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BIOMETRY OF DECAPOD CRUSTACEANS IN THE CANTABRIAN SEA

BY

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ABSTRACT

In this paper the biometric relationships between the different body parts of decapods are described, allowing the reconstruction of size and biomass (weight) of each sample from its hard parts (chelae and cephalothorax).

The usefulness of this study lies in the interpretation of the feeding habits of demersal fish which feed on decapod crustaceans, since the slow digestion of hard skeletons of Decapods gives rise to the appearance of numerous hard parts in fish stomach contents.

RESUMEN

En este estudio se describen las relaciones biométricas entre las distintas partes del cuerpo de los crustáceos decápodos, lo que permite la reconstrucción de la talla y biomasa (peso) de cada ejemplar a partir de sus partes duras (quela y cefalotorax).

La utilidad de este trabajo radica en la interpretación de los hábitos alimenticios de los peces demersales que se alimentan de crustáceos decápodos, ya que la lenta digestión del exoesqueleto de los crustáceos permite la aparición de numerosas partes duras en los contenidos estomacales.

INTRODUCTION

This paper should not be considered as a strict morphometric study of decapods, but rather as a tool to be used in the study of the feeding habits of demersal fish through the use of hard parts of decapod crustaceans which appear in stomach contents, on the one hand to identify the prey species and on the other to obtain quantitative and qualitative data on these, from morphometric relationships.

Decapod crustaceans make up an important taxonomic group within the dynamic ecosystem of the Cantabrian Sea, specifically in the food chain of fish. In previous studies carried out in this geographical area it has been seen that crustaceans are the most important zoological prey group in percentage of frequency (Sorbe, 1981; Olaso, 1990).

On examining a stomach content, a mixture of prey organisms is usually found in different stages of digestion. The soft parts of the prey are quickly digested and it is practically impossible to determine the species they belong to. The exoskeleton of the crustaceans is especially useful in the identification, since the cuticle, which in the case of decapod crustaceas, is impregnated with calcareous salts (carbonates and phosphates) impedes the rapid decomposition of the structure by stomach juices.

This study will permit the calculation of predator-prey weight ratios to aid in the identification of trophic linkages and differences in prey size selection. Such patterns in predator-prey relationships are central to the concept of 'optimal foraging' (Krebs & Davies, 1979), although factors such as prey abundance and prey species composition cannot be ignored.

MATERIAL AND METHODS

The decapod crustaceans used for this study were obtained in 13 fishing surveys carried out between 1981 and 1991 during the months of March, May, June, September, October and November. By collecting samples on different dates, the seasonal effect, which has an influence on the different biometric relationships, is eliminated (Somerton & Macintosh, 1983).

The area of study covers the Cantabrian Sea from Fuenterrabia to Pta. de la Estaca de Bares and is made up of sandy and muddy bottoms, rocky bottoms not being considered due to the impossibility of trawling. Samples were collected at depths of between 35 and 600 m (fig. 1).

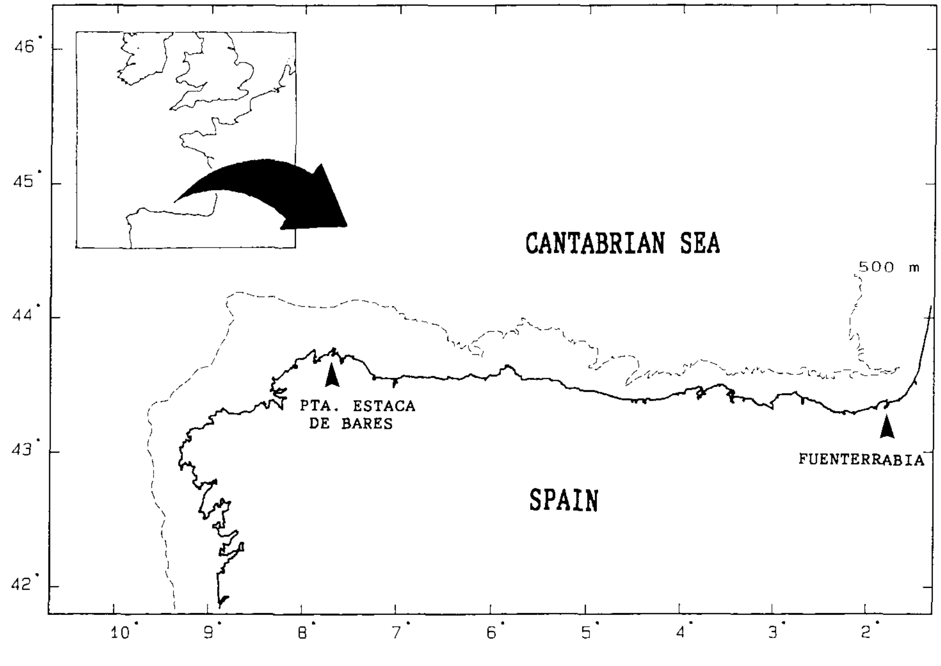

Fig. 1. Area of study.

The fishing was based on daytime trawling, with hauls of 30 minutes duration using a trawl gear, with a mesh-size of 20 mm (for methodology, see Sanchez, 1991).

The biological material was obtained from samples in the trawl net and from the stomach contents of the predators. The interest of using samples from the stomach contents is that they provide small samples and species which, due to their benthic and burrowing behaviour during the day, would normally escape from the trawl net.

More recently, in the laboratory, from the material collected and preserved in 70% alcohol, regression functions of size-weight, chela length-size, cephalothorax length-size etc. were obtained, from which total length and weight were estimated.

Choice of morphometric parameters

From each specimen, measurements were taken as described in fig. 2, according to which of five large groups each species belonged to. The measurements taken were: Total length (Lt), Cephalothorax length (Lc), Propodus length of right chela (Lp).

The measurements were taken with callipers with an accuracy of ± 0.1 mm.

Total wet weight (Wt): Each sample was dried on filter paper and weighed with an accuracy of ± 0.01 g.

Power function

The method of analysis which has been used is that proposed by Huxley (1932), consisting of estimating the relationship between one part or appendix of the body and a measurement of the organism taken as a parameter, that is to say, to estimate the size of one body part, given the size of another body part.

At an early stage in the study of relative growth (Huxley, 1924) it was demonstrated that nearly all samples could be satisfactorily described by the simple allometric equation, $y = ax^b$.

Use of the power function has become a standard technique in studies of relative growth in crustaceans.

Regression techniques

Since the aim of this paper is to provide a single function which describes the whole population, differences in growth rates between male and female mature and immature specimens have not been taken into account.

In studies using regression of two linear morphometric measurements, both are usually measured with error. As assumptions of the model I least squares regression are not satisfied, the model II regression technique should be applied

(Gould, 1966; Sokal & Rohlf, 1981; Hartnoll, 1982). But as the purpose is to predict a value of a variable rather than to describe the relationship between two variables (Lovett & Felder, 1989), and because the results between the two methods, when the determination coefficient is higher than 0.85, are very similar (Härkönen, 1986), the least squares regression equation (model I) was used, applied to untransformed data.

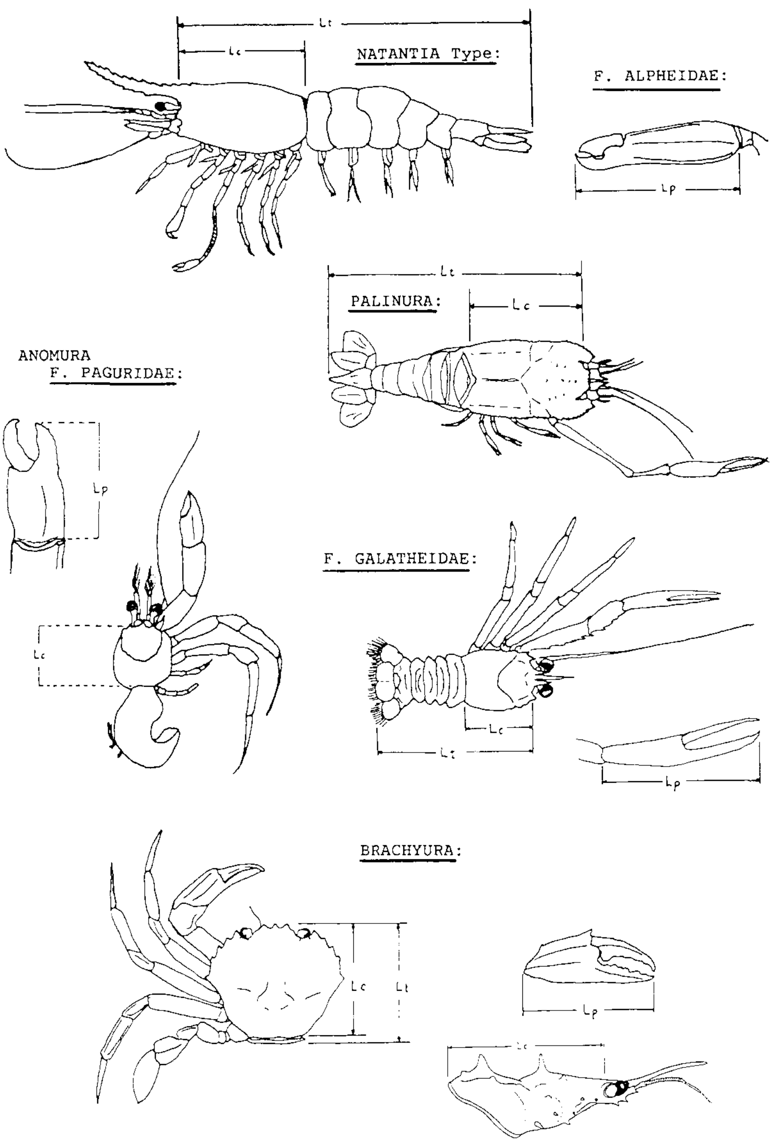

Fig. 2. Morphometric measurements considered: Lt, total length; Lc, cephalothorax length; Lp, propodus length of right chela.

To infer that a given regression function provides an appropriate description of a data set, the statistics F-ratio value (Fisher-exact test) and determination coefficient (r^2) are provided.

RESULTS

In total 32 species of decapod crustaceans were considered, and a total of 1716 specimens were measured (table I).

The parameters of the simple allometric equation, $y = ax^b$ were obtained for each species. In table II the ranges of values, intercept, slope, r^2, F-ratio and number of specimens measured for each relationship are shown.

Natantia (Solenoceridae and Caridea)

In the relationship Lc—Lt for Natantia, the determination coefficient (r^2) is always higher than 0.92 except in *Alpheus glaber* where it has a value of 0.88 owing to the difference in the abdomen between males and females. The relationship Lp-Lt, was only taken for *Alpheus glaber*, giving an r^2 with a value of 0.81. The relationships Lc-Wt and Lt-Wt take values higher than 0.88 and 0.92, respectively. These indices are quite good taking into account that the samples were caught in different seasons of the year.

Infraorder Palinura

Very good fits were obtained in the only species of this group for all biometric relationships. This good fit is due to the great calcification of the cephalothorax and the abdominal somites, which reduces the error in measuring the different body parts.

Infraorder Anomura

Within the Anomura group, the family Paguridae presents good fits, taking into account the variability caused, on the one hand, by measurement of the extremely soft cephalothorax, and on the other by the greater robustness of the chela of males with respect to that of females.

The family Galatheidae presents high values in all relationships, values for r^2 being slightly lower in relationships in which the size of chela propodus length (Lp) is taken into account.

Infraorder Brachyura

In the Brachyura, as I have already mentioned, only the right chela was measured. This is, in most cases, that of robust morphology, and for this reason despite the presence of heterochely the relationships Lp-Lt and Lp-Wt produce

TABLE I

Systematic list and number of specimens measured

		N
Suborder DENDROBRANCHIATA: Superfamly PENAEOIDEA:		
SOLENOCERIDAE	*Solenocera membranacea* (Risso, 1816)	71
Suborder PLEOCYEMATA: Infraorder CARIDEA:		
PASIPHEIDAE	*Pasiphaea multidentata* Esmark, 1866	36
	Pasiphaea sivado (Risso, 1816)	60
ALPHEIDAE	*Alpheus glaber* (Olivi, 1792)	45
PROCESSIDAE	*Processa canaliculata* Leach, 1815	
	Processa nouveli Al-Adhub & Williamson, 1975	
	Total *Processa*	123
PANDALIDAE	*Chlorotocus crassicornis* (Costa, 1871)	37
	Plesionika heterocarpus (Costa, 1871)	83
	Dichelopandalus bonnieri (Caullery, 1896)	92
CRANGONIDAE	*Pontophilus spinosus* (Leach, 1815)	104
	Pontophilus norvegicus (M. Sars, 1861)	29
	Philocheras echinulatus (M. Sars, 1861)	54
Infraorder PALINURA:		
POLYCHELIDAE	*Polycheles typhlops* Heller, 1862	51
Infraorder ANOMURA:		
PAGURIDAE	*Pagurus bernhardus* (Linnaeus, 1758)	43
	Pagurus prideaux Leach, 1815	75
	Pagurus alatus Fabricius, 1775	88
GALATHEIDAE	*Galathea intermedia* Lilljeborg, 1851	
	Galathea squamifera Leach, 1814	
	Galathea strigosa (Linnaeus, 1767)	
	Total *Galathea*	28
	Munida intermedia A. Milne Edwards & Bouvier, 1899	87
	Munida sarsi Brinckmann, 1936	73
	Munida sp.	11
Infraorder BRACHYURA:		
ATELECYCLIDAE	*Atelecyclus rotundatus* (Olivi, 1792)	65
PORTUNIDAE	*Liocarcinus depurator* (Linnaeus, 1758)	130
	Macropipus tuberculatus (Roux, 1830)	23
	Polybius henslowii Leach, 1820	61
	Bathynectes maravigna (Prestandrea, 1839)	26
GERYONIDAE	*Geryon longipes* A. Milne Edwards, 1881	20
GONEPLACIDAE	*Goneplax rhomboides* (Linnaeus, 1758)	78
MAJIDAE	*Inachus dorsettensis* (Pennant, 1777)	
	Inachus leptochirus Leach, 1817	
	Total *Inachus*	15
	Macropodia longipes (A. Milne Edwards & Bouvier, 1892)	108
Total measured		1716

TABLE II

Summary of regression analyses, ($y=ax^b$). Lt, total length; Lc, cephalothorax length; Lp, propodus length of right chela; Wt, total weight; a, intercept; b, slope; F, F-ratio; r^2, determination coefficient. *** = P<0.001

NATANTIA GROUP:	X	Y	Xmin	Xmax	Ymin	Ymax	a	b	r^2	F	N
Solenocera	Lc	Lt	9.00	23.10	32.00	74.45	5.153	0.854	0.94	1101.7***	70
membranacea	Lc	Wt	9.00	23.10	0.22	4.91	4.27E-4	2.975	0.93	868.5***	69
	Lt	Wt	32.00	74.45	0.22	4.91	1.64E-6	3.445	0.97	2137.1***	71
Pasiphae	Lc	Lt	15.3	36.7	52.30	117.20	4.567	0.897	0.99	2997.3***	36
multidentata	Lc	Wt	15.3	36.7	0.72	12.50	2.83E-4	2.912	0.96	920.3***	36
	Lt	Wt	52.3	117.2	0.72	12.50	2.15E-6	3.234	0.97	10.25.3***	36
Pasiphaea	Lc	Lt	11.60	23.30	42.20	80.45	4.360	0.920	0.97	1782.1***	60
sivado	Lc	Wt	11.60	23.30	0.27	2.10	4.54E-4	2.698	0.91	593.0***	60
	Lt	Wt	42.20	80.45	0.27	2.10	6.45E-6	2.917	0.93	775.8***	60
Alpheus	Lc	Lt	8.20	15.90	24.10	44.80	3.430	0.931	0.88	317.6***	44
glaber	Lp	Lt	10.30	32.10	24.10	44.80	9.342	0.418	0.81	101.3***	25
	Lc	Wt	8.20	15.90	0.27	1.97	5.75E-4	2.975	0.73	108.7***	42
	Lp	Wt	10.30	32.10	0.27	1.97	4.29E-3	1.747	0.91	227.0***	25
	Lt	Wt	24.10	44.80	0.27	1.97	1.04E-5	3.218	0.83	208.5***	45
Processa	Lc	Lt	6.35	20.60	25.45	66.15	3.825	0.955	0.95	2063.6***	122
(P.	Lc	Wt	6.35	20.60	0.14	3.41	3.47E-4	3.027	0.89	1020.1***	122
canaliculata	Lt	Wt	25.45	66.15	0.14	3.41	5.59E-6	3.137	0.93	1505.0***	123
P. nouveli)											
Chlorotocus	Lc	Lt	11.10	21.20	33.20	63.65	3.198	0.980	0.99	2730.2***	37
crassicornis	Lc	Wt	11.10	21.20	0.40	3.07	1.64E-4	3.214	0.92	426.8***	37
	Lt	Wt	33.20	63.65	0.40	3.07	3.98E-6	3.256	0.92	414.5***	37
Plesionika	Lc	Lt	9.60	18.60	38.00	74.80	4.662	0.944	0.95	1626.4***	83
heterocarpus	Lc	Wt	9.60	18.60	0.45	5.91	5.86E-4	3.080	0.88	580.6***	81
	Lt	Wt	38.00	74.80	0.45	5.91	4.05E-6	3.250	0.92	904.7***	78
Dichelopan-	Lc	Lt	10.40	25.10	39.50	92.30	4.186	0.971	0.98	3651.6***	92
dalus bonnieri	Lc	Wt	10.40	25.10	0.60	10.35	9.29E-4	2.884	0.96	1960.4***	91
	Lt	Wt	39.50	92.30	0.60	10.35	1.57E-5	2.930	0.95	1818.8***	91
Pontophilus	Lc	Lt	3.40	13.35	13.10	59.00	3.748	1.033	0.97	3770.8***	104
spinosus	Lc	Wt	3.40	13.35	0.03	1.88	9.45E-4	2.874	0.93	1446.8***	104
	Lt	Wt	13.10	59.00	0.03	1.88	2.35E-5	2.787	0.96	2654.1***	104
Pontophilus	Lc	Lt	7.20	11.90	31.40	50.20	5.458	0.890	0.97	826.7***	28
norvegicus	Lc	Wt	7.18	11.90	0.35	1.26	1.05E-3	2.871	0.91	270.8***	28
	Lt	Wt	30.95	50.20	0.29	1.26	5.17E-6	3.183	0.93	336.3***	29
Philocheras	Lc	Lt	5.95	12.10	21.10	53.00	3.038	1.109	0.92	582.7***	54
echinulatus	Lc	Wt	5.95	12.10	0.13	0.99	1.04E-3	2.776	0.89	322.0***	43
	Lt	Wt	21.10	53.00	0.13	0.99	6.80E-5	2.491	0.94	614.7***	43
PALINURA:											
Polycheles	Lc	Lt	13.00	38.40	28.15	84.95	2.150	1.021	0.99	5011.6***	51
typhlops	Lc	Wt	13.00	38.40	0.45	11.50	1.12E-4	3.187	0.91	482.3***	51
	Lt	Wt	28.15	84.95	0.45	11.50	1.23E-5	3.075	0.89	394.6***	51
ANOMURA:											
Pagurus	Lp	Lc	4.30	15.20	6.05	15.26	2.192	0.686	0.84	216.8***	43
bernhardus	Lp	Wt	4.30	15.20	0.14	2.28	6.89E-3	2.089	0.86	246.6***	42
	Lc	Wt	6.05	15.26	0.14	2.28	9.29E-4	2.864	0.92	440.2***	42

TABLE II cont.

	X	Y	Xmin	Xmax	Ymin	Ymax	a	b	r^2	F	N
Pagurus	Lp	Lc	13.20	38.80	12.85	26.10	2.797	0.619	0.83	342.3***	70
prideaux	Lp	Wt	13.20	38.80	1.69	20.10	7.59E-3	2.200	0.86	402.1***	70
	Lc	Wt	12.85	26.10	1.69	20.10	4.09E-4	3.305	0.85	403.3***	75
Pagurus	Lp	Lc	7.28	27.50	8.08	25.80	1.408	0.859	0.85	499.4***	88
alatus	Lp	Wt	13.20	38.80	1.69	20.10	7.08E-3	2.291	0.87	428.8***	66
	Lc	Wt	12.84	26.10	1.69	20.10	3.67E-3	2.568	0.87	438.9***	67
Galathea	Lc	Lt	4.30	13.10	8.60	29.00	2.043	1.045	0.98	1583.7***	28
(G. strigosa,	Lp	Lt	4.80	22.50	8.60	29.00	3.466	0.675	0.94	276.9***	20
G. intermedia,	Lt	Wt	8.60	29.00	0.07	1.76	1.04E-4	2.895	0.96	435.0***	20
G. squamifera)	Lp	Wt	4.80	22.50	0.07	1.76	3.34E-3	2.010	0.95	381.5***	20
Munida	Lc	Lt	10.00	29.50	23.60	71.50	2.732	0.959	0.98	3392.3***	87
intermedia	Lp	Lt	16.45	71.20	23.60	71.50	5.486	0.584	0.80	324.3***	83
	Lt	Wt	23.60	64.25	0.84	20.60	1.35E-5	3.387	0.93	1024.0***	75
	Lp	Wt	16.45	71.20	0.84	20.60	2.27E-3	2.155	0.89	604.5***	76
Munida	Lc	Lt	13.75	27.12	34.70	65.72	2.638	0.981	0.97	2304.6***	73
sarsi	Lp	Lt	21.40	74.05	34.70	65.72	6.324	0.553	0.80	267.0***	73
	Lt	Wt	34.70	65.72	2.37	19.91	5.02E-5	3.040	0.92	828.4***	73
	Lp	Wt	21.40	74.05	2.37	19.91	7.63E-3	1.845	0.88	523.0***	73
BRACHYURA:											
Atelecyclus	Lp	Lt	5.00	25.90	9.90	37.70	4.062	0.701	0.82	284.2***	63
rotundatus	Lt	Wt	8.75	37.70	0.19	14.54	1.17E-4	3.247	0.94	1027.2***	65
	Lp	Wt	5.00	25.;90	0.22	14.54	7.57E-3	2.416	0.86	374.2***	64
Liocarcinus	Lp	Lt	3.69	42.20	5.14	39.50	1.950	0.827	0.97	3987.7***	126
depurator	Lt	Wt	5.14	39.50	0.05	32.87	1.79E-4	3.258	0.98	5186.8***	130
	Lp	Wt	3.69	42.20	0.05	32.87	1.43E-3	2.730	0.98	7337.6***	127
Macropipus	Lp	Lt	20.50	36.20	24.05	34.90	3.006	0.683	0.89	174.4***	23
tuberculatus	Lt	Wt	24.05	34.90	4.48	17.18	4.59E-4	2.914	0.93	269.7***	23
	Lp	Wt	20.50	36.20	4.48	17.18	1.01E-2	2.026	0.86	126.4***	23
Polybius	Lp	Lt	20.40	40.20	31.10	50.70	5.197	0.602	0.89	473.5***	61
henslowii	Lt	Wt	31.10	50.70	7.23	31.21	1.60E-4	3.103	0.96	1264.2***	61
	Lp	Wt	20.40	40.20	7.23	31.21	2.12E-2	1.939	0.91	626.6***	61
Bathynectes	Lp	Lt	17.70	44.75	21.35	51.60	1.251	0.990	0.96	567.7***	26
maravigna	Lt	Wt	21.35	51.60	3.03	55.08	4.65E-4	2.929	0.97	448.9***	16
	Lp	Wt	17.70	44.75	3.03	55.08	6.45E-4	2.993	0.99	1141.1***	16
Geryon	Lp	Lt	17.35	64.30	19.60	68.10	2.127	0.830	0.96	451.1***	20
longipes	Lt	Wt	19.60	68.10	2.25	152.42	1.25E-4	3.329	0.99	1145.9***	18
	Lp	Wt	17.35	64.30	2.25	152.42	1.40E-3	2.786	0.95	319.6***	18
Goneplax	Lp	Lt	3.90	47.30	4.00	20.75	2.930	0.502	0.92	852.0***	74
rhomboides	Lt	Wt	4.00	20.75	0.04	11.44	2.73E-4	3.478	0.99	5505.5***	78
	Lp	Wt	3.90	47.30	0.04	11.44	9.21E-3	1.816	0.95	1431.7***	74
Inachus	Lp	Lt	5.70	22.10	12.50	25.20	5.586	0.483	0.75	39.0***	15
(I. leptochirus,	Lt	Wt	12.50	25.20	0.34	5.14	2.83E-4	2.946	0.78	45.3***	15
I. dorsettensis)	Lp	Wt	5.70	22.10	0.34	5.14	2.15E-2	1.735	0.87	84.9***	15

TABLE III

Regression analyses calculated for *Macropodia longipes* for the total without considering sex, for males, and for females. Notation as table II

	X	Y	Xmin	Xmax	Ymin	Ymax	a	b	r^2	F	N
Macropodia	Lc	Lt	7.70	23.50	9.50	28.35	1.620	0.910	0.81	441.3***	108
longipes	Lp	Lt	6.20	36.80	9.50	28.35	8.675	0.277	0.30	44.9***	107
	Lt	Wt	9.50	28.35	0.20	10.31	2.68E-4	3.014	0.70	234.4***	103
	Lp	Wt	6.20	36.80	0.20	10.31	2.28E-2	1.566	0.71	259.1***	108
Macropodia	Lc	Lt	7.70	23.50	9.50	28.35	1.238	0.986	0.99	5205.0***	63
longipes	Lq	Lt	6.20	36.80	9.50	28.35	3.377	0.555	0.90	542.5***	62
males	Lt	Wt	9.50	28.35	0.20	10.31	6.07E-5	3.609	0.91	558.6***	58
	Lq	Wt	6.20	36.80	0.20	10.31	3.15E-3	2.149	0.94	886.0***	58
Macropodia	Lc	Lt	8.70	18.40	10.70	26.20	1.132	1.077	0.96	1151.9***	45
longipes	Lq	Lt	7.40	17.15	10.70	26.20	1.686	0.955	0.89	333.0***	45
females	Lt	Wt	10.70	26.20	0.24	3.10	2.49E-4	2.929	0.86	270.8***	45
	Lq	Wt	7.40	17.15	0.24	3.10	9.11E-4	2.892	0.80	188.4***	50

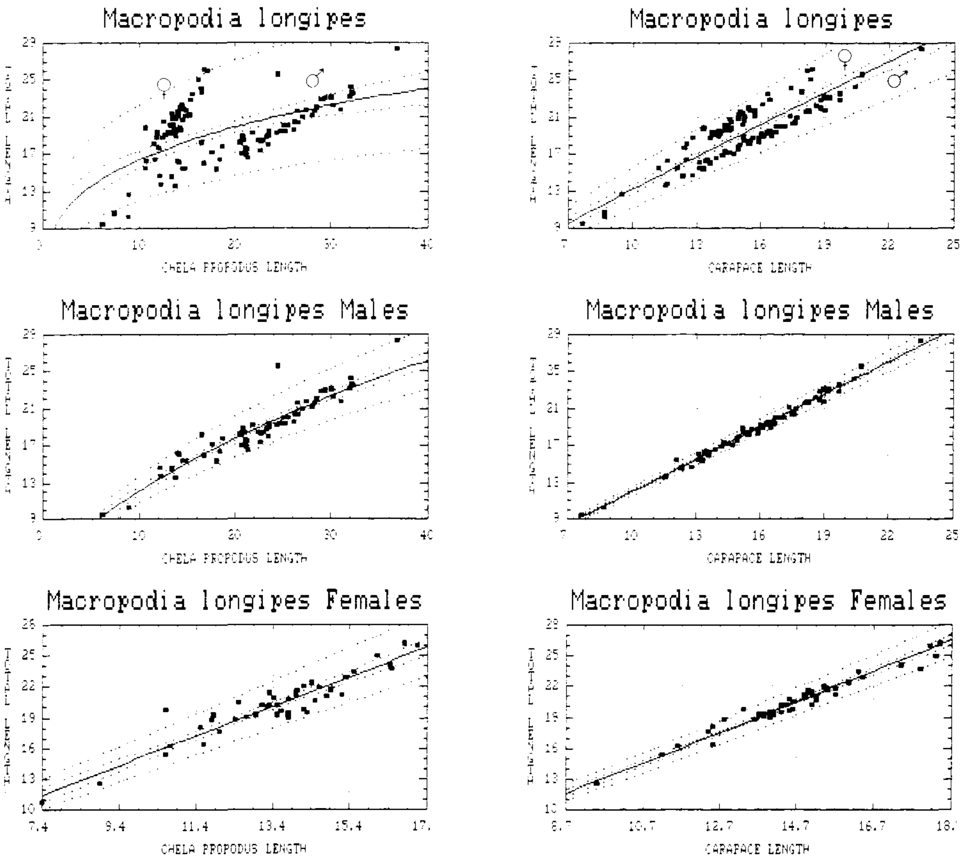

Fig. 3. Relationship between carapace length - total length, and between right chela propodus length - total length for the total, for males and for females of *Macropodia longipes*. Two pairs of dotted lines representing the 95% confidence and prediction limits.

high values of r^2. As the regression Lc-Lt gives values of r^2 of 0.99, only total length has been taken into account in relation to propodus length and weight, except for the genus *Macropodia*, which will be discussed later.

In the Atelecyclidae, Portunidae and Geryonidae, the propodus length is similar for males and females. Chela size is one of the possible morphometric differences that may contribute to the slightly low size-weight relationship observed.

In *Goneplax rhomboides* the propodus length of males is higher than in females, nevertheless the curve fit is satisfactory.

The case of the genus *Macropodia* is the only one in which values for males and females are so different that they cannot be treated together, and it is necessary to separate the sexes into two distinct regression curves. This is to be expected, since slight differences in the rates of female and male abdomen and chela

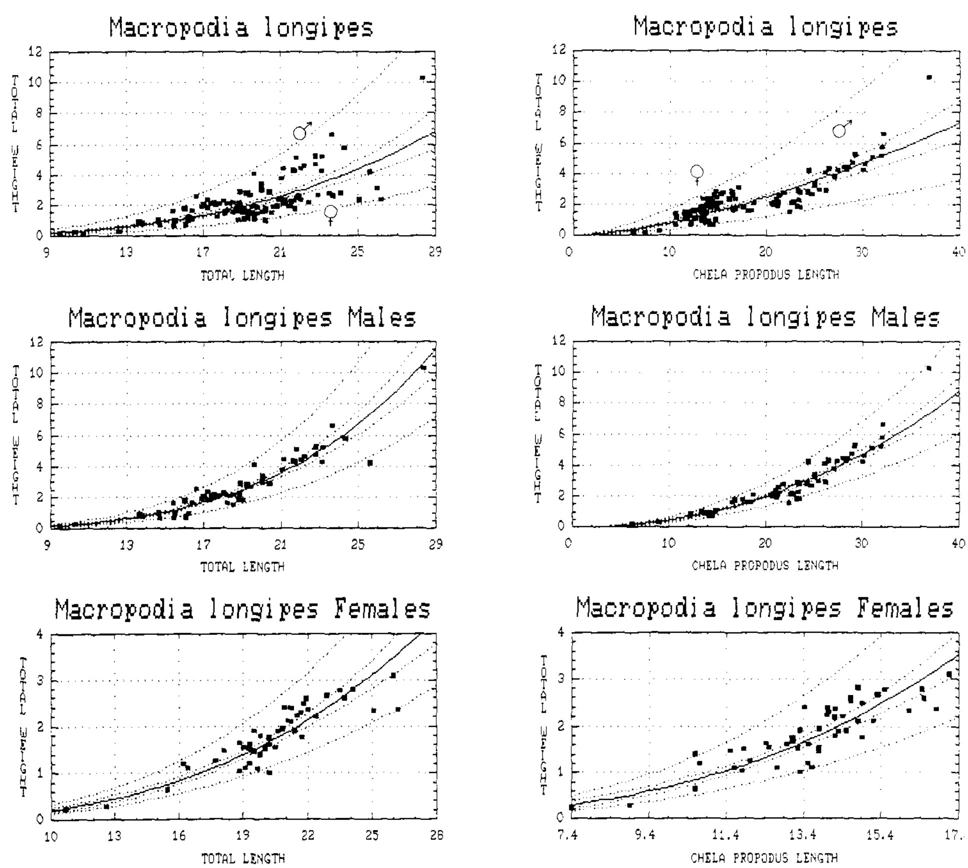

Fig. 4. Relationship between total length - total weight and between right chela propodus length - Total weight, for the total, for males and for females of *Macropodia longipes*. Two pairs of dotted lines representing the 95% confidence and prediction limits.

growth would make a considerable difference to the ratios. As shown by table III, and figures 3 and 4, when the sexes are treated separately the curve fits quite well.

In most species, the power function fits the data better than did the linear function, except for some cases in the relationship Lc-Lt, Lp-Lc and Lp-Lt, where r^2 and F-ratio were slightly higher than in the power function for Natantia, Palinura and Anomura.

In all the examples the F-ratio gives very high values with $p<0.001$.

DISCUSSION

Crustaceans, due to their chitinous exoskeletons, usually underwent slower digestion than other prey like fish and cephalopods. As a result identification of prey and prey size measurements for decapod crustaceans are easy to acquire.

Numerous studies have been made on relative growth rates of crustacean body parts in many taxa (for review, see Hartnoll, 1982), and these well documented accounts show that there is a direct relationship between one body part's size and body length/weight for each species. However, all of these studies take into account the differences in growth between the sexes, and between mature and immature specimens. For the same reasons, in the area studied and for the species considered, little of what has been published (Abelló & Sardá, 1982; Froglia & Gramitto, 1987; Alonso-Allende & Figueras, 1987; Mori & Zunino, 1987; Abelló, Pertierra & Reid, 1990) is applicable in interpreting size-weight composition of decapod crustaceans. Furthermore, in many of these studies the attribution of the x and y variables in the allometric equation is the opposite of that used in this study. For example, in the work by Abelló & Sardá (1982), the sexual dimorphism of the chela (variable y) of *Goneplax rhomboides* is analysed as a function of length of the cephalothorax (variable x), while for the application of the present study in feeding analysis, the cephalothorax length (variable y) is necessarily estimated from the length of the chela found in the stomach (variable x).

In the study of stomach contents the distinction between sexes from one hard part is practically impossible in many species, and furthermore, it is more important to analyse a high number of stomachs rather than to study a few in great detail. For this reason the difference between sexes and between mature and immature specimens is difficult to take into account.

From the results obtained it can be seen that all of the species fit the curves well giving high values of r^2 even in Brachyura where a greater difference would have been expected owing to sexual dimorphism. There is only one exception, that of the genus *Macropodia*. In this case when the measurements of *Macropodia* found in stomach contents are taken, we need to consider the sex to obtain good size and weight estimates (sexual differentiation in this species is very easy to observe from the chela). For the remaining groups the curves fit well for the whole population and so it is not necessary to separate the sexes. Thus, the appearance of 'hard parts' in the stomach contents permits a reliable estimate of the lengths of decapods eaten. Similarly, a reliable estimate of the biomass ingested can be obtained by utilizing a body part size-weight curve for the species in question.

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