Microplastics in Digestive System of Little-black cormorant (Phalacrocorax sulcirostris) in Pulau Rambut Sanctuary

N K Y Susanti¹, A Mardiastuti² and S Hariyadi³

¹ Program Study of Tropical Biodiversity Conservation, Faculty of Forestry and Environment, IPB University
² Department of Forest Resource Conservation and Ecotourism, Faculty of Forestry and Environment, IPB University
³ Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, IPB University

E-mail: kadekyudias@gmail.com

Abstract. Microplastics have been found in many seabirds in various areas in the world, but there has been no report from Indonesia. The objective of this research was to discover whether there were microplastics in the Indonesian Seabirds, represented by the Little-black cormorant (Phalacrocorax sulcirostris). The study site was Pulau Rambut Wildlife Sanctuary, a small island in Jakarta Bay, where a big colony of the cormorants’ nests together with other waterbirds. The gastrointestinal tract of a sample Little-black cormorant was collected to find macroplastic, mesoplastic, or microplastic. Microplastics were detected through NaCl dilution, followed by observation using 10x10 magnification and SRCC. There was no macroplastic and mesoplastic found in the sampled bird. As for microplastic, 16 microplastic particles of different types, sizes, and colours were found, giving an estimation of 320 particles/bird. Microplastic film type were dominant (75.0%), followed by fiber (18.7%) and fragment (6.3%). The size of the microplastic was mostly (68.7%) between 100-1,000 μm. Color-wise, more than half (56.2%) were transparent. Other colors found were red (18.7%), black (12.5%), yellow and blue (6.2% each), no brown or green.

Keywords: cormorants, macroplastics, mesoplastics, Phalacrocorax sulcirostris, Pulau Rambut Wildlife Sanctuary

1. Introduction
Plastic is lightweight, resistant to water, and has low prices, making it ideal for packaging and furniture. Global plastic production has increased from 1.5 million cubic tons per year in 1950 to 359 million cubic tons in 2018 [1]. Plastic waste has also increased with the discovery of a much plastic waste around us. In fact, plastic is the most abundant waste in waters, including in the marine environment. About 4.8 to 12.7 million cubic tons of plastic waste originating from land have been known to enter the oceans [2]. Plastic waste in the sea is commonly referred to as marine litter [3], which is usually grouped into five types according to their size: megaplastics (>100 cm), macroplastics (2.5 cm - 100 cm), mesoplastics (5 mm - 2.5 cm), microplastics (<5 mm) and nanoplastics (<1 μm) [4].
The plastics in the oceans have been shown to have a negative impact on marine life. More than 260 species, including invertebrates, turtles, seabirds, mammals, and fish, accidentally entangled and ingested plastics [5]. Several studies have proven the existence of plastics in the digestive tract of animals including seabirds, for example around 58% in the stomach of 1,295 Fulmarus glacialis in the North Sea [6], 13 out of 65 seabirds in Ireland [7], and 113 seabirds in the Catalan coast (Mediterranean) [8]. Furthermore, plastics were also found in the species Ciconia ciconia, Larus fuscus, and Larus michahellis in Portugal [9].

Pulau Rambut Wildlife Sanctuary - a small island located in Jakarta Bay, about 3 km off the coastline - also facing a plastic problem. The presence of plastic waste in the waters around Pulau Rambut cold has been polluted marine life, including birds. The island is a heronry of 13 waterbird species. Of these waterbirds, cormorants (Little-black cormorants Phalacrocorax sulcirostris and Pygmy cormorants P. pygmaeus) forage for food at sea, although these species are also able to fish in the freshwater wetlands in mainland Java. Fish and insects water are the main food for cormorants [10,11]. Cormorants may accidentally ingest plastic when fishing in the sea water and/or ingest the plastic-contaminated prey fish.

The plastic consumed by animals can indirectly harm them and may lead to death in the long term. In the short term, plastics ingested by animals, including birds, may cause blockage of the digestive tract, decrease secretion of enzymes, decrease levels of steroid hormones, and disrupt reproduction [12]. Research on the impact of plastic on bird especially seabirds in Indonesia, unfortunately, has not been done. This study aims to identify plastics in the digestive system of Little-black cormorants roosting/nesting in Pulau Rambut Wildlife Sanctuary. The Little-black cormorants were selected as the research object due to their habit of fishing on sea water and due to their abundant population on the island. The data that had been obtained can be used as a reference in conservation management, especially seabirds and their habitat at Pulau Rambut Sanctuary.

2. Study Area and Method

2.1. Study Area

The research was conducted in the surrounding waters of Pulau Rambut Wildlife Sanctuary, Kepulauan Seribu (Thousand Islands), DKI Jakarta (106.5°41’30” E, 5.5°58’30” S) (Figure 1). The Sanctuary covers an area of 25 ha land area and 20 ha of surrounding sea water. This island has three types of forest, namely beach forest, mangrove forest, and mixed secondary forest [13]. The diverse habitat conditions make Pulau Rambut an ideal place for various waterbird species: Grey heron (Ardea cinerea), Purple heron (Ardea purpurea), Black-crowned night heron (Nycticorax nycticorax), Great egret (Egretta alba), Intermediate egret (Egretta intermedia), Pacific reef-egret (Egretta sacra), Little egret (Egretta garzetta), Little-black cormorant (Phalacrocorax sulcirostris), becomes Pygmy cormorant (Phalacrocorax pygmaeus), Oriental darter (Anhinga melanogaster), Milky stork (Mycteria cinerea), Black-headed ibis (Threskiornis melanocephalus) and Glossy ibis (Plegadis falcinellus) [14]. Little-black cormorant (Phalacrocorax sulcirostris) is one of the seabirds that inhabit Pulau Rambut Wildlife Sanctuary (Figure 2). These birds forage for food directly in the water and potentially ingested plastic. The last study [15] stated, the abundance of cormorants birds on the Pulau Rambut Sanctuary was 3458 (February) and 4076 (March). During the research period only P. sulcirostris was found on Pulau Rambut Sanctuary.

2
2.2. Methods
Due to its status as a wildlife sanctuary, the local authority (Balai Konservasi Sumberdaya Alam DKI Jakarta) gave permits only to 3 individuals of the Little-black cormorant for this research. The birds were planned to be captured at night at their roosting tree. Fortunately, on the captured day, there was one individual bird found recently dead, and the body was quickly transported by using a cool box to the temporary holding in Taman Mini Indonesia Indah Bird Park in Jakarta. A few days after obtaining the samples, the sanctuary was locked down due to Covid-19, and remained locked down for the next
year or so. Thus, no additional samples were able to be used for this research. We just used one sample Little-black cormorant.

Laboratory analysis was carried out in the Faculty of Fisheries and Marine Science, IPB University. Bird sample dissection followed the standard collection and dissection procedures [16]. The digestive organ from the esophagus to the intestine near the cloaca was removed for further analysis [16]. The contents of the digestive organs were liquefied with 100 ml of saturated NaCl solution. Plastic particles that were directly visible to the naked eye (i.e., mesoplastic and macroplastics) were separated directly. Microplastics were identified and enumerated using a monocular microscope (magnification 10x10) and SRCC (Sedgewick Rafter Counting Cell) with five repetitions [17]. Plastics found then were grouped by type, size, and color.

3. Results and Discussion

3.1 Plastics in Little-black Cormorant

There were no macroplastic and mesoplastics found in the sampled bird. For microplastic, a total of 16 microplastic particles were found, having different types, colors, and sizes. The abundance of microplastics in the digestive tract was estimated at 320 particles. The number of microplastics found in the Little-black cormorants was lower than to other studies elsewhere. The number of microplastics found in the Little-black cormorant was lower than previous research in Florida found 1,189 microplastic particle in 63 samples with the fragment, fiber, and microbeads type [18]. Fewer microplastic particles were found in Fulmarus glacialis and Uria lomvia in the Canadian Arctic Region, as many as 34 particles in 57 individual birds [19]. On the Catalan coast of the Western Mediterranean Sea, 1,168 microplastic particles were found in 113 individual birds [8], while in Ireland, 92 pellets were found inside the Great Cormorant [12].

The types of microplastics found in the study area were mostly film (75%), followed by fiber (18.75%) and fragments (6.25%). A study of microplastics at the Labrador Sea on 30 Fulmar also found microplastics with film, fiber, and pellet types, as well as foam and rubber [21]. In Shanghai, fiber was the type of microplastic that dominate (54.9%) of the 17 sample birds [21]. The fiber was also the predominant type in bird samples observed in Florida at 94% [18]. Other previous studies of microplastics that have focused on contamination of water, sediment, and tissue in animals have shown that fiber was the dominant type [5,23,224].

The type of film that dominated microplastics in this study was related to the number of plastic bags and packaging found in the marine habitat, especially the waters surrounding Pulau Rambut. These plastics have undergone degradation into microplastics which can then be swallowed by the cormorants. As for fiber, it might originate from fishing activities around Pulau Rambut. Fiber is microplastics derived from nylon, polypropylene (clothing fibers, carpets, ropes, and fishing nets), and polyvinyl alcohol, all are common substances for fishing lines [25,4,23].

The color of microplastics has become an important research topic because many animal species forage for food by color [17]. The microplastic found in the sample Little-black cormorant consisted of 5 colors: transparent (dominant, 56.2%), black, red, yellow, and blue (Figure 3; left). Transparent colors were found in the microplastic fiber (3 particles) and film types (6 particles), while fragments (1 particle) were only found in yellow. Apart from transparent colors, films were also found in black (2 particles), red (3 particles), and blue (1 particle).
Figure 3. Microplastics in the Little-black cormorant in Pulau Rambut Wildlife Sanctuary, grouped by colour (left) and size (right).

Plastic with transparent colors was commonly used for various products. Color might be added to polymers during the plastic manufacturing process, and over time these colors may be faded away due to environmental conditions [26]. The result of this research on microplastic color was different from other previous research. In the research on seabirds in the South China Sea, blue was the dominant color (91%), followed by dark and white [27]. Blue and transparent colors dominated two raptor birds, Pandion haliaetus and Buteo lineatus in Central Florida [17]. Furthermore, blue microplastic particles predominate in the seabirds Fulmarus glacialis and Uria lomvia, followed by red and white in Arctic Canada [19]. The different types or colors of microplastics found in animals can be caused by the abundance of microplastics depends on the environment [28]. Birds may ingest transparent or blue microplastic when looking for food or nesting material because they were mistaken to recognize plastic as prey or nest material [29].

Microplastics size of less than 5 μm were easily consumed by small-sized organisms such as phytoplankton and zooplankton, and later on, becomes a pathway for transfer to the food chain [30]. The size of the microplastics commonly was grouped into 8 groups, ranging in size from 0-5,000 μm. Microplastics found in the Little-black cormorant in this study were found in 5 of the 8 size groups. The most common size group was 101-1,000 μm, with a dominating size of 101-500 μm (37.5%, 6 particles), followed by the group size of 501-1,000 500 μm (31.2%, 5 particles; Figure 3b). This bird species catches prey underwater by swimming and diving, by using their large and webbed feet, assisted by the membranes on the feet and the nictitating membranes in the eyes [11]. These are the example of microplastics that were found in the Little-black cormorant digestive tract, fiber type with red color, and film type with blue color (Figure 4).

The Little-black cormorant might ingest microplastics by mistake of detecting plastics as food. Microplastics might accidentally enter the digestive system of the cormorants in the study area through sea water, while diving and swimming for fish and collect nest material, as also observed elsewhere [22]. The discovery of microplastics in the sample of the Little-black cormorant has shown the water pollution from plastic waste already has an impact on waterbirds nesting and roosting in Pulau Rambut. It is possible that microplastics can also be found in other waterbird species as well, either through direct accidental consumption from the sea water or through the food chain or trophic transfer, as reported by other researchers [31,24].
3.2 Environmental Impact

Plastic pollution has a negative impact on the environment and animals, especially marine life. The entanglement and accidental ingestion of macroplastics by animals has occurred, especially in vertebrates [32]. In this present study, no bird was found entangled by macroplastic, either in the sea water or while on the nest. However, the results of laboratory analysis have found microplastics in the digestive tract of the sampled waterbird. The accumulation of plastic in the digestive tract can have an effect on bird health [12,33]. The effects of plastic consumption would not happen in immediately, and likely happen in long term.

Previous studies have shown that polybrominated diphenyl ethers (PBDE) compounds were found in the fatty tissue of the Short-tailed Shearwater (Puffinus tenuirostris) [34]. PBDE is one of the compounds contained in plastics and has persistent and toxic properties. Experimental research on the testing of butyl benzyl phthalate (BBP) in fish (Danio rerio) and bisphenol-A (BPA) in crustaceans (Acartia tonsa) and amphibians (Xenopus laevis ) showed that BBP and BPA could affect the development and reproductive disorders of various species of aquatic species [35]. This can also happen to other species that accidentally ingest plastic, including the Little-black cormorant in the study area, and might lead to the decline in the population of this species.

In conclusion, microplastics (320 items) were already found in the digestive tract of the Little-black cormorant, with the type of film, fragment, and fiber. The two dominant colors of the microplastics were transparent and black, while the dominant sizes were dominated by the 101-1,000 μm. This is the first evidence of the existence of microplastics in a wild bird. The results of this study are expected to help the conservation of seabirds, especially the little black cormorant on Pulau Rambut and in managing their habitat. Further research involving larger samples and various fish-eating species is needed, as a human has the same trophic level as a bird in fish consumption.

4. Acknowledgments

We would like to thank the Balai Konservasi Sumber Daya Alam DKI Jakarta for permit to conduct this study. We appreciate the assistance provided by Dicky, Warsajaya, Budi, Masrul, Iskandar, Hendra, Coki, Suli, Regia and Maya during the data collection, and by drh. M. Piter Kombo and Taman Burung Taman Mini Indonesia Indah for bird dissection process and laboratory support.
5. References

[1] Plastic Europe 2019 An analysis of European plastics production, demand and waste data downloaded on 2021 Februari 05 from https://www.plasticseurope.org/application/files/9715/7129/9584/FINAL_web_version_Plastics_the_facts2019_14102019.pdf

[2] Jambeck J R, Geyer R, Wilcox C, Siegler T R, Perryman M, Andraday A, Narayan R and Law KL 2015 Plastic waste inputs from land into the ocean Science 347 768–771

[3] Jeftic L, Sheavly S and Adler E 2009 Marine Litter: A Global Challenge (Nairobi: UNEP)

[4] Lippiatt S, Opfer S and Arthur C 2013 Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment Technical Memorandum (United States: National Oceanic and Atmospheric Administration) p 5

[5] Thompson RC 2004 Lost at sea: where is all the plastic? Science 304 838–838

[6] Van Franeker J A, Blaize C, Danielsen J, Fairclough K, Gollan J, Guse N, Hansen P L, Heubeck M, Jensen JK, Guilou G L, et al 2011 Monitoring plastic ingestion by the northern fulmar Fulmarus glacialis in the North Sea Environ Pollut 159 2609–2615

[7] O’Hanlon N J, James N A and Bond A L 2017 Seabirds and Marine Plastic Debris in Ireland: A Synthesis and Recommendations for Monitoring (Scotland: Circular Ocean) p 9

[8] Codina-Garcia M, Militiño T, Moreno J and González-Solís J 2013 Plastic debris in Mediterranean seabirds Mar Pollut Bull 77 220–226

[9] Nicastro K R, Lo Savio R, McQuaid C D, Madeira P, Valbusa U, Azevedo F, Casero M, Lourenço C and Zardi G I 2018 Plastic ingestion in aquatic-associated bird species in southern Portugal Marine Pollution Bulletin 126 413–418

[10] Miller B 1979 Ecology of the little black cormorant, phalacrocorax sulcirostris, and little pied cormorant, p. melanoleucos, in Inland New South Wales I. Food and Feeding Habits Aust Wildl Res 1979 79–95

[11] Birdlife 2021 Little Black Cormorant [downloaded on 2021 January 29 from http://birdlife.org.au/bird-profile/Little-Black-Cormorant]

[12] Webb H K, Arnøy J, Crawford R J and Ivanova E P 2012 Plastic degradation and its environmental implications with special reference to poly(ethylene terephthalate) Polymers 4 1-18

[13] Wardhani P K, Sukandar P and Isfaeni H 2014 Studi tempat bertengger Burung Cikalang di Suaka Margasatwa Pulau Rambut BIOMA 10 8

[14] Mardiastuti A 2001 Ecology of Avian Community of Pulau Rambut: Population, Nest Site Distribution, and Foraging Sites (Bogor: Institut Pertanian Bogor) p 6

[15] Azhar A 2002 Evaluasi Terhadap Kelimpahan dan Pola Penggunaan Habitat Bersarang Burung Merandai Pada Musim Berbiak Di Suaka Margasatwa Pulau Rambut (Bogor: Institut Pertanian Bogor)

[16] Van Franeker J A 2004 Save the North Sea Fulmar Litter EcoQO Manual: Collection and Dissection Procedure (Wageningen: Alterra) p 23-26

[17] Boerger C M, Lattin G L, Moore S L and Moore C J 2010 Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre Mar Pollut Bull 60 2275–2278

[18] Carlin J, Craig C, Little S, Donnelly M, Fox D, Zhai L and Walters L 2020 Microplastic accumulation in the gastrointestinal tracts in birds of prey in central Florida, USA Environ Pollut 264 114633

[19] Bourdages M P T, Provencher J F, Baak J E, Mallory M L and Vermaire J C 2020 Breeding seabirds as vectors of microplastics from sea to land: Evidence from colonies in Arctic Canada Sci Total Environ 764

[20] Acampora H, Berrow S, Newton S and O’Connor I 2017 Presence of plastic litter in pellets from great cormorant (Phalacrocorax carbo) in Ireland Mar Pollut Bull 117 512–514

[21] Provencher J F, Vermaire J C, Avery-Gomm S, Braune B M and Mallory M L 2018 Garbage in
guano? Microplastic debris found in faecal precursors of seabirds known to ingest plastics Sci Total Environ 644 477–1484

[22] Zhao S, Zhu L and Li D 2016 Microscopic anthropogenic litter in terrestrial birds from Shanghai, China: Not only plastics but also natural fibers Sci Total Environ 550 1110–1115

[23] Claessens M, Meester S D, Landuyt L V, Clerck K D and Janssen C R 2011 Occurrence and distribution of microplastics in marine sediments along the Belgian coast Mar Pollut Bull 62 2199–2204

[24] Nelms S E 2018 Investigating microplastic trophic transfer in marine top predators Environ Pollut 238 1-9

[25] Hidalgo-Ruz V, Gutow L, Thompson R C and Thiel M 2012 Microplastics in the marine environment: a review of the methods used for identification and quantification Environ Sci Technol 46 3060–3075

[26] Chen Q, Li Y and Li B 2020 Is color a matter of concern during microplastic exposure to Scenedesmus obliquus and Daphnia magna? J Hazard Mater 383 121224

[27] Zhu C, Li D, Sun Y, Zheng X, Peng X, Zheng K, Hu B, Luo X and Mai B 2019 Plastic debris in marine birds from an island located in the South China Sea Mar Pollut Bull 149 110566

[28] Manalu A A 2017 Kelimpahan mikroplastik di Teluk Jakarta (Bogor: Institut Pertanian Bogor)

[29] Foekema E M, De Grujiter C, Mergia M T, van Franeker J A, Murk A J and Koelmans A A 2013 Plastic in North Sea Fish Environ Sci Technol 47 8818–8824

[30] Avio C G, Gorbi S and Regoli F 2017 Plastics and microplastics in the oceans: From emerging pollutants to emerged threat Mar Environ Res 128 2–11

[31] Hammer S, Nager R G, Johnson P C D, Furness R W and Provencher J F 2016 Plastic debris in great skua (Stercorarius skua) pellets corresponds to seabird prey species Mar Pollut Bullet 103 206–210

[32] Wright S L, Thompson R C, Galloway T S 2013 The physical impacts of microplastics on marine organisms: A review Environ Pollut 178 483–492

[33] Gregory M R 2009 Environmental implications of plastic debris in marine settings entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions Phil Trans R Soc B 364(1526) 2013–2025

[34] Tanaka K, Takada H, Yamashita R, Mizukawa K, Fukuwaka M, and Watanuki Y 2013 Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics Mar Pollut Bull 69 219–222

[35] Oehlmann J, Schulte-Oehlmann U, Kloas W, Jagnytsch O, Lutz I, Kusk K O, Wollenberger L, Santos E M, Pauli G C, Van Look K J W, et al 2009 A critical analysis of the biological impacts of plasticizers on wildlife Phil Trans R Soc B 364 2047–2062