Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 91, Number 6, November 1982, pp. 493-499.

Bionomics of hill-stream cyprinids. III. Food, parasites and length-weight relationship of Garhwal mahaseer, *Tor tor* (Ham.)

SANDEEP K MALHOTRA
Parasitological Laboratory, Department of Zoology, University of Garhwal, Pauri Campus, Pauri (Garhwal) 246001, U P, India

MS received 27 October 1981 ; revised 27 July 1982

Abstract. 829 *Tor tor* (Ham.) were examined for food habits, parasites and length-weight relationships. Parabolic equations describing the body length-body weight relationships were $W = 0 \cdot 0009298\ L^{2 \cdot 0553}$, $W = 0 \cdot 0013146\ L^{1 \cdot 9769}$, and $W = 0 \cdot 0010884\ L^{1 \cdot 9561}$ for females, males and pooled fishes respectively. The regression coefficients of the $< 15 \cdot 0$ cm, $15 \cdot 1$–$20 \cdot 0$ cm and $> 20 \cdot 1$ cm length classes and sexes were found to be significantly different from one another and from 3. The regression coefficients of the fishes of larger size classes were higher than those of the fishes of $< 15 \cdot 0$ cm size classes.

Keywords. Gut contents; parasites; length-weight relationship; regression coefficient; parasitocoenosis; variance; Himalayan riverine ecosystem.

1. Introduction

Garhwal mahaseer, *Tor tor* (Ham.), is of economic value in the hilly area and it is available almost throughout the year in the rivers of Garhwal Himalayas. The present investigation was conducted to help fill the need for more information on the general biology of this fish in the area. It deals with the bionomics and helminthocoenoses of *T. tor* in Garhwal Himalayas ; this study is also part of an investigation into the biology and fishery of hill-stream fishes, results of certain aspects of which have already been published by the author and coworkers (Malhotra 1981a, b ; Malhotra (in press) ; Malhotra *et al* 1980a, b).

2. Material and methods

Methods of collection of samples and their analyses were published earlier (Malhotra 1981a ; Chauhan *et al* 1981). 829 *T. tor* of 4·5–79 cm length range (with one fish measuring 125 cm) were used in the present investigation. The length-weight relationship was estimated by the formula,

$$W = aL^n$$

where W = weight, L = body length and a and n are constants. Logarithmic transformation of this 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 variance (Snedecor and Cochran 1967) was applied and the coefficient of determination (r^2) (Croxton 1953) and the values of least squares regression slopes (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 5·49% worms, 8·42% *Cladophora* sp., *Spirogyra* sp., *Sphaerocystis* sp., *Volvox* colonies and plant debris and 86·09% insects, their larvae and nymphs, *viz.*, coleopterans (*Corixa* sp., *Psephenus* sp.), dipterans (*Tendipes* sp.), hemipterans (*Gerris* sp.), trichopteran larvae, ephemeropteran nymphs (*Heptagenia* sp.) and plecopteran nymphs.

3.2. *Parasites*

The frequency of parasites in alimentary canal of examined fishes was 0·20% cestodes, 99·50% nematodes, and 0·30% trematodes. *Bothriocephalus teleostei* (Malhotra 1981b) was the only cestode and *Diplostomum minimum* was the only trematode recorded from the small intestine. However, 79·72% of the nematodes collected were females and 20·28% were males. Out of these 8·09% female and 11·36% male specimens of *Pseudanisakis* sp. were gathered from stomach while 61·85% female ; 50·0% male specimens of *Comephronema* sp. and 30·06% female ; 38·64% male specimens of *Cystidicoloides* sp. were collected from small intestine.

3.3. *Length–weight relationship*

The ratio of total and standard length of fish including body weight have been computed in table 1. It illustrates a comparative account of various relationships between different body measurements and body weight.

3.4. *Estimated regressions*

Altogether 829 fish of the length range 4·5–79 cm (with one fish of 125 cm) were analysed. An initial assessment suggested that the same equation would not fit the data for the entire length range and that breaks occurred around 10·0–15·0 cm ; 15·1–20·0 cm ; and > 20·1 cm groups. Separate parabolic equations, their logarithmic transformations, and linear regression were, therefore, computed for different groups as mentioned in table 2.

The significance of differences between the regression coefficients (b) was tested by the method of analysis of variance. The relevant data have been presented in table 3.

Table 1. Mean values of body weight and ratios of total/standard lengths of *Tor tor* (Ham.).

Sample size		Mean ± S.E.			
		Total length (cm)	Standard length (cm)	TL/SL ratio	Body weight (g)
Female	474	19·4 ±0·6691	16·0109±0·5921	1·2088±0·001	272·8 ± 52·169
Male	355	18·5 ±0·4739	15·4746±0·4345	1·2051±0·0034	131·7 ± 27·3614
<15·0 cm	549	12·5593±0·0923	10·8927±0·0858	1·1530±0·1131	27·2993± 0·7517
15·1–20·0 cm	149	17·0639±0·1168	17·6628±0·1062	1·3458±0·1342	86·0302± 6·1856
>20·1 cm	131	31·8632±1·1824	34·5254±1·5788	1·6186±0·2459	1155·6406±185·1899
Pooled	829	19·0041±0·4349	15·7957±0·3864	1·2017±0·0029	212·1402± 32·1309

Table 2. Regression equations describing length–weight relationship in *Tor tor* (Ham.).

Category	Logarithmic regression equations	Parabolic equations
Female	$\log W = \bar{3}\cdot0316 + 2\cdot0553 \log L$	$W = 0\cdot0009298\, L^{2\cdot0053}$
Male	$\log W = \bar{2}\cdot8812 + 1\cdot9769 \log L$	$W = 0\cdot0013146\, L^{1\cdot9769}$
<15·0 cm	$\log W = \bar{1}\cdot4208 + 1\cdot4819 \log L$	$W = 0\cdot037949\, L^{1\cdot4819}$
15·1–20·0 cm	$\log W = \bar{2}\cdot1459 + 2\cdot00 \log L$	$W = 0\cdot0071466\, L^{2\cdot00}$
>20·1 cm	$\log W = \bar{3}\cdot4281 + 2\cdot4156 \log L$	$W = 0\cdot0003732\, L^{2\cdot4157}$
Pooled	$\log W = \bar{2}\cdot9632 + 1\cdot9561 \log L$	$W = 0\cdot0010884\, L^{1\cdot9561}$

Table 3. Analysis of covariance between the regression coefficients (b) for *Tor tor* (Ham.).

N	Female 474	Male 355	Pooled 829	<15 cm 549	15·1–20·0 cm 149	>20·1 cm 131
$\Sigma (X-\bar{X})^2$	5·0027	4·4227	5·1108	3·3451	2·4386	4·6242
$\Sigma (Y-\bar{Y})^2$	8·7873	7·9748	8·8412	5·0822	5·9265	8·7579
$\Sigma (X-\bar{X})(Y-\bar{Y})$	6·8447	6·1060	6·8854	4·0375	3·5456	6·6699
$b\Sigma (X-\bar{X})(Y-\bar{Y})$	14·0678	12·0710	13·4686	5·9832	7·0912	16·1118
σ^2 unexp.	1·6427	1·415	1·7228	0·3504	0·2417	1·5074
ρ^2	0·7931	0·6512	0·6607	0·4443	0·0532	0·8999
r^2	0·7949	0·6101	0·6397	0·3158	0·0579	0·8684

ρ^2 = Proportion of correlated variance ; σ^2 = Unexplained variance.

The test of heterogeneity of regressions is given below :—

Source of variation	df	Sum of squares	Mean square	F
Between length classes :				
Deviation from average total regression	829	0·5725573		
Deviation from individual regression within sample	825	0·4380454	0·000530964	
Difference	4	0·1345119	0·0336279	63·33 $F_{0.5\%} = 3 \cdot 72$
Between sexes				
Deviation from average total regression	829	0·0054845		
Deviation from individual regression within sample	825	0·0037392	0·0000045	
Difference	4	0·0017453	0·0004363	96·96 $F_{0.5\%} = 3 \cdot 72$

The differences between the regression coefficients were significant at 0·5% level.

A comparison of the regression lines of the length-weight relationship of *T. tor* has been presented in table 4. According to the standardized least squares linear regression, for each standard unit of length, the fish gained 0·890–0·891 ; 0·799–0·836 ; 0·806–0·820 ; 0·562–0·791 ; 0·220–0·242 ; and 0·947–0·950 of a standard unit of weight for females (size group 6–78 cm and one fish of 125 cm); males (size group 4·5–79 cm) ; pooled ; < 15·0 cm ; 15·1–20·0 cm ; and > 20·1 cm groups of *T. tor* respectively. In both the sexes r is significant.

A logarithmic plot of weight (mean values) on length (mean values in 5·0 cm length intervals in 829 fishes and the linear regression for separate groups and pooled fishes are shown in figure 1.

4. Discussion

4.1. *Food and parasites*

The analysis of food reveals that *T. tor* is a carniomnivorous fish but predominantly exhibits carnivorous habit. Nematode (N) parasites were more prevalent (99·50%) than cestodes (C) (0·20%) and trematodes (T) (0·30%). Hence a relationship $C < T < N$ could be established for *T. tor*. A detailed analysis of trends in parasitocoenoses in *T. tor* has been dealt with by Malhotra (in press) recently.

Table 4. Comparison of the regression lines of the length-weight relationship of *Tor tor* (Ham.)

Sample size	Variance		Covariance	Standardized least squares regression slope predicting		Level of significance r (P)
	Length	Weight		X from Y	Y from X	
Female (474)	2·3269	6·1116	4·1689	0·8897	0·8914	0·8916 ($P < 0 \cdot 025$)
Male (355)	1·8724	5·4245	3·5558	0·7794	0·8355	0·7811 ($P < 0 \cdot 100$)
< 15·0 cm (549)	0·6055	2·3427	1·2979	0·7905	0·5619	0·5620 ($P < 0 \cdot 250$)
15·1–20·0 cm (149)	0·2654	3·75342	1·3724	0·2422	0·2197	0·2408 ($P < 0 \cdot 500$)
>20·1 cm (131)	2·5069	6·6441	4·5526	0·9501	0·9471	0·9319 ($P < 0 \cdot 005$)
Pooled (829)	2·1922	5·9226	3·9669	0·8201	0·8057	0·7998 ($P < 0 \cdot 100$)

4.2. *Length–weight relationship*

In the present investigation no major difference was found in the ratio value of total *vis-a-vis* standard length from that reported by earlier workers. There was a highly significant correlation of body length to body weight for female ($P < 0 \cdot 025$), male ($P < 0 \cdot 100$), pooled ($P < 0 \cdot 100$) and > 20·1 cm length classes ($P < 0 \cdot 005$) of *T. tor* (table 4). Based on the coefficient of determination (r^2) (Croxton 1953), more than 79% of the variation in weight in females, 61% in males, 63% in pooled, and 86% in >20·1 cm length class was attributable to the variation in length of the Garhwal mahaseer. However, only 31·58% and 0·06% of the variation in weight in < 15·0 cm and 15·1–20·0 cm length classes respectively was attributable to the variation in length of fish. Similarly the proportion of correlated variance (ρ^2) suggests that 79·31% variance in length in females, 65·12% in males, 66·07% in pooled fishes and 89·99% in fishes of > 20·1 cm length class was associated with weight while only 44·43% and 5·32% variance in length in fishes of < 15·0 cm and 15·1–20·0 cm length classes, respectively, was associated with weight. The length–weight relationship for female, male, pooled and fishes of < 15·0 cm, 15·1–20·0 cm and > 20·1 cm length classes of *T. tor* is defined and illustrated in figure 1.

The differences in regression coefficients between male and female fishes have been reported by Sekharan (1968), Eggleston (1970) and Krishnamoorthi (1971). The results of the present investigation show closeness to these studies in describing a significant difference between regression coefficients of different size classes and the sexes. It, however, does not conform to the views of Sekharan (1968) who regarded in *Sardinella albella* and *S. gibbosa*, higher values of regression coefficients in smaller length classes than in larger ones. Contrary to this, in the present study, the fishes of larger length classes, *viz.*, 15·1–20·0 and > 20·1 cm

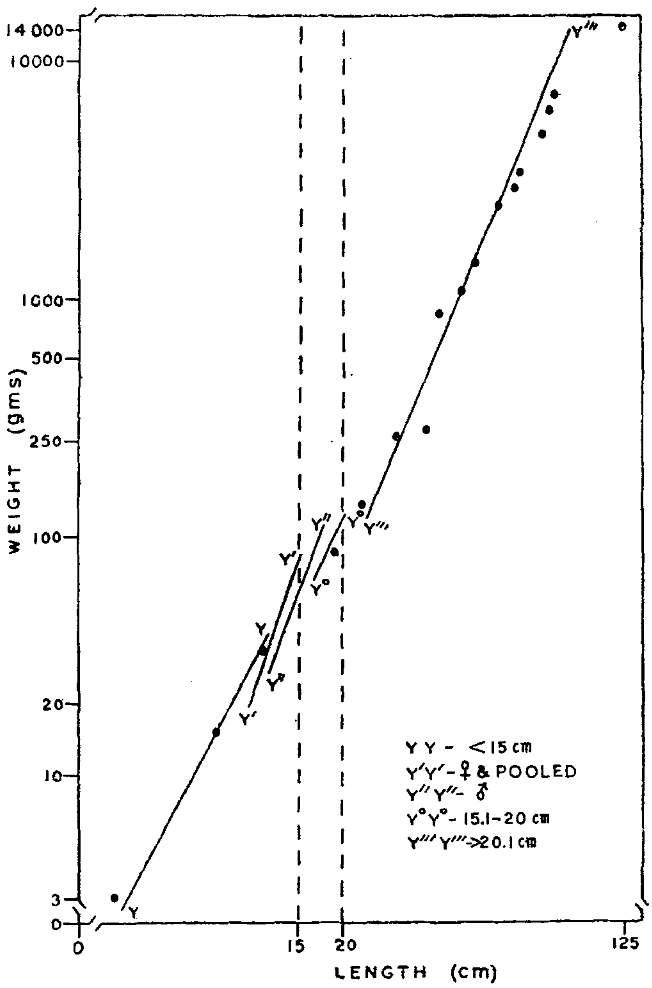

Figure 1. Length-weight relationship in *Tor tor* (Ham.).

showed higher values of regression coefficient ($b = 2{\cdot}00$–$2{\cdot}4156$) than the smaller ones ($< 15{\cdot}0$ cm). This perhaps indicates a relatively rapid change in body outline of the fishes of 15·1 cm to 79 cm size group including 125 cm long fish, when they increase more in length than those of the fishes of smaller size classes.

As '*a*' depends upon the obesity of the fish (LeCren 1951), by comparing the 'log *a*' values it is evident that the general fatness in the two sexes shows no significant difference in the present study like those reported by Narsimham (1970), Mojumdar (1971) and Vinci and Nair (1974). 'Log a' values also show appreciable difference in general fatness of individuals of different length classes contrary to the report of Sekharan (1968).

In this paper as per requirements of the exponential formula ($W = a\ L^n$) there was a consistently significant correlation in length and weight of *T. tor*. The values of regression coefficients indicate that the growth rate is lesser than the cube of length and represent an isometric trend (figure 1). Significant departures from the isometric growth value have been reported by Narsimham (1970), Vinci and Nair (1974), Qadri and Mir (1980) and Malhotra (unpublished). This departure is statistically tested for the significance of the difference of the regression coefficient from 3. The regression coefficient and its standard error for the general relationship being 1·986 and 0·133 respectively, '*t*' test ($t = -7{\cdot}61$ obtained by subtracting 3 from the regression coefficient and dividing the result by S.E.) indicated a high degree of significance, showing that the cubic law ($W = CL^3$; W = weight, L = length, C = constant) does not hold good for *T. tor* in the Himalayan riverine ecosystem.

Acknowledgements

The author is grateful to the Conservator of Forests, Garhwal Division, for permission of ichthyoparasitological survey and Dr R C S Rawat, Principal for facilities. The assistance received from Shri R S Chauhan, SRF, UGC, in collections is acknowledged.

References

Chauhan R S, Malhotra Sandeep K and Capoor V N 1981 The distribution and abundance of cestodes in eleven species of teleosts from Garhwal Himalayas with a note on host biology; *Himalayan J. Sci.* **1** 15–30

Croxton F E 1953 *Elementary statistics with applications in medicine and the biological sciences* New York : Dover Publ., pp. 376

Eggleston D 1970 *A symposium on the Japan current* (ed.) *J C Mar* pp. 417–424

Krishnamoorthi B 1971 Length-weight relationships for *Nemipterus japonicus* of Andhra-Orissa coast; *Indian J. Fish.* **18** 1–21

LeCren E D 1951 The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*) ; *J. Anim. Ecol.* **20** 201–219

Malhotra Sandeep K 1981a Cestode infection in freshwater fishes of Garhwal Himalayas, India ; *Geobios.* **8** 90–92

Malhotra Sandeep K 1981b Systems models for parasite pathways in ichthyoparasitology of the Himalayan riverine ecosystem ; *Curr. Sci.* **50** 874–875

Malhotra Sandeep K (in press) Trends in ichthyoparasitology of *Tor tor* (Ham.) in the Himalayan riverine ecosystem ; *J. Himalayan Stud. Reg. Dev.*

Malhotra Sandeep K, Chauhan R S and Capoor V N 1980a Nematode infection in relation to some ecological aspects of hill-stream fishes ; *Geobios.* **7** 193–198

Malhotra Sandeep K, Chauhan R S and Capoor V N 1980b Statistical analysis of cestode, infection in relation to some ecological aspects of hillstream fishes in Garhwal Himalayas, India ; *Indian J. Helminthol.* **32** 43–52

Mojumdar P 1971 Length-weight relationship in the cat-fish *Tachysurus thalassinus* (Ruppell), *Indian J. Fish.* **18** 179–182

Narsimham K A 1970 On the length-weight relationship and relative condition in *Trichiurus lepturus* Linnaeus ; *Indian J. Fish.* **17** 90–96

Qadri M Y and Mir S 1980 Length-weight relationship of *Oricnus plagiostomus* (McClell.) ; *Geobios* **7** 158–159

Sekharan K V 1968 Length-weight relationship in *Sardinella albella* (Val.) and *S. gibbosa* (Bleek) ; *Indian J. Fish.* **15** 166–174

Snedecor G W and Cochran W G 1967 *Statistical Methods* (6th edn) (Ames. Iowa : Iowa State Univ. Press) pp. 593

Vinci G K and Nair A K K 1974 Length weight relationship in the threadfinbream, *Nemipterus japonicus* along the Kerala coast ; *Indian J. Fish.* **21** 299–302

Zeller R A and Carmines E G 1978 *Statistical analysis of social data* (Chicago; ; Rand McNally College Publ. Co.,) pp. 398