Population dynamics of the Groe fish *Barbodes binotatus* (Pisces: Cyprinidae) in the Nagan River, Aceh Province, Indonesia

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**Abstract.** The assessment of population dynamics of the groe fish *Barbodes binotatus* has never been performed, this species is one of the commercial freshwater fish in Aceh province and one of the main target for fishing by local fishermen. Hence, the objective of this study was to analyze the population dynamics of the groe fish *B. binotatus* in Nagan River, Nagan Raya District, Aceh Province, Indonesia. The survey was conducted from January to December 2016. A total of 409 fish samples were collected. The von Bertalanffy (von Bertalanffy growth function) growth parameters were utilized to analyze the population dynamics of *B. binotatus* using FAO-ICLARM Stock Assessment Tools-II (FISAT II). The results showed that the population dynamics of asymptotic length (*L*∞) was 130.88 mm, coefficient of growth (K) was 0.70 year⁻¹, growth performance index (Ø) was 4.08 year⁻¹, time at which length equals zero (*t₀*) was -0.014 year⁻¹ and the optimum length of catch (*L*opt) was 90.11 mm. In addition, the total mortality rate (Z) was 1.62 year⁻¹ with natural mortality rate (M)= 0.95 year⁻¹, fishing mortality rate (F)= 0.67 year⁻¹, and exploitation rate (E)=0.41 year⁻¹. In conclusion that based on E value analysis displays that the exploitation rate of *B. binotatus* has not yet exceeded the sustainable limit based on the value of *L*∞, K, *t₀*, *L*₁, *L*opt of dominant >1 years old fishes caught.

1. **Introduction**

Nagan Raya is one of the districts in Aceh province, Indonesia. This district has the big potency in inland aquatic resources, for example, the district had three main rivers; Nagan river, Lamie river, and Seumanyam river. Besides, this district has the peat swamp area (Tripa peat swamp); unfortunately, this
peat swamp has been degraded by deforestation and development of palm oil plantation [1, 2]. The previous report by Muchlisin et al. [2] there were at least 73 species of freshwater fish recorded only from the Tripa peat swamp forest. In general, at least 114 species of fresh and brackish waters fishes have been recorded from Aceh province waters [3], of these 17 species have potency for aquaculture and 10 species promises for ornamental fish, where the groe fish *Barbodes binotatus* is one of the species that has potency for both aquaculture and ornamental fish [4].

Based on morphological characters, the groe fish *B. binotatus* had four dorsal spines, eight soft dorsal rays, three anal spines, and five soft anal rays. This species had black spots under below base of the dorsal fin and a small black dot at the caudal peduncle length. The *B. binotatus* inhibits stream river, lakes, small creeks and irrigation [5]. This species has been exploited intensively for consumption and ornamental fish [6-8]. Due to these activities and lack of the study, this species has been listed in the IUCN Redlist at the category of Least Concern [9].

Several studies have been conducted to evaluate the morphological and genetical variations of the *B. binotatus* [5, 10-13], reproduction and breeding [14, 15], bioecology [7, 16, 17]. However, the study on the population dynamic, especially in Indonesia waters, has never been evaluated. Furthermore, analysis of fish population dynamics serves to estimate the recruitment pattern, mortality rate, and assessment of fish stocks in the wild [18-21]. Therefore, the objective of the present study was to analyze the population dynamics of groe fish *B. binotatus* in the Nagan River, Aceh Province, Indonesia.

2. Material and Methods

2.1 Location and time

The study was conducted in the Nagan River from January to December 2016. The fish samples were analysed in the Laboratory of Ichthyology, Faculty of Marine and Fisheries, Syiah Kuala University, Banda Aceh. The fish was taxonomically identified based on Kottelat et al. [22].

2.2 Sampling procedure

The sampling was conducted in three locations along the Nagan River °16’25.25"N and 96°24’22.34"E; 4°17’4.73”N and 96°25’56.83”E; 4°16’48.49”N and 96°27’8.50”E), Nagan Raya District, Aceh Province, Indonesia. The sampling was conducted two times per week from 8 AM to 4 PM for 12 months. The fish was caught using casting nets and gillnets. The sampled fish were kept in an icebox (4 °C) and transported to the laboratory of Ichthyology in Syiah Kuala University, Banda Aceh for further analysis. In the laboratory, the fish samples have measured the standard and total length and weighed for total body weight nearest to gram using a digital balance then preserved in 10% formalin solution.

2.3 Length frequency and Von Bertalanffy growth function

The length frequency analysis refers to Pauly [23] as follow:

\[ Fi = \frac{ni}{N} \times 100 \]

Where \( Fi \) is length frequency (%), \( ni \) is the total number of fish at class length -i, and \( N \) is the total fish sample. The von Bertalanffy growth function was analysed using FISAT II (FAO-ICLARM Stock Assessment Tools-II). The growth parameter was calculated using the ELEFAN-I method. This calculation gave an asymptotic length value (\( L_\infty \)) and coefficient of von Bertalanffy growth function (K). Moreover, the theoretical age at fish length-0 was calculated based on Pauly [23].

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2.4 Total mortality and natural mortality rates

The total mortality rate (Z) was calculated using FISAT II based on Length-converted Catch Curve method. The natural mortality rate (M) was calculated based on Pauly [23]:

\[ \text{Log}(M) = -0.0066 - 0.279\text{Log}(L_{\infty}) + 0.6543\text{Log}(K) + 0.4634\text{Log}(T) \]

Where M is the natural mortality rate, \( L_{\infty} \) is infinity or asymptotic length, K is the growth coefficient, T is the average temperature of the waters/habitat.

2.5 Fishing mortality and exploitation rates

The fishing mortality rate (F) was calculated based on Pauly [23], as follows:

\[ F = Z - M \]

Where Z is the total mortality rate, M is the natural mortality rate. The exploitation rate (E) was calculated based on Sparre and Venema [24] as follow:

\[ E = F/Z \]

Where E is the exploitation rate, F is the fishing mortality rate, Z is the total mortality rate.

2.6 The optimum length of the fish caught and recruitment pattern

The optimum length of fishes caught (Lopt) was calculated based on Froese and Binohlan [25] as follows:

\[ L_{\text{opt}} = \frac{3L_{\infty}/(3+M/K)}{3L_{\infty}/(3+M/K)}, \]

where Lopt is the optimum length of the fish caught, M is the natural mortality rate, \( L_{\infty} \) is infinity or asymptotic length, and K is the growth coefficient. The recruitment pattern was performed using FISAT II.

3. Results and Discussions

A total of 409 fish samples were successfully collected during the sampling with the total length ranges 34.9 mm to 126.0 mm and the average size was 86.49 mm. The previous study by Lim et al. [7], reported that the range size of *B. binotatus* in Kerian River Malaysia was 40.00 - 95.5 mm, while and Ikhwanuddin et al. [26] reported the range size of *B. binotatus* in Pelus River Malaysia was 37.0 - 116 mm. These reports indicate that the maximum size of *B. binotatus* in Nagan River, Aceh Province, Indonesia was higher those in Kerian and Pelus Rivers, Malaysia. The von Bertalanffy growth parameter showed that the infinity length (\( L_{\infty} \)) of *B. binotatus* in Nagan River was 130.88 mm, the optimum length size fishing (\( L_{\text{opt}} \)) was 90.11 mm, growth coefficient (K) was 0.70 year\(^{-1}\), and the growth capability index (\( \Omega \)) was 4.08 year\(^{-1}\) (Table 1). This study indicates that that groe fish can grow well without problems until the average size is 130.88 mm [25].

According to Živkov et al. [27], \( L_{\infty} \) and K values are influenced by the age of fish populations. Furthermore, Lorenzen and Enberg [28], stated that growth parameters (size based on age and fish biomass data) the \( L_{\infty} \) values can be influenced by the density and the recruitment phase during the fish life cycle. The results of the population dynamic study within the Cyprinidae showed the *B. binotatus* had a higher \( L_{\infty} \) value compared to the *Alburnoides qanati* in the Kor River, Iran [29] and *Rasrineobola argentea* on Lake Victoria [30], but lower than the *Carassius gibelio* in the Seyitler Reservoir, Turkey [31] and *Mirogrex terraesanctae* on Lake Kinneret [32].

Based on the length distribution analysis showed that the dominant fish sample (33.91%) within the length class of 72.9-81.4 (Figures 1a and 2a). Furthermore, based on the dominance of length classes, it was estimated that the age of the dominant fish is caught at the age of one-year-old (Figure 2b). The length-age relationships curve of *B. binotatus* showed that in the first year to the second year, the fish was growing faster compared to the following years (Figure 2b). This is in agreement with Poole and Reynolds [33], who stated that in general the growth rate of fish decreased as age increases, besides the sex is also
determines the ability of the fish to grow. The other factors that influence the ability of fish to grow are habitat conditions, life history and bioenergetic fish [34-36].

Table 1. Population dynamic of the groe fish *Barbodes binotatus* in Nagan River, Aceh Province, Indonesia

| Parameters                                      | Value       |
|------------------------------------------------|-------------|
| Infinity or Asymptotic length (*L_∞*)         | 130.88 mm   |
| The optimum fishing length (*L_{opt}* )       | 90.11 mm    |
| Growth coefficient (K)                        | 0.70 year⁻¹ |
| Growth performance index (Ø)                  | 4.08 year⁻¹ |
| Total mortality rate (Z)                      | 1.62 year⁻¹ |
| Natural mortality rate (M)                    | 0.95 year⁻¹ |
| Fishing mortality rate (F)                    | 0.67 year⁻¹ |
| Exploitation rate (E)                         | 0.41 year⁻¹ |

Figure 1. (a) Distribution of the fish sample based on length classes (n = 409) with the optimum length (*L_{opt}* ) of 90.11 mm, (b) the estimation of the growth coefficient (K) was 0.70 year⁻¹ and growth performance index (Ø) was 4.08 year⁻¹ of the groe fish *B. binotatus* in Nagan River, Aceh Province, Indonesia

The results showed that total mortality (Z) was 1.62 year⁻¹, natural mortality (M) was 0.95 year⁻¹, fishing mortality (F) was 0.67 year⁻¹ and exploitation rate (E) was 0.41 year⁻¹ (Table 1 and Figure 3a). Based on the E value indicates that the exploitation of *B. binotatus* in the Nagan River is still in a sustainable limit or it can be interpreted that 41% of fish mortality was due to fishing. According to Kaunda-Arara et al. [37], Hilborn [38] and Batubara et al. [39], states that the value of E is expressed over-exploitation when the E values higher than 0.5 year⁻¹, therefore *B. binotatus* in the Nagan River can still be exploited to achieve optimum exploitation values (E = 0.5 year⁻¹).
Figure 2. (a) growth performance index ($\Theta$) was 4.08 year$^{-1}$; (b) the curve of the length growth and age estimation ($t_0 = -0.014$ year$^{-1}$ and $K = 0.70$ year$^{-1}$) of the groe fish $B. binotatus$ in Nagan Raya Waters, Aceh Province, Indonesia

Figure 3. (a) Total mortality rate ($Z = 1.62$ year$^{-1}$); (b) Percentage of recruitment every month for one year based on FISAT II of the groe fish $B. binotatus$ in Nagan Raya Waters, Aceh Province, Indonesia

4. Conclusion
It is concluded that the exploitation rate of $B. binotatus$ has not yet exceeded the sustainable limit and the dominant fish sample was higher one year old.

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