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Feeding habits and microplastic ingestion of Bogue in Mediterranean Sea

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Abstract This study examines the feeding habits of the bogue (*Boops boops, L.)* and the presence of microplastics (MPs) in the gastrointestinal contents in the North Evoikos Gulf, a region characterized by intense anthropogenic and industrial activity. Seasonal sampling of 230 individuals was conducted during 2022 and 2024. The protocol Medsealitter was used to assess MPs presence, abundance, size, type, color. Diet analysis revealed an opportunistic feeding behavior, with Crustacea being the dominant prey (53.6%). Microplastics, detected in 56.1% of the samples (mean: 1.74 MPs/individual), were the main plastic items found (97%). Most of them were fibers, black in color. Polyethylene (36%) and polypropylene (21%) were the most common polymers. No correlation was found between the microplastics number and biological parameters (length, weight, stomach content weight). A low positive correlation was found between the microplastics number and condition factor, which possibly suggests no effect of microplastics on the species.

Keywords: *Pollution, Microplastics, Bogue, Feeding, Mediterranean*

1. Introduction

Microplastic pollution is particularly evident in the Mediterranean Sea, where its semi-enclosed geomorphology and intense anthropogenic activity contribute to the accumulation of plastic debris [1]. The presence of microplastics in the gastrointestinal contents of *B. boops,* a planktivorous fish species common in the Mediterranean Sea has been studied, with most research focusing on the Western Mediterranean. No study has been conducted on this species in the North Evoikos Gulf, a region characterized by intense anthropogenic and industrial activity [2]. In the North Evoikos Gulf, research is limited: seabed litter densities are relatively low and although data on microplastics in surface waters or sediments are lacking, ingestion by fish has been documented [2].

This research will provide valuable insights into the ecological role of *B. boops* and its potential as a bioindicator for marine pollution in the region.

Table 1. Seasonal percentage composition of the diet and quantity of MPs in *B. boops* from the North Eviokos Gulf.

Categories	Winter	Spring	Summer	Automn
Plantae	6.5	3.0	5.0	10.5
Crustacea	66.5	16.8	68.6	48.3
Mollusca	9.7	35.6	2.9	0.7
Polychaeta	3.8	0.0	11.4	4.9
Ctenophora	0.0	0.0	6.4	0.0
Osteichthyes	10.8	30.7	0.0	31.5
Unidentified	2.7	13.9	5.7	4.2
B. boops with MPs	67	22	21	19
MPs items	127	30	33	35
Mean MPs/fish	1.90	1.36	1.57	1.84

2. Materials and Methods

In 2022 and 2024 seasonal fish sampling were conducted in the N. Evoikos Gulf. Stomach contents were examined in all 230 individuals to identify prey types. The frequency of prey occurrence, numerical abundance, and diet overlap were calculated using standard feeding indices.

Microplastics in gastrointestinal contents were analyzed following the Medsealitter protocol adapted for small fish. Contents were digested with 30% hydrogen peroxide at 60°C for 7 days, then filtered. Filters were examined under a stereomicroscope and microplastics were classified by size, color, and type. Polymer identification was performed using FT-IR spectroscopy (Cary 630 FTIR, HCMR). Only microplastics >300 μm were analyzed. Blank samples were used to check for contamination, and strict protocols minimized external contamination.

Statistical analysis included non-parametric tests (Mann-Whitney U, non-parametric ANOVA, Chi-Square, and Spearman correlation) for data comparison and relationships. Linear and exponential regressions were performed to assess variable relationships. Statistical significance was set at $\alpha = 0.05$.

3. Results

The total length (TL) of the individuals ranged from 138 to 328 mm, with a mean of 188.3 ± 33.0 mm. No statistically

significant differences were observed between sexes in TL (Mann-Whitney U, $p = 0.27$). The mean condition factor was 0.94 ± 0.1, and stomach emptiness was recorded at 24.7% in females and 36.4% in males, with no significant sex-related differences (Chi-square, $p = 0.995$). However, a significant seasonal variation in stomach emptiness was observed. From 217 non-empty stomachs, 569 prey items were identified and classified into six major groups: Plantae, Crustacea, Mollusca, Polychaeta, Ctenophora, and Osteichthyes. The overall trophic level (TROPH) was 3.30 ± 0.44.

A total of 232 plastic items were found, of which 225 were microplastics and 7 macroplastics, with 56.1% of individuals containing microplastics (mean: 1.74 items/individual). No significant sex or seasonal differences were found regarding microplastic presence or size. Microplastics averaged 1.47 ± 1.09 mm in length (range: 0.02–5.00 mm), while macroplastics averaged 7.88 ± 2.19 mm. The majority of microplastics were fibers (83.14%) and exhibited a variety of colors, with black being the most dominant. FTIR analysis revealed that 36% of microplastics were polyethylene. Control samples were free of microplastics. A weak but statistically significant positive correlation was found between condition factor and microplastic count (Spearman's $r = 0.164$, $p < 0.05$), while no significant correlations were found with total length, body weight, or stomach content weight.

4. Discussion

Present findings confirm that *B. boops* is primarily planktivorous, feeding mainly on crustaceans, with algae comprising 6.5% of its diet in the North Evoikos Gulf. Prey items were classified into six major groups: Crustacea (53.6%), Osteichthyes (16.9%), Mollusca (10.4%), Plantae (6.5%), Polychaeta (5.3%), and Ctenophora (1.6%). Crustaceans, particularly Euphausiacea in summer, were the dominant prey year-round, with feeding activity peaking in autumn, as observed by El-Maremie & El-Mor (2015).

Microplastics were found in 56.1% of specimens, a higher rate than other Greek waters (e.g., Ionian Sea 20.7%, Saronikos Gulf 29.7%) [5,6]. The average number of microplastics per individual was 1.74, lower than in more impacted Western Mediterranean areas (2.59–4.89 particles/individual). Most ingested microplastics were fibers (83.1%), mainly black in color (67.8%), and commonly made of polyethylene and polypropylene, widely used polymers in consumer products. These results are in line with other studies [7,8]. Most particles were 0.5–1.5 mm long. A low retention time of microplastics in the digestive system may explain the relatively low particle count despite high frequency.

No significant relationship was found between microplastic count and fish size or stomach content weight, though a weak positive correlation was observed with condition index. Compared to E. encrasicolus and S. sphyraena from the same area [2], *B. boops* showed the highest frequency of microplastic ingestion, but similar particle counts per fish.

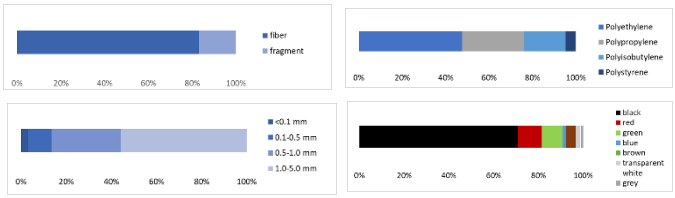

Fig 1. Size, type, color and polymer of MPs found in the gastrointestinal contents in *B. boops* from the North Eviokos Gulf.

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