Environmental Toxicology and Chemistry, 2026, **00**, 1–11
https://doi.org/10.1093/etojnl/vgag130
Published: May 21, 2026
Original Article | Environmental Chemistry

Microplastic prevalence in commercially available petfoods

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Abstract

Plastic production has risen dramatically since the 1950s. While microplastic (MP) contamination of human food has been investigated, commercially available pet and wildlife foods have not. These could provide a contamination route for terrestrial ecosystems, via the feces of pets and wild animals. We assessed 38 pet and hedgehog food products available in the United Kingdom, covering a range of brands, price brackets, and food types. Six 1 g replicates of dried material were tested per product, giving a total sample size of 228. Microplastics were found in 63 samples (27.6%). Of the 38 products, 76% were positive: 29% had one positive sample, and 47% had 2 or more. Most (84%) of the 19 brands tested were contaminated, with value products having more positive samples than mid-range and premium products. The most common polymers were polyester, polyacrylamide, polyethylene, and polypropylene. The mean concentration of MPs was 0.4 pieces g^{-1} (*SD* = 0.84) for the dry foods tested and 0.3 g^{-1} (*SD* = 0.62) in wet foods. Within samples that were plastic-positive, the concentrations were 1.6 pieces g^{-1} (*SD* = 0.73) and 1.2 pieces g^{-1} (*SD* = 0.53), respectively. Given their lower energy content, and correspondingly larger mass consumed, wet foods present the greatest exposure risk. Based on the mean MP content across all samples, a large dog (35 kg) fed wet foods is likely to ingest 313 MPs day^{-1} (*SD* = 263.6). Microplastic concentrations in pet food were higher than those reported for human foods. While concentrations were lower than in wild invertebrates, pet foods had a greater proportion of positive samples, suggesting they may be an important contamination route for pets, wild mammals, and terrestrial ecosystems. This study, therefore, reveals a previously unrecognized pathway for MPs to enter the food chains of both pets and wild mammals.

Keywords microplastics, food web, risk assessment, ingestion, terrestrial

Introduction

The rapid growth in plastic production, which has risen from 2 million tons in the 1950s to 400.3 million tons in 2022, has led some to describe the current era as the "Plasticene" (Harley-Nyang et al., 2022; Petroody et al., 2021). Microplastics (MPs), which are formed through the fragmentation of larger plastics, have been highlighted as a major concern in aquatic and terrestrial ecosystems (Thompson et al., 2024). Recently, it has been estimated that between 10 and 40 million tons of MPs are introduced annually into terrestrial environments—3 to 10 times higher than in aquatic environments—and this rate could double by 2040 (Thompson et al., 2024). A wide range of terrestrial wild animals, humans, and pets have been shown to ingest MPs (Deoniziak et al., 2022; Enyoh et al., 2023; Prata et al., 2022; Sherlock et al., 2022; Thrift et al., 2025). This is a concern as ingested MPs have been shown in laboratory studies to disrupt physiological processes such as organ function and fertility (Jin et al., 2019; Jersey et al., 2025; Wei et al., 2022). Although research has begun to show the presence of MPs in the bodies of humans, wild terrestrial animals, and pets, there is relatively little research on the dietary sources of these MPs or on their transmission through ecosystems. Recent studies have begun to document MPs contamination in human foodstuffs (Milne et al., 2024), but research on pet food is very limited. To date, only a single study in the United States has investigated MPs in pet food, and this analysis was restricted to just two polymer types (Zhang et al., 2019).

Pet foods are massive global commodities. In 2024 alone, 37.6 million tons were produced, and the market was valued at $128 billion (Alltech, 2025; Pet Products & Supplies, 2025). In the United Kingdom alone, there are 10.6 million dogs and 10.8 million cats (People's Dispensary for Sick Animals, 2024), almost all of which are fed commercially available pet food products. In addition, pet foods, alongside foods marketed specifically for wildlife, are frequently fed to wild mammals visiting gardens. A recent study in the United Kingdom showed that European hedgehog (*Erinaceus europaeus*), European badger (*Meles*

Received: September 26, 2025. **Revised:** April 27, 2026. **Accepted:** April 27, 2026

meles), and red fox (*Vulpes vulpes*) all ate cat, dog, or hedgehog food left out in urban gardens (Scott et al., 2023). Further research has found that around a quarter of urban red fox diet comes from pet food in the United Kingdom (Fletcher et al., 2025), and 90% of European hedgehog stomachs in Finland have been shown to contain food items provided by humans (Rautio et al., 2016). Large amounts of pet foods are also used in wildlife rehabilitation centers. For example, one United Kingdom rescue center treated a total of 13,057 mammals over 10 years, most of which would have been fed cat, dog, or hedgehog food (Mullineaux & Pawson, 2023). Recent research has also shown that 19% of 189 fecal samples from European hedgehogs contained MPs (Thrift et al., 2022). These samples were collected in rescue centers and the gardens of volunteers, where pet foods were commonly offered (Thrift et al., 2022). Therefore, pet foods present a potential pathway for MPs exposure for pets and wild animals, with potential implications for their health, as well as an additional route for MPs to enter the wider environment, via the feces of domestic and wild mammals.

This study, therefore, seeks to assess the presence and concentration of MPs and the diversity of polymers in commercial foods fed to pets and wildlife. We hypothesize that contamination rates are likely to be highest in:

i) Low-cost “value range” pet foods, owing to the potential use of lower-quality ingredients.
ii) Dry food compared with wet foods, owing to the concentration of solid materials during the production process.

Materials and methods

Sample collection

We selected a range of products widely available in the United Kingdom, derived from a variety of brands, target animals, and food types (wet vs. dry). In total, 38 products were investigated and six retail units of each product (cans, trays, bags or boxes), each with different batch numbers, were purchased, yielding a sample size of 228. Sampling from different batches minimized the potential for bias from one-off contamination events. The products were 14 cat foods (84 samples), 16 dog foods (96 samples), and eight hedgehog foods (48 samples; Table 1). Of these, 22 were dry food (132 samples), and 16 were wet food (96 samples). They covered the range of available price brackets (see online supplementary material S1): “Value” products (<£3/kg, <€3.48/kg; 12 products, 72 samples), “Mid-range” products (£3–<£9.5/kg, €3.48–<€11.02/kg; 13 products, 78 samples), and “Premium” products (≥£9.5/kg, ≥€11.02/kg; 11 products, 66 samples). All cat and dog foods were chicken-flavored to allow for comparisons to be drawn. The ingredient lists for each product were collated (see online supplementary material S2).

Digestion

The 228 samples were chemically digested to remove biological material so that only MPs remained. To ensure we used a standard methodology across all the products and retail units, we randomly subsampled from six locations within the package for both wet and dry products. For the wet foods, approximately 2 g was removed from the packaging of each retail unit to be tested, using dissection tweezers, and placed in a Petri dish that was closed and dried at 40°C overnight in an incubator. After drying, 1 g of the sample was weighed out using an analytical balance (Sartorius Secura, Germany) and put into an individual 100 ml Erlenmeyer flask containing 3 ml of 10% (w/v) potassium hydroxide (KOH) solution, as recommended by Carlin et al. (2020). The flasks were covered in foil and placed in a shaking incubator at 65 rpm at 60°C for 48 hr, and were then left to rest for 24 hr at room temperature. For the dry foods, 2 ml of 10% KOH was added to the sample in a pestle and mortar and then gently crushed to facilitate digestion. All other treatments were as for the wet foods, but excluding the drying stage. The samples were then filtered through 1.2 µm glass filter papers (CAMlab, U.K.) using a vacuum pump, placed in a Petri dish, which was then closed, and dried at 40°C overnight in an incubator. The sample mass of 1 g was chosen for each replicate because it could be fully digested within a short time frame (48 hr), which minimized any potential damage to MPs while also allowing consistent comparison across products of varying package sizes.

Plastic analysis

The dried filter papers were examined under a dissecting microscope (Leica, S8APO, Germany; magnification 10 × 1.0 and 10 × 6.3 depending on the size of the MP). Dissection tweezers were used to press potential MPs, and every particle that did not break was analyzed further. The suspected MPs were measured using ImageJ software (Schneider et al., 2012) and were classified as either a fragment or a fiber. This approach aligns with the well-established level 2 coarse morphological classification guidelines (Lusher et al., 2020; Yu et al., 2023). A Perkin Elmer Spotlight 400 Fourier Transform Infrared Spectroscopy Imaging System (USA) in transmission mode was used for polymer identification. This approach assesses the spectra and intensity of infrared light reflected from the fragment’s surface, comparing it with a commercially available library to identify the polymer. All spectra were collected in the 4,000–400 cm^{-1} spectral range at the resolution of 4 cm^{-1}, acquiring a minimum of four scans per item (maximum of 16 scans per item if clearer spectra were required). Visual inspection of the spectrogram was used to check that the fit was adequate. Where the spectra showed substantial noise, Perkin Elmer’s Spectrum 10 software was used to provide baseline correction, which removes background noise and so makes the correct identification of the polymer easier. Normalization of the spectra was also conducted as required, adjusting for differences in sample concentration or path length to increase comparability across samples. Only samples with a similarity report of >70% were approved, although some readings that had a similarity of ≥70% were discarded if they had a poor visual spectral match. The criteria for a poor visual spectral match were met if the sample spectra did not follow any of the key characteristic absorbance peaks and troughs within the 600 to 4,000 cm^{-1} range (see online supplementary material S3). The common usage of each identified polymer was established through targeted online searches of manufacturer datasheets, databases such as PubChem (PubChem, 2025), and an industry

Table 1 Products tested, showing brand, target animal, food type, and price. Six replicates of each product were used (n = 96 wet and n = 132 dry samples).

Brand	Target animal	Food type	Price	Product	Package
Canin	Dog	Wet	Premium	Chicken puppy mousse	Can
		Dry	Mid-range	Mini adult chicken dry food	Bag
Harringtons	Cat	Wet	Mid-range	Meaty fillets in jelly chicken	Sachet
		Dry	Mid-range	Adult chicken	Bag
	Dog	Wet	Mid-range	Adult chicken	Tray
		Dry	Value	Adult chicken	Bag
IAMS	Cat	Wet	Mid-range	7 year + chicken	Sachet
		Dry	Mid-range	1 year + chicken	Bag
	Dog	Dry	Mid-range	Adult small/medium dog chicken	Bag
Lily's Kitchen	Cat	Wet	Premium	Tasty cuts in gravy chicken	Can
		Dry	Premium	Chicken with tasty veggies	Bag
	Dog	Wet	Premium	Organic chicken supper	Tray
		Dry	Premium	Countryside casserole chicken	Bag
Nature's Variety	Dog	Wet	Premium	Medium adult dog chicken	Sachet
		Dry	Premium	Freezer-dried 80% chicken	Bag
Pedigree	Dog	Wet	Mid-range	Adult chicken in jelly	Can
		Dry	Mid-range	Adult poultry and veg	Bag
Sainsbury's	Cat	Wet	Value	Sainsbury's Adult Complete Nutrition Meat Selection in Jelly Cat Food 1+ (chicken)	Sachet
		Dry	Value	Complete nutrition chicken 1 year +	Bag
	Dog	Wet	Value	Complete nutrition chicken adult	Can
Scrumbles	Cat	Wet	Premium	Chicken in jelly	Can
		Dry	Premium	Adult and senior 75% chicken	Bag
Tesco	Cat	Wet	Value	Senior with chicken in jelly	Sachet
		Dry	Value	Adult chicken and vegetable	Bag
	Dog	Wet	Value	Adult with chicken in jelly	Can
		Dry	Value	Adult chicken and vegetable	Bag
Waitrose	Cat	Wet	Value	Essential meaty chunky in jelly with chicken	Can
	Dog	Wet	Value	Essential meaty chunky in jelly with chicken	Can
		Dry	Value	Complete and balanced dog food chicken and vegetable	Bag
Whiskas	Cat	Wet	Mid-range	Chicken in jelly	Can
Bramble	Hedgehog	Dry	Mid-range	Semi-moist hedgehog food	Bag
I love hedgehogs	Hedgehog	Dry	Premium	Semi-moist hedgehog food	Bag
Extra select natural	Hedgehog	Dry	Value	Nature hedgehog pellets	Bag
Igelfutter Quiko food	Hedgehog	Dry	Premium	Hedgehog food	Bag
Gardman	Hedgehog	Dry	Mid-range	Hedgehog bites	Bag
Mr Johnson	Hedgehog	Dry	Mid-range	Hedgehog food	Bag
Spikes	Hedgehog	Dry	Mid-range	Semi-moist hedgehog food	Bag
Wild Things	Hedgehog	Dry	Mid-range	Hedgehog food	Bag
Total brands n = 19				**Total products n = 38**	

report (Plastics Europe, 2022). They were then grouped according to their primary use into four categories: additives, industrial, packaging, or textiles. If a polymer was found to have multiple uses, it was assigned according to its main use. Therefore, the categorization is indicative of the most likely source but does not provide definitive evidence that a particular sample was used in a specific way.

Quality assurance and quality control

The KOH solution and Milli-Q water were vacuum-filtered through a 1.2 µm glass filter paper before use. To test whether the filtered solutions were free from MPs, five 50 ml samples of Milli-Q water and KOH were tested and no MPs were found. For every group of samples tested (n = 20), three control filter papers were wetted with filtered Milli-Q water and left out in the laboratory close to the working areas for the duration of the processing time (approximately 4 hr) to allow for any atmospheric MP contamination to be detected. All beakers and funnels were rinsed with tap water, autoclaved, and then rinsed twice with filtered Milli-Q water before use. All equipment was rinsed with filtered Milli-Q water between samples. Bright purple nitrile gloves and a cotton laboratory coat were always worn in the laboratory to allow for any contamination from these sources to be detected easily. One potential contamination event was detected, where a black fiber was found on a control filter paper and matching fibers (n = 2) were detected in one sample in the same laboratory session. These fibers from this sample were therefore disregarded. Polystyrene Petri dishes (n = 10) were also tested for contamination risk, and no fragments or fibers of polystyrene were found.

Quantification and statistical analysis

Quantitative analyses were carried out using R version 4.4.1 (R Core Team 2024) within R Studio (1.3.1093 R Studio, 2020). We investigated whether the brand, food type, price category, or target animal predicted the presence of plastic (1 = present; 0 = absent). These relationships were assessed using generalized linear models with binomial logit link error structures, built with the base "stats" package in R version 4.4.1 (R Core Team, 2024). Because many brands targeted one specific animal (cat, dog, or hedgehog), it was not possible to consider both brand and animal type within the same models. For hedgehogs, all the available products were dry, were marketed specifically for this animal, and did not follow the same price-categories as companion-animal food, so we used a chi-squared test to investigate whether plastic presence varied between brands rather than more complex analyses.

We then assessed whether the characteristics of the plastic particles (shape and size) were predicted by food type, price category, and target animal using the subset of samples that were plastic-positive, with each particle being considered a separate outcome datapoint. As each sample could potentially contain multiple fragments of different shapes, separate models following the same structure were also built to assess the probability of the presence of particles of different shapes. Fiber presence (1 = present; 0 = absent) and fragment presence (1 = present; 0 = absent) were set as binomial outcomes. We then assessed whether the same variables predicted the size and count of plastics in each sample, without separating by shape type. For particle size, the relationships were assessed using generalized linear models built in the "stats" package with Gaussian error structures; for the particle count data, quasi-Poisson error structures were used to allow for over-dispersion. We examined the compositional mix of plastics found in the specimens using two metrics. Polymer richness was calculated by counting the number of distinct polymer types detected in each sample. Relationships between this index, food type, price category, and target animal were then assessed using generalized linear models built with negative binomial error structures. Simpson's Diversity Index was used as a summary measure of the complexity of the mix of polymer types. This index assesses simultaneously richness (numbers of compounds) and evenness (whether the mixture is dominated by some polymer types or not) by estimating the probability that two randomly selected polymer items will belong to different types. This was calculated using the following equation:

$$D = 1 - \sum_{i=1}^{S} \left(\frac{ni}{N}\right)^2$$

where ^{S} is the total number of polymer types, N is the total number of plastic particles across all polymer types, ^{ni} represents the number of plastic particles from each polymer type, and $\left(\frac{ni}{N}\right)^2$ represents the squared proportional abundance of each polymer type. The relationships between this index, food type, price category, and target animal were then assessed using generalized linear models built with Gaussian error structures. Model selection was carried out by using likelihood ratio tests. Starting with the null model, variables were added one at a time, and then each model was compared to the previous using ANOVA (model structures are provided in the online supplementary material S4). The more complex model was selected when it provided a significantly better fit than the simpler model (p = $<$0.05). Multicollinearity of the predictor variables was assessed during the planning stage in a multivariate model including all variables by generating the Variance Inflation Factor (VIF) values using the "car" package (Fox & Weisberg, 2019). Price category and brand were correlated (VIF $>$2.5), due to most brands having the same price category across the products tested; therefore, these predictors were modeled separately (see online supplementary material S4). The "dHARMA" package (Hawkins et al., 2020) was used to assess models for overdispersion, and residual plots were created to check model fit. For the models with quasi-Poisson error structures, the "performance" package (Lüdecke et al., 2021) was used to assess model overdispersion and fit. For the multivariate models, VIF values were generated to ensure there was no multicollinearity (VIF values $<$2.5 were taken to indicate low or no multicollinearity). Post hoc tests (pairwise comparisons) were run on the best model using the package "emmeans" (Lenth, 2020) to identify which levels of categorical variables differed from each other.

Estimation of daily food intake and MP exposure

Three potential scenarios of food consumption patterns for cat, dog, and hedgehog foods were considered in terms of potential daily MP exposure:

1) Worst-case: estimates based on contaminated samples only.
2) High: estimates based on mean numbers of particles in all samples (positive and negative) from contaminated brands (≥1 plastic-positive sample). Represents likely intakes where there is customer loyalty to contaminated brands.
3) Moderate: estimates based on mean numbers of particles across all tested samples, regardless of contamination status. Represents intakes where customers select foods at random.

In each scenario, calculations were made separately for cats, dogs, and hedgehogs, as well as for wet and dry foods. To estimate the likely daily exposure levels of MPs for dogs, it was necessary to estimate the daily intakes of food. This is because there are no set recommendations for the mass of food to be eaten; intakes depend on the energy value of the foodstuff (European Pet Food Industry Federation [FEDIAF], 2024). We therefore estimated the required energy intakes for moderately active animals for wet and dry foods, using three categories of animal size (Table 2). Classes for dogs were based on Dogs Trust (2025), and classes for cats on People's Dispensary for Sick Animals (2025). The mean amount of food, and hence the

Table 2 Estimated weight (kg), resting energy requirement, and maintenance energy requirement for moderately active animals.

Size class[a]	Weight (kg)			Energy requirement		Mean food intake (gd^{-1})[b]	
	Lower range	Median	Upper range	Resting[c]	Maintenance[c]	Wet food	Dry food
Small dog (<12 kg)	1.5	7	12	301	421.4	482.1	114.5
Medium dog (12–25 kg)	12	18.5	25	624	873.6	999.4	237.4
Large dog (>25 kg)	25	35	45	1,007	1,409.8	1,612.3	377.8
Cat	4	4	4	197	256.1	67.3	301.8

[a]Classes for dogs based on Dogs Trust (2025), and cats on People's Dispensary for Sick Animals (2025).
[b]Energy contents of each product (see online supplementary material S3) were used to compute mean intakes for wet and dry foods for each target animal.
[c]Resting energy requirement × 1.4 (dogs) or 1.3 (cats; Merck Sharp Dohme Veterinary Manual; Anderson, 2024).

amount of MPs ingested in each of the above scenarios, was then computed, based on the energy contents and MPs densities (particles per gram) of the relevant food products (see online supplementary material S5). The same process was repeated for cats, but without any differentiation according to body weight, since cat body weights vary much less than dogs. For hedgehogs, our estimated exposure was based on a set daily intake of 70 g for wet food and 20 g for dry food (see online supplementary material S5 and S6) as recommended by the United Kingdom's Royal Society for the Prevention of Cruelty to Animals [RSPCA], 2022).

Results

Plastic prevalence

A total of 228 samples of 38 different commercially available animal feed products were analyzed and 110 potential plastic particles were identified. Six of these were cellulose and classified as natural fibers, and a further 9 were non-plastic compounds, leaving 95 confirmed MPs (see online supplementary material S7). There were 63 confirmed positive samples, giving a sample-level prevalence of 27.6% (95% CI = 22.3%, 33.8%). Among the plastic-positive samples, the number of pieces of plastic per sample ranged from 1 to 4 (mean = 1.5, *SD* = 0.68). Of the 38 products, 76.3% (95% CI = 61.2%, 87.5%) had at least one plastic-positive sample out of the six replicates tested, 47.4% (95% CI = 31.8%, 63.7%) had two or more plastic-positive samples, and three products had five positive samples, 7.9% (95% CI = 1.6%, 20.8%). Twenty-one products had meat and animal derivatives as an ingredient (S2), in addition to their pure meat content. Of these, 90.4% (95% CI = 71.7%, 97.9%) had at least one plastic-positive sample, 61.9% (95% CI = 41.0%, 79.0%) had two or more plastic-positive samples, and 14.3% (95% CI = 3.0%, 36.3%) had five out of six samples test positive. Of the 19 brands tested, three had MPs present in at least eight samples (15.8%, 95% CI = 5.3%, 38.9%), four had at least five contaminated samples (21.1%, 95% CI = 8.1%, 43.6%), seven had at least four contaminated samples (36.8%, 95% CI = 17.2%, 61.1%), nine had at least three contaminated samples (47.4%, 95% CI = 25.2%, 70.0%), 12 had at least two contaminated samples 63.2%, 95% CI = 41.1%, 82.8%), and 16 had at least one contaminated sample (84.2%, 95% CI = 62.0%, 95.0%). There were significant differences between brands in the likelihood of samples being plastic-positive ($\chi^2 = 38.82$, $p = <0.0001$). However, post hoc tests were not able to identify pairwise differences between brands, probably owing to the large numbers of comparisons relative to sample size, and the use of Tukey's Honestly Significant Difference test, which is a conservative method applied to reduce false-positives. Product price was also associated with the prevalence of plastic-positive samples ($\chi^2 = 17.22$, $p = <0.0001$). Post hoc tests showed that Value products had more plastic-positive samples than the Premium product range ($p = 0.0004$). Hence, a higher proportion of brands in the lower cost brackets (Value and Mid-range) were contaminated compared with Premium products (Figure 1c).

Polymer type

In the plastic-positive samples, the most abundant polymers by number of pieces were polyester ($n = 27$, 28.1% [95% CI = 20.2%, 37.4%]), polyacrylamide ($n = 12$, 15.9% [95% CI = 8.5%, 23.3%]), polypropylene ($n = 10$, 10.6% [4.4%, 16.8%]), and polyethylene ($n = 8$, 8.5% [95% CI = 2.8%, 14.1%]; see online supplementary material S8). Polyester was present in 36.8% ($n = 14$, [95% CI = 23.2%, 52.7%]) of the 38 products tested, and in 29% ($n = 18$ [95% CI = 18.9%, 41.8%]) of the 62 plastic-positive samples (see online supplementary material S8). Food type, target animal, and price category were not significant predictors of polymer richness ($\chi^2 = 0.09$, $df = 1$, $p = 0.76$; $\chi^2 = 1.09$, $df = 2$, $p = 0.57$; and $\chi^2 = 1.14$, $df = 2$, $p = 0.56$, respectively). Polymer diversity (Simpson's Diversity Index) varied between target animals ($F = 17.22$, $df = 3$, $p = <0.0001$), but it was not predicted by food type ($F = 0.0014$, $df = 1$, $p = 0.97$) or price category ($F = 0.013$, $df = 2$, $p = 0.98$). Post hoc tests could not identify pairwise differences between the target animals, potentially owing to the conservative nature of the Honestly Significant Difference tests. The polymers identified were most commonly associated with industrial uses ($n = 31$), followed closely by textiles ($n = 36$), packaging ($n = 25$), and additives ($n = 3$; see online supplementary material S9).

Shape

In the plastic-positive samples, 57 confirmed plastic fibers (60% of the total particles, 95% CI = 49.7%, 69.7%) and 38 fragments (40% of the total particles, 95% CI = 30.2%, 50.6%) were isolated (see online supplementary material S10). Target animal, food type, and price category were not significant predictors of shape, with there being no difference between animals in the presence of either fragments (target animal $\chi^2 = 4.76$, $p = 0.09$; food type $\chi^2 = 0.22$, $p = 0.6$; price category $\chi^2 = 2.73$, $p = 0.25$, respectively) or fibers (target animal $\chi^2 = 5.63$, $p = 0.059$; food type $\chi^2 = 0.002$, $p = 0.95$; price category $\chi^2 = 4.27$, $p = 0.11$, respectively; Figure 2a–c).

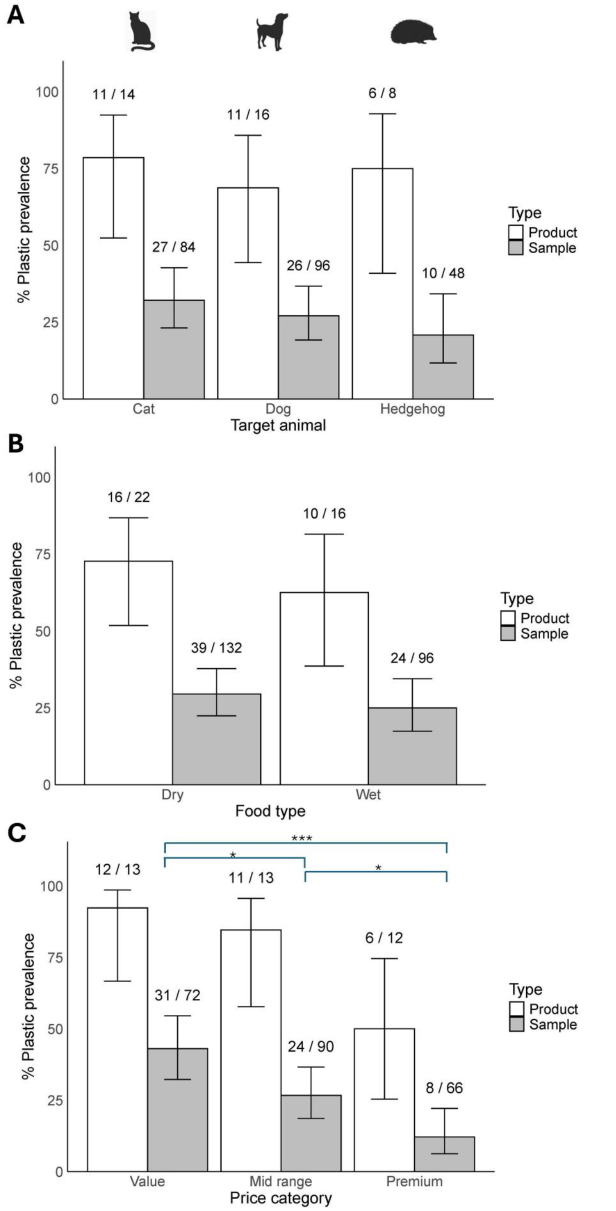

Figure 1 Plastic prevalence (%) in samples and products by (A) target animal, (B) food type, and (C) price category. Bars show Wilson's confidence intervals. Post hoc test significance levels ***$p < 0.001$ and *$p < 0.05$.

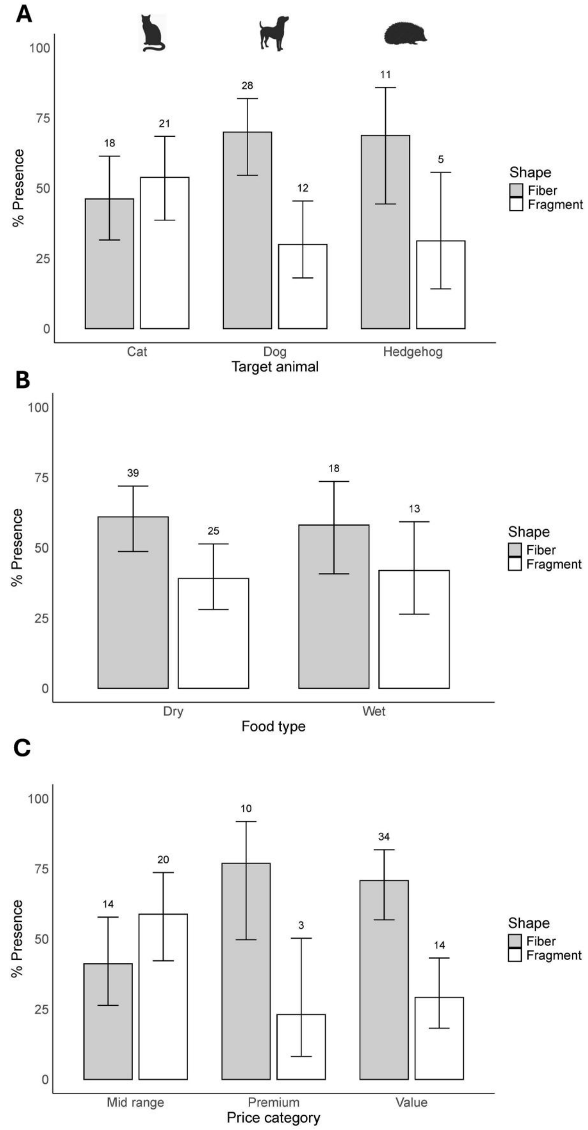

Figure 2 Percentage of each shape in the plastic-positive samples by (A) target group, (B) food type, and (C) price category. Bars show Wilson's confidence intervals.

Size

In the plastic-positive samples, the size of the MPs ranged from 0.09 mm to 3.8 mm (mean = 0.47, *SD* = 0.61; see online supplementary material S11). Target animal, food type, and price category were not significant predictors of MP size (univariate analysis animal: $F = 0.80$, $df = 2$, $p = 0.45$; food: $F = 0.11$, $df = 1$, $p = 0.74$; price $F = 1.13$, $df = 2$, $p = 0.32$, respectively).

Number of plastics

For the plastic-positive samples, the mean number of MPs was 1.6 g^{-1} (*SD* = 0.73; range 1–4) for dry products and 1.2 g^{-1} (*SD* = 0.53; range 1–3) for wet foods (see online supplementary material S12). The mean number across all samples (positive and negative) for dry food was 0.4 g^{-1} (*SD* = 0.84; range 0–4) and 0.3 g^{-1} (*SD* = 0.62; range 0–3) for wet foods. Dry foods had more MPs per gram than wet foods ($F = 4.12$, $df = 1$, $p = 0.046$). Target animal ($F = 0.02$, $df = 2$, $p = 0.97$) and price category ($F = 0.81$, $df = 2$, $p = 0.44$) were not significantly associated with the number of MPs per gram (Figure 3). We also assessed the number of particles per unit of energy for dog and cat foods, since the recommended daily allowances for dogs and cats are based on energy rather than mass. For these calculations, the number of MPg^{-1} in each product was divided by the energy density and expressed as the mean number of particles kJ^{-1} or per $kcal^{-1}$. For the plastic-positive samples, dog wet foods had 0.37 particles kJ^{-1} (1.57 particles $kcal^{-1}$), and dog dry foods had 0.11 kJ^{-1} particles (0.49 particles $kcal^{-1}$). Similarly, cat wet foods had 0.36 particles kJ^{-1} (1.52 particles $kcal^{-1}$), and cat dry foods had 0.11 particles kJ^{-1} (0.48 particles $kcal^{-1}$). When including all the samples, whether positive or negative for MPs, the dog wet foods had 0.05 particles kJ^{-1} (0.22 particles $kcal^{-1}$) and dog dry foods had 0.03

particles kJ^{-1} (0.15 particles $kcal^{-1}$), whereas cat wet foods had 0.13 particles kJ^{-1} (0.56 particles $kcal^{-1}$) and dry foods had 0.03 particles kJ^{-1} (0.13 particles $kcal^{-1}$).

Daily MP intake in cats and dogs

The estimated daily MP intakes of dogs, cats, and hedgehogs under the three scenarios (moderate, high, and worst-case) and according to food type are shown in Table 3. Exposure is likely to be greater from wet foods due to the daily portion size needing to be larger because of its lower energy density compared with dry foods.

Discussion

Our findings indicate that MPs are present across a wide range of pet food brands and food types targeting different animals.

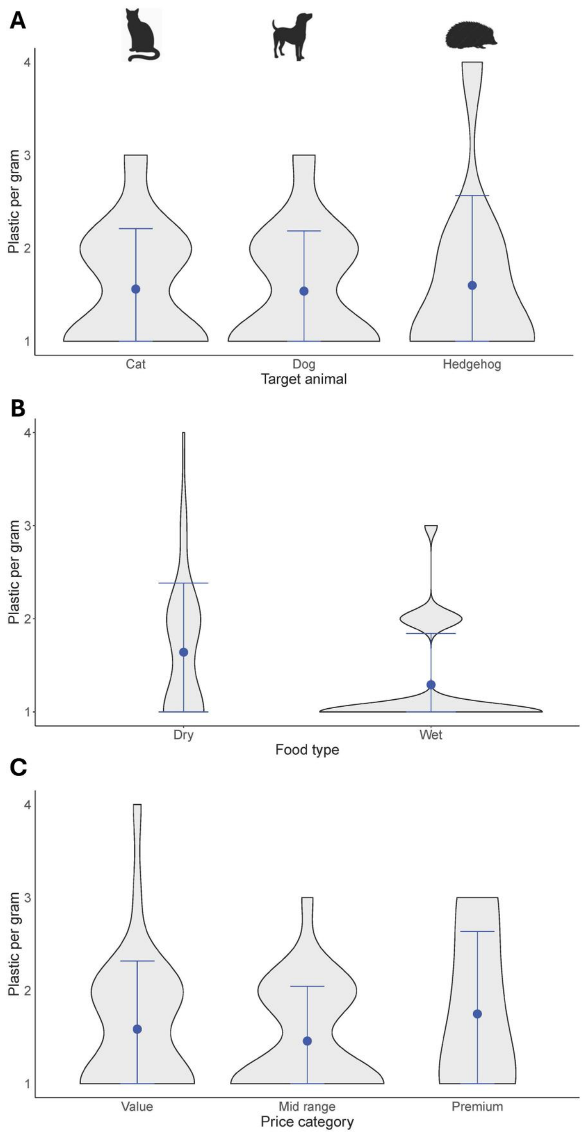

Figure 3 Violin plot to show the number of pieces per gram of pet food in the plastic-positive samples tested by (A) target animal, (B) type of food, and (C) price category. Error bars show standard deviation, and the blue points show the mean.

More than a quarter of the samples tested contained MPs; more than three-quarters of the different products had at least one plastic-positive replicate, and almost half had two or more plastic-positive replicates. Dry foods had more plastic-positive samples than wet foods, and also more pieces of MPs per gram. However, when considering the daily food intake of cats, dogs, and hedgehogs, larger portions of wet food are consumed than dry food owing to its lower energy density, meaning that the estimated daily intakes of MPs were higher for animals consuming wet food. For example, in the plastic-positive dog food samples, we found that per unit of energy (kJ), wet dog food has 0.37 particles kJ^{-1} compared to 0.11 particles kJ^{-1} in dry food. Similar patterns were found for the cat foods. Of the 19 brands tested, only three were found to be completely free of MPs, while the remaining 16 had at least one plastic-positive sample. Among these, 10 brands had MPs in just under a quarter of their samples, and four brands had MPs in around half of their samples. It should also be noted that only 1 g of food was analyzed per can, tray, sachet, or bag; therefore, it is possible that further testing would have identified MPs in those brands found to be plastic-free in this research. In addition, very small MPs would not have been detected using our research methodology. As we predicted, cheaper brands of pet foods showed significant contamination, potentially because of lower-quality ingredients, but high levels were also seen in one mid-range brand. There are multiple potential pathways by which commercially available foods for pets and wildlife may be contaminated by MPs. Although marketed as “chicken” or “chicken flavor,” many pet products contained less than 4% chicken. Most products, therefore, had a high level of meat and animal derivatives added to increase their meat content. These ingredients are not intended for human consumption (Antunes et al., 2024). Of the pet food products containing these derivatives (n = 21), 90% had at least one plastic-positive sample, and 61% had at least two plastic-positive samples. All three of the worst-performing products, which had five out of six samples testing positive, contained these derivatives. Aquatic materials (fish and fish derivatives) were also relatively common, and these could act as a route by which MPs from the marine environment enter terrestrial food chains. Cereal crops, which are common in the pet foods tested, may also be a potential source of MPs due to contamination of soils—for example, by the application of sewage sludge to crop fields (Agricultural Development & Advisory Service, 2001; U.S Environmental Protection Agency [USEPA], 1994; European Union, 1986). Polyester fibers were the most common polymer found in this study. They could contaminate ingredients used in pet food (e.g., via sewage sludge; Sillanpää & Sainio, 2017) or enter the foods during the manufacturing process (e.g., as fibers lost from synthetic clothing; De Falco et al., 2020). Polyethylene and polypropylene, which were also commonly identified, are frequently used for packaging and account for around 39% of all plastics produced annually (Plastics Europe, 2022). It is possible that these polymers indirectly contaminated the pet foods when in the factory, due to MPs being lost to the environment during processing. It is also likely that MPs are shed when the bags of food are subject to mechanical stress (Jadhav et al., 2021) or opened (Sobhani et al., 2020). There is also a possibility that some of the polyethylene and polypropylene particles in dry food samples (n = 10) could have originated from the lining of

Table 3 The estimated daily microplastic intake of dogs, cats, and hedgehogs under moderate, high, and worst-case scenarios.

Type	Size	Food type	Scenario	Estimated daily MP intake
Dog	Small (7 kg)	Wet	Moderate	92.4
			High	123.2
			Worst	664.3
		Dry	Moderate	66.7
			High	100.1
			Worst	208.7
	Medium (18.5 kg)	Wet	Moderate	219
			High	271.6
			Worst	1,434.1
		Dry	Moderate	100.7
			High	161.2
			Worst	386.9
	Large (35 kg)	Wet	Moderate	313.1
			High	438.4
			Worst	2,314.4
		Dry	Moderate	162.6
			High	260.2
			Worst	624.4
Cat	Average (4 kg)	Wet	Moderate	143.5
			High	229.6
			Worst	407.1
		Dry	Moderate	33.5
			High	33.5
			Worst	125.1
Hedgehog	n/a	Wet—cat	Moderate	32.9
			High	51.8
			Worst	105
		Wet—dog	Moderate	14.7
			High	18.9
			Worst	99.4
		Dry—cat	Moderate	9.9
			High	9.9
			Worst	37.2
		Dry—dog	Moderate	11
			High	16.6
			Worst	35
		Dry—hedgehog specific	Moderate	6.6
			High	8.8
			Worst	30.8

packaging they came in. Although it is difficult to be certain of the exposure pathway due to the ubiquitous nature of these polymers in both food processing settings and the wider environment, future research should test the packaging materials used for each product. Of the polymers likely to have originated from industrial use, several were different types of rubbers, such as polynorbornene, which has previously been found in the feces of the European hedgehog (Thrift et al., 2022). These may be derived from machinery in the factories where the pet foods are produced, or from machinery or foods used in chicken rearing. Polyacrylamide, one of the most abundant polymers in this study, was also categorized as industrial because it is often used in water treatment, the manufacturing of paper, or as a flocculant in wastewater treatment plants. The mechanism for contamination with this product is currently unclear. These findings suggest that pet foods are an important source of MPs for pets and wild animals eating supplementary foods. Many of these MPs are excreted in feces, providing a route for environmental contamination. A recent study estimated that, on average, dogs produce 56.5 kg of feces and cats 12.8 kg annually (Okin, 2017). The United Kingdom has a pet ownership rate at the higher end of the international spectrum, with an estimated population of 10.6 million dogs and 10.8 million cats (People's Dispensary for Sick Animals, 2024). This would result in an estimated 599,000 tons of dog feces and 138,000 tons of cat feces each year. A recent study in Ireland suggested that 15% of dog feces were composted and 14% was left in the environment (Sherlock et al., 2023). Applying these proportions to the United

Kingdom would result in an estimated 173,710 tons of dog feces being either composted or left in the environment annually. A study in the United States assessing litter tray usage in domesticated cats found that 44% of them defecated outside 75% of the time (Dabritz et al., 2006). This would result in 45,619 tons of cat feces annually entering the environment in the United Kingdom alone. The feeding of wild animals is also widespread in northwest Europe, offering a further route of environmental contamination, and a possible explanation for the MPs recorded in plastic-positive samples of European hedgehog feces (Thrift et al., 2022). The density of MPs in hedgehog faces (1.5 pieces g^{-1}) is similar to that reported here for plastic-positive pet food samples, but is four to five times higher than the mean density recorded across all pet food samples, which is potentially more representative of the average intake of hedgehogs in the United Kingdom This discrepancy suggests that other contaminated food items are likely to be ingested. The concentration of MPs in their invertebrate prey was recently reported to be 32 pieces g^{-1} among plastic-positive samples, with a mean of 3.8 pieces g^{-1}across all samples (Thrift et al., 2025). Hence, the concentration of MPs in pet foods, although relatively high, is much lower than for wild invertebrates that sit near the base of the terrestrial food web and form a major food source for small terrestrial mammals and other wildlife. It is important to note, however, that the percentage of plastic-positive samples was higher in pet food (27.6%) than in wild invertebrates (11.8%), with certain species such as snails, slugs, and earthworms being more likely to contain MPs. This implies that while the concentration of MPs was higher in individual wild invertebrates, the likelihood of a wild mammal encountering MPs in a particular food item is higher for pet foods than for invertebrates. A study by Milne and colleagues in the United States found the concentration of MPs g^{-1} in meat and vegan protein products to be 0.2 pieces g^{-1} in all the samples tested (Milne et al., 2024). In the current study, the concentration of MPs in wet pet food in all the samples tested was found to be 0.3 pieces $g^{-1,}$ and 0.4 pieces g^{-1} in dry pet food, indicating that MPs contamination is higher in pet foods. Research is now needed to establish whether pet foods within minimal processing (e.g. "raw" products) contain fewer MPs than more conventional feeds. Pet foods have also recently been shown to contain other common contaminants, including pesticide residues and heavy metals (Macías-Montes et al., 2025; Zafalon et al., 2021). Pesticide residues have been detected in pet foods at concentrations below regulated limits (Macías-Montes et al., 2025); however, heavy metals have been reported in some products at concentrations exceeding recommended thresholds (Zafalon et al., 2021). As for MPs, the health implications of these contaminants for pets and for wildlife that consume these pet foods remain unclear. This highlights the need for further investigation into the occurrence and potential biological significance not only of MPs but also of these other contaminants. Interdisciplinary research is now required to explore the long-term health effects of chronic MP exposure in domestic animals and wild mammals, as laboratory research into the health effects of MPs suggests potential impacts on organ function and fertility in model organisms (Deng et al., 2021; Tong et al., 2022). Further research is also required to identify the primary routes by which contamination of animal feeds occurs.

Conclusions

This study demonstrates that commercially available pet and wild mammal feeds are a widespread and previously unrecognized source of MPs. Contamination was observed across the majority of products and brands and in every price category and food type. While levels of MPs varied, our findings indicate that even under the moderate scenario, owing to repeated daily consumption, pet foods are likely to present a chronic exposure pathway for MP ingestion in both pets and wild mammals. The estimated ingestion rates indicate that the exposure risk is greatest from wet foods, which are eaten in larger quantities due to their low caloric density. The calculated MPs per gram in pet foods were higher than those reported in human foods, probably because of the lower quality of the ingredients used, especially in cheaper "Value" products. We have also identified a new pathway by which the feces of both pets and wild mammals act as a direct source of environmental contamination with MPs. For wild mammals, it is possible that other components of the natural food web (e.g., invertebrates) provide another source of MPs in addition to pet foods. Research is now needed to understand the impacts on animal health and to identify the routes of food contamination.

Supplementary material

Supplementary material is available at *Environmental Toxicology and Chemistry* online.

Data availability

Data supporting the findings of this study are included in the supplementary material. The raw data underlying this article and the code used for statistical analysis are available at The Sussex University Figshare at 10.25377/sussex.32537241.

Author contributions

Emily Thrift (Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing—original draft, Writing—review & editing), Tamara S. Galloway (Conceptualization, Supervision, Writing—review & editing), David Santillo (Investigation, Supervision, Writing—review & editing), and Fiona Mathews (Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing—review & editing)

Funding

The British Hedgehog Preservation Society and the University of Sussex jointly funded this research which was conducted as part of ET's PhD studentship.

Conflicts of interest

The authors declare no conflicts of interest.

Disclaimer

Tamara Galloway holds the position of Editor-in-Chief for *Environmental Toxicology and Chemistry* and has not peer-reviewed or made any editorial decisions for this paper.

Acknowledgments

Access to the Spotlight 400 imaging FT-IR microscope was made possible under a Research Partnership Agreement between the Greenpeace Research Laboratories and PerkinElmer.

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