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Note

First evidence of ingested plastics by a high commercial shrimp species (*Plesionika narval*) in the eastern Mediterranean

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ABSTRACT

This study provides the first evidence of nylon filament occurrence in the stomach of an economically important target shrimp species in the Mediterranean Sea, *Plesionika narval* (Fabricius, 1787). Samples were collected monthly from November 2014 to October 2015 from shallow (10–30 m) and deeper waters (150–170 m). The occurrence of plastics in the stomachs of the Narwal shrimp was 5.93% and identified as Nylon by FT-IR analysis. Higher percentages of ingested plastics were found in females from shallower depths and in males from deeper waters. The maximum number of plastics was recorded in January and March, possibly related to the higher feeding intensity of females prior to their reproduction period. A total of 10.3% of females and 4.8% of males with ingested plastics had almost empty stomachs. The presence of plastics in the stomach of *P. narval* is an evidence of passive ingestion which in this study related to fishing activities.

Floating plastic debris in the oceans has been generally considered to be of minor importance compared to other ocean pollution issues, such as heavy metals, organic pollutants (PAHs, PCBs, DDT), oil and other contaminations and was usually characterized as aesthetic concern (Laist, 1987). Since decades ago, the plastic debris issue became one of the largest and most discussed components of marine litter in the International Council for the Exploration of the Sea (ICES) and in the European Marine Strategy Framework Directive (MFSD) (Galgani et al., 2014).

The threatening impacts of plastics, especially on the marine environment are significant (Gregory, 2009). Marine organisms interact with plastic debris in different ways, which lead to sequence of physical and chemical negative effects such as blocking the feeding appendages or hinder the passage of food (Browne et al., 2010) or might facilitate the transport of chemical contaminants to organisms (Mato et al., 2001). Today, over 250 species from different taxa have been reported to be impacted by plastics (e.g., Anastasopoulou et al., 2018; Anastasopoulou et al., 2013; Farrell and Nelson, 2013; Frias et al., 2014; Romeo et al., 2015).

Fishing activities and ghost nets have deleterious effects on marine organisms, through ingestion and/ or entanglement with species (Compa et al., 2018). Comparing to natural fibres used in the 1950s, nylon and other synthetic materials are more buoyant and endurable (Gregory, 2009) with slow degradation process in the water due to the UV exposure and lower temperatures (Barnes et al., 2009). They break up into smaller pieces and finally (Collignon et al., 2014; Cole et al., 2011) and accumulate as marine debris (Nuelle et al., 2014; Andrady, 2011).

Plesionika narval (Fabricius 1787) – narwal shrimp – has a wide geographical distribution, from the Atlantic Ocean to the western central Pacific Ocean including, the whole Mediterranean and the Red Sea inhabiting a wide depth range from 2 to 910 m (Kalogirou et al., 2017; Sousa et al., 2014; Thessalou-Legaki, 1989; Holthuis, 1980). It is recognized as a species of interest to fisheries in many regions (Chan and Crosnier, 1991; Holthuis, 1980). In the Aegean Sea, in particular in Dodecanese Archipelago, the narwal shrimp is one of the most profitable small-scale fisheries contributing to social and cultural cohesion of local fishery communities (Kalogirou et al., 2017; Vasilakopoulos et al., 2018; Maravelias et al., 2018).

There is inadequate and limited information on the presence of plastic debris in the stomach content of crustaceans intended for human consumption. Few evidence of plastic debris was found in the stomach content of Norway lobster (*Nephrops norvegicus*) from Adriatic Sea (Wieczorek et al., 1999) and the British waters (Murray and Cowie, 2011) as well as brown shrimp (*Crangon crangon*) from the channel area between France and Belgium (Devriese et al., 2015).

The aim of this study was to reveal the presence of plastic items in the stomach content of the narwal shrimp from the Aegean Sea (Eastern Mediterranean). Considering the hazardous effects of plastics on the marine organisms, along with the fact that the species is commercially

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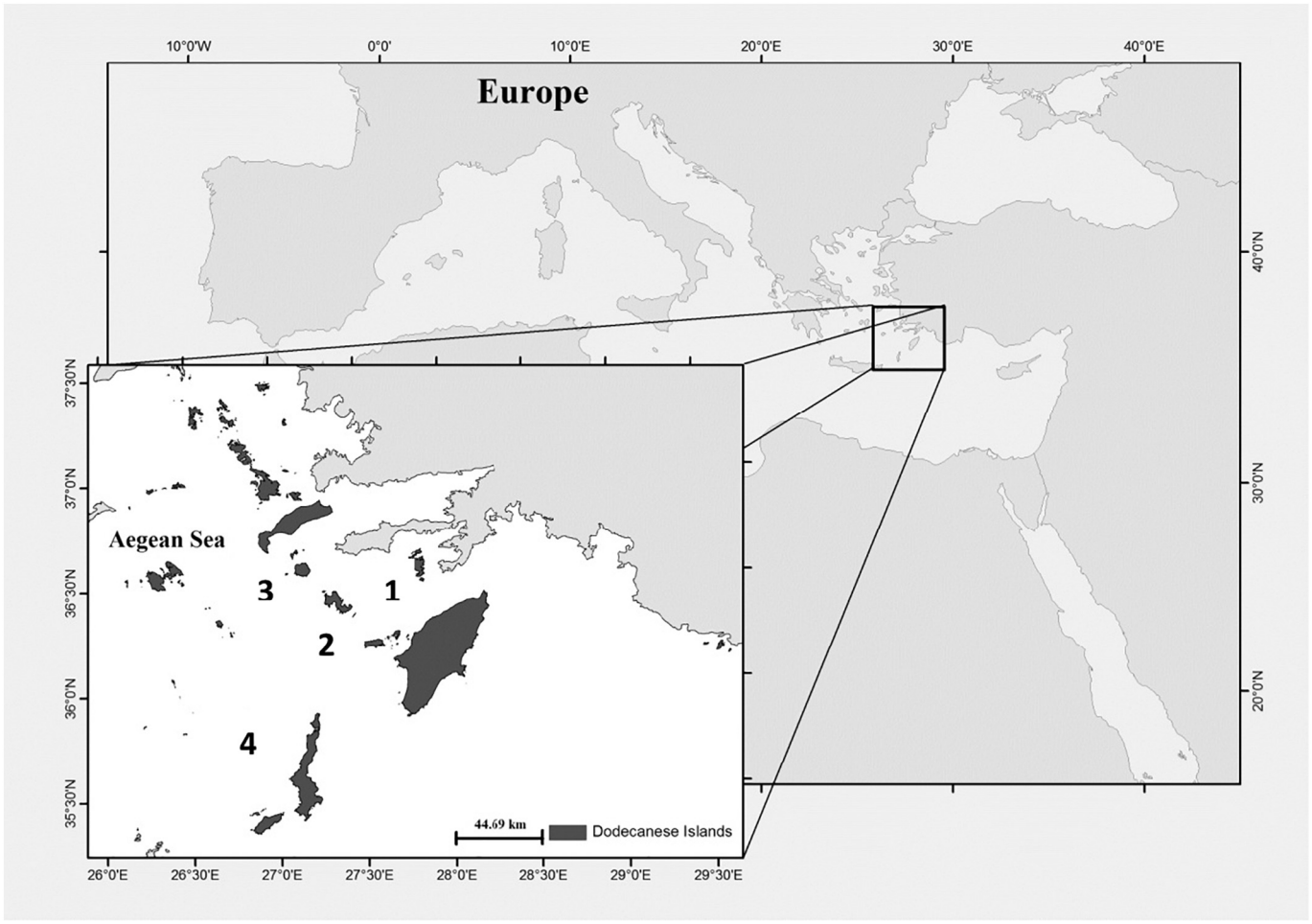

Fig. 1. Sampling area in Dodecanese archipelagos islands (south-eastern Aegean Sea) and locations (1: Simi, 2: Tilos, 3: Nisyros, 4: Karpathos islands).

utilized by humans, this study provides a primary contribution to the knowledge of plastic occurrence in this important commercial resource.

Narwal shrimps were collected from four islands (Karpathos, Nisyros, Tilos and Simi; Fig. 1) of the Dodecanese Archipelagos of the south-eastern Aegean Sea on a monthly basis during an annual cycle from November 2014 to October 2015 within the PLESIONIKA MANAGE project (www.plesionika-manage.eu). Shrimp samples were collected monthly by means of shrimp traps, except for February, from two depth zones; A: (10–30 m), C: (150–170 m). The specimens were chilled on board (+4 °C) and then preserved in 10% formalin solution until further analysis.

In laboratory, all individuals were sexed, their carapace length was measured (CL ± 1 mm) and body wet weight was weighed (BW ± 0.1 g). A total of 30 individuals were randomly selected from each sex (15 males and 15 females) per month and depth zone. The stomach content of each individual was removed and weighed (SC, g). The identification of stomach content was carried out under a microscope (Nikon SMZ 745 T) and the stomachs with ingested plastic were recorded. In order to minimise the risk of airborne contamination during the processing of samples and dissection in the laboratory all equipment was washed with purified water (Milli-Q) before use and workbench was cleaned with water and alcohol (Lusher et al., 2013; Torre et al., 2016). Samples were placed on the clean glass petri-dish and stomach was separated. The ingested plastics were removed, coded and stored in clean vials for further identification. Fourier transform infrared spectroscopy (FT-IR) equipped with a diamond attenuated total reflectance (ATR) unit (Agilent Cary 630 FTIR spectrometer) was used to confirm the synthetic polymer origin of the ingested plastic items, using a self-generated polymer library (i.e. spectra of reference polymer types provided by industry). The level of certainty when comparing sample spectrum to that of the self-generated library database was set up to 80% (Digka et al., 2018). At least a 10% proportion of fragments and filaments recorded, were analysed by FT-IR following guidelines produced by the MSFD technical group on marine litter (Galgani et al., 2013). Stereomicroscope (WILD M240) coupled with digital image (Sony Exwave HAD) process software were also used for taking photo from the plastic items found in the stomachs.

The relative fullness of each stomach recorded was calculated using repletion index (RI) = (SC/BW × 100) (Morato et al., 2000). The condition factor (K) = [(TW/CL^3) × 100)] was calculated for both shrimps with ingested and non-ingested plastics items.

The occurrence of individuals with ingested plastics was calculated to the total number of shrimps examined and the proportion of males and females with ingested plastics was estimated against month and area. The binary logistic model was used to estimate the probability (presence/absence) of plastics occurrence related to month, area, depth and sex.

One-way ANOVA was performed to detect differences associated to shrimp size (CL), body weight (BW), stomach content weight (SC) and condition factor (K) between shrimps with ingested and non-ingested plastic. The same analysis (ANOVA) was also used to reveal correlations between shrimp's stomach fullness with the occurrence of ingested plastic items.

In total, 2516 specimens were sexed (1631 females and 885 males), among which 2411 individuals with full stomachs (1548 females and 863 males) were analysed. The number of individuals with and without