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Plastic fibers in the gastrointestinal tract content of two South Atlantic coastal fish species with different trophic habits (*Urophycis brasiliensis, Paralonchurus brasiliensis*) in Punta del Diablo-Uruguay

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Abstract. Synthetic fibers are ubiquitous in the global oceans and could be potentially consumed by marine biota. The gastrointestinal tract content of two coastal fish species with different trophic habits and exploitation status were analyzed. Presence of synthetic fibers was recorded for the first time in Uruguayan coastal fishes.

Key words: Synthetic fibers, fish, coastal systems, gastrointestinal tract content, trophic habits.

Resumo: Fibras plásticas no conteúdo do trato gastrintestinal de duas espécies de peixes costeiros do Atlântico Sul com diferentes hábitos tróficos (*Urophycis brasiliensis, Paralonchurus brasiliensis*) em Punta del Diablo-Uruguay. As fibras sintéticas são omnipresentes nos oceanos e podem ser potencialmente consumidas pela biota marinha. O conteúdo do trato gastrointestinal de duas espécies de peixes costeiros com diversos hábitos tróficos e estado de exploração, foi analisado. A presença de fibras sintéticas foi registrada pela primeira vez em peixes costeiros uruguaios.

Palavras-chave: Fibras sintéticas, peixes, sistemas costeiros, conteúdo do trato gastrointestinal, hábitos tróficos.

Extraordinary amounts of anthropogenic marine debris are concentrated in oceans worldwide as the result of large plastic production and deficient waste management programmes (Ryan 2009, Derraik 2002). According to Barnes *et al*. (2009), four size classes are operatively defined for plastics found in aquatic ecosystems: megaplastics (>100 mm), macroplastics (> 20 mm), mesoplastics (5-20 mm) and microplastics (< 5 mm). Mega and macroplastic damage to marine biota has been well documented, such as entanglement, external wounds, ingestion, and gut blockage (Possatto *et al.* 2011, Bond *et al*. 2014, Velez-Rubio *et al*. 2018). However, there is increasing evidence of the negative effect of the smaller size classes (meso and microplastics) on marine biota. Laboratory studies have demonstrated the ingestion of microplastic by invertebrates (Browne *et al*. 2008), and trophic transference of plastic particles between planktonic organisms (Setälä *et al*. 2014). Fibers of synthetic origin are one of the most prominent microplastic forms in the marine environment (Wright *et al.* 2013). They are ubiquitous throughout the global oceans (Van Cauwenberghe *et al*. 2013), and are distributed throughout the water column, sediments, and the deep sea, with highest concentrations in populated coastlines and within oceanic gyres (Cole *et al*. 2011, Wright *et al*. 2013). Coastal areas have a crucial role as feeding, spawning and nursery grounds for marine species, including commercially important fishes used for human consumption (Segura *et al.* 2008, Militelli *et al.* 2013). The coastal area of Punta del Diablo, Uruguay (34° 04'– 33° 54' S; 53 °32'– 53° 30' W) is a nursery ground for multiple fish and invertebrate species (Trinchin 2012, Segura *et al.* 2012), among which *Paralonchurus brasiliensis* (“corvalo”) and *Urophysis brasiliensis* (“brotola”) are commonly registered (Trinchin 2012). Although both species have benthic habits, their morphology, adult size and diet differs. *P. brasiliensis* is a small-sized species (24 cm max. size) whose feeding preferences are dominated by polychaeta worms and small crustaceans other than shrimps (Robert *et al.* 2007). Differently, *U. brasiliensis* reach larger adult size (64 cm max. size) and consumes mainly fishes and decapods (Acuña 2000). Since plastic particles are widespread in the marine environment (sea surface, shorelines, and the sea bed), they can potentially be ingested by fish with different trophic preferences such as benthivorous or carcinophagous and piscivorous species (Boerger *et al.* 2010, Davison & Ache 2011, Lusher *et al.* 2013). Research related to registering and evaluating plastic contamination and its effect on marine biota is still incipient in Uruguay (Lozoya *et al.* 2015). Some studies have analysed plastic presence and distribution in sandy beaches (Lozoya *et al.* 2016, Rodriguez 2018), and in the diet of few species such as sea-gulls and turtles (Lenzi *et al.* 2016, Vélez-Rubio *et al.* 2018). However, its presence in marine fish gastrointestinal tract content has not been evaluated.

The objective of the present work is to analyse the presence or otherwise of plastic particles in the gastrointestinal tract of two coastal fish species with different trophic habits. Fishes were collected from coastal waters (z < 15m) in Punta del Diablo, Rocha-Uruguay (34° 04’–33° 54’ S; 53 °32’– 53° 30’ W), during a biodiversity monitoring cruise in 2016 using a small bottom trawl net (Segura *et al.* 2008, 2014). We selected two species with different feeding habitats; *U. brasiliensis*, and *P. brasiliensis*, which are abundant and common in the area (Trinchin 2012, Segura *et al.* 2012). All specimens were frozen within two hours of capture until laboratory analysis. The gastrointestinal tract of all specimens was removed to quantify presence, number and type of plastic ingested. The organic fraction of the gastrointestinal tract content was digested using a 10 % Potassium Hydroxide Solution (KOH) for 20 hours at 80 °C, then filtered through a 30-µm polycarbonate filter (Rochman *et al.* 2015). Each filter was screened under a Nikon SMZ800 stereomicroscope. We recorded color, size and type of plastic particles. To prevent laboratory contamination, work surfaces were thoroughly cleaned with alcohol, and hands and forearms were scrubbed. All instruments were previously washed with distilled water. To identify and quantify possible sources of contamination we used three control treatments as follows: I) to assess possible contamination by the digesting solution, we inspected a solution of KOH 10% (with no sample) which was processed following the same protocol as the samples (named “KOH control”). Contamination during stereomicroscope observations were checked using two complementary controls. We placed and then inspected II) an empty filter next to the sample (“dry control”), and III) a Petri dish filled with distilled water next to the sample (“wet control”). Plastic particles detected in the control treatments were compared in morphology, texture and colour with the plastic particles found in the samples. If their characteristics matched, those particles were excluded from the analysis. All polymers identified were fibers, for which we recorded their, color, size, and shape. We also analyzed the fibers encountered with Raman and Infrared spectroscopy (FTIR), to determine their origin.

We sampled 8 specimens of *P. brasiliensis* and 8 specimens of *U. brasiliensis*. Both species were measured in total length (TL) and presented similar size ranges, but *P. brasiliensis* (Mean size= 17.0 cm, range=14.5-18.7 cm) was composed of both juveniles and adults (Robert *et al.* 2007) while *U. brasiliensis* (mean size= 15.1 cm, range= 14-16.7 cm) was composed of juveniles. The polymers identified were fibers smaller than 1 cm in size (corresponding to the meso and microplastic categories). The total number of synthetic fibers founded was 16, while we discarded any fiber that resembled our lab coats or the color of our clothing on the day of analysis or to any fiber founded in the controls. Contamination by plastic particles was detected in control treatments II and III. In total, 11 fibers were excluded and only 5 fibers were considered (Fig. 1). Raman and FTIR analysis of the fibers showed inconclusive results. Fluorescence was detected in most of the fibers which precluded an accurate identification of their origin. However, in one fiber found in *Paralonchurus brasiliensis*, FTIR analysis found a spectrum corresponding to Zinc Oxide, which is commonly used to colour synthetic fibers. Alternatively, we categorized the fibers based on their color and appearance following Rochman *et al.* (2015). The colours of the fibers counted were violet (3 fibers), sky-blue (1 fiber) and a large dark one. We believe that at least in the first four cases the color is consistent with a synthetic origin, rather than a natural one.

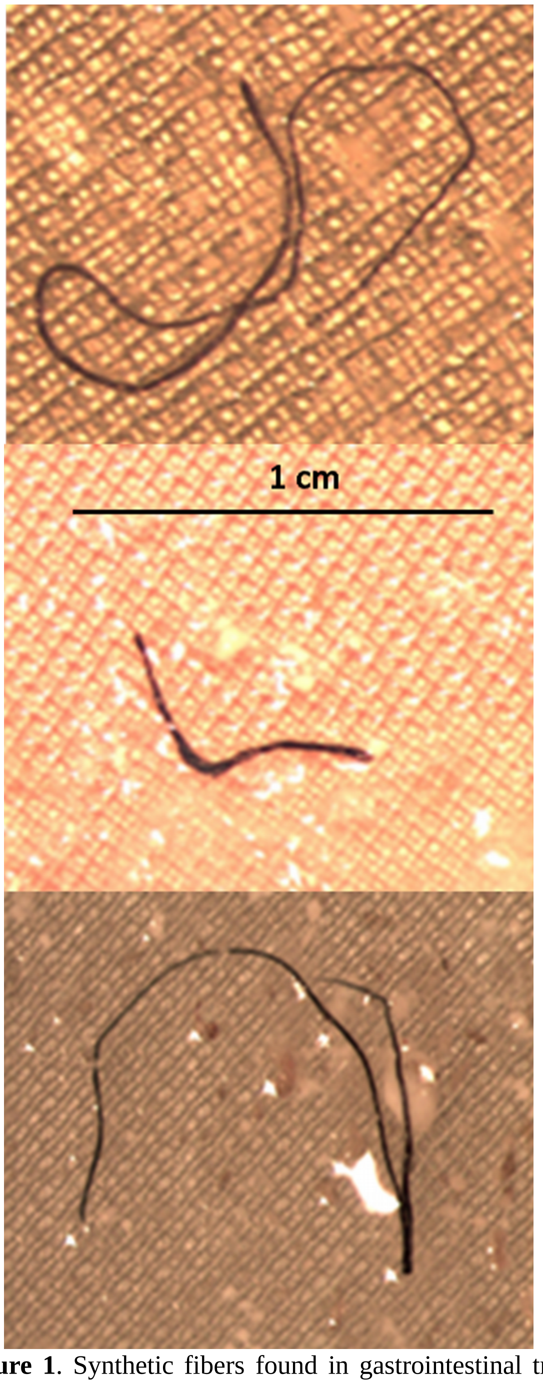

Figure 1. Synthetic fibers found in gastrointestinal tract content of fishes from Punta del Diablo, Uruguay.

To our knowledge this is the first record of synthetic fibers in the gastrointestinal tract of two marine species in the Atlantic coast of Uruguay. Synthetic fibers are the most abundant polymer in the marine environment (Wright *et al.* 2013), and could have diverse origins such as clothing, diapers, fishing nets, and be the result of indirect input through the sewage (eg. washing clothes) or direct input (e.g. fishing nets) (Reed 2015, Cardozo *et al.* 2018).

There are two plausible mechanisms to explain the ingestion of plastic in the species analysed in this study. i) direct ingestion of plastic fibers or ii) indirect ingestion. The carcinophagous-ichtyophagous trophic habit of *U. brasiliensis* (Leoni 2017, Segura Pers. Obs.), and its voracious behaviour, can facilitate direct ingestion of fibers from the water column. *P. brasiliensis* on the other hand, feed mainly on polychaetes (Robert *et al.* 2007, Leoni 2017). While juvenile specimens of *U. brasiliensis* have been described mostly as carcinophagous (Acuña 2000), the size range of the organisms in that study was larger (>20 cm) than the specimens analysed here (<20 cm). The organisms in this study were found to prey on small fish (< 5cm) and shrimps, which are abundant in the coastal zone of Punta del Diablo (Leoni 2017), while *P. brasiliensis* was found to prey on polychaetes, small shrimps and other small crustaceans (not crabs; Leoni 2017). Plastic consumption by polychaetes and other invertebrates such as crustaceans and molluscs has been recorded (Murray & Cowie 2011, Courtene-Jones *et al.* 2017, Jang *et al.* 2018) as well as by small planktonic fishes (Boerger *et al.* 2010), and there is some evidence of indirect ingestion of plastic through food chains (e.g. Setälä *et al.* 2014, Eriksson & Burton 2003), which could be the case here.

This first report of the presence of plastics in small-sized fishes from the Uruguayan coast suggests that this environmental issue might be common. Nevertheless, we found a low proportion of fish with fibers in their gastrointestinal tract (N=3; 18, 7%) compared to previous studies in other regions (37%, Boerger *et al.* 2010). The small sample size (N=16) and the fact that their habitat is close to a Marine Protected Area with relatively low anthropogenic impact could explain the low plastic prevalence in our study. Alternatively, the relatively low trophic position of the fish analysed decreased the probability of indirect ingestion through the trophic web. Future analysis of the condition factor of organisms with plastic particles in the gastrointestinal tract compared to those without them, seems a necessary step to understand the true effect of plastic pollution for coastal fish populations (Rochman *et al.* 2017). This preliminary study, however, should be taken as a first approach to evidence the problem. Systematic studies with larger number of samples, more fish species, and larger size ranges should be conducted in order to quantify more accurately the incidence of plastic in fish gastrointestinal tracts in relation to their trophic habits. In addition, it is necessary to conduct systematic analyses to determine the origin of fibers, such as Raman spectroscopy (Collard *et al.* 2015), to check contamination origin and type of polymers involved. Finally, conducting these studies at different sampling sites would provide a wider picture of the plastic problematic in the Uruguayan coastal zone.

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