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GROWTH PERFORMANCE AND SURVIVAL RATE OF EEL (Anguilla marmorata Quoy & Gaimard, 1824) IN RECIRCULATION SYSTEMS WITH DIFFERENT BIOFILTERS

Performa Pertumbuhan dan Sintasan Ikan Sidat (*Anguilla marmorata* Quoy & Gaimard, 1824) Pada Sistem Resirkulasi Dengan Biofilter Berbeda

Tofik, Samliok Ndobe*, Andi Heryanti Rukka, Fadly Y. Tantu, A. Masyahoro,
Zakirah Raihani Ya'la, Septina F. Mangitung

Aquaculture Study Program, Tadulako University

Jalan Soekarno-Hatta, Kelurahan Tondo Palu 94118, Sulawesi Tengah, Indonesia

*Corresponding Author: samliok@untad.ac.id

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ABSTRACT

The potential of eel (Anguilla marmorata Quoy & Gaimard, 1824) in Indonesia is quite high. The potential of eel seeds from nature has not been optimally utilized for raising to consumption size, so it is necessary to develop rearing technology. It is hoped that the technology applied and developed can be carried out both on a small and large scale. The problem in fish cultivation is maintaining good water quality. One technology that can be applied is the Recirculating Aquaculture System (RAS) technology or a cultivation system with recirculation using natural filters derived from biofilter plants. The purpose of this study was to determine the use of different biofilters in the recirculation system on the growth and survival of eel (A. marmorata). The study was conducted at the Water Quality and Aquatic Biology Laboratory, Aquaculture Study Program, Faculty of Animal Husbandry and Fisheries, Tadulako University, Palu. The study was designed using a Completely Randomized Design (CRD) with 4 treatments and 5 replications. The treatments applied were in the form of biofilters, consisting of: treatment A = Lettuce Biofilter, treatment B = Celery Biofilter, treatment C = Pakcoy Biofilter, treatment D = Water spinach Biofilter. The results of the study showed that the use of different plant biofilters significantly affected the growth of the absolute weight of eels. The use of water spinach biofilter obtained the highest value in absolute weight growth (0.29±0.05 g), specific weight growth (1.83±0.28%); the lowest value of absolute weight growth in the use of lettuce biofilter (0.19±0.03 g) and specific weight growth in the packcoy biofilter treatment (1.38±0.21%). The highest survival rate was in the water spinach biofilter treatment (76±8.94%), while the lowest was in the celery biofilter treatment (60±14.14%). The results of the study concluded that the use of water spinach biofilter is the best treatment for the enlargement of eels (Anguilla marmorata Quoy & Gaimard).

Keywords: Anguilla marmorata, biofilter, recirculation system, growth, survival.

ABSTRAK

Potensi ikan sidat (*Anguilla marmorata* Quoy & Gaimard, 1824) di Indonesia cukup tinggi. Keberadaan potensi benih ikan sidat dari alam belum dimanfaatkan secara optimum untuk dibesarkan sampai ukuran konsumsi, sehingga perlu dikembangkan teknologi pembesaran. Diharapkan teknologi yang diterapkan dan dikembangan dapat dilakukan baik pada skala kecil maupun skala besar. Permasalahan dalam budidaya ikan adalah mempertahankan kualitas air agar tetap baik. Salah satu eknologi yang dapat diterapkan adalah teknologi *Recirculating Aquaculture System* (RAS) atau sistem budidaya dengan resirkulasi menggunakan filter alami berasal dari tanaman biofilter. Tujuan penelitian untuk mengetahui penggunaan biofilter berbeda pada sistem resirkulasi terhadap pertumbuhan dan kelangsungan hidup (sintasan) ikan sidat (*A. marmorata*). Penelitian dilaksanakan di Laboratorium Kualitas Air dan Biologi Akuatik, Program Studi Akuakultur Fakultas Peternakan dan Perikanan Universitas Tadulako, Palu. Penelitian didesain menggunakan Rancangan Acak Lengkap (RAL) 4 perlakuan dan 5 ulangan. Perlakuan diterapkan berupa penggunaan biofilter, terdiri dari: perlakuan A= Biofilter Selada, perlakuan B = Biofilter Seledri, perlakuan C = Biofilter Pakcoy, perlakuan D = Biofilter kangkung. Hasil penelitian menunjukkan bahwa penggunaan biofilter tanaman berbeda berpengaruh nyata terhadap pertumbuhan bobot mutlak ikan sidat. Penggunaan biofilter kangkung diproleh nilai tertinggi pada pertumbuhan bobot mutlak (0,29±0,05 g), pertumbuhan bobot spesifik (1,83±0,28%); nilai terendah pertumbuhan bobot mutlak pada penggunaan biofilter selada (0,19±0,03 g) dan pertumbuhan bobot spesifik pada perlakuan biofilter packcoy (1,38±0,21%). Kelangsungan hidup tertinggi pada perlakuan biofilter kangkung (76±8,94%), sedangkan terendah pada perlakuan biofilter seledri (60±14,14%). Hasil penelitian disimpulkan bahwa penggunaan biofilter tanaman kangkung merupakan perlakuan terbaik untuk pembesaran ikan sidat (*Anguilla marmorata* Quoy & Gaimard).

Kata Kunci: *Anguilla marmorata*, biofilter, sistem resirkulasi, pertumbuhan, sintasan.

INTRODUCTION

The potential for wild eel seeds worldwide is enormous, with Indonesia estimated to be the world's largest source of seeds. However, high demand for eel seeds in international markets (such as China, Japan, and Europe) threatens the sustainability of eel populations, leading to a decline in wild seed production in various countries, particularly for the Japanese eel (*Anguilla japonica*), the American eel *(A. rostrata*), and the European eel (*A. anguilla*). Therefore, the potential of other eel species, including the A. marmorata eel, requires sustainable management. Sustainable management of A. marmorata eels can, of course, be achieved through aquaculture.

Domestic seed utilization for consumption purposes is still very limited. Indonesia, as an archipelagic nation with abundant A. marmorata eel resources spread across the islands of Java, Sumatra, Kalimantan, Sulawesi, and Papua, has the potential to become a global eel aquaculture producer. This can happen if Indonesia successfully develops eel cultivation on both small-, medium-, and industrial scales. Currently, eel resources, especially the abundant seeds available in nature, have not been widely utilized for cultivation activities. To optimally utilize seeds and increase the production of consumption-sized eels, development of rearing technology is necessary. The technology developed must be applicable to both small- and large-scale farmers (Ridwan *et al.,* 2013).

Eels are a type of fish that grow slowly, especially if the water quality in the culture tank cannot be maintained properly during cultivation. One technology that can be developed for rearing eels in controlled environments is the Recirculating Aquaculture System (RAS) using biofilters (plants). RAS technology is a fishery production system that reprocesses used water to meet water quality requirements for cultivation activities. RAS technology is one option that can be used for intensive cultivation activities. Recirculating systems are innovative cultivation systems suitable for applications with limited land and water. The purpose of a recirculation system is to improve water quality so that the culture water can be used continuously. The movement of water from the recirculation system will result in a more even distribution of physical environmental factors such as temperature, oxygen, pH, and others, and even a more even distribution of feed (Kelabora & Sabariah, 2010). Samsundari and Wirawan (2013) conducted research analyzing the application of biofilters in recirculation systems to the water quality of eel (Anguilla bicolor) cultivation. The results showed that the use of different types of biofilters in recirculation eel cultivation systems affected DO, pH, and nitrate. Temperature, nitrite, phosphate, and ammonia had no effect. A type of biofilter that can be used in eel cultivation is a mustard plant biofilter.

Research on fish rearing using RAS biofilters (*aquaponics technology*) has been widely conducted on other fish species, including eels (A. bicolor). However, to the authors' knowledge, this has never been done on eels (A. marmorata). Therefore, it is deemed necessary to conduct this research. The purpose of this research is to examine the use of different biofilters in a recirculation system using different biofilters (lettuce, celery, pakcoy, and kale) on the growth and survival of eel (Anguilla marmorata). The benefits of this research are expected to provide information on the use of biofilters in recirculation eel (Anguilla marmorata) cultivation systems that can be applied so that it becomes a potential solution for the implementation of eel cultivation technology for the community.

RESEARCH METHODS

Place and Time

The research was conducted from March to April 2025. The study took place in the Water Quality and Aquatic Biology Laboratory, Faculty of Animal Husbandry and Fisheries, Tadulako University, Palu, Central Sulawesi Province.

Tools and Materials

The test organisms used in the study were 100 elver-stage eel (Anguilla marmorata) fingerlings, obtained by capture at the Palu River estuary. The fish were first acclimatized to laboratory conditions for three days. Afterward, they were placed in research containers at a stocking density of five fish per container (Rahmawati *et al.,* 2015). Three types of vegetable plants were used as treatments in this study: lettuce (*Lactuca sativa* L.), celery (*Apium graveolens*), bok choy (*Brassica chinensis* L.), and water spinach (Ipomoea aquatica). The plants were sown for 7-10 days before use, indicated by the emergence of perfect leaves. The planting medium for seedlings used rockwool placed in trays. The three plant species were then planted in filter containers filled with gravel as the growing medium, with 10 individuals per container.

Research Design

The study was designed using a Completely Randomized Design (CRD) with four treatments and five replications, resulting in 20 experimental units. The growth and survival of eels were the variables to be tested in the cultivation containers using recirculating aquaponics technology with different biofilters (plants). The tilapia aquaponics method with different plant biofilters was used. The treatments used were biofilters: Treatment A = Lettuce Biofilter, Treatment B = Celery Biofilter, Treatment C = Pakcoy Biofilter, Treatment D = Water Spinach Biofilter. The container layout was determined according to the treatments after randomization. The mathematical model for the one-factor completely randomized design used is as follows:

$$Yij = \mu + \tau i + \varepsilon ij$$

Where:
Yij = The value of the jth observation that received the ith treatment,
μ = Population mean,
τi = The effect of additives from different biofilters i,
εij = Additive effect of the i-th different biofilter on the j-th observation,
i = Treatment (A, B, C and D),
j = Replication (1,2,3,4,5,)

Elver maintenance

Seed maintenance includes the initial stage of maintenance, where the fish are weighed to obtain initial weight data for maintenance. During maintenance, the eels are fed commercial feed twice daily, at 8:00 AM and 5:00 PM WITA. Feeding is carried out ad libitum. Data collected are fish growth and survival data. Data collection is carried out weekly throughout the study. Fish growth data is obtained from fish weighing at the beginning of the study and once a week throughout the study.

Research Variables

Absolute weight growth

The formula used to determine the absolute weight growth of test fish during maintenance uses the formula according to Effendi (1997) in Mulqan et al. (2017), namely:

$$Wm = Wt - W0$$

Where:
Wm = Absolute weight gain (g)
Wt = Biomass weight at the end of maintenance (g)
$W0$ = Biomass weight at the beginning of the study (g)

Daily specific weight growth rate

The daily growth rate is calculated using the formula according to (Muchlisin *et al.,* 2016), as follows;

$$SGR = \frac{Ln(Wt) - Ln(Wo)}{t} x\ 100\%$$

Where:
SGR = Spesifik growt rate (%/days);
$Ln(Wt) - Ln(Wo)$ = Natural logarithm of total fish weight at the end of maintenance (g)
LnW_O = Natural logarithm of total fish weight at the start of maintenance (g)
t = Maintenance time (days)

Survival Rate

The formula used to determine the survival of catfish during maintenance is the formula according to Effendi (1997) in Ihsanudin *et al.,* (2014), namely:

$$SR = \frac{Nt}{N0} \times 100\%$$

Where:
SR = Survival rate;
N_t = population at the end of the study (tail);
N_0 = population at the beginning of the study (tail)

Data Analysis

Data on specific absolute weight growth, absolute weight growth, and survival were analyzed using analysis of variance (ANOVA), followed by an Honestly Significant Difference (HSD) or Tukey test. Meanwhile, water quality data (including temperature, pH, and dissolved oxygen/DO) were processed descriptively and presented in tabular or graphical format.

RESULT

Absolute weight gain

Different biofilter treatments resulted in different absolute weight growth of eels (Figure 1).

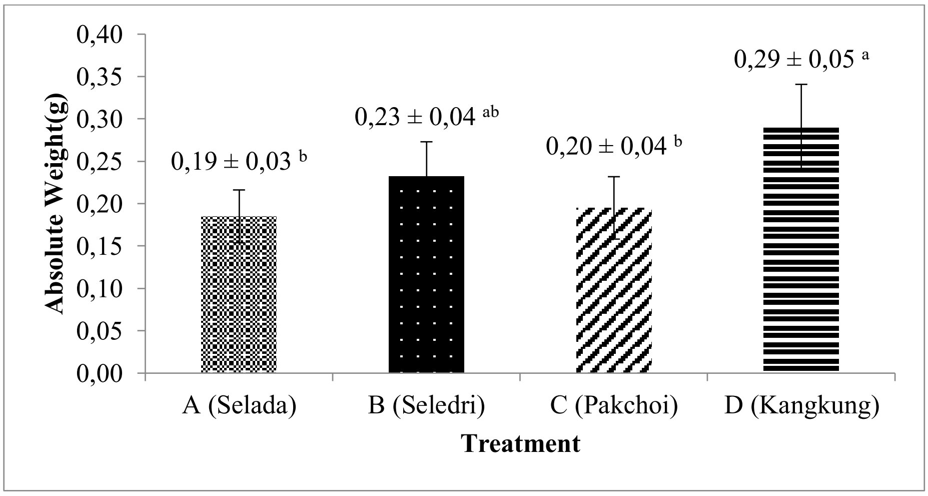

Figure 1. Absolute weight growth of feel

Specific weight growth

Different biofilter treatments resulted in different specific weight growth of eels (Figure 2).

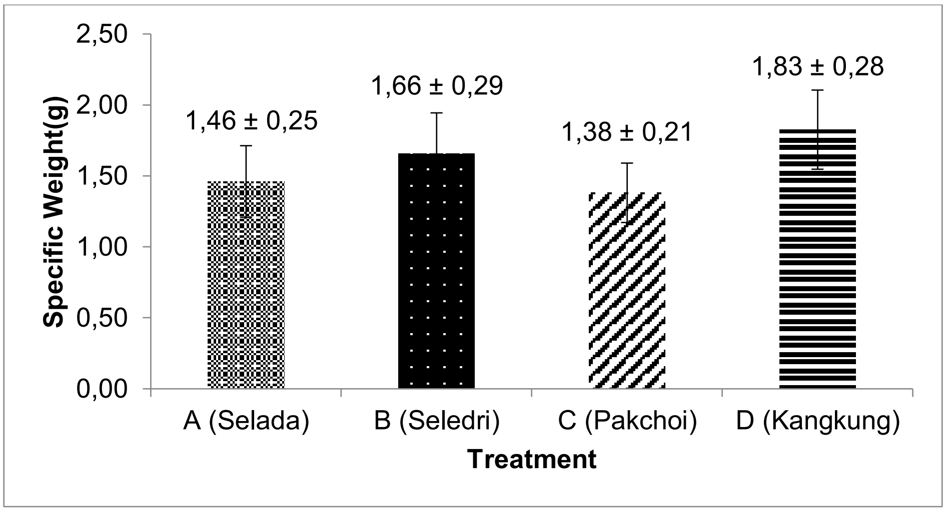

Figure 2. Specific weight growth of feel

Survival Rate

The survival rate of feels obtained during this study is shown in Figure 3.

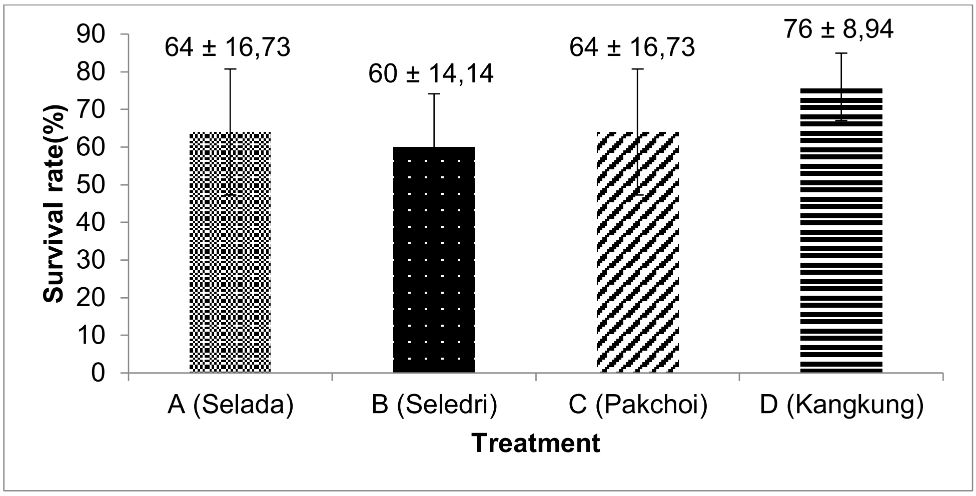

Figure 3. Survival rate of eels

Water Quality

Several water quality parameters measured during the study were temperature, dissolved oxygen, pH, and ammonia. Data from water quality measurements in the eel fry rearing medium during the study are shown in Table 1.

Table 1. Water Quality Measurement Results

Treatment	Water Quality Value Range			
	Temperature (°C)	**Acidity Degree Value /pH**	**Dissolved Oxygen (mg/L)**	**Ammonia (mg/L)**
A	26-31	8,2-8,6	1,9-7,4	0,17-0,30
B	26-31	8,3-8,6	2,1-7,6	0,16-0,70
C	26-31	8,4-8,7	2,0-7,6	0,19-0,30
D	26-31	8,1-8,7	1,9-7,4	0,10-0,30

DISCUSSION

Absolute weight gain

The results of the analysis of variance showed that the use of different plant biofilters significantly affected the absolute weight growth of eels. The treatment using a water spinach biofilter resulted in the highest absolute weight growth of 0.29 g. This indicates that the use of water spinach as a biofilter in eel cultivation is more effective in increasing eel growth.

A similar finding was found in a study by Mulqan *et al.,* (2017), where the use of a water spinach biofilter resulted in the highest absolute weight growth in tilapia fry compared to mustard greens, lettuce, and no biofilter. This was explained as being due to more efficient feed utilization and lower ammonia content compared to other treatments. According to Rokhmah *et al.,* (2020), water spinach can absorb ammonia through its roots and then convert it into nitrate compounds that can be utilized for the metabolism and growth of water spinach.

Specific Weight Growth

The use of different plant biofilters had no statistically significant effect on the specific growth rate of eels. The specific growth rate obtained ranged from 1.38 to 1.83%. The growth rate obtained in this study was quite good, as stated by Retnosari (2007) in Gerung et al. (2022), who stated that the minimum daily growth rate of fish is 1%. Martini (2024) stated that raising fish in an aquaponic system using plants as biofilters can increase dissolved oxygen levels and reduce ammonia and nitrite levels, resulting in healthier, more comfortable fish growth and stress relief. An optimal environment can influence fish appetite and improve fish growth because the consumed feed can be optimally utilized as nutrients for growth.

The highest specific growth rate was obtained with the use of water spinach biofilter treatment D, which produced 1.83%, followed by celery biofilter treatment B at 1.66%, lettuce biofilter treatment 1.46%, and bok choy biofilter treatment 1.38%. A similar finding was also found in research by Samara *et al*., (2022), where the use of water spinach plants provided better filtration than mustard greens and lettuce, resulting in a better rearing environment and supporting the metabolism and growth of fish.

The high specific growth rate in the water spinach biofilter treatment is due to the plant's denser roots compared to other plants, enabling it to absorb and filter toxins produced by leftover feed and organism feces. According to Hasan *et al*., (2017), the absorption of nutrients in the form of nitrate and phosphate by water spinach plants in aquaponic systems is higher because the water spinach roots are more numerous and dense, allowing for better absorption of nitrogen and phosphorus.

The celery biofilter treatment resulted in a specific weight increase of 1.66% due to the celery plant's dense roots, which are able to absorb leftover feed and feces produced during eel rearing. The advantage of absorption through celery roots can promote good growth for eels. Samadan *et al.,* (2023) stated that celery plants are highly effective in absorbing N and P, allowing the plants tested to reduce ammonia and phosphate compared to lettuce and bok choy.

The bok choy biofilter plants produced a specific growth rate of 1.38%. Based on observations, the bok choy treatment performed the lowest. The low specific weight growth in this treatment was due to several factors, one of which was the environment. According to Ni'mah (2024), the environment is the place where bok choy plants can grow and develop. Environmental conditions at the research site can influence bok choy growth and yield. Damanik *et al.,* (2018) also suggested that this was also due to the sparse root absorption of bok choy plants, which facilitated nitrate oxidation and optimized nitrite absorption. The abundant oxygen allowed for smooth water flow in the growing medium.

The lettuce biofilter plants produced a specific growth rate of 1.46%. Based on observations, lettuce was the second lowest-performing treatment compared to bok choy. This is because the lettuce's root system is not as robust as that of kale. Several of its trees did not grow well, possibly due to several external and internal factors, including a lack of nitrogen and the temperature at the research site, which the plants could not tolerate. Optimal lettuce growth occurs at temperatures around 25°C, both during the day and at night.

Survival Rate

In general, the survival rate of eels obtained in this study was >60%. The highest survival rate was achieved in the treatment using a water spinach biofilter. According to Islama *et al.,* (2022), the symbiotic mutualistic interaction between plants and fish in an aquaponic system creates a favorable environment for fish survival.

Some tilapia mortality occurred during culture, particularly in the first week. Mulqan *et al.,* (2017) stated that fish mortality during the early stages of culture is a form of adaptation to the environment and treatment. Kambu *et al.,* (2019) explained that fish survival is also influenced by fish handling during culture, where better maintenance techniques lead to better survival rates.

The survival rate of eels during the study ranged from 60-76%. This is suspected to be due to the ineffectiveness of the research environment and location, which makes the organisms susceptible to disease and death. According to Rahmawati et al. (2015), conditions that cause eel fry to be weak and unable to withstand environmental conditions, resulting in a decreased appetite, and making the fry weak and susceptible to disease. Eel fry also usually lose out in competition for food, making them prey for other eels.

Water Quality

Temperature

The temperature range during observations in the maintenance container was 26-31oC. Karo-Karo (2015) stated that temperature is an environmental factor that has a major influence on the phytoremediation process, fish growth, plant growth, and the decomposition of organic matter in water. Wihardi *et al.,* (2014) stated that the high and low water temperatures can change due to the absorption of temperature from the surrounding air. Suryono and Badjoeri (2013) stated that the appropriate temperature for eel maintenance is 20-29oC. Samsundari and Wirawan (2013) stated that the use of a recirculation system and biofilter can increase the water temperature and tend to be more constant because the water is moved by a water pump and through a biofiltration process, resulting in mechanical friction between water particles, growing media, and plant roots.

Degree of Acidity or pH

The pH values obtained in this study ranged from 8.2 to 8.7. Ritonga et al. (2014) in Fajar *et al.,* (2021) stated that a good pH value for eel cultivation is 6-8. Handayani (2018) explained that pH is an important factor in aquaponic systems because it affects plant nutrient absorption, metabolic performance, and fish growth. According to Utami *et al*., (2019), daily changes in pH can occur due to the concentration of carbon dioxide and oxygen in the water. The high mortality rate in the eels raised in the study is thought to be due to the relatively high pH value.

Dissolved Oxygen

The results of measurements of dissolved oxygen concentration in the eel maintenance media obtained 1.9-7.6 mg/L. Dissolved oxygen is very important for living organisms for the process of respiration, metabolic processes, decomposition of organic matter, and growth (Karo-Karo, 2015). Setiadi *et al.,* (2021), stated that the ideal dissolved oxygen for eels is > 3 mg/L. According to Maulidiyanti *et al.,* (2015), dissolved oxygen content of less than 3 mg/L over a long period of time can disrupt the fish's feeding process and inhibit its growth. The decrease in dissolved oxygen concentration, explained by Gerung *et al.,* (2022), can occur due to the fish's respiration process and the presence of bacteria that require oxygen for the nitrification process in the filtration media.

Ammonia

Karo-Karo (2015) stated that total ammonia consists of ionized ammonium (NH_4^+) and non-ionized free ammonia (NH_3). Martini (2024) stated that high levels of ammonia and nitrite nitrogen waste can cause stress and shortness of breath in fish, ultimately leading to fish death. Samsundari & Wirawan (2013) explained that high ammonia concentrations can reduce the ability of fish to excrete ammonia. This causes ammonia levels in the blood and body to increase, thus increasing blood pH and negatively impacting the performance of various enzymes in the body.

The lowest ammonia concentration at the end of the rearing period was obtained in the treatment using a water spinach biofilter. This indicates that water spinach is able to reduce ammonia better than other treatments. A similar finding was also found by Sabrina *et al.,* (2018), who found that the lowest ammonia levels were obtained using water spinach, which is due to the roots being more fibrous and longer than other plants (mustard greens and lettuce). According to Samara *et al.,* (2022), plant nutrient absorption is influenced by, among other things, the plant's morphology. Hapsari *et al*., (2020) added that water spinach has a hollow, long, and branched stem morphology, allowing it to absorb and store more nutrients.

CONCLUSION

Based on the results and research, it can be concluded that the use of different plant biofilters affects the absolute weight growth of eels (Anguilla marmorata). The use of a water spinach biofilter resulted in the highest absolute weight growth of 0.29 g, a specific growth rate of 1.83%, and a survival rate of 76%. It is recommended that further research be conducted on the use of water spinach biofilters with different numbers of plants in the maintenance of eels and other fish using a recirculating aquaponic system.

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