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Bioecology of African Catfish and Poisonous Marine Fish (Actinopterygii: Teleostei)

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Abstract: *Clarias gariepinus* (Burchell, 1822) (Siluriformes: Clariidae) the African catfish is a large, eel-like fish, usually dark gray or black on the back and white on the ventral part, a smoother flat bony head compared to other catfish, and a wide, terminal mouth with four pairs of barbels. It has an accessory respiratory organ that allows it to breathe atmospheric air and survive in environments with low oxygen levels. They remain in the muddy substrates of lakes and occasionally swallow air through their mouths. It can leave the water at night and walk on dry land using its strong fins and spines, in search of food or migrating to other bodies of water to reproduce. During aggressive intraspecies interactions, this species was observed to generate single-phase discharges through electrical organs in its head that lasted from 5 to 260 ms. The manuscript aimed to investigate the bioecology of African catfish and venomous marine fish (Actinopterygii: Teleostei). To develop the study, the methodology used an integrative literature review, which is a synthesis process with the objective of expanding the understanding of knowledge and achieving the expected results. In this way, the researcher can prepare an integrative review with different purposes, which can be aimed at defining concepts, reviewing theories, or methodological analysis of studies included on a given topic. In its construction process, it is necessary to go through six distinct stages, which are: identification of the theme and selection of the hypothesis or research question; establishment of inclusion and exclusion criteria for studies/sample or literature search; definition of information to be extracted from selected studies/categorization of studies; evaluation of included studies; interpretation of results; and presentation of knowledge review/synthesis. To carry out the study, a search for scientific articles was carried out through the Virtual Health Library, in the SCIELO, LILACS, and Pubmed databases.

Keywords: Invasion, Migration, Predator, Poison, Therapy.

RESEARCH PAPER

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1. INTRODUCTION

Clarias gariepinus (Burchell, 1822) (Siluriformes: Clariidae) the African catfish is a large, eel-like fish, generally dark gray or black on the back and white on the ventral part, a smoother flat bony head compared to other catfish, and a wide, terminal mouth with four pairs of barbels. It has an accessory respiratory organ that allows it to breathe atmospheric air and survive in environments with low oxygen levels. They remain in the muddy substrates of lakes and occasionally swallow air through their mouths. It can leave the water at night and walk on dry land using its strong fins and spines, in search of food or migrating to other bodies of water to reproduce. During aggressive intraspecies interactions, this species was observed to generate single-phase discharges through electrical organs in its head that lasted from 5 to 260 ms (Figure 1) (Maina and Maloiy, 1986; Kolar and Lodge, 2001; Cambray, 2003; Cucherousset and Olden, 2011; Barbosa, 2020).

Clarias gariepinus occurs naturally on the African continent and in parts of Asia, Israel, Syria, and southern Turkey, being one of the 32 species currently recognized for the genus *Clarias* Scopoli, 1763. It inhabits calm waters of lakes, rivers, streams, and flooded plains that they can suffer long periods of drought with the production of mucus, which allows the species to travel long distances out of water. In October 2016, three individuals of *C. gariepinus* were captured using a cast net and a small boat. Two of the specimens were captured in the D'Una River and one was captured in Lago Mirim. This record of *C. gariepinus* documents a recent introduction into Brazil, and the occurrence of this species had never been documented for the D'Una River Basin (Figures 2-3) (Maina and Maloiy, 1986; Kolar and Lodge, 2001; Rocha, 2008; Weyl and Booth, 2008; Cucherousset and Olden, 2011; Froese and Pauly, 2019a; Froese and Pauly, 2019b).

Figure 1: *Clarias gariepinus* (Burchell, 1822) (Siluriformes: Clariidae) or African sharp tooth catfish is a species of the family Clariidae, the airbreathing catfishes
Source: https://www.youtube.com/watch?v=8tDGf8r7nXY

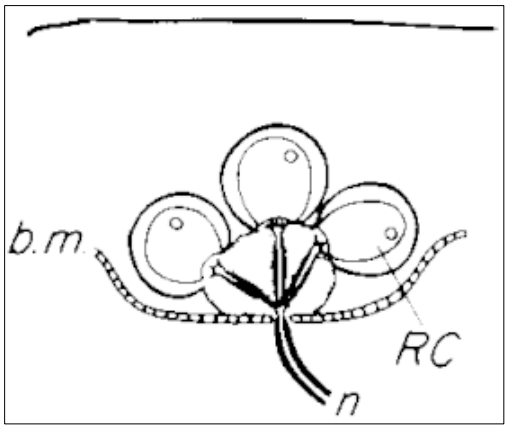

Figure 2: *Clarias gariepinus* (Burchell, 1822) (Siluriformes: Clariidae) discharges through electrical organs located in its head that lasted from 5 to 260 ms. A knollenorgan, a tuberous electroreceptor of weakly electric fish. RC=receptor cell; b.m.=basal membrane; n=nerve
Source: https://en.wikipedia.org/wiki/Electroreception_and_electrogenesis

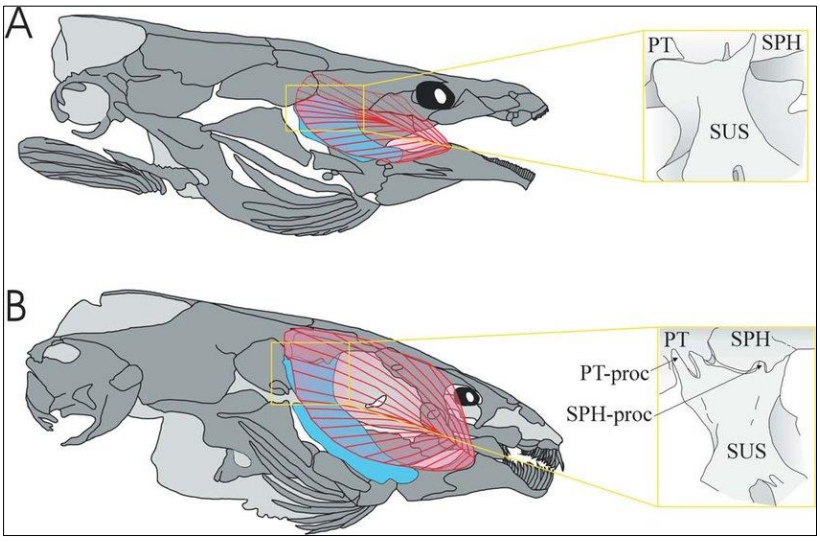

Figure 3: A, B Lateral view of the skulls of *Clarias gariepinus* (Burchell, 1822) (Siluriformes: Clariidae) (A) (modified from Adriaens and Verraes 1996) and *Clariallabes longicauda* (Boulenger, 1902) (Siluriformes: Clariidae) (B). The pink surface represents the adductor mandibulae A2A3 0 (hypertrophied in Clariallabes) which almost entirely covers the suspensorium (in blue). The physiological cross-sectional area of this A2A3 0 of *C. longicauda* is about twice that of *C. gariepinus* [Herrel e*t al*., 2002]
Source: https://www.researchgate.net/figure/A-B-Lateral-view-of-the-skulls-of-Clarias-gariepinus-A-modified-from-Adriaens-and_fig3_225671038

The reproduction process of these animals is characterized by the deposition of eggs in the external environment, most of the time already fertilized. And so, until it becomes one, the process takes place outside the female's body. In the environment, the embryo develops by feeding on the nutritional reserves present in the eggs until they reach the moment of hatching. Note that fertilization in oviparous animals can occur internally or externally (Witte and Winter, 1995; Rechi, 2017; Magalhães, 2024).

Mating is preceded by highly aggressive encounters between males. Courtship and mating occur in shallow waters between isolated pairs of males and females. The male stands in a curved U-shape around the female's head, held for several seconds. A batch of semen and eggs is released, followed by a vigorous flick of the female's tail to distribute the eggs over a wide area. The pair usually rests after mating for seconds to several minutes and then resumes mating (Witte and Winter, 1995; Vitule *et al.*, 2006; Weyl, 2016; Rechi, 2017; Magalhães, 2024).

Most species of oviparous animals have internal fertilization, that is, females lay eggs that have already been fertilized by males. As examples, we can mention all species of birds and crocodilians and some species of fish, lizards, and snakes. On the other hand, in external fertilization, the female deposits the eggs in the environment, and the male releases the sperm onto the eggs. This is the case for animals such as frogs and some species of fish (Figure 4) (Witte and Winter, 1995; Booth, 2008; Weyl, 2016; Rechi, 2017).

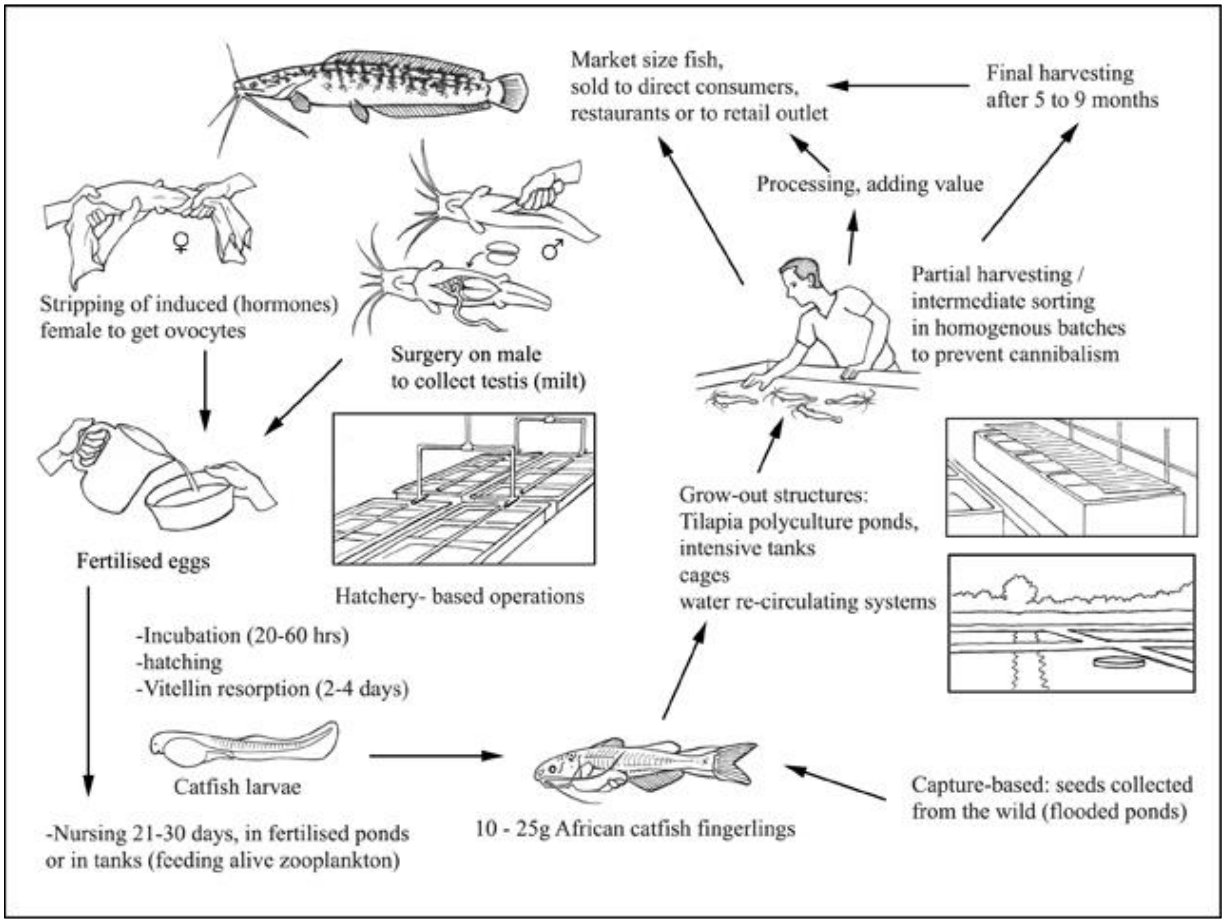

Figure 4: Production cycle of *Clarias gariepinus* (Burchell, 1822) (Siluriformes: Clariidae)
Source: https://www.fao.org/fishery/zh/culturedspecies/clarias_gariepinus?lang=en

Spread occurs mainly in shallow, flooded rivers, lakes, and streams at night. The fish migrate to flooded plains to reproduce and return to the river or lake shortly after the reproduction ritual, while the juveniles remain in the flooded area. Juveniles return to the lake or river between 1.5 and 2.5 cm long. The first sexual maturation occurs when females are between 40-45 cm in size and males are between 35-40 cm. The eggs are greenish. Incubations are short-lived about 33 hours at 25°C (Rechi, 2017; Froese and Pauly, 2019b; Magalhães, 2024).

The African catfish is an omnivorous and predator fish, which feeds on a variety of foods, such as balanced feed, fish, shrimp, plankton, arthropods, mollusks, plants, reptiles, and amphibians. It is important to provide a balanced diet in sufficient quantity to ensure the healthy growth of the fish. *Clarias gariepinus* can

host several species of digenean, as well as other endoparasites and ectoparasites (Figures 5-6) (Witte and Winter, 1995; van Rensburg *et al.*, 2013; Froese and Pauly, 2019a; UMC, 2022).

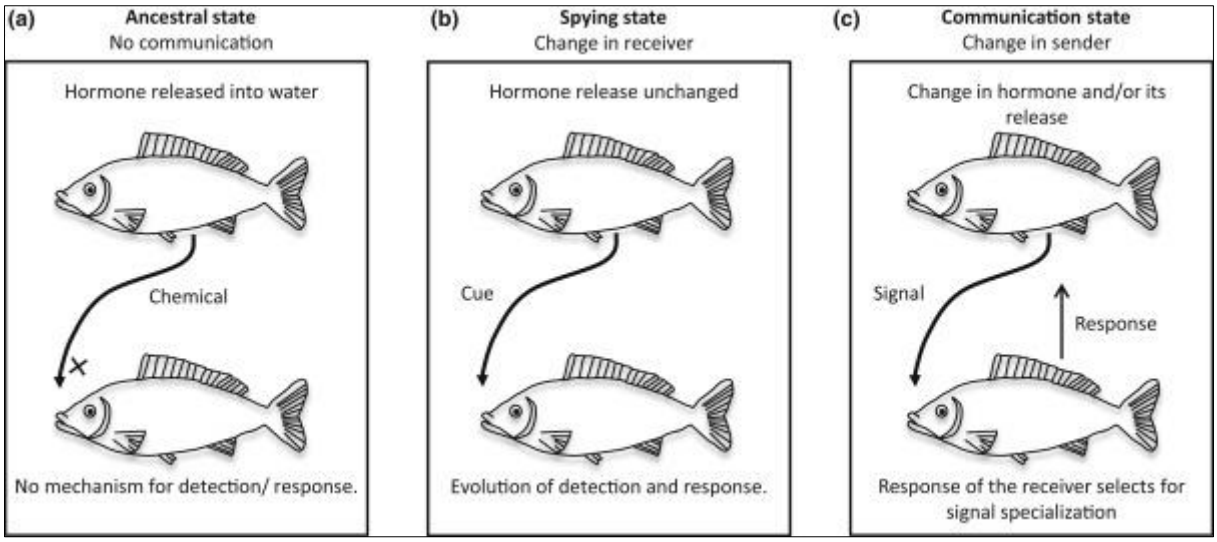

Figure 5: Stages in the evolution of chemical signaling in fish: (a) ancestral state, in which fish release a hormone that is not detected by conspecifics; (b) spying state, where conspecifics can detect and respond adaptively to the hormone; and (c) communication state, characterized by a response of the receiver which selects for signal specialization

Source: https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/clarias-gariepinus

Figure 6: African sharp-tooth catfish *Clarias gariepinus* (Burchell, 1822) (Siluriformes: Clariidae) in mud in the dry season. These fish can breathe air, helping them survive in drying ponds in this highly seasonal ecosystem. Gorongosa National Park, Mozambique

Sources: Jen Guyton - Online Date 1/6/17 - Image number 01568191 - Availability World wid

1.1. 0BJECTIVE

The manuscript aimed to investigate the bioecology of African catfish and venomous marine fish (Actinopterygii: Teleostei).

2. METHODS

To develop the study, the methodology used an integrative literature review, which is a synthesis process with the objective of expanding the understanding of knowledge and achieving the expected results. In this way, the researcher can prepare an integrative review with different purposes, which can be aimed at defining concepts, reviewing theories, or methodological analysis of studies included on a given topic. In its construction process, it is necessary to go through six distinct stages, which are: Identification of the theme and selection of the hypothesis or research question; establishment of inclusion and exclusion criteria for studies/sample or literature search; definition of information to be extracted from selected studies/categorization of studies;

evaluation of included studies; interpretation of results; and presentation of knowledge review/synthesis. To carry out the study, a search for scientific articles was carried out through the Virtual Health Library, in the SCIELO, LILACS, and PUBMED databases.

3.0. SELECTED STUDIES

African catfish can withstand waters with low oxygen concentrations. Individuals of this species have bimodal breathing, that is, they have air-breathing organs present in the brachial arches that allow them to assimilate atmospheric air directly. This species is not a fish from the group of dipnoic fish, known for breathing through an organ that functions like a primitive lung connected to the pharynx (Alexandre Hilsdorf) (Kolar and Lodge, 2001; Cucherousset and Olden, 2011; Froese and Pauly, 2019a; UMC, 2022).

It was introduced around 20 years ago into the ecosystem of the Paraíba do Sul River and lagoons, throughout the North Fluminense region, the African catfish has been dominating the aquatic territory. Fearing the extinction of native species, a group of fishermen bets on aggressive fishing of exotic fish, for their economy and consumption, in addition to trying to guarantee control of the species, which is extremely predatory (Figure 7) (Kolar and Lodge, 2001; Cambray, 2003; Cucherousset and Olden, 2011).

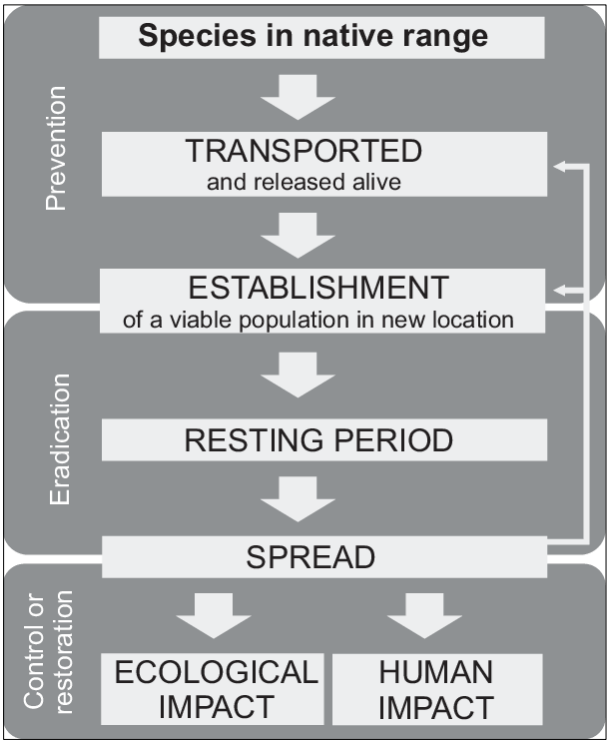

Figure 7: Figure stages in the invasion process of a nonnative species, pointing out activities that need to be carried out at each stage

Source: https://www.researchgate.net/figure/Stages-in-the-invasion-process-of-a-nonnative-species-pointing-out-activities-that-need_fig2_277077683

Researchers and ecologists are not opposed and are betting on large-scale fishing and government programs to completely remove fish, which has become a pest and is causing the disappearance of several species native to the region, threatening artisanal fishing activities in fresh waters. The introduction of fish species resistant to adverse environmental conditions, with low oxygen levels, disease tolerant, top predators and generalists, such as *C. gariepinus*, are strong candidates for becoming invasive (Kolar and Lodge, 2001; Cambray, 2003; Cucherousset and Olden, 2011).

The species is considered a growing threat to aquatic biodiversity due to its great invasive potential throughout the country. and, consequently, there will be an impact on native species and loss of ecological services. The negative impact of species invasions on the sharing economy has already been documented in Brazil. The need for early detection and understanding of the invasion process by aggressive invasive species, such as *C. gariepinus*, to avoid ecosystem and socioeconomic damage. It is a species of great commercial importance both for artisanal fishing, in its countries of origin, and in breeding grounds in the different countries where it was introduced, and, among all catfish, clariids were considered the second group most commercially important in the world (Figure 8) (Alves *et al.*, 2007; Cucherousset and Olden, 2011; Froese and Pauly, 2019a; Froese and Pauly, 2019b; UMC, 2022).

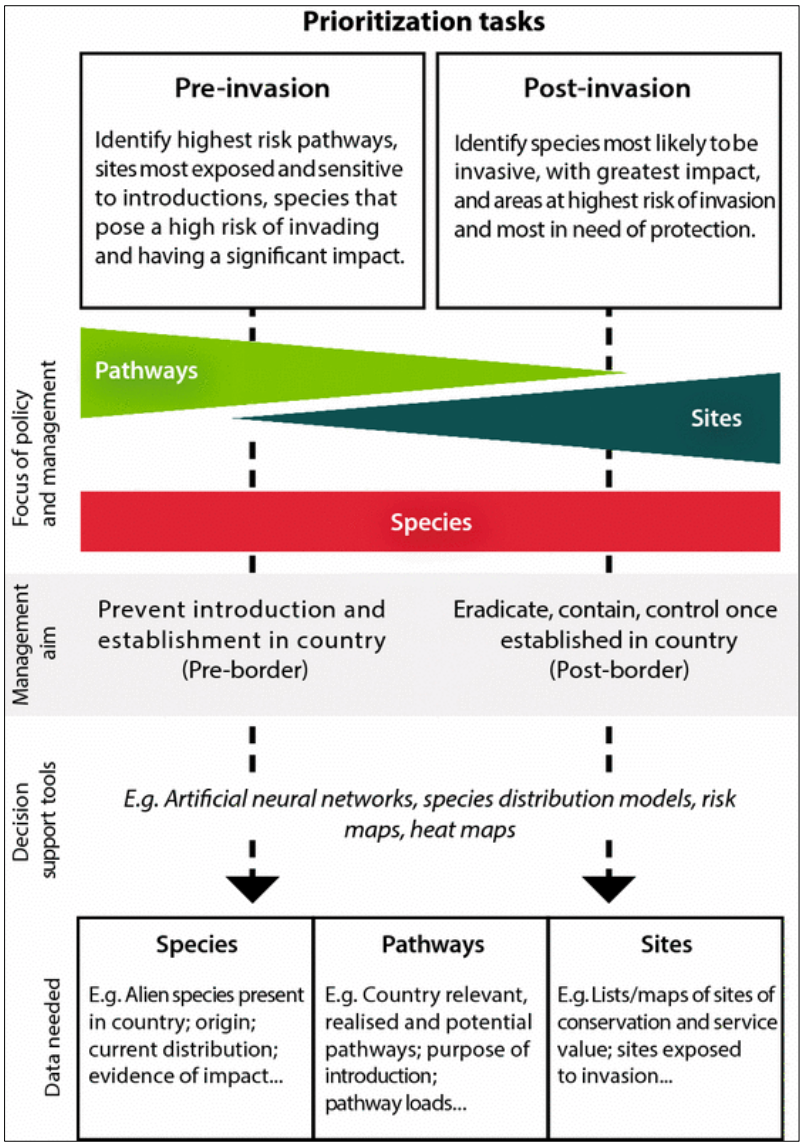

Figure 8: Prioritization takes place within and across stages of the invasion process, both before (pre-border) or after (post-border) invasion. It is therefore relevant to prevention and control objectives and may be supported by a range of analytical decision-support tools. Each focus species, pathway, and site has particular data requirements. In each case, the typical output used in decision-making would be a ranking, or ordered set of categories, of those species, pathways, or sites where action would most effectively prevent or mitigate the impact of biological invasions self-organizing maps are artificial neural network-based, risk assessment method that can contribute to a prioritization scheme

Source: https://www.researchgate.net/figure/Prioritization-takes-place-within-and-across-stages-of-the-invasion-process-both-before_fig1_284359970

It feeds mainly on invertebrates and small fish. Juveniles feed on amphipods, isopods, and copepods. Its meat is considered to be of good quality. It is sold locally. It is found in South America: in shallow coastal marine waters and salty estuaries, lagoons and river mouths that flow into the Atlantic, between Guyana and Brazil. They are fish commonly found in coastal areas with shallow waters and sandy and muddy bottoms (Froese and Pauly, 2019a; Froese and Pauly, 2019b, UMC, 2022).

4.0. Marine Catfish

Marine catfish are animals belonging to the Phylum: Chordata, Subphylum: Vertebrata, Class: Actinopterygii, Infraclass: Teleostei, Order Siluriformes, and the Ariidae family. In Brazil, the species that occurs most abundantly and causes a large number of accidents is the yellow catfish *Cathorops spixii* (Agassiz, 1829) (Siluriformes: Ariidae) known as gonguito catfish or yellow catfish. These fish are found in shallow coastal waters and areas with a muddy or sandy bottom (Figure 9) (Taylor and Menezes, 1978; Haddad, 2003; Haddad, 2018; Ferreira *et al.*, 2023).

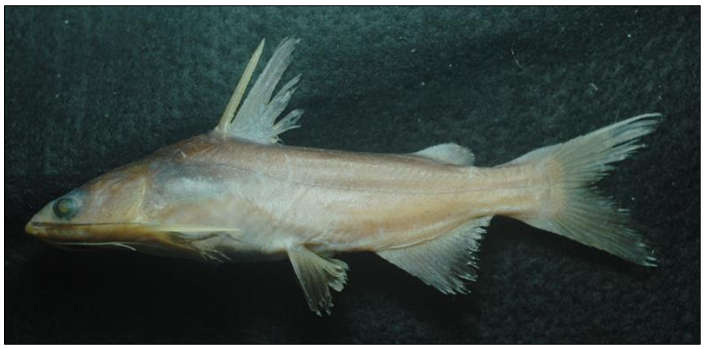

Figure 9: *Cathorops spixii* (Agassiz in Spix and Agassiz, 1829)
Source: http://nossacasa.net/nossosriachos/tabuleiros/cathorops-spixii/

Yellow catfish have an extremely striking characteristic, the presence of whiskers, which are called barbels, enabling the fish to easily locate its prey, with a sensory function. The stinger of the marine catfish is located in the fins, one in the distal region of each pectoral fin and the other in the dorsal. It is worth mentioning that catfish venom is found in three sources: in the stingers, in the glands present at the base of the spines, and the mucus produced by the so-called "club cells". (Figures 10-11) (Taylor and Menezes, 1978; Haddad, 2003; Haddad; 2018; Ferreira *et al.*, 2023).

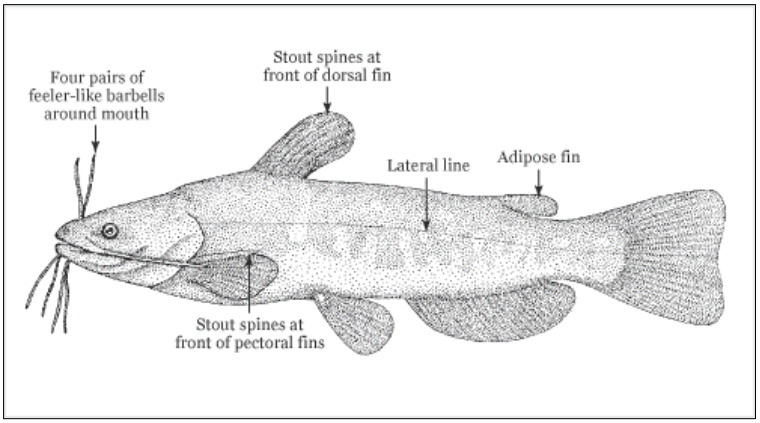

Figure 10: Species of the catfish family, Ictaluridae, can be distinguished from other freshwater fish families in New Zealand as they all have scales, four pairs of long feeler-like barbels around the mouth, stout spines at the front of the pectoral fins, stout spines at the front of the dorsal fin, a lateral line, and an adipose fin. The presence of whiskers, which are called barbels, enables the fish to easily locate its prey, with a sensory function
Source: https://teara.govt.nz/mi/diagram/15735/ictaluridae-features

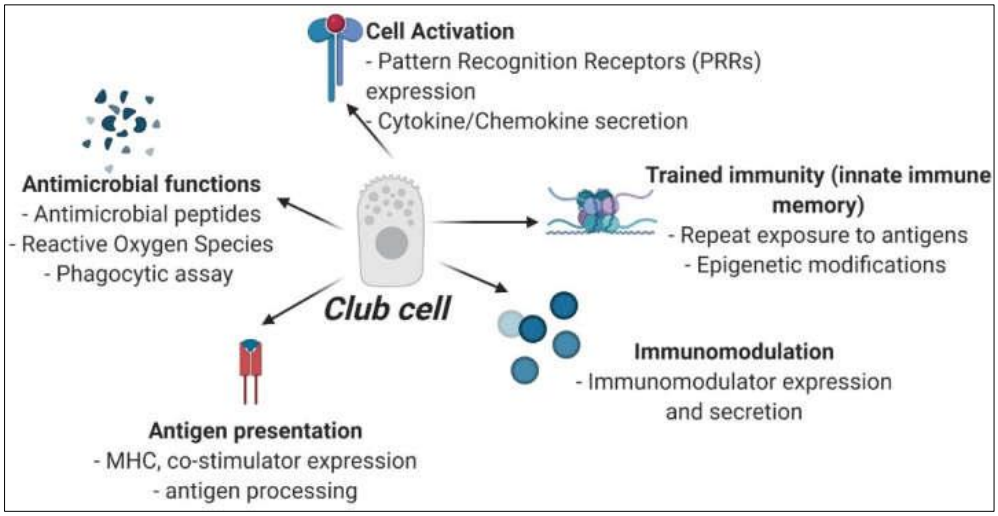

Figure 11: Proposed experiments for in-depth characterization of club cell's immune function
Source: Schematic created using www.biorender.com

Marine catfish have a stinger that can cause unpleasant injuries. The venom of these animals is found in their stingers, in glands located at the base of their spines, and in mucus found on their skin. With the injection of the stinger into the skin, the venom reacts in the body, causing intense pain, which persists for hours, fever, vomiting, sweating, cramps, swelling, paralysis, and, in more serious cases, necrosis of the skin at the site and death due to tetanus infection, although deaths from these fish are not common, and can be prevented by taking the tetanus vaccine regularly (Figure 12) (Taylor and Menezes, 1978; Haddad, 2003; Haddad, 2018; Ferreira *et al.*, 2023).

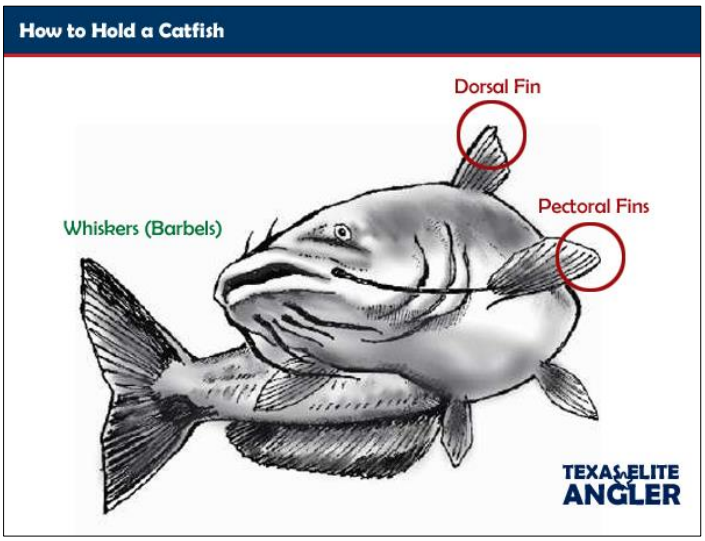

Figure 12: A catfish's whiskers are not defensive structures and they're incapable of delivering a sting of any sort. Whiskers, or more accurately Barbels, are actually an organ that is packed with what amounts to taste buds that help the fish locate food in low visibility waters. Barbels are often referred to as Barbs which may have led to the villainous characterization. A catfish's barbels are quite soft and are more likely to tickle you than sting you
Source: https://texaseliteangler.wordpress.com/2013/11/07/cat-tactics-how-to-hold-a-catfish-without-getting-hurt/

In Brazil, accidents caused by catfish from the Ariidae family are the most common in Brazil, but there are accidents caused by stingrays (various genera), moray eels (*Gymnothorax* Bloch, 1795), scorpionfish (*Scorpaena* Linnaeus, 1758), toadfish (*Thalassophryne* Günther, 1861) and others.

5.1. Therapeutic Use

Sun-dried catfish is an excellent source of protein, in addition to offering nutrients such as vitamin D and omega-3. These nutrients are associated with bone health, immunity, and cardiovascular health. In rodents, the substance was able to treat inflammatory conditions similar to asthma and multiple sclerosis, a disease that affects the central nervous system (Figure 13) (Taylor and Menezes, 1978; Haddad, 2018; Ferreira *et al.*, 2023).

Figure 13: Three species of marine catfish common off the Western Atlantic Ocean coast. Top: the white catfish (*Bagre* sp.) and the yellow catfish (*Cathorops* sp.). Bottom: the white or snake catfish (*Genidens* sp.). Note the stings anterior to the dorsal and pectoral fins
Source: file:///C:/Users/USUARIO/Downloads/CatfishTOXICONfinal%20(1).pdf

The mucus venom contains proteins with a PI close to 5.0. The stinger must be composed of primarily anionic proteins. These results show the important toxic actions induced by the venoms of the marine catfish *C. spixii*, in addition to biochemical aspects, which can be useful in monitoring the clinical evolution and treatment of victims. Mucus venom heals wounds in humans and diabetic wounds have vasoconstrictive factors necrotizing shows antitumor activity and bacterial action (Taylor and Menezes, 1978; Haddad, 2003; Ferreira *et al.*, 2023).

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