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Population dynamics and feeding habit of *Oreochromis niloticus* and *O. mossambicus* in Siombak Tropical Coastal Lake, North Sumatra, Indonesia

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Abstract. *Muhtadi A, Nur M, Latuconsina H, Hidayat T. 2021. Population dynamics and feeding habit of* Oreochromis niloticus *and* O. mossambicus *in Siombak Tropical Coastal Lake, North Sumatra, Indonesia. Biodiversitas 23: 151-159.* Nile Tilapia (*Oreochromis niloticus*) and *O. mossambicus* (Mozambique Tilapia) are economically important fish species in Indonesia. This study aims to determine these two fish species' population dynamics, including growth, reproduction, recruitment, mortality rates, exploitation rates, and feeding habits. Samples were taken from September 2018 to August 2019 in Siombak Lake, North Sumatra Province. Data were analyzed in this study using software FISAT-II and Microsoft Excel. The results showed that Nile Tilapia had an isomeric growth pattern, and Mozambique Tilapia exhibited a negative allometric growth pattern. The estimate von Bertalanffy's growth parameters on ELEFAN-I were asymptotic length ($L\infty$) of Nile tilapia: 36.06 cm and Mozambique tilapia: 26.09 cm. The growth coefficient (K) of Nile tilapia was 0.59, and Mozambique tilapia was 0.54. The mortality rate (Z) of Nile tilapia reached 3.20 per year, and Mozambique tilapia reached 3.04 per year, whereas the natural mortality (M) of Nile Tilapia 1.24 while Mozambique Tilapia was 1.27. Based on the rate of exploitation, both fish have been overexploited. Peak spawning of Nile Tilapia was in August and December, and of Mozambique Tilapia was in March and June. Both species were omnivores, predominantly with herbivorous feeding habits.

Keywords: Cichlid, estuary, food habit, population structure, tidal lake

INTRODUCTION

Nile Tilapia (*Oreochromis niloticus*) and Mozambique Tilapia (*Oreochromis mossambicus*) are two species of popular freshwater fish in the world. Tilapia has a wide distribution in the world (Froese and Pauly 2019). This fish is an introduced fish or not native to Indonesia (Sugianti et al. 2014). It is known as an invasive fish species that has spread widely and threatens various native and endemic fish in Indonesia's inland waters (Latuconsina 2020). Kottelat et al. (1993) stated that before entering Indonesian waters, they originally came from mainland Africa, namely the Nile River (*O. niloticus*) and Mozambique Tilapia (*O. mossambicus*). Furthermore, ISSGS (2020) reports that the Tilapia fish species are among the world's 100 most invasive species. This fact is due to the adaptability and rapid growth outside the place of origin (Ganie et al. 2013; Ian et al. 2014; El-Sayed 2020). Global production data of Tilapia in 2018 reached 5.5 million MT or around 10.1% of total fishery production (FAO 2020).

Now, Tilapia has become an essential commodity and high productivity that is widely cultivated by the community because it has many advantages, including (Gupta and Acosta 2004; Ganie et al. 2013): easy to breed, high survival, fast growth, relatively large body size, and high endurance to changing environmental conditions. According to El-Sayed (2020), other advantages include resistance to water quality and disease, broad tolerance to environmental quality, efficient ability to form high-quality protein from organic matter, domestic waste, and agriculture. Tilapia can tolerate waters with heavy metal waste (Novebrianto et al. 2011; Sunardi et al. 2017; Ouma et al. 2019).

Tilapia fish can live and grow well in natural waters such as swamp lakes, rivers, estuaries, and artificial ecosystems such as ponds, former mines, and rice fields and including sewage channels (Bailey 1994). Tilapia fish live and eat in the entire water column, namely the bottom, middle water, and surface waters. This fish also showed a short migration behavior for spawning, so that it is also known as potamodromous. Tilapia, including oviparous fish that consume phytoplankton or benthic algae as food, live in waters with temperatures ranging from 14°C to 33°C (El-Sayed 2020).

According to Fishbase (Froese and Pauly 2019), research on Tilapia was documented in 104 countries in Africa, Asia, Europe, North America, South America, and Oceania, and 585 references were listed in various aspects of aquaculture and fisheries. However, this research is more on the aspects of growth and reproduction of Tilapia in controlled habitats or aquaculture. Several studies on the dynamics of tilapia populations include Halali Reservoir, Central India (Johnson et al. 2020), in Lake Tana, Northwest Ethiopia (Assefa et al. 2019), Reservoir in Sri Lanka (Bandara et al. 2020), Chashma Barrage, Pakistan (Mehak et al. 2017), and The Nam Theun 2 reservoir, Thailand (Beaune et al. 2020). However, research related to the population dynamics of Tilapia in estuary waters is still rarely reported. One that has been reported is Amponsah et al. (2020), who investigated population dynamics of *O. niloticus* in Sakumo II lagoon (estuary), Ghana. In estuary waters or coastal lakes in Asia and especially in Indonesia, research on Tilapia population dynamics has not been reported.

Belawan estuary waters, located in Medan City, North Sumatra Province, Indonesia, have a unique and distinctive lake known as Siombak Lake. Siombak Lake is a coastal lake ecosystem that is classified as a tidal lake. This lake is unique because the dynamics of its waters are influenced by tides (Muhtadi et al. 2020a). In this lake, various fresh, brackish, and marine organisms are found (Leidonald et al. 2019), including mangrove trees that grow on different lakesides (Muhtadi et al. 2020b). Nile Tilapia and Mozambique Tilapia are some of the fish that live in these waters (Leidonald et al. 2019) and are one of the main catches in the waters of Siombak Lake. Therefore, this study aims to determine the population dynamics of Tilapia: *O. niloticus* and *O. mossambicus*, which include aspects of growth, reproduction, recruitment, mortality, feeding habit, and the rate of exploitation of the two fish.

MATERIALS AND METHODS

Study area

This research was conducted in Siombak Lake, North Sumatra Province, Indonesia, from September 2018 to August 2019. The number of sampling stations is 8 stations. Sampling sites can be seen in Figure 1.

Procedures

Tilapia fish are captured with small seine nets with a mesh size of 0.5 inches. Seine nets operated at every high tide and low tide in the full moon. Fish that are captured directly measure the total length and weight of the fish. Next, the fish's stomach was dissected to determine the sex and maturity level of the gonads. Next, the contents of the stomach and intestines of the fish are preserved with 10% alcohol to observe the type of food.

Data analysis

Length-weight relationship

Analysis of the length-weight relationship of each fish species used a general formula as follows (Le Cren 1951):

$$W = a\,L^{b}$$

Where, W: Weight (gram); L: Length (mm); a: Intercept (the intersection of the length-weight relationship curve with the y axis); b: Growth pattern estimator of length-weight.

To test the value of b = 3 or b ≠ 3, a t-test (partial test) is carried out, with the hypothesis:

H_0: b = 3, The pattern of the relationship between length and weight is isometric.

H_1: b ≠ 3, The pattern of the relationship between length and weight is allometric.

a. Allometric positive if b > 3 (The pattern of weight growth is faster than the growth of length) and,

b. allometric Negative, if b <3 (The pattern of growth of length is faster than the weight growth).

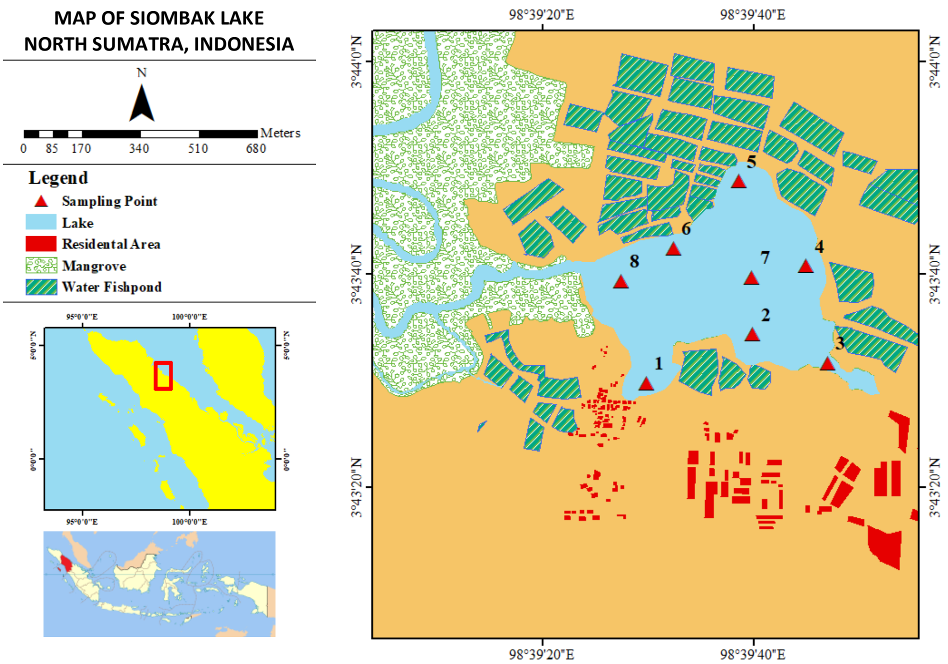


Figure 1. Map of research locations in Siombak Lake, North Sumatra Province, Indonesia: point 1 (3°43'29.44''N, 98°39'29.51''E); point 2 (3°43'36.41''N, 98°39'38.01''E); point 3 (3°43'33.44''N, 98°39'45.69''E); point 4 (3°43'44.31''N, 98°39'43.47''E); point 5 (3°43'48.26''N, 98°39'37.81''E); point 6 (3°43'42.81''N, 98°39'32.69''E); point 7 (3°43'39.37''N, 98°39'37.81''E); point 8 (3°43'39.34''N, 98°39'25.54''E)

Length frequency distribution

length-frequency distribution is to determine the number of size groups required by the formula (Yonvitner et al. 2020):

n = 1 + 3.32 Log N

N = Number of fish observed

Estimated growth model

Estimation of growth parameters to estimate the growth model is obtained by the equation of the growth model of Von Bertalanffy. These models are (Pauly, 1984):

$$L_t = L_\infty\left[1 - e^{-K(t-t_0)}\right]$$

Where, L_∞: asymptotic length (cm); L_t: length of fish at age t (cm); K: growth constant; t: age (time); t_o: Length of fish at age t_0 (usually negative).

Growth parameters (K and L_∞) were estimated using the ELEFAN I method (Pauly 1984; Sparre and Venema 1998), which was accommodated in the FiSAT II software (Gayanilo et al. 2005).

Estimated parameters of mortality and rates of exploitation

Total mortality rates can be estimated from shifts in age group abundance and analysis of the catch curve using length-frequency data (Pauly 1984). The natural mortality rate (M) was estimated using the empirical equation method (Pauly, 1980), with the formula:

$$\text{Log } M = -0{,}0066 – 0{,}279 \log_{10} L_\infty + 0{,}6543 \log_{10} K + 0{,}4634 \log_{10} T$$

Where, L_∞: asymptotik length (cm); K: growth constant; T: average annual temperature (°C).

The mortality due to exploitation (F) can be obtained after knowing the total mortality (Z) and natural mortality (M) from the equation F = Z-M. Meanwhile, the total mortality rate is calculated using the formula:

$$Z = M+F$$

Natural and fishing mortality rates are accommodated in FiSAT II. Furthermore, the exploitation rate (E) is determined by comparing the fishing mortality rate (F) with the total mortality rate (Z) (Pauly 1984):

$$E = \frac{F}{F+M} = \frac{F}{Z}$$

Gonad index and size estimation of the first maturity of gonads

Gonad index knows the fish groups that spawn from the proportion of fish entering the maturity level of gonads 3 and 4. Gonad index was analyzed to determine the success rate of spawning with the potential sex ratios available for both male and female fish. The gonad index is calculated as follows (Yonvitner et al. 2020):

$$IG = \frac{S_{34}}{S_t}$$

Where, IG: gonadal index; S_{34}: Number of fish at the maturity level of gonads 3 and 4; S_t: Number of fish at maturity levels of gonads 2, 3, and 4.

S is the number of fish entering the maturity stage of the gonads, with the criteria used, namely if

GI> 0.50 = Fish tend to be spawning

GI 0.30-0.50 = Fish undergo the ripening process of the gonads

GI <0.30 = The average fish gonad was not developed

The Spearman-Karber used to estimate the average size of the first Tilapia ripe gonads (Udupe 1986):

$$M = \left[x_k + \left(\frac{x}{2}\right) - \left(x \sum pi\right)\right]$$

$$M = \text{antilog}\left[m \pm 1{,}96\sqrt{x^2 \sum \frac{p_i * q_i}{n_i - 1}}\right]$$

Where, m: log length of fish at first maturity of gonads; x_k: log the mean value of the last long class of fish that has matured gonads; x: log of length increment at the middle value; pi: the proportion of gonadal ripe fish in class I length with the number of fish on the length of the i^{th} interval; ni: the number of fish in the interval; qi: 1-pi; M: the length of the fish first matured the gonads.

Food and feeding habit

Food and feeding habit analysis was carried out descriptively with the help of MS Excel. Food and feeding habit analysis data is the result of the identification of the stomach and intestinal contents of Tilapia (Yonvitner et al. 2020).

RESULTS AND DISCUSSION

Length-weight relationship

The length-weight relationship of Nile Tilapia weight showed a stronger correlation (r: 0.97) than Mozambique Tilapia (r: 0.92). However, the length-weight relationship between the two-Tilapia fish is powerful (r>0.85), where the R determinant reaches 85% for Mozambique Tilapia and 94% for Nile Tilapia. In Mozambique Tilapia, both male and female fish showed that the increase in length was more dominant than the weight (b<3) or a negative allometric growth pattern. Meanwhile, Tilapia showed that in male fish, weight growth was higher than long growth (b>3) or positive allometric, in contrast to female fish where the length growth was greater than weight growth (b<3) or negative allometric. Tilapia is an isomeric growth pattern, and Mozambique Tilapia fish is a negative allometric growth pattern. The description of the long relationship between Mozambique Tilapia and Nile Tilapia can be seen in Figure 2.

Length frequency distribution

In general, Mozambique Tilapia fish caught is between 15.1-18.1 cm, which reaches 77.42% of the population. The Mozambique Tilapia size is almost evenly distributed in each month of observation. Meanwhile, the Nile Tilapia size is more evenly distributed than Mozambique Tilapia, where in which the length of 15.1-18.1 cm is only around 45.40%. In other sizes, Nile Tilapia is more evenly distributed than Mozambique tilapia (Figure 3).

Estimated growth model

Based on the analysis of growth parameters, it was found that the asymptote length of Tilapia (L∞: 36.06 cm) was longer than that of Mozambique tilapia (L∞: 26.09 cm). Thus, the growth coefficient of Nile tilapia is slightly faster (K: 0.59) than Mozambique tilapia (K: 0.53). However, Mozambique tilapia's lifespan is longer (17 years) than Tilapia (15 years). As for empirically, the growth models of Mozambique tilapia and Nile tilapia are Lt: 26.09 (1-e-0.53 (t-0.0854)) and Lt: 36.04 (1-e-0.59 (t-0.0874), respectively). An illustration of the Tilapia growth model can be seen in Figure 4.

Estimated parameters of mortality and rates of exploitation

The estimated total mortality (Z) of Mozambique Tilapia fish is 3.20 per year, and Nile Tilapia is 3.04 per year. The natural mortality (M) values of these two fish were smaller (1.27 and 1.24 respectively) than the fishing mortality (F) (1.93 and 1.80, respectively). Therefore, these two-Tilapia fish' fishing rates slightly exceed the optimum value (0.50) with 0.60 and 0.59, respectively. The description of mortality and exploitation of Mozambique and Nile Tilapia can be seen in Figure 5.

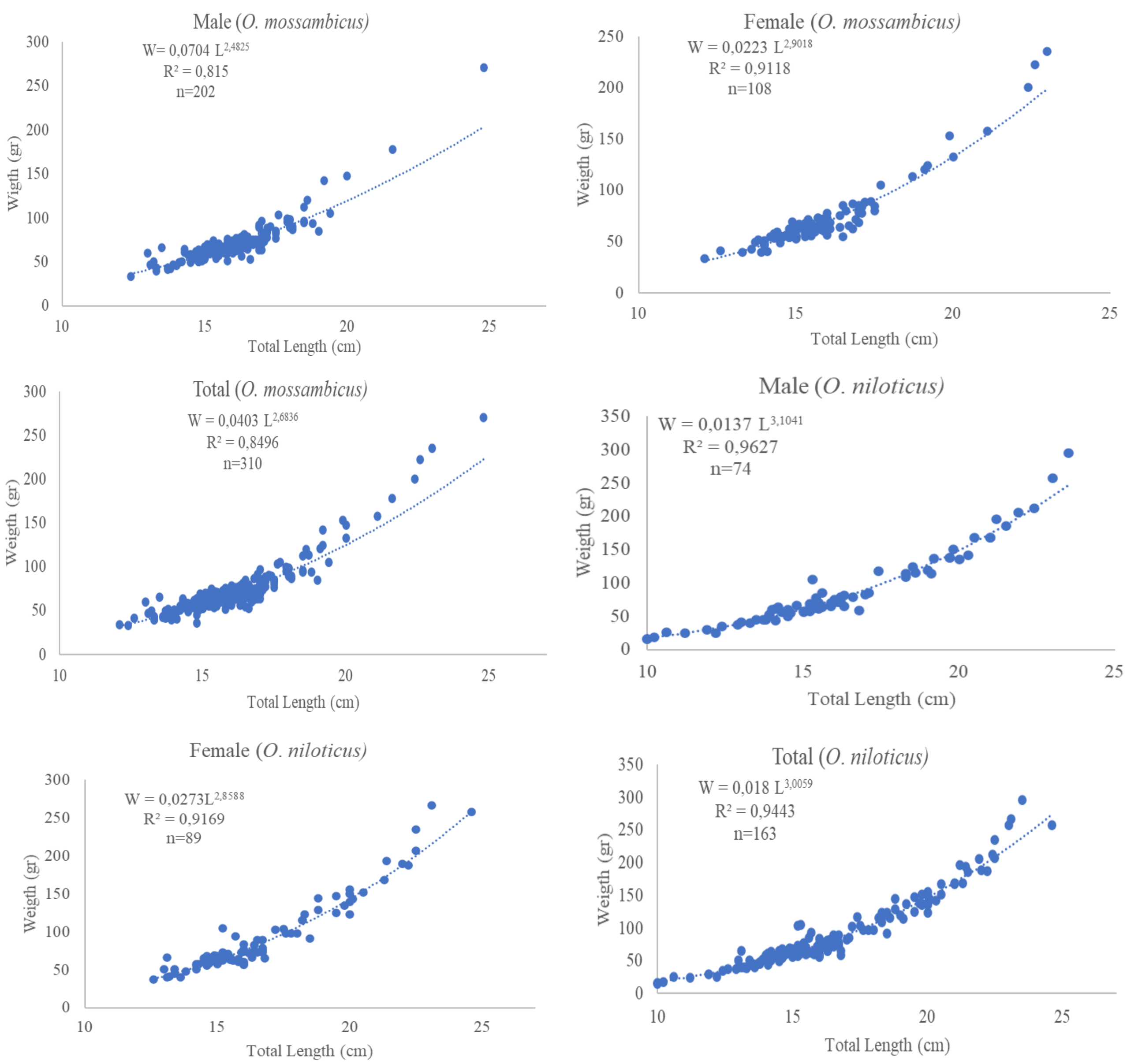
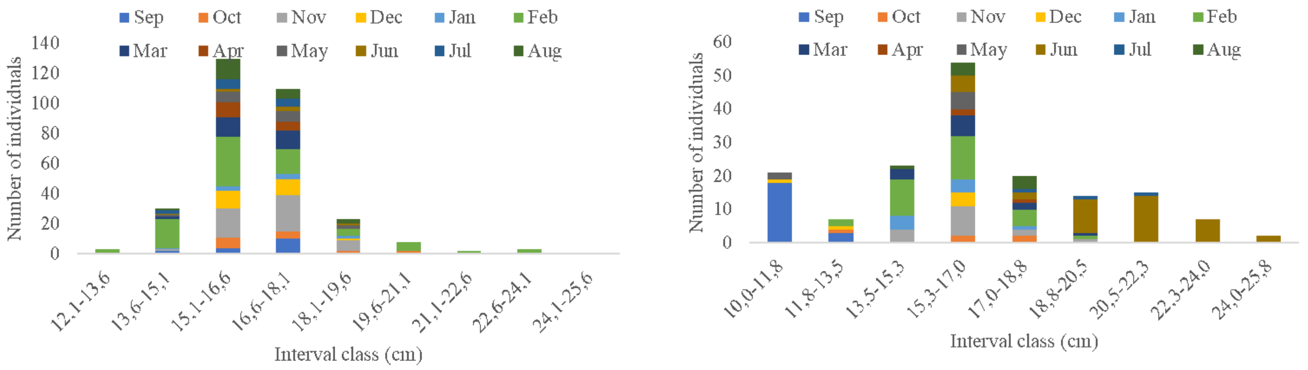
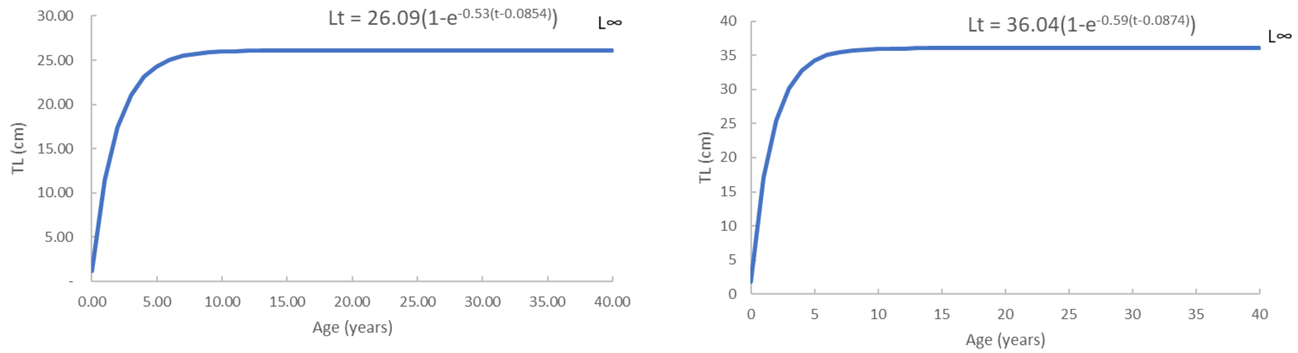


Figure 2. The length-weight relationship of Tilapia in Siombak Lake, Nort Sumatra, Indonesia



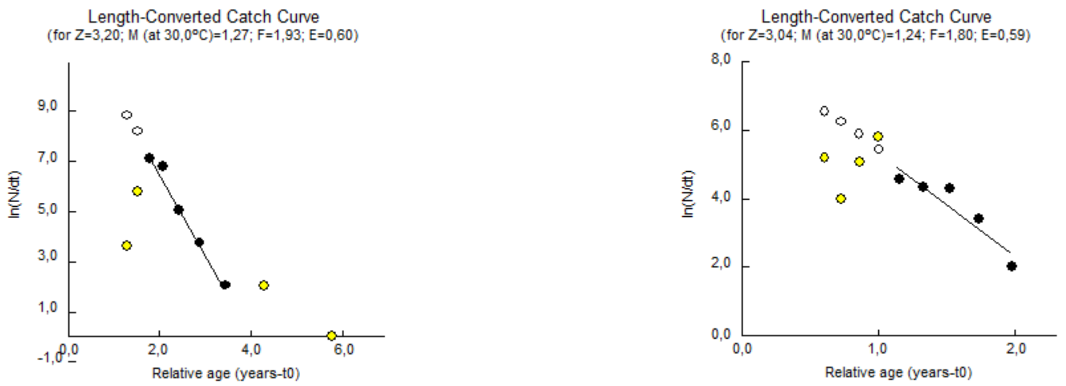
A **B**

Figure 3. Leng frequency distribution of Mozambique Tilapia (A) and Nile Tilapia (B) in Siombak Lake, Nort Sumatra, Indonesia



A **B**

Figure 4. Growth curves of Mozambique Tilapia (A) and Nile Tilapia (B) in Siombak Lake, Nort Sumatra, Indonesia



A **B**

Figure 5. Graph of mortality and exploitation of Mozambique Tilapia (A) and Nile Tilapia (B) in Siombak Lake, Nort Sumatra, Indonesia

Gonad index and size at first maturity

Based on the analysis of the gonad maturity level of Tilapia, it was found that the gonad index of Nile Tilapia was higher (average: 0.46) than the gonad index of Mozambique Tilapia (average: 0.42). However, the gonad index of Nile Tilapia is more varied than that of Mozambique Tilapia. As shown in Figure 4, no Nile Tilapia ripe gonads were found in October, March, and July. Meanwhile, Mozambique Tilapia fish were found every month of gonad ripe fish (Figure 6). Based on the Gonad Index analysis, it can also be predicted that March and June are the peak spawning season for Nile Tilapia, while Mozambique Tilapia spawning is predicted to be in August and December. Therefore, based on the analysis of recruitment patterns, it was found that Nile Tilapia recruitment occurred in December and February, while Mozambique Tilapia recruitment occurred in January and July (Figure 7). The estimated size of the first maturity of gonads is 22.38 cm in Mozambique Tilapia fish and 24.01 cm in Nile Tilapia. The fecundity analysis also shows that the number of Nile Tilapia eggs is much higher than Mozambique Tilapia. Nile Tilapia egg fertility reached

306.00-78,208.00 eggs with an average of 10,158 eggs, while Mozambique Tilapia only 450.00-9898.00 eggs with an average of 1795 eggs.

Food and feeding habit

Mozambique Tilapia food's identification results found seven groups consisting of Cyanophyceae, Chlorophyceae, Dinophyceae, Bacillariophyceae, Copepod, Cladocera, and others (consisting of fish, shrimp, frogs, and crabs). The main diet of Mozambique Tilapia is phytoplankton consisting of Cyanophyceae (19%), Chlorophyceae (44%), and Bacillariophyceae (34%) (Figure 8). Meanwhile, Nile Tilapia were also found in 7 groups consisting of Chlorophyceae, Dinophyceae, Bacillariophyceae, Rotifer, Copepod, Cladocera, and Crab. The main food of Nile Tilapia is Chlorophyceae (70%) and Bacillariophyceae (24%). Thus, these two fish species show that their main food in Siombak Lake is Chlorophyceae, which is always found in these fish' intestines and stomach. However, Cladocera in Mozambique Tilapia is a complementary food because although the proportion is small (1.07%), it is almost always found together with Chlorophyceae. Based on Food Composition Analysis, it shows that tilapia fish are omnivorous fish where the main food is phytoplankton (planktivora). This is confirmed by measuring the intestinal length of Tilapia, which reaches 7-11 times its body length. In comparison, the Mozambique tilapia is slightly shorter, which is five times its body length.

Discussion

This study found that the growth pattern of Nile Tilapia was isometric (b: 3.005). The same thing was also found for Nile Tilapia in the Taquari River, Paranapanema Basin, Brazil (Nobile et al. 2015), in India's Halali reservoir (Johnson et al. 2020). In another study in coastal lakes, the growth pattern of Nile Tilapia was found, which is negative allometric as reported in Sakumo II Lagoon, Ghana (Franco et al. 2014). Meanwhile, Mehak et al. (2017) found a negative growth pattern of allometric Nile Tilapia with a b value of 2.14 in Chashma Barrage, Pakistan. Furthermore, the Mozambique Tilapia's growth pattern showed a negative allometric growth pattern (b: 2.68).

This pattern is as reported by Amarasinghe (2002) with a value of b: 2,699 in the Shallow Irrigation Reservoir in Sri Lanka. The difference in growth patterns is caused by several factors, including differences in age, gonad maturity, sex, geographical location, and environmental conditions (fishing activity), stomach fullness, disease, and parasite pressure (Nobile et al. 2015; Froese and Pauly 2019; Pachla et al. 2020; Yonvitner et al. 2020).

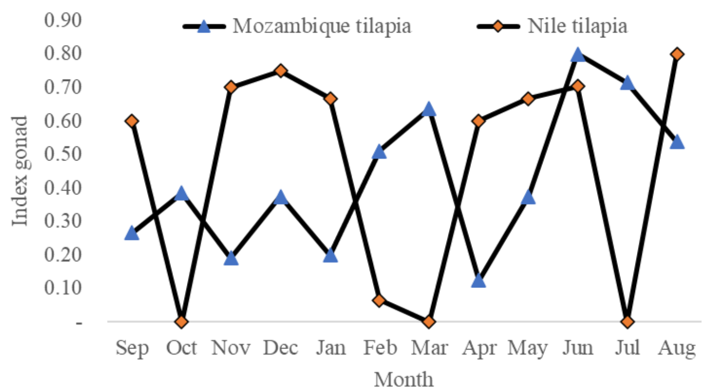


Figure 6. Gonad index of Mozambique Tilapia and Nile Tilapia in Siombak Lake, Nort Sumatra, Indonesia

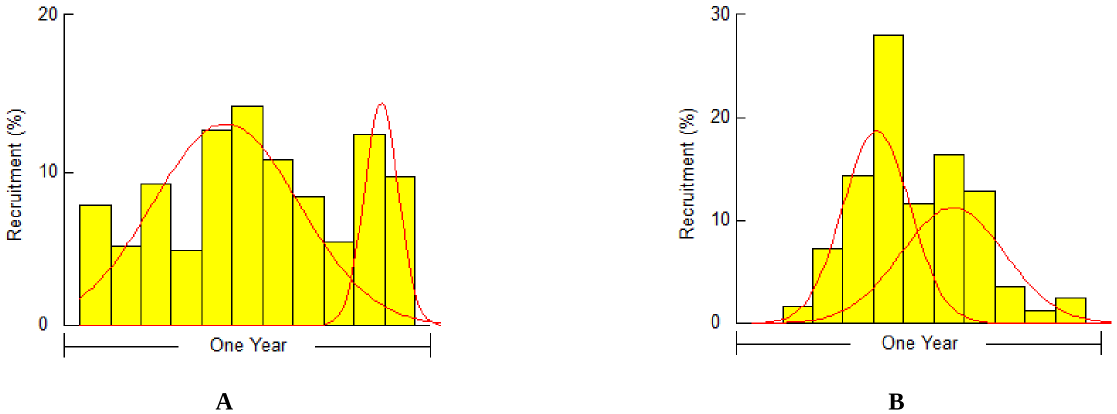


Figure 7. The recruitment pattern of Mozambique Tilapia (A) and Nile Tilapia (B) in Siombak Lake, Nort Sumatra, Indonesia

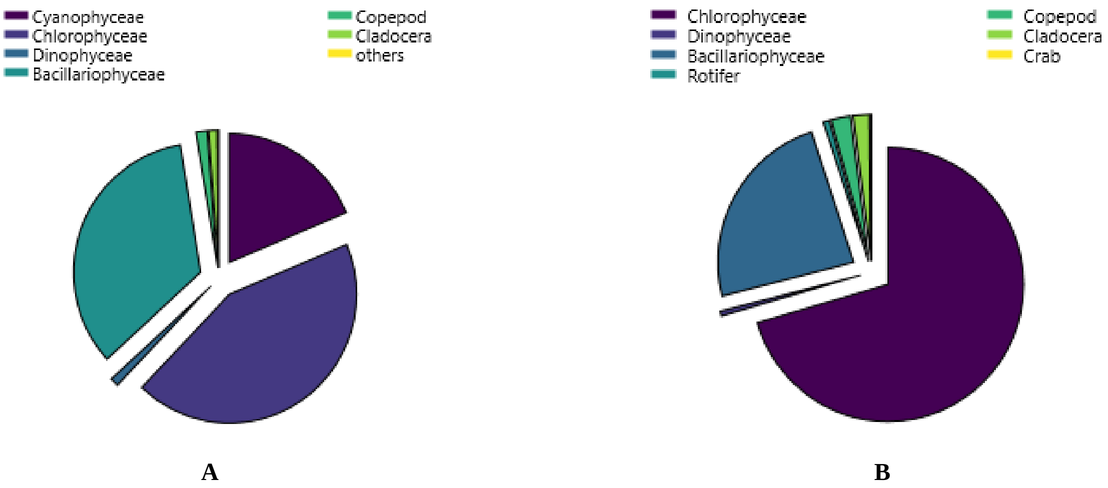


Figure 8. Composition of feeding habit for Mozambique Tilapia (A) and Nile Tilapia (B) in Siombak Lake, Nort Sumatra, Indonesia

The asymptotic length of Nile Tilapia found in Siombak Lake reaches 36.04 cm. This value is greater than that of Nile Tilapia found in the coastal lake of Sakumo (Ghana), 19.4 cm (Amponsah et al. 2020), including in Chashma Barrage, Pakistan, 22.78 cm (Mehak et al. 2017). However, this asymptotic length shows a lower value than freshwater. Several studies reported that the lengths were 46.73 cm in the reservoir, Central India (Johnson et al. 2020), 44.1 cm Lake Tana, northwest Ethiopia (Assefa et al. 2019), 42.8 cm to 53.4 cm in Some Irrigation Reservoirs of Sri Lanka (Bandara et al. 2020), and 52.50 cm in Thai reservoirs (Beaune et al. 2020). Meanwhile, Mozambique Tilapia's asymptotic length in Siombak Lake was lower than that of Nile Tilapia, 26.09 cm. Amarasinghe (2002) found the asymptotic length of Mozambique Tilapia in the Sri Lanka reservoir to reach 37.8 cm. However, this length is still lower than the asymptotic length of Nile Tilapia in the waters, 50.7 cm. Based on this asymptotic length, it shows that Nile Tilapia has a larger size than Mozambique tilapia. In this study, it was shown that the Nile tilapia in Siombak Lake had a larger size than the Mozambique tilapia. There is about 10 cm difference in the maximum size between Nile tilapia and Mozambique tilapia, namely 36.06 cm for Nile tilapia and 26.09 cm for Mozambique tilapia.

The growth constant (K) of Nile Tilapia is faster (K: 0.59 per year) than Mozambique Tilapia (K: 0.53 per year). This value is not much different from the K value found by Amarasinghe (2002), namely 0.51 per year for Mozambique Tilapia and 0.64 per year for Nile Tilapia in Shallow Irrigation Reservoir, Sri Lanka. Meanwhile, the K value of Nile tilapia in other coastal lakes is 0.54 per year in Sakumo II Lagoon, Ghana (Franco et al. 2014). The K value of Nile Tilapia in Siombak Lake is lower than the K value of Tilapia in the Halali Reservoir, India, which is 0.63 / year (Johnson et al. 2020). However, the K value of Nile Tilapia in Siombak Lake is still higher than in other freshwaters, i.e., 0.44 per year in Lake Tana, northwest Ethiopia (Assefa et al. 2019), 0.20-0.49 per year in Some Irrigation Reservoirs of Sri Lanka (Bandara et al. 2020), 0.230 per year in The Nam Theun reservoir, Thailand (Beaune et al. 2020), and 0.070 per year in Chashma Barrage, Pakistan (Mehak et al. 2017). The difference in K value is related to biotic (food, predation, and predation) and abiotic (nutrient, temperature, and salinity) factors, which are factors that affect the growth rate of Tilapia (Assefa and Getahun 2015; Assefa et al. 2019; Bandara et al. 2020; Johnson et al. 2020). The K value in Tilapia in Siombak Lake shows that it is higher than other waters, presumably due to sufficient food availability. Muhtadi et al. (2020a) reported that phytoplankton as a source of food for fish in Siombak Lake is abundant and available all year round.

The size of Nile Tilapia and Mozambique Tilapia captured in Siombak Lake is immature fish (immature gonads), namely 94% and 99%, respectively. This finding shows that the fish that enter this lake are fish looking for food. Muhtadi (2021) reported that Siombak Lake is a feeding ground for freshwater and marine fish from the nearest ecosystem. Therefore, the fish caught in Siombak Lake are small to large fish, but the gonads are not yet ripe. This condition can be seen from the average size of the fish caught below the size of the first maturity of the gonads, namely 22.38 cm in Mozambique Tilapia and 24.01 cm in Nile Tilapia. If this condition continues, it can disrupt the population's survival to become adult fish so that the regeneration process can be hampered. However, the rapid growth of up to 0.5 per year (Johnson et al. 2020) also can accelerate the availability of Tilapia in Siombak Lake. Yet, some of these fish can spawn in December and August for Nile Tilapia and March and June for Mozambique Tilapia, so that the recruitment process still occurs in Siombak Lake. In the waters of Chashma Barrage, Pakistan, Tilapia spawn in May or June (Mehak et al. 2017).

Mozambique Tilapia and Nile Tilapia's exploitation rate in Siombak Lake has passed the optimum catch (E: 0.60 and 0.59). This finding shows that fishing mortality is higher than natural mortality. However, fishing mortality in Siombak Lake is still lower than that in Chashma Barrage, Pakistan, in which the rate of exploitation reaches 0.85 per year (Mehak et al. 2017), 0.79 per year in the Nam Theun 2 reservoir, Thailand (Beaune et al. 2020), 0.14-0.76 per year in Some Irrigation Reservoirs of Sri Lanka (Bandara et al.

2020). Thus, in general, the rate of exploitation of Tilapia in public waters in the Asian region shows that it has passed the optimum fishing, which tends to be over-exploited. However, in the African Region, it has not been overfishing, except in North Hydro drome, Egypt (Mahmoud et al. 2013) (Table 2).

Table 1. Estimated von Bertalanffy growth parameters of Tilapia from Siombak Lake, Nort Sumatra, Indonesia compared to other studies

Location	L∞ (cm)	K (year^{-1})	B	t_0 (year)	Information	Sources
Lake Tana, Ethiopia	44.1	0.44	2.93	-0.34	Nile Tilapia (inland lake)	Assefa et al. (2019)
Lake Koka, Ethiopia	44.5	0.41	2.90	-0.36	Nile Tilapia (inland lake)	Tesfaye and Wolff (2015)
North Hydrodrome, Egypt	38.06	0.21	2.49	-0.43	Nile Tilapia (inland lake)	Mahmoud et al. (2013)
Lake Victoria	46.24	0.69	3.14		Nile tilapia	Yongo and Outa (2016)
Sakumo II Lagoon, Ghana	19.4	0.54			Nile Tilapia (coastal lake)	Amponsah et al. (2020)
Hilali reservoir, India	46.73	0.63	2.96	-0.17	Nile Tilapia (reservoir)	Johnson et al. (2020)
Nam Theun 2 reservoir, Thailand	52.5	0.23			Nile Tilapia (reservoir)	Beaune et al. (2020)
Chashma Barrage, Pakistan	22.8	0.07	2.14	-0.16	Nile Tilapia (reservoir)	Mehak et al. (2017)
Angamuwa (An)	42.8	0.31	2.56	-0.27		
Balaluwewa (Bw)	48.5	0.24	2.56	-0.20		
Dewahuwa (Dw)	48.8	0.42	2.81	-0.34		
Ibbankatuwa (Ib)	46.2	0.24	2.52	-0.20		
Kandalama (Kn)	51.3	0.28	2.67	-0.53	Nile Tilapia reservoir (India)	Bandara et al. (2020)
Katiyawa (Kt)	48.4	0.52	2.89	-0.22		
Kalawewa (Kw)	51.5	0.27	2.66	-0.54		
Rajanganaya (Rj)	53.4	0.49	2.95	-0.29		
Siyambalangamuwa (Sg)	45.1	0.23	2.48	-0.66		
Usgala Siyambalangamuwa	49.9	0.2	2.50	-0.16		
Reservoir Srilanka	50.7	0.51	3.02	-0.16	Nile Tilapia (reservoir)	Amarasinghe (2002)
	37.8	0.64	2.69	-0.13	Mozambique Tilapia (reservoir)	
Paniai Lake, Indonesia	37,28	0.50			Nile Tilapia (inland lake)	Samuel et al. (2018)
Siombak lake, Indonesia	36.06	0.59	3.00	-0.09	Nile Tilapia	*This study* (coastal lake)
	26.09	0.53	2.68	-0.09	Mozambique Tilapia	

Table 2. Estimated mortality (year-1) and exploitation rates of Tilapia from Siombak Lake, Nort Sumatra, Indonesia compared to other studies

Locations	Z	M	F	E	Information	Sources
Lake Tana, Ethiopia	2.37	0.98	1.39	0.59	Nile Tilapia (inland lake)	Assefa et al. (2019)
Lake Koka, Ethiopia	1.47	0.82	0.65	0.45	Nile Tilapia (inland lake)	Tesfaye and Wolff (2015)
North Hydrodrome, Egypt	1.365	0.403	0.962	0.705	Nile Tilapia (inland lake)	Mahmoud et al. (2013)
Lake Victoria, Kenya	2.18	1.14	1.05	0.46	Nile Tilapia	Yongo and Outa (2016)
Sakumo II Lagoon, Ghana	1.83	1.50	0.33	0.29	Nile Tilapia (coastal lake)	Amponsah et al. (2020)
Hilali reservoir, India	1.32	0.60	0.72	0.54	Nile Tilapia (reservoir)	Johnson et al. (2020)
Nam Theun 2 reservoir, Thailand	1.41	0.30	1.11	0.79	Nile Tilapia (reservoir)	Beaune et al. (2020)
Chashma Barrage, Pakistan	1.11	0.16	0.95	0.85	Nile Tilapia (reservoir)	Mehak et al. (2017)
Angamuwa (An)	1.83	0.74	1.09	0.60		
Balaluwewa (Bw)	1.34	0.6	0.74	0.55		
Dewahuwa (Dw)	1.88	0.87	1.01	0.54		
Ibbankatuwa (Ib)	0.71	0.61	0.10	0.14		
Kandalama (Kn)	1.25	0.66	0.59	0.47	Nile Tilapia reservoir (India)	Bandara et al. (2020)
Katiyawa (Kt)	2.87	1.00	1.87	0.65		
Kalawewa (Kw)	2.06	0.64	1.42	0.69		
Rajanganaya (Rj)	3.84	0.94	2.90	0.76		
Siyambalangamuwa (Sg)	0.80	0.6	0.20	0.25		
Usgala Siyambalangamuwa	1.83	0.53	1.30	0.71		
Reservoir Srilanka	2.83	1.10	1.73	0.61	Nile Tilapia (reservoir)	Amarasinghe (2002)
	1.96	1.17	0.79	0.40	Mozambique Tilapia (reservoir)	
Paniai Lake, Indonesia	1.53	0.99	0.54	0.35	Nile Tilapia (inland lake)	Samuel et al. (2018)
Danau Siombak, Indonesia	3.20	1.27	1.93	0.59	Nile Tilapia	*This study* (coastal lake)
	3.04	1.24	1.80	0.60	Mozambique Tilapia	

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