 DOI: 10.35382/TVUJS.13.1.2023.1717

REARING TIRE TRACK EEL (*Mastacembelus favus*) FROM FRY TO FINGERLING IN RECIRCULATING AQUACULTURE SYSTEM IN TRA VINH PROVINCE, VIETNAM

Lai Phuoc Son[1*], Ho Khanh Nam[2], Vo Nguyen Thien Quang[3], Chau Quoc Trung[4]

Abstract – *The rearing experiment of tire track eel (Mastacembelus favus) in the recirculating aquaculture system was conducted at the Freshwater Experimental Research Station, Tra Vinh University from April to June 2022. The experiment concluded four treatments: two experimental treatments in a recirculation aquaculture system with the rearing density of 1,500 individuals/m^3 for the first experiment and 2,000 individuals/m^3 for the second experiment, two control treatments in a free water system with 1,500 individuals/m^3 for the first control and 2,000 individuals/m^3 for the second control, and each treatment was designed with triplicates. The fry with an average initial weight of 0.016 g/fish and an average length of 1,033 cm/fish were reared in the 500-L composite tank. Fish were fed with Moina, worms and pellets (40% protein) and the feed was adjusted to the needs of fish in each treatment. After 60 days of rearing, the highest growth rate was at the first experiment (0.019 g/day and 7.08%/day) and was significantly higher than the two control treatments ($p > 0.05$). The second control treatment had the lowest growth rate (0.010 g/day and 6.11%/day). The first experiment had the highest survival rate (50.6%), which was significantly different ($p < 0.05$) from the second experiment (38.9%) and the second control treatment (33%). Thus, rearing fry of tire track eel in the recirculating aquaculture system with a stocking density of 1,500 individuals/m^3 achieved the best results.*

[1,2]School of Agriculture and Aquaculture, Tra Vinh University, Vietnam

[3,4]Student, Tra Vinh University, Vietnam

*Corresponding author: phuocsontvu@tvu.edu.vn

Received date: 31st October 2022; Revised date: 7th March 2023; Accepted date: 10th March 2023

Keywords: Mastacembelus favus, recirculating aquaculture systems, stocking density, Tra Vinh Province.

I. INTRODUCTION

Tire track eel (*Mastacembelus favus*) is a fish species with high economic value due to its deliciousness. This species is distributed in the regions of freshwater and brackish-water. Insects, trash fish, and crustaceans are the natural diet of *M. favus*. Therefore, the Mekong River Delta of Vietnam is a suitable habitat for rearing this kind of fish [1]. Nguyen Thanh Trung et al. [2] noticed that the farming of this species recently has not been widespread because of the lack of fingerling that is mainly found in nature.

The breeding season of *M. favus* is from April to June annually. However, the breeding capacity of this species is relatively low, ranging from 4,500 – 4,700 eggs per female. In addition, the availability of natural fish has decreased sharply [3]. Manh Hung [4] highlighted that the pilot model of rearing *M. fasvus* in Cang Long District of Tra Vinh Province has brought certain effectiveness. After the rearing period of 8 – 12 months, the fish reached an average weight of 3 – 4 fish/kg, with 350 kg of fish sold out, each household earned a profit of VND 350 million. However, the lack of fingerling sources is an obstacle to the locals.

M. favus is an aquatic species with biological characteristics suitable to ecological and pedological conditions of Tra Vinh City. This fish species has a long-life cycle in the condition of climate change. In other words, it is consider an effective species in the period of livestock plant changing for climate change adaptation of Tra Vinh City. Moreover, the use of current advanced fish rearing system as recirculation aquaculture system, which both saves water and does not affect the surrounding ecological environment and can help to improve the survival rate of the nursery stock as well, currently being prioritized for development. This study was therefore conducted to deal with difficulties in providing fingerlings for meeting the increasing demand of *M. favus* fariming in Tra Vinh Province.

II. RESEARCH OVERVIEW

Besides freshwater habitat, *M. favus* can survive in brackish water with a low level of salt. In the Mekong Delta, there are three species of Mastacembelus, including *M. armatus*, *M. erythrotenia*, and *M. favus*. *M. favus* mainly lives in the bottom-dwelling. This fish species can successfully grow in the living environment with the pH values of 6 – 8 and the temperature of 26 – 33^{o}C [5]. The research on the reproductive biology of *M. favus* conducted by Nguyen Van Trieu [1] indicated that *M. favus* was a carnivorous fish species. Its breeding season was about 5 – 8 months with the greatest breeding number of 11,209 – 45,631 eggs per female. It was regarded as a mature fish having the best breeding capacity after 3 months of rearing with an average maturation rate of 73.89% per female and 33.17% per male. In addition, fish with HCG hormone gave the best fertility at 10,196 eggs/kg of females out of 38.12% successful fertilization [6].

Notable works have been conducted on *M. favus*. Nguyen Thanh Trung et al. [2] made an experiment on producing the fingerling of *M. favus*. After 45 days of rearing, fish fed with fresh food had the highest survival rate compared to fish fed by fertilization for color and pellets at the protein level of 35 – 40%. Aeyrin Afroz et al. [7] noticed that after 80 – 90 hours of hatching, fry started exogenous feeding. Besides, the survival rate of the fry reared in rainwater was higher than in supplied tap water after 390 hours of rearing. Md. Sherazul Isalam et al. [8] reported that *M. pancalus* run out of ovules and started exogenous feeding after four days of rearing. Additionally, within 35 days of rearing, fish were metamorphosed completely, with an average survival rate of 31.5%. The research on the effect of stocking density on the growth and survival rate of Siberian (*Acipenser baerii*) from fry stage to fingerlings suggested that the stocking density of 1,000 individuals/m^2 was the most effective environment for them to grow and survive compared to the density of 2,000 individuals/m^2 and 3,000 individuals/m^2 [9]. Nguyen Van Trieu and Pham Anh Van [10] researched feeding behavior characteristics of Soldier river barb (*Cylocheilichhthys enoplos*) from fry to fingerling with a density of 200 individuals/m^2 within 30 days. They indicated that the stocking density and prey size played an important role in the food choice of *C. enoplos*. There was no selected phytoplankton for feeding. The results represented that *C. enoplos* fry started first feeding at 2-day-olds post-hatching and fed mainly on Nauplius. From the 6th to 11th days, Brachionus was chosen. The research on rearing Lates calcarifer by floating raceway conducted by Hoang Tung et al. [11] showed that after 15 days and 45 days of rearing, the survival rate of fish reached 81.9% and 53.4%, respectively.

There have been many studies on rearing *M. favus* in the recirculation system or on the stocking density of other fish species. Based on the research on rearing Anguilla marmorata with various types of food in the recirculation system, Ly Van Khanh et al. [12] indicated that after eight months of rearing, fish fed by artificial feed and small trash fish had the highest survival rate at 90%. In contrast, the survival rate of fish completely fed by artificial food or trash fish was only at 70% and 53.8%, respectively. According to Tran Van Danh [5], trials of rearing of tire track eel (*Mastacembelus favus*) in tarpaulin tanks with different densities showed that the survival rate in 120 days of rearing in the treatment of 1500 individuals/m^2 (36.63%) was the highest. Next, the treatment of 1,000 individuals/m^2 (31.2%) and the treatment of 2,000 individuals/m^2 (26.73%) achieved the lowest survival rate.

Although there have been many studies on *M. favus*, research on rearing this fish species in a recirculation aquaculture system and stocking density in order to facilitate fish growth and their survival rate has not been paid great attention. Therefore, it is necessary to study this rearing process based on scientific research on other fish species as well as fish in the same species of *M. favus*.

III. METHODOLOGY

The research was carried out from April to June 2022 at the Freshwater Experimental Research Station, School of Agriculture and Aquaculture, Tra Vinh University.

The research was conducted through four rearing treatments, including two experimental treatments in a recirculation aquaculture system with two rearing densities of 1,500 individuals/m^3 (first experiment) and 2,000 individuals/m^3 (second experiment) and two control treatments in a free water system with 1,500 individuals/m^3 (first control) and 2,000 individuals/m^3 (second control). Each treatment was designed with three replications. The fry of tire track eel with average initial weight of 0.016 ± 0.002 g/fish and the average length of 1.033 ± 0.052 cm/fish was transported from Ben Tre Province to Tra Vinh Province. The fry was reared in a 500-L composite tank within the experimental period of 60 days.

The recirculation aquaculture system consisted of a 500-L rearing tank, a 200-L medium tank, and a 50-L microbiological medium tank. Water in the rearing tank was circulated to the medium tank and the microbiological medium tank with a water circulation rate of 100 – 120% of the tank volume per day. All tanks were aerated continuously, siphoned periodically (to get leftover and organic residues in the process of rearing fish), had more water added once a week. The tank system in the control treatments consisted of 500-L rearing tanks which were aerated continuously. Water in these tanks was not replaced during the first week of rearing. From the second week onwards, about 10 – 20% of water in these tanks was changed once a period of 3 or 5 days.

Reared fish were provided with various types of food in different stages. During the first 3 days of age, it was necessary to feed the fry with nothing. From 4 to 10 days of age, fish were fed with moina. From 11 to 30 days, fish were fed with worms. From 31 days onwards, in addition to worms, fish were fed with pellets having 40% of protein. This combination of feed included the rate of 75% worms and 25% pellets (the first week), 50% worms and 50% pellets (the second week), 25% worms and 75% pellets (the third week), and 100% pellets (for fingerlings). The amount of food for feeding was about 8 – 10% of the average body weight of each, which was done three times a day, at 7:00 am, 2:00 pm, and 5:00 pm, respectively.

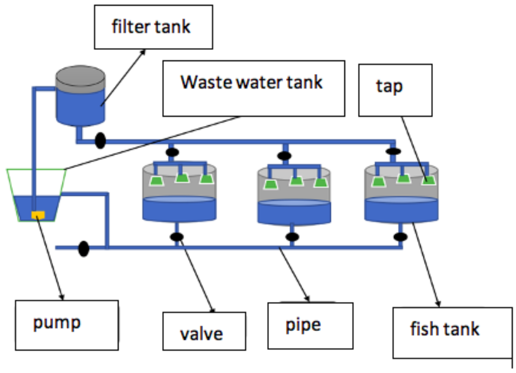

Fig. 1: Recirculating fish rearing system

The environmental conditions were gradually monitored, including twice a day for checking the temperature and pH level (at 7:00 am and 2:00 pm) and once a week for checking NH_3^-, NO_2^-, and alkalinity. These specifications were measured by a Sera test kit – Germany.

Data collection

The samples were weighed and measured every 15 days by digital scale with three odd numbers and a ruler, by randomly picking 30 individuals/tank. Fish weight was calculated to 3 decimal numbers with an accuracy of 0.001 g. The survival rate was based on the number of survival fish in each tank at the end of the experiment. The indicators of growth rate, survival rate, and weight coefficient were determined based on the following formulas:

Daily weight gain = $(W_t - W_o)/t$ (g/individual/day).

Weight specific growth rate = $(\ln W_t - \ln W_o)/t * 100$ (%/individual/day).

Including: W_o: initial fish weight (gram), Wt: fish weight over stages (gram), t: time of the experiment (day)

Daily length gain: $(L_t - L_o)/t$ (cm/individual/-day).

Length specific growth rate = $(\ln L_t - \ln L_o)/t * 100$ (%/individual/day).

Including: L_o: initial fish length (cm), Lt: fish length over stages (cm), t: time of the experiment (day)

Survival Rate (%) = (Number of fish at the end of the experiment / number of fish at the initial stage) * 100

Coefficient of variation: $CV = \frac{S}{X} * 100$

Including: S: standard deviation; X: average weight of fish

Data analysis

The research data were processed by the SPSS software package (version 20.0) by analyzing the Tukey and ANOVA tests that showed the significance level of differences ($p < 0.05$) among the treatments. Data collected from all treatments were presented as mean ± standard deviation.

IV. RESULTS AND DISCUSSION

A. *Factors of water environment*

Table 1 shows the water temperature and pH level during the experiment. Research results indicate that the average temperature of water ranged from 27.2 – 30.2^{o}C. Truong Quoc Phu [13] noticed that fish was a thermogenic species. In other words, the fish's body temperature changed according to the water temperature. The suitable temperature for tropical fish and shrimp ranged from 25 – 32^{o}C. In general, the present study confirms that the water temperature in the rearing tank was suitable for fish growth.

pH values during the experiment ranged from 8.67 – 8.71. Boyd [14] claimed that too low or too high levels of pH significantly influenced the growth of fish. Fish were able to grow successfully in the pH level of 6.5 – 9. The results conclude that the pH level during the rearing period was appropriate for fish growth.

Table 2 shows that the TAN level of all treatments ranged from 0.28 – 0.3 mg/L. The TAN level of both the first and second experiment was higher than both the first and the second control. The TAN level of 0.2 – 2 mg/L was suitable for aquatic species without respiratory organs [13]. The research results indicate that there was no effect of the TAN level of all treatments on the growth of reared fish.

The average level of NO_2^- ranged from 0.39 – 1.19 mg/L. The treatment with the highest NO_2^- coefficient was the first control (1.19 mg/L), the lowest in the second experiment (0.39 mg/L). Compared to the two control treatments, the recirculating rearing system had a positive impact on lowering the NO_2^- concentration.

During the experiment, the temperature of all treatments ranged from 27.2 – 30.2^{o}C, which caused no dangerousness to reared fish. Ta Hong Minh and Huynh Trung Hai [15] concluded that it was suitable for aquatic species to live in a nitrite level of less than 5.05 mg/L. Boyd [14] claimed that a nitrite level of less than 4.5 mg/L would be safe for aquaculture ponds. Because the NO_2^- coefficient of the current experiment was in the acceptable range, there was no negative effect on the survival rate and growth of *M. favus*.

Table 2 shows the alkalinity level of all treatments ranging from 209 – 212.5 mg $CaCO_3$/L. It was found lowest in the second control and highest in second experiment with values of 209 mg $CaCO_3$/L and 212.5 mg $CaCO_3$/L, respectively. In general, the survival rate and growth of fish were not affected by changes in alkalinity level.

B. *The weight growth of fish*

Table 3 indicates that reared fish with an initial weight of 0.016 ± 0.002 g/individual in the recirculation system treatment of 1,500 fish/m^3 for the first experiment had the fastest growth. After a 60-day rearing period, the average body weight of fish reached 1.13 ± 0.35 g/individual. This recorded coefficient was not significantly different ($p > 0.05$) compared to the second experiment. In contrast, the weight growth value significantly differed ($p < 0.05$) compared to the two control treatments of 1,500 individuals/m^3 (first control) and 2,000 individuals/m^3 (second control).

After 60 days of rearing, the absolute and relative weight growth of fish in the first experiment was the fastest at 0.019 ± 0.003 g/day and 7.08 ± 0.28 %/day, respectively. The recorded values were significantly different ($p < 0.05$) compared to the two treatments of first experiment and

Table 1: Hydrophysical factors during the experiment

Treatment	Temperature (°C)		pH	
	7:00 am	2:00 pm	7:00 am	2:00 pm
First experiment	27.6 ± 0.61	30.2 ± 0.23	8.70 ± 0.12	8.71 ± 0.14
First control	27.4 ± 0.44	30.0 ± 0.38	8.70 ± 0.12	8.70 ± 0.14
Second experiment	27.6 ± 0.63	30.2 ± 0.24	8.68 ± 0.10	8.70 ± 01.6
Second control	27.2 ± 0.26	30.2 ± 0.19	8.67 ± 0.16	8.68 ± 0.14

Table 2: Hydration factors during the experiment

Treatment	TAN (mg/L)	NO_2^- (mg/L)	Alkalinity (mg $CaCO_3$/L)
First experiment	0.30 ± 0.07^a	0.44 ± 0.38^a	211.5 ± 6.52^a
First control	0.28 ± 0.06^a	1.19 ± 0.43^b	211.4 ± 3.51^a
Second experiment	0.30 ± 0.07^a	0.39 ± 0.23^a	212.5 ± 5.59^a
Second control	0.28 ± 0.05^a	0.67 ± 0.12^a	209.0 ± 5.48^a

Note: The different superscript letters in columns indicate the significant differences (p < 0.05)

second experiment. However, there was no significant difference (p > 0.05) among the weight growth rates in the second experiment. Reared fish in the second control treatment was found to have absolute and relative weight growth at the level of 0.010 ± 0.002 g/day and 6.11 ± 0.27 %/day, respectively, which was at the lowest rate. The interaction between stocking density and fish rearing system was not statistically significant (p > 0.05).

The weight growth of the fish in the first experiment (1.13 ± 0.35 g/day) was larger than that of the Tran Van Danh [5] research, which had a density of 1,500 individuals/m^2 (0.87 ± 0.11 g/day). The density of 2,000 individuals/m^2 in Tran Van Danh [5] (0.86 ± 0.13 g/day) was the same as the second experiment (0.85 ± 0.27 g/day). However, the weight gain for the two control treatments was less than that of Tran Van Danh [5].

C. The length growth of fish

Table 4 states the length growth of fish after 60 days of rearing. Fish in the first experiment had the fastest length growth from 1.033 ± 0.052 cm/individual to 6.98 ± 0.82 cm/individual. This was significantly different (p < 0.05) compared to the first control and second control, but was not significantly different (p > 0.05) compared to the second experiment. Reared fish in the second control had the lowest length growth at 5.77 ± 0.77 cm/individual. This length growth rate did not significantly differ (p > 0.05) compared to the first control and the second experiment. However, this difference was perceived as statistically significant (p < 0.05) compared to the first experiment.

After 60 days of rearing, the absolute and relative length growth in fish in the first experiment was the fastest at 0.10 ± 0.007 cm/day and 3.18 ± 0.10%/day, respectively. The recorded values were not significantly different (p > 0.05) compared to the second experiment, but were significantly different (p < 0.05) compared to the first and second control treatments. Reared fish in the second control treatment were found to have the lowest absolute and relative length growth at 0.08 ± 0.004 cm/day and 2.84 ± 0.08%/day, respectively. The difference in recorded values was not statistically different (p > 0.05) compared to the second experiment and the first control, but was statistically different (p < 0.05) compared to the first experiment.

Table 3 and Table 4 indicate that *M. favus* in the first experiment had the fastest growth. In addition, the growth rate of fish reared in the recirculation aquaculture system was higher than in normal conditions. The research on rearing Siberian sturgeon under different stocking densities (including 1,000, 2,000, and 3,000 individuals/m^2) conducted by Nguyen Viet Thuy [10], indicated the significant effects of stocking density on fish growth. Especially, it was most effective to rear fish under a density of 1,000 individuals/m^2.

The results of research on length growth during 60 days of rearing (Table 4) in all four treatments showed higher growth in length than Tran Van

Table 3: The weight growth of fish after 60 days of rearing

Treatment	Weight (g/individual)		Weight growth	
	Initial stage	After 60 days of rearing	Absolute (g/day)	Relative (%/day)
First experiment	0.016 ± 0.002^{a}	1.13 ± 0.35^{a}	0.019 ± 0.003^{a}	7.08 ± 0.28^{a}
First control	0.016 ± 0.002^{a}	0.67 ± 0.35^{b}	0.010 ± 0.004^{b}	6.16 ± 0.53^{b}
Second experiment	0.016 ± 0.002^{a}	0.85 ± 0.27^{ab}	0.014 ± 0.003^{ab}	6.54 ± 0.31^{ab}
Second control	0.016 ± 0.002^{a}	0.63 ± 0.25^{b}	0.010 ± 0.002^{b}	6.11 ± 0.27^{b}

Note: The different superscript letters in columns indicate the significant differences (p < 0.05)

Table 4:
The length growth of fish after 60 days of rearing

Treatment	Survival rate (%)	Coefficient of Variantion
First experiment	50.6 ± 1.8^{a}	32.61 ± 5.62^{a}
First control	46.4 ± 1.2^{ab}	36.83 ± 6.36^{a}
Second experiment	38.9 ± 5.0^{bc}	32.03 ± 3.59^{a}
Second control	33.0 ± 3.5^{c}	35.27 ± 5.91^{a}

Note: The different superscript letters in columns indicate the significant differences (p < 0.05)

Danh [5] in two densities. The densities of 1,500 individuals/m^2 and 2,000 individuals/m^2 reached 4.67 ± 0.57 cm/day and 4.55 ± 0.68 cm/day, respectively.

From the above results, it was shown that fish reared in the recirculation system at the density of 1,500 individuals/m^2 would have the fastest growth in weight and length compared to the other treatments (Tables 3 and Table 4).

D. Survival rate and weight coefficient of fish after 60 days of rearing

Table 5 shows that fish in the first experiment had the highest survival rate at 50.6 ± 1.8%, which was significantly different (p < 0.05) compared to the second experiment and second control treatments, but was not significantly different (p > 0.05) compared to the first control treatment. Fish in the second control treatment suffered the lowest survival rate at 33.0 ± 3.5%. This survival rate was insignificantly different (p > 0.05) compared to the second experiment, but was statistically significant (p < 0.05) compared to the first experiment and the first control. The research results confirm that the stocking density significantly influenced the survival rate of *M. favus*. The experimental and control treatments with a stocking density of 1,500 individuals/m^3 brought a better survival rate than the treatments with a stocking density of 2,000 individuals/m^3.

The findings of the study demonstrated that stocking density and fish raising practices had an impact on fish survival. This proved the connection between the rearing system and stocking density. Md. Sherazul Islam and Tandra Rani [8] conducted research on rearing *Mastacembelus pancalus* with supplied tap water, pond water, and rainwater with a density of 100 fish/tank (0.91 x 0.36 x 0.38 m) for 45 days. The survival rate of fish in the condition of rainwater was highest (41.5%) followed by fish reared with pond water (33.5%) and supplied tap water (19.5%). This difference was statistically significant (p < 0.05) among the treatments.

Table 5: Survival rate and coefficient of variantion of fish after 60 days of rearing

Treatment	Survival rate (%)	Coefficient of Variantion
First experiment	50.6 ± 1.8^{a}	32.61 ± 5.62^{a}
First control	46.4 ± 1.2^{ab}	36.83 ± 6.36^{a}
Second experiment	38.9 ± 5.0^{bc}	32.03 ± 3.59^{a}
Second control	33.0 ± 3.5^{c}	35.27 ± 5.91^{a}

Note: The different superscript letters in columns indicate the significant differences (p < 0.05)

Tran Van Danh [5] also showed that the survival rate of rearing fish in 120 days at the density of 1,500 individuals/m^2 was the highest (36.63%) compared with densities of 1,000 individuals/m^2 (31.20%) and 2,000 individuals/m^2 (26.73%). The results of this study confirmed that nursery fish at the density of 1,500 individuals/m^2 in the recirculation system gave a better survival rate than all other treatments.

Table 5 and Figure 1 show that weight coefficients collected from the first and second control treatments were 36.83 ± 6.36 and 35.27 ± 5.91, respectively, higher than the ones offered by the two experimental treatments with 32.61 ± 5.62 and 32.03 ± 3.59. This result indicates that there was no significant difference in the weight of fish when they were reared in the recirculation aquaculture system.

The weight coefficients were not significantly different ($p > 0.05$) among treatments. The study on technical assessment of *Trachinotus blochii* by Ly Van Khanh et al. [16] showed that fish were not different in weight after 30 days of rearing in the recirculation system under various densities (60, 90, and 120 fish/m^3). This recorded result was not significantly different ($p > 0.05$).

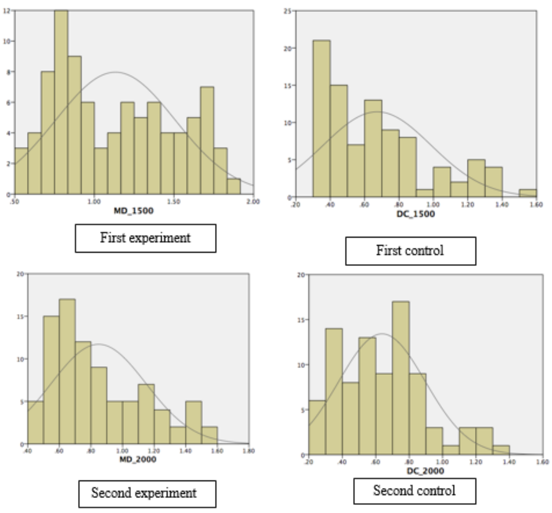

Fig. 2: Weight coefficient of fish after 60 days of rearing

According to Tran Van Danh [5], fish reared on tarpaulin tanks with a density of 1,000 individuals/m^2 will reduce the rate of division compared to fish reared at a density of 1,500 individuals/m^2 and 2,000 individuals/m^2. The data in Table 5 and Figure 2 revealed that, in contrast to fish raised in the control system, fish raised in the recirculation system at two different densities were more comparable in size. This demonstrates how the fish rearing strategy has an impact on the fish stocking ratio.

V. CONCLUSION AND RECOMMENDATION

The present research confirms that the 60-day rearing period of *M. favus* in the recirculation aquaculture system brought the best results. The stocking density of 1,500 individuals/m^3 was considered the most suitable space for fish growth. In terms of weight, fish reached the highest growth rate at 1.13 g/individual with the absolute and relative growth rates at 0.019 g/day and 7.08%/day, respectively. The fish length was at 6.98 cm/fish with the absolute and relative growth rates at 0.10 cm/day and 3.18%/day, respectively. The best survival rate of fish reached 50.6%. It is possible to apply the current research's results to the production of fingerlings in the context of Tra Vinh Province.

There should be more studies on rearing *M. favus* in a recirculation aquaculture system with a higher stocking density which could be gradually decreased from the 30^{th} day of rearing onwards.

ACKNOWLEDGEMENTS

The present research was financially supported by Tra Vinh University based on the contract No. 75/2022/HD.HĐKH&ĐT-ĐHTV.

REFERENCES

[1] Nguyen Van Trieu. Study on the biological characteristics of spiny eel (*Mastacembelus armatus*). *Can Tho University Journal of Science*. 2010;15b: 70–80.

[2] Nguyen Thanh Trung, Nguyen Tuong Anh, Nguyen Quoc Thanh. Preproduciton trial of spiny eel (Mastacembelus armatus). *The Journal of Agriculture and Development – Nong Lam University*. 2010: 16–21.

[3] Rural Economic Magazine. *Cultivation of tiger track eel, economic efficiency*. 2021. Available from: https://kinhtenongthon.vn/nuoi-ca-chach-lau-hieu-qua-kinh-te-cao-post47170.html [Accessed 20^{th} March 2022].

[4] Minh Hung. *The commercial model of raising tire track eel*. 2020. Retrieved from: https://travinh.gov.vn/mDefault.aspx?sid=1472&pageid=7095&catid=70371&id=605291&catname=tin-kinh-te&title=cang-long-hoi-thao-mo-hinh-nuoi-ca-chach-lau-thuong-pham [Accessed 10^{th} February 2022].

[5] Tran Van Danh. *The summary report of the research on rearing trial of tire track eel (Mastacembelus favus) in tarpaulin tanks with different densities of water management using a mechanical circulatory filtration system*. Vinh Long: Department of Agriculture and Rural Development of Vinh Long Province. 2017.

[6] Tran Hoang Diem. *Mature rearing and breeding of spiny eel (Mastacembelus armatus)* [University Graduate Thesis]. Can Tho University, Vietnam; 2009.

[7] Aeyrin Afroz Md. Sherazul Islam Md. Rezwanul Hasan Mst. Hasnahena Dilshad Milky Tuly. Larval rearing of spiny eel, Mastacembelus pancalus in the captivity with emphasis on their development stages. *International Journal of Fisheries and Aquatic Studies*. 2014;1(6): 163–167.

[8] Md Sherazul Islam, Tandra Rani. Larval rearing and the observation of the development features in striped spiny eel, Mastacembelus pancalus in captive condition. *Journal of Entomology and Zoology Studies*. 2017;5(6): 2488–2493.

[9] Nguyen Viet Thuy. Study of the effect of density on the growth and survival of Xi-Be-Gi sturgeon (Acipenser baerii Brandt, 1869) on fingerlings. *Aquaculture Research Institute*. 2008;3.

[10] Nguyen Van Trieu and Pham Anh Van. Study on the nutritional characteristics of soldier river barb (Cyclocheilichhthy enoplos) from fry to fingerling. *Can Tho University Journal of Science*. 2016;47: 79–86.

[11] Hoang Tung, Luu The Phuong and Huynh Kim Khanh. Trial of rearing seabass (Lates calcarifer) from fry to fingerling with floating ditches placed in earthen ponds. *Journal of Fisheries Science and Technology*. 2007;01: 12–18.

[12] Ly Van Khanh, Tran Thi Thanh Hien, Tran Ngoc Hai. Rearing marbled eel (Anguilla marmorata) fry by using different diets in a recirculating system. *Can Tho University Journal of Science*. 2013;26: 143–148.

[13] Truong Quoc Phu. *Water Quality Management in Aquaculture Ponds*. [Lecture] Faculty of Fisheries, Can Tho University. 2005.

[14] Boyd CE. Water quality for pond aquaculture. *International Center for Aquaculture and Aquatic Environments, Alabama Agricultural Experiment Statio*. Auburn University, Alabama, America. 1998;43. Available from: http://soiltesting.tamu.edu/publications/AU43.pdf [Accessed 7^{th} July 2022]

[15] Ta Hong Minh, Huynh Trung Hai. Assessment of some hydration parameters of the water environment in aquaculture in Hai Duong Province. *Environment Magazine – Institute of Strategy and Policy on Natural Resources and Environment, Ministry of Natural Resources and Environment*. 2017;Special Issue I: 50-54.

[16] Ly Van Khanh, Cao My An, Tran Ngoc Hai. Effects of different densities on growth and survival rate of pompano (*Trachinotus blochii*) fingerlings reared in circulating water system. *Can Tho University Journal of Science*. 2021;57: 20–25.