methods (Lagler 1978). After weighing the ovaries, small sub samples equal to a 2 ml spoon from the anterior, middle and posterior portions were removed, weighed, and their eggs counted; the average was calculated and the egg count of the entire ovaries was estimated using the following equation:

$$\text{fecundity} = \text{average number of eggs in subsample x weight of ovary/weight of subsample}$$

Directly after collection, a subsample of *P. pardalis* specimens (n = 25) were preserved in a 10% formalin solution to prevent the breakdown of food materials. In the laboratory, they were washed, cleaned, and worked up for the qualitative and quantitative analyses. The stomach contents of each specimen were analysed by point and percentage of frequency of occurrence methods, as described by Dewan & Shaha (1979). Digestive tracts were removed after dissection and preserved in 4% formaldehyde. Their content was processed in the laboratory and the diet composition was expressed as percentage abundances by weight (% Wi). These were calculated for each food item from the entire food bulk as % Wi = 100 x (Wi/Wt), where Wi = total digestive tract content (by weight) composed of food item i and Wt = total digestive tract content (by weight) of all digestive tracts in the entire sub sample. Identification of stomach contents was based on Brown (1953) and Ali (1976, 1978a, 1978b) for insects, Quigley (1977), Holthuis (1983), Al-Adhub (1987), Al-Adhub & Hamzah (1987), and Al-Qarooni (2005) for other invertebrates, and Al-Handal et al. (1989) and Al-Sabounchi & Abdul-Hussein (1990) for algae.

Results

The specimens of *P. pardalis* collected from the Shatt al-Arab River look like those described by Armbruster & Page (2006) (Fig. 2). Their length ranged from 125.7 to 132.6 mm. The Amazon sailfin catfish has the following set of characteristics: bony plates covering the body (25 rows of armoured plates); body elongated and flat ventrally, with triangular cross section; head depressed and armoured; abdomen naked, with plates occurring on the ventral side of the body only at the caudal peduncle region; snout with plates at the edge; mouth inferior and protrusible, equipped with a sucking disk; both jaws equipped with 17 teeth; presence of a single spine in front of the adipose fin; 1st dorsal fin ray very small, 2nd dorsal fin ray large, and last dorsal fin ray smallest; adipose fin short; pectoral fin solid, with rough surfaces; 1st pectoral fin ray large, reaching origin of pelvic fins; upper and lower lobes of caudal fin elongated; keeled lateral plates, with sharp and short spines directed posteriorly; head grey; snout with reticulated pattern, with large, dark spots behind eye; rest of body with tilted, light-brown marks laterally and on caudal peduncle; all fins grey with light grey spots; well-defined alternating grey and white blotches on anterior rays of all fins and on upper and lower rays of caudal fin; colouration of abdomen consisting of dark spots on light background, forming narrow vermiculation marks with merging spots; head with marks forming a geometric pattern; caudal peduncle with chevron markings.

The analysis showed that *P. pardalis* specimens from the Shatt al-Arab River have allometric growth, where b = 2.548±0.038 and a = 0.041±0.005 ($p < 0.05$). The average condition factor (K) for *P. pardalis* was 8.802±4.208.

Relatively high GSI values were found for both male and female individuals of this species examined during this study, respectively 10.2 and 0.7. Furthermore, the size of the fish measured did not correlate significantly with gonad weight ($r2 = 0.0372$; $p > 0.05$). Ovary weights were recorded between 0.85 and 120.12 g and fecundity was between 2,400 and 19,245. The size of the bright-yellowish, ripe eggs with full yolk ranged in diameter from 2.0 to 3.7 mm.

We found that the analysed subsample of Amazon sailfin catfish from the Shatt al-Arab had consumed nine principal categories of food items: species of algae (14.11%), of which 40% Bacillariophyta, 30% Charophyta, 10% Chlorophyta, 10% Ochrophyta and 10% Rhodophyta; Rotifera (2.82%); insect larvae and pupae (15.53%), of which 44.44% Diptera, 22.22% Hemiptera, 11.11% Ephemeroptera, 11.11% Coleoptera and 11.11% Odonata; species of Crustacea (14.12%), of which 50% Anomopoda, 30% Copepoda and 20% Decapoda; meiofauna (4.24%), including species of Nematoda and Oligochaeta; fish (Cichlidae and Cyprinidae; 7.06%); unidentified cyprinid eggs (7.06%); other fish eggs and larvae (7.06%); and organic detritus and sediment (28%) (Table 1, Fig. 3). The food spectrum of *P. pardalis* in the Shatt al-Arab River was thus primarily insect larvae and pupae, followed by crustaceans and algae.

Insect larvae and pupae were the most diverse food item, with nine species belonging to eight families. Crustaceans such as Anomopoda were represented by five species belonging to three families, whereas Copepoda were represented by three species in two families and Decapoda by two species in one family. Rotifera were represented by two species in one family. The meiofauna was represented by three species belonging to two families. Finally, adult fish specimens retrieved belonged to five species in two families, with some eggs belonging to an unidentified cyprinid species and unidentified eggs and larvae belonging to other fish species.

Discussion

Pterygoplichthys pardalis differs from its congeners in having a geometric marking on its head. The largest specimen in our sample measured 132.6 mm TL (Fig. 2), which falls well below the maximum size (490 mm TL) reported for this species by Jumawan & Seronay (2017) and is also smaller than the only specimen of this species previously reported from the Middle East, from Israel (Golani & Snovsky 2013) (232 mm TL). Over the last few years, three incidences of aquarium fish escapes were reported from the Shatt al-Arab River, Basrah, Iraq [*Pangasianodon hypophthalmus* (Sauvage, 1878) (Khamees et al. 2013), *Atractosteus spatula* (Lacépède, 1803) (Mutlak et al. 2017) and *Mollienesia latipinna* (Lesueur, 1821) (see Al-Faisal et al. 2014)], and the present case is the fourth to be reported so far. Although the aquarium species *M. latipinna* has become well established in Iraqi inland waters, it is unknown when it was released in the natural waters of the country.

Samat et al. (2016) found that the Amazon sailfin catfish reaches maturity at 125 mm and 130 mm SL for males and females, respectively. With a size range of 125.7 to

Fig. 2. Male of *Pterygoplichthys pardalis* (Castelnau, 1855) from the Shatt al-Arab River, Basrah, Iraq; 132.6 mm TL.

Table 1. Stomach contents of 25 specimens of *Pterygoplichthys pardalis* (Castelnau, 1855) collected from the Shatt al-Arab River, Basrah, Iraq.

Biota	Species	Family
Charophyta	*Cosmarium subtumidium* Nordstedt	Desmidiaceae
	Euastrum dubium Naegeli	Desmidiaceae
	Spirogyra nitida (Müller)	Zygnemataceae
Chlorophyta	*Cladophora glomerata* (Linnaeus)	Cladophoraceae
Rhodophyta	*Compsopogon* sp.	Compsopogonaceae
Ochrophyta	*Characiopsis spinifer* Printz	Characiopsidaceae
Bacillariophyta	*Achnanthes brevipes* Agardh	Achnanthaceae
	Achnanthes microcephala (Kützing) Grunow	Achnanthaceae
	Navicula cincta (Ehrenberg)	Achnanthaceae
	Nitzschia amphibia Grunoq	Achnanthaceae
Rotifera	*Brachionus angularis* Gosse, 1851	Brachionidae
	Keratella cochlearis (Gosse, 1851)	Brachionidae
Oligochaeta	*Pristina macrochaeta* Stephenson, 1931	Naididae
	Pristina longiseta Ehrenberg, 1828	Naididae
Nematoda	*Alaimus* sp.	Alaimidae
Anomopoda	*Bosmina coregoni* Baird, 1857	Bosminidae
	Daphnia dubia Herrick, 1883	Daphniidae
	Daphnia longispina (O. F. Müller, 1776)	Daphniidae
	Simocephalus vetulus (O. F. Müller, 1776)	Daphniidae
	Macrothrix rosea (Jurine, 1820)	Macrothricidae
Copepoda	*Acanthodiaptomus denticornis* (Wierzejski, 1887)	Diaptomidae
	Cyclops Müller sp.	Cyclopidae
	Eucyclops agilis (Koch, 1838)	Cyclopidae
Decapoda	*Atyaephyra orientalis* Bouvier, 1913	Atyidae
	Caridina fernandoi Arudpragasam & Costa, 1962	Atyidae
Ephemeroptera	*Baetis rhodani* (Pictet, 1843)	Baetidae
Odonata	*Ischnura evansi* Morton, 1919	Coenagrionidae
Hemiptera	*Velia sauli* Tamanini, 1947	Veliidae
	Anisops sardea Herrich-Schäffer, 1850	Notonectidae
Coleoptera	*Berosus luridus* (Linnaeus, 1760)	Hydrophilidae
Diptera	*Chironomus piger* Strenzke, 1956	Chironomidae
	Simulium assadovi (Djafarov, 1954)	Simuliidae
	Anopheles multicolor Cambouliu, 1902	Culicidae
	Culex pipiens Linnaeus, 1758	Culicidae
Cichliformes	*Coptodon zillii* (Gervais, 1848)	Cichlidae
	Oreochromis aureus (Steindachner, 1864)	Cichlidae
	Oreochromis niloticus (Linnaeus, 1758)	Cichlidae
Cypriniformes	*Mesopotamichthyes sharpeyi* (Günther, 1874)	Cyprinidae
	Carasobarbus luteus (Heckel, 1843)	Cyprinidae
unidentified cyprinid eggs (7.06%)	-	-
other fish eggs and larvae (7.06%)	-	-
detritus and sediment (28%)	-	-

132.6 mm TL, this means that all 175 specimens collected in the present study were mature. This observation of reproductive maturity could indicate that the introduced Amazon sailfin catfish has successfully established a population in the Shatt al-Arab River in Iraq.

Our analysis of the length-weight relationship showed an allometric growth, where b = 2.548±0.038 and a = 0.041±0.005 ($p < 0.05$). The exponent '*b*' value we gained lies far from the model value, which is 3 (Pauly 1984). Results from this sample also showed a negative allometric growth, suggesting that specimens of *P. pardalis* in the Shatt al-Arab River tend to become slimmer as they grow larger. It is common for fish species of tropical and temperate regions to have '*b*' values ranging from 2.7 to 3.3 (Santos et al. 2002). In the present work, the '*b*' value estimated is slightly lower than the common range value. Nevertheless, similar values have been recorded for several fish species of the order Siluriformes, e.g., *Liposarcus multiradiatus* (Hancock, 1828) (Loricariidae), which has its exponential power parameter (*b*) at just 2.5 (Liang et al. 2005); Samat et al. (2008) reported a value of 2.538 for the same species.

Samat et al. (2008) found that there is seasonal variation in the '*b*' values of *P. pardalis* from the Malaysian Peninsula. They found that during August 2003 and October 2004, the values ranged from 2.265±0.202 to 2.879±0.099. Accordingly, they suggested that if $b > 2.5$ represents the lower margin of normal weight increase, then their individuals had grown relatively well during the period of their study. Since the value of '*b*' obtained for the 25 specimens of *P. pardalis* in our samples is very close to that of Samat et al. (2008), then the same conclusion can be reached, implying that the fish individuals in the present study had also grown well.

The average condition factor (*K*) for the 25 specimens of *P. pardalis* was 8.802±4.208. This value is higher than that obtained for the same species by Samat et al. (2008) from the Malaysian Peninsula. Our results are similar to those from other studies, such as those of Anibeze (2000) for *Heterobranchus longifinis* Valenciennes, 1840 (Pisces:

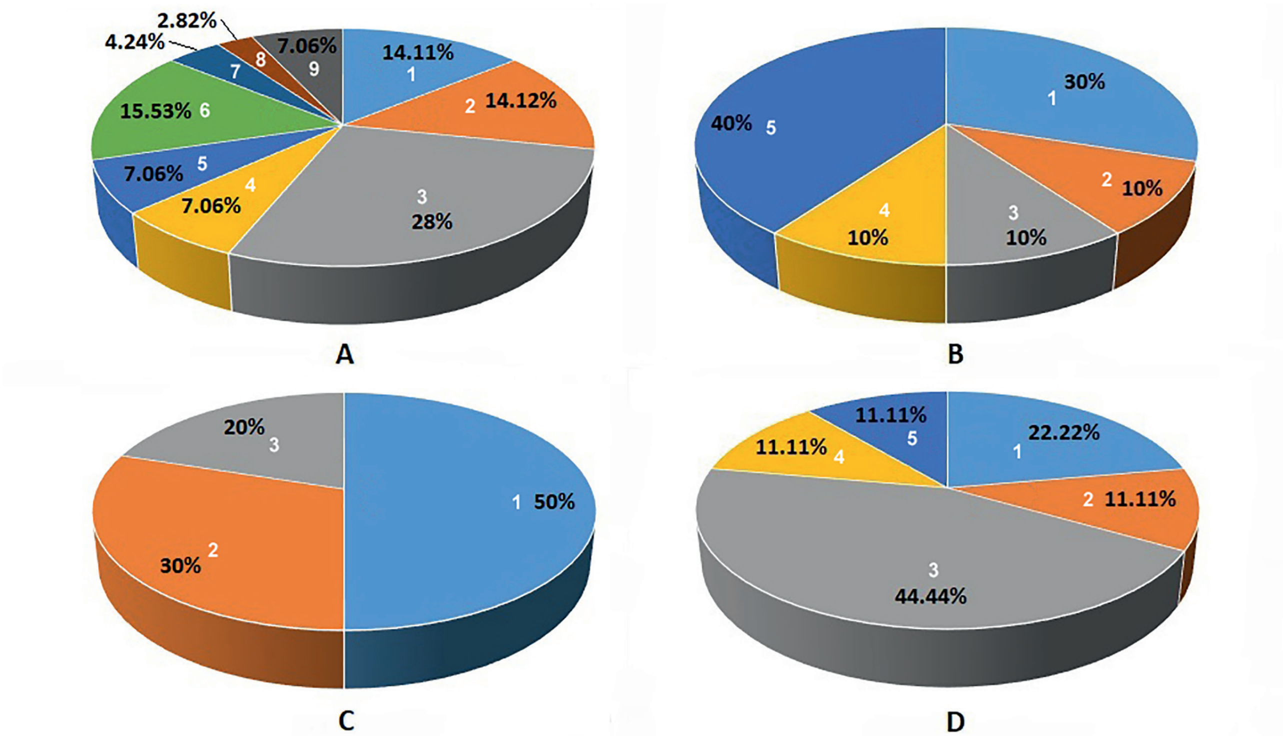

Fig. 3. Percentages of food item categories found in the stomach of 25 specimens of *Pterygoplichthys pardalis* (Castelnau, 1855) collected from the Shatt al-Arab River, Basrah, Iraq. – **A**. Main six food items: 1, algae; 2, Crustacea; 3, organic detritus and sediment; 4, fishes; 5, other fish eggs and larvae; 6, insect larvae and pupae; 7, meiofauna; 8, Rotifera; 9, unidentified cyprinid eggs. **B**. Percentage composition of algae: 1, Charophyta; 2, Chlorophyta; 3, Rhodophyta; 4, Ochrophyta; 5, Bacillariophyta. **C**. Percentage composition of Crustacea: 1, Anomopoda; 2, Copepoda; 3, Decapoda. **D**. Percentage composition of insect larvae and pupae: 1, Hemiptera; 2, Ephemeroptera; 3, Diptera; 4, Coleoptera; 5, Odonata.

Clariidae). The healthy condition of our specimens could be due to the availability of food and to an improved gonad development (Gomiero & Braga 2005).

The stomach contents analysis showed that, in addition to algae and detritus, our specimens appear to have fed on fish eggs, fish, and benthic-dwelling invertebrates such as worms and insect larvae and pupae (Fig. 3). Our results are in line with those of Cook-Hildreth (2009), who reported that the decline of the fountain darter, *Etheostoma fonticola* Jordan & Gilbert, 1886 (Pisces: Percidae), in the San Marcos and Comal River headwaters, Texas, was substantially due to heavy predation by loricariid catfish on their eggs. Our results also support the experiments performed by Chaichana & Jongphadungkiet (2012), which showed that individuals of *P. pardalis* are able to feed on fish eggs, fish larvae and worms. Hoover et al. (2004) suggested that *P. pardalis* possibly caused a decrease in the richness and biodiversity of native fish populations through feeding on their eggs.

In addition, the Amazon sailfin catfish can destroy freshwater habitats by eroding river banks. Males of this species usually dig deep holes, up to over one metre deep, during the breeding season for spawning and protection of young (Nico et al. 2009a, 2009b).

In order to put together a plan for the biological control of *P. pardalis* it is important to take into consideration the following points, to avoid failure and guarantee success: (1) due to the extension of the pectoral fin at the time of facing a predator, it seems hard for birds to swallow this catfish; (2) similarly, it may be difficult for piscivorous fish to swallow this catfish when the pectoral fin is extended; (3) this catfish can hide in the long burrows created by the males during the breeding season, which makes it difficult for piscivorous fish to find and eat them, as they usually hide inside the nest built in the river bank. Since the establishment of the catfish *P. pardalis* in Iraq is likely still in its early stages, further and urgent studies are required to determine whether native Iraqi piscivorous fish can effectively control this species in the natural environment.

In addition to recording the presence of *P. pardalis* in the Shatt al-Arab River, this study has dealt with some aspects of this species' biology. It is clear that *P. pardalis* is able to propagate, survive, and build a sustainable population in Iraqi waters. The overall environmental conditions of the inland waters of Iraq have seemingly enabled this introduced catfish to reproduce, thus making it a successful invader.

Several measures can be taken to eradicate *P. pardalis* from the freshwater system of Iraq. Among these, education programs on the impact of this species on the native fish fauna or a system of financial rewards could encourage locals to catch Amazon sailfin catfish, especially during the breeding season, and mechanical traps can be set in the river from which Amazon sailfin catfish individuals would be removed.

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