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Growth Performance of Flathead Mullet Fry in Green Water as Affected by Dietary Protein Level during Secondary Rearing

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ABSTRACT

The effect of protein content of nursery diet on growth performance of mullet fry (*Mugil cephalus*) and water quality dynamics in green water tanks was studied. The experiment consisted of three treatments, with three replicate tanks per treatment as follows: the corn - fertilizer treatment, the 25% crude protein treatment and the 35% crude protein treatment**.** Grey mullet fry grew heavier when fed on the 25% - crude protein diet than those fed on corn or 35% - crude protein diet. Mean individual weights of fingerlings at harvest after 45 days of rearing were significantly higher for fry stocked in the 25% - crude protein treatment (7.5 gm / fingerling) compared to those reared on the corn treatment (5.9 gm / fingerling) or the 35% - crude protein treatment (6.9 gm / fingerling). Controlled fertilization of culture tanks in the corn treatment was effective in producing good bloom of algae needed for fingerlings nutrition. Therefore, for rearing of grey mullet fry in concrete tanks, it is recommended to fertilize water, when low quality single ingredient diet (such as ground corn) is used to promote growth conditions in green water system. The results indicated that the use of cheap corn and chemical fertilizer can yield moderate growth performance in terms of harvest size (5.9 gm./ fingerling) and specific growth rate (4.0% per day) compared with feeding grey mullet fry with compound diets (25% - crude protein) that yielded significantly higher harvest size (7.5 gm / fingerling) and growth rate (4.8% per day). When searching for alternative sources for the nutrition of mullet fry ,the present study indicated that the best growth and feed performance during secondary rearing were obtained when feeding mullet fry with 25% - crude protein diet while the best economic efficiency was obtained when feeding grey mullet fry with ground corn (6.58 L.E/kg fingerlings)., followed by the use of 25%-crude protein diet (10.16 L.E / kg fingerlings). The least feed costs (6.58 L.E/ kg) with moderate growth (4.0%) per day and survival (65.0%) were obtained when ground corn was used in green water tanks.

Keywords: Mullet, Green Water Dietary Protein Level.

INTRODUCTION

The striped grey mullet (*Mugil cephalus* L.) has a cosmopolitan distribution. It is an economically important euryhaline and eury thermal species contributing to sizable fisheries of estuarine and coastal regions in many countries including China (Chang *et al*., 2004). Since long time, the mullets are considered among the most interesting coastal species for aquaculture (Khemis *et al*., 2006). They are consumers of the low trophic levels, and can therefore be used in most economic and efficient way by culturing them extensively (Crosetti and Cataudella, 1995).

Wild mullet fry especially *Liza ramada* and *Mugil cephalus* are the two species considered as important commercial fishes in Egypt, also they play an important role in world fishery and aquaculture (El- Gobashy, 2009). Flathead grey mullet *Mugil cephalus* is the most important cultured mullet species. Egypt is the largest producer of farmed mullets, producing about 70% of the reported global production (El-Sayed and El-Ghobashy, 2011).

Meanwhile, the annual production of farmed mullet in Egypt is approximately 140 000 tonnes accounting for approximately 15 percent of the total aquaculture production (GAFRD, 2012).

The study of their feeding activity is of particular interest for a better understanding of ecosystem functioning (Lebreton *et al*., 2011), because mullet are among the few large fish able to feed directly on the lowest trophic levels (Laffaille *et al*., 2002; Gautier and Hussenot, 2005). Different kinds of green water techniques are extensively used in the culture of many other marine fish species (Fushimi, 2001; Lee and Ostrowski, 2001; Liao *et al*., 2001; Shields, 2001).

Development of mullet farming will depend on the availability of reliable feeds at a reasonable price (Wassef, 2000). Although natural food may provide certain micronutrients to farmed mullet, the use of supplementary feeds resulted in higher yields and produced high quality fish product (Wassef *et al*., 2001). The importance of algae as a possible alternative protein source for cultured fish feeding has been recognized (Wassef *et al*., 2001).

Unfortunately, there is lack of information on nutrient requirements of mullet, and different species (*Mugil cephalus, Chelon labrosus, Liza aurata, Liza ramada, and Liza saliens*) could have different nutritional requirements according to their feeding habits (Benetti and Fagundes Netto, 1991; Argyropoulou *et al*., 1992; Ojaveer *et al*., 1996).

Despite the worldwide potential of mullet for intensive aquaculture, little attention has been given to their nutritional requirements (EL-Sayed, 1994). Only few studies have been reported on the formulation of practical diets of cultured mullets under different culture conditions (EL-Sayed, 1994).

Because protein is the most expensive component of fish diets, (Carvalho *et al*., 2010), determination of the optimum protein requirement can lead to the development of a diet that will provide high growth rates at a minimum cost (Lee *et al*., 2002).

The present study was conducted to investigate the effect of selected dietary protein levels on the growth and feed efficiency of the fry of mullet in green water, namely *Mugil cephalus*, which are considered as important cultivable species in Egypt.

MATERIALS AND METHODS

Experimental design

The rearing experiment of mullet fry (*Mugil cephalus*) took place at the Fish Research Unit, Faculty of Agriculture, Cairo University, Egypt. The experiment was conducted in outdoor concrete tanks. The experimental tanks were filled with water to a depth of 75-cm from a nearby well water. Each tank had a surface water area 2.4 - 2.6 m^2 and water volume of 2.0 m^3.

The effect of protein content of nursery diet on growth performance of mullet fry (*Mugil cephalus*) and water quality dynamics in green water tanks was studied. The flathead mullet rearing experiment lasted 45 day and took place during May-June 2013,

The flathead mullet fry (initial weight =0.81-1.0g/fry) were randomly distributed among 9 experimental tanks. The experiment consisted of three treatments, with three replicate tanks per treatment as follows:

The corn and fertilizer treatment

The mullet fry were fed fine ground corn in green water tanks at a daily fixed feeding rate of 11 grams/tank/day, six days a week .Water were fertilized with ammonium nitrate and super- phosphate fertilizers at the rate of one gram nitrogen and 0.25 gram phosphorus per square meter of culture tank area on a weekly basis for the whole experimental period.

Green water were developed in the corn treatment before stocking of mullet fry. Mullet fry depended on ground corn and algal matter as sources for nutrition during the rearing period. Grey mullet fry were stocked at 40 fry (I.W=1.0 gram/fry) in each tank.

The 25% crude protein treatment

Grey mullet fry were fed crumbles of 25% -crude protein commercial pellets (Joe, trade company-Nasr city-Egypt) at a daily fixed feeding rate of 11.0 grams/tank/day, six days a week. Water were not fertilized during the rearing experiment. Green Water were developed in each tank as a result of nutrient enrichment induced by feeding. Grey mullet fry were stocked at 40 fry (I. W. = 0.86 gm / fry) per tank.

The 35% crude protein treatment

Grey mullet fry were fed crumbles of 35% crude protein commercial pellets(Joe trade company-Nasr city-Egypt) at a daily fixed feeding rate of 11.0 grams/tank/day, six days a week .Water were not fertilized during the rearing experiment. Green water were developed in each tank as a result of nutrient enrichment induced by feeding. Grey mullet fry were stocked at 40 fry (I.W.=0.81 gram/fry) per tank.

Two week prior to fry stocking, all tanks were fertilized with urea and super-phosphate at a rate of 2.0 grams N and 0.5 grams phosphorus per square meter per week to enhance algal bloom. After stocking, only corn tanks were fertilized weekly at 1.0 gram nitrogen and 0.25 gram phosphorus per square meter per week for the whole experimental period. Ammonium nitrate (33.4% nitrogen) and super phosphate (15.38% P_2O_5) were the nitrogen and phosphorus sources for the chemical fertilizer treatment.

2. Oxygen and pH dynamics

Calculations that predict nighttime decline in DO were based on Boyd *et al*. (1978) and Romaire and Boyd (1979) .The projection method was based on assuming that the DO decline during nighttime is essentially linear with respect to time. When DO concentration at dusk and at nighttime are plotted versus time ,a straight line through the two points was projected to estimate DO at dawn or at other times during night. Boyd and Tucker (1998) indicated the high accuracy of the projection method in predicting DO concentration at dawn compared with measured values. Romaire and Boyd (1979) indicated that the nighttime dissolved oxygen model gave highly reliable prediction of early morning DO concentration. An additional simplifying assumption was made not to correct daytime net primary production (dNPP) or nighttime community respiration (nCR) for diffusion according to Hargreaves and Steeby (1999).

Water temperature was measured at early morning and dusk while DO and pH were measured three times daily (at early morning. dusk and nighttime) The duration of nighttime hours during the last month of the experiment was approximately 11 hours .

Oxygen and pH budget calculations

Oxygen dynamics

- Night time community respiration per hour ($nCRh^{-1}$) = (dusk oxygen concentration - nighttime oxygen concentration) /4
- Night time community respiration (nCR) = hourly nighttime community respiration *11
- Daytime net primary production (dNPP) = dusk oxygen concentration – dawn oxygen concentration
- Dawn oxygen surplus /deficit = dNPP – nCR

Growth Performance

Growth performance of cultured fish was measured in terms of final individual fish weight (g), daily weight gain (g/fish /day),specific growth rate (SGR-%/day), condition factor and feed conversion ratio (FCR).The growth performance parameters were calculated as follows :

Daily weight gain (DWG)

DWG = (final body weight -initial body weight)/ experimental period (days).

Specific growth rate (SGR)

Specific growth rate based on weight (SGRW) were determined as :

$$SGRW = (\ln W_t - \ln W_0)*100 /t$$

Where W_t is weight at time t,
W_0 weight at time 0 and t is the duration of time in days.

Condition factor (CF)

The condition factor was calculated as:

$$CF = \text{body weight}/(\text{fork length})^3*100$$

Feed conversion ratio (FCR) and protein efficiency ratio (PER)

Feed efficiency was determined as the gram of wet weight gain of fish per gram of dry diet consumed.

FCR=dry weight of feed fed (g) /fish weight gain (g).

PER= weight gain (g) / protein intake (g)

Water quality parameters

Water quality parameters relevant to the experiment were measured. Temperature and dissolved oxygen were measured using YSI environmental instrument (model 1700) dissolved oxygen meter .Estimates of secchi disk visibility were made at the same time in each concrete tank. pH was measured by pH digital meter (WTW 315 i set) at the laboratory just after water sample collection in a small container.

Statistical analysis

Growth and feed performances of cultured fishes as well as water quality parameters in culture tanks were subjected to one –way analysis of variance to determine statistical significant differences among treatments. Differences between means were assessed by Duncan multiple range test (Duncan, 1955). Statistically significant differences were determined by setting the aggregate type I error at 5% ($p < 0.05$) for each comparison. These statistical analyses were performed using the software package SPSS for windows, Release 8.0 (SPSS, 1997).

Table 1. ***Chemical composition of experimental diets***.

Proximate composition(%)	Corn	25% CP	35% CP
Moisture	11.00	9.61	9.65
Crude protein	8.50	24.96	35.22
Crude lipid	3.80	2.46	2.00
Ash	1.30	9.37	8.58
Crude fiber	2.60	2.89	2.25
NFE	72.80	44.71	42.30
Total	100	100	100

RESULTS AND DISCUSSION

Growth performance of flathead grey mullet

Average body weight

Growth performance data of flathead mullet are shown in Table 2. Flathead mullet fry were stocked at initial sizes of 0.81 – 1.0 gram in rearing tanks. Mean individual weights of fingerlings at harvest after 45 days of rearing were significantly higher (p<0.05) for fry stocked in the 25% - crude protein treatment (7.5 gm. / fingerling) compared to those reared on the corn treatment (5.9 gm / fingerling) or the 35% - crude protein treatment (6.9 gm. / fingerling). The latter treatments were statistically similar (P>0.05).

During the rearing period, fingerlings fed the 35% - crude protein diet were slightly heavier than those fed on the ground corn (single ingredient diet). This would indicate the role of algal matter in mullet fry nutrition. This was due to the superior nutritional value of algal matter produced in the fertilized (corn) treatment.

Shofiquzzoha *et al*. (2001) demonstrated that *M. cephalus* arrived at 7.30–10.91 g from an initial size of 1.22 g in an 85-day polyculture. However, this fish attained growth of 61–91 g in 90 days under different salinities (Barman *et al*., 2005). Controlled fertilization of culture tanks in the corn treatment was effective in producing good bloom of algae needed for fingerlings nutrition. The addition of corn to fertilized fry tanks, were most efficient in growing mullet fry to large size similar to that of the 35% - crude protein treatment (p>0.05) .

Therefore, for the rearing of grey mullet fry in concrete tanks, it is recommended to fertilize water, when low quality single ingredient diet (such as ground corn) is used to promote growth conditions in green water system.

Condition factor

The condition factor of mullet fingerlings fed on the single ingredient diet (1.07) did not differ significantly compared to those fed on the 25% - crude protein (1.1) or the 35% - crude protein (1.09) diets (p> 0.05) . The condition factor of mullet fingerlings indicated isometric growth and similar roundness of body shape.

Growth rate

Specific growth rates, weight gain and harvest data are shown in Table 3. The highest specific growth rate for grey mullet fingerlings (4.8% per day) was obtained when fry were fed on the 25% - crude protein and 35% - crude protein diets. Mean growth rate

Table 2. ***Growth performance of flathead grey mullet fry under different dietary protein levels uring secondary rearing.***

Parameter	Corn	25%CP	35%CP
Initial weight (gram/fry)	1.0 ^{a} ± 0.1	0.86 ^{a} ± 0.11	0.81 ^{a} ± 0.12
Initial length (cm)	4.9 ^{a} ± 0.07	4.5 ^{a} ±0.44	4.5 ^{a} ± 0.22
Final weight (gram/fingerling)	5.9 ^{b} ± 0.32	7.5 ^{a} ± 0.27	6.9 ^{ab} ± 0.80
Final length (cm)	7.5 ^{a} ± 1.0	8.7 ^{a} ± 0.21	8.5 ^{a} ± 0.18
Conditionfactor (initial)	0.80 ^{a} ± 0.04	0.94 ^{a} ± 0.14	0.86^{a} ± 0.03
Conditionfactor (final)	1.07 ^{a} ±0.051	1.10^{a} ± 0.04	1.09^{a} ± 0.07

Means in the same row with different letters are significantly different (p<0.05)

for fingerlings reared on the ground corn treatment were slightly lower (4.0 % per day), with significant differences among treatments ($p<0.05$) during the experimental period. Nursery rearing of flathead mullet fry in green water tanks fed ground corn was feasible, which indicates a potential for commercial production of flathead mullet fingerlings in green water tanks when fed low quality diets. The results indicated that the use of cheap corn and chemical fertilizer can yield moderate growth performance in terms of harvest size (5.9 gm./ fingerling) and specific growth rate (4.0% per day) compared with feeding grey mullet fry with compound diets (25%- crude protein) that yielded significantly higher harvest size (7.5 gm / fingerling) and growth rate (4.8% per day).

Body weight gain

The importance of algae as a possible alternative protein source for cultured fish feeding has been recognized (Wassef *et al***.,** 2001**).**

The 25% - crude protein diet gave the best weight gain (6.6 gm / fingerling and 0.15 gm / fingerling / day, respectively) and was significantly higher ($p<0.05$) in growth response than those of the ground corn treatment (4.9 gm / fingerling and 0.11 gm / fingerlings/ day, respectively) and the 35% - crude protein treatment (6.1 gm / fingerling and 0.13 gm / fingerling/ day, respectively). Sadek *et al*. (1986) obtained a low net yield of 0.14 g /m^2/ day in a semi-intensive polyculture of mullets (*L. ramada*, *L. scheli and M. cephalus*).

Good results were obtained in the current experiment ,when ground corn and the 25% crude protein diet were used. Consequently, the use of corn can be recommended as suitable diet for the rearing of grey mullet fry and fingerlings. Katz *et al*. (2002) have shown that rearing of mullets on the organically enriched sea floor below commercial fish farms substantially improves the status of these sediments. Mullet has often been stocked in fish ponds and reservoirs to improve sediment quality (Torras *et al*., 2000). However, in such environments, flathead grey mullet behave mainly as a planktivorous pump filter (Cardona, 1996).

Economic efficiency

When searching for alternative sources for the nutrition of grey mullet fry ,the present study indicated that the best growth and feed performance during secondary rearing were obtained when feeding grey mullet fry with 25% - crude protein diet while the best economic efficiency was obtained when feeding grey mullet fry with ground corn (6.58 L.E/kg fingerlings), followed by the use of 25%-crude protein diet (10.16 L.E/ kg fingerlings). Feed costs for the production of one kilogram of mullet fingerlings under different dietary protein treatments are illustrated in Table 4.

Table 3. ***Weight gain and harvest data of flathead grey mullet fry under different dietary protein levels during secondary rearing.***

Parameter	Corn	25%CP	35%CP
Weight gain (g/fry)	4.9 b ± 0.22	6.6 a ± 0.16	6.1 a ± 0.89
Daily weight gain (g/ fry/ day)	0.11 b ± 0.005	0.15 a ± 0.003	0.13 a ± 0.02
SGR	4.04 b ± 0.10	4.8 a ± 0.30	4.8 a ± 0.56
Stocking density (units/tank)	40	40	40
Fry harvest (units/ tank)	26 b	28 a	20 c
Fry harvest (units/ m^2)	10.4 b	11.2 a	8.0 c
Survival (%)	65 b	70 a	50 c

Means in the same row with different letters are significantly different ($p<0.05$).

From economic analysis it is obvious that ponds which received combined fertilization–feeding , significantly outperformed the fertilization or feeding system (Biswas *et al*., 2012). The feed costs applied per one kilogram fingerlings for different protein treatments indicated that these costs were highest for the 35% - crude protein treatment (20.26 L.E./ kg). The feed costs for the ground corn and 25% - crude protein treatments averaged (6.558 and 10.16 L.E/ kg, respectively). The least feed costs (6.58 L.E/ kg) with moderate growth (4.0%) per day and survival (65.0%) were obtained when ground corn was used in green water tanks.

The best growth rate (4.8%) and survival (70.0%) were obtained in the 25% crude protein treatment when feed costs averaged 10.16 L.E/ kg fingerlings. The use of fertilizers in green water tanks enhanced algal biomass and micro- organisms, which provided the essential nutrients needed for mullet fry growth in the ground corn treatment. The use of inorganic fertilizers was recommended for pond production of walleye fry because it is easier and less costly than traditional methods involving the use of organic fertilizers (Soderberg *et al*., 1997).

The use ground corn in green water tanks in the current experiment was the most profitable treatment recommended in terms of costs and production volume, when combining growth performance, survival and feed costs data. The ground corn gave approximately close results to those of compound feeds. This was due to the higher biological value of algal matter produced in green water tanks.

Table 4. ***Feed performance of flathead grey mullet fry under different dietary protein levels during secondary rearing.***

Parameter	Corn	25% CP	35% CP
Feed inputs (g feed / tank)	420	420	420
Feed conversion ratio (FCR)	3.29 a ± 0.15	2.26 b ± 0.068	3.49 a ± 0.47
PER	3.38 a ± 0.15	1.76 b ±0.049	0.82 c ± 0.071
Feed cost/ kg fry harvest(L.E.)	6.58	10.16	20.26

Table 5. ***Water quality of flathead grey mullet*.**

Parameter	corn	25% protein	35% protein
Early morning temperature (ºC)	27.06	27.4	26.7
Dusk temperature (ºC)	29.6	29.9	28.6
Early morning Oxygen(mg/L)	2.53	1.92	2.27
Dusk Oxygen(mg/L)	16.07	11.63	11.47
Oxygen gain (grams O_2/m^2/day)	13.2	9.70	9.19
Secchi disk (cm)	23.0	29.5	30.0
Early morning pH	8.85	8.82	9.05
Dusk pH	9.21	9.13	9.30
pH gain during daytime	0.35	0.30	0.25

Feed efficiency of Mugil cephalus

Depending on their habitat, mullets can have many feeding strategies (e.g. water filtering, sediment scraping) to exploit the most accessible food resources, in terms both of quantity and quality (Almeida *et al*., 1993). Detritus and benthic diatoms constitute a large proportion of stomach contents of mullets (Lebreton *et al*., 2011). *Mugil cephalus* is a bottom feeder and feeds on benthic and periphyton organisms as well as detritus. Grazing pressure is exerted by the mullet, which primarily feed on attached planktonic flora and fauna (Jana *et al*., 2004). Taking the average from three environments, it was seen that decayed organic matter formed 37.6% of the stomach contents of *Mugil cephalus* and the blue-green algae were next in importance, forming 17.8% of the gut content (Das, 1977). *M. cephalus* feeding on diatoms, on the whole, formed 10.8% of the gut contents of the fish. Sand grains, amounted to 29.93% browsing on the bottom, these were swallowed along with the algae and decaying organic matter (Das**,** 1977).

Feed utilization data in terms of feed conversion ratio, protein efficiency ratio and feed inputs are shown in Table (4). Although growth performance parameters were highest among the 25% and 35% - crude protein diets, the highest value for protein efficiency (PER) was obtained in fish fed the corn diet (3.38).The 25% - and 35% crude protein diets yielded lower PER values which ranged between 1.76 to 0.82, respectively ($p<0.05$).

Lupatsch *et al*. (2003) assumed that about 50% of the organic carbon in the sediment was digestible, depending on the enrichment by bacteria or protozoa, and that the other 50% went back unaltered, to the environment. Of the digestible energy and protein, 28% and 30%, respectively, were retained as growth (Lupatsch *et al*., 2003), and the remainders were released as CO_2 and H_2O for energy or NH_3 for protein, respectively.

There was a trend towards decreasing feed efficiency in terms of PER values with increasing dietary protein level in the current experiment. The highest feed efficiency in terms of protein efficiency was obtained in the corn treatment (3.38), followed by that of the 25% -crude protein treatment ($p<0.05$).

Richard *et al*. (2010) reported that natural food in marine ponds were more appropriate for rearing mullet than the classic dry feed and fiberglass tanks. Different vegetable proteins seem to have different nutritional value for mullet and different mullet species may respond differently to the same vegetable protein (Luzzana *et al*., 2005). Das (1977) indicated that the food of *M. cephalus* from the time they attain the fingerling stage largely consists of the decaying organic matter, fresh and decomposing algae, diatoms, copepods and foraminifera.

The corn treatment had feed conversion ratio of 3.29:1, while the 25% - crude protein treatment had a feed conversion ratio of 2.26:1, with significant differences among treatments. The low protein diets were more efficient in terms of protein utilization, indicating higher profitability in producing low cost mullet fingerlings. This was due to the higher capacity of mullet fingerlings in extracting large amounts of natural food organisms high in protein contents.

Mugil cephalus achieved an FCR of 1.6 when fed rice and peanut oil cake (Gautier and Hussenot, 2005). Richard *et al*. (2010) suggested that extensive rearing of mullets in marine ponds could be more efficient than rudimentary intensive rearing in artificial rearing devices.

Moreover, Jana *et al*. (2004) found that grey mullet (*M. cephalus*) could efficiently use periphyton that colonized the bamboo substrates in inland saline ground water. In aquaculture effluents, they are also capable of stimulating bacterial degradation processes and, retaining some waste nutrients as harvestable flesh (Erler *et al*., 2004: cited in Abd-Tawwab *et al*., 2005).

Survival rates of Mugil cephalus

The small fry of *M. cephalus* (15–25 mm) are not suitable for direct stocking in grow-out ponds (Biswas *et al*., 2012). Since the growth of this fish is slow during early life stage (Saleh, 2008), it is desirable to conduct prestocking seed rearing to obtain bigger size individuals suitable for grow-out in culture ponds (Biswas *et al*., 2012).However, there is a lack of substantial information on the rearing density and role of feeding and pond fertilization in production of stockable size grey mullet fingerlings (Biswas *et al*., 2012).

Flathead mullet fingerlings were stocked at 16 fingerlings /m^2 and were harvested from different treatments at the rate of 10.4 to 11.2 fingerlings /m^2 of rearing tanks area in the corn and 25% - crude protein treatments, respectively. The survival rate for those treatments ranged 65 to 70 %, with significant differences among means ($p<0.05$).

Extrapolated harvest volumes in the current experiment were equivalent to 43.0 to 47.0 thousands fingerlings from each feddan of rearing ponds .The current value of farm gate price for mullet fingerlings is 1.5 L.E. /one piece of fingerling .The sale price for the current harvest volume ranged 64.5 to 70.5 thousands Egyptian pounds per one feddan of rearing ponds, which is considered optimal in terms of economic efficiency during 45 day rearing period. The highest survival rate was obtained in fish fed on the 25% protein diets while the lowest survival was obtained in fish fed on the 35% crude protein diet ($p<0.05$).

Water quality dynamics

Water temperature in experiments tanks ranged from 26.7 to 27.4 C^o at early morning, with no significant differences among treatments (p>0. 05). Similarly, water temperature at dusk ranged from 28.6 to 29.9 C^o, with statistical similarity among treatments during the experimental period (p>0. 05). The heat gain from early morning to dusk hours ranged 1.9 to 2.5 C^o during daytime period .Average water temperature was optimal for fish growth and algal production in all treatments according to Boyd (1990).

Oxygen at early morning, dusk and oxygen gain

Early morning oxygen concentrations ranged 1.92 to 2.53 g O_2/m^2 among treatments, with no significant differences among means ($P>0.05$). Early morning oxygen concentrations were close to 2.0 g O_2 / m^2 which are considered optimal concentration at early morning hours. While oxygen concentrations at dusk ranged 11.47 to 16.0 g O_2 / m,^{2} with significant differences between treatments. Oxygen concentration at dusk in the corn treatment was highest 16.0 g O_2/m^2.This was mainly due to the dense algal bloom observed in the corn treatment (secchi disk=23.0 cm) compared with those of the 25% - and 35% - crude protein treatments (29.5 and 30.0 cm, respectively). The dense algal bloom observed in the corn treatment may reflect the good growth performance observed in the corn treatment.

Oxygen gain during daytime ranged 9.19 to13.2 g O_2/m^2/ daytime, with the corn treatment being the highest in terms of oxygen gain compared to all other treatments. This was mainly due to the dense algal bloom observed in the corn treatment .The increase in algal abundance increased the photosynthetic rate and oxygen production (oxygen gain).

Secchi disk

Ponds used for rearing fry are turbid with phytoplankton which grow in response to the application of fertilizer or diets .Thus, the secchi disk visibility provides an index of algal abundance. Boyd (1990) indicated that phytoplankton turbidity between 20-30 cm is considered good for herbivores such as mullet and tilapia.

There is a growing international body of evidence for significant advantages from adding phytoplankton to larval fish rearing systems (Liao *et al*., 2001; Papandroulakis *et al*., 2001, 2002; Faulk and Holt, 2005). Use of algae in the rearing water may be considered as short-term enrichment of the live prey, and can alter both protein and lipid content of the larval food (reviewed by Reitan *et al*., 1997). Algae have also been considered as a stabilizing factor on water quality, particularly with respect to bacterial composition (Van der Meeren, 2007).

Boyd (1990) and Boyd and Tucker (1998) reported that when ponds received the application of fish feed, phytoplankton abundance was good because nearly 75% of the nutrients in feed are excreted into water, thus enhancing algal production and biological turbidity. Secchi disk readings are affected by excretion rates of ammonia and phosphate through metabolic activities of fish (Boyd, 1990).

Secchi disk visibility was lower in the ground corn treatment (23.0 cm) than those of the 25%-crude protein (29.5 cm) and the 35% crude protein (30.0cm) treatments ($p < 0.05$). Phytoplankton abundance is considered good for pond conditions in all treatments since the overall average of secchi disk readings ranged 23.0-30.0 cm among treatments.

Flathead grey mullet have important effects on pond ecology. The stocking of this species at densities of about 240 g/m^3 in fishless microcosmos increased water turbidity (Torras *et al*., 2000). Flathead grey mullet enhanced phytoplankton development due to the removal of large cladocerans and not as a consequence of nutrient release. Furthermore, the flathead grey mullet strongly modified the benthic community, probably due to direct predation (Torras *et al*., 2000). The nutrient regeneration was calculated by the difference between nutrient intake and the contents in growth and feces (Kang and Xian, 2008).

c. PH dynamics

Early morning pH values in rearing tanks ranged 8.82 – 9.0 units among treatments, with no significant differences among means ($P>0.05$).

pH values at dusk time ranged 9.13 to 9.3 unit among treatments ($p>0.05$). The increase in dusk pH value in the 35% - crude protein treatment did not reflect a higher pH gains since early morning pH was high in value. The daytime pH gain was slightly highest in the corn treatment (pH gain = 0.35) compared with those of the 25% - and 35% crude protein treatments (pH gain = 0. 30 and 0.25, respectively). This may reflect the high oxygen gain observed in the corn treatment.

CONCLUSION

The results indicated that the use of cheap corn and chemical fertilizer can yield moderate growth performance in terms of harvest size (5.9 gm./ fingerling) and specific growth rate (4.0% per day) compared with feeding grey mullet fry with compound diets (25%- crude protein) that yielded significantly higher harvest size (7.5 gm / fingerling) and growth rate (4.8% per day). Therefore, for the rearing of grey mullet fry in concrete tanks, it is recommended to fertilize water, when low quality single ingredient diet (such as ground corn) is used to promote growth conditions in green water system. Therefore , It is concluded that the best growth and feed performance during secondary rearing can be obtained when feeding grey mullet fry with 25% - crude protein diet while the best economic efficiency was obtained when feeding grey mullet fry with ground corn (6.58 L.E/kg fingerlings), followed by the use of 25%-crude protein diet (10.16 L.E/ kg fingerlings).

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أداء النمو فى زريعة البورى الحر فى المياه الخضراء تحت تاثير مستوى بروتين العليقه خلال الحضانه الثانويه

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يشمل البحث دراسة تاثير محتوى البروتين فى عليقة الحضانه على نمو زريعة البورى وديناميكية جودة المياه فى احواض المياه الخضراء . تتكون التجربه من ثلاث معاملات بمعدل ثلاث تكرارات لكل معامله كالتالى : معاملة الذره والتسميد ومعاملة التغذيه بمستوى بروتين ٢٥% ومعاملة التغذيه بمستوى بروتين ٣٥%. وعند تغذية زريعة البورى بالعليقه المحتويه على ٢٥% بروتين خام وصلت الزريعه الى احجام اكثر وزنا بالمقارنه بالتغذيه على الذره المطحونه او العليقه المحتويه على ٣٥%بروتين خام (مستوى معنويه٥%). وبعد مرور ٤٥ يوم من فترة الحضانه لوحظ ان الزريعه المغذاه على عليقه ٢٥% بروتين خام قد وصلت الى وزن ٧,٥ جرام للسمكه الواحده بالمقارنه بالزريعه المغذاه على الزريعه الذره المطحونه (وزن الحصاد ٥,٩ جرام للسمكه الواحده) أو الزريعه المغذاه على عليقه ٣٥% بروتين خام (٦,٩ جرام للسمكه الواحده). وقد كانت فاعلية تسميد مياه الاحواض ذات كفائه عاليه فى معاملة الذره حيث تم انتاج ازدهار جيد للطحالب ساهم الى حد كبيرفى تغذية الاصباعيات لذلك توصى التجربه بتسميد احواض الحضانه الخاصه بزريعة البورى حتى تساعد على زيادة انتاج الطحالب فى المياه وبذلك نتمكن من تغذية الزريعه بالذره المطحونه منخفض الجوده الغذائيه وفى نفس الوقت نحصل على نمو جيد لاصباعيات البورى. وتوضح نتائج التجربه ان استخدام الذره المطحونه رخيصة الثمن بالاضافه الى التسميد الكيميائى لمياه احواض الحضانه يعطى سرعة نمو معتدله بالنسبه لحجم حصاد الاصباعيات (٥,٩ جرام للسمكه الواحده) وكذلك سرعة نمو جيده (٤ % فى اليوم)بالمقارنه بتغذية زريعة البورى على العلائق المركبه (٢٥% بروتين خام)التى انتجت وزن حصاد اكبر نسبيا (٧,٥ جرام للاصباعيات) وسرعة نمو عاليه نسبيا (٤,٨ % فى اليوم).وعند البحث عن المصادر البديله المتعدده لتغذية زريعة البورى نجد ان الدراسه الحاليه اوضحت ان افضل نمو واكثرها كفائه غذائيه خلال الحضانه الثانويه يمكن الوصول اليها عن طريق تغذيه زريعة البورى بعليقه تحتوى على ٢٥% بروتين خام بينما يمكن الحصول على افضل كفاءه اقتصاديه من تغذية زريعة البورى على الذره المطحونه (تكلفة تغذية الكيلو جرام الواحد من محصول الاصباعيات يساوى ٦,٥٨ جنيه مصرى) يليها فى الكفاءه الاقتصاديه التغذيه بعليقه تحتوى على ٢٥ % بروتين خام (تكلفة تغذية الكيلو الواحد من محصول الاصباعيات يساوى ١٠,١٦ جنيه مصرى) . وأوضحت الدراسه ان أقل المصادر الغذائيه فى تكلفة التغذيه (٦,٥٨ جنيه مصرى للكيلو جرام اصباعيات) مع الحصول على سرعة نمو معتدله (٤% فى اليوم) والحصول على نسبة اعاشه معتدله (٦٥%) هى عن طريق تغذذية الاصباعيات بالذره المطحونه فى احواض المياه الخضراء.