

Microplastics in the digestive organs of little egret (*Egretta garzetta*) in Tanjung Rejo Village, Deli Serdang District, North Sumatra, Indonesia

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Abstract. Jumilawaty E, Harahap MA, Basyuni M, Slamet B. 2025. Microplastics in the digestive organs of little egret (*Egretta garzetta*) in Tanjung Rejo Village, Deli Serdang District, North Sumatra, Indonesia. *Biodiversitas* 26: 2460-2466. Microplastics, derived from the degradation of plastic waste measuring <5 mm, pose significant environmental risks. In aquatic ecosystems, microplastics can be inadvertently ingested by organisms, including waterbird species such as the little egret (*Egretta garzetta*). Microplastic ingestion may cause internal damage, digestive blockages, and exposure to toxic substances that threaten overall health and survival. This study aimed to identify the types, colors, and abundance of microplastics in the stomach and intestines of *E. garzetta*. Sampling was conducted purposively in Tanjung Rejo Village, North Sumatra, Indonesia, based on the presence of *E. garzetta*. Three individuals were captured using a trapping method, and their digestive tracts were extracted with 10% potassium hydroxide (KOH). Microplastics from the stomach and intestine samples were identified morphologically under a microscope and analyzed descriptively. The results revealed the presence of microplastic contamination in both the stomach and intestines, with synthetic fibers (e.g., nylon, polyester), fragments, and films being the predominant types detected. Fragments were the most abundant microplastic type, likely originating from household waste. A total of 48 particles were found in the stomach and 44 particles in the intestines. Black microplastics were the most prevalent (59%) in proportion, while blue microplastics were the least common (3%). The abundance of fiber as the second most prevalent type of microplastics, averaged 16 particles in the stomach and 14 particles in the intestines per individual. The findings confirmed the presence of microplastic contamination within the body of little egrets, with fibers, fragments, and films identified as the predominant types. These findings promote the need for further research and mitigation strategies to address microplastic pollution in waterbird habitats.

Keywords: Aquatic avifauna, environmental contamination, gastrointestinal tract, microscopical examination, polymer debris

INTRODUCTION

Aquatic pollution occurs when living organisms, substances, energy, or other components enter water environments due to human activities, leading to a decline in water quality. Pollutants include chemical particles, industrial waste, agricultural runoff, and residential waste discharged into aquatic systems. Plastic waste, a significant pollutant, floats and accumulates in aquatic environments, including oceans (Thushari and Senevirathna 2020). Plastics take an extended time to degrade, and their breakdown produces microplastic particles. Microplastics, defined as particles <5 mm in size, pose a severe threat to marine organisms as they can be inadvertently ingested (Beiras and Schönemann 2020). The impact of microplastics is not limited to marine life; it also extends to organisms feeding and foraging in aquatic habitats, including waterbirds. Waterbirds foraging in wetland sediments are particularly vulnerable to microplastic contamination through their diet (Lourenco et al. 2017). Accumulated microplastics in the gastrointestinal tracts of waterbirds can negatively affect their health. Accumulated microplastics in the gastrointestinal tracts of waterbirds may cause physical injuries, disrupt digestion, reduce

nutrient absorption, and introduce toxic substances. These effects can impair physiological condition, hinder growth, and reproduction, and increase susceptibility to disease and predation (Carrasco et al. 2025). While the impacts of microplastic contamination are not immediately evident, long-term adverse effects on bird populations are highly possible (Susanti et al. 2022).

Sumatra, an island spanning 476,000 km², lies at the western end of the Indonesian archipelago, straddling the equator. The island serves as both a migratory passage for waterbirds traveling between northern Asia and Australasia and a key terminus for species that spend their non-breeding season in the tropics (Crossland et al. 2006). The northeastern coastline of Sumatra, facing the Andaman Sea and the northern part of the Strait of Malacca, is characterized by a semi-diurnal tidal cycle and generally low-energy wave environments (Whitten et al. 2000). These conditions, coupled with high sediment loads transported by rivers, have facilitated the formation of extensive soft mudflats along the open shorelines. In many areas, these mudflats are bordered by mangrove forests, nipah (*Nypa fruticans* Wurm) swamplands, or, in regions of land reclamation, aquaculture ponds. The mangrove ecosystems serve as critical habitats for waterbirds,

providing feeding and resting grounds during tidal fluctuations. The sediment-rich mangrove environment hosts diverse food sources for waterbirds, such as macrozoobenthos (Putra et al. 2022).

Tanjung Rejo Village, located in Percut Sei Tuan Sub-district, Deli Serdang District, North Sumatra Province, hosts a significant mangrove ecosystem. The village is located along northeastern coast of Sumatra, covers an area of 19 km² with a population of 10,342, primarily consisting of farmers and fishers. The mangrove ecosystem in this area covers 602.18 hectares (ha) (Samosir and Restu 2017). Despite their ecological significance, the mangroves in Tanjung Rejo are under considerable threat from pollution, particularly plastic waste stemming from fishing activities, tourism, household waste, and nearby port operations. These anthropogenic activities contribute to the alteration and degradation of the mangrove ecosystem, threatening its biodiversity and disrupting its ecological functions. Microplastics, a pervasive form of plastic pollution, are known to have detrimental effects on organisms inhabiting mangrove ecosystems (Deng et al. 2021). However, further scientific investigation is required to establish evidence of their specific impacts in this region.

Several studies have documented microplastic contamination in North Sumatra, including detection in both aquatic environments and the fauna inhabiting these polluted ecosystems. Microplastics have been identified in urban areas, such as in the sediments of the Deli River, which flows through urban regions to its estuary, with potential dispersal to adjacent areas and coastal mangrove ecosystems (Harpah et al. 2021). Other studies have reported microplastic contamination in various fishery

products, including fishermen catches from the Belawan River (Nasution et al. 2024), *Anadara* clams (Rahmatsyah et al. 2024a), and commercial fishes from the region (Rahmatsyah et al. 2024b). These previous studies highlight the urgent need to evaluate the extent of microplastic contamination along the northeastern coast of Sumatra, particularly in mangrove ecosystems and their associated fauna, including waterbirds. In response, this study aims to provide the first evidence of microplastic contamination in the digestive organs of the little egret (*Egretta garzetta* (Linnaeus, 1766)) in Indonesia, specifically in Tanjung Rejo Village, North Sumatra, Indonesia. The study focused on identifying the types, colors, and abundance of microplastics ingested by this species, providing crucial insights into the potential ecological risks posed by microplastic pollution to mudflat communities and the broader coastal ecosystem.

MATERIALS AND METHODS

Study area

This study was conducted from November 2023 to January 2024 in Tanjung Rejo Village, Percut Sei Tuan Sub-district, Deli Serdang District, North Sumatra Province, Indonesia (Figure 1). Microplastic identification and data analysis were carried out in the Laboratory of Animal Systematics, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara (USU), Medan, Indonesia.

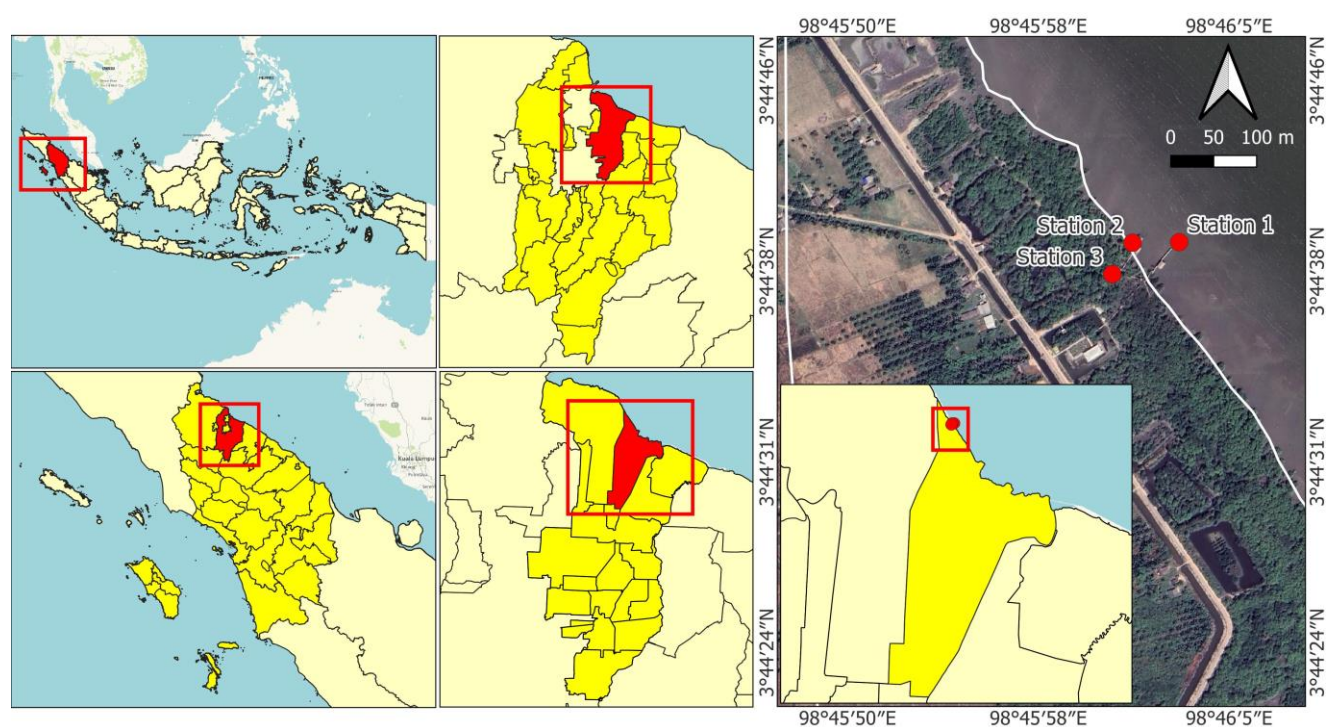


Figure 1. Map of sampling point (yellow dots) in Tanjung Rejo Village, Percut Sei Tuan Sub-district, Deli Serdang District, North Sumatra, Indonesia

Specimen collection and dissection of little egrets (*Egretta garzetta*)

Samples of *E. garzetta* were obtained using a trapping method, with a total of three individuals captured. Traps were placed in areas frequently traversed by the birds, utilizing nets made of nylon string supported by bamboo poles on either side. Birds were ensnared upon contact with the net, preventing their escape. The captured specimens were then processed in the laboratory following ethical guidelines. All procedures involving animal handling and dissection were conducted in accordance with ethical standards to minimize distress and ensure humane treatment. This research was approved by the Health Research Ethics Committee of USU, Medan (No. 0359/KEPH-FMIPA/2024). The euthanasia of *E. garzetta* specimens was carried out in the field using blunt force trauma followed by cervical dislocation, a method commonly applied to avian species to minimize pain and distress. The deceased bird specimens were cleaned in the abdominal to neck region, followed by an incision from the abdomen to the neck for further analysis. Digestive organs, including the stomach and intestines, were extracted, and rinsed with distilled water. The organs were then weighed to facilitate the destruction of organic matter and lipids. Based on the method of Rohcman et al. (2015) for fish, the extracted organs were treated with a 10% potassium chloride (KOH) solution at a ratio of three times the organ volume to ensure complete submersion in a beaker. The addition of 10% KOH aids in breaking down the organ tissues, releasing microplastics for observation. The submerged organs were covered with aluminum foil and heated in an oven at 60°C for 24 hours. The digested organ material was filtered using a 200- μ m sieve cloth and rinsed with distilled water. Filtration was further refined using microfiber glass filter paper (No. 1821-047) placed in a funnel. The filtered material was then air-dried at room temperature. Microplastics were observed under a microscope with 40 \times magnification.

Data analysis

Microplastics extracted from the stomach and intestine samples of *E. garzetta* were identified morphologically using a microscope. The types and quantities of microplastics were recorded and presented in tabular form. Microplastics recovered from digestive organs were categorized by types (fibers, films, and fragments) and colors through direct observation under a microscope. Fibers (synthetic) are elongated and thread-like in shape, often appearing thin and flexible. Films are characterized by their thin, flat, and sheet-like structure. Fragments exhibit irregular, angular shapes with varying sizes and are typically hard and rigid. The percentage distribution of microplastic colors was calculated using Microsoft Excel ver. 2016 and visualized as graphs. The abundance of microplastics within the bird samples was calculated using the formula by Boerger et al. (2010):

$$\text{Microplastic abundance} = \frac{\text{Number of microplastic particles in organ samples}}{\text{Number of organisms (individuals)}}$$

RESULTS AND DISCUSSION

This study identified three types of microplastics in the digestive organs of *E. garzetta*: fragments, fibers, and films (Figure 2). Among these, fragments were the most abundant, with 48 particles found in the stomach and 40 particles in the intestines, resulting in a total of 88 particles. Fiber microplastics were the second most prevalent, with 11 particles in the stomach and 18 in the intestines, totaling 29 particles. Film microplastics were the least abundant, with 7 particles in the stomach and 6 in the intestines, giving a total of 13 particles. The predominance of fragment microplastics in both the stomach and intestines can be attributed to their low density, allowing them to float and disperse easily in aquatic environments. The distribution of microplastics is influenced by ocean currents and tidal movements, which transport low-density microplastics from offshore waters to coastal areas (Hardesty et al. 2017). Ling et al. (2019) further noted that fragment microplastics originate from the degradation of larger plastic debris, including packaging materials, woven plastics, plastic bottles, pipes, and transparent plastic bags. These fragments are characterized by irregular shapes, rough surfaces, and large pores, making them susceptible to fragmentation processes (Ahmed et al. 2021). Fiber microplastics, on the other hand, are commonly associated with marine waste from fishing vessels and discarded fishing gear, such as nets and lines (Montarsolo et al. 2018). The presence of fiber microplastics in the gastrointestinal tracts of waterbirds likely reflects localized sources of pollution, particularly from fishing activities. Film microplastics, while less abundant, are also present in the study area. These likely originate from thin plastic sheets, such as plastic bags and agricultural covers, which degrade into smaller particles over time (Ahmed et al. 2021). The widespread presence of microplastics in waterbird digestive tracts highlights the high levels of plastic waste entering aquatic systems. Poor waste management practices and inadequate plastic disposal are major contributors to the influx of plastic waste into coastal waters (Lestari et al. 2020). Large plastic items entering aquatic systems are fragmented into microplastics by tidal movements and water currents (Li et al. 2023). Additionally, marine-based activities, including aquaculture and fishing operations, are significant sources of microplastic pollution in coastal environments.

The presence of microplastics in the gastrointestinal tracts of waterbirds can be attributed to contamination of their food sources. There are two primary pathways for microplastic contamination in digestive systems: direct and indirect ingestion. Direct ingestion occurs when aquatic organisms inadvertently consume microplastic particles, mistaking them for prey items like zooplankton, resulting in a misleading sensation of fullness or pseudo-satiation (Capone et al. 2020). Indirect ingestion occurs through the food chain, wherein prey species consumed by aquatic organisms are already contaminated with microplastics (Egbeocha et al. 2018). Since waterbirds' diets depend on their foraging environment, microplastic contamination in their digestive systems likely results from bioaccumulation

through the food chain. Biomagnification refers to the concentration of pollutants as they move up or being accumulated to other trophic levels, then amplifying microplastic exposure in higher trophic organisms, including waterbirds (Miller et al. 2020).

Among the identified microplastics, fragments showed the highest abundance (Figure 3.G-I). Fragments, characterized by irregularly shaped shards, originate from the breakdown of items such as plastic bottles, containers, transparent folders, water gallon pieces, and Polyvinyl Chloride (PVC) pipes (Al-Fatih 2021). Their prevalence can be linked to plastic waste from tourism and household activities. Fragment microplastics are commonly made of polymers such as High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), and PVC (Jung et al. 2018). Fragments are found across diverse habitats, including ocean surfaces, seabed sediments, and terrestrial environments, with their distribution shaped by water currents, river flows, and human activities. These particles exhibit a range of colors, such as red, green, blue, brown, black, and yellow, indicating their varied origins and extensive dispersion (Duis and Coors 2016). Additionally, the structural complexity of fragments makes them more challenging to break down and requires a longer digestion

time compared to fibers and films, potentially increasing their retention within organisms, and exacerbating their adverse effects.

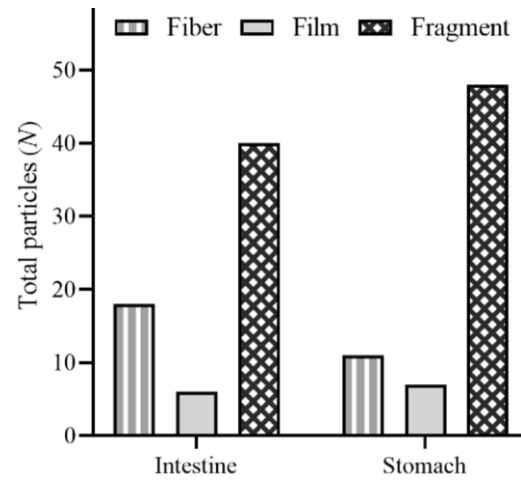


Figure 2. Total abundance of each type of microplastics in the digestive organs of *Egretta garzetta* ($n: 3$)

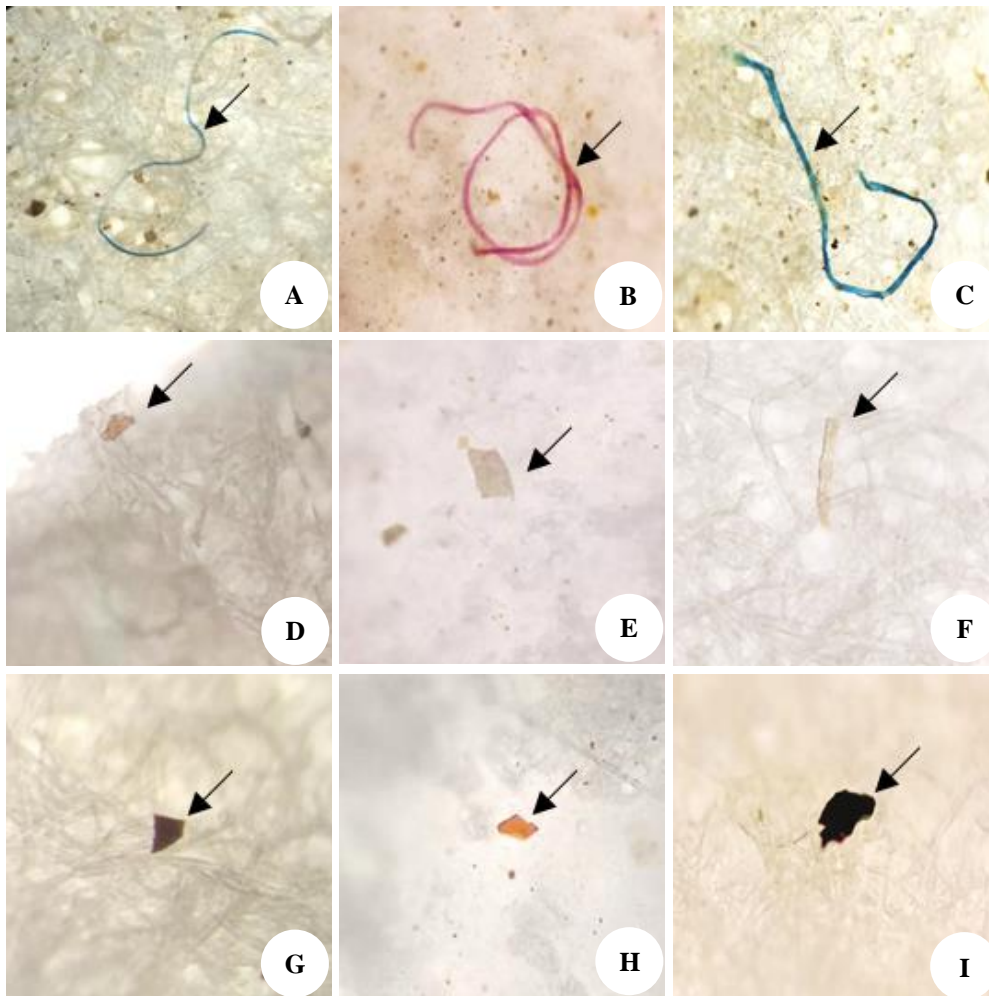


Figure 3. Typical appearances of microplastics in the digestive organs of *Egretta garzetta*. A-C. Fibers; D-F. Films; G-I. Fragments

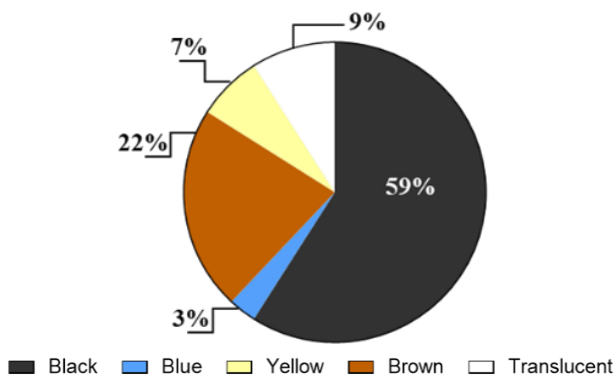


Figure 4. Percentage of abundance of microplastics in the digestive organs of *Egretta garzetta* based on colors

Fiber microplastics (Figure 3.A-C) are primarily derived from fishing nets or synthetic textile waste (Acharya et al. 2021). These fibers often originate from washing synthetic fabrics, where small fibers are released and discharged into aquatic systems (Cesa et al. 2017). Accumulated fibers can form entangled masses, posing risks to digestive tracts by blocking food passage and causing gastrointestinal obstruction. Common fiber polymers, including nylon, nitrile, and cellulose acetate, typically manifest as thread-like structures and are often found in colors such as blue, red, and black. Their physical and chemical properties make fibers persistent pollutants in aquatic environments. Film microplastics (Figure 3.D-F) are thin plastic sheets originating from single-use plastics, such as packaging materials. These films often have lower densities, enabling them to float on water surfaces. Films are predominantly composed of polystyrene (PS) and polypropylene (PP). Film microplastics are typically thin and exhibit dominant colors such as black, white, and gray. Their lightweight nature and widespread use contribute to their pervasive presence in aquatic ecosystems.

The microplastics identified in this study exhibited a range of colors, including black, brown, yellow, blue, and transparent (Figure 4). Black microplastics were the most abundant, accounting for 59% of the total, followed by brown (22%), transparent (9%), yellow (7%), and blue (3%). The variation in color is attributed to prolonged exposure to sunlight, which induces oxidation and causes alterations in the original color (Zhao et al. 2022). Environmental factors contribute to this diversity, as plastic waste entering aquatic systems consists of multiple colors, thereby increasing the variability in microplastic hues. The predominance of black microplastics in this study may be linked to the widespread use of black plastic bags in daily life. Additionally, black microplastics are known to have a high capacity for carrying bacteria, pathogens, and organic pollutants (Huang and Xu 2022). Their persistence in the environment is likely due to their resistance to photodegradation. Lusher et al. (2015) noted that black microplastics are less susceptible to sunlight-induced degradation, enabling them to persist longer in aquatic ecosystems. Their dark color and small size also make them less detectable to marine organisms, increasing the

risk of ingestion. Wang et al. (2020) highlighted that black microplastics are particularly prone to bioaccumulation as they are often mistaken for natural sediment, facilitating their entry into the food chain.

Blue microplastics are often associated with the use of blue-colored plastic materials, such as textiles and packaging, which can release microplastic particles during washing processes (Hernandez et al. 2017). These blue particles are highly visible in aquatic environments, particularly on the water surface and in sediments, due to their contrast with the surrounding environment (Li et al. 2018). This visibility could potentially influence their interaction with aquatic organisms, as species that rely on visual cues for feeding may mistake these particles for food. Transparent microplastics result from prolonged exposure to ultraviolet (UV) radiation, which can cause the color of microplastics to fade over time. Continuous exposure to UV rays leads to photooxidation, breaking down the pigments and causing the particles to lose their original color. Brightly colored and intensely hued microplastics, in contrast, are likely to have undergone limited exposure to environmental degradation or may originate from fresh sources, retaining their original appearance. The environmental conditions surrounding microplastics may significantly influence their coloration. The presence of microplastics in various colors reflects the diversity of their sources and potential interactions within ecosystems. Microplastics in darker hues, such as black and brown, are more commonly encountered due to their ability to absorb heat and resist environmental degradation. These colors also enhance their pollutant-adsorbing properties, making them more likely to accumulate harmful substances. Additionally, their inconspicuous appearance in aquatic environments makes them less likely to be avoided by marine organisms, thereby increasing the risk of ingestion and further bioaccumulation.

Table 1 shows the abundance of microplastics per individual *E. garzetta* captured during the study. The data reveals that the stomach contains the highest abundance of microplastics, dominated by fragments at 16 particles/individual, followed by fibers at 3.6 particles/individual, and films at 2.3 particles/individual. Similarly, in the intestines, fragments were the most abundant at 14 particles/individual, followed by fibers at 6 particles/individual, and films at 2 particles/individual. Microplastic ingestion in waterbirds, particularly the little egrets, may significantly affect digestion and nutrient absorption. Given that fragments are the dominant type detected, these particles are likely retained longer in the digestive tract due to their irregular shape and lower degradability (Hoang and Mitten 2022). In simulated gastrointestinal systems, larger microplastic fragments tend to accumulate in the stomach due to their size and irregular shape, which prevents easy passage through the digestive tract. Conversely, smaller particles are more likely to pass into the intestines, where they may adhere to the mucosal lining or become embedded in the intestinal folds. This differential retention can disrupt normal digestive processes by causing mechanical blockages, impairing nutrient absorption, and inducing local inflammation or lesions.

Table 1. Microplastics abundance in stomach and intestine of *Egretta garzetta*

Types of microplastic	Microplastic abundances	
	Stomach (Particles/ind.)	Intestines (Particles/ind.)
Fiber	3.6	6
Fragment	16	14
Film	2.3	2

Over time, such disruptions may result in physiological stress, reduced digestive efficiency, and overall deterioration of health in affected organisms (Tan et al. 2020). Additionally, digestive processes in birds may alter the physicochemical properties of microplastics, affecting their surface characteristics and facilitating the release of adsorbed contaminants, which could further impact avian health (Cau et al. 2020). The buoyancy of microplastic particles also determines their distribution across water surfaces and sediment layers (John et al. 2022). Polymers such as LDPE, PP, PS, and HDPE, with densities <1 g/mL, are commonly found on water surfaces. Conversely, polymers like Cellulose Acetate (CA), rayon, and nitrile, with densities >1 g/mL, are typically found in bottom sediments.

The presence of fragment-type microplastics in the stomach and intestines indicates that accumulated microplastics within organisms may sediment and disrupt organ systems. Microplastic contamination in aquatic environments altered biodiversity by reducing species diversity and acting as vectors for toxic chemical dispersal. The accumulation of microplastics in the digestive system can lead to blockages in the food filtration pathways. The ingestion of microplastics is a common phenomenon in marine ecosystems, where organisms often consume these particles unintentionally (Egbeocha et al. 2018). This accumulation of microplastics can lead to physical injuries and blockages in the gastrointestinal tract, posing significant risks to their health and overall physiological functions. The polymer compounds in microplastics are known to disrupt physiological systems (Ramsperger et al. 2020). The pervasive presence of microplastics in aquatic ecosystems poses significant risks to organisms that inadvertently consume them, including plankton, benthic organisms, fish, waterbirds, turtles, and marine mammals (Lusher et al. 2015). Over time, accumulated microplastics within organisms can cause adverse effects, such as compromised immune systems, inflammation, potential neurological damage, and disrupted metabolic functions (Sangkhom et al. 2022). The extensive presence of microplastics in the stomach and intestines of the little egrets highlights their potential long-term detrimental effects. Microplastics in digestive organs impair their functional capacity, as their presence creates a false sense of satiety, which can degrade overall health (Zhang et al. 2024). McNeish et al. (2018) emphasized that the accumulation of microplastics in the digestive system could lead to malnutrition, reduced growth rates, weakened immunity, and ultimately increase mortality risks for contaminated organisms.

The findings demonstrate that the digestive organs (stomach, intestine) of *E. garzetta* are contaminated with microplastics, predominantly fibers, fragments, and films, originating from polluted environments. Fragments were the most abundant, likely derived from household waste. Black microplastics were the most frequent, while blue microplastics were the least common. Fragment-type microplastics exhibited the highest abundance, averaging 16 particles per individual in the stomach and 14 in the intestines. Both fragment and fiber microplastics pose potential risks to waterbird species, as these particles can originate from degraded fishing nets, entangled gear, and abandoned trapping devices. The prolonged presence of discarded and damaged fishing equipment in aquatic environments contributes to microplastic pollution, increasing the likelihood of ingestion and entanglement. As this study provides the first documentation of ingested microplastics in *E. garzetta* from the study area, the extent of physiological or morphological impairments remains unknown. Although previous studies have highlighted potential health risks, such as malnutrition, reduced growth, immune suppression, and increased mortality, these effects have not yet been confirmed in this species. Therefore, further research is warranted to assess the potential impacts of microplastic ingestion, using both invasive and non-invasive approaches to evaluate physiological stress, tissue condition, and overall health.

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