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INTENSIVE REARING OF MONO-SEX NILE TILAPIA AND SILVER CARP UNDER MONO-OR POLYCULTURE SYSTEMS AT DIFFERENT STOCKING DENSITIES IN FLOATING NET CAGES

Abdelhamid, A. M.
Dept. of Animal Production, Fac. Agric., Mans. Univ., A.R.E.

ABSTRACT

The experiment of this study was carried out for 6 months on rearing Nile tilapia and silver carp, whether under monoculture or polyculture at different stocking densities. Four floating net cages (10 x 10 x 3 m) were used. The obtained results revealed that the best treatment was the monoculture of all males mono-sex Nile tilapia (10000 fish of 10-g each/cage) followed by that of polyculture (5000 tilapia of 10-g plus 750 carp of 70-g/cage) concerning their superiority in final bodyweight (235 and 545-g/fish), bodyweight gain (225 and 475-g/fish), average daily bodyweight gain (1.21 and 2.55-g), specific growth rate (SGR, 1.70 and 1.01 %/day), feed conversion ratio (FCR, 2.41 and 2.45), feed cost/Kg bodyweight gain (7.78 and 5.89 L.E.), and economic efficiency (144.5 and 77.9%, respectively). Moreover, the monoculture of all males mono-sex Nile tilapia was also the best treatment in return (18855 L.E./cage) followed by the polyculture treatment (7500 tilapia of 10-g with 1100 carp of 70-g/cage) which gave return of 10868 L.E./cage.
Keywords: Cages – Nile tilapia – Silver carp – Stocking rates – Performance – Productivity.

INTRODUCTION

Frankic and Hershner (2003) summarized the benefits of aquaculture in: 1) increase household food supply and improve nutrition, 2) increase household economy through diversification of income and food sources, 3) strengthen marginal economy by increasing employment and reducing food price, 4) improve water resource and nutrient management at household or community levels, 5) preserve aquatic biodiversity through re-stocking and recovering of protected species, 6) reduce pressure on fishery resources if done sustainable, 7) improving/enhancing habitats, 8) stimulates research and technology development, and 9) increase education and environmental awareness. El-Saidy (2005) recommended mono-sex culture of male Nile tilapia for its better growth performance and economics. Abou Zied and Hassouna (2006) concluded that growth performance of sex reversed Nile tilapia tended to decrease as its stocking rate increased, but feed conversion rate showed contra results. Abo-El-Wafa (1996) stated that tilapia cage culture is productive (~28.1 kg/m^3/5 months) and economically feasible when scientific management, using suitable tilapia species and size stocked early at optimum numbers and fed with suitable diet. Moreover, Coulibaly *et al.* (2007) mentioned that production potential of African catfish (*Heterobranchus longifilis*) from floating cages could be increased by the improvement of rearing conditions (feeding systems, culture management) as noted in other species. The aim of the present work was to estimate the benefits of fish (Nile tilapia and silver carp) culture whether under mono-or polyculture systems, particularly at two stocking rates in floating net cages.

MATERIALS AND METHODS

This study was carried out at Al-Manzalah lake (Raswah Lisa Al-Gamaliah) using four floating net cages (10x10x3 m each) for six months (1st May till 30th October 2010). All fish groups were fed on the same diet that contains 25% crude protein (from Al-Schorok Feed Mill, Al-Matariah, Dakahliah governorate) and offered twice daily (at 8.30 a.m. and 15.00 p.m.) at 3% of body weight mass daily. All fish species (all male mono-sex Nile tilapia, *Oreochromis niloticus*, Linn. and silver carp, *Hypophalmichthys malitrix*, Val.) were purchased from Hatchery and Fish Farm of Yosef Asal at the same district (Raswah Lisa Al-Gamaliah). The following schema illustrates the rearing system:

Item	1st Treatment	2nd Treatment	3rd Treatment	4th Treatment
Fish species	All male mono-sex Nile tilapia	Silver carp	All male mono-sex Nile tilapia + Silver carp	All male mono-sex Nile tilapia + Silver carp
Fish weight, g	10	70	10 +70	10 +70
Stocking rate:				
Fish/cage	10000	1500	5000 +750	7500 +1100
Fish/m^3	33.3	5	19.2	28.7
Gram fish/m^3	333.3	350	341.7	506.7
Rearing system	Mono-culture	Mono-culture	Poly-culture, low stocking rate	Poly-culture, high stocking rate

Biweekly measurements for 30 fish of each species within each cage were recorded concerning body weight, length, and depth in g and cm, respectively for calculating the condition factor ($K=W/L^3$, where W and L are body weight and length in g and cm, respectively), bodyweight gain (BWG), average daily bodyweight gain (DBWG), specific growth rate {SGR=100 (ln. W_2 -ln. W_1)/days}, gain of body length (BLG) and depth (BDG), average daily body length gain (DBLG), and average daily body depth gain (DBDG). Accumulative feed consumption per cage was calculated for feed conversion estimation. Also, water parameters (temperature, pH, and dissolved oxygen) were estimated morning and after noon, every 3 days for each cage (according to Abdelhamid, 1996). Water temperature as degree centigrade was recorded using a thermometer. The pH value of water was measured using an electric digital pH meter (Jenway Ltd, model 350-pH meter). Dissolved oxygen concentration was determined using an oxygen meter (model d-5509). Data obtained were statistically analyzed according to Sachs (1976).

RESULTS AND DISCUSSION

Table (1) presents the ranges, means ± standard errors, and coefficients of variance (C.V.) of the measured criteria of the fish rearing water quality, i.e. temperature, pH values, and dissolved oxygen registered on the 1st of May till the 31st 2010. The after noon values were higher than the morning values for the effect of ambient temperature and consequently for the biotic activities. The C.V. values were small enough because of the homogeneity of the estimated values. These values of water parameters are within the acceptable ranges recommended for pisciculture (Abdelhamid, 1996 and 2009; El-Nady *et al.*, 2001; Abdelhakim *et al.*, 2002; El-Saidy, 2004 and Hassan *et al.*, 2006).

Table (1): Data of fish rearing water as ranges during May – October 2010 at Al-Manzalah lake (Raswah Lisa Al-Gamaliah).

Item	Temperature, °C		The pH value		Dissolved oxygen, mg/l	
	Morning	After noon	Morning	After noon	Morning	After noon
No. of estimations	63	63	63	63	63	63
Range	23.2 - 26.9	24.2 – 28.0	6.20 – 7.97	7.20 – 8.10	5.08 – 7.41	7.55 – 8.90
Mean ± SE	25.5 ± 0.15	26.8 ± 0.16	6.90 ± 0.05	7.72 ± 0.04	6.99 ± 0.05	8.22 ± 0.07
C. V. %	3.62	4.61	5.86	3.61	5.44	3.97

C.V. (coefficient of variance) = S x 100 / mean, where S = standard deviation

Table (2) illustrates all collected data of the experimental fish concerning total gains in body weight, length, depth, and condition factor of tilapia [under monoculture (Fig. 1) and polyculture systems at low and high stocking densities (Figs. 3A and 4A, respectively)] and silver carp [under monoculture (Fig. 2) and polyculture systems at low and high stocking densities (Figs. 3B and 4B, respectively)]. Also, comparisons between monoculture and polyculture of either of tilapia or silver carp were given in Figs. (5) and (6), respectively. From the data in these Figs. and Table (2), it is clear that the final body weight of the carp was significantly (P≤0.05) heavier than that of the tilapia, particularly under the polyculture system at the low stocking density. The same trend was recorded too for final body length, depth, and k-factor as well as for the total bodyweight gain and average daily bodyweight gain, but the total body length and depth and averages of daily body length and depth were higher for tilapia than carp, except for total body length in T_3. However, tilapia reflected higher specific growth rates than carp, particularly under monoculture system or polyculture system at the high stocking density.

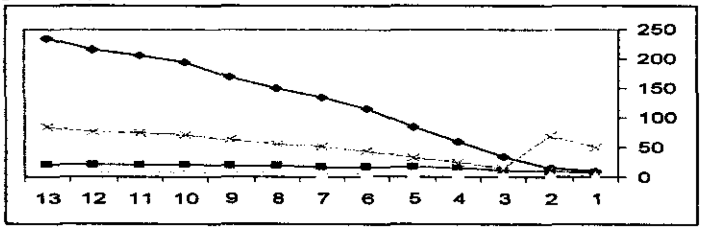

Fig. (1): Body weight (g), condition factor (k), body length (cm), and body depth (cm) curves in descending order (from the upper curve) of the treatment 1 (tilapia, monoculture) throughout the 13-weeks experimental period.

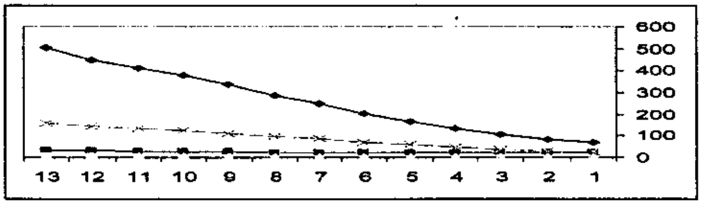

Fig. (2): Body weight (g), condition factor (k), body length (cm), and body depth (cm) in descending order (from the upper curve) of the treatment 2 (silver carp, monoculture) throughout the 13-weeks experimental period.

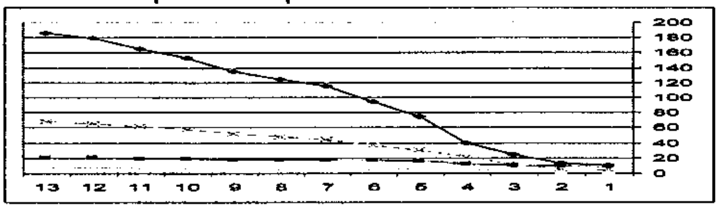

Fig. (3A): Body weight (g), condition factor (k), body length (cm), and body depth (cm) in descending order (from the upper curve) of the treatment 3 (tilapia, polyculture- low density) throughout the 13-weeks experimental period.

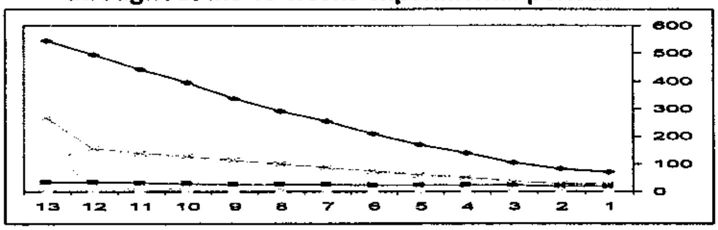

Fig. (3B): Body weight (g), condition factor (k), body length (cm), and body depth (cm) in descending order (from the upper curve) of the treatment 3 (silver carp, polyculture- low density) throughout the 13-weeks experimental period.

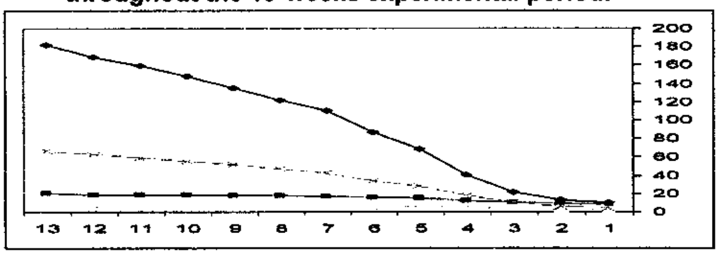

Fig. (4A): Body weight (g), condition factor (k), body length (cm), and body depth (cm) in descending order (from the upper curve) of the treatment 4 (tilapia, polyculture- high density) throughout the 13-weeks experimental period.

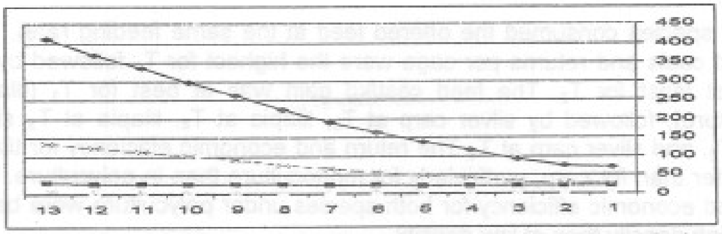

Fig. (4B): Body weight (g), condition factor (k), body length (cm), and body depth (cm) in descending order (from the upper curve) of the treatment 4 (silver carp, polyculture- high density) throughout the 13-weeks experimental period.

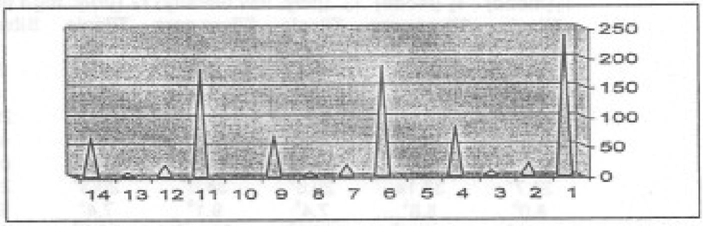

Fig. (5): Comparison between final body measurements (BW, BL, BD, and K-factor) of tilapia under mono (1-4) and polyculture at low (6-9) and high (11-14) stocking densities.

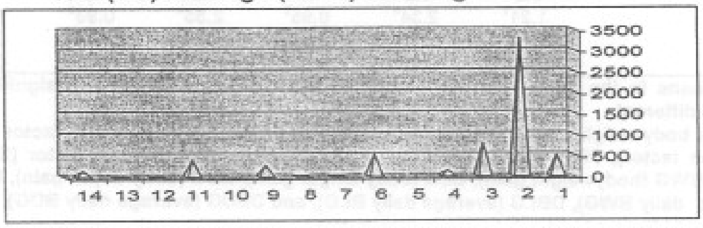

Fig. (6): Comparison between final body measurements (BW, BL, BD, and K-factor) of silver carp under mono (1-4) and polyculture at low (6-9) and high (11-14) stocking densities.

Table (3) presents also a comparison among all the experimental fish groups concerning the catch/ feddan, feed consumption, and feed conversion ratio. The total catch per cage, m^3, or feddan was higher for tilapia than for carp for the higher number at stocking as well as for the higher SGR of tilapia than carp. This may be due to that, tilapia consumed more feed than carp, but convert it to growth more efficient than carp, except at T_3 (polyculture, low stocking rate). Table (3) shows also the feed consumption (consequently feed cost) and weight gain per cage which were also higher for tilapia than silver carp, particularly under monoculture than under polyculture, for the same reasons mentioned before (stocking density and growth rate). Feed conversion was the best (2.41) for tilapia monoculture, but was worst (2.66) for silver carp under polyculture at high stocking density (assuming that both fish species consumed the offered feed at the same feeding rate). The total feed costs and returns per cage were the highest for T_1 followed by T_4, T_3 and at least for T_2. The feed cost/kg gain was at best for T_1 (tilapia, monoculture), followed by silver carp at T_3, tilapia at T_4, tilapia at T_3, silver carp at T_2, and silver carp at T_4. The return and economic efficiency for tilapia were better than for carp, particularly for monoculture than in polyculture. The return and economic efficiency for both species under polyculture were better also at high density than at low density.

Table (2): Summary of the growth performance parameters of intensive fish culture in floating net cages under different rearing systems (mono-and polyculture at different stocking rates).

Criteria	T_1 (mono)	T_2 (mono)	T_3 (poly, low density)		T_4 (poly, high density)	
	Tilapia	Silver carp	Tilapia	Silver carp	Tilapia	Silver carp
IBW, g	10	70	10	70	10	70
IBL, cm	8.4	20.8	8.4	20.8	8.4	20.8
IBD, cm	2.8	4.6	2.8	4.6	2.8	4.6
IK- factor	4.92	25.45	4.92	25.45	4.92	25.45
FBW, g	235^b	505^a	186^c	545^a	182^c	412^a
SGR,%/d	1.68^a	1.06^b	1.57^a	1.10^b	1.56^a	0.95^b
FBL, cm	21.7^b	33.1a	20.6^b	34.0^a	20.3^b	29.7^a
FBD, cm	8.0^b	8.8^a	7.4^c	9.1^a	7.4^c	8.0^b
FK-factor	84.3^c	157.3^b	67.9^c	264.8^a	66.7^c	133.0^b
BWG, g	225^c	435^a	176^d	475^a	172^d	342^b
BLG, cm	13.3^a	12.3^b	12.2^b	13.2^a	11.9^b	8.9^c
BDG, cm	5.2^a	4.2^b	4.6^b	4.5^b	4.6^b	3.4^c
DBWG, g	1.21^c	2.34^a	0.95^c	2.55^a	0.93^c	1.84^b
DBLG,mm	0.72^a	0.66^b	0.66^b	0.71^a	0.64^b	0.48^c
DBDG,m m	0.28^a	0.23^b	0.25^b	0.24^b	0.25^b	0.18^c

a – d: Means in the same row superscripted with different letters are significantly ($P \leq 0.05$) different.

IBW (initial body weight), IBL (initial body length), IBD (initial body depth), IK- factor (initial condition factor), FBW (final BW), FBL (final BL), FBD (final BD), FK-factor (final K-factor), BWG (bodyweight gain), BLG (body length gain), BDG (body depth gain), DBWG (average daily BWG), DBLG (average daily BLG), and DBDG (average daily BDG).

Nour *et al.* (1993) registered that growth performance, fish net production and feed utilization of grey mullet was decreased with increasing the stocking density. Moreover, Sweilum (1995) found that the growth in length and weight of the two rearing fishes (Nile tilapia and silver carp) slightly increased with the decreasing stocking density. Additionally, Khouraiba *et al.* (1996) concluded that growth performance and feed efficiency of *Penaeus japonicus* shrimp were significantly decreased with increasing the stocking density. In addition, Teichert-Coddington (1996) came to the conclusion that total production increased curvilinear but feed conversion ratios, total nitrogen and chlorophyll α decreased linearly as the rate of stocking tilapia increased. He found also that tilapia mean weight decreased curvilinear and tambaqui (*Colossoma macropomum*) mean weight increased linearly as the rate of stocking tilapia increased. Also, Huang and Chin (1997) mentioned that the size, size variation, percentage survival and production of tilapia fry were found to be significantly affected by stocking density, but not for condition factor. Moreover, Sweilum (1998-a) reported that growth and production of *O. niloticus* are related to stocking density, since they increase at low density. El-Sherif (2001) also found improvements in weight and length of the prawn larvae at lower stocking density.

Table (3): Data of fish production and economic efficiency of intensive fish culture in floating net cages under different rearing systems (mono-and polyculture at different stocking rates).

Criteria	T_1 (mono)	T_2 (mono)	T_3 (poly, low density)		T_4 (poly, high density)	
	Tilapia	Silver carp	Tilapia	Silver carp	Tilapia	Silver carp
Catch, kg:						
/cage	2350	757.5	930	408.8	1365	453.2
/m^3	7.83	2.53	3.10	1.36	4.55	1.51
/feddan	98700	31815	39060	17167.5	57330	19034.4
Feed consumptio,kg/cage	5421	1677	2201.6	874.2	3174	1001.8
Gain, kg/cage	2250	652.5	880	356.25	1290	376.2
FCR	2.41	2.57	2.50	2.45	2.46	2.66
Feed cost, LE:						
/cage	13010.4	4024.8	5283.8	2098.1	7617.6	2404.3
/Kg BW gain	5.78	6.17	6.00	5.89	5.91	6.39
Return, LE:						
/cage	18800	2840.6	6324.0	1635.0	9282.0	1586.2
/m^3	62.67	9.47	21.08	5.45	30.94	5.29
/feddan*	789600	119305	265608	68670	389844	66620.4
Economic efficiency(%)**	144.5	70.58	119.7	77.9	121.8	65.97

FCR (Feed conversion ratio), *: Feddan (Egyptian area unit) = 4200m^2, **: Economic efficiency (return x 100/ feed cost), according to the local prices year 2010 for fish and feed, where 1 US dollar ($) = 5.8051 Egyptian pound (L.E.).

Also, El-Saidy and Gaber (2002) confirmed that mean final weight and length, weight and length gain, SGR, and feed conversion of *O. niloticus* were significantly ($P \leq 0.01$) the best at the lower stocking density; while, total production and net production exhibited significantly the opposite trend. Bakeer *et al.* (2003) revealed too that silver carp cultured in cages gave pronounced ($P \leq 0.05$) increases in body weights at lower stocking density. Additionally, Kheir and Saad (2003) proved that the least stocking rate attained the highest significant ($P \leq 0.05$) final weight, weight gain, SGR, feed conversion, and protein efficiency ratio for *O. niloticus*. Abdel-Aal *et al.* (2004) working on *O. niloticus*, revealed that while individual fish weight and dressing percentage as well as flesh percentage decreased, fish yield and money profit increased with the increase in fish stocking density. However, El-Saidy (2004) revealed no significant differences in average final weight and SGR between stocking rates, but mean biomass at harvesting, total weight gain, daily weight gain and survival rate differ significantly ($P \leq 0.05$). The best fish growth, production and profitability were achieved from the highest stocking rate. Mullet growth was the best under the low density, but Nile tilapia grow better under the highest density. Additionally, Abou Zied *et al.* (2005) also revealed that harvesting body weight, total gain, daily gain and SGR of fish were affected by stocking rates, where higher values for tilapia and mullet were obtained at lower densities. Yet, body mass of tilapia at harvesting and the net production per feddan were higher at the highest stocking rate. Since, Abdel-Tawwab *et al.* (2005) concluded that Nile tilapia may quickly adapted to high rearing density by enhancing feed quality especially protein level in the diet to prevent the deleterious effect in fish farm. Recently, Bakeer *et al.* (2006) concluded also that stocking density released significant effects on final body weight and survival in favor of lower stocking density. Hassan *et al.* (2006) noticed also that increasing the stocking density decreased significantly body weight and length of tilapia aurea. Yet, Bakeer *et al.* (2007) recommended the medium stocking density [12 *O. niloticus* fish (50 g initial weight)/m^3] to get the optimum marketable fish size at harvest under monoculture semi-intensive system. Lastly, Alam (2009) concluded that the highest stocking density [150 fish (2.8 g initial weight)/m^3] of monosex male Nile tilapia reared in concrete tanks exhibited the highest production and net profit.

Gonzales-Corre (1988) used mono- and polyculture at different stocking densities and found that a competition was evident between *P. monodon* and *O. niloticus* at a stocking combination of 6,000 *P. monodon* /hectar plus 6,000 *O. niloticus* / hectar. Total yield from polyculture was better than monoculture. Polyculture of *P. monodon* at 6,000/ha and *O. niloticus* at 4,000/ha appeared feasible. However, Khouraiba *et al.* (1991) showed that common carp can be cultured with Nile tilapia in cages without affecting the growth and net production of Nile tilapia at ratios of 1:10 and 2:10 for tilapia and carp, respectively, 21:10 is the optimum ratio. They added that polyculture system gave higher (30%) total net production than that of tilapia alone in a monoculture. On the other hand, Brummett and Alon (1994) concluded that tilapia growth, reproduction and food conversion were adversely affected by the presence of crayfish ($P \leq 0.01$). Sweilum (1998-b) noticed also that the silver carp was the best species in tilapia rearing ponds, with it the weight gain of *O. niloticus* reached its maximum value. The specific growth rate was 1.91 for Nile tilapia reared with silver carp, 1.56 with common carp, 1.43 with the two species of carp and 1.24 for the Nile tilapia reared alone in the pond. On the other hand, the total production of *O. niloticus* was 1.806 Kg in the pond contained silver carp and 1.479 kg in pond contained common carp. This is a result of the observation that the optimum value of feed conversion (2.65) occurred for tilapia reared with silver carp. However, Abdelhakim *et al.* (2001) concluded that tilapia, mullet and eel can be cultured together in earthen ponds. Sweilum (2001) obtained better growth rate and production for *O. niloticus* in polyculture combination (Nile tilapia, *Sarotherodon galilaeus* and *Clarias gariepinus*) than in duoculture and monoculture systems. He added that *O. niloticus* showed better growth rate when cultured with *C. gariepinus* than with *S. galilaeus*. Yet, Kheir *et al.* (2002) reported no significant difference for growth performance among fish or prawn alone or in polyculture. Such a result may indicate that the growth of both species was not affected by the presence of the other. The feed conversion ratio was lower in polyculture than in the monoculture indicating that the polyculture species consumed less feed and utilized the feed more efficiently than the monoculture ones. Additionally, Saad and Habashy (2002) cultured the exotic crayfish (*Procambarus clarkia*, Girard, 1852) with common carp (*Cyprinus carpio*, Linnaeus, 1758); silver carp (*Hypophthalmichthys molitrix*, Valenciennes, 1844); Nile tilapia (*Oreochromis niloticus*, Linnaeus, 1757); and *Sartherodon galilaeus* (Artedi, 1757). There were no significant differences in the survival rate of the four fish species cultured in combination with the crayfish and the fish kept alone. Also, there were no significant differences in weight gain and specific growth rate. However, El-Saidy (2004) concluded that the semi-intensive polyculture of mullet and Nile tilapia is advised to increasing fish production and overcome the problems of land and water shortage. Also, Kheir and Saad (2004) found that the stocking rate of 4:1 *O. niloticus* : *C. gariepinus* produced higher growth, better FCR and higher production of marketable tilapia and catfish, indicating the absence of interspecies competition. So, it may be concluded that 4:1 *O. niloticus* : *C. gariepinus* stocking ratio is sufficient for effective recruitment control of tilapia and achieving higher growth and production of the two species. However, Kheir *et al.* (2004) recommended that rearing of males and females separately is necessary for increasing *O. niloticus* fingerlings growth and production in fish cage farms. De Silva *et al.* (2008) concluded that the introduction of of Jundia *Rhamdia quelen* (Quoy & Gaimard) and Nile tilapia to carp in polyculture had a positive effect on all growth parameters when compared with carp only. The reduction in common carp ratio also had a positive effect on all growth and yield parameters. Moreover, Essa *et al.*(2008) revealed that Nile tilapia and silver carp culture in net-enclosures model was more productive (12.26 kg/m^3/5 months) and economic than monoculture of Nile tilapia model (5.77 kg/m^3/ 5 months).

CONCLUSION

From the obtained results, it could be concluded and recommended that the best treatment is the monoculture of all males mono-sex Nile tilapia followed by that of polyculture for their superiority in final bodyweight, bodyweight gain, average daily bodyweight gain, specific growth rate, feed conversion, feed cost/Kg bodyweight gain, economic efficiency, and return.

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الرعاية المكثفة للبلطي النيلي وحيد الجنس والمبروك الفضي بنظامي منفرد ومتعدد الأنواع على كثافات تخزين مختلفة في أقفاص عائمة شبكية

عبد الحميد محمد عبد الحميد
قسم إنتاج الحيوان، كلية الزراعة، جامعة المنصورة، ج.م.ع.

تم إجراء تجربة لرعاية أسماك البلطي النيلي وحيد الجنس ذكور(١٠جم) وأسماك المبروك الفضي (٧٠ جم) في أقفاص شبكية عائمة(١٠ X١٠ X٣م) لمدة ستة أشهر بنظام وحيد النوع أو نظام متعدد الأنواع (على كثافتين تخزين)، وثبت من النتائج المتحصل عليها تفوق المعاملة التي بها البلطي منفردا، يليها التي بها البلطي مع المبروك (بكثافة ٥٠٠٠ + ٧٥٠ سمكة،على الترتيب في القفص)، وذلك لتفوقهما على باقي المعاملات من حيث الوزن النهائي (٢٣٥ و ٥٤٥جم/سمكة)، الزيادة في وزن الجسم (٢٢٥ و ٤٧٥جم/سمكة)، الزيادة اليومية في وزن الجسم (١.٢١ و ٢.٥٥جم)، معدل النمو النوعي (١.٧٠ و ١.١٠ %/يوم)، معدل التحويل الغذائي (٢.٤١ و ٢.٤٥)، تكاليف التغذية/كجم زيادة في وزن الجسم (٧.٧٨ و ٥.٨٩ جنية)، الكفاءة الاقتصادية (١٤٤.٥ و ٧٧.٩%)، كما تفوقت معاملة البلطي المنفرد يليها معاملة البلطي مع المبروك (بكثافة ٧٥٠٠ + ١١٠٠ سمكة على الترتيب/قفص) على باقي المعاملات من حيث العائد على القفص (١٨٨٥٥ و ١٠٨٦٨ جنية)، وعليه يوصى بالتربية المنفردة للبلطي النيلي وحيد الجنس ذكور أو البلطي مع المبروك الفضي بكثافة عالية كالمستخدمة في هذا البحث.

قام بتحكيم البحث

أ.د / عبد الخالق السيد عبد الخالق	كلية الزراعة – جامعة المنصورة
أ.د / فوزى ابراهيم معجوز	كلية الزراعة – جامعة كفر الشيخ