

Notes on the biology and growth of *Munida intermedia* (Anomura: Galatheidae) in the western Pomo pit (Adriatic Sea)

M. E. GRAMITTO and C. FROGLIA

Istituto di Ricerche sulla Pesca Marittima (Consiglio Nazionale delle Ricerche), Largo Fiera della Pesca, 60125 Ancona, Italy

(Accepted 8 May 1998)

The squat-lobster *Munida intermedia* is very common over the muddy bottoms (depth 200–256 m) of the western Pomo pit (Central Adriatic). Density estimates, obtained from a short underwater television survey, ranged from 0.2 to 0.6 individuals/m². Scientific trawling carried out in the years 1993–1994 with a small mesh net, yielded large catches of *M. intermedia*, and made possible the study of some aspects of its life history. *M. intermedia* is a gonochoric species that spawns once per year. Adult females have ripe ovaries in autumn and become ovigerous in winter. No ovigerous female was found after February. The smallest ovigerous female measured 8.5 mm carapace length, and the largest 23 mm. Fecundity is related to size and ranges between 870 and 5300 new-laid eggs per female. The reproductive season is well defined (from October to February), with a single spawning per year. Therefore, modal components in the length frequency distributions were identified with year classes and the mean lengths at age obtained were used to compute the parameters of the growth equation separately for the two sexes. The average life-span of *M. intermedia* probably does not exceed four years and males reach a slightly larger size than females (maximum carapace length: 25 mm males, 23 mm females). Sexual maturity in both sexes is reached at the end of the first year of life. A high percentage of specimens (males 9%, females 22%) had external evidence of infestation by Rhizocephala and representatives of three genera were recorded. Specimens as small as 7.5 mm carapace length were found parasitized and the highest frequencies of parasites were observed in the size range 10–14 mm.

KEYWORDS: *Munida intermedia*, Galatheidae, biology, growth, parasitism, Rhizocephala, Adriatic Sea, Mediterranean.

Introduction

The Pomo (Jabuka) pit, a depression with a maximum depth of 270 m in its eastern part, is of paramount importance for the Adriatic trawling fleet because it is the main Adriatic nursery for hake (Zupanovic and Jardas, 1986) and a rich ground for *Nephrops norvegicus* (Linnaeus) (Froglia and Gramitto, 1988).

In the last 20 years the Istituto di Ricerche sulla Pesca Marittima (IRPEM) has conducted extensive fishery investigations in the western basin of the Pomo pit. When possible, biological information was also gathered on non-commercial species commonly caught with trawl nets.

Munida intermedia A. Milne Edwards and Bouvier, 1899, ranks first in number

and second in weight among crustacean catches obtained in the western Pomo pit (Frogliá and Gramitto, 1995a). Most of the previous records of *Munida rugosa* (Fabricius, 1775) for the Pomo basin (Frogliá, 1975; Zupanovic and Jardas, 1989) actually refer to *M. intermedia*.

During a co-operative study on the biology and fishery of *Nephrops norvegicus* (1992–1994) funded by the Commission of European Communities (IMBC, UMBSM and IRPEM, 1994), the opportunity arose to collect large samples of *M. intermedia*. The present paper is based on this material and on previous unpublished data, and deals with various aspects of its biology.

The range of *M. intermedia* extends in the eastern Atlantic from 50°N to 15°N and includes the western Mediterranean and the Adriatic Sea (Rice and de Saint Laurent, 1986), in depths of 120–800 m. Because of its small size, *M. intermedia* has marginal commercial value, and its tails are seldom found in coastal Adriatic fish markets. In the world oceans, other larger-sized galatheids sustain important fisheries. Off Chile the annual catch of *Pleuroncodes monodon* (H. Milne Edwards) and *Cervimunida johni* Porter, peaked at 50,000 tons and 14,000 tons respectively in 1976 and in 1965 (Bahamonde *et al.*, 1986). Of potential fishery interest are *Munida gregaria* (Fabricius) off New Zealand (Zeldis, 1985), and *Munida quadrispina* Benedict off west Canada (Burd and Jamieson, 1988), both for meat (tails) and as food for cultured fish.

Information on the biology of the eastern Atlantic and Mediterranean *Munida* species is limited (Hartnoll *et al.*, 1992), and has been mainly concerned with parasitic castration induced by bopyrid isopods and rhizocephalan cirripedes (Attrill, 1989; Brinkmann, 1936).

Preliminary information on the reproductive biology of *M. intermedia* in the Pomo pit was published by Frogliá and Gramitto (1995b). Biological data on *M. intermedia* and other bathyal Crustacea gathered in the western Mediterranean (Catalan Sea) have been reported by Company (1995).

Material and methods

Samples of *M. intermedia* were obtained by trawling in the western part of Pomo pit (figure 1). This area is characterized by muddy bottoms in depths ranging from 200 to 256 m. During fishing operations, carried out by the RV 'S. LoBianco', an experimental gear (Unimesh Scottish prawn trawl) with a wing mesh of 22 mm (stretched) and a cod-end with a mesh of 12 mm (stretched) was used. Under standard conditions the gear had an average horizontal spread (measured between wing tips) of 23 m, and a vertical opening of 0.8 m. Vessel position was monitored with a GPS satellite-based navigation system.

Squat lobster abundance was first estimated from trawl catches by the swept area method (distance trawled \times horizontal spread of net) assuming a gear efficiency equal to 1 (Alverson and Pereira, 1969).

Density was estimated from video-tape recordings obtained in April 1994, when an underwater television survey (UTV) was attempted in order to get a fishery-independent estimate of *Nephrops norvegicus* abundance in the central Adriatic. A television camera (Osprey OE 1360) mounted on an epibenthic sledge (Chapman, 1985) was towed astern of the RV 'S. LoBianco'. The seabed was illuminated using quartz iodine lights (Hydro Products, HQ 250), and the camera mounted to view the seabed obliquely forwards of the sledge, with an estimated field of view 0.5 m

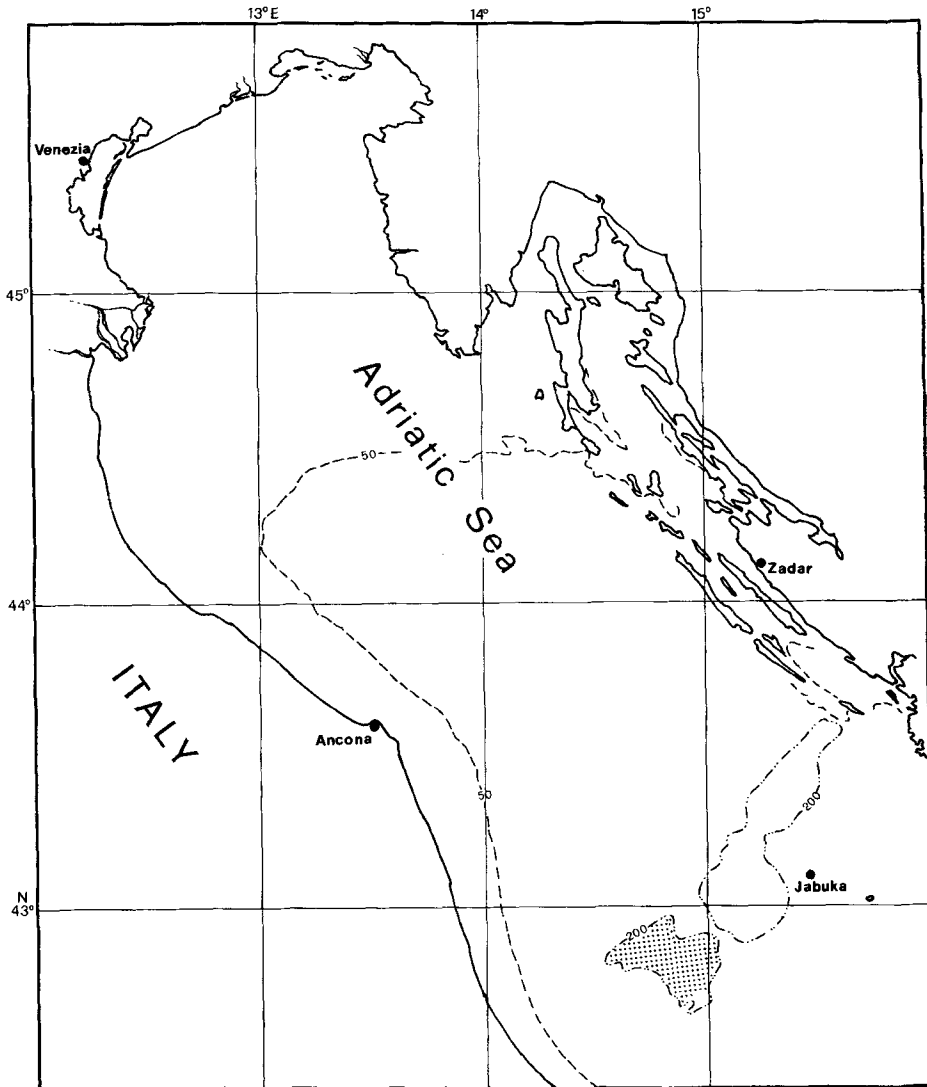


FIG. 1. Sampling area (stippled) for *Munida intermedia* in the western Pomo pit, Adriatic Sea.

wide. Due to poor weather conditions only three stations were examined in the Pomo pit (Frogliola *et al.*, in press).

Counts of *Munida* were made from timed stretches of tape, and divided by the area of seabed viewed by the camera. The area viewed was calculated from the width of camera field view and the speed of the vessel over the ground (computed from frequent position checking by GPS and Doppler log readings).

Dates of fishing trips, number of specimens of *M. intermedia* present in the 'discard' and number of specimens in the subsample examined are detailed in table 1.

For every trawl-catch, after sorting the main commercial species, the whole 'discard' was frozen and transferred to the laboratory. Here it was sorted to species

Table 1. Sampling dates, relative abundance and number of males and females in the subsamples examined in the study of growth, sex-ratio and parasite infestation of *M. intermedia* in the western Pomo pit.

Date	Catch (N/hour)		Subsample size	Males	Females
	Day	Night			
14–15 Dec 1992	730	2960	–	–	–
12 Mar 1993	2132	1503	519	205	314
19–20 May 1993	1058	2143	1349	536	813
8 Jul 1993	686	–	654	291	363
10 Aug 1993	362	1619	940	423	517
18 Jan 1994	***	–	1236	667	569
1 Feb 1994	941	–	911	509	402
15 Apr 1994	1848	–	1783	782	1001

***'discard' from a commercial trawler.

and the samples of *M. intermedia* were stored in 5% formol saline solution. Specimens used for length–weight relationship were examined before preservation.

During the reproductive season ovigerous females without evidence of egg dislodgement during capture, were immediately sorted from the catch at sea and preserved individually. Subsequently in the laboratory only females with 'new-laid' eggs (i.e. embryo without ocular pigment) were used to estimate fecundity ('realized reproduction' *sensu* Corey, 1991) by counting all the eggs in the brood.

Many specimens were infested by Rhizocephala, which were identified using the key provided by Høeg and Lützen (1985). Furthermore, some parasitized specimens of *M. intermedia* were sent to these authors to confirm identification.

Generally the infested specimens bore the externa of the parasites, but in some individuals only scars were evident. These scars were either due to loss of externa after completion of the parasite's life history (Høeg and Lützen, 1985) or to sampling and handling processes (Attrill, 1989). Such individuals were considered infested in further computations. All computations on biological parameters were done on non-parasitized specimens, in order to avoid any possible error caused by rhizocephalan infestation that can alter growth pattern (O'Brien and Van Wyk, 1985; Attrill, 1989).

Sex was determined by position of the gonopores (on coxa of third pereopod, in females, on coxa of fifth pereopod, in males). Shape of the first and second pleopods in males was used with caution, because pleopods can be morphologically altered in specimens parasitized by Rhizocephala.

Size frequency distributions were recorded separately for the two sexes in each sample. Length of specimens, measured with a dial calliper to the 0.5 mm below, is expressed as carapace length (CL) from the posterior margin of the orbit to the posterior dorsomedian edge of the carapace.

For length–weight relationship ($y = ax^b$), 192 undamaged specimens (102 males in the size range 9–24 mm CL and 90 females in the same size range) were individually measured and weighed (wet weight) to the nearest 0.1 g.

To compare growth in weight between sexes, linear regressions ($Y = A + bX$) were calculated on log-transformed data. Homogeneity of variances was verified by the Bartlett's test. Covariance analysis was then performed on regression lines, testing homogeneity of slopes and of elevations by F-test (Snedecor and Cochran, 1967). Departure from isometry ($b = 3$) was tested by t-test.

To verify the existence of significant differences of sex-ratio from 1:1, the χ^2 -test was performed on monthly samples.

Growth information was derived by splitting of the length frequency distributions in their normal components, using the 'Mix 3.0' program (MacDonald and Pitcher, 1979; MacDonald and Green, 1988). Age was computed in years, months were converted to fractions of year. The modal values of the age classes obtained by 'Mix' were then used as input data for the 'Fishparm' program (package FSAS: Saila *et al.*, 1988), which computes the parameters of the von Bertalanffy growth curve using non-linear regression analysis.

Results

Abundance estimates

M. intermedia is an epibenthic species (Frogliia and Gramitto, 1995a) and the UTV images show that it does not burrow, although it can partially hide, in the soft sediment of the western Pomo pit, thus escaping capture. As a rule *M. intermedia* was more abundant in the 'discards' from night-time hauls. Probably greater activity at night results in increased vulnerability to trawl gear. Density estimates, based on the highest trawl catch, as obtained during each cruise, ranged from 136 to 210 individuals per hectare.

The estimates obtained in April 1994 from the UTV profiles (table 2) were greater by one order of magnitude than those obtained from trawl catches, and ranged from 2000 to 6000 individuals per hectare.

On 15 April 1994, station 'Pomo58' was sampled with the trawl net immediately after completion of the UTV profile. The estimates obtained from the two methods were 150 and 5000 individuals per hectare, respectively.

Due to the small number of UTV stations (surface viewed 1120 m²) we can only roughly estimate the abundance of *M. intermedia* for the whole western Pomo pit (360 nautical square miles). Assuming an average individual weight of 4 g, the total biomass of *M. intermedia* in April 1994 is estimated somewhere between 10,000 and 30,000 tons.

Reproduction

Ovigerous females were observed from October to February (Frogliia and Gramitto, 1995b). In March, no female was found carrying eggs. This suggests a single spawning per year, with a well-characterized breeding season extending over 3–4 months.

The smallest ovigerous female (8.5 mm CL) was collected in October. The high percentage of ovigerous females observed at CL of 11 mm (over 90%) suggests that females become ovigerous at the end of the first year of life.

Newly laid eggs are turquoise and spherical, with a diameter of 0.7 mm. Fecundity

Table 2. Abundance of *M. intermedia* based on counts of individuals in video recordings of UTV profiles.

Station	Depth (m)	Area viewed (m ²)	Counts (N)	Density (ind/m ²)
Pomo 15	240	390	78	0.2
Pomo 66	204	380	228	0.6
Pomo 58	213	350	175	0.5

was obtained from 25 females, with CL ranging from 12.2 to 22.8 mm. The number of eggs varied from 870 (smallest female) to 5300 (largest one). Fecundity is correlated with female size (CL) by an exponential relationship. The regression equation (standard errors of parameters in parentheses) obtained after logarithmic transformation of data is:

$$\log \text{Eggs N} = 3.01 (\pm 0.28) \log \text{CL} - 0.23 (\pm 0.33) \quad r^2 = 0.84$$

Variations in sex-ratio and moulting frequency during the sampling period are shown in table 3. The sex-ratio does not show any significant departure from 1:1 in samples taken as a whole ($\chi^2 = 0.06$). However, if only winter months (when females are ovigerous) are considered, a statistically highly significant departure from 1:1 is evident ($\chi^2 = 72.0$, $P < 1\%$) with predominance of males in the catches. Probably, hiding behaviour is enhanced in ovigerous females which then become less vulnerable to the trawl-net.

The proportion of 'soft' specimens can provide an idea of moulting periodicity. 'Soft' specimens are animals in the first post-ecdysis stage, with exoskeleton not yet completely hardened. In males there is no clear evidence of seasonality in moulting. In females there is a single marked peak in April, and most probably adult females moult once per year, after egg hatching.

Growth

Both sexes had similar length frequency distributions, with two or three modal peaks (figure 2). The size range was wide, from 4 to 25 mm CL in males and from 5 to 23 mm in females. The smallest specimens were caught in February, the largest in January. This last sample was obtained from a commercial trawler using a large mesh (40 mm stretched) net. This fact could explain the total absence of small sizes.

Ovigerous females were observed in late autumn-early winter months. Juveniles (4-5 mm CL) appeared in February catches; therefore, larval life probably does not exceed one month. On this basis, to age the modes (year classes) detected by 'Mix' in the length frequency distributions, 1 January was assumed as the conventional birthday of *M. intermedia* in the central Adriatic Sea.

For both sexes, the mean lengths-at-age calculated by 'Mix' are given in table 4, and the theoretical growth curves are reported in figure 3, together with the growth parameters of the von Bertalanffy equation, and the maximum carapace length recorded during this investigation. Our results indicate a similar growth in the two sexes, although it is slightly faster in males after reaching sexual maturity. Lifespan seems not to exceed four years.

Table 3. Total number of non-parasitized specimens of *Munida intermedia*, sex ratio, and percentage of moulted individuals for each sex sampled each month.

	1993				1994		
	Mar	May	Jul	Aug	Jan	Feb	Apr
Non-parasitized M	194	485	265	402	627	442	687
Non-parasitized F	268	640	300	425	479	232	739
Sex-ratio (F/M)	1.38	1.32	1.13	1.06	0.76	0.52	1.08
% of soft M	2.5	2.0	3.6	2.6	0.0	2.2	2.3
% of soft F	0.7	0.5	1.6	0.2	0.0	0.0	4.6

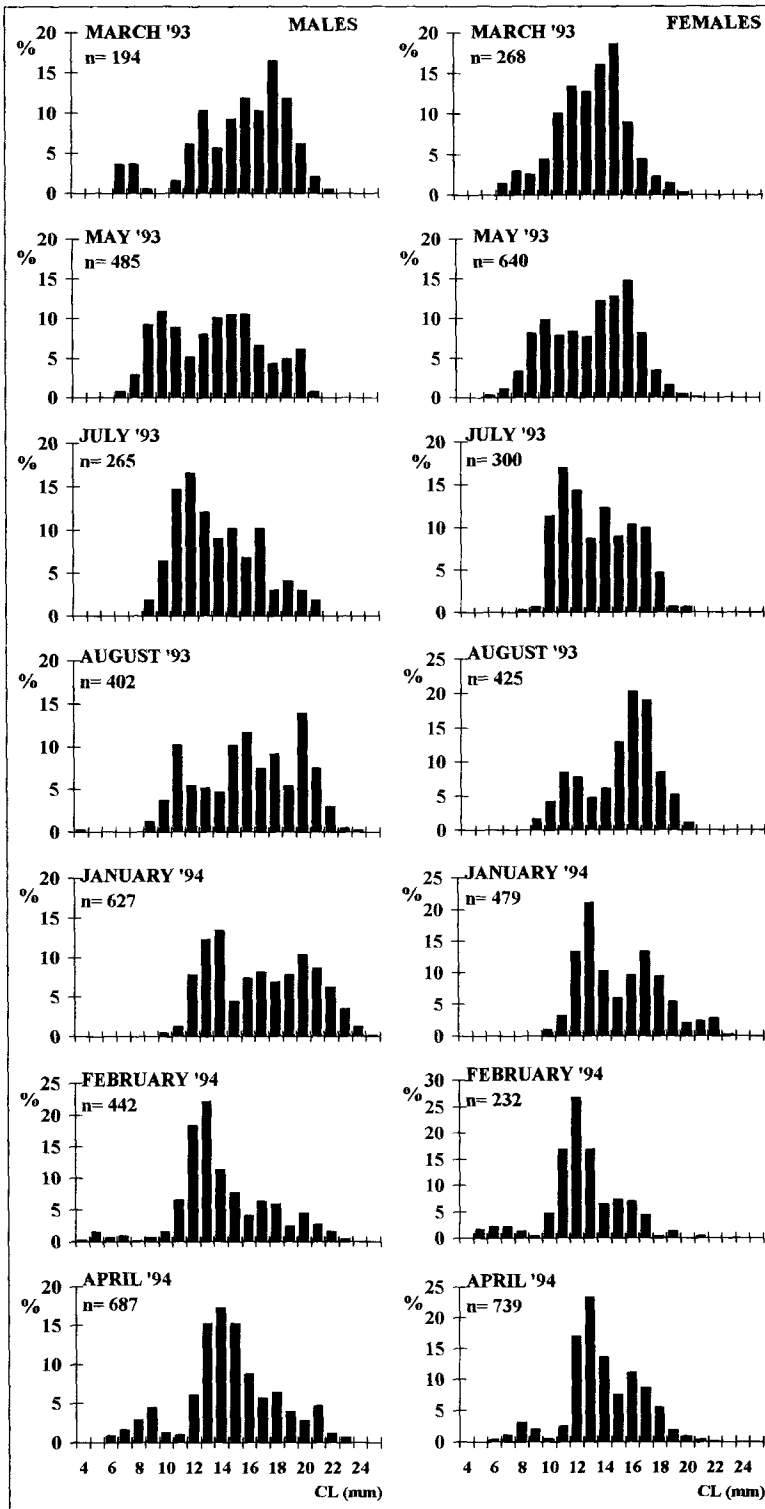
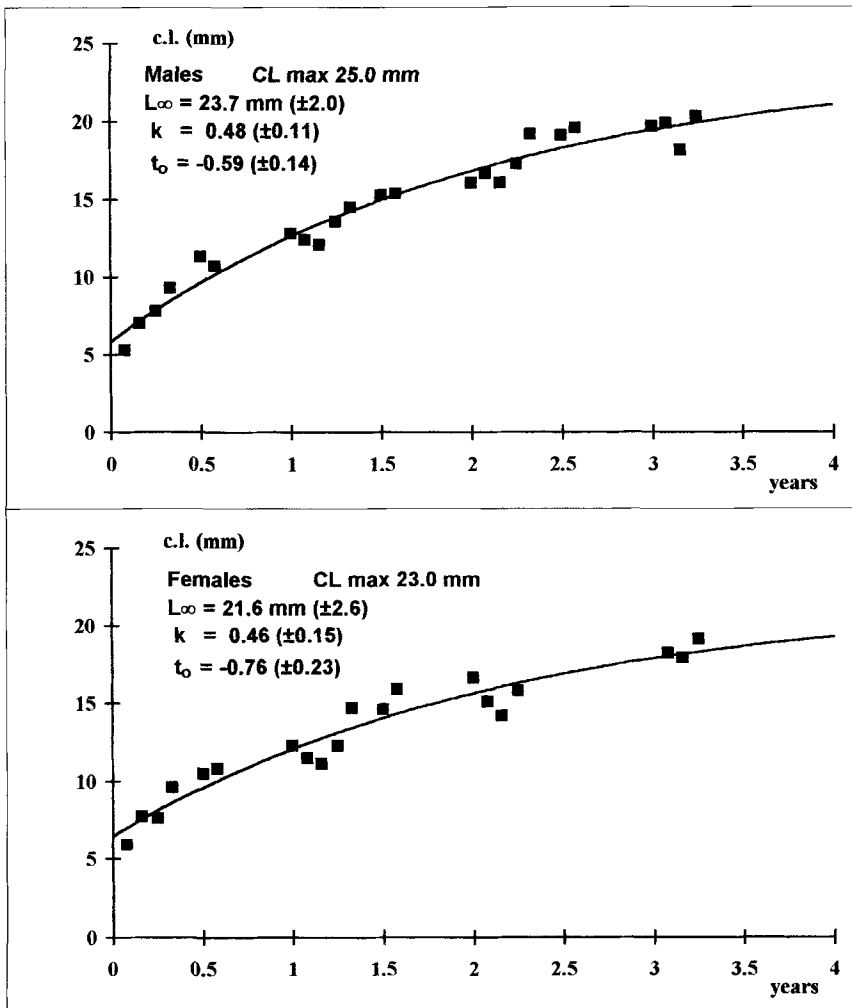


FIG. 2. Size frequency distributions of non-parasitized males and females of *Munida intermedia* used for age and growth analyses.

Table 4. Mean length-at-age (CL, mm) for the Pomo pit *M. intermedia* population obtained using MIX.

	Age	Jan	Feb	Mar	Apr	May	Jul	Aug
Males	0 ⁺		5.3	7.0	7.8	9.3	11.3	10.7
	1 ⁺	12.8	12.4	12.1	13.6	14.5	15.3	15.4
	2 ⁺	16.1	16.7	16.1	17.3	19.2	19.1	19.6
	3 ⁺	19.7	19.9	18.2	20.3			
Females	0 ⁺		5.9	7.7	7.6	9.6	10.5	10.8
	1 ⁺	12.3	11.5	11.1	12.3	14.7	14.6	15.9
	2 ⁺	16.6	15.1	14.2	15.8	—	—	—
	3 ⁺	—	18.2	17.9	19.1			

FIG. 3. von Bertalanffy growth curves and parameters (\pm se) for both sexes of *Munida intermedia* in the Adriatic Sea. Black squares are the experimental data used as input values.

The regression equations for the length–weight relationships calculated separately for each sex after logarithmic transformation of data (standard errors of parameters in parentheses) are:

$$\text{Males (n = 102)} \quad \log W = 3.23 (\pm 0.03) \quad \log CL - 3.22 (\pm 0.04) \quad r^2 = 0.99$$

$$\text{Females (n = 90)} \quad \log W = 2.96 (\pm 0.04) \quad \log CL - 2.93 (\pm 0.04) \quad r^2 = 0.99$$

Comparison of slopes shows a statistically significant difference ($P < 0.05$) between males and females ($F = 34.55$) and a positive allometry ($b > 3$) for the equation for males ($t_{1100} = -7.59$).

Parasite infestation

A high rhizocephalan infestation was found to affect *M. intermedia* in the Pomo pit. Of the 7392 specimens of both sexes examined between March 1993 and April 1994, 16% had external evidence of parasite infestation. The degree of infestation is highest in females (22% females, 9% males). Similar results were obtained by Attrill (1989) in *M. sarsi* in the north-eastern Atlantic.

Three species, all new records for Italian waters (Argano *et al.*, 1995; Øksnebjerg, personal communication), were found infesting *M. intermedia* in the central Adriatic: *Tortugaster boschmai* (Brinkmann), *Triangulus munidae* Smith, and *Lernaeodiscus ingolfi* Boschma. *T. munidae* was by far the most common rhizocephalan species. The proportion of the three infesting species was calculated only from a subsample of 951 specimens of *M. intermedia* collected in April 1994 (table 5), whereas in all previous samples Rhizocephala were not sorted by species.

The degree of rhizocephalan infestation shows differences among size classes and year periods. In table 6, the percentage of rhizocephalan infestation is reported for each sex in different months. It is clearly evident that females are more heavily infested than males all year round, with a maximum of 42% in February, which can be explained by the female preference of *T. munidae*, previously reported by Attrill (1989).

The size frequency distributions by sex and month (figure 4) confirm these data and indicate that hosts in the size range 10–14 mm CL are infected in higher proportion, in both sexes. The smallest specimen bearing externa was a female 7.5 mm CL found in the sample in May 1993, but infestation by the parasite would have occurred at a smaller size. Brinkmann (1936) stated that the duration of the internal stage of *T. munidae* in *M. sarsi* was not less than six months in northern

Table 5. Infestation of *M. intermedia* by species of Rhizocephala, and scarred individuals, recorded in a sample of 453 males and 498 females collected in April 1994.

Species	Sex	Infested	% Infestation
<i>Triangulus munidae</i>	M	47	10.4
	F	144	28.9
<i>Tortugaster boschmai</i>	M	4	0.9
	F	3	0.6
<i>Lernaeodiscus ingolfi</i>	M	1	0.2
	F	8	1.6
Scars	M	16	3.5
	F	40	8.0

Table 6. Rhizocephalan infestation of *M. intermedia* by sex and month.

Month	Total		Infested		% Infestation	
	M	F	M	F	M	F
Mar 1993	205	314	11	46	5.4	14.6
May 1993	536	813	51	173	9.5	21.3
Jul 1993	291	363	26	63	8.9	17.4
Aug 1993	423	517	21	92	5.0	17.8
Jan 1994	667	569	40	90	6.0	15.8
Feb 1994	509	402	67	170	13.2	42.3
Apr 1994	782	1001	95	262	12.1	26.2

Norway. If a similar duration is postulated also in *M. intermedia*, the infection could have taken place at the beginning of the benthic life of the host.

Additional infestation by Bopyridae isopods (species not yet identified) was also observed, and was characterized by expansion of one branchial chamber. These parasites can affect specimens of *M. intermedia* that also have a rhizocephalan infestation. The overall incidence of bopyrid infestation was very low (0.6%), without any preference for host's sex.

Discussion

Munida intermedia dominates the crustacean fraction of the discards of bottom trawlers fishing for Norway lobster in the Pomo pit. Its density, estimated from counts along profiles made with a towed sledge equipped with an UTV, was greater by an order of magnitude than that obtained from trawl data and ranged between 0.2–0.6 individuals/m². These values are similar to those obtained for *Munida* spp. by Christiansen (1993), during a television and photographic survey of megafaunal abundance in the Sognefjorden (western Norway).

Density estimates of megafaunal species obtained from UTV surveys (Christiansen, 1993; Bailey *et al.*, 1993; Frogliia *et al.* in press), are always much greater than estimates based on trawl catches. Clearly data from trawl catches underestimate the abundance of species.

This great density of *M. intermedia* in the Pomo pit may be related to the morphology of the basin and to the circulation of the water masses in the region. Bottom water masses of the Pomo pit are only periodically renewed by the oxygen-rich dense waters formed in the eutrophic coastal regions of the North Adriatic and flowing into the basin (Artegiani, personal communication). A mesoscale experiment carried out in fall 1988 showed a large gyre in the area (Paschini *et al.*, 1993), which may prevent larvae of *M. intermedia* as well as of their rhizocephalan parasites from being dispersed long distances, and could account for the high infestation rate observed.

This species has a single spawning per year, with a breeding period of 3 to 4 months within a well-defined season (October–February). In the Pomo pit, bottom temperature is quite constant all year round, ranging between 10°C and 11°C (Artegiani *et al.*, 1993), and therefore, the seasonality of the reproductive cycle of *M. intermedia* is probably controlled by factors other than temperature. In the eastern Atlantic, Hartnoll *et al.* (1992) observed that within the genus *Munida*, the

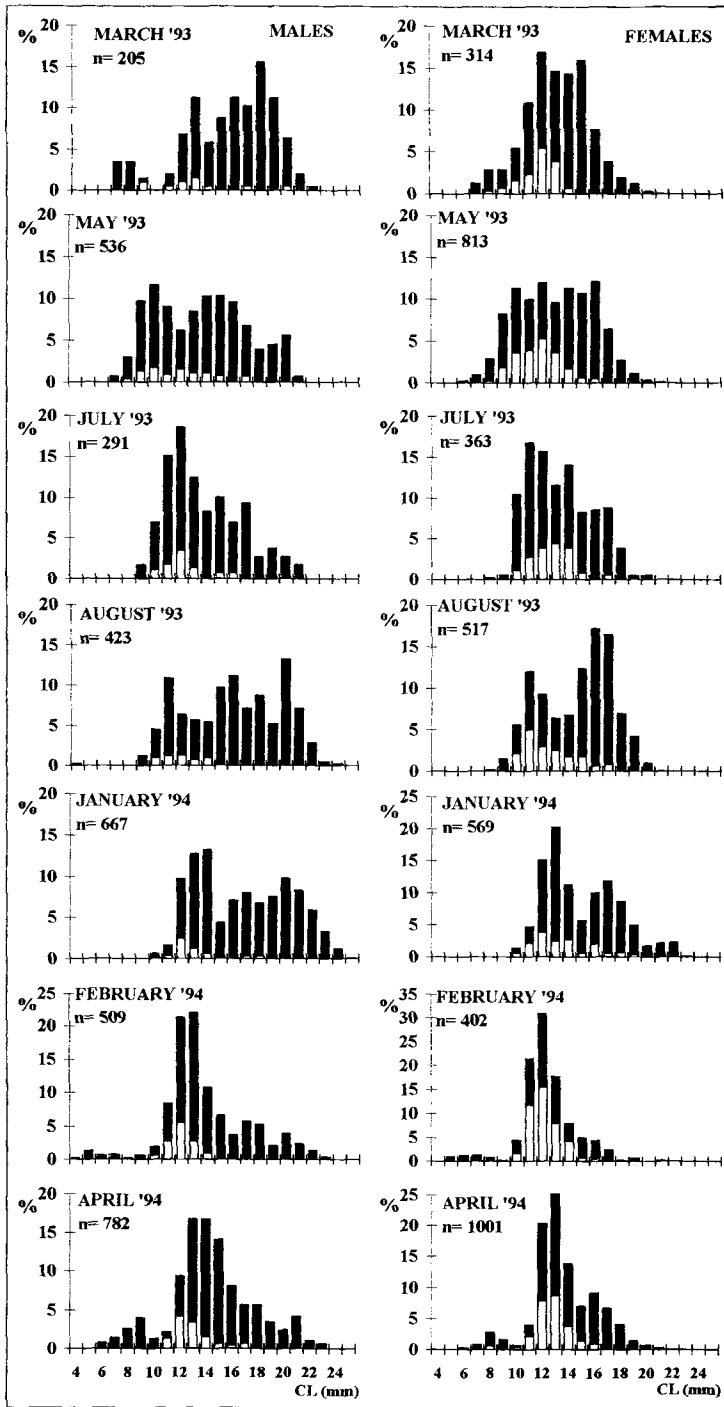


FIG. 4. Size frequency distributions of males and females (\square = parasitized; \blacksquare = non-parasitized) of *Munida intermedia*.

shallower water species generally have a more distinct seasonal breeding period than the deeper ones.

As no ovigerous female was ever found in March catches, larval life may not exceed one month. Adult females moult in the spring, after egg hatching. No such clear moulting period was observed in males, which could be due to paucity of data in autumn to early winter, or to asynchronous moults in males, as observed in the north-eastern Atlantic in *M. sarsi* Huus (Hartnoll *et al.*, 1992) and in Norwegian waters in *M. tenuimana* G. O. Sars (Nielsen, 1969).

The newly recruited year-class of *M. intermedia* appears in February-March catches, with specimens 4–5 mm CL; in late summer its modal length is already 10 mm CL. Brinkmann (1936) considered 4–5 mm CL specimens of *M. sarsi* and *M. tenuimana* to be one year old. These two species reach the same maximum length as *M. intermedia* and the higher growth rate observed for the latter is probably related to the higher temperatures of the Adriatic Sea.

The life-span of *M. intermedia* does not appear to exceed four years, and females reach sexual maturity in their first year of life, at 11 mm CL. Few data are available on the life history of squat-lobsters. In the Magellan Strait *M. subrugosa* has a similar growth pattern but a longer life-span (seven to eight years) and a larger size at first maturity (about 14 mm CL, 2 year old females) (Rodriguez and Bahamonde, 1986).

Growth pattern is similar in the two sexes, with a slightly higher growth in males after reaching sexual maturity. It derives from a lower frequency of moults in females, which do not undergo moult while carrying external eggs. This pattern, common in other lobsters, was already observed by Rodriguez and Bahamonde (1986) in *Munida subrugosa* (White) and by Roa (1993) in *Pleuroncodes monodon* (Milne Edwards), in the southern Pacific.

The statistically significant difference found in the length-weight relationship between males and females and the positive allometry for males is probably due to a higher relative growth of chelipeds in males after reaching the size of first maturity, as observed in *Munida iris* (A. Milne Edwards) (Williams and Brown, 1972). Both Peltogastridae and Lernaediscidae seem not to prevent host moulting after appearance of externa. Male hosts' feminization caused by Lernaediscidae (changes in pleopod structure and widening of abdomen) can alter the growth pattern of parasitized males (O'Brien and Van Wyk, 1985). Relative growth of body parts of infested and non-infested *M. intermedia* will be discussed in another paper (Frogli and Gramitto, in progress).

Attrill (1989) stated that *T. munidae* causes in *Munida sarsi* not only the feminization of pleopods in male hosts (with degeneration of copulatory appendages), but can produce a masculinization of female hosts' pleopods. Moreover, host gonads do not mature, and thus parasitized female hosts will not produce eggs (O'Brien and Van Wyk, 1985). In our samples, no infected female was found carrying eggs.

The discovery of three species of Rhizocephala (*Tortugaster boschmai*, *Triangulus munidae* and *Lernaediscus ingolfi*) previously unknown for the Italian seas shows once more how poor our knowledge is of some 'minor' zoological groups, which have received scant attention in the Adriatic, an area with a long history of marine biological studies.

Acknowledgements

The authors wish to thank Dr J. Atkinson (Marine Station, Millport, UK), Dr R. Lemaitre (Smithsonian Institution, Washington DC, USA) and an anonymous

referee for their critical reading of the manuscript, and for revision of the English. Thanks are also due to Dr A. Giacco for her patience in sorting the 'discards'.

References

- ALVERSON, D. L. and PEREIRA W. T., 1969, Demersal fish explorations in the northeastern Pacific Ocean — an evaluation of exploratory fishing methods and analytical approaches to stock size and yield forecasts, *Journal of Fisheries Research Board of Canada*, **26** (8), 1985–2001.
- ARGANO, R., BRUNO, M. C., CECCHERELLI, V. U., COTTARELLI, V., MARINIELLO, L., MAZZOCCHI, M. G., PESCE, G. L., PRINCIPATO, M., RELINI, G. and STELLA, E., 1995, Crustacea Maxillopoda, Pentastomida, in A. Minelli, S. Ruffo and S. La Posta (eds), *Checklist delle Specie della Fauna Italiana*, **28**, (Bologna: Calderini), pp. 1–57.
- ARTEGIANI, A., GACIC, M., MICHELATO, A., KOVACEVIC, V., RUSSO, A., PASCHINI, E., SCARAZZATO, P. and SMIRCIC, A., 1993, The Adriatic hydrography and circulation in Spring and Autumn (1985–1987), *Deep Sea Research II*, **40** (6), 1143–1180.
- ATTRILL, M. J., 1989, A rhizocephalan (Crustacea; Cirripedia) infestation of the deep-sea galatheid *Munida sarsi* (Crustacea; Decapoda), the effects on the host and the influence of depth upon the host-parasite relationship, *Journal of Zoology, London*, **217**, 663–682.
- BAHAMONDE, N., HENRIQUEZ, G., ZULETE, A., USTOS, H. and BAHAMONDE, R., 1986, Population dynamics and fisheries of squat lobsters, family Galatheididae, in Chile, *Canadian Special Publication of Fisheries and Aquatic Sciences*, **92**, 254–268.
- BAILEY, N., CHAPMAN, C., KINNEAR, J., BOVA, D. and WEETMAN, A., 1993, Estimation of *Nephrops* stock biomass on the Fladen ground by TV survey, *International Council for the Exploration of the Sea CM*, 1993/K, 34.
- BRINKMANN, A., 1936, Die nordischen *Munida*-Arten und ihre Rhizocephalen, *Bergen Museums Skrifter*, **18**, 1–111.
- BURD, B. J. and JAMIESON, G., 1988, Biology and commercial potential of galatheid crabs in British Columbia, *Journal of Shellfish Research*, **7** (1), 112–113.
- CHAPMAN, C. J., 1985, Observing Norway lobster *Nephrops norvegicus* (L.) by towed sledge fitted with photographic and television cameras, in J. D. George, G. I. Lythgoe and J. N. Lythgoe (eds), *Underwater photography and television for scientist* (Oxford: Clarendon Press), pp. 100–108.
- CHRISTIANSEN, B., 1993, A television and photographic survey of megafaunal abundance in central Sognefjorden, Western Norway, *Sarsia*, **78**, 1–8.
- COMPANY, J. B., 1995, Estudi comparatiu de les estratègies biològiques dels crustacis decàpodes del talús de la Mar Catalana, unpublished thesis redactada par optar al grau de Doctor en Biologia, Universitat Barcelona, 213 pp.
- COREY, S., 1991, Comparative potential reproduction and actual production in several species of North American crayfish, in A. Wenner and A. Kuris (eds), Crustacean egg production, Vol. 7 of *Crustacean Issues*, F. R. Schram (ed.) (Rotterdam: A. A. Balkema), pp. 69–76.
- FROGLIA, C., 1975, Preliminary report on the Crustacea Decapoda of Adriatic deep waters, *Thalassia Jugoslavica*, [1972], **8** (1), 75–79.
- FROGLIA, C., ATKINSON, J. R., TUCK, I. and ARNERI, E., in press, Underwater television survey, a tool to estimate *Nephrops* stock biomass on the Adriatic trawling grounds, *Symposium Croatian marine fisheries at the threshold of the 21st century, Split, 16–18 Oct. 1995*.
- FROGLIA, C. and GRAMITTO, M. E., 1988, An estimate of growth and mortality parameters for Norway lobster (*Nephrops norvegicus*) in the Central Adriatic Sea, *FAO Fisheries Report*, **394**, 189–203.
- FROGLIA, C. and GRAMITTO, M. E., 1995a, Crustacea Decapoda assemblage of the Western Pomo Pit. I — Species composition, *Rapport du XXXIVe Congrès de la CIESM*, **34**, 29.
- FROGLIA, C. and GRAMITTO, M. E., 1995b, Crustacea Decapoda assemblage of the Western Pomo Pit. II — Reproduction, *Rapport du XXXIVe Congrès de la CIESM*, **34**, 30.
- HARTNOLL, R. G., RICE, A. L. and ATTRILL, M. J., 1992, Aspects of the biology of the galatheid genus *Munida* (Crustacea, Decapoda) from the Porcupine Seabight, Northeast Atlantic, *Sarsia*, **76**, 231–246.

- HØEG, J. and LÜTZEN, J., 1985, Crustacea Rhizocephala, *Marine invertebrates of Scandinavia*, **6**, 1–90.
- IMBC, UMBSM and IRPEM, 1994, *Nephrops norvegicus*: stock variability and assessment in relation to fishing pressure and environmental factors, *Final Report to the Commission of the European Communities*, Contract XIV.1/MED/91/003, 84 pp.
- MACDONALD, P. D. M. and GREEN, P. E. J., 1988, *User's guide to programme MIX: an interactive programme for fitting mixtures of distributions* (Hamilton, Ontario, Canada: Ichthus Data Systems).
- MACDONALD, P. D. M. and PITCHER, T. J., 1979, Age-group from size frequency data: a versatile and efficient method of analysing distribution mixtures, *Journal of Fisheries Research Board of Canada*, **36**, 987–1001.
- NIELSEN, S., 1969, *Nectonema munidae* Brinkmann (Nematomorpha) parasitizing *Munida tenuimana* G. O. Sars (Crust. Dec.), *Sarsia*, **38**, 91–110.
- O'BRIEN, J. and VAN WYK, P., 1985, Effects of crustaceans parasitic castrators (epicaridean isopods and rhizocephalan barnacles) on growth of crustacean hosts, in A. M. Wenner (ed.), *Factors in adult growth*, Vol. 3 of *Crustacean Issues*, F. R. Schram (ed.) (Rotterdam: A. A. Balkema), pp. 191–218.
- PASCHINI, E., ARTEGIANI, A. and PINARDI, N., 1993, The mesoscale eddy field of the Middle Adriatic Sea during fall 1988, *Deep Sea Research I*, **40** (7), 1365–1377.
- RICE, A. L. and DE SAINT LAURENT, M., 1986, The nomenclature and diagnostic characters of four north-eastern Atlantic species of the genus *Munida* Leach: *M. rugosa* (Fabricius), *M. tenuimana* G. O. Sars, *M. intermedia* A. Milne Edwards and Bouvier, and *M. sarsi* Huus (Crustacea, Decapoda, Galatheididae), *Journal of Natural History*, **20**, 143–163.
- ROA, R., 1993, Annual growth and maturity function of the squat lobster *Pleuroncodes monodon* in central Chile, *Marine Ecology Progress Series*, **97** (2), 157–166.
- RODRIGUEZ, L. and BAHAMONDE, R., 1986, Estimación del crecimiento y mortalidad natural en *Munida subrugosa* del Estrecho de Magallanes, *Investigaciones Pesqueras, Chile*, **33**, 25–32.
- SAILA, R. B., RECKSIEK, C. W. and PRAGER, M. H., 1988, Basic fishery science programs. A compendium of microcomputer programs and manual of operation, *Development in Aquaculture and Fishery Science* (Amsterdam: Elsevier), **18**, 230 pp.
- SNEDECOR, G. W. and COCHRAN, W. G., 1967, *Statistical methods* (Ames: Iowa State University Press), 593 pp.
- WILLIAMS, A. B. and BROWN, W. S., 1972, Notes on structure and parasitism of *Munida iris* A. Milne Edwards (Decapoda, Galatheididae) from North Carolina, USA, *Crustaceana*, **22** (3), 303–308.
- ZELDIS, J. R., 1985, Ecology of *Munida gregaria* (Decapoda, Anomura): distribution and abundance, population dynamics and fisheries, *Marine Ecology Progress Series*, **22**, 77–99.
- ZUPANOVIC, S. and JARDAS, I., 1986, A contribution to the study of biology and population dynamics of the Adriatic hake, *Acta Adriatica*, **27** (1/2), 97–146.
- ZUPANOVIC, S. and JARDAS, I., 1989, Fauna i Flora Jadrana. Jabucka Kotlina. Prva Knjiga, *Fauna et Flora Adriatica* (split: Logos), **4**, 415 pp.