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First Evidence of Potential Microplastic Ingestion of Yellow Striped Goat Fish *Upeneus vitattus* (Forsskal, 1775) Caught in Malita, Davao Occidental, Philippines

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Abstract

Microplastic (MP) study in the Philippines is gaining attention because of the recent trends in macro-microplastic study worldwide and there is already a call for research to help the degrading marine environment in the country. No study in Malita, Davao Occidental was conducted to document microplastic contamination. To address this gap, 30 goat fishes collected in 6 sampling stations were dissected and microplastic were extracted, counted, and characterized. Results revealed that 96.67% of samples were contaminated with microplastic. In terms of microplastic type, fiber was most dominant than fragments, in microplastic hue, color black was the most common and microplastic with size ranging from 50 to 500µm were usually observed. Comparable amount of microplastic was obtained in fish guts across stations (P>0.05) which means that fish ingestion of microplastic were evident in the area. Based on Correlation, the length (r^2=0.13), wet weight (r^2=0.17) and gut wet weight (r^2=0.29) of the fish does not tell the amount of microplastic ingested by each yellow stripped goat fish since there is a weak relationship between the two parameters. The result suggests, Malita's seawater is already polluted with microplastic and demersal fishes that practice high site fidelity were very susceptible to microplastic ingestion. A stronger solid waste management policy must be implemented and activities such coastal clean ups and information drives must be initiated by all stakeholders. Further, microplastic investigation in seawater and sediments must be conducted to have a more detailed study of the whole extent of microplastic contamination in Malita, Davao Occidental.

Keywords: *fragments, fiber, fisheries, goat fish, plastic ingestion, plastic pollution*

Introduction

The world produces 300-350 million tons of plastic in 2017 and from then a projected 15% increase annually was observed. The huge production of plastic on a global scale presents major problems in disposal, recycling of plastic consumption and production of waste (Matsuguma *et al.,* 2017; Kosior and Mitchell, 2020). The increased production of plastic and the ineffective plastic waste management contributed to collective occurrence of plastic in marine environment with estimated 10 million tons of plastic reach the worlds ocean (Wilcox *et al.,* 2020). Based on the study of Okoffo *et al*. (2021), with the inclination of plastic production, usage, and the presences of plastic in the environment, it was undeniably that production, consumption, and pollution of plastics were all linked. In Asia, an estimated 79 and 42 metric tons of municipal and industrial solid waste respectively was composed of plastic material, tagging this as the largest continent that generates and received plastic waste (Liang *et al.,* 2021). In addition, Asia was generating half of the plastic production worldwide (Kosior and Mitchell 2020). In 2018, an increased in imported plastic waste was received by Asian countries like Vietnam and Malaysia leading to strict implementation in limiting imported plastic waste to land in these nations (Liang *et al.,* 2021). Another Asian country considered as major contributor of plastic pollution in the continents water was Philippines (Galarpe *et al*., 2021) in which cases of plastic ingestion of marine organism was reported (Bucol *et al*., 2020). Given the already polluted waters, influx of plastic waste during pandemic worsens the situation, plastic pollution in the ocean of Asia was at risk (Gorrasi *et al.,* 2021; Patrício Silva *et al*., 2021). Plastic debris from several tens of centimeters to micrometers (microplastic) in size was already polluting Asian sea waters and have recorded multiple cases of ingestions, and the trade

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of this contaminated fish and other seafood resources is already in local markets that might affect human health (Rochman *et al.,* 2015; Ter Halle *et al.,* 2016).

Plastic measuring less than 5 mm was considered microplastic (MP) and was widely distributed in marine environment that causes detrimental effects on biota (Li *et al.,* 2021). Microplastics were divided into two types, primary microplastic and secondary microplastic (Murphy *et al.,* 2017). Primary microplastic were direct inputs of microplastic such as micro beads that is used in cosmetics and pre-production pellets (Napper *et al.,* 2015) while secondary microplastic were from larger plastic particle that degraded through physical and chemical process and was more abundant than primary microplastic in the ocean (Taha *et al.,* 2021). Marine organisms may falsely identify minute plastic litter as food and consumed. In the review conducted by Sequeira *et al*. (Sequeira *et al.,* 2020), they found out that 198 species of fish caught in 24 countries (wild and cultured) contain microplastic in their organs and carnivores ingested more than omnivore fish species. Findings on microplastic ingestion between pelagic and demersal fishes was an indication that microplastic in the ocean can be found in the water column and sediments (Lusher *et al.,* 2013; Murphy *et al.,* 2017).

Microplastic study is gaining attention in the Philippines because of the recent trends in macro-microplastic study worldwide and there is already a call for research to help the degrading marine environment in the country (Abreo, 2018). Various research on marine and aquatic environments has evidence of microplastic pollution such as in the surface water of Laguna de Bay, sediments in Baseco Port, Manila, surface sand in Macajalar Bay, surface sediments in Molawin watershed in Los Baños, Laguna and in Pasig River to site a few (Deocaris *et al.,* 2019; Kalnasa *et al.,* 2019; Limbago *et al.,* 2021; Castro *et al.,* 2022; Arcadio *et al.,* 2023). Given that microplastic is already contaminating the water and sediments of river and seas, ingestion of microplastic by aquatic organism whether accidentally or intentionally has been documented. Various investigations suggest that MPs affect marine organisms across different trophic levels (Onda *et al.,* 2020). Microplastic ingestions were reported in invertebrates such as in cultured green mussel (*Perna viridis*) in Sorsogon Bay (Malto *et al.,* 2021) and farmed oyster (*Crassostrea iredalei*) in Capiz (Braña *et al.,* 2021). Multiple research projects on MPs ingestion of different fish species were also documented such as *Siganus* spp. in Tañon Strait, Central Philippines (Paler *et al.,* 2021), siganids and mullets in Eastern Visayas (Cabansag *et al.,* 2021), and multiple sampled fish species (Labridae, Serranidae, Lutjanidae, Mugilidae) collected in San Juan Batangas (Espiritu *et al.,* 2019). Commonly, microplastic ingested by fish stays in the gut, however a study of Feng *et al*. (2019) reveals that it also adhered to non-digestive tissues such as skin and gills. Microplastic consumption by fish provides a significant health danger, as well as a variety of additional harmful impacts in their body. This includes an adverse reaction on their reproduction, blockage throughout the gut due to accumulation, alteration of microbiota in their digestive system and liver that could activate inflammation pathway, reduce feeding intensity, improper gill functioning and immune suppression that threats their population (Mallik *et al.,* 2021; Pirsaheb *et al*., 2020; Wang *et al.,* 2019). Predation of microplastic-contaminated marine organisms may, on the other hand, provide an avenue for plastic transfer in the marine food web (Wright *et al.,* 2013). Hence, the global consumption of sea food allows microplastic to easily penetrate the human food chain (Gola *et al.,* 2021).

Goat fishes were among the most common and top commercially important marine fish in the Philippines with a recorded harvest of 243.88 MT (PSA 11, 2021). Fish is the main source of protein in human population and microplastic ingestion by fishes has been very well documented. As a result, the occurrence of microplastics in fresh seafoods and high consumption rate in some countries, raises alarms about microplastics' potential health impacts (Barboza *et al.,* 2018). In which, an alternate intake of microplastic has the possibility to produce genetic changes in humans, which can lead to infertility, obesity, and cancer (Sharma and Chatterjee, 2017). Given its risk to human health and its threat to fish populations, microplastic study in Davao Occidental is lacking and this paper aims to fill that gap and intends to document the first evidence of potential microplastic ingestion of the marine demersal goat fish (*Upeneus vitattus*) in the locality. Specifically, the purpose of the current investigation was to determine the relationship of the amount of microplastic ingested in every individual fish to its total length, wet weight, and gut wet weight. However, this study is limited only to microplastic type according to shape, length and color and polymer type was not determined.

Materials and Methods

Description of the study area

The study was conducted in Malita, Davao Occidental with 800 total registered fishers exploiting the local waters. These fishers commonly used plastic based material fishing gears. In addition, a 600 MW coal fired power plant was situated in one of the coastal barangays of Malita that were said to be one of the major contributors of pollutants in the area. The municipality also accommodated various aquaculture industries with a recorded harvest of 6, 638.93 MT in 2019, which means that additional point source of plastic waste played a major role in the economy of the locality (PSA, 2020; Bersaldo and Lacuna, 2022; Avenido *et al.,* 2023). Aside from this multiple potential plastic waste sources, the first-class municipality of Malita was the capital town of Davao Occidental that consisted of 30 barangays and was the most populous area in the province. Most of its inhabitants were living along its nine coastal barangay and the minority were residing in the upland areas with agriculture and livestock farming are their main livelihood. During rainy season, plastic waste was very evident in the coast of the municipality as three major river system runs from upland and flows through the residential areas in the coastal barangays that brought adequate plastic pollutants to the ocean. This plastic waste will undergo weathering and gives birth to microplastic existence in the seawater (Figure 1.).

Fish sample collection, microplastic extraction, characterization and contamination control

Fish sampling was done with the aid of hired fishers and the time of collection was according to the fishers' preference. To limit the exposure of plastic material that would potentially increase the exposure to microplastic polymer and accidentally ingest microplastic, thirty fish samples (5 ind. fish.station^{-1}) were collected in the sampling stations through spear fishing and line fishing with live bait (Table 1.). Fish that belongs to family Mullidae (Goat fish) were the sampled fish because it was the most common demersal fish in the local market and the most common fish caught by municipal fishers. Further goat fish were among the top commercially important marine fish in Davao with 243. 88 MT recorded catch in the year 2020 (PSA, 2020). Further, goat fishes were also a good biological sample for microplastic research because these fish have a reduced range of territory and were isolated. According to research, they are also affected by microplastic pollution because they ingest these minute plastic particles while feeding (Bucol *et al.,* 2020; McGregor and Strydom 2020; Sembiring *et al.,* 2020). Immediately after catching, samples were photo documented for identification using fish identification guides of Gonzales *et al.* (2013) and White and Last (2013) and confirmed using fishbase database (Froese, 2023), total length (mm) and total weight (g) were obtained then packed in aluminum foil and labelled, chilled on ice in a properly sealed containers and was frozen within 2 to 3 h after captured (Cabansag *et al.,* 2021; Paler *et al.,* 2021). The sample size in the current study does not follow the required 50 samples for microplastic investigations, however, 30 samples of fish would suffice to prove that microplastic pollution was existing in the area (Hermsen *et al.,* 2018; Paler *et al.,* 2021).

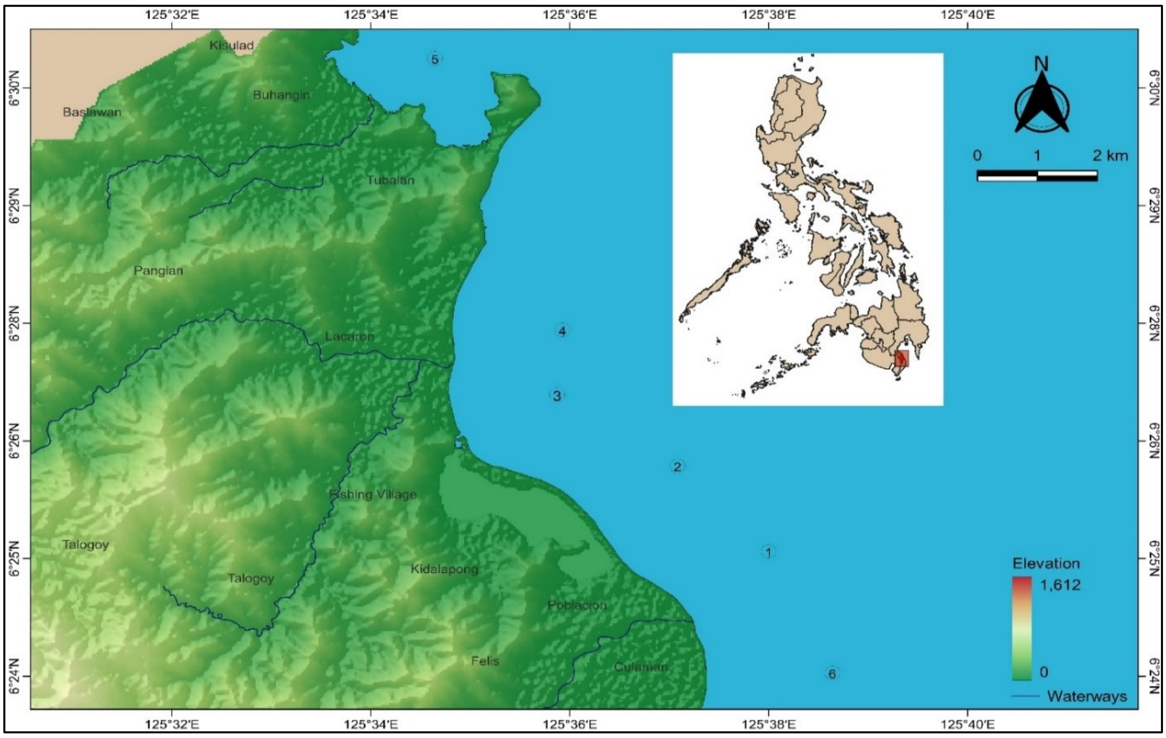


Figure 1. Map of the study area showing different collection points. A major river system flows in the study area that may influence microplastic contamination. The map was rendered using QGIS V 3.28.

Table 1 Location and Description of Sampling stations

Sampling Area	Station	Location (Coordinates)	Description
Poblacion	1	6°25'4.55"N, 125°37'2.21"E	Adjacent to river mouth, residential and commercial area.
Poblacion	2	6°25'23.58"N, 125°36'48.22"E	Adjacent to residential area, school, and beach resorts.
Fishing Village	3	6°26'23.59"N, 125°35'23.71"E	Adjacent to residential area, school, and aquaculture site.
Lacaron	4	6°27'14.58"N, 125°35'20.60"E	Adjacent to residential area and beach resorts.
Tubalan	5	6°30'18.19"N, 125°34'45.84"E	Adjacent to residential area, beach resorts, and mariculture parks.
Culaman	6	6°23'49.58"N, 125°37'29.96"E	Adjacent to residential and commercial areas.

Prior to laboratory examination, fish samples were thawed at 20ºC to 25ºC. The sample was placed in a metal tray and a longitudinal incision was made in the abdominal area to remove the gastrointestinal tract (GIT: esophagus to cloaca) and placed in a clean dry petri dished for volume measurement (g) (Cabansag *et al.,* 2021). The protocol established by Karami *et al*. (2017) for microplastic extraction in fish was followed with minor modifications. The entire GIT was chemically digested in a 50 ml 10% Potassium hydroxide (KOH) solution (1g of KOH.10ml^{-1} of distilled water) and incubated at 40ºC for 48-72 h. Following digestion, the sample was filtered through filter paper with 25 µm pore size (Whatman No. 4) using a glass membrane filtration system that was connected to a vacuum pump. The filter membrane with sample residues was dipped into 15 ml hyper-saturated NaCl saline solution (1.2g.ml^{-1}) for density separation in a glass jar with metal cover for 2-5 h. The sample was agitated on an orbital shaker (200 rpm) for 5 min. After agitation, the sample was poured into glass centrifuge tubes covered with cork and centrifuged at 1,725 rpm for 2 min. The supernatant was poured to a filter paper with 25 µm pore size (Whatman No. 4) using the same glass membrane filtration system. The particles retained in the filter paper were examined using a stereomicroscope. Visual inspection to determine the shape and color of microplastic in every filter paper were done methodically to avoid double counting and was identified based on several criteria (Napper *et al.,* 2015; Peters *et al.,* 2017; Garnier *et al.,* 2019; Esquinas *et al.,* 2020). All microplastic particles observed within the same sample and station were collected using clean forceps and transferred to a clean sterile filter paper then covered and labelled accordingly. The hot needle tip process was used in the study after microplastic extraction and visual inspection to initially confirm microplastic particles.

For contamination control, laboratory materials that were used during dissection, digestion and processing of samples were either made of glass, ceramic, or metal to minimized contamination and all laboratory activity were done at Southern Philippine Agri-business and Marine and Aquatic School of Technology (SPAMAST) General Science Laboratory Malita, Davao Occidental. Before actual microplastic extraction in the collected samples, a dry run test was conducted first using non-sampled species to familiarize the types of microplastic present in the study.

Data analyses

SPSS version 20.0 and Microsoft Excel 365 data analysis tool pack were used to run statistical tests with a 95% confidence level (*P*= 0.05). ANOVA was used to determine whether there was a significant difference in the mean number of microplastics found in fish between sampling stations. Prior to analysis, the data was checked for homogeneity and log transformed to ensure that the ANOVA assumptions were not violated. Spearman's correlation analysis was also performed to determine the relationship between fish total length and the amount of microplastic, fish wet weight and the amount of microplastic, and fish gut wet weight and the amount of microplastic found in the fish sample.

Result and Discussion

Microplastic in fish gut

Microplastic ingestion of demersal fish is not common and is already documented in other parts of the Philippines (Alcala *et al.,* 2015; Bucol *et al.,* 2020; Paler *et al.,* 2021). In consonance with the existing literature, the current study reveals the first evidence of potential microplastic fish ingestion cases in Malita, Davao Occidental. A total of 214 (7.5±7.1 mp.ind^{-1}) microparticles were extracted from 30 individual fish guts collected in six sampling stations (5 fish.station^{-1}) with the same seawater. In the 30 goat fishes sampled, 29 (96.67%) individuals have at least one ingested microplastic (max. ingested MP is

64), and majority (86.67%) of the goat fishes have found to have two or more microplastic in their gut (Table 2.). The amount of microplastic ingested by goat fishes might be driven by the increased source of pollution especially during covid-19 pandemic in which single used plastic-based PPEs and mask have been used consistently and excessively and this study was conducted post pandemic in year 2023 that would give enough time for the covid-19 related materials to degrade. It was reported in the review of Silva *et al*. (2021) that an increase in plastic pollution due to the pandemic was very evident, and an increase in demand of these materials were directly proportional to the waste generated. Aside from the rate of increased in plastic pollution, another factor that supports the result of this study is the feeding behavior of the goat fishes in which they mainly feed on benthos community. A review of Pinheiro *et al*. (2017) supported this claim as several literatures reveals high ingestion rate of microplastic in demersal fish species due to its feeding mechanism and habitat type. Microplastic that sinks in the bottom is being mixed into the sediments that are accidentally ingested directly by the fish or preyed on contaminated food items (Sanchez *et al.,* 2014; Silva-Cavalcanti *et al.,* 2017). Moreover, the findings of the study were comparable to the reports of Hastuti *et al*. (2019) in Indonesia with all 30 samples of siganids have ingested microplastics but higher compared to red mullets with 33.3% from Barcelona (Bellas *et al.,* 2016) and 73% of benthopelagic *Diplodus vulgaris* in Portugal (Bessa *et al.,* 2018). However, it is within the range in the study of Neves *et al*. (2015) with 0-100% using multiple demersal and pelagic fishes caught in Portuguese Coast. Goat fishes are demersal fish which commonly thrive in near substrate waters and this species was one of the commonly studied fish species for microplastic ingestion (Savoca *et al.,* 2021). The microplastic ingested by goat fishes were plastic particles that settle in the bottom since they indiscriminately feed on benthos (Naidoo *et al.,* 2016). The number of ingested microplastic might be driven by their food items since goat fish main diet were small crustaceans that might already contaminated with microplastic, or they ingested microplastic accidentally as they perceived it as prey (Lusher *et al.,* 2015).

Accordingly, ANOVA results show that no significant difference was detected in the number of microplastic ingested in the fish collected in different sampling stations. This result implies that the municipal seawater of Malita was already contaminated with microplastic since almost all fish samples collected have ingested several microplastic that were available in their environment. The potential source of microplastic contamination in the seawater might be the presence of major rivers, commercial and residential areas, numerous beach resorts along the coastline and the presence of major aquaculture and mariculture parks in Malita, Davao Occidental. Multiple studies have already identified the above-mentioned point sources. Residential and commercial areas in which a river or creek runs through brought majority of microplastic pollutants in the seawater (Luo *et al.,* 2019; Esquinas *et al.,* 2020). Further, some microplastic were also derived from degraded fish nets, buoys, cages, and nylons which were earlier used by fishing industries such as aquaculture and mariculture parks (Pazos *et al.,* 2017). Furthermore, due to the presence of recreational beach resorts, increased plastic-based waste material was commonly observed, and the long-term dilution of these polymers give rise to more microplastic in the coastal beaches (Cole *et al.,* 2011).

Microplastic shape and color

Various studies revealed that the most common type of microplastic either in seawater, sediments and demersal or pelagic fish were fiber and fragments (Hossain *et al.,* 2019; Dantas *et al.,* 2020; Zhang *et al.,* 2020a; 2020b). This claim supported the current paper since only fiber and fragments were found in the fish gut among sampled goat fish. Fiber being the most abundant amounted to 12-89 pieces while fragments accounted for 1-3 pieces (Figure 2, 3A.). The possible source of microfiber contamination in the seawater because of high fiber ingestion of goat fishes were ropes, personal care products, fishing lines and other fishing related materials. Additionally, the presence of river water tributaries may provide an even higher source of microplastic contamination (Arias *et al.,* 2019; Feng *et al.,* 2019; Klangnurak and Chunniyom, 2020). Having said that, we can attribute some of the microplastic contamination in the study area to the presence of a fishery industry, residential areas, and recreational beaches on the coast of Malita, Davao Occidental. As observed during the entire duration of sampling, countless plastic debris are observed in the coast especially in highly populous areas. If this plastic debris was not collected, in time, it would degrade and turn into minute plastic particles that are highly consumable by fish in all sizes. Moreover, the most common color of microplastic ingested by goat fishes were black (56%), transparent (17%), red (11%), blue and white (6%) and, green and brown (2%) (Figure 3B.). The observed variations in microplastic color were very common in microplastic study. In accordance with this paper, the microplastic investigation conducted in Haizhou Bay, China using farmed fish reveals that color black is the dominant color found in their sampled fish (Feng *et al.,* 2019; Hossain *et al.,* 2019). This might be attributed to the fishing materials like nylons, ropes, nets, and buoys that were damaged through time. There are also studies that reveal red (Klangnurak and Chunniyom, 2020), transparent (Dantas *et al.,* 2020; Hossain *et al.,* 2019; Zhang *et al.,* 2020b) and white (Hossain *et al.,* 2019) hues as dominant color observed. The color difference of microplastic ingested might also reflect their diet or a resemblance to a prey which the goat fishes mistakenly identify microplastic as food item (Ory *et al.,* 2018; Zhu *et al.,* 2018; Zhang *et al.,* 2020b).

Microplastic size frequency and its relationship to fish size

Microplastic extracted from the gut of goat fishes varies in size from 50-2500µm (520.17±451.99µm) with majority of the microplastic measured between 50-500µm (65.45%) and the least was 1501-2500µm (1.81%) (Figure 4.). To compare, the sizes of microplastic in the current paper

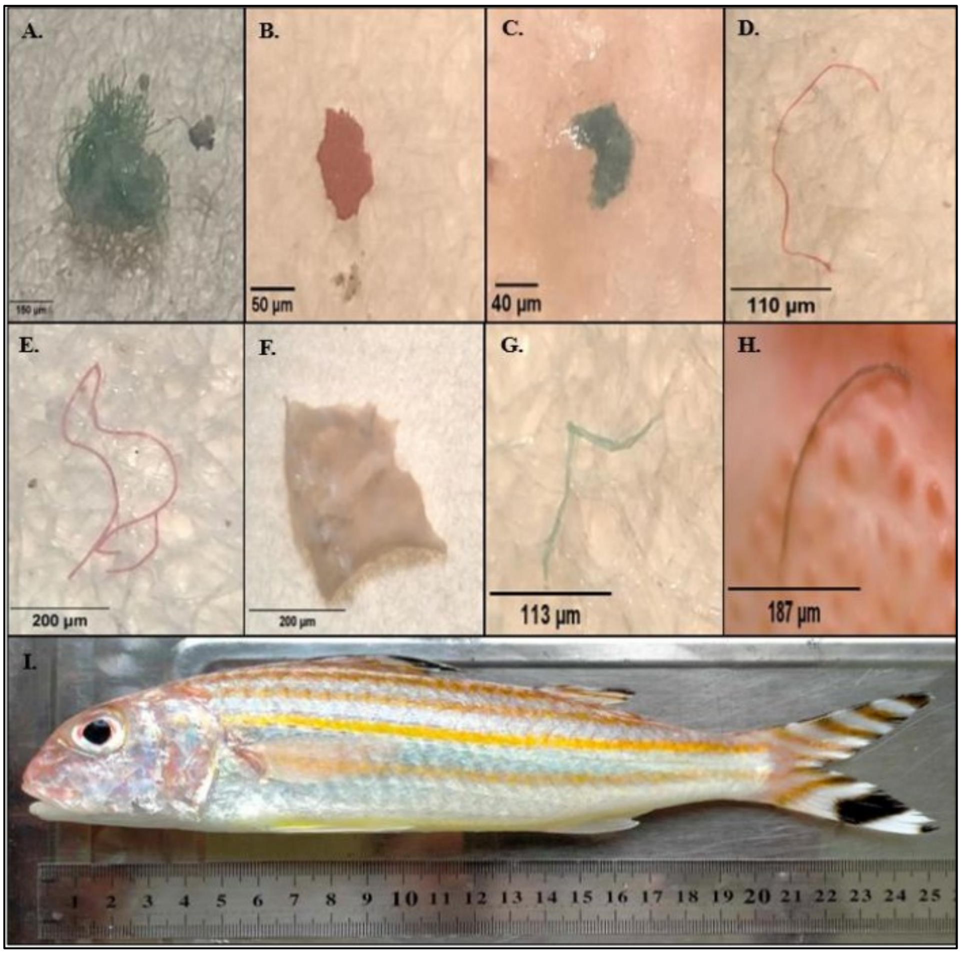


Figure 2. Microplastic extracted from the sampled goat fish *Upeneus vitattus* (I) collected in the municipal waters of Malita, Davao Occidental. The common microplastic hue observed in the fish gut are green fibers (A,G) ref fibers (D,E) and black fiber (H) with micro fragments colored red (B), blue (C) and white (F).

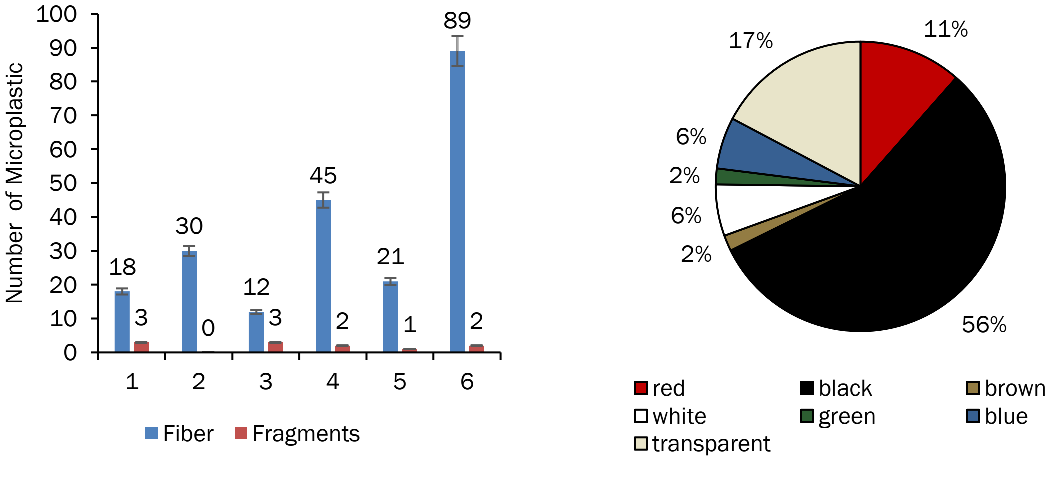
Table 2. Number of microplastic collected in fish gut between different sampling stations in Malita, Davao Occidental (n=30)

Sampling Station	Average fish total length (cm)±SD	Average wet weight of individual fish (g)±SD	Average wet gut weight of individual fish (g)±SD	Mean microplastic per fish±SD
1	23.60±1.20	169.45±22.61	6.41±2.05	4.2±3.49^a
2	21.50±1.23	123.27±23.45	3.12±0.63	6±2.83^a
3	21.62±1.26	127.38±24.10	5.01±2.12	3±1.22^a
4	22.20±1.58	141.53±36.99	4.50±2.48	9.4±6.35^a
5	22.02±0.79	137.79±16.44	4.65±1.81	4.4±2.79^a
6	20.58±0.62	99.21±9.70	2.99±1.31	18±25.73^a

Note: Similar superscript denotes no significant level p>0.05

is within the range of microplastic size observed in the study of Sun *et al.* (2019) with size limit of 16-5000µm extracted in several fish species collected in Yellow Sea while lower than the average size of microplastic observed in the study of Zhang *et al.* (2021) with mean size of 697.96±4808.06µm and Ory *et al.* (2018) with mean length of 3800±2400µm conducted in East China and Southeast Pacific Ocean respectively. Moreover, smaller microplastic size (250µm) was generally observed in fishes caught in Persian Gulf (Abbasi *et al.,* 2018) and in Ciliwung Estuary, Jakarta, Indonesia with particle size ranging 300-500µm extracted from blue panchax fish (Cordova *et al.,* 2020). Based on these comparisons, the microplastic size observed in the current study were typical size brackets for microplastic studies conducted worldwide. Plastic particles measuring less than 5mm are considered microplastic and among the most frequent plastic ingestion cases relative to size. Microplastic ingestion by fish is very common due to the possibility that fish species may mistakenly identify and ingest minute plastic particles as part of their food due to their resemblance to prey such as planktons and benthic organisms, or accidentally consume microplastic during filter feeding or grazing (Wesch *et al.,* 2016). Moreso, microplastic ingestion by fish could also be the result of microplastic entry in marine food web as microplastic affects organisms across trophic level and was observed to be the most common interaction between marine species and plastic litter (Lusher *et al.,* 2015).

The number of microplastic pieces ingested by individual fish and the relationship to its morphometric measurements such as fish total length (cm), wet weight (g) and gut weight (g) were determined through Pearson's correlations test. Accordingly, all morphometric measurements have significantly positive weak relationship to the microplastic pieces ingested by each sampled fish (Table 3.). This finding implies that the frequency of microplastic ingestion of stripped goat fish were independent to its body size in terms of length, weight, and gut size meaning, despite the length, weight and gut size of the fish, the possibility of microplastic ingestion were possible. Another explanation why there was a weak relationship between the three parameters is that the presence of microplastic in the environment is evident and the exposure of the fish towards the pollutants is one of the possible reasons for microplastic ingestion despite the fish age or the time duration of its exposure towards the polluted habitat. This finding is in accordance and commonly observed in various literatures such as in Mondego Estuary, Portugal (Bessa *et al.,* 2018), Northeast Atlantic near Scotland (Murphy *et al.,* 2017) and in Hongkong (Chan *et al.,* 2019). However, there are also several investigations in which microplastic ingestion was strongly correlated to fish size like the study of Akhbarizadeh *et al.* (2018) and Zhang *et al.* (2020b) conducted in Persian Gulf and Maán Archipelago, China. The relationship between fish size and microplastic pieces ingested are still not clearly understand due to the discrepancies observed between published studies however, the presence of microplastic in fish gut is strong evidence that microplastic ingestion of fish is much more related to its exposure to the polluted aquatic environment and its feeding behavior. Demersal fishes which generally swim near the sediments are very susceptible to microplastic pieces since they tend to sink and accumulate in the substrates (Wesch *et al.,* 2016). In addition, goat fishes are carnivorous fish that fed on small shrimp and crabs which could also influence ingestion of microplastic as commonly observed in predatory fish species (Huang *et al.,* 2020).



A B

Figure 3. (A) Abundance of microplastic type (fragments and fiber) and (B) relative frequency of microplastic hue collected in fish gut in Malita, Davao Occidental.

Table 3. Spearman's correlation analysis results between fish measurements and amount of microplastic ingested per individual fish collected in Malita, Davao Occidental.

	r^2	df	MS	F	Sig. F
Total Length vs MP Ingested.Fish^{-1}	0.1262	29	0.0025	4.0433	0.0441
Wet Weight vs MP Ingested .Fish^{-1}	0.1748	29	0.0462	5.9324	0.0215
Wet Gut Weight vs MP Ingested.Fish^{-1}	0.2946	29	0.3321	11.6935	0.0019

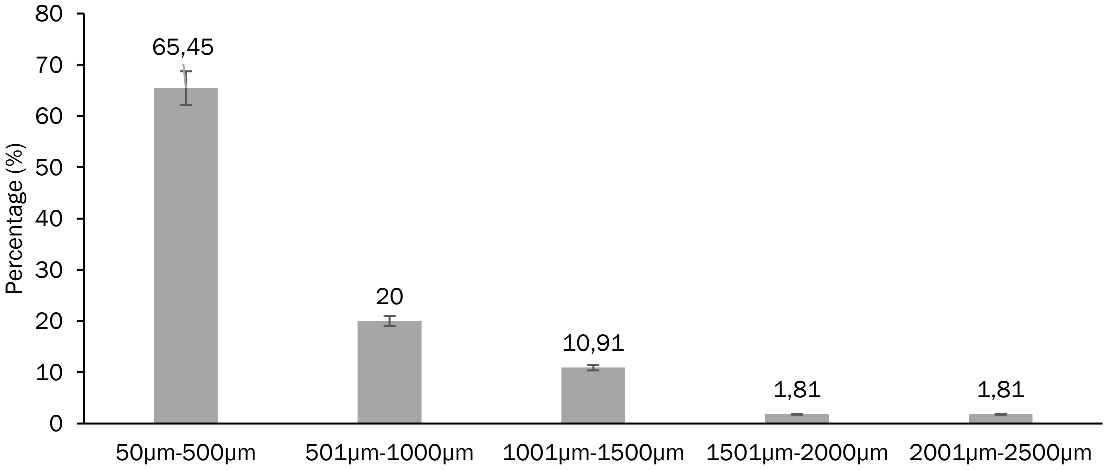


Figure 4. Relative frequency of microplastic according to size range collected in fish guts in Malita, Davao Occidental

Conclusion

Microplastic ingestion of fish is a very common phenomena nowadays, this is the result of the increase in plastic production, usage and improper disposal of these polymers that threatens marine biotas. Demersal goat fish (Mullidae) microplastic ingestion is recorded in the municipality of Malita, Davao Occidental in which 96.67% of sampled fish was observed to have ingested 1 or more microplastics (N=30). Minute plastic particles that are commonly observed are fibers and fragments. Varied colors (red, black, transparent, blue) and sizes (50-2500µm) were also noted. The fish total length, wet weight and gut weight were weakly correlated to the number of microplastic ingested by the sampled goat fish which suggested that microplastic ingestion were very possible in immature and mature fishes if it was exposed to contaminated seawaters. As results revealed, this paper concluded that the seawater of Malita is contaminated with microplastic, and a stronger solid waste management is needed. Moreover, microplastic study in the marine and aquatic environments, and microplastic ingestion to other demersal and pelagic fishes is necessary to evaluate the level of contamination in Malita, Davao Occidental, Philippines.

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