Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(3): 2739 – 2753 (2025)
www.ejabf.journals.ekb.eg

Morphometric Traits and Reproductive Performance of the Nile Tilapia (*Oreochromis niloticus*): A Study of Condition Factor and Egg Production Across Broodstock Weight Classes

Nasuki[1*], Putri Nurhanida Rizky[1], Dinno Sudino[2], Mohsan Abrori[3], Nazran[1], Ari Kiswanto[3]

[1]Department of Aquaculture Engineering, Sidoarjo Marine and Fisheries Polytechnic, Indonesia
[2]Department of Aquaculture, Pangandaran Marine and Fisheries Polytechnic, Pangandaran, Indonesia
[3]Department of Aquaculture, Jembrana Marine and Fisheries Polytechnic, Jembrana, Bali, Indonesia
[*]**Corresponding Author: caknash64@gmail.com**

ARTICLE INFO

Article History:
Received: May 2, 2025
Accepted: June 6, 2025
Online: June 18, 2025

Keywords:
Kekar Tilapia,
Morphometrics,
Condition factor,
Egg production

ABSTRACT

The Kekar tilapia strain has more aggressive and territorial characteristics. Its fast growth, level of disease resistance, and meat structure that is softer than other tilapia strains, make this strain one of the freshwater tilapia strains that have been widely cultivated. This study aimed to analyze the relationship between morphometric characters and egg production in Kekar tilapia. Six weight groups of stocked tilapia broodstock were used in this study, with weights of 350, 450, 1,100, 1,200, 1,300, and 1,700g, respectively. Calculating condition factors begins with determining the relationship between the length and weight of fish, which is used to determine the development of gonads, the percentage of feed that must be given, and the maturity level of fish. The results showed a positive correlation between broodstock size (length and weight) and the number of eggs produced. A Kekar tilapia weighing 1,200g can produce more eggs than Kekar tilapia weighing 1,100, 450, and 350g. Spawning frequency, food availability, and environmental conditions also affect the number of eggs. Regression modeling showed that increased weight and number of spawners could accurately predict increases in egg count, with larger Kekar tilapia producing more eggs in subsequent spawning periods

INTRODUCTION

Indonesia, as the largest archipelagic country in the world, holds significant potential for freshwater aquaculture due to its vast inland water resources, including rivers, lakes, reservoirs, and man-made ponds **(Hasan *et al.*, 2023; Nazran *et al.*, 2025)**. The tropical climate, year-round water availability, and growing domestic and export demand for fish have supported the rapid development of freshwater aquaculture as a key sector in national food security and economic growth **(Samara *et al.*, 2024**). Among the various commodities cultivated, freshwater species such as tilapia (*Oreochromis* spp.) **(Hasan *et al.*, 2019)**, catfish (*Clarias* spp.) **(Ihwan *et al.*, 2020; Saptadjaja *et al.*, 2020)**,

Indexed in Scopus ELSEVIER DOAJ IUCAT

snakehead **(Pratama *et al.*, 2020)**, common carp, and gourami **(Syofriani *et al.*, 2025)** dominate production volumes.

Tilapia (*Oreochromis niloticus*) is one of the freshwater fish species with great potential in aquaculture development **(Hasan & Tamam, 2019; Henish & Badrey, 2024)**. Historically, the Nile tilapia is native to Africa, particularly the Nile River basin, and was introduced to Indonesia in the 1960s through international aquaculture development initiatives aimed at improving protein sources and rural livelihoods **(Insani *et al.*, 2020; Nugroho *et al.*, 2023; Islami *et al.*, 2024)**. Since its introduction, *O. niloticus* has become one of the most widely cultivated fish species across the Indonesian archipelago due to its adaptability to diverse environmental conditions, rapid growth, and tolerance to variable water quality **(Hasan *et al.*, 2019; Serdiati *et al.*, 2021)**. Over the decades, Indonesian aquaculture has selectively bred and developed several tilapia strains tailored to local environments and market demands, including the Kekar (stocky) strain.

The Kekar tilapia strain is characterized by its fast growth, high level of disease resistance, and softer meat texture compared to other strains, making it a preferred option in freshwater aquaculture. Morphologically, Kekar tilapia tends to have a broader body and a flatter head relative to other strains, which usually exhibit a more elongated form. Its head is relatively large with a wide mouth, and it exhibits more aggressive and territorial behavior, especially during feeding **(Musadar *et al.*, 2021)**.

Success in fish farming is not only influenced by factors such as environmental conditions, pond management, and feed but also largely depends on the morphometric characteristics of the fish and genetic **(Darmadi *et al.*, 2024; Irmawati *et al.*, 2024; Robledo *et al.*, 2024)**. Morphometric characteristics such as total length, body weight, as well as the proportion of various body parts, can affect fish growth, survival, and productivity **(Schneider *et al.*, 2000)**. Previous research has revealed that morphometric variations in fish can significantly impact various aspects of biology, including the reproductive process **(Wahana *et al.*, 2021; Fadli *et al.*, 2022; Kwikiriza *et al.*, 2023)**.

The specific relationship between morphometry and egg production in the stocky tilapia must still be fully understood. Therefore, this study aimed to investigate the morphometric variation of Kekar tilapia on egg production. The output of this study is expected to be used as an effective and sustainable farming strategy and to improve the quality and quantity of stocked Kekar tilapia in the global market.

.

MATERIALS AND METHODS

1. Time and place

This research was conducted for 3 months, from the spawning period of the broodstock to the observation of the hatching of Kekar tilapia broodstock, from June to September 2024 at Hatchery Nila Kekar (HNK) Pasuruan, East Java. This research is an experimental study using two designs, namely a completely randomized design to determine the real difference in morphometric diversity or Coefisien Varian (CV) in six groups of Kekar tilapia with three replications. Groups under study were: group 1 (350g), group 2 (450g); group 3 (1,100g); group 4 (1,200g); group 5 (1.300g); and group 6 (1,700g). Regression and correlation analysis determines the relationship or influence between all morphometric characters and egg production.

2. Kekar tilapia fish

The strain of Kekar tilapia used in this study is the result of spawning from HNK Pasuruan with code 015, which is the result of a cross of Male Kekar tilapia 010 from KJA Grati with Female tilapia of Gesit and Sultana Strain. The Kekar tilapia broodstock used has passed various series of broodstock selection such as the level of gonad maturity, round body posture with a back higher than the head, body thickness greater than head thickness, and sound production growth. The stock weight used in this study varied between 350 grams, 450 grams, 1.100 grams, 1.200 grams, 1.300 grams, and 1.700 grams.

3. Morphometric test

The measurement of morphometric character is carried out by determining a definite reference point (landmark) on the body of the test fish **(Sari & Elvyra, 2018)**. The reference points are connected to get a picture of the fish's body plane (body conformation) and measured using a metric scale (**Kusmini *et al.*, 2017**). Morphometric measurements were taken at one month of rearing in the pond, including total length, standard length, parent weight, dressing, head length, tail length, and fatness **(Wijayanti *et al.*, 2017)**.

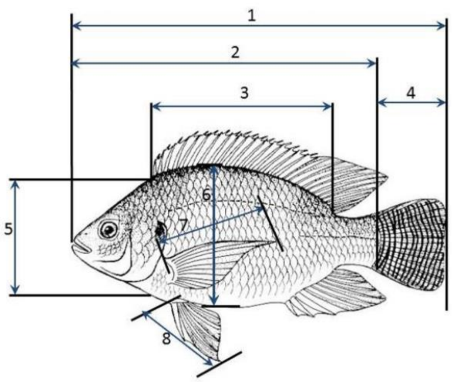

Fig. 1. Morphometric measurements of tilapia *O. niloticus*: 1. Total length, 2. Standard length, 3. Dorsal fin length, 4. Caudal fin length, 5. Head length, 6. Body width, 7. Pectoral fin length, 8. Pelvic fin length

4. Fish length and weight relationship (HPB)

The calculation of the condition factor starts with determining the relationship between length and weight of the fish using the equation:

$$W = aL^b$$

Where, W = fish weight (grams), L = total length (cm), a = constant, dan b = exponent with values between 2 – 5.

The values of W and L are transformed into logarithmic equations **(Schneider *et al*., 2000)**, as follows:

$$\log W = \log a + b \log L$$

To determine whether the value of b is equal or different from 3, the t test was used. The calculation of the t value (t^) was done using the following equation **(Pauly, 1984)**:

$$t^{\wedge} = \frac{sdx}{sdy}\frac{lb - 3l}{\sqrt{1 - r^2}} - \sqrt{n-2}$$

Where, sdx is the standard deviation of the log L value, sdy is the standard deviation of the log W value, and n is the number of samples. The value of b is different from 3 if the calculated t value (t^) is higher than the t table value at n-2 free degrees.

To find out the fish performance, in HPB there is also a condition factor (FC) to determine the level of fatness of the fish. HPB is allometric and isometric. The value of b in the equation above provides information about the growth pattern:

- Value b = 3 :isometric growth (fixed length and weight rasio)
- b value < 3 : negative allometric growth (weight increases slower than length)
- b value > 3 :positive allometric growth (weight increases faster than length).

5. Broodstock rearing and spawning

Broodstock rearing is conducted in round tarpaulin ponds with a diameter of 8m^3 and a height of 70m with a water level of 50m. Each pond was equipped with a central drain and aeration system. Broodstock was fed pellets with 30% protein content at satiation three times for 30 days. The spawning process is carried out naturally with a ratio of male and female broodstock of 1 : 4. During the spawning process, the male tilapia fish nests at the bottom of the pond edge, followed by a female tilapia fish with mature gonads. The female Kekar tilapia releases eggs then the male Kekar tilapia fish sprays his sperm so that fertilization occurs.

The female tilapia incubates fertilized eggs for 5 to 7 days. Tilapia are mouthbrooders, meaning the female carries the eggs in her mouth during incubation. Egg harvesting is performed on the 10th day after spawning, typically around 07:00 WIB, to minimize stress on the female.

During the egg harvesting process, the female tilapia is gently caught while she is still incubating the eggs. The eggs are carefully removed from her mouth and collected in a basin. The total number of eggs is then counted.

To determine the number and weight of the eggs produced, the female tilapia is weighed before and after egg removal. After counting, the eggs are returned to the spawning basin for hatching.

RESULTS

1. Morphometric characters of Kekar tilapia

The result of morphometric character measurements and the number of eggs can be seen in Table (1) below.

Table 1. Morphometric measurements and egg counts of Kekar tilapia broodstock

No	Weight average	Laying period	Number of eggs	Dressing			Overweight Index		
	Gram	Times	Grain	PS	PK	PS-PK	TB	PS	PS/TB
1	364±14,42	1	1076±32,7	26,12±3,74	5,88±1,40	20,2±2,38	9,58±0,4	26±3,7	2,75±0,5
2	461±11,7	3	2124±18	28,92±0,85	7,34±0,5	21,58±0,44	9,82±0,49	28,92±0,85	2,95±0,14
3	1124±18	16	4185±51,7	30,29±0,37	9,4±0,4	20,9±0,6	11,18±0,27	30,26±0,37	2,71±0,04
4	1212±8,3	17	4473,6±33,9	41,48±0,83	11,48±0,36	30±0,93	14,06±0,15	41,48±0,83	2,95±0,06
5	1309,8±3,56	12	4183,8±45	47,74±0,5	11,74±0,32	36,00±0,74	16,16±0,21	47,74±0,5	2,95±0,04
6	1713,4±4,56	7	4097,2±34,2	59,38±0,6	15,36±0,46	44,02±0,19	19,50±0,38	59,38±0,62	3,05±0,06

Fig. (2) shows the upward trend in the number of eggs of Kekar tilapia with an average brood weight of ±1.700 grams after several spawning periods (2, 5, and 7 times).

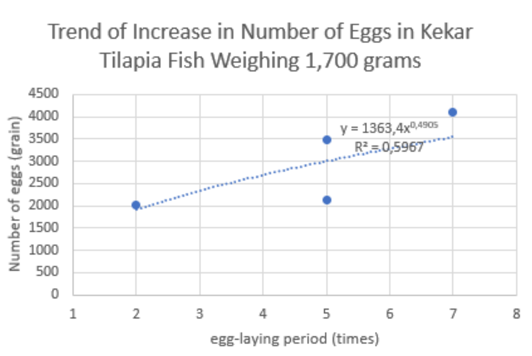

Fig. 2. Number of tilapia eggs with a weight of 1,700 grams

Fig. (3) shows the projeted number of eggs of Kekar tilapia with an average brood weight of ±1.700 grams after several spawning periods throug regression model calculations.

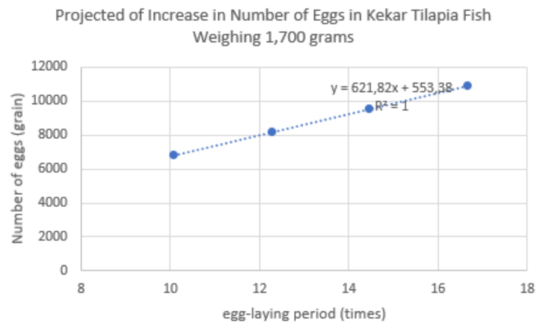

Fig. 3. Projected increase in the number of eggs of tilapia weighing ±1.700 grams after several spawning periods

The relationship between length and weight of fish can be used to determine the development of gonads, the percentage of feed that should be given, and the maturity level of fish. Analysis of the length–weight relationship of tilapia broodstock in this study is presented in Table (2) below.

Table 1. Analysis of the length–weight relationship of tilapia broodstock at different weight groups

No.	Parameter	Tilapia Broodstock Weight					
		350	450	1100	1200	1300	1700
1	Value of a (constant)	183,58	40,826	4089,3	487,29	2932,2	1720,5
2	Coefficient of determination	0,8405	0,8405	0,785	0,725	0,234	0,53
3	Regression value (b)	2,108	2,7207	3,79	2,448	2,08	1,10
4	FK	0,41	1,0001	0,81	0,99	0,99	0,99

2. Morphometric characters of Kekar tilapia

Table (2) shows that Kekar tilapia broodstock with an average weight of ±350 grams has a skinny condition factor (0.41).

Table 3. Regression analysis results of fatness index on egg production

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Fatness	50327.254	6529.610	10.389	7.708	.005
Fatness ** 2	-9936.457	1416.834	-9.453	-7.013	.006
(Constant)	-59392.920	7430.830		-7.993	.004

The relationship equation between fatness index and egg production resulting from regression analysis forms a quadratic Y = -9.936,4x2 + 50.327,25 x + (-59.392,9) with a coefficient of determination (R2) of 0,993 meaning that the estimated model can explain 99,3% of the actual model and a correlation coefficient (r) 0,997 meaning that there is a very close relationship of 99,7% between fatness index and egg production. The modeling formed by the quadratic equation between fatness index and egg production can be seen in the graph below.

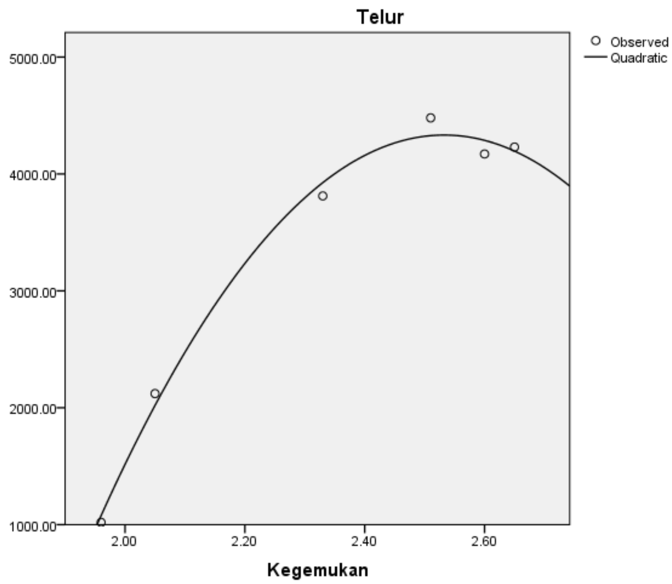

Fig. 4. Model graph of the relationship between fatness and egg production

Fig. (4) visualizes the model formed by the quadratic equation and depicts a parabolic curve. It can be explained that the highest egg production is achieved at a fatness value of 2.5 and decreases beyond this point as the fatness or growth rate increases.

DISCUSSION

The results of this study (Table 1) show morphometric character measurements of Kekar tilapia grouped by biomass weight class and spawning period. The data above illustrate that the weight of Kekar tilapia was produced by broodstock weighing 1212±8,3grams with 4473,6±33,9 of eggs, followed by broodstock weighing 1124±18 grams with 4185±51,7 eggs, broodstock weighing 1309,8±3,56 gram with 4183,8±45 eggs, 1713,4±4,56 grams with 4097,2±34,2 eggs, s461±11,7 grams with 2124±18 eggs, and 364±14,42 grams with 1076±32,7 eggs. However, there is a positive correlation between parent size (both length and weight) and the number of eggs produced. Larger fish broodstock usually have more energy reserves **(Izquierdo *et al.*, 2001)**. This energy is needed to make many eggs and for the egg maturation and spawning process **(Hernandez de-Dios *et al.*, 2022; Skjærven *et al.*, 2022; Bogevik *et al.*, 2024)**.

Therefore, Kekar tilapia weighing 1212±8,3 grams can produce more eggs when compared to Kekar tilapia broodstock weighing 1124±18 grams, 461±11,7 grams, and 364±14,42 grams.

In addition, several factors affect the number of fish eggs produced, among others: food availability (good quality and quantity of food) **(Volkoff *et al.*, 2018; Temesgen *et al.*, 2022)**, aquatic environmental conditions (temperature, water quality, and other environmental factors) **(Wild *et al.*, 2023)** that are by the standards of tilapia cultivation and hatcheries, and the frequency of fish spawning where the more often the fish spawns in a year, the more the number of eggs produced **(Campos-Mendoza *et al.*, 2004)**. This explains the low number of eggs produced by Kekar tilapia broodstock weighing 1713,4±4,56 grams, compared to Kekar tilapia broodstock weighing 1212±8,3 grams, 1124±18 grams, and 1309,8±3,56 grams. The Kekar tilapia weighing 1713,4±4,56 grams spawned seven times, while the Kekar tilapia weighing 1212±8,3 grams spawned 17 times, Kekar tilapia weighing 1124±18 grams spawned 16 times, and the Kekar tilapia weighing 1309,8±3,56 grams spawned 12 times.

Fig. (2) shows the upward trend in the number of eggs of Kekar tilapia with an average brood weight of ±1.700 grams after several spawning periods (2, 5, and 7 times). The R2 value is a statistical measure that shows the percentage of the dependent variable (number of eggs) that can be explained by the independent variable (spawning period). The tren value of the regression line shows that the R2 value is more significant than 0.5. This indicates that the regression model can explain more than 50% of the variation in the dependent variable. Therefore, this model can predict egg count values with a higher level of confidence (Fig. 3).

Fig. (3) shows the projeted number of eggs of Kekar tilapia with an average brood weight of ±1.700 grams after several spawning periods throug regression model calculations. Fig. (3) shows that the R2 value increases to 1, which is the maximum value that a coefficient of determination can achieve. This explains the positive relationship of the increase of Kekar tilapia eggs after several spawning periods. It is demonstrated that after 12 spawning periods, Kekar tilapia with a brood size of ±1.700 grams can produce ±8.179 eggs and ±10.906 eggs after 17 spawning periods. This shows that Kekar tilapia weighing ±1.700 grams can produce more eggs than Kekar tilapia weighing ±1.200 grams and ±1.300 grams after 12 and 17 spawning periods.

The relationshop between length and weight of fish can be used to determine the development of gonads, the precentage of feed that should be given, and the maturity level of fish. The relationship between length and weight of fish (HPB) is different in species depending on body shape and other factors such as the level of gonadal maturity and spawning **(Schneider *et al.*, 2000)**.

The coefficient of determination shows how the linear regression equation can predict fish weight values based on fish length vales. In Table (2), it is explained that the coefficient of determination for stocky tilapia weighing ±350 grams and ±450grams shows a high value of above 0,8 and above 0,7 at a weight of ±1.200 grams and ±1.300 grams. This indicats that the weight of the fish at an average of 350 grams, 450 grams, 1.100 grams, and 1.200 grams greatly affects the length of the fish. In addition, fish with an average weight of ±1.300 grams and ±1.700 grams have a relativel low coefficient of determination. This indicates that the larger the broodstock size of Kekar tilapia, its growth is strongly influenced by other factors, such as sex, age, environmental conditions, and genetic factors.

Condition factor is an index used to measure the fatness or thinness of an individual fish. Values above 1 indicate fish in fat or good condition, while values below 1 indicate fish in thin or imperfect condition. Table (2) shows that Kekar tilapia broodstock with an average weight of ±350 grams has a skinny condition factor (0.41). This is caused by factors such as lack of food, disease, or poor environmental conditions. Meanwhile, fish with an average weight of ±450 grams, ±1.100 grams, ±1.200 grams, ±1.300 grams, and 1.700 grams have an almost ideal condition factor. These data indicate that these fish have sufficient energy reserves and are healthy. This difference in the condition factor of some fish is caused by several factors, such as differences in age, sex, food availability, water quality, or the presence of disease **(Nugroho *et al.*, 2024)**. Morphometric character measurements are carried out by determining a definite reference point (landmark) on the body of the test fish **(Sari & Elvyra, 2018)**. The reference points are connected to get a picture of the fish's body plane (body conformation) and measured using a metric scale **(Kusmini *et al.*, 2013)**.

However, to support the sustainable development of Kekar Tilapia aquaculture, several directions for future research are essential. First, genetic analyses using molecular marker approaches should be conducted to identify genes or loci associated with superior morphometric traits and high reproductive performance **(Insani *et al.*, 2022; Valen *et al.*, 2022)**. This research will contribute to the development of more precise selection programs based on genetic and morphological traits **(Valen *et al.*, 2024)**. Second, the effects of feed formulation and nutritional composition on body morphology and egg productivity across different broodstock weight classes should be investigated **(Serdiati *et al.*, 2024; Islamy *et al.*, 2025)**. This aims to determine the specific nutritional requirements for each broodstock group. Third, gonadal histology and reproductive hormone profiling—such as estradiol and gonadotropin analyses—are needed to provide deeper insights into the physiological readiness and reproductive dynamics within each weight class **(Zulfahmi *et al.*, 2018)**. Fourth, assessments of larval quality and seed viability derived from broodstock with varying morphometric characteristics are necessary, including evaluations of larval growth rate and immune response **(Yossa *et al.*, 2024)**. Lastly, comprehensive broodstock health studies are required, encompassing hematological tests, immune status assessments, parasitic infections, and stress biomarkers, to evaluate the internal physiological condition of the fish **(Islamy *et al.*, 2024a, b; Kilawati *et al.*, 2024a, b)**. Such information is crucial for establishing selection standards for superior broodstock that integrate morphometric, reproductive, and health traits, thereby enhancing the effectiveness and sustainability of Kekar tilapia farming systems.

CONCLUSION

The results showed that morphometric characters, especially the broodstock's weight, significantly affected egg production, with the highest diversity in the 1,200-gram weight group. In addition, environmental factors, food availability, and spawning frequency also play a role in determining the number of eggs. The more often the fish spawn in a year, the greater the potential production. Regression modeling showed that increases in weight and number of spawners could accurately predict increases in egg count, with larger stocky tilapia producing more eggs in subsequent spawning periods. This study highlights the importance of morphometric characters in fish farming strategies, as larger fish are more efficient in reproduction. These results can be used to improve the quality and quantity of egg production on a commercial scale.

ACKNOWLEDGMENT

This research was generously supported by Politeknik Kelautan dan Perikanan Sidoarjo under Publication Grant sheme 2024 and the Ministry of Marine Affairs and Fisheries (BIMA KKP). The author would like to thank Hatchery Nila Kekar Pasuruan for supporting and contributing to this research.

REFERENCES

Bogevik, A.S.; Krasnov, A.; Burgerhout, E.; Berge, K.; Martinsen, I.; Hoel, E.; Erik Dalva, L.; Kilane, S.; Eriksen Vold, J.; Aarhus, B.; Østbye, T.K.; Rosenlund, G. and Morken T. Effect of prolonged feeding of broodstock diet with increased inclusion of essential n-3 fatty acids on maturing and spawning performance in 3-year-old Atlantic salmon (*Salmo salar*). Gen Comp Endocrinol., 348:114434.

Campos-Mendoza, A.; McAndrew, B. J.; Coward, K. and Bromage, N. (2004). Reproductive response of Nile tilapia (*Oreochromis niloticus*) to photoperiodic manipulation; effects on spawning periodicity, fecundity and egg size. Aquaculture, 231(1-4): 299-314.

Darmadi.; Hidayat, D.; Hendra, D.K.; Sutandi, L.; Risdianto, A.; Setyani, A.L.; Astuti.; Kasmono, Y.; Wargiatno.; Muktitama, A.M.; Rustadi.; Kurniasih, T.; Hayuningtyas, E.P.; Wahidah,; Amrullah. and Nugroho E. (2024). Comparative analysis of morphometric characters and genetic diversity of superior Nile tilapia, Tilapia niloticus, populations in Indonesia. AACL Bioflux, 17(6):2943-2953

Fadli, N.; Zhelfi, Z.; Damora, A.; Muchlisin, Z A.; Dewiyanti, I.; Ramadhaniaty, M.; ... & Siti-Azizah, M.N. (2022). Morphometric variation and reproductive aspects of the coral hind grouper (*Cephalopholis miniata*) harvested in the northern coast of Aceh, Indonesia. Egyptian Journal of Aquatic Biology & Fisheries, 26(2).

Hasan, V. and Tamam, M.B. (2019). First record of the invasive Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) (Perciformes, Cichlidae), on Bawean Island, Indonesia. Check List, 15(1): 225 – 227

Hasan, V.; Andraini, N.E.; Isroni, W.; Sari, L.A.; Nafisyah, A.L.; Dewi, N.N.; Putri, D.N.A.; Prasasti, T.A.B.; Ramadhani, A.A.; Daniel, K.; South, J.; Vieira, L.O.; Ottoni, F.P.; Maftuch.; Faqih, A.R.; Wirabuana, P.Y.A.P.; Tamam, M.B. and Valen F.S. (2023). Fish diversity of the Bengawan Solo River estuary, East Java, Indonesia. Biodiversitas, 24 (4): 2207 – 2216.

Hasan, V.; Mukti, A.T. and Putranto, T.W.C. (2019). Range expansion of the invasive nile tilapia *Oreochromis niloticus* (Perciformes: Cichlidae) in Java sea and first record for Kangean island, Madura, east Java, Indonesia. Ecology, Environment and Conservation, 25: S187 - S189

Hasan, V.; Pratama, F.S.; Malonga, W.A.M. and Cahyanurani, A.B. (2019). First record of the Mozambique tilapia, *Oreochromis mossambicus* Peters, 1852 (perciformes, cichlidae), on Kangean Island, Indonesia. Neotropical Biology and Conservation, 14 (2): 207 – 211

Henish, S. and Badrey, A.E.A. (2024). The Growth Rates of the Nile Tilapia (*Oreochromis niloticus*) and the Common Carp (*Cyprinus carpio* L.) Under Biofloc Technology by Using Different Carbon Sources. Egyptian Journal of Aquatic Biology and Fisheries, 28(3), 415-425.

Hernandez de-Dios, M.A.; Tovar-Ramírez, D.; Maldonado, G.D.; Galaviz-Espinoza, M.A.; Spanopoulos, Z.M. and Maldonado-García, M.C. (2022). Functional Additives as a Boost to Reproductive Performance in Marine Fish: A Review. Fishes, 7(5):262.

Ihwan.; Pratama, F.S.; Yonarta, D.; Faqih, A.R.; Widodo, M.S.; Valen, F.S.; Tamam, M.B. and Hasan V. (2020). Presence of asian catfish *Clarias batrachus* (Siluriformes, clariidae) in Madura Island, Indonesia. AACL Bioflux, 13 (2): 958 – 962

Insani, L.; Hasan, V.; Valen, F.S.; Pratama, F.S.; Widodo, M.S.; Faqih, A.R.; Islamy, R.A.; Mukti, A.T. and Isroni, W. (2020). Presence of the invasive nile tilapia *Oreochromis niloticus* linnaeus, 1758 (Perciformes, cichlidae) in the Yamdena Island, Indonesia. Ecology, Environment and Conservation., 26(3): 1115 – 1118

Insani, L.; Jatayu, D.; Valen, F.S.; Widodo, M.S. and Hasan, V. (2022).Comparing genetic *Mystacoleucus marginatus* and *Mystacoleucus padangensis* (Cypriniformes: Cyprinidae) based on Cythochrome C Oxidase sub unit I (COI) gene. Iranian Journal of Ichthyology, 9 (4): 195 - 203,

Irmawati, I.; Rosmiati, R.; Budi, D.S.; Kamaruddin, K.; Kadriah, I.A.K.; Ulkhaq, M.F.; Aslamyah, S.; Larekeng, S.H. and Iswanto, I. (2024). Identification, Genetic Diversity and Phylogenetics of Germplasm using COX1 Marker: Preliminary Study for New Tilapia Breeding Scheme. International Journal of Agriculture and Biology, 31(4): 243-249.

Islamy, R.A.; Hasan, V.; Mamat, N.B.; Kilawati, Y. and Maimunah, Y. (2024b). Immunostimulant evaluation of neem leaves against non-specific immune of tilapia infected by A. hydrophila. Iraq. J. Agric. Sci., 55(3): 1194–1208.

Islamy, R.A.; Hasan, V.; Poong, S.-W.; Kilawati, Y.; Basir, A.P. and Kamarudin, A.S. (2025). Nutritional value and biological activity of Kappaphycus alvarezii grown in integrated multi-trophic aquaculture. Iraq. J. Agric. Sci., 56(1): 617–626.

Islamy, R.A.; Hasan, V.; Poong, S.W.; Kilawati, Y.; Basir, A.P. and Kamarudin A.S. (2024a). Antigenotoxic Activity of *Gracilaria* sp. on Erythrocytes of Nile Tilapia Exposed By Methomyl-Based Pesticide. Iraqi Journal of Agricultural Sciences, 55 (6):1936 – 1946

Izquierdo, M. S., Fernandez-Palacios, H. and Tacon, A. G. J. (2001). Effect of broodstock nutrition on reproductive performance of fish. Aquaculture, 197(1-4): 25-42.

Kilawati, Y.; Fadjar, M.; Maimunah, Y.; Lestariadi, R.A.; Yufidasari, H.S.; Ma`Rifat, T.N.; Syaifullah; Salamah, L.N.; Amrillah, A.M.; Perdana, A.W.; Rangkuti, R.F.A. and Islamy, R.A. (2024a). Innovations in Shrimp Aquaculture: Optimizing Seaweed Biostimulants as an Integrated Approach to Disease Prevention. Egypt. J. Aquat. Biol. Fish, 29(2): 1221–1234.

Kilawati, Y.; Maimunah, Y.; Widyarti, S.; Amrillah, A.M.; Islamy, R.A.; Amanda, T.; Atriskya, F. and Subagio, F.R. (2024b). Molecular Identification and Hemocyanin Gene (HMC) Characterization of the Shrimp *Litopenaeus vannamei* Infected by Acute Hepatopancreatic Necrosis Disease (AHPND). Egypt. J. Aquat. Biol. Fish, 28(5): 1807–1820.

Kusmini, I.I; Soelistyowati, D.T.; Gustiano, R.; Pitriani, P. and Prakoso, V.A. (2013). Phenotype Diversity of BEST Nila Fish of F4, F5 and The Nirwana 2 Nila Fish Using Truss Morphometric Analysis. Jurnal Sains Natural, 3(2), Pp. 154–160.

Kwikiriza, G.; Yegon, M.J.; Byamugisha, N.; Beingana, A.; Atukwatse, F.; Barekye, A.; Nattabi, J.K. and Meimberg, H. (2023). Morphometric Variations of Nile Tilapia (*Oreochromis niloticus*) (Linnaeus, 1758) Local Strains Collected from Different Fish Farms in South Western Highland Agro-Ecological Zone (SWHAEZ), Uganda: Screening Strains for Aquaculture. Fishes, 2023; 8(4):217.

Musadar.; Muthalib, A.A.; Nuryadi, A.M.; Murniati, M. and Hartono, Y.D. (2021). Feasibility Analysis of Kekar Tilapia Farming in South Konawe Regency. Buletin

Penelitian Sosial Ekonomi Pertanian Fakultas Pertanian Universitas Haluoleo., 23(2): 51-55.

Nazran.; Syofriani.; Ulfauza.; Valen, F.S.; Oktaviandi, D.; Prayoga, A.; Ilmia, M.; Czech, M. Kamarudin A.S. and Hasan V. (2025). DNA Barcoding of *Rasbora sp.* from Bangka Island: A Genetic Identification Basis and Its Potential Application in Aquaculture. Egyptian Journal of Aquatic Biology and Fisheries, 29 (3): 213 – 226

Nugroho, K.C.; Rizky, P.N.; Harijono, T.; Halim, A.M. and Ritonga, L. B. (2024). Comparative Study of Growth Performance of Three Tilapia Strain in Intensive Culture System. In IOP Conference Series: Earth and Environmental Science, 1328(1): 012011).

Pratama, W.W.; Nursyam, H.; Hariati, A.M.; Islamy, R.A. and Hasan V. (2020). Short communication: Proximate analysis, amino acid profile and albumin concentration of various weights of giant snakehead (*Channa micropeltes*) from Kapuas Hulu, West Kalimantan, Indonesia. Biodiversitas, 21 (3): 1196 – 1200

Robledo, D., Ogwang, J., Byakora, E., Nascimento-Schulze, J. C., Benda, K. K., Fraslin, C., ... & Mukiibi, R. (2024). Genetic diversity and population structure of farmed and wild Nile tilapia (*Oreochromis niloticus*) in Uganda: The potential for aquaculture selection and breeding programs. Genomics., 116(1): 110781.

Samara, S.H.; Amin, M.; Isroni, W.; Hasan, V.; Santanumurti, M.B.; Nugraha, M.A.R. and Abualreesh, M.H. (2024). Production, Diversity, and Distribution of Aquaculture Commodities in Tuban, Indonesia. Jurnal Ilmiah Perikanan dan Kelautan, 16 (2): 498 – 509

Saptadjaja, A.M.; Hasan, V.; Arief, M.; Isroni, W. and Rozi. (2020). First record of threatened asian catfish, *Clarias batrachus* (Linnaeus, 1758) (siluriformes, clariidae) from Kangean Island, Indonesia. Ecology, Environment and Conservation, 26 (3):1055 – 1058

Sari, D.M. and Elvyra, R. (2018). Morfometrik Ikan Selais Bungkuk (*Hemisilurus Heterorynchus*, Bleeker 1854) Di Desa Langgam Dan Mentulik Sungai Kampar Provinsi Riau', Jurnal Riau Biologia, 3(1): 23–29. [In Indonesia]

Schneider, J.C.; Laarman, P.W. and Gowing, H. (2000). Length-Weight Relationships. Manual of Fisheries Survey Methods II. Michigan Department of Natural Resources. Ann Arbor. 18 p

Serdiati, N.; Insani, L.; Safir, M.; Rukka, A.H.; Mangitung, S.F.; Valen, F.S.; Tamam, M.B. and Hasan V. (2021). Range expansion of the invasive Nile tilapia *Oreochromis niloticus* (Perciformes: Cichlidae) in Sulawesi Sea and first record for Sangihe Island, Tahuna, North Sulawesi, Indonesia. Ecology, Environment and Conservation, 27 (1): 168 - 171,

Serdiati, N.; Islamy, R.A.; Mamat, N.B.; Hasan, V.; Valen, F.S. (2024). Nutritional Value of Alligator Weed (*Alternanthera philoxeroides*) and Its Application for

Herbivorous Aquaculture Feed (2024) International Journal of Agriculture and Biosciences, 13 (3): 318 – 324.

Skjærven, K.H.; Mommens, M.; Adam, A.C.; Saito, T.; Oveland, E. and Espe, M. (2022). Earlier or delayed seasonal broodstock spawning changes nutritional status and metabolic programming of growth for next-generation Atlantic salmon. Aquaculture, 554, 738187.

Syofriani.; Ulfauza.; Nazran.; Azrita,; Syandri, H.; Valen, F.S.; Kamarudin, A.S.; Hasan, V. (2025). Application of Young Coconut Water in Gourami (*Osphronemus gourami*) Egg Incubation: Impacts on Hatch Rate, Larval Viability, and Growth Performance. Egyptian Journal of Aquatic Biology and Fisheries, 29(3), 911-927.

Temesgen, M.; Getahun, A.; Lemma, B.; Janssens, G.P.J. (2022). Food and Feeding Biology of Nile Tilapia (*Oreochromis niloticus*) in Lake Langeno, Ethiopia. Sustainability, 14: 974.

Valen, F.S.; Mamat, N.B.; South, J.; Ottoni, F.P.; Vieira, L.O.; Kamarudin, A.S.; Afandi, A.Y. and Hasan V. (2024). Unveiling the occurrence of vulnerable Sisorid catfish (Teleostei: Sisoridae) in Bangka based on morphological and molecular evidence. Biodiversitas, 25 (11): 4543 - 4550,

Valen, F.S.; Widodo, M.S.; Islamy, R.A.; Wicaksono, K.P.; Soemarno.; Insani, L. and Hasan V. (2022). Molecular phylogenetic of silver barb *Barbonymus gonionotus* (bleeker, 1849) (cypriniformes: Cyprinidae) in Java, Indonesia. IOP Conference Series: Earth and Environmental Science, 1036 (1): 012011.

Volkoff, Helene, and Sydney London. (2018). Nutrition and reproduction in fish. Encyclopedia of reproduction, 9 (2018): 743-748.

Wahana, S.; Nur, M. and Nasyrah, A.F.A. (2021). Length Weight Relationship And Several Reproductive Aspects Of Bullet Tuna (*Auxis Rochei* Risso, 1810) In Bone Bay Waters. Jurnal Airaha, 10(02).

Wijayanti, A.; Hasan, V. and Tamam, M.B. (2021). Range expansion of *Oreochromis niloticus* (Linnaeys, 1758) (Perciformes, Chichlidae) in Java Sea and first record for Masalembo Island (2021) IOP Conference Series: Earth and Environmental Science, 718 (1): 012096

Wijayanti, T.; Suryaningsih, S. and Sukmaningrum, S. (2017). Analisis Karakter Truss Morphometrics Pada Ikan Kemprit (*Ilisha Megaloptera*) Familia Pristigasteridae. Scripta Biologica., 4(2): 109–112.

Wild, R.; Nagel, C. and Geist, J. (2023). Climate change effects on hatching success and embryonic development of fish: Assessing multiple stressor responses in a large-scale mesocosm study. Science of the Total Environment, 893: 164834.

Yossa, R.; Basiita, R.K.; Mushagalusa Namegabe, J.; Trinh, T.Q.; Matempa, D.; Manzwanzi, P.; Bwamayama, L.; Cole, S.M.; Matungulu, P.; Dontsop Nguezet, P.M.; et al. (2023). Performance Evaluation of Available Strains of

Nile Tilapia (*Oreochromis niloticus*) Fed Commercial and Locally-Made Feeds in the Democratic Republic of the Congo. Applied Sciences., 13(1):424.

Zulfahmi, I.; Muliari, M.; Akmal, Y. and Batubara, A. S. (2018). Reproductive performance and gonad histopathology of female Nile tilapia (*Oreochromis niloticus* Linnaeus 1758) exposed to palm oil mill effluent. Egyptian journal of aquatic research, 44(4), 327-332.