M. R. Cunha · M. H. Moreira · J. C. Sorbe

The amphipod *Corophium multisetsom* (Corphiidae) in Ria de Aveiro (NW Portugal). II. Abundance, biomass and production

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Abstract The abundance and biomass of *Corophium multisetsom* Stock, 1952 were determined from benthic corer samples collected monthly over 1 yr in the upper reaches of Canal de Mira (Ria de Aveiro, Portugal). Both density and biomass over the sampling period were negatively correlated with water temperature and positively correlated with chlorophyll *a* concentration in the sediment. *C. multisetsom* density was significantly negatively correlated with plant biomass and positively correlated with salinity. The nature of the sediment, favourable environmental conditions, high availability of food and low interspecific competition allowed the population to reach a maximal density of 200 × 10^3 individuals m^-2 and a maximal biomass (ash-free dry wt, AFDW) of 62 g_AFDW m^-2. The population was highly productive, especially during the autumn/winter period. Production, estimated by two different methods (Hynes method: 251 g_AFDW m^-2 yr^-1; Morin–Bourassa method: 308 g_DW m^-2 yr^-1), was much higher than the values reported for other *Corophium* species. The annual P:B ratio (10) was high, but similar to values reported for Swedish populations of *C. volutator* and lower than the values estimated from Mediterranean populations of *C. insidiosum*.

Introduction

*Corophium* Latreille, 1806 is a cosmopolitan genus in temperate and tropical waters, and is represented by 58 species, mostly shallow marine, and often found in estuaries, harbours and in European and Ponto Caspian rivers (Barnard and Karaman 1991). *Corophium* species are burrow- or tube-dwellers, feeding preferentially on detritus and epipelagic microalgae, and can establish populations of extremely high densities in intertidal and subtidal areas. These amphipods are considered a key food source in mudflats used as foraging areas by migrating shorebirds, and are also an important part of the diet of fishes in sheltered coastal habitats that act as nursery and feeding grounds (Segestrèle 1959; Goss-Custard 1977; Peer et al. 1986; Wilson 1989; Matthews et al. 1992).

In Europe, the most widespread and well studied species are *Corophium volutator*, *C. arenarium* and *C. insidiosum*. *C. multisetsom* was described by Stock (1952) from Dutch brackish waters and, since then, it has been reported from European brackish waters of the Baltic Sea and Atlantic coast (Janta 1995). In Portugal it is known from the Ria de Aveiro, the Mondego and Sado estuaries, and also from Ria Formosa, the southern limit of its distribution (Marques and Bellan-Santini 1985, 1986, 1990; Queiroga 1990; Cunha and Moreira 1995). This species preferentially inhabits low-salinity waters (0 to 20 psu) and sandy sediments (250 to 1000 μm), where it establishes populations reaching 200 000 individuals m^-2 (Baltic Sea: Janta 1995; Ria de Aveiro: Cunha and Moreira 1995). This amphipod is often found coexisting with the gastropod *Potamopyrgus jenkinsi* and the amphipod *Gammarus chevreuxi*. *C. multisetsom* is an abundant species in Ria de Aveiro, and its distribution in one of the main channels (Canal de Mira) was reported by Queiroga (1990). The species is also known from the other channels of the Ria, especially in shallow low-salinity areas. In higher-salinity areas it occurs mainly on intertidal sandy sediments near mean high water level (Cunha unpublished data).
In this study, the fluctuations in density and biomass of *Corphium multisetsosum* over 1 yr period are discussed in relation to the temporal variation of some environmental factors. Its production in a shallow area at the upper reaches of Canal de Mira is estimated and compared to values for other *Corphium* populations.

**Material and methods**

**Study area**

The area investigated (Areão) in the Ria de Aveiro is located in the upper reaches of Canal de Mira (Fig. 1). The morphodynamics, circulation patterns and environmental gradients in Canal de Mira have been described by several authors (Teles et al. 1990; Moreira et al. 1993; Corrochano et al. 1997).

In Areão, the channel is narrow and shallow (average depth < 0.5 m at low water), with small intertidal areas (0 to 1 m) and extensive macrophyte meadows (mainly Potamogeton spp. and Myriophyllum spp.) that almost completely cover the channel bed.

The maximal tidal range is about 1 m at spring tides. During the sampling period, the salinity ranged from 0 to an extreme of 15, but usually varied between 1 and 3. Water temperature ranged from 8 °C (early morning during winter) to 25 °C (afternoon during summer). Sediment type varied from medium sand (75% of particles in the 250 to 500 μm range) in the central channel to muddy sand in the banks. Fine particles (< 63 μm) represented 7% of the sediment dry weight, and the average organic content was 3.5%.

[For further details on sampling and laboratory procedures see study of Cunha and Moreira (1995), who also provide complete description of the macrobenthic community structure and temporal (tidal, diurnal and seasonal) variation of several environmental factors (salinity, temperature, dissolved oxygen, chlorophyll *a*, micro-seston dry weight, current velocity and plant biomass) in Areão.]

**Sampling and laboratory procedures**

Sampling was carried out monthly between May 1988 and April 1989 at low water of new-moon spring tides. Ten core samples (10 × 0.01 m²; 20 cm depth) were taken randomly in a 500 m² area bounded by the channel banks and including both subtidal and intertidal areas. The samples were sieved in the field through a 0.5 mm mesh and preserved in 10% formalin. *Corphium multisetsosum* specimens were separated from the remaining macrobenthos and kept in 70% ethanol for further examination.

All collected individuals were counted, and undamaged specimens over a wide size range were selected for measurement of head length (Lₜ, dorsal view, from tip of rostrum to posterior margin of head) and individual weight (w). Individual weights were recorded to the nearest 0.001 mg by means of a CAHN electrobalance. The total biomass (ash-free dry weight, AFDW) of each replicate in the monthly samples was determined to the nearest 0.1 mg by ignition of the dried specimens in a muffle-oven for 2 h at 450 °C.

**Data analysis**

The non-parametric Kendall’s rank correlation coefficient was used to determine the association of density and biomass of *Corphium multisetsosum* with several environmental variables recorded monthly in the study area. This statistical analysis is appropriate for variables not normally distributed. Abundance data of *C. multisetsosum* and other species present in the study area were normalised by a log((n + 1))-transformation to allow a Pearson product-moment correlation analysis. Details on environmental variables and species are given by Cunha and Moreira (1995).

The relationship between the ash-free dry weight (AFDW, mg) and head length (Lₜ, mm) of *Corphium multisetsosum* was established by the equation:

\[
AFDW = a \times L_h^b, \tag{1}
\]

and its physiological condition was assessed using a condition index (CI) determined by the equation:

\[
CI = \bar{w}_j/L_h^b, \tag{2}
\]

where \(\bar{w}_j\) is average individual weight (mgAFDW), \(L_h\) is average head length (mm), and \(b\) is exponent of the allometric equation (1).

Annual production (P) was estimated using the Hynes size-frequency method modified by Menzies (1980):

\[
P = \left[ i \sum (\bar{w}_j - \bar{w}_{j+1}) \times \sqrt{(\bar{w}_j \times \bar{w}_{j+1})} \right] 12 CPI, \tag{3}
\]

where \(i\) is number of size classes; \(\bar{w}_j\) is mean density in size class \(j\) (individuals m⁻³); \(\bar{w}_j\) is mean individual weight in size class \(j\) (mgAFDW); and \(CPI\) = cohort production interval (mo); and the multiple regression equation of Morin and Bourassa (1992):

\[
\log P = -0.75 + 1.01 \log B - 0.34 \log M + 0.037T, \tag{4}
\]

where \(B\) is mean annual biomass (gdw m⁻³); \(M\) is mean individual weight (gdw) = \(BD^{-1}\); \(D\) is mean annual density; \(DW\) is dry