EVALUATION OF NET ENCLOSURES SYSTEMS ON SEX REVERSED NILE TILAPIA, *OREOCHROMIS NILOTICUS*, FRY PRODUCTION AT A COMMERCIAL HATCHERY IN FAYOUM GOVERNORATE.

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ABSTRACT

The present work was conducted in a commercial hatchery at Shakshuk, Fayoum Governorate. The fry were transferred after yolk-sac had been absorbed to fry hapas which situated in a ½ feddan (fdn) earthen pond with 1.0 m depth. Water turnover rate was about 44 m^3 / h. Fry were fed 5 times daily starting on 14/ 6/2004 by herring fish meal (72 % crude protein, CP) containing 17 α methyl-testosterone (MT), 80 ppm MT/kg fishmeal, was used during sex reversal period (21 days period). The fry were fed such feed at a rate of 20% of their live body weight. Two experiments were conducted, the first dealt with the effect of stocking rate using 12 m^2 fry hapas, where the fry were stocked at rates of 3500, 3000, 2500, 2000, 1500, 1000 fry/m^2, forming 6 systems of fry stocking. The second dealt with the effect of hapa area (28, 12, 6, 4 m^2) using 3500 fry/m^2 area/hapa, forming four area systems. Growth and feed parameters, survival rates and production economics were calculated. Water quality parameters (water temperature, pH, dissolved oxygen and NH_3-N) were determined.

As for fry stocking rate/m^2 experiment, in the sex reversal period, fry growth tended to decrease as its stocking rate increased. But the fry biomass/ hapa and its survival rate were in favor with the higher stocking rate. However, FCR showed contra results. Net returns/1000 fry were nearly similar. But it tended to increase as fry stocking rate increased up to 3500, with better investment with the higher stocking rate.

Regarding area of hapa experiment, fry growth increased significantly as the area of hapa increased. Fry production parameters /hapa showed increases associated with the increase in hapa area. Survival rate was differed insignificantly, meanwhile FCR tended to improve as hapa area increased. The net returns were nearly similar/1000 sex reversed fry produced, the difference was only about 2%. However net returns/hapa were increased as its area increased.

In conclusion it seems that the best stocking was the highest. The best area is the highest regarding fry producers, while the lower areas were in favor with investors.

Key words: Nile tilapia, sex-reversed fry, stocking rate, hapa area, growth, production, and economics.

INTRODUCTION

Fish culture in Egypt is in progress, so that its production now is the highest in the near- east region, the GAFRD (2004) reported that its production increased from 53,000 tons in 1994 to 445,181 tons in 2003, with about 1.8 % annual increase. Regarding tilapia, FAO (2004) indicated that tilapia sp. represent 6 % of total the farmed fish, where Nile tilapia represent 81 % among of them.

The efficient culture of Nile tilapia in ponds requires population control due to its early maturing and frequent spawning characteristics. The Philippines and other countries used synthetic androgen like methyl testosterone that is orally administered to sexually undifferentiate tilapia fry at a given dosage and duration for the sex reversal of its females; i.e., for it's masculinity (Popma and Green, 1990 and Guerrero, 1996). Due to the possible negative impact of the excreted metabolic products, workers on human food safety and environment indicated that such method is safe and had no adverse effect (Curtis *et al*, 1991 and Green and Teichert-Coddington, 2000). Fry are most commonly stocked at densities of 3000-4000 fry/m^2 of hapa (Phelps and Popma, 2000) and 3000 – 5000 fry/m^2 of hapa (Popma and Green, 1990). Vera Cruz and Mair (1994) compared stocking densities of 1000, 3000 and 5000/m^2 of hapa and found best sex reversal at 3000 and 5000/m^2. high densities help insure an active feeding response needed so all fish are consuming feed. Gale *et al.* (1999) reported that the use of all male population increases the efficiency and feasibility of tilapia aquaculture. Also, Popma and Green (1990) reported that fry have been successfully sex reversed at lower densities, but the enclosures are inefficiently utilized and the relative abundance of natural food may endanger the treatment if the diet is not highly palatable. Higher densities may also be possible, but competition for feeding space may result in more undersize fish that have not consumed sufficient hormone.

In Fayoum Governorate the cultured fish production exceeded 9 thousand tons in 2003 (about 63.5% of the Governorate total production when natural resources were included) with an average of 3 tons/ feddan, where Nile tilapia is the main crop (GAFRD, 2004). The commercial hatcheries use different systems to produce sex reversed Nile tilapia fry. Such systems differed in fry stocking rate and in the area of net enclosure. Therefore the applied systems that used in such hatcheries were put in consideration in the present study and performed at a commercial hatchery to justify the unstudied factors. Accordingly to coincide the systems applied, two experiments were conducted. The first dealt with fry stocking rate and the second dealt with net enclosure (hapa) area effects on fry growth and production economics.

MATERIALS AND METHODS

The present work was conducted at the commercial hatchery in Shakshuk, Fayoum Governorate (its annual production is four million fry). The brood fish were put in 28 m^2 fine mesh net enclosures (hapas).

Nile tilapia, *Oreochromis niloticus* eggs were collected from brood fish hapa and transferred to hatchery Lab. until hatching. Then fry were transferred after yolk-sac had been absorbed to fry hapas that situated in a ½ feddan (fdn) earthen pond with 1.0 m depth. Water turnover rate was about 44 m^3 / h. Fry were fed 5 times daily (Popma and Green, 1990; Bocek *et al*, 1992) starting on 14/ 6/ 2004.

Herring fish meal (72% crude protein, CP)* containing 17 α methyl-testosterone (MT)**, 80 ppm MT/kg fishmeal (Popma and Green, 1990), was used during sex reversal period (21 days period). The fry were fed such feed at a rate of 20% of their live biomass (Phelps *et al.,* 1992; Green and Teichert-Coddington, 1994 and Phelps and Popma, 2000). Such trend acts that used in commercial hatcheries at Fayoum.

Two experiments were conducted, the first dealt with the effect of stocking rate using 12 m^2 fry hapas, Table 1. The second dealt with the effect of hapas area using 3500 fry/m^2 area, Table 2. In experiment one, fry were stocked at rates of 3500, 3000, 2500, 2000, 1500 and 1000 fry/m^2, with duplicate hapas per treatment. In the second, the tested areas were 28, 12, 6, 4 m^2/hapa, with duplicate hapas per treatment.

Table 1. Stocking rate systems, Exp. 1.

Items	Treatments					
	1	2	3	4	5	6
Number of fry						
/m^2	**3500**	**3000**	**2500**	**2000**	**1500**	**1000**
/hapa* **	**42000**	**36000**	**30000**	**24000**	**18000**	**12000**

**** From triple nine fish protein, DK-6700 Esbjerg, Denmark.***
***** From Argent laboratories Inc., Makati city, Philippines.***
****** Net enclosure, 12-m^2 area each.***

Table 2. Hapa area systems, Exp. 2.

Items	treatments			
	1	2	3	4
Net enclosure (hapa) area, m^2.	**28**	**12**	**6**	**4**
Number of fry/ hapa*	**98000**	**42000**	**21000**	**14000**

**** 3500 fry / m^2.***

Fry fresh weight, number, feed offered, feed costs and selling prices were obtained. Growth and feed parameters, survival rates and net returns were calculated. Water quality parameters, i.e., water temperature, pH values, dissolved oxygen and NH_3-N concentrations were determined through centigrade thermometer, Oreon digital pH meter model 201, Col Parmer oxygen meter model 5946 and Hann instruments ammonia test kit (HI 4829), respectively.

Analysis of variance and comparisons between means were conducted applying Statgraphic Package Software (SPSS, 1997).

RESULTS

Water quality:

Average water quality parameters tested were 30.2 ± 2.0 C$^{\circ}$, 7.9 ± 0.1, Nil and 6.8 mg/l for water temperature, pH, NH_3-N and dissolved oxygen.

Experiment one:

Table 3 shows that the effect of stocking rate of Nile tilapia fry on its growth performance. Significant ($P \leq 0.05$) differences were obtained among treatments. In general, as fry stocking rate decreased as growth performance improved. However the 3500 fry stocking rate showed better performance than that stocked at a rate of 3000 or 2500, the differences did not exceed 5% regarding specific growth rate (SGR). Final weight of 1000 fry/m^2 was nearly twice of that stocked at a rate 3500 fry / m^2 (675 vs. 355 mg/fry).

Fry production parameters/hapa (Table 3) indicated that increasing fry stocking rate resulted in increasing number of fry, survival rate, weight of fry, fry total gain and feed offered. However the lowest feed conversion ratio (FCR) was obtained with 2500 and 3000 fry/m^2 compared to the other stoking rates applied.

Table 3. Growth performance / fry and fry production /hapa as affected by fry stocking rate (Exp. 1).

Items	Treatments (fry stocked/ m^2)						SED
	1 (3500)	2 (3000)	3 (2500)	4 (2000)	5 (1500)	6 (1000)	
	Growth performance/fry						
Fresh weight, mg.							
At the start.	10	10	10	10	10	10	----
At the end.	355^d	320de	300^e	440^c	500^b	675^a	15
Gain, mg.							
Total (TG).$^{(1)}$	345^d	310de	290^e	430^c	490^b	665^a	15
/day $^{(2)}$.	16.43^d	14.76^{de}	13.81^e	20.48^c	23.33^b	31.67^a	0.75
% SGR$^{(3)}$.	17.00^d	16.50^{de}	16.20^e	18.02^c	18.63^b	20.06^a	0.13
	Fry production parameters / hapa						
No. of fry.							
At the start.	42000	36000	30000	24000	18000	12000	----
At the end.	34250^a	27000^b	22500^c	18000^d	11500^e	7750^f	736
% Survival rate$^{(4)}$.	81.55^a	75.00^a	75.00^a	75.00^a	63.89^b	64.58^b	3.39
Fry weight/hapa, g.							
At the start.	420	360	300	240	180	120	----
At the end.	12160^a	8640^b	6750^c	7930^b	5750^d	5225^d	423
Total gain/hapa$^{(5)}$, g.	11740^a	8280^b	6450^c	7690^b	5570^d	5105^d	423
Feed offered/hapa, g.	10500	9000	7500	6000	4500	3000	----
FCR$^{(6)}$.	0.89^b	1.09^a	1.16^a	0.78^b	0.81^b	0.59^c	0.05

(1) Final weight (Fw) per fry - Initial weight (Iw) per fry. (2) TG/period in days (P), 21 day. (3) 100 (ln Fw - ln Iw) / P, where ln is the natural log. (4) 100 (No of fry at the end / No of fry at start). (5) Fw per hapa- Iw per hapa. (6) Feed Conversion ratio, i.e., feed offered per hapa/ TG per hapa, SED is the standard error of difference.
Averages in the same row having different superscripts differ significantly ($P \leq 0.05$).

Regarding the economic evaluation (Table 4), the net returns to produce 1000 fry were nearly similar where the differences did not exceed 5%. Even though hapa net returns tended to increase as its stocking rate increased, i.e., increasing fry stocking rate from 1000 to 3500 fry/m^2 increased net returns by about 4.6 folds. Such trend was observed in such a way with net returns /cost per hapa (%).

Table 4. Economic evaluation as affected by fry stocking rate/m^2 (Exp. 1).

Items	Treatments (fry stocked/m^2)					
	1 (3500)	2 (3000)	3 (2500)	4 (2000)	5 (1500)	6 (1000)
	Per 1000 fry					
Fry production costs@, LE.	**28.13**	**28.40**	**28.40**	**28.40**	**28.99**	**28.95**
Fry selling price, LE.	**50.00**	**50.00**	**50.00**	**50.00**	**50.00**	**50.00**
Net returns, LE.	**21.87**	**21.60**	**21.60**	**21.60**	**21.01**	**21.05**
Relative % of net returns.	**104**	**103**	**103**	**103**	**100**	**100**
	Per hapa					
Total costs, LE.	**963**	**767**	**639**	**511**	**333**	**224**
Fry selling price, LE.	**1713**	**1350**	**1125**	**900**	**575**	**388**
Net returns, LE.	**750**	**583**	**486**	**389**	**242**	**164**
Relative % of net returns.	**547**	**356**	**296**	**237**	**148**	**100**
Net returns/ total costs, %.	**77.88**	**76.01**	**76.06**	**76.13**	**72.67**	**73.21**

@ for brood fish, hapas, labor, equipments and feed.

Experiment two:

Table 5 indicates that the area of hapas has a significant effect on the growth performance of fry, fish fresh weight at the end, gain and SGR% after 21 days. All of three parameters increased significantly as the area of hapa increased. Fry production parameters/hapa showed increases in its number at the end associated with the increase in area of hapa. Accordingly, fry weight and gain/ hapa increased as the area of hapa increased. Survival rate was differ insignificantly. But FCR improved significantly ($P \leq 0.05$) as the area of hapa increased.

Table 5. Growth performance / fry and fry production /hapa as affected by hapa area (Exp. 2).

Items	Treatments (Hapa area / m^2)				SED
	1 (28)	2 (12)	3 (6)	4 (4)	
	Growth performance/fry				
Fresh weight, mg.					
At the start.	10	10	10	10	----
At the end.	517^a	415^b	334^c	318^c	15
Gain, mg.					
Total (TG).$^{(1)}$	507^a	405^b	324^c	308^c	15
/day$^{(2)}$.	24.14^a	19.29^b	15.43^c	14.67^c	0.69
% SGR$^{(3)}$.	18.79^a	17.74^b	16.71^c	16.47^c	0.20
	Fry production parameters / hapa				
No. of fry.					
At the start.	98000	42000	21000	14000	----
At the end.	75000^a	32500^b	17750^c	11500^d	375
% Survival rate$^{(4)}$.	76.53	77.38	84.52	82.14	5.76
Fry weight /hapa, g.					
At the start.	980	420	210	140	----
At the end.	38768^a	13502^b	5925^c	3660^d	485
Total gain/hapa$^{(5)}$, g.	37788^a	13082^b	5715^c	3520^d	485
Feed offered/hapa, g.	24500	10500	5250	3500	----
FCR$^{(6)}$.	0.65^b	0.80^{ab}	0.92^{ab}	0.99^a	0.09

(1) Final weight (Fw) per fry - Initial weight (Iw) per fry. (2) TG/period in days (P), 21 day. (3) 100 (ln Fw - ln Iw) / P, where ln is the natural log. (4) 100 (No of fry at the end / No of fry at start). (5) Fw per hapa- Iw per hapa. (6) Feed Conversion ratio, i.e., feed offered per hapa/ TG per hapa, SED is the standard error of difference.
Averages in the same row having different superscripts differ significantly, ($P \leq 0.05$).

Table 6 shows that the net returns were nearly similar/1000 fry produced, where it ranged between 21.6 to 21.9 (LE) (the difference was only about 2%). However, per hapa the net returns increased obviously as the area of hapa increased. The relative % of net returns showed to what extent such increases were found. However, net returns/total costs showed differences ranged between 0.8 to 2.0% between the smallest area and the other treatments.

Table 6. Economic evaluation as effected by hapa area (Exp. 2).

Items	Treatments (area of hapa, m^2)			
	1 (28)	2 (12)	3 (6)	4 (4)
	Per 1000 fry			
Fry production costs[@], LE.	**28.33**	**28.30**	**28.02**	**28.10**
Fry selling price, LE.	**50.00**	**50.00**	**50.00**	**50.00**
Net returns, LE.	**21.60**	**21.70**	**21.98**	**21.90**
Relative % of net returns.	**100**	**101**	**102**	**102**
	Per hapa			
Total costs, LE.	**2125**	**920**	**497**	**323**
Fry selling price, LE.	**3750**	**1625**	**888**	**575**
Net returns, LE.	**1625**	**705**	**391**	**252**
Relative % of net returns.	**645**	**280**	**155**	**100**
Net returns/ total costs, %.	**76.47**	**76.63**	**78.67**	**78.02**

@ for brood fish, hapas, labor, equipments and feed.

DISCUSSION

Water quality:

In the present study, water quality parameters tested (temperature, pH, NH_3-N and dissolved oxygen) were in the acceptable limits (Popma and Green, 1990; Milstein, 1995; Egan and Boyed, 1997; Siddiqui and Harbi, 1997 and Hassouna *et al*, 2002). So, water environment had no obvious adverse effect on fry rearing.

Experiment one:

Stocking rates used in the present study are used by fry producers in Fayoum Governorate. However in other countries such stocking rates reached up to 6000 fry/m^2 (Popma and Green, 1990). Also, Popma and Green (1990) suggested stocking density in net enclosures as 3000 to 5000 graded fry/m^2 of net enclosure. Hence, it may need further investigation. Fry weight at the end of sex reversal period (Table 3) was higher than that reported by Popma and Green (1990). Such oversize is a target for fry producers. The higher weight of fry herein seams to be due to the use of Herring fishmeal (72% crude protein, CP) as a feed compared to that reported by those authors. They used diets containing lower CP (did not exceed 45% CP), at least half of which is of animal origin.

The increase in fry stocking rate showed a reduction in growth rate in general (SGR, Table 3). The exception that the 2500 fry/m^2 had the lowest growth. Such result could be neglected since the differences in SGR did not exceed 5 % compared to that stocked by 3500 fry. It seems that the competition for feeding space is behind such results. On the other hand, fry survival rate tended to improve by increasing fry stocking rate. Also, there is a negative response between fry weight and their survival (Table 3). It seems that fry do higher competition activity to feed, associated with increasing fry stocking rate, increased its viability, and reduced feed residue problems and fry weight at the end of sex reversal period.

Fry production was in favor of the increase in their stocking rate. Net returns per 1000 fry were nearly similar (Table 4). Furthermore, the increase in fry stocking rate increased net returns/hapa and in such a way in the invested money (net returns/costs), as shown in Table 4. Such trends eliminate the importance of FCR and fry SGR, as the economic results are favorable for both fry producers and investors in aquaculture sector.

Experiment two:

Areas of hapa tested (28, 12, 6, 4 m^2) are used in commercial hatcheries. All of them were stocked at a fixed rate (3500 fry/ m^2) and maintained for 21 d for sex reversal. The fixed rate / m^2 resulted in an increase in fry number (No) as the area of hapa increased (Table 5).

It was observed that as the area of hapa increased from 4 to 28 m^2 as growth of fry increased, about 14% regarding SGR (Table 5). The increase in fry final weight as the area of hapa increased is desirable by fry producers. Also, FCR tended to improve as the area of hapa increased but survival rate tended to decrease with 12 and 28 m^2 hapa compared with the smallest area. Such results may suggest that FCR is pseudo due to the higher presence of natural feed as the hapa area increased. Such increase in natural food is due to the higher fry population beside their residues (feces and feed residues). So fry tended to depend on such food beside that supplied. Also, the increase in fry raceway by increasing hapa area may had a role in this connection. But the higher competition on natural and artificial food as well as the longer raceway may resulted in lower survival rate with larger hapa (12 & 28 m^2 ones). Moreover, the increase in growth rate as area of hapa increased may had a role in reducing survival rate due to the expected higher predation between fries (Popma and Green, 1990).

However the net returns for 1000 fry were nearly similar, it increased/hapa as its area increased due to the fixed stocking rate per m^2 (Table 6). Even though, the net returns /costs tended to be in favor for the hapa of small area.

CONCLUSION

As evident from Exp. 1, the general trend including the economic evaluation was in favor of 3500 fry stocking rate / m^2. But more than this rate may need further investigation. Data in Exp. 2 may suggest the use of 28m^2 hapa for more SGR, production and net returns regardless to the investment returns (net returns /costs).

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تقييم نظم الحاويات الشبكية في إنتاج زريعة البلطي النيلي المحولة جنسيا في مفرخ تجارى بمحافظة الفيوم.

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أجرى البحث في مفرخ تجارى بمنطقة شكشوك بمحافظة الفيوم. حيث نقلت الزريعة بعد امتصاص كيس المح الى الهابات الموضوعة في حوض ترابي (0.5 فدان) بعمق واحد متر، وكان معدل تغيير المياه به 44 م^3/ الساعة. وغذيت الزريعة 5 مرات يوميا ابتداء من يوم 2004/6/14 بمسحوق سمك الرنجة (72% بروتين) محتويا 17 الفا ميثيل تستوستيرون بتركيز 80 جزء في المليون/ كجم مسحوق أثناء فترة تحويل الجنس (21 يوما) بمعدل 20% من وزنها. أجريت تجربتان اشتملت الأولى تأثير معدلات التكثيف/م^2 للزريعة باستخدام هابات مساحة كل منها 12 م2 (3500، 3000، 2500، 2000، 1500، 1000 زريعة / م^2)، مكونة 6 نظم لتكثيف الزريعة (6 معاملات). واشتملت الثانية تأثير مساحة الهابات (28، 12، 6، 4 م^2) باستخدام معدل تكثيف 3500 زريعة / م^2، مكونة 4 نظم لمساحات الحاويات (الهابات). أخذت بيانات جودة المياه (الحرارة، اللوغاريتم السالب لتركيز أيون الهيدروجين، تركيز الأكسوجين الذائب، ونيتروجين الامونيا)، الوزن، العدد، الغذاء المقدم، والأسعار اللازمة بالجنيه المصري. وحسب النمو والمقاييس الغذائية ومعدل البقاء واقتصاديات الإنتاج.

أوضحت نتائج معدلات التخزين المستخدمة انخفاض نمو الزريعة كلما ارتفع معدل تخزينها مع زيادة كتلة الزريعة بالهابة وكذلك معدل إعاشتها بزيادة معدل تكثيف الزريعة ورغم انخفاض معدل التحويل الغذائي بزيادة الكثافة، فقد تماثل العائد / 1000 زريعة منتجة، مع زيادة عائد الهابة وكذلك العائد الاستثماري (العائد على الجنيه) بزيادة كثافة الزريعة بالهابة.

أوضحت نتائج مساحة الهابات المستخدمة ارتفاع نمو الذريعة ومعدل التحويل الغذائي و كتلة الزريعة / هابة و العائد / هابة مع زيادة مساحة الهابة، رغم انخفاض معدل العائد على الجنيه.