Microplastics in fishes as seabird preys in Jakarta Bay Area

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Abstract. There has been some growing research on plastics in fishes as human food in Indonesia, but none linked to fishes as seabirds’ prey. The objective of this research was to reveal whether there were microplastics in fishes as prey of little-black cormorant. The study site was the coastal area of Pulau Rambut Wildlife Sanctuary in Jakarta Bay, where the cormorants search for fish food. Fish samples (12-16.8 cm, 5 species; n=8) were collected by using fish-rod, at the usual fishing area of cormorants along the southern coast of the reserve. Gastrointestinal tracts of the samples were observed to find macro, meso and microplastic. After NaCl dilution, followed by observation using SRCC and microscope (10x10 magnification), followed by grouping based on type, color, and size. No macro or mesoplastic found. Total of 110 microplastics particles were found from all samples (range 7-26 particles/fish), with Lutjanus vitta having the highest number (15-26 particles/fish). Film (2-21 particles/fish) and fiber (1-10 particles/fish) were found, but no fragment. Transparent microplastics were found the most (57.3%), followed by blue (26.4%), black (10.0%), and red (6.4%). The size of the microplastic found were mostly (64.5%) between 100-1.000μm. A more intensive research is needed, as these sampled fishes might also consumed by human.

Keywords: cormorants; Lutjanus vitta; mesoplastics; microplastics; Pulau Rambut Wildlife Sanctuary

1. Introduction
Garbage in the ocean or known as marine litter is currently dominated by plastic. At least 8 million tonnes of plastic enter the oceans annually [1]. It was predicted that by 2050 the oceans will have more plastic than fish [2]. Plastics is persistent and take a very long time to degrade. Eventually, plastics degrade into smaller sizes and might be ingested by marine biota [3]. Plastic breaks down into smaller sizes called microplastics (< 5 mm) and even smaller is nano plastics [4]. Plastic degradation in water is slower than on land because the temperature in the water is lower than land and UV light plays an important role in degradation [5].

Plastics have a negative impact on marine life, such as entanglement, swelled, and malnutrition [6]. More than 260 species, including invertebrates, turtles, seabirds, mammals and fish, accidentally entangled and ingested plastics [3]. Ingestion of plastic by marine organisms occurs from the lowest trophic level to the highest trophic level [7]. Research on plastic ingestion by marine biota in Indonesia is still lacking. This study aims to identify microplastics in the digestive tract of fish, especially fish that are potentially consumed by Little-black cormorant (Phalacrocorax sulcirostris). The hypothesis proposed in this study is if there are microplastics in the digestive tract of fish, it is likely that microplastics will also be found in bird. This study is a part of a bigger study on plastic detection in the digestive system of Little-black cormorant and aquatic ecosystem in Pulau Rambut Wildlife Sanctuary.
Table 1. Length and weight of fish samples as preys of the Little-black cormorant.

| No. | Family       | Species                | Number | Diet     | Length (cm) | Weight (g) |
|-----|--------------|------------------------|--------|----------|-------------|------------|
| 1   | Lutjanidae   | Lutjanus vitta         | 3      | Carnivore| 12.0–14.0   | 21.0–29.0  |
| 2   | Serranidae   | Cephalopholis boenak   | 2      | Carnivore| 15.0–16.8   | 47.0–71.0  |
| 3   | Cephalopholis formosa | 1 | Carnivore | 13.8    | 34.0       |
| 4   | Haemulidae   | Plectorhinchus gibbosus| 1      | Carnivore| 15.0        | 62.0       |
| 5   | Cyprinidae   | Cyprinus sp.           | 1      | Omnivore | 12.5        | 9.8        |

The research was conducted at Pulau Rambut Wildlife Sanctuary, Seribu Islands, Jakarta Bay. This island has three types of forest: mangrove forest, mixed secondary forest, and coastal forest [8]. The diverse habitat conditions have created an ideal place as the habitat of various bird species. The dominant birds are waterbirds, including Little-black cormorant (Phalacrocorax sulcirostris), Pygmy cormorant (Phalacrocorax pygmaeus), Purple heron (Ardea purpurea), Grey heron (Ardea cinerea), Black-crowned night heron (Nycticorax nycticorax), Great egret (Egretta alba), Little egret (Egretta garzetta), Intermediate egret (Egretta intermedia), Pacific reef-egret (Egretta sacra), Milky stork (Mycteria cinerea), Oriental darter (Anhinga melanogaster), Black-headed ibis (Threskiornis melanocephalus), and Glossy ibis (Plegadis falcinellus) [9]. Cormorants are bird species that forage directly in marine waters and have the possibility to ingest plastic from their main prey, fish.

2. Method
Samples collected were fish eaten by the Little-black cormorant. Of the waterbird species inhabiting Pulau Rambut, Little-black cormorant was selected is as the main focus of this research because they prey on fish from the seawater nearby the island, and they have a big population number, especially compared to its congeneric species, the pygmy cormorant. The Little-black cormorant looks for prey by swimming and diving and it has the possibility of eating plastic directly and indirectly. The prey fish might contain plastic in its body.

Sample of fishes (n=8) were collected by using fish-rod at the usual fishing area of cormorants along the southern coast of the sanctuary. One fish species found under the bird's nesting tree was freshwater fish namely Cyprinus sp., and thus this species and other species having similar morphological characters would be the main sample target. Each fish was measured for (a) total body length using a ruler with an accuracy of 1 mm, (b) weight by using a digital scale with an accuracy of 0.01 mm. Following the measurements, sampled fish were dissected and the guts were removed. Fish guts contents were diluted with 10 ml of saturated NaCl solution [10]. Microplastic particles were identified and counted using a binocular microscope (10 x 10 magnification) and SRCC [11]. Liquid samples of fish digestive contents were observed five times per individual fish. Microplastic found then were grouped by type, color, and size.

3. Results and discussion
3.1 Result
The eight fish samples belonged to 5 species from 3 families. There was one fish that could only be identified up to the family level, namely Cyprinidae sp. The total length of the fish ranged from 12.0 to 16.8 cm and weigh 9.8–71.0 g (table 1).

Observations of digestive contents of fish samples showed that the number of microplastics in each fish ranged from 7–26 particles/individual. The highest number of microplastic was found on Lutjanus vitta (15–26 particles/individual; average 21.0, n=3). Meanwhile, the number of microplastic found on Cephalopholis boenak, Cephalopholis formosa, Plectorhinchus gibbosus and Cyprinus sp. was more or less similar at 7-11 particles/individual (figure 1).
Microplastic types found in the digestive tract of the samples fish in this study consisted of film and fiber, no fragment. Film was the most common type of microplastic found in fish digestion, up to 21 particles/individual, while fiber type was found up to 10 particles/individual (Figure 2). Based on color, microplastics in the fish digestion were found in four color groups: transparent, blue, black, and red (Figure 3). Transparent was the most common color of the microplastics found, as many as 63 particles (57.3%) (Figure 4).

As for the size, the microplastics found could be grouped into eight size groups from <20-5000 μm. The dominant size group was 101–5000 μm, with the 101–500 μm size group having the highest number of particles (43.6%; 48 particles). Microplastics in the size class 0-100 μm have smaller amounts, each was no more than 8% (figure 5).
3.2 Discussion

Many studies have confirmed that microplastics were found in the digestive tracts of many fish species, as also confirmed in Pantai Indah Kapuk [12] and Ciliwung River [13], both are not too far from Pulau Rambut Wildlife Sanctuary. In this study, the number of microplastic found in each fish was ranging from 7 to 26 particles.

The number of microplastic particles in Cyprinus sp. is less than Lutjanus vitta or other fish, this might be due to habitat differences. Cyprinus sp. is a freshwater fish whose habitat is likely to have a lower abundance of microplastics than in Pulau Rambut. Mouth openings of fish also influenced the discovery of microplastics. Cyprinus sp. has the smallest mouth opening (9.05 mm) compared to other fish (13.08-28.05 mm). Prey selection is related to mouth biometrics instead of nutrition or prey type [14].

The number of microplastics in fish in this study was higher than other studies in Indonesia. In Pangandaran Bay was found 193 microplastic particles in 18 individual fish [15]. The different results were also found in the fish observed at Pantai Baron, Yogyakarta, the total microplastic in 78 fish was 3651 particles [16]. In other tropical country, previous study on 116 marine fish observed in the Gulf of Mexico also reported that 12 individuals were detected having 10.4% of microplastics [17]. Study in Balearic Island showed that microplastic was found on 68% of 337 Boops boops fish, averaging 3.75 particles/fish [18], scored fewer than the results in this study.

Ingestion of plastic by fish has been known to occur directly or indirectly [6,19]. Direct ingestion was from debris floating on the water’s surface, the water column, and marine waste on the ocean floor, while indirect ingestion was from small fish or plankton that contain plastic in their bodies. Fish samples in this study could ingest plastic directly, as there was much plastic debris in the seawater surrounding Pulau Rambut, and also indirectly, considering that almost all samples were carnivorous fish.

In this study, two types of microplastics were found in fish digestion: film and fiber, with film as the dominant type. The different results were found in the research in the coastal area of Java in the Jakarta
Bay area [12], which revealed that fiber was the dominant type of microplastic (89.63%), followed by fragments (62.4%) and film (4.13%). Although the study site (i.e., Pantai Indah Kapuk) was not too far from Pulau Rambut, fragments found in the fish of Pantai Indah Kapuk were not found in the fish samples of Pulau Rambut. Meanwhile, in other studies in the Ciliwung River (also in the Jakarta Bay area), observations made on Aplocheilus sp. showed that both fiber and fragments were dominant (46.61% and 39.83%, respectively) [14]. In English Channel [20], fiber was dominant (68.3%) in 184 fish samples.

Research conducted in the same year on Pulau Rambut reported that plastic (plastic bags, food packaging and cups) was the dominant type of plastic waste, along with foam [21]. Film and fragments are microplastic that are degraded from plastic bags, plastic packaging, plastic bottles, plastic containers and others that float in water. Therefore, the film could be originated from plastic degradation commonly found in Pulau Rambut. Fiber is a microplastic derived from nylon and polypropylene (clothing fibres, carpets, ropes and fishing nets) and polyvinyl alcohol (generally for fishing lines) [22, 23, 24]. The different types found in this study could be caused by the abundance of microplastics in the fish environment [10].

Transparent was the color that dominated microplastics in fish. The same results were also found on fish at Pantai Indah Kapuk Jakarta [13], transparent was the dominant color (79.20%) and blue was 7.03%. Plastic colors as white, blue, and transparent are similar to plankton, a source of fish food [11]. This similarity causes fish to mistakenly recognize microplastics as their prey. A study in the North Pacific Ocean suggested that plankton often misrecognizes white, light-colored plastic fragments as prey [24]. Plastic entered the fish from their food sources that already contain microplastics in their bodies. Ingestion of plastic by marine biota was mostly reported as “misidentification” due to the similarity of the plastic to its natural prey [6].

The abundance of small microplastics in the water also might cause accidental consumption by fish, and eventually allow them to be transferred from the digestive system to body tissues. Previous studies have found that microplastics were translocated to the liver of wild freshwater fish [26]. Thus, the microplastics in the digestive tract of fish indirectly reflect pollutants in the marine environment [17].

The effect of plastic contamination on fish health has not been proven in previous studies. However, the polymers and chemicals contained in plastics could be harmful to fish and humans who consume fish. Chemical materials added during the plastic manufacturing process include polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, polybrominated diphenyl ethers, alkylphenols, polychlorinated biphenyls (PCBs), bisphenols, and organochlorine pesticides and these chemical substances can cause a decrease in human immunity if consumed [27]. Ingestion of microplastics by commercial fish has become a global concern because it is related to human health.

The fish samples in this study were potentially consumed by Little-black cormorant, and thus there was a possibility that microplastic could be transferred within the food chain (i.e., trophic transfer). Several studies have confirmed the transfer of plastic in the food chain from prey to predator. A previous study showed the transfer of plastic particles of prey Atlantic mackerel (Scomber scombrus) to top predators, namely grey seals (Halichoerus grypus) [7]. As there has been no similar research in the marine trophic transfer in Indonesia, further research is needed, especially when human health is involved, through the consumption of the same fish species by human.

4. Conclusion

Microplastics were already been found in eight fish samples of 5 fish species, namely (i.e., Lutjanus vitta, Cephalopholis boenak, Cephalopholis formosa, Plectorhinchus gibbosus and Cyprinus sp.) in the amount of 7-26 particles/individu. The types of microplastics found were film and fiber with the dominant color were transparent (57.3%) and the dominant microplastic size group were 101-500 m. This research is the first study of microplastics on fish which also seabird food on Pulau Rambut.
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