Relative growth of the freshwater prawn *Macrobrachium borellii* (Nobili 1896) (Decapoda: Palaemonidae).

Collins, P.

Escuela Superior de Sanidad, Fac.Bioq. y Cs.Biológicas, UNL – Instituto Nacional de Limnología, José Maciá 1933, 3016 Santo Tomé, Santa Fe, Argentina, e-mail: pcollins@arnet.com.ar

Abstract

This study analyzed the relative growth on the freshwater prawn *Macrobrachium borellii* and its behavioural importance. The following structures were measured: total length (TL), cephalothorax length (CL); cephalotorax width (CW); propodus length of second pereiopod (PL); dactyl length of second pereiopod (DL) and chela width of second pereiopod (CHW). For males, the chela was the body part with the highest allometric growth. Besides, variability could introduce factors that determining dominance when two individuals encounter. Chela size could be an indicator of the prawn potentially aggressive behaviour or it might be taken as weapon of the outcome of fights than body size.

Key words: relative size, relative growth, prawn, Palaemonidae, *Macrobrachium borellii*,

Introduction

The field of morphometrics is concerned with descriptive and statistical methods for the analysis of variation shape. These meristic ways are needed whenever one requirements to describe and compare shapes of organisms or particular structures. The samples may represent geographic localities, developmental stages, genetic effects, environmental effects, etc. (Rohlf and Marcus, 1993).

In studies carried out on crustaceans about ethological and empirical aspects, the body size indicate that is an important element in the interactions between males and females engaged in fighting (Hazlett and Bossert, 1965; Nolan and Salmon, 1970; Rubenstein and Hazlett, 1974; Caldwell and Dingle, 1978; Hyatt and Salmon, 1978; Knowlton and Keller, 1982; Hughes, 1996). Moreover, the allometric growth of several body parts is, associated with sex and maturity, determines of some kind of dominance, fighting ability or agonistic behaviour.

Furthermore changes of growth, between the larval eclosion and death of decapods, may occur gradually over a series of molts, or abruptly at a single molt (Tessier, 1960; Hutchinson, 1967; Hartnoll, 1982; Primavera *et al.*, 1998) and perhaps, there may show some other dimorphism sexual in relation to the growth of some body parts.

In the freshwater environment of southern South America inhabits *Macrobrachium borellii*, an endemic prawn of La Plata basin (Boschi, 1981; Morrone and Lopretto, 1995) with an abbreviated larval development (Jalihal *et al.*, 1993). Both sexes are morphologically similar, being males a bit bigger in size (Boschi, 1981), establishment of hierarchical relationships in the populations (Williner and Collins, 2000).

The present study was done in order to compare the relative growth of body parts in juveniles, males and females of *M. borellii* as tools for sexual characterization and its significance in their agonistic behaviour.

Material and Methods

During winter (July), three samplings were carried out for the morphometric study. The areas covered are located on the Paraná river floodplain (Madrejón Don Felipe (31°40´ S y 60°30´ O), laguna

N°1 (31°39´ S y 60°41´ O), laguna Alejandra (31°45´ S y 60°31´ O); Santa Fe, Argentina). The prawns were collected using a bottom net (8 m length, 1 mm mesh size). Juvenile and adult specimens were separated according to Bond and Buckup (1988). Males and females were differentiated with reference to the masculine appendix.

Several morphometric variables were measured to the nearest 0.01 mm using a calliper under a stereomicroscope in order to determine the variables that best described the growth phases. The following variables: total length (TL), cephalothorax length (CL); cephalotorax width (CW); propodus length of second pereiopod (PL); dactyl length of second pereiopod (DL) and chela width of second pereiopod (CHW) were measured in living prawns. Wet weight (about 0.01 g) was obtained with a digital balance.

The allometry of the different variable measurement was estimated by simple linear regression using log-transformed data, taking the largest body parts as reference variables and the slopes as the growth constant.

$$\log_{10} y = \log_{10} a + b \cdot \log_{10} x$$

The parameters of the allometry equation were calculated by determining the regression of log y on log x using the least square method. All correlation coefficients (r) from the linear regression analyses were tested for significance using ANOVA (Zar, 1996). The growth constant (b) of the relationships were tested in order to analyze isometry (i.e. 1) using a t-statistic function (Sachs, 1974) as follows:

$$t = (s.d.(x) / s.d.(y)) \cdot (|b-1| / (1 - r^2)^{1/2}) \cdot (n-2)^{1/2} \quad g.l.= n-2$$

The relationships between body size and weight were determined for each sex by fitting the log-transformed data. Fulton's condition factor (CF) was calculated by the formula:

$$CF = W \cdot 100 / CL^3$$

Only individuals in intermolt phase C were considered in the analysis. The molt phase was based on the microscopic examination of the pleopod, according to Drach's method (1939).

Results

A total of 1024 specimens of *M. borellii* were measured and weighted from the three site without any statistical difference (ANOVA, $p<0.05$). The TL of the field caught animals ranged from 12.4 mm to 59.2 mm and weight about 0.04 g to 3.32 g. In all samples, it was observed two clear cut developmental phases in relative growth with differences in several body parts (TL< 22.4 mm and TL > 22.4 mm).

The 8.11 % were juveniles and 91.89 % adults. Male percentage was 53.43 % and 38.46 % for females, with a 1.391 male/female ratio. Mean and standard deviation of morphometric characters in all developmental phases and sexes are shown in Table I. Moreover any relationships showed differentiation between sexes. The relationships CL-TL, CW-TL and CW-CL for juveniles were statistically correlated, being isometric (Table II). Other body parts such as the cheliped length in this undifferentiated phase have erratic values thus they have being discarded for further analysis.

Males and females grew more the cephalotorax than the abdomen (or total lenght) but with the similar magnitude increased the cephalotorax width. Adult measurements with same growth between sexes and with isometric relationships were the lengths: DL-CL and CHW-PL (Table II).

Slopes were statistically different between male and female in the following relationships: PL-TL, CHW-TL, PL-CL, CHW-CL, PL-CW, DL-CW, CHW-CW, W-PL and W-CHW (Fig. 1 and 2). Moreover the regressions among CHW-CL, PL-CW and DL-CW were only isometric for males (Table II).

The sexual dimorphism was observed among the relationships TL, CL and CW with second pereiopod chela lengths as the PL and CHW (Fig.1). In the chela, the relationships DL and CHW showed strong differences between sexes too. Propod length incremented more in males than females according to positive allometric dependence with total length in the first. In females, the relationships among TL, CL and CW were negative allometric (Fig.1; Table II).

Cephalothorax length and width was isometric in males but negatively allometric in female. Chela width was another body part that differently grew between sexes. CHW increased more in males than in females with a positive allometric relation among TL, CL and CW. These associations were negatively allometric for female.

However dactilo length did not show any differences between sexes in the relationships TL, CL and CW (Table II).

The correlation coefficients for relationships that involve any body parts with second pereiopod chela were larger in females than males (Table II).

Length and weight logarithmic plots are shown in Fig. 2, being the biomass increase similar for males and females. Sex differences were only observed in dependence with PL and CHW (Fig.2). It was calculated Fulton's condition factor: 0.1306 for juvenile, 0.0296 for males, 0.0314 for females and 0.0403 for all prawns.

Table I: Mean values and standard deviation (s) for length and weight in *Macrobrachium borellii* (n°: 1024).

	TL mm (s)	CL mm (s)	CW mm (s)	PL mm (s)	DL mm (s)	CHW mm (s)	W g (s)
Juvenil	15.54 (2.17)	4.1 (0.78)	2.53 (0.41)	**	**	**	0.09 (0.05)
Male	28.1 (9.79)	13.15 (2.89)	7.68 (1.82)	3.76 (1.61)	3.42 (1.78)	0.94 (0.47)	0.65 (0.71)
Female	25.11 (8.96)	11.98 (2.85)	7.74 (1.86)	2.54 (0.87)	2.11 (0.51)	0.67 (0.12)	0.54 (0.69)
Total	24.12 (10.02)	10.82 (3.15)	6.82 (2.04)	2.58 (1.71)	3.28 (1.96)	0.67 (0.55)	0.51 (0.89)

** values with statistical significant errors

Discussion

Relative growth of several body parts showed different patterns, associated with sex and maturity in Decapoda (Teissier, 1960; Hartnoll, 1982). Within this context, *M. borellii* has an undifferentiated phase, which determines an isometric growth (Collins and Petriella, 1999), the transition between the phases must occur by means of critical moults. This stage is finished by a change in the increase of some organ growth after the puberty moults. These differences were relatively small at the allometric level and in some cases of uncertain significance. The relationship between total length and cephalothorax length was isometric in juvenile and positively allometric in adults indicating gonadal development. In addition, size variation of cephalothorax length was isometric in relation to cephalothorax width for juveniles and negatively allometric for adults. All relations in juveniles and adults describing the growth were best defined by a linear equation having a poor fits others expressions.

Sex ratios did not differ significantly from 1:1 among sites and there were no discrimination in the morphological variables was evident among sits too. Sex differentiations were viewed particularly in relation to the chelae, which in males was longer than in females. Moreover, a high level of allometry was found in the size of chela relationships with other measures. The functional significance of sex difference may be understood as the territorial defence, combat, display and courtship, which it occurs in other decapods (Hartnoll, 1982; Lynne *et al.*, 1997).

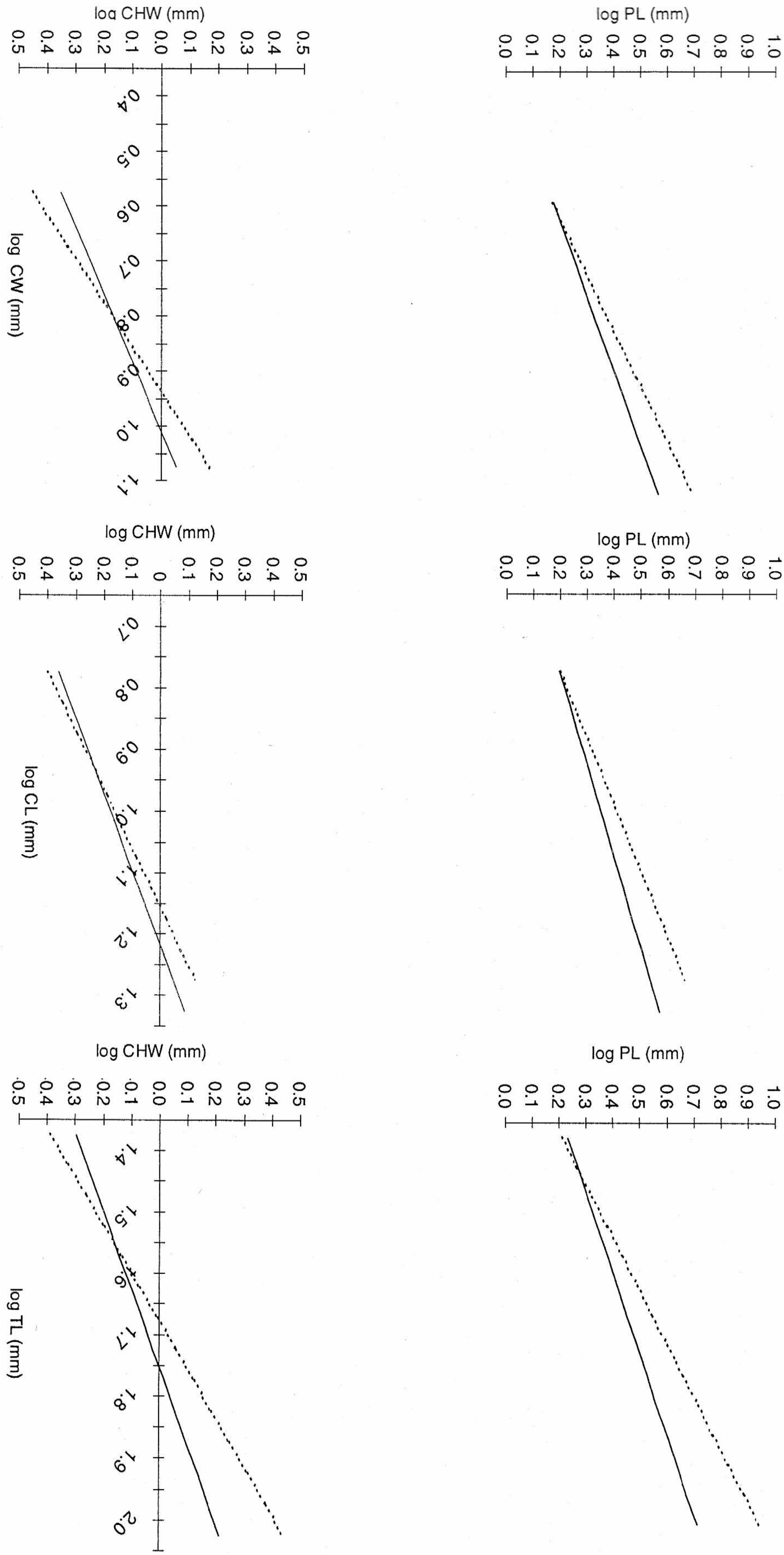

Figure 1: Some body parts relationships of *Macrobrachium borellii* with significant differences between sexes. Males (547 individuals) (—) and females (394 individuals) (---), (total n = 941 prawns). The PL-TL, CHW-TL, PL-CL, CHW-CW, and CHW-DL slopes between males and females were statistically different ($p<0.05$).

Table II: Values of different parameters calculated by linear regression for juveniles, males and females logarithmic data of *Macrobrachium borellii* captured at three ponds at Río Paraná Medio floodplain. TL: total length; CL: cephalothorax length; CW: cephalothorax width; PL: propodus length; DL: dactilo length; CHW: chela width; W: weight. First midway: intersection values / slopes value; Second midway: coefficients of regression.

		TL	CL	CW	PL	DL	CHW	W
	Juvenile		-0.55 / 1.05[a]	-0.97 / 1.08[a]	——	——	——	-4.44 / 2.83[c]
TL	Males		-0.77 / 1.24	-0.72 / 0.98[a]	-1.32 / 1.13[c]	-1.32 / 1.17[c]	-2.11 / 1.28[c]	-4.68 / 2.97[c]
	Females		-0.66 / 1.161[a]	-0.69 / 0.96[b]	-0.77 / 0.74[b]	-1.39 / 1.17[c]	-1.36 / 0.79[b]	-4.58 / 2.92[c]
	Juvenile	0.928		-0.08 / 0.99[a]	——	——	——	-2.42 / 2.17[c]
CL	Males	0.990		-0.03 / 0.88[b]	-0.51 / 0.94[b]	-0.52 / 1.00[a]	-1.18 / 1.05[a]	-2.75 / 2.65[c]
	Females	0.985		-0.05 / 0.91[b]	-0.31 / 0.67[b]	-0.68 / 1.08[a]	-0.98 / 0.82[b]	-2.85 / 2.75[c]
	Juvenile	0.923	0.787		——	——	——	-1.81 / 1.82[c]
CW	Males	0.963	0.951		-0.40 / 1.05[a]	-0.39 / 1.09[a]	-1.14 / 1.24[c]	-2.34 / 2.87[c]
	Females	0.960	0.982		-0.26 / 0.78[b]	-0.53 / 1.19[c]	-0.80 / 0.81[b]	-2.39 / 2.89[c]
	Juvenile	——	——	——		——	——	——
PL	Males	0.856	0.851	0.739		-0.01 / 1.19[c]	-0.57 / 0.96[a]	-0.96 / 2.13[c]
	Females	0.872	0.887	0.819		-0.10 / 1.40[c]	-0.51 / 1.02[a]	-1.27 / 3.14[c]
	Juvenile	——	——	——	——		——	——
DL	Males	0.876	0.858	0.775	0.711		-0.51 / 0.81[b]	-0.82 / 1.67[c]
	Females	0.894	0.884	0.781	0.785		-0.38 / 0.57[b]	-0.95 / 2.04[c]
	Juvenile	——	——	——	——			——
CHW	Males	0.858	0.750	0.715	0.785	0.725		0.20 / 1.46[c]
	Females	0.900	0.799	0.824	0.802	0.764		0.25 / 2.31[c]
	Juvenile	0.952	0.990	0.847	——	——	——	
W	Males	0.963	0.962	0.941	0.835	0.841	0.794	
	Females	0.968	0.962	0.959	0.912	0.922	0.918	

a) isometric significance (t'student $p<0.05$); b) negative allometric significance (t'student $p<0.05$); c) positive allometric significance (t'student $p<0.05$).

Furthermore males have a great chela size variability for the same size of medium and large individuals. This must be attributed to an unlike size in the individual of the same cohorts with some agonistic behaviour and a differential growth in any prawns as dominant animals (Williner and Collins, 2000). The fact that males are morphologically more specialized for an aggressive interaction implies that conflicts are more recurrent in males (Knowlton and Keller, 1982) than females. However, in competitive situations as observed in previous works (Collins, 1997; Williner and Collins, 1997) fights between individuals of the same sex, in both males and females, are very frequent. Large individuals win and prawns with longer chela than their opponents but the similar size are more aggressive (Volpato and Hoshino, 1984; Karplus *et al.*, 1989; Karplus *et al.*, 1991; Casas-Sánchez *et al.*, 1995; Hughes, 1996; Sneddon *et al.*, 1997). In this case, the chela size plays a small function of body size in males, though it could be used to assess body size in early interactions, before engaging in more risky behaviours. A similar trend was analysed in others decapods (Maynard and Price, 1973; Caldwell and Dingle, 1978) in which cannibalism or injury of risk may be increased during moult events, when their cuticles are softened and their mobility is reduced (Kurihara *et al.*, 1989; Dick, 1995).

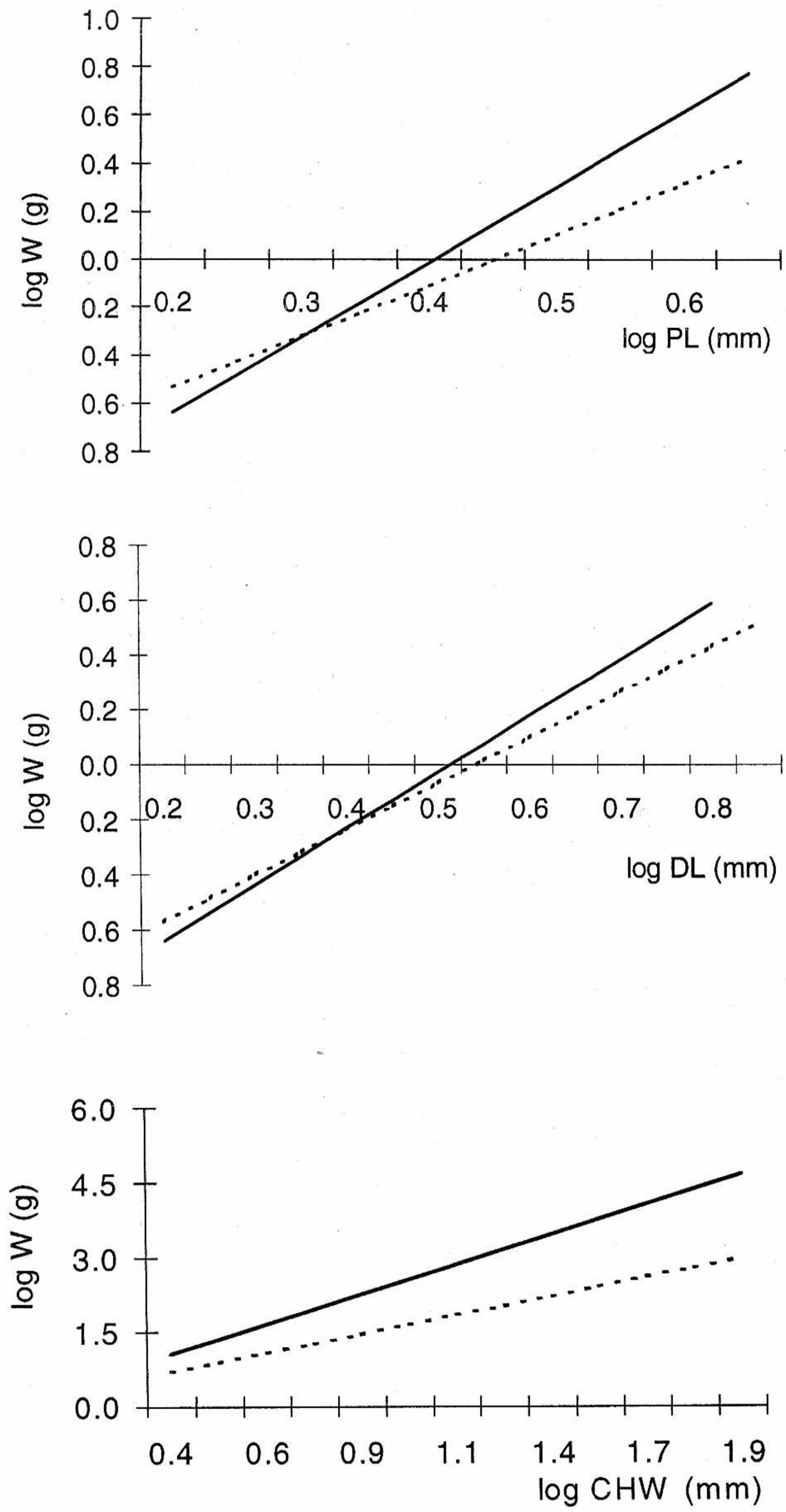

Figure 2: Relationships between chela lengths and weight for males (547 individuals) (—) and females (394 individuals) (—) (total n = 941 prawns) of *Macrobrachium borellii*.

The degree of male-biased size dimorphism was correlated with body size. This analysis revealed that male biased size dimorphism was based on contrasting sets of external characters as another sexual dimorphisms.

Males and females have not relevant difference in CW and cephalothorax length (CL), although there is a large difference in body weight. The relationship weight-length was significantly high and it may be used to convert body length to weight. The slopes of *M. borellii* were similar to *Palaemonetes argentinus* (Rodriguez-Capitulo and Freyre, 1989), *Nematopalaemon hastatus* (Enin, 1994), *Palaemon serratus* (Reeve, 1969), *Pandalus borealis* (Butler, 1964) and *Panulirus longipes* (Chittleborough, 1976); but smaller than *M. macrobrachium* (Enin 1994), *Pandalus jordani* and *Pandalopsis dispar* (Butler, 1964). Body weight is directly related to characters measures but other factors also influence upon weight, such as sex, maturity and the presence of a brood in females. In this study, the samples are taken in winter and female prawns were nonovigerous adults what not affect data in the calculation by maturity and/or brood females. However males and females have difference in this weight curve.

The different measurements and relations have provided information for traditional taxonomic procedures with new insight into the problems of cryptic species and sexual and ontogenetic polymorphism in freshwater prawns.

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