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On-farm evaluation of formulated diets on the growth and body composition of *Etroplus suratensis* reared in cages in low-saline coastal ponds

P. Sayooj[1, 2]*, P. Vijayagopal[1], P. A. Vikas[3], V. N. Anusree[1] and K. K. Vijayan[4]
[1]ICAR–Central Marine Fisheries Research Institute, Kochi- 682 018, Kerala, India.
[2]School of Marine Sciences, CUSAT, Lakeside Campus, Kochi- 682 016, Kerala, India.
[3]ICAR-Krishi Vigyan Kendra, Narakkal, Kochi-682 505, Kerala, India.
[4]ICAR–Central Institute of Brackishwater Aquaculture, Chennai-600 028, Tamil Nadu, India.

*Correspondence e-mail: sayoojba@gmail.com

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Original Article

Abstract

A 90-day on-farm feeding experiment was carried out in the installed cages in brackishwater ponds to evaluate the efficiency of three formulated diets on the growth performance and body composition of *Etroplus suratensis*. Two diets DI and DII were in-house formulations based on optimum macronutrient requirements (protein and fat) derived from an indoor nutritional evaluation of *E. suratensis,* and diet three DIII was a commercially available pellet meant for pearl spot fish. A sum of 900 fishes were randomly distributed with an average weight of 18.2±0.02g into three different treatment groups each in triplicate, and each replicate had 100 fishes stocked in cages with dimensions 2×2×1.5 m. At the end of the feeding trial, the fish were weighed to assess growth parameters in terms of % gain in weight, feed conversion ratio (FCR), and specific growth rate (SGR). The diet (DI) displayed significantly ($p<0.05$) higher % weight gain, and SGR than (DII) and (DIII). The FCR of diet (DI) was significantly ($p<0.05$) lower than diets (DII) and (DIII). Diet (DI) showed better growth when compared with other feeds. The study emphasized the need for species-specific diets for application at the farm level for an effective return on investment.

Keywords: *Etroplus suratensis, diet, cages, Specific Growth Rate, Feed Coversion Ratio*

Introduction

Etroplus suratensis (Bloch) commonly known as pearl spot, belongs to the family Cichlidae and is considered a suitable fish for diversified coastal aquaculture in South Asia (Padmakumar *et al*., 2009). It is widely distributed in freshwater and backwater resources of the coastal states of India. Owing to its good taste, unique colouration, and remarkable patterns it possesses high consumer preference as an edible and ornamental fish, especially in Kerala. Exploitation of the fish from the wild has limitations when the demand is found to be ever-growing. To sustain the production of these fish, they have to be reared in captivity and grown to the requisite sizes. In fish farming, nutrition is important as feed accounts for 40–50% of the production cost (Craig and Helfrich, 2002). As a fast-growing sector in the food industry, aquaculture is distinguished by its diversity of species relative to terrestrial agriculture, which could improve the sustainability of the global food system (FAO, 2019; Cai *et al*., 2023). The main goal for aquaculture producers is to maximize fish performance while minimizing production costs, particularly the price of fish feed. Aqua feed manufacturers therefore aim to provide products that effectively use dietary nutrients while minimising the inclusion of expensive ingredients (Hixson, 2014).

Globally, fish consumption has increased due to the availability of high-quality protein, polyunsaturated fatty acids (PUFAs), vitamins, and minerals (Tocher, 2015). Aquaculture has contributed greatly to the growth in fish consumption, as wild catch fisheries cannot meet their exploitable limits (FAO, 2014). Aqua feeds must be economically utilized to support the sustainable expansion of aquaculture, which is anticipated to double between 2017 and 2050 (Gebauer *et al*., 2023). As aquaculture grows rapidly, the aquafeed business will need to expand simultaneously (Xie *et al.,* 2013). Since 1995, aquafeed consumption has grown by an average of

11% annually, reaching a volume of 49.7 million metric tons worldwide FAO (2014).

Though various commercial diets of *E. suratensis* are available, feed with optimal diet requirements for different life stages of *Etroplus* should be better defined. Thus, there is an urgent need to develop a feed for *E. suratensis* juveniles that can give faster growth by considering the specific requirements of the species. The present study aimed at an on-farm evaluation of the effects of formulated feed on the growth and body composition of *E. suratensis*.

Material and methods

Experimental design

On-farm experiments were carried out at the ICAR-Krishi Vigyan Kendra (KVK) pond, Ernakulam (27.2038° N, 77.5011° E). The total spread of the demonstration pond is 800 m^2 with an average depth of 1.2 m. The pond is directly connected to the Njarakkal backwaters of Cochin through a sluice gate. Daily water exchange was natural as per the tide pattern. The experiment was carried out for 90 days from December to March (2018). Nine nylon net (mesh size=0.85×0.50 mm) cages of size 2×2×1.5 m were fixed in the pond on both sides of a catwalk kept 0.25 m height above the water surface. The experiment was conducted with three diets and was tested in triplicate.

Pond management and seed stocking

Ponds were dewatered, dried, and treated with quick lime (CaO) @ of 1000 kg/ha. The ponds were then filled with water from adjoining brackishwater ponds to the level of 1.5 m and fertilized with a mixture of dried cow dung, ground nut oil cake, and single super phosphate at the dose of 1000, 75 and 2.5 kg/ ha, respectively. Each experimental cage was stocked with 100 numbers of juveniles of *E. suratensis* (18.82±0.02 g) after a dip treatment of $KMnO_4$ (5 mg/l). Pond water quality (temperature, salinity, dissolved oxygen, pH, and total alkalinity) was monitored weekly throughout the experimental trial between 09:00 and 09:30 h following standard methods (APHA, 1995).

Diet selection and preparation

The experimental diets Diet I (DI) and Diet II (DII) used were in-house formulations and Diet III (DIII) was a commercially available pearl spot feed. The ingredient composition of the in-house experimental diet (DI) is presented in Table 1. The experimental diet (DI) was produced at the experimental feed mill of CMFRI. Feed ingredients were pulverized in a hammer mill, sieved and mixed (Hobart mixer – DL 200) and extruded in a lab-scale twin screw extruder (BTPL Kolkata) to produce 2-3 mm sized slow-sinking pellets. The pellets were dried at 60°C for 12h in a feed dryer and stored in air-tight containers till used. Diet II was prepared at the KVK centre of CMFRI through outsourcing.

Table 1. Composition of the formulated diet (g/kg) on a dry matter basis (DM)

Ingredients (g/kg)	DI
Marine protein mixture	320
Soy flour	320
Wheat flour	240
Sardine oil	60
Soy Lecithin	3
Vitamin C	5
Vitamin Mixture	20
Mineral Mixture	30
Antifungal agent	1
Antioxidant	1

Sample collection

At the beginning of the experiment, fifteen fishes were sampled for the analysis of whole-body proximate composition. After the termination of the 90-day trial, fish in individual cages were weighed separately. Ten fishes from each cage were used for the analyses of proximate composition. Feed was not offered to fish on the day of sampling.

Growth performance in cages

Specific growth rate (SGR) and weight gain (WG %) were used as indicators for growth performance. The feed conversion ratio (FCR) was used as an indicator for feed utilization. The survival rate (%) after the completion of the experiment was also noted. The variables were calculated as follows.

WG (%) = 100× (final body weight–initial body weight) / initial body weight)

SGR (%) = 100× (ln final weight – ln initial weight)/days of the experiment)

FCR = feed fed (g) / dry weight/body weight gain (g)

Survival % = 100 × (number of fishes harvested /number of fishes stocked)

Chemical analysis

The crude protein, crude fibre, crude lipid, ash, and moisture contents of both fish and experimental diets were determined by standard methods (AOAC, 2005). The samples were kept for oven-drying at 100°C until constant weight to determine the moisture content. The Kjeldahl method was used to determine the amount of crude protein (N×6.25) using a semi-automated Kjeldahl System (FOSS Kjeltec 2300) after acid digestion. The ether-extraction method using a Soxhlet System (FOSS Soxtec 2043) was used to calculate the crude lipid content. Ash content was determined by incinerating the sample in a muffle furnace at 550 °C for 3 hours; crude fibre by acid digestion (1.25%) followed by alkali digestion (1.25%). The combustion of the sample in the bomb calorimeter yielded a measurement of gross energy.

Statistical analysis

Data obtained were examined by one-way analysis of variance (ANOVA) among all the treatments. Comparison between the two treatments was made using Duncan's multiple range test (DMRT) at a 5% probability level ($p < 0.05$). SPSS 16 (SPSS Inc., USA) was used to perform the statistical analysis.

Results

Water quality in the experimental pond did not exhibit any marked variation throughout the rearing period (Table 2). Proximate and energy analyses of the diets are provided in Table 3. Overall, the diets were in a range of similar protein and lipid profiles for growth trial assessment, as well as a variation in ingredient selection among the commercial and in-house formulated feed. The effect of different experimental diets on growth performance and the statistical significance of the estimated parameters are shown in Table 4. The responses such as final weight, WG %, SGR, and FCR, of *E. suratensis* fed with extruded diet DI were significantly greater than those fed with other cost-effective and commercial diets ($p<0.05$) (Fig.1). No significant differences in moisture content were detected among the treatments (Table 5). Dietary protein intake and fish weight had a significant impact on both the protein and lipid contents, while their combination had a significant impact solely on the lipid contents ($p<0.05$; Table 5). Ash content significantly differed due to fish weight ($p<0.05$). The maximum lipid and protein content in the whole body was obtained with the DI in all weight classes followed by DII and DIII. Not many significant differences were perceived in ash content in the whole body which was unaffected by dietary protein levels at all fish weights.

Table 2. Water quality parameters of the experimental pond

Parameters	Range
Salinity (ppt)	16 – 24
Temperature (°C)	26.9 – 28.2
Dissolved oxygen (mg/l)	5.8–6.4
Total alkalinity (mg/l)	174–189
pH	6.8–7.2

Table 3. Composition of experimental diets (on a dry matter basis) by proximate analysis

Composition (%)	DI	DII	DIII
Crude Protein	40.29	38.95	37.73
Crude Lipid	9.07	8.25	8.26
Crude Ash	12.52	13.21	7.96
Crude Fibre	0.91	1.01	1.19
Nitrogen-free extract (NFE) %	35.27	28.16	24.47
Gross energy (GE),(kJ/g)	18.8	11.28	14.64

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

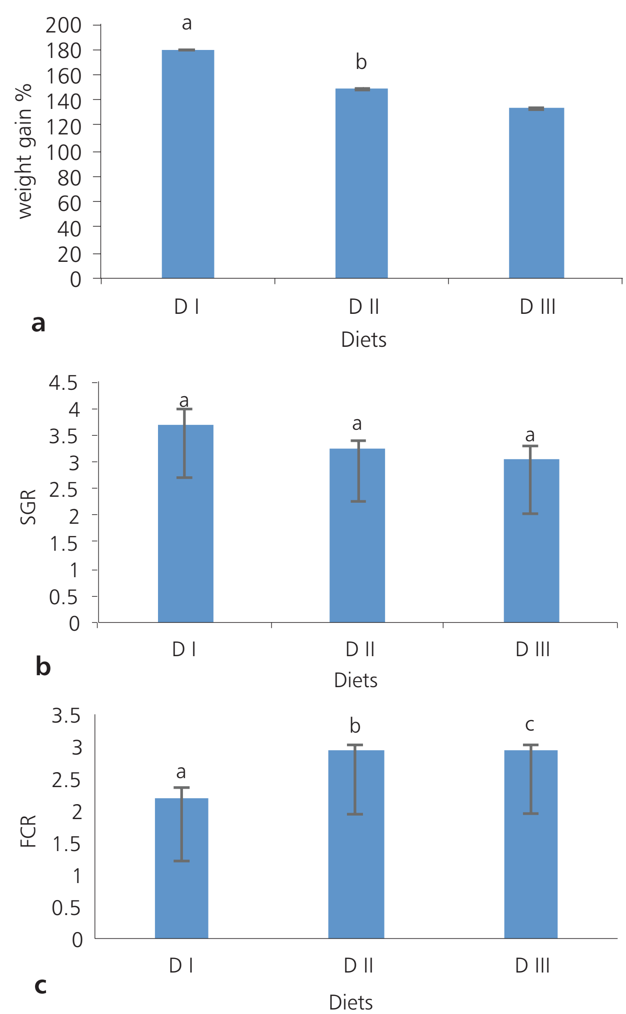

Fig. 1. a) Weight gain%, b) Specific growth rate (SGR), c) Feed conversion ratio (FCR) of *E. suratensis* reared in cages installed in brackishwater ponds with the different experimental diets, DI (in-house formulation) with 40%, DII, (in-house formulation) with 38% dietary protein, DI (commercially available pearl spot feed) with 37% dietary protein

Table 4. Growth performance of experimental diets

Parameters	DI	DII	DIII
Average initial weight (g)	18.23±0.03	18.24±0.02	18.23±0.02
Average final weight (g)	51.06±0.11[a]	45.44±0.05[b]	42.58±0.02[c]
Weight gain (%)	180.08±0.34[a]	149.05±0.23[b]	133.59±0.31[b]
Specific growth rate (% day)	3.68±0.28[a]	3.25±0.16[a]	3.03±0.25[a]
Feed conversion ratio	2.21±0.14[a]	2.92±0.11[b]	2.95±0.09c
Survival (%)	89.00	88.03	89.00

Data were presented as the means ± SD (n = 3). Different superscript letters indicate significant differences among treatments at the time of harvest (p<0.05)

Table 5. Proximate composition (% on dry matter basis) of experimental fishes

	Initial	DI	DII	DIII
Moisture (%)	69.11	69.84	69.82	68.56
Crude protein (%)	44.43 ± 0.01[a]	54.71 ± 0.02[c]	52.18 ± 0.1[b]	50.08 ± 0.04[a]
Crude fat (%)	6.41 ± 0.01[b]	19.16 ± 0.02[b]	12.16 ± 0.02[a]	10.66 ± 0.03[a]
Ash (%)	10.46 ± 0.02[a]	22.40 ± 0.04[a]	21.71 ± 0.03[b]	21.72±0.02[c]

Results are presented as mean ± SE. Means values with dissimilar superscripts were significantly different (p < 0.05).

Discussion

The study indicated that the growth performance of *E. suratensis* can be improved by using diets with higher nutrient content than those frequently used in commercial grow-out diets. Overall, the best growth performance was achieved with diet DI, which contained 40% crude protein and 9% crude fat. Feed conversion ratios were higher and proximate composition showed less favourable energy contents for fish-fed diets with lower levels of protein and lipid and fish regulate their feed intake to meet their energy needs (Kaushik and Medale, 1994). Sayeed *et al.* (2008) reported that the final weight and specific growth rate of Thai pangus (*Pangasius hypophthalmus*) increased with increasing protein levels in feed which agreed with the results though the protein range varied from 26 to 40% indicating a comparatively higher protein level are inevitable for better growth and production. Abdel-Tawwab *et al.* (2010) found comparable results in Nile tilapia, and *Oreochromis niloticus* and reported the highest growth for fry with a 45% protein diet and the lowest with a 25% protein diet. In the present study, *E. suratensis* showed optimum growth efficiency at 40% protein and the survival rate also remained higher for the D1 diet. The magnitude of the relative feed intake of *Etroplus* was shown to vary depending on the protein content of the diet. This indicates that energy requirements alone do not drive feed intake but the requirements for nutrients, in this case protein, also play a very important role. In addition, cages are the most practical culture system for growing brackishwater fish in commercially significant quantities. In fish nutritional studies dietary protein plays a significant role (Jauncey and Ross, 1982), thus sufficient supply of dietary protein is needed for rapid growth (Lovell, 1989). In the present study, the growth performance of juvenile *E. suratensis*, in terms of specific growth rate (SGR) and weight gain (WG), was significantly increased with the increase in dietary protein level, and the highest values were seen in those fishes fed the highest dietary protein level of 40%. El-Dahhar *et al.* (2000) and Prabu *et al.* (2020) obtained similar results for juveniles of Nile Tilapia and snub nose pompano respectively. The fish fed at 40 or 38% protein level showed significantly better body weight gain in comparison to that fed 37% protein, the value fits within the range of those reported in previous studies for other fish species, such as yellow snapper, *Lutjanus argentiventris* (Maldonado-Garcia *et al*., 2012), Senegalese sole, *Solea senegalensis* (Rema *et al.,* 2008), common dentex, *Dentex dentex* (Espinos *et al*., 2003), and Mediterranean yellowtail, *Seriola dumerilii* (Jover *et al.,* 1999; Wilson, 2002; NRC, 2011), that generally have higher dietary protein requirements. In the present study fish fed with diets containing 40% protein showed higher growth rates than those fed the diets containing dietary protein of 38 and 37%, it could be suggested that *Etroplus* fish juveniles require dietary protein of at least 40% to sustain their fast growth. The better growth performance of fish in diet DI might be due to protein and other necessary micronutrients in the diets and mode of feed presentation influencing the growth rate of the fish.

The survival rate is usually influenced by optimum conditions like food and environment. Inadequate food and environmental conditions will negatively affect the fish's health and reduce survival. Fish of higher survival is needed to obtain good growth. The results of the present study corroborate this and had better survival in DI-fed groups. Dietary treatments had an impact on the entire body composition of *E. suratensis*, except for ash. Body ash content showed no significant differences among the experimental treatments. This effect has previously been observed in other fish species and aquatic animals (Burr *et al*., 2006; Sa *et al.,* 2006; Hu *et al.,* 2008). In the present study, an increase in dietary protein levels was similarly accompanied by an increase in body protein content. The maximum protein content obtained in this study, when fish fed a 40% protein diet could be because it is the optimum protein requirement for better growth than those fed other dietary protein levels. Similar results on body protein content have also been reported by Kim *et al.* (2004) on juvenile olive flounder *Paralichthys olivaceus*. According to Kim and Lee (2005), the body protein content responded to dietary protein levels in a dose-dependent manner and exhibited maximum protein content on that dietary protein level where maximum growth rate was also achieved.

Conclusion

E. suratensis juveniles can achieve maximum growth, survival, and better feed conversion if they are fed with a diet comprising approximately 40% crude protein and 9% crude lipid, at a given ration with three times daily feeding. The findings of the current study have practical significance as a major step towards the development of the *E. suratensis* farming practice package and will directly benefit farm-level operations.

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