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Population characteristics and level of exploitation of *Anabas testudineus* (Bloch, 1792) in Rudrasagar Lake, a Ramsar site in North-eastern India

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Population characteristics and exploitation level of *Anabas testudineus* from Rudrasagar lake, North-eastern India were studied to understand the dynamics of resource for suggesting necessary strategies for sustainable exploitation. A total of 1187 specimens were sampled to collect the length frequency data from May, 2015 to April, 2016. The length-weight relationship of the fish was found to be Log W = - 4.08+2.9 LogL (r^2=0.99). The Von Bertalanffy growth parameters i.e., asymptotic length (L_∞)and growth coefficient (K) were estimated using ELEFAN-I as 216.25 mm and 0.78 yr^{-1}respectively.The growth performance index (φ') was calculated as 4.56. The approximate longevity (T_{max}) was estimated as 3.8 years. The total mortality (Z), natural mortality (M) and fishing mortality (F) rates were estimated to be 1.95, 1.54 and 0.41 per year, respectively. The exploitation ratio (E) and exploitation rate (U) were observed to be 0.21 and 0.18, respectively. The results of relative yield-per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) estimated as a function of Lc/L_∞ and M/K were 0.46 and 1.95 respectively. The MSY level was estimated at 3.8 tonnes per year at F factor-0.8. Since the current level of exploitation of the species is well below E_{max}(0.50) and the observed landings are lower than the MSY level, it could be concluded that the fish is presently underexploited in the Lake. Reasonable fishing effort can be increased in order to obtain more yields so as to reach the MSY level and in that way increase the income of the economically poor fishermen communities of North-eastern India.

[Keywords: *Anabas testudineus*; Exploitation rate; Exploitation ratio; FiSAT; Growth; Mortality; MSY]

Introduction

Owing to diversity of topographic and climatic features, the aquatic resources of North-eastern India are rich in piscine germplasm and hence, recognized as one of the global hotspots of freshwater ichthyofaunal biodiversity[1]. Four hundred and twenty two fish species have been reported from this region, belonging to 133 genera and 38 families[2]. Many of these species are commercially exploited for food and aquarium industry. However, except taxonomic accounts[3,4] no authentic studies have been conducted on the stock status and exploitation levels of these fishes. On the other hand, uncontrolled exploitation, ever increasing pollution, habitat destruction etc. have caused large scale depletion of many of the fish stocks, as anecdotally revealed by many fishermen in this area[5]. Hence, authentic studies on population characteristics and exploitation level of these fishery resources have become very important to assure their sustainability and conservation.

Rudrasagar Lake situated between latitude 23°29' N and longitude 90°01' E (Fig. 1) also known as Rudijala, has been identified as one of the wetlands of National Importance of Conservation and later as one of the Ramsar sites of international importance[6]. This water body has an oval shape, with maximum water spread area of about 8.16 km^2 during monsoon and reduces to 1.0 km^2 during dry season. It gets connected during monsoon with Gumati river, one of the largest rivers in North-eastern India, and in that way facilitates the natural breeding for the majority of the indigenous fish species. About 53 fish species are reported so far from this Lake[6]. Unfortunately, the Lake is also prone to severe anthropogenic disturbances in the form of overfishing, pollution, agricultural encroachments etc.

Anabas testudineus commonly called as climbing perch is one of the small to medium sized freshwater fishes under the family Anabantidae of the order Perciformes. It is an omnivorous species generally found in lakes, swamps, canals, rice fields and river streams[7-9] with distribution restricted to India and South-east Asia[10]. This is an abundant, regularly harvested and economically important fish in Rudrasagar Lake. The present research work was conducted to estimate the population characteristics and level of exploitation of

A. testudineus in Rudrasagar Lake so asto suggest suitable management measures for the sustainable utilization of this important fish resource.

Materials and Methods

A. testudineus is mainly exploited by gill nets of 40 mm mesh size in the Lake, and all other gears used in the Lake are very small in numbers. The length and weight data was collected weekly in each month from June 2015 to May 2016 from the Lake. We measured 1187 specimens for total length (TL, from snout tip to caudal fin end to the nearest value 0.1 mm) using digital vernier caliper. The total weight was recorded to the nearest 0.1 g using digital electronic balance. Since there is a fishing ban in the month of July every year, no sample was collected during that month. The sampling data was converted to the daily catch and subsequently to monthly catch following Sekharan's method[11].

For deriving the length-weight relationship, we fitted the linear equation (Log W = a + b Log L) for the log transformed data following Le Cren[12]. The regression analysis was conducted for determining the value of the constant parameters a and b and the length-weight relationship. The length-frequency data was arranged in 10 mm class intervals and analyzed to estimate growth and mortalities parameters, recruitment pattern and rate of exploitation etc. using FiSAT package[13]. The growth parameters *viz*., asymptotic length (L∞) and growth co-efficient (K) were determined using the ELEFAN-I module in FiSAT software[14]. The estimated value of L∞ and K were used for the calculation of growth performance index (φ') using the equation[13]: φ'= 2 Log L∞+ Log K. The age at length zero (t_0) was assumed zero. The approximate longevity (T_{max}) was calculated as T_{max}=3/K (Pauly[15]). We took the mid-point of the smallest length group as the length at recruitment (Lr).

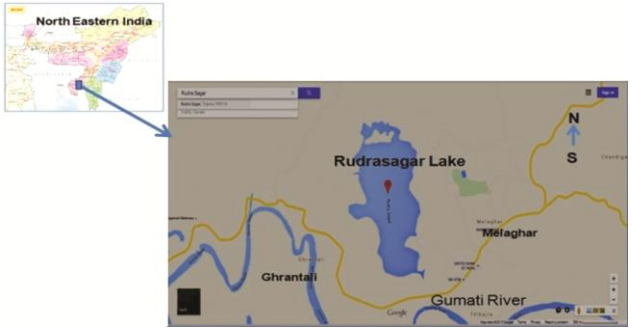

Fig. 1 — Rudrasagar Lake, North-eastern India

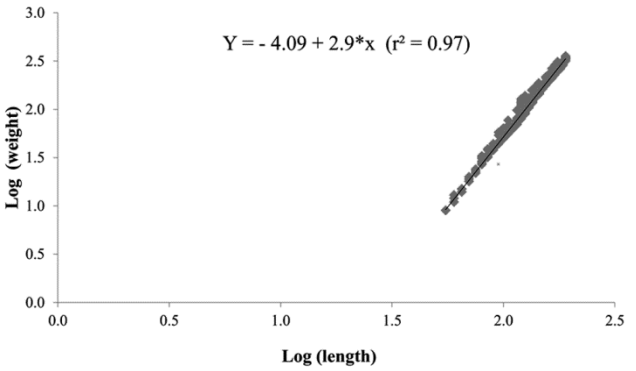

Fig. 2 — Length-weight relationship of *Anabas testudineus* in Rudrasagar Lake

The natural mortality coefficient was determined by Pauly's empirical formula[16]: ln(M) = – 0.0152 – 0.279 ln(L∞) + 0.6543 ln(K) +0.463 ln(T), where T is the annual average water temperature in °C; L∞, asymptotic length in cm and K, the growth co-efficient. For the estimation of M, the annual average water temperature was taken as 25 °C (as recorded by the mini weather station, Devis, Vintage Pro2 of the institute). The total mortality rate (Z) was estimated following cumulative catch curve method[17] in FiSAT program. The fishing mortality rate (F) was estimated as: F=Z-M.

We estimated the exploitation ratio (E) and exploitation rate (U) following the formulae: E=F/Z and U=F/Z *(1e^{-z}), respectively[18,19], where Z and F are the total mortality and the fishing mortality parameters, respectively. The Beverton and Holt[20] yield per recruit, biomass per recruit, relative yield-per-recruit and relative biomass-per-recruit analyses were done and the recruitment pattern was analyzed using FiSAT software[12]. The length structured Virtual Population Analysis (VPA) was also performed to estimate the fishing mortality rate for each length class.

Results

The length-weight relationship for the species could be established as Log W = - 4.09 + 2.99 Log L. The coefficient of determination (r^2) was found to be 0.97 revealing that the length and weight of the fish has statistically significant correlation ($p<0.05$). Since the calculated b value is 2.99, which is almost equal to 3.0, the fish could be considered as undergoing isometric growth. Further, it can be concluded that the fish's length and weight grow collinearly.

The growth parameters, viz. asymptotic length (L_∞) was found as 216.25 mm and growth co-efficient (K) was 0.78 per year with goodness of fit index (Rn) value as 0.2. The growth curve produced using Von Bertalanffy restructured length frequency distribution plot is shown in figure 2. With the estimated value of

aforementioned growth parameters, the growth performance index (φ') was calculated as 4.56. The approximate longevity (T_{max}) was found to be 3.8 years. The length at age data analysis revealed that *A. testudineus* attains mean length 55 mm, 140 mm and 185 mm, respectively at the end of first, second and third year. The growth estimates indicated that the species grow faster but life span is short. The length at first capture (Lc) was estimated as 110 mm whereas length at recruitment (Lr) as 60 mm.

The annual mortality rates *viz.* total mortality (Z), natural mortality (M) and fishing mortality (F) were found to be as 1.95, 1.54 and 0.41, respectively. Figure 3 represents the cumulated catch curve plot[17] applied for the estimation of Z.

The current exploitation rate (U) for *A. testudineus* was estimated as 0.18 per year and the exploitation ratio (E) 0.21 per year. The Beverton and Holt[20] yield per recruit and biomass per recruit analysis revealed that the stock is underexploited, hence the number of efforts could be enhanced to obtain maximum sustainable yield. The relative yield-per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) were estimated as 0.46 and 1.95, respectively.

The recruitment pattern (Fig. 4) revealed that this species has been recruited to the fishery almost throughout the year with a single peak, in the month of September (20.3 % recruitment).

The length-structured Virtual Population Analysis (VPA) was carried out to estimate the mortality in each length class caused by means of fishing. The VPA results revealed that the major loss in the stock up to 55 mm size was due to natural causes and the fishing mortality starts only after attaining the length 55 mm. It was also found that mortality due to exploitation (F) increased gradually and exceeded the natural mortality losses at the highest recorded length of 21.6 cm (Figs. 5-6). The predictive modeling[21] analysis suggested MSY level at 3.8 tones for *A. testudineus* at F- factor 0.8.

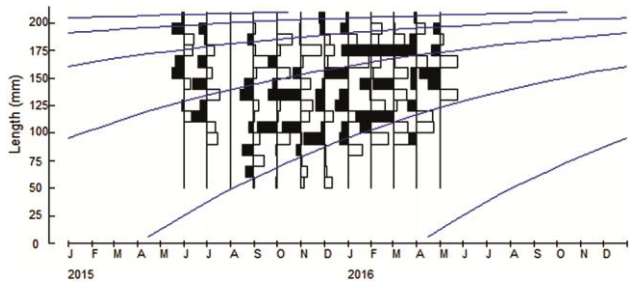

Fig. 3 — Growth curve of *A. testudineus* (L∞ = 216.25 mm and K = 0.782 per year)

Discussion

The length-weight relationship showed isometric growth for *A. testudineus* (b = 2.99) in Rudrasagar Lake. During isometric growth, fish become more robust with increasing length[22] and when b turns to be far less or greater than 3, growth is said to be allometric meaning that the fish becomes much

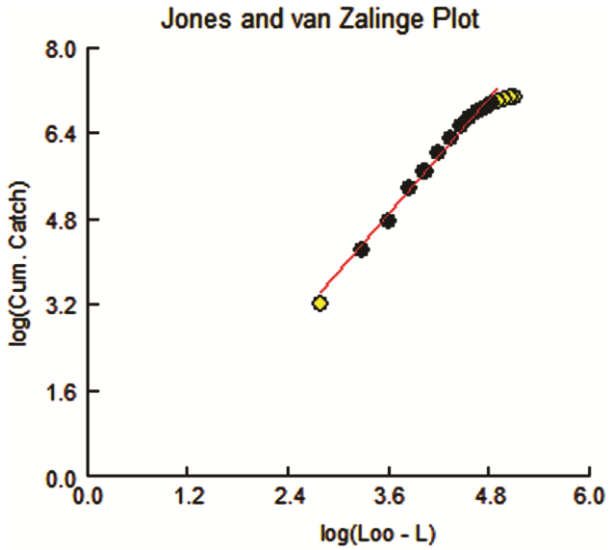

Fig. 4 — Jones and Van Zalinge cumulative catch curve plot for the estimation of Z, i.e., 1.94 (R^2=0.99)

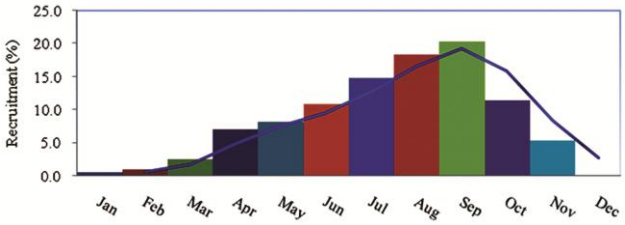

Fig. 5 — Recruitment patter of *Anabas testudineus* from Rudrasagar Lake

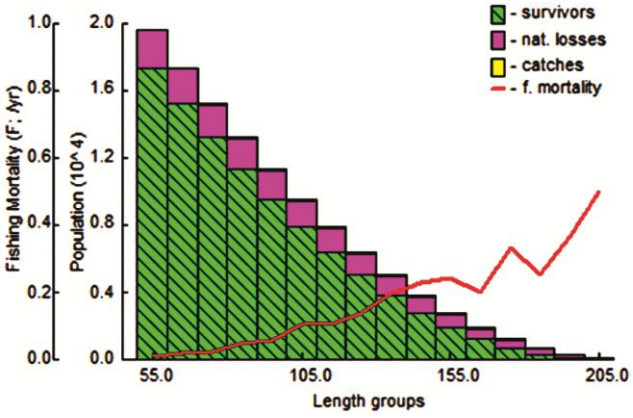

Fig. 6 — The VPA analysis depicting natural and fishing mortality and numbers of survivors

thinner or thicker with increasing length[23,24]. Hile[25] was of the opinion that the b value for an ideal fish might fall between 2.5 to 4.0. A combination of factors such as number of specimens analyzed, geographical area, seasonal variation, river habitat, feeding intensity, gonadal maturity, sex, health of the fish, preservation techniques and length ranges of the specimens caught may be attributed to the observed difference in b values[26]. Kumary and Raj[27] estimated the relationship between length and weight of *A. testudineus* from Kuttanad waters of Kerala as $W = 0.000298\ L^{2.85}$. The estimated K value was 0.78^{yr-1}, growth performance index (φ') 4.56 and the approximate longevity (T_{max}) was found to be 3.8 years. These growth estimates indicated that the species grow faster but life span is short. The length at recruitment (L_r) was observed as 6.0 cm. The mortality due to fishing (F) was observed to be less than that by natural causes (M), and therefore it could be concluded that the stock is underexploited. The exploitation rate (U) for *A. testudineus* was estimated as 0.18 per year and exploitation ratio (E) 0.21 per year which also substantiate the mortality estimates that the stock is underexploited. Gulland[19] stated that the stock is considered to be exploited optimally when F=M or E=0.50 and, if E is more than 0.50, the stock is usually overexploited. Hence, the fishing pressure can be increased until E_{max}(0.50) to get maximum sustainable yield for *A. testudineus* in Rudrasagar Lake. The results of relative yield-per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) indicated that the current level of exploitation is much lower than it should be to exploit the resources in maximum sustainable manner. The recruitment peak pulse was observed in the month of September (20.3 %). The recruitment of *A. testudineus* was recorded historically to be maximum (75.0 %) during monsoon period from June to September. The VPA results revealed that major reduction in the stock up to 55 mm size was due to natural reasons and fishing mortality starts only after attaining the length 55 mm. Kumar *et al*.,[28] reported the length at first maturity of *A. testudineus* as 80-100 mm; however, estimated mean length in the catch found to be above 100 mm. It could be therefore concluded that the gear being used for its capture is not a threat for its growth as well as recruitment. It was found that mortality due to fishing (F) increases eventually once the fish become vulnerable to the gear and outnumbered the natural mortality rate at a length of 21.6 cm. The MSY was estimated to be 3.8 tonnes per year in the present research. The annual average landing of this species from Rudrasagar Lake was estimated and recorded to be 0.5 to 2.0 tones only. It indicated that still there is scope for further increasing in the catch. The fishing pressure could be enhanced to increase the landings to reach the MSY level.

Conclusion

A. testudineus is a small indigenous fresh water fish exploited and utilized as a food fish throughout India and adjacent countries. Rudrasagar Lake in North-eastern India is one of the Ramsar sites, where this species has been mainly exploited by gill net of 40 mm mesh size, and all other gears landed it in very small numbers as by-catch only. The present study is very much significant as it provides comprehensive knowledge on the population dynamics parameters and current exploitation level of *A. testudineus* in the Lake. It confirms that the species is currently underexploited as the exploitation rate and exploitation ratio is below 0.5. The fish landings also observed to be well below the MSY level. Reasonable fishing effort can be increased in order to obtain more yields of the candidate species so as to reach the MSY and in that way increase the income and enhance the lively-hood level of the economically poor fishermen communities of North eastern India.

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