Influence of salinity on survival and growth of early juveniles of Spotted scat *Scatophagus argus* (Linnaeus, 1766)

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Abstract

We evaluated the effect of salinity on survival and growth of brackishwater ornamental fish *Scatophagus argus.* Thirty days old Scat fry (0.151±0.02 g; 16.1±0.13 mm) were randomly stocked in different salinity viz., 5, 10, 15, 20, 25 and 30 ppt and reared for 30 days. All the treatments were conducted in triplicate. Survival rate (SR), total length (TL), total weight (TW), specific growth rate (SGR) and mean growth rate were evaluated. Maximum SR of 98.33±2.89% was recorded at 5 ppt salinity followed by 96.67±2.89, 90.0±5.00, 88.33±2.89, 76.67±2.89 and 68.3±2.89% respectively at 10, 15, 20, 25 and 30 ppt salinity. Statistically, SR indicated significant ($p<0.05$) differences between different salinity except between 5 and 10 ppt. Scat fry attained maximum TW of 0.550±0.03g at 5 ppt and minimum of 0.415±0.01g at 30 ppt and statistically it was significant ($p<0.05$) between 5 and 30 ppt. *S. argus* reached maximum TL of 26±0.03 mm at 5 ppt and minimum of 22.9±0.98 mm at 30 ppt. However, the differences noticed in TL were statistically insignificant ($p<0.05$) between different salinity. Highest SGR (4.31±0.18%/day) was observed at 5 ppt salinity with the lowest (3.37±0.12%/day) at 30 ppt and statistically significant differences noticed between 25 and 30 ppt. The present study revealed that *S. argus* fry capitulate better growth and survival rate in the lower range of salinity from 5 to 20 ppt compared to 25 and 30 ppt salinity range and there by indicated the optimal range for fry rearing.

Keywords: Spotted scat, Salinity, Survival, Growth, Length, Weight.

1. Introduction

The spotted scat *Scatophagus argus* (Linnaeus 1766) (Perciformes: Scatophagidae), is an euryhaline teleost widely distributed in the near shore waters of the Indo-West Pacific Ocean and forms as an important food fish in Southeast Asia [1-2]. It is also a popular aquarium fish because of their quadrangular shape and attractive colour pattern [3]. This species is mostly found in estuaries, mangrove swamps, surf zone of beaches, coastal mudflats and harbours [4-5]. Due to increase demand of this species for aquarium trade, scat juveniles collected extensively from natural water bodies that have caused sharp decline in their abundance. This would cause not only the species decline but also affects the biodiversity. Keeping these factors in view, Central Institute of Brackishwater Aquaculture, Chennai has standardized the captive broodstock development, induced breeding and larval rearing protocols for *S. argus* for the first time in India [6-7] in order to produce the supply of hatchery produced scat juveniles for aquarium trade, which would reduce the pressure from the natural collection. Optimization of water quality parameters during hatching and rearing is one of the key aspects needs to be thoroughly investigated to achieve better hatching, growth and survival rate.

Among the water quality parameters, salinity is considered as one of the most important abiotic factors, which can directly influence on the growth and survival of aquatic organisms. Scat being an estuarine fish, it is often exposed to a wide range of salinities which can influence on the growth, reproduction and survival of the fish. Varying salinity to fish larvae may have effect on the osmotic concentration, concentration of selective ions, and the availability of oxygen due to the inverse correlation with salinity [8]. Effects of salinity on osmoregulatory processes and their impact on growth have been studied in estuarine species such as the milkfish (*Chanos chanos*) fry [9] and striped bass (*Morone saxatilis*) larvae [10] and they have stated that the younger fishes prefer the environments of lower salinity levels. It is reported that salinity can affect yolk utilization, larval growth and survival by influencing the amount of energy needed for osmoregulation [11]. Since, the energy cost due to the process of osmoregulation may be lower at iso-osmtotic salinities since the gradients between body fluids and the external environment are minimal [12]. The effect of salinity on the survival and growth of euryhaline fish is species-specific, and may also change during the ontogenetic development. The southern flounder *Paralichthys lethostigma* was found to have improved growth and survival rate in higher salinities of 34 ppt and above, the intermediate salinity ranges showed increased survival and growth rate in fat snook *Centropomus parallelus* [13] and seabream *Sparus aurata* [14]. Furthermore, the adaptive response of fish to varying salinity in the environment is also depends on the age and size. Considering the importance of salinity on the estuarine fish, the present investigation was taken up to assess the influence of salinity on growth and survival in the fry of brackishwater ornamental fish the Spotted scat *Scatophagus argus.*

2. Materials and methods

2.1. Fish and experimental design of the rearing trials

The present experiment was carried out at the Muttukadu experimental station of Central Institution of Brackishwater Aquaculture (MES, CIBA), Chennai, India. Thirty days old weaned fry (0.151±0.02g weight and 16.1±0.13mm total length) of the Spotted scat *Scatophagus argus* produced through induced breeding of captive reared broodstock in the hatchery at MES of CIBA were obtained. The fry were then acclimatized to laboratory condition for a week prior to experiment. Then they were acclimated to six different salinities (5, 10, 15, 20, 25 and 30 ppt) by gradually reducing or increasing salinity by 5 ppt, per 12 hr every day until attain desired salinities [15]. After acclimatization, the fry were stocked @ 4 nos.l^{-1} in 8 litre capacity glass aquaria tanks. Air stones at the bottom were placed in the centre of each tank to provide gentle homogeneous aeration.

During the experimental period of 30 days, the fish were maintained under natural photoperiod (12 hrs light and 12 hrs dark). Mean water temperature, pH and dissolved oxygen were monitored where 28±1.0^{o}C, 7.8±0.2 and 5.5±04 ppm respectively. Fishes were fed with the granulated feed (INVE Aquaculture Nutrition, Belgium) twice a day at 09:00 hrs and 15:00 hrs @ 3% body weight. Dead larvae, faecal matter and left out food if any were removed by siphoning and the mortality was recorded for each tank. Water exchange to the extent of 70% was done daily in the water of the same salinity. Total weight (TW) and total length (TL) of the fish were measured at the interval of every five days of the experimental period after the fry were anaesthetized in 100 ppm 2-phenoxyethanol solution [16]. Twenty fish randomly sampled from each group were individually weighed to the nearest 0.001g in an electronic balance (Citizen scale (I) Pvt. Ltd, Model CX 220, Mumbai, India) after removing the moisture content using by water blot paper. Total length (from the most anterior extremity – mouth closed – to the caudal rays squeezed to give the maximum length measurement) was measured to the nearest 0.1 mm using ictiometer.

2.1.1. Effect of salinity on survival rate

Separate set of experimental trials were conducted to estimate the survival rate of *S. argus* fry by exposing them into different salinity. Scat fry (0.151±0.02g weight and 16.1±0.13mm total length) were reared in 8 litre capacity glass aquaria tank and filled with 5 litre of filtered sea water. Scat fry were stocked @ 4 nos.l^{-1} in the salinities of 5, 10, 15, 20, 25 and 30 ppt. The feeding protocol was followed as same as mentioned in growth experiment. The experiment was continued up to 30 days and all the treatments were conducted in triplicates. Survival rate was estimated after 30 days of rearing.

2.1.2. Effect of salinity on growth

Mean growth rate for each replicate was calculated as the daily length increase (mm day^{-1}) using the formula as described by Nash *et al*. [17]; Final total length (mm) - Initial total length (mm)/Experimental duration (days). Daily specific growth rate (weight) was calculated as SGR=100 (ln Wt − ln W0) /T (%/day), where ln Wt and ln W0 are the natural logarithms of final and initial weight, respectively, and T is the duration of the experiments (days) [18]. The survival rate was calculated using the formula, (Final number of fish at the end of the experiment/Initial number fish at the beginning of the experiment) x 100 [19].

2.1.3. Statistical analysis

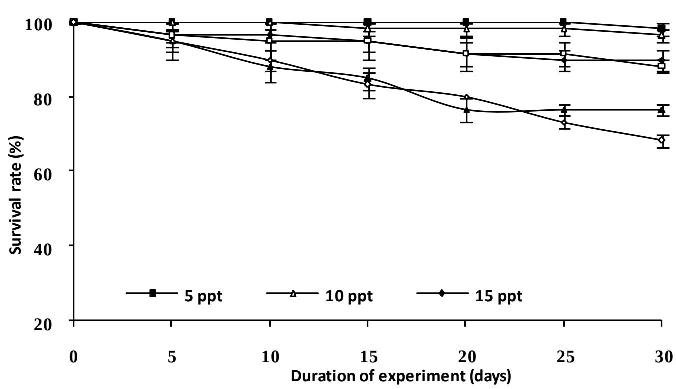
The effects of salinity on the larval survival rate, total weight, total length, specific growth rate and mean growth rates were analyzed using a one-way ANOVA followed by Duncan's method [20]. In the case of percentage data, the arcsine transformation was first performed before statistical analyses. The significance level was set at $p<0.05$. Statistical analyses and regression among the variables studied were conducted using the SPSS 16.0 software.

3. Results

3.1. Survival

Survival rate was affected by the salinity. Maximum survival rate could be observed (98.33±2.89%) at 5 ppt salinity followed by 96.67±2.89, 90.0±5.00, 88.33±2.89, 76.67±2.89 and 68.3±2.89% respectively in the salinities 10, 15, 20, 25 and 30 ppt (Fig. 1). The differences noticed in the mean survival rate of scat fry reared at 5 and 10 ppt was statistically significant with 15, 20, 25 and 30 ppt salinity. However, no significant ($p<0.05$) differences could be observed between 15 and 20 ppt and also between 25 and 30 ppt. The survival rate and growth parameters showed that the performance were better in the lower salinity range between 5 and 20 ppt.

Figure 1. Influence of salinity on survival rate (Mean±S.E (%), n=3 replicates) of S. argus fry reared in different salinities.



3.2. Growth

After 30 days of rearing, the scat fry attained the maximum mean total length of 26.0±0.03 mm at 5 ppt salinity followed by 24.6±1.07, 24.5±1.21, 24.4±1.55, 23.1±1.33 and 22.9±0.98 mm in the salinities of 10, 20, 15, 30 and 25 ppt respectively (Fig. 2). Data clearly indicated that *S.argus* fry has grown slightly better in the lower salinity, ranging from 5 to 20 ppt than the higher salinity ranges. However, the difference noticed in total length between different salinity was statistically insignificant ($p<0.05$). *S.argus* fry attained the maximum and minimum mean body weight of 0.550±0.03g and 0.415±0.01g at 5 and 30 ppt salinity respectively (Fig. 3). Mean body weight of 0.531±0.05, 0.519±0.09, 0.503±0.06, 0.419±0.06 and 0.415±0.01g was observed in the salinity of 10, 15, 20, 25 and 30 ppt respectively. Statistically, significant ($p<0.05$) differences observed in the values of weight between 5 and 30 ppt salinities. However, the differences noticed between 5, 10, 15, 20 and 25 salinities were statistically found to be insignificant ($p<0.05$). Although, salinity did not affect the growth of scat fry, lower range of salinity indicated slight better growth rate.

Figure 2. Mean total length (Mean±S.E (mm), n=3 replicates) of S. argus fry reared in different salinities.

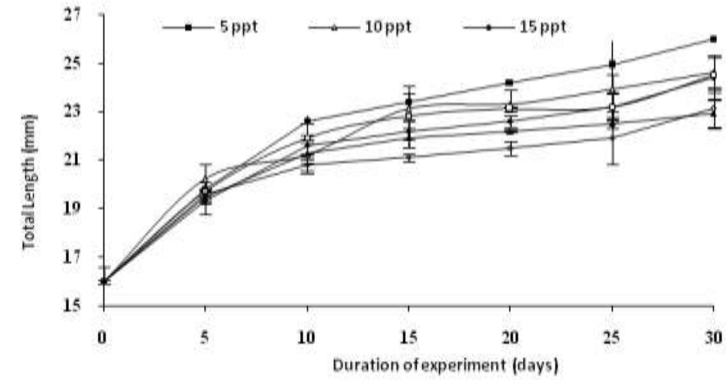
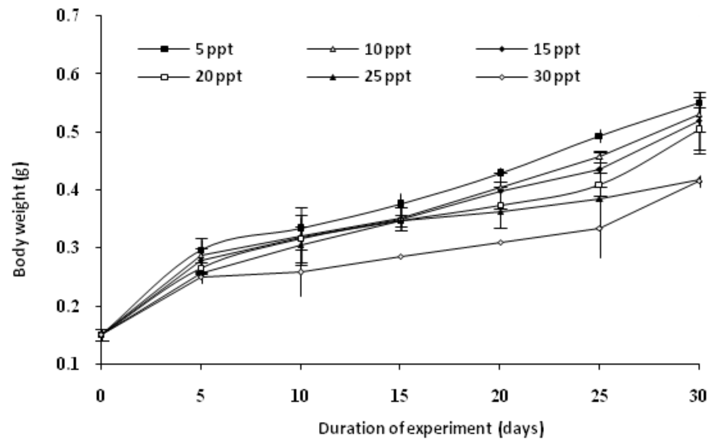


Figure 3. Mean body weight (Mean±S.E (g), n=3 replicates) of S. argus fry reared in the different salinities.



The specific growth rate of scat fry reared in different salinity ranges are shown in Fig. 4. The highest SGR of 4.31±0.18%/day was estimated in the scat fry reared in 5 ppt salinity followed by 4.18±0.33, 4.08±0.56, 4.00±0.40, 3.38±0.43 and 3.37±0.12 %/day respectively in salinities of 10, 15, 20, 25 and 30 ppt respectively indicating that Scat fry prefer lower saline conditions. Statistically, no significant ($p<0.05$) differences could be noticed in the SGR between 5, 10, 15 and 20 ppt. Highest mean growth rate (MGR) could be estimated in fish maintained at 5 ppt (0.33±0.00 mm day^{-1}) salinity followed by 0.28±0.04, 0.28±0.04, 0.28.±0.05, 0.23±0.04 and 0.23±0.03 mm day^{-1} in the salinities of 10, 20, 15, 30 and 25 ppt respectively (Fig. 5). These results with higher SGR and MGR of *S. argus* in the lower salinities ranging from 5 to 20 ppt compared to that of higher salinities confirmed the desirability of estuarine habitat for the rearing of the scat fish.

Figure 4. Specific Growth Rate (SGR) (Mean±S.E, (%/day) n=3 replicates) of S. argus fry reared in the different salinities.

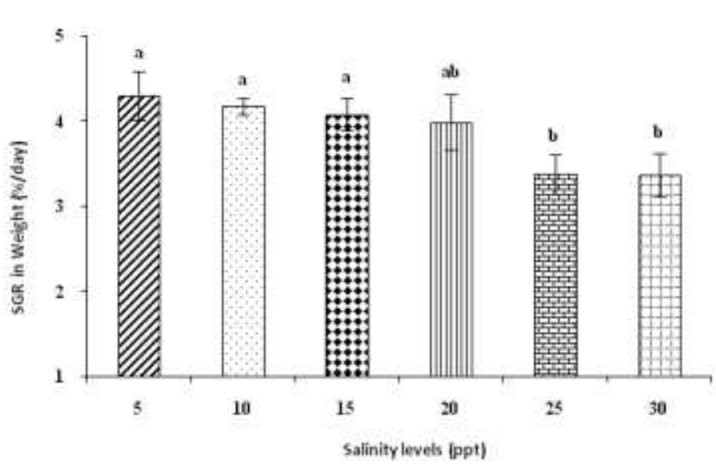
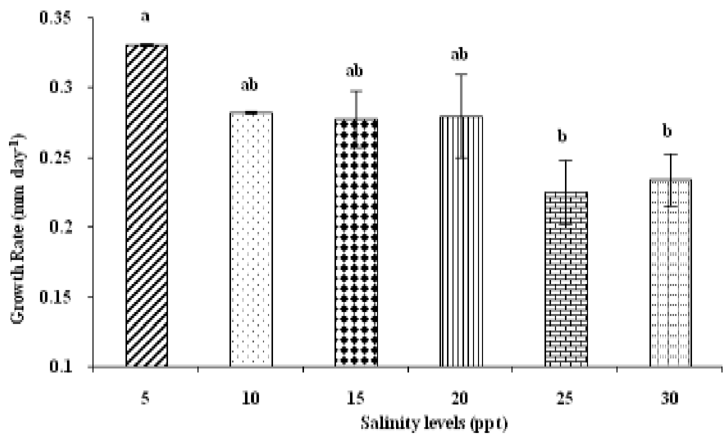


Figure 5. Growth rate of Total Length (Mean±S.E, (mm day^{-1}), n=3 replicates) of S. argus fry reared in the different salinities



4. Discussion

The present study findings illustrate that salinity is able to influence the growth and survival of *S. argus* fry. But, lower and intermediate saline conditions (5-20 ppt) favoured for better survival and growth. Differences that are observed in production characteristics of marine fish reared at lower salinities can be attributed to a multitude of variables including metabolism, activity, endocrinology and culture conditions [21]. Growth of tawny puffer (*Takifugu flavidus*) reared at 5 and 30 ppt salinity was significantly lower than that of 15 and 25 ppt [22]. Moutou *et al*. [23] have reported better growth rate in *Sparus aurata* at an intermediate salinity of 20 ppt compared to 33 ppt. However, higher total length was reported in the juveniles of fat Snooker *Centropomus parallelus* at 15 ppt when compare to that at 5 ppt [24]. The effect of salinity has profound influence on the growth of the fish and it is related not only to the total concentration of dissolved solids but also to the concentration of divalent ions. These dynamic changes in the concentration directly affect the permeability of membrane and osmoregulation. Growth in some fish species can be optimized when cultured at a salinity that minimizes osmoregulatory demands and increase the amount of energy available for growth [25, 21]. The alevins of *Oncorhyncus tschawytscha* survived longer in seawater than alevins of *O. kisutch* and *O.nerka* by virtue of high tissue tolerance to regulate serum chloride concentrations and blood osmotic pressure [26]. The results obtained from the present study were similar to the earlier reports where higher survival rate could be attained in intermediate salinity compared to that of very higher or low salinity conditions. The declined growth noticed in the higher salinity could be attained to the energy cost for metabolic and osmoregulatory function of the fish, than for growth.

It is reported that metabolic demand of fish larvae increases in hyperosmotic conditions as the fish attempt to maintain homeostasis of body fluids [27] and larvae in such environments needed to divert more energy into metabolism rather than growth [28]. The lower growth rate noticed in *S. argus* fry at 25 and 30 ppt than the 5-20 ppt might be due to higher metabolic rate towards the osmoregulatory function as reported by several researchers in various species. Boeuf & Payan [21] have suggested that the salinity can change the amount of energy available for body growth by altering the energetic cost for osmotic and ionic regulation. Many fish larvae usually regulate their plasmatic ions in a way that the osmotic pressure of their fluids is kept at 10 and 15 ppt [29-30].

The hypotheses that the energetic cost for osmoregulation is lower at an isosmotic medium, where the gradients between blood and water are minimum and the energy saved is sufficient enough to increase growth is supported by a number of studies [31]. In the present study, *S. argus* attains higher mean and specific growth rates in the salinity range between 5 and 20 ppt compared to 25 and 30 ppt. Similar trend was reported in the case of white fish (*Christoma stor estor*) larvae, where greater specific growth rate was observed at 10 and 15 ppt compared to that at 0 and 5 ppt. Since, variation in salinity can influence number of physiological processes [32], further study on the influence of salinity, on oxygen consumption, ammonia excretion, nutrient utilization in different age groups of *S. argus* during hatchery and nursery rearing phase would throw more light for better understanding on the physiology of this fish, for the production of high quality scat at shorter duration.

5. Conclusion

Exposure of *S.argus* fry to different salinity has resulted differences in survival rate and growth. Lower salinity range from 5 to 20 ppt performed better survival rate and growth compared to that of with higher salinity rage from 25 to 30 ppt. However, there is a need to understand the other physiological activities such as oxygen consumption and ammonia excretion, which would uncover the metabolic pathways involved due to salinity stress in *S.argus*

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7. References

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