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Effects of frequency of eggs and fry harvest on seed production and growth of Nile tilapia

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Abstract
This study analyzed the potential of harvesting eggs and fry at different time intervals for improved seed production of Nile tilapia. Broodstock were put in 3x1m^2 hapas at a sex ratio of 3 females: 1male. Eggs and fry were harvested at intervals of 8 days, 10 days, 12 days and 14 days respectively. The results showed a direct positive relationship between the harvesting frequencies and total seed production, where Broodfish in the 14 days treatment produced the highest total seed output (13979 ± 314) followed by 12 days (10167 ± 248), 10 days (6645 ± 135) and 8 days (4509 ± 112) respectively. The 8 days harvesting frequency consistently recorded zero swim up fry throughout the study while the 10 days treatment yielded the highest egg counts of 4272 ± 127. The specific growth rates and condition factors of females did not significantly differ among all the treatments.

Keywords: Broodstock, fry, hapa, Nile tilapia, seed

Introduction

Fish is an important source of nutritious food, providing over 70% of total animal protein [1], vitamins, minerals and essential trace elements in the diet of many Ghanaians. The people of Ghana have a vibrant fish eating culture, spending 61% of their animal protein source expenditure on fish, primarily due to its relative affordability [1, 2, 3]. This makes fish and fish products very important in Ghana's economy, providing jobs to over 10% of the national populace and generating about US$ 1 billion in revenue annually [4, 5, 6].

Over the past five decades, the annual production of fish from marine capture fisheries has declined to levels that are unable to meet the national demand, therefore leaving a deficit of about 50% annually [4]. The prospects for increased fish production from Ghana's marine fisheries sector seem to dwindle due to the high level of stress in both national and global capture fisheries [7]. Efforts at bridging the national deficit has been through fish importation [8] and promotion of aquaculture as a sustainable way of accelerating the recovery of wild fish stock in Ghana and the world at large [7, 9]. The aquaculture sector in Ghana is dominated by fish farming, which is gradually manifesting itself as an immediate option for fish production through its rapid growth from 720mt in the late 1990's to 52,470mt in 2016 [10, 11].

Nile tilapia (*Oreochromis niloticus*) is the most cultured species in Ghana, which has grown significantly over the last few decades in global fish culture [7]. Mensah and Attipoe outlined the attributes of Nile tilapia that make them suitable for culture using their rapid growth rates, high tolerance to adverse environmental conditions, efficient feed conversion, ease of spawning, resistance to diseases and good consumer acceptance [12]. Despite some successes in the Nile tilapia culturing business, the industry is faced with major challenges such as inadequate production of quality seed for stocking, feed supply, land acquisition, credit availability and technology transfer [13]. This species has for a long time remained the fish about which more complaints are made with respect to small harvest size in culture due to lack of quality fish seed available for stocking in production facilities [14]. In Ghana, it has been estimated that 50 million fingerlings are required annually to offset the fish seed deficit [15]. However, the current number of operational hatcheries are not able to supply enough quality fingerlings for stocking in production facilities [16]. This challenge is mainly due to the natural mouth brooding reproduction strategy of the fish, as well as the high level of technical expertise required in managing Nile tilapia broodstock under culture conditions [17].

It is therefore important to identify sustainable seeds production strategies to enhance the farmed fish output in the country. One important broodfish management strategy that ultimately maximizes seed output by yielding uniformly-sized fry is the frequent harvest of eggs and fry from the mouths of fish for artificial incubation and larval rearing [18]. This strategy helps the fish to quickly regain lost energy and become available for the next spawning cycle [18, 19, 20, 21]. A report by Urman showed that *Nile tilapia* offsprings produced from broodstock during 11 to 14 days grow faster and better [17, 22]. Moreover, the inter-spawning interval of the fish is reduced and production is increased from an average of one spawn to two spawns per month if the eggs and fry are harvested frequently [20]. The current therefore aimed at establishing the most appropriate inter-seed-harvesting frequency for Akosombo strain of Nile tilapia to enhance the technical efficiency of operational hatcheries in Ghana. Such pertinent knowledge can improve our understanding of hatchery management measures that sustainably yield the seeds required by fish farmers in Ghana and the world at large. The study gives further information on hatchery management to enhance fish production and income of fish farmers; which could enhance the United Nations Sustainable Development Goals of zero hunger and poverty.

Materials and Methods

Site of study

The study was conducted in an earthen pond at the Aquaculture Demonstration Center of Department of Fisheries and Water Resources, University of Energy and Natural Resources. The site (longitude 07˚20'44.948'N, latitude 02˚21'37.99'W) is located at Berlin Top, Sunyani in the Bono Region of Ghana. Hapas for the experiment were sewn from mosquito nets with surface area dimension of $3x1m^2$ and fixed to bamboo poles using nylon ropes and mounted in an 0.5 ha earthen pond to maintain a water depth of 0.6 m inside.

Stocking and Feeding

The Nile tilapia used for the study were obtained from Aquaculture Research and Development Centre and acclimatized before the commencement of the experiment. The broodfish were manually sexed and randomly stocked at a sex ratio of 3 males to 9 females in treatment hapas. The average initial weight of male broodfish was 133.7 ± 9.7g and that of female, 104.3 ± 6.5g. Altogether, twelve hapas were utilized with three replicates for each of the four treatment. Broodfish were fed with pelleted commercial feed containing 40% crude protein by hand broadcast three times daily at 08:00, 12:00 and 16:00 GMT at 3% body weight daily.

2.3 Eggs and Fry Harvest

The frequency of eggs and fry harvest (treatments) were 8 days, 10 days, 12 days and 14 days. During harvest, the treatment hapas were carefully bagged and all broodfish were removed. The mouths of broodfish were carefully inspected for eggs, sac-fry and swim-up fry after which, the broodfish were put back gently into their respective hapas. The eggs, sac-fry and swim-up fry were sorted, and counted on petri dishes. The experiment was completed in ninety seven days, allowing 7 times collection of seeds from each treatment.

Water quality measurement

Water quality parameters such as dissolved oxygen (DO), temperature, pH, ammonia (NH_3-N) and turbidity in the hapas were monitored bi-weekly.

Statistical analysis

The following parameters were calculated to evaluate the growth performance of broodfish:

Weight gain (g) = Mean final weight - Mean initial weight

Specific Growth Rate (%/day) = (In final weight –In initial weight) $100t^{-1}$

Condition factor= weight of fish (g) /standard length^3

Survival (%) = No. of fish harvested/No. of fish stocked × 100

Data emanating from the study were analyzed using one-way analysis of variance (ANOVA) using the SPSS ANOVA procedure. Treatment effects were considered significant at $P< 0.05$. Tukeys tests were used to compare differences between treatment means.

Results

There was a clear evidence from this study that the frequency of eggs and fry harvest significantly ($P< 0.05$) affected the spawning success of female Nile tilapia in each of the treatments in the experiment. The 14 days treatment recorded the highest total seed output (13979 ± 534) followed by the 12 days interval with 10167 ± 453 seeds (Fig. 1). The other treatments produced relatively low number of seeds with the 8 days interval yielding the least output of 4508 ± 310 in total seed.

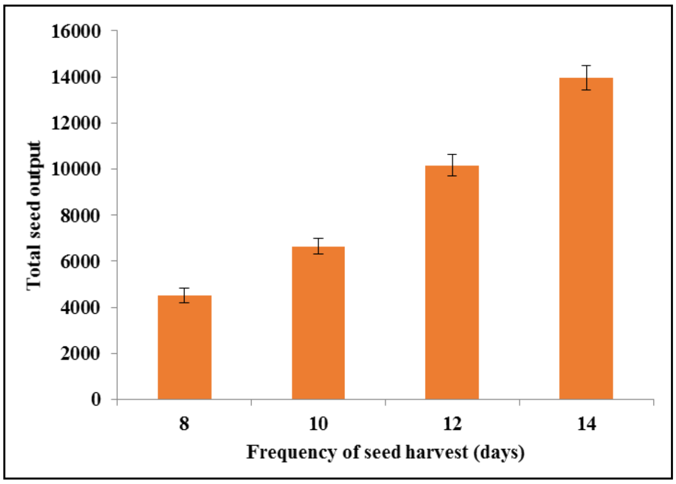

Fig 1: Total seed production of Nile tilapia broodfish at different harvest intervals in a hapa-in-pond hatchery system.

The 10 days and 14 days treatments recorded a significantly high number of eggs (4272 ± 127 and 4151 ± 200 respectively) compared to the 8 and 12 days treatments that produced statistically same (p>0.05) eggs count. However, the average number of sac-fry counted was higher in the 8 days and 10 days treatment and significantly different from the output of the other treatments (Table 1; figure 2). The least (322 ± 57) sac-fry was recorded in the 12 days treatment. The results in Table 1 and figure 3 also revealed higher swim-up fry counts for the 12 and 14 days treatments, with 14 days interval observed to be highest (13979 ± 534) although not significantly different from the 12 days treatment. There was no swim-up fry observed for the 8 days treatment throughout the study.

Table 1: Output of seeds by Nile tilapia females harvested at different frequencies in a hapa-in-pond hatchery

Treat.	No. Eggs	No. Sac-fry	No. Swim-up	Total seed
8 days	2111 ± 148[a]	2397 ± 162[a]	0[a]	4508 ± 310[a]
10 days	4272 ± 127[b]	2167 ± 183[a]	198 ± 34[b]	6637 ± 344[b]
12 days	2379 ± 106[a]	322 ± 57[b]	7466 ± 290[c]	10167 ± 453[c]
14 days	4151 ± 200[b]	1188 ± 79[c]	8640 ± 255[c]	13979 ± 534[d]

Means in the same column having different letters are significantly ($P \leq 0.05$) different

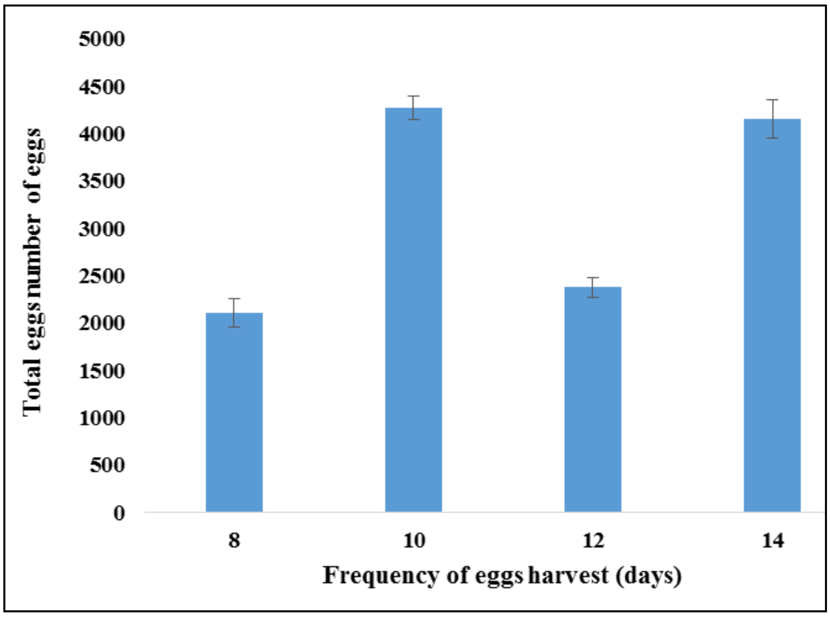

Fig 2: Eggs production of Nile tilapia broodfish at different seed harvesting days in a hapa-in-pond hatchery system.

The average initial and final weights as well as growth and condition factors of the female broodfish used in the study are shown in Table 2. The condition factors and specific growth rates did not differ among the treatments (p>0.05) although the final condition factors were observed to be lower when compared with the initial conditions. No mortalities were observed throughout the period of study.

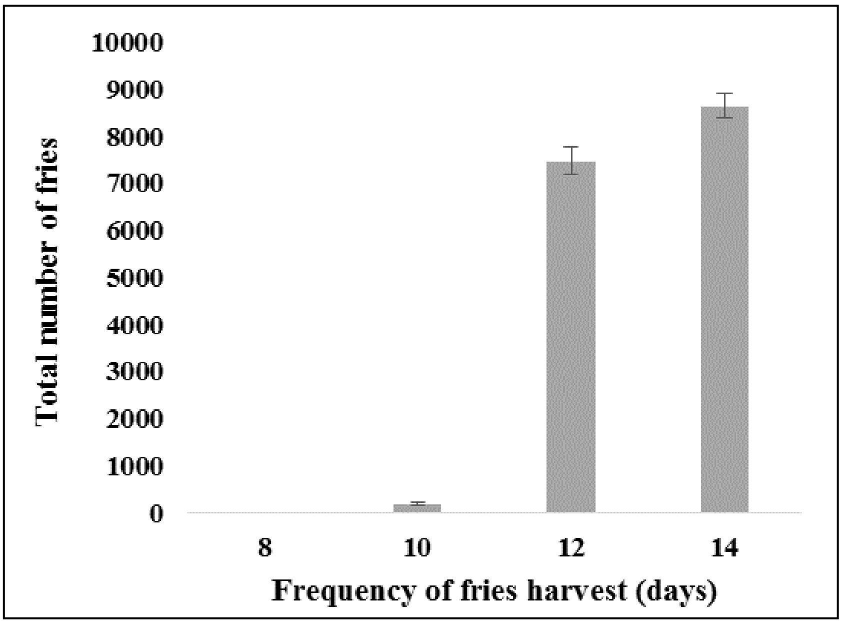

Fig 3: Fries output of Nile tilapia broodfish at different seed harvesting days in a hapa-in-pond hatchery systems

Table 2: Effect of frequency of eggs and fry harvest on growth parameters and survival rates of Nile tilapia female broodstock

Parameters	Harvesting Frequencies (DAYS)			
	8	10	12	14
Initial female body weight (g)	91.1 ± 1.0	112.1 ± 2.9	114.7 ± 0.7	99.4 ± 1.9
Final female body weight (g)	95.0 ± 6.5	125.4 ± 1.9	115.2 ± 3.9	100.7 ± 6.9
Female specific growth rate (%g per day)	0.019± 0.007 ^{a}	0.049± 0.088 ^{a}	0.002± 0.075 ^{a}	0.007± 0.022 ^{a}
Initial female condition factor (g/cm^3)	3.30 ± 0.82 ^{a}	3.56 ± 0.24 ^{a}	3.64 ± 0.33 ^{a}	3.53 ± 0.31 ^{a}
Final female condition factor (g/cm^3)	2.78 ± 1.15 ^{a}	2.89 ± 1.15 ^{a}	3.52 ± 0.61 ^{a}	3.50 ± 0.37 ^{a}
Female survival (%)	100	100	100	100

Means in the same row having same superscripts are not significantly ($P \leq 0.05$) different.

Table 3 shows a summary of the average values of water quality parameters of the pond recorded throughout the study. The parameters reflected the environmental conditions under which the fish were cultured and all parameters were within the optimal range for tilapia growth although dissolved oxygen levels (3.9 ± 0.7 mg/l) was observed to have never reached 5 throughout the period.

Table 3: Mean values of physicochemical parameters of the pond

Parameter	Mean ± SD
Temperature	30.0 ± 0.7
pH range	6.1-7.3
Dissolved Oxygen (mg/L)	3.9 ± 0.7
Total Hardness (as CaCO3) (mg/L)	27.0 ± 0.4
Total Alkalinity (as CaCO3) (mg/L)	35.3 ± 0.6
Phosphate (PO4-P) (mg/L)	0.12 ± 0.03
Nitrate (NO3-N) (mg/L)	0.17 ± 0.05
Nitrite (NO2-N) (mg/L)	0.04 ± 0.03
Ammonia (NH3-N) (mg/L)	0.06 ± 0.13

Discussion

The need for a reliable production of quality fingerlings in Ghana's fish farming business cannot be overemphasized. The inadequate supply of fingerlings discourages financial investments in the tilapia industry. Therefore, a more efficient strategy to improve seed production is cardinal. Results from the current study showed that harvesting eggs and fry at different intervals significantly affects the efficiency of seed production in female Nile tilapia. An increase in the frequency of eggs and fry harvest led to a progressive increase in the total seed output. This suggests that, the performance of Nile tilapia with respect to spawning and hatchability of eggs is influenced by the frequency of seed harvest in broodstock management. This observation was confirmed by Bhujel and Suresh who stated that, female Nile tilapia spawn, incubate and release fry at different times in hapas [18].

The highest seed output from the 14 days harvesting frequency might be an indication that as the time for seed harvest increases, the broodfish had sufficient time to release the eggs and fry to coincide with the inter-harvesting times. The high number of harvested swim-up fry under 12 days and 14 days treatments (Fig. 3) strongly suggests that they are best time intervals for the production of Nile tilapia fry in a hatchery. This observation authenticates the recommendation by Rana, that, fry harvesting frequency of 13 to 14 days should be adopted by hatchery operators for optimum reproduction, spawning efficiency and larval growth of Nile tilapia [20]. The 10 days treatment recorded the highest number of eggs (4272 ± 127) and could be due to adequate time provided within the 10 days for laying of eggs. However, the low count for eggs in the 8 days treatment (2111 ± 148) might be ascribed to a relatively shorter inter-harvesting resting period [20] when compared with the other treatments. The time period for development of eggs and sac-fry into swim-up fry in the 8 days treatment might have accounted for the observed zero records for fry.

According to *Tahoun et al*., an inadequate attention given to broodstock selection and handling, past spawning activities, and production conditions may have serious repercussions on the efficiency of seed production and could also be a major setback on commercial tilapia seeds production and its future expansion [23]. From the current study it was realized that the net weight gain of females in the 12 days and 14 days treatments was less than those that were harvested during 8 and 10 days intervals (Table 2). The observed trend in this study agrees with Rana who stated that frequent removal of eggs or newly hatched fry from the mouths of female *Oreochromis* helps them to quickly regain lost energy and become available for the next spawning [20]. However, the mean specific growth rates of the female brooders in all treatments were very slow (Table 2). This was because female broodfish are known to channel their energy to egg/fry production instead of somatic growth [24]. Additionally, the females were seen to barely feed during mouth brooding. This also probably accounted for the lower final condition factor of the females in all the treatments when compared to the initial condition factors recorded in Table 2.

According to Hasan *et al*., oral incubation is very delicate and could be affected by any stressful condition in the environment [25]. One other major factor that influences seed output in tilapia culture is water quality [18]. The mean water quality parameters measured in this experiment were within the optimum ranges proposed for Nile tilapia production in ponds [19, 26]. However, the average dissolved oxygen levels that were below 5 mg/l throughout the study may have stressed the broodfish to some extent, leading to the poor specific growth rates of the females in all the treatments. We therefore advocate for hatchery managers to keenly monitor the quality of water to ensure optimum environmental conditions for broodstocks.

Conclusion

Based on results from this study, there were clear evidence that the frequency of eggs and fry harvest significantly ($P <$ 0.05) affected the spawning success of female Nile tilapia in each of the treatments in the experiment. A farmer targeting swim-up fry, could use the 14 days fry-harvest intervals. However, hatchery operators targeting fertilized eggs for artificial incubation could adopt the 10 days eggs inspection for better yield. It is recommended that further experiments be carried out to study the fertilization and hatchability efficiency of the eggs and sac-fry harvested from the broodfish.

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