



Investigations on age, growth and mortality parameters of *Ailia coila* (Hamilton, 1822) (Siluriformes: Ailiidae) from Brahmaputra river system of Assam, India

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ABSTRACT

The present study deals with the detailed investigation on population dynamics of the near-threatened catfish *Ailia coila* (Hamilton, 1822), which inhabits the Brahmaputra River of India and forms an important component of freshwater inland fishery, providing nutritional and financial security to the local community. A total of 1034 individuals were collected by weekly sampling from the Uzanbazar and Dhubri landing centres of this river system from September 2013 to April 2014. The estimated asymptotic length (L_{∞}), growth coefficient (K) and age at zero length (t_0) of *A. coila* were 268 mm, 0.87 yr⁻¹ and $t_0 = 0.000028$ years respectively. Estimated total mortality (Z), natural mortality (M) and fishing mortality coefficient (F) were 5.76, 1.63 and 4.13 yr⁻¹ respectively. Using von Bertalanffy growth formula (VBGF) the length attained at the end of first, second and third years of life were estimated at 156, 221 and 248 mm, respectively. The von Bertalanffy growth equation of this fish can be written as $L_t = 268 \{1 - e^{-0.87(t+0.000027866)}\}$. The exploitation ratio (U) and exploitation rate (E) and M/K ratio were estimated at 0.71, 0.72 and 1.87, respectively.

Keywords: *Ailia coila*, Asymptotic length, Fishing mortality, Growth co-efficient, M/K ratio

Introduction

The fisheries sector is a major supplier of high quality animal protein, supporting the livelihoods and well being of more than 12% of the world's population (FAO, 2020). Commercial fishing continues to be a major contributor to the economics of developing and developed countries. In addition to the large worldwide value of the catch, approximately 36 million people are employed in capture and culture fisheries activities (Lackey, 2005). India has 18% of the world population, with only 4% of the world's freshwater resources (Anon., 2018). Estimated total fish production during 2018-19 was 13.42 million t, of which 3.71 was from the marine sector and 9.71 from culture fisheries (Anon., 2019). Catfishes are one of the largest groups of teleosts containing around 6750 species under 38 families. The family Ailiidae contains 6 genera and 17 species. The genera are represented by *Ailia*, *Ailiichthys*, *Clupisoma*, *Laides*, *Eutropiichthys* and *Proeutropiichthys* (Fricke *et al.*, 2020). Among these,

Ailia coila which is near-threatened (Habib *et al.*, 2020) forms a major fishery among catfishes in the Brahmaputra river system. Found throughout the year, it is locally known as *Kajoli* or *Bahpati* in Assamese.

A sound knowledge of growth and age of species contributing to the fishery is essential for understanding the longevity of exploited stocks, age composition of the catch, age at sexual maturity, the suitability of different environments for growth, population dynamics and possible identification of stocks based on growth differences. It is also essential to determine the mortality and survival rate of various year classes and success of the yearly broods after recruitment. This would allow fishery managers to understand the dynamics of fish stocks and how fish populations would react to external pressures like commercial fishing and predation. Estimates of total mortality are used in stock assessments to determine sustainable harvest levels of exploited species and rebuilding plans for overexploited species. However,

no information is available on age, growth and mortality parameters of *A. coila* from the Brahmaputra River. Therefore, the present study was carried out to generate information on the growth, mortality and population parameters of *A. coila* from Brahmaputra river system to form baseline data for developing fishery management plans for the resource.

Materials and methods

Sampling

A total of 1034 fish samples were collected through weekly sampling from drift gillnets, river shore seines and drag nets (8.2 mm) operated off Uzanbazar, Guwahati (26°11'43.25" N; 91°45'20.90" E) and Dhubri landing centre, Dhubri (26°01'23.62" N; 89°59'31.72" E) of

Brahmaputra River in Assam (Fig. 1). The length range of the sampled fishes was 63-166 mm total length (TL).

Growth parameters

All collected specimens were placed in insulated ice boxes and transported to the laboratory where they were screened, cleaned and identified with the help of established keys (Day, 1878; Talwar and Jhingran, 1991; Nelson 2006). The fishes were measured for TL from the tip of the snout to the tip of the caudal fin to the nearest 1mm using a digital measuring scale (Mitutoyo: CD-6"ASX) and wet weight was recorded to the nearest 1 g using a digital balance (Fig. 2).

The length frequency data were distributed at 10 mm class intervals, frequency raised for the day and

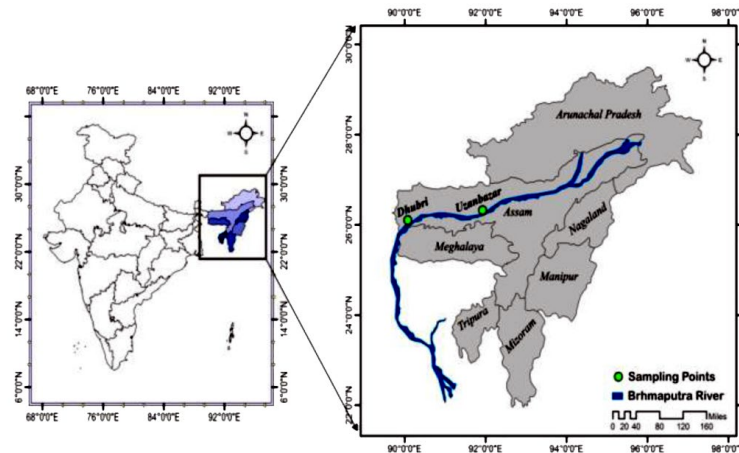


Fig. 1. Map showing the sampling places along the Brahmaputra river system



Fig. 2. Sampling and segregation of different length groups

subsequently for the month (Sekharan, 1962). Several methods such as modal progression analysis, Ford-Walford and computer-based FiSAT programme, ELEFAN, Bhattacharya analysis (Bhattacharya, 1967) as well as Gulland and Holt plot (Gulland and Holt, 1959) were used to estimate the growth parameters. In Bhattacharya's method, the composite distribution was separated to the normal distribution to represent the cohorts. Gulland and Holt's plot further refined the preliminary estimates made by Bhattacharya's method. Intercept 'a' and slope 'b' provided the K and L_{∞} through the relationship: $K = -b$ and $L_{\infty} = -a/K$, and an analysis was done using FiSAT programme (Gayanilo *et al.*, 1996). The age at zero length (t_0) of von Bertalanffy growth formula (VBGF) was estimated using the equation: $-\ln [1-L(t)/L_{\infty}] = -K*t_0 + K*t$, with a series of length at age data and an estimate of L_{∞} , the intercept 'a' and 'b' were calculated to obtain the K and t_0 as: $K = b$ and $t_0 = -a/b$ (Bertalanffy, 1934).

Mortality parameters

Estimates of instantaneous mortality Z were obtained through different methods (Beverton and Holt, 1957; Jones and Van Zalinge, 1981; Pauly, 1984). Natural mortality was estimated by the formula of Pauly given as: $\ln M = -0.0152 - 0.279 \ln L_{\infty} + 0.6543 \ln K + 0.463 \ln T$, where L_{∞} is in cm, K annual and T is the mean environmental temperature taken in degree celsius (Pauly, 1980). Estimates of natural mortality were also obtained by other methods for comparison (Taylor, 1960; Cushing, 1968; Alagaraja, 1984; Srinath, 1998). Fishing mortality (F) was estimated by subtracting natural mortality (M) from total mortality (Z).

Exploitation rate and ratio

Exploitation rate (E) was calculated as $E = F/Z$ and the exploitation ratio (U) was calculated by $U = F/Z * (1 - e^{-Z})$ (Beverton and Holt, 1957).

Results

Growth parameters

In scatter diagram technique, seven identical curves could be drawn by tracking the progression of modes and growth was read at random intervals for the calculation of L_{∞} and K. Asymptotic length and growth coefficient were estimated at 265 mm and 0.84 yr^{-1} , respectively (Fig. 3). In Ford-Walford plot, by employing monthly mean length, calculated asymptotic length and growth coefficient value were similar to that estimated by modal progression. Linking of means was done by the Bhattacharya method using FiSAT programme after separating the Gaussian components and the estimated values of L_{∞} and K were 264.35 mm and 0.74 yr^{-1} respectively (Fig. 4).

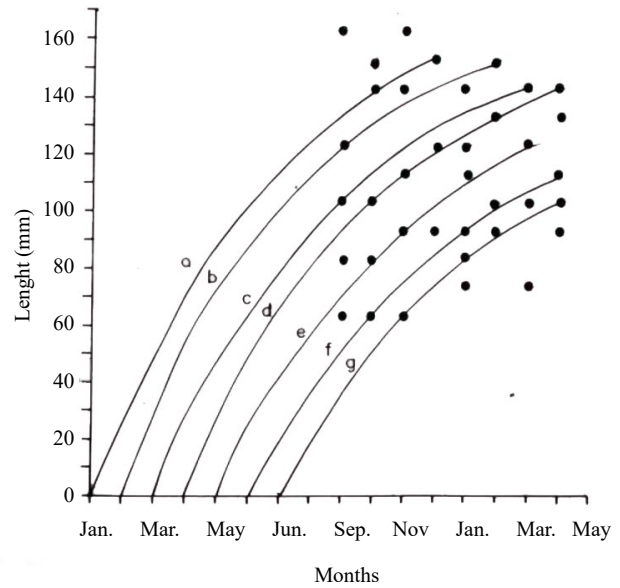


Fig. 3. Monthly modal progression analysis of *A. coila*

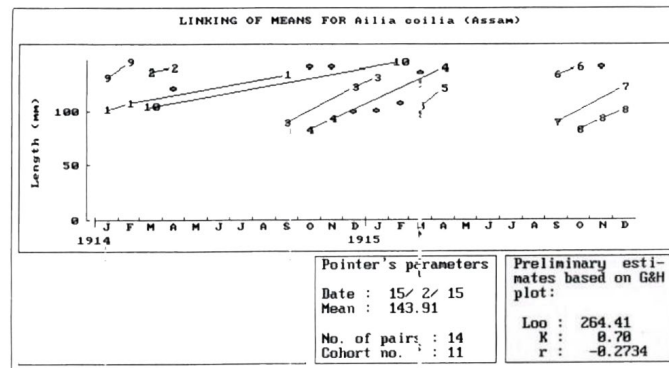


Fig. 4. Linking of means by employing Modal Progression Analysis (Bhattacharya method) for *A. coila* using FiSAT

Data was further refined through employing Gulland and Holt plot of FiSAT programme and the values of L_{∞} and K obtained were 265 mm 0.84 yr^{-1} . The ELEFAN technique gave the best fitting growth line with the goodness of fit value of 0.174; L_{∞} and K values were 268 mm and 0.87 yr^{-1} , respectively (Fig. 5). The value of age at zero length (t_0) using von Bertalanffy's plot and monthly mean length obtained by the scatter diagram technique was -0.000028 years.

The growth performance index (ϕ) was found to be 4.79 in the present study. Table 1 summarises the final estimates of growth parameters, mortality and longevity estimated

Age and growth

Using the growth parameters, the sizes attained by *A. coila* were estimated to be 156, 221 and 248 mm at the end of first, second and third years of its life, respectively (Fig. 6). The maximum observed length of the fish in the fishery in the course of this study was 166 mm TL. Based on this, the estimated fishable life span of the species is 1.12 years.

Mortality and exploitation

Beverton and Holt method showed that the instantaneous rate of total mortality is 4.78 yr^{-1} , while Jones and Van Zalinge cumulative catch curve method estimated it at 6.27 yr^{-1} . Pauly's length converted catch curve method estimated its value at 5.76 yr^{-1} , which was considered for further calculations as it is one of the most widely used

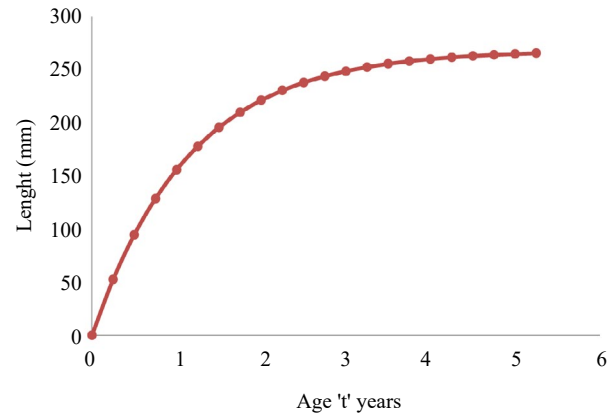


Fig. 6. Estimated von Bertalanffy's growth curve for *A. coila*

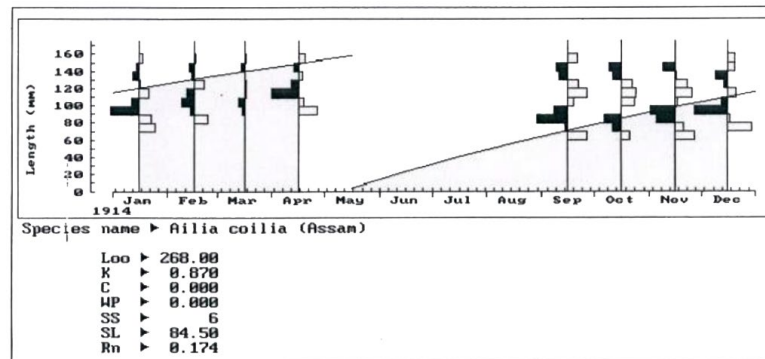


Fig. 5. ELEFAN curve of *A. coila* employing computer based FiSAT programme

Table 1. Yearly growth parameters of *A. Coila* from Brahmaputra river system

Population parameters	Estimated values
Asymptotic length (L_{∞}), ELEFAN FiSAT (mm)	268
Growth coefficient (K), ELEFAN FiSAT (yr^{-1})	0.87
Age at zero length (t_0), von Bertalanffy's growth equation	- 0.000027
Total mortality (Z) (yr^{-1})	5.76
Natural mortality (M) (yr^{-1})	1.63
Fishing mortality (F) (yr^{-1})	4.13
M/K ratio	1.87
Exploitation rate (E) = F/Z	0.72
Exploitation ratio (U) = (F/Z) * (1 - e^{-Z})	0.71
Phi-prime ($\phi = \log K + 2 \log L_{\infty}$)	4.79
Length attained at the end of I, II, III year of life (mm)	156, 221, 248
Estimated fishable life span of fish (years)	1.12

methods in the tropics and the value obtained is nearest to the average value of “Z” obtained by the other methods. Results presented in Table 2 indicate the value of natural mortality estimated by different methods. The value of 1.63 yr^{-1} obtained by Pauly’s method was used for further calculations. Fishing mortality (F), estimated by subtracting natural mortality (M) from the total mortality coefficient (Z) was obtained as 4.13 yr^{-1} . Exploitation ratio (U), exploitation rate (E) and M/K ratio was estimated as 0.71, 0.72 and 1.87 in the present study.

Discussion

Growth parameters

Age, growth and mortality parameters of a fish species provides information on life span, maturity, stock composition and their growth pattern. However, not much work has been done on age, growth and population parameters of *A. coila* and other species under this family from Brahmaputra River in Assam and other riverine waters of India. In the present study, a number of methods were used for the estimation of growth parameters, the values obtained from ELEFAN I of FiSAT programme (L_{∞} , 268 mm and K, 0.87 yr^{-1}) were considered reasonable and used as input parameters for estimation of other population parameters. The asymptotic length (L_{∞}) and growth co-efficient (K) was quite similar to the estimates of Abobi and Ekau (2013) for *Schilbe intermedius* ($L_{\infty} = 289$, $K = 0.95 \text{ yr}^{-1}$) from Volta River of Ghana. According to Pauly and Morgan (1987), higher values of K are typically connected with lower values of L_{∞} and *vice versa*, since these parameters are interrelated with each other *i.e.*, smaller fishes usually have faster growth rates. The estimated value of t_0 (-0.000028) indicated higher growth rate in early life stages as compared to adult size; *A. coila* was found to attain a length of 156, 221 and 248 mm after completion of first, second and third years of its life, respectively. Growth rate was much higher in the first and second years. Ahirwal *et al.* (2018) observed that the lower length group of fishes feed actively and more frequently than the larger length group; this may be due to high food requirements in the younger stage. In the present study, the growth performance index (O) was 4.79, which was found similar to the observation made by Prasad *et al.* (2012)

on *Horabagrus brachysoma* (4.89) from Periyar River of southern Western Ghats, India.

Mortality parameters

The estimated values of total mortality (Z), fishing mortality (F) and natural mortality (M) were 5.76, 4.13 and 1.63 yr^{-1} , respectively. Mortality parameters may not stop at a stable level and are liable to change from time to time depending on supply of good quality food, maturation and spawning period of fishes (Bagenal and Tesch, 1978; Sparre and Venema, 1992). This is the first study documenting growth and mortality parameters of *A. coila* and there is no documented information on mortality parameters of *A. coila* and other species under this family, hence, a comparative assessment of the estimates cannot be made. The estimated M/K ratio of 1.87 falls within the range 1.5-2.5, given by Beverton and Holt (1956) for the accurate estimation of natural mortality coefficient, indicating that the estimates of both M and K done in the present study are reasonable and reliable.

Exploitation rate and ratio

The current exploitation rate and ratio of *A. coila* are similar (0.72 and 0.71). Gulland (1971) stated that for the optimal exploitation of a stock, it is assumed that exploitation rate (E) should be equal to 0.5 for optimising the sustainable yield when the fishing and natural mortality is quite similar. In the present study, as both, the exploitation rate and ratio were above 0.5 and the fishing mortality was higher than the natural mortality, it can be concluded that the population of *A. coila* in Brahmaputra River is overexploited. One of the reasons for overexploitation of this resource may be its high market price (₹400-800 kg^{-1}). Of late, the catch of this species has also declined due to indiscriminate fishing of juveniles through the deployment of small mesh sized gillnets, river shore seines and drag nets. The present study provides basic information required to initiate management practices for sustainable fishery of the resource in the Brahmaputra River. While strict management practices like protected waters, mesh size regulations, restriction of non-selective gears, destructive fishing and restricting the discharge of untreated effluents into the natural water bodies are immediate options, the study also warrants close monitoring and assessment

Table 2. Estimated values of natural mortality coefficient “M” by different methods

Method applied	Natural mortality (M)
Cushing’s method (Cushing, 1968).	1.97 yr^{-1}
Taylor’s method (Taylor, 1960).	1.30 yr^{-1}
Pauly’s empirical method (Pauly, 1980).	1.63 yr^{-1}
Alagaraja’s method (Alagaraja, 1984).	1.97 yr^{-1}
Srinath’s empirical formula (Srinath, 1998).	1.46 yr^{-1}

of the resource for a continued period of time until the exploitation levels are considerably reduced.

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