

## Reproductive biology of striped snakehead, *Channa striata* (Bloch, 1793) in Lake Rawa Pening, Central Java

[Biologi reproduksi ikan gabus *Channa striata* Bloch, 1793 di Danau Rawa Pening, Jawa Tengah]

Djumanto✉, Atik Murjiyanti, Nuravida Azlina, Aisyah Nurulitaerka, Anissa Dwiramdhani

Laboratorium Manajemen Sumberdaya Perikanan  
Jurusan Perikanan, Fakultas Pertanian UGM.  
Jalan Flora Gedung A4, Bulaksumur Yogyakarta 55281  
✉: [lely4192@yahoo.com](mailto:lely4192@yahoo.com)

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### Abstract

The striped snakehead (*Channa striata* Bloch, 1793) is the top predator fish found in Lake Rawa Pening and other freshwaters. Its population was declining due to very high fishing pressures, habitat quality decreases, and other factors. The aim of this study was to examine the condition factor and fecundity of snakehead in Lake Rawa Pening. Fish sampling was carried out monthly from October 2017 to August 2018, using fish fence made from bamboo blinds operated by local fishermen. Total length, individual body weight, stage of gonadal maturity (MS), gonadal weight, and oocytes diameter of fish samples were measured. Fish condition factor, gonado somatic index (GSI), oocyte diameter, fecundity, and the size of first maturity of fish were determined. There were 409 individuals snakehead fish collected consisting of 138 females and 271 males. Fish length ranged from 234-646 mm (males) and 242-648 mm (females). The average of the condition factor (K) of male ranged from 0.778 to 0.923, while in female ranged from 0.826 to 0.929. The relationship between the length-weight of male and female was isometric. The percentage of female snakehead that reached MS I; II; III; IV was 15.6; 27.0; 37.4; 20.0%, respectively. The GSI ranged from 1.52 to 3.54. Oocyte diameter ranged from 0.5 to 1.7 mm with an average of 1.2 mm. Fecundity ranged from 2,843-23,230 eggs with an average of 9,167 eggs. The female snakehead was predicted to reach the first sexual maturity at a total length of 315 mm.

Keywords: fecundity, maturity level, snakehead, spawning

### Abstrak

Ikan gabus (*Channa striata* Bloch, 1793) merupakan ikan predator puncak yang ditemukan di Danau Rawa Pening dan perairan tawar lainnya. Keberadaan populasinya semakin menurun disebabkan oleh tekanan penangkapan yang sangat tinggi, kualitas habitat semakin menurun, dan oleh faktor lainnya. Tujuan penelitian ini adalah untuk mengkaji faktor kondisi dan reproduksi ikan gabus di Danau Rawa Pening. Pengambilan sampel ikan dilakukan setiap bulan dari Oktober 2017 hingga Agustus 2018 menggunakan perangkap yang terbuat dari kirai bambu dan jaring. Ikan gabus yang dikumpulkan sebanyak 409 ekor yang terdiri atas 138 betina dan 271 jantan. Panjang ikan contoh berkisar antara 234-646 mm (jantan) dan 242-648 mm (betina). Parameter yang diukur meliputi panjang total, bobot individu, tingkat kematangan gonad, berat gonad, dan diameter oosit. Faktor kondisi, indeks kematangan gonad, fekunditas, dan ukuran pertama matang gonad ditentukan. Faktor kondisi rata-rata pada ikan jantan berkisar antara 0,778 hingga 0,923; sedangkan ikan betina berkisar antara 0,826-0,929. Hubungan panjang-bobot ikan jantan dan betina adalah isometrik. Persentase ikan gabus betina yang mencapai TKG I; II; III; IV masing-masing adalah 15,6; 27,0; 37,4; 20,0% dengan indeks kematangan gonad berkisar antara 1,52 hingga 3,54. Ukuran diameter oosit berkisar antara 0,5 hingga 1,7 mm dengan rata-rata 1,2 mm. Adapun fekunditas berkisar antara 2.843-23.230 telur dengan rata-rata 9.167 telur. Ukuran ikan gabus betina saat kali pertama dewasa seksual diperkirakan pada panjang total 315 mm.

Kata penting: fekunditas, ikan gabus, pemijahan, tingkat kedewasaan

### Introduction

The striped snakehead *Channa striata* (Bloch, 1793) is one of the freshwater fishes in Lake Rawa Pening, which has various economic benefits (Suwandi *et al.* 2014). The benefits of

snakehead are as high protein food (Asfar *et al.* 2014), source of albumin for pharmaceuticals (Romadhoni *et al.* 2016), target fish for sport-fishing, and ecologically play a role as top predator that control fish population (Nurdawati *et*

*al.* 2007). The high demand for snakehead and tends to increase caused by the expensive price, around IDR 50,000 - IDR 70,000 per kilogram. This condition resulting in the snakehead catching in Lake Rawa Pening occurred most of the year. The local fishermen usually use various fishing gear, including fishing rods, traps, spears, "widik", surrounding nets, and lift nets. Most of the catches were sold to retailers in Salatiga, Semarang, Demak, Kudus and other cities (Puspaningdiah *et al.* 2014).

The population of snakehead in Lake Rawa Pening was influenced by some factors. For instance, the number of new recruits, growth rate, fishing pressure, and natural mortality due to diseases, predation, starvation, and old age. Meanwhile, the new recruits were determined by the reproductive number and capacity of the spawning brood, habitat suitability for spawning, and abundance of food for fish larva (Hadiaty 2016). Snakehead spawned while the environmental conditions are suitable for spawning, waters suitability for fish larvae nursing, and food availability for larval growth (Nasmi *et al.* 2017).

The fishing pressure of snakehead in Lake Rawa Pening is high, so the population tended to decreases, and its sustainability is vulnerable. According to the fish seller, the number of snakeheads caught from Lake Rawa Pening is estimated to reach 360 tons/year (Suyanto 2017, personal communication). This fishing pressure directly affected the snakehead population size, the higher fishing level will decline the population faster. Conversely, the amount of recruitment and growth rate will increase the population. The number of broodstock in mature condition and ready to spawn would affect the quantity of recruitment so that this information

was essential to be studied as a basis for managing the snakehead population (Wahyu *et al.* 2015).

Some previous studies on the snakehead have been carried out such as feed of snakehead (Zehra & Khan 2012), domestication of snakehead (Ndobe *et al.* 2013), induce breeding of snakehead (Yulintine *et al.* 2017), reproductive biology of snakehead in the Musi river floodplain (Makmur *et al.* 2003), and the reproductive aspects of snakehead in Lake Rawa Pening which dominated by gonadal maturity index at stage II (Puspaningdiah *et al.* 2014). Research on the reproductive biology aspects of female snakehead in a paddy irrigation system in Malaysia was conducted by Ali (1999), which obtained the results of gonadal development occurring throughout the year, multi-modal oocyte frequency distribution, and relative fecundity estimates ranging from 10.5 to 36.3 oocytes per g body weight. This study aimed to determine the snakehead reproductive capacity in Lake Rawa Pening more comprehensive so that the results can be used as a basis for snakehead fisheries management in the lake.

## Materials and Methods

Fish sampling was carried out in Lake Rawa Pening, which is the main fishing area of the snakehead in Central of Java, in five locations representing Bawen and Ambarawa Districts (Figure 1). The sampling sites were located in an area that had a relatively high density of water hyacinth (*Eichhornia crassipes*) as a suitable habitat for snakehead. Fish sampling was taken monthly from October 2017 to August 2018, which included dry and rainy seasons.

The fish samples were collected from morning to evening, supported by local fisher-

men using “widik” or fish fences as fishing trap. The fish fences were made of bamboo slats which were strung together using yarn into blinds with a height of 2 m along 10 m. It was operated by encircling a fishing area of 50 m<sup>2</sup> which had aquatic plants in high density. Fish were confined when the gear was narrowed and caught using a scoop net. The collected fish was stored in a cool box filled with ice.

Fish samples were measured in total length, body weight, and maturity stage (MS). Male and female fish were differentiated based

on the presence of gonads it has, whether testis or ovaries. The determination of GSI was modified after Biswas (1993) based on Table 1 (Ghaedi *et al.* 2013, Mahmud *et al.* 2016, Sary *et al.* 2017, Milton *et al.* 2018).

Gonads in the anterior, middle, and posterior parts of female at maturity stage III and IV were weighed using a digital scale (accuracy 0.01 mg). Oocytes were counted manually using a magnifying glass and egg's diameter was measured by microscope equipped with a micrometer.

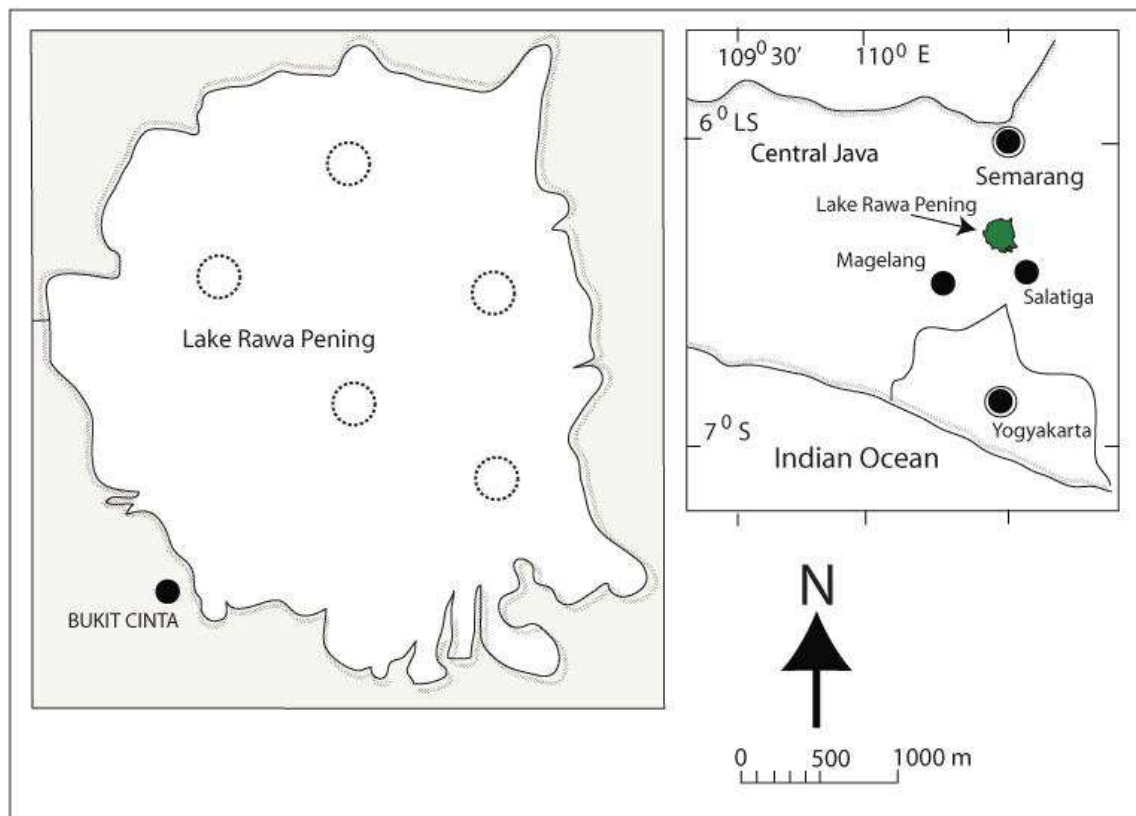


Figure 1 Map of Lake Rawa Pening. The sampling stations are indicated by an open circle dotted line

Table 1 Gonadal maturity stages of *Channa striata* from Lake Rawa Pening

Maturity stage	Male	Female
Stage 1 (Immature)	Testes were very tiny and translucent containing many spermatogonia. A few spermatocytes were also thinly scattered macroscopically, the testicles were flat, transparent white and notched. Microscopically, thick testicular walls with primary spermatocytes dominate the peritoneum.	Macroscopically, the ovary was small, thin, transparent, soft texture and blood vessels were not visible yet. Oocytes were not visible through the ovary wall. Histologically, oocytes were located in the germinal epithelium, each with mild eosinophilia cytoplasm to basophilic. Cytoplasmic diameter of 0.05 mm.
Stage 2 (Maturing)	Testes at this stage were larger than the immature stage. Spermatocytes and spermatids were more abundant. In the early stages, the testes enlarge, white. Capillary blood vessels were seen in the testicular wall. In the final stage, the testes become more supple and whiter and occupy 1/5 of the abdominal cavity.	Macroscopically the ovary was elongated and only a few oocytes were seen. Blood vessels look unclear. Histological observation of the ovary was the initial stage of yolk oocyte formation from the germinal epithelium; yolk egg was covered by a simple squamous follicle epithelium. Oocyte size between 0.01 and 0.45 mm.
Stage 3 (Mature)	Testes showed the largest volume with a pinkish white color. A large amount of spermatozoa were observed. The testicles were getting bigger and squiggly. Creamy white. Secondary and tertiary spermatocytes were dominant, whereas primary spermatocytes were few.	The ovary size continues to grow bigger. Yellowish oocytes and blood vessels continue to develop well. Round eggs with rough surfaces, no ovulation yet. The blood vessels combine to form larger capillaries on the external surface of the ovarian wall. Oocytes were clearly visible through the reddish yellow ovary wall, filling the half of the abdominal cavity. Histologically, it was the initial stage of vitellogenesis, yolk egg vacuole seen and fat in ooplasm. Oocyte sized between 0.45 to 1.50 mm
Stage 4 (Spent)	Testes were darker, opaque and flaccid. The testicles widen, most of them appear springy but some were soft and very squiggly. There were blood vessels and thick, at a gentle pressure the cement will radiate. Lumen contained spermatozoa. Most spermatozoa migrate towards the periphery of the lobule	Macroscopically a large ovary with a thin and transparent membrane. Ovaries were larger, yellow or orange, fill the abdominal cavity, oocyte grains were able to separate from each other, peripheral blood vessels and central clear. Microscopically an increase in egg yolk vesicles that fills the entire ooplasm. Oocytes were mature, most oocytes were in the tertiary vitellogenin stage, oocyte diameter 0.50-1.80 mm.

Data were analyzed descriptively by presenting pictures and graphs, such as length and weight distribution, length and weight relationship, condition factors, the distribution of gonadal maturity stage (MS), gonadal somatic index (GSI), length or weight relationship with MS, fecundity and oocyte diameter. The sex ratio was determined by comparing the number of

males on females monthly and tested with the chi-squared ( $\chi^2$ ) test.

The relationship of fish weights was analyzed using the linear regression test with the following formula (Biswas 1993, Effendie 2002):

$$W = a L^b$$

W = weight (g); L = Length (cm); a and b = constants.

The constant values of  $b$  were tested for similarity against the value of 3 using the t-test.

Fish condition factors ( $K$ ) on isometric growth were calculated by formula according to Biswas (1993), that is:

$$K = \frac{10^5 W}{L^3}$$

$w$  = body weight (g),  $L$  = length (mm)

In allometric conditions, the relative condition factor ( $K_n$ ) of fish was calculated by the following formula:

$$K_n = \frac{W}{aL^b}$$

The gonado somatic index (GSI) is calculated with the following formula:

$$GSI = \frac{Wg}{W} \times 100$$

$Wg$  = gonad weight;  $W$  = body weight

Fecundity ( $F$ ) was calculated by the following formula:

$$F = \frac{Wg}{gs} \times nt,$$

$gs$  = weight of gonad samples;  $nt$  = number of oocytes of gonad samples

Relative fecundity ( $Fr$ ) is the number of eggs that have matured in an ovary before spawning, calculated by the following formula:

$$Fr = \frac{F}{W}$$

$F$  = fecundity,  $W$  = body weight

The fish size of the first gonad matured or the value of  $L_{m50\%}$  was calculated by plotting the proportion between gonadal maturity of fish and the total gonad in each length class. The size of the first gonad was calculated using the following formula:

$$L_{m50\%} = \frac{1}{(1 * e^{(a-b*L)})}$$

The formula can be reconstructed into a linear regression equation as follows:

$$\ln\left(\frac{1}{L_{m50\%}} - 1\right) = a - b*L$$

## Result

The length and weight of fish caught during the study are presented in Figure 2 and 3. The total number of fish caught were 409 individual, consisting of 271 males and 138 females. The length of male fish was distributed over the range of 234-646 mm (average  $\pm$ s.d;  $330 \pm 7$ ), and weights in the range of 82-2,284 g ( $347.4 \pm 317$ ). In female fish, the length of fish was distributed over the range of 242-648 mm ( $366 \pm 7$ ), and weights in the range 125-2,373 g ( $486.9 \pm 385$ ). The length and weight modes in male and female fish were smaller than the average or tend to the left. In general, the female fish were bigger than male. During the dry season, the average weight of male fish (480.4 g) was almost twofold than in the rainy season (256.9 g). Meanwhile, female fish were slightly heavier during the dry season (494.3 g) compared to in the rainy season (483.8 g).

Male fish tended to be smaller than female. Most of the male size was 280-360 mm, while the female was 340-400 mm long. Both male and female rarely had a length of 400-600 mm. Most of the male and female fish weight 200-500 g and few weighted at 500-2,500 g. Generally, large fish were caught during the dry season.

The equation of the length-weight relationship for male was  $W = 0,0078 L^{3,0171}$  with  $R^2 = 0.94$  and female was  $W = 0,007 L^{3,060}$  with  $R^2 = 0.95$  (Figure 4).

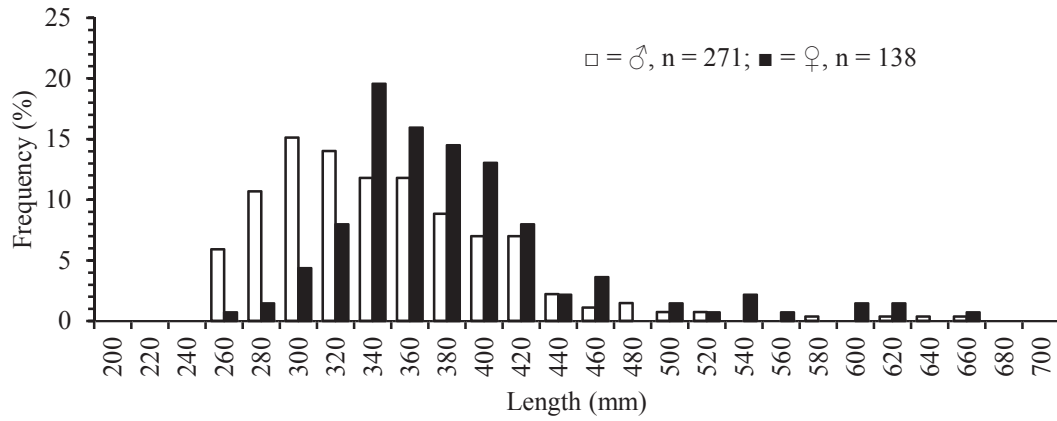


Figure 2 The length distribution of *Channa striata* in Lake Rawa Pening

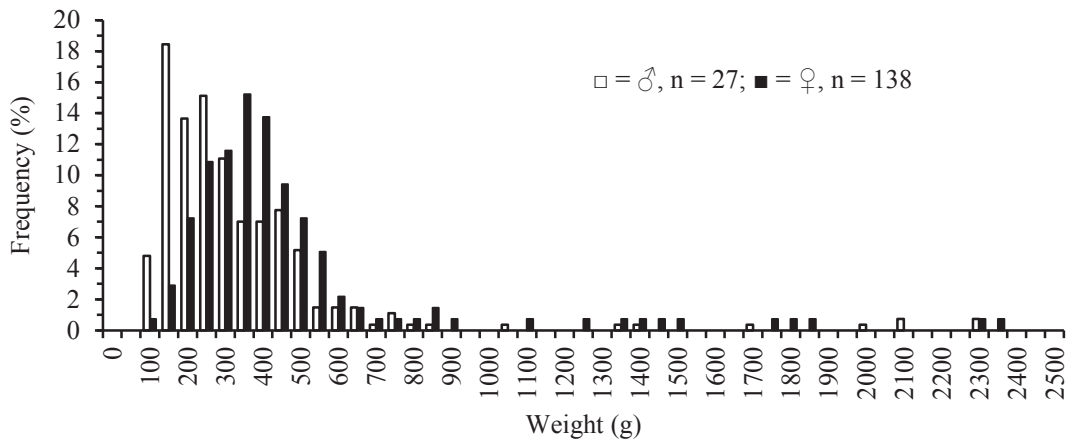


Figure 3. The weight distribution of *Channa striata* in Lake Rawa Pening

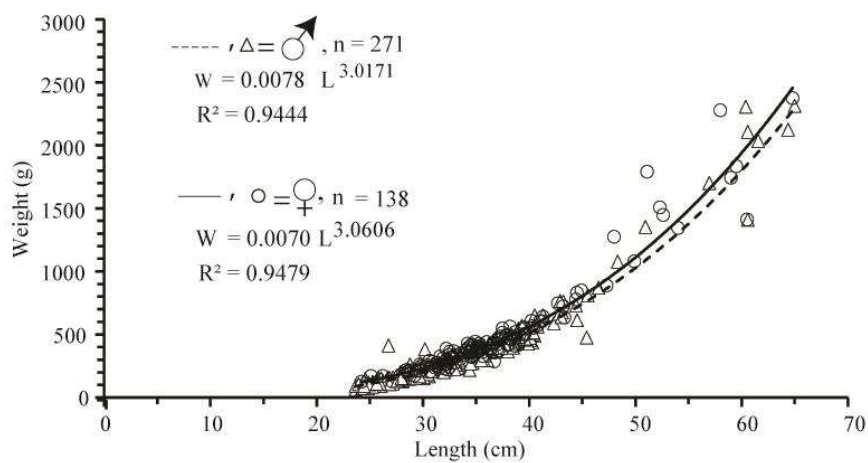


Figure 4 The length-weight curvature of *Channa striata* in Lake Rawa Pening

Based on the curvature of the length-weight relationship both of the male and female snakehead was obtained a value of  $b=3$  that indicated the male and female have an isometric growth pattern. The long growth rate for the male and female was proportional to the weight.

Monthly variations in condition factor (K) of male and female snakehead are presented in Figure 5. The condition factor of male snakehead ranged 0.528-1.197 ( $0.847 \pm 0.092$ ). Female fish had condition factor ranged 0.110-1.341 ( $0.876 \pm 0.118$ ). Overall, the average condition factor of female snakehead was higher and had a wider range of minimum and maximum. The

mean condition factor was  $<1$  indicates the fish was not in good condition due to environment stressing or other factors, for example, the limited feed availability.

The lengths of male and female snakeheads were grouped into small ( $q_1 < 25$  cm), medium ( $q_2 = 25-35$  cm) and large ( $q_3 > 36$  cm). The female in each group has condition factor (0.87-0.97) greater than male (0.83-0.84) as in Figure 6. The variation in the condition factor values for each male group was relatively similar, whereas female tended to widen as the length group increased.

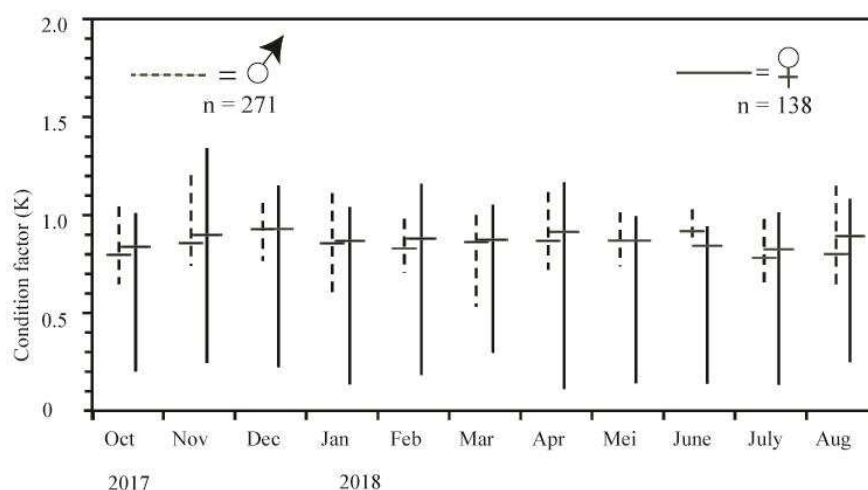


Figure 5 The average condition factor of *Channa striata* in Lake Rawa Pening

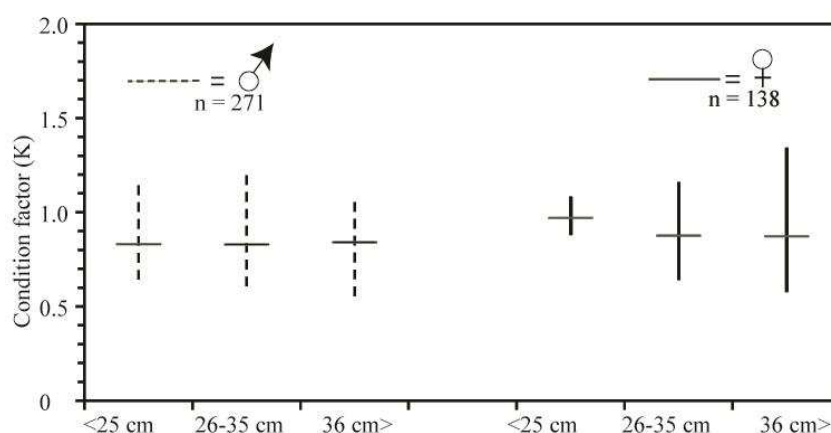


Figure 6 Average condition factor (K) of small, medium and large group of male *Channa striata* in Lake Rawa Pening.



The sex ratio of each month sampling was presented in Table 1. Based on the chi-square test, the sex ratio was unbalanced ( $p > 0.05$ ), which male (66.3%) was almost doubled more than female (33.7%).

Female snakehead in the MS IV stage was more abundant in the rainy season (December-May), whereas in the dry season were few, even in June, October, and November there was no mature female (Figure 7). Fish in the MS III stage was often caught during the dry season, but in the rainy season, there was fewer so that the proportion of fish in MS IV to MS III was high. This condition was estimated that the

gonadal at MS III developed further into MS IV during the dry season to the rainy season.

The maturity stage of the male snakehead in Lake Rawa Pening was shown in Figure 8. Percentage of male maturity stage in ascending order was as followed: MS III (34.4%), MS II (28.2%), MS I (25, 0%), and MS IV (12.4%). During the rainy season, males tended to be found at MS IV, whereas in the dry season it was relatively few. At the beginning of the rainy season, there were many males at the first stage of maturity, while at the end of the rainy till dry season the MS III was found.

Table 1 The sex ratio of *Channa striata* in Lake Rawa Pening

	2017			2018								Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	
♂	8	13	6	34	20	24	17	21	24	41	63	271
♀	3	17	5	19	16	14	17	18	6	14	9	138
Total	11	30	11	53	36	38	34	39	30	55	72	409*
X count.	2.27	0.53	0.09	4.25*	0.44	2.63	0.00	0.23	10.80*	13.3*	40.5*	

Note: Sign \* shows significantly different ( $p > 0.05$ ), X table > 3.84

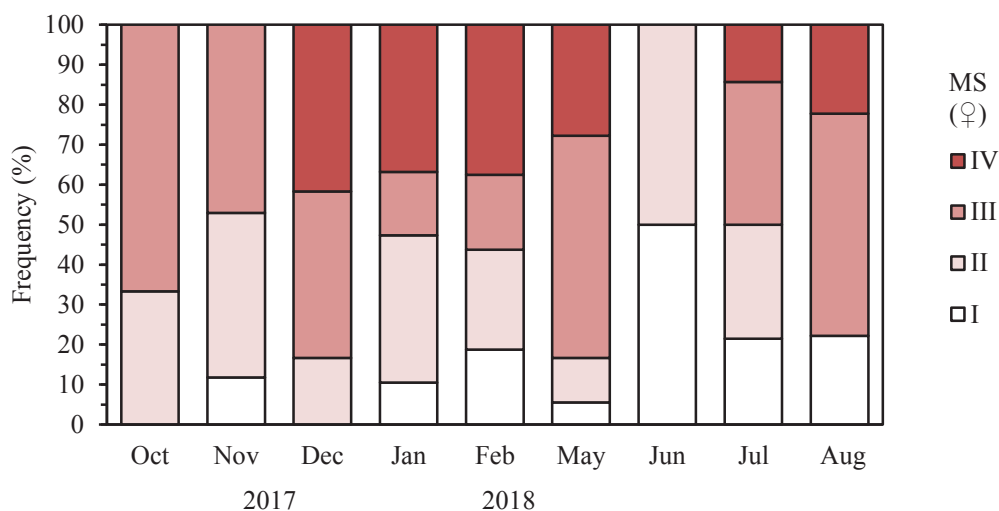


Figure 7 The maturity stage distribution of female *Channa striata* in Lake Rawa Pening



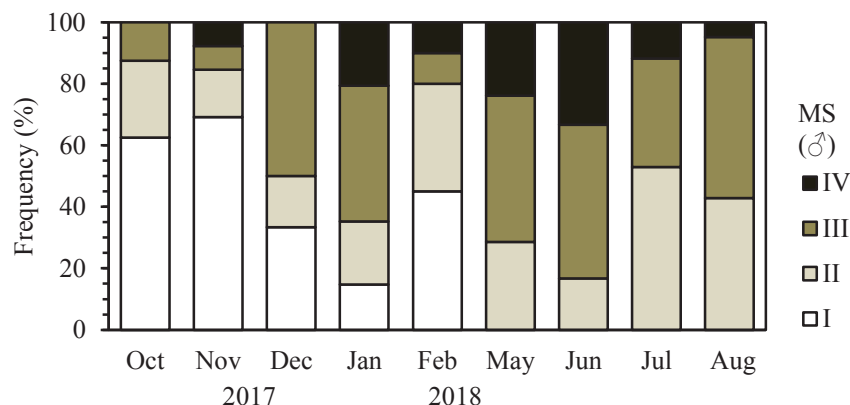


Figure 8 The maturity stage distribution of male *Channa striata* in Lake Rawa Pening

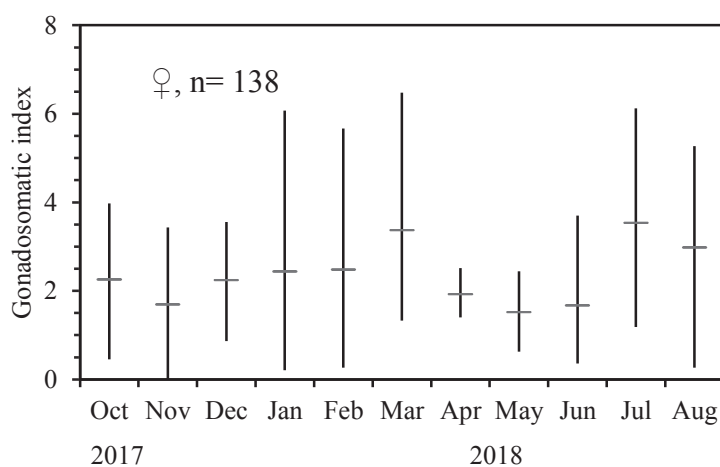


Figure 9 The average gonadal somatic index of female *Channa striata* in Lake Rawa Pening

The gonadosomatic index (GSI) monthly is presented in Figure 9. Female had an average GSI of 2.38, ranged from 1.52 to 3.54. The highest GSI (6.48) was found in the rainy, while the lowest (0.02) was in the dry season. The average GSI at the rainy was higher (2.42) than the dry season (2.33) and reached a peak at spawning season which was expected occurred in the rainy season.

The oocyte diameter distribution was found in one peak at one modus (Figure 10). The average oocyte diameter was 1.2 mm and ranged 0.5-1.7 mm so that this fish was total spawner and spawning occurred once in each spawning season.

The relationship between absolute fecundity to the length and weight of the snakehead is shown in Figure 11. The female gonads of snakehead by 365 mm (359 g) had at least 2843 eggs, while the most fecundity (approximately 23,230) was in female measuring 511 mm (1.790 g). The average absolute fecundity of the individual snakehead was 9167 eggs, while the relative fecundity was 20.6 eggs/g body weight. The smallest snakehead that has reached maturity stage IV was 294 mm (212 g). There were high variations in oocyte fecundity at the same length or individual weight. The relationship between fecundity and length was  $F = 19.474 L^{1.6737}$  ( $R^2 = 0.24$ ), and the fecundity-weight relationship was  $F = 360.64 W^{0.5116}$ .

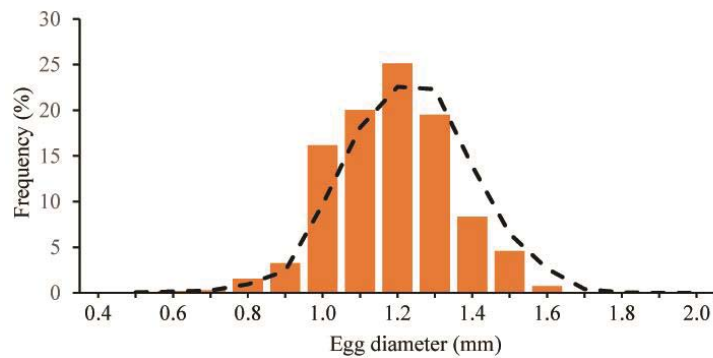


Figure 10 The oocyte diameter (MS III & IV) distribution of *Channa striata*

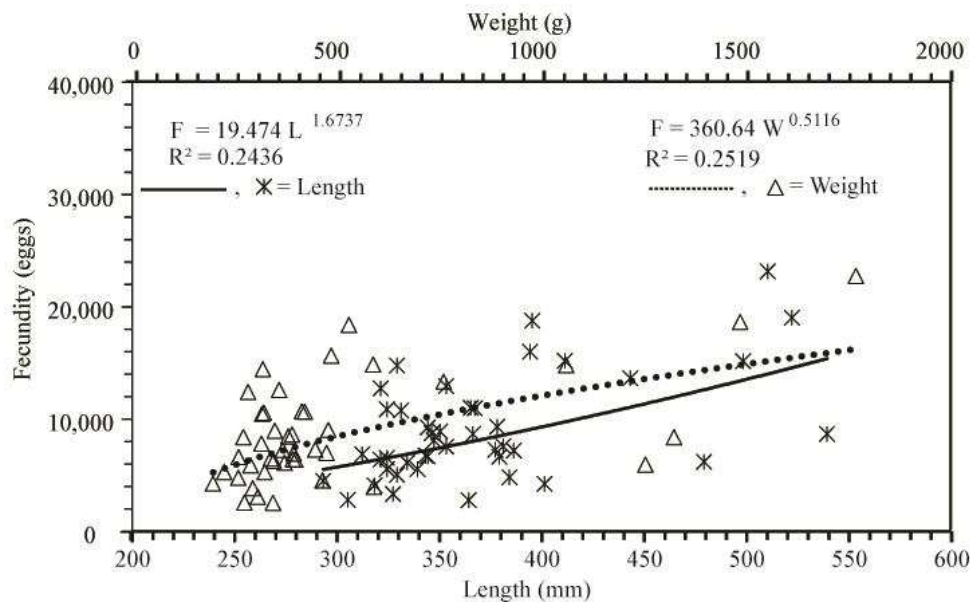


Figure 11 The relationship of absolute fecundity to length and weight of *Channa striata* in Lake Rawa Pening

( $R^2 = 0.25$ ). Fecundity tended to rise by increasing length or weight, but the relationship was weak as indicated by low of  $R^2$ -value. At the same weight or length female had varying fecundity so that the relationship between fecundity and weight was weak, as well as the fecundity-length relationship.

The relationship of relative fecundity to length and weight is presented in Figure 12. The relative fecundity decreased with increasing weight and length in the equation of  $Fr = 26.11 -$

$0.0109 W$  ( $R^2 = 0.17$ ) and  $Fr = 43.62 - 0.6198 L$  ( $R^2 = 0.16$ ). The relative fecundity ranged of 4.9 to 44.5 eggs  $g^{-1}$  with an average of 20.6 eggs  $g^{-1}$  of body weight.

The size prediction of the first spawning of female in Lake Rawa Pening is presented in Figure 13. The female is estimated to spawn for the first time at a length of 315 mm. The longest female caught was 649 mm, so the size was double the size of the first spawning.

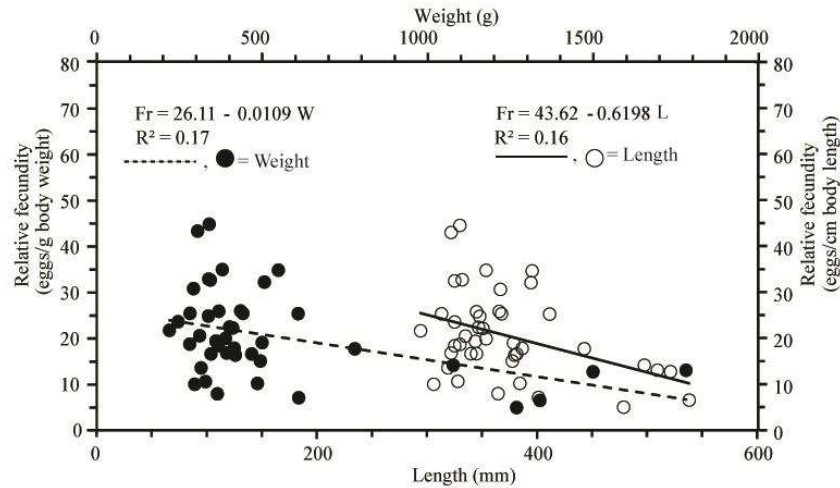


Figure 12 The relative fecundity-length and weight relationship of *Channa striata* in Lake Rawa Pening

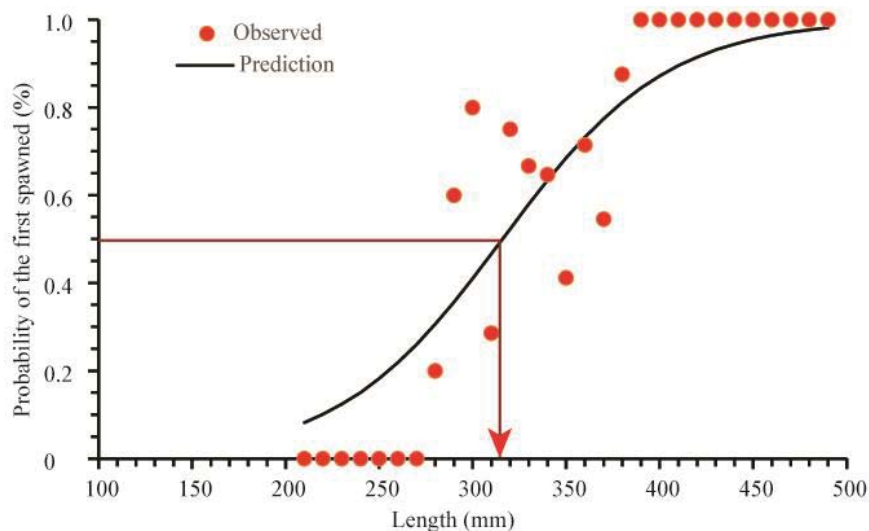


Figure 13 The estimated length at first maturity of female *Channa striata* in Lake Rawa Pening

## Discussion

The length and weight range of snake-head captured in this study was wider than observed by Puspaningdiah *et al.* (2014) who caught fish using lift nets in Jan-Mar 2014 and obtained a range of 240-600 mm in length and weight of 100-1600 g. This may be caused by various types of fishing gear used for sampling, and longer sampling periods that affect the size of the fish caught.

In the rainy season, except for January, the ratio of male and female snakehead was balanced, whereas in the dry season more male fish were caught. This result was different from the snakehead population in the Musi River Basin, which was a balanced sex ratio of males and females (Makmur *et al.* 2003). On the other hand, in Bantimurung River, Maros Regency, the female population was three times more than males (Irmawati *et al.* 2017). It shows that the

sex ratio of males and females varies greatly. The snakehead sex ratio might be influenced by habitat, location, season, and stage in fish life and other factors (Mian *et al.* 2017). The balanced ratio of male and female snakehead in Lake Rawa Pening during the rainy season coincided with the spawning season. Water hyacinth and other aquatic weeds as a snakehead habitat for shelter and spawning, so that during the spawning season, many adult male and female snakehead gather to spawn. Snakehead requires water hyacinth and aquatic plants as shade to lay eggs and care for their offspring (Yulintine *et al.* 2017). During the dry season, male snakeheads hide under a bunch of aquatic plants to protect their territory, while female snakeheads hunt for prey. The sex ratio of males and females is an indicator of the health of fish populations so that a balanced male and female population is expected to guarantee maximum recruitment.

Snakehead growth patterns in various types of freshwater vary greatly, caused by multiple external and internal factors. External factors that affect snakehead growth patterns include habitat or environmental factors, food availability, seasonal differences, density, and so on. Internal factors that influence include fish development stage, sex, gonad maturity level, and other factors (Safran 1992). Snakehead can grow very well in Lake Rawa Pening, because various types of feed are available. The main feed of snakehead fish is animal groups consisting of fish, crustaceans, and shellfish. Male snakehead preys on balanced fish and shrimp, while females prey more on crustaceans. The types of prey consumed depend on their preferences and availability. Biologically the value of  $b$  is closely related to the health of the fish, whereas the condition of the fish depends on

food, age, sex, and gonad maturity (Effendie 2002).

In this study, male and female snakehead growth patterns in Lake Rawa Pening were isometric ( $b = 3.0$ ), while Puspaningdiah *et al.* (2014) who conducted a study at the same location (in Lake Rawa Pening) found a negative allometric growth pattern ( $b = 2.8$ ). This difference was thought to be caused by different phases of growth or development, habitat, and season when capturing snakehead. The snakeheads captured in this study were mostly 280-360 mm (male) and 340-400 mm (female) in length with an average of MS III, whereas Puspaningdiah *et al.* (2014) found a length that was dominated by 230-370 mm with an average of MS II. Snakehead in the vegetative growth phase stores a lot of energy from food for the formation of muscle tissue, whereas in the generative growth phase most of the energy was used for gonad growth (Ali 1999). Snakeheads found in the Banjarn River Basin (Sinaga *et al.* 2001) and the Musi River Basin (Makmur *et al.* 2003) have negative allometric growth patterns. Habitat flowing with a slight density of prey causes snakehead to use a lot of energy to find prey, so the growth pattern tends to be allometric negative (Mohanty *et al.* 2017). Snakehead in the spawning season or entering the reproductive phase will store energy from food for gonad development, so it tends to have a positive or allometric isometric growth pattern (Ghaedi *et al.* 2013). Isometric growth shows that the snakehead in Lake Rawa Pening has enough food to form its weight growth. Changes in fish weight are generally faster than their length.

The oocyte diameter in this study was consistent with the oocyte diameter in the Musi River flood area, which ranges from 0.65 to

1.34 mm (Makmur *et al.* 2003). The average oocyte diameter was closely related to MS, the snakehead which has a higher MS, the average diameter of the oocyte was greater (Ali 1999), the higher the level of gonad maturation, the greater the oocyte diameter in the ovary. Research conducted by Makmur *et al.* (2003) showed that the diameter of MS III snakehead oocytes ranged from 0.65 to 1.27 mm and MS IV ranged from 0.65 to 1.34 mm.

During the spawning season, the snakehead oocyte diameter in the gonad can be ovulated to a minimum size of 1.00 mm (Ghaedi *et al.* 2013). The snakehead oocytes that able to ovulate were those who have reached MS III and IV. The size range of snakehead oocytes obtained from this study was varied. It only mature oocytes will be ovulated during the spawning season. While immature oocytes or diameter <1.00 mm will develop further and will be ovulated in the next spawning season. These results indicate that the snakehead at the time of spawning ovulated all the mature oocytes, and the next time will be used to guard the progeny. Snakehead broodfish protect their offspring from eggs to post-larval stages to ensure high survival (Selvaraj & Francis 2007). These results were different from snakeheads that were spawned in ponds or captivity where the broodstock has no chance to guard for the offspring. In captivity, oocytes in the final stage will receive a response to synthetic hormones to develop and ovulate. Then after the broodstock recovers, it can be immediately spawned again for the rest oocyte (Marimuthu & Haniffa 2010).

The overall maturity stage of the snakehead was MS III, while the proportion of MS IV was the most during the rainy season. The gonadosomatic index (GSI) of the rainy season tend-

ed to be higher and overall ranges from 1.52 to 3.54. These results indicated that every month there was available some snakehead to spawn, and the peak of spawning season was coinciding with the rainy season. This result was in accordance with the snakehead spawning pattern in the flood area of the Musi river (Makmur *et al.* 2003) and in the Bantimurung River in Maros district (Irmawati *et al.* 2017) and several other places. Snakehead has a partial spawning pattern that lasts a long time by ovulating mature oocytes. Monthly both male and female were in gonadal maturity to spawn (Mahmud *et al.* 2016). This condition was thought to compensate for the high larvae and juvenile phase mortality (Yulintine *et al.* 2017) due to predation or starvation.

The snakehead fecundity in this study ranged from 2,843 - 23,230 eggs with an average of 9,167 eggs. This result was relatively similar to previous researchers that found the snakehead fecundity ranged from 1,282-20,035 eggs (Puspaningdiah *et al.* 2014). The snakehead fecundity in the Sambujur River Barito flood area ranged from 621-15,430 eggs (Makmur & Prasetyo 2006), while the snakehead fecundity in the Musi River Basin ranged from 7,141-16,486 eggs (Makmur *et al.* 2003). The total fecundity of the snakehead in Lake Tempe ranged from 1,062-57,200 eggs (Harianti 2012). The fecundity of snakehead in Lake Tempe was relatively more, it supposed due to the oocyte diameter was smaller (0.2000 - 0.9247 mm). Snakeheads that have smaller oocytes will have more fecundity. Snakehead in Lake Rawa Pening has an average diameter of a larger oocyte, and this was thought to be due to the type and availability of abundant prey. The habitat under the hyacinth bunch was a hiding place for fish

and shrimp. Snakehead, when taking shelter under a bunch of hyacinths could prey on the abundant available fish and shrimp. Larger diameter oocytes have more feed reserves, so larger oocyte diameters have better survival (Effendie 2002).

Fish that get enough nutrients or feed would be able to produce more oocytes (Mohan-ty *et al.* 2017), so fish fecundity reached the maximum during the spawning season (Effendie 2002). Fluctuations in fecundity could also be caused by differences in the size of total length and body weight that were not the same, so fish that have a size of total length and greater weight would have more fecundity.

The 50% length of the first gonads matured of the snakehead was 315 mm, while the female average snakehead length of captured was 366 mm and the male was 330 mm. This shows that the snakehead was caught in the juvenile stage to adulthood, so the minimum length of the fish caught needs to be raised, so that the fish caught was mature or at least have spawned once (King 2003). Water hyacinth and other aquatic weed were ideal for snakeheads habitats. Catching snakehead in waters that have a lot of water hyacinth cover will get fish from young to adult. In Lake Rawa Pening, many snakeheads were caught by widik, a type of fishing gear, lift nets, and traps. The management that needs to be done is capturing the mature and passing the young to grow bigger. This can be done by adjusting the space between the blades in the Widik fishing gear, increasing the opening of the mesh net and increasing the escape space in the trap. The size of the space between the bamboo blades in the Widik and other types of fishing gear can be increased by 10% to increase the average catch (King 2003).

The socialization to the shareholder is intended to capture snakeheads that have been properly captured, so that the snakehead can reproduce to preserve the population in the waters of Lake Rawa Pening.

## Conclusion

In Lake Rawa Pening, snakehead has an isometric growth pattern. The gonadosomatic ratio in broodstock ready for spawning was low. GSI in the rainy season was higher than in the dry season. Oocyte fecundity and relative fecundity were low. Relative fecundity tends to decrease with increasing length or weight. Oocyte diameter size was medium. Oocyte diameter distribution has one size group and has total spawning patterns. In the spawning season, mature oocytes were ovulated, while young ones develop and spawn the following season. Every month there was broodstock ready to lay eggs, and it was estimated that peak spawning occurs during the rainy season. The first spawning broodfish was expected to have a length of 31.5 cm.

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