The Bioscan 11(1): 101-106, 2016
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF PARTIAL SUPPLEMENTATION OF DUCKWEED (*LEMNA MINOR*) ON GROWTH AND SURVIVAL OF *LABEO ROHITA* (HAMILTON, 1822) FRY

R. R. MER, K. H. VADHER AND M. R. PATEL*
[1]Department of Aquaculture,
College of Fisheries, Veraval - 362 265, Gujarat, INDIA
e-mail: mika.patel9@gmail.com

KEYWORDS
Duck weed
Growth performance
Partial supplementation
Fish meal
Labeo rohita.

Received on :
13.09.2015

Accepted on :
19.02.2016

***Corresponding author**

ABSTRACT
The acceptable nutritional value of Lemna as an ingredient in diets for *Labeo rohita* fry was experimented under aquarium culture system for 60 days. For that purpose fry of approximately equal weight(51.70 mg ± 1.18)were distributed in groups of 15 to each four aquaria at 0% (T1), 10% (T2), 20% (T3), 30% (T4) and 40% (T5) inclusion levels of Lemna. Maximum mean weight gain (136.19 ± 26.85 mg) was observed in T1 and minimum (106.11 ± 36.60 mg) was observed in T5 at the end of the experiment.Among the treatments tested, the highest survival (86.66% ± 9.43) was recorded in treatment T3 and minimum was found in T5 (41.66% ± 13.74). Lowest FCR was recorded in treatment T3 (2.36 ± 0.55) and highest was found in T5 (2.65 ± 0.14).Higher SGR was observed in treatment T1 (226.98 ± 44.74%) and minimum was observed in T5 (176.84 ± 61.00%). Higher PER was observed in Treatment T3 (1.10 ± 0.22) and minimum was found in T5 (0.34 ± 0.31).The study clearly showed that fry fed diet of 20% duckweed dietary inclusion performs best result and fishmeal was non replaceable but can be supplemented with duckweed up to an optimum level to produce cost effective feed.

INTRODUCTION

The effect of partial supplementation of duckweed on growth, survival rate, Feed conversion ratio (FCR), Specific growth rate (SGR) and Protein efficiency ratio (PER)of *L. rohita* were evaluated.Disposal of domestic wastewater in to fresh water bodies is constantly adding nutrients in to water, which is mainly responsible for increase in the concentration of nitrogen and phosphorus (Patel and Kanungo, 2010).

Bairagi *et al.* (2002) conducted an experiment on Duckweed (*Lemna polyrhiza*) leaf meal as a source of feedstuff in formulated diets for rohu (*Labeo rohita* Ham.) fingerlings after fermentation with a fish intestinal bacterium. Growth response of common carp, *C. carpio* to aquatic weed incorporated diets was studied by Somashekar *et al.* (2003). *Pistia stratiotes* and *Lemna major* as major ingredients and dried silkworm pupae powder as minor ingredient were used for advanced fry of common carp and growth was compared with conventional feed *i.e.* rice bran and ground nut oil cake in the ratio of 1:1. Yilmaz *et al.* (2004) studied use of duckweed, *Lemna minor*, as a protein feedstuff in practical diets for common carp, *Cyprinus carpio*, fry. Effect of feeding duckweed (*Lemna Minor*) based diets on the growth performance of Rohu, *L. Rohita* (Ham.) was studied by Kaur *et al.* (2012). Mohapatra and Patra (2013) studied effect of partial replacement of fishmeal with duckweed (*L. minor*) feed on the growth performance of *C. carpio* fry.

Significant efforts has been directed towards evaluating the nutritive value of different non-conventional feed resources including terrestrial and aquatic macrophytes to formulate nutritionally balanced and cost effective diet for fish and poultry {Edward *et al.* (1985).; Patra and Ray (1988); Ray and Das (1995).; Wee and Wany (1987)} and use of plant proteins in fish diets will reduce feed cost, which will also assist in reducing the total dependence on fishmeal as the protein source.The present trial was undertaken to quantitatively analyze the comparative efficacy of different formulated feeds of plant and animal origin in relation to growth of fry of *Labeo rohita*. The feeds selected for this investigation are fish meal of animal origin and duckweed (*Lemna minor*) meal of plant origin. Duckweed meal has been known for its high nutritive value with as much as 40% and above crude protein depending on the culture system reported by Ahamad *et al.*, 2003.; Leonard (1995).; Hassan and Edwards (1992).; Robinnette *et al.*, (1980).; Hanczakowski *et al.*, (1995). At present both protein and energy rich conventional dietary ingredients are of short supply. Therefore, there is a need to incorporate unexplored unconventional locally available cheaper feed stuffs in fish feeds. To reduce the dependence on animal based protein in fish diet, plant based protein food stuffs are used to decrease artificial fish meal cost (Mohapatra and Patra,2014). The present study was conducted to assess the suitability or otherwise of duckweed meal as a partial replacement for the artificial meal in the diet of *Labeo rohita* fry.

MATERIALS AND METHODS

Experimental fish

Labeo rohita was selected for the present experiment. The rationale of its selection was that it has excellent growth rate, easy availability, wide distribution, commercial importance and tastiest fishes among the Indian major carp.

Fry of *Labeo rohita* were obtained from Government fish farm and acclimatized for 15 days interval in laboratory condition on the feed supplement containing rice bran and Groundnut oil cake (GNOC) in order to habituate them for artificial feeding. Thereafter, during experimental period of 60 days(Pattanaik and Patra, 2012), the fishes were fed with formulated artificial diets @5% body weight/day.

The weight of fry were measured after every 15 days and based on the increase in body weight of fry and their ration was readjusted @ 5% of their body weight twice daily {Mohapatra and Patra (2013)}.

Experimental diets

The present experiment was undertaken to utilize the aquatic weeds, ground nut oil cake (GNOC) and fishmeal to prepare the experimental diet. The ingredients, i.e. rice bran, tapioca starch were also used. Duckweed (*Lemna minor*)were procured from local area and were dried and ground to powder form. Five diets were formulated in which fish meal and ground nut oil cake (GNOC) was partially supplemented with duckweed meal at 0%, 10%, 20%, 30% and 40% levels (Pattanaik and Patra, 2012).The diets were fortified with vitamins and minerals.Experimental feed were formulated following the Pearson Square method (Pearson and Tauber, 1984).

Experimental procedure

The experiment was carried out in a completely randomized design (CRD) and consisted of 5 treatments with four replicates for each treatment. *L. rohita*fry (51.70 mg ± 1.18 mg) were stocked at 15 nos. /plastic aquarium tank (2 x 2 x 1 feet) filled with 35 liters of filtered fresh water (Mohapatra and Patra, 2013). Continuous aeration was provided throughout the experimental period in order to maintain dissolved oxygen level in each aquarium. The study was conducted for 60 days. The water quality parameters, temperature, pH, DO, hardness were analysed through the methods outlined by APHA and weekly(A.P.H.A, 1998).

Proximate composition of ingredients

Proximate composition analysis of ingredients was performed by following standard methods AOAC (1995). Crude protein values were obtained by the micro-Kjeldahl digestion and distillation method.

Statistical analysis

All data presented are expressed as means ± standard error and was subjected to two way analysis of variance (ANOVA), followed by Duncan's Multiple Range Test with the help of SPSS-16.0 version software (Duncan, 1955).

RESULTS AND DISCUSSION

Feeds from plant origin have an excellent amino acid profile and have been reported to be highly effective and less expensive ingredient for formulation of fish diets (Jackson *et al.*, 1982; Mohapatra and Patra, 2013). In the past few decades, feeds from plant origin have been accepted for Indian major carps because the growth observed in these fish has been reported to be as good as that obtained with the traditional feed. In tropical developing countries, where algal production rates are high, algae have been receiving increasing attention as an alternate protein possessing relatively high protein content (50-65%), which may be included in balanced fish feeds (Ray and Das, 1995).

Incorporation of *Lemna* feed (commonly known as duckweed meal) to replace the fish meal in formulated fish feed can be attributed to achieve the goal of formation of cost-effective fish feed. The four inclusion levels of duckweed is experimental feed supported the growth for *Labeo rohita*. However, growth performance was favoured by optimum inclusion levels of duckweed meal in the experimental feed. In the present study, the experimental diets of *Lemna* meals are represented in Table 1.The ingredients of experimental diet include Fishmeal,

Table 1: Percentage composition of experimental feed of *Lemna*

Ingredients (%)	Diets (%) T1Control	T2(10%)	T3(20%)	T4(30%)	T5(40%)
Fish meal	32	30.5	29	27.5	26
GNOC	32	30.5	29	27.5	26
Duck weed	00	10	20	30	40
Rice bran	17	13.5	10	6.5	3
Tapioca powder	17	13.5	10	6.5	3
Vitamins and minerals	2	2	2	2	2
Total	100	100	100	100	100

Table 2: Proximate composition of experimental feed of *Lemna*

Lemna Feed	% Crude Protein	% Crude Lipid	% Ash	% Moisture	% Crude Fiber
0%	30.40	8.5	13.0	2.2	4.9
10%	30.21	6.8	12.2	1.4	4.5
20%	30.30	6.4	11.0	1.3	4.8
30%	30.02	6.0	10.3	1.6	5.2
40%	30.00	5.9	10.1	2.0	5.4

Table 3: Growth performance of *L. rohita* fry fed *Lemna* meal based feed for 60 days (± SE)

Parameters	0%	10%	20%	30%	40%
Initial weight (mg)	50.56 ± 1.24[a]	52.08 ± 0.65[a]	50.35 ± 0.77 [a]	52.63 ± 0.58 [a]	52.90 ± 0.59 [a]
Final wt. (mg)	186.75 ± 13.10 [a]	178.81 ± 12.67 [a]	182.68 ± 15.30 [a]	161.30 ± 16.43 [a]	159.00 ± 18.76 [a]
Total wt. gain (mg)	136.19 ± 13.43 [a]	126.73 ± 12.40 [a]	132.33 ± 15.53 [a]	108.67 ± 16.45 [a]	106.11 ± 18.30 [a]
FCR	2.1 ± 0.37 [a]	2.39 ± 0.10 [a]	2.04 ± 0.29 [a]	2.40 ± 0.23 [a]	2.58 ± 0.18 [a]
SGR	226.98 ± 22.37 [a]	211.22 ± 22.67 [a]	220.55 ± 25.89 [a]	181.12 ± 27.42 [a]	176.84 ± 30.50 [a]
PER	0.64 ± 0.43 [a]	0.89 ± 0.48 [a]	1.10 ± 0.22 [a]	0.76 ± 0.18 [a]	0.34 ± 0.31 [a]
% of survival	79.83 ± 6.03 [a]	78.32 ± 5.00 [a]	86.66 ± 4.72 [a]	78.33 ± 3.19 [a]	41.66 ± 6.87 [a]

Groundnut oil cake, *Lemna* (Duck weed), Rice bran, Tapioca powder, and vitamins and minerals at different proportions of *Lemna* meal. The proximate composition of the *Lemna* feeds are recorded in Table-2. The fish meal was supplemented by 0%, 10%, 20%, 30% and 40% *Lemna* feed. The highest percentage of crude protein (30.40%) was recorded at 0% replacement of *Lemna* feed and the least (30.00%) was at 40% replacement.

Data on growth performance, weight gain, survival rate, FCR, SGR and PER are presented in Table 3. A decreasing trend in growth performance was noticed with increasing level of *Lemna* feed from 10% to 40% replacement. It has also been observed that the growth performance of *L. rohita* in 0% replacement was more than the 10%, 20%, 30% and 40% replacement of *Lemna* feed so far as the protein content in respective replacement was concerned. This result is in agreement with the results obtained by Okoye and Mbagwu (1984), Bairagi *et al*. (2002), Das *et al*. (2007), Kalita *et al*. (2007) and Tavares *et al*. (2008). Mohapatra and Patra (2013) concluded that 15% lemna feed would be optimum for the maximum growth of *Cyprinus carpio*. In the present investigation also at lower supplementation rate of *L. minor* the growth rate was recorded higher.

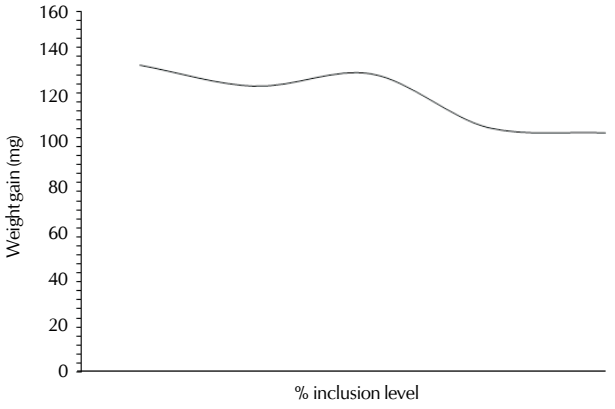

Figure 1: Total weight gain (mg) of *Labeo rohita* fed with % inclusion of *Lemna* meal based feed

The result indicated that as the *L. minor* incorporation level increased in the diet of *L. rohita* the survival rate was increased upto 20% supplementation but drastic reduction in survival rate was noticed at 40% supplementation of duckweed. Yilmaz *et al* .(2004) revealed that the highest survival rates were obtained in groups that were fed 5% and 10% duckweed diets. Mohapatra and Patra (2013) revealed that the percentage of survival rate was highest in 0% and lowest in 30% *Lemna* replacement with fish meal.

FCR was lowest in 20% and highest in 40% *Lemna* replacement fish meal. The result indicated that as the *L. minor* incorporation level increased in the diet of *L. rohita* the FCR was increased. Bag *et al*. (2012) revealed that low FCR of *L. minor* meal indicated that fish can easily digest the feed and convert these feed into their body mass. The lower FCR indicating an encouraging effect on economic involvement in fish farming. Fasakin *et al*. (1999) found that the difference in feed conversion ratio of tilapia that were fed diets containing up to 20% duckweed were not significantly different from those of tilapia that were fed the control diet. Das *et al*. (2007)

Village Pond fully covered with duckweed

Washing of Duckweed

Sun drying of duckweed

Vacuum packed *L. minor* powder in plastic bag

Siphoning of experimental tanks

Experimental animal

recorded 205% higher weight gain and about 105% higher feed conversion ratio in *L. rohita* fed with diets containing 20% dried *L. minor* powder and also saved about 20% of feed cost.

SGR was highest in 0% and lowest in 40% *Lemna* replacement fish meal. Guru and Patra (2007) also reported higher specific growth rate in *L. rohita* fingerlings fed with diets having 13.2% dried *Lemna* powder.Das and Ray (1989) demonstrated the possibility of incorporation of dried *Lemna polyrhiza* as a feed ingredient for *L. rohita* fingerlings, and recorded higher carbohydrate digestibility in relation to that of the control diet although the SGR and percent weight gain in fish fed *Lemna* meal were slightly lower than with the control diet.

The result of the present study indicated that as the *L. minor* supplementation level increased in the diet of *L. rohita* the PER was increased upto 20% supplementation of duckweed but reduction in PER was noticed at 30% and 40% supplementation of duckweed. Bag *et al*. (2012) revealed that protein efficiency ratio was significantly higher in *L. minor* meal fed fish than water hyacinth meal and azolla meal feed treatment indicating the better quality of protein in the feed produced from *L. minor* meal.

No doubt, animal protein is essential for the growth of carp, plant protein has no less importance for the same cause. Probably, due to that reason, the *Lemna* feed at 20% replacement has shown significantly higher ($P < 0.05$) impact than the other four treatments on the growth performance of the *L. rohita* (Figure 1). Therefore, considerable research effort is needed to determine the quantity and quality of dietary protein necessary to achieve optimum growth performance of fish. To formulate a low cost feed, ingredients from plant and animal sources are used to fulfill the protein requirement of the fish meal, fully or partially. So, fish nutritionists pay greater attention to reduce the cost of artificial diets by introducing alternative protein sources from plant and animal (Das *et al*., 1991).

This result is similar to the report of several authors who have demonstrated the use of several species of duckweed as partial replacement for fishmeal in the diet of fish and other animals. Bairagi *et al*., 2004 and Effiong *et al*., 2009 revealed that 30% formulated *Lemna minor* leaf meal incorporated in diet of *Clarias batrachus* fingerlings gave best performance in terms of growth response, food conversion ratio and protein efficiency.

Yilmaz *et al*. (2005) also observed no weight difference when 20% duckweed meal substituted for commercial fish meal in common carp *(Cyprinus carpio)*. The growth depression that was observed at 30% fermented Lemna leaf meal incorporated in the diet of *Labeo rohita* gave the best performance in term

of efficiency. The complete replacement of fish meal with duckweed is detrimental to fish production reported by Yilmaz *et al*. (2005). Tavares *et al*. (2008) who have reported that 100% inclusion of duckweed does not favor growth performance of Nile Tilapia. The study clearly showed that fish fed diet with 15% duckweed perform excellently well compared to other treatment.

The experiment concludes that fish meal could not be replaced totally with plant origin feed; however, partial replacement can be done by using duckweed meal to reduce the cost without affecting growth rate. The present study revealed that 20% *Lemna* feed would be optimum for the maximum growth of *Labeo rohita*. Further, such aquatic weed based feeds are cheaper as compared to the conventional feeds, supplementation of aquatic weeds in carp diets would also prove economically viable.

REFERENCES

A. P. H. A. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed. American Public Health Association, the American Water Works Association and the Water Environment Federation. p. 1268.

Ahamad, M. U., Swapon, M. R .S., Yeasmin, T. U., Raham, M. S. and Ali, M. S. 2003. Replacement of sesame oil cake by Duckweed (Lemna minor) in broiler diet. *Pakistan J. Biological Science*. **6(16):** 1450-1453.

AOAC 1995. Association of Official Analytical Chemist. *16th Ed; vol. 1. AOAC. Washington, DC, USA*. p. 1141.

Bag, M. P., Mahapatra, S. C. and Rao, P. S. 2012. Aquatic weed as potential feed for Mozambique tilapia, *Oreochromis mossambicus*. *J. Aquaculture Research and Development*. **3(8):** 124-129.

Bairagi, A., Sarkar, G. K., Sen, S. K. and Ray, A. K. 2004. Evaluation of the nutritive value of *Leucaena leucocephala* leaf meal, inoculated with fish intestinal bacteria *Bacillus subtilis* and *Bacillus circulans* in formulated diets for rohu, *Labeo rohita* (Hamilton) fingerlings. *Aquaculture Research*. **35:** 436-446.

Bairagi, A., Sarkar, G. K., Sen, S. K. and Ray, A. K. 2002. Duckweed (*Lemna polyrhiza*) leaf meal as a source of feedstuff in formulated diets for rohu (*Labeo rohita* Ham) fingerlings after fermentation with a fish intestinal bacterium. *Bio resour-Technol*. **85(1):** 17-23.

Das, I. and Ray, A. K. 1989. Growth performance of the Indian Major Carp *Labeo rohita* (Ham.) on duckweed incorporated pelleted feed: a preliminary study. *J. Inland Fish. Soc. Ind.* **21(1):** 1-6.

Das, K. M., Mohanty, S. N. and Sarkar, S. 1991. Optimum dietary protein to energy ratio for *Labeo rohita* fingerlings. In Proceedings of the Fourth *Asian Fisheries Society, Spec. Publ*. **5:** 205.

Das, N., Sharma, B. K., Sharma, L. L., Saini, V. P. and Upadhyay, B. 2007. Efficacy of certain formulated diets of plants and animal origin-in relation to growth of rohu (*Labeo rohita*) fry. *Fishing chimes*. **27(7):** 24-26.

Duncan, D. B. 1955. Multiple range and multiple F-tests. Biometrics, **11:** 1-42.

Edward, P., Kamal, M. and Wee, K. L. 1985. Incorporation of composted and dried water hyacinth in pelleted feed for the tilapia *Orechromis niloticus* (Peters). *Aquaculture and Fisheries Management*. **1:** 233-248.

Effiong, B. N., Sanni, A. and Fakunle, J.O.2009. Effect of partial replacement of fish meal with duckweed (*Lemna paucisostata*) meal on the growth performance of *H. longifiis* fingerlings. *Report and Opinion*. **(3):** 28-33.

Fasakin, E. A., Balogun, A. M. and Fasuru, B. E. 1999. Use of duckweed, *Spirodela polyrhiza* L. schleiden, as a protein feedstuffs in practical diets for tilapia, *Oreochromis niloticus* L. *Aquaculture research*. **30:** 313-318.

Guru, S. R. and Patra, A. K. 2007. Evaluation of nutritional impact of water weed-based feeds on the growth of *Labeo rohita*. *Fishing chimes*. **27(4):** 28-30, 35-36.

Hamilton, B. 1822. An account of the fishes found in the river Ganga and its branches. *Edinburgh*. p. 405.

Hanczakowski, P., Szymczyk, B. and Wawizynski, M. 1995. Animal Feed Science and Technology. *Institute of Animal Production. Balice, Poland*. **53:** 3-4, 339-343.

Hassan, M. S. and Edwards, P. 1992. Evaluation of Duckweed (*Lemna perpusilla* and *Spirodellapolyrrhiza*) as feed for Nile Tilapia (*Oreochromis niloticus*). *Aquaculture*. **104:** 315-326.

Jackson, A. J., Capper, B. S. and Matty, A. J. 1982. Evaluation of some plant proteins in compound diets for the tilapia *Sarotherodon mossambicus*. *Aquaculture*. **27:** 97-109.

Kalita, P., Mukhopadhyay, P. K. and Mukherjee, A. K. 2007. Evaluation of the nutritional quality of four unexplored aquatic weeds from northeast India for the formulation of cost-effective fish feeds. *Food Chem.***103:** 204-209.

Kaur, V. I., Ansal, Meera . D. and Dhawan, Asha. 2012. Effect of feeding duckweed (*Lemna Minor*) based diets on the growth performance of rohu, *Labeo rohita*(Ham.). *Indian J. Animal Nutrition*. **29(4):** 406-409.

Leonard, V. 1995. Are aquatic plants particularly Azolla a useful source of food fish. In: (J.J. Symoens and J.C. Micha, eds). The management of Integrated Freshwater agro - Piscicultural Ecosystems in Tropical Areas. *Proceedings Royal Academy of Overseas Science, Brussels, Belgium*. pp. 511-529.

Mohapatra, S. B. and Patra, A. K. 2013. Effect of partial replacement of fishmeal with duckweed (*Lemna minor*) feed on the growth performance of *Cyprinus carpio* fry. *J. Agriculture and Veterinary Science*. **4(2):** 34-37.

Mohapatra, S. B. and Patra, A. K. 2014. Evaluation of nutritional value of water lettuce (*Pistia stratiotes*) meal as partial substitution for fish meal on the growth performance of *Cyprinus carpio* fry. *International J. Agricultural Science Research (IJASR)*. **4(3):**147-154.

Okoye, F. C. and Mbagwu. I. G. 1984. Duckweed (*Lemna paucicostata*) in the diet of tilapia (*Sarotherodongalilaeus*). *J. Fish. Biol*. **7:** 136-140.

Patel, D. K. and Kanungo, V. K. 2010. Phytoremediation potential of duckweed (*Lemna Minor* L: a tiny aquatic plant) in the removal of pollutants from domestic wastewater with special reference to nutrients. *The Bioscan*. **5(3):** 355-358.

Patra, B. C. and Ray, A. K. 1988. A preliminary study on the utilization of the aquatic weed *Hydrilla Verticillata* (L.f.) Rayle as feed by the carp, *Labeo rohita* (Hamilton): growth and certain biochemical composition of flesh. *Indian Biology*. **XX(I):** 44-50.

Pattanaik, N. and Patra, A. K. 2012. Partial replacement of fishmeal with *Lemna minor* leaf meal on the growth performance of *Clarias batrachus*. *International J. Sustainable Development and Green Economics*. **1(1):** 28-30.

Pearson, A. M. and Tauber, F. W. 1984. Analytical method. *In* processed meats, 2nd ed. (A. M. Pearson and F. W. Tauber, eds.). AVI Publishing, Westport, Conn. pp. 360-361

Ray, A. K. and Das, I. 1995. Evaluation of dried aquatic weed, Pistia stratiotes meal as feedstuff in pelleted fed for rohu, *Labeo rohita* fingerlings. *J. Applied Aquaculture*. **5:** 35-44.

Robinnette, H. R., Brunson, M. W. and Day, E. J. 1980. Use of Duckweed in diets of channel cat fish. Mississippi Agricultural

Experiment station. *Publication No. 4532 Mississippi State University Mississippi State*. p.13.

Somashekar, D. S., Venkateshwarlu, M., Shanmugam, M. and Rangaswamy, B. L. 2003. Growth response of common carp, *Cyprinus carpio* to aquatic weed incorporated diets. *Indian J. Fish*. **50(3):** 409-413.

Tavares, F. A., Bosco Rodrigues, J., Fracalossi, D. M., Esquivel, J. and Rouback, R. 2008. Dried duckweed and commercial feed promote adequate growth performance of Tilapia fingerlings. *Biotemas*. **21(3):** 91-97.

Wee, K. L. and Wany, S. S. 1987. Nutritive value of Leucaena leaf meal in pelleted feed for Nile Tilapia. *Aquaculture*. **62:** 97-108.

Yilmaz, E., Sahin, A., Duru, M. and Akyurt, I. 2005. The effect of varying dietary energy on growth and feeding behaviour of common carp, Cyprinus carpio under experimental conditions. *Appl. Ani. Behav. Sci.* **92(1-2):** 85-92.

Yilmaz, E., Akyurt, I. and Gunal, G. 2004. Use of duckweed, *Lemna minor*, as a protein feedstuff in practical diets for common carp, *Cyprinus carpio*, fry. *Turkish J. Fisheries and Aquatic Sciences*. **4:** 105-109.