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SOME FACTORS AFFECTING FRY PRODUCTION OF THE NILE TILAPIA, *OREOCHROMIS NILOTICUS*

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Abstract

The present experiment was carried out during July 2005 to October 2006 in large heated indoors recycling facilities at the Faculty of Agriculture, Ain Shams University, Cairo, to study some factors affecting fry production in the Nile tilapia *Oreochromis niloticus*. Experimental design included two stocking densities (1 kg fish/m^3 and 1.5 kg fish/m^3), three different broodstock body weights (100g, 200g, and 300g) and three sex ratios (1: 2, 1: 2.5 and 1: 3, male: female, respectively). The study continued for five successive harvests and each treatment was represented by 3 to 6 replicates. Two more experiments were also carried out to investigate the effect of male size and the effect of the shape of spawning units on tilapia fry production. Therefore, two more treatments included three male brood sizes (80g–90g, 145g–150g and 240g–300g) and two types of breeding units similar in volume (867 and 855 liters) but different in shapes (circular and squared tanks) were established. High fry production was achieved with the following treatment combinations: stocking densities 1.5 kg/m^3 and average size of brood fish 100g, 300g. Fecundity was influenced by brood size, in terms of fry numbers per female (absolute fecundity) and per kg of female weight per day (relative Fecundity). The maximum fry number per kg female per day produced with fish averaging 100g body weight, but the highest fry production per female were produced with brood averaging 300g body weight. A significant interaction between brood fish size and stocking density was observed ($P<0.05$) for both total fry production and fry number per m^2 per day. Low sex ratio (1: 2, males: females, respectively) produced less fry numbers ($P<0.05$) than the higher ratios (1: 2.5 and 1: 3), although the difference was not significant between the latter two sex ratios. Large and medium size males produced comparable numbers of fry, whilst smaller males were not able to spawn efficiently. Circular shaped units produced higher fry production compared with that produced from squared units. It has been concluded that best fry production may be obtainable with a combination of a stocking density of 1.5 kg/m^3 with broodstock size in the range of 100–300g at a sex ratio of 1: 3 when spawning is allowed in circular spawning units.

Key words: Nile tilapia, fry production, broodstock densities, broodstock size, broodstock sex ratios, shape of breeding units.

INTRODUCTION

The maternal mouth-brooding tilapia of the genus *Oreochromis niloticus* is characterized by a low females fecundity coupled with a low degree of spawning synchrony (Hughes and Behrends, 1983; Little *et al.*, 1993). However, continues supply of high quality fry and fingerlings is a prerequisite for sustaining intensive tilapia culture systems. Many of the problems associated with tilapia farming arise from the difficulty of producing large numbers of mono-sexed fry (Bhujel, 2000). Therefore broodstock management is a key to improve fry yield and overall system efficiency. Under intensive hatchery systems, broodstock is often stocked at high densities in small and confined breeding units such as tanks and net enclosures (hapas) resulting in aggression and social interactions between males that affects seed production (Behrends *et al.*, 1993). In subtropical and temperate areas such as Egypt, tilapia fry demand ceases during the cold season of the year, after which time a high demand become evident. Therefore, hatchery producers, need to maximize seed output during periods of high demand and may necessitate additional fry holding units until demand rises (Bhujel, 2000). Holding tilapia fry during low demand season incurs high cost and may be a probably wasteful effort (Wangpen, 1996 and Brummett, 1995). Economic viability of tilapia farms may be enhanced when farmers have a more control over seed production.

A number of broodstock management strategies were adopted by different workers to optimize tilapia seed production and breeding synchrony including manipulation of brood stock density (Little, 1989), frequency of seed collection (Little *et al.*, 1993), brood fish age and size (Smith *et al.*, 1991; Ridha and Cruz, 1989) and brood stock exchange and conditioning techniques (El-Gamal, 2002; Little *et al.*, 1993; Abella and Baton, 1989; Lovshin and Ibrahim, 1988). The use of different brooder sizes with varying brood stock densities have been attempted to optimize seed output through investigating the best possible combinations. Furthermore, a number of reasons were known to cause low seed productivity, including low density of broodstock; inappropriate sex ratio; inadequate spawning technique were investigated (Salama, 1996; Santiago *et al.*, 1985 and Mires, 1982).

The present study was conducted to investigate some factors that may affect tilapia seed production including broodstock size, stocking density, sex ratio and shape of breeding units, hoping that the results would add knowledge for developing system productivity and enhancing tilapia seed output.

MATERIAL AND METHODS

Culture system

Four experiments of the present study were carried out during the period of July 2005 to October 2006 in large heated indoors recycling facilities at the Faculty of Agriculture, Ain Shams University, Cairo. One more experiment was performed in a private hatchery at Wady El-Natron during the spawning season of 2006 to investigate the best possible broodstock sex ratio. The recycling system utilized in the present study was 270m^3 in volume and consisted of 36 circular fiberglass tanks, 1.62 m in diameter, which were designed with slopping bases and central outlets fitted with sleeved stand pipes, and were effectively self-cleaning. The experimental tanks were vigorously aerated by supplying air to each individual tank through air lines and air stones.

Water quality

Water volume in each tank was adjusted by altering the length of the central stand pipe and water level within the breeding tanks was maintained at an average depth of 0.3–0.6m. Water quality was stable and regularly monitored and evaluated during the experimental period. Data obtained from chemical analyses are summarized in Table 1.

Experimental Fish

Brood fish were obtained from earthen ponds, at EL-Kanatar El-Khyria and were raised in the tilapia hatchery system at Ain Shams University, Cairo. Fish used in the experiment which was carried out in Wady El-Natron originated from different private stocks. Experimental brood fish were firstly conditioned in 5m-diameter concrete tanks before they were distributed among the experimental spawning units (36 spawning tanks). They fed 3 times a day at a ratio of 3% of their body weight on a pelleted ration (25% crude protein). Brood fish losses were replaced with comparable fish that were stocked in the conditioning tanks.

Table 1. Results of water quality analyses in the experimental recycling system.

Criteria	Average value ± SD
Water temperature °C	27.25 ± 1.82
Dissolved Oxygen (mg/l)	6.95 ± 0.15
pH	8.18
Unionized ammonia NH^3 mg/l	0.03
Total alkalinity as calcium carbonate mg/l	400
Total Hardness as calcium carbonate mg/l	450

Experimental designs

Experiment 1 (effect of broodstock size and stocking density):

An experimental design was conducted to investigate the effect of two main factors and a possible interaction that may affect tilapia seed production. These were broodstock size and broodstock density. Therefore, a total of 288 brood fish were randomly distributed into two different stocking densities (1.0 kg/m³) and (1.5 kg/m³), each was represented with three different brood fish sizes averaging 100g, 200g and 300g. Six replicates were performed for each individual treatment as shown in (Table 2).

Table 2. Experimental design, two main treatments, brood fish density (kg/m^3) and three sub-treatments, brood fish body weight (g).

Brood stock density (kg/m^3)	Brood stock weight (g)		
1.0	100	200	300
(No. of fish/m^3)	(10)	(5)	(3)
1.5	100	200	300
(No. of fish/m^3)	(15)	(7)	(5)

Experiment 2 (effect of sex ratio)

Experiment 2 was carried out in a private hatchery at Wady El-Natron to assess the effect of sex ratios on fry production. Total number of 159 brood fish with an average body weight of 250g for females and 300g for males were stocked in 3 x 8 x 1 m (W x L x D) rectangular concrete tanks. Three sex ratios of male to females were used in this experiment as follow: 1: 2, 1: 2.5 and 1: 3, respectively. Brood fish were stocked at 2 fish/m^2. Three replicates for each sex ratio were performed and the experiment lasted for 5 successive harvests, after which time the total number of fry produced in each treatment was calculated.

Experiment 3 (effect of male size)

The present experiment was conducted to investigate the effect of different male body weight (male size) on fry production. Three male groups with different body sizes (80g–90g, Group 1; 145g–150g, Group 2 and 240g–300g, Group 3) were used and stocked with females of body weight ranging between 250g–300g in spawning cylindrical tanks (1.62m in diameter) at a stocking density of 2 fish/m^2 with a constant sex ratio of 1: 3 (male: female). Three replicates were performed for each treatment. The total numbers of fry produced in each male group were counted throughout five successive harvests.

Experiment 4 (effect of the shape of rearing units)

This study was conducted to investigate the effect of two shape types of spawning units (circular and squared tanks) on tilapia seed production. A total number of 48 brood fish with average body weight of 120g and 150g for female and male, respectively, were used in this experiment. Three replicates of the same stocking density of 4 fish/m^2 and the same sex ratio of 1: 3 (male: female) were employed for each treatment. The experimental units were similar in volumes containing 867 and 855 liters for cylindrical and cubical units, respectively. The total numbers of fry produced in each treatment were counted throughout five successive harvests.

Statistical analysis

The total numbers of fry; fry produced per female, fry produced per m^2/day and per kg^{-1} fish/day in each treatment were counted and were analyzed using one or two way analysis of variance using SAS program. Duncan's multiple range tests were performed to detect differences among treatment means in each experiment.

RESULTS AND DISCUSSION

Experiment 1 (effect of broodstock size and stocking density)

Results of the first experiment are illustrated in Table 3 and Figure 1. The effect of broodstock density on fry production showed that total fry production was associated positively with high stocking density. Maximum fry production was found in the brood of 300g body weight stocked at a density of 1.5 kg/m^3, followed by those produced when brood of 100g body weight stocked at a density of 1.5 kg/m^3. Generally, spawning parameters that include total fry production, number of fry produced /m^2/day and number of fry produced kg^{-1} fish/day were significantly ($P<0.05$) higher at the large broodstock size, especially when coupled with high stocking densities (Table 3), whilst high brood size (300g) reared under a low stocking density (1 kg/m^3) produced the lowest total fry numbers, fry produced /m^2/day and also lower fry numbers kg^{-1} /fish/day. The latter results could probably be due to the low fish number (3.3 fish/m^3) used in such a treatment.

Effects of broodstock size

Analyses of the present data showed that the higher brood fish sizes (300g) produced significantly ($P<0.05$) the higher fry numbers per female (1185.7 fry) when compared with treatments with lower body size fish, 200g and 100g which produced 793.5 and 514.6 fry, respectively (Table 4). Fry numbers produced /female/day were significantly ($P < 0.05$) affected by female sizes (Table 4). In contrast, small broodstock produced relatively higher fry number kg^{-1} female/day (relative fecundity, 78.8 fry). On the other hand, neither total fry production nor fry numbers /m^2/day was affected by brood size.

Table 3. Some spawning parameters of brood *Oreochromis niloticus* of three different size classes reared under two different stocking densities. Data are presented as means ± SE.

Stocking density	**1 kg/m³**			**1.5 kg/m³**		
Stocking size (g)	**100**	**200**	**300**	**100**	**200**	**300**
No. of Fish/m³	10	5	3.3	15	7.5	5
Parameters						
Total Fry	3215±222[c]	3354±610[c]	1973±312[d]	4861±288[b]	4400±146[b]	5339±368[a]
Fry/m²/day	24.2±1.8[b]	25.1±4.5[b]	14.8±2.3[b]	38.0±3.7[a]	33.0±1.0[a]	40.0±2.7[a]
Fry kg⁻¹ fish/day	77.4±9.6[b]	81.7±16.7[a]	61.7±12.7[c]	80.70±7.2[a]	69.9±1.1[b]	85.0±6.4[a]
Fry/female/day	9.3±0.7[c]	14.4±2.6[b]	17.0±2.7[a]	8.7±0.9[c]	12.6±0.4[b]	23.0±1.6[a]

Means in each row with the same letter are not significantly different ($P>0.05$).

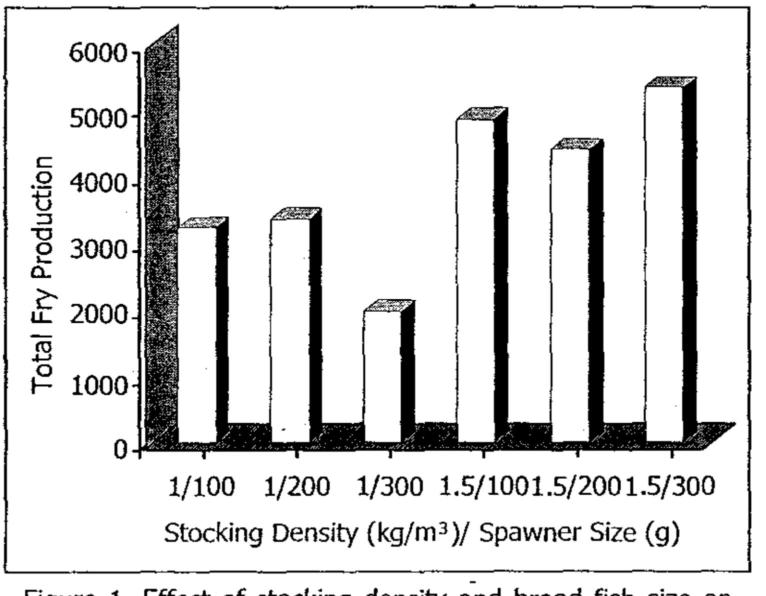

Figure 1. Effect of stocking density and brood fish size on fry yield in *Oreochromis niloticus*.

Table 4. Effects of broodstock size on some spawning parameters of *Oreochromis niloticus*. Data are presented as means ± SE.

	Size of brood fish			
Parameters	**100g**	**200g**	**300g**	**± SE**
Total fry production	3921[a]	3897[a]	3802[a]	274.6
Fry /m²/day	30.1[a]	29.1[a]	28.5[a]	2.2
Fry /female	514.6[c]	793.5[b]	1185.7[a]	80.3
Fry /female/day	9.05[c]	13.68[b]	20.44[a]	2.14
Fry kg⁻¹fish/day	78.8[a]	76.6[a]	75.0[a]	7.3

Means in each row with the same letter are not significantly different (P>0.05).

Effects of broodstock density

Total fry numbers and number of fry produced /m²/day were significantly (P<0.01) higher at higher stocking densities (Table 5). The higher brood density (1.5 kg/m^3) yielded 4914.4 fry/m^2 whilst that in the lower density (1 kg/m^3) produced only 2927 total fry, where number of fry produced was 37.3 and 22.0 fry per m^2/day for the former two treatments, respectively. No significant differences were observed between the two different stocking densities (1.5 kg/m^3 vs. 1 kg /m^3) in terms of fry production per female (865 vs. 800) and fry production kg^{-1} female/day (79.4 vs. 74.5), respectively.

Table 5. Effects of broodstock densities on some spawning parameters of *Oreochromis niloticus*. Data are presented as means ± SE.

	Stocking density	
Parameters	**1 kg/m³**	**1.5 kg/m³**
Total fry production	2927±219.0[b]	4914±229.0[a]
Fry number /m²/day	22.0±1.7[b]	37.0±1.8[a]
Fry number /female	800.5±64.2[a]	864.9±67.3[a]
Fry number kg⁻¹ fish/day	74.5 ±5.8[a]	79.4 ±6.2[a]

Means in each row with the same letter are not significantly different (P>0.05).

The present results are in agreement with that found by Bhujel (2000), who reported that relative size or brooder biomass, as an expression of fish density is probably more important than the number of broodstock /m^2. The data showed that total fry production increased with increasing brood fish size. It should be mentioned, however, that employing small broodstock size means increased brood fish number per water volume or per m^2. Hence, in the present study lower size treatments stocked 10 and 15 100g-fish /m^3. However, the brood number decreased to 3–5 fish /m^2 when 300g fish were utilized. As such, fish in treatments with a low fish number had better chance to establish breeding areas resulting in increased total fry production. Furthermore, a number of authors believe that tank size is the probably the most important element in fry production (Siddique and Al-Harbi, 1997) whilst in small tanks not all males are able to spawn due to competition for space.

It appears that the number of broodstock is a prime factor for increased fry production kg^{-1} fish. This may explain that the present data showed that fry produced kg^{-1} fish/day of 100g fish size (the lower density) was higher than that produced in 300g fish size class. Furthermore, results of the present study may suggest that broodstock biomass is probably a more accurate indicator for measuring stocking density, which is in accordance with that opined by Bhujel (2000). The highest total number of fry yield ($P<0.05$) was found in the treatment that utilized a stocking density of 6.5 fish/m^2 followed by treatments of 3.9 fish/m^2 and 2.6 fish/m^2, at a stocking biomass of 1.5 kg/m^3.

Studies on several tilapia species showed that larger females produced more seed per clutch but fewer seed per unit weight than smaller females (Smith *et al.*, 1991; Watanabe and Kuo, 1985; Payne and Collinson, 1983). Furthermore, Macintosh and Little (1995) and Rana (1986) found that younger females are less efficient in incubation of eggs than older females because of their relative inexperience. Smith *et al.*, (1991) and Siraj *et al.* (1983) reported that although spawning frequency, egg hatching success and fry survival were higher in large female of *O. niloticus* (429g) than in small individuals (172g), the size due to their higher fecundity (egg numbers kg^{-1} fish, production of fingerlings kg^{-1} fish was higher in small brood). The authors demonstrated that it is important to replace brood stock with yearling breeders each year as seed production declines dramatically by the age of 2 years. Working with *O. Spilurus*, Ridha and Cruz (1999) reported that seed production (seed kg^{-1} fish/day) was higher in younger than older fish and recommended using younger brood stock (one year old) and discarding older spawners considering them unproductive. Siddiqui and Al-Harbi (1997) found that although smaller brood fish (100g) yielded higher fry production when expressed as fry kg^{-1} fish/day, large brood fish weighing 300g produced higher percentage of fry when expressed as fry produced per female, which is in agreement with the resent findings. The latter authors reported that mean seed production kg^{-1} fish/day was greater ($P<0.05$) in one year old (96g) than in 2 and 3 years old females (195 and 261g, respectively). In addition, the number of seed produced /female/day in 3 years old females was significantly higher than that produced by one year old females. On contrary, El-Gamal (2002) reported that intermediate sized brood fish (250g) produced significantly ($P<0.05$) more fry than both smaller (125g) and larger class sizes (more than 350g).

The current results showed that the highest seed production ($P<0.05$) was obtained from treatments where brood fish were stocked at 1.5 kg/m^3 (6.5 100g-fish /m^2 and 2.6 300g-fish /m^2). The total fry numbers produced in the later two groups were 4861 and 5339, respectively. When system productivity expressed as fry/m^2/day, fry per m^2/day were (38 and 40) for the latter two treatments, respectively. Similar results were obtained for *O. niloticus* by El-Gamal (2002) and Siddique & Al-Harbi (1997). A maximum mean total fry production (5552 seeds) was obtained from 4 fish/m^2 of 163g average weight broodfish (Ridha and Cruz, 1999). The latter authors opined that the use of low stocking densities would maximize the production of seed and lead to a more efficient utilization of the limited hatchery space and would, therefore, reduce manpower and the amount of feed required. Nevertheless, Ridha and Cruz (1999) believe that the use of broodstock number or broodstock biomass as a basis for stocking is still unclear.

High interaction (P<0.05) was observed between brood fish size and brood stocking density in the terms of total fry production and fry/m^2/day (Table 6). Both brood fish with average body weight of 100g and 300g at stocking density of 1.5 kg/m^3 (6.5 fish/m^2 and 2.6 fish/m^2, respectively) produced significantly higher total seed production than those produced by similar size groups stocked at (1 kg/m^3). These results are comparable to that reported by Ridha and Cruz (1999) who obtained maximum seed output at stocking density of 4.8 fish /m^2 of brood fish weighing 176.8g. Similar findings were reported by Bautista *et al.* (1988).

Table 6. Two-way ANOVA showing the effects of stocking density and brood stock size on spawning parameters of *Oreochromis niloticus.*

Two way ANOVA		Mean square	F value	Pr > F	Mean square	F value	Pr > F	Mean square	F value	Pr > F
S.O.V	d.f	Total fry			Fry/m²/day			Fry kg-¹/day		
Size of Spwaner	2	20973^{ns}	0.48	0.63	23.62^{ns}	0.70	0.50	83.53^{ns}	0.09	0.91
Stocking density	1	25197**	39.73	0.01	1254.6**	37.30	0.01	74.63^{ns}	0.33	0.57
Interaction	2	24845*	4.71	0.03	133.87*	3.98	0.04	410.68^{ns}	1.10	0.36
Error	5	52789			33.63			372.17		

*= Significant (P <0.05); **= Significant (P <0.01); ns= non significant (P >0.05).

Experiment 2 (effect of sex ratio)

Analysis of variance showed that sex ratio affected total fry production significantly (P<0.05). Maximum fry production was recorded in the 2nd and 3rd treatments which were higher than that in the 1st one (Table 7, Fig. 2). It has been suggested that because of males' readiness to court and successfully mate with several females in one day, its ability to maximize fertilization rates declines with increased spawning frequency. In most situations, especially when synchronized spawning is required, less than three females per male are optimal (Hughes and Behrends, 1983; Siddique and Al-Harbi, 1997).

Table 7. Effect of sex ratio (male: female) on the total fry production of Nile tilapia, *O. niloticus*. Data represented as mean ± SE.

Treatments	Sex ratio	Total fry produced
Treatment 1	1: 2	13,766.6 ± 425.5[b]
Treatment 2	1: 2.5	18,133.3 ± 698.4[a]
Treatment 3	1: 3	17,733.3 ± 392.9[a]

Means in each row with the same letter are not significantly different (P>0.05).

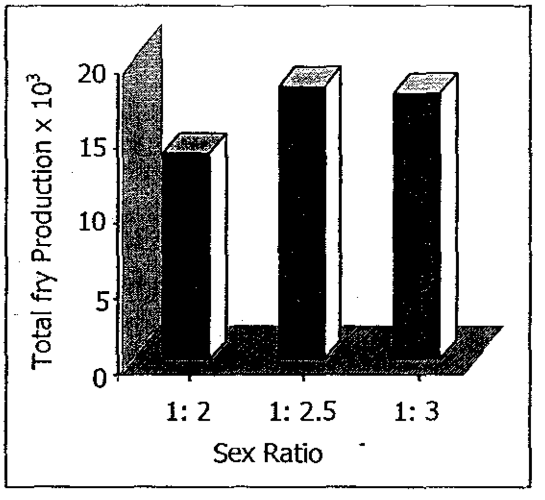

Figure 2. Fry yield of *Oreochromis niloticus* produced at different sex ratios.

Although individual male can court and successively spawn with several females, research showed that fertilization rates drop rapidly (Little and Hulata 2000; Rana and Macintosh, 1988). In both species *O. niloticus* and *O. aures*, the proportion of developing eggs declined rapidly with increased spawning frequency, irrespective of male age. A drop from 96% in the first spawning to 22% in the fourth spawning was recorded in *O. niloticus* (Rana, 1996). Results of the present experiment showed significant differences (P<0.05) in fry production between the 1st treatment (low sex ratio) and the other two treatments (Table 7), although the difference was not significant (P>0.05) between the two sex ratios, 1: 3 and 1: 2.5

male to female, respectively. These results agree with that reached by Siddiqui and Al-Harbi (1997), and Bautista *et al.* (1988). The former authors mentioned that seed production female^{-1} day^{-1} and kg^{-1} female day^{-1} was better for brood fish stocked at sex ratios of 1: 2 and 1: 3 (male: female) than those of the other two sex ratios (1: 4 and 1: 5). The latter authors highlighted the effect of the type of breeding units on results of seed production in relation to sex ratio. They found that broodstocks kept at similar stocking densities, produce more fry in earthen ponds than in tanks at sex ratios of 1: 3 and 1: 4 (male: female) than at either more or less other sex ratios (1: 7 and 1: 10), as such employing higher sex ratios, (more females /male) failed to improve *O. niloticus* seeds in concrete tanks and hapa hatcheries. Such results could be attributed to males' diminished sexual capability due to over use and fatigue leading to exhaustion. El-Gamal (2002) opined that high seed production at female: male ratios of 1: 3 and 1: 4 compared to a narrow sex ratio (e.g., 1: 2) is obviously because of the increased numbers of females in the former two treatments.

Experiment 3 (effect of male body size)

Analysis of variance showed a significant ($P<0.05$) effect of male body size on number of fry produced (Table 8), either as a total number of fry produced or number of fry/female. Both maximum fry production and fry produced per female were recorded for females spawned with large size males (Fig. 3), whilst females kept with small males failed to spawn. No significant differences, however, were observed between the two large male sizes (150 and 300g). It is documented that success in gaining access to courtship and spawning is related to males' size (Turner and Robinson, 2000). In laboratory studies, larger male *O. mossambicus* initially occupied preferred territory sites and monopolized most of the courtship. Over period of several months, these males were overtaken in size by the smaller males, presumably because the non-territorial males expend less energy in fighting, digging and courting. Hence, males that increased in size would gain access to courtship and spawning, while formally larger males were then lose their ability to gain access to better territories (Turner and Robinson, 2000). Therefore, male size and territory quality have been considered important factors in female preference.

Table 8. Total fry production of three different male sizes of *Oreochromis niloticus*. Data represented as mean ± SE.

Males' size	Total fry production	Fry numbers /female
80 gram	0^b	0^b
150 gram	1310^a ±166.6	436^a±55.6
300 gram	1530a ±166.6	510a±55.6

Means in each column with the same letter are not significantly different (P>0.05).

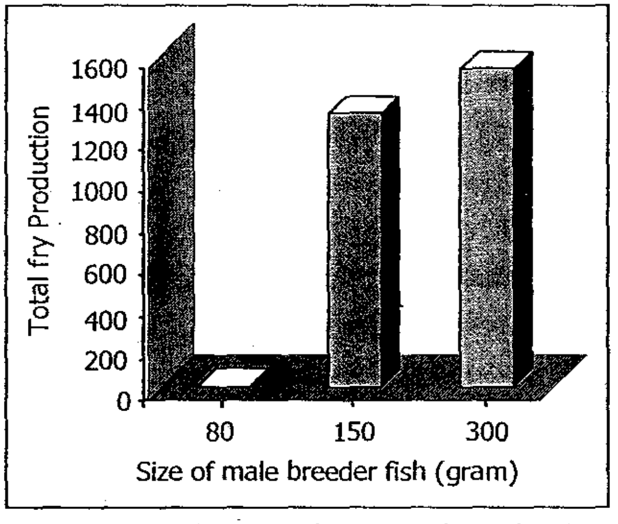

Figure 3. Effect of male size on fry yield of *Oreochromis niloticus*.

Experiment 4 (effect of the shape of spawning tank)

Analysis of variance showed a significant effect (P<0.05) of breeding unit shape on the total number of fry produced. Maximum fry production was obtained from the circular shape tanks, which was significantly higher than that produced from squared tanks. Furthermore, circular units produced significantly more fry per m^2/day (Table 9).

Table 9. Effects of shape of breeding units on spawning parameter of *Oreochromis niloticus*. Data represented as mean ± SE.

Spawning parameter	Circular units	Squared units
Total fry production	4,010 ± 342.7^a	2,469.6 ± 342.7^b
Fry /m² /day	22.3 ± 1.63^a	11.3 ± 1.63^b

Means in each column with the same letter are not significantly different (P>0.05).

The present data showed that circular units produced more fry when compared with that produced from similar size squared units (Table 9). Similar results have been obtained by Ridha and Cruz (2003). Nevertheless, the use of squared shape hatchery units is wide spread and frequently reported (Bautista *et al.*, 1988; Ridha and Cruz, 1999). It is well known that circular tanks are favorable for some reasons including: provide uniform water quality; self cleaning ability which is a key advantage of such a shape and better solids settle ability that can be rapidly flushed through the center drain (Timmons *et al.*, 1998). However, self cleaning ability is probably a key advantage of such a shape. On the other hand, squared shape tanks tend to have dead areas, where adverse conditions may be developed. These characteristics which are strongly related to tank shapes may explain the present results.

In conclusion, the results of the present study suggest that fry production is significantly affected by interactions between certain environmental factors, namely stocking density and brood fish weight. Maximum fry production is probably obtainable at a stocking density of 1.5 kg/m^3 for fish weighing 100 gram to 300 gram. The effect of these recommended parameters could be enhanced when coupled with a sex ratio of 1: 2.5 and 1: 3 (male to females). Furthermore, the results showed a significant effect of the shape of the breeding unit, where circular units are clearly advantageous.

It has been concluded that best fry production in *O. niloticus* may be obtainable with a combination of a stocking density of 1.5 kg/m^3 with broodstock size in the range of 100–300g at a sex ratio of 1: 3 when spawning is allowed in circular spawning units.

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أثر بعض العوامل على إنتاج زريعة البلطي النيلي

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أجريت أربعة تجارب لدراسة تأثير أوزان الأمهات وكثافة تسكينها وشكل أحواض التفريخ وأوزان الذكور والنسب الجنسية (ذكور: إناث) علي إنتاجية زريعة أسماك البلطي وتم حصاد الزريعة كل ١٢- ١٤ يوم ولمدة ٥ تفريخات متتالية. التجربة الأولى: تم استخدام ثلاث أوزان للأمهات هي ١٠٠، ٢٠٠، ٣٠٠ جرام/أم لتوفير كثافتين هما ١ ، ٥و١ كجم أمهات/م^{3} بنسبه جنسية ١: ٢. التجربة الثانية: استخدمت أفراد بمتوسط وزن ٢٥٠جم للإناث، ٣٢٠جم للذكور بالنسب الجنسية الآتية: ١: ٢، ١: ٥و٢، ١: ٣ في أحواض مستطيـلة. التجربة الثالثة: تم توزيع الأسماك بكثافة ٤ سمكة/م^{2} ونسب جنسية ١: ٢ بمتوسط وزن ١١٧- ١٤٥جم لكل من الإناث والذكور علي الترتيب في أحواض دائرية ومستطيلة. التجربة الرابعة: تم استخدام ثلاث أوزان من الذكور هي في المتوسط (٨٤، ١٤٧، ٢٧٠جم) مع ثبات وزن الأمهات عند ٢٨٧جم وكثافة سمكية ٢ سمكة/م٢ ونسبة جنسية ١: ٣. وتتلخص أهم النتائج فيما يلي: أعلى معدل للإنتاج الكلي للزريعة ٥٣٣٩، ٤٨٦١ زريعة لأمهات أوزانها ٣٠٠، ١٠٠جم وعند كثافة سمكية ٥و١كجم/م^{3} مقارنة بباقي المعاملات. وأوضح التحليل الإحصائي أن إنتاج الزريعة/م^{2}/يوم كان أعلى معنويا في الكثافة الأعلى مقارنة بالكثافة الأقل. أقصي قيمة للخصوبة المطلقة للأمهات كانت عند متوسط ٣٠٠جم، بينما أعلي خصوبة نسبية كانت عند متوسط ١٠٠جم. أظهرت نتائج تأثير النسبة الجنسية أن أعلي قيم معنوية لإنتاج الزريعة كانت للنسبة الجنسية ١: ٥و٢، ١: ٣ حيث بلغ الناتج الكلى ١٨١٣٣،٣، ١٧٧٣٣،٣ زريعة على التوالي. وفى تجربة حجم الذكور وجد أن أعلي إنتاج من الزريعة سواءً الإنتاج الكلى أو الخصوبة المطلقة كان في صالح المعاملة الثانية والثالثة وكانت الفروق بين تلك المعاملتين غير معنوية. في التجربة الرابعة حققت الأحواض الدائرية اختلاف معنوي حيث وصل الإنتاج الكلي للزريعة إلى ٤٠١٠ مقارنة بـــ ٢٤٦٩ للأحواض المربعة. كذلك كان إنتاج الزريعة/م^{2}/يوم في الحوض الدائري ٣و٢٢ زريعة/يوم مقارنة ٣و١١ للأحواض المربعة. من هذه الدراسة نوصي باستخدام أمهات بأوزان ١٠٠- ٣٠٠جم وكثافة ٥و١ كجم/م^{3} ونسبة جنسية ١: ٥و٢ أو ١: ٣ وأستخدام ذكور بمتوسط وزن ١٥٠جم تقريبا كآباء لمعظمة إنتاج الزريعة.