WVJ
World's
Veterinary Journal

World's Vet. J. 2(2): 17-22, 2012

Original Article

Growth Performance, Proximate Muscle Composition and Dress-Out Percentage of Nile Tilapia (*Oreochromis niloticus*), Blue Tilapia (*Oreochromis aureus*) and their Interspecific Hybrid (♂ *O. aureus X* ♀ *O. niloticus*) Cultured in Semi-Intensive Culture System

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ABSTRACT

O. niloticus and *O. aureus* and their interspecific hybrid (♂ *O. aureus* x ♀ *O. niloticus*), frys were produced in early September 2008 from a mass spawning of brooders in earthen spawning ponds. Frys for each genotype were nursed and overwintered in deep nursery ponds. Thereafter; six earthen growout ponds were used for communal stocking of each genotype (two replicates genotype^{-1}). The growth performance of purebred *O. niloticus*, *O. aureus* and their interspecific hybrid (♂*O. aureus* x ♀*O. niloticus*) were studied. The highest records ($P<0.05$) of final body weight (FBW), average daily gain (ADG, g fish^{-1} day^{-1}), specific growth rate (SGR, % day^{-1}), total fish yield (TFY, kg feddan^{-1} day^{-1}) and net fish yield (NFY, kg feddan^{-1} day^{-1}) were achieved by interspecific hybrid (♂*O. aureus* x ♀*O. niloticus*) compared with the other purebred genotypes of tilapia. *O. niloticus*, *O. aureus* and their hybrids reached 237.81±36.65g, 142.97±11.45g, 281.23±45.52 g, respectively, at the end of a 112 day culture period. Both purebred genotypes and their interspecific hybrid had similar moisture, crude protein content and crude lipid content ($P>0.05$); however; it should be noted that value of the crude lipid content was lower in the interspecific hybrid (♂*O. aureus* x ♀*O. niloticus*) than in purebred genotypes. Meanwhile, the hybrid dress-out% was intermediate to the purebred parental genotypes. These advantages of hybrid (♂*O. aureus* x ♀*O. niloticus*) together with its characteristics for salinity, cold tolerance and disease resistance as reported in previous works are highly indicative for the commercialization of hybrid tilapia farming in Egypt. It should also pointed out that it is not an intention to promote hybridization as the only method of genetic improvement, but simply as one method of improvement that has potential for some immediate gains. Desirable traits can usually be passed to the hybrid in one generation but it should be appreciated that hybridization can be a hit and miss proposition. Additionally; it may be desirable to backcross to either parental line or to breed the hybrids together and then select the best animals, thus combining hybridization and selective breeding.

KEY WORDS: Purebred, *Oreochromis niloticus*, *Oreochromis aureus*, Inter-Specific Hybrid Tilapia, Growth and Production Traits.

INTRODUCTION

In North Africa, Egypt is by far the dominant country in terms of tilapia production (99 percent of the regional total) and, in fact, is now the second largest producer of tilapia after China. The native species are: Nile tilapia (*Oreochromis niloticus*), blue tilapia (*Oreochromis aureus*). It was only during the 1990s that Nile tilapia was rediscovered as an important aquaculture species. The expansion in Nile tilapia was associated with the production of all male tilapia and since then Nile tilapia has become the most important aquaculture species in Egypt.

Heterosis (hybrid vigour) resulting from crosses between inbred lines or between different races or varieties is well known, and is an important component of breed improvement in plants and animals (Falconer and Mackay, 1996). Hybridization has been studied extensively mainly to improve commercial traits and to control unwanted reproduction of tilapia in ponds. Early research work of Hickling (1960) on hybridization between various species of *Oreochromis* (*O. urolepis*, *O. hornorum* and *O. mossambicus*) resulting in all male hybrids was pivotal in subsequent investigations that led to important milestones in tilapia farming (Lazard, 1996; Shelton, 2002). Subsequent interspecific crossing and

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Journal homepage: http://wvj.science-line.com/

various culture methods for commercial application were tried and it was found that crossing male *O. hornorum* or *O. aureus* with *O. mossambicus* or *O. niloticus* also produced all male or nearly all-male progeny (Shelton, 2002).

Similarly, hybridization between Nile tilapia and blue tilapia resulted in the production of predominantly male offspring which eliminates reproduction in culture ponds (Pullin, 1988; Hulata, 2001). This hybrid combines well the advantageous characteristics of both species, having higher traits of growth performance and feed utilization than those of purebred of *O. niloticus* and *O. aureus* **(**Siddiqui and Al-Harbi, 1995; Dikel, 2001; El-Zaeem, 2011) and being more cold tolerant than *O. niloticus* (Pullin 1988 and Pullin et al., 1988) and less borrowing in the mud than *O. aureus.* This hybrid was also found to be superior to other hybrids (*O. mossambicus* x *O. aureus*, *O. mossambicus* and *O. niloticus* x *O. urolepis hornorum*) when growth rate, body coloration, cold sensitivity and sex ratio are considered together (Wohlfarth et al., 1990). The most widespread culture of nearly all-male hybrid tilapias is in Israel. Variations in growth rate among *O. niloticus* x *O. aureus* hybrids from different farms in Israel (Hulata et al., 1988) have led to further evaluation of various parental stocks for this hybrid (Hulata et al., 1993). These studies have indicated significant differences in growth rate among the various *O. niloticus x O. aureus* hybrids tested. However; the potential of tilapia hybrids for culture is under exploited, due mainly to management problems (Wohlfarth, 1994). The major reason for this failure is the instability in production of all-male hybrids. All-male progeny are only produced from crossing pure species. Eventually; a local 'Israeli tilapia stock' was developed by continuous further hybridization and sexreversing the fry to become practically all male.

Resistance of consumers and health authorities to the consumption of fish treated with hormones may lead to a renewed interest in tilapia hybrids in the future. Therefore, the present study aimed to investigate the variations in growth performance, body composition and dress-out percentage of *O. niloticus* and *O. aureus* and their hybrid (♀ *O. niloticus* x ♂ *O. aureus*).

MATERIAL AND METHODS

Experiment was conducted in both earthen pond hatchery (E1) and growing ponds (E2) during the growing seasons 2008 & 2009 in a private fish farm located in Edko, Behera Governorate.

Experimental fish

Broodstock: Two Oreochromis species belong to family Cicllidae were obtained randomly from natural water body. They were classified according to their morphological features as pure *O. niloticus* and *O. aureus* mixed sex species. Each species was sexually separated and stocked in conditioning pond. They were fed a commercial diet (25% protein) at a rate 3% of BW twice a day.

Fry production: *O. niloticus* and *O. aureus* and their hybrid (♀ *O. niloticus* x ♂ *O. aureus*) frys were produced in early September 2008 from a mass spawning of brooders in earthen spawning ponds (Phelps and Popma, 2000). Six spawning ponds; (two ponds for each pure species and the last two ponds were assigned for the production of their hybrid (♀ *O. niloticus* x ♂ *O. aureus)*. Fry harvested from ponds were graded through a grader fitted with 3.2-mm square mesh netting to obtain a uniform sized fry and to prevent cannibalism between fry in the nursery ponds. Thereafter; the obtained fry were held in deep nursery ponds (six nursery ponds 2000 m^2 $pond^{-1}$; stoking density 25 fry^{-1} m^2); two ponds for each pure genotype and the last two ponds were assigned for their hybrid (♀ *O. niloticus* x ♂ *O. aureus*), where, they kept through the winter period from December 2008 to March 2009. The size of fry before overwintering was 2.11±0.12 g. During overwintering, fry were fed with a commercial pelleted feed containing 30–35% crude protein at a rate of 1–2% fish biomass day^{-1} on days when water temperature exceeded 16°C (Dan and little, 2000).

Experimental design and set up

Six earthen growout ponds were used for communal stocking of each genotype (two replicates $genotype^{-1}$) in an 112ds growout experiment. Ponds were similar in shape and size, with a surface area of one feddan (4200 m^2) and water depth of 1.5 m. The six ponds stocked with overwintered fry on 1st May 2009. Irrigation water was added to all the ponds biweekly, via an irrigation canal, to replace water losses due to seepage and evaporation. Fingerlings of the three genotypes were stocked at 3 fish m^{-2} in earthen ponds. Fish were fed twice daily, 6 day $week^{-1}$ with a commercial pelleted feed containing 25% crude protein.

Feeding rate was set at 5% of fish biomass day^{-1} in the first month, 3% in the second month and 2% thereafter, adjusted biweekly based on sampled mean weight and on the assumption of 100% survival (Muendo et al., 2006). Recruits produced from reproduction in the communally stocked ponds were removed during monthly sampling by seine net (Dan and little, 2000). Fertilizers (urea and trisuperphosphate) were applied weekly to all experimental ponds, after soaking in water and broadcasting, at rates of 4 kg $hectar^{-1}$ day^{-1} of nitrogen and 1 kg $hectar^{-1}$ day^{-1} of phosphorus.

At initial stocking, fish from each genotype were counted and batch weighed and so as for biweekly samples. At final harvest, fish were batch weighed and counted after draining of ponds. The following growth variables were calculated; average daily gain (ADG, g $fish^{-1}$ day^{-1}), specific growth rate (SGR, % day^{-1}), total fish yield (TFY, kg $feddan^{-1}$ day^{-1}), net fish yield (NFY, kg $feddan^{-1}$ day^{-1}) and condition factor (CF) as described by Jauncy and Ross (1982).

Water quality sampling and analysis procedure

For each experimental pond water temperature was measured daily, dissolved oxygen (DO) (7.5:8.3mg/l), total ammonia nitrogen (TAN) (0.01:0.16mg/l), organic matter (32-55mg/l), total hardiness (22:75mg/l), water transparency (22:35) and pH (7:8.5) were measured biweekly (12:00-13.00 hours) . Samples were collected from three points in each

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pond (Boyd and Tucker, 1992). Samples were mixed together; a one L sample was collected from the homogenously mixed composite sample and taken to the laboratory for the various analyses.

Dissolved oxygen (DO), was measured using a digital oxygen meter (OXYGUARD HANDY III, Oxyguard International, Birkerod, Denmark), pH using a pH paper (Wide range 1-14 Whatman, UK) and water transparency using a Secchi disk (Boyd and Tucker, 1992). Total ammonia nitrogen (TAN), organic matter and total hardiness were analyzed using analytical kits (HACH Company, Loveland, CO 80539 USA).

Sample collection and analytical methods

The Dorsal muscles of ten fish were sampled, sealed in plastic bags, and stored frozen (−18 °C) until analysis for the muscle nutrient compositions. The livers and viscera of ten fish per treatment were weighed for calculation of hepatosomatic index (HSI) and viscerosomatic index (VSI). Dress-out percentage was the weight of the fish without head, viscera and fins divided by total weight.

Crude protein, crude lipid, moisture in muscle samples (five pooled samples for each genotype) were determined following standard methods (AOAC, 1992). Crude protein (N×6.25) was determined by the Kjeldahl method according to Randhir and Pradhan (1981). Crude lipid was determined by the ether-extraction method according to Bligh and Dyer (1959) technique as modified by Hanson and Olly (1963). Moisture was determined by oven drying at 105 °C until a constant weight was achieved.

Statistical analysis

One-way analysis of variance (ANOVA) was applied using Statistical analysis System (SAS) software (SAS Institute Cary, North Carolina, USA, 2004) to fulfill the requirements of the following statistical model: $X_{ijk} = \mu + T_i + R_j + e_{ijk}$; X_{ijk} = observed value; μ = population mean; T_i = Effect of treatment i; R_j = Effect of replicate j; e_{ijk} = random error.

RESULTS

The growth performance of purebred *O. niloticus*, *O. aureus* and their interspecific hybrid (♂*O. aureus x* ♀*O. niloticus*) are presented in Table 1. The highest records (P<0.05) of final body weight (FBW) and average daily gain (ADG, g fish^{-1} day^{-1}), specific growth rate (SGR, % day^{-1}), total fish yield (TFY, kg feddan^{-1} day^{-1}), net fish yield (NFY, kg feddan^{-1} day^{-1}) were achieved by interspecific hybrid (♂*O. aureus x* ♀*O. niloticus*) compared with the other purebred genotypes of tilapia. The condition factor (CF) was significantly higher (P<0.05) in hybrid (♂*O. aureus x* ♀*O. niloticus*) than purebred *O. aureus* and insignificantly higher (P>0.05) than the purebred *O. niloticus.* But still, no significant differences observed between the purebred genotypes. The average survival rate (%) was almost similar for the purebred genotypes (90%) and their hybrid (89.5%).

Table 1. Growth performance parameters (Mean±SD) of Nile tilapia (*O. niloticus*), blue tilapia (*O. aureus*) and their interspecific hybrid (♂*O. aureus* x ♀*O. niloticus*)

Item	*O. niloticus*	*O. aureus*	*Hybrid (♂O. aureus x ♀O.*
Initial body weight (g)	10.65±0.61^{a}	10.22±1.17^{a}	9.97±1.32^{a}
Final body weight (g)	237.81±36.65^{b}	142.97±11.45^{c}	281.23±45.52^{a}
[1]SGR (% day^{-1})	2.76±0.15^{b}	2.36±0.10^{c}	2.98±0.19^{a}
[2]DWG (g d^{-1}fish^{-1})	2.03±0.33^{b}	1.186±0.10^{c}	2.42±0.40^{a}
[3]TFY (kg feddan^{-1} day^{-1})	2996±462^{b}	1801±144^{c}	3544±574^{a}
[4]NFY (kg feddan^{-1} day^{-1})	2571±415^{b}	1497±125^{c}	3059±510^{a}
[5]CF (%)	1.62+0.19^{ab}	1.52+0.15^{b}	1.72+0.17^{a}

Values in the same row with different superscripts are significantly different (P< 0.05). [1]Specific growth rate = 100(LN final wt – LN initial wt)/Duration. [2](ADG) = Final wt – initial wt / $T_2 - T_1$. [3](Total fish yield) = Mean fish weight × number of fish. [4](Net fish yield) = Fish biomass at week$_{final}$– Fish biomass at week$_{initial}$ [5]Condition factor (CF) = 100x (body weight, g)/ (body length, cm)^3.

Table 2. Fillet composition, dress-out (%), head (%), HIS and VSI (Mean±SD) of Nile tilapia (*O. niloticus*), blue tilapia (*O. aureus*) and their interspecific hybrid (♂*O. aureus* x ♀*O. niloticus*)

Item	*O. niloticus*	*O. aureus*	*Hybrid (♂O. aureus x ♀O.*
Moisture (%)	79.09±1.02^{a}	79.12±1.62^{a}	80.45±1.64^{a}
Crude protein (%)	11.32±3.94^{a}	13.10±1.70^{a}	9.8±3.21^{a}
Crude fat (%)	0.92±0.41^{a}	1.01±0.17^{a}	0.74±0.28^{a}
Dress-out %	64+4.43^{b}	68.68+4.14^{a}	66.32+2.47^{ab}
[1]Head%	20.18+1.73^{a}	17.59+2.95^{b}	16.90.+0.97^{b}
[2]HSI (%)	1.59+0.46^{b}	2.52+0.49^{a}	1.73+1.17^{b}
[3]VSI (%)	7.85+4.44^{ab}	6.73+0.65^{b}	9.81+1.85^{a}

Values in the same row with different superscripts are significantly different (Pb0.05).[1]Head %=100x (head weight/whole body weight). [2]Hepatosomatic index (HIS) = 100x (liver weight/whole body weight). [3]Viscerosomatic index (VSI) = 100x (viscera weight, g)/ (whole body weight, g).

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Body composition, fillet proximate composition and dress-out% are given inTable2. Both purebred genotypes and their interspecific hybrid had similar moisture, crude protein content and crude lipid content (P>0.05); however; it should be noted that value of the crude lipid content was lower in the interspecific hybrid (♂*O. aureus* x ♀*O. niloticus*) than in purebred genotypes. On the other hand, purebred *O. aureus* showed significantly higher dress-out% when compared with the other purebred *O. niloticus*. Meanwhile, the hybrid (♂*O. aureus* x ♀*O. niloticus*) dress-out% was not significantly different from the parental purebred *O. niloticus*.

DISCUSSION

Interspecific hybridization was successfully obtained in many fish and shellfish genera and/or families as a mean of improving production traits (Dunham et al., 2001; Hulata, 2001). Generally, F_1 hybrids of *O. niloticus* x *O. aureus* have been found to show better growth than the parent species as a results of production of predominately male offspring, whereas, males grow faster than females in many tilapia (Liao and Chen, 1983; Wohlfarth et al., 1983, 1990; Hulata, 2001). Similarly, the overall performance, based on fry, fingerling, sub-adult and adult rearing and the ranking based on final mean weight, specific growth rate, survival, and yield proved hybrid tilapia to be the best candidate for intensive tank culture, closely followed by *O. niloticus* and *O. aureus* (Siddiqui and Al-Harbi, 1995). Additionally; Dikel (2001) and El-Zaeem (2011) demonstrated higher growth rates of hybrid (♂*O. aureus x* ♀*O. niloticus*), which was significantly higher than the purebred *O. niloticus* and *O. aureus*. On the contrary, the comparative growth performance of the juveniles of six pure tilapia species, *Oreochromis mossambicus, O. spilurus, O. macrochir, O. aureus, O. niloticts* and *Sarotherodon galilaeus* were assessed under standardized conditions in a recirculated water system. No hybrid performed significantly better than the best parent for SGR, although *O. aureus* X *O. niloticus* hybrid was significantly better than *O. niloticus* when corrected weight gain was used (McAndrew and Majumdar, 1989).

The results of the current study are consistent with these findings, thus the hybrid of ♀*O. niloticus* x ♂*O. aureus* and ♀*O. aureus* x ♂*O. niloticus* had significantly higher (P≤0.05) traits of growth performance than those of purebred of *O. niloticus* and *O. aureus*. The improvement of growth in hybrid may be attributable to combination of production traits making the all-male *O. niloticus* x *O. aureus* hybrid more suitable for culture than either parental pure species (Pullin 1988; Lahav & Lahav 1990; Wohlfarth et al., 1990) or by other word the heterosis effect resulting from the cross of *O. niloticus* and *O. aureus* (Rodriguez et al., 1995).

Researches on fillet proximate composition demonstrating differences according to genotype are scarce. Garduno-Lugo et al. (2003) reported, that the lipid content in red hybrid tilapia (Florida red Tilapia x Stirling red *O. niloticus*) fillets (0.33%) was significantly lower (P>0.05) than that of the stirling Nile tilapiafillets (2.07%). On the contrary, the hybrids' fat content was significantly higher (P<0.05) than those in the carcass of purebred *O. niloticus* and *O. aureus*. There was no significant difference among the crude protein level of the groups (Dikel, 2001). On the other hand, El-Zaeem (2011) addressed significant differences in carcass composition of different tilapia genotypes. He reported that, genetically modified *O. niloticus* that received *O. aureus* DNA, had showed significantly higher protein and fat contents when compared with the other non-transgenic genotypes of tilapia (*O. niloticus, O. aureus* and their reciprocal hybrid), but did not differ significantly (P≤0.05) from that of genetically modified *O. aureus* that received *O. niloticus* DNA. Meanwhile, the non-transgenic genotypes were similar in the crude protein and crude fat carcass contents.

Generally, the dress out percentage on tilapia is relatively low compared to species such as trout and catfish (Popma and Masser, 1999). The dress out yield of tilapia will increase slightly with fish size and if the tilapia is well fed and robust. Interspecific differences in dress-out and fillet yield are minimal (Popma and Lovshin, 1996). Results of the current study followed the same trend addressed by the former authors. However, these results disagreed with results obtained by Dikel (2001), who concluded that edible proportion of the hybrid carcass (59.4±0.12%) was significantly higher than those of the purebred *O. niloticus* (57.83±0.4%) and *O. aureus* (57.00±0.14%). On the contrary, the dress-out percentages did not differ significantly between the species strains or hybrids tilapia, with the exception of the Arizona Red strain which did not reach market size (SIUC, 1999).

CONCLUSION

The current study indicated the superiority of hybrid (♂*O. aureus x* ♀*O. niloticus*) over its parental purebred *O. niloticus* and *O. aureus* in its growth parameters. Meanwhile, the hybrid dress-out% was intermediate to the purebred parental genotypes. These advantages of hybrid (♂*O. aureus x* ♀*O. niloticus*) together with its characteristics for salinity, cold tolerance and disease resistance as reported in previous works are highly indicative for the commercialization of hybrid tilapia farming in Egypt. However, sustained production of all-male hybrid tilapias should be aided by paying more attention to broodstock purity, involving routine inspection of every brooder and culling all doubtful individuals. It should also pointed out that it is not an intention to promote hybridization as the only method of genetic improvement, but simply as one method of improvement that has potential for some immediate gains. Desirable traits can usually be passed to the hybrid in one generation but it should be appreciated that hybridization can be a hit and miss proposition. Additionally; it may be desirable to backcross to either parental line or to breed the hybrids together and then select the best animals, thus combining hybridization and selective breeding.

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To cite this paper: El-Hawarry W.N. 2012. Growth Performance, Proximate Muscle Composition And Dress-Out Percentage of Nile Tilapia (*Oreochromis Niloticus*), Blue Tilapia (*O. Aureus*) and their Interspecific Hybrid (♂ *O. Aureus X* ♀ *O. Niloticus*) Cultured in Semi-Intensive Culture System. *World's Vet. J.* 2(2): 17-22.
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