EFFECT OF DAILY DECREASING RATE OF WATER SALINITY ON SURVIVAL AND CHEMICAL COMPOSITION OF *SPARUS AURATA* FRY

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SUMMARY

The present study was conducted to investigate the effect of daily decreasing rate (DDR) of water salinity, from saline water (32 ppt) to fresh water, on survival, condition factor (k), growth performance and chemical composition of *Sparus aurata* fry. Eight daily dilution rates were investigated, these are : 1, 2, 3, 4, 8, 16, 24 and 32 ppt in triplicated treatments. Natural food composed of *Brachionus plicatilis* and *Artemia salina* nauplii were introduced, through feeding sequence, twice daily at 8.0 a.m. and 2.0 p.m. during the experimental period (32 days). The results explain the possibility of transferring gilthead sea bream (*S.aurata*) fry, either gradually (survival rates were 100%) or directly (survival rates were 96% and 92%), from seawater to fresh water, which were exposed to different daily salinity decreasing rates. Condition factor average daily gain, (ADG),specific growth rate (SGR %), protein, fat and energy gains were increased with decreasing the daily dilution rate of water salinity. In addition, chemical composition for the experimental fry was affected, where dry matter (DM%), crude protein (CP%), ether extract (EE%) and energy centent (EC) increased with decreasing daily dilution rate of water salinity, while ash content decreased.

It could be concluded that *Sparus aurata* fry can tolerate fresh water to up to 98.85 % survival and can grow well through gradual dilution system, under laboratory conditions.

Keywords: Sparus aurata, salinity, daily dilution, performance

INTRODUCTION

Salinity, temperature and photoperiod are the most important environmental factors affecting survival, growth, reproduction and other physiological activities of fish. Salinity is epigenetic abiotic determinant environmental parameter considered as one of the most causative agents of osteological, shape, and pigmentation defects in fish (Divanch *et al.*,1996).

Gilthead sea bream is an euryhaline marine fish, tolerate a wide range of salinity and highly esteemed for brackish water farming. Sea bream farming depends mainly on the abundance of the fry with a corresponding numbers and quality. Because of the inadequate numbers of sea bream fry collected from the natural source in Egypt, especially, when taking into account the handling mortality, sea bream culture still poor industry. This led to the importance of studying induced spawning, broodstock and larvae nutritional and environmental optimal conditions for this commercial fish. Some steps had been taken in Egypt for acclimation of marine fish in brackish water, *Sparus aurata* (Wassef, 1979) and fresh water, *Mugil cephallus* (Mabrouk, 1991).

Cultivation of *Sparus aurata* in mariculture systems, in addition to attempts in order to adapt it under different water salinities, will led to increase sea bream production through aquaculture activities. The majority of fishes are adapted to living in solutions of more or less definite osmotic pressure, and when transferred to water of different osmotic pressure they die fairly rapidly. There are some beneficial effects of isosmotic salinities to teleost larvae, these beneficial effects include enhanced swimming ability, reduced metabolic activity, and increased growth rate (Holliday ,1969). On the other hand, gilthead sea bream (*S.aurata*) has an additional attraction for mariculture and it thrives at salinities exceeding 40 ppt (Ben-Tuvia, 1970) and (Porter, 1980). The more or less complete constancy of the internal environment is an extremely impotant factor which enables fishes to adapt themselves to living in waters of various salinities. This constancy is attained by the development of various osmoregulatory adaptations, which enable the fish to regulate the osmotic pressure of its body fluids. The more perfect the osmoregulatory adaptations, the greater the difference between the compositions and the pressures of the internal fluids of the organism and its external environment, Nikolsky (1962). Therefore, the present study was carried out to investigate the effect of 8 daily decreasing rates (DDR) of sea water salinity (1, 2, 3, 4, 8, 16, 24 and 32 ppt/day), from sea water to fresh water, on survival, condition factor, growth and carcass composition of acclimatized *S. aurata* fry.

MATERIALS AND METHODS

Gilthead sea bream (*S.aurata*) fry, 38 day old, were obtained from (induced spawning) the marine fish hatchery, Mariout Fish Farming Company, 21 km near Alexandria. It were with a medium length of 21 mm and medium weight of 0.069 g per larva. The experimental larvae were transported from the hatchery to the laboratory in aerated polyethylene bags and then stocked for 48 hours for the purpose of releasing the dead ones due to transportation and also to realize adaptation in the new media. Dead individuals, due to transportation and handling, were kept frozen for chemical analysis. At the end of the experiment (32 days), all acclimatized larvae were taken from each treatment, killed, oven dried at 70°C for about 48 hours and kept for chemical analysis.

Twenty four experimental glass aquarium, 6 mm thickness, 100 cm in length, 40 cm in width, and 30 cm in height, were used in this experiment. Water volume in each aquarium was adjusted at 100 liter of sea water at the beginning of the experiment, which was filtered and aerated with oxygen.

Experimental fry were stocked at a rate of 25 fry per treatment (aquarium) where the fry were collected, approximately, of the same size to prevent cannibalism.

All experimental initial treatments were started with 32ppt water salinity and then changed in which dilution was done using overnight aerated fresh water every 24 hours, in order to reach 0.45 ppt final salinity in all treatments. Temperature was recorded twice daily (8.00 a.m. and 2.00 p.m.) and salinity was adjusted once daily using refractometer. Each treatment was triplicated. Daily allowance from live food for fry in all treatments were 6 rot./ml *Brachionus plicatilis* plus 10 ind./ml *Artemia salina nauplii. Chlorella salina* was firstly cultured indoor as a basic food for *B.plicatilis*. Feeding sequence was carried out according to the method of Freddi (1985) for *S.aurata*.

Water quality

Table 1 shows the parameters of water quality used in the present study during the experimental period. Salinity values was 32 ppt, dissolved oxygen 4.69-4.77 mg/l, ammonia 3.82-3.88 μM, nitrite 1.02-1.16μM, nitrate 0.31-0.37μM, total inorganic nitrogen 5.22-5.34μM and phosphate 1.03-1.11μM.

Table 1. Quality of sea water used throughout the present study

Content	Mean values
Salinity (ppt)	32
Dissolved oxygen mg / L	4.73
Ammonia -N (μM)	3.85
Nitrite (μM)	1.09
Nitrate (μM)	0.34
Total inorganic N (μM)	5.28
Phosphate (μM)	1.07

(μM): Micro mole.

The experimental period lasted for 32 days for the first treatment and for other treatments, it was reduced with increasing the salinity daily decreasing rate (DDR) as indicated in Table (2). Data were analyzed using generalized linear model procedure (SAS,1995). Chemical approximation were analyzed according to AOAC (1985).

Table 2. Plane of daily decreasing rate (DDR) of sea water salinity* by fresh water

Treatment	Daily Decreasing Rate(DDR) of Salinity (ppt).	Experimental duration (days)
1	1	32
2	2	16
3	3	11
4	4	8
5	8	4
6	16	2
7	24	2
8	32	1

*Initial and final water salinity in all treatments were 32 and 0.45 ppt, respectively

RESULTS AND DISCUSSION

Survival

The Results in Table 3 showed that survival rates among all treatments were 100%, except for treatments 7 and 8 (96% and 92%), respectively which were exposed to higher daily salinity decreasing rates (24 and 32 ppt of sea water, respectively). Yet, the results explain the possibility of transferring gilthead sea bream (*S.aurata*) fry, either gradually or directly, from seawater to fresh water. No significant differences (P<0.01) were revealed between the first six treatments (from 1 to 6) in survival percent, while a significant difference (P<0.01) occurred between treatments 7 and 8 on one side and the previous six treatments on the other side.

Table 3. Effect of daily decreasing rates (DDR) of water salinity, from sea water to fresh water, on survival and growth of gilthead sea bream (*S.aurata*) fry

Treatment / Item	1	2	3	4	5	6	7	8	
No. of fish at the end of experiment	25	25	25	25	25	25	24	23	$L.S.D._{0.01}$
Survival %	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	96^{b}	92^{c}	1.088
Initial weight (g)	0.069^{a}	0.069^{a}	0.069^{a}	0.069^{a}	0.069^{a}	0.069^{a}	0.069^{a}	0.069^{a}	0
Final weight (g)	0.879^{a}	0.815^{b}	0.805^{c}	0.719^{d}	0.720^{d}	0.695^{e}	0.692^{ef}	0.690^{f}	0.006
Weight gain (g)	0.81^{a}	0.75^{b}	0.74^{c}	0.65^{d}	0.65^{d}	0.63^{e}	0.62^{ef}	0.62^{f}	0.006
ADG (mg/fish/day)	25.31^{a}	23.31^{b}	23.00^{c}	20.31^{d}	20.34^{d}	19.56^{e}	19.47^{ef}	19.41^{f}	0.19
SGR %	7.95^{a}	7.72^{b}	7.68^{c}	7.32^{d}	7.33^{d}	7.22^{e}	7.21^{e}	7.20^{e}	0.024
Condition factor	3.20^{a}	3.13^{ab}	3.01^{bc}	2.96^{bc}	2.86^{c}	2.56^{d}	2.91^{bc}	2.46^{d}	0.11

Treatments in rows with the same letters are not significantly different (P<0.01) .

Treatments from 1 to 8 : 1, 2, 3, 4, 8, 16, 24 and 32 (ppt) DDR of water salinity, re of water salinity, respectively.

ADG : Average daily gain

SGR : Specific growth rate = (log final wt. _ log initial wt.) *100/ Time in days

Condition factor = [live wt.(g) / length^3 (cm)] * 100

The results of the present experiment showed that *S.aurata* fry can tolerate the sudden change from sea water (32 ppt) to fresh water, 0.45 ppt within one day with 92% survival. The values of survival rates improved to 96% and 100% with increasing the time to change from sea water to fresh water from 1.25% to 2 days, respectively. Decreasing the rates of changing water salinities from sea water to fresh water through 2, 4, 8, 11 ,16 and 32 days were equal in its response on 100% survival of *S.aurata* fry.

These results clearly showed that *S.aurata* fry can tolerate the higher rates (or even the sudden) change of salinity from sea water (32 ppt) to fresh water (0.45 ppt). Previous results of Chervinski (1975,1979 and 1984) clearly indicated that *S.aurata* fry (0.38 g) have the ability of tolerance and growth in 1.2 ppt salinity through gradual adaptation (from hypersaline water, 41 ppt) for seven days.

Tandler and Helps (1982) indicated that high losses were observed at early larval stages of *S.aurata* for the first three weeks (6-7mm SL), these losses may be attributed mainly to nutritional and other environmental factors. *Sparus aurata* larvae which have just been hatched are still unable to achieve active contacts with the environment (pre larval period) (Freddi, 1985).

In agreement with the present results, Wassef (1979) concluded that gilthead sea bream succeeded to be acclimatized and adaptable to pond conditions in brackish water (18 ppt). However, Chervinski (1984) concluded that *S.aurata* could adjust to direct transfer from sea water to up to 90 % fresh water, and up to 95 % fresh water when they were given time to adapt.

Condition factor

Table 3 viewed the effect of daily decreasing rate of water salinity on condition factor, where the fry exposed to (1 ppt) DDR demonstrated the highest condition factor, while that exposed to (2ppt) DDR of water salinity was slightly differed from the first treatment. While treatments 3 and 4 which were exposed to 3 and 4 (ppt) DDR of water salinity, respectively differed significantly (P<0.01), compared to treatment 1.The lowest values of condition factor were recorded in treatments 5, 6, 7 and 8, respectively which were exposed to higher rates of DDR of water salinity without any significant difference between each other. A slight significant differences were revealed between treatments 2, 3 and 4 which exposed to 2, 3 and 4 DDR, of water salinity, respectively, however, differences were not significant . In the light of the previous results, it was observed that increasing DDR of water salinity resulted in a significant ($P<0.01$) decrease in weight and condition factor of *S.aurata* fry.

Lein and Tveite (1995) revealed that Atlantic halibut new hatched larvae kept at lower salinity showed high survival rates, but the frequencies of jaw deformation increased in groups kept in low salinity water. In addition, Saunders and Henderson (1969a) reported that Atlantic salmon parr experienced heavier mortality at 30 ppt salinity than at 0,7, or 15 ppt. However, Ben-Tuvia (1970) reported that sea bream thrives at salinities exceeding 40 ppt. On the other hand, Cataudella *et al.* (1991) concluded that direct transfer of *D.labrax* wild fry to fresh water led to the death of all individuals in 48 h, independently on origin. However, the tolerance to fresh water was significantly lower in wild fry.

Growth performance

Table 3 showed that average daily gain (ADG=mg/fish/day) and specific growth rate (SGR %) were decreased with increasing DDR of water salinity. A significant difference ($P<0.01$) was observed in SGR% between treatment No. 1 (exposed to 1ppt DDR) and other treatments. On the other side, no significant discrepancies were observed in SGR % among treatments No. 6, 7 and 8 (exposed to 16ppt, 24ppt and 32ppt DDR of water salinity , respectively).

Results of growth performance of *S.aurata* fry increased with decreasing DDR of water salinity from 32 ppt to 0.45 ppt. The present results are in corresponding with the results of Chervinski (1975). The author found that decreasing water salinity from 5 ppt to 2.5 ppt increased the average daily gain (ADG) from 7 to 9.12, in *S.aurata* larvae. In addition, Tandler *et al.* (1995) found that *S.aurata* larval wet weight were over 16 % higher at 25 ppt than 40 ppt salinity, which mean that decreasing salinity stimulate survival and growth.

Fish chemical composition

The results in Table 4 indicate the chemical composition of *S.aurata* fry at the beginning and at the end of the of acclimatization period (32 days). The results viewed that fish dry matter (DM) content decreased significantly ($P<0.01$) with increasing DDR of water salinity. Otherwise, DM in initial and final (all treatments) fry samples were discrepanced significantly ($P<0.01$).

Table 4. Effect of daily decreasing rate (DDR) of water salinity, from sea water to fresh water, on chemical composition % of *S.aurata* fry

Item Treatment	DM %	CP %	EE %	Ash %	Energy kcal/g*DM
Initial	$20.43^{g} \pm 0.15$	$48.75^{i} \pm 0.21$	$19.03^{i} \pm 0.36$	$32.23^{a} \pm 0.15$	$4.55^{i} \pm 0.17$
Final:					
1	$22.47^{a} \pm 0.29$	$51.44^{a} \pm 0.36$	$21.07^{a} \pm 0.12$	$27.49^{i} \pm 0.19$	$4.89^{a} \pm 0.21$
2	$22.28^{b} \pm 0.20$	$51.13^{b} \pm 0.28$	$20.85^{b} \pm 0.24$	$28.02^{h} \pm 0.18$	$4.85^{b} \pm 0.17$
3	$22.04^{c} \pm 0.13$	$50.98^{c} \pm 0.25$	$20.59^{c} \pm 0.20$	$28.43^{g} \pm 0.14$	$4.82^{c} \pm 0.14$
4	$21.88^{c} \pm 0.15$	$50.56^{d} \pm 0.31$	$20.33^{d} \pm 0.16$	$29.11^{f} \pm 0.08$	$4.77^{d} \pm 0.10$
5	$21.67^{d} \pm 0.12$	$50.18^{e} \pm 0.10$	$20.07^{e} \pm 0.12$	$29.75^{e} \pm 0.32$	$4.72^{e} \pm 0.25$
6	$21.36^{e} \pm 0.12$	$49.94^{f} \pm 0.30$	$19.87^{f} \pm 0.15$	$30.20^{d} \pm 0.09$	$4.69^{f} \pm 0.14$
7	$21.05^{f} \pm 0.08$	$49.53^{g} \pm 0.20$	$19.63^{g} \pm 0.19$	$30.84^{c} \pm 0.14$	$4.65^{g} \pm 0.13$
8	$20.87^{f} \pm 0.20$	$49.14^{h} \pm 0.10$	$19.40^{h} \pm 0.14$	$31.46^{b} \pm 0.15$	$4.60^{h} \pm 0.14$
$L.S.D._{0.01}$	0.4	0.59	0.47	0.41	0.4

Means in columns with the same letters are not signifinatly different ($P<0.01$).
* Energy content calculated according to NCR (1993) using the following calorific values: 5.64 and 9.44 K cal/g of protein and fat of fish, respectively.
DDR: Daily decreasing rate of water salinity.
Treatments from 1 to 8 : 1, 2, 3, 4, 8, 16, 24 and 32 (ppt) DDR, respectively.

Final crude protein percentage (CP%) increased significantly ($P<0.01$) in all treatments with decreasing DDR of water salinity. The highest value of CP% was recorded in the first treatment (51.44%) which exposed to (1ppt) DDR of water salinity during the experimental period, while the lowest value was recorded in the eighth treatment (49.14%) which exposed to (32ppt) DDR of water salinity. There was significant differences between the initial and final CP%.

Fish ether extract (EE%) decreased significantly ($P<0.01$) with increasing DDR of water salinity. Also, it was found that differences in EE% between initial and final bodies of fry were significant ($P<0.01$).

A significant differences between initial and final ash % in fish bodies were observed. On the other side, all treatments differed significantly (P<0.01) in its body ash % and it was observed that fish body ash % progressively increased with increasing DDR of water salinity.

Energy content (kcal/g DM) reflected a significant difference between initial and final analysis of fry bodies, and the values of energy content of fish bodies were decreased with increasing DDR of water salinity.

Results in Table 5 show the protein, fat and energy gains for *S.aurata* fry after acclimatization process through different DDR of water salinity levels. The results demonstrated that protein, fat and energy (Kcal /g) gains were decreased with increasing DDR of water salinity. A significant (P<0.01) differences in protein, fat and energy gains were observed between all treatments (No. 1 to No. 8). It was observed that protein, fat and energy gains were increased with increasing DDR of water salinity. Also, gain of body nutrients from protein, fat and energy for acclimatized *S.aurata* fry was increased with lower DDR of water salinity, while decreased with increasing DDR.

Table 5. Effect of daily decreasing rate (DDR) of water salinity, from sea water to fresh water, on body gain of nutrients in *S.aurata* fry

Item Treatment	Protein gain (g/fish)	Fat gain (g/fish)	Energy gain (K cal/g/fish)
1	$0.095^{a} \pm 0.00$	$0.039^{a} \pm 0.00$	$0.91^{a} \pm 0.00$
2	$0.086^{b} \pm 1.70$	$0.035^{b} \pm 0.00$	$0.82^{b} \pm 9.45$
3	$0.084^{c} \pm 9.36$	$0.034^{c} \pm 0.00$	$0.79^{c} \pm 0.00$
4	$0.073^{d} \pm 9.36$	$0.029^{d} \pm 0.00$	$0.68^{d} \pm 0.00$
5	$0.071^{e} \pm 9.36$	$0.028^{e} \pm 9.36$	$0.67^{e} \pm 0.019$
6	$0.067^{f} \pm 9.36$	$0.027^{f} \pm 9.36$	$0.64^{f} \pm 9.45$
7	$0.065^{g} \pm 9.36$	$0.026^{g} \pm 9.36$	$0.62^{g} \pm 9.45$
8	$0.064^{h} \pm 9.36$	$0.025^{h} \pm 0.00$	$0.60^{h} \pm 0.00$
L.S.D.0.01	0.001	0.001	0.01

Treatments from 1 to 8 : 1, 2, 3, 4, 8, 16, 24 and 32 (ppt) DDR, respectively.
Study was lasted for 32 days.
Treatments in columns with the same letters are not significantly different (P<0.01) .

Finally, it could be concluded that *S.aurata* fry could tolerate the direct change from seawater (32 ppt) to fresh water within one day with a survival rate of 92% and with gradual change from 2 – 32 days, it could achieve 96-100% survival rates. At the same time, gradual salinity decreasing rate of 1ppt (DDR) of water salinity improved growth performance, chemical composition and gain of nutrients in bodies of *S.aurata* fry.

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