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Potentially dangerous fish of the Paraiba Estuary: Identification and envenomation mechanisms

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ABSTRACT

Objective: To present venomous and poisonous fish species in the Paraiba Estuary, Paraiba State, Brazil, with a description of the envenomation mechanisms and characteristics of the toxins.

Methods: Fishes were caught by beach seine in the dry and rainy season (November 2013 and June 2014) and bimonthly between May 2016 and March 2017.

Results: Eight potentially dangerous species belonging to the families Batrachoididae, Ariidae and Tetraodontidae were identified. The representatives of the former two families, toadfish and catfish, respectively had specific venom inoculating apparatuses that could penetrate tissues, releasing toxins that caused injuries mainly to fishermen. The family Tetraodontidae had poisonous species, once the pufferfish could accumulate biotoxins (especially tetrodotoxin, which is a neurotoxin produced by bacteria). Despite being toxic for consumption, these fish were often consumed by fishermen and their families.

Conclusions: The present study is the first record of venomous and poisonous species in the Paraiba Estuary and contributes to the knowledge of the identification of the species and the mechanisms that cause severe envenomation and even deaths in artisanal fishing communities. Such knowledge is fundamental to future campaigns aimed at the prevention of injuries involving fish in the region and in other estuarine environments, where such fishes are common.

1. Introduction

Brazil has more than 8 500 km of coast line and the largest network of freshwater systems in the world, with a richness of aquatic fauna. Some specimens have the ability to injure and/or poison humans[1,2]. The tropical climate attracts a large number of beach goers and practitioners of aquatic activities, such as commercial fishing, sport fishing, scuba diving and underwater fishing, which favor the occurrence of accidents, many of which are caused by venomous aquatic animals. However, such events are insufficiently recorded, partially to the great number of victims that do not seek medical help[3].

The production of toxins by aquatic animals is an important strategy that ensures survival in a highly competitive ecosystem[4]. Fishes of toxicological importance are grouped into venomous and poisonous species. Venomous fishes have cells, glands or organs that produce toxic substances and an apparatus to inoculate the venom and they can provoke serious trauma in cases of injuries caused by bites, spines or stingers[4,5]. Such species use the venom for the purposes of defense and feeding[2]. Poisonous fishes either have metabolic pathways for the production of poison or acquire toxins from plants, algae or other organisms through the food chain[6], which make these species poisonous to whoever eats them.

Practically all families and genera of venomous fishes have representatives in the marine and freshwater environments of Brazil, but those that cause the most accidents are catfishes,

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stingrays, toadfish and scorpionfish[7]. Some species of poisonous fish that represent a risk to human life if consumed are common on the coast of Brazil, especially those of the family Tetraodontidae, the pufferfish[8,9].

Knowledge on potentially toxic species in estuaries is important due to the common practice of artisanal fishing in such regions, which can lead to the inadequate consumption of catches and increase the risk of envenomation due to contact with dangerous fishes in estuarine environments. Thus, the aim of the present study was to identify potentially dangerous fishes in the Paraiba Estuary in the Paraiba State, Brazil, based on sampling conducted at the site and describe the envenomation mechanisms as well as the characteristics of toxins found in species of potentially dangerous fishes that occur in this estuary.

2. Materials and methods

The Paraiba Estuary is located between latitudes 6°54'14" and 7°07'36" S and longitudes 34°58'16" and 34°49'31" W (Figure 1). The estuary has typical characteristics of a river submitted to a medium flow regimen that enables the formation of small sand banks and is surrounded by extensive sugarcane plantations, shrimp farms, the Cabedelo Harbour and a metropolitan area composed of five municipalities that together have more than one million inhabitants. The depth in the main channels is 3.0 m, except near the port, where frequent dredging maintains a depth of 11.0 m[10,11]. The estuary is flanked by what remains of the mangrove forest, which has been quite altered due mainly to sugarcane plantations and urban clusters, which are sources of considerable anthropogenic impact[12].

Fishes were caught in the dry and rainy season (November 2013 and June 2014) and bimonthly between May 2016 and March 2017. Both sampling efforts were performed in approximately 30 m sections using a net measuring 10 m in length × 1.5 m in height and conducted during daylight hours at low tide in the quarter phase of the moon. The sampling sites were defined along the estuary and three beach seines were performed on the banks of the estuary at each site.

The specimens were stored in a polystyrene chest with ice and fixed with a 10% buffered formalin solution for subsequent identification.

The relative abundance was calculated as $RA = n_{sp} \times 100/T$, where RA is relative abundance, n_{sp} is number of individuals of each species and T is total of individuals.

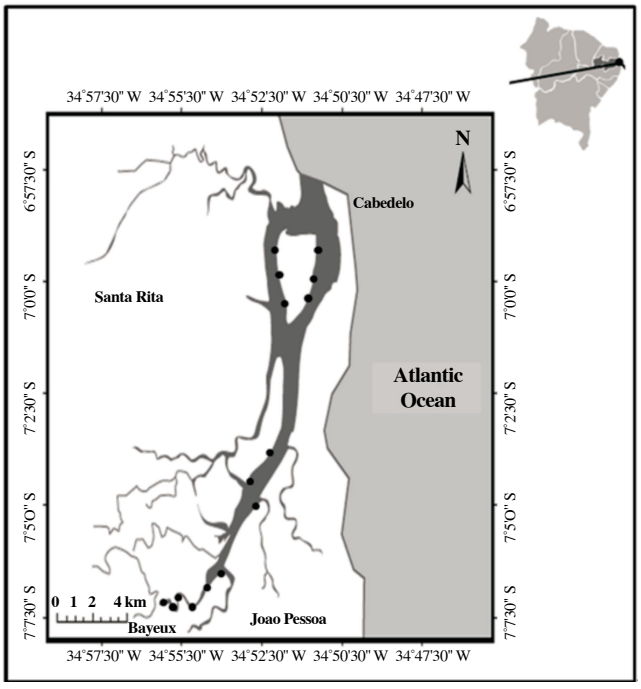

Figure 1. Map showing the study area and sampling sites for the fishes in the Paraiba Estuary, Paraiba, Brazil.

3. Results

Among a total of 80 species captured (5 536 individuals), eight species (144 individuals) belonging to five genera and three families were classified as both venomous (Batrachoididae and Ariidae) or poisonous (Tetraodontidae) (Table 1).

3.1. Venomous fishes

Among the species classified as venomous *Thalassophryne nattereri*, the toadfish known locally as Aniquim, is the most common representative of the family Batrachoididae (Figure 2A). Three marine venomous catfishes were caught in the Paraiba

Table 1
Venomous and poisonous fish in Paraiba Estuary, Paraiba, Brazil.

Family	Species	Risk	Toxin	*n*	RA
Ariidae	*Cathorops agassizii* (Eigenmann & Eigenmann, 1888)	Venomous	Not available	1	0.02
	Cathorops spixii (Agassiz, 1829)	Venomous	Not available	5	0.08
	Sciades herzbergii (Bloch, 1794)	Venomous	Not available	68	1.03
Batrachoididae	*Thalassophryne nattereri* Steindachner, 1876	Venomous	Natterins and Nattectins	6	0.09
Tetraodontidae	*Colomesus psittacus* (Bloch & Schneider, 1801)	Potentially poisonous by bioaccumulation	Tetrodotoxin	12	0.18
	Sphoeroides greeleyi Gilbert, 1900	Potentially poisonous by bioaccumulation	Tetrodotoxin	34	0.51
	Sphoeroides spengleri (Bloch 1785)	Potentially poisonous by bioaccumulation	Tetrodotoxin	2	0.03
	Sphoeroides testudineus (Linnaeus, 1758)	Potentially poisonous by bioaccumulation	Tetrodotoxin	105	1.59

n: Number of individuals; RA: Relative abundance in %.

Estuary: *Cathorops agassizii*, *Cathorops spixii* (Figure 2B) and *Sciades herzbergii*.

3.2. Poisonous fishes

The fishes classified as poisonous, such as the pufferfishes *Sphoeroides testudineus* (Figure 2C), *Sphoeroides greeleyi* (Figure 2D), *Colomesus psittacus* (Figure 2E) and *Sphoeroides spengleri*, bioaccumulated tetrodotoxin (Table 1).

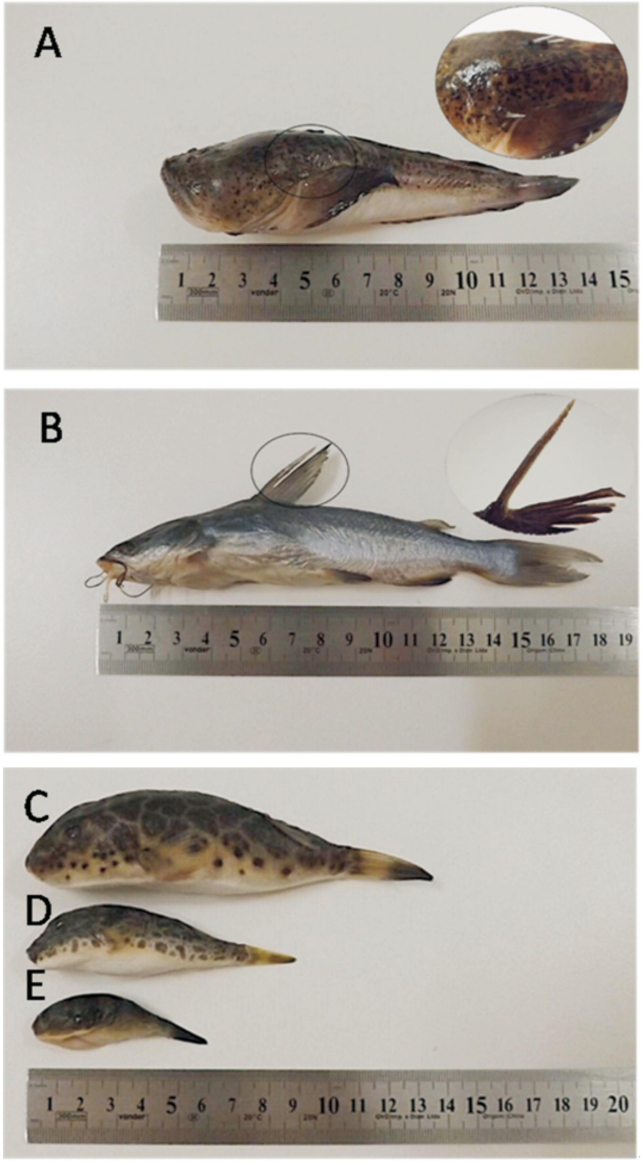

Figure 2. Photos of *Thalassophryne nattereri* (A), *Cathorops spixii* (B), *Sphoeroides testudineus* (C), *Sphoeroides greeley* (D) and *Colomesus psittacus* (E).
Details: Spines of venomous fishes.

4. Discussion

4.1. Venomous fishes

Thalassophryne nattereri is the most common species of Batrachoididae family in the region studied[13]. Envenomation by this fish is frequent in the northern and northeastern regions of Brazil[13]. This family has the most complete venom inoculating apparatus, which is formed by four canaliculated spines (two lateral and two dorsal) located in a preoperculum position and anterior to the dorsal fins, all of which are directly linked to venom glands[13,14]. The stingers function like needles. Upon penetrating the tissue of the victim, the integumentary sheath ruptures, pushing the venom into the duct and injecting it into the victim[13,15]. In Brazil, theses fishes are small to medium sized (approximately 15 cm) and are numerous in estuarine areas in the northern and northeastern regions of the country[13].

Venomous representatives of the Ariidae family have no scales, possess barbels and have stingers positioned on the anterior part of the dorsal fin as well as one on each pectoral fin[4]. Among the 120 known species, only three were caught in the Paraiba Estuary. The stingers of catfishes are slightly arched, tapered at the anterior and posterior portions and have a serrated edge[16]. The venom is in the glandular epithelium that covers the stingers and is a gelatinous protein material[17]. The stinger is enveloped in a thin layer of skin, denominated the integumentary sheath[18,19], which is made up of a thick layer of epidermis and a thin layer of dermis[20]. The glandular cells responsible for the production of venom are between the epidermis and dermis and are concentrated on the anterolateral and posterolateral edges of the stinger[20]. The venom inoculation system responds to a completely involuntary mechanical action rather than a controlled, dosed expulsion of venom[21]. When the spine perforates the tissue of a victim in an injury, the integumentary tissue is ruptured and the venom is released into the wound[18].

4.2. Poisonous fishes

The poisonous pufferfishes can accumulate tetrodotoxin, which is the principal neurotoxin found in pufferfish[7,22]. For a long time, tetrodotoxin was considered a metabolic product of fishes[23], but studies have demonstrated that certain bacteria, such as *Vibrio* sp., produce the toxin and are incorporated into fishes through the food chain[23,24]. The toxin is then stored in some organs and used as a defense against predators[9,25]. These fishes are mainly consumed by fishermen and their families[1], who end up being poisoned by the tetrodotoxin, which can occasionally cause death[26,27].

The record of potentially dangerous venomous and poisonous fishes in the Paraiba Estuary offered in the present study can assist in the establishment of accident prevention campaigns directed at the local population. The information in this study can also contribute a better understanding of the mechanisms that cause serious accidents and deaths in fishing communities of Brazil.

Conflict of interest statement

We declare that we have no conflict of interest.

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