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STUDIES ON THE GROWTH OF PENAEID PRAWNS: I. LENGTH-WEIGHT RELATION AND CONDITION FACTOR UNDER DIFFERENT LEVELS OF FEEDING

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ABSTRACT

Length-weight relation and earthworm feeding conditions under different levels for *Penaeus indicus* and *Metopenaeus dobsoni* were estimated. Length-weight exponent in both species was unaffected by the feeding levels and the consequent differences in the growth rate. The coefficient of condition *k* was surprisingly constant in both the speoies although the growth rates varied considerably with the feeding level. This may be because the prawns were fed by earthworm alone which probably did not constitute a complete diet. The low values of *k* irrespective of the feeding level supports this conclusion. The condition factor did not indicate any change with increase in size of the prawn.

Key Words: Penaeid prawn, length-weight, condition factor, growth.

INTRODUCTION

Growth of penaeid prawns in India have been dealt by number of authors as can be seen from the reviews compiled by Jones (1969) and Mistakidis (1970) and from more recent papers by George (1974), George (1975), Suseelan (1975 a & b), Aravindakshan, Paulinose, Balasubramanian, Gopala Menon and Krishnan Kutty (in press) and others. However, detailed studies involving various aspects of growth such as the growth pattern and development of a growth equation, growth in relation to moult cycle, length-weight relation and condition factor etc. were not studied together to understand the dynamics of the growth of these important species. The present work is therefore designed to study the dynamics of the growth of two species of penaeid prawns, *Penaeus indicus* and *Metapenaeus dobsoni* from the Cochin backwater. In this paper the length-weight relation and condition factor under four different levels of feeding are discussed.

MATERIAL AND METHODS

Juveniles of *M. dobsoni* and *P. indicus* were collected from the tidal ponds in Ramanthuruthu Island near the Cochin harbour entrance and kept in the laboratory for 24 hours for observation. The most active of the smallest juveniles of nearly the same size available in adequate numbers were first visually selected. They were measured and weighed to select twenty experimental animals of the nearest size and

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weight. Care was taken to see that even the small differences in size among them were distributed uniformly in the four experimental tanks. Initial size of all the selected individuals of *M. dobsoni* was 2.45 cm and that of *P. indicus* 3.2 cm.

A closed system of seawater aquarium was designed for conducting the experiment and was provided with a biological filter. The experimental tanks were made of PVC and measured $61 \times 36 \times 22$ cm.

Length-weight data were collected in the laboratory on individual prawns for a period of 14 weeks. The measurements were taken regularly once a week. *M. dobsoni* was maintained at 15‰ salinity while *P. indicus* was reared in 20‰ salinity to correspond to the salinity in natural environment at the time they were collected for study. The two species were not reared simultaneously since juveniles of *M. dobsoni* were available at the sampling site during the postmonsoon months and those of *P. indicus* during the premonsoon months. Prawns were fed on live earthworm and four different frequency of feeding were maintained in the experimental tanks by giving food 2, 3, 4 and 5 times a day. During each feeding time prawns were allowed to feed for one hour after which the excess food was removed. Five prawns were maintained under each feeding level, in individual containers in respective tanks A, B, C and D. Prawns in Tank A were fed at 6.00 a.m. and 6.00 p.m., in tank B at 6.00 a.m., 2.00 p.m. and 10.00 p.m., in Tank C at 6.00 a.m., 11.20 a.m., 4.00 p.m. and 10.00 p.m., and Tank D at every four hours from 6.00 a.m. to 10.00 p.m.

RESULTS AND DISCUSSION

Length-weight relation

The estimation of the length-weight relation for each level of feeding was based on 75 observations made on five prawns spread over a period of three and half months. Since weekly measurements were made on the same prawns under controlled conditions the data showed very little scatter. The length-weight relation was based on the formula.

$$w = a\, l^{b} \qquad (1)$$

where w = weight in gm and l = length in cm.

The fitted curves are given in Figs. 1 and 2 for the two species. The corresponding equation in order, for the different levels of feeding for the two species are:

P. indicus

$$\left.\begin{array}{l} w = 0.0027813\ l^{2.9526232} \\ w = 0.0027871\ l^{2.9531953} \\ w = 0.0028274\ l^{2.9463670} \text{ and} \\ w = 0.0027807\ l^{2.9527357} \end{array}\right\} \qquad (2)$$

M. dobsoni

$$\left.\begin{array}{l} w = 0.0037607\ l^{2.9178820} \\ w = 0.0037784\ l^{2.9177522} \\ w = 0.0038278\ l^{2.9054932} \text{ and} \\ w = 0.0037936\ l^{2.9078891} \end{array}\right\} \qquad (3)$$

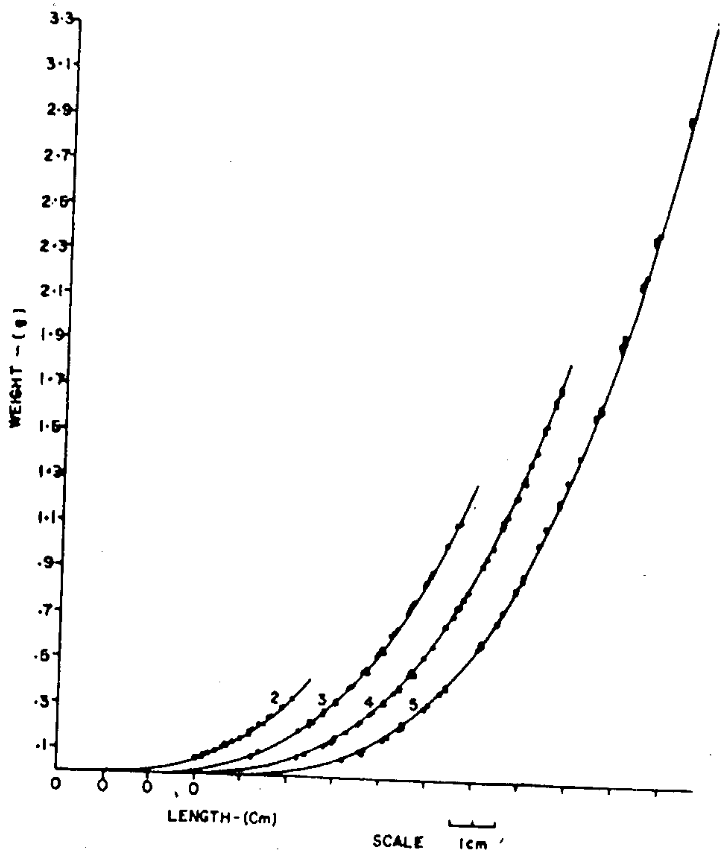

Fig. 1. Length-weight relation of *P. indicus* under different levels of feeding. The number adjacent to each curve indicates the corresponding frequency of feeding.

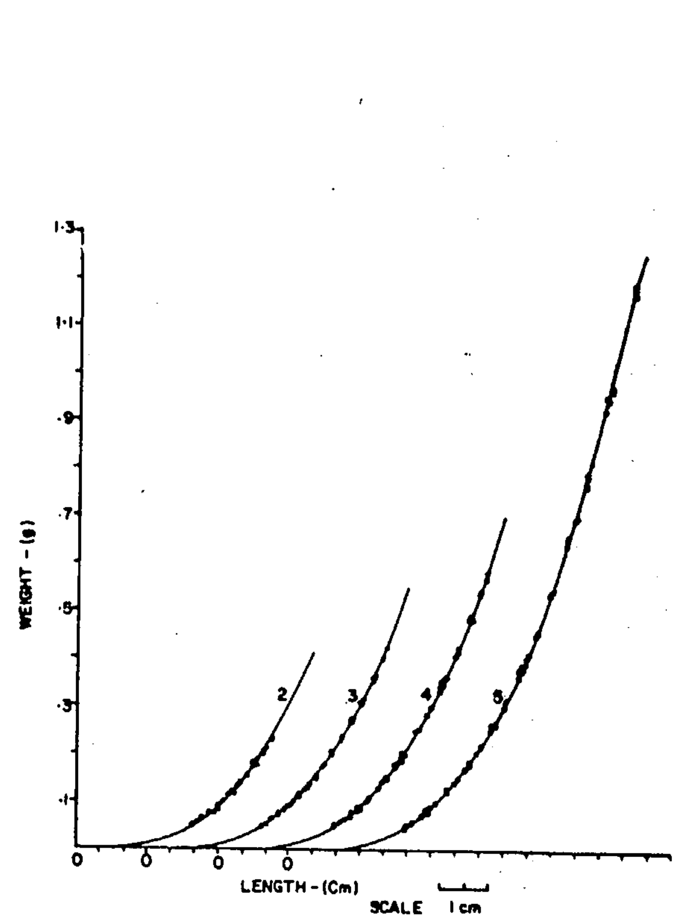

Fig. 2. Length-weight relation of *M. dobsoni* under different levels of feeding. The number adjacent to each curve indicates the corresponding frequency of feeding.

Table I. Analysis of covariance on the length-weight data of *P. indicus* under four different levels of feeding.

Source of variation	(SS) 10^{3}	df	(MS) 10^{4}	F
Tank A	0.3744	73	0.0513	
Tank B	0.3189	73	0.0437	
Tank C	0.9555	73	0.1309	
Tank D	4.6001	73	0.6302	
Within treatment	6.2489	292	0.2140	
Reg. Coef.	0.0402	3	0.1340	0.6262
Common	6.2891	295	0.2132	
Adj. Means	0.2493	3	0.8311	3.899*
Total	6.5384	298		

* $P < 0.05$

Table II. Analysis of covariance on the length-weight data of *M. dobsoni* under four different levels of feeding.

Source of variation	(SS) 10^{3}	df	(MS) 10^{4}	F
Tank A	6.9767	73	0.9557	
Tank B	3.8678	73	0.5298	
Tank C	2 0571	73	0.2818	
Tank D	6.2742	73	0.8595	
Within treatment	19.1757	292	0.6567	
Reg. Coef.	0.0894	3	0.2980	0.4539
Common	19.2651	295	0.6531	
Adj. Means	0.6113	3	2.0377	3.12*
Total	19.8764	298		

* $P < 0.05$

The two constants in the length-weight relation under different levels of feeding were tested for significant difference by analysis of covariance (Tables I and II). The variance ratio for the slopes was not significant at the 5% level in both species suggesting that all the four lines are parallel and therefore the corresponding length-weight exponents are not statistically different from one another. But the adjusted means showed significant difference at the 5% level. The second constant in the length-weight relation therefore appears to be different from one another. In order to find whether each intercept in the four different regression lines corresponding to four different levels of feeding is significantly different from the other, least significant difference (LSD) for elevations at 5% level was calculated. Results indicated that tank C alone was different from the rest for *P. indicus* while for *M. dobsoni*, tank A was different from tank D. This suggests that the difference is not primarily due to variations in the feeding level. As already indicated the intercepts in both the species were significantly different only at the 5% level. Besides, since the experiments were conducted under controlled conditions and observations were all consecutive measurements on individual prawns, there was little scatter in the data (Figs. 1 and 2) and hence the magnitude of the sample variances was very low. This magnifies the power of the statistical test considerably showing statistical significance even when the differences in elevation may well be within tolerable limits. It may also be noted that the intercepts differ only in their fourth decimal place. Hence for all practical considerations significant difference in the elevation of the lines as shown by the statistical test may be neglected. This inference is further corroborated by the identical fortnightly values of the condition factor (see below).

To conduct an analysis of covariance two assumptions to be met are (i) that the lines are parallel and (ii) that there is homogeneity of variances. The latter condition is not fully met in both the species since Bartlet's test gave highly significant x^2 values ($P < 0.001$). One of the two required assumptions that the regression lines should be parallel is adequately met by the data. Higher scatter is to be expected at larger values of the length and weight which is normally accounted by the usual log transformation of the data carried out for estimating the length-weight relation. Some lack of homogeneity of variance in the data should also be expected since individuals under different levels of feeding have shown widely different growth rates and moulting frequency. Hence the length-weight measurements taken at regular intervals did not synchronise with the moulting frequency especially at higher feeding levels and this might have affected the length-weight data. Heterogeneity of variance probably introduced into the data in this manner, however is occurring in the data at a low level of overall variability and hence may justifiably be ignored.

From the above discussion it is reasonable to conclude that the different levels of feeding did not exert any influence on the two coefficients of the length-weight relation.

The value of *b* in both *P. indicus* and *M. dobsoni* is fairly close to three. However t-test has shown that it is statistically different from three with probability less than 0.001 for all levels of feeding excepting for *P. indicus* in tank A having $P < 0.01$. The length-weight relation obtained by Hall (1962) for *P. indicus* is

$$w(g) = 0.6918 \quad C^{2.922} \tag{4}$$

and for *M. dobsoni*

$$w(g) = 0.7691 \quad C^{2.736} \tag{5}$$

where C is the carapace length in cm. His coverage of the data was fairly extensive for *P. indicus* but not for *M. dobsoni* and this might account for the lower length-weight exponent obtained for *M. dobsoni*. Krishnankutty (1972) has pointed out that the estimates of the two constants in the length-weight relation can be biased if the coverage is not adequate especially in the region nearer to the origin. In the present study there is a good coverage of the data in this region since the smallest size was 2.45 and 3.2 cm respectively for *M. dobsoni* and *P. indicus*. The data therefore appears to be adequate and does not seem to have tilted the regression lines and hence estimates of the two constants should be reasonably accurate. The results of the analysis of covariance that the lines are parallel even when the length range varied considerably (Figs. 1 and 2) under different levels of feeding due to differences in the growth rate (dl/dt) substantiates this conclusion. Regression coefficient was therefore estimated for the two species for the combined data and the respective values of b obtained for *P. ndicus* and *M. dobsoni* were 2.95074 and 2.91023. The length-weight exponent obtained by Hall for *M. dobsoni* is not comparable with that obtained in the present study but it compares favourably well in the case of *P. indicus*. Unfortunately literature is completely devoid of any study on the length-weight relation of these two species except that of Hall (1962). A more detailed comparison with published results is therefore not possible. Nevertheless fairly close value obtained by Hall for *P. indicus* and the fact that even significant difference in the growth rates due to differences in the feeding level did not exert any influence on b suggest that the length-weight exponent may be characteristic of the species and the respective pooled value obtained for the two species may be a reliable estimate of b.

Condition Factor

Fatness or quality of a fish or prawn is often described by calculating the coefficient of condition or Ponderal index, k which may be obtained from

$$k = Aw/l^3 \qquad (6)$$

where w and l are the weight and length of the fish and A is an arbitrary constant for getting a convenient result, 10^2 being the most commonly chosen value (Allen, 1951) which gives values of k in the region of 1.0. Condition factor is estimated in the present study using the equation

$$k = Aw/l^b \qquad (7)$$

where b is the length-weight exponent. Allen has mentioned that equation (7) has certain advantages over equation (6) in estimating the condition factor as it reduces the variation in k arising from changes in form associated with growth and therefore brings out short term changes in the condition more clearly. Hart (1946) has pointed out that the value of k may change with length often attaining a maximum at size of maturity. This has since been corroborated by many authors, Pillay (1958), Qasim (1957), Qayyam and Qasim (1964) and others. Allen (1951) used the condition factor to examine the changes in trout in two consecutive year classes with respect to size, season, habitats, peak growing season, gonad condition etc. He found that k showed a decreasing trend with age. Pillay (1954) also found that the condition factor in *Mugil tade* decreased with increase in length until it reached the size at maturity. Pillay (1958) found that the condition factor in *Hilsa ilisha* showed the same seasonal trend when estimated for the whole fish but when gonad and Viscera were removed k was much higher.

Table III. Fortnightly estimates of the condition factor, *k* of *P. indicus* at four different levels of feeding.

Frequency of feeding: 2			3			4			5		
Length (cm)	Weight (g)	k	Length (cm)	Weight (g)	k	Length (cm)	Weight (g)	k	Length (cm)	Weight (g)	k
3.200	0.08656	0.27923	—	—	—	3.200	0.08706	0.28294	3.200	0.08680	0.21700
3.330	0.09720	0.27975	4.020	0.15894	0.27763	3.814	0.14574	0.28222	4.154	0.18742	0.27977
3.640	0.12644	0.27875	4.510	0.23824	0.27861	4.446	0.22826	0.28132	5.032	0.32810	0.27782
3.850	0.14916	0.27849	5.064	0.33478	0.27829	5.252	0.37260	0.28100	6.152	0.59520	0.27865
4.204	0.19294	0.27809	5.680	0.47118	0.27897	6.056	0.57228	0.28373	7.004	0.87172	0.27833
4.448	0.22904	0.27925	5.996	0.55446	0.27975	6.970	0.86336	0.28298	7.952	1.27174	0.27895
4.686	0.26692	0.27912	6.662	0.75472	0.27891	7.818	1.21434	0.28372	8.682	1.82612	0.30915
5.124	0.34616	0.27782	7.500	1.06778	0.27807	8.660	1.63812	0.28322	10.122	2.61728	0.28188

Table IV. Fortnightly estimates of the condition factor, *k* of *M. dobsoni* at four different levels of feeding.

Frequency of feeding: 2			3			4			5		
Length (cm)	Weight (g)	k	Length (cm)	Weight (g)	k	Length (cm)	Weight (g)	k	Length (cm)	Weight (g)	k
2.450	0.05028	0.36781	2.450	0.05006	0.36620	2.450	0.05100	0.37722	2.450	0.04964	0.36635
2.632	0.06640	0.39407	2.650	0.06680	0.38905	2.798	0.07720	0.38833	2.926	0.08680	0.38238
2.900	0.08104	0.36260	2.956	0.09090	0.38484	3.216	0.11320	0.37999	3.644	0.16302	0.37947
3.100	0.10288	0.29849	3.376	0.13158	0.37799	3.768	0.18098	0.38343	4.226	0.25202	0.38144
3.306	0.12248	0.31414	3.678	0.16934	0.37858	4.220	0.25114	0.38295	4.798	0.36554	0.38260
3.568	0.15342	0.29939	4.124	0.23598	0.37811	4.730	0.34920	0.38210	5.436	0.52458	0.38151
3.766	0.18010	0.32029	4.540	0.31284	0.37847	5.028	0.41658	0.38183	6.154	0.75118	0.38092
4.088	0.22268	0.29588	5.004	0.41142	0.37504	5.642	0.57926	0.37959	7.004	1.07904	0.37584

The mean fortnightly estimates of the condition factor for *P. indicus* and *M. dobsoni* are given in Tables III and IV. In both species the values were surprisingly constant showing also no change with increase in size. The different feeding levels showed definite effects on the growth rate, the maximum growth being shown by the prawns fed five times a day (Figs. 1 and 2). But it has almost no effect on the condition of the prawn and this may be because they were uniformly fed by only one kind of food. All *k* values were also uniformly low, being much lower, than one. Condition of all prawns irrespective of the level of feeding was therefore low suggesting that earthworm when given alone does not form a balanced diet. Except for minor geographical difference, the length-weight exponents in equations (2) and (4) are nearly equal and this enables an assessment of the condition of the two populations of *P. indicus* by comparing the respective values of second constant in the two equations. The condition of the population of *P. indicus* studied by Hall is expected to be much higher as judged from the value of the intercept in equation (4) – because, although the choice of carapace length as the abscissa instead of body length has raised his value of the intercept, a difference of the order of more than 10^2 in the respective values in equations (2) and (4) cannot be explained by the choice of the carapace length alone as the abscissa. Varied food in the natural environment is a more complete diet which if also abundant in the environment as observed by Hall may be an important factor in determining the condition of the prawn especially since they are almost continuous feeders as observed by Dall (1968) and Balasubramanian, Lalithambika Devi and Krishnankutty (1979).

Since differences in the values of *b* in the length-weight relation corresponding to different levels of feeding have been found statistically non-significant, the second constant or the intercept indicating the elevation of the regression lines also gives a general estimate of the condition of the prawn under the different feeding levels. The values were found to be very similar in both the species. When fed with only one kind of food the quantity consumed appears to exert less influence on the condition of the prawn than the quality of the food atleast above the level where it is sufficient to register some growth. Quality of food may not exert much marked effect on the length-weight exponent. Large variations in the value of *b* are however seen in the literature and is often associated with life history stages (Tesch, 1971), geographical variations, sexual differences, seasonal variations arising from allometric growth of the gonads during the breeding season, variations in the quantity of food in the stomach etc. or due to errors arising from inadequate representation of all sizes in the length-weight data. Changes in the environmental factors especially food is mostly reflected on the elevation of the regression line only. Nevertheless, experimental confirmation of the effect, if any, of different kinds of food on the length-weight exponent is desirable especially since *b* is often considered to be characteristic of the species as is also strongly suggested by the present study. Experimental studies are also more reliable since some of the above variations generally present in the field data will mask the actual value of *b* if the latter is indeed species specific.

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