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PENGARUH AIR KELAPA (*Cocos nucifera*) UNTUK PENGARAHAN KELAMIN JANTAN PADA IKAN PLATY PEDANG (*Xiphophorus hellerii*)

The Effect Of Coconut (Cocos nucifera) Water For Male Sex Reversal In Green Swordtail (Xiphophorus hellerii)

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ABSTRAK

Ikan pedang hijau jantan (*Xiphophorus hellerii*) merupakan salah satu ikan yang banyak digemari oleh masyarakat Indonesia dan termasuk dalam sepuluh besar ekspor perdagangan ikan hias. Permintaan pasar terhadap ikan pedang hijau jantan semakin meningkat, sehingga perlu dicarikan metode yang dapat menghasilkan ikan jantan secara massal. Salah satu teknik yang dapat digunakan adalah sex reversal. Salah satu bahan alami yang dapat digunakan adalah air kelapa (*Cocos nucifera*). Penelitian ini bertujuan untuk menganalisis pengaruh perbedaan konsentrasi air kelapa terhadap sexing ikan pedang hijau jantan. Penelitian ini dilaksanakan selama 60 hari pada bulan Juni-Agustus 2023 di Laboratorium Produksi dan Reproduksi Ikan, Program Studi Akuakultur, Fakultas Pertanian, Universitas Mataram. Metode yang digunakan adalah eksperimen dengan menggunakan Rancangan Acak Lengkap (RAL) yang terdiri dari 4 perlakuan dan 3 kali ulangan, yaitu tanpa pemberian air kelapa atau kontrol (P1); pemberian air kelapa 20% (P2); pemberian air kelapa 40% (P3); pemberian air kelapa 60% (P4). Hasil penelitian menunjukkan bahwa metode perendaman air kelapa dengan berbagai konsentrasi selama 24 jam memberikan pengaruh yang nyata ($p<0,05$) terhadap persentase ikan todak hijau jantan dan tingkat kelangsungan hidup, sedangkan terhadap pertumbuhan panjang dan berat ikan tidak memberikan pengaruh yang nyata pada masing-masing perlakuan, karena pertumbuhan ikan dipengaruhi oleh pakan yang diberikan. Perlakuan terbaik diperoleh pada perlakuan P3 dengan konsentrasi air kelapa 40% yaitu menghasilkan ikan jantan sebanyak 91,84% dengan tingkat kelangsungan hidup 89,52%.

ABSTRACT

Male green swordtail (*Xiphophorus hellerii*) is one of fish that is widely favored by the Indonesian people and included in the top ten exports of ornamental fish trade.

Market demand for male green swordtail is increasing, so it is necessary to find a method that produces male in mass. One technique that can be used is sex reversal. One of the natural ingredients that can be used is coconut (*Cocos nucifera*) water. This study aims to analyze the effect of different concentrations of coconut water on the sexing of male green swordtail. This study was conducted ford 60 days in June-August 2023 at the Fish Production and Reproduction Laboratoryd, Aquaculture Study Program, Faculty of Agriculture, University of Mataram. The method used was an experiment using a Completely Randomized Design (CRD) consisting of 4 treatments and 3 replications, namely without coconut water administration or control (P1); 20% coconut water administration (P2); 40% coconut water administration (P3); 60% coconut water administration (P4). The results showed that the method of soaking coconut water with different concentrations for 24 hours had a significant effect ($p < 0.05$) on the percentage of male green swordtail and survival rate, while the growth in length and weight of the fish did not have a significant effect on each treatment, because the growth of the fish was influenced by the feed given. The best treatment was obtained in treatment P3 with a coconut water concentration of 40%, which produced 91.84% male fish with a survival rate of 89.52%.

Kata Kunci	*Air Kelapa, Ikan Pedang Hijau, Pembalikan Jenis Kelamin*
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INTRODUCTION

Male green swordtail (*Xiphophorus hellerii*) is one type of fish that is widely favored by the Indonesian people and is included in the top ten exports of ornamental fish trade. Green swordtail has a very attractive body shape and color and are easy to cultivate. Green swordtail has high market demand, so there is potential that can attract the Indonesian people to develop this fish (Munandar, 2021).

Market demand for male green swordtail is increasing, so it is necessary to find a method that produces male offspring in mass. One technique that can be used to produce male fish seeds is through sex reversal which applies hormonal engineering to change the sexual characteristics of females to males (Siregar *et al*., 2018). The masculinization technique is one method to direct the sex of fish to male during the sex differentiation period. Thus, it can produce more males and great profits (Malik *et al*., 2019).

Masculinization has been widely carried out on several ornamental fish using different materials. Masculinization is carried out by administering androgen hormones during the gonad differentiation phase in fish. Synthetic hormone 17α-methyltestosterone is prohibited in aquaculture activities because it is difficult to degrade naturally so it has the potential to pollute the environment. There are several other materials that can be used as alternatives to synthetic hormone substitutes and are

more environmentally friendly and easy to obtain such as coconut water (Amin *et al*., 2019).

Coconut (*Cocos nucifera*) is a plantation plant with an unbranched stem from the Palmae family. Coconut contains coconut water which is one of the sources of drinks that contain high ions. According to Dwinanti *et al*. (2018) in 100 mL of coconut water there are 250 mg K^+, where potassium is one of the ions that plays a very important role in regulating changes in cholesterol contained in fish body tissue into pregnenelone which is the biosynthesis of steroid hormones in the adrenal glands, where steroids help in the formation of androgen hormones, namely testosterone which affects the development of male genitals in the process of sex reversal or sex direction (Perdana *et al*., 2022).

In a previous study conducted by Malik et al. (2019), the results of masculinization of guppy fish using coconut water produced a male percentage of 70.00% with survival during immersion of 91.00% with a coconut water solution concentration of 20%, but the highest percentage of males produced was 83.33% with a coconut water solution concentration of 40%. Meanwhile, in the research of Selfiaty *et al*. (2022), the results of masculinization of betta fish using coconut water with a method of soaking embryos with a concentration of 10%/L produced the best percentage of male fish at a soaking time of 12 hours, which was 83.69%. This means that there is still a possibility that if the concentration is increased, it will produce a higher percentage of males and survival.

This study was conducted to evaluate the effect of increasing the concentration of coconut water solution on male sex reversal in green swordtail. The aim is to determine whether this treatment can increase the proportion of male offspring. In addition, this study also aims to see its impact on the survival rate of the fish produced.

METHOD

Time and Place

This research was conducted for 60 days in June-August 2023 at the Fish Production and Reproduction Laboratory, Aquaculture Environment Laboratory, Aquaculture Study Program, Faculty of Agriculture, University of Mataram. Potassium content test was conducted at the Agricultural Instrument Standardization Agency Testing Laboratory, West Nusa Tenggara.

Method

The method used was an experiment with a Completely Randomized Design (CRD). The treatments tested were differences in coconut water concentrations in soaking pregnant green swordtail broodstock. The treatment consisted of four coconut water concentrations and three replications. The concentration of coconut water used to use green swordtail (*Xiphophorus hellerii*) is as follows:

P1 = without coconut water administration (control)
P2 = 20% coconut water administration
P3 = 40% coconut water administration
P4 = 60% coconut water administration

The container used for soaking pregnant broodstock and maintaining larvae uses a 20 x 20 x 20 cm jar with a capacity of 5 liters filled with 800 mL of water and coconut water with different concentrations, namely without giving coconut water (control), giving 20% coconut water, giving 40% coconut water and giving 60% coconut water. Spawning of green swordtail broodstock with a ratio of 1:1 as many as 12 male broodstock and 12 female broodstock. Broodstock were obtained from green swordtail

farmers in Pemepek Village, Pringgarata District, Central Lombok Regency, West Nusa Tenggara.

Maintenance and Feeding

The larvae in each jar have been fitted with aeration and maintained for 60 days. In the larval maintenance stage, there are several stages that will be carried out, namely feeding the larvae and observing water quality.

1) Feeding Larvae

Feeding is carried out when the larvae are 2 days old. The feed given is natural food in the form of artemia until the larvae are 1 month old, while silkworms (*Tubifex* sp.) are given to larvae that are 60 days old until they can be distinguished between males and females. Feeding the green swordtail larvae is carried out ad libitum which aims to provide an excess supply of feed so that the green swordtail get enough food, so that the possibility of death due to lack of food can be prevented.

2) Water Quality Observation

Water quality observations are carried out on the 1st day, 15th day, 30th day, 45th day, and 60th day of maintenance. The dirt in the larval maintenance container is cleaned every 3 days by siphoning and changing the water by 30%.

Observation of the Number of Living Larvae

Observations will be carried out every day during the research by seeing how many larvae die or live in the maintenance media and are carried out using the naked eye without the aid of any tools.

Identification of Fish Sex

Identification of the sex of green swordtail is carried out by looking at the morphology or physical characteristics of the fish. This method is considered ideal for fish that have very clear sexual dimorphism between male and female fish. Secondary sexual characteristics are sexual characteristics that are marked by looking at physical characteristics. Parawangsa et al. (2021) stated that swordtail fish have sexual characteristics, namely the lower tail fin leaves of the male are shaped like a sword and the body shape is laterally flat, while in female fish it is larger in the stomach when incubating its young.

Observation of Gonad Histology

Observation of fish gonad histology was carried out on male and female offspring after 60 days of maintenance. Observations regarding the differences in gonad tissue of male and female fish need to be carried out, because the reproductive aspect of fish is closely related to the level of gonad maturity. Histological observations were carried out as a method to analyze the level of gonad maturity that occurs in fish microscopically and to determine more accurately the differences in gonad tissue structure in male and female fish kept during the study.

Potassium Content of Coconut Water

At this testing stage, 200 mL, 400 mL and 600 mL of coconut water samples were filtered to obtain filtrate and residue. This is intended to remove impurities mixed in the sample. The coconut water sample was put into a measuring flask, then diluted to the limit mark, then the sample was analyzed using the AAS (Atomic Absorption Spectrophotometry) method (Hikmawandari *et al*., 2019).

Percentage of Male Sex

According to Laheng *et al*., (2022) the percentage of male sex ratio can be calculated using the following formula:

$$J(\%) = \frac{A}{T} \times 100\%$$

Where:

J = percentage of male sex (%)
A = number of male fish
T = number of fish samples observed

Survival Rate

According to Azhar *et al*. (2025); Setyono *et al*. (2024); Saomadia *et al*. (2024); Affandi & Muahiddah (2024), the survival rate of green swordtail can be calculated using the following formula:

$$SR(\%) = \frac{N_t}{N_0} \times 100\%$$

Where:

SR = Survival rate (%)
Nt = Number of green swordtail larvae alive at the end of the study
N0 = Number of green swordtail larvae alive at the beginning of the study

Weight Growth

According to Saputra *et al*. (2025); Maulana *et al*. (2024); Annisa & Affandi (2024); Setyono *et al*. (2024), the weight growth of green swordtail fry can be calculated using the following formula:

$$W = Wt\text{-}W0$$

Where:

W = Weight growth (g)
Wt = Final weight (g)
Wo = Initial weight (g)

Length Growth

According to Setyono *et al*. (2024); Mas'ud & Affandi (2024); Pebrianti & Affandi (2024); Setyono *et al*. (2023), the total length of green swordtail fry can be calculated using the following formula:

$$L = Lt\text{-}Lo$$

Where:

L = Length growth (mm)
Lt = Final length of fish at maintenance (mm)
Lo = Initial length of fish at maintenance (mm)

Gonad Histology

The steps in making histology preparations are as follows:

1. Prepare the tools and materials that will be used to take the fish gonads
2. The fish is cut using a surgical razor on the stomach to take the clear or milky white gonads
3. The gonads are taken using scissors and placed on an object glass
4. Then the gonads are dripped with 1-3 drops of acetocarmine dye, then slowly covered using a cover glass so that no air bubbles appear

5. Pressed on the edge of the cover glass to color the gonads evenly so that they are easy to observe under a microscope
6. The prepared gonad samples are then observed using a microscope at the desired magnification
7. The desired gonad tissue is searched for until it is clearly visible, then the results obtained are documented.

Water Quality

The water quality parameters measured were temperature, dissolved oxygen and pH. Measurements were carried out during maintenance 5 times, namely on day 1, day 15, day 30, day 45, and day 60 of maintenance.

Data Analysis

The data obtained from the research results will be analyzed using analysis of variance (ANOVA). ANOVA test was carried out at a confidence level of 95% ($P < 0.05$). If there is a difference between the treatments obtained, it will be further analyzed using Duncan's advanced test. Data analysis carried out in this study used the IBM SPSS Statistics Version 29.0.1.0.

RESULT AND DISCUSSION

Result

Potassium Content of Coconut Water

The coconut water used for the sex reversal of green swordtail is young coconut (*Cocos nucifera*) which is obtained directly from the seller. Coconut water is tested to determine the amount of potassium content in coconut water. The results of the potassium content test using the AAS method in 1 mL of coconut water sample contained potassium with a total of 0.53%.

Percentage of Male Sex

Based on the research results obtained that the highest percentage of male green swordtail was in the P4 treatment with a total of 96.97%. This was followed by the P3 treatment with a total of 91.84%. While in the P2 treatment, the results were 77.44% and the lowest percentage of male sex was in the P1 treatment, which was 47.78%. The results of the analysis of variance (ANOVA) test showed that the duration of soaking pregnant green swordtail in coconut water with different concentrations can affect the percentage of male offspring produced ($P < 0.05$), so a test was carried out to determine the differences in each treatment, the results of which were then carried out through Duncan's further test. The percentage of male green swordtail is presented in the following figure.

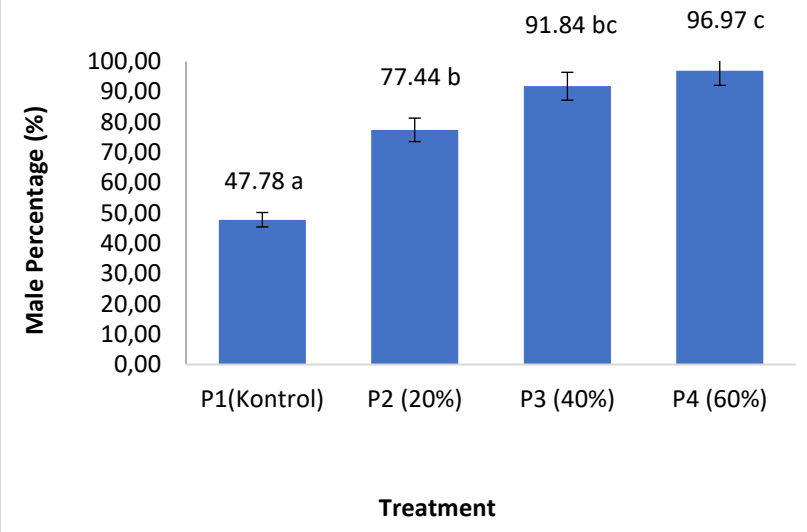

Figure 1. Percentage of Male Green Swordtail

Survival Rate

Based on the use of coconut water in the process of directing male sex to the number of fish that lived at the beginning and at the end of maintenance showed significantly different results between treatments P3 and P4, while in treatment P3 it was not significantly different from treatments P1 and P2. Based on the results of maintaining green swordtail larvae for 60 days, the percentage of the number of green swordtails that lived in each treatment was obtained (Treatment P3 98.52%, Treatment P1 80.77%, Treatment P2 74.43% and Treatment P4 61.10%). The percentage of fish survival rate at the end of maintenance in this study can be seen in the following figure.

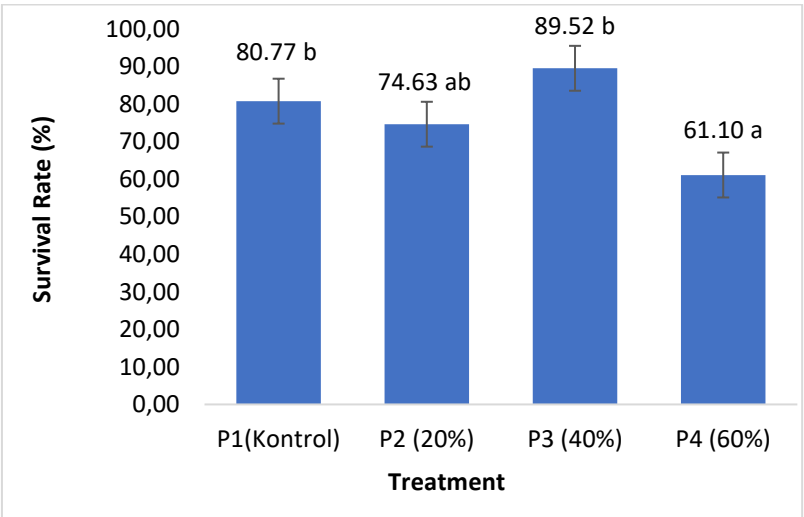

Figure 2. Percentage of Survival Rate

Weight Growth

Based on the results of the research conducted during the maintenance, it was found that the weight growth was not significantly different for each treatment, namely in P1 (control) of 12.5 g, P2 treatment with a dose of 20% of 12.26 g, P3 treatment with a dose of 60% of 12.56 g, while P4 with a dose of 40% was 10.27 g. The weight growth of green swordtail is presented in the following figure.

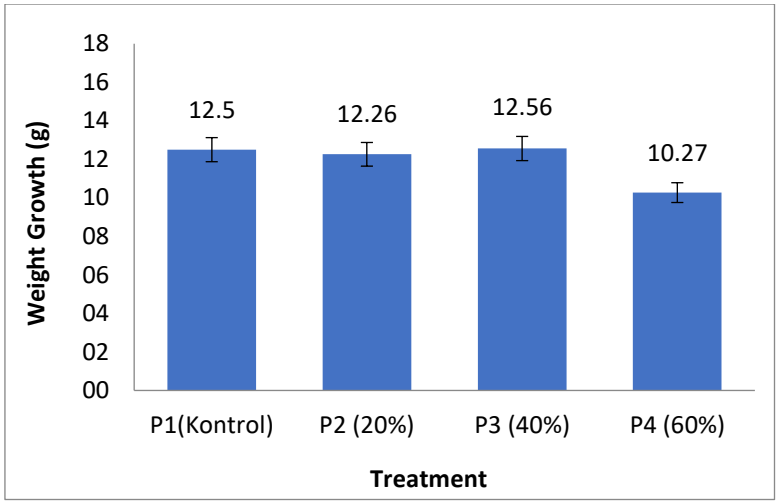

Figure 3. Fish Weight Growth

Length Growth

Based on the results of the research conducted, the results of the growth in length during maintenance were not significantly different, namely in the P1 treatment of 6.87 mm, P2 treatment with a dose of 20% of 6.37 mm, P4 treatment with a dose of 60% of 6.33 mm, while P3 with a dose of 40% was 6.03 mm. The total length growth of green swordtail is presented in the following figure.

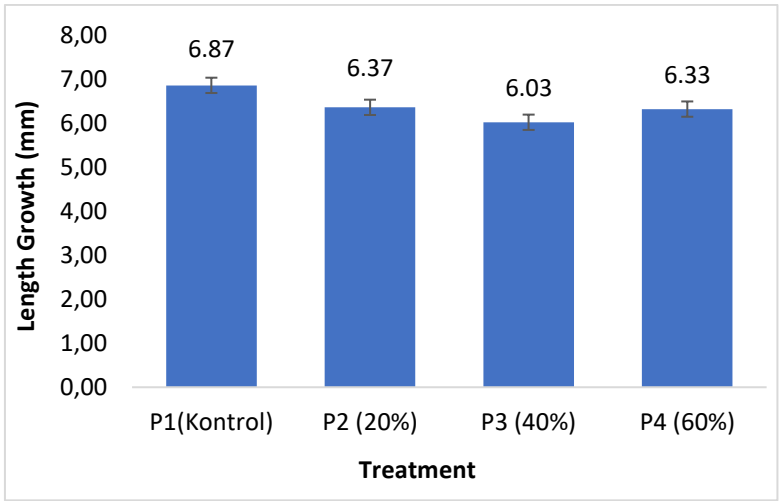

Figure 4. Fish Length Growth

Gonad Histology

The histology of male and female green swordtail is presented in the following figures.

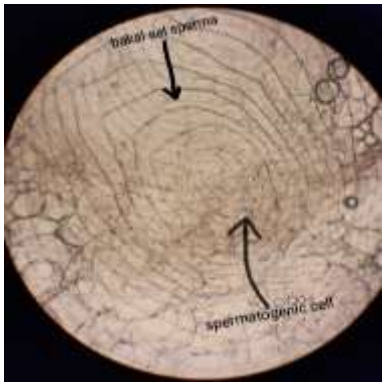

Figure 5. Male Fish Gonad

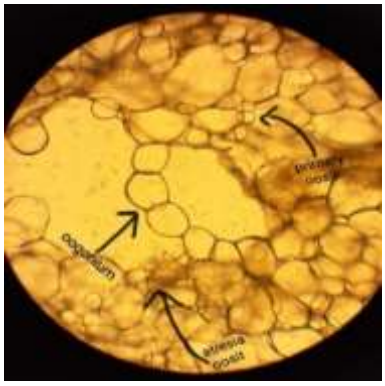

Figure 6. Female Fish Gonad

Water Quality

The results of observations made on water quality including temperature, pH and DO are presented in the following table.

Table 1. Water Quality Data During Maintenance

Parameter	Treatment				Optimum Value	Reference
	P1	P2	P3	P4		
DO (mg/L)	4.3-5.1	4.3-5.5	4.4-5.7	4.3-5.8	3-5 mg/L	Deriyanti (2016)
Temperature (°C)	27.1-29.2	27.4-29.1	27.6-29.5	27.7-29.8	25-30°C	Fazil *et al.* (2017)
pH	6.4-7.3	6.6-7.5	6.7-7.2	6.7-7.1	7.0-7.5	Johan & Hasby (2021)

Discussion

Selfiaty *et al*. (2022) stated that the coconut water used in fish masculinization is young green coconut water obtained directly from the seller and contains a total potassium of 0.57%. The potassium content produced is different from previous studies due to the age of the coconut used and the length of time the test was carried out on the coconut water so that the total potassium content is different. According to Hikmawandari *et al*. (2019) who stated that potassium content can decrease with the age of the coconut used.

The high and low percentage of male fish produced during maintenance can be influenced by the ability of the fish to absorb and maintain the palatability of the coconut water in the fish's body which was tested through the suitability and carrying capacity of the maintenance environment. The high percentage of males produced cannot be separated from the influence of the concentration of the coconut water solution used and

the specified soaking time. Coconut water solution contains high potassium where potassium itself plays an important role in the sex direction process in fish. The percentage of male green swordtail in this study increased, due to the addition of a 60% higher concentration of coconut water solution than other treatments. According to Renaldi (2021), one of the factors that influences the success of male sex direction is the accuracy of the determining phase of sex formation and the dose of the material used is the trigger for the resulting sex direction. The success of maleization using coconut water is because coconut water contains steroid hormones that directly affect the sex direction process of fish. The sex direction process of fish in male sex direction is caused by the presence of potassium contained in coconut water, where potassium functions to change cholesterol in all body tissues of young fish into pregnenolone. Pregnenolone is a source of biosynthesis of steroid hormones by the adrenal steroid glands which can affect the formation of testosterone in young fish. The dosage of the material used is a factor in directing sex reversal as one of the important aspects of increasing the sex ratio of the fish offspring to be obtained (Selfiaty *et al*., 2022).

Sex identification can be done when the green swordtail is 60 days old. At that age, the morphological differences between males and females can be seen. Physically, it can be seen that the body color of the male green swordtail is brighter and more attractive, the body shape is slimmer, the shape of the ventral fin near the stomach tends to be tapered and long, the tail fin is shaped like a sharp sword and its movements are more agile and aggressive, while the female green swordtail body color is not too bright, the body shape is larger and the stomach is bulging, the shape of the ventral fin near the stomach is rounder and shorter and the female tail fin does not have a sword. These characteristics are reinforced by Parawangsa *et al*. (2021) stated that green swordtail have sexual characteristics, namely that the lower tail fin blade of the male is shaped like a sword and the body shape is laterally flat, while the female fish is larger in the stomach area and does not have a swordtail.

In treatment P4 with a coconut water concentration of 60%, it was 96.97% where in treatment P4 the percentage of males produced was high, but the percentage of survival rate in this treatment tended to be lower. The high percentage of males in the P3 treatment was due to the concentration of 40% coconut water solution used when soaking the test fish and the long soaking time, resulting in a higher percentage of males. This is because the dose used and the length of soaking time used are still within normal limits, so that they do not affect the number of fish that live during the maintenance period. According to Findayani & Madinawati (2022), soaking using coconut water for too long makes the water quality worse so that the water quality in the media is disturbed and less than optimal, the higher the dose of coconut water used, the better it will be for directing male sex, but the longer the soaking time can cause the maintenance media to become cloudy and smelly so that the ammonia levels in the media become high.

The weight growth of green swordtail larvae that increased during the study was influenced by the natural feed given because it was in accordance with the needs of the fish. Natural feed contains high protein so it is good for a source of energy and nutrition, as well as the growth and survival of fish. The feed given was in the form of *Artemia* sp. for 1 month and silk worms were given until the larvae were 60 days old. The statement above is reinforced by Azis & Simanjuntak (2019) who stated that fish growth is closely related to the availability of protein in feed, because protein is a source of energy for fish and a nutrient that is very much needed for growth.

Therefore, different doses of coconut water do not affect the growth of fish weight because the target of soaking using coconut water is to produce testosterone hormone in

the body of green swordtail for male sexual orientation, while what is needed for fish growth is high protein. According to Qotijah *et al*., (2021) effective and optimal utilization of feed will make the feed consumed by fish truly utilized as a nutritional intake for fish needed for their growth.

The dose of coconut water given did not affect the growth of green swordtail larvae. The growth of the larvae produced was more influenced by the feed given during the maintenance period. Green swordtail larvae were given natural feed in the form of *Artemia* sp. and silk worms 3 times a day. Natural feed has a high protein content so that it can help the growth of green swordtail during the maintenance period. High water quality and nutrition are included in the factors that affect the total length growth of green swordtail, so that optimal temperatures will also be able to increase good length growth for green swordtail. This is in line with the statement of Jele *et al*. (2023) stated that increasing water quality in the form of temperature to a certain limit can stimulate the fish's metabolic process and increase the rate of feed consumption, thereby accelerating growth.

Based on the image of the results of the dissection of a 60-day-old green swordtail with a microscope magnification of 10x, there is a very clear difference between the gonads of male fish and the gonads of female fish above. The gonads of male fish are characterized by the presence of sperm cells in the gonads that are straight and elongated, milky white in color, and the gonads of male fish are small. The gonads of female fish are characterized by the presence of ovum cells that are round when viewed using a microscope, the gonads of female green swordtail are in pairs and elongated, small in shape and milky white in color. This gonad coloring method is very economically detrimental because it must kill the test animals. The differentiation period influenced by testosterone occurs at the beginning of an individual's development. Lubis *et al*. (2017) stated that, under normal conditions, individuals will be able to develop according to the phenotype expressed by their genotype. Individuals with the XX genotype will develop into females, while individuals with the XY genotype will develop into males. However, during the differentiation period, gonad development is very unstable and can be easily disrupted by environmental factors that cause the phenotypic sex to be different from the genotypic sex.

As a fairly important role holder, optimal water quality can support the growth and survival of the fish being kept. Based on the results of water quality measurement parameters for 60 days of maintenance, it is known that the water quality in all treatments showed optimal values for the survival of green swordtail. From the table, it can be seen that the average water temperature during the study was 27.1-29.8^{o}C. The high and low temperatures in the waters depend on the environmental conditions during the maintenance of the biota. Water temperature plays a very important role in fish respiration, appetite levels and also affects the fish's body metabolism system. However, the temperature range is still within the normal range for the life of the green swordtail being kept. This statement is in accordance with the statement of Fazil *et al*. (2017) which states that the optimal temperature for green swordtail that can still be tolerated is between 25-30^{o}C. Temperature is also one of the factors that influences the success of the fish sex direction process. If the water temperature conditions are associated with the sex direction process in test fish, then a temperature of 27.1-29.8^{o}C has shown the optimum temperature range for the development of test fish in directing the sex of fish to male.

The degree of acidity (pH) is a description that shows how acidic or wet the conditions of a body of water are used in a cultivation activity. The pH range of water in the maintenance media for each measurement was obtained on average, namely 6.7-7.4.

The high and low pH values obtained will inhibit the growth process in green swordtail and can even cause fish death. According to Johan & Hasby (2021) as a maintenance medium, the pH value of the water must be adjusted to its original condition, namely a good pH value for cultivating green swordtail is around 7.0-7.5. Mulyani *et al*. (2014) stated that optimal water quality can support the growth, development, stocking density and survival of fish.

Based on the results of the study, the results of dissolved oxygen (DO) measurements during the study were 4.3-5.8 mg/L. In the maintenance media, high and low dissolved oxygen content can cause fish stress and can reduce fish appetite, so from the table it can be concluded that the dissolved oxygen content in the maintenance of green swordtail is fairly normal for the survival of the fish itself. Green swordtail is one of the ornamental fish that can survive at very low dissolved oxygen levels, because green swordtail is able to adapt to various existing aquatic environmental conditions. However, it would be much better if the dissolved oxygen content in the available media is sufficient because if it is lower it can reduce fish appetite and interfere with fish growth. Therefore, it is very important to continue to maintain the dissolved oxygen content at 5 mg/liter (Deriyanti, 2016), while according to Mangia *et al*. (2013) the dissolved oxygen needed for the growth of green swordtail is more than 2.0 mg/L. Green swordtail are also fish that can adapt to various water quality conditions (Taradhipa *et al*., 2018).

CONCLUSION

Based on the results of the research that has been done, it was found that the use of coconut water in the sex reversal of green swordtail (*Xiphophorus hellerii*) using the method of soaking pregnant broodstock with different concentrations had a significant effect on the percentage of male green swordtail, but did not have a significant effect on the survival rate, total length growth of fish and growth of fish weight. The best treatment was obtained in treatment P3 with a coconut water concentration of 40%, which produced 91.84% male fish with a survival rate of 89.52%.

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