Indian Journal of Geo Marine Sciences
Vol. 49 (09), September 2020, pp. 1571-1579

A study on growth, feed efficiency and hematological changes in Pearlspot, *Etroplus suratensis* (Bloch, 1790) in response to varied salinities in raceway-based culture system

V Ezhilarasi*, S Felix, T L S Samuel Moses & S Selvaraj

Tamil Nadu Dr. J. Jayalaithaa Fisheries University, Nagapattinam, Tamil Nadu – 611 001, India

*[E-mail: ezhilarathana@gmail.com]

Received 29 May 2019; revised 18 December 2019

A 60 days experiment was conducted in raceway tanks to determine the impact of salinity on growth, survival, carcass composition and hematology of *Etroplus suratensis* fingerlings. The experimental unit consisted of three treatments *viz.*, T1 (0 ppt), T2 (15 ppt), and T3 (25 ppt). Complete randomized design (CRD) was followed with each treatment in triplicate. A total of 1500 fingerlings were stocked in each tank with an average body weight of 22.43±0.88 g. The results of the present experiment showed that fishes reared in 15 ppt salinities has showed an improved growth performance in terms of specific growth rate (0.35±0.01 % day^{-1}), feed conversion ratio (0.11±0.01), feed efficiency ratio (8.72±0.52) and protein efficiency ratio (0.20±0.01), compared to 0 ppt and 25 ppt. Similarly, fishes reared in lower salinity (0 to 15 ppt) showed a better proximate composition compared to higher salinity of 25 ppt. In addition, fishes reared in 15 ppt salinity showed higher levels of hemoglobin (7.63±0.08 gm dl^{-1}), red blood cell (1.6±0.12 million cum m^{-1}), white blood cell (253000±57735 cells cum m^{-1}) and packed cell volume (21.63±0.08 %). Likewise, low levels of platelet, mean corpuscular volume (135.80±0.32 Fl), mean corpuscular hemoglobin (48.53±0.17 pg) and mean corpuscular hemoglobin concentration (35.46±0.20 gm %)) were observed in 15 ppt reared fishes. From the current study it is concluded that *E. suratensis* can be acclimatized to different water salinity and thereby it can be suggested as a potential candidate for farming at 15 ppt salinity.

[**Keywords**: Carcass composition, Growth, Hematology, Salinity]

Introduction

Pearlspot, *Etroplus suratensis* belonging to the family Cichilidae is a common food fish in southern Asia. It is considered as one of the most economically important local fishery resources in the southern states of India. It inhabits coastal lagoons, lower reaches of river, brackish water and estuaries[1]. It is used as an ornamental fish because of its colouration[2] and as food fish, owing to its taste and traditional flavor. It is an euryhaline species with omnivorous feeding habits[3,4] and is distributed along the west and east coast of India[5]. Among the total fish landings from backwater lakes it contributes 8–10 % during sixties which has been reduced severely due to overfishing[6]. On the other hand, the demand for pearl spot is growing day by day and at the same time it is declining at an alarming rate due to over exploitation in their natural habitat and boom in backwater tourism[6].

In recent times, pearl spot is gaining attention as candidate species in aquaculture. In cages the average production rate is above 20 kg m^{-3} in 6–7 months *i.e.*, 12 to 50 times higher compared to pond based system. The survival rate of pearlspot varies between 45 to 100 %[7]. Hence from the researches on enclosure farming it is confirmed that pearlspot can be reared under high intensive culture unit. Intensive farming has proved to be a vital approach for addressing the land and water resource challenges. Accordingly raceway system has proved to control fish excrement disposal and thereby it maintains the captivity of the feeding fish, during the aquaculture period[8]. Pearl spot (*E. suratensis*) is known for its survival in both freshwater and brackish water environments by means of its competent osmoregulatory process[9] with differential Na+, K+-ATPase (NKA) and Na-K-Cl co-transporter (NKCC) expressions to sustain ion and water homeostasis in various salinity ranges[10]. Pearlspot being a euryhaline species, the scientific data regarding optimized salinity to achieve consistent production of healthy pearlspot is lacking.

Salinity is a single ecological factor which tremendously affects the growth[11], physiology and immune response[12]. The growth and survival

relationship were found to be negatively affected because of use of energy for osmoregulation in spite of its growth[11]. Several studies on brackish water fish species like Tilapia[13], Turbot[14], and Pompano[15] reported that they often prefer intermediate salinity (8–16 ppt) for their growth[16]. In addition, a change in salinity causes alteration in oxygen transportation in blood across the gills and also in hematological components[17]. Hence, the aim of the current study is to compute the effect of salinity on growth performance, feed utilization and hematology changes of *E. suratensis* fingerling which will ameliorate the aquaculture production in future.

Materials and Methods

Experimental site

The experiment was conducted in 2019 at the Raceway unit of Advanced Research Farm Facility (ARFF), Madhavaram, Dr. M. G. R. Fisheries College and Research Institute, TNJFU, Thiruvallur district, Tamil Nadu.

Experimental setup

A 60 days experimental study was performed in raceway tanks having a total capacity of 50,000 L with three treatments *viz*., T1 (0 ppt), T2 (15 ppt) and T3 (25 ppt) in triplicate. Initially for disinfection, the tanks were dewatered, cleaned and treated with bleaching powder. The fingerlings were segregated according to the size and acclimatized to different salinity for a month. The cleaned and dried treatment tanks were filled with water by pumping from bore well. Different salinities *viz*., 0, 15 and 25 ppt was achieved by mixing freshwater and brackish water. Once the required salinity was achieved the acclimatized fingerlings were stocked at a density of 1500 numbers $tank^{-1}$ with an initial average body weight of about 22.43±0.88 g per treatment. Aeration was provided by roots blower. For feeding, commercial diet (Growbest feed) with a crude protein of 32 % was fed twice a day at 3 % of body weight during morning and evening at 08.00 h and 20.00 h, respectively.

Physico-chemical analysis

The quality of water was analyzed on weekly basis for all tanks. Parameters like temperature, pH and salinity were measured by means of multiparameter analyzer (Hanna Instruments, Mumbai). Dissolved oxygen in the water was estimated using DO meter (YSI instruments, Mumbai). Furthermore, carbon dioxide, total hardness, calcium hardness, magnesium hardness, total alkalinity and Ammonia – nitrogen (NH_3-N) were estimated titrimetrically in the laboratory following the standard protocols (APHA)[18].

Growth analysis

For growth analysis, the fishes (25 %) were collected randomly from all tanks using hand net and the total length (cm) and weight (g) were measured once in fifteen days interval using a 30 cm ruler and digital balance. At the end of the experimental trail growth performances were calculated and assessed by means of percentage weight gain (PWG), mean growth rate (MGR), specific growth rate (SGR), feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and survival rate (SR) using following fish growth parameters calculations/ formulae.

Percentage weight gain = (Final weight (g) – Initial weight (g)/ Initial weight (g)) x 100

Specific growth rate (SGR) = (ln Final weight – ln Initial weight)/ Number of days) x 100

Feed conversion ratio (FCR) = Feed given (dry weight)/ Body weight gain (wet weight)

Feed efficiency ratio (FER) = Body weight gain (wet weight)/ Feed given (dry weight)

Protein efficiency ratio (PER) = Body weight gain (wet weight)/ Crude Protein fed

Mean growth rate (MGR) = Mean growth rate (mg/day) = 1000 x (W2-W1)/0.5 x (W1+W2) x t

Where, W1 = Initial body weight (g), W2 = Final body weight (g) and T = Culture duration (days)

Survival rate (SR) = (Total number of animal harvested/ Total number stocked) x 100

Carcass composition

The carcass composition of the fish such as moisture, ash, crude protein, ether extract, and digestible energy were measured at the end of the experimental period following a standard method (AOAC)[19].

Hematological study

The blood samples were collected randomly from three fishes from each tank, 0 ppt, 15 ppt and 25 ppt. For collecting the blood, the caudal vein was punctured using a sterile 1 ml syringe and 0.5 ml of blood was drawn by anesthetizing the fish using clove

oil. Before collecting the blood samples, the syringe was precoated with EDTA (2.7 %) as an anticoagulant. Cell count of red blood cells (RBC) and white blood cells (WBC) was measured by means of Neubauer hematocytometer by making 1-1000, 1-100 dilution of blood, respectively. Packed cell volume was calculated using glass capillary tube by centrifuging in a micro-hematocrit centrifuge for 5 min at 12,000 rpm. Mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were measured and calculated using following formulae.

Mean corpuscular volume (MCV) = (PVC/ RBC) x 10
Mean corpuscular hemoglobin (MCH) = (Hemoglobin/ RBC) x 10
Mean corpuscular hemoglobin concentration (MCHC) = (Hemoglobin/ PCV) x 100

Statistical analysis

Statistical analysis was made by means of SPSS VERSION 16.0 through one-way analysis of variance (ANOVA). For post hoc comparison of mean ($P < 0.05$) between different groups, Duncan's multiple range test was performed.

Results

Physico-chemical parameters

The physico-chemical parameters recorded throughout the 60 days experimental trial are given in Table 1. The temperature of water in the treatment tanks varied between 27.33±0.21 to 28.53±0.52 °C. The concentration of dissolved oxygen in all experimental tanks varied between 5.3±0.27 to 5.7±0.20 mg L^{-1}. The pH observed was within the range of 7.7±0.05 to 8.0±0.05 where, 0 ppt and 15 ppt reared fishes showed no significant difference. However the 25 ppt reared fishes recorded the lowest. The total alkalinity showed significant differences between treatments throughout the study with mean total alkalinity value ranging from 75.33±6.35 to 136.67± 23.33 mg $CaCO_3$ L^{-1}. The total hardness varied between 206.67±28.48 to 3166.7±166.6 mg $CaCO_3$ L^{-1}. The highest mean value of 3166.7±166.6 mg $CaCO_3$ L^{-1} was observed in 15 ppt and lower mean value of 206.67±28.48 mg $CaCO_3$ L^{-1} was recorded in 0 ppt.

Growth performance

Growth parameters recorded in various treatment groups are given in Table 2. Final body weight differed significantly among various treatment groups with the highest growth in terms of final biomass (45.280±402.65 kg), MGR (3.85±0.20 mg d^{-1} day^{-1}) and SGR (0.35±0.01 % day^{-1}), and better FCR (0.11±0.01) was observed in 15 ppt salinity tank compared to other treatments (Figs. 1 – 3). Similarly, 15 ppt salinity reared fishes recorded with higher FER and PER while the 25 ppt salinity reared fishes recorded the lowest. The survival rate showed a significant difference between different treatment groups (Fig. 4).

Carcass composition

The results of carcass composition recorded at the end of 60th day of experimental trial are presented in Table 3. The body of *E. suratensis* reared under high salinity level accumulated significantly higher level of moisture, total carbohydrate and digestible energy and decreased level of crude protein, ether extract, and ash content. Whereas the crude protein content significantly raised with raise in salinity.

Hematological analysis

The results of hematological analysis obtained at the end of the 60th day are presented in Table 4.

Table 1 — Physico-chemical parameters observed during the growth of *Etroplus suratensis* fingerling under the influence of salinity for a period of 60 days

Water quality parameters	Salinity treatments		
	0 ppt	15 ppt	25 ppt
Temperature (°C)	$28.53_a \pm 0.52$	$27.33_b \pm 0.21$	$27.80_{ab} \pm 0.05$
DO (mg L^{-1})	$5.7_a \pm 0.20$	$5.3_a \pm 0.27$	$5.6_a \pm 0.33$
pH	$8.0_a \pm 0.05$	$8.0_a \pm 0.03$	$7.7_b \pm 0.05$
Salinity (ppt)	$0.00_c \pm 0.00$	$15.21_b \pm 0.12$	$24.9_a \pm 0.29$
Total alkalinity (mg $CaCO_3$ L^{-1})	$136.67_a \pm 23.33$	$111.00_{ab} \pm 6.65$	$75.33_b \pm 6.35$
Total hardness (mg $CaCO_3$ L^{-1})	$206.67_c \pm 28.48$	$1860.0_b \pm 320.83$	$3166.7_a \pm 166.6$
Calcium hardness (mg $CaCO_3$ L^{-1})	$50.66_b \pm 5.81$	$36.50_b \pm 4.07$	$82.00_a \pm 3.05$
Magnesium hardness (mg $CaCO_3$ L^{-1})	$168.00_c \pm 13.85$	$285.47_b \pm 55.18$	$529.83_a \pm 1.33$

Values are expressed as Mean ± SE. Values in the same row with different superscripts differ significantly ($P < 0.05$) for each parameter. One-way ANOVA was used by following Duncan multiple range test for post hoc analysis

Table 2 — Growth parameters and survival rate of *Etroplus suratensis* fingerlings cultured in different salinity ranges for a period of 60 days in raceway-based system

Growth parameters	Salinity treatments		
	0 ppt	15 ppt	25 ppt
Initial total biomass (kg)	$35.893_a \pm 141.10$	$35.893_a \pm 1$ 41.10	$35.89_a \pm 141.10$
Initial mean weight (g)	$22.43_a \pm 0.88$	$22.43_a \pm 0.88$	$22.43_a \pm 0.88$
Final biomass (Kg)	$41.760_b \pm 646.63$	$45.280_a \pm 402.65$	$37.600_c \pm 320.0$
Final mean weight (g)	$26.10_b \pm 0.40$	$28.30_a \pm 0.25$	$23.50_c \pm 0.20$
Weight gain percentage (%)	$16.33_b \pm 1.44$	$26.16_a \pm 1.57$	$4.75_c \pm 0.51$
Mean growth rate (mg d^{-1} day^{-1})	$2.54_b \pm 0.20$	$3.85_a \pm 0.20$	$0.77_c \pm 0.08$
SGR (% day^{-1})	$0.23_b \pm 0.01$	$0.35_a \pm 0.01$	$0.07_c \pm 0.01$
FCR	$0.18_b \pm 0.01$	$0.11_b \pm 0.01$	$0.64_a \pm 0.06$
PER	$0.13_b \pm 0.01$	$0.20_a \pm 0.01$	$0.03_c \pm 0.00$
FER	$5.44_b \pm 0.48$	$8.72_a \pm 0.52$	$1.58_c \pm 0.17$
Survival (%)	$62.27_b \pm 0.53$	$76.89_a \pm 1.02$	$40.10_c \pm 0.94$

Values are expressed as Mean ± SE. Values in the same row with different superscripts differ significantly ($P < 0.05$) for each parameter. One-way ANOVA was used by following Duncan multiple range test for post hoc analysis

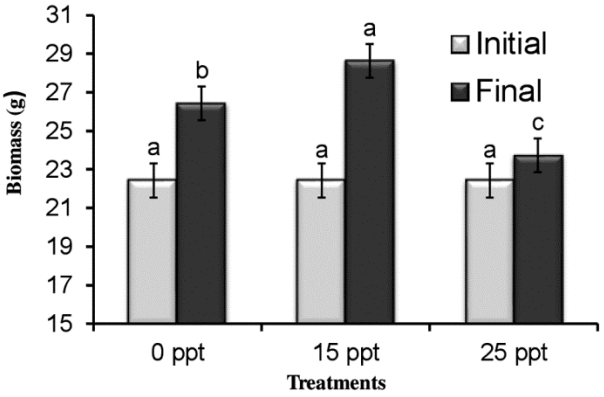

Fig. 1 — Biomass (g) of *Etroplus suratensis* fingerlings reared under different salinities for a period of 60 days (Initial a = 0.88, Final a = 0.25, b = 0.46, c = 0.20)

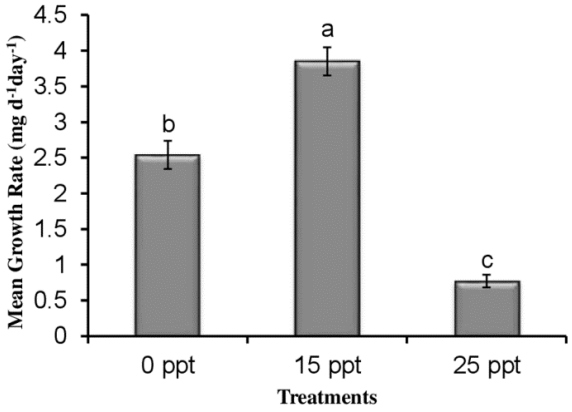

Fig. 2 — MGR (mg d^{-1} day^{-1}) of *Etroplus suratensis* fingerlings reared under different salinities for a period of 60 days (a = 0.20, b = 0.20, c = 0.08)

Pearlspot fingerlings reared under different salinities were recorded with significant differences in hematological parameters. The RBCs (Fig. 5) and

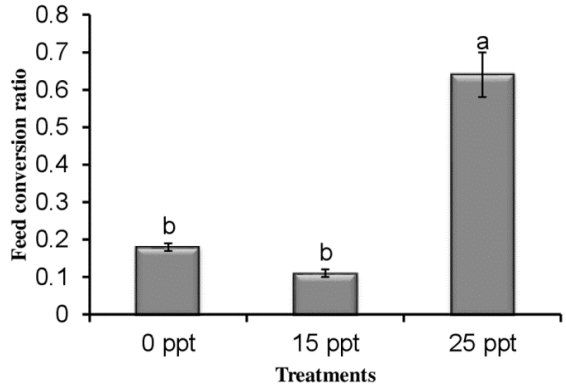

Fig. 3 — FCR of *Etroplus suratensis* fingerlings reared under different salinities for a period of 60 days (a = 0.06, b = 0.01, c = 0.01)

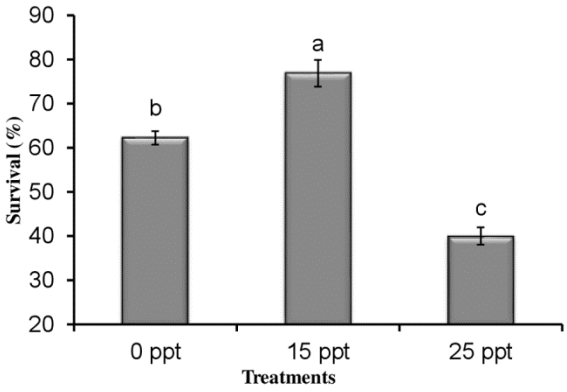

Fig. 4 — Survival rate (%) of *Etroplus suratensis* fingerlings reared under different salinities for a period of 60 days (a = 1.02, b = 0.53, c = 0.94)

WBCs (Fig. 6) content were observed to be affected at high salinity and found to be decreasing significantly ($p < 0.05$) from 0 to 25 ppt. Similarly, packed cell volume was found to be lowest in fishes reared in 25 ppt (4.50±0.17 cells cum m^{-1}) salinity and

Table 3 — Carcass composition (% wet basis) of *Etroplus suratensis* fingerlings reared under different salinities for a period of 60 days

Proximate composition	Salinity treatments		
	0 ppt	15 ppt	25 ppt
Moisture (%)	$74.27_{c} \pm 0.44$	$76.21_{b} \pm 0.19$	$77.58_{a} \pm 0.15$
Crude protein (%)	$32.24_{b} \pm 0.13$	$34.04_{a} \pm 0.10$	$28.17_{c} \pm 0.10$
Ether extract (%)	$4.48_{a} \pm 0.08$	$4.64_{a} \pm 0.17$	$3.59_{b} \pm 0.17$
Ash (%)	$6.54_{a} \pm 0.13$	$6.71_{a} \pm 0.18$	$4.27_{b} \pm 0.06$
Total carbohydrate (%)	$59.00_{b} \pm 0.19$	$54.60_{c} \pm 0.25$	$61.68_{a} \pm 0.09$
Digestible energy (Kcal 100 g^{-1})	$396.35_{b} \pm 0.98$	$391.81_{c} \pm 1.13$	$405.31_{a} \pm 0.63$
Dry matter (%)	$25.72_{a} \pm 0.44$	$23.78_{b} \pm 0.19$	$22.41_{c} \pm 0.15$
Organic matter (%)	$93.34_{c} \pm 0.15$	$94.32_{bc} \pm 0.75$	$95.56_{a} \pm 0.11$

Values are expressed as Mean ± SE. Values in the same row with different superscripts differ significantly ($P < 0.05$) for each parameter. One-way ANOVA was used by following Duncan multiple range test for post hoc analysis

Table 4 — Hematological parameters of *Etroplus suratensis* fingerlings cultured in different salinity ranges for a period of 60 days.

Haematological parameters	Salinity treatments		
	0 ppt	15 ppt	25 ppt
Haemoglobin (gm dl^{-1})	$7.23_{a} \pm 0.14$	$7.63_{a} \pm 0.08$	$4.20_{b} \pm 0.11$
RBC (million cum m^{-1})	$1.40_{a} \pm 0.01$	$1.6_{a} \pm 0.12$	$0.34_{b} \pm 0.02$
WBC (cells cum m^{-1})	$247500.0_{b} \pm 57735$	$253000_{a} \pm 57735$	$97667.0_{c} \pm 33333$
Platelet (cells cum m^{-1})	$335670_{b} \pm 10170.00$	$140000_{c} \pm 5773.5$	$1156000_{a} \pm 5773.5$
PCV (%)	$21.63_{a} \pm 0.14$	$21.63_{a} \pm 0.08$	$4.50_{b} \pm 0.17$
MCV (Fl)	$129.17_{c} \pm 0.43$	$135.80_{b} \pm 0.32$	$154.47_{a} \pm 0.49$
MCH (pg)	$49.43_{b} \pm 0.12$	$48.53_{b} \pm 0.17$	$54.00_{a} \pm 0.57$
MCHC (gm %)	$32.40_{c} \pm 0.20$	$35.46_{b} \pm 0.20$	$91.40_{a} \pm 0.20$

Values are expressed as Mean ± SE. Values in the same row with different superscripts differ significantly ($P < 0.05$) for each parameter. One-way ANOVA was used by following Duncan multiple range test for post hoc analysis

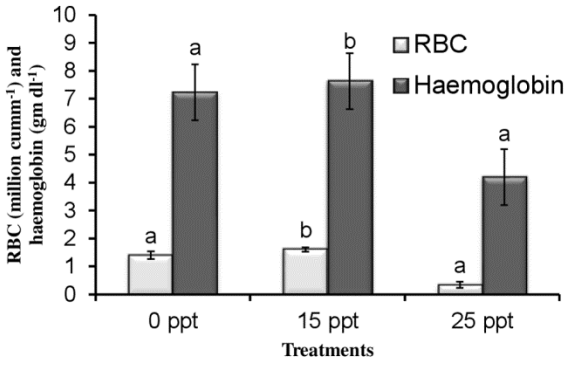

Fig. 5 — RBC (million cum m^{-1}) and haemoglobin content (gm dl^{-1}) of *Etroplus suratensis* fingerlings reared in different salinities for a period of 60 days (RBC: a = 0.12, a = 0.01, c = 0.02; Haemoglobin: a = 0.08, a = 0.14, b = 0.11)

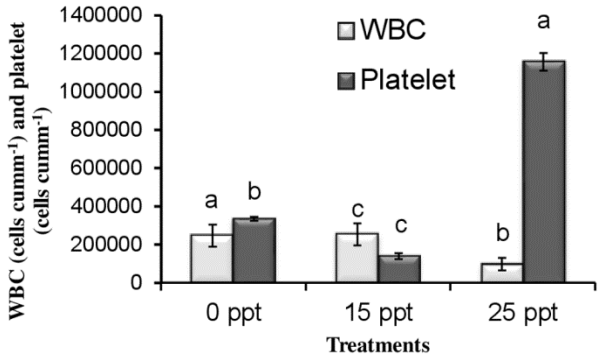

Fig. 6 — WBC (cells cum m^{-1}) and platelets content (cells cum m^{-1}) of *Etroplus suratensis* fingerlings reared in different salinities for a period of 60 days (WBC: a = 57735, b = 57735, c = 33333; Platelet: a = 5773.5, b = 10170.00, c = 5773.5)

no significant difference was observed in those fishes reared in 0 ppt (21.63±0.14 cells cum m^{-1}) and 15 ppt (21.63±0.08 cells cum m^{-1}) salinities. Further, MCV, MCH and MCHC also showed similar results with a significant difference ($p < 0.05$) between treatment groups (Fig. 7).

Discussion

Physico-chemical parameters were within the favorable range for rearing *E. suratensis*, representing that the new environmental condition was acceptable for the growth of the fish (Table 1). Temperature is considered as one of the vital physical factors which influence the growth of fish by affecting the rate of metabolism, oxygen consumption, and survival. Throughout the experimental period the temperature was recorded within the range of 27 to 28 °C. Joseph & Ignatius[20], reported that this species can grow well in temperatures of 24-32 °C. Hence the recorded temperature changes during the experiment were

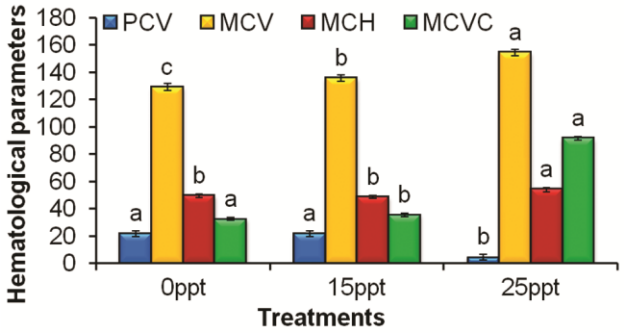

Fig. 7 — Haematological parameters (PCV (%), MCV (fL), MCH (pg) and MCHC (gm %) of *Etroplus suratensis* fingerlings reared in different salinities for a period of 60 days (PCV: a = 0.14, b = 0.08, c = 0.17; MCV: a = 0.49, b = 0.32, c = 0.43; MCH: a = 0.57, b = 0.17, b = 0.12; MCVC: a = 0.20, b = 0.20, c = 0.20)

conducive for the growth of *E. suratensis*. On the other hand, the growth and physiological changes in fishes is not greatly affected by temperature. To achieve an optimum growth, adequate dissolved oxygen content was maintained through aeration. In the present study, DO level was maintained above 5 mg L^{-1}. No significant difference was observed in DO levels, as the mean values varied between 5.3-5.7 mg L^{-1}, which was sufficient for the respiration of pearlspot which need more than 3 mg L^{-1} DO for its survival and proper growth. Pearlspot tolerates wide range of salinity ranging from freshwater to seawater[21]. In the present study, fish reared at 15 ppt (brackish water) and 0 ppt (freshwater), revealed better growth which was evident from the results of growth parameters. Similarly, pearlspot juveniles reared in RAS tanks also exhibited superior growth at 15 ppt salinity[22]. Semra *et al*.[12], also found that 15 ppt (isosmotic environments) as an optimum salinity for tilapia farming. Mapenzi *et al*.[22], studied the effect of salinity on growth of hybrids of *O. niloticus* (female) and *O. urolepis urolepis* (male) and stated that fishes exposed to 24 ppt of salinity were sturdily affected due to osmoregulatory changes in euryhaline fishes. The recorded pH during the experiment varied within 7.7-8.0. The results obtained were similar to the observations of El- Sherif & El-Feky[23]. The authors found that the water pH 7-8 could be more suitable for tilapia culture to improve growth in fish when salinity is altered. Several reasons have been hypothesized for better performance in brackish water and *vice-versa* due to changes in the activity of gill chloride cells[21]. In water, the total alkalinity varied between 75-136 mg $CaCO_3$ mg L^{-1}. Cavalcante *et al*.[24], also founded an acceleration in fish growth when it is maintained in alkaline water. Accordingly, in the present study, highest growth was obtained in 0 and 15 ppt salinities. The results observed were similar to Kumar *et al*.[25] which reported a similar range of water hardness to culture pearlspot in inland saline water.

In the present study, *E. suratensis* reared in lower salinities (15 ppt) recorded an improved performance in growth in terms of weight gain and mean growth rate. Similar results were observed in Milkfish[26], European seabass[27], Blue tilapia[12], Grey mullet[28] and in Pearlspot[10]. Highest growth was achieved when salinity was lowered from seawater salinity of 32 ppt to brackish water salinity of 15 ppt. An increased weight gain in lower salinity is may be due to an isosmotic point between the water salinity and blood. Boeuf & Payan[16], stated that in teleost fish, isosmotic point normally equates with a salinity of 12 ppt. Kidder *et al*.[29] also reported that euryhaline fish can adapt well to a broad salinity levels because of their capability to create salt transporting proteins, which helps to drift from saltwater to fresh water and *vice versa*. SGR of the present study was highest in 15 ppt salinity, compared to 0 ppt and 25 ppt. The reasons behind highest SGR in lower salinity is attributed to the less energy expenditure for osmoregulation and thereby increase in energy for other metabolic process such as muscular growth which results in increased fish growth[30]. Accordingly, in the present study, fishes reared in the lower salinity level would have effectively utilized the energy for growth rather than for osmoregulation, resulting in higher specific growth rate. Similarly, the FCR and FER of 15 ppt salinity reared fishes showed lowest FCR and highest FER, in comparison to other treatments which exhibited the highest FCR and the lowest FER. Ndome *et al*.[31] reported that FCR within the range of 1.5-2.0 has performed better growth. Previous studies on influence of salinity on growth of fish showed that FCR was affected at higher salinity as it increases stress, and lowers feed intake resulting in poor growth[32]. Similarly, Imsland *et al*.[14] documented that the growth and food consumption decreases with increase in salinity. Based on above studies, it can be concluded that lower salinity (15 ppt) lowers stress and increases feed intake resulting in superior growth performance in pearlspot. From the current study it is identified that pearlspot can be reared at 15 ppt as it produces lowest FCR and the highest FER. The PER values of the present study was also observed to be highest at 15 ppt salinity reared fishes compared to 0

ppt and 25 ppt. The results of the current study clearly showed that salinity and the survival rate of pearlspot has an indirect relationship between each other.

The carcasses composition of fish body is one of the important parameters affected by salinity. The present findings were supported by previous results reported in Milkfish[26], Silver pompano[33], and Nile tilapia[34]. In the current study, the moisture content of fish was found to increase significantly with the increase in salinity, which might be due to the excess rehydration, which makes the fish to absorb more water[35]. In the present study, *E. suratensis* reared in lower salinity showed higher percentage of protein and lipid levels, compared to other treatments. Evans[9] reported that when the salinity increases it indirectly affects the digestibility and feed intake which results in poor growth and carcasses composition owing to the suppression in gastric enzymatic activity because of the sea water which surrounds the solid meal. Fu[36] explained that the energy utilized by an organism to maintain osmotic pressure, mainly comes from the fats and protein content of the body. Similarly, in the current study, significantly higher digestible energy was recorded at increased salinity which might be due to the utilization of energy for the maintenance of osmotic pressure rather than the growth.

Hematological analysis is considered as one of the main indicators of salinity stress as it alters the blood parameters including blood components[16]. The efficiency of oxygen transport from gill to tissues was evaluated based on the RBCs, hemoglobin and hematocrit content[37]. Earlier researches on rearing of fishes in varied salinities showed a decreased RBCs and hemoglobin content at higher salinity compared to lower salinity. The results obtained were similar to the results reported in Guinean tilapia[38], Mullet[39], Blue tilapia[12] and Nile tilapia[40]. In the current study, RBC content was observed to be highest in fishes reared in 15 ppt salinity compared to 0 ppt and 25 ppt salinities. The reason behind an increase in RBCs and hemoglobin might be the adaptiveness towards saline conditions. Witeska[41] reported that the water salinity is considered as one of the important environmental factor which has a direct effect on RBCs and hematocrit value due to their effect on hemoglobin oxygen binding affinities towards oxygen transport. Similarly, fishes reared in lower salinity showed the fastest movement and were found to be highly active and this might be one of the possible reason for higher growth rate in low salinity reared fishes. In contrast, fishes maintained at higher salinity exhibited a lower RBCs and hemoglobin content, because of the changes in osmosis caused by ion secretion from the plasma. WBCs are the main immune cells having the capability to play a major role in immune response by producing and releasing a wide array of bioactive proteins of phagocytosis in nature[42]. In the current study, WBC count was highest in fishes reared at 15 ppt salinity compared to 0 ppt and 25 ppt salinities. Similar results have been earlier reported in different fishes like Guinean tilapia[38] and Nile tilapia[41]. The current results showed that fishes reared in 25 ppt salinity showed a reduced number of WBCs suggesting that the fishes were susceptible to diseases which also correlate with the reduced survival rate at higher salinity as a result of salinity stress. Platelet count is also a one of the indicators of non-specific immune response because the stress is induced through high salinity[43]. In the present study, highest platelet count was obtained in 25 ppt compared to 0 ppt and 15 ppt salinities. These results are in agreement with the findings in different fishes like Guinean tilapia[35] and Nile tilapia[40]. The mean corpuscular values such as mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) are correlated with hemoglobin concentration of erythrocyte and erythrocyte volume and weight, respectively. Similar results were obtained in Atlantic halibut[11], Guinean tilapia[35], Nile tilapia[40] and Grouper[44]. In the present study MCH, MCHC and MCV values were increased as salinity increases. The reason behind the increased corpuscular values with salinity in the present study might be due to osmoregulatory dysfunction induced at high salinity levels caused by ion leakage from the plasma[45].

Conclusion

The present study, *E. suratensis* fingerlings reared under different salinities in raceway based system resulted in a series of observations. The scarcity of water and the conflict for land usage for the expansion of aquacultural practices can be surmounted by using flow-through system and the fishes reared in 15 ppt salinity has showed good improvement in the growth performance and carcass composition and hematological studies. Therefore, rearing of pearlspot at 15 ppt salinity is recommended for maximizing its aquaculture production in future.

Acknowledgements

The authors are thankful to the TNJFU, Tamil Nadu for providing facility to carry out this work.

Conflict of Interest

The authors declare that they have no known conflict of interests.

Author Contributions

VE: Conceptualization, designing of study, data analysis and writing of original draft, SF: Resources procurement, supervision and final critical revision of the manuscript, SM: contributed in the supervision of investigation, SS: contributed in the Drafting and revising the manuscript.

References

1 Hora S L & Pillay T V R, Handbook on fish culture in the Indo-pacific region, *FAO Fisheries Biology Technical Paper, 14*, (1962) 1-203.

2 Rattan P, *Ecobiology of Pearlspot (Etroplus suratensis, Bloch) in Goa Waters*, Ph.D. Thesis, Goa University, Goa, India, 1994.

3 Bindu L & Padmakumar K G, Reproductive biology of *Etroplus suratensis* (Bloch) from the Vembanad wetland system, Kerala, *Indian J Geo-Mar Sci*, 43 (4) (2014) 646-654.

4 Prasadam R D, Observation on the biology of the Pearlspot, *Etroplus suratensis* (Bloch) from the Pulicat lake, *J Inland Fish Soc*, 3 (12) (1971) 12-78.

5 Swaminathan T R, Lakra W S, Gopalakrishnan A, Basheer V S, Khushwaha B, *et al*., Development and characterization of a new epithelial cell line PSF from caudal fin of Green chromid, *Etroplus suratensis* (Bloch, 1790), *In Vitro Cell Dev-AN*, 46 (2010) 647-656.

6 Padmakumar K G, Krishnan A, Radhika R, Manu P S & Shiny C K, Open water fishery interventions in Kuttanad Kerala, with reference to fishery decline and ecosystem changes, In: *Riverine and Reservoir Fisheries, Challenges and strategies*, edited by M R Boopendranath, B Meena Kumari, J Joseph, T V Sankar, P Pravin & L Edwin, (Society of Fisheries Technology, CIFT, Cochin, India), 2002, pp. 15-24.

7 Padmakumar K G, Krishnan A, Joetreson S, Reynold M & Bindu L, Potentials of open water fish culture in net cages in Vembenad lake, Kerala, In: *Proceedings of 3rd Indian Environmental Congress*, edited by Babu Ambat (Centre for environment and development, Trivandrum), 2004, pp. 155-165.

8 Brown T W, Boyd C E & Chappell J A, Approximate water and chemical budgets for an experimental, in-pond raceway system, *J World Aquacult Soc*, 43 (2012) 526-537.

9 Evans T G, Co-ordination of osmotic stress responses through osmosensing and signal transduction events in fishes, *J Fish Biol*, 76 (2010) 1903-1925.

10 Chandrasekar S, Nich T, Tripathi G, Sahu N P, Pal A K, *et al*., Acclimation of brackish water pearl spot (*Etroplus suratensis*) to various salinities: relative changes in abundance of branchial Na+/K+-ATPase and Na+/K+/2Cl− co-transporter in relation to osmoregulatory parameters, *Fish Physiol Biochem*, 40 (3) (2014) 983-996.

11 Lisboa V, Indianara F B, Luis A S & Adalto B, Effect of salinity on survival, growth and biochemical parameters in juvenile Lebranch mullet, *Mugil liza* (Perciformes: Mugilidae), *Neotrop Ichthyol*, 13 (2015) 447-452.

12 Semra K, Karul A, Yildirim S & Gamsiz K, Effects of salinity on growth and metabolism in blue tilapia (*Oreochromis aureus*), *Afr J Biotechnol*, 12 (19) (2013) 2715-2721.

13 Watanabe W O, Olla B L, Wicklund R I & Ernst D H, Rearing experiments with Florida red tilapia for saltwater culture, *Proc Gulf Caribb Fish Inst*, 40 (1991) 405-412.

14 Imsland A K, Gunnarsson S, Asgeirsson A, Roth B, Schram E, *et al*., Commercial- scale validation of temperature- step rearing on growth physiology in turbot, *Scophthalmus maximus*, *J World Aquacult Soc*, 39 (5) (2008) 684-691.

15 Kalidas C, Sakthivel M, Tamilmani G, Ramesh kumar P, Abdul Nazar A K, *et al*., Survival and growth of juvenile silver pompano, *Trachinotus blochii* (Lacepede, 1801) at different salinities in tropical conditions, *Indian J Fish*, 59 (2012) 5-98.

16 Boeuf G & Payan P, How should salinity influence fish growth, *Comp Biochem Physiol C Toxicol Pharmacol*, 130 (2001) 411-423.

17 Yada T, Uchida K, Kajimura S, Azuma T, Hirano T, *et al*., Immunomodulatory effects of prolactin and growth hormone in the tilapia, *Oreochromis mossambicus*, *J Endocrinol*, 173 (2002) 483-492.

18 APHA, *Standard methods for the examination of water and wastewater*, 22nd edn, edited by E W Rice, R B Baird, A D Eton & L S Clesceri, (DC: American Public Health Association, American Water Works Association, and Water Environment Federation, Washington), 2012.

19 AOAC, *Official methods of analysis of AOAC international*, Vol 1, 16th edn, edited by P A Cunniff, (AOAC international, Arlington, USA), 1995.

20 Joseph S & Ignatius B, Captive seed production of pearl spot in backyard hatcheries, *Mar Fish Infor Serv*; *T&E Ser*, 227 (2016) 3-7.

21 Selvaraj S, Jayakumar N, Pavinkumar P, Rajagopalasamy C B T, Ahilan B, *et al*., Role of gill chloride cell in teleost growth, *Indian J Res*, 8 (3) (2019) 1-3.

22 Mapenzi L L & Mmochi A J, Role of salinity on growth performance of *Oreochromis niloticus* ♀ *and Oreochromis urolepis urolepis* ♂ hybrids, *J Aquac Res Dev*, 7 (6) (2016) 85-89.

23 El-Sherif M S & El-Feky A M I, Performance of Nile tilapia (*Oreochromis niloticus*) fingerlings. I. Effect of pH, *Int J Agric Biol*, 11 (3) (2009) 297-300.

24 Cavalcante D G, Martinez C B & Sofia S H, Genotoxic effects of roundup on the fish *Prochilodus lineatus*, *Mutat Res-Gen Tox En*, 655 (1-2) (2008) 41-46.

25 Kumar K V, Hari K, Reddy A K, Chadha N K & Babitha A M, Effect of salinity on proximate composition of *Pangasianodon hypophthalmus* reared in inland saline water, *Int J Zool Stud*, 3 (2016) 19-21.

26 Alava V R, Effect of salinity, dietary lipid source and level on growth of milkfish (*Chanos chanos*) fry, *Aquacult*, 167 (3-4) (1998) 229-236.

27 Eroldogan O T, Kumlu M & Aktaş M, Optimum feeding rates for European sea bass *Dicentrarchus labrax* L. reared in seawater and freshwater, *Aquacult*, 231 (1-4) (2004) 501-515.

28 Olukolajo S O & Omolara L A A, Salinity tolerance of grey mullet, *Mugil cephalus* (linnaeus) fry in the laboratory, *Iran J Fish Sci*, 7 (4) (2013) 292-296.

29 Kidder III G W, Petersen C W & Preston R L, Energetics of osmoregulation: II. water flux and osmoregulatory work in the euryhaline fish, *Fundulus heteroclitus*, *J Experi Zool*, 305 (2006) 318-327.

30 Sampaio L A & Bianchini A, Salinity effects on osmoregulation and growth of the euryhaline flounder *Paralichthys orbignyanus*, *J Exp Mar Bio Ecol*, 269 (2) (2002) 187-196.

31 Ndome C B, Ekwu A O & Ateb A A, Effect of feeding frequency on feed consumption, growth and feed conversion of *Clarias gariepinus* X *Heterobranchus longifilis* hybrids, *Eur J Sci Res*, 6 (1) (2011) 6-12.

32 Pandley K & Shukla J P, *Fish and Fisheries*, 2nd edn, (Rastogi Publication, New Delhi), 2007, pp. 261-275.

33 Hamed S S, Jiddawi N S & Bwathondi P O J, Effect of salinity levels on growth, feed utilization, body composition and digestive enzymes activities of juvenile Silver Pompano, *Trachinotus blochii*, *Int J Fish Aquat Stud*, 4 (2016) 279-283.

34 Hasbullah D, Karim M Y & Trijuno D D, Physiological performance of osmotic work, survival, and growth rate of hybridized brackish Nile tilapia (*Oreochromis niloticus*) juveniles at various salinities, *Aquacult Aquarium Conserv Legis*, 11 (2) (2018) 327-332.

35 Kaushik S J & Oliva-Teles A, Effect of digestible energy on nitrogen and energy balance in rainbow trout, *Aquacult*, 50 (1989) 89-101.

36 Fu L V, Qing N, Yebing Y, Fei L, Linlan L V, *et al*., Effect of salinity on the growth performance, body composition, antioxidant indexes of *Perinereis aibuhitensis* and total nitrogen in the substrate, *J Agric Sci*, 8 (2017) 1239-1252.

37 Cook D G, Iftikar F I, Baker D W, Hickey A J & Herbert N A, Low-O_2 acclimation shifts the hypoxia avoidance behaviour of snapper (*Pagrus auratus)* with only subtle changes in aerobic and anaerobic function, *J Exp Biol*, 216 (3) (2013) 369-378.

38 Akinrotimi O, Agokei E & Aranyo A, Changes in blood parameters of *Tilapia guineensis* exposed to different salinity levels, *J Environ Eng Technol*, 1 (2012) 4-12.

39 Fazio F, Marafioti S, Arfuso F, Piccione G & Faggio C, Influence of different salinity on haematological and biochemical parameters of the widely cultured mullet, *Mugil cephalus*, *Mar Freshwater Behav Physiol*, 46 (4) (2013) 211-218.

40 De Azevedo R V, De Oliveira K F, Flores-Lopes F, Teixeira-Lanna E A, Takishita, S S, *et al*., Responses of Nile tilapia to different levels of water salinity, *Lat Ame J Aqua Res*, 43 (5) (2015) 828-835.

41 Witeska M, *The effect of metals (Pb, Cu, Cd and Zn) on hematological parameters and morphology of blood cells in common carp*, (Akademia Podlaska Publishers, Siedlce), 2003, pp.113.

42 Semple J W, Italiano J E & Freedman J, Platelets and the immune continuum, *Nat Rev Immunol*, 11 (2011) 264-274.

43 Sahafi H H, Masaeli S, Alizadeh M, Negarestan H & Naji T, A study on growth parameters, blood factors and proximate composition of rainbow trout (*Oncorhynchus mykiss*) cultured in underground brackish and freshwater, *Iranian J Fisheries Sci*, 12 (2013) 836-842.

44 Noor N M, Das S K, Cob Z C & Ghaffar M A, Effects of salinity on gastric emptying time in hybrid grouper, *Epinephelus fuscoguttatus* x *E. lanceolattus* juveniles, In: *AIP Conference Proceedings*, (AIP Publishing), 1940 (1) (2018) pp. 020052.

45 Alwan S, Hadi A & Shokr A, Alterations in hematological parameters of fresh water fish, *Tilapia zillii*, exposed to aluminum, *J Sci Appl*, 3 (2009) 12-19.