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Weight–length relationships of 25 bivalve species (Mollusca: Bivalvia) from the Algarve coast (southern Portugal)

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Weight–length relationships of some of the most abundant bivalve species from the Algarve coast (southern Portugal) captured during several exploratory fishing surveys carried out during 2000 on a soft bottom in the subtidal zone down to 25 m depth are reported. For this study a total of 7429 individuals were sampled, belonging to 25 bivalve species in nine families. The most represented families were Mactridae and Veneridae with six species, immediately followed by the families Cardiidae (five species) and Donacidae (three species). The results revealed that most species presented isometric (11 species) or positive allometric relationships (11 species), while only a small minority of species displayed negative growth (three species).

INTRODUCTION

Harvesting bivalve molluscs is an ancient and traditional activity in Portugal, and a very important bivalve fishery occurs along the Algarve coast (southern Portugal). Periodic fishing surveys are carried out by IPIMAR to evaluate the exploitation intensity of this fishery and its impact over bivalve populations. This paper reports weight–length relationships of some of the most abundant bivalve species that occur along the Algarve coast.

Weight–length relationships have several uses, namely the estimation of weight from length for individuals and for length classes (Anderson & Gutreuter, 1983), and the conversion of growth-in-length equations to growth-in-weight, for prediction of weight-at-age and subsequent use in stock assessment models (Pauly, 1993). Additionally, weight–length relationships allow life history and morphological comparisons between species or between populations of a species from different habitats and/or regions.

MATERIALS AND METHODS

The specimens were collected during several exploratory fishing operations carried out by IPIMAR during 2000 along the Algarve coast. Individuals were caught with a clam dredge (mesh size of 25 mm) in the subtidal zone, on soft bottoms down to 25 m depth. Bivalve species were identified following Tebble (1966) and Poppe & Goto (1993), and the nomenclature adopted was that of Poppe & Goto (1993).

The measurement of the bivalve shell length (maximum distance along the anterior–posterior axis) was made to the nearest 0.01 mm, with a digital calliper, and the weighting of the individuals was made on a top loading digital balance with a precision of 0.01 g.

The estimation of the weight–length relationship was made by adjustment of an exponential curve to the data:

$$W = aL^b \quad (1)$$

This equation can be expressed in its linearized form:

$$\log W = \log a + b \log H \quad (2)$$

where W=wet weight (g), L=length (mm), a=intercept: initial growth coefficient, b=slope: relative growth rates of the variables.

The parameters of the weight–length relationships were estimated by linear regression analysis (least squares method), and the association degree between variables was calculated by the determination coefficient (r^2). Additionally, data were submitted to an analysis of variance (ANOVA) to estimate the 95% confidence limits of b and the significance level of r^2.

In order to confirm if the values of b obtained in the linear regressions were significantly different from the isometric value (b=3), a t-test (H_0, b=3) with a confidence level of ±95% was applied, expressed by the following equation (Sokal & Rohlf, 1987):

$$t_s = (b - 3)/s_b \quad (3)$$

where t_s=t-test value, b=slope, s_b=standard error of the slope (b).

Subsequently, the comparison between the obtained value of the t-test and the tabled critical value of the t-test, allowed the determination of the statistical significance of the b value and its inclusion in the isometric range or allometric ranges.

RESULTS

For this study a total of 7429 individuals were sampled, belonging to 25 bivalve species distributed in nine families. The results obtained for the weight–length relationships, along with some sample descriptive statistics are given in Table 1.

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Table 1. *Descriptive statistics and weight–length relationship parameters for 25 bivalve species caught by dredge in the Algarve coast (southern Portugal). Length units (L mean, L minimum and L maximum) are given in mm.*

Family/Species	N	L mean ±SD (L min – L max)	Allometric equation	Determination coefficient (r^2)	SE of b (95% CI of b)	Relationship (t-test)
Family Anomiidae						
Anomia ephippium	73	39.75 ±13.43 (5.74–60.46)	$W=0.00005L^{3.097}$	0.964**	0.071 (2.955–3.239)	isometric
Family Cardiidae						
Acanthocardia aculeata	210	37.26 ±16.86 (11.30–95.97)	$W=0.00005L^{3.423}$	0.976*	0.037 (3.349–3.497)	+ allometry
Acanthocardia paucicostata	657	26.00 ±4.84 (7.81–35.78)	$W=0.0002L^{3.133}$	0.911*	0.038 (3.058–3.208)	+ allometry
Acanthocardia tuberculata	514	40.84 ±17.18 (9.92–77.05)	$W=0.0002L^{3.143}$	0.986*	0.016 (3.111–3.175)	+ allometry
Laevicardium crassum	369	39.43 ±14.98 (13.96–63.39)	$W=0.0002L^{3.106}$	0.988*	0.018 (3.071–3.141)	+ allometry
Corbula gibba	44	7.59 ±1.65 (4.33–10.87)	$W=0.0004L^{2.963}$	0.863***	0.182 (2.595–3.330)	isometric
Family Donacidae						
Donax semistriatus	255	27.37 ±4.62 (17.40–42.80)	$W=0.00006L^{3.173}$	0.923**	0.057 (3.060–3.286)	+ allometry
Donax trunculus	740	27.25 ±5.52 (16.00–44.00)	$W=0.0006L^{2.572}$	0.991*	0.049 (2.471–2.673)	− allometry
Donax variegatus	164	31.25 ±4.51 (21.00–40.12)	$W=0.00002L^{3.379}$	0.945**	0.064 (3.252–3.506)	+ allometry
Family Mactridae						
Lutraria angustior	76	35.15 ±6.84 (19.80–51.15)	$W=0.00003L^{3.149}$	0.898***	0.123 (2.904–3.395)	isometric
Mactra corallina corallina	172	41.27 ±8.97 (22.33–63.53)	$W=0.00009L^{3.128}$	0.884**	0.087 (2.956–3.300)	isometric
Mactra corallina stultorum	480	38.43 ±8.75 (15.00–56.76)	$W=0.00003L^{3.456}$	0.935*	0.042 (3.374–3.538)	+ allometry
Mactra glauca	464	62.28 ±25.70 (21.40–109.90)	$W=0.00002L^{3.450}$	0.988*	0.017 (3.416–3.485)	+ allometry
Spisula solida	574	26.95 ±6.77 (11.00–39.29)	$W=0.0002L^{3.074}$	0.998*	0.025 (3.022–3.126)	+ allometry
Spisula subtruncata	650	17.98 ±3.70 (5.30–26.35)	$W=0.0002L^{3.044}$	0.931*	0.033 (2.980–3.108)	isometric
Family Mytilidae						
Modiolus adriaticus	134	31.80 ±6.61 (9.00–47.76)	$W=0.00006L^{3.062}$	0.844***	0.114 (2.836–3.289)	isometric
Family Pandoridae						
Pandora albida	165	23.74 ±2.87 (15.58–30.35)	$W=0.0001L^{2.761}$	0.724***	0.133 (2.498–3.025)	isometric
Family Solecurtidae						
Pharus legumen	119	75.89 ±18.36 (32.55–99.82)	$W=0.00001L^{2.995}$	0.992*	0.069 (2.847–3.142)	isometric
Family Solenidae						
Ensis siliqua	225	98.05 ±27.45 (45.00–155.00)	$W=0.00001L^{3.030}$	0.990*	0.059 (2.909–3.152)	isometric
Family Veneridae						
Callista chione	172	61.65 ±22.49 (19.08–101.00)	$W=0.0002L^{3.041}$	0.990*	0.024 (2.995–3.087)	isometric
Chamelea gallina	695	23.45 ±5.84 (8.10–40.00)	$W=0.0007L^{2.801}$	0.998*	0.024 (2.752–2.850)	− allometry
Dosinia exoleta	258	30.68 ±6.95 (13.97–46.15)	$W=0.00007L^{3.398}$	0.963*	0.042 (3.316–3.480)	+ allometry
Dosinia lupinus	51	21.17 ±2.99 (16.36–31.20)	$W=0.0003L^{2.980}$	0.851***	0.178 (2.622–3.338)	isometric
Venerupis rhomboides	90	37.99 ±4.88 (24.00–45.00)	$W=0.00002L^{3.611}$	0.902***	0.127 (3.359–3.862)	+ allometry
Venus fasciata	78	21.35 ±2.74 (12.58–28.00)	$W=0.001L^{2.626}$	0.859***	0.122 (2.383–2.869)	− allometry

N, number; SD, standard deviation; SE, standard error; CI, confidence interval; $P<0.01$; **, $P<0.025$; ***, $P<0.05$.

It is important to note that this data collection is not representative of a particular season and was not collected during a specific period of the year (temperature range from January to August: 14–21°C), thus these parameters should only be considered as mean annual values. Additionally, and despite the selectivity of the fishing gear, samples still contain some small sized individuals. However, it is necessary to stress that the present weight–length relationships should be limited to the sizes used for the parameters estimation, being particularly dangerous to extrapolate data to juvenile stages (Kato & Hamai, 1975).

For the 25 species studied, 11 isometric relationships (44%), 11 positive allometric relationships (44%), and only three negative allometric relationships (12%) were detected. This reveals that for the first 11 species the growth in length is accompanied by weight increase (isometric growth), for the other 11 species the weight increase is even superior to the growth in length (positive allometric growth), and only in the case of three species is the growth in length superior to weight increase (negative allometric growth).

DISCUSSION

In terms of eventual connections between the type of bottom substrata and the weight–length relationships, the prevalence of isometric relationships and positive allometries over negative allometries is a very interesting phenomenon, since the vast majority of these species are typical inhabitants of sandy or sandy-mud bottoms. This phenomenon may be explained by the fact that density of substrata is not a limiting factor on firmer sediments, therefore the parameter b of weight–length relationships may exceed three in such environments (Thayer, 1975).

In the present study, this fact can be illustrated by the genus *Acanthocardia*, in which three species consistently display positive allometric growth. This finding is interesting, since underwater observations indicate that *Acanthocardia aculeata*, *Acanthocardia paucicostata* and *Acanthocardia tuberculata* exhibit the same burrowing strategy, being only half-burrowed in the substrata (M.B. Gaspar, unpublished data). For these species, positive allometries may also reflect non-burrowing strategies or even burrowing difficulties associated with their globous shape.

Another interesting finding is that *Donax* is the only genus that presents opposite types of growth among species. Since *Donax semistriatus*, *Donax trunculus* and *Donax variegatus* are all common inhabitants of strictly sandy bottoms, this fact may eventually be related to the different bathymetric distribution of these species.

In this study an isometric growth was detected for both *Callista chione* and *Ensis siliqua*, which is in apparent contradiction with some studies in other geographical areas (Valli et al., 1983–1984; Henderson & Richardson, 1994). Both for *Chamelea gallina* and *Donax trunculus* a negative allometric growth was found, which is in agreement with other studies of these species in several geographical areas (Froglia, 1975; Ansell & Lagardère, 1980; Cano & Hernández, 1987; Ramón, 1993). Finally, for *Spisula solida* a positive allometric growth was determined, which corroborates with the results obtained in the only known related study of this species (Sobral, 1987–1990).

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