Growth and distribution of *Solenocera membranacea* (Risso, 1816) (Decapoda, Dendrobranchiata) in the northwestern Mediterranean Sea*

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**SUMMARY:** The shrimp *Solenocera membranacea* occurs on muddy and sandy-muddy bottoms on the continental shelf and slope of the Mediterranean and northeastern Atlantic. Its main concentrations are localised on the upper slope (200-500 m). A significant trend was found in both male and female sizes to increase with increasing depth. This species shows a marked sexual size dimorphism. Sizes of males ranged between 11 and 21 mm carapace length, whereas females ranged between 10 and 30 mm. Cohort analysis of the size frequency distributions suggests the occurrence of two recruitment periods in the study area in a year. The method of Bhattacharya was used to estimate the number and mean size of each normally distributed group of sizes within each quarterly polymodal size frequency distribution. The von Bertalanffy growth parameters have also been estimated. The growth patterns are different for the two sexes. The maximum asymptotic length is markedly higher in females. The growth coefficient shows intermediate characteristics between those of shallow-water and deep-sea penaeid shrimps.

**Key words:** Growth, distribution, *Solenocera membranacea*, northwestern Mediterranean.

**RESUMEN:** CARACTERÍSTICAS DEL CRECIMIENTO Y DISTRIBUCIÓN DE *Solenocera membranacea* (Risso, 1816) (Decapoda, Dendrobranchiata) EN EL MEDITERRÁNEO NOROCCIDENTAL. — *Solenocera membranacea* es un decápodo dendrobranchiático presente en fondos fangosos y fangosos—arenosos de la plataforma y talud en el Mediterráneo y Atlántico noroeste. Las principales abundancias se han localizado en los fondos del talud superior (200-500 m). La distribución de las tallas en función de la profundidad presenta una tendencia al aumento de la talla con la profundidad. La especie presenta un marcado dimorfismo sexual de tallas. Las tallas de los machos oscilaban entre 11 y 21 mm de longitud de cefalotórax, mientras que las de las hembras oscilaban entre 10 y 30 mm. El seguimiento de las cohortes obtenidas a partir de las frecuencias de talla, sugiere la existencia de dos periodos de reclutamiento en la zona estudiada a lo largo de un año. Se ha utilizado el método de Bhattacharya para estimar el número y talla media de cada grupo de tallas distribuido normalmente en las distribuciones trimestrales de frecuencias de tallas. Se han estimado los parámetros de crecimiento de la ecuación de von Bertalanffy. Las partes de crecimiento son distintas para los dos sexos. La talla máxima asintótica es notablemente superior en las hembras. La tasa de crecimiento presenta características intermedias entre las obtenidas para penaeidos litorales y de gran profundidad.

**Palabras clave:** Crecimiento, distribución, *Solenocera membranacea*, Mediterráneo noroocidental.

**INTRODUCTION**

*Solenocera membranacea* (Risso, 1816) is a dendrobranchiate shrimp occurring on muddy and sandy-muddy bottoms on the shelf and upper slope in the Mediterranean and northeastern Atlantic (Zari-

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**QUIEY-ÁL VAREZ, 1968; ABELLÓ et al., 1988**, and constitutes an important by-catch of the demersal fishery in the study area. It is often captured together with hake *Merluccius merluccius*, monkfish *Lophius* spp. and Norway lobster *Nephrops norvegicus*. Its population densities indicate an important role within the bentthic ecosystem. Not much attention however has been given to the study of its fishery, nor to its biology and ecology (Heegaard, 1967, 1972; Fro-
GLIA and GRAMITTO, 1981, 1987). There are also few studies concerning the biology and fishery of other species of the family Solenoceridae (SUKUMARAN, 1978; KAGWADE, 1980; SUSEELAN et al., 1982; DUTT and RAMASESHAIKL, 1986; DESEMUCK, 1988). Another congeneric species, Solenocera indica, is found in the eastern Mediterranean, an immigrant from the Red Sea (ABDEL-RAZEK et al., 1981), but does not seem to be of fishery interest.

This investigation was undertaken to provide information on the population structure and distribution patterns of Solenocera membranacea in the western Mediterranean, as well as to study the growth characteristics of this species in the study area based on time series analysis of size frequency distributions.

MATERIAL AND METHODS

Data were obtained from a total of 185 trawls performed quarterly on muddy and sandy-muddy bottoms off the Catalan coast between Cape Creus and the Ebre delta, using fishing trawlers in 1981-83. The trawl net was equipped with a codend cover of 9 mm mesh size (4.5 mm side). All trawls were performed during the day. They had a mean duration of two hours. The weight and number of individuals caught was standardized to number of individuals (ind/h) and grammes (g/h) per hour trawled. The mean trawling depth was used to assign each trawl to a depth.

All individuals captured, or a representative sample, were sexed and measured. Carapace length (CL) was taken in mm from the right orbital margin to the mid posterior edge of the carapace.

The BHATTACHARYA (1967) method was applied to the quarterly size distributions by sex to identify the number and mean sizes of the different normally-distributed size groups (cohorts) cooccurring in the polymodal distributions. The parameters of the von Bertalanffy growth equation \( L_t \) and \( K \) were estimated for each sex by running the program ELEFAN (GAYANILLO et al., 1988) on the overall size distribution.

RESULTS

Bathymetric distribution and abundance

Solenocera membranacea occurred in a total of 91 samples in a depth range of 16-871 m. The highest concentrations were on the muddy bottoms of the upper slope, especially at depths between 200 and 500 m (Fig. 1). In this depth range, densities usually varied between 50 and 250 ind/h. Values higher than 500 ind/h were occasionally found. The biomass distribution follows the same pattern (Fig. 1). The shallowest occurrences of this species took place especially in the area around the Ebre delta at depths of around 20-30 m (the shallowest being 16 m).

Size distribution by depth

In both males and females a significant trend (p<0.001) was found for size to increase with increasing depth (Figs. 2 and 3). The sizes that form the bulk of the population (15-25 mm CL) are however found within the whole bathymetric range of the species.

Growth characteristics

Solenocera membranacea shows a marked sexual dimorphism of sizes: males ranged between 11 and 21 mm CL; females between 10 and 30 mm CL. The quarterly size frequency distributions of male and female S. membranacea are shown in Fig. 4. The sexual size dimorphism shown by this species allowed the study of the growth patterns separately for each sex.

The Bhattacharya method was used to identify the different normally-distributed size groups in the
quarterly polymodal distributions for each sex. The mean size of every normal distribution identified is shown in Table 1. Four normally distributed size groups have been identified in females: around 12, 18, 22 and 26 mm CL. In males, only two normally distributed size classes have been detected: around 13 and 17 mm CL.

The analysis of the size frequency distributions (Fig. 4) shows that in both males and females, recruitment takes place mainly in summer and winter (July and February samples). Two recruitment periods accordingly seem to occur. Sizes smaller than 15 mm were however found throughout the year. The follow-up of the mean sizes through time, taking into account the occurrence of two recruitment periods in a year, shows a maximum expected life-span of around one and a half years for each cohort. Thus, during the two studied years, between three and four
Fig. 4. — Quarterly size frequency distributions of male and female Solenocera membranacea in the northwestern Mediterranean Sea (1981-82).

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modes can be identified, depending on the occurrence of recruitment to the fishery and the disappearance of the oldest size classes.

The values obtained in the estimation of the von Bertalanffy growth parameters suggest rapid growth for both sexes. The estimated asymptotic size for females (31.5 mm) is much larger than for males (24.0 mm). The growth coefficients, $K$, are rather similar in both sexes (0.6 for females and 0.5 for males).

**DISCUSSION**

*Solenocera membranacea* is one of the most important decapod crustacean species of the upper slope, in both total number of individuals and biomass, and can be considered one of the dominant nektobenthic species of the upper slope community (ABELLO et al., 1988). Off the north and north-west coast of Spain in the Atlantic Ocean, *S. membranacea* also shows its greatest densities at depths higher than 200 m, especially between 300-500 m, but is also present, as in the Mediterranean Sea, on the continental shelf (GONZÁLEZ-GURRIARAN and OLASO, 1987; OLASO, 1990). Its distribution indicates a high affinity for muddy bottoms (GONZÁLEZ-GURRIARAN and OLASO, 1987; ABELLÓ et al., 1988), as in other congeneric species like *Solenocera australiana* (SOMERS, 1987).

*Solenocera membranacea* shows a marked circadian activity pattern, burying in the mud during the day and emerging at night (HEEGAAARD, 1967, 1972; FROGLIA and GRAMITTO, 1987). The characteristics of the present samplings do not accordingly allow us to estimate the actual densities of the species, since all the trawls were performed during day-time hours. They do however allow us to estimate the relative abundance between the different depth strata sampled.

Size distribution data indicate that size increases with depth, and that the main habitat of the species is the upper continental slope, especially at depths between about 200 and 500 m. A somewhat similar distribution is also shown by the upper-slope penaeid shrimp *Parapenaeus longirostris* (ARDIZZONE et al., 1990).

The comparison of the present size frequency distributions with those of the shrimps caught in the Adriatic Sea (FROGLIA and GRAMITTO, 1987) shows that both females and males in the western Mediterranean reach larger sizes than those of the Adriatic, even though they do not reach the maximum size found by HEEGAAARD (1967, 1972) in the Gulf of Naples.

The growth coefficients estimated for *Solenocera membranacea* show intermediate values between those of shallow-water penaeid like *Metapenaeus spp.*, *Penaeus spp.* and *Trachypeneaus* (PAULY et al., 1984) and deep-water penaeid like *Artemia antennata* (SARDA and DEMESTRE, 1987). *Parapenaeus longirostris*, an upper-slope penaeid like *Solenocera membranacea* also shows values of the growth coefficient (RIBEIRO-CASTALHO and ARROBAS, 1987; ARDIZZONE et al., 1990) somewhat intermediate between shallow and deep-water species.

The lack of knowledge of the reproductive biology of *Solenocera membranacea* does not allow us to accurately estimate the period of reproduction and spawning. Maximum larval densities are found at the end of spring in the study area (FUSTE, 1982). The follow-up of the modal classes in the size frequency distributions shows, however, a recruitment of young individuals to the fishery twice a year: at the beginning of winter and at the end of spring — beginning of summer. Two cohorts can be detected once the individuals between 10 and 14 mm CL are properly caught by the trawling gear. This is in agreement with the statements of FROGLIA and GRAMITTO (1987) about the occurrence of two spawnsings per year, the main one at the end of spring, and another at the beginning of winter. Females reach larger maximum sizes than males, a fact commonly found in most Dendrobranchiata.

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<th>TABLE 1. – Mean values of the normally distributed size classes identified in each polynomial size frequency distribution</th>
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