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Bionomics of hill-stream cyprinids. I. Food, parasites and length-weight relationship of *Labeo dyocheilus* (McClell)*

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Abstract. Food habits, parasites and length-weight relationship in the hill-stream fish *Labeo dyocheilus* were examined. The frequency distribution of the pseudophyllidean cestode, *Bothriocephalus teleostei* in this fish has been reported to be log-normal.

Keywords. Parasites; riverine ecosystems; cyprinids; parasitization index; *Labeo dyocheilus*.

1. Introduction

Studies on the biological and statistical significance of length-weight relationship among ichthyofauna of Himalayan riverine ecosystems are available on only three fish species: *Barilius bola* (Ham) (Chauhan and Malhotra 1981). *Labeo dero* (Ham) (Malhotra and Chauhan 1984) and *Tor tor* (Ham) (Malhotra 1982). The present investigation is aimed at analysing the biology and length-weight relationship in *L. dyocheilus* (McClell) in high altitude ecosystems.

2. Materials and methods

Methods of collection of fish samples (N = 152) and their analyses were published earlier (Malhotra 1982). *L. dyocheilus* (9·5–49 cm length range) collected from River Nayar (650 meters ASL) were used in the present investigation. The length-weight relationship was estimated by the formula, $W = aL^n$ where W is the weight, L the body length, and a and n are constants. Logarithmic transformation of the equation may be written as $\log W = \log a + n \log L$ where, $\log W$ is the dependent variable (y), $\log L$ the independent variable (x), n the regression coefficient or slope (b), and $\log a$ the y-intercept. Analysis of covariance and student's t-test were applied and the coefficient of determination (Croxton 1953), the values of least squares regression slopes and the proportion of correlated variance (Zeller and Carmines 1978) were computed.

3. Results

3.1 *Food*

Qualitative and quantitative (percentage by weight) analysis of gut contents including food and parasites showed 0·496 % worms, and 99·504 % *Cladophora* sp., *Spirogyra* sp., *Sphaerocystis* sp., *Volvox* colonies and plant debris.

3.2 *Parasites*

The frequency of parasites (mean worm burden, 2–3(2) in the alimentary canal of the examined fishes was 0·49 % cestodes (female, 0·248 %; male, 0·248 %). *Bothriocephalus teleostei* Malhotra, 1984a was the only cestode recorded. Interestingly, no trematode, nematode or acanthocephalan infection was found in *L. dyocheilus*. The parasitization index and prominence values of the cestode were 0·004–0·009 and 1·277–1·592 respectively. The optimum water temperature and humidity during infection period were 13·75 ± 0·25/0·18°C (13·5–14°C) and 85 ± 5/3·54 % (80–90 %) respectively.

3.3 *Length-weight relationship*

Various body measurements in the ratio of total and standard length of fish including body weight are given in table 1.

3.4 *Estimated regressions*

An initial assessment of the fishes of the length range 9·5–49 cm suggested that the same equation would not fit the data for the entire length range and that a break occurred around < 17 cm and > 17.1 cm groups. Separate parabolic equations and linear regressions were therefore computed for both the sexes and length classes as mentioned in table 2. The significance of the differences between the regression coefficients (*b*) was

Table 1. Mean values of body weight and ratios of total *vis-a-vis* standard length of *Labeo dyocheilus*.

		Mean ± S. E.			
Category	Sample size	Total length (cm)	Standard length (cm)	TL/SL ratio	Body weight (g)
Female	86	22·6116 ± 0·9789	19·6209 ± 0·7323	1·1524 ± 0·0123	178·9419 ± 45·5443
Male	66	20·5955 ± 0·9744	17·2773 ± 0·7458	1·1921 ± 0·0039	132·2879 ± 29·0144
< 17 cm	76	14·956 ± 0·2062	14·4605 ± 0·2718	1·0343 ± 0·0110	49·84 ± 3·6949
> 17·1 cm	76	32·391 ± 0·6251	22·7461 ± 0·7849	1·4240 ± 0·0379	268·2368 ± 54·5471
Pooled	152	21·7362 ± 0·7016	18·6033 ± 0·5342	1·1684 ± 0·0631	159·0395 ± 28·7343

Table 2. Regression equations describing length-weight relationship in *Labeo dyocheilus*.

Category	Logarithmic regression equations (log W + log L)	Parabolic equations (W =)
Female	$= \bar{2}{\cdot}946 + 2{\cdot}2103$	$0{\cdot}0011324L^{2.2103}$
Male	$= \bar{2}{\cdot}5998 + 2{\cdot}1396$	$0{\cdot}00251304L^{2.1396}$
Pooled	$= \bar{2}{\cdot}8199 + 2{\cdot}0871$	$0{\cdot}00151391L^{2.0871}$
< 17 cm	$= \bar{1}{\cdot}7670 + 1{\cdot}7559$	$0{\cdot}00171002L^{1.7559}$
> 17·1 cm	$= \bar{3}{\cdot}0889 + 2{\cdot}2850$	$0{\cdot}000814892L^{2.2850}$

tested by the method of analysis of covariance. The relevant data has been presented in table 3. The test for heterogeneity of regressions revealed that the differences between the regression coefficients were significant at 1 % level (sum of squares 0·0239149, mean square 0·00797163, df 3, $F = 8{\cdot}337$, $F_{1\%} = 3{\cdot}91$). The test of heterogeneity was again performed for the sexes (within and with each of the two length classes) and length classes (within). It was observed that the differences between the regression coefficients between male and female ($F = 0{\cdot}002$, $F_{5\%} = 3{\cdot}91$ df 1; 151) and between < 17 cm and > 17·1 cm ($F = 0{\cdot}139$, $F_{5\%} = 3{\cdot}91$, $df = 1$; 151) were not significant while those between sexes and < 17 cm ($F = 141{\cdot}521$, $F_{1\%} = 4{\cdot}71$, df 2; 226) and between sexes and > 17.1 cm ($F = 10{\cdot}693$, $F_{1\%} = 4{\cdot}71$, df 2; 226) were significant at 1 % level.

The application of t-test revealed that the departures of regression coefficients from the isometric growth value of 3 were significant at 1 % level in < 17 cm ($b - 3$, $-1{\cdot}1609$; t, $-19{\cdot}720$; df, 74; $t_{1\%} = 2{\cdot}66$), > 17·1 cm ($b - 3$, $-0{\cdot}8842$; t, $-7{\cdot}392$; df, 74; $t_{1\%} = 2{\cdot}66$) and sexes ($b - 3$, $-0{\cdot}9129$; t, $-31{\cdot}325$; df, 150; $t_{1\%} = 2{\cdot}58$).

A comparison of the regression lines of the length-weight relationship of *L. dyocheilus* has been presented in table 4. According to the standardized least squares linear regression line, for each standard unit of length, the fish gained, 0·8703–0·8722; 0·7888–0·7918; 0·8192–0·8291; 0·5509–0·5584; and 0·88–0·9074 of a standard unit of weight for females, males and pooled, and < 17 cm and > 17.1 cm classes of fish, respectively. In both the sexes and weight classes r is significant.

Table 3. Analysis of covariance between the regression coefficients (b) for *Labeo dyocheilus*.

	Female	Male	Pooled	< 17 cm	> 17.1 cm
N	86	66	152	76	76
$\Sigma(X-\bar{X})^2$	3·5984	3·3848	3·8244	2·6300	3·5445
$\Sigma(Y-\bar{Y})^2$	7·1849	6·5631	7·2805	4·8910	7·2417
$\Sigma(X-\bar{X})(Y-\bar{Y})$	5·3318	4·8717	5·4684	3·5046	5·3443
$b\Sigma(X-\bar{X})(Y-\bar{Y})$	11·7849	10·4235	7·9819	6·1537	12·2117
ρ^2	0·7590	0·6245	0·6792	0·3077	0·7986
r^2	0·7572	0·6233	0·6874	0·3035	0·7979

N = numer of observations; ρ^2 = proportion of correlated variance; r^2 = coefficient of determination.

Table 4. Comparison of the regression lines of the length-weight relationship of *Labeo dyocheilus*.

Category	Sample size	Variance		Covariance	Standardized least squares regression slope predicting		P
		Length	Weight		X from Y	Y from X	
Female	86	1·6639	5·2504	3·3973	0·8703	0·8722	P < 0·001
Male	66	1·5652	4·7435	3·0522	0·7888	0·7918	P < 0·001
Pooled	152	1·6426	5·0987	3·2866	0·8192	0·8291	P < 0·001
< 17 cm	76	0·7492	3·0102	1·6238	0·5509	0·5584	P < 0·001
> 17·1 cm	76	1·6637	5·3609	3·4634	0·9074	0·8800	P < 0·001

4. Discussion

4.1 *Food and parasites*

The analysis of food reveals that *L. dyocheilus* maintains a predominantly herbivorous feeding habit. The curves for frequency distribution of *B. teleostei* during infection period, fish age, size and weight classes have been reported to be a simple logarithmic function and revealed the familiar gaussian hump when plotted in octaves (Malhotra 1984b). The implications of this tendency have already been discussed by the author in the earlier study (Malhotra 1984b).

4.2 *Length-weight relationship*

To conform to the results based on analysis of samples of *L. dero* collected from natural habitats in the same locality (Malhotra 1984b) no major difference was noted in the ratio values of total *vis-a-vis* standard length of *L. dyocheilus*. The agreement between fish length and weight was good ($P < 0.001$) in female, male and pooled fishes and by < 17 cm and > 17·1 cm classes of fish (table 4). Based on coefficient of determination more than 75 % of the variation in weight in females, 62 % in males, 68 % in pooled, 30 % in < 17 cm length class and 79 % in > 17·1 cm length class was attributable to the variation in length of *L. dyocheilus*. Similarly the proportion of correlated variance (ρ^2) suggests that 75·9071 % variance in length in female fishes, 62·4532 % in males, 67·9212 % in pooled, 30·7659 % in fishes of < 17 cm length class, and 79·8611 % in fishes of > 17·1 cm length class was associated with weight.

The length-weight relationship for female, male, pooled, < 17 cm and > 17·1 cm length classes of *L. dyocheilus* is defined and illustrated in this investigation. Similar to the earlier observations in *T. tor* (Malhotra 1982) and *L. dero* (Malhotra 1984b) in the Himalayan riverine ecosystem the larger fishes (> 17·1 cm) showed higher value of regression coefficient ($b = 2.2850$) than the smaller ones i.e. < 17 cm ($b = 1.7559$). This conclusion illustrates a relatively rapid change in body outline of the fishes of > 17·1 cm length class as they increase in length compared to those of the fishes of smaller length class (< 17 cm).

As a depends upon the obesity of the fish (LeCren 1951), by comparing log a values it becomes obvious that there is no significant difference ($F_{1;151} = 0.002$) in the general fatness of the two sexes in the present study similar to the findings of Malhotra (1982). The regression for the pooled lot of fishes was calculated. The value of n (2·0871) indicated that the growth rate is lesser than the cube length. Similar deviations have been discussed earlier by Malhotra (1984b) on another species of the genus *i.e. L. dero* from the same locality. In the present case too the departures of regression coefficients from 3 were found highly significant (1 % level) for sexes and both length classes. As emphasized earlier (Malhotra 1984b) the suitability of the exponential formula $W = aL^n$ used in the present analysis to the cubic formula $W = CL^3$ (C, constant) has been justified by several authors (Sekharan 1968) in similar studies. Beverton and Holt (1957) discussed the merit of both allometric and cubic formula and reported that the former works much better as a and n of the allometric formula vary within a wide range for very similar data and are very sensitive to even quite unimportant variations in n. Hence the high value of coefficient of correlation indicates that the allometric relationship of length and weight is suitable for the fish.

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