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First record of the Southern Platyfish, *Xiphophorus maculatus* (Günther, 1866), (Cyprinodontiformes: Poeciliidae) in coastal streams of Venezuela and implications for conservation

Primeiro registro do Platyfish do Sul, *Xiphophorus maculatus* (Günther, 1866), (Cyprinodontiformes: Poeciliidae) em riachos costeiros da Venezuela e implicações para a conservação

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Abstract: Several fishes of the family Poeciliidae are commonly produced in ornamental aquaculture and also used for pest control, leading to their introduction in numerous countries. Many of these species exhibit tolerance and invasiveness, as exemplified by *Xiphophorus maculatus* (Günther, 1866). This report documents the presence of *X. maculatus* in a Caribbean coastal stream in Venezuela. Quizandal Creek has experienced significant human intervention in its lower drainage and channel area. In the final segment of the creek the fish were captured using hand nets and beach seines. The specimens were transported alive to the laboratory for evaluation and subsequently preserved according to standard methods and later were cataloged in the fish collection. 16 males ♂ and 8 females ♀ (16.6-29.4 mm SL. CPUCLA-3630) from the Quizandal Creek, part of the coastal drainage of the Borburata River, were analyzed. This is the first report on the occurrence of *Xiphophorus maculatus* in natural environments of Venezuela. These coastal streams are situated in a zoogeographic transition zone between regional freshwater ichthyofaunas that have a limited number of species, primarily secondary and amphidromous, which could be susceptible to the presence of introduced species. *Xiphophorus* fish demonstrate the ability to thrive in highly degraded environments, promoting their dispersion and amplifying the impact on the habitat and local fish, particularly small endemic fish, such as the Rivulidae and Poeciliidae.

Keywords: Poeciliidae; ornamental fish; invasive species; coastal rivers; environmental stressors.

Resumo: Vários peixes Poeciliidae são comumente empregados na aquicultura ornamental e no controle de pragas, levando à sua introdução em vários países. Muitas dessas espécies exibem tolerância e invasividade, exemplificadas por *Xiphophorus maculatus* (Günther, 1866). Esta nota documenta a presença de *X. maculatus* em um riacho costeiro na encosta do Caribe, Venezuela. O riacho Quizandal sofreu intervenção humana significativa na drenagem inferior e na área do canal. No trecho final do riacho os peixes foram capturados com redes de mão e arrastos. Os espécimes foram transportados vivos ao laboratório para avaliação e posteriormente preservados segundos métodos padronizados para posterior catalogação na coleção de peixes. Foram analisados 16 machos ♂ e 8 fêmeas ♀ (16,6-29,4 mm SL. CPUCLA-3630) provenientes do Córrego Quizandal, associado à drenagem costeira do Rio Borburata. Este é o primeiro relato da ocorrência de *Xiphophorus maculatus* em ambientes naturais da Venezuela. Estes riachos costeiros estão situados numa zona de transição zoogeográfica entre ictiofaunas regionais de água doce e apresentam um número limitado de espécies, principalmente secundárias e anfidromas, que podem ser suscetíveis à presença de espécies introduzidas. Os peixes *Xiphophorus* demonstram a capacidade de prosperar em ambientes altamente degradados, promovendo a sua dispersão e amplificando o impacto no habitat e nos peixes locais, particularmente pequenos peixes endêmicos, como os Rivulidae e Poeciliidae.

Palavras-chave: Poeciliidae; peixes ornamentais; espécies invasivas; rios costeiros; estressores ambientais.

The family Poeciliidae (274 species) is mainly characterized by small-sized individuals with distinctive sexual dimorphism and ovoviviparity (Fricke et al., 2023). The males often display vibrant colors, and have the anal fin modified into a gonopodium, used to introduce sperm into the female reproductive tract (Rosen & Bailey, 1963). In Poeciliinae, one of the subfamilies, the genus *Xiphophorus* Heckel 1848 has 26 species (Fricke et al., 2023) that were originally distributed in Gulf of Mexico drainages from northeastern Mexico to Caribbean drainages of northeastern Honduras (Kallman & Kazianis, 2006). Many *Xiphophorus* species, known for their exceptional beauty, have become popular choices for ornamental aquariums and have been utilized for the biological control of mosquitoes. Consequently, numerous species are now invasive in various aquatic ecosystems worldwide (Froese & Pauly, 2023).

Fishes of the genus *Xiphophorus* are popularly known as platyfish and swordtails by aquarists and can be found in ornamental aquaculture operations and pet stores in most South American countries. Moreover, their introduction and established populations in natural environments have already been reported from Brazil (Ottoni et al., 2021), Colombia (Albornoz-Garzón & Villa-Navarro, 2017) and Peru (Cossíos, 2010). The presence in captivity of *Xiphophorus helleri* Heckel 1848, *X. maculatus* (Günther, 1866) and *X. variatus* (Meek 1904) in Venezuela has been documented (Ojasti, 2001) but there are no reports of its occurrence in natural environments. While monitoring of coastal drainages in Venezuela and surveying fish, we surprisingly found a population of *X. maculatus*. In this study, we provide a description of the characteristics of *X. maculatus* and the aquatic and riparian habitat. Additionally, we discuss the threats posed by the introduction of this alien species to the local ichthyofauna.

The Borburata River (5661 ha. mouth: 10°28'23" N; 67°57'34" W) is a small drainage on the Caribbean slope of the Coastal Range of Venezuela (Figure 1). The climate in its headwaters (1975 meters above sea level) is humid, with 800-1200 mm precipitation and cool, temperatures 10-14 °C. Close to the mouth, the climate is semiarid with low precipitation of 500-600 mm and hot temperatures of 24-26 °C (Rodríguez-Olarte et al., 2018). The San Esteban National Park (43,500 ha) covers most of this drainage and allowed the preservation of humid and cloud forests in the mountains and dry forests in the lower areas. In the plains human activities prevail in a mosaic with deforestation, agriculture, villages (Borburata and Gañango, ~6000 people) and beaches with permanent tourism. The above conditions of the Borburata River drainage are common to most of the coastal rivers in this region of Venezuela.

Quizandal Creek is a tributary in the plains with severe intervention of its drainage and channel. The habitat was characterized and quantified using a standard method developed by Rodríguez-Olarte et al. (2006). In a section of this creek about 30 m long the fish were collected with hand nets and seines with different mesh sizes (1-5 mm). In the laboratory, all individuals of *X. maculatus* were maintained alive; subsequently, the fishes were euthanized with ice, fixed in formalin [10%], preserved later in ethanol [70%], and catalogued in the Colección Regional de Peces (CPUCLA), Museo de Ciencias Naturales

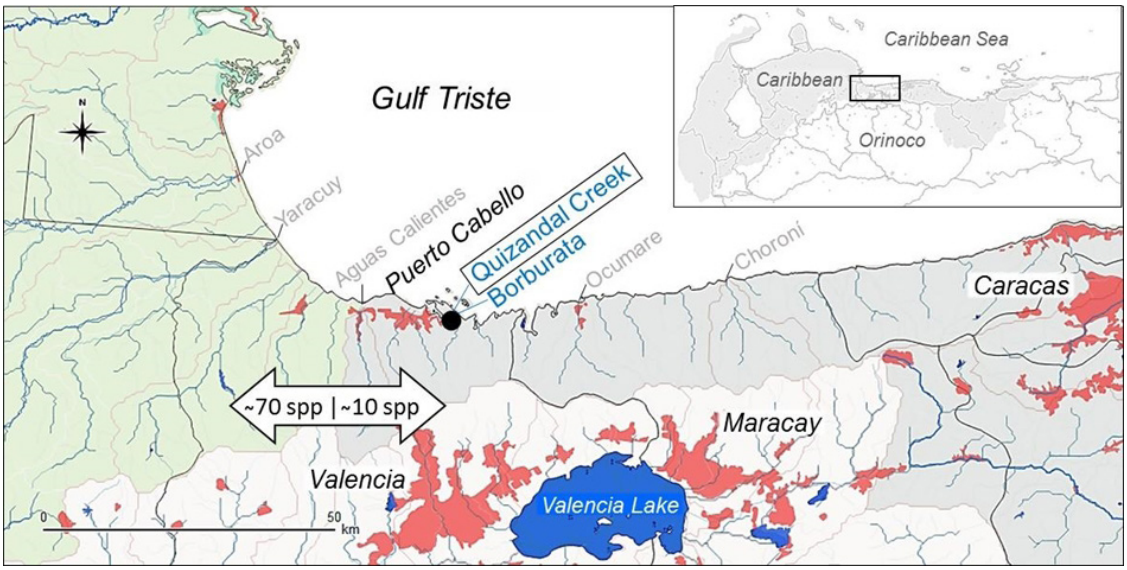

Figure 1. Locality record of species *Xiphophorus maculatus* from Quizandal Creek (black dot) in the Borburata River drainage, Western Caribbean Province of Venezuela. Double arrow indicates a change in fish richness: few species of freshwater fishes have been found towards the east but over 70 have been collected in west.

of Universidad Centroccidental Lisandro Alvarado (UCLA, Barquisimeto, Lara). The taxonomic identification was made with diagnosis and keys (Rosen, 1960; Rosen & Bailey, 1963). The counts and measurements were made with a digital caliper and were expressed in 0.1 mm increments.

The aquatic habitat in Quizandal Creek was surrounded and shaded by a patch of secondary forest with profuse understory (Figure 2). The channel had a width of 0.4-2.3 m and a maximum depth of 0.5 m, while the substrate was a mixture of mud and sand covered by dense debris of branches and leaves. The flow was low (~5 l/s), with waters crystalline and slightly tinted. The water parameters were: pH: 7.5, conductivity: 81 µS/cm, total dissolved solids 34 mg/l. The contamination of the water was evident and caused by sewage coming from nearby agricultural and urban areas. The density for *X. maculatus* was 2.1 ind/m^2, calculated from a littoral transect long of the locality and before sampling. A few small individuals of *Gobiomorus dormitor* Lacepède 1800 and *Eleotris* sp. (Gobiiformes: Eleotridae) were also collected. No other species was observed at the site.

The specimens examined of *Xiphophorus maculatus* were 16 males (♂) and 8 females (♀) (16.6-29.4 mm SL CPUCLA-3630) all of Quizandal Creek in Borburata drainage (10°28′09″ N; 67°58′07″ W; 5 meters above sea level), June 2022, coll. D. Rodríguez-Olarte and C. J. Marrero. All specimens were identified as *X. maculatus* because they have 22-25 scales in the lateral line and 7-11 rays in the dorsal fin. They are small fish, the body is compressed laterally, with a maximum body depth close to half the standard length (SL) and below the origin of the dorsal fin. The head

Figure 2. Sampling site in the Quizandal creek corresponding to voucher collection (CPUCLA-3630) of *Xiphophorus maculatus*.

is small, and less compressed than the body. The mouth is superior and somewhat protrusible, and the eyes are of medium size. The maximum length is for males 40 mm and females 60 mm. The caudal peduncle is long, very deep and compressed laterally. The caudal fin is round. They are sexually dimorphic fish: the males have a modified anal fin (gonopodium) that does not reach the base of the caudal fin. Due to the polymorphism of the species the meristics vary, but the usual values are dorsal fin with 7-11 rays (usually 8-10) and lateral scales 22 to 25 (usually 23-24, 26 in other platys).

The individuals of *X. maculatus* introduced in Quizandal Creek showed color patterns and combinations of black spots as follows (Figure 3): (a) on the body sides above the midline and before the origin of the dorsal fin; (b) covering most of the caudal peduncle and (c) at the base of the upper and lower external rays of the caudal fin or black lines extended only on the external rays. The literature reports wild populations with colors between silvery and pale olive, with iridescences in a reticulated pattern and eventually with melanic spots (Günther, 1866; Rosen 1960). With a roundish black spot on the middle of the caudal base and another on the middle of the side of the trunk. The dorsal fin has small dark spots on the interradial membranes and often has the color of the body or black. A mid-lateral stripe is absent. Ornamental individuals have intense or iridescent colors, principally orange, red, yellow and black. Often, they have pure colors or mixtures with patterns of spots and varied lines. The variety of color pattern observed in Quizandal Creek indicates a possible mix of ornamental varieties (Figure 3).

Most species of *Xiphophorus* have a notable physiological tolerance and are capable of living in environments with low water quality; moreover, they have rapid growth, possible sex reversal, ovoviviparity and high abundance (Meffe & Snelson, 1989; Balon, 2004). These attributes explain the high success in the colonization and invasion of different aquatic ecosystems by *X. maculatus*, however there is little evidence available on specific ecological impacts. The contamination in regional coastal rivers could also favor *X. maculatus* due to their tolerance to living in disturbed habitats, because these rivers are in risk mainly to pollution by urban and industrial effluents, transformation and loss of channels, deforestation of riparian zones and watersheds, and water extraction (Rodríguez-Olarte et al., 2018). Thus, the invasive condition of *X. maculatus* could have a detrimental effect on the local ichthyofauna in coastal drainages, such as the killifish *Austrofundulus leohoignei* Hrbek, Taphorn & Thomerson (Rivulidae), an endemic and highly restricted species to local coastal floodplains and which is threatened by the loss of its habitat (Rodríguez-Olarte et al., 2011), but also several Poeciliidae fishes species, which include *Poecilia dauli*, *P. koperi*, *P. reticulata* and *P. heterandria*, this last is endemic and restricted to local drainages toward in the Caribbean Sea (Rodríguez-Olarte et al., 2009). *Poecilia* fish are common in a wide range of habitats, principally in creeks, swamps, lagoons and estuaries; they are omnivores with a tendency to insectivory (Zandonà et al., 2015). These features are very similar to those of *X. maculatus*, which usually is twice the size of the majority of local poeciliids.

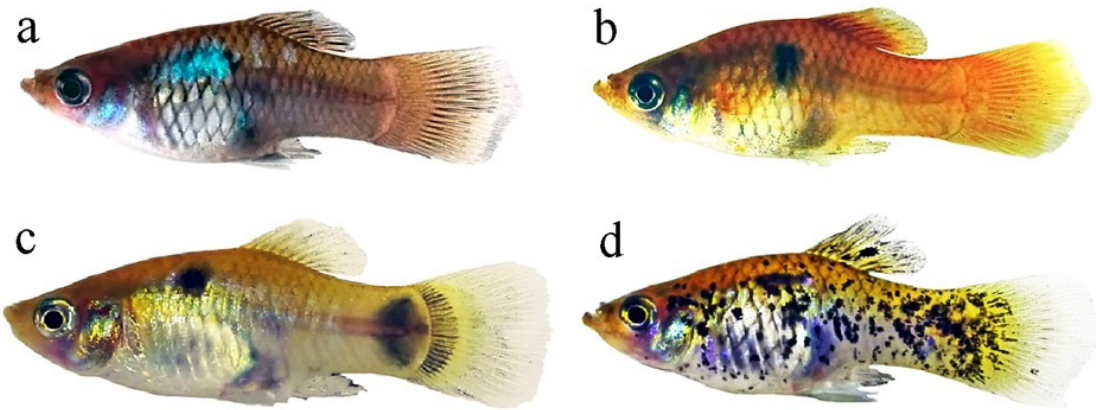

Figure 3. Live specimens of *Xiphophorus maculatus* from Quizandal Creek (Borburata drainage) in Coastal Range of Venezuela. All specimens preserved (CPUCLA 3630. (a) 27.5 mm SL; (b) 25.5 mm SL; (c) 28.5 mm SL; (d) 27.0 mm SL). Scale bar 10 mm.

In consequence, the introduction of an invasive competitor such southern platyfish could displace certain species due to similar requirements of habitat. Furthermore, in Quizandal Creek juveniles and pregnant females of *X. maculatus* were collected, suggesting reproductive success and populations of relative permanence.

The zoogeographic patterns of the regional ichthyofauna in combination with human intervention of rivers can limit or favor the permanence of alien species and increase the risk for the local fishes. In this province, the richness of freshwater fishes in the western drainages reaches about 70 species (Rodríguez-Olarte et al., 2009), the majority of which are primary species living mostly in freshwaters; but in small rivers to the east, no more than 10 freshwater species occur, all are secondary, amphidromous or catadromous (Figure 1). This longitudinal gradient in the fish richness can favor the establishment of alien species such as *X. maculatus* in drainages to the east, because there could be less competition for resources and a lower chance of predation by other fishes.

Although the fish of the genus *Xiphophorus* are the most commercialized ornamental fish in Venezuela (Salazar et al., 2008) and have already been observed in artificial environments and creeks of some cities, the species *X. maculatus* has not been reported formally as living in natural environments of the country. In Venezuela two aspects may be added to the list of possible causes leading to the dissemination of ornamental fish: electronic commerce and the economic crisis. The commercialization of ornamental fish on social networks is very common, even more so in post-pandemic conditions, because contact is direct between private breeders and enthusiasts, thus avoiding government controls and commercial records on the sales or trafficking of ornamental fish. On the other hand, the economic crisis has limited the ability to maintain ornamental fish, mainly due to the exaggerated increase in the cost of equipment, food and veterinary services. This could explain in recent years the many cases where fish have been abandoned or released into both natural and artificial environments.

An evaluation of factors promoting the introduction and spread ornamental freshwater fishes in coastal drainages of Venezuela is a priority. There are observations of alien species (e.g. *Cichla*, *Metynnis*, *Prochilodus*) and some biological collections have museum records, but there is no adequate and updated data on the status of those introductions (Rodríguez-Olarte et al., 2018). Consequently, the first step is to apply periodic monitoring in rivers and lakes where the state and integrity of aquatic habitats and native fish communities can be recognized. The second step involves the development of citizen science training and outreach programs, which will allow the effects associated with the introduction of exotic fish to regional freshwater ecosystems to be recognized and assessed. At the same time, it is necessary to facilitate procedures to develop and adapt legislation that regulates aquaculture and the management of ornamental fish species.

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