GROWTH EVALUATION, SEX CONVERSION RATE AND PERCENT SURVIVAL OF NILE TILAPIA (*OREOCHROMIS NILOTICUS* L.) FINGERLINGS IN EARTHEN PONDS

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Abstract

The objective of the study was to assess growth, sex conversion rate and percent survival of Nile tilapia (*Oreochromis niloticus* L.) fingerlings of the GIFT strain reared in twelve 500 m^2 earthen ponds. Each pond was stocked with size #24 sex-reversed tilapia fingerlings at a density of 4 pcs/m^2. The kinds of hatching system where the tilapia fry were hatched served as the treatments in this study and were as follows: I – artificial incubation-hatched fry, II – hapa-hatched fry, III – pond-hatched fry and IV – combination of hatched fry by stocking 33.3% from each hatching system. Each treatment was replicated three times. After the pond rearing, analysis of variance indicated no significant differences on the gain in length, gain in weight, specific growth rate, sex conversion rate and survival of tilapia fingerlings among treatments (P>0.05). It is concluded that the hatching systems used in the study had no significant effects on the specific growth rate, gain in length and weight, sex conversion rate and percent survival of tilapia fingerlings. Therefore, any hatching system can be used to produce tilapia fry for pond rearing.

INTRODUCTION

Tilapia is the third among the major species produced in Philippine aquaculture in 2005, contributing 8.6% to the total aquaculture production (BFAR, 2005).

Data from the Philippine Fisheries Profile by BFAR (2005) shows that in terms of the aquaculture production by culture environment, region and species, tilapia ranked first among the cultured finfishes in freshwater pond production. It also shows that Region III (Central Luzon) leads in terms of freshwater fishpond production with a total production of 70,182.97 MT wherein 96.5% came from tilapia pond production.

Nile tilapia, scientifically known as *O. niloticus* L. is the main species cultured in freshwater ponds and cages in Central and Southern Luzon (Guerrero, 2002).

Other species like Mozambique tilapia and its hybrids with *O. niloticus* and *O. hornorum* are also significant for brackishwater pond production in the country.

According to Guerrero (2002), identifying "best practices" is important in any industry for providing good and exact examples for a successful operation. For tilapia farming to develop on a sustainable way there is a need in knowing the best practice to guide those who want to start up businesses and to allow those already into tilapia farming to find out how they can improve their present practice.

Along with the aim to meet the prevailing seed demand, seed quality is also of great importance to achieve in order to provide quality seed that can be widely distributed and increase the entry of small-scale farmers to tilapia farming. Production of more uniform-sized fry could prove advantageous for more effective sex reversal treatment and consistently high quality fingerling.

Also, there are anecdotal opinions from tilapia hatchery operators that tilapia seed collected from ponds are hardier. This kind of judgment by farmers may limit the sourcing out of tilapia fry/fingerlings from other hatching units.

Indeed, there is a need to identify the most effective hatching system to guarantee the success of fingerling production.

Several hatching systems are used by tilapia fingerling producers on seed production. This study focus on artificial incubation units, hapas and ponds and the most effective system in producing quality most uniform size of fingerlings will be noted.

The use of artificial incubation units involves the removal of eggs and sac fry from the mouth of females and incubating them artificially as an effective method of tilapia fry production. It is preferable to natural incubation due to several reasons. These include the elimination of cannibalism, high production of even-sized fry, increased spawning synchrony, shortened inter-spawning intervals, reduction of hatching time and facilitation of research on tilapia genetics and reproduction.

Net enclosures or hapas are also used for the hatchery of tilapia (Guerrero, 1997). Hapas has many attributes that make them an excellent hatchery system for tilapia, especially in developing countries (El-Sayed, 2006). These include easy construction, easy management, easy seed harvest and low cost. Hapas can also be suspended in fertilized earthen ponds, deep water bodies and concrete tanks supplied with clear water.

Spawning in earthen ponds is the oldest method used for seed production of tilapia, and is still widely used in different regions of the world. Tilapia can spawn easily in ponds, regardless of pond size and depth, once the environmental requirements (temperature, salinity, etc.) and biological criteria (stocking density, sex ratio, etc.) are met (El-Sayed, 2006). However, according to Guerrero (1997) fry production in ponds is subject to predation and cannibalism.

Growth in fishes is a complex process by which ingested energy is converted to biomass. The efficiency of this conversion is regulated by the growth potential of the organism and various abiotic factors such as food supply, temperature and adverse environmental factors brought about by the conditions in which the fish are cultured (Soderberg, 1997). The aforementioned factors are considered exogenous factors which greatly affect growth in a varied manner depending on the prevailing condition during the culture period. Food supply varies greatly among different environmental conditions, most importantly to differences in the quantity and quality of the food resources provided by these environments.

Temperature and other environmental factors dictate the progress of growth of the fish whether it will be at its optimum or not. When desirable levels of these factors are reached, growth will take place and if possible, optimum growth will be attained.

Also, influence on growth is sometimes due to endogenous factors which involve diversion of energy from growth to gonadal development along with the use of ingested energy for maintenance. In addition, Soderberg (1997) states that fish typically have sexual differences in growth, like the male tilapias grow to larger sizes than the females.

The objective of the study was to evaluate growth, sex conversion rate and percent survival of tilapia fingerlings reared in ponds.

MATERIALS AND METHODS

Tilapia breeders of the same cohort (GIFT selected generation 11) were used to produce fingerlings in artificial incubation units, hapas and ponds at the GFII facility.

There were four treatments used with three (3) replicates in the study. The four treatments were as follows; I – incubation-hatched fry, II – hapa-hatched fry, III – pond-hatched fry and IV – combination of hatched fry (artificial incubation units, hapas and ponds). Each treatment was replicated three times.

Sex-reversed tilapia fingerlings with size #24 were stocked in twelve 500 m^2 earthen ponds at the Freshwater Aquaculture Center, CLSU, Philippines and were reared for 90 days for growth, survival and sex determination. Each pond was stocked at 4 pcs/m^2 for each replicate per treatment. The fish were fed with commercial feed twice a day between 8-9:30 in the morning and 2-3:30 in the afternoon, seven days a week.

Commercially available feeds were used according to the age of the fry. The respective crude protein (CP) contents were as follows: fry mash (48.0% CP), starter feeds (34.0% CP) and grower feeds (24.0% CP). The amount of feeds was also based from estimated percent survival for the first, second and third month of pond rearing of 100, 90, and 80%, respectively.

Application of inorganic fertilizer was carried-out weekly with urea (46-0-0) and ammonium phosphate (16-20-0) at a rate of 28 kg of N/ha/wk and 5.6 kg of P/ha/wk. Pond fertilization was done by dissolving 2.6 kg of urea and 1.4 kg of ammonium phosphate in water for each 500 m^2 pond and broadcast on the pond surface to enhance the growth of natural food. For ponds with higher seepage, regular replenishment of pond water was done along with the weekly monitoring of water quality parameters such as dissolved oxygen (D.O.) and temperature using YSI Model 55.

Fish sampling was done twice a month. During the sampling day, the stocks were not fed. Feeding resumes on the following day following the adjusted computation of feed to be given per day. This practice is observed in order to prevent accumulation of uneaten feeds that can lead to deterioration of the water quality. The experiment was laid-out following a randomized complete block design.

Manual sexing was used in the study in determining the sex ratio after rearing in pond with the help of the skilled laborers from the GFII.

The differences among the fry rearing systems were analyzed using analysis of variance (ANOVA) in Randomized Complete Block Design with three replications followed by Least Significant Difference for comparison of means. Statistical analysis was carried out by using the Statistical Analysis Software (SAS) Version 9.0.

RESULTS AND DISCUSSION

Table 1 presents a summary of the observed percentages of males per treatment.

Table 1.Observed values of percentage of males subjected to sex reversal treatment

Treatment	No. of Fish Examined*	Percent Male $\pm$ S.D.
I – incubation-hatched fry	4097	96.15 $\pm$ 0.70
II – hapa-hatched fry	2971	96.91 $\pm$ 0.88
III – pond-hatched fry	3842	95.61 $\pm$ 0.78
IV – combination of hatched fry	4401	94.99 $\pm$ 1.12

Note: Treatment means on percent male is not significantly different at 5% level of significance.

*The number of fish examined for sex represents the total number of fish which survived in the pond at the end of the study.

The result showed that the highest percentage of male was obtained in fry hatched in hapas (96.91%) followed by fry hatched in incubation units (96.15%), fry hatched in ponds (95.61%) and combination of fry hatched from three sources (94.99%), however, analysis of variance on the percentage of male indicated no significant difference ($P>0.05$) among the different treatment means. Percentage of males and females is graphically shown in Figure 2.

Male and female percentages were subjected to binomial testing. Results showed that feeding of 17 α-methyltestosterone to the fry significantly altered the sex ratio towards male from the expected 1:1 ($P<0.0001$). Percentage male and female of the treated fry differed from the normal condition but the difference in percentage male and female of the fish treated in hapas were not significant.

Percent male among treatments were similar to the findings of Vera Cruz and Mair (1994). The androgen had no significant effect on growth and survival of fry during the treatment period and produced mean sex conversion rate of 95.4% male in hapas. Macintosh *et al.* (1988) reported a sex conversion of 95.7% and 92.8% in their experimental units stocked with methyltestosterone-treated fry.

The availability of phytoplankton as an alternative source of food for fry may have had a slightly adverse effect on the efficacy of the hormone treatment in hapas. Suspension of feed in water causing the possible dilution of hormone and the minimal feeding reaction of fry to the given feed due to the low temperature was also observed. Thus, it is apparent that a small proportion of females are still observed, emphasizing the need for optimizing sex-reversal to produce very high sex conversion rate, preferably in excess of 98% male. Vera Cruz and Mair (1994) also mentioned that higher doses of MT (60mg per kg) at higher stocking densities induced almost 100% sex-reversal.

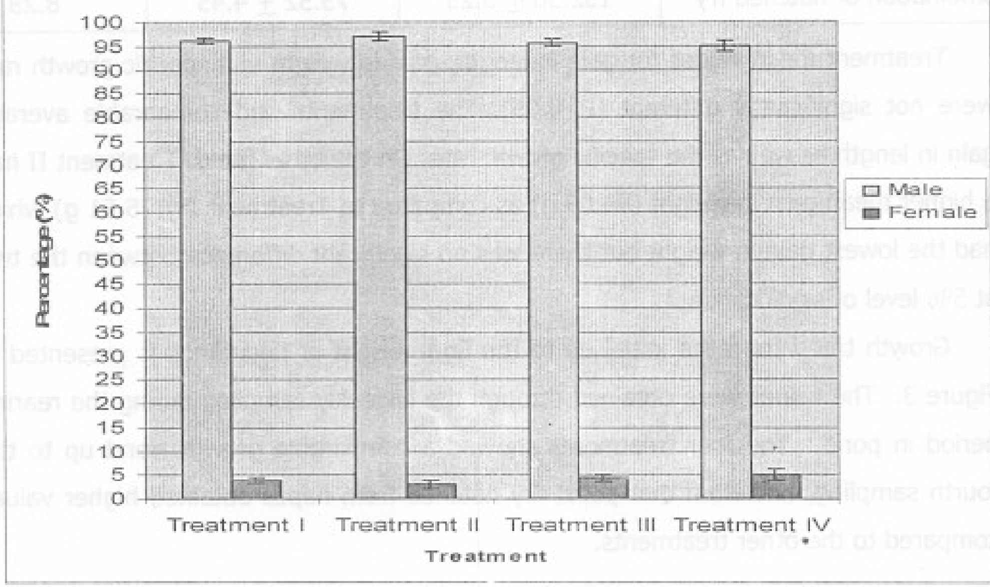

Figure 2. Percentage of male and female per treatment

The initial and final mean length and weight were taken as presented in Table 2. ANOVA showed no significant differences among treatment means at 5% level of significance.

Table 2. Initial and final mean length and weight of fry reared in ponds

Treatment	Initial Length (mm) ± S. D.	Final Length (mm) ± S. D.	Initial Weight (g) ± S. D.	Final Weight (g) ± S. D.
incubation-hatched fry	17.41 ± 0.82	155.13 ± 4.75	0.07 ± 0.01	81.48 ± 11.14
hapa-hatched fry	17.33 ± 0.44	155.13 ± 4.75	0.08 ± 0.01	94.17 ± 30.08
- pond-hatched fry	17.40 ± 0.49	152.56 ± 4.39	0.07 ± 0.01	78.72 ± 6.22
- combination of hatched fry	17.57 ± 0.61	149.93 ± 5.14	0.07 ± 0.00	75.59 ± 4.45

Differences in initial length and weight of the stock used for rearing in pond were not significantly different and of the same value showing the efficiency of the grading procedure done prior to stocking in ponds. Growth performances including gain in length, gain in weight and specific growth rate were obtained as shown in Table 3.

Table 3.Mean growth performances of fingerlings reared in pond

Treatment	Gain in Length (mm) ± S. D.	Gain in Weight (g) ± S. D.	Specific Growth Rate (%) ± S. D.
incubation-hatched fry	137.72 ± 4.02	81.41 ± 11.14	8.39 ± 0.22
II – hapa-hatched fry	137.80 ± 14.00	94.09 ± 30.08	8.38 ± 0.31
III – pond-hatched fry	135.16 ± 4.12	78.65 ± 6.22	8.39 ± 0.12
combination of hatched fry	132.36 ± 5.25	75.52 ± 4.45	8.28 ± 0.09

Treatment mean values for gain in length, gain in weight and specific growth rate were not significantly different (P>0.05). The treatments had comparable average gain in length as well as the specific growth rate. On the other hand, Treatment II had a higher mean gain in weight (94.09 g) as compared to Treatment IV (75.51 g) which had the lowest gain in weight but there was no significant difference between the two at 5% level of significance.

Growth trend from the initial up to the final weight of fingerlings is presented in Figure 3. The values were obtained through the biweekly sampling during the rearing period in pond. The four treatments showed a comparable growth trend up to the fourth sampling, and from that point, fry hatched from hapas obtained higher values compared to the other treatments.

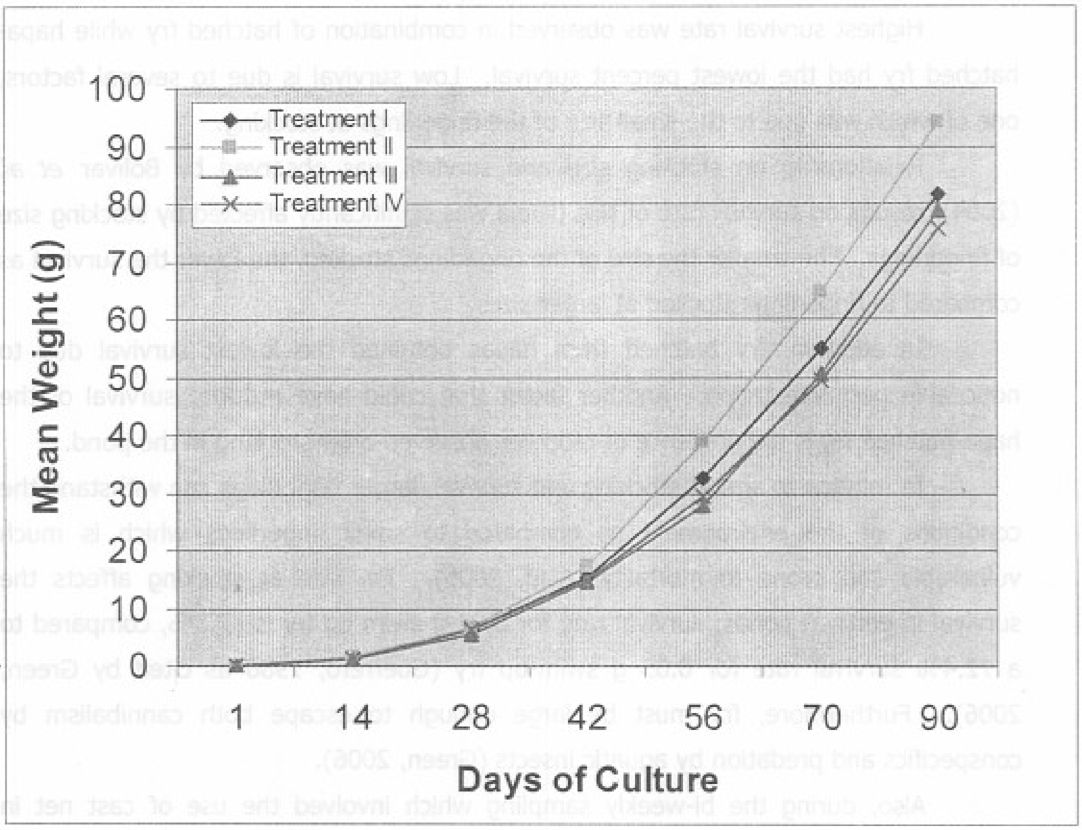

Figure 3.Growth pattern of fingerlings reared in pond

Percent survival of fingerlings after rearing in pond

Table 4 shows the percent survival of the four treatments. Percent survival was obtained after the rearing period in ponds.

Table 4.Mean percent survival of fingerlings reared in ponds

Treatment	Survival (%) ± S. D.
I – incubation-hatched fry	67.26 ± 8.38
II – hapa-hatched fry	49.52 ± 13.45
III – pond-hatched fry	64.03 ± 7.10
IV – combination of hatched fry	73.35 ± 5.56

Note: Treatment means are not significantly different at 5% level of significance.

Survival in incubation-hatched fry (67.27%) as compared to other treatment means like hapa-hatched fry (49.52%), pond-hatched fry (64.03%) and combination of hatched fry (73.35%) may differ numerically but statistically, the treatment means have no significant difference at 5% level of significance.

Highest survival rate was observed in combination of hatched fry while hapa-hatched fry had the lowest percent survival. Low survival is due to several factors, one of which was due to the small size of the fingerlings at stocking.

Relationship on stocking size and survival was observed by Bolivar *et al.* (2004), results on survival rate of Nile tilapia was significantly affected by stocking size of fingerlings. The smaller the size of the fingerlings stocked, the lower the survival as compared to fingerlings stocked at larger sizes.

In addition, fry hatched from hapas obtained the lowest survival due to noticeable pest infestation. Another factor that could have reduced survival of the hapa-hatched fry is the presence of tadpoles observed after stocking in the pond.

In relation to size at stocking and survival, larger fingerlings can withstand the conditions of the environment as compared to small fingerlings which is much vulnerable and prone to mortality (ADB, 2005). Fry size at stocking affects the survival in earthen ponds; survival rate for 0.01-g swim up fry is 57.3%, compared to a 72.4% survival rate for 0.05 g swim-up fry (Guerrero, 1986 as cited by Green, 2006). Furthermore, fry must be large enough to escape both cannibalism by conspecifics and predation by aquatic insects (Green, 2006).

Also, during the bi-weekly sampling which involved the use of cast net in collecting the samples, stress may have possibly cause mortality. Samples were measured and weighed individually and often, the use of cast net caused the fish to be entangled and afflicted with wounds. Also, natural mortality was unavoidable.

Pest infestation is also observed in the rearing ponds. With various insects present, predation may have occurred, increasing mortality because some of the larger insect larvae, such as water scorpions, will attack and eat small fish fry. These can be very damaging in nursery ponds and may have possibly affected the survival of the fingerlings.

Rearing ponds also attract birds like kingfishers and egrets which occasionally prey on fish. The presence of these predators reduces survival of the stock although most birds are scared away by regular human activities and by shooting (Arrignon, 1998).

Mortality can also be due to the stress brought about by the abrupt changes in water temperature especially when it rains due to typhoons which prevailed during the conduct of the study.

Figures 4 and 5 present the mean values of the water quality parameters in ponds. Average measurements for Treatment I were: DO: 5.55 mg/l (range: 1.6-10.95), SDVD: 31.17 cm (18-60), water temperature 25.06 °C (range: 21.3-28). Water quality parameters in Treatment II were: DO: 5.58 mg/l (range: 1.67-11.5), SDVD: 35.75 cm (18-60), water temperature 25.26 °C (range: 21.7-28). Readings for Treatment III were: DO: 5.83 mg/l (range: 2.2-19.62), SDVD: 27.05 cm (16-60), water temperature 24.96 °C (range: 21.1-27.8). Finally, recorded measurements for

Treatment IV were: DO: 5.56 mg/l (range: 1.65-17.9), SDVD: 30.04 cm (14-60), water temperature 24.98 °C (range: 21.4-27.8).

Average dissolved oxygen concentrations as well as the recorded mean water temperature during the rearing in pond fall within the desirable range for the culture of tilapia. However, fluctuations on dissolved oxygen concentration and water temperature are evident during the culture period which is caused by the variation in the prevailing weather during the conduct of the activity.

Water temperature is the most important factor regulating the rate of metabolism in fishes, therefore sudden change in water temperature leads to immediate changes in fish metabolism. This change leads to reduction in feeding activity, growth rate and making the fish more susceptible to diseases (Neil and Brayan, 1991 as cited by Almoudi *et al.*, 1996).

Charo-Karisa *et al.* (2004) also reported the relation of size to low temperature similar to this study which can possibly caused low survival. The study indicated that small fingerlings are more susceptible to cold stress than larger fingerlings. This also confirms the observation by other farmers that smaller fish are more vulnerable during the cold months, dictating the use of larger sizes of fingerlings.

On pond productivity, Secchi Disc Visibility Depth was maintained at 30 cm for the growth of natural food. The turbidity of the water was observed whether it was due to clay or mud or due to phytoplankton. Clay or mud turbidity may limit the effect of fertilizer as it reduces light penetration. Inorganic fertilizer was applied to augment the production of natural food.

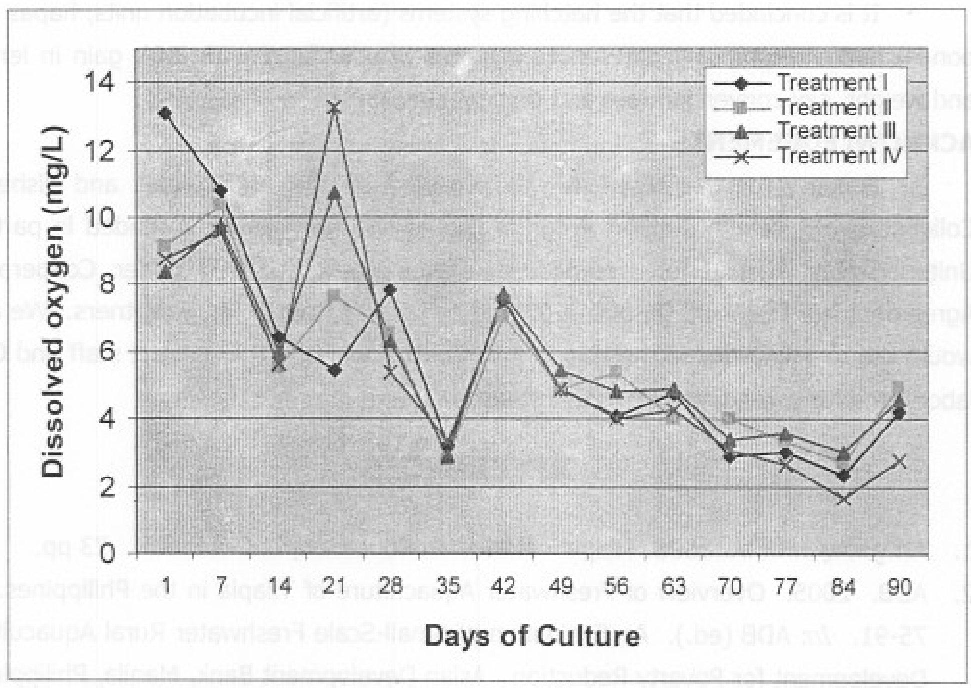

Figure 4.Average dissolved oxygen during rearing in ponds

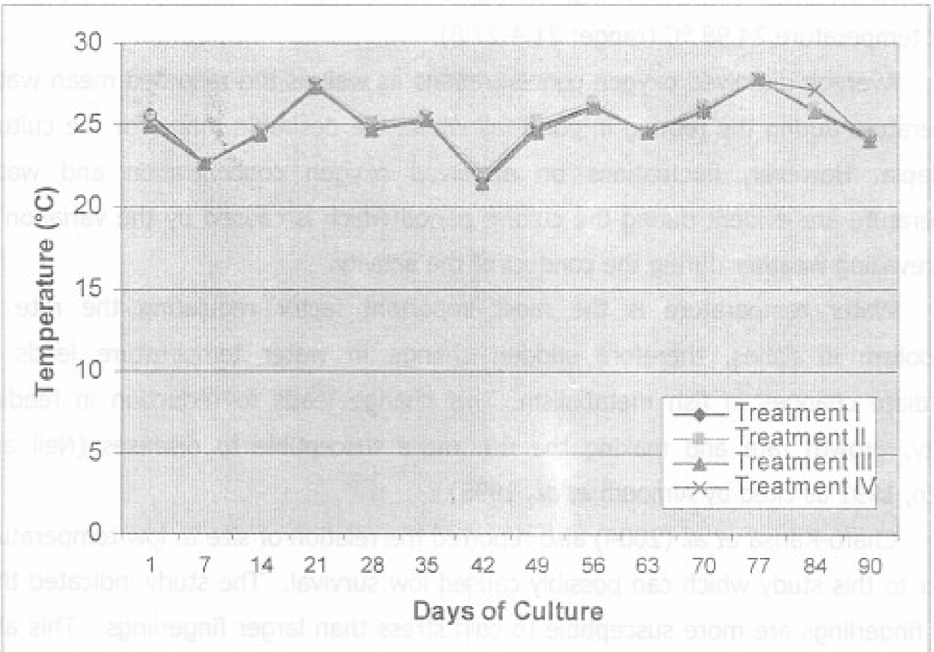

Figure 5.Average water temperature during rearing in ponds

CONCLUSION

In the experiment, hapa-hatched fry had the highest gain in length (140.73 ± 14.00 mm), weight (94.09 ± 30.08 g) and male percentage (96.91 ± 0.88 %). While the combination of hatched fry had the highest survival (73.35 ± 5.56 %) among treatments, however, no significant differences were found among treatments.

It is concluded that the hatching systems (artificial incubation units, hapas and ponds) had no significant differences in terms of specific growth rate, gain in length and weight, sex conversion rate and percent survival.

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