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Morphometric study of the nereidid *Laeonereis acuta* (Annelida: Polychaeta)

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In order to find the most suitable parameter for measuring the nereidid *Laonereis acuta*, correlations between total length or weight and eight morphological measurements: width of prostomium and 2nd, 6th, 13th and 19th setigers, length of the prostomium, length through segment 6th and length through segment 13th, were established. The width measurements showed the highest values of *r*, and were the most reliable indicators of size. Comparisons between weight and morphological measurements showed a similar pattern as well as negative allometric growth.

INTRODUCTION

The estimation of the size of worms is a basic question in studies of population ecology, secondary production and morphometric analysis. In order to determine the cohorts and age classes of invertebrate populations, the total length, biomass, and certain hard appendages (jaws and teeth) were measured. This type of study, which requires examination of large numbers of specimens representing all size-classes, is sometimes complicated by the occurrence of autotomy and mechanical breakage during sampling and sieving (Desrosiers et al., 1988). Moreover, worms can become distorted or shrink during preservation, which makes accurate size estimation difficult (Warwick & Price, 1975). As a consequence of this difficulty, a great diversity of growth parameters have been used in population studies of polychaetes. The width or length of setigers (segments bearing parapodia), width or length of the prostomium and the anterior part of the body, or the size of jaw appendages are common morphometric parameters used in such studies (Gentil & Dauvin, 1989; Fauchald, 1991; Sardá et al., 1995; Caron et al., 1995; Ieno et al., 2000).

The nereidid polychaete *Laeonereis acuta* (Treadwell, 1923) is a common infaunal species in estuaries along the Atlantic coast of South America, ranging from Recife, Brazil, to the Peninsula de Valdés, Argentina (Orensanz & Gianuca, 1974). These worms can reach high abundance and biomass on sheltered beaches, mangrove flats and sand flats, occurring mainly in the upper level of the intertidal region (Lana et al., 1997). The broad distribution of *L. acuta* and its probable ecological importance in marine food webs have interested many authors (Amaral, 1979; Bemvenuti et al., 1992; Ieno & Bastida, 1998; Ieno et al., 2000). Its population dynamics and secondary production on a tidal flat on the south-east coast of Brazil were also investigated (Omena & Amaral, 2000).

Laeonereis acuta has a well-developed prostomium with large palps, a pair of short antennae, and two pairs of eyes. The eversible pharynx with a pair of jaws is adorned with minute papillae arranged in patches. There are four pairs of tentacular cirri (Figure 1). The first segment is apodous; thereafter all segments bear parapodia and setae (i.e. setigerous).

In order to find the most suitable method to measure the nereidid *L. acuta*, correlations between the total length or weight and eight morphological measurements were established. Analysis of the morphometric relationships between such parameters is basic to future studies of the growth rate and secondary production of *L. acuta*.

MATERIALS AND METHODS

Specimens of *Laeonereis acuta* were collected from the upper intertidal region of Enseada Beach, a 700-m wide sand flat, located on the northern coast of São Paulo. Samples were taken randomly with a 10-cm diameter corer, to a depth of 20 cm. In order to capture recruits and young nereidids living in the surface layers (Mazurkiewics, 1975), additional samples were taken with a similar corer, to a depth of 2 cm. Fauna samples were sieved through 0.5 and 1-mm mesh sieves, fixed in 10% formalin, and preserved in 70% ethanol. Samples from the recruitment cores were sieved through 0.25-mm mesh sieves.

All measurements, from a total of 78 specimens, were made using a stereomicroscope. The measurements included: total length (TL), width of the prostomium (W Prostomium), widths (excluding parapodia) of the 2nd, 6th, 13th, and 19th setigers (W Set 2nd, W Set 6th, W Set 13th, W Set 19th), length of the prostomium (L Prostomium); and length from the prostomium to the 6th and 13th setigers (L Set 6th, L Set 13th).

A linear regression analysis ($y=ax^b$) between the total length or the weight and all the morphological measurements was performed. In this equation b is termed the allometric coefficient, and a is the linear coefficient. The allometric coefficient, which can be either positive, negative, or zero expresses what change in y is associated with a

change in x during growth. If b=3, it means an isometric growth, i.e. a change in weight corresponds to a similar change in setiger width. If b<3, it means a negative allometric growth, setiger width increases on a higher rate than weight and, if b>3, a positive allometric growth, the weight increases on a higher rate than setiger width.

The correlation values (*r*) for the all measurements were statistically compared (χ^2-test). The precision of b was also determined (*t*-test) (Zar, 1974).

RESULTS

Since many specimens suffered mechanical breakage and autotomy during the collection and sieving, determination of total length was obtained from only 49 specimens. Comparing the correlation values between total length and the other morphometric measurements; the setiger width showed higher *r* than the length measurements (Table 1). Apart from the correlation value obtained from 2nd width which was very low, possibly due to the influence of the position of proboscis which could vary between specimens, there was no statistical difference between the correlation values from total length and the width of the setigers (χ^2=0.5881). The correlations between these parameters showed the existence of an isometric relationship.

Table 1. *Correlation between total length TL (mm) and morphometric parameters (mm) for* Laeonereis acuta.

Parameters	N	*r*	a	b
TL×W	48	0.82	9.54	0.33
TL×W Set 2nd	48	0.40	30.22	0.67
TL×W Set 6th	48	0.76	29.66	1.04
TL×W Set 13th	48	0.66	31.35	0.84
TL×W Set 19th	47	0.74	31.13	0.96
TL×W Prostomium	48	0.52	33.34	0.69
TL×L Prostomium	48	0.23	25.40	0.27
TL×L Set 6th	47	0.27	18.62	0.56
TL×L Set 13th	47	0.42	10.00	0.82

N, total number; *r*, correlation coefficient; a, linear coefficient; b, angular coefficient.

Table 2. *Correlation between total weight TW (mg) and morphometric parameters (mm) for* Laeonereis acuta.

Parameters	N	*r*	a	b
TW×L	48	0.79	0.06	1.74
TW×W Set 2nd	48	0.34	25.65	1.13
TW×W Set 6th	48	0.64	24.14	1.80
TW×W Set 13th	48	0.47	23,82	1.19
TW×W Set 19th	47	0.54	23,92	1.38
TW×W Prostomium	48	0.33	25,14	0.93
TW×L Prostomium	48	0.02	12,79	0.06
TW×L Set 6th	47	0.65	9,52	2.27
TW×L Set 13th	47	0.78	1,03	2.91

N, total number; *r*, correlation coefficient; a, linear coefficient; b, angular coefficient.

By comparison, the correlations between total weight and the morphometric measurements, yielded higher values for total length and length of setigers (13th and 6th) (Table 2). There was no statistical difference between these correlation values (χ^2=9.488). All the allometric coefficients had values significantly less than 3, indicating negative allometric growth (t=1.86; P<0.05). However, the allometric coefficient obtained from the length of prostomium to setiger 13 showed a close value from an isometric growth (2.91). These results show that an increase in length corresponds to a similar change in total weight, which indicates that the length measurements were more important to weight than the width of setigers.

Table 3. *Some references on morphometric parameters used to estimate the growth of polychaetes.*

Reference	Species	Parameter
Bloom (1983)	*Laeonereis culveri*	Width of 1st setiger
	Onuphis simoni	Width of 1st setiger
Gentil & Dauvin (1989)	*Owenia fusiformis*	Length of 4th setiger
Sardá & Martín (1992)	*Streptosyllis verrilli*	Width of proventricular setiger
Gillet (1990)	*Nereis diversicolor*	Length of first segments
Moore & Dillon (1993)	*Nereis arenaceodentata*	Wet weight
Vedel & Riisgard (1993)	*Nereis diversicolor*	Wet weight
Caron et al. (1993)	*Nereis virens*	Width of 3rd setiger
Caron et al. (1993)	*Nephtys caeca*	Width of 7th setiger
Santos (1994)	*Scolelepis gaucha*	Width of 5th setiger
Bridges et al. (1994)	*Streblospio benedicti*	Total number of setigers
	Capitella sp. I	Volume
Sarda et al. (1995)	*Marenzelleria viridis*	Width of 5th setiger
Shimizu (1995)	*Scolelepis squamata*	Width of 3rd setiger
Seitz & Schaffner (1995)	*Loimia medusa*	Width of prostomium
Olivier et al. (1996)	*Nereis diversicolor*	Wet weight
Ieno et al. (2000)	*Laeonereis acuta*	Width of 10th setiger

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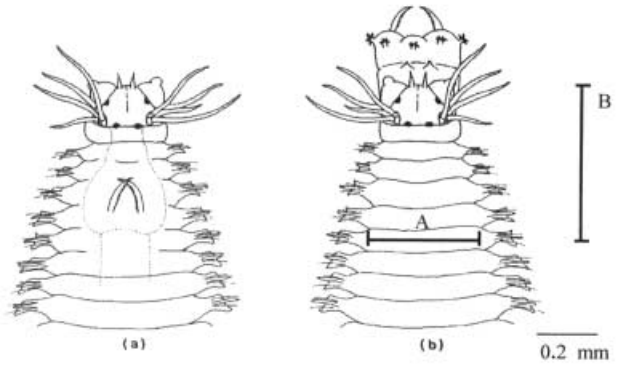

Figure 1. *Laeonereis acuta*. Dorsal view of the worm with the proboscis (A) retracted; and (B) everted. a, width of 6th setiger; and b, length from the prostomium to the 6th setiger.

DISCUSSION

The growth of elongated organisms with a vermiform body, as with many polychaete species, occurs by the addition of new setigers in the region just anterior to the pygidium. The distortion and breakage of soft body organisms during preservation make the estimation of total length very difficult. In the present study, total length was estimated from only 50% of the specimens collected. Mechanical breakage and autotomy of worms, especially nereidids, during collection and sieving has been observed by many authors (Warwick & Price, 1975; Desrosiers et al., 1988; Gillet, 1990). For example, Desrosiers et al. (1988) obtained only 30% of the worms intact. In order to enable the use of many broken worms that would be discarded in other studies, these authors suggest the use of partial weight of worms that had their body cut at the 25th setiger.

The results of the present study showed that the width of setigers can give a better estimation of size than the length measurements. Although many authors have been using body width, especially from anterior setigers, there is a great variety in the setiger number used in such studies (Table 3). The lower correlation observed between the length of anterior body and total length (Table 1) may be a result of longitudinal contraction of the body. The circular muscles of nereidids are not as strong as the longitudinal muscles, and the main body may become distorted in the fixation process.

Recent results have shown a close relationship between body width at segment 10 and body length for *Laeonereis acuta* (Ieno et al., 2000). The width of 1st setiger was used for *Laeonereis culveri* to evaluate its population dynamics (Bloom, 1971). The present study suggests that for *L. acuta*, setigers near the prostomium have only a weak correlation with total length and weight. The position of the proboscis during worm fixation can influence the estimation of the width of anterior setigers, since it may become lodged in the space related to these anterior segments (Figure 1).

Hard appendages such as jaws and teeth have proved to be good estimators of size, since they are highly correlated with biomass and length (Olive & Garwood, 1981). The jaw length can also be used to evaluate prey size selection of birds and fish feeding on polychaetes, as they can be found inside the guts of predators (Ieno et al., 2000).

The relationship between morphometric parameters and weight indicated allometric growth, as would be expected for elongated animals that grow by segment acquisition. The length of the anterior region increased isometrically. Because the anterior region lengthens in proportion to weight, this part of the body is more important in the worm's total weight than the posterior part. Also the high correlation between weight and length of the anterior region (L Set 6th and L Set 13th) showed that they are more suitable surrogates for weight estimation.

Although correlation analysis has been used to find the most suitable morphometric parameters for size estimation, the results of such analysis are rarely published. The evaluation of eight morphometric parameters in the present study showed that the width of the setigers, except those that are very close to the prostomium, were good surrogates for total length and therefore good estimators of the growth of *L. acuta*. Of the setigers analysed in this study, we suggest the use of the 6th setiger, since it is located in the more rigid anterior region, and moreover it is not influenced by movement of the proboscis.

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