

# Reproduction cycle of Longtail shad (*Tenualosa macrura*) in Bengkalis Waters, Riau, Indonesia



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**Abstract** *Tenualosa macrura* is an endangered fish in Riau Province, which is classified as a protected fish. Therefore, the first step is to study the reproductive cycle, aiming to prevent these species from extinction. The observation was carried out for 13 months from January 2019 to February 2020 (except February 2019) in Indonesia's Bengkalis waters. This study's purpose was to determine the spawning season, fecundity, and behavior of this species. The results showed that the relationship between length and weight positively correlates with the length-weight of male *T. macrura* ( $R^2 = 0.84$ ) and female ( $R^2 = 0.67$ ), while the length-weight of all males and females were reported to be ( $R^2 = 0.95$ ). Meanwhile, the relationship between fecundity and length-weight has no relationship. Furthermore, the spawning season lasted throughout the year, and it occurred at every low tide (dark moon) and high tide (full moon). Despite being discovered occasionally in a limited amount, the greatest amount of *T. macrura* was reported between July and September each year.

**Keywords:** oocytes, reproductive cycle, spawning fecundity, testes

## 1. Introduction

Research on the reproductive cycle of various tiny organisms, including a group of fish, has been conducted (Johannes 1981; Taylor 1984; Roberstson et al 1990; Peristiwady 1991; Crabtree 1995; Roberston et al 1999; Parrish 1999; Sokołowska and Skóra 2002; Thamrin 2019). This study was carried out mainly concerning the breeding season so that the researchers can easily find out the mating or spawning season in water creatures. The results are used for various purposes, such as aquaculture and sea renting, to increase fish.

Indonesia is known for having high biodiversity worldwide, including marine animals such as fish with a wide variety. However, in general, investigation on these organisms does not agree with the number of different biodiversities. The reproductive cycle of any organism, including fish species, is much less when compared to research on the same topic in other countries. Moreover, compared to marine waters and the country's population, the study on fish reproduction is tiny and not comparable to the research results discovered. Furthermore, Indonesia has a water area of about 70% of 2,001,648.97 km<sup>2</sup> of the total area of land and waters. However, research on reproduction in fish itself is mainly conducted on fish groups that live freshwaters (freshwater fish) compared to marine fish.

Research on the reproductive cycle of fish, both marine and river fish, has been widely conducted, including fish types that live in coral reef areas (Fahy et al 2007; Medeiros et al 2009). Research on the reproductive cycle of

fish helps facilitate the aquaculture business, especially in the hatchery. This situation is vital, especially concerning wild fish groups, where each organization usually has a clear cycle of gametogenesis. However, it will be different from keeping in confinement in a crab and pond because the gamete ripening process can be conditioned according to the time available. The quality of good feed is needed to stimulate gametogenesis, and this accelerates the ripening of gametes.

Reproductive research on fish is generally carried out, as mentioned above. However, there is a concern on the topic of gonad maturation and its relationship to the hatchery. The observations made were towards types of freshwater fish. In contrast, studies related to seawater fish are limited. Besides that, research carried out in a relatively long period, such as the reproductive cycle, is restricted in number. Furthermore, research related to the reproductive cycle includes basic research; however, it is indispensable because it is related to the spawning season and leads to managing aquatic resources.

The longtail shad (*T. macrura*) is a protected species included in the appendix for international endangered species. However, it is an economically important fish with a high price. *T. macrura* are hunted by fishermen operating in the waters of Bengkalis Riau. This fish population depends on the season; however, it is caught by fishermen in the season. As the prohibition on fishing is only a slogan, fishers use the same net for other types of fish, including caught *T. macrura*. Research on *T. macrura* has been conducted by Bleber et al (1999) and Efizon et al (2012). However, many factors must be observed, including the reproductive cycle of the *T.*

*macrura* that must be investigated to prevent them from going into extinction. Since *T. macrura* are a protected group of fish, it is urgent to examine the species further.

*T. macrura* is a species discovered throughout the year in different populations. Furthermore, this study was conducted to determine the spawning time and peak spawning. Besides, to describe the reproductive behavior of *T. macrura*, especially to find out if the *T. macrura* solely migrates only for spawning simultaneously or partially. Besides that, it is also to determine the relationship between long or heavy fish fecundity.

## 2. Materials and Methods

### 2.1. Sample collection

This research focused on the fishing catches in the Bengkalis waters to Lalang Strait, between Sumatra and Padang Island (Figure 1). All samples were obtained from Bengkalis fishers involved in fishing activities in the area. The samples were taken from the fish caught by fishermen at least once a month using the gillnet fishing gear. The sampling takes place from January 2019 to February 2020.

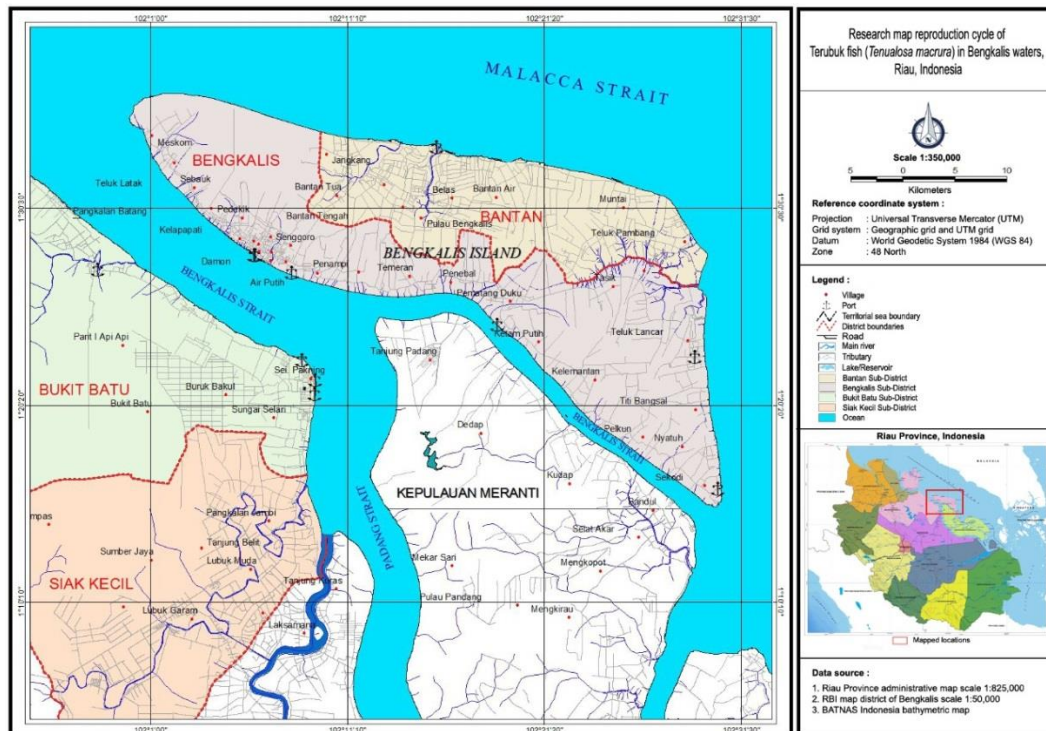


Figure 1 Map of the Bengkalis waters to the Lalang Strait as a research location for sampling station.

### 2.2. Determination of sample size

The sample size depends on the number of catches caught by fishermen. The fishermen who caught the *T. macrura* do not necessarily have to come from the same person who fishes in the fishing ground around Bengkalis Island and the Lalang Strait. The *T. macrura* was obtained from the same zone in which the area becomes the usual fishing area.

The samples are endangered species, and the numbers of each sample are very limited. Each sampling depends on the amount of catch obtained by the fishermen. The number of samples ranges from 6-72 individuals, depending on the fishing season. Small samples are not obtained every month. In contrast, the large ones were discovered every time the sampling was conducted. This condition is because *T. macrura* is hermaphroditic, so the specimen is small and becomes female of a specific size.

### 2.3. Data collection

The data collected were Total Length (TL, cm), fish weight (gr), gamete weight, and fecundity. The fish samples collected are preserved using ice crystals to keep the samples fresh. Data on the length and weight of fish, gamete weight (eggs), and fecundity level were measured at the Fisheries Biology Laboratory, Faculty of Fisheries and Marine Affairs, University of Riau. The total fish lengths were measured by Sigmat Digital Vernier Caliper with LCD Screen and had an accuracy of 0.1 mm. The weight of fish and gamete were scaled by digital weight WJEUIP, Model WA20002Y, display LCD with accuracy 0.01g. The sampling location's water temperature was measured periodically by Digital thermometer -50 - Tool master Salinometer Digital measured 110c Celsius probe 1m waterproof, and salinity 2 In 1, waterproof 0-199.9ppt - 50 °C. While, gamete and fecundity observation was carried out by Binocular Microscope, SHINER Microscope XSZ 107BN.

### 2.4. Data analysis

The relationship between length and weight of the fish was analyzed using linear regression. The fish analyzed were divided into two, namely male and female. Fish whose size and weight have been analyzed are specific to fish obtained on the fishing days in March and July. The relationship between body weight and standard length of sample fish was analyzed by the Ricker equation (1975), where  $W = aL^b$ ,  $W$  is fish weight,  $L$  is total length,  $a$  is the slope, and  $b$  is intercepting.

The total fecundity analysis was observed using Perik equation, where  $F = (Bg/Bs).Fs$ .  $F$  is total fecundity (eggs),  $Bg$  is total of gonad weight (g),  $Bs$  is the weight of egg (g), and  $Fs$  is the number of the egg at sub gonad (eggs). The development between the number of male and female fish at each sampling used the following equation  $X = B/J$ , where  $X$  is gender ratio,  $B$  is the number of female fish (individual), and  $C$  is the number of male fish (individual).

The maturity of *T. macrura* is determined according to the level of gonad maturity (TKG), which observes the general

signs and size of the gonads (modification of the Cassie method in Effendie 1979). The fecundity was only measured by four samples from June 2019 to February 2020, especially for eggs that had the maturity level of the gonads IV. The data obtained are processed in tables and images, and then the data obtained are analyzed descriptively.

### 3. Results

The Bengkalis Strait is the water that is flanked between Sumatra and Bengkalis Island. The Siak River is believed to flow into the Bengkalis Strait at low tide on the Sumatra island. Therefore, the Bengkalis Strait is influenced by the Siak River and the Melaka Strait behind Bengkalis Island. As the deepest river in Indonesia and the current direction at low tide leads to the Bengkalis Strait, the highest tide conditions towards the lowest tide affect the Bengkalis Strait waters' salinity (Table 1). The lowest salinity was about 28‰, and in high tide conditions, it has a salinity of 30‰.

**Table 1** Water parameters of the *T. macrura* spawning ground in the Bengkalis Strait.

N <sup>o</sup>	Sampling station	Temperature (°C)	Salinity (‰)	pH
1	Bengkalis strait (low tide)	30	30	7
2	Bengkalis strait (high tide)	31	28	7

The results showed that not all samples (375 individuals) of male and female fish are the same. This is because the *T. macrura* are synchronous hermaphrodites. While they are small, they are male, and after growing, they are female. Not every sampling was discovered for small fish (males) in June 2019, October 2019, and January 2020. Then the buried fish migrate when spawning. *T. macrura* carries out other activities in the Malacca Strait and then migrates to marga areas for spawning (Blebber et al 1999).

The *T. macrura* was not reported every time. However, they can be discovered every month, especially during the high tide (full moon), low tide (dark moon), or between the two when the moon is dead or full. Apart from that time, no fish was reported in the Bengkalis Strait, and even though it was reported at that time, the numbers of males and females were also not the same. The ratio between males and females is uncertain. There is a ratio of 1:1; and found 30:9:1, and there was also no male. The number 1 in the ratio of 30:9:1 is the transition period for fish from male to female (Table 2).

The length-weight relationship of *T. macrura* is required to determine male and female. The length-weight analysis uses linear regression analysis for groups of males and females of various sizes. Furthermore, the relationship is also used to analyze the combined data of male and female fish groups. This analysis was carried out from the sampling results in July 2019 (Figure 2). The linear regression results showed a positive correlation between the length and weight of male and female fish; the longer the fish, the heavier the fish. This is illustrated by the correlation coefficient  $R^2 = 0.84$  for male fish and  $R^2 = 0.95$  for female fish (Figures 2a, 2b and

2c). Linear regression showed a stronger positive correlation between male and female fish. The length-weight relationship was significantly different between male and female fish (ANCOVA,  $P < 0.05$ ). A relatively weak length-weight correlation was reported in all-female fish groups ( $R^2 = 0.67$ ).

#### 3.1. Fecundity of *T. macrura*

All *T. macrura* discovered contains sperm or oocytes, ranging from 35-610 g in body weight. The smallest male fish was discovered at a bodyweight of 35 g with a length of 182 mm in total length, and the largest fish was producing sperm with a bodyweight of 275 g, with a body length of 328 mm in total length when sampling in August 2019. The smallest produces eggs weighing 180 g and a length of 288 mm in total length. There is an overlap of sperm and egg production between 180-275 g body weights, or in this size, you can find both male and female categories.

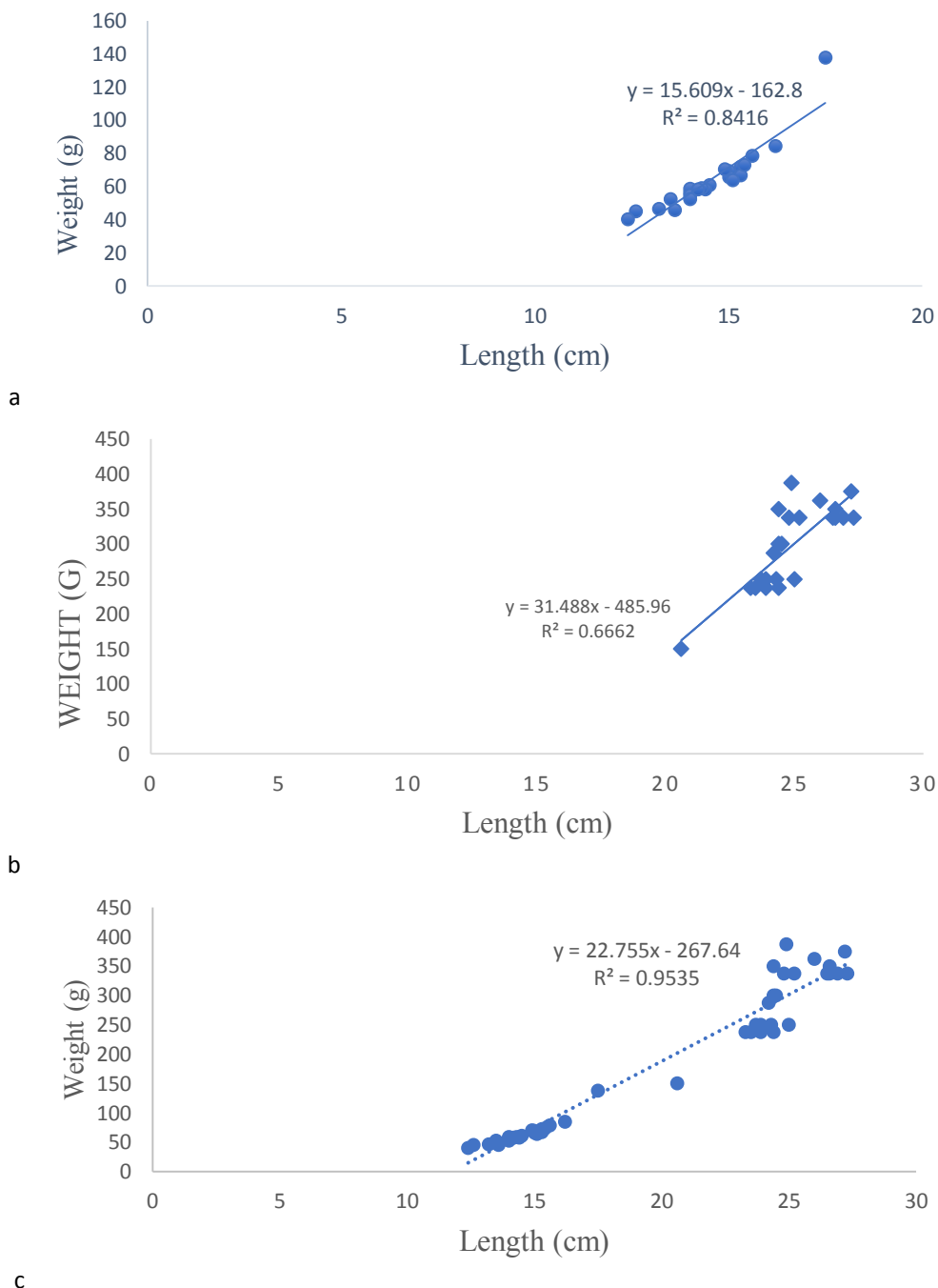
When *T. macrura* was spawned in total (all eggs are removed), as measured by the fecundity, it was reported that the *T. macrura* had no relationship between fish length or fish weight and fecundity. The lowest total fecundity amounted to 16.150 items with a body length of 259 mm, and the highest number was reported to be 417.280 items at a fish length of 269 mm in total length. Meanwhile, other sizes, such as the length of the fish body 382 mm, have a fecundity of 138.942, and a fish body length of 371 mm has a fecundity of 173.415 eggs.

#### 3.2. Reproductive cycle

The reproductive cycle of *T. macrura* places more emphasis on oocyte development. This condition occurs because the sample size is more stable than the male. The reproductive cycle of *T. macrura* was monitored from January 2019 to February 2020.

During the observation of samples carried out within thirteen months, it was reported that there were no eggs in one month, which contained oocytes at gonad maturity level

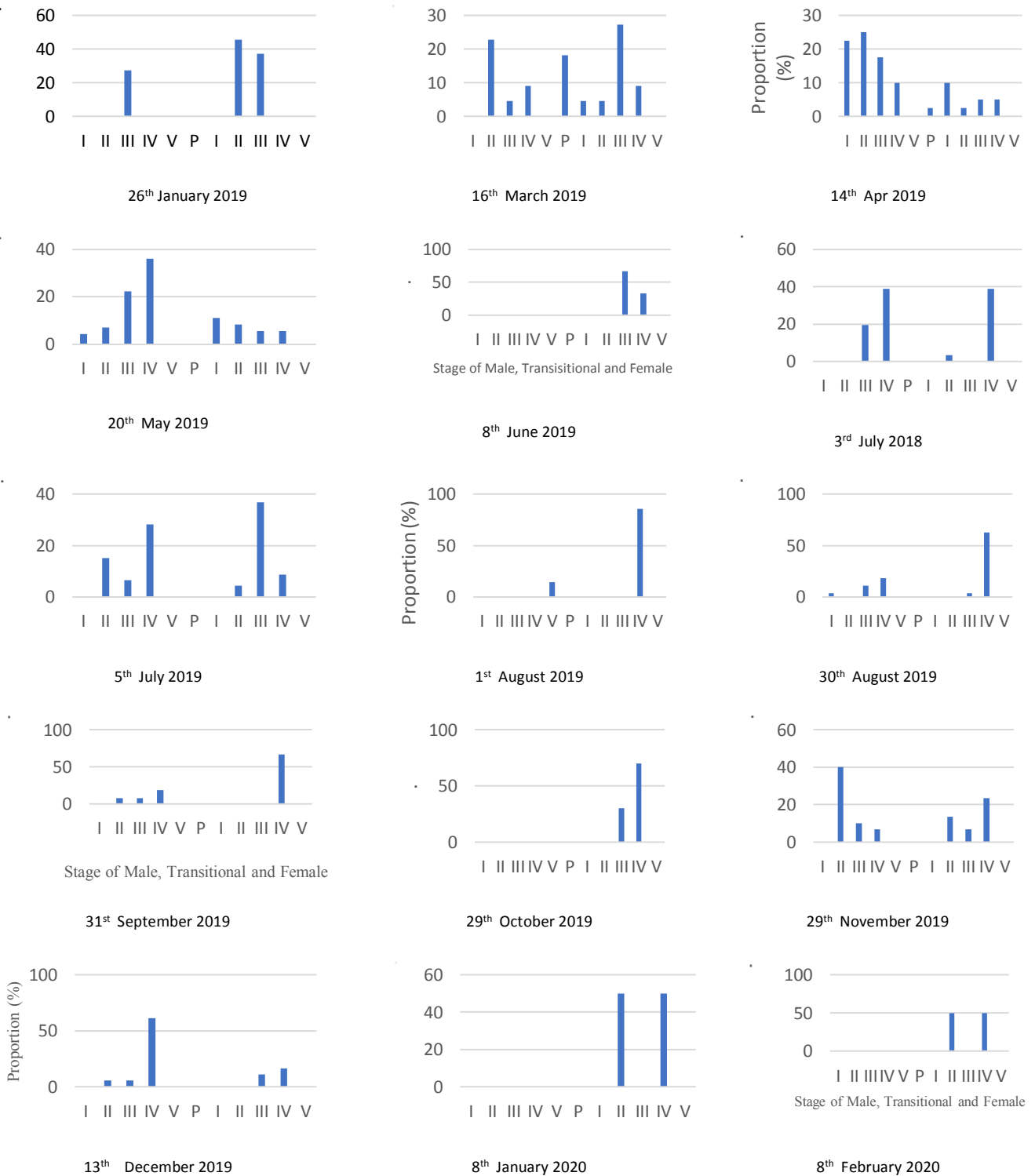
IV. There was no sampling in February; however, two samples were carried out in July and August. Therefore the total sampling becomes 15, and the samples obtained were at least six individuals, and the most were 72 individuals. Meanwhile, samples obtained from March to September reported gonad maturity level IV. There are fluctuations from month-month, but those containing gonad maturity level IV, except for January (Figure 3).



**Figure 2** Length-weight relationship of *T. macrura* for both male and female samples from the sample on July 2019.

*T. macrura* is not always reported, but this fish can be discovered every new month (low tide) or during the full moon (high tide). However, the *T. macrura* fish are reported throughout the year, only during low tide or high tide. During

this research, the number of samples was 375 individuals, and all samples were only discovered during the low tide or high tide. They were never reported at a time.



**Figure 3** Proportion and presence of each Stage of male, transitional, and oocyte from January 2019 to February 2020.

The sampling results obtained the number of fish at least six individuals in February 2020, 10 individuals in January, and August 2019 amounted to 14 individuals. In the other sample, 20-72 individuals were obtained. Out of the samples obtained, it is precisely female fish that are much more stable, namely six individuals in February 2020, 12 individuals in March, nine individuals in April, 22 individuals

in May, nine individuals on June, 13-23 in July, 13-23 individuals on August, 12-18 individuals and September totaled 27 individuals. Meanwhile, the number of samples of males fluctuated wildly. In June and September 2019, there were no female fish samples, while in January, only two males were reported, and the most in May were 50 individuals.



The smallest male size obtained weighed 40.37 g with a body length of 177 mm in July 2019. At this size, it was reported that the fish had produced sperm. The largest male size was reported with 307 g, with a length of 216 mm in total length obtained in January 2019. While the female weighs between 180 g, with a length of 288 mm, and the total length was obtained in May 2019. The largest size of *T. macrura* was 610 g, with a length of 434 mm in April 2019. Therefore, there is an overlap in the size of male and female fish by 118g (288 mm) to 307 g (216 mm).

The number of *T. macrura* eggs has no relationship with body length or weight. Therefore, sometimes the size is small; however, they have many eggs, even with few eggs. Contrary to what was reported by (Kjesbu et al 1991, 1996), the number of eggs in spawning fish has a positive relationship with fish mother length, age, and nutritional conditions. The egg size and quality variability affect the initial survival rate (Trippel 1998; Lambert et al 2003). The size of *T. macrura* was reported to have sperm, and the size producing sperm is unknown.

**Table 2** Period and sex category and the number of *T. macrura* samples obtained by each sampling.

Nº	Sampling time	Male	Female	Others	Ratio	Total
1.	26 Jan. 19	3	8	-	1,5: 4	11
2.	Feb. 19	-	-	-	-	-
3.	16 Mar. 19	8	14	4	2:3,5:1	26
4.	19 April 19	30	9	1	30:9:1	40
5.	20 Mei 19	50	22	-	25:11	72
6.	23 Jun 19	-	9	-	0:9	9
7.	3 Jul 19	12	13	-	12:13	25
8.	5 Jul 19	23	23	-	1:1	46
9.	1 Agust. 19	2	12	-	1:6	14
10.	30 Agust. 19	9	18	-	1:2	27
11.	30 Sept 19	9	18	-	1:2	27
12.	29 Okt. 19	-	10	-	0:10	10
13.	29 Nov. 19	17	13	-	17:13	30
14.	13 Des. 19	13	5	-	13:5	18
15.	08 Jan. 19	-	6	-	0:6	6
16.	08 Feb. 19	13	5	-	13:5	18
		181	189	5		375

*T. macrura* conducts spawning every month because of the gonad maturity level of Oocytes, which are discovered all year. In April and May, it was reported that 5% of the oocytes contained gonad maturity level IV. In January 2020, it had the fewest samples, namely six individuals, with a ratio of 50% of the sample containing gonad maturity level IV. In July, oocytes gonad maturity level IV was almost 40% (or about 90% of the total female). However, in July, oocytes gonad maturity level IV was almost 10%.

Most of the samples that had gonad maturity level IV were reported in August. Sampling in August 2019 did not reveal sperm gonad maturity level IV, but the degree of maturity of the gonadic sperm-V is estimated to be 15%. The remainder is almost 85%, consisting of gonad maturity level IV, in the sense that 100% consists of gonad maturity level IV (Figure 3). Meanwhile, in August 2019, Oocyte gonad maturity level IV was reported to get about 63%. When sampling in the following month of September, it was reported that the *T. macrura* whose females had gonad maturity level IV also amounted to 100%.

According to the development of the degree of maturity of the gonadal oocytes, *T. macrura* appears to have a size when the gonads are mature. When viewed from the beginning, oocyte development consists of several sizes. However, *T. macrura* spawns simultaneously (all oocytes come out together). The conditions can be seen in (Figures 4 and 5). They are quite large when mature, with fecundity reaching about 300 eggs. While seeing the size between males and females, it can be seen in figure 7.

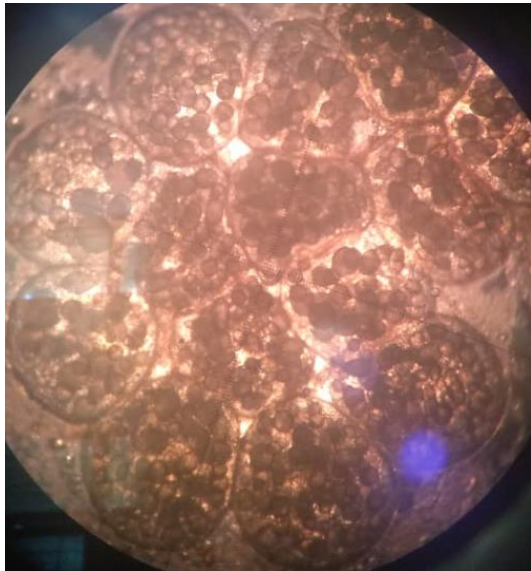
Each time the samples were obtained, various levels of gonad size maturity were reported in both male and female samples. The number of males' samples varies widely and from the two months of collection, namely May and September. There were no males because all samples are large females. In other months, several males were reported, with a total of 2-50 tails. The ratio obtained is as in Figure 7.

From January 2019 to February 2020, the development of eggs and sperm of the *T. macrura* was not detected at first with gonad maturity level IV in January. In February 2019, there was no sampling. Besides, when sampling was carried out, not all fish sizes could be

discovered. Especially small or male *T. macrura* are not always reported. Likewise, large ones, at certain times, are only reported in limited numbers.

The *T. macrura* also has a migratory nature, and therefore these fish are only found reported during the high

tide (Full Moon) or when the low tide (dark moon). However, it is estimated that the *T. macrura* migrate not only for spawning in such a way that they are reported in various sizes of the gonad maturity level (Gonad maturity level I, II, III, IV and V).



**Figure 4** The condition of *T. macrura* eggs in a ready spawning condition (Gonad maturity level IV) shows the similarity size.



**Figure 5** The size comparison of male and female *T. macrura* and their sperm and eggs in mature conditions from a sample of August 2019.

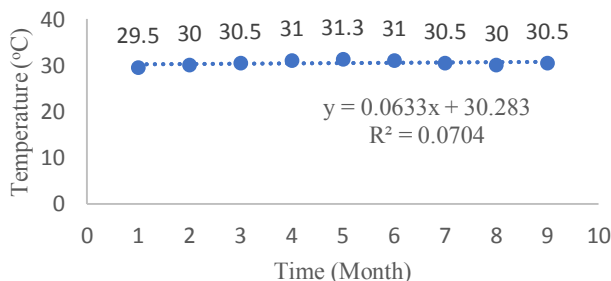
**4. Discussion**

The waters of Bengkalis show less striking fluctuations between measured parameters. The salinity shows little difference between low tide time and high tide time between 28-30‰. This condition occurs due to the possibility of an influence on the flow of the Siak River in the Bengkalis Strait. At high tide, the effect of the Melaka Strait affects the Bengkalis Strait. Blebel et al (1999) stated that the Bengkalis waters area around this salinity. Meanwhile, the impact of temperature is not striking, which is between 30-31 °C, depending on the penetration of sunlight (Figure 6), and also, the pH is only around.

fish, with an estimated range of orders of about 7-9 (Kiu et al 2016). When they are young, this species is male, and when they are mature, the sex changes to be female. (Blaber and van der Velde 1999). To analyze the length and weight, some were separated between the sex and some were tried by combining male and female fish.

The Length-weight regression analysis of males reported that the value was  $R^2 = 0.84$  (Figure 2a). Meanwhile, the female fish reported the value of  $R^2 = 0.67$  (Figure 2b). The difference reported between males and females was about  $R^2 = 0.18$ . In the sense of the word, there are differences in the size of male with female growth. This difference is due to the female group that spots the difference between mature oocytes and immature ones. Murua and Sabarido-Rey (2003) state that oocyte development can be synchronous, group-synchronic, and non-synchronous. In this study, including group synchronization with the same fish and sometimes not with other individuals. However, it is believed that the spawning peak in the population is synchronous. Meanwhile, if combined between male and female, the correlation between length and weight becomes  $R^2 = 0.95$  (Figure 2e).

Samples were collected from January 2019 to February 2020. Out of the 13 months of sampling (except February), only samples in January 2019 were not reported to contain gonad maturity level IV. The other twelve months contain gonad maturity level IV. This is more due to the effect of small sampling because, in January 2020, it was reported to have gonad maturity level IV. For this reason, it is stated that the *T. macrura* spawn throughout the year.

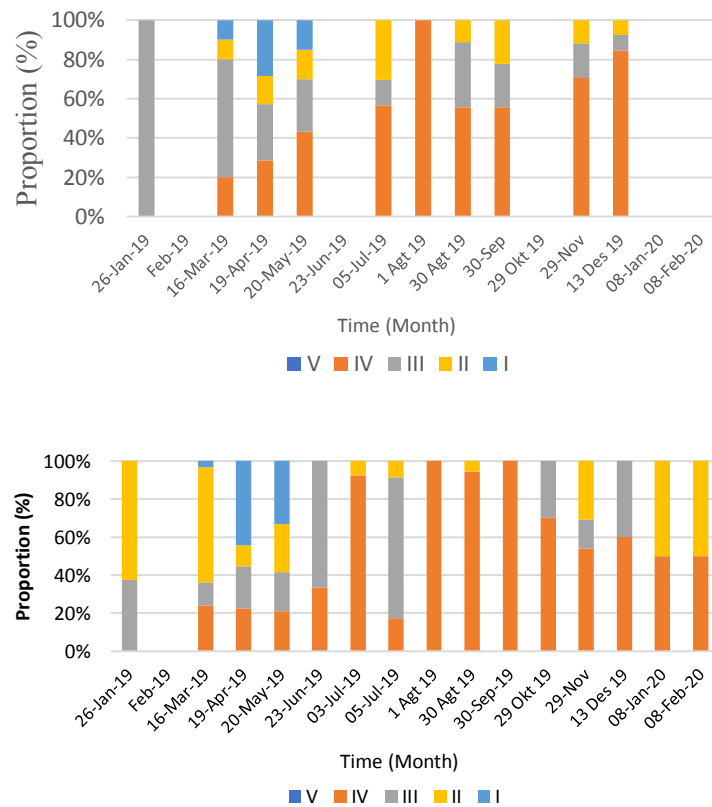


**Figure 6** Temperature of Bengkalis strait waters between January 2019-February 2020.

This research focuses on developing eggs (oocytes) in *T. macrura*, which is a hermaphrodite fish. When they are small in size, they are male, and after adults, they change sex to female. This hermaphrodite species is scattered among

The fecundity of *T. macrura* has no relationship with the length-weight of the fish. Because they have some characteristics, if it gets bigger, the stomach becomes smoother as it gets bigger, while at the size it starts to lay eggs, it has a bulging (enlarged) stomach. Paredes and Bravo (2005) reported that the relationship between fecundity and body length of fish showed a weak correlation, with the

relationship,  $R^2 = 0.33$ . Furthermore, they stated that the relationship between fecundity and total weight showed a better relationship, with a value of  $R^2 = 0.44$ . However, fish have a fragile relationship as they have discovered the condition with *T. macrura*. Alamsyah (2013) reported that *Plectropomus areolatus*, which have fecundity where their body size is large, has decreased fecundity (small).



**Figure 7** Ratios between male, male-female and female transitions in samples from January 2019 - February 2020. The blue color is male, red is sex transition, and green is female.

*T. macrura* was reported only at full moon or during the dark moon, and there are times when it is reported on the dark moon, it will not be discovered again at full moon. However, sometimes it is reported outside the full and dark moon; however, it is found in very limited numbers. Every time the sample was taken, only the female fish samples were reported at any time, while the male samples were sometimes reported and sometimes not. The number of males' samples varies widely, and in two months of collection, namely June, August, October 2019, January, and February 2020, there were no male samples. While in other months, there are only two and some up to fifty tails. The smallest male size was reported; the smallest male size was 40.37 g with a total length of 177 mm as of July 2019. At this size, it was reported that the fish had produced sperm. The largest male size was reported at 307 g with a fish body length of 216 mm, which was discovered in January 2019. In comparison, the female has a size between 180 g, with the smallest fish body length of 288 mm, reported in May 2019. The largest size was 610 g with a body length of 434 mm, reported in April 2019. Therefore, there is an overlap in the

size of male and female fish between 188 g (288 mm in total length) to 307 g (216 mm in total length). It is possible that *T. macrura* of this size was female or transitioned from male to female. Meanwhile, Blebber et al 1999 reported that the largest male *T. macrura* was 200 g.

Bleber et al (1999) reported not finding a peak spawning time for *T. macrura*. However, this study reported spawning peaks around July to September. The spawning peak of *T. macrura* is likely related to inconsistent sampling, as August samples had a ratio of nearly 85% of females to IV gonad maturity. In August 2019, it was reported that almost 100% of females had gonad maturity level IV in a condition ready to spawn. Likewise, what was reported in September also discovered that 100% of the females were ready to spawn.

Among the *T. macrura*, the development of the gonads was not clear because every month, there were oocytes with the size of gonad maturity IV. Furthermore, *T. macrura* spawning every month, namely on the dark or full moon; however, the number is uncertain. Some species living in the four-season regions have more pronounced gonadal



development. As reported by Sokołowska and Skóra (2002), the reproduction of the nine-spine stickleback (*Pungitius pungitius* L.) occurs in spring and summer, from April to July in the Baltic Sea Puck Bay. *T. macrura* is only associated with the full moon or dark moon every month. Apart from that time, this species is not reported. *T. macrura* migrates every month on the full moon or dark moon, and it is estimated that all levels of oocytes migrate.

The synchronous spawning associated with the lunar cycle is generally documented for shallow-water species with large tidal fluctuations (Tailor, 1984). Coral reef fish often perform mass spawning groups at the specific moon and seasonal cycles (Johanes 1981; Roberstson et al 1990). While seasonal spawning is likely to differ between fish groups, small fish are likely to spawn earlier and stop earlier than large fish (Trippel and Morgan 1994; Trippel et al 1997). Furthermore, it was reported that the *T. macrura* was migratory and discovered during the full moon or at the dark moon. However, at the time of migration, it was estimated that it is not only for spawning. Because in migration, it is also accompanied by fish consisting of various sizes of gonad maturity levels.

*T. macrura* experienced total spawning, especially when it was ready to be spawned. This is because the oocytes have almost the same size when they are almost mature. Likewise, in local fishermen's opinion, if the *T. macrura* fish is already spawned, it can be seen from the anus, which is slimy. According to the fishermen, this indicates that the fish have spawned. Meanwhile, Murua and Saborido-Rey (2003) stated that mature oocytes may be entirely excreted during spawning or have their spawning characteristics. However, since this type of fish is migratory and each migration also has different gonad maturity levels, the population has an extended range of bodies to carry out the spawning.

*T. macrura* is also a group of fish that migrate in the dark or full moon. However, they are not only seen while spawning. Because the *T. macrura* at dark or full moon also have oocytes, besides gonads maturity level IV. It differs from that in the Pacific on an empty stomach and actually prepares energy for the pulling forces and then reaches its playground to reproduce and die (Cooke et al 2011). *T. macrura* is also migrating, but it is estimated that most of these fish will follow as spawning will not just migrate. It is proven that fish that migrate also have gonad maturity levels I, II, and III.

According to local fishers, the *T. macrura* spawns around the Lalang Strait, a strait between Padang and Sumatra Islands. This place may have a location related to salinity suitable for spawning because it is not far from the Siak River's mouth. Because the *T. macrura* does not enter the river, nor the Rokan River (Bleber et al 1999). It may also be associated with lower predators because water quality is believed to be lower. Leggett (1985) states that the location of spawning sites and the timing of fish reproduction always have specificity according to population and are related to natural selection and ecology compatible with growth and survival. Meanwhile, in *Eleotris acanthopoma*, it was reported that the spawning period of *E. acanthopoma* started

with an extension of days and an increase in water temperature in early summer in the Kaoping River Estuary of China (Wang et al 2003).

*T. macrura* is likely to spawn more than once a year, but each fish's gametogenesis consists of only one level. In contrast to *Urobatis jamaicensis*, where Fahy et al (2007) stated that the yellow stingray female has two reproductive cycles, where the female can reproduce two periods each year, the first birth occurs between June-April and the second occurs between November-January each year in the South East in USA coral reef waters.

Spawning is usually associated with seasons, especially the rainy season. However, it is different from *T. macrura*, which does not correlate with the rainy season. The spawning peak that occurs in July-September coincides with the dry season on Sumatra Island. This finding contrasts with Mendoza-Carranza and Hernández-Franyutti (2005), who stated that migration to lay eggs coincides with the end of the rainy season. Moreover, *T. macrura* is reported to spawn throughout the year. This research was conducted in a tropical area so that the humidity throughout the year is almost the same and is not a determining factor. Furthermore, it is concluded that what determines the migration of the *T. macrura* is related to its gonad maturity itself. In the maturity process of *T. macrura* gonads, it is the migration of the species that has to do with spawning to the marge, which is in the Lalang Strait.

## 5. Conclusions

There are several topics related to *T. macrura*. Therefore, it can be concluded that it does not migrate mainly for spawning purposes because there are gametes with other gonad maturity levels caught during spawning. Its fecundity is not related to length-weight. Furthermore, it is a hermaphrodite and a male while young, and when it grows up, it becomes a female. There was an overlap of the fish's size between 180 g in body weight, 275 g in the transition. The species are discovered throughout the year in different populations. It was reported that the *T. macrura* experience spawning throughout the year, namely on the full and dark moon, and the species in the population are not the same during the spawning period. However, the fish has a spawning peak, which is expected to be between July and September. Although each fish is buried, and it is created simultaneously.

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## Conflict of Interest

The authors declare that no conflicts of interest exist are included in the manuscript. Disclosures include financial support for this study, consultation fees and stocks, and

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