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Growth Performance and Survival of Red Tilapia (*Oreochromis* spp.) Larva Rearing in Floating Hapa-canvas in Kenyir Lake, Terengganu

Noor Faizah Ismail and Siti Norita Mohamad*

Fisheries Research Institute of Glami Lemi, 71650 Titi, Jelebu, Negeri Sembilan, Malaysia

ABSTRACT

Water quality in the larvae-rearing environment plays a significant role in its growth and survival, especially in an open water body system. The effect of hapa placed in a tank-like structure made of canvas (hapa-canvas; HC) on the growth performance and survival of red tilapia larvae reared in Kenyir Lake was evaluated in wet and dry seasons compared to hapa without canvas as a control. The experiment was conducted for five weeks, and the stocking density of larvae in wet and dry seasons was 1500 larvae/m^3 and 400 larvae/m^3, respectively. Larvae were fed with commercial powdered feed until satiation twice daily and sampled weekly. The final weight of larvae reared in HC in the wet (603.3 ± 25.9 mg) and dry (1,308.7 ± 60.7 mg) seasons were higher ($p<0.05$) than control (398.7 ± 68.0 mg and 807.3 ± 47.9 mg; respectively). The survival rate was also higher ($p<0.05$) in HC (68.6 ± 7.3% and 87.7 ± 1.7%) compared to control (7.3 ± 1.0% and 74.8 ± 0.3%) in wet and dry seasons, respectively. Thus, hapa-canvas may be a good alternative to rear tilapia larvae in an open water body based on its growth performance and survival rate.

Keywords: Canvas, dry season, stocking density, temperature, wet season

INTRODUCTION

Kenyir Lake, located in Terengganu, Malaysia, is the largest man-made lake in Southeast Asia and was built for electricity generation. Under the government initiative, up to 2000 floating cages were assembled in the aquaculture industrial zone to boost freshwater fish production with red tilapia, *Oreochromis* spp. becomes the dominant fish cultured in Kenyir Lake. According to annual statistical data, red tilapia is among the three major freshwater species being cultured in Malaysia (Department of

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E-mail addresses:
nfaizah@dof.gov.my (Noor Faizah Ismail)
ctnorita@dof.gov.my (Siti Norita Mohamad)
* Corresponding author

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Fisheries, 2022). Several issues arise regarding the inconsistency of tilapia seed supply, either from the quantity or quality aspect. High mortality of fish is usually caused by stress due to the long distance of travel and fish handling during packaging for transportation because fish seed hatcheries are typically situated far away from the culture site (Honryo et al., 2018; Husen et al., 2021). Thus, cage operators have been encouraged to produce fish seeds in the cage system.

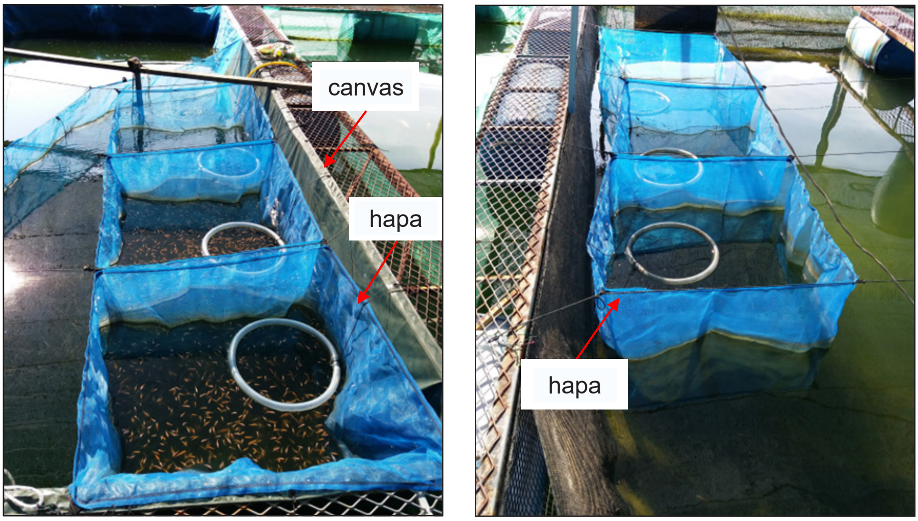
Water quality in Kenyir Lake falls into Class II based on the National Water Quality Index by the Department of Environment, Malaysia (Subramaniam et al., 2023). Kenyir Lake is an oligotrophic lake because of its low primary productivity, nutrient content, and algal production (Suratman et al., 2019) and is illustrated as 'clear water.' According to Ismail et al. (2016), the Secchi disc reading of Kenyir Lake was 425 cm deep, indicating the water's clarity. In the natural habitat, phytoplankton serves as a major food source for a wide range of aquatic organisms, including fish fry, especially after the egg-yolk development of the fish larvae has been completed (Raja et al., 2018). Phytoplankton is consumed by the zooplankton, which then becomes a feed source for the fish fry in the food web (Soukaina et al., 2022). The growth and diversity of the phytoplankton depend on the water condition (Jewson et al., 2015) and nutrient availability.

Water consists of microalgae or phytoplankton, which is beneficial for fish rearing, especially during the nursery stage (Chen & Zeng, 2021), often referred to as 'green water.' In this study, the canvas was used as an impoundment in cages to entrap nutrients and induce the development of 'green water' for rearing red tilapia larvae in cages. A fine mesh of nylon net called hapa was inserted into the canvas, called hapa-canvas. Early-stage larval rearing becomes a challenge in floating cages due to 'clear water,' which indicates low natural food availability and direct sunlight penetration into the waterbed, affecting larvae viability (Pan et al., 2020). Therefore, the objective of this study was to evaluate the effect of using hapa-canvas on the growth performance and survival rate of red tilapia larvae reared at the cage culture of Kenyir Lake.

MATERIALS AND METHODS

Study Site and Experimental Set-up

The location of the study was at Como River, Kenyir Lake, Terengganu (5°00'N, 102°48'E). Kenyir Lake has an average depth of 37 m and 260 km^2 of surface area in a 38,000-ha area (Freshwater Fisheries Research Centre [FFRC], 1995). Cages with a dimension of 6 m × 6 m × 3 m were used. Nylon canvas (6 m × 3 m × 1.5 m) was hanging in the cage frame before hapa (1 m × 1 m × 1 m) was put inside the canvas, known as hapa-canvas (HC). HC provided an enclosed water system to entrap nutrients and induce the development of green water, while hapa without canvas was used as a control (Ctl) (Photo 1). In this study, hapa was made of nylon with 20 strands per inch mesh size.



(a) (b)

Photo 1. (a) Hapa-canvas and (b) hapa without canvas acted as a control at the end of the experiment

Fish Stocking and Sampling

An average of 14 ± 1 mg and 17 ± 1 mg of tilapia larvae were stocked at 1500 larvae/m^3 and 400 larvae/m^3 in the wet and dry seasons, respectively. Larvae were weighed using an analytical balance (ELB2000, Shimadzu) before being stocked into the hapa. A total of 100 larvae were assigned into a group of ten at each time of weighing and sampled weekly. Larvae were supplied by Telaga Juta Solution (M) Sdn. Bhd. that produces red tilapia fry at their cage facility. The difference in stocking density between the two seasons was based on the larvae's availability when the experiment started. The first experiment was conducted in an inter-monsoon to wet season (September till October 2019) with a stocking density of 1500 larvae/m^3 in hapa-canvas (HC-W) compared to control (Ctl-W) without canvas. The second experiment was conducted in the dry season (July until August 2020) with a stocking density of 400 larvae/m^3 in hapa-canvas (HC-D) compared to the control (Ctl-D) without canvas. Larvae were fed with marine fish feed (Cargill; 38%–40% crude protein) twice daily until satiation. The rearing was conducted for five weeks. At the end of the experiment, all surviving fish in the treatment and control group were harvested, counted, and weighed in a group of twenty to determine their survival and final body weight. Treatment and control were performed in triplicate.

Water Analysis

Water quality was monitored biweekly using Horiba LAQUAact DO-110 portable water quality meters for measuring dissolved oxygen (DO) and temperature. In contrast, a Horiba LAQUAtwin pH sensor was used to determine the pH. Water quality parameters during the study period were reported in the range of 26.8°C –30.0°C, pH 7.1–7.6, and 5.4–6.5 mg/ml of dissolved oxygen. Plankton samples were taken at 8 a.m. at the end of the experiment (fifth week) using a plankton net with a mesh size of 35 µm. The plankton net was placed for five minutes in the HC and Ctl, respectively, horizontally 0.5 m below the water surface. Then, 100 ml of the water sample in the sampling bottle was transferred to a plastic sampling bottle. A few drops of formalin were put in the samples for preservation. A 1 ml water sample was drawn into the Sedgwick-Rafter chamber for cell counting under a compound microscope (Motic BA200) using 10× and 20× magnification lenses.

Parameter Observed

All parameters related to fish growth were calculated, including the body weight (BW), specific growth rate (SGR) and survival rate (SR). These parameters were calculated based on Equations 1 and 2:

$$SR(\%) = 100 \times \left(\frac{Final\ \ count}{Initial\ \ count}\right) \qquad [1]$$

$$SGR\ (\%)\ per\ day = \frac{log_{final\ weight} - log_{initial\ weight}}{time_{days\ of\ rearing}} \times 100 \qquad [2]$$

Statistical Analysis

Data on growth and survival were analyzed using an independent *t*-test between treatments in the same season. All analysis was performed using Statistical Product and Service Solutions (SPSS) version 20 software for Windows (SPSS Chicago, IL, USA), and values were presented as means ± SEM (standard error of means). All statistical analyses were tested with a significance level of $\alpha = 0.05$ ($p<0.05$).

RESULTS

The mean body weight and survival of red tilapia larvae at harvest reared in hapa-canvas for both stocking densities (HC-W and HC-D) were higher than in control (Ctl-W) and Ctl-D) (Table 1). Red tilapia larvae achieved the highest mean body weight of 1.310 ± 0.250 g reared at 400 fish/m^3 in HC-D, while the lowest was 0.313 ± 0.115 g of red tilapia fry raised in Ctl-W at 1500 larvae/m^3. In the fifth week of rearing, the mean body weight of red tilapia larvae was significantly higher ($p< 0.05$) in hapa-canvas for both seasons compared to the control. At the end of rearing, the survival rate of larvae in hapa-canvas was highly significant ($p<0.05$, 0.001) during the wet season and significant in the dry season ($p<0.05$, 0.010) when compared to the control. The SGR was significantly higher ($p<0.05$) in HC-D when compared to control (Ctl-D); however, it was not significantly different ($p>0.05$) in the wet season.

The growth of red tilapia larvae in both hapa-canvas (HC-W and HC-D) significantly increased (p<0.05) after the second (HC-W) and third week (HC-D) of rearing at 1500 larvae/m^3 and 400 larvae/m^3, respectively (Figure 1). The final body weight of red tilapia larvae at a lower stocking rate (dry season) showed a higher result than at a higher stocking rate (wet season) after five weeks of rearing.

Water samples from hapa-canvas and control were checked for collective phytoplankton; however, no plankton was identified. The phytoplankton was not reported in the first experiment (wet season) due to sample degradation during preservation. The phytoplankton and zooplankton density in HC-D was 356 ± 19 individuals/ml and 433 ± 22 individuals/ml, respectively, and significantly (p<0.05) higher when compared to Ctl-D, which was 130 ± 13 individuals/ml and 59 ± 22 individuals/ml; respectively.

Table 1
Comparison of body weight, survival rate and specific growth rate of tilapia larvae reared in different seasons in hapa-canvas and control

	Wet Season			Dry Season		
	Ctl-W	HC-W	p-value	Ctl-D	HC-D	p-value
Stocking density, larvae/m^3	1500			400		
Initial BW, mg	13.9 ± 0.3	13.6 ± 0.3	0.664	17.0 ± 0.6	17.3 ± 1.2	0.815
Final BW, mg	398.7 ± 68.0^a	603.3 ± 25.9^b	0.048	807.3 ± 47.9^a	1308.7 ± 60.7^b	0.003
SR, %	7.3 ± 1.0^a	68.6 ± 7.3^b	0.001	74.8 ± 0.3^a	87.7 ± 1.7^b	0.010
SGR	9.5 ± 0.5	10.9 ± 0.2	0.070	11.4 ± 0.2^a	12.7 ± 0.1^b	0.006

Note. Values are the mean of three replicates ± SEM. The means on the same row within the same season, the different superscripts are significantly different (p<0.05). BW=Body weight; SR=Survival rate; SGR=Specific growth rate

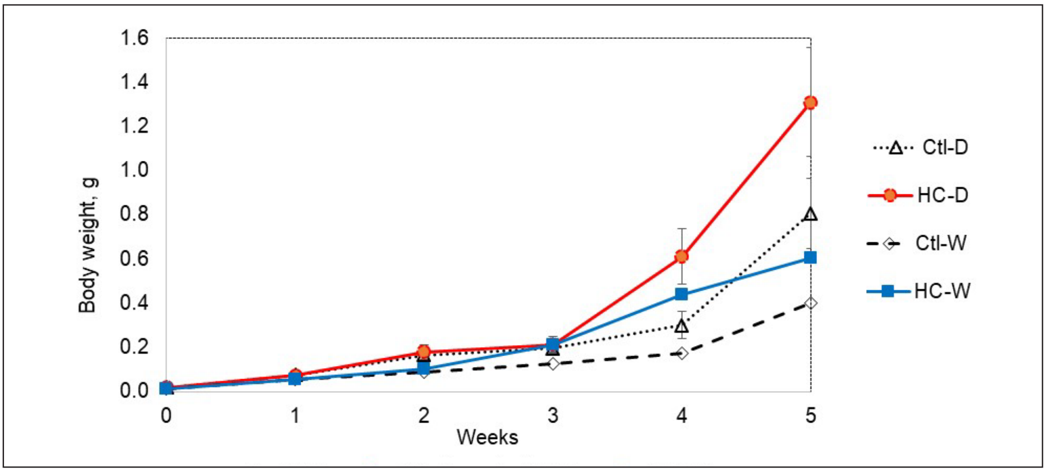


Figure 1. Growth performance of tilapia larvae rearing in hapa-canvas compared to control during wet inter-monsoon (HC-W and Ctl-W) and dry (HC-D and Ctl-D) seasons

The trend of environmental temperature was higher for eight days or points in the dry season compared to the wet season (Figure 2). The mean temperature was 28°C in both seasons. The same trend was also recorded for wind speed, where the wind speed was higher during the dry season (5.9 m/h) compared to the wet season (4.2 m/h). The highest wind speed was 10.1 m/h. The average precipitation was 11.3 mm for the wet and 8.1 mm for the dry season. The highest precipitation was 23.7 mm during the experimental period.

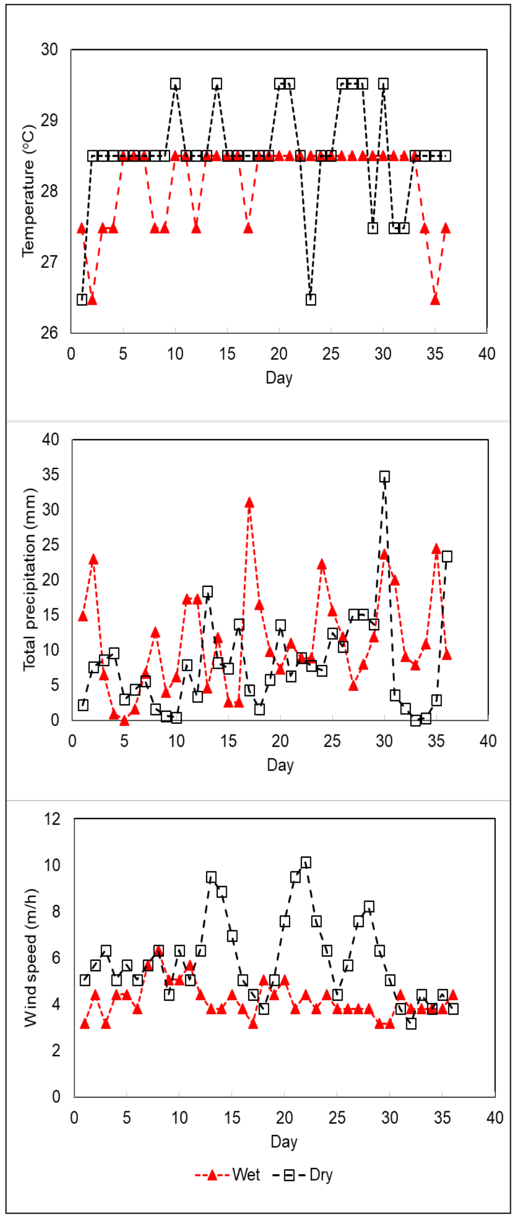


Figure 2. Trends of temperature, total precipitation, and wind during the inter-monsoon (wet) and dry seasons (Kuala Berang, Terengganu, 2023)

DISCUSSION

Kenyir Lake's water bodies are associated with 'clear water,' which scarcely holds onto the nutrients from the aquaculture activities that provide a platform for phytoplankton to bloom. The development of green water in hapa-canvas might contribute to better growth (final mean weight and SGR) and survival of red tilapia larvae during the rearing period compared to the control hapa. Basford et al. (2021) found that the growth and survival of *Portunus armatus* larvae in green water were superior to those of the crabs that were reared without green water. The higher density of phytoplankton and zooplankton in the hapa-canvas compared to the control might offer natural feed availability for larvae to graze on. Post-larvae of *Penaeus monodon* showed better growth performance and survival after having a diet supplemented with algae and co-feeding with *Artemia* (Jaseera et al., 2021). Meanwhile, the mean body weight of larvae reared in HC-D was higher than HC-W due to a negative correlation between stocking density and weight increment of the fish (Ani et al., 2022).

The formation of green water, which contains phytoplankton, was faster at higher stocking density, which could possibly cause the difference in mean body weight after two weeks of rearing compared to low stocking density, which occurred after the third week. More solid waste and excess feed were expected to be produced from 1500 larvae/m^3 than 400 larvae/$m^{3,}$ which would then serve as nutrients for phytoplankton to bloom. Excess feed and fish waste can fertilize the pond and increase fish production (Boyd et al., 2020). The most important elements the phytoplankton requires for growth and reproduction are nitrogen and phosphorous (Cremen et al., 2007). According to Zhang et al. (2022), tilapia affected the water quality by increasing the amounts of total nitrogen, total dissolved nitrogen (TDN), NH^{4+}, and total suspended solids in the mesocosms study.

Larvae are fragile, and exposure to extreme environments can have a fatal impact. The canvas surrounding the hapa provided a conducive, secure, and stable environment for the larvae rearing, thus not affected by the water current or turbulence during the wet season. It was observed that larvae reared in hapa-canvas showed higher survival in the wet season than in the control. This study was conducted in the inter-monsoon seasons of September to October, entering the wet season. The drastic changes in water quality or turbulent water can be avoided in the hapa-canvas compared to the control hapa. Rain coming with the heavy wind could cause water turbulence in Kenyir Lake and affect larvae in the control hapa more than in the hapa-canvas. Hence, the turbulence during heavy rain could possibly contribute to higher survival in HC-D than in HC-W. Wind speed seems to have a minimal impact on water bodies compared to precipitation or rainfall. Abdulqadir et al. (2016) have reported that weather conditions seem to be the major factor contributing to the fluctuation of water quality parameters and primary production in the man-made lakes in Selangor. They found that water parameters such as pH, water temperature and alkalinity were changed due to the impact of rainfall dilution. In addition, green water also acts as a shade to protect fish from direct light (Sanaye et al., 2014), reducing the stress on the fish larvae.

CONCLUSION

Hapa-canvas is a suitable tool for rearing tilapia larvae in an open or large water body because it can help develop ‘green water’ and reduce the impact of drastic changes in the surrounding environment due to weather changes. Further research can be conducted on the effects of water quality parameters, plankton distribution, and other factors affecting fish growth, such as stocking density and depth of hapa-canvas.

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