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Biological aspects of *Medorippe lanata* (Linnaeus, 1767) (Brachyura: Dorippidae) from the eastern Ligurian Sea (western Mediterranean)

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Abstract

The aim of the present study is to investigate the demographic structure and to identify some aspects of the biology of an exploited population of *Medorippe lanata* (Brachyura: Dorippidae) in the eastern Ligurian Sea, western Mediterranean. 1364 specimens (639 males and 725 females) of *M. lanata* were collected on a monthly basis from January to December 2001, in a wide area of the eastern Ligurian Sea usually exploited by the Viareggio 'rapido' trawl fleet. *M. lanata* represented an important fraction of the discard, both in weight and in number of individuals. Maximum abundance of this species occurred in late summer-early autumn (up to 3369 ind. km^{-2} and 50.6 kg km^{-2} in August). The overall females:males sex-ratio was 1.13:1, while the monthly sex-ratio did not differ statistically from 1:1 in all months, except in September and October, when females significantly outnumbered males. The sampled population was composed of two cohorts from November to April. Sizes ranged from 10 to 29 mm carapace length (CL) for females and from 9 to 29 mm CL for males. The von Bertalanffy growth curve, computed for both sexes, gave a higher growth rate in males than in females. Recently moulted males and females were observed throughout the year, except in summer, when the highest number of ovigerous females was present. Females with external eggs were collected from March to November, with peaks in August and September. The monthly evolution of the ovarian maturity stages showed no clear temporal trend. At 21 mm CL, 50% of females were ovigerous or showed macroscopically mature ovaries. According to the dimorphism in chelae size, the presence of adult males (post-puberty stage) was observed all year round, from 18 to 29 mm CL, without evident temporal trends.

Introduction

The hairy crab *Medorippe lanata* (Linnaeus, 1767) is distributed in the eastern Atlantic Ocean and in the Mediterranean Sea (Manning & Holthuis, 1981), on sandy and muddy-sandy bottoms from 9 to 952 m (d'Udekem d'Acoz, 1999), but most abundantly between 20 and 100 m depth (Zariquiey Alvarez, 1968; Abelló et al., 1988b). It is a benthic crab distributed on soft bottoms of the Mediterranean continental shelf (Abelló et al., 1988b), belonging to the demersal assemblages currently exploited by trawling (Biagi et al., 2002). *Medorippe lanata* is devoid of commercial interest and is habitually discarded by the Mediterranean trawlers (Carbonell et al., 1997; Fabi & Sartor, 2002).

Classical approaches based on single species evaluation are often found to be inadequate in providing reliable information for a correct management of many fisheries. For this reason, a more holistic approach designed to gather information at the ecosystem level is needed (Caddy & Sharp,

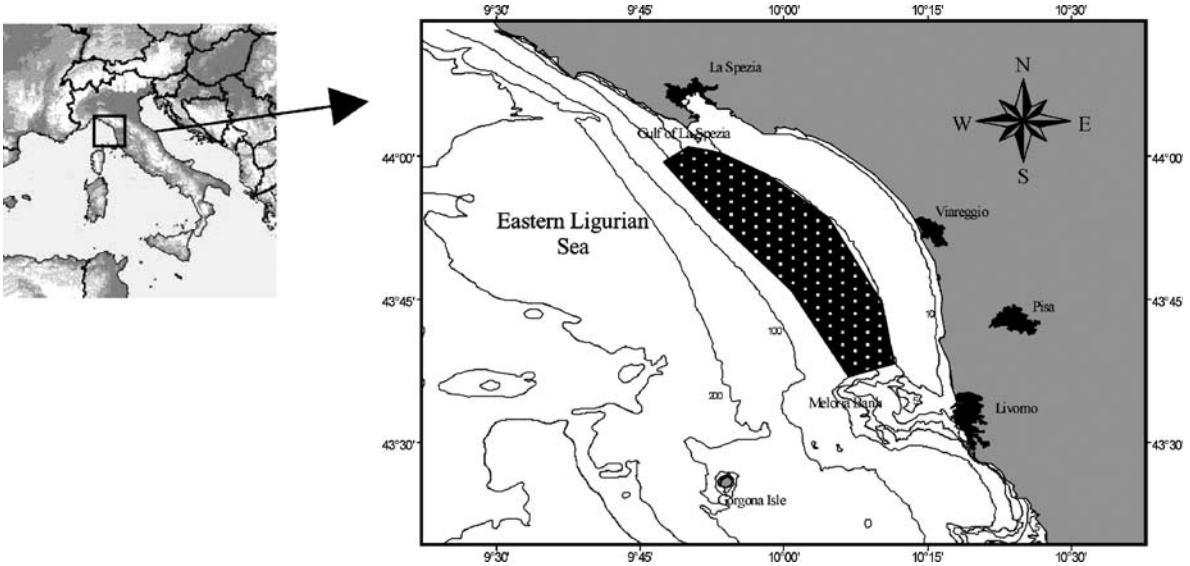

Figure 1. Investigated area, represented by the fishing grounds of the 'rapido' trawl fleet of Viareggio (shaded area).

1986; Brugge & Holden, 1991). In this context, studies designed to increase the knowledge of biology and ecology of species belonging to by-catch and discard have recently been added to the classical investigations focused only on the target species (Alverson et al., 1994; Gislason, 1994; Crowder & Murawski, 1998).

Despite the high occurrence and abundance of *M. lanata* on the continental shelf soft bottoms, only scanty information is available for this species, in particular concerning its reproductive biology and population dynamic. The aim of the present study, performed in the eastern Ligurian Sea (western Mediterranean), was to characterise the demographic structure of an exploited population of *M. lanata* and to identify several peculiar aspects of its life cycle.

Materials and methods

The study area is located in the eastern Ligurian Sea, on fishing grounds generally utilised by the Viareggio 'rapido' trawl fleet. It consists of a wide zone with muddy or sandy-muddy bottoms, comprised between the Meloria Bank to the south and the Gulf of La Spezia to the north (Fig. 1). The area, located between 8 and 12 miles from the coast, extends over a surface of about 800 km^2; the depth range varies between 20 and 60 m. This zone is strongly influenced by the supplies of the rivers Magra (North), Serchio and Arno (South), which carry notable amounts of organic matter and sediments, especially in fall and winter.

Samples of *M. lanata* were collected on a monthly basis during 2001 in the framework of a research project funded by the European Community focused on the 'rapido' trawl fishery characterisation (Fabi & Sartor, 2002). Data collection was performed by scientific personnel on board of a commercial vessel of the fleet of Viareggio, during habitual fishing operations. The 'rapido' trawl is a modified beam trawl with rigid mouth and iron teeth along the lower part, typically used in Italy, above all in northern and central Adriatic Sea (Giovanardi et al., 1998; Pranovi et al., 2001; Fabi & Sartor, 2002). This gear is mainly targeted to exploit flatfishes (*Solea* spp., *Psetta maxima* (Linnaeus, 1758) and *Scophthalmus rhombus* (Linnaeus, 1758)) and scallops (*Pecten jacobaeus* (Linnaeus, 1758) and *Aequipecten opercularis* (Linnaeus, 1758)). At present, in the eastern Ligurian Sea, the 'rapido' trawl is employed by only two vessels of the Viareggio fleet. The fishing boat used for sampling had the following characteristics: overall length of 18.4 m, gross tonnage of 26 and engine power of 206 kW. Two 'rapido' trawls were simultaneously towed at

a speed of 9–10 km h^{-1}; each haul lasted about one hour and half. Each gear was equipped with a 4.8 m-long net, with a codend of 39.7 mm mesh size (stretched). Fishing activity was carried out for about 12 h per day, performing a total of 7–8 hauls.

During the period studied, data of 91 commercial hauls were collected. The species composition of each haul was analysed according to the retained and discarded fractions (Alverson et al., 1994); in addition, data on number of individuals and total weight (kg) of the catch of *M. lanata* were collected. Catch data were successively standardised as density and biomass indices (number of individuals km^{-2} and kg km^{-2}, respectively); the area swept was estimated by taking into account the speed and the duration of each haul and the horizontal opening of the gears. These indices were expressed as mean monthly values (with the corresponding standard error, SE).

On each specimen of *M. lanata*, the carapace length (CL) to the next lower 1 mm and sex were recorded. For females, three maturity stages were assigned on the basis of macroscopic analysis of the ovaries, using the scales available for brachyuran crabs (Ryan, 1967; Haefner, 1977; Choy, 1988; Erdman & Blake, 1988), modified as follow:

Stage 1 – Immature or resting gonads: the ovary is small and thin, whitish or translucent;

Stage 2 – Maturing: the ovary begins to develop and swell; it is clearly visible and pale yellow–orange;

Stage 3 – Mature: the gonads are swollen and occupy most of the dorsal part of the carapace cavity; the ovary is dark orange.

In addition, the number of ovigerous females was recorded on a monthly basis.

Maturity of males was assessed by observing the occurrence of heterochelid specimens (right chela clearly bigger than the left one) in the sampled population. According to Mori (1986a), this sexual dimorphism can be referable to different maturity stages: the homochelid situation corresponds to the pre-puberty phase (juveniles and subadults), the heterochelid situation to the post-puberty one (adults). The right chela palm width was measured (to 0.1 mm); a linear regression between size of the chela and CL was computed on Log-transformed data, in order to study the relative growth as a function of the morphological maturity stages.

Finally, the number of recently moulted individuals and the possible presence of specimens carrying parasites among the eggs or in the branchial chambers were investigated.

Sex ratio (f/m + f) was computed monthly and for each 1 mm size class; this analysis was not performed for samples lower than 30 specimens. Statistical significance of the deviations from 1:1 of the sex-ratio was analysed using the Chi-square test.

Monthly size frequency distributions (SFDs) of males and females were calculated using a 2 mm CL interval. The von Bertalanffy absolute growth parameters were estimated by the analysis of the modal progression of SFDs, using the FISAT routine (Gayanilo et al., 1995).

Results

Catch composition

In the studied period, 53.5% of the biomass caught by 'rapido' trawl was represented by commercial species (of which 69.1% fishes, 5.4% crustaceans and 25.5% molluscs) and 46.5% by discarded species (of which 1.8% fishes, 16.5% crustaceans, 63.2% molluscs, 17.9% echinoderms and 0.6% others). The most important discarded species, both in weight and number of individuals, were the gastropods *Turritella communis* Risso, 1826 and *Aporrhais pespelecani* (Linnaeus, 1758) and the crabs *M. lanata, Liocarcinus depurator* (Linnaeus, 1758) and *Goneplax rhomboids* (Linnaeus, 1758). Depending on the season, *M. lanata*, represented 6 to 77% in weight and 4 to 69% in number of the total crustacean discard.

The monthly trend of *M. lanata* density and biomass indices showed a clear temporal pattern, with a marked peak in late summer–early autumn (3369 ± 843.7 ind. km^{-2} and 50.6 ± 12.6 kg km^{-2} in August, 2890 ± 568.1 ind. km^{-2} and 43.5 ± 9.0 kg km^{-2} in September) (Fig. 2). In the subsequent months, the values were considerably lower with the only exception recorded in March, mainly concerning the density index.

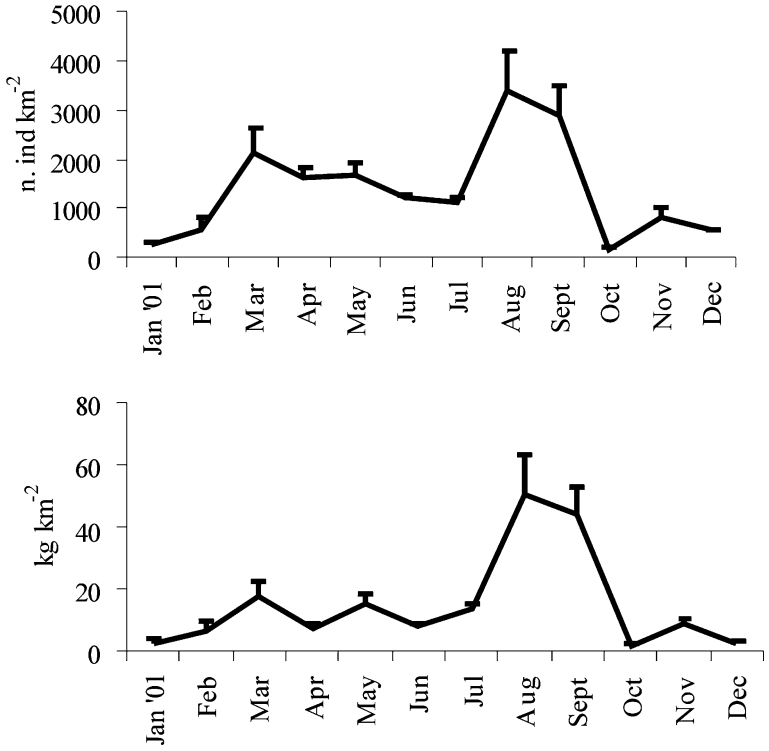

Figure 2. Monthly density and biomass indices of *M. lanata* obtained in the studied period.

Sex ratio

During the monthly sampling at sea, a total of 1364 specimens (639 males and 725 females) were studied. Sizes ranged from 10 to 29 mm CL for females and from 9 to 29 mm CL for males. The overall sex ratio observed (1.13:1) was biased toward females (Chi square Test = 5.42, $p < 0.05$). The monthly sex ratio was not statistically different from 1:1, except in September and October ($p < 0.001$ and $p < 0.05$, respectively), when females significantly outnumbered males. The sex ratio favoured males in the smallest size classes (≤20 mm CL) and females in the largest classes (≥22 mm CL) (Fig. 3).

Demographic structure and growth parameters

The monthly mean sizes of females were higher than those of males ($p < 0.05$, Student's *t*-test) and showed a peak in summer (August and September, with 23.55 ± 0.05 mm CL and 23.64 ± 0.05 mm CL, respectively).

From the analysis of SFDs (Fig. 4), at least two cohorts were singled out and their evolution was followed during the studied period. In January the sampled population was composed of a little amount of small individuals (10–12 mm CL) and of a second demographic component, more abundant, represented by larger specimens (16–26 mm CL); in the following months the first cohort showed a constant increase in size and abundance, becoming dominant in the April and May samples, while the second disappeared from the catch in June. In November, other small

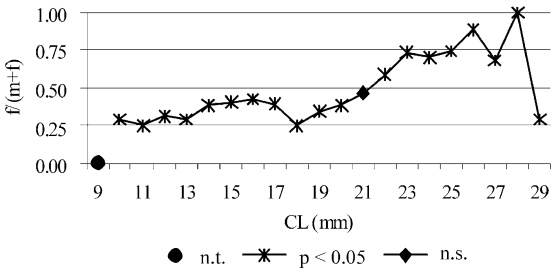

Figure 3. Sex-ratio in relation to carapace length (CL). (n.t. = not testable; n.s. = not significant).

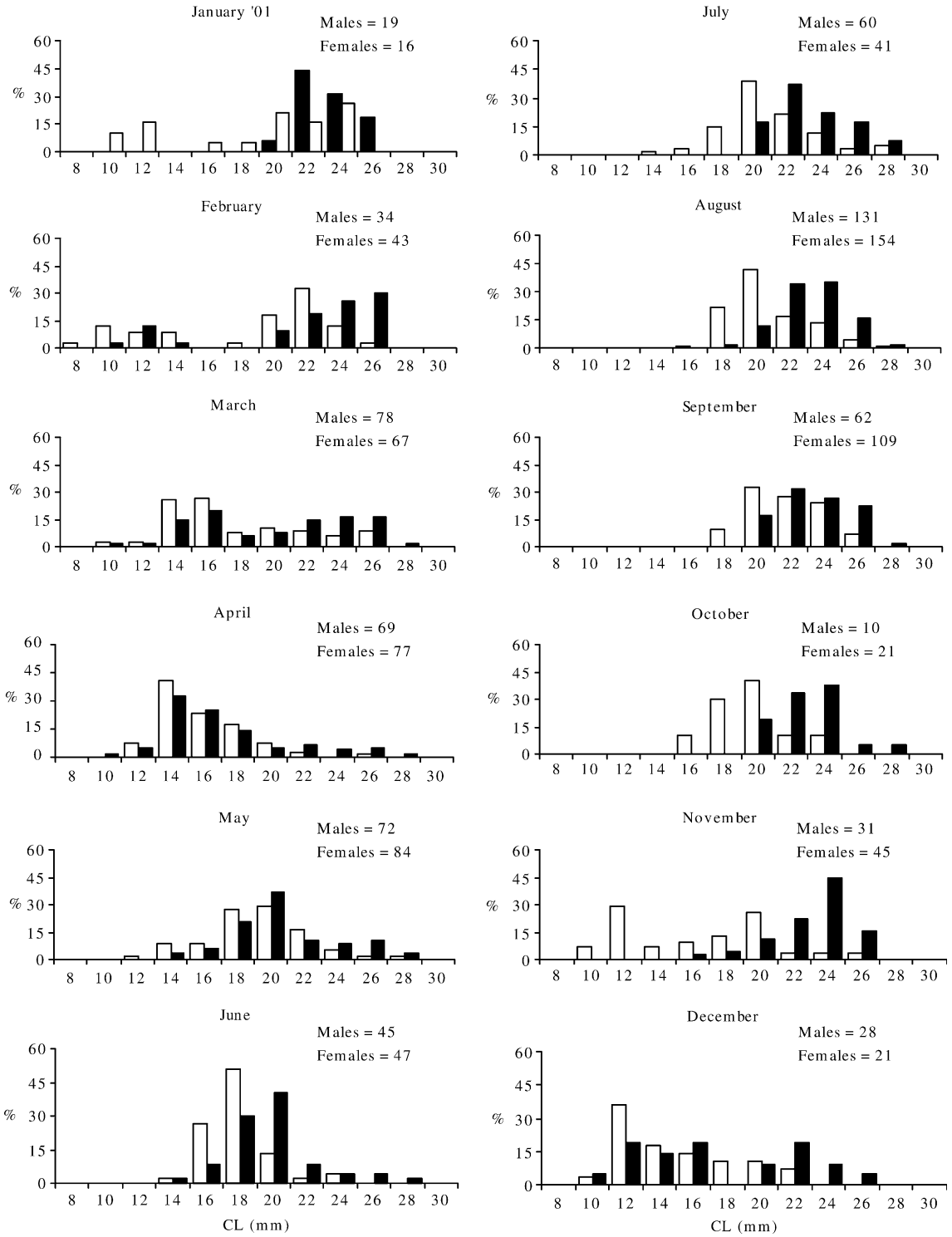

Figure 4. Monthly size frequency distributions for males (white) and females (black) of *M. lanata*.

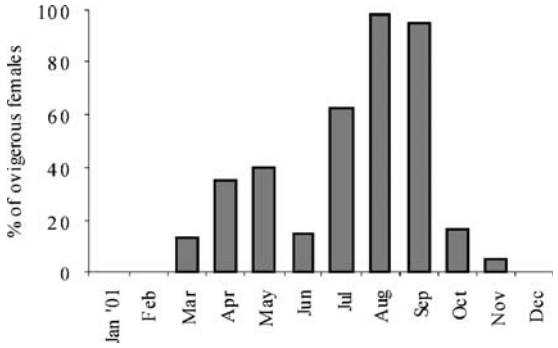

Figure 5. Monthly percentages of ovigerous females related to the total number of females collected each month.

specimens (from 10 to 14 mm CL) appeared in the catch, subsequently constituting the majority of the catch in December.

The estimation of the von Bertalanffy growth parameters gave the following values: $CL_\infty = 33.5$ mm and $K = 1.050$ for females; $CL_\infty = 31.1$ mm and $K = 1.575$ for males.

Maturity aspects

Ovigerous females were observed from 18 to 29 mm CL; from 22 mm CL they represented about 60% of the total females collected. The monthly percentage of ovigerous females in relation to the total number of females showed a clear temporal trend (Fig. 5): females carrying eggs were collected from March to November, with high values recorded from July to September, showing a peak of 98.6% in August. On the other hand, it proved more difficult to single out a clear temporal trend from the monthly evolution of the ovarian maturity stages (Fig. 6). Females with mature ovaries were recorded in almost all months (except June), but they didn't show a temporal pattern. They were observed from 17 to 29 mm CL; at a size of 22 mm CL they represented about 30% of the collected females, and from 28 mm CL they were about 45%.

Taking into account the females with ovaries in stage 3 (mature) plus the ovigerous ones in stages 1 and 2 (immature-resting and maturing), an indication of females that have reached maturity can be obtained. In this way, at 21 mm CL about 50% of the females of our sample was mature and this percentage reached 80% for females greater than 25 mm CL.

Males showed an evident dimorphism in the size of right and left chela during their life span. Two different morphologic patterns were observed during the study: males with both chelae similar in shape and size (homochelid males, juveniles and subadults) and males with right chela typically enlarged and markedly bigger than the left one (heterochelid males, adults). Two different slopes were observed when the regression analysis between CL and right chela palm width was computed, confirming these two different morphological phases in males (Fig. 7). The presence of homochelid (from 12 to 25 mm CL) and heterochelid (from 18 to 29 mm CL) males was observed throughout the year, without

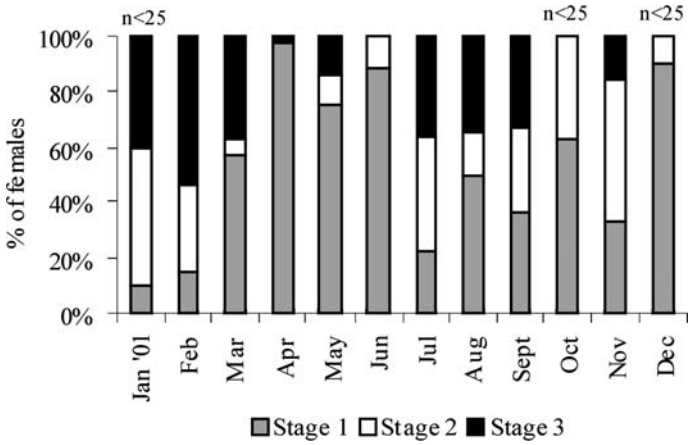

Figure 6. Monthly percentages of females in the three different maturity stages. (n = number of specimens; stage 1: immature or resting; stage 2: maturing; stage 3: mature).

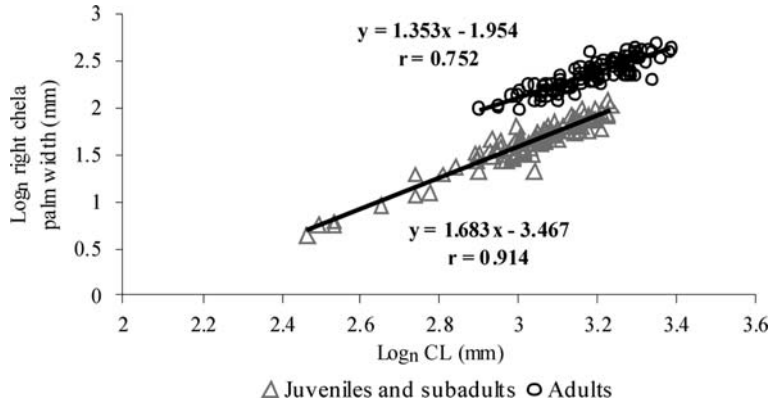

Figure 7. Relationship between carapace length (CL) and right chela palm width in males of *M. lanata*. (Log_n transformed data; r = correlation coefficient).

a clear temporal trend. Adult specimens represented from 2.1 to 34.3% of the males sampled each month.

Worthy of note was the finding, in September, of an adult male of 25 mm CL with both chelae enlarged (right and left chela palm width of 11.9 and 11.6 mm, respectively).

Moulting

Recently moulted males and females were observed in most of the sampled months, except from July to October. The percentage of these individuals was in general low, ranging from 6 to 25% of the sampled population, apart from December when a greater proportion (42%) was observed. All females with soft carapace had macroscopically immature ovaries (stage 1) and did not carry external eggs. No evident differences in the occurrence of recently moulted specimens were detected between males and females or in function of the body size.

Presence of parasites

No nemertean predators were found among the eggs carried by ovigerous females, nor were iphitimid polychaete parasites observed in the branchial chamber of both sexes.

Discussion and conclusions

The results of this study highlighted the importance of *M. lanata* in the discarded fraction of the 'rapido' trawl fishery of the eastern Ligurian Sea. In the area studied, abundance and biomass of the species were highest in summer, when the population was mostly constituted of adult specimens. The depth range investigated in the present study (20–60 m) is narrower than that generally reported for this species, mostly found between 20 and 100 m (Abelló et al., 1988b); thus, the temporal peaks in the abundance detected in this study could be explained by the seasonal spatial distribution pattern of the species.

The overall annual reproductive cycle of *M. lanata* described in this study is not markedly different from that recorded by Mori (1986a) in the Gulf of Genoa (western Ligurian Sea). The highest presence of ovigerous females detected in summer is in agreement with the findings of Lo Bianco (1909) in the Gulf of Naples, Pesta (1918) in the Adriatic Sea and Zariquiey Alvarez (1968) in Spain.

In the western Ligurian Sea, small specimens of *M. lanata* were collected from November to May (Mori 1986a), confirming our results that recruitment to the adult population probably occurs during this period. This finding substantially agrees with the high presence of ovigerous females from July to September and indirectly confirms the observations of Lo Bianco (1909) on the presence

of pelagic larvae from September to March in the Gulf of Naples.

Males of *M. lanata* are homochelid up to prepuberty, then heterochelid at the post-puberty stage (Mori, 1986a). Hartnoll (1982) explained this sexual dimorphism in terms of the greater role played by adult males in courtship, display and combats. The same morphologic pattern has also been reported for *Corystes cassivelaunus* (Pennant, 1777) (Hartnoll, 1972), *G. rhomboides* (Abellò & Sardà, 1982), *Paromola cuvieri* (Risso, 1816) (Mori, 1986b) and for many brachyuran species (Hartnoll, 1974, 1978).

The von Bertalanffy growth parameters, as well as the analysis of the modal progression of different cohorts during the period of study, identified *M. lanata* as a fast-growing species. However, the growth rate was found to be slower in females than in males, probably due to the energy losses endured by females during the maturing process (Hartnoll, 1982). This result is in agreement with data reported for other brachyurans (Fernández et al., 1991).

In females, the present study revealed an inverse relationship between the maturing process and moulting frequency: recently moulted females showed very low ovarian development, if any. Similar findings have been reported for other brachyuran crustaceans (Mori, 1987; Mori & Zunino, 1987). The temporal shift between moulting and maturation, according to the observations of Abelló (1989) on *L. depurator*, probably is a tool for the reduction of the energy cost of these two processes and for the avoidance of egg loosing. In this context, it is interesting to note that a disjunction between moulting and reproductive cycle of females is reported for many decapods; in general, the minimum percentage of moulting individuals corresponds to the maximum ratio of ovigerous females, and *vice versa* (Gonzalez-Gurriaràn, 1985; Mori & Zunino, 1987; Fernández et al., 1991).

The absence of parasites is at variance with previous studies performed on species of crabs living in similar habitats, such as *L. depurator* (Belloni & Mori, 1985; Mori & Zunino, 1987; Abelló et al., 1988a) and *P. cuvieri* (Mori, 1986b). Such differences could be explained by the different lifestyle and behaviour adopted by *M. lanata*.

The results of this study increase the information on the biology and ecology of *M. lanata*. Further investigations on this species, especially concerning trophic spectrum and post fishing mortality, are therefore advisable in order to acquire a better knowledge of the exploited species assemblage where *M. lanata* is present.

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