REPRODUCTIVE PERFORMANCE OF *OREOCHROMIS NILOTICUS* FEMALES AS AFFECTED BY AGE AND SIZE

MOHAMED, G.A., A. M. KHATER AND A. M. AKAR

Centeral laboratory for Aquaculture Research, Abbassa, ARC, Egypt

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Abstract

Seed productivity of three different age and size groups of *Oreochromis niloticus* females brooders, 8, 12 and18 months old having an average body weight of 77.9 ± 7.1, 99.1± 9.7 and 145.6 ± 13.9 g, respectively were assessed throughout 6 successive harvestings, at an interval of 25 days. Three groups of concrete tanks 3.5 x 1.5 x 1.2 m inside a green house were used representing three treatments (3 replicates, 15 female and 8 males each). The experiment lasted 150 days from March to August 2004. Fish were fed 6 days a week and water was renewed every week. Water temperature ranged between 25 and 29 °C during the experimental run.

Analysis of variance and Duncan's multiple range test were used to detect differences in seed production due to treatment effects.

The highest seed production, expressed in terms of seed/female/day, was obtained from the one-year old females (10.7 seed/female/day) that had median initial body weight followed by 10.6 seed/female/day from females of the 1.5-years fish class that had the largest size (120-170 g). Seed production of the smallest 6-months old females (70-90 g/female) was the lowest (8.6 seed/female/day).

Growth rate of females of first group was faster than that of females of the second group that had a faster growth rate than females of the third one that ceased growth and their seed production showed a continuous reduction. Mean seed production of females of groups 1 and 2 increased gradually with increasing their body weight and reached that of group 3. A mean total seed production of 18750, 24049 and 23952 for the three female groups 1, 2 and 3, respectively, was obtained. Average body weight and length of fry increased with increasing body weight of the parents. A linear equation to approximate seed production that can be obtained from different age and size groups of females within 6 successive spawnings under the same conditions was derived: Y= 1.9152 x 18.496 x, where Y= seed production and x = female body weight.

INTRODUCTION

Nile tilapia (*Oreochromis niloticus*) had rapidly become important species for aquaculture, although their intensive culture remained constrained by poor synchronization and low fecundity (Mendoza *et al.*, 2004). Therefore, one of the most important requirements for the advancement of tilapia culture is the development of

systems for mass production of seed, free-swimming fry, sac fry and eggs released from the females mouth, to satisfy the needs of the cultural people at low cost that will permit financial success (Hughes and Behrends, 1983). Among factors considered to be important in seed production are brood fish age and size (Berrios–Hernandez, 1979). For raising the skill of hatchery management procedures of tilapia, hatchery operations have tended to increase the number of broodfish in order to optimize tilapia seed production and guarantee mass production of homogenous stock of first-feeding fry (Coward and Bromage, 2000, Bhujel *et al.*, 2001a, Bhujel, 2000). In earthen ponds, spawning takes place in April and May and may extend to November with a maximum spawning in early summer (Mires, 1983). Spawning of *Nile tilapia* for production of pure or crossed fry is an established practice in the fish farms. A single female may spawn three to four times during summer season. After introduction of the breeding stocks into the spawning pond, the first fry are expected to be seen after three weeks. Number of eggs per spawn may differ among species, but, within species, the number of eggs increased with increasing weight of female (Badawy, 1993). In Aquaria kept under optimal conditions, intra-specific spawning may take place throughout the whole year (Rothbard and Pruginin, 1975).Spawning can be easily accomplished throughout the whole year at a temperature range of 25-29 °C to trigger ovarian development. Methods of reproducing *Oreochromis* sp. are well documented (Green *et al.*, 1997 and Macintosh and Little, 1995). Mohamed *et al.* (2003) approximated the egg production of only the first spawning of different sizes of Nile tilapia females, from the same age group, by a linear predicative regression curve.

The aim of the present study was to evaluate the reproductive capability of different age and size groups of *Oreochromis niloticus* females throughout sucessessive spawnings to establish possible broodstock management strategies that may be adopted by hatcheries to improve fry production on large scale.

MATERIALS AND METHODS

Three different age and size groups of *Oreochromis niloticus* female brooders, 8, 12 and18 months old having average body weights of 77.9 ± 7.1, 99.1± 9.7 and 145.6 ± 13.9 g, respectively, were randomly divided to 9 groups representing three treatments (3 replicates, 15 female fish each). The fish were accommodated in 9 concrete tanks 3.5 x 1.5 x 1.2 meter, filled with fresh water 1 meter depth and supplied with pressurized aeration and fresh water pipes, inside a green house. Eight active males having the same average body weight of females were placed with females in each tank. Hygienic precautions for vitality of fish were considered. Fish were disinfected using potassium permanganate water bath before accommodation of

fish into the tanks. Fish were fed at a rate of 2% of their body weight supplementary feed containing 25 crude protein 6 days a week. Feeding frequency was twice a day. Feeding quantity was adjusted according to the total biomass every 25 days after harvesting. Feed remnants represented organic matter that fertilized the water. Sun and warm temperature inside the greenhouse allowed dense algal bloom. Water was renewed every week for an hour with feeble running fresh water. Nylon screens with suitable mesh size were used to prevent the parents and fry from escaping. Water temperature ranged between 25 and 29 °C during the experimental run. Dissolved oxygen, pH and ammonia ranged between 5.5-6.2 mg/l, 7.9-8.6 and 0.2-0.5 ppm, respectively. The tanks were drained and harvested 6 times at an interval of 25 days between harvestings, during which all the fish were spawned.

At every harvesting, females were collected gently, weighed and isolated separately and temporarily with their males in hapas (net cages) installed in tanks nearby. All seed (free-swimming fry and remaining few number of eggs released from the females mouth) were collected from each tank separately and counted. From a sample of 30 fry, each tank weight and length measurements were taken. The tanks were cleaned, disinfected and refilled with fresh water and the parents were disinfected and released into their tanks again for the next harvesting.

Analysis of variance and Duncan's multiple range test (1955) were used to detect differences in seed production due to treatment effects.

RESULTS

First harvesting

As demonstrated in Table 1, body weight of females increased and reached 85.5 ± 13.5, 120.8 ± 10.2 and 156.6 ± 6.6 g for the three groups 1, 2 and 3, respectively. Average total seed production of the smallest age and size group of females (first group) was 2280 ± 452/tank. Fry attained an average fry body weight of 6.2 ± 1.5 mg/fry and average body length of 6.6 ± 2.3 mm/fry. The median age and size group (second group) produced 3250 ± 403 seed/tank. Average body weight was 7.0 ± 2.5 mg/fry and average body length was 8.7 ± 2.6 mm /fry. Mean number of seed/tank obtained from the largest group (the third one) was 4400 ± 254. Fry reached 7.5 ± 2.2 mg and 9.9 ± 1.8 mm/fry average body weight and length, respectively. ANOVA analysis of the mean values of data and Duncan's multiple range test indicated that mean of the total seed production, mean number of seed/female, average body weight and length of fry of the third group were significantly higher ($P<0.05$) than those of the second group which were significantly higher than those of

the first one ($P<0.05$). There were no significant differences among means of the relative fecundity.

Table 1. Effect of female age and size on reproductive performance of Nile tilapia.

Item	Size group 1	Size group 2	Size group 3
Ave. body weight/females (g)***	85.5 ± 13.5 ^{c}	120.8 ± 10.2 ^{b}	156.6 ± 6.6 ^{a}
Average body weight/fry (mg)***	6.2 ± 1.5 ^{c}	7.0 ± 2.5 ^{b}	7.5 ± 2.2 ^{a}
Ave. body length/fry (mm)***	6.6 ± 2.3 ^{c}	8.7 ± 2.6 ^{b}	9.9 ± 1.8 ^{a}
Mean number of seed**	2280 ± 452 ^{c}	3250 ± 403 ^{b}	4400 ^{a}
Number of seed/female**	152.0 ± 30.2 ^{c}	216.7 ± 26.9 ^{b}	293.3 ± 17 ^{a}
Relative fecundity ^{ns}	1.8 ± 0.3 ^{a}	1.8 ± 0.2 ^{a}	1.9 ± 0.0 ^{a}

Relative fecundity = number of seed/female/ body wt. of female

a, b, c: means within the same raw having the same superscripts don't differ ($p<0.05$) significantly otherwise they do.

Second harvesting

As shown from Table 2 and Figure 1, mean weight of females increased by 16, 10 and 3%, and seed production increased by 14, 11 and 7%.for age class 1, 2 and 3, respectively. There was insignificant difference between seed production of females of age class 1 and 2, while, significant difference was observed between average body weight and length of their fry. However, seed production of age class 3 was significantly higher than that of the other two classes ($P<0.05$). No significant difference was detected between the average body weight and length of fry that were produced by females of class 2 and 3. Differences in mean relative fecundity were insignificant for the three age groups.

Table 2. Reproductive performance of *Nile tilapia* of different age and size groups in the second harvesting.

Item	Size group 1	Size group 2	Size group 3
Ave. body weight/females (g)***	99.6 ± 7.3 ^{c}	133.2 ± 13.0 ^{b}	161.2 ± 8.9 ^{a}
Average body weight/fry (mg)**	6.6 ± 1.3 ^{b}	7.2 ± 1.0 ^{a}	7.6 ± 1.1 ^{a}
Ave. body length/fry (mm)**	7.7 ± 1.5 ^{b}	9.2 ± 1.8 ^{a}	10.2 ± 1.2 ^{a}
Mean number of seed**	2598 ± 344 ^{b}	3596 ± 275 ^{b}	4699 ± 357 ^{a}
Number of seed/female***	173.2 ± 22.9 ^{c}	239.7 ± 18.3 ^{b}	313.3 ± 23.8 ^{a}
Relative fecundity ^{ns}	1.7 ± 0.1 ^{a}	1.8 ± 0.2 ^{a}	1.9 ± 0.2 ^{a}

Relative fecundity = number of seed/female/ body wt. of female

a, b, c: means within the same raw having the same superscripts don't differ ($p<0.05$) significantly otherwise they do.

Third harvesting

Average body weights of females of age class 2 and 3 were not significantly different, while, they were significantly higher than those of age class1 and produced significantly (p<0.05) larger fry than those of the former two age classes (Table 3).

Table 3. Reproductive performance of *Nile tilapia* of different age and size groups in the third harvesting.

Item	Size group 1	Size group 2	Size group 3
Ave. body weight/females (g)**	111.2 ± 8.3 [b]	148.2 ± 15.5 [a]	165.5 ± 11.5 [a]
Average body weight/fry (mg)*	6.8 ± 0.2 [b]	7.4 ± 0.4 [a]	7.6 ± 0.3 [a]
Ave. body length/fry (mm)*	8.2 ± 1.5 [b]	9.9 ± 1.1 [a]	10.3 ± 1.6 [a]
Mean number of seed**	2582 ± 474 [c]	3606 ± 159 [b]	4357± 218 [a]
Number of seed/female**	172.1± 31.6 [c]	240.4 ± 10.6 [b]	290.5 ± 14.6 [a]
Relative fecundity [ns]	1.5 ± 0.2 [a]	1.6 ± 0.2 [a]	1.8 ± 0.1 [a]

Relative fecundity = number of seed/female/ body wt. of female

a, b, c: means within the same raw having the same superscripts don't differ (p<0.05) significantly otherwise they do.

Fourth harvesting

Average body weights of females, seed production, average body weight and length of fry and number of seed/female were insignificantly increased in the third group than in second group, whereas, those of the first group were significantly (p<0.05) lower than those of the other two groups (Table 4).

Table 4. Reproductive performance of *Nile tilapia* of different age and size groups in the fourth harvesting.

Item	Size group 1	Size group 2	Size group 3
Ave. body weight/females (g)***	125.6 ± 8.7 [b]	159.8 ± 7.5 [a]	167.9 ± 13.1 [a]
Average body weight/fry (mg)**	6.7 ± 2.3 [b]	7.6 ± 2.2 [a]	7.5 ± 2.0 [a]
Ave. body length/fry (mm)**	8.1 ± 0.8 [b]	10.3 ± 0.3 [a]	10.0 ± 0.1 [a]
Mean number of seed*	3389 ± 478 [b]	4460 ± 90 [a]	4187 ± 439 [a]
Number of seed/female*	225.9 ± 31.8 [b]	297.3 ± 6.0 [a]	279.1 ± 29.3 [a]
Relative fecundity [ns]	1.8 ± 0.1 [a]	1.9 ± 0.1 [a]	1.7 ± 0.2 [a]

Relative fecundity = number of seed/female/ body wt. of female

a, b, c: means within the same raw having the same superscripts don't differ (p<0.05) significantly otherwise they do.

Fifth harvesting

No significant difference between average body weights of females of class 2 and 3 that had significant larger average body weight than females of class 1 was

noticed. Mean number of seeds were insignificantly different in the three treatments ($P<0.05$) (Table 5).

Table 5. Reproductive performance of *Nile tilapia* of different age and size groups in the fifth harvesting.

Item	Size group 1	Size group 2	Size group 3
Ave. body weight/females (g)**	138.0 ± 10.6 [b]	165.8 ± 9.3 [a]	168.5 ± 9.5 [a]
Average body weight/fry (mg)*	6.7 ± 1.7 [b]	6.8 ± 1.6 [b]	7.6 ± 1.4 [a]
Ave. body length/fry (mm)	8.2 ± 0.6 [b]	8.3 ± 1.2 [b]	10.1 ± 1.0 [a]
Mean number of seed [ns]	3837 ± 782 [a]	4356 ± 426 [a]	3311 ± 156 [a]
Number of seed/female [ns]	255.8 ± 52.1[a]	290.4 ± 28.4 [a]	220.7 ± 10.4 [a]
Relative fecundity *	1.8 ± 0.3 [a]	1.8 ± 0.2 [a]	1.3 ± 0.0 [a]

Relative fecundity = number of seed/female/ body wt. of female

a, b, c: means within the same raw having the same superscripts don't differ ($p<0.05$) significantly otherwise they do.

Sixth harvesting

Average body weight of females of classes 2 and 3 was significantly different than that of females of class 1. Mean number of seed production of females of the three groups was not significantly different.

A mean total seed production of 18750 ± 208, 24049 ± 267 and 23952 ± 266 per treatment was obtained from the three female groups 1, 2 and 3, respectively, throughout 6 harvestings. Figure 2 illustrates the seed production of the three groups of fish within 6 months. The relative proportion of each seed type is illustrated in Figure 3.

Table 6. Reproductive performance of *Nile tilapia* of different age and size groups in the sixth harvesting.

Item	Size group 1	Size group 2	Size group 3
Ave. body weight/females (g)*	145.4 ± 13.2 [b]	169.1 ± 8.1 [a]	169.6 ± 12.1 [a]
Average body weight/fry (mg)*	6.7 ± 1.4 [b]	6.8 ± 1.3 [b]	7.6 ± 2.1 [a]
Ave. body length/fry (mm)	8.1 ± 1.5 [b]	8.3 ± 2.0 [b]	10.2 ± 1.9 [a]
Mean number of seed**	4065 ± 399 [a]	4780 ± 393 [a]	2997 ± 378 [b]
Number of seed/female**	271.0 ± 26.6 [a]	318.6 ± 19.5 [a]	199.8 ± 25.1 [b]
Relative fecundity *	1.9 ± 0.1 [a]	1.9 ± 0.1 [a]	1.2 ± 0.2 [b]

Relative fecundity = number of seed/female/ body wt. of female

a, b, c: means within the same raw having the same superscripts don't differ ($p<0.05$) significantly otherwise they do.

The correlation analysis between the body weight of all females *of O. niloticus* and the corresponding number of seed/harvest showed that significant correlation

existed among both. The following simple linear correlation as indicated in Figure 4 gave a reasonable approximation for the number of seed in relation to the body weight. The following linear predicative regression equation was applied:

Y = a + b X, where Y = number of seed per harvest and X = weight of female brooder.

Fig.1. growth of the three age groups of *O. niloticus* females within six harvestings, 150 days.

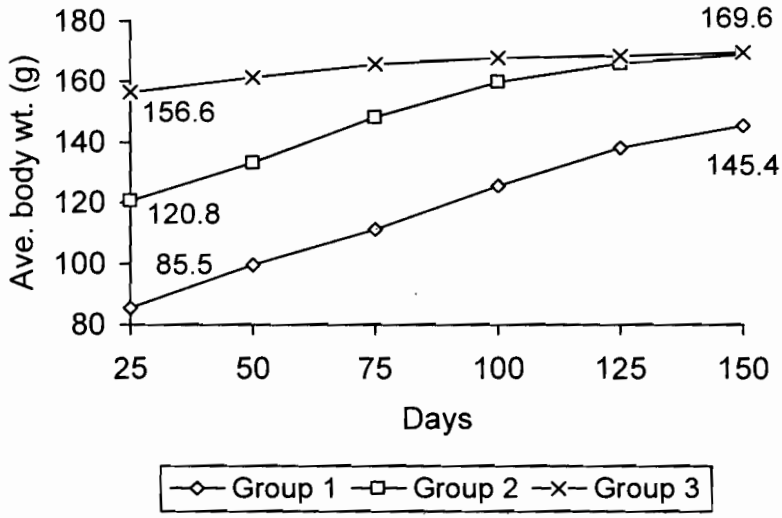
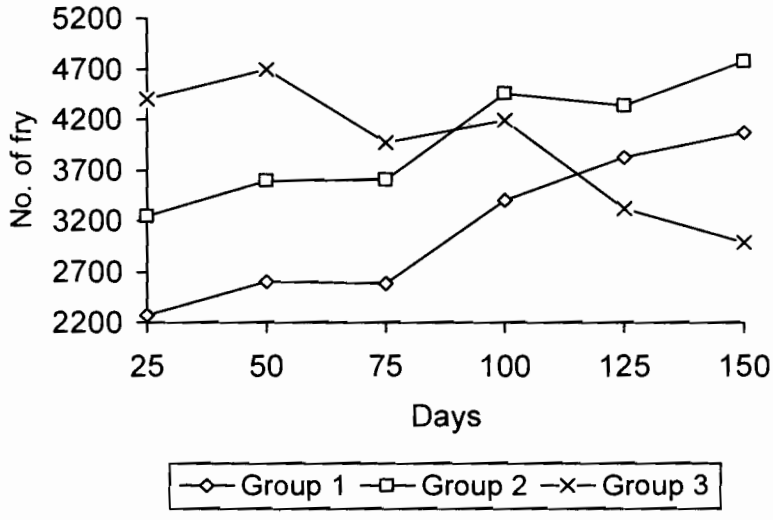


Fig. 2. Average number of seed produced from three different age groups of *O. niloticus* females within 6 harvestings, 150 days.



No significant difference was observed in relative fecundity among females of groups 1 and 2 throughout the experiment. Relative fecundity of females of group 3 decreased gradually until it became significantly lower (Figure 5).

Fig. 3. Mean number of *O. niloticus* seeds (eggs and free swimming fry) produced from 3 different age and size groups of females throughout 6 harvestings from March to August, 2005.

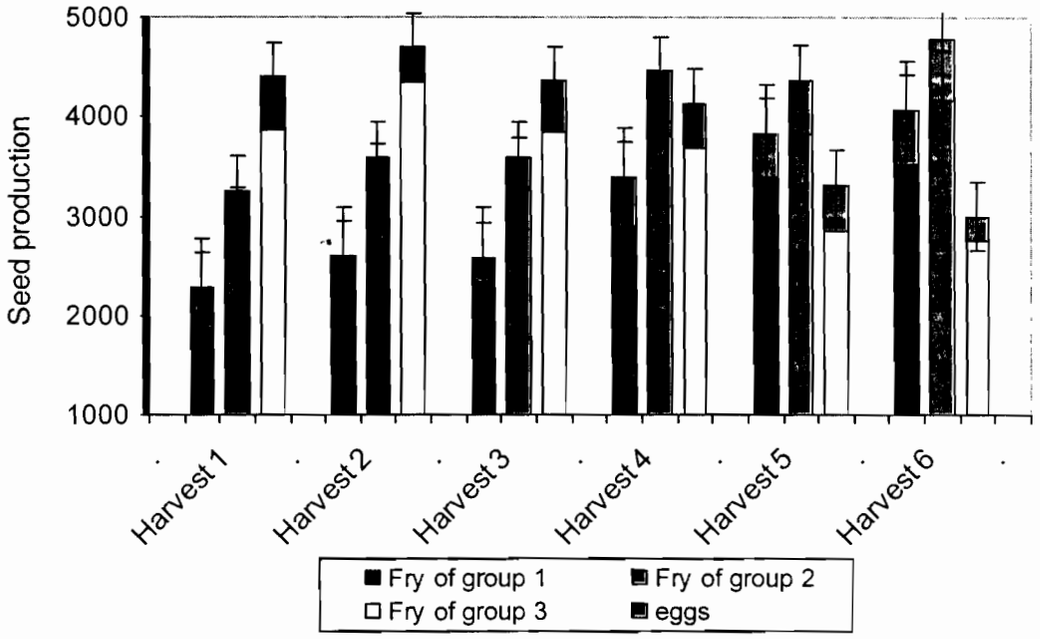


Fig. 4. Linear regression for seed production (free swimming fry and eggs) from *O. niloticus* broodstock females of different age and size groups.

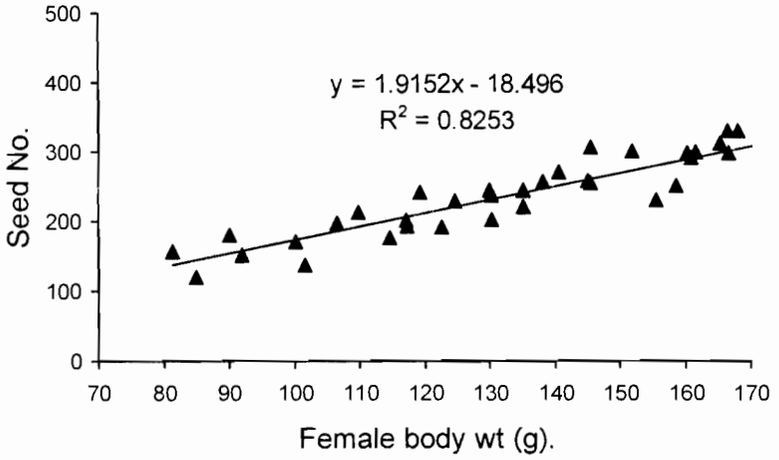
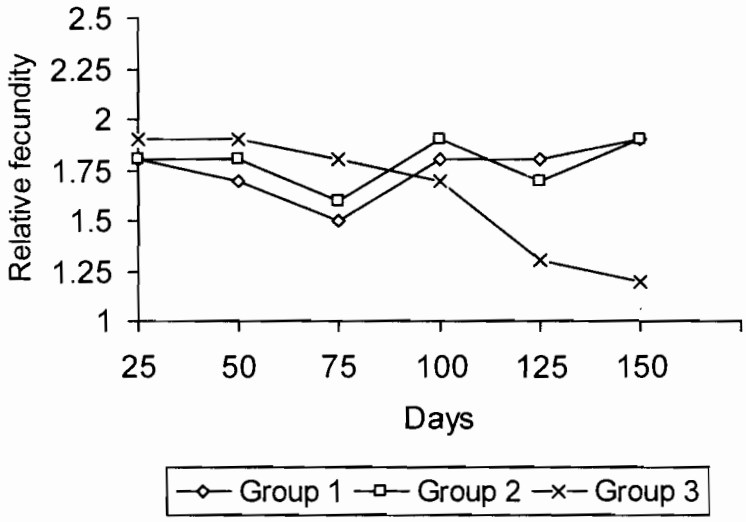


Fig. 5. Relative fecundity of three different age groups of *O. niloticus* females within 6 harvestings, 150 days.



DISCUSSION

A total of 6 successive harvestings, at an interval of 25 days, were made throughout 150 days from March to August 2005, resulting in a mean total seed production of 18750, 24049 and 23952 for the three female groups 1, 2 and 3, respectively.

The highest seed production expressed in terms of seed/female/day, was obtained from the one-year old females (10.7 seed/female/day) that had median initial body weight ranging between 90-120 g/female followed by 10.6 seed/female/day from females of the 1.5-years fish class that had the largest size (120-170 g). Seed production of the smallest 6-months old females (70-90 g/female) was the lowest (8.6 seed/female/day).

During the period of experiment, females of the three groups attained larger size, however, growth rate of females of first group was faster than that of females of the second group that had a faster growth rate than females of the third one. The living space effect of the concrete tanks that sustained under the conditions of this experiment may elucidate the difference in growth magnitude of the three different age and size groups of females.

Average body weight and length of fry increased with increasing body weight of the parents.

With regard to productivity of females of groups 1 and 2, seed production of females of the two groups increased gradually with increasing their body weight. The

trend coincides with Badawy (1993) who reported that egg production increased with increasing weight of females.

Concerning seed productivity of the larger females of group 3, it showed a different trend. According to Hughes and Behrends (1983), Siraj *et al.* (1983) and Watanabe and Kuo (1985), their results of egg and fry production of females of group 3 were expected to be much greater than those of the yearling females of group 2 and the younger females of group 1, however, in their study, growth of females of group 3 ceased, and a continuous reduction in seed production, potential rate and relative fecundity was observed since the second harvest to the end of the experiment. Therefore their productivity throughout the whole period of the experiment was insignificantly lower than that of the former group and significantly higher than that of the later one.

The continuous reduction of seed production from the older and larger females of group 3 may be attributed to the high total weight of females/m^2 as compared to Silvera (1978) who found a significant reduction in seed production of *Nile tilapia* when a total female weight was 526 g/ m^2. It may also be probable that females of this group reached an age at which reproductive inhibition occurred.

The following simple linear equation could be used for estimating the number of seed/harvest in relation to the body weight of females of groups 1 and 2: $y = 1.9152x - 18.496$, where Y = number of seed per harvest and X = weight of female brooder.

According to the present results, in order to produce a total of one million seed each 4 months, a tilapia fish hatchery needs to prepare more or less 1000 broodstock *O. niloticus* females of 6 months old with an average body weight ranging between 70-90 g/female, or 780 females, 1 year old, of the median size (90 -120 g/female).

It is advisable for fish hatcheries not to use females older than 1 year and having body size larger than 120 g/female unless further research would be conducted to assess the productivity of such females under lower density/m^2. After 1.5 years, hatcheries have to replace females of the 6-month old with a new stock of female breeders. After one year, the yearling females ought to be replaced with another younger and vital stock. If it is difficult to prepare female broodstock with these qualifications, different age and size groups of females can be exploited and the expected seed production/female/day under the same conditions could be approximated using the following equation derived from the present data: $y = (1.9152x - 18.496)/25$, when female body weight is 70-120 g/female and age is 1-1.5. years old.

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أثر الحجم والعمر علي الأداء التناسلي لإناث البلطي النيلي

جمال عبد الناصر محمد ، أحمد مصطفي خاطر ، عادل محمد عكر

المعمل المركزي لبحوث الثروة السمكية بالعباسة- أبوحماد- شرقية- مركز البحوث الزراعية – وزارة الزراعة – الدقى - مصر

تم عمل دراسة لتقييم إنتاجية الزريعة والبيض لثلاث مجموعات من أمهات البلطي النيلي ذات ثلاثة أحجام وأعمار مختلفة في أحواض خرسانية بصوبة زراعية. المجموعة الأولي كان عمرها ٦ شهور بمتوسط وزن ٧٧,٩± ٧,١جم للأم ، وعمر المجموعة الثانية عام واحد بمتوسط وزن ٩٩,١± ٩,٧جم للأم ، وعمر المجموعة الثالثة عام ونصف بمتوسط وزن ١٤٥,٦± ١٣,٩جم للأم. تراوحت درجة الحرارة أثناء التجربة بين ٢٥- ٢٩م^{o}. واستمرت التجربة لمدة ١٥٠ يوما تم صيد الأحواض فيها ٦ مرات كل ٢٥ يوما لتجميع الزريعة والبيض ولأخذ قياسات الطول والوزن والعدد ووزن الأمهات. كانت أعلي إنتاجية من الزريعة والبيض هي من أمهات المجوعة الثانية حيث وصلت إنتاجيتها ١٠,٧ لكل أم في اليوم، تلاها إنتاجية أمهات المجموعة الثالثة ١٠,٦ لكل أم في اليوم، ثم إنتاجية أمهات المجموعة الأولي ٨,٦ لكل أم في اليوم بمتوسط ٢٤٠٤٩، ٢٣٩٥٢، ١٨٧٥٠إجمالي الإنتاج للثلاث مجموعات علي التوالى.

أزداد وزن الأمهات أثناء التجربة بمعدلات نمو مختلفة فكان معدل نمو أمهات المجموعة الأولي أسرع من معدل نمو أمهات المجموعة الثانية ، وكان معدل نمو أمهات المجموعة الثانية أسرع من معدل نمو أمهات المجموعة الثالثة. وازداد معدل إنتاج أمهات المجموعة الأولي والثانية من الزريعة والبيض مع إزدياد الوزن . أما أمهات المجموعة الثالثة فقد تلاحظ أن نموها قد توقف تقريبا وأن إنتاجها من الزريعة والبيض أخذ يقل تدريجيا حتي أصبح أقل من معدل إنتاج أمهات المجموعتين ألأولي والثانية وكذلك الخصوبة النسبية.

تلاحظ أيضا أن متوسط وزن وطول الزريعة كان يزداد تدريجيا بإزدياد وزن الأمهات.

أمكن التوصل إلي معادلة خطية لحساب متوسط الإنتاج المتوقع من الزريعة والبيض في التفريخة الواحدة طوال ٦ تفريخات لأمهات لها نفس مواصفات العمر والحجم المستخدمة وتحت نفس الظروف وهي كالآتي : س= ١,٩١٥٢ X ص – ١٨,٤٩٦ حيث س = الإنتاج من الزريعة والبيض ، و ص = وزن ألأم.

وعلي ضوء هذه النتائج قدمت الدراسة توصيات للمفرخات السمكية بمواصفات وأعداد أمهات البلطي النيلي التي ينبغي إعدادها لإنتاج مليون زريعة خلال مدة ١٢٠ يوما.