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Niche separation and reproduction of *Clausocalanus* species (Copepoda, Calanoida) in the Atlantic Ocean

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ABSTRACT

The distribution and reproductive traits of copepods of the genus *Clausocalanus* were investigated during the Atlantic Meridional Transect cruise AMT-15, in September–October 2004 to estimate their ecological niches and secondary production in the epipelagic layer along a latitudinal cline (48°N–40°S). The distribution patterns of selected environmental parameters, i.e., temperature, salinity and chlorophyll *a* concentration, enabled eco-provinces to be identified as described by Longhurst (2006). *Clausocalanus* represented on average 34% of total copepod abundance, with a large predominance of adult females and copepodites over males. Among the eleven *Clausocalanus* species found during the survey, eight species showed a wide distributional range, i.e., *C. paululus*, *C. pergens*, *C. furcatus*, *C. arcuicornis*, *C. jobei*, *C. parapergens*, *C. lividus*, and *C. mastigophorus*, while *C. ingens*, *C. brevipes*, and *C. laticeps* were recorded only in the South Atlantic. The smallest *C. furcatus*, *C. paululus*, and *C. pergens* together accounted for 85% of total *Clausocalanus* adult abundance. The ecological niches were clearly separated among congeners of similar size and largely overlapped in congeners whose size differed. The small- and medium-sized species, which are egg-sac-spawners, had smaller clutch size and lower egg-production rate than the larger broadcaster congeners. Nevertheless, embryo viability was lower in broadcasters, which may explain their low abundance in terms of lower recruitment. A sex ratio largely skewed toward females in all *Clausocalanus* species and the observation of viable eggs in successive clutches from isolated females seem to indicate that re-mating is not necessary in this genus. Broadcast-spawners showed the highest weight-specific fecundity rates in the genus but similar secondary production to sac-spawners despite the fact that they never occurred at high abundance. In light of their abundant occurrence in oceanic waters and well-defined ecological niches, *Clausocalanus* species may be considered as good indicators of environmental conditions and monitored in relation to changes in ecosystem structure due to climate change.

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1. Introduction

The oceans have been successfully colonized by planktonic copepods, which occur with large numbers of individuals and species, mostly concentrated in the epipelagic domain (Huys and Boxshall, 1991). Even in oligotrophic marine environments, which represent the vast majority of the oceans and where abundances are limited by very low primary production, numerous copepod species coexist. “How is it possible for a number of species to coexist in a relatively isotropic or unstructured environment all competing for the same sort of materials?”. This question posed decades ago

(Hutchinson, 1961) and known as *the paradox of the plankton* remains still open and species niche characterization still represents one of the most challenging issues in plankton ecology. In copepod communities, large overlap of species distribution can be observed with persistent co-occurrence of species similar in body size and believed to utilize the same or similar resources (e.g., Hayward and McGowan, 1979). The large number of copepod genera present in a water mass and the co-occurrence of many congeneric species challenge the niche definition for this crustacean group.

In copepod assemblages, the importance of small-size species in terms of abundance, biomass and grazing impact is now widely recognized (Morales et al., 1991; Roman et al., 1993; Calbet et al., 2001; Hopcroft et al., 2001; Gallienne and Robins, 2001; Turner, 2004). Among the small calanoids, *Clausocalanus* (0.47–1.90 mm body length, Frost and Fleminger, 1968) is one of the

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