

4. Comparison of mesozooplankton faecal pellet characteristics from the southern North Sea and the Mediterranean Sea during spring bloom conditions

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Introduction

Mesozooplankton faecal pellets participate in the carbon and nutrient cycles, in the nutrition of marine organisms, and in the transport of toxins, pollutants, and sediments. The importance of this role depends on their nature and production, which are highly variable parameters that, in turn, depend on many factors. For example, a phytoplankton bloom may significantly change the nature of mesozooplankton faecal pellets because it affects their shape, content, density, and volume (Frangoulis *et al.*, 2005).

The aim of the present study is to compare the eutrophic southern North Sea and the oligotrophic Bay of Calvi in the Mediterranean Sea with respect to the seasonal variability of faecal pellet characteristics (shape, size, sinking speed, density) during bloom conditions.

Material and methods

Samples were taken in the Mediterranean Sea, close to oceanographic station STARESO in the Bay of Calvi, Corsica, in spring 1999, and in the southern North Sea during eight cruises on board RV "Belgica" in spring 1995, 1996, and 1997. In both areas, 0.25–1.5 l of subsurface water (2 or 3 m) was filtered for phytopigment analysis by HPLC (high-performance liquid chromatography). Details of HPLC methodology can be found in Frangoulis *et al.* (2001) and Goffart *et al.* (2002).

Collection of faecal pellets was started within 5 min of a mesozooplankton collection with a subsurface haul (~5 m) using a 200 µm mesh WP-2 net. Organisms were placed in a bucket containing a hollow cylinder, the bottom of which was covered with a net (200 µm mesh in the southern North Sea and 100 µm mesh in the Bay of Calvi) that retained the copepods but not their faecal pellets. Organisms were allowed to defecate for 3–5 h in the dark at ambient temperatures. The pellets were then concentrated using "reverse filtration": a smaller cylinder with a 20 µm mesh net at the bottom was used to ladle water from within the cylinder. After reducing the initial volume of water to ~100 ml, pellets were collected using a screen of 25 µm mesh. After collection, the faecal pellets were either immediately fixed with 4% formalin or preserved at 4°C for no more than 24 h and then fixed with formalin.

The sinking speed of faecal pellets was measured using the method described by Frangoulis *et al.* (2001). A large glass burette (85 cm high, 6.5 cm inside diameter) was filled with seawater filtered through GF/F glassfibre filters and left to stabilize for a minimum of 1 h. Several faecal pellets at a time were gently released under the water's surface using a Pasteur pipette. A 200 µm mesh net was placed 5 cm below the water's surface to retain aggregates of faecal pellets. After the pellets had passed through the netting, the net was slowly removed and a stopwatch was started once the pellets had sunk 5 cm. After a delay of 2 or 3 min, the tap of the burette was opened and 1.5 ml samples were taken every 20 sec. This procedure was continued for approximately 30 min. The sinking speed was calculated from the time taken to collect each sample and the distance covered (taking into account the decrease in height of the water column caused by the sampling). Intact pellets in each sample were counted and measured (length and width) under a stereomicroscope. Estimates

of faecal pellet density were obtained from the values for faecal pellet length, width, and sinking speed, based on the relationship of Komar *et al.* (1981).

Results and discussion

The dominant shape of faecal pellets in both areas was cylindrical (<1% being elliptical). As copepods were dominant in both areas, it is likely that almost all cylindrical pellets were released by copepods. In the Bay of Calvi, faecal pellet volume values varied from $0.4 \times 10^4 \mu\text{m}^3$ to $149 \times 10^4 \mu\text{m}^3$, with a mean of $11 \times 10^4 \mu\text{m}^3$, whereas in the southern North Sea, the values were higher, varying from $1.8 \times 10^4 \mu\text{m}^3$ to $183 \times 10^4 \mu\text{m}^3$, with a mean of $38 \times 10^4 \mu\text{m}^3$ (Figure 4.1a). Pellet size is known to be influenced by body size/weight, food concentration, and food quality (Frangoulis *et al.*, 2005). In the Bay of Calvi, pellet volume was positively related to the subsurface mean dry weight of mesozooplankton individuals ($r^2 = 0.61$, $p < 0.001$; Figure 4.1d), as already reported in other studies (Paffenhöfer and Knowles, 1979; Uye and Kaname, 1994). However, there appeared to be no relationship with Chlorophyll *a* (Chl *a*), probably because variations in food concentration (Chl *a* $< 0.5 \mu\text{g l}^{-1}$) were small when pellet volume was measured; this was indicated by Dagg and Walser (1986), who obtained a positive relationship between pellet volume and Chl *a* only above $0.5 \mu\text{g Chl } a \text{ l}^{-1}$. In the southern North Sea, a negative, but not significant, correlation ($r^2 = 0.40$, $p = 0.18$) with Chl *a* appeared (Figure 4.1c). This lack of relationship between faecal pellet volume and Chl *a* in the southern North Sea can be explained by changes in phytoplankton quality during its bloom (presence of *Phaeocystis* colonies, which are commonly considered unpalatable to mesozooplankton), resulting in less food being available (Frangoulis *et al.*, 2001).

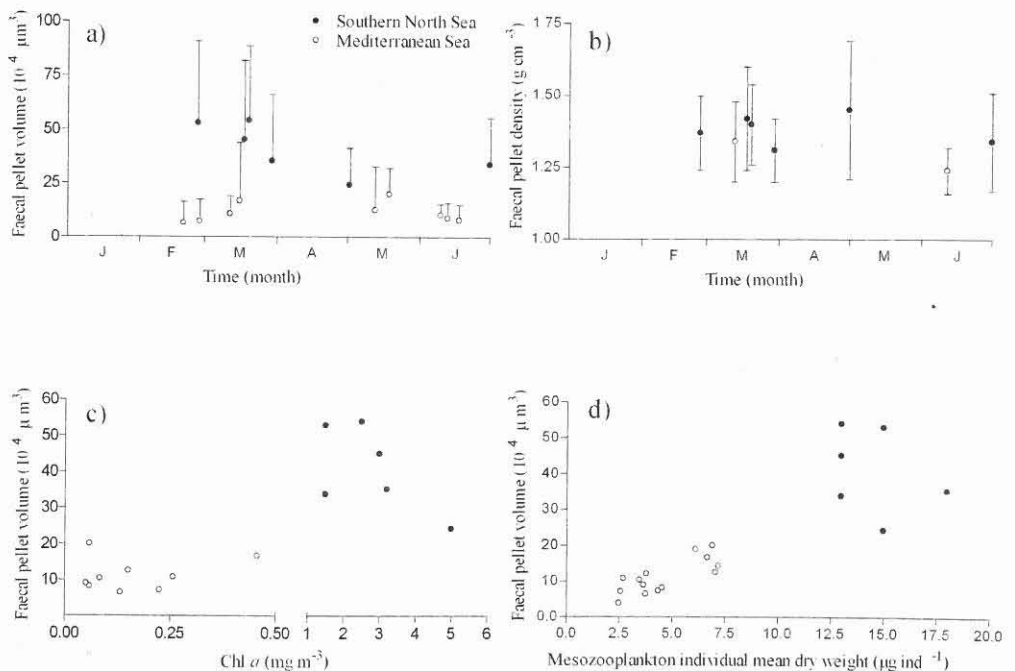


Figure 4.1. Seasonal variations of subsurface mesozooplankton faecal pellets in the southern North Sea and in the western Mediterranean Sea (Bay of Calvi): (a) volume; (b) density. Values are means, and vertical bars show standard deviations. (c) Relationship between mean faecal pellet volume and Chl *a*. (d) Relationship between mean faecal pellet volume and subsurface mesozooplankton individual mean dry weight. Data from southern North Sea are taken from Frangoulis *et al.* (2001).

In both areas, the sinking speed of mesozooplankton faecal pellets was positively related to faecal pellet volume ($r^2 > 0.5$, all $p < 0.05$). Values varied from 14 to 57 m d⁻¹ in the Bay of Calvi and from 37 to 251 m d⁻¹ in the southern North Sea. Estimated faecal pellet density varied seasonally in both the Bay of Calvi and the southern North Sea (Figure 4.1b). As faecal pellet density depends on the concentration and packing of ingested material into pellets and the type of material ingested (see e.g. Fowler and Small, 1972; Urban *et al.*, 1993; Hansen *et al.*, 1996), the higher density values during the phytoplankton bloom period could be attributable to a change in diet during and after the phytoplankton bloom period. In the case of the Mediterranean, this is probably caused partly by the transition from a more herbivorous diet of phytoplankton, dominated by small flagellates, to a more carnivorous diet of mesozooplankton after the bloom, whereas, in the case of the North Sea, it is probably caused by the transition from a diatom-dominated bloom to a *Phaeocystis* sp.-dominated bloom.

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