**Length Weight Relationship (LWR), Growth estimation and Length at maturity of *Etroplus suratensis* in Chilika Lagoon, Orissa, India**

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**ABSTRACT**

The growth features of a commercially important fish species, i.e. *Etroplus suratensis* (local name “Kundala”) was studied in the Chilika Lagoon. In total, 4192 of *E. suratensis* samples were measured with their total length during the period of June 2008 to May 2009. Different cohorts were identified through multiple length frequency analysis on the total length of these species and their growth curves were estimated. The estimated growth parameters like, L_inf (cm), K, and t0 was 33.7cm, 0.20, and 0.01 for the species respectively. Length at 50% maturity (L_{50}) of the fish samples was also examined. The estimated L_{50} for *E. suratensis* was 165mm (TL). Length-weight relationship (LWR) of *Etroplus suratensis* also estimated and the equation found y = 1E-005x^{3.134} (n=118) for male, y = 3E-005x^{2.998} (n=184) for female and y=2E-005x^{3.101} (n=302) as unsexed samples. Here the computed growth coefficient (b) was 3.134, 2.998 and 3.101, where the regression coefficient (r^2) was 0.982, 0.96 and 0.977 for male, female and unsexed samples respectively.

**Keywords:** *Etroplus suratensis*, growth estimation, length at maturity, L_{50}, Chilika Lagoon.

1. Introduction

The Length-Weight Relationship (LWR) is an important tool to analyze fish populations. Its applications range from simple estimates of an individual's weight to indication of fish body condition factor or inferences regarding sexual development (Le Cren, 1951). Knowledge on this relationship also helps to identify energy investments for growth or reproduction as a natural cyclic phenomenon of natural populations (Bolger & Connolly, 1989).

Age and size at first reproduction have broad implications for studying population and community ecology. The biological relationship between age and length is fundamental to many fisheries population dynamics models. Estimates of growth drive size and age structured stock assessment models (Quinn and Desiro, 1999), and is related to life history traits such as natural mortality (M) and age or length at maturity (Charnov, 1993). Again, age and growth studies are also important in describing the basic biology and ecology of fishes (Weatherley and Gill, 1987; Cailliet and Goldman, 2004). Age and growth determinations are important in studying longevity, age at first maturity, catchable size and other life history problems in fishes (Ricker, 1971; Lagler et. al., 1977). Age with growth parameters of fishes constitutes essential data to control the dynamic of ichthyologic populations. They give an important indication on the fishery resource management and on the level of their exploitation (Summerfelt and Hall, 1975). For a management regime to ensure, in the face of exploitation that a sufficient number of juveniles reach maturity usually requires information on the size and age at first maturation. Again, surviving to sexual maturity and being able to
contribute to the gene pool define fitness for an individual. Collectively, those surviving individuals determine the survival of the population. Sexual maturation has been known to be associated with physiological and behavioral changes.

The relationship between the biological changes and growth, mortality and longevity has been studied by Alm (1959) and Pauly (1984). Using data in FishBase, Froese and Binohlan (2000) have likewise demonstrated that size and age at sexual maturity are strongly correlated with growth, maximum size and longevity.

Besides growth of a species, it is also very important to study about the reproductive cycles for better understanding and management in an ecosystem. Proper estimation of size at first maturity (L₅₀ - length at which 50% of the fish are mature) is very useful for fish stock management. Different methods have been proposed to estimate L₅₀. According to a very useful study by Trippel & Harvey (1991), each individual fish should be identified as reproductive or non reproductive. This recognition is usually visual and subjective descriptions of macroscopic aspects of ovaries and testes at different maturation stages have been published frequently (e.g. Gerritsen et al., 2003). Although a diverse methods are available for assessment of L₅₀, but most of the researchers apply some kind of logistic functions (Gonçalves & Erzini, 2000; Dadebo et al., 2003; Lewis & Fontoura, 2005; Gerritsen et al., 2003; Tokai and Mitsuhashi, 1998).

Pearl spot (Etroplus suratensis) is one of the most popular and very important fish species in not only in Chilika lagoon but also throughout India having a high commercial value. But this species becomes gradually insufficient in the captures of the fishermen in Chilika lagoon. However, there is no growth parameters estimation for the greater number of fishes of E. suratensis in the lagoon. Therefore, to estimate the growth parameters of E. suratensis species, we have taken length data of a large number of samples from different landing center for one year of survey. This is very important to provide baseline scientific data for input policy and better sustainable exploitation of the fish stock in Chilika lagoon where an intensive overexploitation of ichthyologic resources is observed.

Considerable work has been done on seasonal changes of size and morphology occurring in the gonadal maturation of many teleost fish (Satyanesan, 1962 and 1963; Overbeeke and McBride, 1967; Van Oordt and Ekengren, 1978). However, similar studies on estuarine fishes of India are very limited. Although Jhingran and Natarajan (1966 and 1969) have studied about the body size, analysis of gonad, age of maturity and secondary sexual characters of E. suratensis in Chilika lagoon, but still the works are few, insufficient and old. Hence in the present work preliminary investigation has been made to study the growth, seasonal changes in the gonads and the length at 50% maturity (L₅₀) of commercially important fish species, i.e. E. suratensis (“Kundala” in local name) for the future management of their stocks.

2. Materials and Method

2.1 Study area

Chilika Lagoon, the largest lagoon of India lies in the east coast of India, situated between latitudes 19°28’ and 19°54’ North and longitude 85°05’ and 85°38’ East. It is designated as an important Ramsar site (No.229) of India on 1st October 1981. The water spread area of the lagoon varies between 906 km² to 1165 km² during summer and monsoon respectively. The total lagoon is divided into four ecological sectors (Figure 1) i.e., Northern sector in fresh water zone, Central is brackish, Southern is marine type but the Outer Channel sector in
marine in nature but during monsoon it becomes fresh as 52 rivers and rivulets entering the lagoon in the northern sector discharging their fresh water load through outer channel sector to the sea. So the estuarine lagoon is a unique assemblage of marine, brackish and fresh water eco-systems.

Figure 1: Chilika map showing four ecological sectors.

2.2 Length-Weight Relationship (LWR)

For length and weight analysis, fish samples were collected inside the lagoon from the fishing boats. Collected samples were caught by gill nets of mesh size 16 mm, 24 mm, 32 mm & 36 mm and Khonda nets (fixed net) of mesh size 40-20 mm. Then samples were transported to the research laboratory in polythene bags for measurement of length and weight. Total length (L) and body weight were measured to the nearest 0.1cm and 0.01g respectively of the fresh samples. All total 302 fish samples were used to measure both length and weight for LWR. The length-weight relationship (LWR) was estimated by the equation \( W = aL^b \), where ‘W’ is body weight (g), ‘L’ is total length (cm), ‘a’ and ‘b’ are two constant.

2.3 Growth

The commercially important fish species, i.e. *E. suratensis* samples were measured with their total length (cm) by using a measuring board at the fish landing centers of Balugaon in the central sector and Kalupadaghat in the northern sector of Chilika Lagoon. In total, 4192 number of fish samples was measured from June 2008 to May 2009 and the length data were recorded in the sampling format at those fish landing centers. The length composition data of the species were used in this study.

Multiple length frequency data sets on total length of the fish species, aggregated into 1-cm interval length class by month, were analyzed to separate different cohorts and estimate their growth. Parameters on growth curve, occurrence rate of each cohort, and the standard deviation of length (\( \sigma \)) in each cohort were simultaneously estimated by maximizing the log-likelihood function composed of the multinomial statistical model after Yamakawa and Matsumiya (1997). By using this model, we analyzed multiple length frequency data sets simultaneously and obtained accurate and stable parameter values consistently. The \( \sigma \) was assumed to be constant irrespective of age and size of shell. No discrimination was made between males and females.
The von Bertalanffy Growth Formula (VBGF) growth equation was used in order to determine the relationship between length and age. The VBGF was fitted to estimates of length-at-age curve using non-linear squares estimation procedures (Pauly et al., 1992). The VBGF is defined by the equation:

$$L_t = L_\infty [1 - e^{-kt}]$$

Where,
- $L_t =$ mean length at age $t$;
- $L_\infty =$ asymptotic length;
- $K =$ growth co-efficient, determining the rate of change in the length increment;
- $t =$ age of the $E. suratensis$
- $t_0 =$ the hypothetical age at which the length is zero.

The asymptotic length ($L_\infty$) of $E. suratensis$ was fixed to 33.7cm, considering the largest individual observed during the study period.

### 2.4 Length at 50% maturity ($L_{50}$)

In total, 108 females of $E. suratensis$ sampled from April 2008 to May 2009 in the Lagoon were examined. Concerning fish species, to calculate the length at 50% maturity ($L_{50}$), the proportion of mature fish, of which the gonads was observed by eye according to the description of Pollard (1972), was calculated in each body length class of 5-mm interval.

The $L_{50}$ was estimated by calculating coefficients $a$ and $b$, respectively, in the following equation of logistic curve by maximizing the likelihood of binomial distribution by using Excel add-in tool “solver” (Tokai and Mitsuhashi, 1998):

$$M(L) = 1 / (1 + \exp (-aL + b))$$

### 3. Results

**Length-Weight Relationship (LWR)**

Length-weight relationship (LWR) of $Etroplus suratensis$ estimated in Chilika lagoon and the equation found $y = 1E-05x^{3.134}$ $(n=118)$ for male and $y = 3E-05x^{2.998}$ $(n=184)$ for female. Here the computed condition factor ($a$) was $1E-05$ and $3E-05$ for male and female respectively. The growth coefficient ($b$) was 3.134 and 2.998, where the regression coefficient ($r^2$) was 0.982 and 0.96 for male and female respectively. Finally putting together all the data, LWR for the species was estimated. The estimated equation $y=2E-05x^{3.101}$, in which condition factor (‘a’ value), growth co-efficient (‘b’ value) and regression co-efficient ($r^2$) was $2E-05$, 3.101 and 0.977 respectively (Table-1).
Figure 2: Monthly frequency distributions of fork length of *E. suratensis* and the estimated composition of cohorts and growth curves; N = total number of fish measured each month.

**Growth**

From the multiple length frequency analysis of *E. suratensis*, five cohorts were detected (Figure 2). The cohort with 9.1cm TL in June grew to 13.1cm TL by the next May. The estimated growth parameters are shown in Table 2. And the von Bertalanffy growth equations are as follows.

\[ L_t = 37.9 \times (1 - \exp \left[ -0.16 \times (t - 0.12) \right] ) \]

The estimated asymptotic length (L∞) and growth coefficient (K) of the von Bertalanffy Growth Formula (VBGF) for *E. suratensis* were 37.9cm and 0.16year⁻¹ respectively.

**Length at 50% maturity (L₅₀)**

Logistic equations are used to estimate L₅₀, because these simple mathematical functions can follow a cumulative normal curve where L₅₀ correspond to normal average. That is, L₅₀ is the average size of a species when it starts to reproduce for the first time. The parameters a and b of the logistic curves on the proportion of maturation of the females of *E. suratensis* was estimated as follows and those logistic curves are shown in Figure 3.
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M(TL) = 1/[1+exp(aTL+b)]

Where, M is the maturation length, a and b are two constants.

M(FL) = 1/[1+exp(-0.07777 FL+ 12.8432)]

The estimated L_{50} of *E. suratensis* was 165mm TL. So, at 165mm and above of total length, most of the females were identified as reproductive (maturation+spawning+post-spawning).

Figure 3: Observed (dots) and estimated (lines) proportion of mature female of varying body lengths of the females of *E. suratensis*; N = total number of fish observed.

4. Discussion

The calculated ‘b’ value for *E. suratensis* is 3.134 and 2.998 for male and female and 3.101 for both sexes, are all within the limits for most fishes (Royce, 1972; Lagler et. al., 1977). In general, ‘b’ values of fish are closer to 3, even though many variations of fish form [King, R. P. (1996). Such variations in ‘b’ value may depend upon various factors like number of specimen examined, condition of places of sampling, sampling season etc (Gokce et. al., 2007). Even though the change of b values depends primarily on the shape and fatness of the species, also depends upon various factors like temperature, salinity, food (quantity, quality and size), sex and stage of maturity (Pauly, 1984; Sparre, and Venema, 1992). Again, LWR in fish is affected by a number of other factors including gonad maturity, sex, diet, stomach fullness, health, and preservation techniques as well as season and habitat (Cherif et al., 2008). But these factors were not accounted for the present study. The length-weight relationship presented here may facilitate fish biologists to derive weight estimates for fishes that are measured but not weighed.

Table 1: Estimated parameters of *E. suratensis* i.e., number of samples (N), sex (M-male, F-female, B-both), length range (min.-max.), weight range (min.-max.), equation and regression co-efficient (r^2) in Chilika lagoon

| Sex | N  | TL/FL | Length(mm) | Weight(gm) | W=aL^b | b value | r^2 |
|-----|----|-------|------------|------------|--------|---------|-----|
| M   | 118| TL    | 79-238     | 11.46-383.95 | y = 1E-05x^{3.134} | 3.134  | 0.982 |
| F   | 184| TL    | 103-234    | 27.14-342.33 | y = 3E-05x^{2.998} | 2.998  | 0.96  |
| B   | 302| TL    | 79-238     | 11.46-383.95 | y = 2E-05x^{3.101} | 3.101  | 0.977 |

Table 2: Growth parameters and L_{50} of *E. suratensis* (Kundala) in Chilika lagoon

| Parameters | Present Study | Jhingran and Natarajan (1969) |
|------------|---------------|-------------------------------|
| L_{\infty} (cm) | 37.9          | 48.1                          |
| K (1/year)  | 0.16          | 0.24                          |
Table 3: Length and age at reaching sexual maturity

| Lm* (cm) | Length type | Age (year) | Sex    | Country     | Source                        |
|----------|-------------|------------|--------|-------------|-------------------------------|
| 15.2-17.8| -           | -          | -      | India       | Chacko and Ganapati (1949)    |
| 10       | -           | 0.7-0.8    | Unsexed| India       | Alikunhi (1957)               |
| 10.5     | -           | -          | Unsexed| India       | Natarajan (1966 and 1969)     |
| 15       | TL          | 2.0        | Unsexed| India       | Talwar & Jhingran (1991)      |

*Lm: length at reaching sexual maturity, **tm: age at reaching sexual maturity

Table 2 and 3 shows the results obtained from the studies on the growth and length (age) at maturity of *E. suratensis*. The L∞ and K value of *E. suratensis* estimated by this study was 37.9cm and 0.16year⁻¹ respectively. Both the L∞ value and K value are smaller as compared to the results reported by Jhingran and Natarajan (1969). Alikunhi (1957) reported that *E. suratensis* attains maturity when about 7-8 months old and about 100mm in length. Jhingran and Natarajan (1966 and 1969) stated that the minimum size at maturity of this fish in Chilika Lagoon is 105mm where as Chacko and Ganapati (1949) mentioned that the species attains sexual maturity at a length of 152-178mm. Males are slightly larger in size.

Environmental conditions also induced phenotypic flexibility in fishes which may changing age and size at maturity (Ishida et al., 1993; Cox and Hinch, 1997; Pyper et al., 1999; Wertheimer et al., 2004). Most studies suggest relationships among temperature, population size, and body size at maturity. Growth of a fish species is also density-dependent. Increase in population size may have led to a decrease in per-capita food availability and, thus, a decrease in the size at maturity (Bigler et al., 1996). In Chilika, total catch of Kundala is rapidly decreasing year by year (Figure 4). During the period of 2001-02 to 2006-07, Kundala fishery averages 72 MT per year and the annual landing varies from 23 MT to 122 MT. So, it shows fluctuating trends throughout the above period in which the maximum catch recorded during 2004-05 and in the following year minimum catch recorded. Hence, the conditions of the hydrology of the lagoon must changed in a great extend, which might results better conditions for food availability and ultimately fish growth. The recent increase in size at maturity of the species can be largely attributed to a phenotypic response to a complete growth rate.

Figure 4: Annual landing (MT) of Kundala in the Lagoon during the period of 2001-02 to 2006-07.
The size at sexual maturity of *E. suratensis* is an important life history parameter that has been estimated in previous studies of sexual maturity but inadequately. The noticeable size at first maturity is often reported, however, which is not enough and very old. The current study has derived a functional relationship between the estimated proportion mature and length of the species.

This paper provides the information on the growth and the length (age) at maturity of commercially important fish species in Chilika Lagoon, India. This information is required by most of models of stock assessment to estimate fishing mortality, population of cohorts, population of spawning stock, etc.

5. Conclusion

This paper provides information on the growth and the length (age) at maturity of commercially important fish species i.e., *Etroplus suratensis* (Kundala) in Chilika Lagoon. This information is required by most of models of stock assessment to estimate fishing mortality, population of cohorts, population of spawning stock etc. This investigation could strongly helpful to the researchers and policy makers for the preparation of very effective sustainable management plans of fishery resources of the lagoon.

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