CLSU International Journal of Science and Technology
www.clsu-ijst.org
ISSN 2507 -9638 (online)
The CLSU International Journal of Science and Technology was previously published as CLSU Scientific Journal since 1965.

Evaluation of the Influence of Sex Composition on the Growth, Survival, and Cannibalistic Behavior of African Catfish (*Clarias gariepinus*) Juveniles

Elmar P. Egarta[1], Hazel Monica M. Peralta[1,2], Emmanuel M. Vera Cruz[1,2], Karl Marx A. Quiazon[1,2]

[1]Department of Aquaculture, College of Fisheries, Central Luzon State University, Nueva Ecija, Philippines
[2]Freshwater Aquaculture Center, Central Luzon State University, Nueva Ecija, Philippines

Email for correspondence: hazelperalta@clsu.edu.ph

Submitted: September 28, 2023. Accepted: October 8, 2024. Published Online: October 14, 2024.

Abstract

Significant losses due to cannibalism are one of the issues in farming predatory fishes like African catfish. In this study, the influence of sex composition on the cannibalistic behavior of African catfish was analyzed along with the growth and survival. There were two treatments and control for the experiment namely, all-male group (masculinized), all-female group (feminized), and mix-sex culture. The highest percentage of cannibalism was observed in the masculinized group (T1) with 40.67 ± 7.02% compared with the feminized group (20.67 ± 1.15%) and control group (32.0 ± 11.13%). However, no significant difference between the control group and the masculinized group existed. In terms of survivability, the feminized group has the highest percentage (79.33 ± 1.15%) of survival compared to the masculinized group (59.33 ± 7.02%) and control (68.0 ± 11.13%). Similarly, there was no significant difference between the masculinized group and control group. In terms of aggressive behavior, the highest ($p<0.05$) percentage of aggressiveness was observed among all male African catfish (38.72 ± 6.79%) as compared to all females (28.83 ± 6.71%) and mixed groups (35.67 ± 7.95%). At the end of the experiment, the masculinized group achieved the highest ($p<0.05$) average final weight of 40.16 ± 3.22g followed by the feminized group (35.41 ± 3.0g) and control (34.23 ± 2.93g). Likewise, the masculinized group also showed the highest ($p<0.05$) SGR with 7.46 ± 0.08 compared to both the feminized group 7.14 ± 0.02 and the control 7.07 ± 0.05. The results proved that all male African catfish have better growth than all-female group, however, male African catfish exhibit more aggression and cannibalistic behavior compared to females.

Keywords: Aggression, Cannibalism, Feminized, Masculinized, Mixed-sex

Introduction

Aggression and cannibalism are among the leading problems in African catfish aquaculture which leads to negative economic effects in the commercial hatcheries and in the grow-out culture of this species (Mehrim et al., 2014). Aggression and cannibalism are interrelated and this behavior is present in all types of African catfish. Cannibalism has two known categories according to the incidence; type I or "tail first" cannibalism and type II or "head first" cannibalism. Type I cannibalism is usually present among siblings that have approximately equal sizes where the predator cannot consume the prey entirely. This happens when the young fish weigh 0.006-0.9 g/individual, while type II cannibalism usually occurs when there is a presence of a predator that overweighs the prey, being about 0.9-4.6 g/individual (Bologan, 2011).

The usual strategy to avoid or lessen this incidence is grading. In the study of Biu et al. (2015), grading done on a weekly basis gathered an 85% survival in reared catfish. But grading on a weekly basis is impractical for it is labor-intensive and induces stress. Therefore, finding a more efficient way to reduce aggression and cannibalism in African catfish is needed. It is proved by literature that the monosex culture of one species promotes higher growth rates and greater uniformity in sizes (Beardmore et al., 2001) thus preventing heterogeneity in sizes that often leads to social dominance resulting in aggressive behavior and cannibalistic responses (Baras & Jobling, 2002).

The choice of sex is totally dependent on the species under consideration, but regardless of male or female, the reduced variety of size at harvest and intermediate stages of growth is a highly desirable feature in aquaculture (Beardmore et al., 2001). This will lessen the need for constant grading which is usually a practice in catfish culture mainly to avoid depletion of the stock.

This will also reduce the stress on the fish caused by frequent grading and save labor (Beardmore et al., 2001). The aim of the present study is to evaluate the influence of sex composition on the growth, survival, and cannibalistic behavior of African catfish juveniles.

Materials and Methods

Experimental Layout

The experiment was laid out in a completely randomized design. It was composed of two treatments (T1 and T2) and a control, all replicated three times. Treatment 1 was the all-male or masculinized group, treatment 2 was the all-female or feminized group, and the control was composed of mixed-sex African catfish juveniles.

Experimental Procedure

A total of 450 catfish juveniles were used in the experiment (150 masculinized, 150 feminized, and 150 mixed culture or non-sex-reversed). The fish were transferred and placed accordingly in a 100-liter capacity plastic tank with 80 liters of water at 50 fish per tank or 1.6pcs/L. A total of nine tanks were used in the experiment. The experiment was conducted in an outdoor hatchery facility. After stocking, the fish were first acclimatized in their tanks for 24 hours before feeding and monitoring.

Mortality during the acclimatization period was replaced with reserved fingerlings. The feeding and monitoring started after 24 hours of acclimatization. The fish in each treatment group along with its replicates was fed with commercial feeds in ad libitum. Feeding was done four times a day at 8:00 am, 12:00 pm, 4:00 pm, and 8:00 pm. The fish was reared and observed for 40 days, and the data on growth, survival, and cannibalistic behavior was gathered.

The water quality parameters (dissolved oxygen, temperature, pH, and ammonia) were also monitored daily at 8:00 am in the morning and 4:00 pm in the afternoon. Mortality was counted, and dead individuals were removed from the tanks daily before feeding and examined under a microscope for any signs of injuries in order to categorize if the mortality was due to natural occurrence or cannibalism.

At the end of the experiment, the fish were weighed and counted to determine their growth and survival.

DOI: https://doi.org/10.22137/ijst.2024.v8n1.04

Recording of Fish Aggression

A video recording camera with 108 megapixels, motion sensitivity, and night vision was used to record the fish's behavior. The tank water was replenished daily by at least 30% through overflow to maintain visibility of the water in order to facilitate clear observation of the fish. Prior to recording, the tank water was reduced to half.

The recording was done for 5 minutes before feeding and 5 minutes during feeding following the method of Putri et al. (2020) at 8:00 – 10:00 pm daily. Aggression or attack is considered when the resting or calmly swimming fish is in sudden aggressive contact with any part of the body or crashes against another fish (Mukai, 2013).

Data Gathered

The water quality parameters such as dissolved oxygen (mg/l), temperature (0C), pH, and Ammonia (ppm) were measured daily throughout the study period. Other parameters measured were computed using the following formulas:

Percentage mortality (%) (Siregar et al., 2020)

$$= \frac{Number\ of\ fish\ died}{Number\ of\ fish\ stocked}\ x\ 100$$

Survival rate (%) (Putri et al., 2020)

$$= 100\% - Percentage\ mortality$$

Cannibalism (%) (Putri et al., 2020)

$$= \frac{no.of\ fish\ missing + injured}{Number\ of\ fish\ stocked}\ x\ 100$$

Aggressive behavior (%) (Putri et al., 2020)

$$= \frac{no.of\ observed\ aggression}{no.\ of\ observed\ fish}\ x\ 100$$

Specific Growth rate (%/day) (Siregar et al., 2020)

$$= \frac{Ln\ Final\ weight - Ln\ Initial\ weight}{Time}\ x\ 100$$

Analysis of Data

All the dependent variables (water quality parameters, percentage mortality, survival rate, specific growth rate, cannibalism, and aggression) were compared across treatments using analysis of variance (ANOVA) for completely randomized design using SAS On Demand for Academics. Comparison among means of variables with $p < 0.05$ was conducted using Tukey's honest significant difference (HSD) test

Results and Discussion

Cannibalism, Survival, and Aggression

The results on cannibalism, survival, and aggression showed a significant difference among treatments ($P<0.05$). Throughout the study, it is observed that every dead individual was injured, had bite marks, and missing body parts, therefore, there is no recorded natural mortality in the experiment. All mortality is presumably due to cannibalism. Cannibalism was counted as; injured larvae + missing larvae. The percentage of cannibalism in the masculinized group (T1) (40.67 ± 7.02%) showed to be significantly higher than the feminized group (T2) (20.67 ± 1.15%) but no significant difference with the control (32.0 ± 11.13%) (Table 1). In terms of survival, the feminized group (79.33 ± 1.15%) showed to be significantly higher than the masculinized group (59.33 ± 7.02%) but no significant difference from the control (68.0 ± 11.13%) (Table 1).

On the other hand, the highest percentage of aggressive behavior was seen in the masculinized group with 38.72 ± 6.79% followed by the control group (35.67 ± 7.95%) and the feminized group (28.83 ± 6.71%) (Table 1).

Table 1. Percentage of cannibalism, survival, and aggression of masculinized, feminized, and mixed-sex African catfish reared for 40 days.

Parameters (%)	Treatments			
	Control	T1	T2	F value
cannibalism/ mortality	32.0 ± 11.13^{ab}	40.67 ± 7.02^{a}	20.67 ± 1.15^{b}	5.18 *
- survival	68.0 ± 11.13^{ab}	59.33 ± 7.02^{b}	79.33 ± 1.15^{a}	5.18*
- aggression	35.67 ± 7.95^{b}	38.72 ± 6.79^{a}	28.83 ± 6.71^{c}	59.74**

Different superscripts in the same row indicate significant difference (P<0.05).
Note: Control (mixed-sex); T1 (masculinized); T2 (feminized)

Cannibalism is a significant issue in the commercial production of many fishes, particularly in predatory species where it is mostly observed in the families of *Clariidae* (to which African catfish belong), *Esocidae*, *Percidae*, *Characidae*, *Latidae*, and *Gadidae* (Hecht & Appelbaum, 1988; Smith & Reay, 1991; Hecht & Pienaar, 1993; Qin et al., 2004). Cannibalism is a type of feeding strategy through predation that involves killing and consuming individuals of the same group which is denoted by mortality caused by injuries or missing individuals that are totally consumed (Naumowicz et al., 2017). In this study, every dead larvae exhibit injuries, bite marks, and missing body parts. Some individuals were also missing, presumably eaten by other individuals.

The result of the study demonstrates the effect of sex composition on cannibalism which is linked with the aggression that will affect the survival rate of the fish. It appears that the masculinized catfish population exhibits a high percentage of cannibalism (40.67 ± 7.02) and aggression (38.72 ± 6.79) compared to the feminized catfish population which has significantly lower cannibalism (20.67 ± 1.15) and aggression (28.83 ± 6.71). In line with this, the survival rate of masculinized catfish (59.33 ± 7.02) became significantly lower compared to the feminized (79.33 ± 1.15) group.

These results were in agreement with the study of Nitithamyong (1989), Forsatkar et al. (2013), and Zairin et al. (2016) who reported that the increase in testosterone level induced by 17α-methyltestosterone can conceivably increase the aggressiveness of *Oreochromis aureus* and *Betta splendens*. The aggressiveness of fish that leads to cannibalism is an effect of neuromodulators that is facilitated by increased levels of testosterone (Kania et al., 2012; Forsatkar et al., 2013).

In African catfish, the increased aggression caused an increase in cannibalism, resulting in lower survival of the fish. On the other hand, the feminized catfish showed significantly lower cannibalism and aggression compared to the masculinized population, resulting in a higher survival rate. These findings were in agreement with the results of Siregar (2017) and Putri et al. (2020) who reported that elevating the level of estrogen or female hormone in catfish seeds through 17β-estradiol can significantly reduce cannibalism.

Stress can also trigger aggressiveness in fish and estrogens are known to reduce stress (Calmarza-Font et al., 2012). Estradiol is also used to inhibit anxiety in various animal species because of its ability to boost serotonin levels (Walf & Frye, 2009). Krol & Zakes (2016) reported that the increase of serotonergic activity in the brain of pikeperch larvae (*Sander lucioperca*) decreases the incidence of aggression and cannibalism of the fish. In this study, the low level of cannibalism is associated with a low incidence of aggression exhibited by the feminized catfish. These in return resulted in a higher percentage of survival

Growth performance

The results of the growth performances of the treatments and control showed a highly significant difference among treatments (P < 0.01). The initial weight for the control, treatment 1, and treatment 2 is 2.02 ± 0.10g, 2.03 ± 0.10g, and 2.04 ± 0.13g respectively. At the end of the experiment, the masculinized group showed to have the highest final weight value at 40.16 ± 3.22g which shows a significant difference from the feminized group and a highly significant difference from the control (Table 2).

On the other hand, the feminized group with a final weight value of 35.41 ± 3.0g also showed a significant difference from the control group with a 34.23 ± 2.93g final weight value. In relation to this, the masculinized group (7.46 ± 0.08) showed to be significantly higher than the feminized group (7.14 ± 0.02) and the control (7.07 ± 0.05) (Table 2).

Table 2. Growth performance of masculinized, feminized, and mixed-sex African catfish reared for 40 days.

Parameters	Treatments			
	Control	T1	T2	F value
Initial weight	2.02 ± 0.10	2.03 ± 0.10	2.04 ± 0.13	_
Final weight	34.23 ± 2.93^{c}	40.16 ± 3.22^{a}	35.41 ± 3.0^{b}	99.68 **
SGR (%/day)	7.07 ± 0.05^{b}	7.46 ± 0.08^{a}	7.14 ± 0.02^{b}	37.84 **

Different superscript in the same row indicates significant difference (P<0.01).
Note: Control (mixed-sex); T1 (masculinized); T2 (feminized)

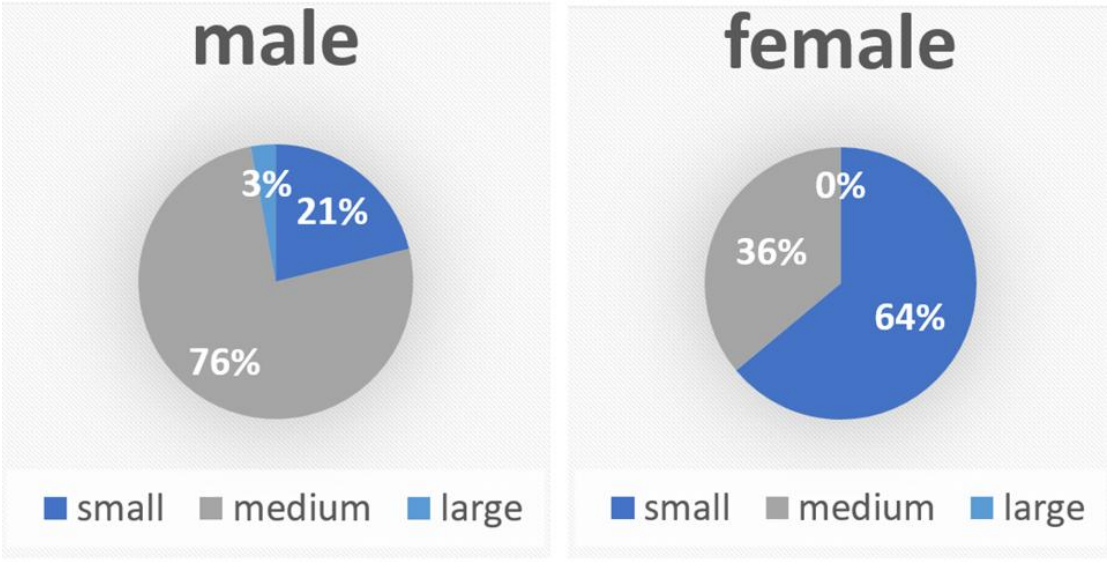

Figure 1. Size distribution of male and female catfish.

Table 3. Water quality parameters of masculinized, feminized, and mixed-sex African catfish reared for 40 days.

Treatments	Water quality parameters			
	Temperature (°C)	pH	DO (mg L^{-1})	Ammonia (mg L^{-1})
Control	27.05 ± 1.09	6.90 ± 0.23	3.81 ± 0.45	0.38 ± 0.40
T1	26.67 ± 3.29	6.84 ± 0.15	3.87 ± 0.45	0.30 ± 0.38
T2	26.89 ± 1.16	6.85 ± 0.21	3.72 ± 0.53	0.31 ± 0.34
References	22 – 35 °C (Akinyemi, 1988)	6.5 – 9.0 (Boyd & Tucker, 1998)	3.0 – 8.0 (Akinwole & Akinnuoye, 2012)	<4 (Stone & Thomforde, 2004)

Note: Control (mixed-sex); T1 (masculinized); T2 (feminized)

The result of this study also proved that male catfish grow faster than female. The masculinized group showed to have a significantly higher final weight and specific growth rate (40.16 ± 3.22g; 7.46 ± 0.08g) than the feminized group (35.41 ± 3.0g; 7.14 ± 0.02g) and control (34.23 ± 2.93g; 7.07 ± 0.05g). According to Dekimpe & Micha (1974), male African catfish grow larger than females due to the anabolic effect of androgen on the fish.

Androgen encourages the production of flesh and male sexual characteristics of the fish thereby improving its growth by redirecting the use of energy for reproduction into muscle growth (Enuekwe & Okonji, 2019). In an all-male culture, the conversion of feed is more effective due to the fact that the energy is used only for growth and not for reproduction (Kamler, 2012).

On the other hand, feminized catfish are relatively smaller than males which can be attributed to the negative effect of estrogens on fish metabolism and liver functions (Haux & Norberg, 1985; Washburn et al., 1993; Shved et al., 2007).

In the study of Krol et al. (2014), all estrogen-treated European catfish (*Silurus glanis*) have significantly lower body weight than the non-estrogen-treated group. In the study of Gannam & Lovell (1991), channel catfish fed with a diet associated with 17β-estradiol showed slower growth compared to other groups. While depressed growth was also observed in estrogen-treated fish like halibut and sunshine bass (Hendry et al., 2003; Davies & Ludwig, 2004).

These findings prove that estrogens – a hormone that is abundant in female fish can cause a slower growth rate in African catfish. In support of this, the size distribution of both hormones showed that the masculinized group had a higher number of medium-sized juveniles than the feminized group (Figure 1). On the other hand, the feminized group has more small sizes juveniles than the masculinized group (Figure 1).

Water Quality

All the collected water parameter measurements were in the acceptable range throughout the study period (Table 3). There were no significant differences observed among the treatments (Table 3).

Conclusion

The study proved that male African catfish have better growth compared to females and the use of the androgen 17α-methyltestosterone can boost the fish's growth. However, male African catfish showed to be more aggressive than females which promotes cannibalism, higher mortality, and lower survival. On the other hand, female African catfish were shown to be less aggressive, therefore having lesser cannibalism, and thereby achieving a higher survival rate. Normally, the use of hormonal sex reversal is done in order to produce one sex that grows faster and has a higher survival rate. But in the case of African catfish, males tend to grow faster but females have higher survival rates.

Acknowledgement

The DOST-ASTHRDP program is gratefully acknowledged for the scholarship and research funding provided for this study. The author would also like to acknowledge the faculty and staff of the Freshwater Aquaculture Center/College of Fisheries Central Luzon State University for their support of this study. The author also expresses his acknowledgment to the Institute of Fisheries and Aquatic Sciences of Bataan Peninsula State University for the facilities and tools used for this study as well as the support from student researchers.

References

Akinwole, A. O., & Faturoti, E. O. (2007). Biological performance of African Catfish (*Clarias gariepinus*) cultured in recirculating system in Ibadan. *Aquacultural engineering*, *36*(1), 18-23.

Baras, E., & Jobling, M. (2002). Dynamics of intracohort cannibalism in cultured fish. *Aquaculture research*, *33*(7), 461-479.

Beardmore, J. A., Mair, G. C., & Lewis, R. I. (2001). Monosex male production in finfish as exemplified by tilapia: applications, problems, and prospects. *Reproductive biotechnology in finfish aquaculture*, 283-301.

Biu, A. A., Mohammed, G. A., Yachilla, B. K. M., Modu, B. M., Wakil, U. B., Mai, A. M., ... & Adarju, M. B. (2015). Effects of sorting on cannibalism in Catfish (*Clarias gariepinus*) rose in concrete tanks in maiduguri, North-Eastern Nigeria. *Animal and Veterinary Sciences*, *3*(2), 67-73.

Bologan, R. G. (2011). *Breeding of African Catfish (Clarias gariepinus Burchell, 1822) and Diseases Encountered in Monoculture* (Doctoral dissertation, University of Agricultural Science and Veterinary Medicine CLUJ – NAPOCA.)

Calmarza-Font, I., Lagunas, N., & Garcia-Segura, L. M. (2012). Antidepressive and anxiolytic activity of selective estrogen receptor modulators in ovariectomized mice submitted to chronic unpredictable stress. *Behavioural Brain Research*, *227*(1), 287-290.

Davis, K. B., & Ludwig, G. M. (2004). Hormonal effects on sex differentiation and growth in sunshine bass *Morone chrysops*× *Morone saxatilis*. *Aquaculture*, *231*(1-4), 587-596.

De Kimpe, P., & Micha, J. C. (1974). First guidelines for the culture of *Clarias lazera* in Central Africa. *Aquaculture*, *4*, 227-248.

Enuekwe, R. C., & Okonji, V. A. (2019). Effects of dietary 17-methyl testosterone on sex reversal and growth performance of African mud catfish (*Clarias gariepinus*). *Niger J Fish*, *16*, 1806-12.

Forsatkar, M. N., Abedi, M., Nematollahi, M. A., & Rahbari, E. (2013). Effect of testosterone and fluoxetine on aggressive behaviors of fighting fish, *Betta splendens*. *International Journal of Aquatic Biology*, *1*(6), 289-293.

Gannam, A. L., & Lovell, R. T. (1991). Effects of feeding 17α-methyltestosterone, 11-ketotestosterone, 17β-estradiol, and 3, 5, 3′-triiodothyronine to channel catfish, *Ictalurus punctatus*. *Aquaculture*, *92*, 377-388.

Haux, C., & Norberg, B. (1985). The influence of estradiol-17β on the liver content of protein, lipids, glycogen and nucleic acids in juvenile rainbow trout, *Salmo gairdnerii*. *Comparative Biochemistry and Physiology Part B: Comparative Biochemistry*, *81*(2), 275-279.

Hecht, T., & Appelbaum, S. (1988). Observations on intraspecific aggression and coeval sibling cannibalism by larval and juvenile *Claias gariepinus* (Clariidae: Pisces) under controlled conditions. *Journal of zoology*, *214*(1), 21-44.

Hecht, T., & Pienaar, A. G. (1993). A review of cannibalism and its implications in fish larviculture. *Journal of the World Aquaculture Society*, *24*(2), 246-261.

Hendry, C. I., Martin-Robichaud, D. J., & Benfey, T. J. (2003). Hormonal sex reversal of Atlantic halibut (*Hippoglossus*

hippoglossus L.). *Aquaculture*, *219*(1-4), 769-781.

Kamler, E. (2012). *Early life history of fish: an energetics approach* (Vol. 4). Springer Science & Business Media.

Kania, B. F., Zawadzka, E., & Dębski, B. (2012). Neurohormonal basis of aggression in fish. *Medycyna Weterynaryjna*, *68*(4), 195-198.

Król, J., Pobłocki, W., Bockenheimer, T., & Hliwa, P. (2014). Effect of diethylstilbestrol (DES) and 17 β estradiol (E2) on growth, survival and histological structure of the internal organs in juvenileEuropean catfish *Silurus glanis* (L.). *Aquaculture International*, *22*, 53-62.

Król, J., & Zakęś, Z. (2016). Effect of dietary L-tryptophan on cannibalism, survival and growth in pikeperch *Sander lucioperca* (L.) post-larvae. *Aquaculture International*, *24*, 441-451.

Mehrim, A. I., Abdelhamid, A. M., Radwan, I. A., & Abdelhamid, A. F. (2014). Comparative study for different sources of reproductive stimulating materials and their effects on the reproductive performance of African catfish *Clarias gariepinus* (Burchell, 1822). *Asian Journal of Animal and Veterinary Advances*, *9*(7), 414-427.

Naumowicz, K., Pajdak, J., Terech-Majewska, E., & Szarek, J. (2017). Intracohort cannibalism and methods for its mitigation in cultured freshwater fish. *Reviews in Fish Biology and Fisheries*, *27*, 193-208.

Nitithamyong, C. (1989). Bioenergetics approach to the study of anabolic effects of 17alpha methyltestosterone in blue tilapia, *Oreochromis aureus*.

Putri, H. K., Zairin Jr, M., Carman, O., & Diatin, I. (2020). The use of different 17β-estradiol hormone doses and water temperatures to control cannibalism in catfish *Clarias gariepinus* seed. *Jurnal Akuakultur Indonesia*, *19*(2), 171-180.

Qin, J. G., Mittiga, L., & Ottolenghi, F. (2004). Cannibalism reduction in juvenile barramundi *Lates calcarifer* by providing refuges and low light. *Journal of the World Aquaculture Society*, *35*(1), 113-118.

Shved, N., Berishvili, G., D'Cotta, H., Baroiller, J. F., Segner, H., Eppler, E., & Reinecke, M. (2007). Ethinylestradiol differentially interferes with IGF-I in liver and extrahepatic sites during development of male and female bony fish. *Journal of Endocrinology*, *195*(3), 513-524.

Siregar, K. N., Maulana, F., Zairin Jr, M., Alimuddin, A., & Widanarni, W. (2021). Controlling the cannibalism of African catfish juvenile by 17β–estradiol hormone administration and the stocking density determination. *Jurnal Akuakultur Indonesia*, *20*(1), 72-81.

Angilletta, Jr, M. J., & Dunham, A. E. (2003). The temperature-size rule in ectotherms: simple evolutionary explanations may not be general. *The American Naturalist*, *162*(3), 332-342.

Stone, N. M., & Thomforde, H. K. (2004). *Understanding your fish pond water analysis report* (pp. 1-4). Cooperative Extension Program, University of Arkansas at Pine Bluff, US Department of Agriculture and county governments cooperating.

Walf, A. A., & Frye, C. A. (2009). Effects of two estradiol regimens on anxiety and depressive behaviors and trophic effects in peripheral tissues in a rodent model. *Gender medicine*, *6*(1), 300-311.

Washburn, B. S., Krantz, J. S., Avery, E. H., & Freedland, R. A. (1993). Effects of estrogen on gluconeogenesis and related parameters in male rainbow trout. *American Journal of Physiology-Regulatory,*

Integrative and Comparative Physiology, *264*(4), R720-R725.

Zairin Jr, M., Rahmawati, N. R., & Maulana, F. (2016). Aggressiveness and growth of male Siamese fighting fish treated with different dose and duration of 17α-methyltestosterone immersion. *Aquaculture, Aquarium, Conservation & Legislation*, *9*(6), 1364-1371.