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Impact of duration of stunting on compensatory growth and biometrics of snubnose pompano, *Trachinotus blochii* (Lacepede,1801) in low saline conditions

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Abstract

Compensatory growth (CG) pattern in snubnose pompano, *Trachinotus blochii*, stunted in low saline condition (< 15 ppt) was evaluated for its field level application. The fish were stunted for 30, 60 and 90 days by stocking 100 fish m^{-3} providing a commercial feed (45% crude protein, 0.8 to 1.2 mm size) at sub-optimal level [3% of average body weight (ABW)]. Post-stunting rearing was carried out in triplicates for 30, 60 or 90 days at a stocking density of 20 fish m^{-3} providing the same feed approximately 15% of ABW. Normal fish were maintained in triplicate at 20 fish m^{-3} providing feed at optimum level (10% of ABW) throughout the experiment. Parameters such as weight gain pattern, final ABW and specific growth rate (%) per day (SGR/day) indicated near complete CG in 30 days stunted fish. A partial CG in 60 days stunted fish and no CG in 90 days stunted fish compared to corresponding normal fish was observed. The 60 days stunted fish was found ideal for field adoption with longer stunting period with better CG and survival. A field trial was conducted in circular cage by stunting the fish at 40 fish m^{-3} (ABW = 5.4 g) feeding at 3% of ABW for 60 days. During post stunting, the stunted fish (10 fish m^{-3}) were reared in two cages feeding approximately 15% of ABW for 190 days. Parallely, normal fish (10 fish m^{-3}) were reared by feeding at 10% of ABW for 250 days. During stunting phase, the experimental fish exhibited a retarded growth (ABW = 18.9 g; SGR/day = 2.1) compared to normal (ABW = 27.9 ± 0.5 g; SGR/day = 2.7). In contrast, in post stunting phase, stunted fish exhibited partial CG (ABW = 116.23 ± 2.1 g; SGR/day = 0.71) compared to normal (ABW = 139.5 ± 15. 7 g; SGR/day = 0.8) with similar production (28.9 ± 1.8 g for stunted and 30.36 ± 4.3 g for normal) and higher survival (88.7%) than normal (77.5%). Biometric characteristics such as length - weight relationship (b value near 3) and condition factor (above 1) indicate natural growth in both stunted and normal fish. But size variation was higher in normal fish than stunted fish. Over all the experiments suggests that 60 days stunting in low saline conditions is ideal for ensuring good quality seed for farming of snubnose pompano.

Keywords Feeding regime · Growth metrics · Hatchery · Silver pompano · Cage

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Introduction

Quality stocking material is one of the important prerequisites for cage farming. As an innovative approach, the concept of compensatory growth (CG) in fish is well exploited in aquaculture. Stunted fingerlings are used as stocking material for farming (Cho and Cho 2009; Lingam et al. 2019; Santiago et al. 2004). CG in fish is a phase of augmented growth when favourable conditions are restored, after a period of growth depression, that may be classified as over compensation, full compensation, partial compensation and no compensation based on the rate of recovery of the growth

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(Ali et al. 2003). Won and Borski (2013) emphasised that endocrine regulation during the catabolic and hyperanabolic phase plays a major role in CG. CG pattern has been evaluated in several commercially important fishes such as hybrid Sun fish, *Lepomis cyanellus* × bluegill *L. niacrochirus* (Hayward, et al. 1997); Channel catfish, *Ictalurus punctatus* (Hatch et al. 1998); Asian seabass, *Lates calcarifer* (Tian and Qin 2003); Big Head Carp, *Aristichthys nobilis* (Santiago et al. 2004); Nile Tilapia, *Oreochromis niloticus* (Bhujel et al. 2007), Oliver Flounder, *Paralichthys olivaceus* (Cho and Cho 2009); Red seabream, *Sparus aurata* (Bavcevic et al. 2010), Milkfish, *Chanos chanos* (Lingam et al. 2019) and Atlantic salmon, *Salmo salar* (Hvas et al. 2022). It is found that the degree of compensation largely varies with the nature, severity and duration of the under-nutrition, the stage of development at the start of under-nutrition, the age at sexual maturity and the pattern of re-alimentation (Ali et al. 2003).

Pompano is an important group of candidate fish for marine farming (Pfeiffer and Riche, 2011; Tutman et al. 2004). Snubnose pompano, *Trachinotus blochii* (Lacepede, 1801) is an important candidate species for aquaculture due to the availability of standardized seed production technology, adaptability to pellet feed and good market demand (Abdul Nazar et al. 2012; Kalidas et al. 2020). Snubnose pompano is getting acceptance as a good candidate species for coastal low saline aquaculture in India (Jayakumar et al. 2014). This species is proven as ideal for pond culture and cage culture in coastal low saline conditions (Damodaran et al. 2019; Jayakumar et al. 2014; Kalidas et al. 2012).

Suresh Babu et al. (2019) summarised the importance of stunted fingerling production in marine finfish and indicated the possibility of employing stunting technique to prolong the seed availability of fish and production of healthy and hardy stocking material with more survival. Our previous report (Anikuttan et al. 2020) revealed the possibility of achieving compensatory growth in stunted fingerling of snubnose pompano reared under indoor marine conditions. The present study evaluated, the degree of compensation in stunted fingerling of snubnose pompano in low saline conditions by conducting series of indoor experiments and a field trial, using circular cages in an estuarine area, to assess the possibility of its field application. Also, the study evaluated the impact of stunting on biometric characteristics of snubnose pompano.

Materials and methods

The study followed the prevailing laws related to animal ethics in India. The experiments were conducted at two separate levels; in the first set of experiments, CG of fish stunted for different durations was evaluated in indoor conditions. Followed by this, a field trial was conducted, using circular cages, for the confirmation of CG of stunted fish in low saline field conditions. The indoor experiments were conducted at the marine hatchery complex of Karwar Regional Station of ICAR-CMFRI and the field trial was done at the backwaters near the Station. For both the experiments, snubnose pompano fingerling procured from the marine finfish hatchery of Mandapam Regional Centre of ICAR-Central Marine Fisheries Research Institute (CMFRI), Mandapam, Tamil Nadu, India was used. The feed used for both the experiments was a commercial feed (Nutrila, Growel India Pvt. Ltd; 45% crude protein; 10% crude Fat; 2.5% crude Fibre; 11% moisture, 0.8 to 3 mm size). Water quality parameters such as dissolved oxygen, pH, temperature, salinity and NH_3-N were monitored at 15 days intervals following standard procedures (APHA, 1981) for all the experiments.

Evaluation of compensatory growth of snubnose pompano stunted for different durations in indoor conditions

Three sets of experiments for 30, 60 and 90 days stunting was carried out separately. The experiments were conducted in two phases such as stunting phase and post-stunting phase. Fibre Reinforced Plastic (FRP) tanks of 3 m^3 capacity filled with 2 m^3 of clean filtered and chlorinated low saline water (15 ppt) was used for the experiments. The water was chlorinated (10 ppm Sodium Hypochlorate) and dechlorinated by aeration for 48 h, before adding to the tanks. Water exchange was carried out daily at 100% during the stunting period in order to prevent ammonia accumulation at higher stocking densities, where as during post stunting period water exchange was reduced to 30% per day. Continuous aeration was provided throughout the experimental period so as to ensure sufficient dissolved oxygen in the water. Initial average weight of the fish was noted prior to the stocking in experimental tanks. Growth sampling was done fortnightly for recording the average weight and feed rations. The feed ration was divided and feed was given morning 10 am and night 10 pm for all the indoor experiments. Length and weight of individual fish were noted for morphometric analysis.

The experiments were conducted following the protocol described by Anikuttan et al. (2020) with slight modifications. Schematic representation of design of indoor experiments is given in Fig. 1. In the stunting phase, fish were stocked, at a stocking density (SD) of 100 m^{-3} and fed @ 3% of body weight (ABW), and reared for various stunting periods [30 days (E1), 60 days (E2) and 90 days (E3)]. After stunting phase, fish (E1, E2 & E3 stunted groups) were

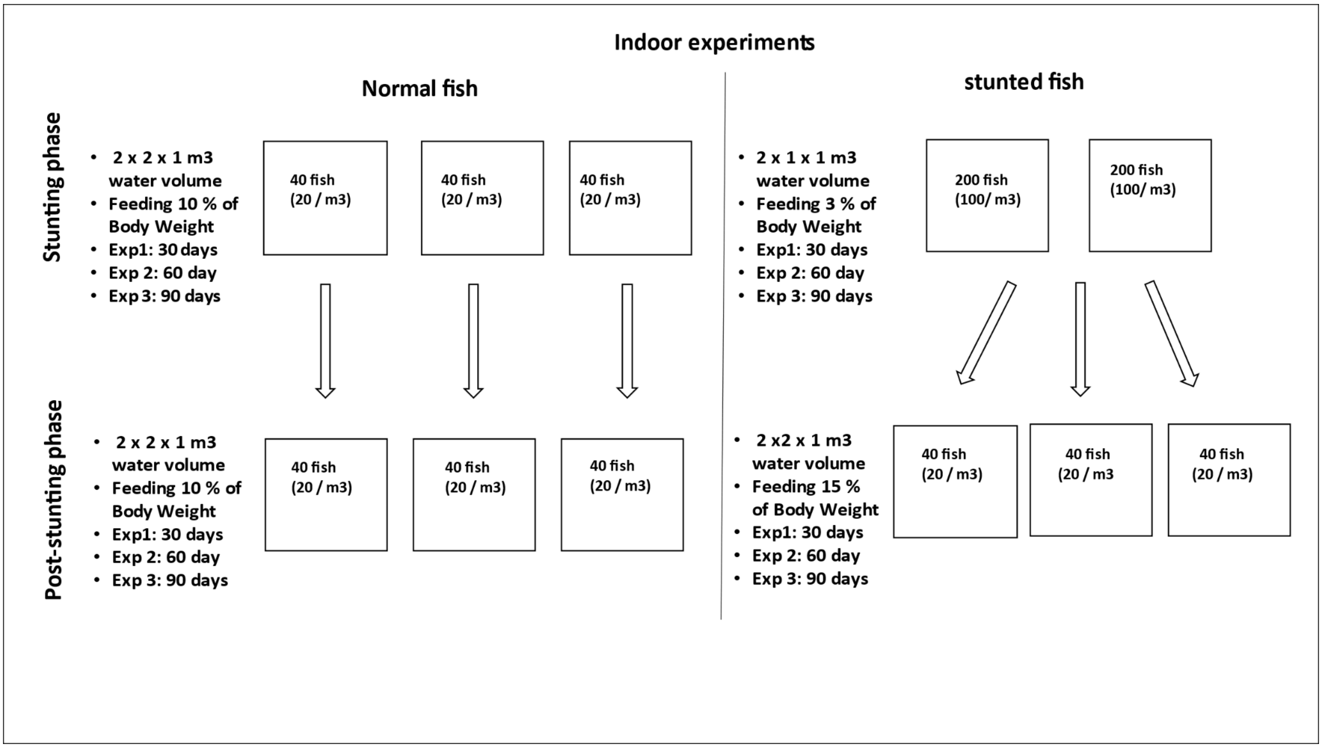

Fig. 1 Schematic representation of design of Indoor experiment

further reared for another 30, 60 and 90 days, respectively, as the post stunting phase. During this phase, stunted fish were restocked at a lower SD (20 m^{-3}) and fed approximately at 15% of ABW. Similarly, three normal group of fish were maintained, separately, in FRP tanks at a SD of 20 m^{-3} and fed @ 10% of ABW throughout the experiment (stunting and post-stunting phases).

Validation of compensatory growth in low saline field conditions

Schematic representation of design of field experiment is given in Fig. 2. The field trail was carried out in the backwater area near the station using circular GI cage (3 m diameter and 3 m depth) for confirming the CG of stunted fish in cages. Fish (840 numbers) were stunted for 60 days in a circular GI cage at a SD of 40 fish m^{-3} feeding at 3% of body weight. Similarly normal fish (210 fish/cage; SD = 10 fish m^{-3}) were reared in 2 cages (3 m diameter and 3 m depth) feeding at 10% of body weight. The feed ration was divided and given in the morning 9 am and evening 5 pm daily throughout the experiment.

The stunted fish were restocked (210 fish/cage; SD = 10 fish m^{-3}), in two cages (3 m diameter and 3 m depth), and reared for 190 days (post-stunting phase) by feeding approximately 15% of ABW initially and gradually reduced to 6%. The normal fish reared in the same cages for another 190 days at the same SD with feeding rate at 10% of body initially gradually reduced to 6% at the end of experiment. Sampling was done at monthly intervals for recording the average weight and to regulate the feed rations. Length and weight of individual fish were recorded for biometric analysis.

Growth and production characteristics

In each growth sampling 30% of the stock was sampled to record the length and weight of individual fish. Total length of the fish from tip of snout to tip of the caudal fin was measured using a 1 m wooden scale with an accuracy of 1 mm. Total weight of fish was measured using an electronic weighing balance (Sartorius, Germany) with an accuracy of 0.001 g for smaller fish and for bigger fish, a pan balance with an accuracy of 1 g was used. Specific growth rate per day (SGR / Day %) was calculated according to De Silva and Anderson (1995) as Specific growth rate (% / day) = [ln (Final weight) - ln (Initial weight)] / [Experimental days] x 100, Where 'ln' is the natural logarithmic value. Condition factor (k) of the fish in their habitat was determined as per Gomiero & Braga (2005) as k = (W x 100) / L^3, where k = condition factor; W = the weight of the fish in gram (g); L = the total length of the fish in centimetres (cm). Total biomass, at different growth phases, was derived by multiplying average weight of individual fish with total number of

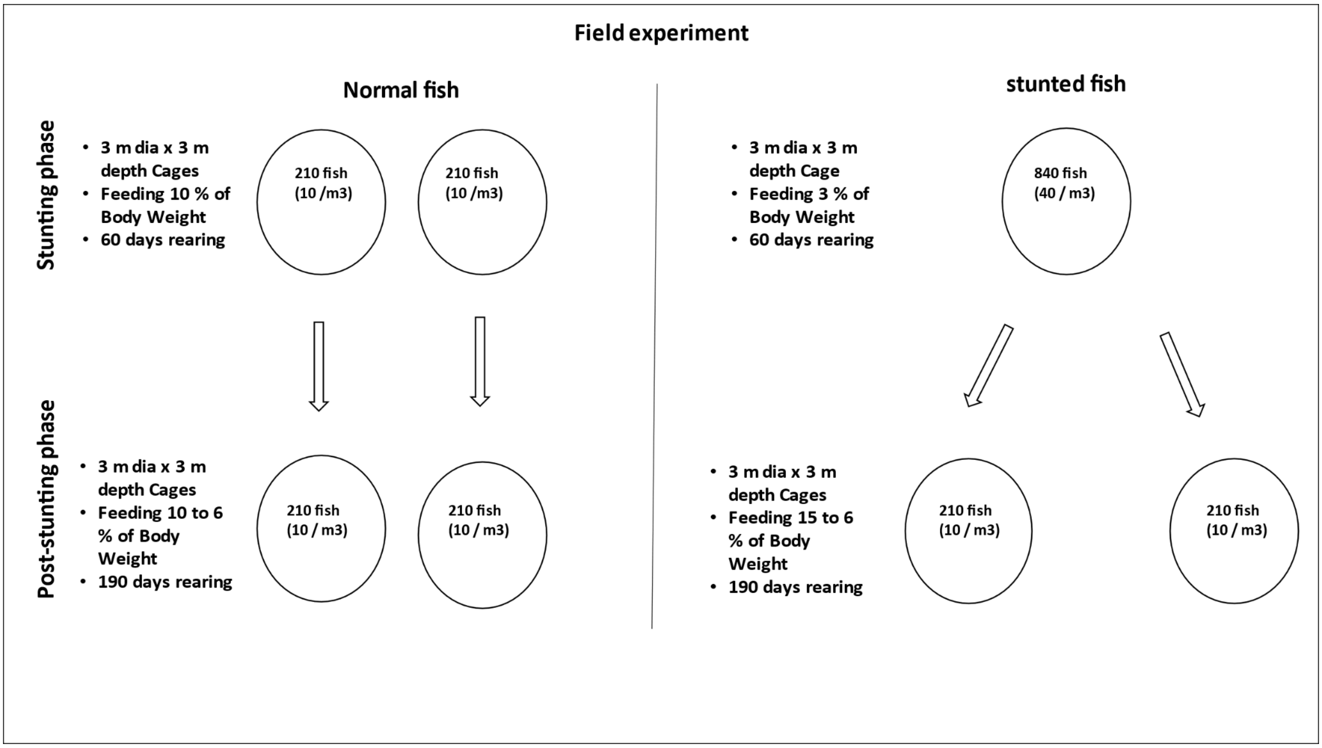

Fig. 2 Schematic representation of design of Field experiment

fish harvested at the end of the experiment. At the end of the experiment, the number of fish in each tank was counted and the survival rate (%) was calculated as Survival (%) = (Total number of fish present x 100) / Total number of fish stocked. Length-weight relationship was calculated from the log transformed total body length and body weight data as Log (WEIGHT) = a + [b x log (LENGTH)] where 'a' is the intercept and 'b' is the slope of the linear regression on the log transformed weight (g) and length data (cm). Pooled samples from all replications of each treatment were used for this analysis.

Statistical analysis

Statistical significance for the tested parameters has been fixed at $p < 0.05$. The mean values were compared using Student's t test for significant difference ($p < 0.05$) among the stunted and normal fish. Results either in ratio or percentage were not subjected to t test similar to our previous report (Anikuttan et al. 2020).

Table 1 Average values of water quality parameters for the stunting experiments

Parameters	Indoor experiments			Field trial
	30 days stunting	60 days stunting	90 days stunting	60 days stunting
Temperature ^{0} C	29.7 ± 0.47	30.78 ± 0.21	28.9 ± 0.48	29.03 ± 0.2
pH	7.24 ± 0.05	7.34 ± 0.07	7.31 ± 0.06	7.53 ± 0.062
Salinity (ppt)	10.75 ± 0.28	12 ± 0.6	13.2 ± 0.42	18 ± 0.82
Dissolved oxygen (ppm)	5.2 ± 0.06	5.4 ± 0.18	5.18 ± 0.12	4.4 ± 0.04
NH_4^+ (ppm)	0.067 ± 0.006	0.052 ± 0.008	0.078 ± 0.04	0.064 ± 0.06

Results

Water quality parameters

Average values of water quality parameters such as dissolved oxygen, pH, temperature, salinity and NH_3-N was monitored and given in Table 1. The parameters were within the optimum range for the normal growth of snubnose pompano.

Table 2 Status of stunting in snubnose pompano subjected to different durations of stunting in indoor tanks

Parameter	30 days group		60 days group		90 days group	
	Stunted	Normal	Stunted	Normal	Stunted	Normal
Initial length (cm)	5.8 ± 0.2	5.8 ± 0.2	4.37 ± 0.1	4.37 ± 0.1	4.93 ± 0.3	4.93 ± 0.3
Final length (cm)	6.58 ± 0.2^{a}	7.1 ± 0.2^{b}	4.65 ± 01^{a}	6.6 ± 0.4^{b}	7.16 ± 0.4^{a}	9.02 ± 0.2^{b}
Initial weight (g)	4.2 ± 0.1	4.2 ± 0.1	0.8	0.8	2.04	2.04
Final weight (g)	6.0 ± 0.3^{a}	8.4 ± 0.5^{b}	2.4 ± 0.4^{a}	5.0 ± 0.8^{b}	4.1 ± 0.2^{a}	12.3 ± 0.6^{b}
SGR / day (%)	1.81	2.18	1.8	2.3	0.77	1.99
Status of stunting	stunted		stunted		stunted	

Values with different superscripts in the same row in each experimental group differ significantly ($p < 0.05$)

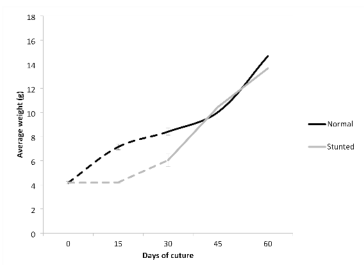

Fig. 3 Depiction of the gain in weight in 30 days stunted fishes. Dotted line indicates the weight (g) during stunting period and solid line indicates the weight (g) during post stunting period

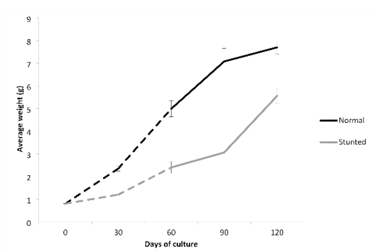

Fig. 4 Gain in weight in 60 days stunted fishes. Dotted line indicates the weight (g) during stunting period and solid line indicates the weight (g) during post stunting period

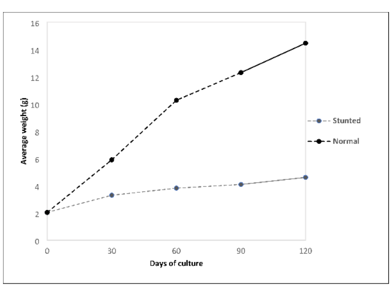

Fig. 5 Gain in weight in 90 days stunted fishes. Dotted line indicates the weight (g) during stunting period and solid line indicates the weight (g) during post stunting period

Evaluation of compensatory growth of snubnose pompano stunted for different durations in indoor conditions

Growth characteristics of stunted and normal fish during the stunting phase of the experiments is given in Table 2. Final weight and SGR/ day (%) for the treated fish were significantly lower ($p < 0.05$) than that of the normal fish in all the three groups indicating that the fish, subjected to stunting, were stunted and thus they can be further explored for studying the CG pattern. The dotted lines in the Figures (Figs. 3, 4 and 5) indicate that the weight gain of stunted fish which was lower than the normal fish.

Growth characteristics of stunted and normal fish during the post stunting phase of the experiment is given in Table 3. During the post stunting phase, the stunted fish exhibited diverse degree of compensation in growth. In the first group (30 days), the final weight and final length did not differ significantly ($p > 0.05$) and the SGR / day (%) was higher than the normal fish indicating complete growth compensation. The gain in weight (Fig. 3) also indicates complete compensation in growth in 30 days stunted fish. Total biomass ($p > 0.05$) was significantly lower in stunted fish and survival was same in both the treatments.

During post stunting phase of the 60 days group, the final weight and length of stunted fish was significantly ($p < 0.05$) lower than normal fish, but the stunted fish have shown a higher SGR / day (%) compared to normal fish. Data on weight gain among stunted fish (Fig. 4) indicates that the treated fish have shown a lower growth during the stunting phase but has partially compensated the growth during the post stunting phase and the growth rate of normal fish was higher during this phase. On closure of the experiment after 120 days, the study found significantly lower total biomass in stunted fish with similar survival between the stunted and normal fish. During post stunting phase of the 90 days groups (Fig. 5), the stunted fish could not initiate the CG. Additionally, the experiment revealed mass mortality during the post stunting phase of fish.

Condition factor was above 2 in both stunted and normal fish in both 30 days and 60 days group of experiment. Since size variation was negligible and the length weight data not yielded a proper relationship, the data is not compared for the indoor experiments.

Table 3 Status of compensation in snubnose pompano subjected to different durations of stunting in indoor tanks

Parameter	30 days group		60 days group		90 days group	
	Stunted	Normal	Stunted	Normal	Stunted	Normal
Initial length (cm)	6.58 ± 0.2[a]	7.1 ± 0.16[b]	4.65 ± 01[c]	6.6 ± 0.4[d]	7.16 ± 0.37[e]	9.02 ± 0.24[f]
Final length (cm)	8.5 ± 0.1[a]	8.6 ± 0.14[a]	6.7 ± 0.22[c]	7.4 ± 0.64[d]	7.23 ± 0.4[e]	9.34 ± 0.41[f]
Initial weight (g)	6.0 ± 0.3 [a]	8.4 ± 0.5[b]	2.4 ± 0.4[c]	5.0 ± 0.8[d]	4.1 ± 0.2[e]	12.3 ± 0.6[f]
Final weight (g)	13.7 ± 0.6[a]	14.67 ± 0.3[a]	5.56 ± 0.6[c]	7.7 ± 0.5[d]	5.9 ± 0.4[e] (30 days)	14.5 ± 0.6[f] (30 days)
SGR / day (%)	2.7	1.9	1.38	0.72	-	-
Condition factor	2.2	2.08	2.1	2.2	-	-
Survival (%)	98	98	97	98	32 (30 days)	68(30 days)
Total Biomass (g)	564.4 ± 5[a]	578.8 ± 8[b]	228 ± 1.83[c]	310 ± 1.65[d]	-	-
Degree of compensation	Nearcomplete compensation		Partial compensation		No compensation (fatal)	

Values with different superscripts in the same row in each experimental group differ significantly ($p < 0.05$)

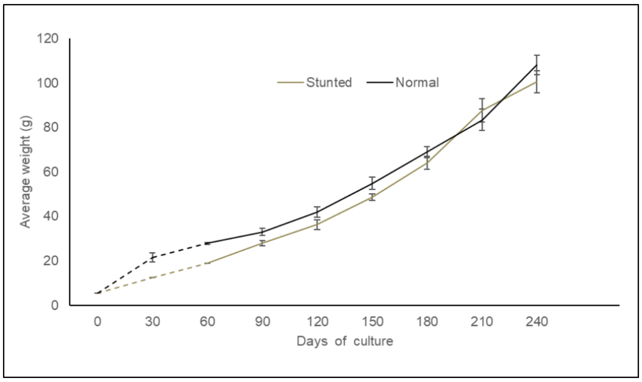

Fig. 6 Growth of on-farm stunted snubnose pompano during farming in low saline cages. Dotted line indicates the weight (g) during stunting period and solid line indicates the weight (g) during post stunting period

Validation of compensatory growth in snubnose pompano at low saline field conditions

Progress in average weight gain during the field trial among stunted fish and normal fish is depicted in Fig. 6. The growth characteristics recorded during the field trial is given in Table 4. During stunting phase, the experimental fish exhibited a retarded growth (ABW = 18.9 g; SGR/day = 2.1) compared to normal (ABW = 27.9 ± 0.5 g; SGR/day = 2.7), whereas during post stunting, stunted fish exhibited partial CG (ABW = 116.23 ± 2.1 g; SGR/day = 0.71) compared to normal fish (ABW = 139.5 ± 15. 7 g; SGR/day = 0.8) with a higher survival (88.7%) than normal (77.5%). During the stunting period, the SGR / day pattern (Fig. 7) was higher in the normal fish but during the post stunting period the stunted fish exhibited a higher SGR than the normal fish. The predicted biomass at different growth phases is given in Fig. 8. and the total biomass was almost similar in both stunted and normal fish throughout the experiment. There was no significant difference ($p > 0.05$) between the total biomass harvested from both the groups by the end of the

Table 4 Growth characteristics of stunted and normal fish in the field trial

Parameter	stunting		Post stunting	
	Stunted	Normal	Stunted	Normal
Days of Culture	60	60	190	190
Stocking density (m^3)	30	10	10	10
Initial length	6.7	6.7	10.5	11.78 ± 0.2
Final length	10.5	11.78 ± 0.2	20.4 ± 0.4[a]	21.8 ± 0.3[b]
Initial weight (g)	5.4	5.4	18.9	27.9 ± 0.5
Final weight (g)	18.9	27.9 ± 0.5	116.23 ± 2.1[a]	139.5 ± 15. 7[b]
Condition factor	1.6	1.68	1.43	1.45
SGR / day (%)	2.1	2.7	0.71	0.8
Survival (%)			88.7	77.5
Total Biomass (Kg)			28.9 ± 1.8[a]	30.36 ± 4.3[a]
Coefficient of variation (Length)			0.07	0.09
Coefficient of variation (weight)			0.22	0.26

Values with different superscripts in the same row differ significantly ($p < 0.05$)

experiment (Table 4). Size variation was also noticeably lower in stunted fish. Condition factor was above 1.4 in both normal and stunted fish during the stunting and post stunting period. Length weight relationship for fish harvested from the field experiment is given in Table 5. Fish from all the treatments were following a near isometric growth ($b = 2.9$) and the equations maintained a higher R^2 values for the treatments.

Discussion

Water quality is important for any fish rearing experiments. Water quality parameters such as dissolved oxygen, pH, temperature, salinity and NH_4^+ were within the range

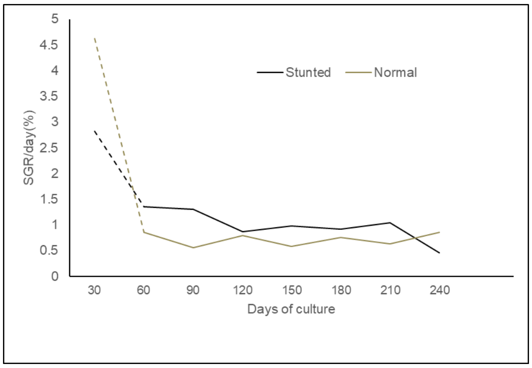

Fig. 7 Specific Growth Rate / day of on-farm stunted snubnose pompano in low saline cages. Dotted line indicates the growth during stunting period and solid line indicates the weight (g) during post stunting period

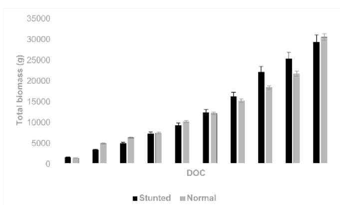

Fig. 8 Predicted biomass for stunted and normal fishes at different DOC during field trials

Table 5 Length weight relationship of fish harvested from field trial

	Sample size (n)	Intercept (a)	Slope (b)	R^2
Stunted fish	60	3.98	2.900	0.938
Normal fish	60	3.99	2.896	0.961

required for the growth of snubnose pompano in low saline condition (Jayakumar et al. 2014). In all the three stunted groups (30, 60 and 90 days stunting) the slower weight gain pattern, lower final body weight and SGR / day confirm growth restriction in stunted fish at the end of stunting phase. Stunting in fishes is attained either by ration restriction, density manipulation, thermal and salinity manipulation, and other resource restrictions (Ali et al. 2003). In the present work a combination of restricted feeding and over crowding was employed for stunted fingerling production as per Anikuttan et al. (2020). In nature, the stunted growth in fishes, during unfavourable conditions, has been reported years back (Burrough and Kennedy, 1979). Ylikarjula et al. (1999) reported that resource limitation and size or age dependent survival probabilities are the two probable reasons for occurrence of natural stunting. Lingam et al. (2019) in milkfish and Suresh Babu et al. (2021) in rohu reported that long term stunting can be achieved in culture systems by increasing stocking density and sub-optimal feeding. In 30 and 60 days stunted groups, survival rate was not differing among the normal and stunted fish but the total biomass was significantly lower ($P < 0.05$) in stunted fish than normal fish at the end of stunting phase. In our previous report, also, stunting was achieved with similar survival rate in snubnose pompano under marine condition up to 90 days at similar stocking rate and feeding protocol (Anikuttan et al. 2020). During stunting period, majority of the stored bio-molecules in tissues and energy were metabolised which in turn impart a major role in inducing the CG under optimal conditions (Enberg et al. 2008; Won and Borski, 2013).

In the present study during the post stunting experiment, the 30 and 60 days stunted fish shown a higher SGR / day (%) compared to normal fish indicating compensation of growth. In the 30 days stunted group, there was no significant difference ($p > 0.05$) in the final weight of stunted and normal fish at the end of the post stunting phase revealing complete growth compensation. In the 60 days stunted group, the final weight of the stunted fish were significantly ($p < 0.05$) lower than the normal fish, however, the weight gain pattern and the SGR / day (%) indicated partial growth compensation. According to Paul et al. (1995) in partial growth compensation, food-restricted (stunted) fish shows enhanced growth after the resumption of normal feeding (post stunting phase), but do not achieve the same body mass as that of continuously fed (normal) fish. Cho and Cho (2009) in *Paralichthys olivaceus*, Kim and Lovell, (1995) in *Ictalurus punctatus* and Tian and Qin, (2003) in *Lates calcarifer* reported partial growth compensation in feed deprived fishes. The stunted fish need to be fed at higher feeding rates in order to obtain compensatory growth (Das et al. 2006; Lingam et al. 2019; Anikuttan et al. 2020, Hvas et al. 2022).

In 90 days stunted group, retarded growth was observed during the stunting phase, but the fish has not shown any sign of initiation of compensation during the post stunting phase. Moreover, high rate of mortality was noticed in this group at the end of stunting phase which was continued when the remaining stunted fish were restocked in the post stunting phase.The stunted stock has shown complete mortality on 10th day of post stunting phase. Normal fish were not showing any mortality. Das et al. (2016) also reported no growth compensation in long term stunted rohu, *Labeo rohita* due to crowding stress during stunting. Raina and Sachar (2014) stated that prolonged feed deprivation needs to be avoided in aquaculture practices to avoid unhealthy seed development. The ability of the fish to overcome long term stunting effect is species specific and it depends on their capacity to utilize endogenous energy reserve and lifestyle adaptation during stunting process (Collins and Anderson, 1995). On contrary to our previous report (Anikuttan et al. 2020), where complete CG was recorded in 90 days stunted snubnose pompano in marine conditions, over crowding along with lower salinity might have imparted additional stress to the fish.

Previous reports suggests that same species may yield different degree of CG according to the stunting period. Anikuttan et al. (2020) reported varying degree of CG in subnose pompano stunted in marine condition. In Oliver Flounder *Paralichthys olivaceus*, Cho and Cho (2009) reported a partial compensation in feed deprived fish, but Cho (2005) reported full compensation in the same species with altered experimental conditions. Lingam et al. (2019) also reported varying degree of CG in milk fish, *Chanos chanos* stunted for different duration.

The degree of growth compensation, in ration restricted fish, is influenced by the species studied (Bavcevic et al. 2010; Bhujel et al. 2007; Cho and Cho, 2009; Hatch et al. 1995; Santiago et al., 2004; Tian and Qin, 2003,), duration of stunting (Das et al. 2016; Lingam et al. 2019) and method of stunting (Ali et al. 2003). From the indoor experiments, it was realized that snubnose pompano can be stunted successfully for 60 days for CG response. Therefore, it has been decided to conduct a field trial, with same stunting duration, in open water cages with a prolonged post-stunting period, for further examination of CG response. At the end of stunting phase, stunted fish, reached a lower size than the normal fish indicating stunted growth in on-farm condition also. During post stunting phase, the stunted fish have registered a slow growth in the initial period whereas in the later part of the rearing period achieved complete growth compensation. Additionally, specific growth pattern of the stunted fish was higher than the normal fish throughout the post stunting period. Anikuttan et al. (2020) reported complete growth compensation in stunted snubnose pompano during a 90 days post-stunting phase. Lingam et al. (2019) also reported complete growth compensation in milkfish. *Chanos chanos* stunted for 8 months in a 10 months grow out period. The field trial suggests that stunted snubnose pompano can attain complete CG in prolonged culture durations. The predicted biomass at different phase of the experiment was similar among stunted and normal fish. Lower growth during the fag end of the farming trial in stunted fish may be attributed to the higher survival and biomass attained during this period. Even though, the stunted fish attained lower final average weight, total biomass did not differ significantly ($p > 0.05$) owing to higher survival than the normal fish.

The present study adopted ideal stocking density of 10 numbers m^{-3} for pond rearing of snubnose pompano in low saline conditions (Damodaran et al. 2019; Jayakumar et al. 2014). In contrary, Kalidas et al. (2020) reported better performance of snubnose pompano grown in lower stocking density (5 m^{-3}) in marine cages. The slower growth rate obtained in the post stunting phase for both stunted and normal fish compared to previous pond trials, can be correlated with the higher stocking density adopted for the low volume cages.

Uniform size for the harvested fish is a desirable attribute for marketing. Coefficient of variation is an index of size variation of harvested fish (Costa-Bomfim et al. 2014; Yu and Ueng, 2007). In the present field study, the harvested fish have shown vast variation in body weight (CoV above 0.2) both in stunted as well as normal fish. However, a noticeably lower variation was seen in the stunted fish (0.22 or 22%) than the normal fish (0.26 or 26%) which indicates the possibility of getting comparatively more uniform harvest size if stunted fish are used as stocking material for farming. This finding is in line with that of Anikuttan et al. (2020) who reported reduced size variation in stunted pompano than the normal fish in indoor experiments conducted in marine condition.

Analysis of length -weight relationship of snubnose pompano from the field trial reveals that, b value (slope) is nearer to 3, for both normal and stunted fish, indicating isometric growth pattern irrespective of the treatment. This indicates that the stunted fish have grown isometrically at par with the normal fish. Lingam et al. (2019) also reported near isometric growth in stunted milk fish grown in brackish water ponds.

Condition factor ‘K’ is a good indicator of degree of well-being of the fish in their habitat based on the isometric growth pattern (Datta et al. 2013; Gomiero and Braga, 2005). Stunted growth is having impact on condition factor of the fish (Hossain et al. 2006). Luo et al. (2009) reported a significant reduction in condition factor of long-term starved channel catfish, *Ictalurus punctatus*. Condition factor of the stunted fish during indoor experiments as well as field trial were above 1 indicating that the fish have grown ‘well’ during the entire farming period (Datta et al. 2013) at par with the normal fish. Condition factor in the stunted fish were always above 1.4 in the present work. Damodaran et al. (2019) reported an ideal k value of above 1.5 for snubnose pompano in pond rearing experiments which is similar to the k value of present study.

The practical application of the concept of CG is influenced by factors such as growth pattern and physiology of the species, environmental conditions of the farming system and the feeding strategies followed in the culture practice. Cho and Cho (2009) opined that restricted feeding and subsequent compensation can be applied in Oliver flounder, *Paralichthys olivaceus* farming, if unfavourable environmental conditions such as red tides and cold water masses persists in the farming environment. In the case of carps, stunting is done to remove weak and sick fry so as to produce healthy larger fish seed, as a stocking material for grow-out culture (Radheysham and Saha, 2009). Indian major carps are stunted mainly for enhancing the somatic growth and to reduce the culture duration (Charan et al. 2014). In the present study, we aimed to develop a strategy to maintain stunted fingerling in hatcheries and nursery systems, during unfavourable conditions, so that the fish can be stocked in the cages when favourable conditions resume. Stunting of fish in the nursery facilities can assure the availability of healthy, hardy and stockable size seed for an extended (60 days) period. Suitable hatchery strategies may be developed, using this stunted seed production technique, for keeping the smaller transportable size fish in the rearing facilities for a prolonged period, with minimum input cost, which ensure seed availability of snubnose pompano for farming.

The present work gives baseline information on stunted fingerling production of snubnose pompano in low saline conditions for extending the availability of good quality seed for farming and can be considered as a model for other commercial species also. The results need to be validated further with more field trials for evaluating the economic viability of this technique.

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Statements and declarations

Conflict of interest The authors share no competing interest regarding this research publication.

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