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Environmental Chemistry

Microplastic accumulation in various bird species in Turkey

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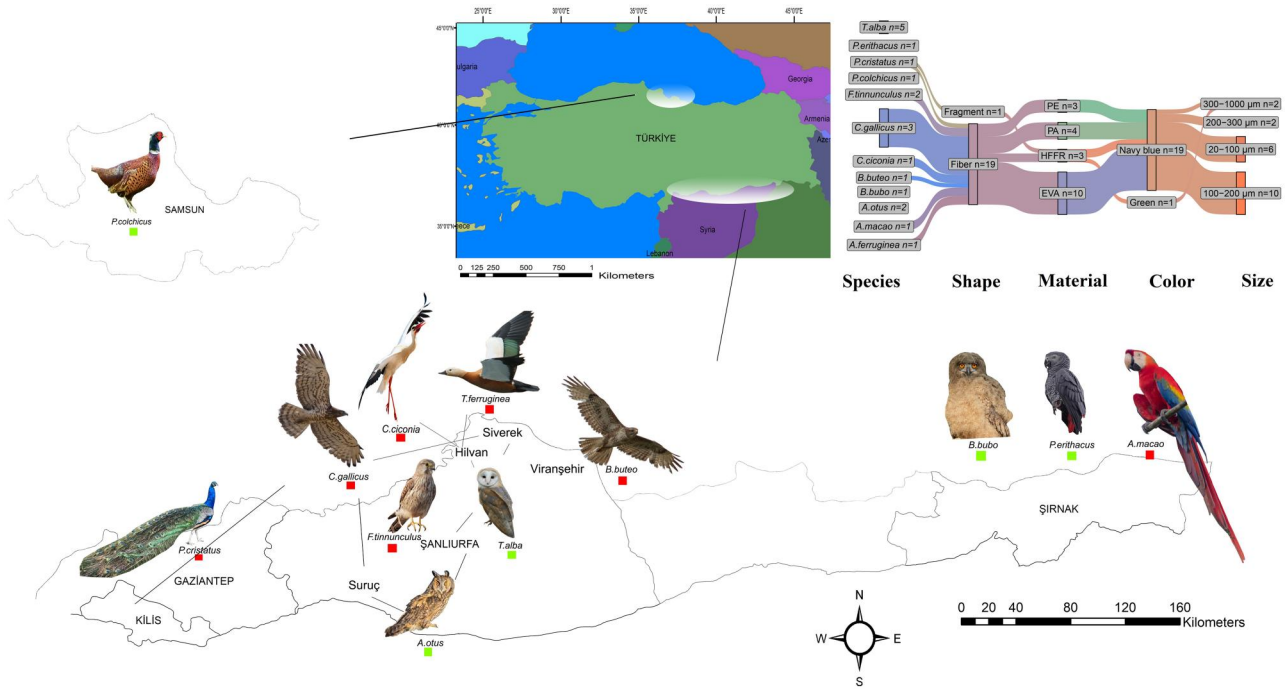
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Abstract

Plastic pollution constitutes one of the major environmental problems of our time, and in recent years, it has emerged as a significant threat to the environment and to various organisms, including bird species. In this context, this study, which provides the first data in Türkiye, aimed to determine the level of microplastic (MP) pollution in 12 bird species (Eurasian buzzard; short-toed snake-eagle; white stork; northern long-eared owl; common barn-owl; ruddy shelduck; Eurasian eagle-owl; scarlet macaw; common pheasant; Indian peafowl; common kestrel; and gray parrot). The results indicate that MPs were detected in 50% of the specimens ($n = 20$), with an average of one MP/item per individual. With an average of three MPs per individual, the short-toed snake-eagle was found to be the species with the highest MP accumulation. Fibers (range: 51–534 μm) were the most common type of plastic found in the gastrointestinal tract of birds, with ethylene vinyl acetate and navy blue being the most common polymer type and color, respectively. It was also found that the abundance of MPs increased with the weight of specimens, contributing to the hypothesis that there is a correlation between the size/weight of animals and increased levels of MP accumulation. These findings highlight the impact of plastic pollution on birdlife and the need for further monitoring to assess the ecological impact of pollution.

Graphical abstract



Keywords: avian, biosampling, microplastics, plastic pollution, birds

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Introduction

The versatile properties and affordable production of plastic-based materials have led to a rapid daily increase in their usage, with the marketed quantity surpassing 400 million tons in 2022 (Plastics Europe, 2023). Plastics do not biodegrade under natural conditions and within a reasonable period (Altunışık, 2023a, 2023b; Barceló et al., 2023; Deoniziak et al., 2022). Rather, they break down and degrade into microscopic plastic particles (0.1 μm–5 mm in a single dimension) known as microplastics (MPs; Hafeez et al., 2023; Ostle et al., 2019; Rochman et al., 2019; Whitacre, 2014). Microplastics can absorb potentially toxic substances when introduced into the environment or cause multiple and potentially diverse physical and synergistic toxic effects on wildlife when ingested (Leviner & Perrine, 2023; Prata et al., 2021; Prokić et al., 2019; Xu et al., 2020). Microplastics can especially hinder the movement of animals (Kim & An, 2019) and cause blockage of the gastrointestinal tract when swallowed, which can lead to decreased food consumption and direct death in animals (Fossi et al., 2018; Pierce et al., 2004; Ryan et al., 2016; Unger et al., 2017; von Moos et al., 2012).

Microplastics that accumulate in the tissues of animals can be transferred through food chains, ultimately posing a risk to human health (Dong et al., 2023; Al Mamun et al., 2023; Altunışık et al., 2024a, 2024b). High amounts of plastic are common, such as in landfills, making these species more vulnerable to plastic ingestion (Wang et al., 2021a). This potential lies in birds occupying a variety of ecological niches in different terrestrial environments (Deoniziak et al., 2022). Birds are crucial components of the global food web and are commonly used as indicators of biodiversity, pollution, and environmental changes (Gottschalk et al., 2010; Gregory, 2006; Lodenius & Solonen, 2013). Studies to date indicate that MPs are ingested by a handful of wild land birds, from small songbirds to large birds of prey and scavengers (Wang et al., 2021b). There is still a significant knowledge gap about the extent and source of MP contamination among wild terrestrial bird populations (Deoniziak et al., 2022). In particular, birds require further study due to their potentially long lifespans, long-distance movements, and high prevalence of predation in many ecosystems (Carlin et al., 2020; Wang et al., 2021b). Large-scale predators may be useful markers for monitoring environmental contamination at the landscape scale and determining MP bioconcentration and biomagnification (Carlin et al., 2020).

Türkiye is one of the largest plastic producers in Europe, with a total production of 10.9 million tons, and the packaging sector has the largest share of total production, with approximately seven million tons (Turkish Plastic Industry Foundation [PAGEV], 2023). In addition, soil-based plastic pollutants such as agricultural films, disposable irrigation pipes, and plastic packaging materials for pesticides and fertilizers cause plastic pollution, and approximately 90% of municipal waste (of which 10%–15% is plastic) is left in landfills (Çevik et al., 2021). To support its national zero-waste policy, Türkiye has recently barred the importation of the majority of plastic garbage (Gündoğdu & Walker, 2021). It will be possible to manage its plastic trash as a nation if this choice is backed by a determined effort to put refuse, reduce, reuse, repair, and recycle (5R) policies into practice (Çevik et al., 2021).

In Türkiye, which produces such plastic waste, no study has been conducted on the MP content in naturally living terrestrial birds. Of the 491 bird species in Türkiye, 28 are endangered on a global scale (Yavuz et al., 2021). Conservation studies of these species generally include features such as preventing habitat loss, restoring habitats, and stopping hunting. Nevertheless, the potential risks associated with MPs have not been fully evaluated, and the requisite research on this topic has yet to be conducted. In this context, the main purposes of this pioneering study are to (1) investigate the accumulation of MPs in 12 bird species brought to a wild animal rescue and rehabilitation center for treatment; (2) identify the characteristics (type, shape, size, and color of polymers) of MPs detected in the digestive systems of the studied birds; (3) compare the prevalence of MPs in the birds from Türkiye to previous research that has been done in other regions.

Materials and methods

Collection of samples and MP extraction

A total of 20 specimens of 12 bird species (Eurasian buzzard: *Buteo buteo*; short-toed snake-eagle: *Circaetus gallicus*; white stork: *Ciconia ciconia*; northern long-eared owl: *Asio otus*; common barn-owl: *Tyto alba*; ruddy shelduck: *Tadorna ferruginea*; Eurasian eagle-owl: *Bubo bubo*; scarlet macaw: *Ara macao*; common pheasant: *Phasianus colchicus*; Indian peafowl: *Pavo cristatus*; common kestrel: *Falco tinnunculus*; gray parrot: *Psittacus erithacus*) were used for this study (Figure 1). The animals were injured or exhausted in nature and were brought to the Gölpınar Wild Animal Rescue and Rehabilitation Center in Şanlıurfa Province, Türkiye, for treatment (July 2023–October 2023); however, the animals died during the initial stage of treatment. The locations of the birds brought to this center are given in Table 1. This study was carried out with the permission of the Republic of Türkiye, Ministry of Agriculture and Forestry, General Directorate of Nature Protection and National Parks (date: January 17, 2024, number: 300990). To minimize the risk of contamination, we only selected birds that died within 24 hrs of admission to the Gölpınar Wild Animal Rescue and Rehabilitation Center (provided they had not received any food during this time). The birds were then wrapped in aluminum foil and stored at −20°C for further analysis.

The gastrointestinal tract (GIT) of the specimens was subsequently extracted using a stainless-steel dissection tool, after which the weight of the GIT was measured (Wayman et al., 2024). The GITs were then transferred to separate flasks, and 150 ml of H_2O_2 (30%) was added (Tatlı et al., 2022). The flasks were covered with aluminum foil and left for three days at 65 °C with shaking at 80 rpm. Two flasks from each batch received H_2O_2 (30%) without the addition of the GIT (referred to as "blank" samples), and the digestion process was carried out at the designated temperature and time to ensure contamination control during the procedure (Taurozzi et al., 2024). After the flasks were allowed to cool to room temperature, the contents were filtered using a vacuum pump and a Whatman GF/C filter. After the filtration process, the filters were placed on glass Petri plates and kept at room temperature (Tatlı et al., 2022).

Contamination control of MPs

A robust set of precautions was implemented to ensure the utmost precision and to mitigate the risk of MP contamination during the experimental phase. Of paramount importance among these precautions was the scrupulous upkeep of laboratory hygiene. Throughout the experiments, researchers have consistently worn cotton laboratory coats and gloves devoid of any polymer materials. Furthermore, all the liquid substances, including dH_2O, H_2O_2, and ethanol, underwent meticulous filtration using Whatman GF/C filter paper, which has a pore size of 1.2 μm and a diameter of 47 mm. Moreover, laboratory equipment such as beakers, glass jars, aspirator bottles, flasks, and Petri plates, which are crucial for the sampling process, were carefully

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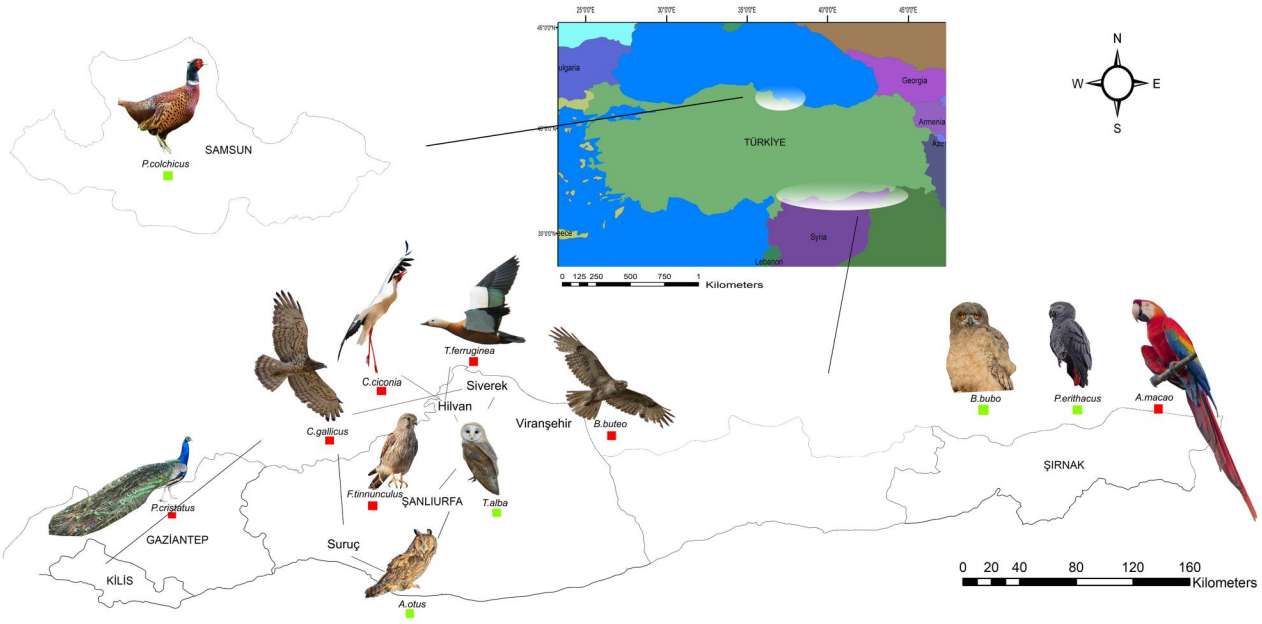


Figure 1. Sampling locations of 12 wild bird species in this study.

Table 1. Data on various birds sampled from different locations in Türkiye.

Sample no.	Species	Location	Prey type (food)	Average size (cm)/Mean weight (g)[a]	Lifespan (Year)[a]	MP presence	MP per g^{-1}	Mean MP size (μm)	MP (*n*)
1	Common barn-owl (*Tyto alba*)	Hilvan	Carnivorous, rodents and other small mammals make up 90% of its prey. Other prey species include birds, lizards, amphibians, fish, spiders, and insects.	33–39/260	4–35	–	–	–	–
2	Common barn-owl	Siverek				–	–	–	–
3	Common barn-owl	Siverek				–	–	–	–
4	Common barn-owl	Şanlıurfa				–	–	–	–
5	Common barn-owl	Şanlıurfa				–	–	–	–
6	Common kestrel (*Falco tinnunculus*)	Şanlıurfa	Carnivorous, wild-fed, fed with small mammals (especially small rodents), birds, large insects, frogs, etc.	34–38/155–190	15	+	1.10	102	1
7	Common kestrel	Şanlıurfa				+	0.14	534	1
8	Common pheasant (*Phasianus colchicus*)	Samsun	Omnivorous, fed with commercial feeds at the breeding station	60–89/500–3,000	3	–	–	–	–
9	Eurasian buzzard (*Buteo buteo*)	Viranşehir	Carnivorous, feeding in the wild with small mammals and birds, large insects	50–60/700–1,200	25	+	0.28	139	1
10	Eurasian eagle-owl (*Bubo bubo*)	Şırnak	Carnivorous, fed with rodents, lagomorphs, hedgehogs, and small birds	75/1,750–4,600	20	–	–	–	–
11	Gray parrot (*Psittacus erithacus*)	Şırnak	Omnivorous, fed with commercial and domestic feed such as cereals, nuts, etc.	33/400	23	–	–	–	–
12	Indian peafowl (*Pavo cristatus*)	Gaziantep	Omnivorous, feeds on grains and seeds	100–115/155–190	15	+	0.14	311	2
13	Northern long-eared owl (*Asio otus*)	Şanlıurfa	Carnivorous, fed with many species of mice, small mammals, small rodents, small birds	31–40/280–320	11	–	–	–	–
14	Northern long-eared owl	Suruç				–	–	–	–
15	Ruddy shelduck (*Tadorna ferruginea*)	Hilvan	Omnivorous, feed on cereals and aquatic plants, as well as invertebrates	58–70/725	2–12	+	0.40	115	2
16	Scarlet macaw (*Ara macao*)	Şırnak	Omnivorous, fed with domestic feed such as cereals, nuts, etc.	81/1,000	40–50	+	0.60	97	2
17	Short-toed snake-eagle (*Circaetus gallicus*)	Kilis	Carnivorous, feeds on small mammals, lizards, snakes, and frogs	59–70/1,700	17	+	1.00	173	4
18	Short-toed snake-eagle	Siverek				+	0.52	118	4
19	Short-toed snake-eagle	Suruç				+	0.21	277	1
20	White stork (*Ciconia ciconia*)	Hilvan	Carnivorous, feeds on small mammals, insects, amphibians, snakes, lizards, small birds, etc.	100–115/2,300–4,500	25	+	0.14	121	2

[a] References (Adamian & Klem, 1999; Arking, 2006; Bakaloudis & Vlachos, 2011; Bannikov & Tarasov, 1957; BirdLife International, 2021; Bogdanova & Zehtindjiev, 2000; Hancock & Kushan, 1992; Ingles, 1995; Isakov, 1952; Kirwan et al., 2010; Lavariega et al., 2015; Mead & Ogilvie, 2007; Mikula et al., 2013).
Note. MP = microplastic; *n* = number.

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cleaned with filtered water and safeguarded with aluminum foil before utilization (Tatlı et al., 2022).

Microscopic examination

A thorough examination of the filter papers was carried out to determine their classification as MP using a Leica S6D microscope. This determination was made based on the physical properties as described in a previous study by Hidalgo-Ruz et al. 2012. After a meticulous visual assessment, particles suspected to be MP were delicately transferred onto fresh filter papers using a needle. These particles were subsequently documented via photography using a digital camera (Leica S6D, Switzerland) affixed to the microscope, and their morphologies were utilized to categorize them into fibers, fragments, or other types. The application ImageJ (http://imagej.nih.gov/ij/) was used to compute the length of the particles. To monitor for possible air contamination during microscopy, a separate clean Petri plate filled with appropriately filtered water was kept near the microscope throughout the observation period. After comprehensive analysis of all the filter papers, the Petri dish, which was maintained as a blank control for detecting MP contamination, was subjected to microscopic examination. In the event of MP detection in the blank samples, background verification was conducted by subtracting the number of MPs observed in the blank from the respective set. The recovery efficiency (%) of MP extraction was recorded using three different polymers and the spiking approach using polyethylene (PE), polyethylene terephthalate (PET), and polypropylene (PP) particles. The MPs were introduced into blank glass flasks (containing 150 ml H_2O_2), after which the blank process was performed. After filtration, the recoveries (%) for PE, PET, and PP were 92.6%, 93.3%, and 95.4%, respectively.

Polymer verification

A PerkinElmer Spectrum 100 Fourier transform infrared (FTIR) spectrophotometer equipped with an attenuated total reflectance (ATR) instrument was used for sample characterization. The FTIR data collection involved 32 scans for each reading, spanning the range of 4,000–650 cm^{-1}, with a resolution set at 2.0 cm^{-1} (Figure 2). Subsequently, the acquired spectra were compared against FTIR spectra from reference polymer materials and subjected to library searches using Spectrum Search Plus Software. Only particles showing a match of more than 70% were deemed to be MPs, provided the data were aligned with available spectral information in the library (Tatlı et al., 2022).

Data analysis

The MP data are presented as the number of MPs per individual across all specimens/locations. Parametric tests (e.g., *t* tests) were also conducted to compare the prevalence of MPs between locations. Pearson correlation was used to determine the association between size/weight and the prevalence of MPs in the GIT of the birds. The analyses were conducted using R Programming Language v4.3.1 (R Core Team, 2023), and the data were visualized using the ggplot2 package (Wickham, 2016).

Results and discussion

Our study highlights the presence of MP accumulation in the gastrointestinal tracts of 12 bird species (20 specimens) that were injured or exhausted in the wild and brought to the Wild Animal Rescue and Rehabilitation Centre in Şanlıurfa, Türkiye, suggesting that MPs may be impacting avian health. However, further research is needed to determine whether these findings are representative of healthier bird populations in the field.

General characterization of MPs

The ATR-FTIR device analyzed the 28 particles suspected to be MPs, and 20 of them (71%) were identified as synthetic polymers (Figure 2). Overall, MPs were detected in the GIT of 50% of the birds ($n = 10$ of 20) and were not detected in the three combined laboratory/procedural blank samples. Based on their physical characteristics, the MPs were divided into two groups: fragments and fibers (Figure 3). Of the total 20 microplastics, 19 were fibers and only one was a fragment. Similarly, a study on birds in the United States reported that 86% of the MPs found were of the fiber type (Carlin et al., 2020). Wayman et al. (2024) also reported that 72 of the 73 MPs detected in the digestive and respiratory systems of four bird species from Spain were of the fiber type. Moreover, the majority of studies (17 out of 26) on MP pollution in birds living in terrestrial and freshwater environments revealed that fiber-type MPs are dominant (Mansfield et al., 2024). Likewise, the most prevalent form of MPs detected in seabirds was fiber, accounting for 79% of the total, whereas fragments accounted for only 21% (Taurozzi & Scalici, 2024). This can be attributed to the differences in the diets of seabirds and birds in terrestrial and freshwater environments, as well as the variability of pollutants in the environment. Seabirds, for example, primarily consume marine organisms that may bioaccumulate higher levels of certain pollutants, such as mercury and persistent organic pollutants, compared to the diets of terrestrial and freshwater birds (Monteiro & Furness 1997). These latter groups may be exposed to pollutants through different sources, such as agricultural runoff or industrial emissions, which vary in both type and concentration (Holland et al., 2016). Therefore, the diet of each bird group not only reflects their ecological niche but also influences their exposure to specific pollutants present in their respective environments.

Birds can also ingest fiber-shaped MPs through the food chain (e.g., ingestion of flying insects; Hoang & Mitten, 2022). The fact that fiber-type MPs are more abundant than fragments is not limited to birds; rather, they have also been recorded in many other vertebrate species, such as fishes (Güven et al., 2017; Kılıç et al., 2022), amphibians (Burger et al., 2024; Tatlı et al., 2022), and reptiles (Mackenzie & Vladimirova, 2023). The abundance of fiber-shaped MPs in these organisms is thought to be related to their release into the environment due to the production and washing of textiles and the wearing of synthetic clothing (De Falco et al., 2018).

Four different polymer compositions were found in the identified MPs (Figure 4), with a prevalence of 50% ethylene vinyl acetate (EVA), 20% polyamide (PA), 15% PE, and 15% halogen-free and flame retardant (HFFR). In a Japanese study, MPs were found as three different polymer types: EVA, PP, and PE (Tokunaga et al., 2023). However, Wayman et al. (2024) and Carlin et al. (2020) reported more than seven and ten polymers, respectively. The variability in polymer diversity may be due to differences in the birds' feeding habits and species and the pollution level in the region where the birds live. In addition, the sample size is another factor that can influence the results.

The dimensions of MPs are important because they affect how long they stay in organisms (Yu et al., 2021), especially because of the ability of smaller MPs to accumulate at lower trophic levels (Wang et al., 2021a). The lengths of the MPs in the GITs of the studied birds varied from 51 to 490 μm, with an average length of 175 ± 130 μm (Table 1). Compared to those in

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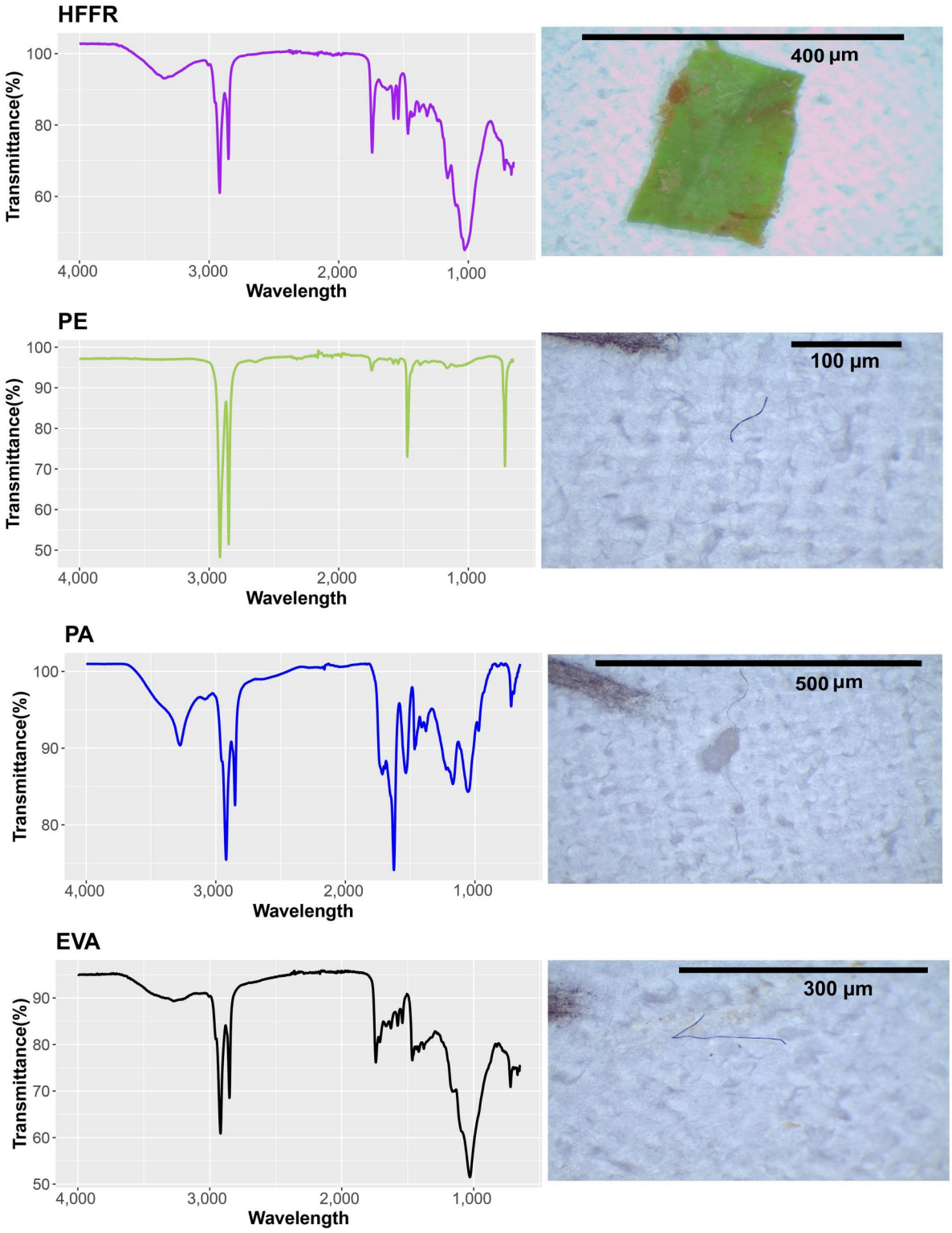


Figure 2. Fourier transform infrared spectrums and stereomicroscope photographs of microplastics detected in the sampled birds. HFFR = halogen-free and flame retardant; PE = polyethylene; PA = polyamide; EVA = ethylene vinyl acetate.

studies in Japan (43.6 µm; Tokunaga et al., 2023) and Spain (58.4 µm; Wayman et al., 2024), the mean size of the MPs in this study was greater. Remarkably, the vast majority (90%) of the MPs measured were less than 300 µm in length, and within this subset, the most common size range was between 100 and 200 µm (median 152 µm), accounting for 50% of the total MPs analyzed. Animals can take up MPs in several ways, including directly through primary consumption, indirectly through prey consumption (such as trophic transfer from tadpoles to fish and from them to birds or mice), or, in the case of aquatic species, through gills (de Souza Machado et al., 2018; Da Costa Araújo et al., 2020). A study of free-living Eurasian dippers in Wales has shown how plastics are passed through the food chain to river birds. Plastics are also known to pass from adult birds to their

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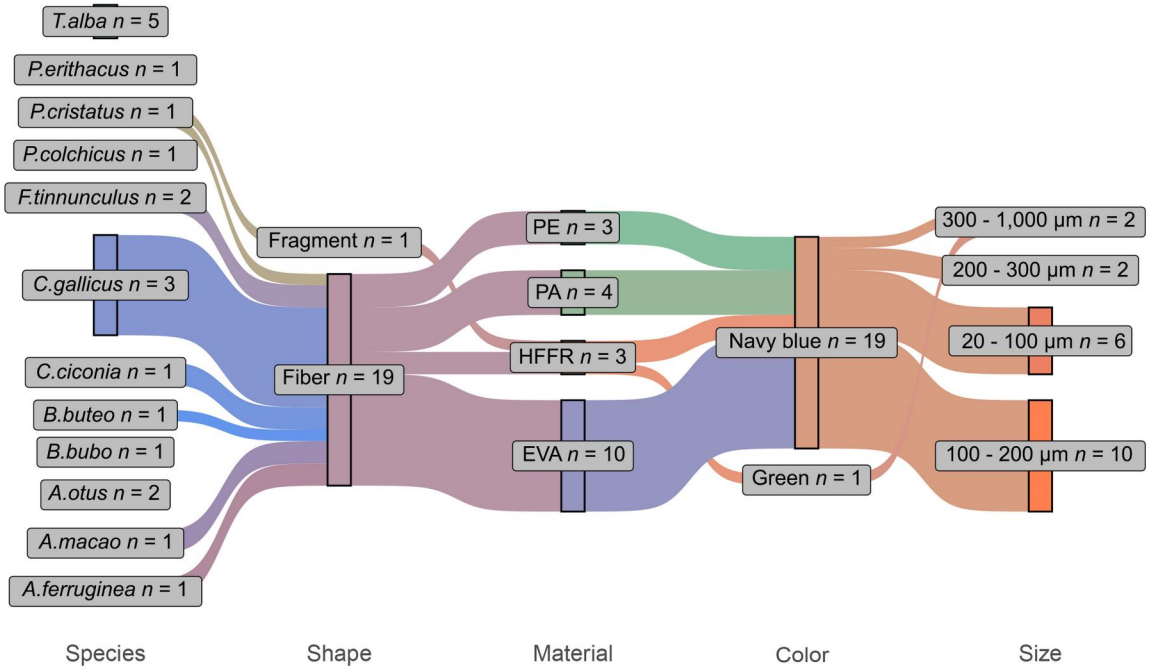


Figure 3. A Sankey diagram illustrating the intricate relationships among the locations, shapes, materials, colors, and size. Nodes in flow were shaped by microplastic patterns. HFFR = halogen-free and flame retardant; PE = polyethylene; PA = polyamide; EVA = ethylene vinyl acetate.

altricial offspring during provisioning (D'Souza et al., 2020). The abundance of small MPs in the GIT samples we analyzed suggest that these particles may have entered the food chain from lower trophic levels.

The predominant hue of the MPs discovered in the birds' GIT was blue (95%) > green (5%; Figure 4). Similarly, marine birds in the South China Sea (Zhu et al., 2019) and birds of prey in central Florida in the United States (Carlin et al., 2020) have been reported to ingest more blue MPs than other colors. The blue color that was frequently found in this study is thought to have originated in people's clothing, because color is perceived to be a useful indicator for identifying potential sources of MP products (Hammer et al., 2016).

MP distribution in species

Microplastics were found in seven out of the 12 bird species (58.3%; Table 1). Among these species, 10 out of the 20 (50%) gastrointestinal tract samples were found to contain MPs. Tokunaga et al. (2023) detected MPs in the lungs of 13.6% (3 out of 22 specimens) of birds. On the other hand, Wayman et al. (2024) analyzed both the gastrointestinal tract and respiratory system of birds and found the presence of MPs in all GIT samples and 65% of respiratory tract samples. The short-toed snake eagle (*C. gallicus*) was the species with the highest prevalence, with MPs detected in all three individuals analyzed and an average of three MPs per individual in its GIT. This species was followed by ruddy shelduck, Indian peafowl, white stork, and scarlet macaw, with two MPs per individual. On the other hand, the northern long-eared owl, Eurasian eagle owl, gray parrot, and common pheasant were the species with no MPs in their GITs (Table 1). The species did not differ from each other in terms of the MP concentration per individual ($t = -0.321$, $df = 11$, $p = 0.754$).

Because they are at the top of food chains, predatory birds are essential for determining the dynamics of ecosystems, trophic relationships, and habitat management (Wayman et al., 2024). As shown in Table 1, MPs were found in the entire GIT of the specimens of several species (e.g., short-toed snake-eagle and common kestrel), whereas no MPs were detected in some species (e.g., common pheasant and common barn owl). The species examined in this study exhibited a range of dietary preferences, including carnivorous and omnivorous habits (Table 1). The presence or absence of MPs in the stomachs of both carnivorous and omnivorous individuals did not allow us to draw inferences based on the type of diet. This situation may be related to the feeding habits of the species (Cauli et al., 2022; Gil & Pleguezuelos, 2001) or to the plastic pollution of the region where the birds live. Previous studies have shown that direct plastic intake and indirect consumption through trophic transfer have combined effects (Carlin et al., 2020; Wayman et al., 2024).

A diagram (Figure 3) depicts the relationships between different locations and shows that nodes are used to symbolize categorical factors. The number of MPs per individual was 1.00 (Table 1). In total, 20 MPs were detected, and they were from four different types of plastic: EVA, PA, PE, and HFFR. Three (EVA, PA, and HFFR) of these polymers were found together in *C. gallicus*. An examination of the distribution of MPs revealed that at least one blue-colored fiber-type MP was present in all the species in which the MPs were present (Figure 4). The only fragment-type MP with a green color was found in *P. cristatus* (Figure 4). The largest and smallest particles in the gastrointestinal tract were PA fibers 534 µm in length in the common kestrel and EVA fibers 51 µm in length in the short-toed snake-eagle. Among the birds with MPs found in their GITs, more than 85% were identified as EVA, and this polymer type was detected in six out of the seven species (Figure 4). It is estimated that EVA polymers accounted for approximately 2% (200 thousand tons) of total plastic production of Türkiye (PAGEV, 2023). Ethylene vinyl acetate, referred to as foamed rubber, is extensively used in sports equipment padding. Its applications include bicycle saddles, ski boots, boxing gloves and helmets, hockey pads, waterski and wakeboard boots, reel handles, and fishing rods. This polymer, which is found in

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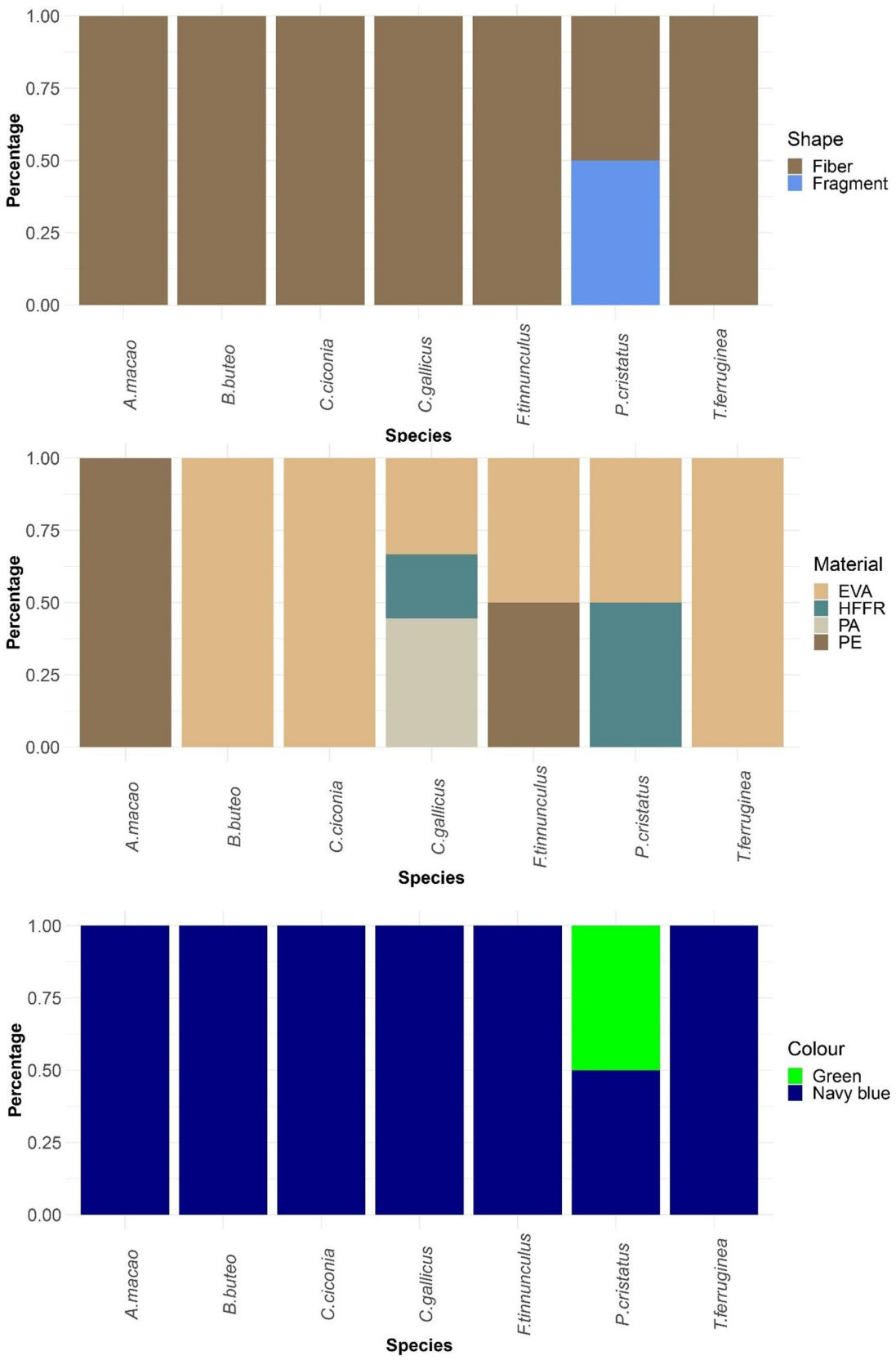


Figure 4. Characterization (shape, material, and color) of microplastics according to bird species. HFFR = halogen-free and flame retardant; PE = polyethylene; PA = polyamide; EVA = ethylene vinyl acetate.

both terrestrial and aquatic environments, is thought to be ingested directly by birds or indirectly through the food web (e.g., snake prey; Teampanpong and Duengkae, 2024).

Polyethylene is the most widely used plastic in the world, and it is used in products ranging from transparent food packaging and shopping bags to detergent bottles and automobile fuel tanks

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(Perera et al., 2020). In addition, PE is the most produced type of plastic in Türkiye with 40% (PAGEV, 2023). Considering that 10.9 million tons of plastic products will be produced in 2023, PE likely remains prevalent in the habitats of the studied birds. Polyamide, commonly referred to as nylon, has widespread applications, with its most common use being in the textile and apparel industry. Nylon is extensively used to make clothing items such as hosiery, lingerie, activewear, and outdoor gear. Beyond clothing, nylon is also crucial in the automotive and industrial sectors. Halogen free and flame retardant plastics are used primarily in applications where fire safety and reduced toxic gas emissions are critical. The most common use of HFFR plastics is in the cable and wire industry (Sabet, 2024). The widespread use of PA in industry and the use of HFFR, particularly in cable and wire construction, overlap with bird habitats. Various bird species benefit from landfills and adjacent land-use areas, providing essential opportunities for foraging and rest. The prevalence of HFFR in these areas (Tongue et al., 2019), the association of birds with wires and cables, and scientific evidence of collisions with power lines (Bernardino et al., 2018) suggest that birds may have ingested these plastics through these cables.

We found a positive and significant correlation between the weight of the specimens and the number of MPs in their GITs (Pearson correlation coefficient; $r = 0.54$, $p < 0.05$). However, the correlation between the size of the MPs and the weight of the birds was weak and statistically insignificant (Pearson correlation weight: $r = 0.236$, $p = 0.317$). In addition, no significant relationship was detected between human population density and the quantity of MPs found in the GITs of the birds (Pearson correlation weight: $r = -0.229$, $p = 0.941$). Although some studies have reported a correlation between population density and MP abundance (Ta & Babel, 2023; Zhou et al., 2021), this study on birds does not support this hypothesis. Due to their mobility and variability in feeding and climatic conditions, birds are not consistently exposed to the same level of pollution as terrestrial organisms (Mansfield et al., 2024; Prokić et al., 2021). However, our findings align with the hypothesis that animals of greater size/weight tend to accumulate more MPs (Berglund et al., 2019; Kankılıç et al., 2023).

Conclusion

Plastic pollution is a critical environmental issue, posing a serious threat to wildlife, including avian species. This study provides the first data on the accumulation of MPs (type, shape, size, and color) in 12 bird species in Türkiye. The results indicate that MPs were detected in 50% of the sampled individuals, with an average of one MP per individual. The short-toed snake-eagle exhibited the highest level of MP accumulation, with an average of three MPs per specimen. The most common types of MPs detected were fibers (51–534 μm in length), with EVA as the dominant polymer. Notably, a significant positive correlation was observed between the weight of the birds and the abundance of MPs, supporting the hypothesis that larger species may accumulate more MPs. The significance of this research lies in its demonstration of the pervasive impact of MP pollution on terrestrial bird species and its implications for ecosystem health. Our results underscore the need for increased biomonitoring and targeted conservation strategies. Policy makers should consider implementing and enforcing stricter regulations to curb plastic pollution, emphasizing the 5R approach and promoting public awareness campaigns about the hazards of plastic waste. Future research should expand on this foundational work by investigating the effects of MPs on avian health, reproductive success, and behavior, and exploring MP contamination across different ecosystems and broader geographical regions. Additionally, studies should focus on identifying specific sources of MPs to design more effective mitigation strategies. Collaboration between scientists, government agencies, and conservation organizations is crucial to safeguard avian biodiversity and mitigate the ecological threats posed by plastic pollution.

Data availability

All data generated or analyzed during this study are included in this article.

Author contributions

Hatice Hale Tatlı (Conceptualization, Formal analysis, Investigation, Methodology, Software), Arif Parmaksız (Conceptualization, Data curation, Investigation, Project administration, Resources, Supervision, Writing—review & editing), Adil Uztemur (Conceptualization, Data curation, Formal analysis, Investigation, Project administration, Resources, Visualization), and Abdullah Altunışık (Formal analysis, Investigation, Methodology, Supervision, Visualization, Writing—original draft, Writing—review & editing)

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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