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Length-Weight Relationship and Relative Condition of Bundh and Hatchery-bred *Labeo rohita* (Ham) During the Early Period of Development

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Abstract

Length-weight relationship and relative condition factor for the early period of development of *Labeo rohita* (Ham) collected from hatchery and bundh and reared in experi-mental hoopnets have been calculated. The source wise difference in the exponent value 'b' was significant (P<0.001) at 236 d.f. From the length-weight regression the exponent value 'b' was 3.125 for the hatchery and 3.306 for the bundh-bred species and these values from both sources were found to depart significantly (P<0.001) at 118 d.f. from the conventional 'cubic law'. The correlation coefficient 'r' was found to be 0.998 for bundh and 0.997 for hatchery and was highly significant (P<0.001). Low 'Kn' values of the species at 6.0 mm size, gradually increased upto 7.5 mm size may be related to the 'lag phase' period of the growth of the species. In the 8.0-35.0 mm size range, 'Kn' value stabilized above '1' prob-ably due to good fertility and food supply of the pond as well as the high feeding intensity of the fishes. The results are reported in the text.

Introduction

Greater emphasis is being laid by fishery biologists in recent years to find out the possible mathematical relationship between the length and weight of the fishes with the end in view of studying the growth, gonodal development and general well being of the fish population (Le Cren 1951; Pauly 1993) and comparing the life history of the different localities (Petrakis and Stergion 1995). Several studies have been made on the relationship between the length and weight of mature freshwater fishes (Agarwal and Saxena 1979; Ahmed and Saha 1996; Chatterjee et al. 1977; Desai and Srivastava 1990; Jhingran 1952; Johal and Tandon 1992; Kulshrestha et al. 1993; Pratap and Mkamba 1987; Quddus and Dewan 1988; Raizada and Raizada 1982; Raizada et al. 1986;

Reddy and Rao 1992) but there is little information on the length-weight relationship and relative condition factor 'Kn' during the early stages of major Indian carps. The present investigation compares the length-weight relationships and 'Kn' values between hatchery and bundh-bred juvenile species of *Labeo rohita* (Ham). This species is an indigenous major carp commonly known as 'Rohu' (Family : Cyprinidae) and is widely distributed in the inland waters of India.

Materials and Methods

Brood fish of either sex weighing 2.0-2.5 kg from two different sources viz. dry bundh (Fish Farm, Ramsagar, Bankura) and hatchery (Fish Farm, Hooghly) were induced by hormone (Chaudhury and Alikunhi 1957) and released eggs were fertilized in the respective sources. Two day old post-hatch spawns of *L. rohita* were collected from the two sources and reared separately in an identical condition in experimental hoopnets (150 cm x 140 cm x 90 cm) installed in the same pond of our Institute. Hoopnets were fixed 120-150 cm away from the bank. The tiniest spawns (2-3 days old) were kept in a nylon mosquito net (mesh size 2 mm). The nets were placed inside a bamboo structure by firmly binding four corners to have sufficient water space to rear the experimental spawns. About 5000 spawns were kept in each hoopnet. Pond water was monitored daily for temperature, pH and dissolved oxygen that ranged from 30-32 °C, 6.9-7.2 and 5.8-10.8 ppm respectively. Zooplankton, being the preferred food of the spawns (Jhingran 1991) was collected from the pond using a plankton net and filtered through a larger mesh (mosquito net) to remove the dirt and insects and counting was done using Sedgewick Rafter counting chamber on a weekly basis. Average percentage of zooplankton was represented by cladocera (79%), copepoda (15%) and rotifera (6%). The experimental protocol involved random collection of five spawns of the species *L. rohita* from two sources separately every third day from the experimental hoopnets installed in the same pond. The experiment was started on the 5th day and continued up to 74th day. Surface water from individual spawn was absorbed using Whatman filter paper no 1. The total length (from tip of the snout up to the end of caudal fin) was measured in 'mm' and each fish was weighed in a precision balance in 'mg' (Bagenal 1978). Length-weight relationship and 'Kn' values at different time points of the species *L. rohita* two sources (bundh and hatchery) were calculated by taking 120 specimens from each source. The length and weight of the experimental fishes ranged from 6.0-52.0 mm and 1.1-984.0 mg respectively.

The parameters studied here are measured using the following formulas:

Length-weight relationship

The 120 observations on length and weight from each source were subjected to statistical analysis. The mathematical relationship between length and weight was calculated using the conventional formula $W = aL^b$ and using the logarithmic transformation Log W = log a + b log L, where W = weight of the fish, L = total length of the fish and the parameters 'a' and 'b' are intercepts and regression coefficient estimated by linear regression of the log transformed variates.

Relative condition factor

The relative condition factor of the specimens 'Kn' was calculated using the formula Kn = W/w, where W = observed average weight of fish at a time point, w = estimated (from regression equation) weight for the observed length.

Response parameter

To evaluate the growth of the species under a natural environment, we have considered two growth parameters viz. length and weight in the present report. Equations for growth measurement in terms of weight were:

Absolute growth = (W_2-W_1)
Average daily weight gain = $(W_2-W_1)/(T_2-T_1)$
Relative growth rate = $(W_2-W_1)/W_1\ (T_2-T_1)$
Specific growth rate = $(\ln W_2-\ln W_1) \times 100/(T_2-T_1)$
W_1 = Mean (based on five observations) weight of the species at time T_1
W_2 = Mean (based on five observations) weight of the species at time T_2

These growth parameters were calculated based on the total experimental period (5-74 days).

Average daily weight gain (ADG) and specific growth rate (SGR)

To obtain the average growth rate, successive periods of observations were used. Average growth for each period were then compared. ADG was computed by dividing the growth rate for a period by the number of days in the period i.e. 3 days. This ADG is thus the ADG of the mid point of the period. Similarly SGR was computed using logarithm of the raw observations.

MS Excel '97 software was used for the graph (Figs. 1, 2 and 3). Statistical analyses were conducted on the results of the experiment according to Steel and Torrie (1960).

Results

The sample size, the maximum, minimum, and mean length (± SE) of the species are shown in Table 1. The coefficient of correlation (r) between Log length and Log weight of *L. rohita* was found to be 0.998 for bundh and 0.997 for hatchery and it was highly significant ($P<0.001$).

The parameters 'a' and 'b' of the length-weight relationship is shown in the logarithmic equation as follows:

Log W = -5.766 + 3.306 Log L for bundh

Log W = - 5.252 + 3.125 Log L for hatchery

The standard error of 'b' values are 0.399 for bundh and 0.049 for hatchery. It was revealed from the 't' test that there was a significant variation (P<0.001) at 236 d.f. among the sources as far as their regression values is concerned. The departure of 'b' values from the conventional 'cubic law' was found to be significant (P<0.001) for bundh and hatchery at 118 d.f. Using 't' test it was observed that there was a significant difference between bundh and hatchery-bred species of *L. rohita* during development with regard to absolute growth and average daily weight gain (Table 2).

A straight linear relationship between Log length and Log weight of the species *L. rohita* was observed.

Low relative condition (Kn) was observed at 6.0 mm size which gradually increased upto 7.0 mm size and it stabilized above '1' in the 7.5-35.0 mm size group for hatchery and 8.0-16.0 mm for bundh. Finally, these values did not show much variation from '1' (Figs. 1 and 2).

Specific growth rate (% weight per day) and average daily weight gain (mg/day) in different periods of hatchery and bundh-bred species *L. rohita* reared in the same natural environmental condition are shown in Fig. 3. SGR was found to increase upto 15.5 days then gradually decreases though there were several ups and downs up to the age of 54.5 days in both the species from two sources. This value gradually increased among the bundh-bred species compared to hatchery afterwards. A fluctuating low value of ADG among bundh-bred species in comparison to hatchery was found up to the period of

Table 1. The sample size, length characteristics (in mm) viz. the maximum, minimum, mean length (± SE) of the bundh and hatchery-bred species of *L. rohita* during developmental period.

Species	Sources	Length	Length characteristics				
			N	Mean	SE	Min.	Max.
L. rohita	Bundh	Total length	120	15.0	± 1.8703	6.0	40.0
L rohita	Hatchery	Total length	120	25.5	± 2.8065	6.0	52.0

N = Number of fish, S. E. = Standard Error
Min. = Minimum and Max. = Maximum

Table 2. Mean values of different growth parameters (absolute growth, average daily weight gain, relative growth rate and specific growth rate) of hatchery and bundh-bred species of *L. rohita* during early developmental period.

Growth parameters	Unit	Bundh	Hatchery
Absolute growth	mg	742.1 ±0.03	982.8* ±0.02
Average daily weight gain	mg/day	10.60 ±0.03	14.04* ±0.02
Relative growth rate	unit/day	9.63	11.79
Specific growth rate	% weight/day	9.31 ±0.01	9.62 ±0.15

*P<0.001
Each value is the average of five replications ± S. E.

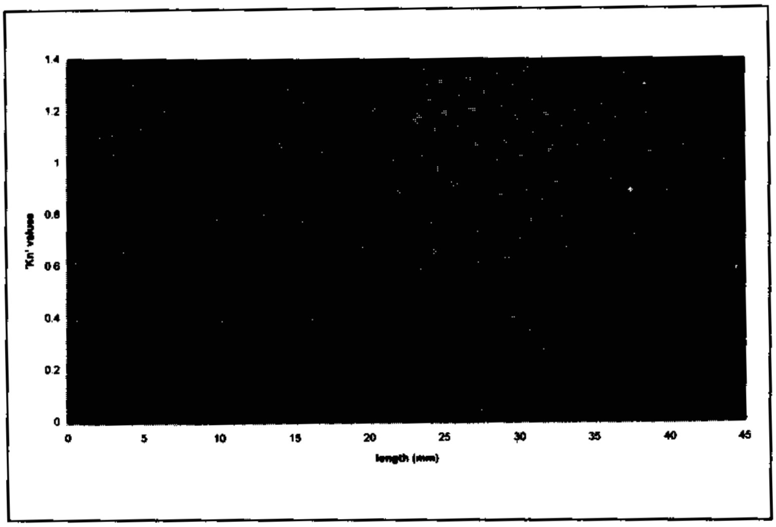

Fig. 1. 'Kn' values at different lengths of *L. rohita* (Bundh) during early developmental period.

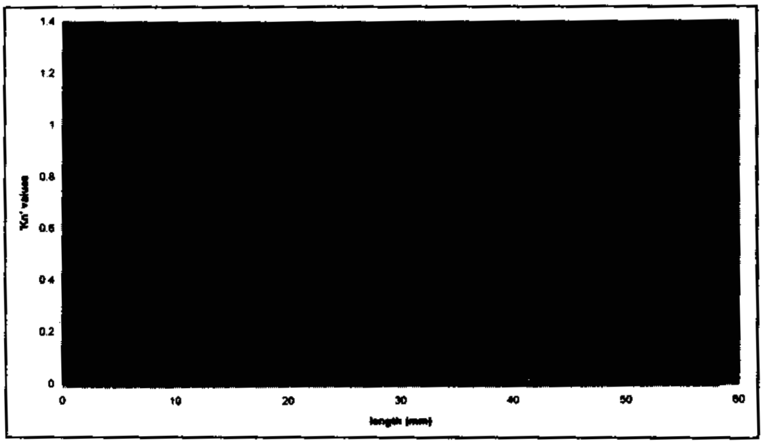

Fig. 2. 'Kn' values at different lengths of *L. rohita* (Hatchery) during early developmental period.

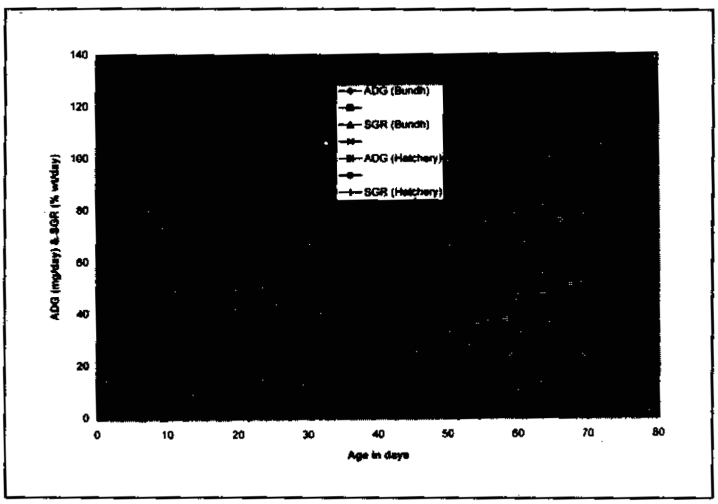

Fig. 3. Average daily weight gain (mg/day) and specific growth rate (% wt/day) of *L. rohita* (Bundh and Hatchery) during early developmental period.

63.5 days. But a significant increase ($P<0.001$) of ADG among bundh-bred species in comparison to hatchery was observed afterwards.

Discussion

Hile(1936) and Martin (1949) have measured this exponent value 'b' and they found it within the range 2.5-4.0. On the contrary, Beverton and Holt (1957) observed that most of the adult fishes follow an 'isomeric growth'. Ricker (1958) suggested that deviation from this 'cubic law' is common. On the other hand, LeCren (1951) observed 'isomeric growth' in *Salmo trutta* in Windermere during development. Jhingran (1952) also observed an exponent 'b' (3.0104) of the 'riverine species' of *L. rohita* in the size range 50-620 mm. It was revealed from our experiment that the growth of the species is 'allometric' ($b \neq 3$) during early developmental period. In our earlier observations we found that the bundh-bred species of *C. catla* behaved in the same way as adult 'riverine species' during early developmental period (Sarkar et al. 1997). The bundh-bred species *L. rohita* in their early developmental period did not follow the same pattern as adult 'riverine species' (Jhingran 1952).

Low 'Kn' values in the size range 6.0-7.5 mm may be related to the 'lag phase' period of growth of the species. In the present case we observed that the estimated weight of the fishes was much higher than the observed weight during the period 2-14 days. Chatterjee et al. (1977) and Jhingran (1952) also noticed that the estimated weight of smaller sized fish was higher than the observed weight. They found the reverse result in larger fish. High 'Kn' values above '1' in the 8.0-35.0 mm size group indicated that the fertility and food supply of the pond was quite good. This could also indicate high feeding intensity of the fishes after the 'lag phase' period. Raizada and Raizada (1982) suggested that high 'Kn' values in smaller immature *C. mrigala* may be due to its high feeding intensity for rapid growth.

Apparently it can be said that the overall growth pattern of hatchery-bred species of *L. rohita* is higher than bundh (Table 2). But a critical study of the growth rate of the species *L. rohita* revealed that there were three time periods within which the growth rate of the species with respect to ADG and SGR varied (Fig. 3). These are period 1 : ADG value was low upto 9.5 days and SGR increases upto 15.5 days; period 2 : a gradual fluctuating increase in ADG from 12.5 days and SGR on the whole gradually decreases, though there were several ups and downs, upto the age 54.5 days; period 3 : sudden fluctuating increase in ADG and SGR from 57.5 days in the species from both sources, but a significant increase ($P<0.001$) in ADG was observed among bundh-bred species after 66.5 days compared to hatchery. A significant increase ($P<0.001$) in SGR among bundh-bred species was observed from 60.5 days in comparison to hatchery. Estimates of ADG and SGR are highly reliable because all standard errors are very small. During the period of study i.e. 54.5 days L-W relationship was almost perfect both for bundh ($r = 0.998$) and hatchery ($r = 0.997$). So it is enough to measure the length and use the regression equation to get the weight. Our results corroborate the findings of Brown (1957) where she reported a gradual declining and fluctuating nature of SGR in fishes during early development. Brown (1946) also reported a gradual decline in SGR among large and small fry of *Salmo trutta* before the 8th week of growth after feeding started. Abbas and Siddiqui (1987) also observed a decreased SGR in *Channa punctatus* with the increasing age and size of the fish. Another important finding noted here is that during early developmental period the growth of hatchery-bred species is much higher than bundh. This result continued upto 66.5 days of experiment and after that bundh-bred species showed greater growth rate than the hatchery. The important finding of the present study is that the growth rate of the species *L. rohita* spawned in bundh and hatchery were acclerated after 57.5 days. This also indicates that the growth performance of the species spawned in age old traditional system (bundh) is quite superior in the long run.

The difference in growth performance between the species from two different sources, bundh and hatchery may be due to intrinsic changes in their physiological system. It is not clear which factor is really responsible for this growth difference in the species between two sources. It needs further investigation.

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References

Abbas, M. and M. S. Siddiqui. 1987. The age and growth of *Channa punctatus* (Bloch) in a direct water ecosystem. Indian Journal of Ecology 14 (1): 170-172.

Agarwal, S. S. and D. N. Saxena. 1979. Length-weight relationship in *Catla catla* (Ham). Geobios 6: 129-132.

Ahmed, K. K. and S. B. Saha. 1996. Length-weight relationships of major carps in Kaptai lake, Bangladesh. NAGA, The ICLARM Quarterly 19 (2): 28.

Bagenal, T. 1978. Methods for assessment of fish production in fresh waters. 3rd ed. Blackwell Scientific Publishing. Oxford, London. 365pp.

Beverton. R. J. H. and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fisheries investigation. London, Series 2: 533.

Brown, M. E. 1946. The growth of brown trout (*Salmo trutta* Linn) 1, Faetrous influencing the growth of trout fry. Journal of Experimental Biology 22: 118-129.

Chatterjee, A., A. Q. Siddiqi and A. A. Khan. 1977. Length-weight relationship of a carp of *Labeo rohita* (Ham). Proceedings of the Indian Academy of Sciences 86b: 189-194.injection. Current Science 26: 381-382.

Desai, V. R. and N. P. Srivastava. 1990. Studies on age, growth and gear selectivity of *Cirrhinus mrigala* (Ham) from Rihand reservoir, Uttarpradesh. Indian Journal of Fish 37 (4): 305-311.

Hile, R. 1936. Age and growth of the cisco, *Leucichthys artedi* (Le Sueur) in the lake of the North Eastern highlands, Wisconsin. Bull. U. S. Bur. Fish Washington 48: 211-237.

Jhingran, V. G. 1952. General length-weight relationship of three major carps of India. Proceedings of the National Institute of Sciences of India 18: 449-460.

Jhingran, V. G. 1991. Fish and Fisheries of India (3rd ed). Hindusthan Publishing Corporation (India), Delhi. 727pp.

Johal, M. S. and K. K. Tandon. 1992. Age and growth of the carp *Catla catla* (Hamilton, 1822) from Northern India. Fisheries Research 14: 83-90.

Kulshrestha, S. K., M. Srivastava., M. P. George., R. Saxena and A. Tieari. 1993. Length-weight relationship of a major carp *Catla catla* (Ham) from two water bodies of Bhopal. In : H. R. Singh (Editor), Advances in Limnology. Narendra Publisher, Delhi. 329-392.

Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Pearca fluviatilies*). Journal of Animal Ecology 20: 201-239.

Martin, W. R. 1949. The mechanisms of environmental control of body form in fishes. University of Toronto Studies in Biology 58: 1-91.

Pauly, D. 1993. Editorial Fish byte. NAGA, The ICLARM Quarterly 16 (2-3): 26.

Petrakis, G. and K. I. Stergion. 1995. Weight-length relationships of 33 fish species in Greek waters. Fisheries Research 21: 465-469.

Pratap, H. B. and Mkamba, S. R. N. 1987. The length-weight relationship of *Oreochromis urolepis* (Cichlidae) from Msewe Stream, Dar es Salaam, Tanzania. Indian Journal of fish. 34 (1): 112-114.

Raizada, M. N. and S. Raizada. 1982. A note on the ponderal index (K) in *Cirrhinus mrigala* (Ham). Geobios 9: 42-43.

Raizada, M. N., S. D. Misra, K. K. Jain and S. Raizada. 1986. Studies on the ponderal index (K) of a fresh water teleost *Labeo rohita* (Ham). International Journal of the Academy of Ichthyology 7 (2): 39-41.

Reddy, Y. S. and M. B. Rao. 1992. Length-weight relationship and relative condition of *Puntius sophore* (Hamilton- Buchanon) from the lake Hussain Sagar, Hyderabad. Journal of the Inland Fisheries Society of India 24 (1): 22-25.

Ricker, W. E. 1958. Hand book of computation for biological studies of fish populations. Bulletin of the Fisheries Research Board of Canada 119: 300.

Sarkar, S. K., S. Ganguly, T. K. Basu and C. Medda. 1997. Length-weight relationship and relative condition of hatchery and bundh-bred *Catla catla* (Ham) spawn during development. Asian Fisheries Science 9: 295-299.

Steel, R. G. D. and H. T. James. 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill Book Co., Inc, New York, 481 pp.

Quddus, M. A. and S. Dewan. 1988. Studies on monthly growth, length-weight relationship and condition factor of *Oreochromis niloticus* (Linnaeus). Bangladesh Journal of Fish 11 (1): 13-18.

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