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Impact of the Initial Body Weight (Stocking Density) and Daily Feeding Rate in Performance of Nile Tilapia and (*Oreochromisniloticus*) and Thin-Lipped Mullet (*Mugilcapito*) Under Mono-Culture System

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ABSTRACT

Two mono-culture experiments were under taken on mono-sex all males Nile tilapia (Oreochromisniloticus) and thin-lipped mullet (Mugilcapito/Liza ramada, Bouritobara, Tobara) in eighteen (nine / fish species, three initial weights x three feeding levels) Hapas stocked in an earthen pond for five months. Fish fed a commercial diet (30% crude protein). The obtained results revealed that both variables (initial body weight and feeding rate) affected all criteria measured including feed and nutrients utilization, growth performance, chemical composition and the cost of food required to produce one Kg body gain.

Keywords: *Bolty, Tobara, initial weight, feeding rate, performance, feed utilization, fish composition.*

INTRODUCTION

Fish are the most feed converser than all terrestrial animals' species. So, the world population consumes 17% of their food protein from fish. Nowadays, aquaculture production in Egypt reached to 80% of the total local fish production (**GAFRD, 2016** and **Abdelhamid, 2019b**). **Milstein and Svirsky (1996)** reported that an appropriate-adequate fish density will utilize the available resources efficiently and fish environment relationships and minimize the antagonistic ones. So, in recent years it has begun to regain attention as a possible mean to increase efficiency in aquaculture production systems, and to reduce environment impacts **(Lutz, 2003).** Nile tilapia (*Oreochromisniloticus*, Bolty, Soltany, Abyad) and thin-lipped mullet (*Mugilcapito*, Tobara) are among the famous fish species for the Egyptians, concerning their natural production, fish culture, and consumption. The increase of fish production from aquaculture led to an increase in per capita consumption of fish (**FAO, 2018**). In Egypt, aquaculture has become the main source of fish protein to cope with the country's growing population (**GAFRD, 2016**). In pisciculture, initial body weight of the fish and its source besides daily feeding rate, frequency of daily feeding (number of meal), food quality, and rearing water suitability (**Abdelhamid, 2019a**) are among the most important factors on which the fish yield would depend (**Abdelhamid, 2009 a & b** and **Abdelhamid, 2019 c & d**). Nutrition is the heart of aquaculture; so, nutrition is the essential area to be focused by aquaculture industry. So, higher growth, best food conversion ratio and less polluting to the environment could be achieved (**Prabu*et al*., 2017**).

The objectives of the present study were to determine the best conditions for aquaculture, concerning initial body weight and daily feeding rate. So, it was designed to evaluate the effects of variable initial body weights of two fish species [mainly Nile tilapia (*Oreochromisniloticus*, 15, 25, and 40 g) and thin-lipped mullet (*Mugilcapito*, 5, 10, and 15)] as well as variable daily feeding rates (2, 3 and 5%) on growth performance of fish, their feed and nutrients utilization, body composition, and economic efficiency after 4 months of the experimental feeding in Hapas stocked in an earthen pond.

MATERIALS AND METHODS

The present study was carried out in a private farm at Tolombat-7, Alriad, Kafr El-Sheikh governorate in a cooperation with Animal

Production Department, Faculty of Agriculture, Mansoura University, Dakahlia governorate, Egypt and Sakha Aquaculture Unite (Kafr El-Sheikh governorate) belonging to Central Lab. for Aqua cultural Research, Abbasa, Abou Hammad, Sharqia governorate, Agricultural Research Center, Ministry of Agriculture, Cairo, Egypt. The study was carried out during the period from 15/4/2017 till 15/9/2017.

Experimental Fish and Rearing Management

Mono-sex all males Nile tilapia (*Oreochromi sniloticus*) and thin-lipped mullet (*Mugilcapito* /*Liza ramada*, Bouritobara, Tobara) were chosen herein for their high economic importance. Both fish are available from natural sources and accept feeding the artificial food. The experimental farm was irrigated from Tolombat-7, El-Riad Center, Kafr El-Sheikh governorate. The water depth in the pond was 100-125 cm. Nile tilapia fry was obtained from a private hatchery. The fry was catched from the pond, filtered, and classified into the recommended (required) initial body weights. The selected fry was transferred in oxygenated plastic bags early morning at 7 a.m. to the experimental farm. Tobara fry was incubated too in an earthen pond in the same farm of tilapia, after obtaining it from the collection center (station) on the sea (Motobus). It was transferred also in early morning to be adapted before stocking. The first three experimental treatments (Hapas) for tilapia weighing in initial 15, 25, and 40g, respectively. Hundred fish of each initial body weight were stocked (5.56 fish / m^3) into one Hapa (3m x 6m x 0.8m). Therefore, the stocking rate was 104.2, 173.6, and 277.8 g/m^3, respectively according to the initial body weight in the three groups of initial body weight. Fish were fed daily at 2% of the body mass of each Hapa. Fish were adapted for 10 days before the start of the experiment. The second three Hapas for tilapia with the same initial body weight as in the first three Hapas, but fed daily at 3% of each Hapa's fish mass. The third three Hapas as in the first and the second ones but their fish were offered their diet at daily feeding rate of 5% (Table 1).a

Table1. *Details of the tilapia experiment*

IBW	15			25			40		
STH	100			100			100		
STM	5.56			5.56			5.56		
STG	104.2			173.6			277.8		
DFR	2	3	5	2	3	5	2	3	5

Initial Body weight (IBW), g; Stocking rate (STH), fish per Hapa; Stocking rate (SRM), fish per cubic meter; Stocking rate (STG), gram per cubic meter; and Daily feeding rate (DFR), % of BW.

Nine other similar Hapas were used for Topara in the same manner as in tilapia (each three Hapas were allotted for each feeding rate within each initial body weight), the same stocking and feeding rates, the only difference was the initial body weights for Topara, being 5, 10, and 15g, respectively. Therefore, the stocking rate was 34.7, 69.4, and 104.2 g/m^3, respectively according to the initial body weight in the three groups of initial body weight (Table 2).

Table2. *Details of the thin-lipped mullet experiment*

IBW	5			10			15		
STH	100			100			100		
STM	5.56			5.56			5.56		
STG	34.7			69.4			104.2		
DFR	2	3	5	2	3	5	2	3	5

Initial Body weight (IBW), g; Stocking rate (STH), fish per Hapa; Stocking rate (SRM), fish per cubic meter; Stocking rate (STG), gram per cubic meter; and Daily feeding rate (DFR), % of BW.

Experimental Diet

All fish groups were fed a floating diet. A sample of fish from each Hapa was weighed biweekly to correct the feed quantity according the actual bodyweight changes. Diets were hand-offered once daily at 10 a.m. for 6 days a week. Diets were hand-offered once daily at 10 a.m. for 6 days a week. Commercial fish diet was used in feeding the experimental fish. It composed of 35.6 % yellow corn, 21.3 % fish meal, 16.5 % cottonseed meal, 15 % soybean meal, 6 % fish oil, 3.4 % minerals mixture, and 2.2 % vitamins mixture. It contains 92.65 % dry matter, 29.87 % crude protein, 6.5 % ether extract, 5.5 % ash, 13.5 % crude fiber, 46.3 % nitrogen free extract, and 18 MJ / kg gross energy. So, the studied factors within each fish species (under mono-culture system) are stocking rate (in weight, g/m^3) and daily feeding rate (% of the actual body weight).

Assessment of Water Quality Parameters

Samples of water (1-litre each) were collected from four sites of the raring pond (at 9.00 to 9.30 a.m.) weekly and transferred to the laboratory for the following measurements. Water temperature and dissolved oxygen was recorded using dissolved oxygen meter (Thermo Orion, model 835A, Orion Research Inc.). The pH values were recorded twice a week (Orion pH meter, Abilene, Texas, USA). Total ammonia-N (Ammonia test kits Hanna

Instruments (HI) 4829 kit range from 0-2.5 mg NH4-N/L were used to estimate the concentration of the total ammonia in water samples, nitrite (Nitrite-N was measured by Nitricol model LP-55 code 3274 Lamotte company range from 0.2 -0.8 ppm 32), and nitrate-N (Nitrate-nitrogen was measured by using phenol-di-sulphonic acid method) using spectrophotometer (Model Milton Roy 21D), at a wavelength of 410 nm (**APHA, 1998**). Conductivity meter (model 4070 Jen way electro-chemical product) was used to determine salinity in water samples as ppt (g/L).

Growth Parameters and Feed and Nutrients Utilization

At the beginning of the experiment, randomly samples of fishes were measured for its weight and total length. At the end of experiment, body weight of mono-sex Nile tilapia and thin-lipped mullet in each Hapa were measured to calculate the growth performance and feed utilization such as final weight (FW), total weight gain (TWG, g), average weight gain (ADG, g/fish/day), relative growth rate (RGR, g), specific growth rate (SGR, %/day), feed intake (FI, g), feed conversion ratio (FCR), feed efficiency (FE, %), protein efficiency ratio (PER, %), and protein productive value (PPV, %) according to **Hung *et al.* (1993), Abdelhamid (1996) and Halver and Hardy (2002).**

Chemical Analysis of Fish Body

For chemical analysis of the whole fish body, fish samples at the beginning and at the end of the experiments (n=5/ each fish species in each Hapa) were taken, dried, ground and kept frozen (–20°C) until the chemical analysis (in triplicates) was done. The chemical analysis of the whole fish body was carried out according to **AOAC (2004)**.

Statistical Analysis

The collected numerical data were subjected to factorial design analysis of variance using **SAS (2006)** and **Duncan's (1955)** least significant difference.

Results and Discussion

Quality Criteria of Fish Rearing Water

As shown from Table 3, all measured criteria were suitable for fish rearing, whether for Nile tilapia or thin-lipped mullet, where its values ranged between 23.33 and 27.5ºC for temperature, 5.70-8.40 pH, 4.23-7.67 mg/L DO, 0.23-0.47 mg/L NH_3-N, 0.23-0.43 mg/L NO_3-N, 0.17-0.36 mg/L NO_2-N, and 2.31-2.35 g/L salinity.

It was brackish water rich in DO. Yet, increasing feeding rate significantly ($P \leq 0.05$) increased water level of NO_2, NH_3, and pH but significantly ($P \leq 0.05$) decreased DO concentration. Increased initial weight (stocking density) also increased significantly ($P \leq 0.05$) the water temperature, the concentration of NO_2 and NH_3 but decreased significantly ($P \leq 0.05$) the DO concentration.

Table3. *Quality criteria (means ± standard errors) of fish rearing water*

	NO_2, mg/L	NO_3, mg/L	Salinity, g/L	pH	DO, mg/L	NH_3, mg/L	Temperature, ºC
Feed rate (%)							
2	0.23b±0.01	0.28±0.02	2.32±0.00	6.58b±0.51	7.06a±0.15	0.29b±0.03	25.11±0.43
3	0.21b±0.02	0.33±0.02	2.33±0.01	7.46ab±0.08	7.02a±0.28	0.37a±0.03	25.00±0.47
5	0.32a±0.01	0.34±0.04	2.35±0.00	8.06a±0.17	5.74b±0.51	0.41a±0.03	25.72±0.57
Initial weight							
1	0.22b±0.02	0.37±0.03	2.34±0.00	6.91±0.55	7.56a±0.09	0.30b±0.02	23.50c±0.12
2	0.24b±0.02	0.29±0.03	2.33±0.01	7.43±0.24	6.58b±0.33	0.39a±0.04	25.72b±0.21
3	0.30a±0.02	0.30±0.02	2.34±0.01	7.74±0.17	5.69c±0.41	0.38a±0.03	26.61a±0.27
Interactions							
2*1	0.20±0.01	0.30±0.06	2.33±0.01	5.70±1.55	7.33±0.17	0.23±0.03	23.50±0.29
2*2	0.21±0.01	0.23±0.03	2.31±0.01	6.70±0.17	7.00±0.29	0.30±0.06	25.67±0.17
2*3	0.27±0.02	0.30±0.00	2.32±0.01	7.33±0.17	6.83±0.33	0.33±0.03	26.17±0.33
3*1	0.17±0.02	0.37±0.03	2.33±0.01	7.50±0.17	7.67±0.12	0.30±0.00	23.33±0.17
3*2	0.20±0.01	0.33±0.03	2.33±0.02	7.37±0.19	7.40±0.10	0.40±0.06	25.50±0.58
3*3	0.28±0.02	0.30±0.06	2.34±0.01	7.50±0.00	6.00±0.29	0.40±0.06	26.17±0.33
5*1	0.30±0.02	0.43±0.07	2.35±0.01	7.53±0.29	7.67±0.09	0.37±0.03	23.67±0.17
5*2	0.30±0.00	0.30±0.06	2.34±0.01	8.23±0.15	5.33±0.17	0.47±0.03	26.00±0.29
5*3	0.36±0.02	0.30±0.06	2.35±0.00	8.40±0.10	4.23±0.15	0.40±0.06	27.50±0.29

A-c: *Means in the same column within each variable superscripted with different letters, significantly (P≤0.05) differ.*

Most of water parameters measured in fish rearing water herein was suitable for tilapia culture as given by **Abdelhamid (1996), Abdelhakim *et al*. (2002 and 2013)** and **Abdelhamid *et al.* (2000** and **2002).** Since water quality management is akey factor for successful aquaculture practices. It is therefore necessary to interpret the water quality parameters and their inter relationships, which affect fish growth and health and consequently determine the failure or success and sustainability of the aquaculture (**El-Sayed, 2006**). The optimal temperature range for their development is 25-30ºC. All tilapias are sensitive to low temperatures and do not survive at temperature below 10ºC approximately **(Beveridge and Mc Andrew, 2012** and **Perschbacher and Stickney, 2017).**

Nile Tilapia Performance

Feed and Nutrients Utilization

Table 4 presents data of feed and nutrients utilization for the experimental tilapia. Feeding rate and initial body weight of fish significantly (P≤0.05) affected all criteria measured, where FI and FCR increased (for the positive relationship between them) by increasing either of feeding rate or initial body weight, but FE, PER, and PPV were decreased significantly (P≤0.05). Since, FCR is the opposite of FE. Results of the present study are also in partial agreement with the findings of **El-Dahhar *et al*. (2006)** who reported that the best FCR values of Nile tilapia and striped mullet was obtained in poly culture system when 3 mullet were stocked with 7 tilapia/ m3 compared to ratios of 5:5 or 7:3 mullet to tilapia. In this connection **Aksungur *et al.* (2007)** tested the effect of stocking density of turbot (*Psetta maxima*) reared in marine cages at densities of 30; 60; 90 and 120 fish m3. They reported that FCR values were estimated at 1.95; 1.85; 2.09 and 1.88 for the stocking densities cited above, respectively. The same authors added that stocking density of turbot had no significant effects on FCR. In this connection **El-Naggar *et al*. (2008)** tested growth performance of Nile tilapia stocked in poly-culture system with African catfish and silver carp (85% tilapia, 15% catfish and 300 specimen silver carp) at densities of 3 or 5 fish/m^3. They reported that the best (lowest) FCR was achieved with the stocking density 3 fish/m^3 with chemical fertilizers followed in an increasing order by 3 52fish/m^3 with organic fertilizer, 5 fish/m3 with chemical fertilizer and 5 fish/m3 with organic fertilizers, respectively. These results are in partial agreement with the findings of **Ammar (2009)** who found that stocking of Nile tilapia (0.3g initial weight) at densities of 30; 40 and 50 thousand fish/Fadden resulted in FCR values of 1.8; 1.8 and 1.9, respectively indicating that 40 thousand stocking density / Fadden tensed to increase FCR.

The same author reported also that the highest fish production (total biomass) per Fadden increased with each increase in the fish stocking density. **Paul *et al.* (2018)** treated mono-sex (all male) *O. niloticus* for ten weeks with experimental treatments: T1 (natural feed), T2 (feeding with 10% body weight) and T3 (feeding with 5% body weight).The highest weight gain, length gain and SGR were found in T3 and the lowest was found in T1. The survival rate was 82%, 88% and 94% in T1, T2and T3, respectively. FCR values were found as 3.49 ± 0.5 and 2.51 ± 0.4 in T2 and T3. The result demonstrated that feeding with 5% body weight had a better effect (than at 10%) on the growth and survival rate.

Table4. *Feed and nutrients utilization (means ± standard errors) of Nile tilapia*

	FI	FCR	FE	PER	PPV
Feed rate (%)					
2	200.44c±8.57	1.42c±0.04	0.71a±0.02	2.37a±0.06	2.51b±0.11
3	329.78b±28.30	1.61b±0.04	0.62b±0.01	2.07b±0.05	2.96a±0.26
5	538.67a±49.32	2.20a±0.03	0.46c±0.01	1.52c±0.02	1.05c±0.10
Initial weight					
1	258.89c±31.49	1.65b±0.13	0.64a±0.05	2.12a±0.15	2.75a±0.37
2	355.67b±44.51	1.78a±0.10	0.58b±0.03	1.93b±0.11	2.05b±0.27
3	454.33a±72.30	1.80a±0.12	0.57b±0.04	1.92b±0.12	1.72c±0.25
Interactions					

2*1	168.00±3.61	1.29±0.01	0.78±0.00	2.59±0.01	2.92±0.06
2*2	213.33±7.51	1.47±0.05	0.68±0.02	2.27±0.07	2.33±0.08
2*3	220.00±3.46	1.49±0.02	0.67±0.01	2.24±0.03	2.29±0.03
3*1	229.67±1.45	1.50±0.03	0.67±0.01	2.22±0.05	3.93±0.03
3*2	334.67±2.40	±1.72±0.05	0.58±0.02	1.94±0.05	2.80±0.02
3*3	425.00±6.56	1.62±0.02	0.61±0.01	2.06±0.03	2.16±0.03
5*1	379.00±10.69	2.16±0.04	0.46±0.01	1.54±0.03	1.40±0.04
5*2	519.00±4.73	2.13±0.04	0.47±0.01	1.56±0.03	1.01±0.01
5*3	718.00±5.57	2.29±0.02	0.44±0.00	1.46±0.01	0.73±0.01

A-c: *Means in the same column within each variable superscripted with different letters, significantly (P≤0.05) differ.*

Growth Performance

Tilapia growth performance is presented in Table 5. Increasing feeding rate significantly (P≤0.05) and gradually elevated each of FL, FW, WG, ADG, SGR, and RGR, but significantly (P≤0.05) and gradually decreased K and SR. Also, increased IW significantly (P≤0.05) and gradually increased IL, FL, IW, FW, WG, and ADG, but gradually and significantly (P≤0.05) reduced SGR, RGR, K, and SR, may be for increased stocking density that led to significantly (P≤0.05) higher rearing water temperature, NO_2**,** NH_3**,** and lower DO (Table 3).These results are in agreement with the findings of **Moustafa (1993)** who reported that increasing the stocking density of tilapia reared in cages constructed in earthen ponds decreased significantly the final weight of the fish. Also, the results of the present study are in agreement with the findings of **AbouZied *et al.* (2005)** who reported that at the harvesting tilapia body weight, total and daily gain and specific growth rate were significantly affected with stocking density of tilapia and mullet. Condition factor showed significant increase, with each increase in the stocking density. In general condition factor reflects through its variations information on the physiological state of the fish in relation to its welfare. The increase in condition factor with each increase in the stocking density, indicate that at higher density the fish gain more in weight than in length. These results are in accordance with the findings of **AbouZied *et al.* (2005) and AbouZied and Hassouna (2007)**. Results of the present study are also in accordance with the findings of **Danaher *et al*. (2007)** who reported that the average harvesting weight of tilapia stocked at low density in poly-culture system was significantly higher than that stocked at high density in poly-culture system. Results also are in agreement with the findings of **Mahmoud (2007)** who studied the effect of stoking density of Nile tilapia (102 fish/m^3 and 204 fish/m^3) with an initial weight of 7g on growth performance for 14 weeks. He reported that live body weight, daily weight gain, and specific growth rate of Nile tilapia were significantly decreased with increasing stocking density during most of the experimental periods studied**.**

Table5. *Growth performance (means ± standard errors) of Nile tilapia*

	IL	FL	IW	FW	WG	ADG	SGR	RGR	K	SR
Feed rate (%)										
2	11.49 ±0.92	19.92c ±1.49	26.67 ±3.74	167.78c ±6.41	141.11c ±2.95	1.18c ±0.02	1.60c ±0.09	612.4c ±76.37	2.63a ±0.50	99.00a ±0.37
3	11.51 ±0.90	25.72b ±1.73	27.11 ±3.88	230.56b ±19.80	203.44b ±15.94	1.70b ±0.13	1.83b ±0.05	813.1b ±57.11	1.50b ±0.22	98.67a ±0.41
5	11.46 ±0.96	29.32a ±1.23	27.11 ±3.95	271.11a ±23.89	244.00a ±19.97	2.03a ±0.17	1.97a ±0.05	976.3a ±67.52	1.04b ±0.07	93.89b ±1.27
Initial weight										
1	7.93c ±0.21	19.67c ±1.48	14.78c ±0.32	167.78c ±6.72	153.00c ±6.67	1.28c ±0.06	2.02a ±0.04	1038.6a ±49.69	2.71a ±0.50	99.00a ±0.37
2	12.47b ±0.15	25.52b ±1.45	25.00b ±0.29	219.44b ±14.37	194.44b ±14.33	1.62b ±0.12	1.80b ±0.06	777.9b ±56.86	1.43b ±0.15	97.00b ±1.00
3	14.06a ±0.05	29.78a ±1.27	41.11a ±0.68	282.22a ±24.67	241.11a ±24.44	2.01a ±0.20	1.58c ±0.08	585.3c ±57.60	1.07c ±0.04	95.56c ±1.44
Interactions										
2*1	8.00	14.77	14.67	145.00	130.33	1.09	1.91	889.7	4.54	99.00

	±0.58	±0.39	±0.33	±2.89	±2.91	±0.03	±0.03	±30.00	±0.37	±0.58
2*2	12.47 ±0.29	20.00 ±0.58	25.00 ±0.58	170.00 ±2.89	145.00 ±2.31	1.21 ±0.02	1.60 ±0.01	580.2 ±4.16	2.14 ±0.15	99.67 ±0.33
2*3	14.00 ±0.12	25.00 ±0.17	40.33 ±0.88	188.33 ±1.67	148.00 ±1.15	1.23 ±0.01	1.29 ±0.01	367.2 ±7.44	1.21 ±0.02	98.33 ±0.88
3*1	8.03 ±0.15	19.27 ±0.37	15.00 ±0.58	168.33 ±4.41	153.33 ±3.84	1.28 ±0.03	2.01 ±0.01	1023.3 ±15.04	2.36 ±0.09	99.67 ±0.33
3*2	12.47 ±0.29	26.90 ±0.21	25.00 ±0.58	220.00 ±5.77	195.00 ±5.20	1.63 ±0.04	1.81 ±0.00	779.9 ±2.78	1.13 ±0.01	98.00 ±0.58
3*3	14.03 ±0.09	31.00 ±0.58	41.33 ±1.86	303.33 ±3.33	262.00 ±1.53	2.19 ±0.01	1.66 ±0.03	636.0 ±24.22	1.02 ±0.05	98.33 ±0.88
5*1	7.77 ±0.39	24.97 ±0.15	14.67 ±0.88	190.00 ±2.89	175.33 ±2.03	1.46 ±0.02	2.14 ±0.04	1202.8 ±61.69	1.22 ±0.00	98.33 ±0.88
5*2	12.47 ±0.29	29.67 ±0.33	25.00 ±0.58	268.33 ±4.41	243.33 ±3.84	2.03 ±0.03	1.98 ±0.01	973.7 ±8.05	1.03 ±0.02	93.33 ±0.88
5*3	14.13 ±0.07	33.33 ±0.67	41.67 ±0.88	355.00 ±2.89	313.33 ±2.03	2.61 ±0.02	1.79 ±0.01	752.5 ±11.49	0.96 ±0.05	90.00 ±0.58

A-c: *Means in the same column within each criterion superscripted with different letters significantly ($P \leq 0.05$) differ, IL: initial length (cm), FL: final length (cm), IW: initial weight (g), FW: final weight (g), WG: weight gain (g), ADG: average daily gain (g), SGR: specific growth rate (%/d), RGR: relative growth rate (%), K: condition factor, SR: survival rate (%).*

Whole-Fish-Body's Chemical Analysis

Proximate chemical analysis (DM-basis) at the start of the experiment for whole tilapia body was 27.43 ± 0.03 % DM, 62.75 ± 0.02 % CP, 18.18 ± 0.08 % EE, 12.73 ± 0.03 % ash, and 547.42 ± 0.06 Kcal/100 gEC (Energy contents of the experimental fish samples were calculated by using factors of 5.65, 9.45 and 4.22 Kcal/g of protein, lipid and NFE, respectively, **NRC, 1993**). At the end of the experiment, all items of the chemical composition increased comparing with that at the beginning of the experiment (effect of aging). However, 3% daily feeding rate and the middle initial body weight (25 g) reflected significantly ($P \leq 0.05$) the best chemical composition (highest CP %) as shown from Table 6. In this respect, **Hassouna *et al.*(1998)** reported that energy contents (Kcal/gm.) in whole Nile tilapia bodies were 5.57; 5.60 and 5.56 kcal/ g in fish reared in ponds fertilized only with chicken litter + urea + super phosphate; ponds received artificial feeds only and ponds received fertilization and artificial feed, respectively. The results concerning NFE contents in Nile tilapia whole bodies were lower than that reported by **El-Kotamy (2008)** who showed that NFE contents in whole tilapia bodies ranged between 15.12 and 20.58%. Also, **Abdel-Hakim *et al*. (2013)** reported that NFE contents in whole tilapia bodies ranged between 3.02 and 9.41% and was affected by the type of fertilizer and feeding. As presented in the same Table averages of GE contents in the DM of tilapia whole bodies ranged between 556.51 and 557.94 kcal/100gm and differences in this trait among the stocking densities tested were insignificant. Furthermore**,** **Florence and Harrison (2012)** studied the effect of stocking ratios 1:1; 1:2 and 1:3 *Clariasgariepinus* African catfish and Nile tilapia *Oreochromisniloticus*, respectively at 10 fish/m^2 reared in concrete tanks for twelve weeks on growth performance and survival rate of both tested species. The authors reported that the highest stocking density produced the highest (157.85g) mean weight gain for the catfish. Mean weight gain for Nile tilapia in the same tank took the opposite order. They added that specific growth data recorded for the catfish revealed an intermediate value at the highest (4.25%) and lowest (4.32%) stocking densities, while the highest was recorded at the intermediates stocking density (4.41).These results are in partial agreement with the finding of **Abdel-Hakim *et al.* (2013)** who reported that DM contents in whole tilapia bodies ranged between 30.65 and 27.29%. Regarding the CP contents in tilapia whole bodies results of table (10) indicate that CP contents of T1; T2 and T3 were 64.20 and 64.85 and 65.40%, respectively and T3 showed significantly ($P \leq 0.05$) higher CP contents in the DM compared to T2 and T1. In this respect, the same authors reported that CP contents in tilapia whole bodies ranged between 61.81 and 65.40% and significantly affected with type of fertilizer and feeding. Furthermore averages of EE contents ranged between 19.65 and 19.83% with insignificant differences among treatments. **Abdel-Hakim *et al.* (2013)** reported also that EE contents in whole tilapia bodies ranged between 17.50 and 19.84% and was significantly affected by feeding type. Ash contents in the DM of 54whole Nile tilapia bodies ranged between 13.16 and 13.67% and differences among stocking densities were insignificant. **Abdel-Hakim *et al.* (2013)** reported also higher values of ash contents in whole bodies of Nile tilapia which ranged between 10.36 and 11.74% and the ash values were significantly affected with the type of fertilizer with feeding. **Abdelhamid *et al.* (2017)** carried out an experiment for 75 days on Nile tilapia (*Oreochromisniloticus*) fingerlings to evaluate the best stocking rate. The obtained results revealed that the lowest stocking rate (5 fish/m^3) reflected the best results in most studied measurements for the nutrients utilization and carcass physical and chemical quality.

Table6. *Proximate chemical analysis (means ± standard errors, DM-basis) of Nile tilapia carcass at the end of the experiment*

	DM, %	CP, %	EE, %	Ash, %	EC*, Kcal/100 g
Feed rate (%)					
2	28.14b±0.08	64.27c±0.01	19.67b±0.00	13.35b±0.01	557.07c±0.32
3	30.55a±0.01	65.47a±0.02	19.82a±0.01	13.67a±0.01	557.88b±0.05
5	±27.93c±0.03	64.33b±0.01	19.64c±0.01	13.15c±0.00	558.39a±0.03
Initial weight					
1	28.83±0.43	64.67b±0.19	19.72a±0.03	13.39±0.07	557.65b±0.29
2	28.93±0.42	64.72a±0.21	19.72a±0.03	13.39±0.08	558.20a±0.06
3	28.86±0.42	64.70a±0.19	19.70b±0.03	13.39±0.08	557.49c±0.30
Interactions					
2*1	28.02±0.01	64.26±0.01	19.68±0.01	13.34±0.01	556.52±0.01
2*2	28.37±0.19	64.26±0.01	19.67±0.01	13.36±0.02	558.34±0.01
2*3	28.03±0.01	64.30±0.00	19.67±0.01	13.36±0.01	556.35±0.05
3*1	30.56±0.02	65.41±0.01	19.82±0.01	13.66±0.01	557.95±0.00
3*2	30.57±0.02	65.54±0.01	19.84±0.01	13.67±0.01	557.95±0.01
3*3	30.52±0.01	65.47±0.01	19.81±0.01	13.67±0.01	557.73±0.11
5*1	27.91±0.01	64.32±0.01	19.65±0.00	13.16±0.01	558.47±0.09
5*2	27.86±0.01	64.35±0.02	19.66±0.01	13.15±0.00	558.32±0.01
5*3	28.03±0.01	64.32±0.02	19.62±0.01	13.14±0.01	558.38±0.01

A-c: *Means in the same column within each criterion superscripted with different letters significantly ($P \leq 0.05$) differ, and *: Energy contents of the experimental fish samples were calculated by using factors of 5.65, 9.45 and 4.22 Kcal/g of protein, lipid and NFE, respectively (**NRC, 1993**).*

Hassanen *et al*. (1995) found the chemical composition (% dry matter basis) of the whole body of Nile tilapia fingerlings as 52-64 crude protein (CP), 18-25 ether extract (EE), 15-23 ash, and 490-533 Kcal/100g gross energy (GE) content; and for Nile tilapia fingerlings whole body as 60, 27, 13, and 316, respectively. Moreover, the gross body composition of Nile tilapia (% DM basis) was 62 CP, 25 EE, and 13 ash. Also, as % DM basis, Nile tilapia carcass had 60 CP, 21 EE, 11 ash, and 541 Kcal/100g GE. However, body composition (% DM basis) of Nile tilapia contains 69 CP, 14 EE, and 15 ash. **Abd Elmonem *et al*. (2002)** gave the following chemical composition (% fresh weight basis) of red tilapia body: 15.5 Cp, 7.81 EE, 4.33 ash and 161 Kcal/100 g GE. They gave also the following blood values: glucose 72.1 mg/dl, total protein 6.20 g/dl, total lipids 5.64 g/l. The body composition (% DM basis) of Nile tilapia is 57 CP, 23 EE, 20 ash, and 537 Kcal/100g GE. Yet, **El-Ebiary and Zaki (2003)** found that tilapia carcass contains 54 % CP, 30 % EE, and 16 % ash on DM basis. **El-Dakar (2004)** and **El-Dakar *et al.* (2004)** added that body composition of hybrid tilapia consists of 63 % CP, 16 % EE, and 21 % ash, DM basis. Also, the following proximate analysis of Nile tilapia carcass (% DM basis) was given: 58.6 CP, 25.1 EE, 16.3 ash, and 568 Kcal/100g GE. Whereas, it was (% fresh weight basis) 13.5-15.4 CP, 5.50-8.10 EE, 3.03-4.70 ash, and 129-164 Kcal. /100g GE (**Gaber, 2006**). **Salem *et al.* (2008)** gave also the following values (% DM basis) 61.3-61.6, 17.3-18.6, 12.1-18.3, and 521, respectively. The negative relationship between fish carcass crude protein and ether extract percentages is to great extent a fact (**Farrag *et al*., 2013** and **Abdelhamid *et al*., 2015**). Yet, other researchers came to the opposite conclusion, positive relationship (**Eweedah *et al*., 2006** and **Soltan *et al.*, 2008).** Others did not find any effect of the experimental diets on chemical composition of fish (**Soltan *et al.*, 2002** and **El-Dakar, 2004**).

Economic Evaluation:

Cost calculations of the experimental diet depended on the average local prices (LE) of dietary ingredients of year 2017, where one ton of the whole diet coasted 7500 LE. From the calculations of feed intake and price and total body gain, it was found that the first treatment (lowest initial body weight at 2% daily feeding rate) was the best economically. Generally, increasing initial body or feeding rate expectedly increased feed cost/Kg gain (Table 7).

Table7. *Effect of feeding rate and initial body weight on the economic efficiency of Nile tilapia*

Feeding rate, %	Feed cost / kg gain (LE)	Feed intake (g/fish)	Initial weight (treatment No.)
2	**1**	168.00	9,66
	2	213.33	11,03
	3	220.00	11,14
3	**4**	229.67	11,23
	5	334.67	12,87
	6	425.00	12,16
5	**7**	379.00	16,21
	8	519.00	15,99
	9	718.00	17,18

Thin-Lipped Mullet's Performance

Feed and Nutrients Utilization:

Table 8 shows that increasing daily feeding rate from 2 to 5 % significantly ($P \leq 0.05$) increased gradually both FI and FCR and significantly ($P \leq 0.05$) decreased gradually each of FE, PPV, and PER. The same trend was recorded for the effect of Tobara initial body weight, where FI and FCR increased but PPV decreased without significant ($P \geq 0.05$) effects on FE neither PER. Aquaculture plays an important role in the economy (**Soliman and Yacout, 2015**).

Table8. *Feed and nutrients utilization (means ± standard errors) of thin-lipped mullet*

	FI	FCR	FE	PPV	PER
			Feed rate (%)		
2	164.56c±2.56	1.28c±0.02	0.78a±0.01	3.08a±0.04	2.61a±0.03
3	235.78b±12.99	1.45b±0.02	0.69b±0.01	2.58b±0.15	2.30b±0.03
5	518.00a±29.30	1.96a±0.04	0.51c±0.01	1.90c±0.11	1.71c±0.03
			Initial weight		
1	258.22c±43.43	1.54b±0.09	0.67±0.03	2.77a±0.13	2.22±0.12
2	301.89b±49.79	1.56ab±0.09	0.66±0.04	2.55b±0.18	2.19±0.12
3	358.22a±69.11	1.59a±0.13	0.66±0.05	2.24c±0.24	2.20±0.16
			Interactions		
2*1	156.67±3.48	1.32±0.01	0.76±0.00	2.96±0.07	2.53±0.01
2*2	165.33±2.91	1.30±0.03	0.77±0.02	3.15±0.06	2.57±0.05
2*3	171.67±1.20	1.23±0.02	0.81±0.01	3.13±0.02	2.72±0.05
3*1	187.33±1.45	1.40±0.02	0.71±0.01	3.10±0.03	2.38±0.03
3*2	245.00±2.65	1.49±0.03	0.67±0.01	2.56±0.03	2.23±0.04
3*3	275.00±5.51	1.46±0.04	0.68±0.02	2.09±0.04	2.28±0.06
5*1	430.67±8.82	1.89±0.02	0.53±0.01	2.25±0.04	1.76±0.02
5*2	495.33±8.69	1.89±0.03	0.53±0.01	1.94±0.04	1.76±0.03
5*3	628.00±5.51	2.09±0.02	0.48±0.01	1.51±0.01	1.60±0.02

A-c: *Means in the same column within each criterion superscripted with different letters significantly ($P \leq 0.05$) differ.*

Growth Performance

All growth performance parameters measured herein, except IW and IL, significantly ($P \leq 0.05$) affected with Tobara feeding rate; since, FW, FL, WG, and SGR gradually increased whether SR and K gradually decreased (Table 9). Also, initial body weight significantly ($P \leq 0.05$) elevated IW, FW, IL, FL, and WG, but decreased each of SGR, RGR, and K without significantly affect (P≥0.05) on SR. These results are expected for the effect of increased feeding rate on water pollution as well as the effect of heavy stocking rate (fish body mass) on the crowding and competition. In this connection, **Chen and Prowse (1964)** showed that there are effects of the free movement of fish in a body of water on their growth rate. They called this the living space effect. Furthermore**, Coche (1976)** reported that the growth rate of fish decreased with increasing stock density but the production increased in the cage up to an initial stocking density of 36 to 50 kg/m^3. The same author added that the apparent drop in productivity above this range could suggest some of social interaction, due to crowding that affecting growth. Gray mullet (*Mugilcephalus*) gave significantly the best growth performance (average daily gain and specific growth rate), feed utilization (feed conversion ratio, protein efficiency ratio, protein productive value, and energy utilization) and net fish production at the lowest stocking density (40 fish / m^3**)** without effect on carcass composition. Also, significantly negative effects were reported of stocking density on growth performance, feed and nutrients efficiency, antibody titer and survival of Nile tilapia fingerlings. Moreover, **Abdel-Gawad and Salama (2007)** referred to the treatment that received the lowest stocking density of *Mugilcephalus* fingerlings as the best one that gave the highest final body weight, growth rate, net return and rate of return. Condition factor showed significant increase, with each increase in the stocking density.

In general condition factor reflects through its variations information on the physiological state of the fish in relation to its welfare. The increase in condition factor with each increase in the stocking density, indicate that at higher density the fish gain more in weight than in length. These results are in accordance with the findings of **AbouZied and Hassouna (2007)** and **Awad (2015).**

Table9. *Growth performance (means ± standard errors) of thin-lipped mullet*

	IW	FW	IL	FL	WG	SGR	RGR	SR	K
Feed rate (%)									
2	10.89±1.36	139.67c±4.53	6.61±0.45	18.72c±0.52	128.78c±3.24	2.18c±0.09	1350c±175	99.00a±0.29	2.16a±0.11
3	10.44±1.43	172.44b±9.40	6.46±0.44	21.86b±1.02	162.00b±7.99	2.40b±0.08	1760b±201	96.67b±0.58	1.73b±0.15
5	10.78±1.49	273.89a±12.16	6.40±0.47	30.57a±1.21	263.11a±10.69	2.76a±0.09	2765a±307	90.78c±1.14	1.02c±0.09
Initial weight									
1	5.78c±0.28	165.78c±17.08	5.17c±0.06	20.43c±1.38	160.00c±17.02	2.77a±0.08	2796a±295	95.89±1.10	2.05a±0.17
2	11.00b±0.44	195.22b±19.84	6.11b±0.13	24.13b±2.03	184.22b±20.01	2.37b±0.10	1721b±227	96.22±1.23	1.57b±0.21
3	15.33a±0.33	225.00a±24.01	8.19a±0.06	26.58a±1.95	209.67a±23.84	2.20c±0.08	1358c±140	94.33±1.80	1.28c±0.21
Interactions									
2*1	6.00±0.58	125.00±2.89	5.20±0.12	17.23±0.15	119.00±2.31	2.54±0.06	2013±157.45	±99.00±0.58	2.44±0.01
2*2	11.67±0.88	139.00±2.08	6.37±0.09	18.27±0.15	127.33±1.20	2.07±0.05	1103.00±76.57	99.00±0.58	2.28±0.02
2*3	15.00±0.58	155.00±2.89	8.27±0.09	20.67±0.33	140.00±2.65	1.95±0.03	935.7±35.70	99.00±0.58	1.76±0.09
3*1	5.33±0.33	±139.00±1.00	5.07±0.07	18.17±0.09	133.67±1.33	2.72±0.06	2527±172.2	96.67±0.33	2.32±0.04
3*2	11.00±0.58	175.00±2.89	6.23±0.12	22.23±0.12	164.00±2.31	2.31±0.03	1496±57.81	98.00±1.15	1.59±0.01
3*3	15.00±0.58	203.33±3.33	8.07±0.07	25.17±0.09	188.33±2.85	2.18±0.02	1258±35.74	95.33±0.88	1.28±0.01
5*1	6.00±0.58	233.33±4.41	5.23±0.15	25.90±0.21	227.33±3.84	3.06±0.06	3848±309.6	92.00±1.15	1.35±0.02
5*2	10.33±0.88	271.67±1.67	5.73±0.27	31.90±0.21	261.33±0.88	2.73±0.06	2563±205.2	91.67±0.88	0.84±0.01
5*3	16.00±0.58	316.67±3.33	8.23±0.15	33.90±0.21	300.67±2.85	2.49±0.02	1883±53.87	88.67±3.18	0.81±0.01

A-c: *Means in the same column within each criterion superscripted with different letters significantly (P≤0.05) differ, IL: initial length (cm), FL: final length (cm), IW: initial weight (g), FW: final weight (g), WG: weight gain (g), ADG: average daily gain (g), SGR: specific growth rate (%/d), RGR: relative growth rate (%), K: condition factor, SR: survival rate (%).*

Whole-Fish-Body's Chemical Analysis

The initial chemical composition of the whole Tobara carcass revealed its inclusion on 30.44 % DM, 56.34 % CP, 19.96 % EE, 14.76 % ash, and 540.66 Kcal/100 g, DM basis. At the end of the experimental period (aging effect), most component of the proximate analysis increased comparing with that of the experimental start, particularly as affected by the initial body weight. However, feeding rate significantly (P≤0.05) increased each of final DM, CP, and ash but significantly (P≤0.05) decreased each of EE and EC, for the negative relationship between CP and EE. Initial body weight (Table 10) significantly (P≤0.05) also increased EC, but the middle weight particularly was the best in CP %, without significant (P≥0.05) effect on either EE or ash %.

Table10. *Proximate chemical analysis (means ± standard errors, DM-basis) of thin-lipped mullet's carcass at the end of the experiment*

	DM, %	CP, %	EE, %	Ash, %	EC*, Kcal/100 g
Feed rate (%)					
2	29.86b±0.02	57.80c±0.07	24.75a±0.01	15.48c±0.08	559.30a±0.07
3	29.71c±0.11	58.10b±0.04	21.74b±0.02	15.75b±0.05	539.69b±0.16
5	33.29a±0.02	59.34a±0.05	20.38c±0.03	16.54a±0.05	539.29b±0.06
Initial weight					
1	30.97b±0.59	58.28c±0.26	22.310.64	15.88±0.17	545.95b±3.31
2	31.07a±0.56	58.54a±0.24	22.300.64	15.87±0.17	546.01a±3.31
3	±30.82c±0.60	58.42b±0.22	22.260.65	16.02±0.17	546.32a±3.29
Interactions					
2*1	29.82±0.01	57.54±0.02	24.77±0.01	15.30±0.05	559.21±0.20
2*2	29.83±0.02	57.92±0.01	24.75±0.03	15.50±0.10	559.25±0.03
2*3	29.93±0.01	57.95±0.01	24.73±0.01	15.65±0.18	559.45±0.08
3*1	29.76±0.02	58.03±0.02	21.72±0.01	15.85±0.02	539.32±0.02
3*2	30.06±0.03	58.24±0.02	21.76±0.01	15.61±0.11	539.52±0.21
3*3	29.33±0.01	58.03±0.02	21.75±0.08	15.78±0.08	540.24±0.21
5*1	33.33±0.01	59.28±0.02	20.44±0.04	16.48±0.06	±539.33±0.13
5*2	33.32±0.02	59.45±0.11	±20.39±0.06	16.51±0.05	539.27±0.03
5*3	33.22±0.02	59.28±0.04	20.30±0.05	16.62±0.15	539.28±0.13

A-c: *Means in the same column within each criterion superscripted with different letters significantly (P≤0.05) differ, and *: Energy contents of the experimental fish samples were calculated by using factors of 5.65, 9.45 and 4.22 Kcal/g of protein, lipid and NFE, respectively (**NRC, 1993**).*

Economic Evaluation

Cost calculations of the experimental diet depended on the average local prices (LE) of dietary ingredients of year 2017, where one ton of the whole diet coasted 7500 LE. From the calculations of feed intake and price and total body gain, it was found that the first treatment (lowest initial body weight at 2% daily feeding rate) was the best economically. Generally, feeding rate expectedly increased feed cost/Kg gain (Tabl11). Comparing between Tables 7 and 11, it was noticed that feed cost/Kg gain in thin –lipped mullet was cheaper than feed cost of producing one Kg tilapia growth, except in case of the 1st treatment only.

Table11. *Effect of feeding rate and initial body weight on the economic efficiency of thin-lipped mullet*

Feed cost / kg gain (LE)	Feed intake (g/fish)	Initial weight (treatment No.)	Feeding rate, %
2	**1**	156.67	9,87
	2	165.33	9,73
	3	171.67	9,19
3	**4**	187.33	10,51
	5	245.00	11,20
	6	275.00	10,95
5	**7**	430.67	14,20
	8	495.33	14,21
	9	628.00	15,66

Concerning whole body composition of Tobara (*Liza ramada*), results reveal that DM, CP, EE, ash, NFE% and GE/Kcal/1000g were 30, 60, 55.37, 20.97, 15.00, 8.66% and 543 kcal/100g, respectively. At termination of the experimental period T3 recorded higher EE (P≤0.05) DM and CP contents compared to the other groups, while T1 recorded the highest (P≤0.05) EE; NFE and GE contents compared to T2 and T3. Furthermore, T3 recorded the highest (P≤0.05) ash contents in the whole body which reflected on the lower GE contents in this group (**Awad, 2015**).In this context, **Abdel-Hakim *et al.* (2013)** reported that in the DM of Tobara (*Liza ramada*) DM contents in whole fish body ranged between 28.5 and 33.00 %; CP 53.07 - 58.21 %; ash 15.13 - 16.57 %; NFE 4.87 - 7.19 % and GE 538.03-559.19 kcal/1000 g. Moreover, whole body composition of Tobara (*Liza ramada*) revealed that DM, CP, EE, ash, NFE% and GE/Kcal/1000g were 30, 60, 55.37, 20.97, 15.00, 8.66% and 543 kcal/100g, respectively (**Awad, 2015)**. The negative relationship between fish carcass crude protein and ether extract percentages is to great extent a fact (**Salem *et al*., 2008** and **Farrag *et al*., 2013**). Yet, other researchers came to the opposite conclusion, positive relationship (**Eweedah *et al*., 2006** and **Soltan *et al.*, 2008).** Others did not find any effect of the experimental diets on chemical composition of fish (**Soltan *et al*., 2002** and **El-Dakar, 2004**).

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