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Food Characterization of the Spotted Pimelodid Fish *Pimelodus maculatus* from a Polluted Urban River in Argentina

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ABSTRACT

On the present study, the nourishment and the digestive system of a population of the spotted pimelodid *Pimelodus maculatus* Lacepède 1803 from a polluted urban river in Argentina were analyzed (Reconquista River, Buenos Aires province). The specimens are characterized by having benthic habits and an omnivore diet. In their intestinal content, a diversity of components was identified. Such components were grouped into ten alimentary items, with dietary variations according to body size while the longitude of the intestine remained proportional to standard length. Microbiological analysis in the gills, stomach and intestine showed the occurrence of *Staphylococcus aureus, Escherichia coli* and *Salmonella* sp. Fungi and yeast were also detected. Bacterial accounts were very high both in the analyzed organs as well in water samples. The ecological and sanitary significance of the identified bacteria is discussed.

Keywords: *aquatic bacteriology, fish nourishment analysis, Pimelodus maculatus (Siluriformes, Pimelodidae), polluted urban rivers*

INTRODUCTION

Continental waterbodies constitute an invaluable natural resource that humanity has always benefited from due to a diversity of linked activities. Its fauna, especially fishes, have been evidenced as a food source and raw material for many industries, also, to be used with recreational and cultural purposes, such as fishing and aquarium.

Buenos Aires city and surrounding area constitutes one of the most populated sites in South America. It is crossed by the Reconquista River (figure 1), which is strongly influenced by discharges and wastewaters from more than 4,000.000 people and 12,000 industries. As occurs in many urban rivers worldwide, the Reconquista River shows high levels of pollution from various anthropogenic sources. *Nevertheless, in* its lower basin *it is possible to find an* ichthyological fauna coming from nearby powerful courses as the Parana River and the Plata River [1,2].

Pimelodus maculatus Lacepède 1803 is an endemic species from South American rivers [3,4] commonly fished for nutritional and recreational purposes [2,5,6]. It is characterized for being an omnivorous fish, therefore is said that it can be found in almost all trophic levels of freshwater ecosystems [1]. Its nutrition is mainly based on molluscs, crustaceans, plankton and other residues on the sand and mud [7,8,9].

In the present work, we analyzed the nourishment and some aspects of the digestive system of a population of *P. maculatus* from the lower basin of the Reconquista River. Results contribute to understanding the area's trophic frame as well as its possible adaptation to pollution and other anthropic influences.

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Studies related with Pimelodus

The Parana Basin and the Rio de la Plata in South

Figure1. Reconquista River (Buenos Aires, Argentina) showing the study area.

Table 1. Three group size of population in global analysis

Size	Size Range (cm)
Small	10.00-13.5
Medium	13.51-16.5
Large	16.51-19.5

America are the geographic locations for *P. maculatus,* which lives in streams, rivers, and lentic waters. It is omnivorous and has an ample plasticity of feeding on organic matter, invertebrates, insects, and fish. Ramos et al. [1] did a large review about this species at the Parana basin. They consider that it is a migratory fish with migrations up to 1,000 km, and its reproduction is related with the period of higher rainfall in the upper Parana basin. The species has a large genetic plasticity to accommodate in a new habitat [3]. They analyzed the effect of the temperature and lunar phase on stream fish passage at Igarapava Dam, Brazil.

Arantes et al. [5] studied the reproduction and embryogenesis in captivity concluding that this species at high water temperature reached the maturity but did not spawn. Hirt et al. [2] analyzed the reproduction and growth of *P. maculatus* on the Yacitreta Dam. The results showed the species had an extended reproductive cycle, and it has ample growth and reproductive strategies that indicate its plasticity to adjust to new environmental conditions. Garcia et al. [10] found that native fishes of South America as *P. maculatus* had altered their diets to consume invasive bilvalves. These organisms ingest trace metals, and they could impact the human consumption. Chemes and Takemoto [11] did a study in the middle Parana water system, and they observed that the intestine and the gills were the places more infected by parasites in siluriform fishes. The structure of fish assemblages at Itaipu Reservoir (Parana River) was studied by Oliveira et al. [12]. The results demonstrated that the relation predator-prey and the preference of feeding habitat could handle a random structure assemblage in omnivorous as *P. maculatus*.

Figure 2. The first plane of dissection with internal organs visualization.

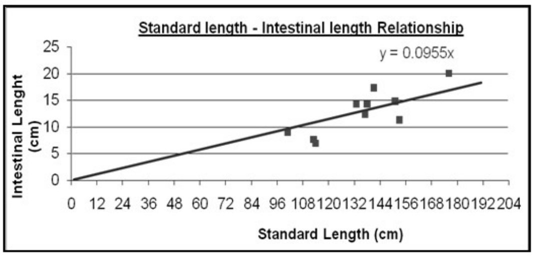

Figure 3. The relationship among intestinal length and standard length in the study population

The application of technology helps for studying the population of fishes and the entrance in new environments. Paiva and Kalapothakis [13] evaluated the genetic variability in the species concluding that the use of polymorphic markers is a useful mean for studying the genetic structure of populations of *P. maculatus*.

MATERIALS AND METHODS

Samples were taken in the Reconquista River lower basin (Buenos Aires province, Argentina), a very crowded region (figure 1). Work was performed using specimens from both male and female sexes in all obtainable sizes. Specimens were captured mainly by using bottom lines and then transported in anairtight plastic container inside a cooler.

Once in the laboratory the following analysis were performed: morphometry and external anatomy observation, dissection and analysis of the digestive tract, stomach content analysis, intestine length and microbiological aspects of stomach, intestine and gills.

Morphometric study

The following measurements were performed: wet weight, standard length, and body width (at the level of the pectoral fins).

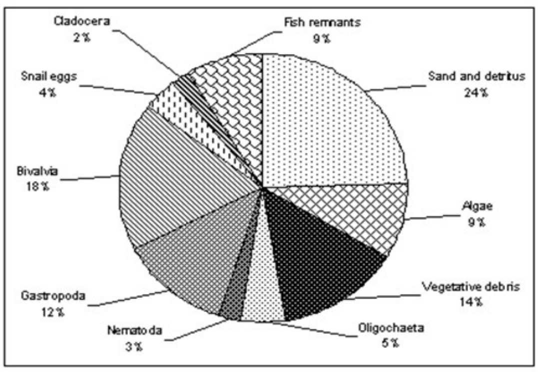

Figure 4. Diet components proportions of the stomach content for the analyzed population

Table 2. Primary alimentary items percentages found in *Pimelodus maculatus* stomach contents.

Alimentary Item	**Percentage**
Sand and detritus	24.33
Algae	9.19
Vegetative debris	14.05
Oligochaeta	4.87
Nematoda	2.70
Gastropoda	12.43
Bivalvia	17.84
Snail eggs	3.78
Cladocera	2.16
Fish remnants	8.65

Dissection and digestive tract study

The dissection technique was to pinch the skin of the fish in the area just before the anus using a mouse tooth tweezer and with a scalpel, carry out a small incision. A ribbed tube was inserted through the incision to make the cut without the possibility of damaging the tissue. Using the scalpel, following the path indicated by the cannula, a longitudinal cut was made from the middle of the gills to the anterior to anal opening. Then, four transverse cuts were made, two close to the gills, parallel to the lids, and two at the sides of the anal orifice. Such cuts were made in order to be able to open the trunk fully onto two sheets to the side to allow visualization of internal organs (figure 2).

Table 3. Percentages (%) of dietary components proportions according size range.

Stomach content	**Size range (cm)**		
	10.0-13.5	**13.51-16.5**	**16.51-19.5**
Sand & detritus	28.57	26.72	0
Algae	28.57	2.59	0
Vegetative debris	20.41	12.09	10.0
Oligochaeta	0	6.03	10.0
Nematoda	10.21	0	0
Gastropoda	4.08	18.10	0
Bivalvia	4.08	26.72	0
Snail eggs	4.08	4.31	0
Cladocera	0	1.72	10.0
Fish remnants	0	1.72	70.0

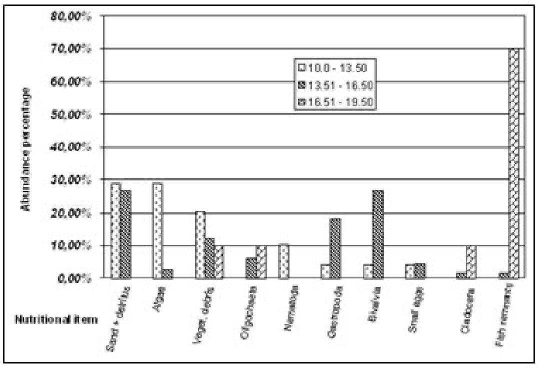

Figure 5. *Pimelodus maculatus'* diet comparison according specimen size range

Digestive system analysis

With the help of the tweezers and scalpel, the viscera were carefully separated from the body wall. Followed by an incision made at the base of the esophagus and in the mouth of the intestine in the anal orifice, to remove the stomach and intestines and place it on a tray. All bowel mesentery was cut and extended as straight as possible, to determine the length. Stomach was separated from the intestine and weighed. A longitudinal incision in the stomach wall was performed and carefully poured its contents were poured into a Petri dish. Using distilled water the contents were dispersed, and the resulting material was observed under a 40x microscope.

For the analysis of the stomach content, a measure of relative abundance of four levels was assigned (abundant, frequent, less frequent, and scarce).In addition to global analysis, the population was divided into three group sizes in the following ranges (table 1).

Bacteriological analysis

The bacteriological analysis was performed on stomach, intestine and gills swabbing in fresh specimens. Stomach and intestine previously underwent dissection removing and sectioning both viscera.

Standard culture media were followed for the analyses of mesophilic aerobic bacteria (TSA), total coliform (Mac Conkey) and *Enterobacteriaceae* (VRBL). Specific media were employed for identification of *Staphylococcus aureus* (BP), *Escherichia coli* (EMB), *Pseudomonas aeruginosa* (Cetrimide) and *Salmonella* sp./*Shigella* sp. (Bismuth sulfite). SDB medium was employed for molds and yeasts [14].

Culture broths and bacterial enrichment were prepared using TSB broth for general bacteria, Lactose broth for *Salmonella* and coliforms and Selenite Cystine Broth for *Salmonella* sp.

Furthermore, microbiological analysis of the water from the research area was made, following respective standardized techniques.

RESULTS AND DISCUSSION

General and external anatomy

Average specimen weights ranged from 14.90-115.14 g. The size structure presented a range of 10.0-20.0 cm standard length and 1.7- 4.0 cm in maximum width.

Digestive system and stomach content

The length of the intestine seems to keep a constant proportion with the standard length. Randomly selecting different specimens, data conforms to the theoretical information that responds to the equation:

$y = 0.0955\ x$ (figure 3).

The diet of the specimens analyzed presented high diversity. The alimentary items and their relative percentages are summarized in table 2 and figure 4.

Moreover, the composition of the diet showed some variation in body size, allowing differentiated into three groups as shown in table 3. Small individuals showed the highest percentages of sand and debris as well as algae, less plant debris and a total absence of Oligochaeta, Cladocera and fish remains. In the second group size predominated in the diet Bivalvia Mollusces, with much sand and debris, while the nematodes were absent. In large specimens, fish remains predominated, with small percentages of oligochaetes, cladocerans and plant debris and total absence of the other components of the diet. The comparison of the three diet groups is shown in figure 5.

Bacteriological aspects

High concentrations of aerobic mesophiles were detected in stomach, intestine and gills. Abundant colonies of *Staphylococcus aureus* and *Enterobacteriaciae* were also observed. The presence of fungi and yeasts is evident in the three organs. Coliform colonies' were higher in the intestines than in the gills and somewhat lower in the stomach. *Escherichia coli* was present in all plates. It was most abundant in the material derived from the intestine. Bismut Sulfite culture confirmed the presence of *Salmonella* sp. Its colonies were abundant in intestines and gills and relatively scarce in the stomach.

Regarding the water where these specimens were extracted from, *high levels of bacteria were present.* Total bacteria ranged from $2x10^5$ to $1x10^6$ cfu/ml while coliform amounts usually exceeded 10^6 MPN/100 ml.

The diet and nutritional habits corresponded to those referenced for Catfish [7,8,9]. General anatomy and morphometric ratios were in concordance with the literatures [15,16,17].

With a 24% of detritus in their diet, the concern of a possible heavy metal intrusion in their food chain, and therefore in ours, is also present [18,19]. Heavy metals are proven to cause changes in fish cells and therefore adversely affect their development [20,21].

Regarding microbiological analysis in gills, intestine and stomach, results are indicative of pollutant alteration of the aquatic environment. Many of the isolated bacteria are also closely linked to infectious disease in humans. Local fishermen commented that they used the fish as a food source. Though to cook the fish eliminates the bacteria, preparation or handling can be a risk for health and sanitary prevention. In the same area, many children and adults who use fishing for this species as recreational way were seen manipulating the fish directly with their hands and at the same time-consuming food, with the consequent danger.

Fish fauna can be considered valuable indicators of the health of our aquatic ecosystems. Fishes contain information for the assessment of the present and past of the basin where they live. These circumstances allow us to predict environmental impacts by phenomena of different origins.

Analyzes related with the bioaccumulation of pollutants in water, gills and liver [21]. They analyzed *P. maculatus* in a hydroelectric station in Minas Gerais. The results indicated that organic pollutants and metal traces (Cr, Cu, Fe, and Zn) were higher concentrated in liver than the gills. The changes in liver and gills could be used as a bioindicator of water pollution. The changes in the mitochondrial cells of *P. maculatus* induced by organochlorines and metals were investigated in the Furnas hydroelectric reservoir [20]. The results demonstrated that Cu, Cr, Fe, Zn, and organochlorines were detected in the gills. These species are vulnerable to the effects of pollution, which affects their survival and reproduction along with the rest of the organisms in the food web [4,21]. Shenone et al. [19] analyzed *Parapimelodus valenciennis* at Chascomus Lake, Argentina. The industrial and agricultural wastes could pollute the water ecosystems, and the fish becomes an indicator of contamination. Higher metal contamination was determined in skin and muscle. Transfer mechanisms for other components of the ecosystem occur through fish. Even contaminants that do not directly affect adult fish, such as organochloride biocides, with the bioconcentration process can cause lethal effects affecting fish and unbalancing the basic balance of the entire ecosystem.

The cited literatures indicates the potential use of *P. maculatus* as a bioindicator of the water quality of the Reconquista River. The results of this study suggest a possible correlation between heavy metal concentration in tissues of *P. maculatus* and water of is important watercourse.

CONCLUSIONS

The analyzed population of *Pimelodus maculatus* from the Reconquista River shows an omnivore diet. Their intestinal content can be grouped into ten alimentary items. Specimens have dietary variations according to body size. Microbiological analysis in gills, intestine and stomach are indicative of pollutant alteration of the aquatic environment. Bacterial accounts are very high both in the analyzed organs and in the water sampled within the research area. The isolated bacteria from the organs are closely linked to infectious diseases in humans. Inappropriate handling and cooking of specimens increase the potential risk to human health.

Results suggest a possible correlation among heavy metal concentrations in tissues of *P. maculatus* and the waters of the river. However, further analyses are needed to better understand *P. maculatus* ecological adaptations to polluted urban rivers.

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