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Biological aspect of the Grey-eel catfish (*Plotosus canius* Hamilton, 1822) in Kuala Langsa Estuaries, Aceh Province, Indonesia

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ABSTRACT

The grey-eel catfish is a highly valued fish species in some parts of Indonesia. The fish is common in the brackish water of estuaries, and marine, or freshwater ecosystems. They are not usually caught on a commercial scale because of the limited population in their habitat. Although the status is not evaluated, the fish is predicted to face extinction in several countries. This research was conducted from March to August 2021 in Kuala Langsa Estuary, Aceh Province. A research was conducted to examine the reproductive biology of the fish to gather the information that can be utilized to evaluate the reproductive status of the fish in several habitats. Parameters tested in the study include sex ratio, length-weight relationships, condition factor, size at first maturity, fecundity, and reproductive potential of the fish. Research results provide information that the fish follows a negative allometric model with condition factors showing that the female population was in a better state of wellbeing compared to the males. Size at first maturity was 422.5 mm, and the sex ratio was balanced. The fish with high reproductive potential occurred in those who are in groups of 500 – 550 mm in length.

Introduction

Plotosus canius or grey-eel catfish is widely distributed in Indo-West Pacifics. They normally inhabit marine and brackish water (Usman *et al*., 2013; Samani *et al*., 2016; Kundu *et al*., 2019; Yulianto *et al*., 2020), but have also been found to live further uphill of the freshwater river (Hortle and Phommanivong, 2021). The fish are euryphagic with the main diet consisting of crustaceans, shellfish, muds, other fishes, and water insects (Fatah and Asyari, 2011; Leh *et al*., 2012; Jumiati *et al*., 2018; Usman *et al*., 2018; Makri *et al*., 2021).

The morphology of grey-eel catfish resembles those of other catfish, with subcylindrical bodies, which flattened and compressed towards the tail. The fish has two dorsal fins, with the first having a spike that stings venom while the other one is long and merged with the dorsal fin (Usman *et al*., 2013). The fish venom exhibits antifungal activity (Pritihiviraj *et al*., 2014) and can be lethal to small mammals.

Even though the fish is not included in IUCN indices as a species that needs attention, the population of the fish has shown a decline (Gurning *et al*., 2019; Asriyana *et al*., 2020), whilst in India and Bangladesh, the fish is facing extinction due to fishing pressure and habitat changes.

In Kota Langsa, grey-eel catfish is considered a delicacy by local people for traditional cuisine. This fish is never exploited on a commercial scale. However, its fishery needs attention from the government and other stakeholders to ensure its sustainability. Continuous exploitation in the absence of management can be a threat to the population (Gurning *et al*., 2019). Accordingly, information on

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the biological aspect of the fish locally is needed to ensure a sustainable fishery (Hasan *et al.*, 2021). Furthermore, the information can also be used to further initiate aquaculture of the species (Amornsakun *et al.*, 2018; Putra *et al.*, 2020). Therefore, this research investigates biological and reproductive biological information of the fish including sex ratio, length-weight relationship, condition factor, size at first maturity, fecundity, and reproductive potential.

Materials and Methods

Location and time of research

Kuala Langsa is an estuary located in Kota Langsa District and Aceh Timur Regency on the east coast of Aceh Province. The estuary is bordered directly by the Malacca Strait to the east. The research was conducted from March to August 2021 with four times of samplings done every month in three stations of Kuala Langsa Estuary (Figure 1). Sampling was conducted using bottom longline or locally called rawai dasar, which were set up in grey-eel catfish habitats in a mangrove ecosystem for 12 hours. Samples obtained were kept in an ice coolbox and transported to the laboratory of fish biology of Universitas Samudra for further analysis.

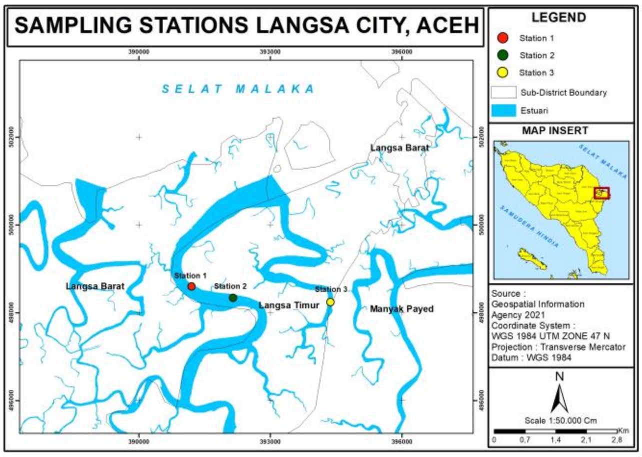

Figure 1. Study site, at two estuaries in Kuala Langsa, Kota Langsa, Aceh.

Samples

Samples were segregated based on their sex and each specimen was measured for its length, weight, and fecundity. Total length was measured using a ruler with 1 mm accuracy whilst the weight was measured using a digital scale with 1 mg accuracy.

Fecundity was estimated based on gravimetry protocol. Egg samples were immersed in Gilson mixture for 24 hours to dissolve the outer membrane to ease the counting of eggs for fecundity estimation prior to counting. The number of eggs was counted under the microscope, and gonad maturity was visually assessed based on ovaries' development following Putra *et al.* (2020).

Data analysis

Sex ratio of male and female fish was analyzed using the following formula:

$$SR = \frac{M}{F}$$

Where SR is the sex ratio; M is male grey-eel catfish and F is female grey-eel catfish. The significance of the sex ratio differences was computed using the Pearson Chi-Square test of independence with the following formula:

$$\chi^2_{df} = \frac{(O_i - E_i)^2}{E_i}$$

Length-weight relationship of the fish was computed using Le Cren (1951) as follows:

$$W = aL^b$$

Where W is fish weight (gr); L is total length (mm); a is the intercept of the loglinear equation; and b is the slope. The fish are considered to follow an isometric growth model when b=3, negative allometry if b<3 and positive allometry if b>3. The significance different of the exponent-b value from 3 is computed using t-test following the formula below:

$$t_s = \frac{b-3}{S_b}$$

t_s is the t student value and S_b is the standard error of the slope at α=0.05.

Fulton condition factor would be computed if the growth model satisfies the assumption of isometric growth (Blackwell *et al.*, 2000) following the formula:

$$K = 100\,\frac{W}{L^3}$$

When the isometric growth model assumption was not satisfied, the condition factor would be computed as the relative condition factor (Blackwell *et al.*, 2020), based on Rypel and Richter (2008) with the formula:

$$Wr = \frac{W}{Ws}$$

Wr is relative weight, W is the weight of each fish, and Ws is the estimated weight which was counted based on:

$$Ws = aL^b$$

If relative condition factor <1 shows that feed availability is inadequate. Relative factor condition

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>100 indicates feed surplus (Anderson and Neumann, 1996).

Size at first maturity (Lm) was analyzed using logistic function (King, 1995) by the equation:

$$P = \frac{1}{(1 + \exp^{-r(L-Lm)})}$$

P is the proportion of mature grey-eel catfish, L is the length of the fish and r is the slope.

Fecundity was assessed using gravimetric methods as follows:

$$F = \frac{Wg}{Ws} Fs$$

F is fecundity, Fs is the number of eggs from the subsamples, Wg is gonad weight (g) and Ws is the weight of the subsamples.

Reproductive potential of the grey-eel catfish was calculated using the formula given by Achmad *et al.* (2020):

$$RP = \sum N \times F$$

N is number of individuals per size class, F is mean fecundity for size class

Results

Size, composition, and sex ratio

The total samples obtained during the study period were 147 specimens. Female fish had lengths ranging from 420-780 mm (with an average of 600.81±72.66 mm), while the male's length ranged from 320-1,673 g (with an average of 1,207.88±251.70 g). In general, female in Kuala Langsa are larger than the male. The abundance of male and female populations also showed a different pattern, where female fish tend to be more abundant in larger size groups as opposed to the male, which tend to be more abundant in smaller size groups. A complete figure of grey eel catfish distribution frequencies for male and female groups is described in the following Figure 2.

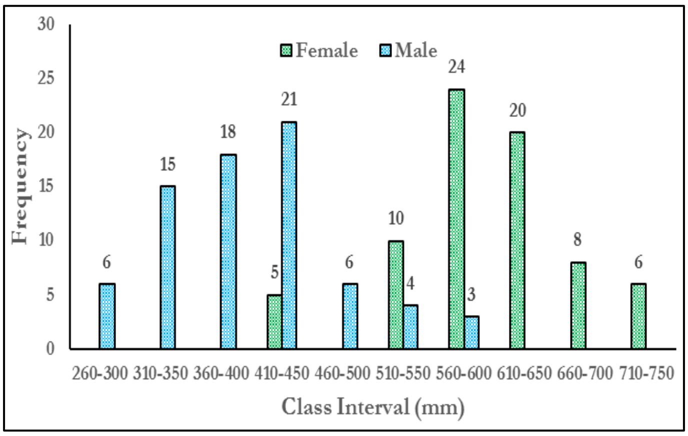

Figure 2. Frequency distribution of male and female grey eel in Kuala Langsa.

Analysis results using King (1995) for the size at first maturity for the grey-eel catfish in Kuala Langsa is 422.52 mm (Figure 3).

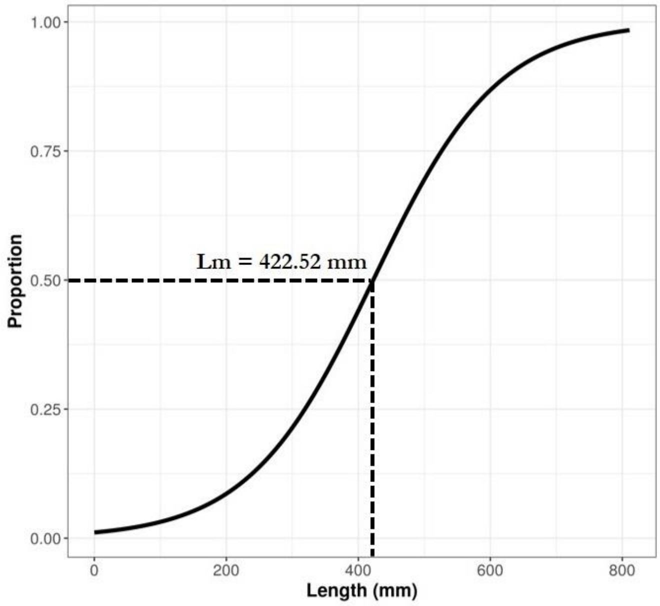

Figure 3. Size at first maturity for the grey-eel catfish in Kuala Langsa Estuary.

Taking the Lm as the threshold to segregate the mature and immature fish, it can be seen that all females caught during the samplings are mature females, while only 48% of males are categorized as mature.

The sex ratio quantification of the grey-eel catfish caught in Kuala Langsa was 1:1.01 (male: female). The Pearson Chi-Square test of independence resulted in there being no significant difference between the male and female population of grey eel catfish (p-value 0.297), which suggests the balanced sex ratio of the population.

However, having a look at the size distribution of the two sexes of the grey eel catfish caught in Kuala Langsa, it is necessary to investigate the adult sex ratio (ASR) of the fish. The significant difference in the fish's sex ratio in groups larger than 410 mm (class of adult fish) was re-computed and the Chi-Square Pearson statistics analysis resulted in the p-value 0.26 against the α=0.05.

Growth Parameters

Log-linear regression result for the length-weight relationship shows that the exponent-b value of the male, female, and combined sex population is less than 3 (Table 1). Even though the male and female populations follow the negative allometry growth model, the value of exponent b in the female population is far smaller than that of the male.

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The t-student statistic to test differences of the exponent-b value resulted in all the three values from the segregated and combined sexes being significantly different from the isometric value of 3 at 0.95 confident intervals. Therefore, the condition factor was assessed as a relative condition factor according to Le Cren (1951). The condition factor in combined sex and in the female population is larger than 1 (1.01±0.17 and 1.004±0.11), while the condition factor for males is smaller than 1 (0.729±0.146).

Table 1. Length-weight relationship of the grey-eel catfish.

Parameters	Male	Female	Combined Sex
Model	$W=4.441L^{1.491}$	$W=4.396L^{0.676}$	$W=7.51L^{1.25}$
Growth model	Negative allometry	Negative allometry	Negative allometry
Relative factor condition	0.729±0.146	1.004±0.11	1.01±0.17

Table 2. Fecundity averages and reproductive potential of the grey-eel catfish.

Class size (mm)	Quantity	Fecundity	Reproductive Potential
410-450	2	1,531	3,062
460-500	6	2,005	12,027
510-550	10	2,390	23,903
560-600	3	1,465	4,395
610-650	2	1,394	2,787

The fecundity of individual grey-eel catfish in Kuala Langsa water ranged from 1,022 to 2,772 grains (with an average of 1,774±551 grains), while the fecundity of each group is described in Table 2.

From the above table, it can be seen that the highest fecundity was possessed by a group with a length of 510-550 mm followed by those in a group length of 460-500 mm. These two groups also have higher reproductive potential compared to other groups in the table, with the RP of group three (510-550 mm) almost double group 2.

Discussion

The descriptive description of the size structure of the grey eel catfish population shows different patterns of abundance between males and females. The female fish is more abundant in the larger size. Conversely, the male fish is more numerous at a smaller size. However, the data analysis shows that the overall population is still in an ideal condition. Even though the size distribution shows different patterns of abundance, the Chi-square analysis accepts the hypothesis that the male and female sex composition of the population is statistically equal in general, and within the adult fish groups. A balanced sex ratio is the desired condition in a population because it can ensure enough fertilization to reproduce (Mardlijah and Patria, 2012) to sustain the population.

The length-weight relationships of grey-eel catfish within this study are negative allometry in general (b=1.25). This metric reflects that the weight of the grey eel fish in Kuala Langsa increases disproportionately to the length. Furthermore, since the length is the function of age in tropical fishes (Anderson and Seijo, 2010) the negative allometry also means that the fish will become more slender as they are getting older. A similar growth model is also identified when the male and female populations were analyzed as segregated groups. The model provided in Table 1. shows that the exponent b value of females (0.676) is smaller than the males (1.491). At the same value of the constant (a), this statistic will lead the male fish to grow faster than females. However, since the constant value of the female population is far larger than the males (81.125 as opposed to 4.441), then according to their growth model, females grow faster than the males in weight at their initial growth.

Other studies from several localities in Indonesia also found that the grey eel catfish exhibit negative allometry growth models which proves that negative allometry is a common growth model among the grey eel catfish populations in Indonesia (Table 3).

Table 3. Growth pattern of grey-eel catfish in Indonesia.

No	Location	b	Growth Pattern	Source
1	Tanjung Pinang	2.76^{m}	Negative allometry	Hasan *et al.*, 2021
2	Bintan Bay	2.53^{f}	Negative allometry	Yulianto *et al.*, 2020
3	South Konawe	2.49^{f}	Negative allometry	Jumiati *et al.*, 2018
4	Central Kalimantan	0.34^{b}	Negative allometry	Harteman, 2015
5	Kuala Langsa	1.25^{b}	Negative allometry	This Research

f= female; m=male; b= both

The average relative condition factor of the females (1.004) is bigger than the males (0.729). Condition factor usually reflects the state of well-being or fitness of the fish which may be caused by the feed availability in their habitat and reproductive status (Gomiero and Braga, 2005). The Wr value ≥ 1 indicates that the fish is in a good state of well-being while when the value is < 1 suggests that the fish is in a poor condition (Froese, 2006). The fact that the two sexes' populations live in the same habitat while they have different well-being states may indicate that the difference does not come from poor environmental quality (inadequate food). The better plumpness of the female fish in the Kuala Langsa estuary may be owed to the reproductive state, where mature fish carrying eggs tend to be plumper than the fish without eggs, because a portion of the weight comes from the gonad (Hoar *et al*., 1983). These also might be explained by the fish size distribution where most of the female fish caught are mature (Figure 2) while more than 50% of males caught have not reached the length of the first maturity yet. However, this study cannot confirm the hypothesis since samplings were only done for six months and thus cannot capture the fluctuations of relative condition factors caused by the reproductive state.

The fecundities of grey eel catfish obtained from this study are still in the range of results from previous publications (Table 4). This result is also evident that the Kuala Langsa estuary can maintain factors affecting the fish fecundity including environmental variations, food adequacy, spawning prevalence, and duration of the breeding season (Rizzo and Bazzoli, 2020).

Table 4. Grey-eel catfish fecundity in several waters.

No	Location	Fecundity (grain)	Source
1	Tanjung Pinang, Kepulauan Riau	110-2,829	Hasan *et al.*, 2021
2	Kolono Bay, South East Sulawesi	1,415-2,194	Asriyana and Halili, 2021
3	Pattani Bay, Thailand	1,156-2,942	Amornsakun *et al.*, 2018
4	Krobokan, Semarang	700-4,010	Dewanti *et al.*, 2012
5	Kuala Langsa, Aceh	1,022-2,772	This Research

Data analysis for fish fecundity results in the highest fecundity obtained by fish from group three, with lengths 510-550 mm, followed by those whose lengths are between 460-450 mm (group two) with the number of eggs were estimated to be 2390 and 2005 respectively. The highest reproductive potential also occurred in group three with an RP of 23,903 which is almost two times higher than group 3 (12,027). The two size groups must be a subject of interest to fishery scientists and managers because these two groups produce more than 50% of eggs within the population.

The fecundity is subsided when the fish reach the size of 560-600 mm which indicates that at this length, the number of oocytes produced decreases as the fish is aging (Nikolsky, 1963). Therefore, at this size, the grey eel catfish no longer hold vital roles in the succession within the population.

Conclusion

The grey eel population in Kuala Langsa estuary follows a negative allometric growth model for the two sexes male and female. The females captured tend to be larger than the males with a condition factor was larger than one, while the males' condition factor is less than one. The sex ratio was balanced between the sexes and the group producing the most eggs and having the highest reproductive potential are those who are in the range size of 460 – 550 mm.

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