CHAPTER 6.
LENGTH – WEIGHT RELATIONSHIP
AND
RELATIVE CONDITION FACTOR
6. LENGTH – WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR

6.1. Introduction

Length – weight relationship studies in fishes serve to establish a mathematical relationship between length and weight and their interconversion (Beyer, 1987) as required in the setting up of yield equations for estimating population strength (Beverton and Holt, 1957). It also helps to measure the variations from the expected and observed weight for length of individual fish as indication of the pattern of growth, fatness, general well being or gonad development (Le Cren, 1951; Bolger and Connolly, 1989). Growth fluctuations are more frequent in fishes of tropical and subtropical waters due to variations in seasons, multiple spawning and food composition (Rounsefell and Everhart, 1953; Lagler, 1956).

Information on the length-weight relationship of fishes of the family Hemiramphidae from Indian waters are limited to *H. georgii* of the Gulf of Mannar and Palk Bay (Talwar, 1962 b); *H. gaimardi* of Pulicat Lake (Sultana et al. 1980) and *H. marginatus* of Gulf of Mannar (Kasim et al. 1996). Length-weight relationship of *H. brasiliensis* and *H. balao* of South East Florida was described by Berkeley and Houde (1978).
No information is available on the length-weight relationship and relative condition factor of *H. (H). limbatus* and *H.(H). xanthopterus* of the Cochin coast. Hence an attempt is made to work out the length-weight relationship and condition factors of these two species from the south-west coast of India.

### 6.2. Materials and Methods

Monthly samples of fishes were collected from different fish landing centres, markets of Cochin coast and some fishing grounds in Vembanad Lake like Eloor, Varapuzha, Mulavukadu, Arookutty, South Parur and Murinjapuzha. The locations of collection are shown in the map. (Fig. 1.1). These fishes were caught mainly by the drift gill net, murasu vala. Fishes were separated into three categories as males, females and indeterminates after examining the gonads. Fishes were measured and weighed in fresh condition. Total length was taken from the tip of the lower jaw to the end of caudal fin ray to the nearest millimetre and weight was recorded up to 0.01g.

A total of 865 specimens of *H.(H) limbatus* comprising 503 males, ranging from 120 to 202mm total length (TL) and 4.05 to 24.30g weight; 344 females ranging from 126 to 229 mm TL and 4.51 to 30.559 weight and 18 indeterminates ranging from 68 to 121 mm TL and 0.82 to 4.029 weight were studied. In the case of *H. (H) xanthopterus* a total of 540 specimens comprising 238 males ranging from 139 to 220mm TL and 7.43 to 42.07g
weight; 282 females ranging from 131 to 249mm TL and 7.10 to 54.35g weight and 20 indeterminates ranging from 75 to 130mm TL and 1.01 to 6.90 g weight were used for the present study.

The data on length-weight relationship were analysed separately for each category as per Le Cren (1951). The length-weight relationship can be expressed as:

\[ W = aL^b. \] (Huxley, 1924)

Logarithmic transformation of the above formula gives a linear equation:

\[ \ln W = \ln a + b \ln L. \] (Le Cren, 1951)

Where \( W = \) weight in g, \( L = \) total length in mm, \( a \) and \( b \) are constants.

Conversion of the resultant transformed equation to the original equation was achieved by rewriting the equation as:

\[ W = e^a \times L^b. \]

Significance of difference at 5% level between regression coefficients of the sexes were tested by ANACOVA (Snedecor and Cochran 1967; Zar 1996). To test whether the regression co-efficient depart significantly from 3, ‘t’ test was employed by using the formula

\[ t = b-3/Sb \]

where \( b \), the regression coefficient and \( S \), the standard error of \( b \).

Relative condition factor ‘Kn’ for different months as well as different length groups of 10mm class interval was also estimated by employing the equation of Le Cren (1951).
\[ Kn = \frac{W}{\hat{W}} \]

Where 'W' represents the observed weight and \( \hat{W} \) the expected weight derived from the length-weight relationship.

6.3. Results

6.3.1. Length-weight relationship

Statistical details regarding the length-weight relationship of \( H.(H) \) limbatus and \( H.(H) \) xanthopterus are shown in Table 6.1. The logarithmic relationship between length and weight of males, females and indeterminates are presented Figs. 6.1 to 6.6. The logarithmic regression equations were as follows.

\( H. (H) \) limbatus

- Male \[ \ln W = -14.123 + 3.266 \ln TL \quad r=0.970 \]
- Female \[ \ln W = -13.986 + 3.244 \ln TL \quad r=0.983 \]
- Indeterminates \[ \ln W = -14.873 + 3.401 \ln TL \quad r=0.934 \]

\( H.(H) \) xanthopterus

- Male \[ \ln W = -12.860 + 3.025 \ln TL \quad r=0.963 \]
- Female \[ \ln W = -12.128 + 2.941 \ln TL \quad r=0.948 \]
- Indeterminates \[ \ln W = -15.491 + 3.589 \ln TL \quad r=0.949 \]
The corresponding exponential relationship can be represented in Figs. 6.7 to 6.12 and the exponential formula can be represented as follows.

\( H. (H) \text{ limbatus} \)

- **Male**  \( W = 1.139 \times 10^{-2} L^{3.266} \)
- **Female**  \( W = 1.072 \times 10^{-2} L^{3.244} \)
- **Indeterminates**  \( W = 6.288 \times 10^{-3} L^{3.401} \)

\( H. (H) \text{ xanthopterus} \)

- **Male**  \( W = 9.969 \times 10^{-3} L^{3.025} \)
- **Female**  \( W = 1.355 \times 10^{-2} L^{2.941} \)
- **Indeterminates**  \( W = 1.342 \times 10^{-2} L^{3.589} \)

The regression equations of males and females of the two species were subjected to analysis of covariance ANACOVA (Snedecor and Cochran, 1967; Zar 1996) and the results are presented in Table 6.2 and 6.3. The results of analysis of covariance revealed significant difference at 5% levels in both the species. Therefore the length-weight relationships for males and females of \( H. (H) \text{ limbatus} \) and \( H. (H) \text{ xanthopterus} \) were considered as different and therefore combined relationships could not be derived. Separate regression analysis was needed and carried out.

The co-efficient of correlation \((r)\) for males and females and Indeterminates of \( H. (H) \text{ limbatus} \) was 0.970, 0.983 and 0.934 and those of \( H. (H) \text{ xanthopterus} \) was 0.963, 0.948 and 0.949, respectively. This showed that there is a very good relationship between the measures of length and weight of \( H. (H) \text{ limbatus} \) and \( H. (H) \text{ xanthopterus} \).
In *H. (H) limbus* the b values were 3.266 for males, 3.244 for females and 3.401 for indeterminates whereas that of *H. (H) xanthopterus* were 3.025 for males 2.945 for females and 3.589 for indeterminates. The 't' test was conducted to see whether the 'b' values of these two species were different from the expected value 3.0 for ideal fish. The 't' values revealed that the regression coefficient of males and females of *H. (H). limbatus* differed significantly from 3.0 while the indeterminates did not show any significant difference from the isometric value of 3.0. In the case of *H. (H) xanthopterus* the males and females strictly followed the cube law while the indeterminates deviate from it significantly.

### 6.3.2. Relative condition factor

Monthly and length-wise fluctuations in relative condition (‘Kn’) values of males and females of *H. (H) limbus* and *H. (H) xanthopterus* during 2001 May to 2003 April are depicted in Fig 6.13 to 6.16.

In *H. (H) limbus* the relative condition factor (‘Kn’) values were highest during November and April (1.04) in both the years for females whereas that of males were in November and March (1.04) in the first year and February and September (1.03) in the second year. The lowest ‘Kn’ values were observed in the month of May (0.97) during the first year and June and January (0.98) during the second year for females whereas in the
case of males the months April and May (0.96) showed low values during the first year and October (0.95) in the second year.

In *H.(H) xanthopterus* the highest ‘Kn’ values were observed for females during the month of June (1.039) whereas lowest values were observed in September (0.96) in both the years. In the case of males the highest values were observed in the month of May and November (1.02) during the first year and August (1.01) during the second year whereas the lowest values were in September (0.98) in the first year and March 0.99 in the second year. The variation in ‘Kn’ values can be attributed to the maturity process in the fish as manifested by increase in weight of gonads and to spawning activity as manifested by loss of weight.

In the case of females of *H. (H) limbatus* the ‘Kn’ values were above 1.0 in length groups 120-130mm and 140-180mm. Values less than 1.0 were noticed in the older and younger length groups. In males the highest values were observed in 110-130mm length group. In all other length groups the males followed the same pattern as in the case of females.

The length groups 160-180mm and 210-230mm showed ‘Kn’ values above 1.0 with the highest ‘Kn’ value 1.07 in the 220-230mm length group in the case females of *H. (H) xanthopterus* The lowest values were observed in the 130-140mm length group. In males the lowest ‘Kn’ value was in the 130-140mm and highest in 210 to 230 mm length group. Males followed a more or
less similar pattern as that of females in all other length groups. 'Kn' values were high in younger fishes, however, a decline in the values with length increment is noteworthy.

6.4. Discussion

Significant differences could be found while comparing the regression co-efficient of males and females *H. (H) limbatus* *H. (H) xanthopterus* and so separate equations were computed to describe the length-weight relationship of males and females of both species. Talwar (1962 b) reported separate regression equation for *H.georgii*. Contrary to this Sultana et al.(1980) used a common regression equation for *H. gaimardi*. The 'b' values obtained for males and females of *H. (H) limbatus* and indeterminates of *H. (H) xanthopterus* showed significant variation from the isometric value of '3' whereas the males and females of *H.(H) xanthopterus* and indeterminates of *H. (H) limbatus* did not show significant variation from the cube law.

In ideal fish which exhibits isometric growth, the value of regression coefficient shall not be different significantly from 3.0 (Allen, 1938). In this study the 'b' values of *H. (H) limbatus* were slightly above the isometric value of 3.0, indicating that the weight increased by a power more then three with unit increase in body length. Similar results were reported in *H. gaimardi* (Sultana et al.1980), males of *H.georgii* (Talwar, 1962 b) and *H.brasiliensis* (Berkley and Houde 1978. However, in *H. (H) xanthopterus* males and females strictly followed cube low indicating that the weight increased by a
power of 3 with unit increase in body length as observed in females of *H. georgii* (Talwar, 1962b) and *H. margiantus* (Kasim et al., 1996). Slope value less than 3.0 indicates that the fish becomes more slender as it increase in length while slope greater than 3.0 denotes the stoutness, leading to the conclusion that growth is allometric (Grover and Juliano, 1976). However a deviation from the cube law is often observed in most of the fishes as they change their body shape during growth. The value of ‘b’ usually varies between 2.5 and 4.0 (Hile, 1936 and Martin, 1949). The reasons for this variation are seasonal fluctuations in environmental parameters, physiological conditions of the fish at the time of collection, sex, gonadal development and nutritive conditions of the environment of the fishes (Sinha, 1973).

While discussing the merits of allometric formula with cube formula- Beverton and Holt (1957) have stated that instances of important deviation from isometric growth in fishes are rare. In the present study deviation from the isometric value of ‘3’ was evident in *H. (H) limbatus* and such deviation has been reported by Venkataramani and Kingsten (1998) in *Selaroides leptolepis*, Sunil (2000) in *Rasbora daniconius*, Doddamani et al. (2001) in *Stolephorus batavience* whereas *H. H. xanthopterus* follow isometric pattern of growth and similar instances were reported by Batcha and Badrudeen (1992) in *Leiognathus brevirostris*, Venkataramani and Gopalakrishnan (1993) in *Parastromateus niger* and Sunil Kumar et al. (1999) in *Horabagrus brachysoma*. 
The relative condition factor values were highest during April and November in the case of *H. (H) limbatus* and in June and July for *H.(H) xanthopterus*. These months were considered as the spawning period of these fishes (Refer the chapter on maturation and spawning for details). It may therefore be inferred that the high condition values may be due to intense gonad maturation, as reported by Sultana *et al.* (1980) in *H. gaimardi*. High Kn values noticed in the younger length group fishes of *H.(H) limbatus* and *H.(H) xanthopterus* can be attributed to the high feeding intensity of the young growing fish. In *P. hamrur* the condition is greatly influenced by feeding intensity rather than the cyclic changes taking place in the gonads (Philip and Mathew, 1996). Qasim (1957) explained that the increase or decrease of condition in the shanny *Blennius pholis* is probably due to general building up and loss of reserves respectively. It is reported that ‘Kn’ values depend on physiological factors like maturity and spawning and environmental factors like availability of food (Brown, 1957).

The ‘Kn’ values of males and females of *H.(H) limbatus* and *H.(H) xanthopterus* were around and above 1 in most of the months, which indicated that these fishes showed good condition throughout the year. Berkley and Houde (1978) reported that the males of *H. brasiliensis* had a higher condition factor.

The reason for the incidental fluctuation of ‘Kn’ values are not fully understood and therefore assumed as due to inexplicable causes. It may be
inferred that Kn values were not only influenced by sexual cycle but also due to some other unknown factors. James (1967) suggested that the changes in the condition of ribbon fish *Eupleurogrammus intermedius* was related to factors other than reproductive cycle and the feeding habits.

Significant differences could be found while comparing the regression co-efficient of males and females *H. (H) limbatus* *H. (H) xanathopterus* and so separate equations were computed to describe the length-weight relationship of males and females of both species. The ‘b’ values obtained for males and females of *H. (H) limbatus* and indeterminates of *H. (H) xanathopterus* showed significant variation from the isometric value of ‘3’ whereas the males and females of *H. (H) xanathopterus* and indeterminates of *H. (H) limbatus* did not show significant variation from the cube law.
Fig. 8.1
Length weight relationship of *H. (H) limbatis* male

\[ \ln W = -14.123 + 3.281 \ln TL \quad r = 0.970 \]

Fig. 8.2
Length weight relationship of *H. (H) limbatis* female

\[ \ln W = -13.986 + 3.244 \ln TL \quad r = 0.983 \]

Fig. 8.3
Length weight relationship of *H. (H) limbatis* indeterminates

\[ \ln W = -14.873 + 3.401 \ln TL \quad r = 0.934 \]
In $W = -12.860 + 3.025 \ln TL$  \( r = 0.963 \)

**Fig. 6.4**
Length weight relationship of *H. (H) xanthopterus* male

In $W = -12.128 + 2.941 \ln TL$  \( r = 0.948 \)

**Fig. 6.5**
Length weight relationship of *H. (H) xanthopterus* female

In $W = -15.491 + 3.589 \ln TL$  \( r = 0.949 \)

**Fig. 6.6**
Length weight relationship of *H. (H) xanthopterus* indeterminates
Fig. 6.7
Length weight relationship in exponential form of *H. (H) limbatus* male

\[ W = 1.138 \times 10^{-2} \times L^{3.286} \]

Fig. 6.8
Length weight relationship in exponential form of *H. (H) limbatus* female

\[ W = 1.072 \times 10^{-2} \times L^{3.244} \]

Fig. 6.9
Length weight relationship in exponential form of *H. (H) limbatus* indeterminates

\[ W = 6.288 \times 10^{-3} \times L^{3.401} \]
Length weight relationship in exponential form of

Fig. 6.10
H. (H) xanthopterus male

W = 9.969 E-03 L^{3.025}

Fig. 6.11
Length weight relationship in exponential form of
H. (H) xanthopterus female

W = 1.355 E-02 L^{2.541}

Fig. 6.12
Length weight relationship in exponential form of
H. (H) xanthopterus indeterminates

W = 1.342 E-02 L^{3.589}
Fig. 6.13
Monthly 'Kn' values of males and females of *H. (H) limbatus*

Fig. 6.14
Monthly 'Kn' values of males and females of *H. (H) xanthopterus*
Fig. 6.15
'Kn' values for different length groups of males and females of 
*H. (H) limbatus*

Fig. 6.16
'Kn' values for different length groups of males and females of 
*H. (H) xanthopterus*
Table 6.1
Details of statistical analysis of length weight relationship of

*H. (H) limbatus and H. (H) xanthopterus*

<table>
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<tr>
<th>Source</th>
<th>Number</th>
<th>Regression Co-efficient b</th>
<th>Intercept log a</th>
<th>Correlation coefficient r^2</th>
<th>Standard error of b</th>
<th>t = b-3 / Sb</th>
<th>Relation to ‘3’</th>
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<td><em>H. (H) limbatus</em></td>
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<td>-0.037</td>
<td>7.24</td>
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<td>3.244</td>
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<td>-0.033</td>
<td>7.39</td>
<td>Different *</td>
</tr>
<tr>
<td>Indeterminates</td>
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<td>3.401</td>
<td>-14.873</td>
<td>0.934</td>
<td>-0.314</td>
<td>1.27</td>
<td>Not different</td>
</tr>
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<td><em>H. (H) xanthopterus</em></td>
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<td>Males</td>
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* Significantly different from 3.
Table 6.2  
Comparison of regression lines of males and females of *H. (H) limbatus* by ANACOVA

Dependent variable: LOG_WT

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<th>P value</th>
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* Significant at 5% level.
Table 6.3
Comparison of regression lines of males and females of H. (H) xanthopterus by ANACOVA

Dependent variable: LOG_WT

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* Significant at 5% level.