





NOTE

Baseline data of the presence of meso and microplastics in the digestive tract of a commercially important teleost fish from Río de la Plata Estuary System (Southwest Atlantic Ocean)

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ABSTRACT. White croaker (*Micropogonias furnieri*) is the most important commercial fish of Río de la Plata Estuary System (RLPES), one of the most extensive on the western South Atlantic coast. This paper describes the occurrence, abundance, and type of plastic debris (PD) present on the digestive tracts of 65 white croakers in the RLPES. Eighty percent of analyzed individuals had ingested PD, 156 of which (FO = 83.9%) were thread-like plastics and 30 were fragments (FO = 16.1%). The average number of pieces per digestive tract was 2.83 ± 3.14 . Microplastic represented 85% of PD, most of them were < 2 mm and the prominent color was blue. Our results demonstrate the high occurrence of meso and microplastics in one of the most important species from an ecological and commercial viewpoint in the RLPES. The RLPES is the area of the Southwest Atlantic Ocean that concentrates most of the records of plastic waste in the environment, where the white croaker is the main commercial fish. In addition, *M. furnieri* is a main prey for several predators in the area. Although preliminary, this is a relevant contribution to the knowledge of marine debris pollution and its impact on the marine community of the region.

Key words: Marine debris ingestion, plastic pollution, *Micropogonias furnieri*, estuary, South America.



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Primeros registros de la presencia de meso y microplásticos en el tracto digestivo de un importante pez comercial del Sistema del Estuario del Río de la Plata (Océano Atlántico Sudoccidental)

RESUMEN. La corvina rubia (*Micropogonias furnieri*) es el pez comercial más importante del Sistema del Estuario del Río de la Plata (RLPES), uno de los más extensos en la costa atlántica sudoccidental. En este trabajo se describe la ocurrencia, abundancia y tipo de desechos plásticos (DP) presentes en el tracto digestivo de 65 ejemplares de corvina rubia del RLPES. El 80% de los individuos analizados había ingerido DP, de los cuales 156 eran plásticos filiformes (FO = 83,9%) y 30 eran fragmentos (FO = 16,1%). El número medio de piezas por tracto digestivo fue de $2,83 \pm 3,14$. El microplástico representó el 85% de los DP, la mayoría de las cuales eran < 2 mm y el color predominante fue el azul. Nuestros resultados demuestran la alta ocurrencia de meso y microplásticos en una de las especies más importantes desde el punto de vista ecológico y comercial en el RLPES. El RLPES es el área del Océano Atlántico Sudoccidental que concentra la mayor parte de los registros de desechos plásticos en el medio ambiente, donde la corvina rubia es el principal pez comercial.

Además, *M. furnieri* constituye una presa principal de varios depredadores de la zona. Aunque preliminar, esta es una contribución relevante al conocimiento de la contaminación por desechos marinos y su impacto en los organismos del Océano Atlántico Sudoccidental, particularmente en el RLPES.

Palabras clave: Ingestión de basura, plásticos marinos, *Micropogonias furnieri*, estuario, América del Sur.

Nowadays, there is growing global concern about pollution by plastic debris (PD), and marine ecosystems are particularly involved in this problem, being the final destination of most marine debris (Eriksen et al. 2014). An estimated 6-12 million tons of plastic enter the oceans each year (Jambeck et al. 2015), these circumstances are persistent in the environment and have negative impacts on marine fauna (Gregory 2009).

Entanglement and ingestion are the two main types of interaction by aquatic organisms (Laist 1997; Gall and Thompson 2015; Kühn and van Franeker 2020). The former is the most visible effect of PD on organisms and is mainly associated with suffocation and general debilitation (Gregory 2009; Jepsen and de Bruyn 2019), whereas the latter is less visible and recorded, and is related to satiation (Derraik 2002; Machovsky-Capuska et al. 2019; Santos et al. 2020). In fact, at least 750 marine species interact with PD (Gall and Thompson 2015). Records of PD ingestion on some marine species of commercial importance for human consumption have significantly increased over the last years throughout the world (Foekema et al. 2013; Lusher et al. 2013; Van Cauwenberghe and Janssen 2014; Devriese et al. 2015; Neves et al. 2015; Rochman 2015; Liboiron et al. 2016; Bessa et al. 2018; Ory et al. 2018; Arias et al. 2019; Azevedo-Santos et al. 2019). However, there is a lack of evidence of plastic transfer from seafood to humans (Akhbarizadeh et al. 2019).

In Argentina, fishing represents one of the most important economic activities for the country; in fact, more than 450,000 t corresponding to 57 species of fish were caught in 2020 (MAGyP 2021). Nowadays, records of plastic ingestion in Argentine commercial fishes are very few, namely in silverside (*Odontesthes bonariensis*) from Río

de la Plata Estuary System (RLPES) (Pazos et al. 2017) and white croaker (*Micropogonia furnieri*) from Bahía Blanca Estuary (Arias et al. 2019).

Estuaries and coastal areas of heavily anthropogenic impacted regions are the most polluted ecosystems with plastic debris (Eriksen et al. 2014; Galgani et al. 2015; Frère et al. 2017). In Argentina, the RLPES is an extensive and shallow coastal plain estuary on the western South Atlantic coast (35° S-36° S) (Mianzan et al. 2001). The presence of more than 5 million inhabitants on its coasts (Baigún et al. 2016), added to oceanographic characteristics of the area, makes the estuary an area with high concentration of PD (Acha et al. 2003). In particular, the presence of PD has been found on different species, ranging from freshwater fishes to marine turtles, marine birds and marine mammals (Denuncio et al. 2011, 2017; Gonzalez Carman et al. 2014; Lenzi et al. 2016; Pazos et al. 2017; BURGUES et al. 2020).

This area is also a highly productive system, where industrial and artisanal fisheries are very valuable, being *M. furnieri* one of the main species from the ecological (Denuncio et al. 2017; Franco Trecu et al. 2017) and commercial (Mianzan et al. 2001) viewpoints of the area. Due to the high concentration of PD found in the RLPES, this study is meant to assess the occurrence, abundance, and type of PD present on the digestive tract of this species.

Fish samples were purchased from a bottom trawling fishery company operating on the coastal area of Bahía San Borombón (RLPES, 36° 26' S-57° 70' W) in August 2017 (Figure 1). Sixty-five individuals of *M. furnieri* were measured (mm) (TL), weighted (g) (W), classified in juvenile or adult class following the guidelines

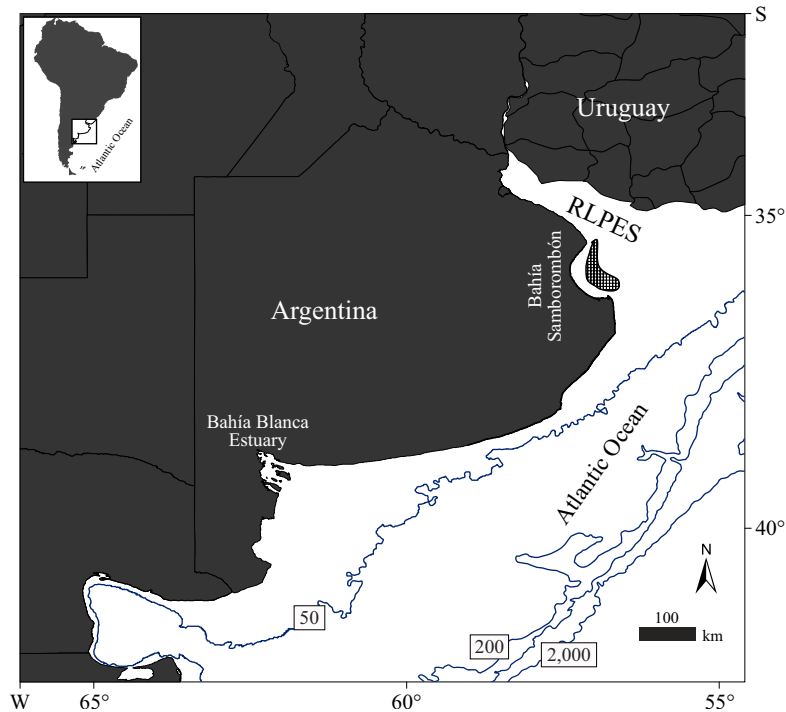


Figure 1. Location where commercial company caught white croaker (*Micropogonias furnieri*) in Río de la Plata Estuary System (RLPES) during 2017 (reticulate area).

set out by Vizziano et al. (2002), who determined the size at first maturity in 202 ± 4.0 mm and 195 ± 0.4 mm for females and males, respectively. In addition, the Condition Factor (CF) was calculated according to $CF = (W \times 100)/(TL)^3$ (da Costa and Araújo 2003).

Complete digestive tracts were removed and examined for PD ingestion analysis. Digestive tracts were dissolved and fully digested with a solution of hydrogen peroxide (H_2O_2), adjusting the methodology used in several studies (Avio et al. 2015; Pazos et al. 2017; Arias et al. 2019). In order to reduce the time under chemical digestion (7 d for digestion with 30% H_2O_2 for Arias et al. 2019), 48 h in H_2O_2 60% solution was the optimal method used to obtain complete organic digestion. PD were identified and separated. Separation of long size fragments was made by the naked eye, while microplastics were identified by means of a magnifying glass and removed. PD

obtained were counted, measured, and classified by type (sheet plastics, thread-like plastics, foamed synthetics, and hard fragments), color and size (microplastics: < 5 mm, mesoplastics: 5–20 mm and macroplastics > 20 mm; Barnes et al. 2009) according to the recommended standardization for the ingestion of marine debris from megafauna proposed by Provencher et al. (2017). The presence of PD was expressed as the frequency of occurrence (FO%), defined as the proportion of individuals analyzed where PD was found. General Additive Models (GAM) were used to explore differences between total PD related to total length, weight, sex, and condition factor of fishes. Models were tested for goodness of fit and the most parsimonious model was chosen using the Akaike's Information Criteria (AIC) (Burnham and Anderson 2003). Statistical analyses were performed using the free access program R (R Core Team 2021).

Fish body lengths ranged from 229 to 759 mm (mean 397.5 ± 146 mm) and weight ranged between 235 and 632 g (mean 347.8 ± 87 g). The proportion of males was 57%, while females represented 36% of samples, 7% of the specimens could not be identified; all fish sampled were adults.

Eighty percent of analyzed individuals ingested PD. A total of 186 items were counted, of which 156 were thread-like plastics (FO = 83.9%) and 30 were fragments (FO = 16.1%) (Figure 2). Average number of pieces of PD per digestive tract was 2.83 ± 3.14 (max = 17 pieces). The number of PD per digestive tract was not significantly affected by the total length, weight, sex, and condition factor of fishes (GAM model, $R^2 = -0.0492$; $p = 0.62$). Microplastic debris accounted for 85% of pieces found, most of which were < 2 mm (FO = 57.5%) (Figure 3). There was no macroplastic presence in the guts analyzed.

Most prominent colors were blue (FO = 59.9%), followed by brown (FO = 14%), black (FO = 9.3%), red (FO = 9.3%), violet (FO = 2.3%), yellow (FO = 2.3%), white (FO = 1.7%), and green (FO = 1.2%) (Figure 4).

Our results demonstrate a high occurrence of meso and microplastics in *M. furnieri* from RLPES, where pieces < 2 mm and thread-like plastics were predominant. Microplastics comprised a very heterogeneous assemblage of particles that varied in size, shape, color, chemical composition and density (Galgani et al. 2015). Thread-like plastics dominated marine debris, including mainly fibers, which were also the predominant type of micro-debris in almost all studies of PD in fishes (e.g. Boerger et al. 2010; Lusher et al. 2013; Pazos et al. 2017; Arias et al. 2019).

PD found in *M. furnieri* had been previously reported only once in a different estuary area of Argentina (Bahía Blanca), located *ca.* 700 km southern away from our study area (Arias et al. 2019) (Figure 1). The number of pieces found per individual (~ 12) in Arias et al. (2019) was greater than the values obtained in our paper, but the type of PD dominant in both was the same (thread-like plastics/fibres). White croaker is a benthic and generalist species (Carozza et al. 2004), previous reports have observed that benthic and demersal fish contained more fibres, while pelagic fish contained more fragments (Markic et al. 2018).

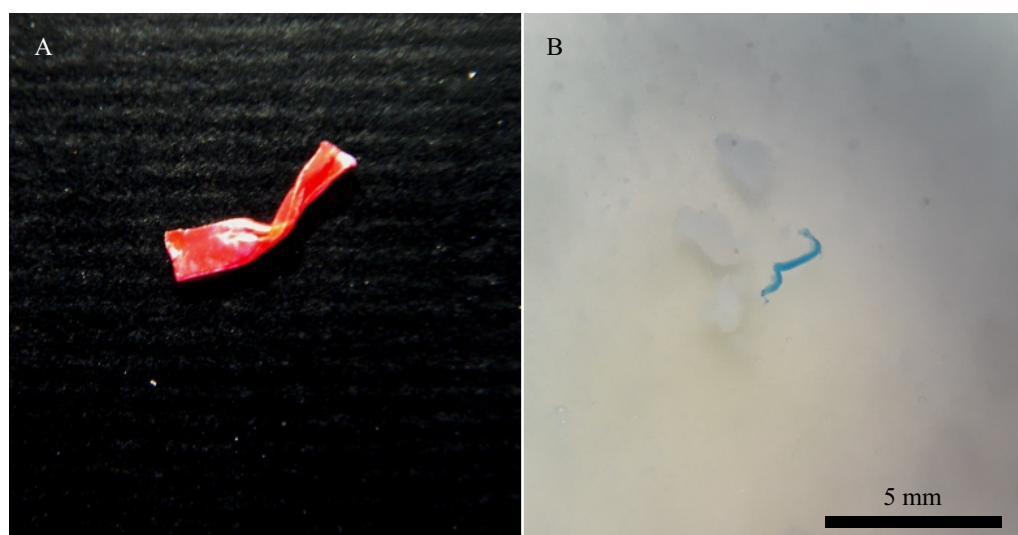


Figure 2. Fragment (A) and thread-like (B) microplastics extracted from the guts of *Micropogonias furnieri* from Río de la Plata Estuary System (RLPES).

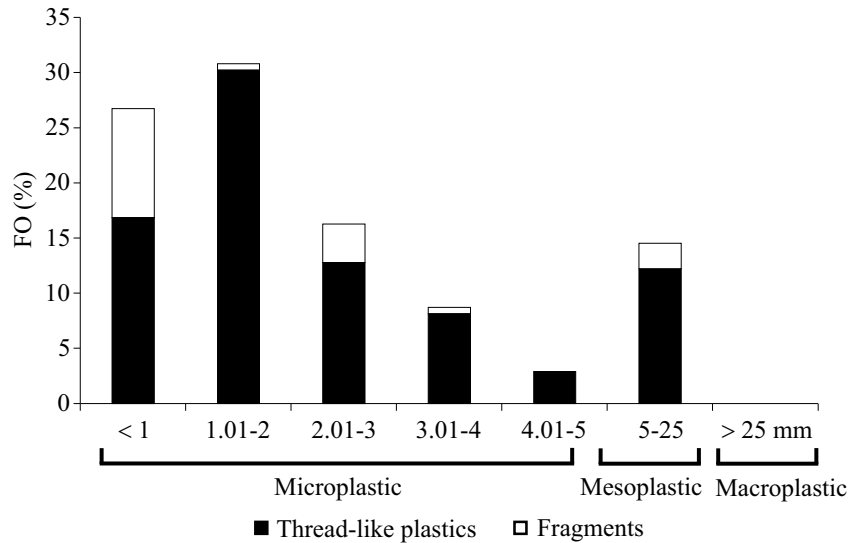


Figure 3. Frequency of occurrence (FO%) of plastic debris (PD) classified by size and type from the digestive tract of *Micropogonias furnieri* from Río de la Plata Estuary System (RLPES) in 2017.

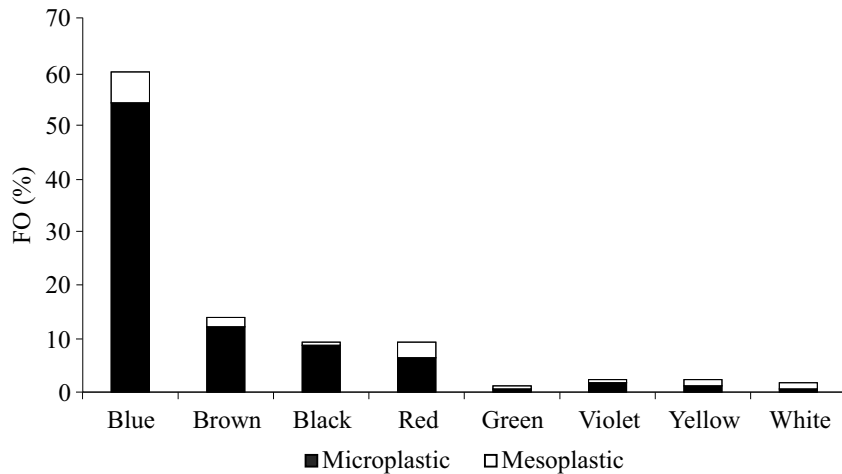


Figure 4. Frequency of occurrence (FO%) of plastic debris (PD) classified by size and colors from the digestive tract of *Micropogonias furnieri* from Río de la Plata Estuary System (RLPES) in 2017.

Probably, this is a consequence that fibres are also commonly found as the prevalent type of PD in benthic sediments (Claessenes et al. 2011; Frias et al. 2016).

Differences obtained in the number of pieces per digestive tract in both studies could be related to several non-exclusive factors. Although PD biomagnification across a general marine food

web is not supported by current field observations, it is not ruled out (Miller et al. 2020). There are differences in the feeding ecology between croakers from RLPES and from Bahía Blanca Estuary (Carozza et al. 2004) that could explain such differences. Besides that, the methodology used by Arias et al. (2019) was different from the one used in this paper. They used different con-

centration and time of exposition of H₂O₂ to fully digest the digestive tract, and PD were inspected under a stereomicroscope, allowing the detection of plastic sizes not detected by our procedure. Despite the latter, our study represented a preliminary assessment and was focused on larger (mesoplastics and large microplastics) marine debris, and differences could be related to the low capability and equipment to detect the smallest range of microplastics.

In our study, blue color was remarkably more frequent than others. Blue PD, particularly microplastics, dominated microplastics found in many species, from freshwater fishes to marine megafauna (e.g. Ory et al. 2017; Meaza et al. 2020; Zantis et al. 2020); but for the same species Arias et al. (2019) observed that predominant colors were transparent and red. It was also observed that there was a difference in color distribution depending on locations (Markic et al. 2018), which could explain differences found between both areas.

Plastic ingestion causes physical and chemical effects on organisms (Kühn et al. 2015). Despite plastics are not bioaccumulated in individuals (Grigorakis et al. 2017), they can produce different chemical effects in individuals, such as changes in the body condition of the animals (Rochman et al. 2014; Luis et al. 2015). Several studies correlated the body condition of fish with plastic load but results were irresolute and opposite (Rummel et al. 2016; Cardozo et al. 2018; Compa et al. 2018). Our study, therefore, suggested that there was no evidence that total length, weight, sex, and condition factor were related with the PD presence in white croaker from RLPES, and probably that plastic ingestion occurred as a result of a certain individual trait (e.g. Toms et al. 2010).

Microplastics ingestion has been well documented for a range of commercially interested animals for human consumption in several countries, mainly in Europe and Asia (Barboza et al. 2018). Recently, the translocation of microplas-

tics from the digestive tract to muscle tissue (Abbasi et al. 2018; Zitouni et al. 2020; Rasta et al. 2021) and the transfer of toxins from microplastics to tissue have been documented (Rochman et al. 2014). Even if the trophic transfer of microplastics in marine food webs remains unknown (Akhbarzadeh et al. 2019), physical and chemical studies of microplastics in marine commercial species of the region should continue as an essential topic in terms of public health and food security. At present, there are very few studies of microplastics in commercial species from Argentina (Pazos et al. 2017; Arias et al. 2019).

The presence of PD in the digestive tract of *M. furnieri* registered in this paper contributes to the evaluation of the overall impact of plastic pollution on the marine community of the region. Nonetheless, this work is a baseline study; future works could include chemical characterization of PD and new methodology for detection of smaller MPs.

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