Journal of Aquatic Biology & Fisheries | 2023 | 11(1) | pp. 46-50
ISSN 2321–340X
OPEN ACCESS
http://www.jabf.in/
University of Kerala, INDIA

Growth, survival and feed utilization of Pearl spot, *Etroplus suratensis* larvae co-fed with atremia and micro diets of varying protein levels under controlled conditions

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ABSTRACT

Nutrition is a dominant factor influencing larval growth; knowledge of the larval nutritional requirements would contribute to optimising diets and feeding protocols, which improve larval and juvenile quality. Feeding with a limited number of dry feeds as a supplement or replacement of live feeds has led to poor larval nutrition in many fish species. Therefore, the study aimed at (1) evaluating the efficacy of live food organism (*Artemia salina*) and micro diets in the rearing of 8-day-old (12.5-13 mg) pearl spot, *Etroplus suratensis* larvae and (2) determining the effects of varying protein levels on growth and survival for appropriate rearing conditions for the larvae. The experiment ended after 30 days of culture and respective groups were compared based on growth parameters and survival. There were 8 treatments in triplicates and four experimental diets were formulated to contain 40%, 45%, 50%, and 55% dietary protein with 9% lipid levels to feed the fish. In the first four treatments, the fish larvae were provided with formulated micro diet only and in the subsequent four treatments, co-feeding was done with artemia for an initial 10 days thereafter, fed only with formulated micro diets. Larvae co-fed using artemia and 50% protein micro diet resulted in significantly better growth in terms of weight gain, feed conversion ratio and specific growth rate than other treatments. The lowest growth occurred in larvae weaned using 40% formulated feed. Better survival was obtained in larvae weaned with co fed diets, while abrupt weaning using 100% dry diets resulted in lower survival (<66%). These results recommend co-feeding *E. suratensis* larvae using a formulated dry diet and artemia for the successful culture under controlled conditions.

ARTICLE HISTORY

Received on: 29-01-2023
Revised on: 27-10-2023
Accepted on: 04-12-2023

KEYWORDS

Etroplus suratensis,
Co-feeding, micro diets,
Protein levels

1. Introduction

The pearl spot (*Etroplus suratensis*), family: Cichlidae, inhabits both freshwater and brackish water ecosystems and has a widespread distribution in India and Sri Lanka (Hora and Pillay, 1962). This species gains popularity as an ornamental fish due to its brilliant coloration and high demand as a food source. This fish shared a good percentage (8–10 percent) of total fish landings in the backwaters (George and Sebastian, 1970), which has been drastically reduced due to overfishing and facing serious extinction in its natural habitat (Padmakumar et al*.,* 2002). The optimum conditions of rearing from the onset of exogenous feeding have not been identified, and one of the main drawbacks is to provide nutritionally adequate food for their larval stage. Larval development and the survival of aquatic animals are among the most important factors for successful aquaculture (Gong et al., 2014). Generally, larval rearing in hatcheries primarily depends on live foods. Live feeds such as rotifers (*Brachionus* sp.) and brine shrimp (artemia) are considered as excellent food for successful fish larviculture (Baskerville-Bridges and Kling, 2000; Sorgeloos et al., 2001). Live food organisms stimulate larval feeding activity through their movement and release of metabolic wastes and chemicals (e.g. amino acids, peptides and ammonium salts) that act as attractants (Kolkovski et al., 1997). Absolute dependence on live feeds as the source of diet is a major constraint in larval nutrition (Kerdchuen and Legendre, 1994). The continued utilization of live feeds as live and dry diets is likely to bring considerable challenges because of the intensive production techniques as well as the cost of live feed production and labour requirements along with the highly variable nutritional value of live feeds (Cahu and Zambonino Infante, 2001; Langdon, 2003) and the unreliability of mass cultures illustrate the need to find viable micro diet alternatives (Baskerville-Bridges and Kling, 2000).

Developing a formulated micro diet with a full nutritional complement, good physical and biochemical properties for partial or complete replacement of live food will decrease production costs for larviculture. However, these micro diets must meet the nutritional requirements, and the larval fish should be readily accepted. Defining an effective diet is one of the most important steps towards a successful larval culture (Nasrolahi et al., 2007). The dietary protein requirement of a species is of prime importance in aquaculture because protein influences fish growth and determines the cost of feeding in fish feed. The level of protein utilization by the fish depends on the quantity and quality of dietary protein. (Li and Lovell, 1992; Li et al., 2008).

The main objective of the experiment was to evaluate the effects of different micro diets with ascending levels of protein for maximizing growth and larval survival of *E. suratensis* when used within various co-feeding weaning protocols aimed at minimizing the use of artemia.

2. Materials and Methods

2.1 Source of fish larvae and experimental facility

Eight-day-old (8 dph) *Etroplus suratensis* larvae were obtained from Azhikode Hatchery, Thrissur, Kerala, transported and acclimated for 7 days at CMFRI wet lab facilities. Larvae were transferred into 24 nos of, 20 L rectangular glass tanks (initial density: 50 larvae L^{-1}, mean weight 12.5-13 ± 0.02 mg). The facilities were aerated throughout the 30 days study period. Water conditions were as follows: temperature 28.4 ± 0.4 °C, salinity 20 ppt, pH 8.0 ± 0.2, dissolved oxygen 7.5 ± 1.3 mg $L^{-1}$and 50% daily water renewal done in the system.

2.2 Ingredients and formulation of experimental diets

Dietary treatments consisted of live food (*Artemia salina*) and four micro diets were formulated to contain 40, 45, 50, 55 g kg^1 protein levels, with a constant lipid of 9 g kg^1 and tested in triplicates. As per the formulations, all ingredients were weighed, ground, mixed, mechanically extruded, dried at 60-65^{0}C in hot air oven, and packed air-tight until use. For feeding the dried pelleted feed were ground in a grinder and then sorted with sieves (150, 200, 250 µm mesh) to obtain the desired particle size. The composition of the ingredients and the formulated feeds are presented in Table 1.

2.3 Mass production of artemia

Artemia cysts (INVE aquaculture nutrition, High HUFA 430µ) were incubated and hatched under optimal conditions according to the manufacturers protocol. After 24 h newly hatched artemia nauplii were collected using a 100 µm sieve. The artemia were washed with 25 ppt water. About 50 numbers of artemia were fed four times a day for each treatment and provided to larvae without any further enrichment.

2.4 Dietary treatments and feeding

The experiment was performed under eight different treatments. In the first four treatments, the diets: Diet 1 (D1) larvae were fed with 40% dietary protein micro diet only, diet 2 (D2) 45% dietary protein micro diet, diet 3 (D3) 50% dietary protein micro diet and diet 4 (D4) 55% dietary protein micro diet were provided and in the subsequent four treatments, co-feeding was done with live feed (artemia) for initial 10 days and formulated micro feed alone subsequently, Diet 5 (D5) live artemia and 40% dietary protein micro diet, Diet 6 (D6) live artemia and 45% dietary protein micro diet, Diet 7 (D7) live artemia and 50% dietary protein micro diet, Diet 8 (D8) live artemia and 55% dietary protein micro diet. Each feeding experiment was conducted in triplicate. Prior to feeding, the aeration was interrupted for at least 10 minutes. Pre weighed portions of each of the formulated diet were taken and fed to the fish larvae *ad libitum* four times a day between 08:00 h and 19:00 h. The artemia nauplii were added at a density of 3.0 nauplii mL^{-1} four times per day.

Table 1. Ingredients used and proximate composition of the experimental diets (g /kg) on dry matter basis

Ingredients (g/kg)	D40	D45	D50	D55
Marine protein mixture	320	370	410	650
Soy Flour	320	370	410	210
Wheat Flour	240	140	60	40
Sardine Oil	60	60	60	40
Lecithin	3	3	3	3
Vitamin C	5	5	5	5
Vitamin Mixture	20	20	20	20
Mineral Mixture	30	30	30	30
Antifungal	1	1	1	1
Antioxidant	1	1	1	1
Proximate composition of experimental diets [a] (dry matter basis) (g/100g)				
Dry matter	95.57	96.13	96.02	95.81
Crude Protein	40.82	45.67	49.31	54.85
Crude Lipid	9.02	9.09	9.24	9.12
Crude Ash	12.03	14.18	19.47	19.7
Nitrogen free extract (NFE)[b]	37.86	30.95	21.8	15.72
Gross energy (MJ kg^{-1})[c]	11.92	12.74	13.33	13.41

[a] Values are mean of triplicate analysis.
[b] Nitrogen-free extract (calculated by difference).
[c] Gross energy, calculated based on 0.017, 0.0398 and 0.0237 MJ/g for carbohydrate, lipid and protein, respectively

2.5 Sample collection

At the beginning of the experiment, thirty fishes were sampled to analyse proximate whole body composition. After the experiment fishes in each treatment were individually weighed, and fishes from each tank were used for further analysis.

2.6 Chemical analysis

Crude protein, crude lipid, moisture and ash in diets and whole body were determined by standard methods (AOAC, 2005). Moisture was determined by oven-drying at 105°C until constant weight. Crude protein (N×6.25) was determined by Kjeldahl method after acid digestion using a semi-automated Kjeldahl System (FOSS Kjeltec 2300). Crude lipid was determined by ether-extraction method using a Soxhlet System (FOSS Soxtec2043). Ash content was determined by incinerating the sample in muffle furnace at 550°C for 24 h.

2.7 Water quality management

The experimental tanks were cleaned daily, and the water was partially (2/3) replaced before the first feeding schedule in the morning. Temperature, dissolved oxygen and pH were monitored once per day. Total Ammonia-N and Nitrite-N were recorded every week and determined spectrophotometrically following the Nessler and diazotization methods respectively.

2.8 Growth performance and survival determination

Performance of fish on test micro diet was assessed by final body weight (FBW), total length (TL), weight (%WG), percent survival (%), Feed conversion ratio (FCR), specific growth rate (SGR) based on the following standard formulae.

Weight gain % (WG) =100 (final weight- initial weight)/ initial weight

Specific growth (SGR) = 100 (ln final weight-In initial weight)/no of days of feeding trial

Feed conversion ratio

(FCR) = Feed intake / Weight gain

Survival % = 100 (final no. of fish harvested /initial no of fish stocked)

2.9 Data analysis

The experimental data were statistically analysed using the Statistical Package for the Social Sciences (SPSS) version 16. Comparison between two treatments was made using Duncan's multiple range test (DMRT). Comparison among all the treatments was made by one-way ANOVA. Comparisons were made at 5% probability level.

3. Results

3.1 Physicochemical parameters of water

The water quality parameters like temperature, pH, dissolved oxygen (DO), ammonia nitrogen and nitrite nitrogen were recorded. Dissolved oxygen (DO) and pH ranged from 6.25 to 7.09 mg/L and 6.9 to 7.3 respectively. The total ammonia and nitrite levels varied from 0.19 to 0.44 mg/L and 0.03 to 0.15 mg/L, respectively. Water temperature varied from 27 to 28.7 ^{0}C. The values were in tolerable limits for larviculture.

3.2 Growth parameters

The body growth parameters are given in Table 2. The weight gain percentage was significantly different ($p<0.05$) among the various treatment groups. The highest weight gain percentage was recorded in the D7 group (50% protein + artemia) (662.56 ± 3.46), followed by the other groups, and the lowest growth was recorded in the D1 group (429.56 ± 11.42[a]). The highest specific growth rate (SGR) was found in the D7 group and the lowest SGR was found in the D1 group, which was significantly ($p<0.05$) different from other experimental groups. The feed conversion ratio (FCR) of different experimental groups varied significantly ($p<.05$). Better FCR value was observed in D7 group followed by other groups. On the 30 dph the treatment groups showed no significant difference in total length (TL) (210.476 ± 26.70). The highest survival (%) was found in the D7 group and the lowest in D1 group ($p<0.05$).

3.3 Whole body proximate composition

The final mean carcass composition of pearl spot larvae maintained on different experimental diets is presented in Table 3. Among the different feeding schedules, highest ($p<0.05$) protein and lipid content were recorded in the D7 group, whereas the lowest in the D1 group.

4. Discussion

The larval period is extremely important stage in fish species in their life history (Wang et al., 2005). The digestion of dietary protein in larval fish has been known to differ from that in juvenile fish (Kolkovski, 2001). Therefore, the study was designed to see the effects of different dietary protein levels on the pearl spot larvae.

In most of the fish species used in fish farming, the best survival and growth results in larval rearing are usually obtained with natural foods, preferably live or with a combination of live food and dry diet (Evangelista et al., 2005; Wang et al., 2005; Policar et al., 2007). Feeding live natural zooplankton or artemia to the fish larvae exploits the inherent predatory nature of the larva to catch mobile, live food particle. Our observations on co-feeding weaning protocols as used in experiments of the *E. suratensis* with artemia and formulated micro diet in experiments (D5 –D8) simultaneously used to allow a fast and efficient change

Table 2. Growth parameters *Etroplus suratensis* larvae in the different experimental diets

Parameters	DI	D2	D3	D4	D5	D6	D7	D8
Initial mean weight (mg) at day 8	12.57±0.2	12.60±0.3	13.40±0.2	13.10±0.2	12.89±0.4	12.54±0.2	12.53±0.3	12.52±0.3
Final mean weight (mg) at day 30	63.90±3.1[b]	70.00±37.[d]	73.23±2.9[a]	72.87±2.6c	75.57±2.7a	93.03±3.4 b	95.37±2.9 c	91.01±3.3 d
Mean weight gain (mg)	51.33±11.42[a]	57.40±17.79[a]	59.83±3.97[bc]	59.77±2.27[bc]	62.68±13.49[c]	80.49±4.19[d]	82.85±13.45[d]	78.49±3.66[a]
SGR	5.81± 0.8[a]	6.12± 0.11[b]	6.07± 0.2[bc]	6.13± 0.2[bc]	6.32± 0.8[c]	7.16± 0.20[d]	7.25± 0.13[d]	7.0± 0.17[d]
FCR	2.55± 0.2[c]	2.48± 0.2[a]	2.37± 0.4[b]	2.37± 0.3[d]	2.22± 0.2[c]	2.12± 0.3[b]	1.93± 0.3[a]	2.13± 0.2[b]
% Survival	66.00± 1.15[a]	68.67± 2.42[bc]	70.67± 2.17[c]	66.67± 2.20[bc]	76.00± 1.58[d]	77.67± 2.33[d]	80.87± 2.59[c]	77.00± 1.86[d]

Values are the mean ± SE of triplicate groups of 20 fishes.
a, b,c,d Values in the same row with different letters differ significantly ($P < 0.05$)
D1, 40% dietary protein micro diet, D2, 45% dietary protein micro diet, D3 50% dietary protein micro diet, D4, 55% dietary protein micro diet; D5, 40% dietary protein micro diet + artemia, D6, 45% dietary protein micro diet + artemia, D7, 50% dietary protein micro diet + artemia, D8, 55% dietary protein micro diet + artemia
SGR, specific growth rate; FCR, food conversion ratio.

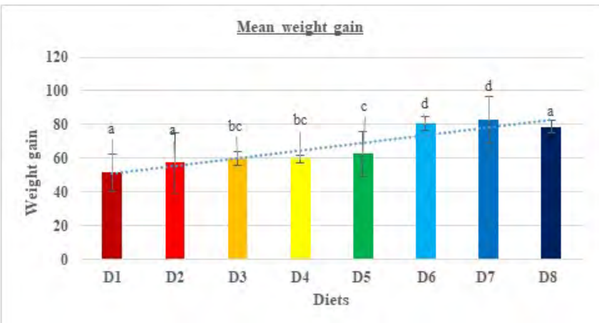

Fig. 1. Mean weight gain (mg) of *Etroplus suratensis* larvae in the different experimental diets. D1, 40% dietary protein micro diet, D2, 45% dietary protein micro diet, D3 50% dietary protein micro diet, D4, 55% dietary protein micro diet; D5, 40% dietary protein micro diet + artemia, D6, 45% dietary protein micro diet + artemia, D7, 50% dietary protein micro diet + artemia, D8, 55% dietary protein micro diet + artemia

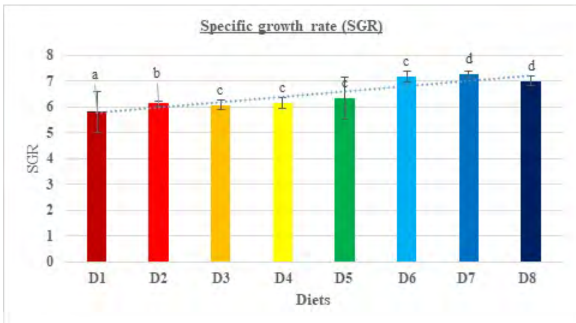

Fig. 2. SGR (specific growth rate) of *Etroplus suratensis* larvae in the different experimental diets. D1, 40% dietary protein micro diet, D2, 45% dietary protein micro diet, D3 50% dietary protein micro diet, D4, 55% dietary protein micro diet; D5, 40% dietary protein micro diet + artemia, D6, 45% dietary protein micro diet + artemia, D7, 50% dietary protein micro diet + artemia, D8, 55% dietary protein micro diet + artemia

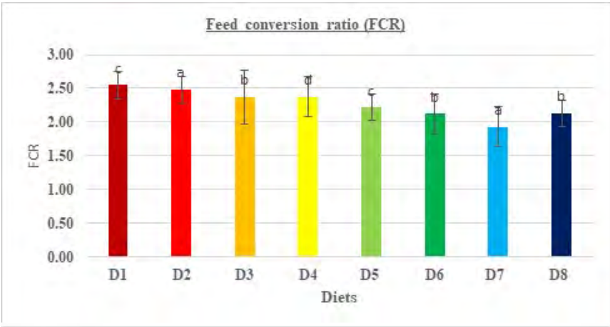

Fig. 3. FCR (feed conversion ratio) of *Etroplus suratensis* larvae in the different experimental diets. D1, 40% dietary protein micro diet, D2, 45% dietary protein micro diet, D3 50% dietary protein micro diet, D4, 55% dietary protein micro diet; D5, 40% dietary protein micro diet + artemia, D6, 45% dietary protein micro diet + artemia, D7, 50% dietary protein micro diet + artemia, D8, 55% dietary protein micro diet + artemia

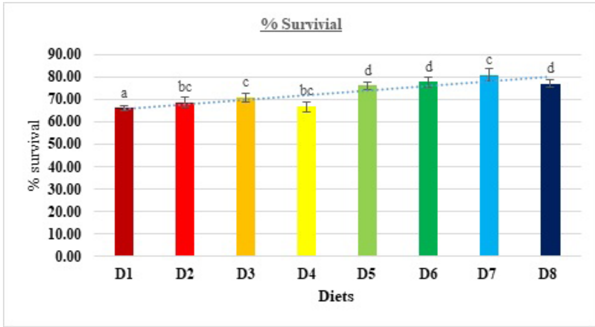

Fig. 4. (%) Survival of *Etroplus suratensis* larvae in the different experimental diets. D1, 40% dietary protein micro diet, D2, 45% dietary protein micro diet, D3 50% dietary protein micro diet, D4, 55% dietary protein micro diet; D5, 40% dietary protein micro diet + artemia, D6, 45% dietary protein micro diet + artemia, D7, 50% dietary protein micro diet + artemia, D8, 55% dietary protein micro diet + artemia

Table 3. Proximate composition of the whole body of *Etroplus suratensis* larvae in different experimental groups (g/kg on wet weight basis ±SE)

Treatments	Moisture	Crude protein	Crude Lipid	Crude Ash
D1	76.13±1.09^b	14.27±0.23^a	1.87±0.18^b	2.16±0.31^a
D2	76.78±1.16^b	13.97±0.18^b	1.88±0.15^a	2.14±0.45^c
D3	75.04±1.89^a	15.27±0.32^c	2.07±0.21^b	2.18±0.41^a
D4	76.64±1.46^c	14.25±0.16^a	1.98±0.42^c	2.17±0.75^b
D5	76.99±2.03^b	15.32±0.24^b	1.99±0.19^b	2.16±0.15^a
D6	76.19±1.73^a	15.79±0.13^b	2.11±0.36^b	2.19±0.38^a
D7	76.29±1.23^c	16.22±0.21^b	2.20±0.29^a	2.15±0.39^c
D8	76.79±1.41^b	15.91±0.11^c	2.19±0.21^c	2.14±0.18^c

Values are the mean ± SE of triplicate groups of 20 fishes.
^{a,b,c} values in the same row with different letters differ significantly ($P < 0.05$).

over period onto dry micro diets from live feed (Daniels and Hodson 1999; Koven, et al., 2001). This method has been found to achieve higher growth and survival than feeding either live feeds or micro diets on their own (Wang et al., 2009).

At the end of the larval rearing period (30 days) in this study, the lowest weight and SGR were found in the group of larvae fed with micro diet (D1). In micro diet group (D5) to (D8). The co-fed groups had the higher larval survival and growth rate. These results are almost similar to those obtained in *Clarias macrocephalus* (Evangelista et al., 2005), *Barbus barbus* (Policar et al., 2007) when comparing larvae fed live foods and micro diets. During the experiment, the larvae fed with micro diet grew considerably less than larvae co fed with artemia. This result shows that larvae initially need to receive live food to maintain their high growth (Rust, 2002). The low survival and growth rates of larvae fed only on artificial diet could result from non or poor use of the artificial dry food during the first weeks of life due to the ineffectiveness of their developing gut. It was reported that the inappropriate use of artificial diets by fish larvae come mainly from a lack of equipment in digestive enzymes, particularly proteolytic (Evangelista et al., 2005; Policar et al., 2007).

In the present study the increment of protein levels from (400 g kg^{-1} to 550 g kg^{-1}) in the diets influenced a significant improvement in growth, percent body weight gain, SGR, FCR, survival and body indices in *Etroplus suratensis* larvae. This might be why the body weight gain, SGR, FCR values varied significantly in response to the dietary protein content. These increased differences have also been observed in *Cyprinous carpio* (Ogino and Saito, 1970) and *Sparus auratus* (Santinha et al., 1996).

Whole-body composition is often used to indicate fish quality (Zhang et al., 2011). In the present study, the body lipid and protein content was significantly higher in the co-fed diet (D7). Higher body protein content in the treatment groups implies that by co-feeding with live feeds, the ingested micro diets were converted more effectively into structural protein, resulting in maximum growth and survival, a desirable aspect in fish farming.

5. Conclusion

The present study indicated the feasibility of producing *E. suratensis* fingerlings for stock enhancement or grow-out purposes. During the larval rearing period, better growth and survival rates were found when fishes were fed with live feeds for the first week, and feeding micro diet alone had a positive effect on the growth rate of larvae. These results revealed that co feeding can be considered as a suitable method for maximum growth, body composition, and best feed utilization for *E. suratensis* fingerlings.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships

Acknowledgements

The authors are grateful to the Director, Indian Council of Agricultural Research Institute (ICAR) - Central Marine Fisheries Research Institute (CMFRI), Kochi for providing necessary research facilities. Sayooj P acknowledges CUSAT (Cochin University of Science and Technology, Cochin) for his PhD registration. This work was done under the institute funded project (MBTD/FEEDS/27) of ICAR-CMFRI, Kochi, which is duly acknowledged

6. References

Baskerville-Bridges, B and Kling, L.J. 2000. Early weaning of Atlantic cod (*Gadus morhua*) larvae onto a microparticulate diet. Aquaculture, 189: 109–117.

Cahu, C and. Zambonino Infante, J. 2001. Substitution of live food by formulated in marine fish larvae. Aquaculture, 200:161–180.

Daniels H.V. and Hodson R.G.1999. Weaning success of southern flounder juveniles: effects of changeover period and diet type on growth and survival. North American Journal of Aquaculture 61, 47–50.

Evangelista, A.D., Fortes N.R. and Santiago. C.B. 2005. Comparison of some live organisms and artificial diet as feed for Asian catfish *Clarias microcephalus* (Gunther) larvae. Journal of Applied Ichthyology. 21: 437–443.

George, A.I and Sebastian. M.J .1970. Review of the backwater fisheries and brackish water fish culture in Kerala state. In: Proceedings of the symposium on coastal aquaculture. Indo-Pacific Fisheries Council, Bangkok. p. 18–27.

Gong, W., Lei .W., Zhu. X., Yang .Y., Han. D and Xie. S., 2014. Dietary myo-inositol requirement for juvenile gibel carp (*Carassius auratus gibelio*). Aquaculture Nutrition, 20(5): 514-519

Hora, S.L and T.V.R Pillay. 1962. Handbook on fish culture in the Indo-Pacific region. FAO. Fish. Biol. Tech. Pap, 14:1–204

Kerdchuen, N and Legendre, M. 1994. Larval rearing of an African catfish, *Heterobranchus longifilis* (Teleostei, Clariidae): a comparison between natural and artificial diet. Aquatic Living Resources. 7: 247–253.

Kolkovski, S. 2001. Digestive enzymes in fish larvae and juveniles- implications and applications to formulated diets. Aquaculture, 200: 181–201.

Kolkovski, S., Arieli .A, and Tandle, A. 1997. Visual and chemical cues stimulate microdiet ingestion in sea bream larvae. Aquaculture International. 5: 527–536.

Koven W., Kolkovski S., Hadas E., Gamsiz K. & Tandler A. 2001. Advances in the development of MD's for gilthead seabream, Sparus aurata: a review. Aquaculture 194, 107–121.

Langdon, C. 2003. Micro particle types for delivering nutrients to marine fish larvae. Aquaculture, 227: 259–275.

Li, M. and Lovell, R.T. 1992. Growth, feed efficiency and body composition of second- and third-year channel catfish fed various concentrations of dietary protein to satiety in production ponds. Aquaculture, 103: 153–163.

Li, M.H., Robinson, E.H., Peterson, B.C and Bates, T.D. 2008. Growth and feed efficiency of juvenile Channel catfish reared at different water temperatures and fed diets containing various levels of fish meal. North American Journal of Aquaculture. 70: 347–352.

Nasrolahi A., Sari, A., Saifabadi, S and Malek, M.2007. Effects of algal diet on larval survival and growth of the Barnacle *Amphibalanus* (Balanus) *improvisus*. . Marine Biological Association. UK, 87: 1227–1233.

Ogino, C. and Saito, K., 1970. Protein nutrition in fish. 1. The utilization of dietary protein by carp. Bull. Jpn. Sot. Sci. Fish., 36: 250-254

Padmakumar, K.G., Krishnan, A.., Radhika, R.., Manu, P.S. and Shiny, C.K.2002. Open water fishery interventions in Kuttanad, Kerala, with reference to fishery decline and ecosystem changes. In: Boopendranath MR, Meena Kumari B, Joseph J, Sankar TV, Pravin P, Edwin L (eds) Riverine and Reservoir Fisheries Challenges and strategies. Society of Fishery Technologists (India), CIFT, Cochin, p. 15–24.

Policar, T., P. Koza´k, J., Hama´cˇkova´., A. Lepicˇova´., J. Musil and J. Kourˇil .2007. Effects of short-time Artemia spp. feeding in larvae and different rearing environments in juveniles of common barbel (*Barbus barbus*) on their growth and survival under intensive controlled conditions. Aquatic Living Resources. 20: 175–183.

Rust, M.B. 2002. Nutritional physiology. In: Fish Nutrition (ed. by J.E. Halver & R.W. Hardy), Academic Press New York, New York, USA. 367–452 pp.

Santinha, P. J. M., Gomes, E. F. S., and Coimbra, J. O. 1996. Effects of protein level of the diet on digestibility and growth of gilthead sea bream, *Sparus auratus* L. Aquaculture Nutrition, 2(2), 81-87.

Sorgeloos, P., Dhert, P., and. Candreva, P. 2001. Use of brine shrimp, Artemia spp., in marine fish larviculture. Aquaculture, 200 : 147– 159.

Wang C., Xie S., Zheng, K.,. Zhu. X., Lei, W., Yang., Y and J. Liu .2005. Effects of live food and formulated diets on survival, growth and protein content of first feeding larvae of *Plelteobagrus fulvidraco*. Journal of Applied Ichthyology. 21: 210–214.

Wang Y., Hu M., Wang W. and Cao L.2009. Effects on growth and survival of loach (*Misgurnus anguillicaudatus*) larvae when co-fed on live and micro particle diets. Aquaculture Research 40, 385–394.

Zhang, L., Zhao, Z.G., Xiong, D.M., Fang, W., Li, B., Fan, Q.X., Yang, K. and Wang, X.Y.2011. Effects of ration level on growth, nitrogenous excretion and energy budget of juvenile yellow catfish, *Pelteobagrus fulvidraco* (Richardson). Aquaculture Research. 42: 899–905.