J.Animal and Poultry Prod., Mansoura Univ., Vol.9 (7): 315 - 323, 2018

Influence of *Nigella sativa* Oil on Growth Performance and Feed Utilization and Comparison of Different Non-Linear Functions against Linear Model to Describe the Growth Curve in Nile Tilapia

El-Moghazy, M. M.[1]; M. A. A. Mostafa[2] and A. S. Shosha[3]
[1]Department of Animal Production, Faculty of Agriculture, Damietta University, Egypt.
[2]Department of Production Research and Aquaculture Systems, Central Laboratory for Aquaculture Research (CLAR), Agricultural Research Center, Egypt.
[3]Egyptian Plant Quarantine (Port Said), Egypt.
***Corresponding Author *(Mostafa El-Moghazy)* E. Mail Address: el-moghazymm@yahoo.com.**

ABSTRACT

This study was conducted to evaluate the effects of different levels from *Nigella sativa* oil on growth performance and feed utilization and comparison of different nonlinear functions against linear model to describe the growth curve in Nile tilapia in order to select the best function. *Nigella sativa* oil was added at 1 ml, 2ml and 3 ml /1010 g diet to Nile tilapia diets based control diet and each diet was fed in two replicates during the period from 21/10/2014 to 7/4/2015.Winter experiment started at 27/1/2015 as the amount of feed decreased to be 5 g /tank every 2 days to study the effect of *Nigella sativa* oil on fish resistance to the decrease in bodyweight during winter season. *Nigella sativa* oil in Tilapia rations had significant effect on the different body weights. Specific growth rate did not affect significantly by elevated *Nigella sativa* oil levels except specific growth rate between 8 and 10 weeks (p=0.050), also, condition factor did not affect significantly except initial condition factor and after 12, 14, 16 and 22 weeks. Increasing the level of *Nigella sativa* oil in fish diet improved body length and body depth significantly. Furthermore, *Nigella sativa* oil had significant effect on feed intake and feed conversion ratio. In connection to non linear models and growth curve description, Weibull and Morgan-Mercer-Flodin equations gave the highest accuracies followed by Von Bertalanffy and linear regression. The present results showed that inclusion of *Nigella sativa* oil in Nile tilapia (*Oreochromis niloticus*) diets improved growth performance and feed utilization relatively. Regarding growth curve, Weibull and Morgan-Mercer-Flodin models were the best equations to describe growth curve.

Keywords: Nigella sativa oil; Nile tilapia; Feed utilization; Non linear models; Growth curve.

INTRODUCTION

The ability of tilapia (*Oreochromis niloticus*) to reproduce easily, environmental stress tolerate and grow at a fast rate has made it an important fish in aquaculture production (El-Sayed, 2006). In Southeast Asia and Middle East Nigella sativa plants were used to promote fight disease and health. It is called Kalonji in South Asia and its Arabic name is Habat-ul-Sauda, while its English name is Black cumin (Nadkarni, 1976).The active constituents of Nigella sativa are volatile oil, P-cymene, d-limonene, terpene and unsaturated ketone (Kapoor,1990). Nowadays, medicinal herbs are becoming more popular than ever before as far as the possible adverse effects of synthetic drugs are concerned (Rawling *et al*., 2009; Bilen *et al*., 2011, 2013 and 2014). Several studies demonstrated positive effect of medical herbs and oil on growth performance and feed utilization in different types of fish (Dias, 2002; Metwally, 2009; Abdelwahab and El-Bahr, 2012; Sönmez *et al*., 2015).In connection to growth curve, numerous growth equations have been fitted to describe the nonlinear relationship between growth and age of animal such as Brody, Morgan-Mercer-Flodin, weibull, Gompertz, Logistic and Von Bertalanffy models (Tekel *et al*,2005;Tariq *et al*., 2013; Sieklicki *et al*., 2016).The objective of the present study is to investigate the effect of different dietry levels of *Nigella sativa* oil on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus*) and comparison of different non-linear functions to describe growth curve against linear function.

MATERIALS AND METHODS

1. Experimental design and procedure:

This experiment was carried out at Animal Production Laboratory, Animal Production Department; Faculty of Agriculture, Damietta University during the period from 21/10/2014 to 7/4/2015.Winter experiment started at 27/1/2015 as the amount of feed decreased to be 5 g/ tank every 2 days. A total of 8 experimental fiberglass tanks were used in the present study with dimensions 70 cm length, 30 cm width and 50 cm height with capacity about 60 liters of water. Oxygen supply was through compressor air. Tanks are cleaned twice weekly before partial replacing (75%) of water for removing the faeces. The water source was Chlorine-free tap water. The lighting period in lab was 12 hours. A total of 120 Nile tilapia (*Oreochromis niloticus*) fingerlings were obtained from special hatchery located in Faraskour–Damietta and divided to four groups (two replicates treatment) and distributed to the tanks (15 fingerlings in each tank).

2. Experimental diets:

Four experimental diets were mixed as following:

1- Control treatment contained 800 g diet (21% protein) +200 g fish powder (65% protein) +10 g black honey.
2- TR1 contained 800 g diet (21% protein) +200 g fish powder (65% protein)) +10 g black honey + 1 ml *Nigella sativa* oil.
3- TR2 contained 800 g diet (21% protein) +200 g fish powder (65% protein) +10 g black honey + 2 ml *Nigella sativa* oil.
4-TR3 contained 800 g diet (21% protein) +200 g fish powder (65% protein) +10 g black honey + 3 ml *Nigella sativa* oil.

Fish powder was imported from china. Biscuit machine was used to convert the mixture to granules with diameter 3 ml and the drying was aerobic. Feed amounts were adjusted according to body weight and total number of fish / tank. Daily feed ration was calculated according to the following formula

DFR= (MBW×N×FR)/day. (Nandlal and Pickering, 2004).

Where **DFR = daily feed ration; MBW = mean body weight; N= number of the fish and FR= feeding rate.**

3. Proximate analysis for tested diets:

Chemical composition of experimental diets fed to Nile tilapia (*Oreochromis niloticus*) was recorded in Table 1. The tested diet for each treatment was chemically analyzed for protein, moisture, fat and ash according to standard methods of AOAC (1990). Crude fiber was determined according to Goering and Soest (1970).

Table 1. Chemical composition (% as feed) of experimental diets fed to Nile tilapia (*Oreochromis niloticus*).

Treatments	Moisture	Protein	Fat	Fiber	Ash	Carbohydrates
Control	10.73	30.5	13.95	3.17	7.17	34.49
TR1	10.14	30.54	13.94	2.61	8.12	34.65
TR2	10.29	30.23	14.3	3.08	7.91	34.2
TR3	10.36	29.98	14.78	2.87	8.31	33.72

4. Fish performance:

Body weight, body length and body depth were taken every 15 day. Specific growth rate was described according to Sveier *et al*. (2000), while condition factor was calculated according to Eyo and Ekanem (2011) as following:

Specific growth rate (SGR, % / day) = (log W2 - logW1/T2-T1) x 100.

Condition factor= {(W/L^3)*100}

Where: W1 = initial weight; W2 = final weight; T1 = begin of experiment (day); T2 = end of experiment (day); W = mean body weight (g); L = Mean standard length (cm).

Feed intake (FI) is the total feed consumed (g) during experimental period.

Feed conversion ratio (FCR) = FI / WG.

5. Statistical analysis:

The obtained data were statistically analyzed according to PROC ANOVA using the Statistical Analysis System (SAS, 2012) to test the effect of different treatments on body weight, body length, body depth, specific growth rate, condition factor, feed consumed, feed intake and feed conversion ratio. The differences between means were detected by Duncan`s Multiple Range Test (Duncan, 1955).

Three non linear growth functions and linear regression model had been used to describe the changes in growth curve with time under the effect of adding different levels from *Nigella sativa* oil in tilapia diets. The mathematical relations of these equations are:

Von Bertalanffy: Wt=A (1-exp (-k (t- I)).

Weibull: Wt=A-(A-B) exp (-(kt)δ).

Morgan-Mercer-Flodin: Wt=A-((A-B)/(1+(kt)δ)).

Where: Wt is the live body weight at time t of tilapia fish; k is the rate of maturing; A is the asymptotic weight when age approaches infinity; I is the ordinate of the inflection point; B is the lower asymptote and δ is the parameter that controls the point of inflection.

RESULTS AND DISCUSSION

1. Body weights:

As presented in Table 2, adding different levels from *Nigella sativa* oil in Tilapia rations had significant effect on the different body weights, except initial body weight and body weight after 2 weeks. Higher level from *Nigella sativa* oil (3ml) coupled with higher body weight followed by the level of 2ml and 1ml may be due to its antimicrobial effect and the abundance of essential amino acids which satisfy fish requirements as reported by Amal (1997).The difference between control diet and diet with 1ml *Nigella sativa* oil was not significant (P>0.05) for all body weights except after 6 and 8 weeks that showed significant differences (P≤0.05) in favor of diet with 1ml *Nigella sativa* oil. Body weights after 18, 20 and 22 weeks on diets with 2ml and 3ml *Nigella sativa* oil; after 20 and 22 weeks in diets with 1ml *Nigella sativa* oil and after 22 weeks in control diet decreased compared to the previous weights in sorting may be due to over-wintering regimes.

Table 2. Means±SE for body weights (g/fish) in Nile tilapia (*Oreochromis niloticus*).

Weaks	Control	TR1	TR2	TR3	P-Value
Initial	19.985±1.267	18.836±1.602	19.544±1.328	20.824±1.247	0.774
W 2	24.194±1.628	23.113±1.987	23.774±1.546	24.908±1.469	0.807
W 4	26.517±1.613^b	30.469±2.299^{ab}	29.245±1.570^{ab}	33.695^a±1.671^a	0.049
W 6	29.609±1.863^c	36.377±2.578^b	35.447±1.665^{cb}	43.320^a±2.344^a	0.0003
W 8	35.560±2.143^c	45.245±3.025^b	43.138±2.117^b	55.485^a±2.505^a	<.0001
W 10	43.517±2.613^c	50.615±3.381^{cb}	57.750±2.510^b	66.592^a±2.881^a	<.0001
W 12	51.916±2.738^b	53.694±3.471^b	72.344±3.027^a	71.035^a±2.212^a	<.0001
W 14	52.901±2.957^b	57.070±3.923^b	72.684±3.258^a	73.997^a±3.209^a	<.0001
W 16	53.954±3.039^b	58.819±4.043^b	74.114±3.335^a	74.717^a±3.249^a	<.0001
W 18	54.886±3.159^b	59.922±4.144^b	72.081±3.257^a	74.265^a±3.177^a	0.0002
W 20	59.238±3.742^b	59.106±5.117^b	71.702±3.930^a	70.094^{ab}±3.297^{ab}	0.045
W 22	57.395±3.729^c	58.738±5.132^{cb}	71.241±3.741^a	69.805^{ab}±3.091^{ab}	0.0248

a-c: means within a row not followed by the same letter differ significantly at P≤0.05.

The present results correspond with Abdelwahab and El-Bahr (2012) as they found significant influence of Black cumin seed and Turmeric mixture on body weight gain in Asian sea bass. Also, Qatnan and Al-Owafeir (2014) showed significant differences in final weights for Nile tilapia under the effect of different levels from *Nigella sativa* (0, 5, 10 and 20 g/kg). Concerning other medical oils and its effects on body weights in freshwater fish, Ayisi *et al*. (2017) obtained significant effect for palm oil on growth performance of Nile Tilapia. Sonmez *et al*. (2015) reported significant differences in final body weight between control diet and the diets with different levels from sage oils (0.5, 1 and 1.5%) in rainbow trout fingerlings. Regarding medical herbs, Dias (2002) and Metwally (2009) reported that using of garlic resulted in improving the growth performance of *Oreochromis niloticus* fingerlings and *Tilapia nilotica*, respectively.

2. Specific growth rate:

Results in Table 3 revealed that all specific growth rate estimates was not significantly affected by adding different level from *Nigella sativa* oil (P>0.05), except specific growth rate between 8 and 10 weeks (P=0.050) what in accordance with the statements of Al-Dubakel *et al*. (2012), they found non significant differences in specific growth rate under the effect of different levels from Nigella sativa oil (0, 1 and 3%) in a study conducted on common carp *(Cyprinus carpio*) fingerlings. In contrast; Abdelwahab and El-Bahr (2012) in a study conducted on Asian sea bass found significant differences in specific growth rate (P≤0.05) with increasing the levels of Black cumin seed (*Nigella sativa*) and Turmeric mixture in fish diets being at range from 1.77% to 1.93% .

Table 3. Means±SE for specific growth rate (SGR, %/day) in Nile tilapia (*Oreochromis niloticus)*.

Intervals	Control	TR1	TR2	TR3	P-Value
0-2 W	0.610±0.309	0.676±0.212	0.611±0.254	0.651±0.227	0.997
2-4 W	0.980±0.293	0.976±0.201	0.806±0.234	1.014±0.232	0.237
4-6 W	0.638±0.214	0.620±0.326	0.659±0.203	0.794±0.231	0.621
6-8 W	0.620±0.190	0.752±0.325	0.650±0.235	0.890±0.170	0.853
8-10 W	0.680^{ab}±0.163	0.371^{b}±0.223	0.998^{a}±0.150	0.615^{ab}±0.138	0.050
10-12 W	0.641±0.269	0.187±0.276	0.761±0.128	0.292±0.203	0.231
12-14 W	0.076±0.211	0.099±0.261	0.122±0.154	0.078±0.206	0.964
14-16 W	0.062±0.267	0.098±0.244	0.062±0.120	0.034±0.110	0.996
16-18 W	0.053±0.200	0.058±0.266	-0.092±0.152	-0.018±0.149	0.942
18-20 W	0.035±0.359	-0.456±0.420	-0.115±0.278	-0.441±0.188	0.637
20-22 W	-0.111±0.254	-0.018±0.161	-0.007±0.188	-0.004±0.179	0.977

a-b: means within a row not followed by the same letter differ significantly at P≤0.05.

Higher specific growth rates were in primary ages of fish due to the good response to feeding in this period. Fish fed diets with 2 and 3 ml *Nigella sativa* oil decreased in weight during winter experimental faster than those fed diets with 1 ml *Nigella sativa* oil and control diet as negative signs were showed with the last three estimates for the diets with 2ml and 3ml *Nigella sativa* oil and with last two estimates for the diet with 1ml *Nigella sativa* oil and with the final estimate in control treatment as a consequence of feeding behavior in fish during winter season. Khattab (2001) reported that the highest estimate of average specific growth rate was recorded in group reared on diets with 10% black seed cake (*Nigella sativa*). Regarding other medical herbs and oils, Sahu *et al*. (2008) reported significant increase in specific growth rate in *Labeo rohita* fingerlings fed diets contained four levels from turmeric (0.1, 0.5, 1.0 and 5g). Altundag *et al* (2014) reported significant differences in specific growth rate in favor of diets contained sun flower oil (0.65%) compared to diets contained fish oil (0.58%) in a study on turbot (*Psetta maxima*).

3. Condition factor:

Results in Table 4 clearly demonstrated that adding different doses from *Nigella sativa* oil had no significant effect on condition factor, except initial condition factor and after 12, 14, 16 and 22 weeks . Concerning other medical oils, Ayisi *et al.* (2017) used four levels from palm oil (0, 2%, 4%, 6% and 8%) and did not find significant differences in condition factor in different treatments (1.88, 1.92, 2.00, 2.00, and 1.87, respectively). Also, Diler *et al.* (2017) did not record significant differences in condition factor in a study on oregano (*Origanum onites* L.) in rainbow trout (1.24, 1.25, 1.23, 1.23 and 1.24 for control, 0.125 ml kg−1, 1.5 ml kg−1, 2.5 ml kg−1 and 3.0 ml kg−1, respectively).

Table 4. Means±SE for condition factor (CF) in Nile tilapia (*Oreochromis niloticus)*.

Intervals	Control	T1	T2	T3	P-Value
Initial	1.724±0.035^{ab}	1.738±0.025^{ab}	1.939±0.146^{a}	1.642±0.018^{b}	0.048
W 2	1.700±0.024	1.739±0.029	1.751±0.033	1.744±0.019	0.547
W 4	1.633±0.026	1.668±0.027	1.600±0.041	1.649±0.018	0.420
W 6	1.659±0.016	1.676±0.015	1.693±0.018	1.737±0.123	0.841
W 8	1.635±0.012	1.598±0.019	1.605±0.024	1.612±0.017	0.540
W 10	1.634±0.019	1.595±0.021	1.552±0.055	1.601±0.016	0.359
W 12	1.680±0.013^{b}	1.607±0.025^{c}	1.789±0.027^{a}	1.646±0.017^{bc}	<.0001
W 14	1.592±0.017^{b}	1.595±0.019^{b}	1.680±0.020^{a}	1.623±0.019^{b}	0.004
W 16	1.610±0.018^{b}	1.631±0.031^{ab}	1.700±0.023^{a}	1.635±0.020^{ab}	0.051
W 18	1.590±0.017	1.571±0.017	1.608±0.024	1.568±0.057	0.810
W 20	1.574±0.021	1.527±0.017	1.862±0.246	1.540±0.016	0.186
W 22	1.523±0.028^{ab}	1.473±0.020^{b}	1.589±0.030^{a}	1.521±0.024^{ab}	0.024

a-c: means within a row not followed by the same letter differ significantly at P≤0.05.

4. Body length:

The effects of elevated dietary *Nigella sativa* oil levels on all body length estimates were significant during experimental trail, except initial body length and after 2, 10 and 20 weeks. Non significant differences (P>0.05) were showed between control diets and diets with 1ml *Nigella sativa* oil except after 6 and 8 week showed significant differences (P≤0.05) in favor of diet with 1ml *Nigella sativa* oil (Table 5). Regarding medical herbs, Nwabueze (2012) used different concentration from garlic and showed a slight differences in body length of *Clarias gariepinus* fingerlings but did not differ significantly (P>0.05).

Table 5. Means±SE for total body length (cm) in Nile tilapia (*Oreochromis niloticus*).

Intervals	Control	T1	T2	T3	P-Value
Initial	10.363±0.218	10.050±0.272	10.070±0.281	10.713±0.234	0.279
W 2	11.073±0.265	10.760±0.298	10.965±0.287	11.138±0.231	0.681
W 4	11.613±0.207^{b}	12.000±0.299^{ab}	12.136±0.298^{ab}	12.590±0.202^{a}	0.031
W 6	11.963±0.251^{c}	12.726±0.299^{b}	12.700±0.217^{b}	13.606±0.233^{a}	0.0002
W 8	12.786±0.265^{c}	13.936±0.320^{b}	13.806±0.235^{b}	14.996±0.244^{a}	<.0001
W 10	13.683±0.271	14.466±0.319	13.266±0.445	14.980±0.227	0.216
W 12	14.407±0.259^{b}	14.789±0.339^{b}	15.825±0.234^{a}	16.196±0.582^{a}	<.0001
W 14	14.764±0.282^{b}	15.050±0.358^{b}	16.196±0.238^{a}	16.489±0.265^{a}	<.0001
W 16	14.810±0.295^{b}	15.085±0.339^{b}	16.239±0.245^{a}	16.507±0.265^{a}	<.0001
W 18	14.939±0.279^{b}	15.371±0.377^{b}	16.403±0.262^{a}	16.621±0.527^{a}	0.0002
W 20	15.390±0.356	15.386±0.463	16.000±0.373	16.481±0.266	0.115
W 22	15.409±0.376^{b}	15.545±0.464^{ab}	16.400±0.265^{ab}	16.559±0.285^{a}	0.051

a-c: means within a row not followed by the same letter differ significantly at P≤0.05.

5. Body depth:

As showed in Table 6, adding different levels from *Nigella sativa* oil in tilapia diets had significant effect (P≤0.001) on all estimates except initial body depth and after 2 and 20 weeks. Higher level from *Nigella sativa* oil (3ml) coupled with higher body length followed by the level of 2ml and 1ml.

Table 6. Means±SE for body depth (cm) in Nile tilapia (*Oreochromis niloticus*).

Intervals	Control	T1	T2	T3	P-Value
Initial	3.353±0.075	3.086±0.099	3.253±0.083	3.200±0.078	0.166
W 2	3.493±0.099	3.250±0.098	3.406±0.083	3.438±0.070	0.230
W 4	3.433±0.096^{b}	3.630±0.100^{ab}	3.590±0.073^{b}	3.866±0.064^{a}	0.005
W 6	3.536±0.091^{c}	3.606±0.099^{c}	3.886±0.074^{b}	4.340±0.092^{a}	<.0001
W 8	3.753±0.098^{c}	4.096±0.112^{b}	4.133±0.078^{ab}	4.386±0.091^{a}	<.0001
W 10	4.116±0.092^{b}	4.276±0.108^{b}	4.396±0.086^{b}	4.680±0.101^{a}	0.0008
W 12	4.364±0.101^{b}	4.353±0.114^{b}	4.785±0.122^{a}	4.685±0.110^{ab}	0.016
W 14	4.335±0.105^{b}	4.457±0.132^{b}	5.000±0.088^{a}	4.975±0.092^{a}	<.0001
W 16	4.496±0.112^{b}	4.582±0.120^{b}	5.164±0.094^{a}	5.117±0.084^{a}	<.0001
W 18	4.503±0.116^{b}	4.510±0.147^{b}	4.946±0.104^{a}	4.857±0.103^{a}	0.013
W 20	4.572±0.130	4.413±0.163	4.818±0.124	4.781±0.110	0.119
W 22	4.063±0.126^{b}	4.172±0.163^{b}	4.900±0.096^{a}	4.659±0.100^{a}	<.0001

a-c: means within a row not followed by the same letter differ significantly at P≤0.05.

The differences between control diet and diet with 1ml *Nigella sativa* oil were not significant (P>0.05) for all body depth estimates, except after 8 weeks showed significant differences (P≤0.05) in favor of diet with 1ml *Nigella sativa* oil. The loses in body depth during winter period were on line with that observed in body weight [Last three estimates in diet with 2ml and 3 ml *Nigella sativa* oil; last two estimates in diet with 1ml *Nigella sativa* oil and last estimate in control diet] may be due to the losses in belly fat.

6. Feed utilization:

It is clearly appears that feed intake (Table 7) increased with increasing the level of *Nigella sativa* oil in tested diets. With regard to feed conversion ratio, significant differences were showed between all tested diets, being at range from 1.670± 0.041 for control diet to 2.153±0.084 in ration with 3 ml *Nigella sativa* oil.

Table 7. Means±SE for feed intake (FI, g/fish) and feed conversion ratio (FCR) throughout the experiment.

Items	Control	T1	T2	T3	P-Value
FI	97.216±4.09^{c}	108.427±5.437^{cb}	117.966±3.73^{b}	133.557±4.285^{a}	<.0001
FCR	1.670± 0.041^{b}	1.921±0.094^{a}	1.969±0.092^{a}	2.153±0.084^{a}	0.0008

a-c: means within a row not followed by the same letter differ significantly at P≤0.05.

The present results comply with Qatnan and Al-Owafeir (2014), they found significant differences in feed conversion ratio for tilapia fish, being at range from 1.12 to 3.73 under the effect of different levels from black seed meal. Contradictory results were showed by Khattab (2001) who found non significant differences in feed conversion ratio for tilapia fish under the effect of adding black seed meal in tested diets, also Abdelwahab and El-Bahr (2012) came to same conclusion in a study on Asian sea bass.

7. Growth curve:

Different non linear functions were used to describe growth curve in the present study such as Von Bertalanffy model, Weibull model and Morgan-Mercer-Flodin model in addition to linear model. Different authors in different studies reported that non linear models gave highest accuracies in the description of growth curve (Esenbuğa *et al*., 2000; Lewis *et al*., 2002; Bilgin and Esenbuga, 2003; Topal *et al*., 2004; Tekel *et al*, 2005;Tariq *et al.,* 2013 and Sieklicki *et al.,* 2016).

Results in Table 8 showed the different parameters along with their standard error for different growth models fitted to body weight in Nile tilapia (*Oreochromis niloticus*) reared on diets with different levels from *Nigella sativa* oil. Sieklicki *et al*. (2016) reported that the knowledge of the different parameters for non linear models is very important to establish specific feeding managements and determine the marketing age.

Concerning control treatment, K parameter which shows the maturating rate was at range 0.0073±0.003 (Von Bertalanffy) to 0.0157±0.001 (Morgan-Mercer-Flodin), while *l* parameter which shows the ordinate of the inflection point was -31.415±11.466 (Von Bertalanffy model). Highest value of A parameter (81.3257±17.168) was showed with Von Bertalanffy model followed by 59.7215±2.2657 with Morgan-Mercer-Flodin model and 57.3579±1.2801 with Weibull model.the σ parameter estimates were 2.4083±0.365 and 3.4269±0.6613 for Weibull model and Mercer-Flodin model, respectively like A parameter estimates has no biological interpretation, while β parameters estimates were 21.6443±1.3941 and 22.4347±1.3393 for Weibull model and Mercer-Flodin model, respectively. Linear regression equation was incorporated as

W=20.9902+0.27831*t.

Regarding tested diet with 1ml *Nigella sativa* oil, A parameters along with their standard errors were 66.8631±3.536±0.540, 59.733±0.540 and 63.0340±1.6187 for Von Bertalanffy, Weibull and Morgan-Mercer-Flodin, respectively, while K parameters were 0.0150±0.002, 0.0178±0.001 and 0.0208±0.001 for the same order mentioned before. The *l* parameter was -17.246±4.416 (Von Bertalanffy). The σ parameters were 1.7341±0.102 and 2.3349±0.267, while β parameters were 19.2198±0.719 and 19.8276±1.0687 for Weibull model and Morgan-Mercer-Flodin model, respectively. Linear regression equation was formulated as

W=24.39925+0.28023*t.

In connection to tested diet with 2ml *Nigella sativa* oil, A parameter was at range from 72.8906±1.3009 (Weibull model) to 90.7900±15.8147 (Von Bertalanffy model), while K parameter was at range from 0.0115±0.005 (Von Bertalanffy model) to 0.0171±0.001 (Morgan-Mercer-Flodin model). The *l* parameter had a negative sign (-13.2211±9.1931) for Von Bertalanffy model. The σ parameter was 3.4190±0.5558 and 5.1267±1.2291 while β parameters were 23.1895±1.8252 and 24.2225±2.2484 for Weibull model and Morgan-Mercer-Flodin model, respectively. Linear regression was designed as W=22.78007+0.39968*t. Regarding test ration with 3ml *Nigella sativa* oil, the values of A parameter were 80.3951± 6.2638, 72.7904±0.9729 and 74.1651±1.9073, while the values of K parameter were 0.0178±0.004, 0.0189±0.001 and 0.0219±0.001 for Von Bertalanffy, Weibull and Morgan-Mercer-Flodin models, respectively. The values of σ and β parameters were 2.4179±0.2963 and 22.1651±1.6812, respectively for Weibull equation; 3.6746±0.715 and 23.3427±2.1743, respectively for Morgan-Mercer-Flodin equation. The value of *l* parameter was -10.6172±5.8713 for Von Bertalanffy equation. Linear regression equation was recorded as

W=28.66147+0.36195*t.

Table 8. Estimated parameters±SE for different growth models fitted to body weight in Nile tilapia (*Oreochromis niloticus*) reared on diets with different levels from *Nigella sativa* oil.

Treatments	Model	Parameters				
		A	*K*	*l*	σ	*β*
Control	Von Bertalanffy	81.3257 ±17.168	0.0073 ±0.003	-31.514 ±11.466	---	---
	Weibull	57.3579 ±1.2801	0.0140 ±0.001	---	2.4083 ±0.365	21.6443 ±1.3941
	Morgan-Mercer-Flodin	59.7215 ±2.2657	0.0157 ±0.001	---	3.4269 ±0.6613	22.4347 ±1.3393
	Linear regression	W=20.9902+ 0.27831t				
T1 (1ml *Nigella sativa* oil)	Von Bertalanffy	66.8631 ±3.536	0.0150 ±0.002	-17.246 ±4.416	---	---
	Weibull	59.733 ±0.540	0.0178 ±0.001	---	1.7341 ±0.102	19.2198 ±0.719
	Morgan-Mercer-Flodin	63.0340 ±1.6187	0.0208 ±0.001	---	2.3349 ±0.267	19.8276 ±1.0687
	Linear regression	W=24.39925+ 0.28023t				
T2 (2ml *Nigella sativa* oil)	Von Bertalanffy	90.7900 ±15.8147	0.0115 ±0.005	-13.2211 ± 9.1931	---	---
	Weibull	72.8906 ±1.3009	0.0154 ±0.001	---	3.4190 ±0.5558	23.1895 ±1.8252
	Morgan-Mercer-Flodin	74.1083 ±2.2551	0.0171 ±0.001	---	5.1267 ±1.2291	24.2225 ±2.2484
	Linear regression	W=22.78007+0.39968t				
T3 (3ml *Nigella sativa* oil)	Von Bertalanffy	80.3951 ±6.2638	0.0178 ±0.004	-10.6172 ±5.8713	---	---
	Weibull	72.7904 ±0.9729	0.0189 ±0.001	---	2.4179 ±0.2963	22.1651 ±1.6812
	Morgan-Mercer-Flodin	74.1651 ±1.9073	0.0219 ±0.001	---	3.6746 ±0.715	23.3427 ± 2.1743
	Linear regression	W=28.66147+0.36195t				

Figures 1, 2, 3, 4, 5, 6, 7 and 8 show the fitted curves for Moran-Mercer-Flodin, Von Bertalanffy, and Linear and Weibull models against the observed values of body weight. From these figures it is evident that Weiblull growth curve followed by Moran-Mercer-Flodin curve and Von Bertalanffy curve predicted the values of body weight better than linear regression model in all experimental diets. Morgan-Mercer-Flodin and Weibull curves are the best curves as they took the optimum shape of biological growth curve which take *S* shape as growth evolution from period to another is nonlinear compared to linear regression curve that took line shape (Ibáñez-Escriche and Blasco, 2011). Fernanda *et al.* (2015) used non linear model (Gompertz) to describe the growth curve in males and females in *Colossoma macropomum* and showed that growth curve took *S* shape in both sexes from the birth up to 1000 day and the equations were formulated as W=5010*EXP(-EXP((-0.00507*(t-488)))and W= 4641* EXP (- EXP ((-0.00507*(t-474.7)))) in females and males respectively. Maunder *et al.* (2017) reported that growth Cessation curve was better than Richards and Von Bertalanffy curves in bigeye tuna (*Thunnus obesus*).

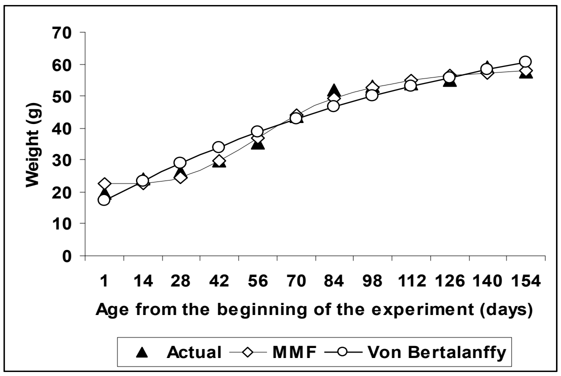

Fig. 1. Actual, Morgan-Mercer-Flodin (MMF) and Von Bertalanffy growth curve fitted to body weights for control diet.

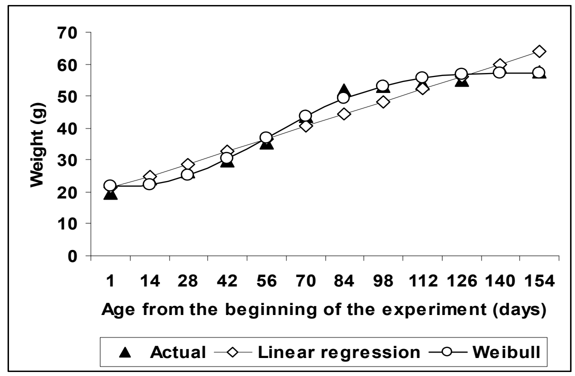

Fig. 2. Actual, linear regression and Weibull growth curve fitted to body weights for control diet.

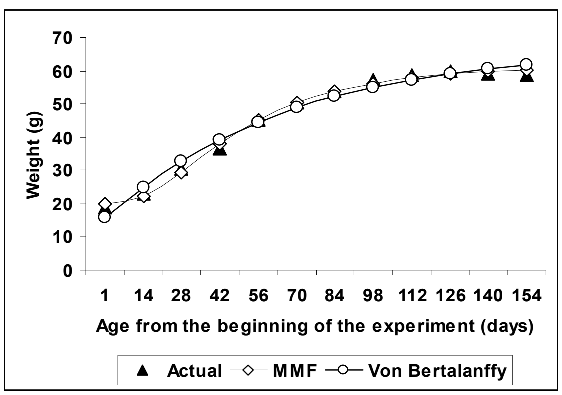

Fig. 3. Actual, Morgan-Mercer-Flodin (MMF) and Von Bertalanffy growth curve fitted to body weights for tested diet with 1ml *Nigella sativa* oil.

Fig. 4. Actual, linear regression and Weibull growth curve fitted to body weights for control diets for tested diet with 1ml *Nigella* sativa oil.

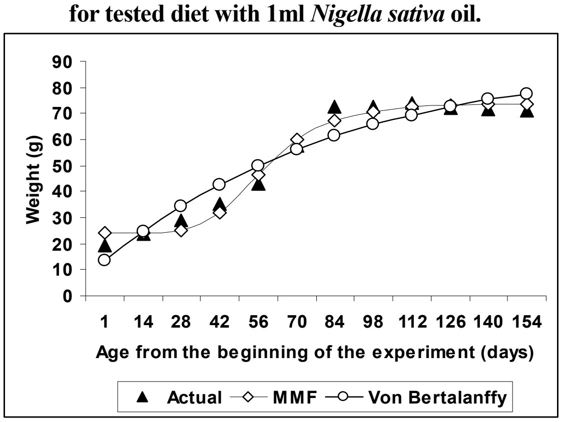

Fig. 5. Actual, Morgan-Mercer-Flodin (MMF) and Von Bertalanffy growth curve fitted to body weights for tested diet with 2ml *Nigella sativa* oil.

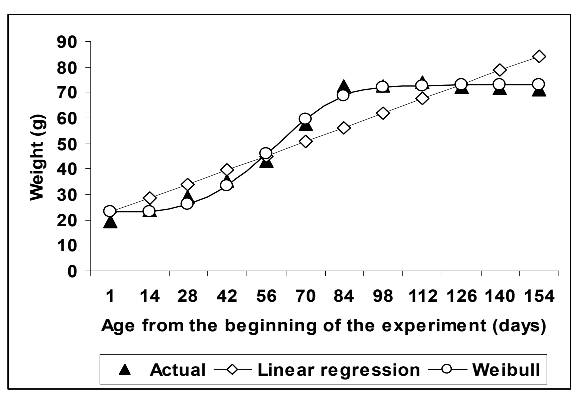

Fig. 6. Actual, linear regression and Weibull growth curve fitted to body weights for control diets for tested diet with 2ml *Nigella sativa* oil.

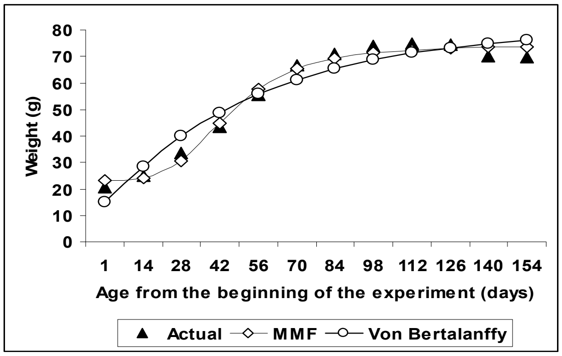

Fig. 7. Actual, Morgan-Mercer-Flodin (MMF) and Von Bertalanffy growth curve fitted to body weights for tested diet with 3ml *Nigella sativa* oil.

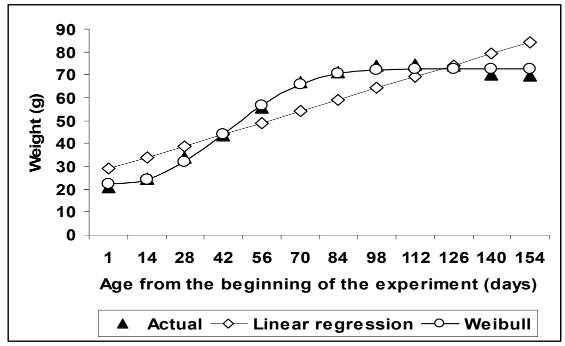

Fig. 8. Actual, linear regression and Weibull growth curve fitted to body weights for control diets for tested diet with 3ml *Nigella sativa* oil.

Results in Table 9 presented the goodness of fit measures for different growth models fitted to body weight in Nile tilapia (*Oreochromis niloticus*) reared on diets with different levels from *Nigella sativa* oil according to coefficient of determination and the mean standard errors. Weibull and Morgan-Mercer-Flodin models were the best equations to describe growth curve in Nile tilapia as they gave higher accuracies followed by Von Bertalanffy and linear regression. The present result agreed with Al- Anbari *et al*. (2013) who found that non linear models were higher in their accuracies in the description of growth curve than linear model as the mean standard error was 58463.46 for linear regression model and decreased to be 637.11 for weighted least square growth function.

Table 9. Goodness of fit measures for different growth models fitted to body weight in Nile tilapia (*Oreochromis niloticus*) reared on diets with different levels from *Nigella sativa* oil.

Ages from the beginning of the experiment (days)	MMF	Von Bertalanffy	Linear regression	Weibull
Control:				
MSE	3.8540	10.069	15.325	3.6022
R^2 (%)	98.67	96.08	93.37	98.75
T1 (1ml *Nigella sativa* oil):				
MSE	1.5115	5.6890	30.2306	0.6400
R^2 (%)	99.51	97.94	87.87	99.79
T2 (2ml *Nigella sativa* oil):				
MSE	13.3921	45.8823	76.2735	7.5443
R^2 (%)	97.94	92.08	85.38	98.84
T3 (3ml *Nigella sativa* oil):				
MSE	8.6411	30.9931	94.23936	4.3389
R^2 (%)	98.49	93.93	79.49	99.24

CONCLUSION

The present results concluded that inclusion of *Nigella sativa* oil in Nile tilapia (*Oreochromis niloticus*) diets improved growth performance and feed utilization relatively at 3 ml concentrate. For growth curve description under the effect of different treatments, Weibull and Morgan-Mercer-Flodin models were the best equations to describe growth curve in Nile tilapia followed by Von Bertalanffy and linear regression.

REFERENCES

Abdelwahab, A.M. and El-Bahr S.M. (2012). Influence of black cumin seeds (*Nigella sativa*) and turmeric (*Curcuma longa* Linn.) mixture on performance and serum biochemistry of Asian sea bass, *Lates calcarifer*. World Journal of Fish and Marine Sciences, 4 (5): 496-503.

Al- Anbari, E.H., Ahmed, A. A., Firas, R. A., Jenan, S. A. and Falah, H. A. (2013). Effect of using cumin oil (*Cuminum cyminum*) as feed additives on profile analysis and growth curve of broiler. G.J.B.B., 2 (3): 326-330.

Al-Dubakel, A.Y., Al-Mhawe, B.H., Majeed, M.F. and Shaeyal, L.W. (2012). Preliminary study on the effect of dietary black seed (*Nigella sativa*) on growth and blood glucose of common carp (*Cyprinus carpio*) fingerlings. J. of Thi _Qar Univ. for Agri. Researches, 1 (2): 41-51.

Altundag, M.S., Tiril, S.U. and Ozdemir, A. (2014). Effects of safflower oil supplementation in diet on growth performance and body fatty acid composition of turbot (*Psetta maxima*). Aquacult. Int., 22: 597–605.

Amal, F. (1997). Pharmacological studies on *Nigella stavia* L. on chickens infected with *Salmonella typhimurium*. M.V.Sc. (Pharmacology). Zagazig Univ., Egypt.

AOAC. (1990). Association of Official Analytical Chemists Official Methods of Analyses. 15th Ed. In: K. Helrich Ed. Inc., Arlington, VA, USA.

Ayisi, C.L., Jinliang Z. and Emmanuel, E.J. (2017). Growth performance, feed utilization, body and fatty acid composition of Nile tilapia (*Oreochromis niloticus*) fed diets containing elevated levels of palm oil. DOI: 10.1016/j.aaf.2017.02.001

Bilen, S., Bulut, M. and Bilen, M.A. (2011). Immunostimulant effects of *Cotinus coggyria* on rainbow trout (*Oncorhynchus mykiss*). Fish and Shellfish Immunology, 30 (2): 451-455.

Bilen, S., Yılmaz, S. and Bilen, M.A. (2013). Influence of tetra (*Cotinus coggygria*) extract against *Vibrio anguillarum* ınfection in koi carp, *Cyprinus carpio* with reference to haematological and ımmunological changes. Turk. J. Fish. Aquat. Sci., 13 (3): 527-532.

Bilen, S., Yılmaz, S., Bilen, M.A. and Biswas, G. (2014). Effects of dietary incorporation of tetra (*Cotinus coggygria*) extract on immune response and resistance to *Aeromonas hydrophila* in koi Carp (*Cyprinus carpio*), 7 pages. The Israeli Journal of Aquaculture – Bamidgeh, 66: 1-6.

Bilgin, O.C. and Esenbuga, N. (2003). Parameter estimation in nonlinear growth models. J. Anim. Prod., 44: 81–90.

Dias, A.S., El-Nagar, G.O. and El-Hady, Y. M. (2002). Evaluation of *Nigella sativa* (black seed, baraka), *Allium sativum* (garlic) and BIOGEN as feed additives on growth performance and immunostimulants of *Oreochromis niloticus* fingerlings. Suez Canal Veterinary medical Journal, 1; 745-750.

Diler, O.; Gormez, O.; Diler, I. and Metin, S. (2017). Effect of oregano (*Origanum onites* L.) essential oil on growth, lysozyme and antioxidant activity and resistance against *Lactococcus garvieae* in rainbow trout, *Oncorhynchus mykiss* (Walbaum). Agriculture Nutrition, 23: 844-851.

Duncan, D. B. (1955). Multiple range and multiple F-test. Biometrics, 11: 1 – 24.

El-Sayed, A. F. M. (200). Tilapia culture. CABI publishing, oxfordshire fatty acid metabolism. Journal of Nutrition, 132: 222-230.

Esenbuğa, N.; Bilgin, Ö.C.; Macit, M. and Karaoğlu, M. (2000). Growth curves in Awassi, Morkaraman and Tushin lambs. Atatürk Univ. The J. Agric. Fac., 31: 37-41.

Eyo, V.O and Ekanem, A. (2011). Effect of feeding frequency on the growth, food utilization and survival of African catfish (*Clarias gariepinus*) using locally formulated diet. Afr. J. Environ. Pollut. Health, 9: 11-16.

Fernanda, M.; Carlos, A.L.; Ricardo, P.; Emiko, K.; Resende, J.; Povh, D.; Rogério, V.; Concepta, M. and Danilo, S. (2015). Growth curve by Gompertz nonlinear regression model in females and males in tambaqui (*Colossoma macropomum*). Anais da Academia Brasileira de Ciências, 87 (4): 2309-2315.

Goering, H.K. and Soest, P.G.V. (1970). Forage Fiber Analysis (apparatus, reagent, procedures, and some applications). US Dept. Agric. Handbook, Washington, D.C., USA, 379.

Ibáñez-Escrich, E N and Blasco, A. (2011). Modifying growth curve parameters by multitrait genomic selection. J. Anim. Sci., 89: 661-668.

Kapoor,L.D. (1990). Handbook of ayurvedic medicinal plants. CRC. press, Inc., Boca Ration, Florida, USA.

Khattab, Y.A. (2001). Effect of substituting black seed cake (*Nigella sativa* jl) for soybean meal in diets of Nile tilapia (*Oreochromis niloticus* l.) on growth performance and nutrients utilization. Egypt. J. Aquat. Biol. & Fish., 5 (2): 31- 46.

Lewis, R.M.; Emmans, G.C.; Dingwall, W.S. and Simm, G. (2002). A description of the growth of sheep and its genetic analysis. Anim. Sci., 74: 51-62.

Maunder, M.; MRichard B.; Deriso, K.M.; Schaefer, D.W.; Alexandre M.; Aires, S.; Carolina V.; Minte, V. and Steven E.C. (2017). A growth curve for species showing a near cessation in growth: application to bigeye tuna (*Thunnus obesus*) in the eastern pacific ocean. Inter.-American Tropical Tuna Commission, 1-12.

Metwally, M.A.A. (2009). Effects of garlic on some antioxidant activities in *Tilapia nilotica* .World Journal of Fish. and Marine Sciences, 1: 56-64.

Nadkarni, A.K. (1976). Indian material medica popular prakashan Pvt. Ltd., Bornbay, India.

Nandlal, S. and Pickering, T. (2004). Tilapia fish farming in Pacific island countries: Tilapia hatchery operation, Noumea, New Caledonia. PMid, 22 (1): 6-13.

Nwabueze, A. (2012). The Effect of Garlic (*Allium sativum*) on Growth and Haematological Parameters of *Clarias gariepinus* (Burchell, 1822). Sustainable Agriculture Research, 1 (2): 222-228.

Qatnan, K.A. and Al-Owafeir, M.A. (2014). Response of Nile tilapia *Oreochromis niloticus* to fed diets supplemented with graded levels of black seed *Nigella sativa* l. stored under tropical conditions. J.Animal and Poultry Prod., Mansoura Univ., 5 (12): 605 – 618.

Rawling, M.D.; Merrifield, D.L. and Davies, S.J. (2009). Preliminary assessment of dietary supplementation of Sangrovit® on red tilapia (*Oreochromis niloticus*) growth performance and health. Aquaculture, 294 (1-2): 118-122.

Sahu, S.; Das, B.K.; Mishra, B.K.; Pradhan, J.; Samal, S.K. and Sarangi, N. (2008). Effect of dietary *Curcuma longa* on enzymatic and immunological profiles of rohu, *Labeo rohita* (Ham.), infected with *Aeromonas hydrophila*. Aquaculture Res., 39: 1720-1730.

SAS. (2012). Version 90 SAS Institute Inc Cary NC.

Sönmez, A.Y.; Soner, B.; Mevlüt, A.; Sevdan, Y.; Gouranga, B.; Olcay, H. and Talat, Y. (2015). Effects of dietary supplementation of herbal oils containing 1,8-cineole, carvacrol or pulegone on growth performance, survival, fatty acid composition, and liver and kidney histology of rainbow trout (*Oncorhynchus mykiss*) Fingerlings. Turk. J. Fish. Aquat. Sci., 15: 813-819.

Sieklicki, M.F.; PedrosA, V.B.; Rocha, C.G.; Moreira, R.P.; Falcao, P.R.; Santos, I.C.; Ferreira, E.M. and Martins, A. (2016). Growth curves of Texel male lambs. Acta Scientiae Vet., 44 (1396): 1-6.

Sveier, H.; Raae, A.J and Lied, E. (2000). Growth and protein turnover in Atlantic salmon (*Samo salar* L.); the effect of dietary protein level and protein particle size. Aquaculture, 185: 101-120.

Tariq, M.M.; Iqbal, F.; Eyduran, E.; Bajwa, M.A.; Huma, Z. E. and Waheed, A. (2013). Comparison of non-linear functions to describe the growth in mengali sheep breed of Balochistan. Pakistan J. Zool., 45: 661-665.

Tekel, N.; Sireli, H.D.; Elicin, M. and Elicin, A. (2005). Comparison of growth curve models on Awassi lambs. Indian Vet. J., 82:179–182.

Topal, M.; Ozdemir M.; Aksakal, V.; Yildiz, N. and Dogru, U. (2004). Determination of the best nonlinear function in order to estimate growth in Morkaraman and Awassi Lambs. Small Rum. Res., 55: 229–232.

تأثير زيت حبة البركة على أداء النمو والاستفادة الغذائية ومقارنه معادلات غير خطية مختلفة مقابل النموذج الخطى لوصف منحنى النمو فى البلطى النيلى

مصطفى ماهر محمد المغازى[١]، محمد التميمى عبده مصطفى[٢] وأحمد صلاح شوشه[٣]
[١]قسم إنتاج الحيوان ، كلية الزراعة ، جامعة دمياط ، مصر
[٢]قسم بحوث الإنتاج ونظم الإستزراع السمكى، المعمل المركزى لبحوث الثروة السمكية، مركز البحوث الزراعية ، مصر
[٣]الإدارة المركزية للحجر الزراعى (بور سعيد) ، مصر

تم اجراء هذه الدراسة لتقييم تأثير مستويات مختلفة من زيت حبة البركة على أداء البلطى النيلي ومقارنة معادلات غير خطية مختلفة مقابل الانحدار الخطى لوصف منحنى النمو فى البلطى النيلى بهدف اختيار أفضل معادلة. تم إضافة زيت حبة البركة بتركيزات مختلفة (١ و ٢ و ٣ مل/ ١٠١٠جم عليقة) بواقع مكررتين لكل معاملة فى الفترة من ٢٠١٤/١٠/٢١ م الى ٢٠١٥/٤/٧ م وأبتدت تجربة الشتاء فى ٢٠١٥/١/٢٧ م حيث انخفضت كمية الغذاء لتصبح ٥ جرام للتانك كل يومين لدراسة تأثير زيت حبة البركة على مقاومة الاسماك للانخفاض فى الوزن خلال فصل الشتاء. كان لزيت حبة البركة تأثير معنوى على أوزان الجسم. لم يتأثر معدل النمو النوعى معنويا بالتركيزات المتزايدة من زيت حبة البركة فيما عدا بعد ٨ و١٠ أسابيع. أيضاً لم يتأثر معامل الحالة معنوياً فيما عدا بعد ١٢ و ١٤ و١٦ و٢٢ أسبوع. زيادة مستوى زيت حبة البركة أدى الى تحسين معنوى فى طول وعمق الجسم، وبالإضافة الى ذلك كان لزيت حبة البركة تأثير معنوى أيضاً على كمية الغذاء المأكولة، بينما لم تظهر فروق معنوية فى معامل تحويل الغذاء لجميع العلائق المختبرة. فيما يتعلق بالمعادلات غير الخطية ووصف منحنى النمو أعطت معادلة Weibull و Morgan-Mercer-Flodin أعلى دقة يتبعهما معادلة Von Bertalanffy ثم النموزج الخطى. وتوصى هذه الدراسة أن اضافة زيت حبة البركه فى علائق البلطى النيلى أدى الى تحسين اداء النمو والإستفادة من الغذاء وبالنسبة لمنحنى النمو كان نموذج Weibull و Morgan-Mercer-Flodin أفضل النماذج لوصف منحنى النمو.