ORIGINAL PAPER

Microplastics in the digestive tracts of reef fish in the Eastern Gulf of Thailand

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Abstract. Plastic use and disposal have increased as a consequence of industrial development in most countries, resulting in plastic pollution in marine and coastal ecosystems. Several studies reported plastic ingestion by sea turtles, seabirds and marine mammals, however much less is known about the consumption of plastic debris by marine fishes, particularly in Thai waters. The aim of this study was to analyze the abundance of microplastics in gut contents of reef fishes in Trat Province, the Eastern Gulf of Thailand. The reef fishes were collected using fish traps during January – October in 2016. The stomachs of the fishes were removed, opened and then the contents were rinsed into vials. The abundance of microplastics in the fish was examined by hydrogen peroxide and floatation then filtration with saline (NaCl) solution treatments. A total of 17 reef fish species were collected. The most abundant species were *Siganus canaliculatus*, *Sargocentron rubrum*, and *Lutjanus russellii*. The microplastic sizes ranged between 500 and 4,000 µm. the highest abundance of microplastics was found in *Siganus canaliculatus*, while the lowest abundance levels were observed in *Sargocentron rubrum* and *Lutjanus russellii*. Most microplastics were blue and colorless fibers. This study highlights the importance of public awareness regarding microplastic pollution in coastal and marine ecosystems.

Keywords: microplastics, fish, coral reef, pollution, Gulf of Thailand

1. Introduction

The production and use of plastic have been continuously increasing as a consequence of industrial development. From 1995 to 2016, global plastic production increased to 335 million tons (PlasticsEurope, 2017), these activities have raised the number of plastics entering the oceans, reaching approximately 5-13 million tons per year (Jambeck et al., 2015). Plastic debris are accumulated in the oceans, as well as coastal ecosystems directly and indirectly by different kind of sources that causes plastic pollution (Andrady 2011).

Microplastics are a substantial proportion of plastic debris but not a specific kind of plastic: they are particulate plastic pieces smaller than 5 mm (Arthur et al., 2008). The estimation of the accumulated number of microplastic particles in 2014 that is approximately 51 trillion particles, weighing 260 thousand tons, more or less enter the oceans (Van Sebille et al., 2015). Several studies and researches have reported plastic ingestion in sea turtles, sea birds, and marine mammals, evidencing how microplastics can enter food chains of marine ecosystems (Boerger et al., 2010; Lazar and Garcan 2011). However, the studies relating to microplastics ingestion of marine fishes in Thai waters are limited. The objective of this study was to assess the abundance of microplastics in the stomach content from three abundant reef fishes that were caught by fish trap in Trat Province, Eastern Gulf of Thailand.

2. Materials and Methods

The study was conducted at Ko Mak in Trat Province (Figure 1.), the easternmost Thai portion of the gulf. Reef fishes were caught by fish traps during January – October 2016.

2.1 Sample collection

The reef fish samples were caught by fish trap at Ko Mak. During study period, 17 reef fish species were caught. Three species namely, *Siganus canaliculatus*, *Sargocentron rubrum*, and *Lutjanus russellii* were selected for microplastics extraction due to these three species were the most abundant reef fishes caught by fish trap at Ko Mak. Ten individuals of each species; *Siganus canaliculatus* (n=10), *Sargocentron rubrum* (n=10) and *Lutjanus russellii* (n=10) were collected and measured for morphological characters including the length from mouth to central point of caudal fin (cm) and total body weight (g).

2.2 Microplastic extraction

Then their stomachs were removed, opened and rinsed into vials. The samples were then dissolved in 30% H_2O_2 at 55–65 °C until it was completely digested follow in Avio et al. (2015). The digested samples were mixed with saturated saline (NaCl) solution and filtered. Particles retained on the filter paper were observed and inspected for microplastics under a stereomicroscope.

2.3 Statistical analysis

The abundance of microplastics was expressed mean with standard deviation. In addition, the One-way ANOVA with Tukey's HSD was performed to test the difference of microplastics density among three reef fish species.

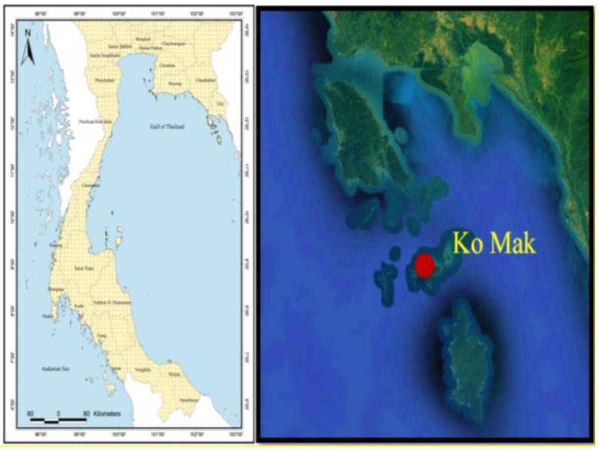

Figure 1. Map of the study site at Ko Mak, Trat Province, the Eastern Gulf of Thailand

3. Results

A total of 17 reef fish species were caught by fish trap during January-October in the year 2016 (Table 1). The most abundant fishes were *Siganus canaliculatus*, *Sargocentron rubrum* and *Lutjanus russellii* (Figure 2). The largest body length was found in *Lutjanus russellii* with 20.06±0.78 cm, whereas the highest weight was found in *Siganus canaliculatus* (Table 2.)

Table 1. A list of reef fish species collected from the fish traps at Ko Mak, Trat Province

Family	Common name	Scientific name
Caesionidae	Red-bellied fusilier	*Caesio cuning*
Chaetodontidae	Copperbanded butterflyfish	*Chelmon rostratus*
Diodontidae	Black-blotched porcupinefish	*Diodon liturosus*
Holocentridae	Doubletooth soldierfish	*Myripristis hexagona*
Holocentridae	Redcoat	*Sargocentron rubrum*
Labridae	Tripletail Wrasse	*Cheilinus trilobatus*
Lutjandae	Russell's snapper	*Lutjanus russellii*
Monacanthidae	Fan-bellied leatherjacket	*Monacanthus chinensis*
Nemipteridae	Pearly monocle bream	*Scolopsis margaritifera*
Nemipteridae	Whitecheek monocle bream	*Scolopsis vosmeri*
Ostracidae	Boxfish	*Acanthostracion polygonius*
Scaridae	Bluebarred parrotfish	*Scarus ghobban*
Serranidae	Two-banded soapfish	*Diploprion bifasciatum*
Siganidae	White-spotted rabbitfish	*Siganus canaliculatus*
Siganidae	Yellow-spotted rabbitfish	*Siganus guttatus*
Siganidae	Java rabbitfish	*Sigunus javus*
Siganidae	Double-barred rabbitfish	*Siganus virgatus*

Table 2. The body length and weight of selected reef fish species

Species	Total body length (cm)	Total body weight (g)
Siganus canaliculatus	19.73±0.94	110.11±7.82
Sargocentron rubrum	19.44±0.75	76.66±5.23
Lutjanus russellii	20.06±0.78	109.66±5.94

The average abundance of microplastics varied from 1.5 to 11.0 items/individual. The abundance of microplastics varied across species revealing that the abundance of microplastics found in *Siganus canaliculatus* was significantly different with *Sargocentron rubrum* (p = 0.03) and *Lutjanus russellii* (p = 0.01). The highest abundance of microplastics was found in *Siganus canaliculatus*, while the lowest one was observed in *Sargocentron rubrum* and *Lutjanus russellii* (Figure 3).

The four microplastic size classes ranging between 100 and 5000 µm were investigated. The highest composition of microplastics size class was found in the range of 1001–2000 µm, while the lowest one was found in the range of 100–500 µm (Figure 4). The highest average length of microplastics found in digestive tract of selected fish species was found in the Redcoat, *Sargocentron rubrum*, (2125.13+408.25 µm), whereas the lowest one was observed in the White-spotted rabbitfish, *Siganus canaliculatus* with average length of 1541.67+627.77 µm. In addition, most microplastics recorded among fish stomach contents were fiber, as well as blue and colorless (Table 3. and Figure 5).

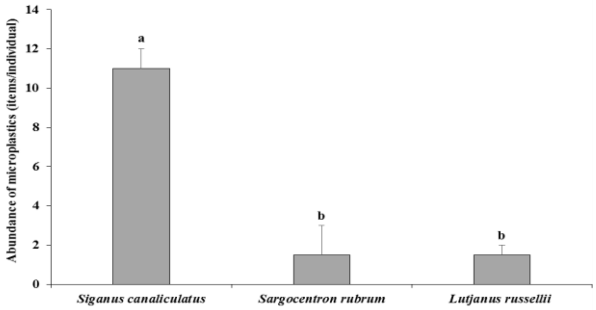

Figure 3. Abundance of microplastics in the stomach contents of three reef fish species

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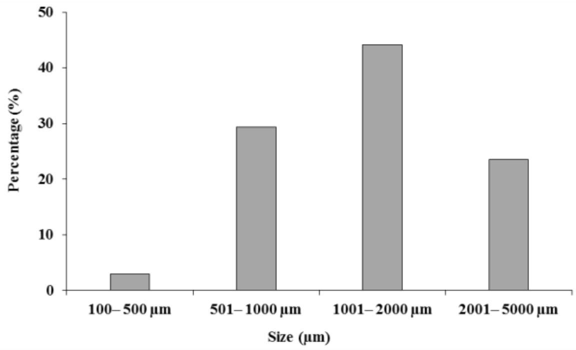

Figure 4. Size-class frequency distribution of microplastics

Figure 2. Most abundance of reef fish caught by fish trap at Ko Mak: A) *Siganus canaliculatus* (Park, 1797), B) *Sargocentron rubrum* (Lacepède, 1802), C) *Lutjanus russelli* (Forsskål, 1775)

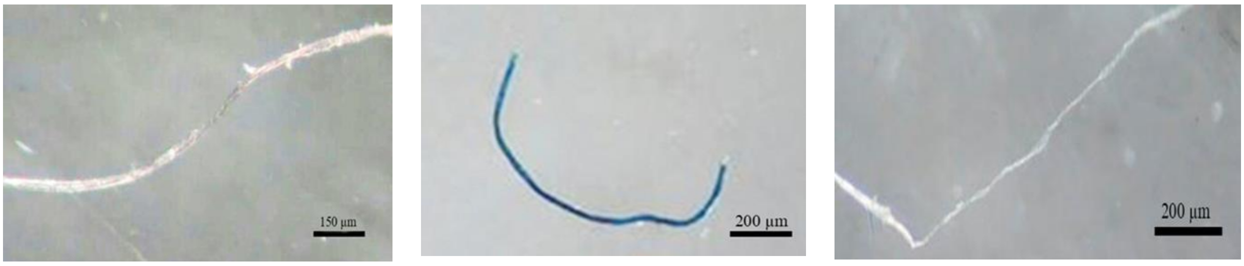

Figure 5. Type and size of microplastics were found in reef fishes.

Table 3. Details of microplastic found in digestive tract of selected reef fish species

Species	Average length of microplastics (µm)	Types of microplastics	Colors
Siganus canaliculatus	1541.67+627.77	Fiber	Colorless (58%) Blue (42%)
Sargocentron rubrum	2125.13+408.25	Fiber	Blue (50%) Colorless (43%) Green (7%)
Lutjanus russellii	1833.33+235.70	Fiber	Blue (65%) Colorless (29%) Green (6%)

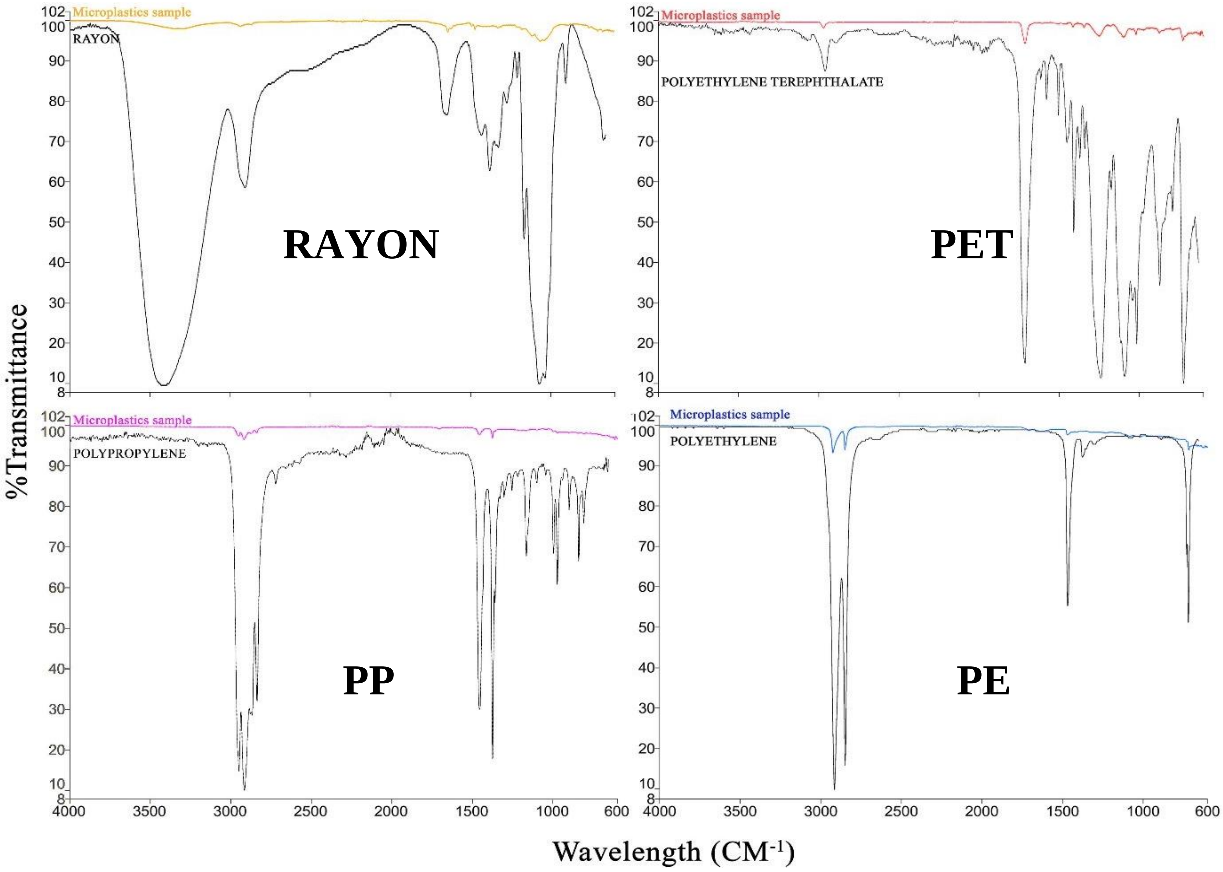

Figure 6. The FTIR spectrum of microplastics in the digestive tract fish. Black curves are the FTIR spectra of standard polymers in spectral libraries. The color curves are the FTIR spectra of microplastics samples.

A total of microplastic particles were identified through FTIR (Fourier-transform infrared spectroscopy). Four microplastic types were polyethylene terephthalate (PET), polyethylene (PE), Rayon, and polypropylene (PP) (Figure 6). PET was the most common type of microplastic found in the digestive tract, followed by PE, Rayon, and PP. The only type of microplastic found in this study was fiber. The color of microplastics was classified into three types viz blue, green, and colorless. Blue particulates were the most abundant in *Sargocentron rubrum* and *Lutjanus russellii*, and colorless particulates were abundant in *Siganus canaliculatus*.

4. Discussion

This study provides the first assessment of microplastic ingestion by reef fish in the Gulf of Thailand. The average abundance of microplastics per individual fish from our results are comparable with the data collected in other studies (Avio et al., 2015; Bellas et al., 2016). The fish taxonomic groups which were examined in this study belong to different trophic guilds. The White-spotted rabbitfish *Siganus canaliculatus,* is an herbivore and a bottom feeder (Sale, 1991; Fox and Bellwood 2008). Conversely, both species *Sargocentron rubrum* and *Lutjanus russellii* are carnivorous fishes that feed benthic crabs and shrimps including small fishes (Golani et al. 1983; Hajisamae et al., 2006). Benthic fish have been observed to ingest more microplastics than pelagic fish (Neves et al., 2015), supporting the claim that fibers are more common in the sediment while fragments are dominant in surface waters (Eriksen et al., 2013; Frias et al., 2016; Maes et al., 2017).

All examined fish had microplastics in their stomachs. The blue microplastics were the most dominant color in the samples. It might be possible blue particulate could attract predators because colors are similar to their prey. The dominant types of microplastics were identified fibers, which was in accordance with previous reports (Güven et al., 2017; Ferreira et al. 2018). The plastic particulates obtained in this study were either fiber type or fragment type, which might have been from fishing gears by fishery activities. As a result of the FTIR test, most samples had detected to be produced by PET and PE, which is the fishing net composition, whereas rayon that component of fabric found much fewer samples than these. However, several marine activities affected the higher occurrence of microfibers, such as coastal development, tourism, and fishery activities that could be enhanced microplastic in the marine environment (Güven et al., 2017; Ferreira et al., 2018).

Further studies should investigate microplastic ingestion by several reef fish species, comprising both pelagic and benthic species, which have different feeding strategies. Studies to quantify presence and abundance of microplastic pieces in the sediment and throughout the water column of coral reefs are also required. Monitoring programs should be carried out in order to better understand microplastics contamination in marine organisms. Although Trat Province is not an industrialized area in Thailand, microplastics are also present in its coral reef ecosystems. This study highlights the importance of public awareness regarding microplastic pollution in coastal and marine ecosystems.

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