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Microplastic Occurrence in the Gastrointestinal Tract of Rabbitfish (*Siganus canaliculatus*) in Pujada Bay, Philippines

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ABSTRACT

Microplastic (MP) ingestion by marine fish species has recently been studied and have become a growing global concern. This study evaluates the MP's characteristics, and their polymer type found in the gastrointestinal tract (GIT) of common rabbitfish *Siganus canaliculatus*. The study utilized standard methods in extracting MPs from the fish samples and a Fourier Transform Infrared Spectroscopy (FTIR) was used to identify the plastic polymers. A total of eleven (11) confirmed MPs and sixteen (16) suspected MPs were found in the GIT of 22 (27.5%) contaminated rabbitfish out of 80 individuals of *S. canaliculatus* examined. The most prevalent synthetic polymers ingested are thermoplastic (n = 4) and synthetic rubber (n = 4). The dominant characteristics of confirmed MPs are colored blue and fragment shape. This study is a preliminary report of MP occurrence in the GIT of rabbitfish in Pujada Bay, a common fish eaten by coastal communities in the Philippines.

Keywords: Microplastic (MP), polymer, rabbitfish, synthetic rubber, thermoplastic

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INTRODUCTION

Plastic materials have shaped human daily lives for they are heavily used by man due to economic practicality. Almost all aspects of society rely on plastic as the main ingredient in the materials used. However, mismanaged disposal of plastic poses a serious pollution challenge. As it accumulates, plastic pollution becomes transboundary (Borrelle et al., 2020; Avery-Gomm et al., 2019; Stafford and Jones, 2019) and is recognized as a global threat that impacts multiple countries and ecosystems.

Microplastics (MPs) occur when plastic breaks down into small particles, about less than 5 millimeters in diameter (Kershaw, 2015). Generally, MPs are categorized into two, primary MPs are produced intentionally while secondary MPs are produced from the degradation (mechanically or chemically) and breakdown of large plastics into small particles (Jaikumar et al., 2019). Secondary MP outnumber primary MPs as large plastics continuously breakdown and accumulates more in the natural environments (Song et al., 2024; Wang et al., 2020). With their small size, ranging from one (1) micrometer to five (5) millimeters (Kershaw, 2015), MPs are easily introduced, distributed, and pollute marine environments (Tang et al., 2021). Consequently, MPs are easily ingested mistakenly as food by marine organisms that may result in accumulation of toxic substances, affecting higher trophic levels in the food chain (Guzzetti et al., 2018).

The ingestion of MPs by marine organisms, particularly fish, has recently ignited global research (Wootton et al., 2021). For instance, Egbeocha et al., (2018), Guzzetti et al., (2018), and Wright and Kelly (2017) investigated the threats and effects of microplastic (MP) ingestion on marine organisms. The MPs ingested by fish represent a risk of exposure to the human population, especially to coastal communities that frequently eat fish as a source of daily protein (Mazurais et al., 2015; Oliveira et al., 2013). There is a knowledge gap in the accumulation of MPs in the ecosystem and the effects of consuming MPs in humans (Barboza et al., 2018; Toussaint et al., 2019). The MPs may be the source of other chemical contaminants and if ingested pose health risks (Makhdoumi et al., 2023). MPs are already detected in plants, animals, and human tissues (Jung et al., 2022), highlighting the potential risks of MPs. For example, Smith et al., (2018) outlined the potential health risks and challenges of ingestion of MPs via seafood. The presence of MPs in humans potentially causes adverse effects such as inflammation, and disorders in reproduction, respiratory, and metabolism (Blackburn and Green, 2022).

In semi-enclosed bays, such as the Pujada Bay in the Philippines, there may be difference in plastic accumulation between the inner part of the bay compared to the outer part of the bay (Liu et al., 2021), and this may in turn affect the ingestions of MPs in fish. The rabbitfish *Siganus canaliculatus*, locally known as "kitang" or "kitong" is a common demersal and seagrass dwelling fish. Since Pujada Bay has abundant shallow to deep seagrass beds[1], rabbitfish is a common diet by the coastal human communities. This study describes the collected MPs from the gastrointestinal tract (GIT) of *S. canaliculatus* through their polymer type, color, and shape, as well as accounts the density of MPs. This study hypothesizes that the common rabbitfish *S. canaliculatus*, collected from the inner part of Pujada Bay harbor more MPs compared to those collected from the outer part. The result of this study may have implications to the solid waste management and mitigation of plastic pollution in the country.

MATERIALS AND METHODS

Description of the study area

The study is designed as descriptive research that compares the occurrence of MPs in the gastrointestinal tract (GIT) of *S. canaliculatus* collected from the inner and outer parts of Pujada Bay, Davao Oriental, Philippines (Figure 1). Pujada Bay, a declared Protected Landscape and Seascape is a semi-enclosed bay with an estimated area measuring 168 square kilometers, surrounded by ten (10) coastal barangays belonging to the City of Mati (Abreo et al., 2020). The two study sites are Barangay Dahican which is located at the inner part of Pujada Bay with a population of 23,496, as well as Barangay Lawigan which is at the outer part of the bay with a population of 3,637[2].

[1]Department of Science and Technology – Japan Society for the Promotion of Science (DOST – JSPS) entitled *"Development of a Comprehensive Coastal Ecosystem Modelling, Mapping and Monitoring System (CCEMMMS) in Pujada and Mayo Bays Philippines"* from Davao Oriental State University (2021)
[2]Personal Communication to the Barangay Hall of Dahican and Lawigan, Barangay profile, 2025

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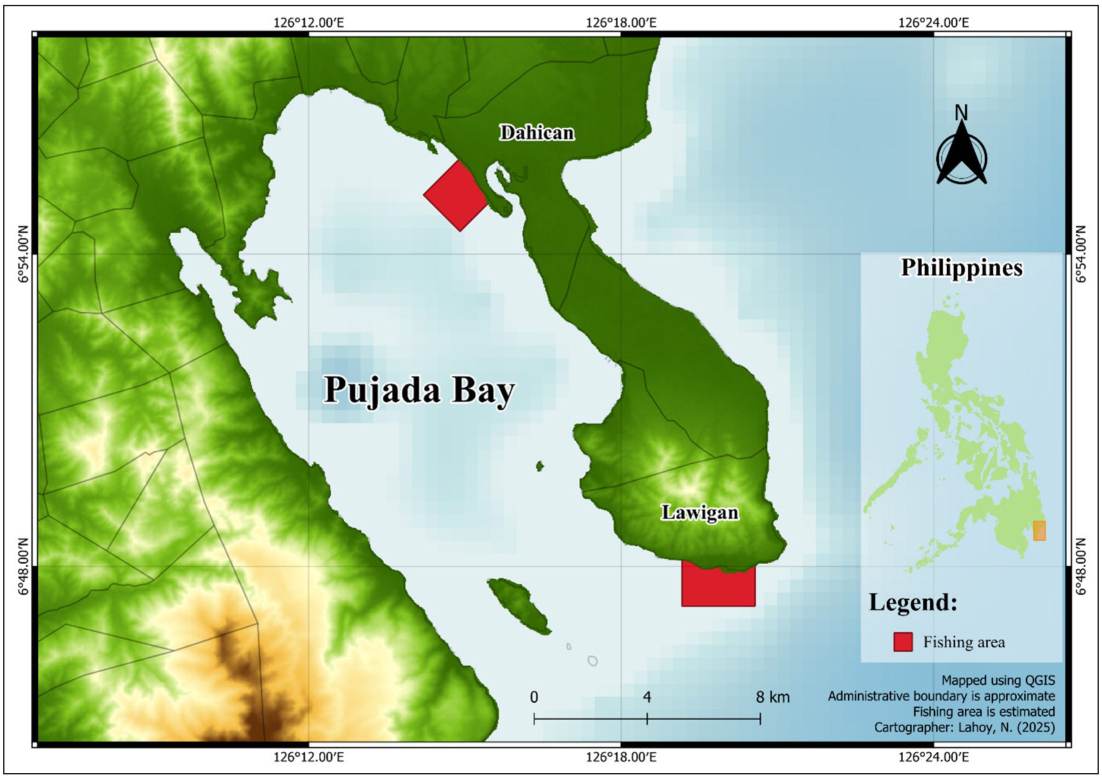


Figure 1. The study area is in Pujada Bay, where rabbitfish *Siganus canaliculatus* were collected within the seagrass meadows (3 x 3 km^2 red box) in Dahican (inner part) and Lawigan (outer part).

Initially, the researchers went with the fishermen during their fishing trip to verify and check the area where they fish. Fish collection was within the 3 X 3 km^2 seagrass meadows per study site (Figure 1). The rabbitfish were bought and collected from hired small-scale fishermen, who used net, handline, and spear gun to catch the target fish species within three days per site.

Field and Laboratory Processing of samples

A total of eighty (80) individuals of rabbitfish *S. canaliculatus* were bought from hired fishermen, forty (40) samples from Barangay Dahican, and another forty (40) samples from Barangay Lawigan. Each rabbitfish was individually wrapped in foil envelopes, placed in an ice box from the study sites to the DOrSU-RIC 11 (Davao Oriental State University-Regional Integrated Coastal Resource Management Center, Region 11) laboratory, and frozen. The samples were then thawed and the total length in centimeters (cm), standard length (cm), total weight in grams (g), and gut weight (g) were measured per individual fish sample.

The study used the standard methodology in the analysis of MPs described by the handbook entitled "Toolkit for Quantifying Microplastics in the Marine Environment: Sampling Methods" from the Microbial Oceanography Laboratory, Marine Science Institute, University of the Philippines Diliman (Microbial Oceanography Laboratory, 2023). The fish were dissected to obtain the GIT, and each was placed separately in a glass container with 10% Potassium Hydroxide (KOH) solution, sealed with aluminum foil, and stored at room temperature for at least three days until completely dissolved (Kühn et al., 2017). Thereafter, the dissolved samples were filtered through vacuum filtration. The dried residue on the filter paper was examined using a stereomicroscope for visual inspection. A particle found was considered suspected plastic and becomes confirmed plastic polymer only after subjecting individually to confirmation analysis using Fourier Transform Infrared Spectroscopy (FTIR, Cary 630 model) with a polymer library (Agilent Polymer handheld ATR library, Agilent Elastomer Oring and Seal Handheld ATR library) with about 2.5 micrometers (μm) and 25 micrometers (μm) wavelength. Above 0.80 (or 80%) is the accepted percentage similarity used to confirm MP. However, when the particle was too small to be analyzed by the FTIR but had characteristics (definite shape and color) of a synthetic plastic, it was considered as a suspected plastic. The color and shape were noted, and if possible, the particle sample was encapsulated between two slides.

To supplement the MP analysis, the study utilized three positive controls (spike samples), and three negative controls (blank samples) to account for human error and contamination, respectively (Yuan et al., 2022). Further, air contamination control was also used to account for potential contamination of the samples from the air, both in the field and laboratory (Prata et al., 2021). The spiked samples demonstrated a 98% retrieval rate from five types of spike samples[3] and zero contamination from the blank and air contamination controls.

RESULTS

1. Occurrence and density of microplastics

A total of 22 out of 80 individuals of rabbitfish (27.5%) showed positive occurrences of MPs (confirmed and suspected plastics) in their GIT. In general, about 10 rabbitfish ingested confirmed plastics, and 12 rabbitfish ingested suspected plastics (Table 1). Specifically, about 14 out of 40 (35%) rabbitfish collected from Dahican ingested MPs, of which 5 (12.5%) harbored confirmed plastics, and 9 (22.50%) had suspected plastics (Table 1). These results were higher compared to Lawigan where 8 (20%) were positive with MPs, of which 5 (12.5%) harbored confirmed MPs and 3 (7.5%) had suspected MPs.

Generally, about 0.34 MPs (confirmed and suspected) per fish was the average density at both sites and MPs found in fish gut ranged between one to four pieces (Table 1). Rabbitfish from Dahican showed elevated density of ingested confirmed MPs (6) and suspected MPs (13), with an average of 0.47 pieces per fish, ranging from one to four pieces per fish (Table 2). On the other hand, Lawigan showed lesser density of ingested confirmed (5) and suspected (3) MPs with an average of only 0.20 pieces per fish, and a maximum of only one (1) piece per fish was observed.

Table 1. Number of rabbitfish *Siganus canaliculatus* that ingested confirmed or suspected MPs.

Site	Without MP	With confirmed MP	With suspected MP
Dahican	26	5	9
Lawigan	32	5	3
Total	58	10	12

Note: n = 40 rabbitfish per site

Table 2. Number of occurrences of confirmed and suspected MPs as well as density of MPs per rabbitfish and average density of MP per rabbitfish collected from Dahican and Lawigan study sites in Pujada Bay.

Site	Confirmed MP	Suspected MP	Density of MP per fish	Average density of MP per fish
Dahican	6	13	1-4	0.47
Lawigan	5	3	1	0.20
Total	11	16	1-4	0.34

2. Characteristics of microplastics

2.1 Types of plastic polymer

A total of 11 confirmed MPs were obtained from the rabbitfish samples (Tables 2 and 3, Figures 2 and 3). Elastomers showed the highest occurrence (45.45%) which are composed of two Ethylene Propylene Diene Monomer (EPDM), two Buna-N (butadiene-acrylonitrile rubbers), and a FKM06 Terpolymer Type GLTS 06. Polyolefins showed the second highest occurrence (27.27%), consisting

[3]Each spike sample is consisting of 10 pieces of known plastic particles, a total of 50 pieces

of two MELFORM 200 I (polyethylene) and one Polypropylene+poly (ethylene: propylene). Other polymers such as the semi-synthetic fiber (i.e., rayon fiber), polyester (i.e., Polyethylene terephthalate (PET)) and polyamide occurred rarely. Dahican showed the most diverse polymer types among the samples analyzed. The results revealed that elastomers and polyolefins were common in both sites, while semi-synthetic fibers and polyester were found only in Dahican and Polyamide was found only in Lawigan rabbitfish samples.

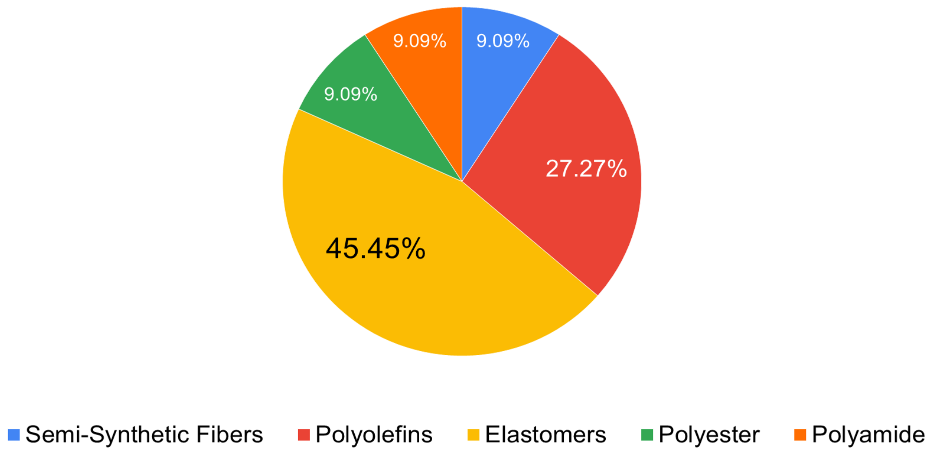


Figure 2. Percent occurrence (%) of polymer type of MPs in the GIT of rabbitfish.

Table 3. Plastic polymer composition of microplastics , frequency, and percent similarity (%) of FTIR spectra with known polymers.

FTIR Result	Polymer	Frequency	Similarity (%) with known Polymer
DAHICAN			
Rayon Fiber	Semi-synthetic fibers	1	84.2
MELFORM 200 I (polyethylene)	Polyolefins	1	83.3
Polypropylene+poly (ethylene: propylene)	Polyolefins	1	87.7
Ethylene Propylene Diene Monomer (EPDM)	Elastomers	1	84.4
FKM06 Terpolymer Type GLTS 06	Elastomers	1	80.8
Polyethylene Terephthalate (PET)	Polyester	1	85.2
LAWIGAN			
Buna-N (Butadiene-acrylonitrile rubbers)	Elastomers	2	93.6, 91.9
MELFORM 200 I (polyethylene)	Polyolefins	1	86.0
Polyamide	Polyamide	1	80.7
EPDM (Ethylene Propylene Diene Monomer)	Elastomers	1	92.1

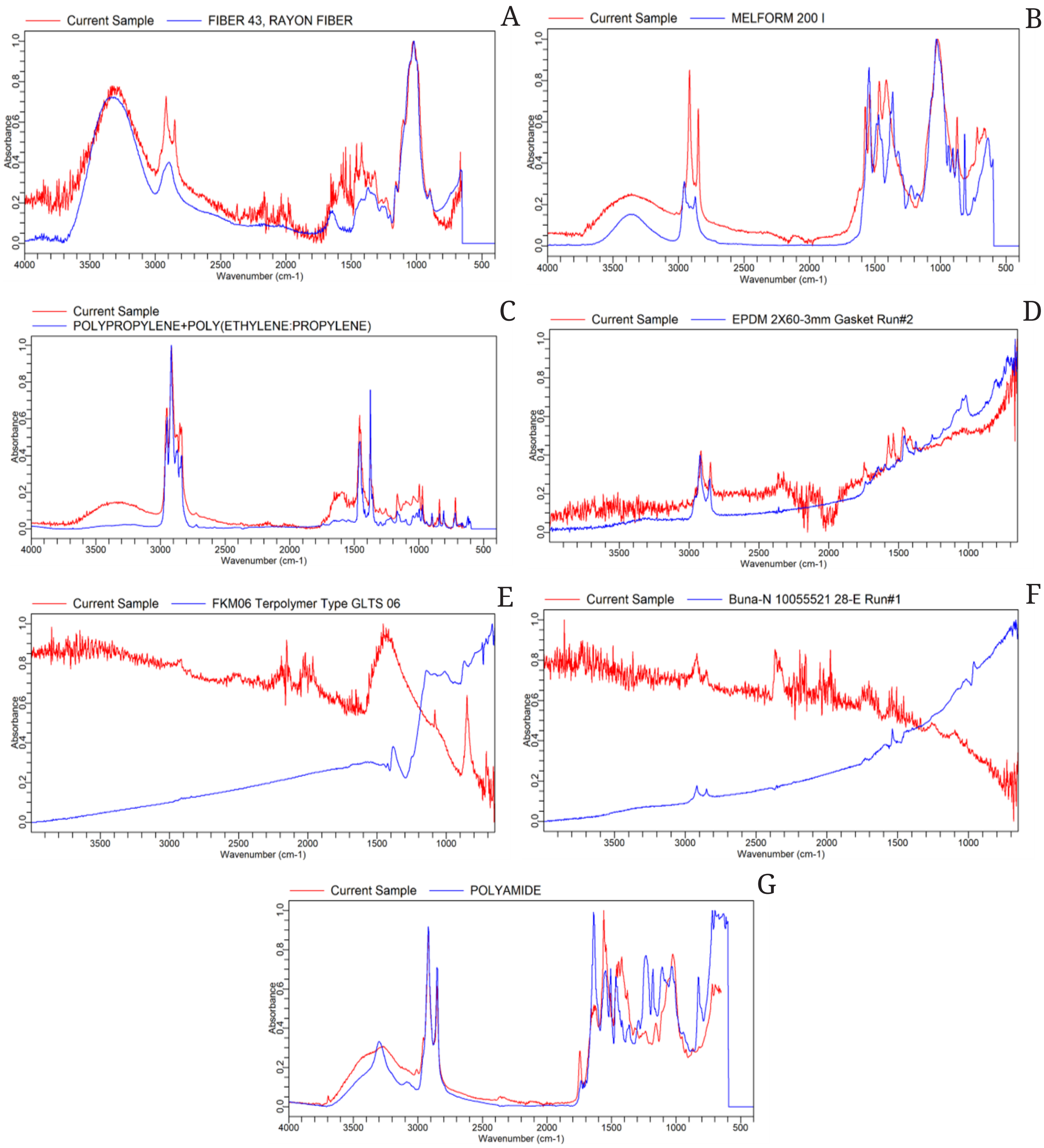


Figure 3. FTIR spectra of the MPs identified as synthetic polymers found in the GIT of rabbitfish: Semi-synthetic Fiber (rayon fiber) (A), Polyethylene (Melform 200 l) (B)[4], Polypropylene (C), Synthetic Rubbers: Ethylene Propylene Diene Monomer (EPDM) (D), Terpolymer Fluoroelastomer (FKM06 Terpolymer Type GLTS 06) (E), and Buna-N (nitrile rubber) (F), and Polyamide (G).

2.2 Microplastic color and shape

In terms of color, blue (36%) and white (36%) were dominant (Figure 4A), while in terms of shape, fragment (45%) showed the highest occurrence among MPs analyzed from the GIT of rabbitfish (Figure 4B). The colors blue, white, and green were common colors of MPs in both sites. However, brown (9%) MP was unique in Lawigan. On the other hand, the common shapes of MPs in both sites were fragment (45%) and fiber (36%). Other MP shapes observed rarely were sphere in Dahican and film in Lawigan.

[4]Based official Melform website: https://demo.melform.com/en/refrigerated-and-insulated-containers/products-catalog/

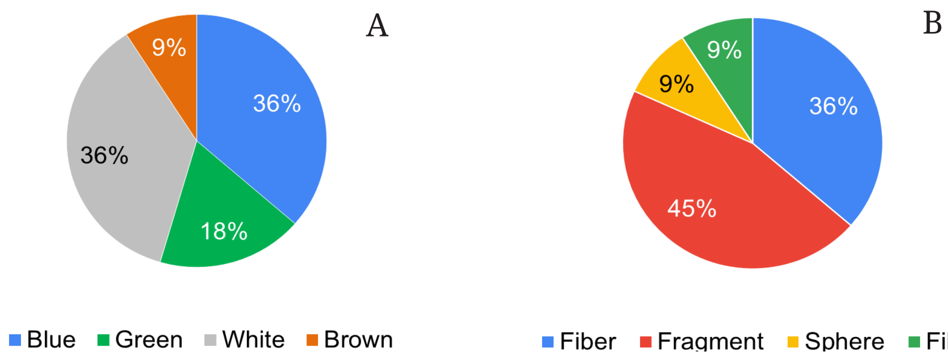
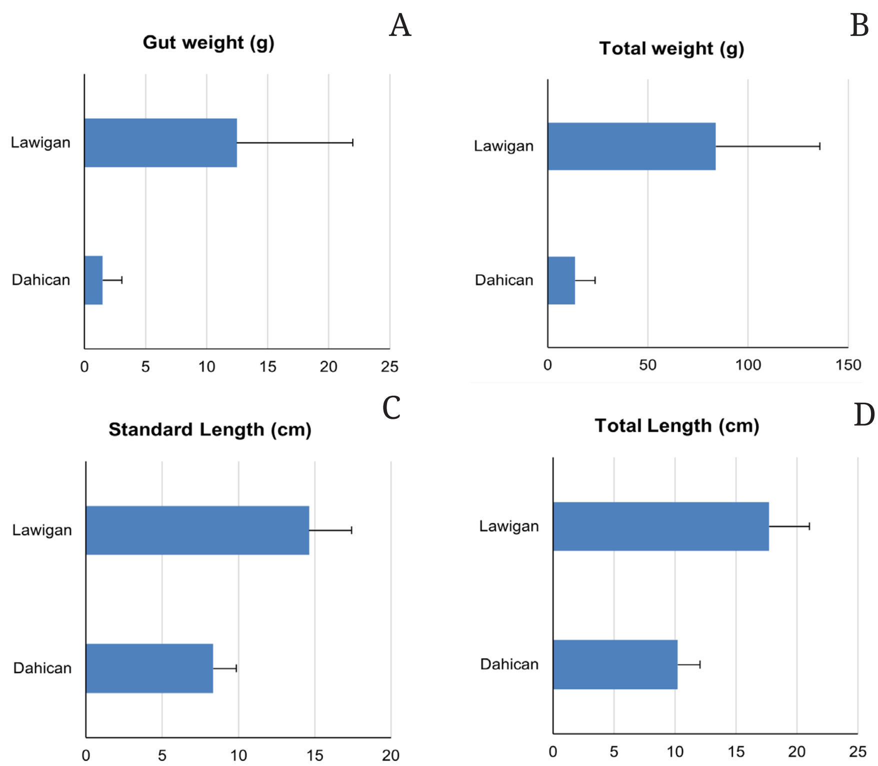


Figure 4. Percent occurrence (%): Colors (A), and shapes of MPs in the GIT of rabbitfish (B).

3. Morphometrics of rabbitfish samples

The collected rabbitfish in Lawigan were generally bigger, with heavier average gut weight (12.48 g ± 9.50), heavier average total weight (83.98 g ± 51.89), higher average standard length (14.63 cm ± 2.79) and higher average total length (17.72 cm ± 3.29) compared to rabbitfish samples from Dahican (Figure 5). Dahican had generally smaller rabbitfish collected with an average of 1.49 g ± 1.56 of gut weight, 13.68 g ± 9.95 of total weight, 8.34 cm ± 1.52 of standard length, and 10.21 cm ± 1.85 of total length.



Note: Only +SD are shown for uniform presentation

Figure 5. Average morphometrics of *Siganus canaliculatus* (rabbitfish) collected from Lawigan (outer part) (n=40) and Dahican (inner part) (n=40) of Pujada Bay: Gut weight (A), total weight (B), standard length (C), and total length (D).

DISCUSSION

A total of 22 sampled rabbitfish (22.5%) were detected with confirmed and suspected MPs out of 80 rabbitfish collected from Pujada Bay. This result is lower, about half than the percent contamination in Negros Oriental, Philippines which showed 46.7% (56 out of 120) contamination of MPs in GIT of rabbitfish *S. fuscescens* (Bucol et al., 2020) as well as in Canacabato Bay, Tacloban City, Leyte, Philippines that showed 58.57% (41 out of 70) contamination of MPs in GIT of rabbitfish *S. canaliculatus* (Cabansag et al., 2021).

An average density of 0.34 MPs per fish was obtained from the GIT of rabbitfish sampled from Pujada Bay. The maximum number of MPs acquired per fish was four (4) and the lowest was one (1). Most rabbitfish only ingested one (1) piece of MP. This result is lower than the density of MPs in *S. fuscescens* of Negros Oriental, Philippines which showed 0.6 MPs per fish (n = 120) (Bucol et al., 2020) as well as in *S. canaliculatus* of Canacabato Bay in Tacloban City, Leyte, Philippines that showed 1.21 MPs per fish (n = 70) (Cabansag et al., 2021).

Out of 11 confirmed MP polymers obtained from the GIT of rabbitfish in Pujada Bay, the most prevalent confirmed synthetic MP found in the GIT of rabbitfish were elastomers (45%) and polyolefins (27%). This study is the first report on the occurrence of MP polymers in rabbitfish guts collected from Pujada Bay, Philippines. The results exhibited scientific evidence of ingesting synthetic rubber i.e., elastomers, and thermoplastic i.e., polyolefins. Rubber breaks down into smaller components due to exposure of plastic materials to natural physicochemical degradation such as sunlight, heat, and oxygen (Singh et al., 2002; Mao et al., 2020) in the marine environment. Common materials that are made of synthetic rubber are rubber bands, tires, hoses, sealing materials, and gaskets. The popularity of rubber as the main ingredient in manufacturing various materials is due to its flexibility, style, and low cost (DiLaura, 1985; Bhattacharya et al., 2020). Moreover, rubber is one of the land-based sources (Opfer et al., 2012) of marine litter/debris that negatively impacts marine ecosystems, habitats, and biodiversity (Muhammad et al., 2023). It is widely used to manufacture fishing gear due to its durability and flexibility (Yang et al., 2020). However, once rubber deteriorates, they are thrown as waste and may contribute to marine litter (Kole et al., 2017). In the present study, rubber is an important MP polymer in the marine environment and may enter the human food chain through ingestion by rabbitfish.

Polyolefins i.e., polyethylene and polypropylene polymers were also found in the GIT of rabbitfish; commonly used to make disposable items generally known as "Single-use plastic products" (SUPs) (Tun et al., 2023). These items are easily discarded without consideration (Gomes et al., 2022). For instance, during the COVID-19 pandemic, there was exponential demand for single-use medical items i.e., face masks (Dharmaraj et al., 2021). This polymer is also one of the land-based sources that negatively impact the marine environment and lifeform (Wang et al., 2025; Corti et al., 2023). Furthermore, the recycling process of thermoplastics is gaining traction but is not widely implemented (Millican and Agarwal, 2021).

The blue color and fragment shape of MP exhibited the most prevalent characteristic features of confirmed polymers ingested by rabbitfish. The data indicated the popularity of the color blue and the shapes of fragment and fiber in the manufacture of plastics and are reflected in the prevalent plastic polymers ingested by the rabbitfish. The color influences the properties of the polymer as a colorant that can synergize or interfere with physical reactions e.g., the thermal and ultraviolet (UV) stability of the material (Pfaff, 2021). The presence of fragmented MPS is a sign of environmental degradation of large plastic (Wang et al., 2021). While MPs fiber-shaped plastics are widely used in the textile industry and are alternatives to natural fibers (Fried, 2014). The mechanical removal of fiber during laundry creates significant waste management problems (Napper and Thompson, 2016). For instance, Browne et al., (2011) stated that a single polyester garment can unleash over 1,900 microfibers per wash while Napper and Thompson (2016) showed that up to 496,000 microfibers are released in a standard six-kilogram load. Thus, the color and shape of the polymer may help to define the origin of the MPs as a point source of the plastic uptake by the rabbitfish.

The results of the study also highlight spatial distribution of MPs. Water movement may have influenced the intensity of exposure of the rabbitfish to the MPs between the inner and outer parts of the Pujada Bay. Previous study showed that Pujada Bay has a general counterclockwise surface water movement where water moves from the mouth towards the inner part of the bay and out (Antonio et al., 2021). This water movement may drive the distribution of light materials such as MP, resulting in MPs being trapped in the inner part of the bay, while the MPs at the outer part are being washed away from the bay. The result of this study is similar to previous results of Yin et al., (2022) in a semi-closed bay in Xiangshan Bay, China where MPs tend to accumulate and are trapped more in the inner part of the bay due to weak water circulation and tidal flushing.

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Another reason could be the denser presence of human settlements and urban activities in Dahican compared to Lawigan. Dahican has a higher population size of 23,496 compared to only 3,637 population of Lawigan[5]. In addition, there are a greater number of registered fisherfolks in Dahican (987) than in Lawigan (427) which may have resulted in greater fishing activities[6].

Greater fish demand and fishing pressure could have contributed to smaller fish sizes of target fish such as the *S. canaliculatus* in Dahican. Moreover, Browne et al., (2011) proved a positive correlation between MPs and human population density. Consequently, high human density is more prone to contamination of MP (Zitko and Hanlon, 1991). Thus, MP pollution is expected to increase as human population exponentially grows, accelerated by various human activities that are concentrated in large coastal cities (Browne et al., 2011).

This study may have some researcher bias during the visual extraction of suspected MPs. The researcher may have overlooked other MPs during the preselection process (Primpke et al., 2017). Also, some particles are too small to analyze and confirm when placed on the FTIR stage. Hence, particles not confirmed by FTIR fall into the category of suspected MPs. The results of this study highlight the need to improve FTIR analysis and utilization of better equipment capable of confirming the polymer type of small particles (Primpke et al., 2017).

The MP pollution poses an ecological threat to marine biodiversity, food safety, and more importantly becomes a health hazard to humans. The ingestion of MPs accumulates persistent toxic compounds and potentially toxic elements associated with serious health problems considered an omnipresent contaminant (Alberghini et al., 2022). For example, the presence of plastic leads to chronic inflammation and an increased risk of neoplasia (Prata et al., 2020). Furthermore, the ingestion of MPs by rabbitfish has implications of potential introduction of plastic contaminants into the human food chain (Chen et al., 2024).

CONCLUSION

Fish are good bioindicators of microplastic pollution in marine ecosystems. To date, this is the first data available on MP ingestion by rabbitfish *Siganus canaliculatus* in Pujada Bay, Philippines. Eleven (11) confirmed MPs and sixteen (16) suspected MPs were found in the GIT of 22 out of 80 sampled rabbitfish (27.5%) from two sites with an average density of 0.34 MPs per fish. The rabbitfish caught from the inner part (Dahican) of Pujada Bay showed higher percent occurrence (35%) and greater density of MPs (0.47 MPs per fish) relative to the outer part (Lawigan). Elastomer and Polyolefins are the common type of plastic polymers found in the GIT of rabbitfish. In addition, MPs that have blue color as well as with fragment and fiber shapes are the most dominant features among the collected confirmed MPs. The findings are preliminary report of MPs found in guts of rabbitfish collected in the region. Given the fact that rabbitfish are common source of food, the ingestion of MPs is both an ecological and public concern, although the level of contamination is significantly lower than previous reports in the country.

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CONFLICT OF INTEREST

The study declares no conflict of interest.

[5]Personal Communication to the Barangay Hall of Dahican and Lawigan, Barangay profile, 2025
[6]Personal Communication to the Department of Agriculture–Bureau of Fisheries and Aquatic Resources (DA-BFAR) – Davao Oriental, registered fisherfolk, 2025

AUTHOR CONTRIBUTIONS

Nemore M. Lahoy: Writing – original draft, resource, conceptualization, field laboratory and analysis. Emily S. Antonio: Conceptualization, resource, writing, review, editing, validation and guidance.

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