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ORIGINAL PAPER

Non-predatory mortality in Mediterranean coastal copepods

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Abstract Mortality affects the dynamics of zooplankton populations with important effects on trophic interactions and biogeochemical fluxes in marine environments, but is still one of the processes least investigated in the field. In the present study, the non-predatory mortality in copepod assemblages and species was investigated by applying the neutral red staining method to identify and quantify copepod carcasses throughout an annual cycle in a Mediterranean coastal site (station LTER-MC in the inner Gulf of Naples). Carcasses accounted on average for 10.3% (±9.7%) of total copepod abundance and were most abundant in spring, summer and autumn. Carcasses were represented predominantly by copepodites (78.9 ± 22.0%) and occurred more frequently and abundantly in calanoids than in other copepod orders, with interspecific differences in their abundance and temporal patterns. Using carcass abundances from field data and decomposition times from laboratory observations, we estimated non-predatory mortality rates of key calanoids that are common and abundant in Mediterranean coastal waters. Non-predatory mortality rates averaged 0.13 day^{-1} in *Paracalanus parvus*, 0.07 day^{-1} in *Clausocalanus* spp., 0.06 day^{-1} in *Temora stylifera* and 0.04 day^{-1} in *Acartia clausi*. Non-predatory mortality rates in these populations were not correlated with temperature, salinity or chlorophyll *a*.

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Introduction

Mortality is an inherent process of life that affects population dynamics and eventually community structure in both terrestrial and aquatic ecosystems. Despite its acknowledged importance, mortality is still one of the most neglected aspects of zooplankton biology (Ohman and Wood 1995; Hirst and Kiørboe 2002). Studies addressing mortality in marine zooplankton are limited and discouraged by a belief that the problem is intractable (Ohman 2012). Estimating mortality rates in situ is challenging indeed, and the critical issues that should be addressed to render the problem tractable have been examined recently (Ohman 2012). Quantifying mortality is fundamental for understanding the development of populations under different conditions (Carlotti et al. 2000). Field and modeling studies show that mortality varies among species and stages, and plays a major role in determining zooplankton population dynamics (e.g., Ohman and Hirche 2001; Eiane and Ohman 2004; Mazzocchi et al. 2006), though its causes remain generally undefined. The main cause of mortality in zooplankton is generally attributed to predation (Genin et al. 1995), but many other factors can be responsible, such as disease (Delgado and Alcaraz 1999), parasites (Kimmerer and McKinnon 1990; Burns1985; Ohtsuka et al. 2004; Duffy et al. 2005), environmental stress of physical and/or chemical origin (Carpenter et al. 1974; Hall and Alden 1997; Roman et al. 1993), starvation (Tsuda 1994), and senescence (Ceballos and Kiørboe 2011; Saiz et al. 2015). The relative role played by each of these factors in pelagic communities is still to be clarified, but it is expected to vary in different assemblages, environments, and conditions.

Mortality in planktonic copepods can be estimated in field samples from the occurrence of carcasses, which can be distinguished easily from the exuviae generated by molting

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