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Relative growth and sexual maturity of *Ilia nucleus* (L.)

(Crustacea, Decapoda)

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Morphological variation related to sexual maturity is examined in the little crab *Ilia nucleus* (L.), captured in the Northern Tyrrhenian Sea (Central Mediterranean) at 8 m depth in a sand biocoenosis characterized by prairies of *Cymodocea nodosa* (Ucria). Five morphometric relationships were investigated on 25 females and 19 males, ranging from 10 to 23,5 mm and from 10 to 25 mm carapace width (CW), respectively. Sexual dimorphism was demonstrated for all examined morphometric characters. The carapace and the abdomen are respectively longer and larger in females than in males. The chelae are longer in males than in females. The male body is higher than the female body in juvenile individuals, while in the adults the body becomes higher in females than in males. In the juvenile individuals the chelae are longer in females than in males, while in the adult specimens they appear longer in males than in females. The female abdomen grows remarkably at the puberty, forming an abdominal chamber. Pubertal moult females were observed in the size range of 12.7 - 13.9 mm CW, while the male one was estimated to occur at about 15 mm CW. The possibility that the pubertal moult in *Ilia nucleus* is terminal or not is discussed.

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Introduction

Relative growth has been investigated particularly in crustacean brachyurans species (Hartnoll 1974, 1982, Cau et al. 1981, Abelò & Sardà 1982), and in a variety of ways (see Gore & Scotto 1983), but it has been mainly studied in order to estimate the onset of sexual maturity (Watson 1970, Hartnoll 1972, 1982, Arnaud & Do Chi 1977, Mori 1986 a, b, Gaertner & Laloé 1986, Vannini & Gherardi 1988, Felder & Lowett 1989, Abelló et al. 1990).

The only informations available on the biology of *Ilia nucleus* (L., 1758) (Brachyura, Leucosidae) are records of ovigerous females (Zariquiey Alavarez 1968).

In this paper we investigated the relative growth of the crab *I. nucleus* captured in the Northern Tyrrhenian (Central Mediterranean) with the principal aim to estimate the size range over which the pubertal moult may occur and whether this moult is terminal or not.

Materials and Methods

The crab (25 females and 19 males) were caught by mean of an otter trawl, during an one hour haul, on March 1986, at 8 m depth, in a sand biocoenosis characterized by prairies of *Cymodocea nodosa* (Ucria), in front of the Ombrone river (North Tyrrhenian Sea, Central Mediterranean).

The size of individuals collected ranged from 10 to 23.5 mm carapace length for females and from 10 to 25 mm CL for males.

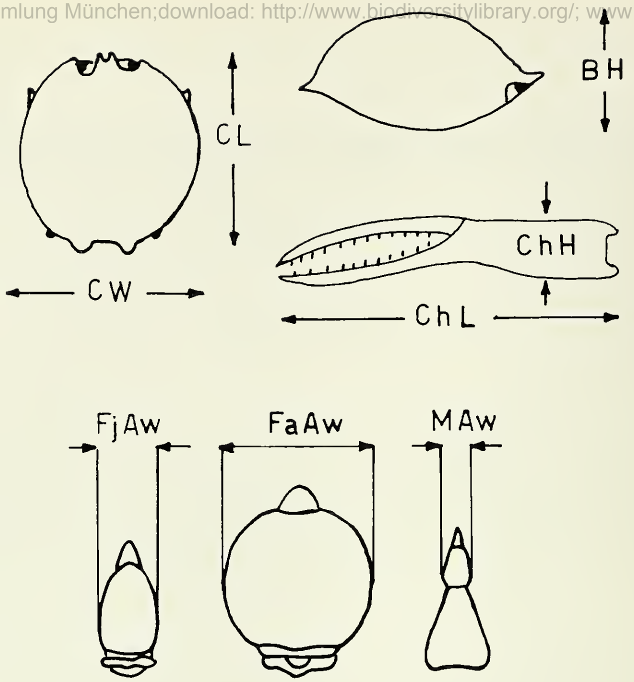

Fig. 1. Diagram of *Ilia nucleus* showing the measurements taken. CL = carapace length; CW = carapace width; BH = body height; ChH = chela height; Chl = chela length; FjAW = abdomen width of juvenile females: FaAW = abdomen width of adult females; MAW = abdomen width of males.

The following measurements were made on each specimen, using vernier calipers to the nearest 0.1 mm (Fig. 1): (CL) maximum carapace length, frontal spinae comprised; (CW) maximum carapace width; (ChH, ChL) height and length of the right chela propodus, and in the case that this was lacking, of the left chela, as *I. nucleus* is an homochelid species; (AbW) maximum abdomen width; (BH) height of the carapace. The carapace width (CW) was chosen as the main reference dimension. These data were analysed, to study relative growth, using the potential model $Y = aX^b$ in its logarithmic transformation ($\log Y = \log a + b \log X$). Least square regression equation (Model I) was used in agreement with the argumentations given by Huber (1985), although Lowett & Felder (1989) recommend the use of the so-called functional regression methods. Allometry was determined by testing the slope of the log-transformed regressions against the isometric slope of 1 with Student's t-test. Statistical equality of morphometric relationships between juveniles and adults, and between sexes were tested using Ancova (Sokal & Rohlf 1981).

Results and Discussion

Female allometry

In female *I. nucleus*, as described for *Ebalia tuberosa* by Schembri (1982), the eggs are enclosed in an abdominal chamber formed by apposition of the abdomen to the ventral surface of the cephalothorax. The abdominal chamber is formed only at the pubertal moult. In the juvenile females the abdomen is flat and the space between the abdomen and sternum is negligible in comparison with that of sexually mature females. Juvenile females were observed in the size range from 9.7 to 13.9 mm CW, while adult females from 12.7 to 23.5 mm CW (Fig. 2).

In the juveniles the abdomen grows in width with a positive allometry, the carapace isometrically both in length and in height, while the chelae with an isometry in height and an negative allometry in length (Tab. I and Fig. 2).

Tab. 1. Allometric statistics for females and males of *Ilia nucleus* and comparisons of log-log regressions of the relative parameters by meaning covariance analyses. The intercepts were not compared when slopes were significantly different. CW = carapace width; CL = carapace length; ChL = crusher chela length; ChH = crusher chela height; AbdW = abdomen width; BH = carapace height; r = correlation coefficient; n = number of specimens; Seb = standard error of the slope; As = allometric status on testing the slope against a standard of 1, $\alpha = 0.05$; + = positive allometry; 0 = isometry; - = negative allometry.

Equations	r	n	Seb	As	Stages
Females					
$\log \mathrm{AbW} = 1.3770 \log \mathrm{CW} - 0.8677$	0.976	5	0.17	+	juveniles
$\log \mathrm{AbW} = 0.9598 \log \mathrm{CW} - 0.1175$	0.972	20	0.05	0	adults
Equality juv. vs. adults, slopes F = 9.95 P < 0.01					
$\log \mathrm{CL} = 0.9638 \log \mathrm{CW} + 0.0689$	0.997	5	0.03	0	juveniles
$\log \mathrm{CL} = 0.9875 \log \mathrm{CW} + 0.0351$	0.996	20	0.02	0	adults
Equality juv. vs. adults, slopes F = 0.21 P > 0.05; intercepts F = 3.05 P > 0.05					
$\log \mathrm{CL} = 0.9622 \log \mathrm{CW} + 0.0671$	0.997	25	0.01	0	juveniles + adults
$\log \mathrm{BH} = 1.1331 \log \mathrm{CW} - 0.3546$	0.966	5	0.17	0	juveniles
$\log \mathrm{BH} = 0.9804 \log \mathrm{CW} - 0.1667$	0.953	19	0.07	0	adults
Equality juv. vs. adults, slopes F = 0.73 P > 0.05; intercepts F = 1.79 P > 0.05					
$\log \mathrm{BH} = 1.0717 \log \mathrm{CW} - 0.2806$	0.976	24	0.05	0	juveniles + adults
$\log \mathrm{ChL} = 0.8436 \log \mathrm{CW} + 0.2405$	0.990	5	0.06	–	juveniles
$\log \mathrm{ChL} = 0.9922 \log \mathrm{CW} + 0.0718$	0.972	18	0.05	0	adults
Equality juv. vs. adults, slopes F = 1.20 P > 0.05; intercepts F = 0.29 P > 0.05					
$\log \mathrm{ChL} = 0.9478 \log \mathrm{CW} + 0.1273$	0.984	23	0.03	0	juveniles + adults
$\log \mathrm{ChH} = 1.0936 \log \mathrm{CW} - 0.8869$	0.970	5	0.02	0	juveniles
$\log \mathrm{ChH} = 1.2395 \log \mathrm{CW} - 1.0663$	0.973	18	0.07	+	adults
Equality juv. vs. adults, slopes F = 0.68 P > 0.05; imtercepts F = 1.58 P > 0.05					
$\log \mathrm{ChH} = 1.1571 \log \mathrm{CW} - 0.9627$	0.982	23	0.04	+	juveniles + adults
Males					
$\log \mathrm{AbW} = 0.7707 \log \mathrm{CW} - 0.5558$	0.966	19	0.04	–	juveniles + adults
$\log \mathrm{CL} = 0.9648 \log \mathrm{CW} + 0.0771$	0.993	19	0.02	0	juveniles + adults
$\log \mathrm{BH} = 0.9807 \log \mathrm{CW} - 0.1588$	0.962	17	0.11	0	juveniles + adults
$\log \mathrm{ChL} = 1.0479 \log \mathrm{CW} + 0.0522$	0.986	19	0.04	0	juveniles + adults
$\log \mathrm{ChH} = 1.5205 \log \mathrm{CW} - 1.3594$	0.981	19	0.07	+	juveniles + adults

Equality		slopes		intercepts	
CL/CW	males vs. females	F = 0.08	P > 0.05	F = 19.23	P < 0.01
BH/CW	males vs. females	F = 1.09	P > 0.05	F = 4.45	P < 0.05
ChL/CW	males vs. females	F = 3.22	P > 0.05	F = 49.26	P < 0.01
ChH/CW	males vs. females	F = 16.44	P < 0.01	–	–

In adults the abdomen grows isometrically in width, as well as the carapace, that grows isometrically both in length and in height. The chelae grow isometrically in length and with a positive allometry in height (Tab. I and Fig. 2).

Since the abdomen is the only character that morphometrically differentiates the juveniles from the adults (Tab. I and Fig. 2), all the other relationships have been reported for all the individuals, i.e. juveniles plus adults (Tab. I).

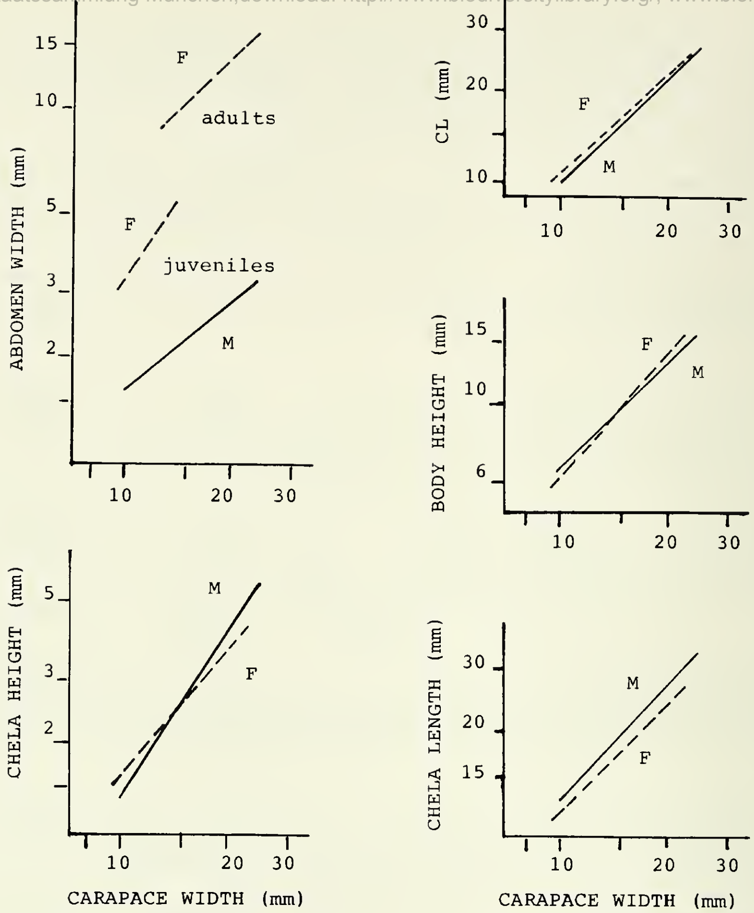

Fig. 2. Log morphometric dimensions plotted against log carapace width. See Tab. I for regression formulae. M = males; F = females.

Male allometry

As we had no possibility to separate juveniles from adults, all the relationships are combined for both stages. The abdomen grows with a negative allometry, while the carapace grows isometrically both in length and height. The chelae grow isometrically in length and with high positive allometry in height (Table I and Fig. 2).

Sexual dimorphism

The male abdomen is narrower as compared to the female one (Fig. 2), because in the males the abdomen has the function to cover and to protect the gonopods. For this reason, as in the major part of the brachyurans, the male abdomen does not increase in size faster than the carapace itself because no reproductive advantage is gained by possessing larger gonopods (Finney & Abele 1981). On the contrary, the female abdomen has the function to carry and to protect the eggs, and as bigger the abdominal chamber is, as reproductive fitness potential increases (Hartnoll 1974).

The carapace length is significantly longer, at all the sizes, in females than in males (Tab. I, Fig. 2). The body becomes slightly higher in females than in males starting from about 14 mm CW, i.e. the size close to the sexual maturity. Finney & Abele (1981) suggest that this statement is in relation with the reproductive system, because in the females the reproductive tract does expand in comparison to the males due to the production of eggs; so that the internal carapace volume is bigger in females than males.

The chelae are significantly longer, at all sizes, in males than in females (Tab. I, Fig. 2).

The chelae are higher in juvenile females than in juvenile males, while at the maturity the chelae are higher in males than in females. The difference between the two coefficient regressions is significant (Tab. 1). The point of intersection between the two straight lines is about 15 mm CW, that is the size that probably corresponds to the onset of male sexual maturity. From the literature the chelae of the brachyuran males are known to be bigger than the female ones, because the males use the chelae in a wide variety of behavioural interactions, as courtship, combat and display (Hartnoll 1974, Finney & Abele 1981, Vannini & Gherardi 1988). Instead, no logical explanation was found for the fact that female chelae are higher than male chelae in juvenile individuals, as well as the juvenile body height that is higher in males than in females. Perhaps these results are due to random variability, but they were also observed in other decapods, like *Nephrops norvegicus* (L.) (Mori in prep.).

Conclusions

The format of relative growth in *I. nucleus* follows several patterns described in other decapods (Hartnoll 1982). We had no direct evidence of the possibility that the puberty moult in *I. nucleus* is the terminal one, but Scembri (1982) describes the same growth pattern for the abdomen of *Ebalia tuberosa* (Leucosidae), i. e. the formation of an abdominal chamber at the pubertal moult, as observed for *I. nucleus*. This author affirms that such pattern is a criterion of terminal moult. The members of the Majidae family, in which the pubertal moult is known to be the terminal one, show at maturity an abdominal chamber (Teissier 1935, Vernet-Cornubert 1958, Hartnoll 1963, Chaix 1979). On the basis of the presence of epizoites and of characters indicating the moult, Mori (1986 a, b) and Mori & Manconi (1990) have supposed that *Paromola cuvieri* (Homolidae) and *Medorippe lanata* (Dorippidae) - species that present at the maturity an abdominal chamber - do not undergo further moults after the pubertal one. These results allow to suppose that the formation of an abdominal chamber at the pubertal moult could really be a clue to a terminal moult. If such assumption is confirmed by studies on the functional activity of the Y-gland and by observations in captivity also in other brachyuran families, presenting an abdominal chamber at the sexual maturity - as Calappidae, Dromiidae, Latreilliidae, Palicidae, Parthenopidae, Pinnotheridae, etc. -, it could give a useful contribution for the understanding of the brachyuran phylogenetic relationships.

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