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A preliminary study of the *Caprella scaura* amphipod culture for potential use in aquaculture

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ABSTRACT

The caprellid amphipod *Caprella scaura* Templeton, 1836 was investigated as a mass culture organism, for potential use as natural prey in aquaculture. *C. scaura* showed good population growth during 3 months of culturing with nauplii of *Artemia* sp. and microalgae as food source. A final mean population size of 12,510.67 individuals/tank and a maximum density of 10,460 individuals m^{-2} were obtained; a 50-fold increase of the initial population was observed. Juveniles were the most abundant stage in the culture (86.0% of total), followed by mature females (5.4%) and immature males (3.1%). Three kinds of plastic mesh with different complexity levels were used as artificial substrates for amphipods to attach to and shelter. There were no significant differences in the total number of individuals present on each kind of mesh, although female and male adults were more abundant in folded meshes with larger pore diameter. This research demonstrated that the caprellid amphipod *C. scaura* may be readily cultured at high densities with a variety of mesh morphologies allowing more efficient use of tank volume and improved handling.

1. Introduction

Amphipods are small, benthic crustaceans that usually live in groups, associated with a wide variety of substrates in the seas around the world (Woods, 2009). They can reach high densities under optimal environmental conditions of suitable space, habitat complexity and trophic resources. Amphipods constitute an important trophic link between primary producers and higher trophic levels, since marine finfish and other marine species use these small crustaceans as the main food source in their diets (e.g. Bilecenoglu, 2009; Cui et al., 2012; Dubiaski-Silva and Masunari, 2008; Padovani et al., 2012). The bodies of caprellid amphipods are longer and thinner than other amphipods. They exhibit a sedentary behavior pattern and cling to a substratum. Because caprellids attach to the outer branches of algae, bryozoans or other structures, they are more exposed to predators than are gammarids, which are amphipods that usually live within the matrix of their substrates (Vázquez-Luis et al., 2010). Larval or juvenile stages of many marine species reared under culture conditions are fed with a relatively limited range of live food such as, *Artemia*, copepods, mysids and rotifers. The use of caprellids as prey items could complement the traditional food items and expand the nutritional range available for larviculture (Woods, 2009). Although these organisms are frequently found in high numbers in their natural habitats, it is necessary to establish an adequate culture methodology to avoid environmental impacts on their populations and also to produce a constant supply of food, which is difficult to guarantee with wild populations. It is known that amphipods, especially caprellids, have a short life cycle, reproducing continuously throughout the year in temperate waters, with several broods along the cycle and a large number of juveniles with direct development emerging from the brood pouch of the female after each reproductive event (Baeza-Rojano et al., 2011; Cook et al., 2007; Hosono, 2009; Takeuchi and Hirano, 1991, 1992). These characteristics make caprellids good candidates for culture under controlled conditions. Nakajima and Takeuchi (2008) described the rearing of *Caprella mutica* for over 5 years with production of multiple generations annually. However, there are no more literature descriptions of the rearing methods for the *Caprella* species in large volumes for aquaculture purposes. The only other reported research with this group focused on completing the life-cycle, with caprellids being kept in small containers (Baeza-Rojano et al., 2011).

C. scaura is a species native to the western Indian Ocean that has been established in several regions of the world (Krapp et al., 2006). It is readily found in harbor habitats and their populations have high densities and mature reproductive females throughout the year (Guerra-García et al., 2011). Several marine fish species feed on *C. scaura* (Kwak et al., 2005; O'Gorman et al., 2008) and recent studies have examined caprellid use in cephalopod culture with promising results for feeding cuttlefish hatchlings (Baeza-Rojano et al., 2010). The main objectives of the present study is to explore the potential culture of *C. scaura* in large tanks at high density and to study the effects on population growth and structure using three types of meshes as substrate.

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2. Material and methods

Caprellid culture was conducted at the IFAPA center "Agua del Pino" experimental aquaculture station (Cartaya, Huelva, Spain), from April to June, 2011. Three cylindrical tanks of 100 L each were used for each replicate. The tanks were supplied with running seawater, with a complete water replacement of the tank each hour. Salinity ranged between 37 and 39 g L^{-1} and dissolved oxygen between 5 and 9 ppm. Water temperature fluctuated naturally (18–23 °C) and a natural photoperiod, 14 h light–10 h dark, was used. During the experimental period, caprellids were fed daily with *Artemia* sp. nauplii (500 mL of seawater with a density of 1400 nauplii/mL) and a mixture of two microalgae: *Isochrysis galbana* and *Tetraselmis suecica* (2 L of seawater with a mean density of 11.9×10^6 cells L^{-1} and 2.9×10^6 cells L^{-1}, respectively). *Artemia* nauplii were previously enriched with a synthetic market product (Selco® S.presso, INVE Technologies, NV, Belgium) and when the *Artemia* and microalgae were added to the tanks, the water inflow was reduced to increase their residence time (Nakajima and Takeuchi, 2008). *C. scaura* were collected from the bryozoan *Bugula neritina* in Cádiz harbor, southern Spain (36° 32′ 28.04″ N–6° 17′ 00.35″ W). The individuals were isolated from the bryozoans and were transported with aeration together with some bryozoan colonies to the experimental station. Caine (1978) observed that caprellid species living on algae and hydroids require highly ramified substrates with small diameters in most branches to allow caprellid pereopods to encircle them. Inside each tank, 3 different plastic meshes of 30 × 50 cm were used as artificial substratum for the caprellids. The first mesh (S1) was folded on itself making a ball, the second one (S2) was also folded but compacted and with a smaller pore diameter, and the third one (S3) was placed in an upright position without folding, making better use of the space in the tank (Fig. 1). Six replicates of each mesh were placed in each tank. At the commencement of the study, 125 females and 125 males were added to each tank. Three months after the introduction of the caprellids to the tank, the plastic meshes containing caprellids were recovered individually and fixed in 80% ethanol. All specimens were sorted carefully from the mesh and counted. Sex was determined and maturity stages were classified based on the development of oostegites. Photomicrographs were taken of 30 females and 30 males from each mesh and tank with a stereo microscope (Motic K-400L) and measures of total body length were taken using imaging software (Scion Image Alpha 4.0.3.2, Scion Corporation). The number of eggs in ovigerous females with brood pouch completely closed was counted using a compound microscope (Leica CM E, Leica Microsystems).

2.1. Statistical analyses

All data were expressed as mean ± SE (standard error). To test for significance of differences among meshes in the total number of individuals, the number of mature and immature males and females, juveniles, sex ratio and body length of males and females, a two-way ANOVA was used (Underwood, 1981), which incorporated the following factors: (i) "Substrate" (fixed) with three levels: compact (S1), more compact (S2) and unfolded (S3); and (ii) "Tanks" (orthogonal and random) with three levels: tank 1, tank 2 and tank 3. For each substrate and tank, the experiment was replicated six times. Prior to carrying out the ANOVA, the data were tested for homogeneity of variance using Cochran's C test (Cochran, 1951). Data that did not meet the homogeneity of variance were transformed previously with sqrt(x + 1) and, if treatment variances were still heterogeneous, data were transformed by ln(x + 1) prior to analysis (Underwood, 1997). When the homogeneity of variance test failed even after transformation, untransformed data were analyzed, as ANOVA is a robust statistical test and is relatively unaffected by heterogeneity of variances, particularly in balanced experiments (Underwood, 1997). To reduce type I error, the level of probability used to detect significance was fixed to 0.01. When ANOVA indicated a significant difference for a given factor, the source of difference was identified using Student–Newman–Keuls (SNK) tests (Underwood, 1981). The model for this analysis was: X = Mean + Su + Ta + Su × Ta + Res, where Su = substrate, Ta = tank and Res = residual.

To test whether the number of eggs in ovigerous females differed significantly between the morphological different meshes employed, one-way ANOVA was used, after verifying normality using the Kolmogorov−Smirnov test, and the homogeneity of variances using Cochran's C test. Two-way ANOVA was impossible to perform considering that during the handling of the caprellid samples a lot of females had their brood pouch opened, which made it difficult to find an enough number of reliable amount of eggs for each treatment in each tank. The possibility of a correlation between the female body length and the number of eggs/embryos presented in the brood pouch was examined using Pearson's correlation coefficient.

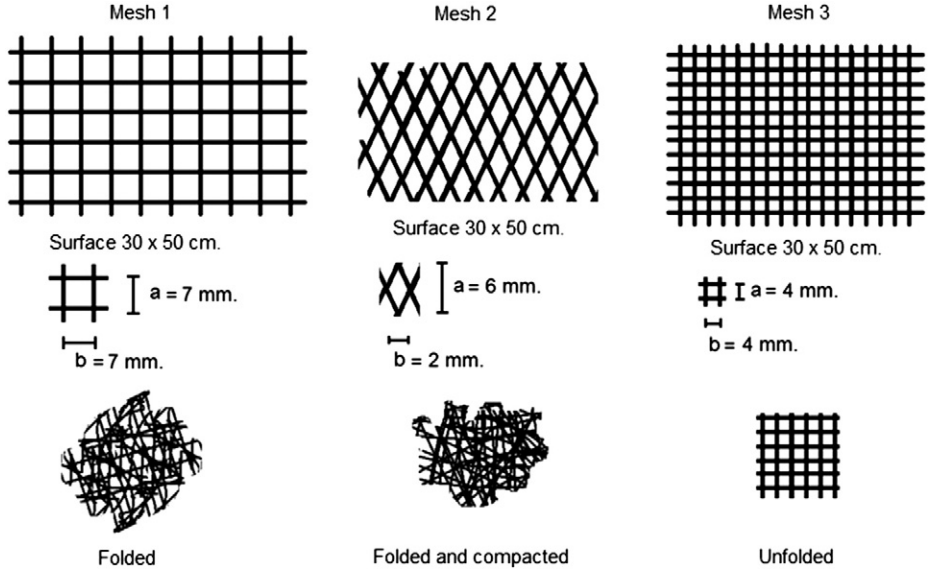

Fig. 1. Illustration of the different plastic meshes employed. N = 6 per tank. Mesh 1: folded upon itself making a ball. Mesh 2: folded on itself in a circular shape but with a greater degree of compaction. Mesh 3: held vertically without any degree of compaction.