International Journal of Aquaculture, 2015, Vol.5, No.22, 1−5
http://ija.biopublisher.ca

Research Report Open Access

Effect of Stocking Density and Rearing Facility on Growth and Profitability of *Tilapia rendalli* Fry

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International Journal of Aquaculture, 2015, Vol.5, No.22 doi: 10.5376/ija.2015.05.0022
Received: 05 Jun., 2015
Accepted: 07 Jul., 2015
Published: 06 Aug., 2015

Preferred citation for this article:
Zidana H., Phiri F., Kapute F., Ajiboye O. and Singini W., 2015, Effect of Stocking Density and Rearing Facility on Growth and Profitability of *Tilapia rendalli* Fry, International Journal of Aquaculture, 5(22): 1-5

Abstract A study was conducted to compare the growth potential of *Tilapia rendalli* at three different stocking densities, using different rearing facilities. *T. rendalli* fry of 0.9±0.1g average weight were stocked in tanks and hapa-in-ponds at the stocking density of 30, 60 and 90 fry/m^3. Locally made feed (CP-18%) was administered at 5% body weight three times a day for three months. Monthly sampling was conducted to assess growth by measuring weight and length for specific growth rate (SGR), average daily gain (ADG), weight gain (WG), and biomass (BM). The results of the study showed a significantly higher ($P < 0.05$) growth rate in low stocking density (30 fry/m^3) as compared to 60 and 90 fry/m^3. There was a highly significant ($P < 0.05$) growth rate from hapas mounted in pond rearing facility as compared to tanks. There was no significant difference in profitability between the two rearing facilities ($P > 0.05$) as well as within the stocking densities ($P > 0.05$). The results of this study have a significant contribution towards stocking densities as well as rearing facilities used by hatchery operators. It is recommended that hapas mounted in pond fry rearing for *T. rendalli* fingerling production is most ideal. The results of the present study suggested that production of good quality fingerlings at stocking densities of 30 fry/m^3 must be adopted in the culture of *T. rendalli* as fish grows faster than the other stocking densities of 60 and 90 fry/m^3 as demonstrated in this study.
Keywords *Tilapia rendalli* Fry; Stocking Density; Rearing Facility; Growth

Introduction

Tilapia, that is native to Africa and Middle East, has emerged from mere obscurity to one of the most productive and internationally traded food fish in the world (Gupta and Acosta, 2004). It is a popular food fish species with great aquaculture potentials in many tropical and subtropical regions of the world (Ajiboye and Yakubu, 2010). Global aquaculture production of tilapias increased from 28,000 tonnes to over 3 million tonnes from 1970 to 2012 (FAO, 2012). Currently, tilapia is farmed commercially in almost 100 countries worldwide, with over 98 percent of the production occurring outside their original habitats (FAO, 2011). Now, it is being regarded as both a commodity or speciality crop such as poultry (Fitzsimmons, 2010).

The most cultured fish species in Malawi are Tilapias, namely *Tilapia rendalli*, *Oreochromis shiranus* and *Oreochromis karongae*, which together account for about 93% of production (Chirwa, 2009; Russell et al., 2008). These herbivorous-cum-omnivorous fish have a good aquaculture potential because they are exceptionally hardy and prolific, easy to farm and thus ideal for both small farmers and industrial sized aquaculture (Chirwa, 2009; Maluwa and Gjerde, 2006).

Seed for tilapia can be basically produced through three rearing facilities: pond, hapa and tank rearing systems. According to Guerrero (2002), identified “best practices” is important in any industry for providing good and exact examples for a successful operation. Knowledge on good aquaculture practises (GAPs) in tilapia farming will ensure sustainably development in its farming by employing environmentally and economically friendly culture techniques (Orina et al., 2014). This would ensure all-year round tilapia quality seed production and supply to grow out farmers which is one of the constraints to the industries’ production potential.

In Malawi, there is an increasing interest in the culture of *Tilapia rendalli*. One of the major problems facing small-holder aquaculture in Malawi is the precocious breeding of this species and the resultant fish density-driven stunting, compounded by lack of capacity to control fingerling numbers in the ponds (Chirwa, 2009; Russell et al., 2008). Various efforts have been made to determine appropriate stocking densities to overcome this limitation with considerably varied stocking density recommendations (Russell et al., 2008). Most farmers have problems with stocking densities as well as favourable rearing facilities for fry rearing. The present study was carried out to investigate the effect of stocking density and rearing facility on the growth and economic potential of *T. rendalli* fingering production.

Methodology

The present study was carried out at the National Aquaculture Centre in Domasi, Zomba, from January to March 2014. *T. rendalli* fry of 0.9±0.1g average weight from National Aquaculture Centre hatchery were stocked in 1x1x1 m outdoor concrete tanks and 1x1x1 m hapas mounted in a 650 m^2 pond at a space of 1m between hapas, at the stocking density of 30, 60 and 90 fry/m^3 designated as Treatments: T_1, T_2 and T_3 respectively in three replicates. Local feed (CP; 18%) was administered at 5% body weight three times a day for three months. Initial weight and length of fry was recorded at the start of the experiment followed by monthly sampling to assess the fish's growth with a sample size of 30, 60 and 90 fish for T_1, T_2 and T_3 respectively. At close of three months, the experimental fish was harvested and final body weight and length recorded. Dissolved oxygen, pH and temperature were recorded twice a day (8am and 2 pm) in the entire experimental period using HANNA Multi-parameter HI 8424.

Growth indices were calculated using the following formula:

Specific Growth Rate (SGR) = [Ln(Wf) – Ln(Wi) / Time (days)] x 100

Where Wf is Final average weight, Wi is Initial average weight, Ln is Natural logarithm and Time is Number of experimental days.

Average Daily Gain (ADG) = $Wt_2 – Wt_1 /t$

Where $Wt_2$is final mean weight of fish at time t_2, Wt_1 is Initial mean weight of fish at time t_1 and t is time in days.

Weight Gain (WG) = $Wt_2 – Wt_1$

Where Wt_2 is final mean weight of fish at time t_2, and Wt_1 is Initial mean weight of fish at time t_1.

Biomass (BM) = Wt_2 x N_2

Where Wt_2 is final mean weight of fish at time t_2, and N_2 is fish that survive until the end of the time interval (t_2).

Profit index was used as an economic indicator using the following formula as adopted from (Ita and Okeoye, 1988).

Profit index = value of fish crop / total cost of feed

Data Analysis

Data on growth and profitability were analyzed using Two-Way Analysis of Variance (ANOVA) at 95% confidence interval. Least Significant Difference (LSD) was used to separate the means among stocking densities and within rearing facilities. Statistical Package for Social Scientists (SPSS) 16.0 was used for the analysis.

Results and Discussion

Growth and Economic Parameters

To assess *T. rendalli* fry growth within the treatments, SGR, ADG, WG, MBW, BM and Lt for both tanks and hapas-in-ponds were calculated and presented in Table 1 and Figure 1.

Table 1: Growth (g) of *T. rendalli* fry in the two rearing facilities under three stocking densities

Parameter	Treatments					
	Tanks			Hapas		
	30	60	90	30	60	90
Specific Growth Rate	2.12	1.68	1.52	2.54	1.98	1.44
Average Daily Growth	0.03	0.02	0.02	0.04	0.03	0.02
Weight Gain	1.07	0.86	0.75	1.6	1.1	0.71
Mean Body Weight	1.87±.06	1.76±.05	1.65±.04	2.51±.08	2.01±.09	1.62±.07
Biomass	56.10	105.60	148.50	75.30	120.60	145.80
Length	4.43±.04	4.35±.03	4.31±.03	5.11±.06	4.68±.08	4.43±.06

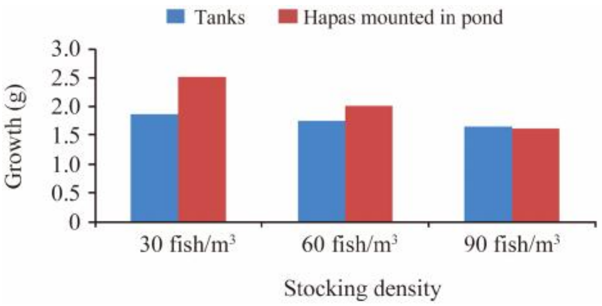

Figure 1 *T rendalli* fry growth rate per stocking density within rearing facilities

A two-way ANOVA was conducted to examine the effect of stocking density and rearing facility on growth of *T. rendalli* fry. There was significant interaction between stocking density and rearing facility on growth of *T. rendalli* fry, F (2, 12) = 17.132, $p = 0.001$. Statistical significant differences were also observed in both the rearing facility, F(1,12) = 1918.00, $p = 0.001$, with fry reared in hapas mounted in pond (4.67±0.42) growing better than fry reared in tanks (1.67±0.19). Stocking density, F (2,12) = 17.61, $p = 0.001$, with fry in T_1 (3.45±1.81) grew better than fry in T_2 (3.07±1.79) and the least being T_3 (2.98±1.34). The results show that rearing facility had more influence on fry growth than stocking density. Rearing facilities play a great role in fry growth as they provide a platform for natural feed enhancement depending on the nature of the facilities. The potential for enhanced primary productivity in ponds made hapas mounted in pond more productive compared to the tank. These results agree with Keremah and Esquire (2014) who attributed the differences in growth to the availability of natural food (plankton) induced by decomposed and degraded uneaten artificial feed for fish in the pond unlike in the tank, where the fish relied solely on artificial feed as the only food source. The availability of additional dietary protein source may attribute to the highest SGR for fry reared in hapas mounted in pond.

The results also show that growth performance of *T. rendalli* fry is affected by stocking density. This is in agreement with Mensah (2013) and (King et al., 2000) who observed that social interactions through competition for food and/or space negatively affect fish growth, hence higher stocking densities lead to increased stress, resulting into increase in energy requirements thereby causing a reduction in growth rate and food utilization. Stocking density is an important parameter which directly affects the growth of fish and hence its production (Backiel and Le Cren, 1978). Thus the present study has demonstrated that fry in low stocking densities grow faster hence attain fingerling stage earlier than fry in high stocking densities. The results in this study are in agreement with the findings of Abdel-Hakim and Ammar (2005) who reported that lower stocking densities resulted in significantly higher final weights and lengths of fish compared with the higher stocking densities.

To assess the profitability potential of the treatments, economic parameters of production for both tanks and hapas-in-ponds were calculated and presented in Table 2.

The results show that there were no statistically significant interaction between the effects of stocking density and rearing facility on profitability of *T. rendalli* fry, F (2, 12) = 0.18, $p = 0.98$. These results show that both stocking density and rearing facility do not affect profitability of fingering production. This could be as a result of the pricing policy of fingerlings where fingerings are sold in numbers and not biomass. However, selling fingerlings after attainment of a stock-able size, thus reducing the rearing time can limit production costs and affect profitability, especially with the fast growing hapas mounted in pond system.

Table 2: Profit index among the treatment groups

Treatment		Biomass (g)	Cost of feed (MK)	Value of fingerlings (MK)	Profit index
Tank	30	25.40±0.35	421.99	450	1.29±0.02^a
	60	52.00±2.77	794.33	900	1.26±0.07^a
	90	92.70±28.84	1117.02	1350	1.12±0.30^a
Hapa	30	27.10±0.17	514.19	450	1.31±0.01^a
	60	54.60±0.01	823.53	900	1.30±0.01^a
	90	102.00±36.37	995.61	1350	1.12±0.33^a

Means with the same superscript on the same column are not significantly different at α = 0.05, 1USD=450MK

Low stocking densities can also prove profitable if fingerlings get out of the production system as soon as they attain a good stocking size of 3 g.

Water Quality Parameters

To assess the effect of environmental factors on growth; water temperature, dissolved oxygen (DO) and pH were taken in the rearing facilities during the experimental period and are presented in Table 3.

Findings observed in this study show that tilapia grow successfully at temperature range of 20-30°C and this allowed better feeding of the cultured tilapia species at a favourable temperature, hence better fry growth. These results have been reported in several earlier studies such as El-Sayed (2006), El Naggar et al. (2000), Popma and Masser (1999) and Balarin & Haller (1982). The ideal DO level for tilapia culture is 4-5 mg/l (Frank, 2000; Marjani et al., 2009; Chakraborty and Banerjee, 2010) and the present study showed higher DO values in the two rearing facilities irrespective of the stocking densities thereby attributing good environment for tilapia culture. The pH values of the two rearing facilities in all the density classes were within the permissible optimum range of 6.5 to 11.0 for tilapia culture as stated by (Frank, 2000; Marjani et al., 2009; Chakraborty and Banerjee, 2010). Generally, all the water quality parameters were within the acceptable ranges as recommended for tropical aquaculture (Boyd, 1982; Beveridge, 1996).

Table 3: Mean water quality parameters for the rearing facilities

Rearing facility	Temp (℃)		DO (mg/l)		pH	
	Min	Max	Min	Max	Min	Max
Tank	25.65±1.95	28.51±2.19	6.74±0.30	7.08±0.22	7.29±0.43	7.55±0.33
Hapa	26.49±1.10	29.88±0.78	7.32±0.38	7.40±0.33	7.20±0.18	6.88±0.15

Conclusion and Recommendations

T. rendalli is an economically important fish species whose production is mostly hampered by unavailability of fingerlings. The research findings in this present study have demonstrated that *T. rendalli* fry reared in hapas mounted in pond is a more productive and favourable rearing system than tanks. This therefore calls for the promotion of hapas mounted in pond system of fry rearing for *T. rendalli* fingerling production. For production of good quality fingerlings, stocking densities of 30 fry/m^3 have proven to be more effective as fish grows faster than the other stocking densities of 60 and 90 fry/m^3. In terms of economic profitability, the present study has found that no rearing facility had a superior economic potential over the other.

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