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RESEARCH PAPER

Effect of duo-culture on the first feeding transition success and growth performance for black sea trout (*Salmo trutta labrax*, pallas, 1811*)* with rainbow trout (*Oncorhynchus mykiss*, walbaum, 1792)

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Abstract

In this study, Black Sea trout (*Salmo trutta labrax,* Pallas, 1811) and Rainbow trout (*Oncorhynchus mykiss,* Walbaum 1792) were reared in mono and duo-culture groups. Duo-culture groups were designed to include changing numbers of individuals for each species to assess the effect of dominance. The effect of the culture strategy on growth and survival rates during the feeding transition period was compared. The growth performance of mono and duo-culture groups were found similar whereas the survival rates of the groups differed significantly. The survival rate of the duo-culture group with the 75/25 stock density for two species was found lower when compared with monoculture groups and groups of 50/50 stock density. The feed conversion ratio (FCR) for all groups was similar.

Introduction

Aquaculture industry is one of the fastest-growing industries amongst all animal production sectors in the world. Aquaculture production started in the 1970s and substantial commercial status was achieved in the 1990s in Turkey. In 2020, %53,6 of all fisheries production was procured from aquaculture. Three species, rainbow trout (*Oncorhynchus mykiss*), back sea trout (*Salmo sp*), and carp (*Cyprinus carpio*) have remained the key species for freshwater aquaculture and contribute 30% of the total aquaculture production (TUİK 2021). Salmonidae species is a high-demand group of cultured species with their extensive economic value and their adaptive ability to many environmental conditions. The need for product variety increases the importance of salmonids aquaculture in Turkey. Rainbow trout production reached 128.000 tons in 2020. There are few experimental or commercial cultures of Salmonidae species in Turkey besides the rainbow trout.

The Black Sea trout, *Salmo trutta labrax*, is a native finfish species of the Eastern Black Sea coast and rivers. In recent times, the Black Sea trout has generated new interest for culture in Turkey. Although it has a substantial economic value and acceptance by the consumers, this species has been cultured in limited numbers by private trout farms placed in the Black Sea region. Black Sea trout has a low feed intake and survival rate during first feeding in the hatcheries in comparison to Rainbow trout (Okumuş et al. 2007).

Duo-culture, the production of two species in the same artificial environment, has the potential to increase the productivity of at least one of the chosen species for culture. It has been reported that many freshwater fish species such as Cyprinidae and Cichlidae families performed better in duo-culture than in monoculture because of the useful effects caused by the simultaneous presence of species (synergism) and behaviour (Chikafumbwa et al. 1993, Pousao et al. 1995, Teichert-Coddington 1996, Papoutsoglou et al. 2001). The usefulness of duo-culture depends on the compatibility of the species and fish size and stage (Mims and Clark 1991, Siddiqui et al. 1993, Jobling et al. 1993). Using duo-culture systems may increase feed intake and survival of a species like *S.t. labrax* due to interaction and learning through behavior within a mixed culture environment resulting in enhanced growth parameters (Karakatsouli et al. 2006, Janssen et al. 2016). The larval stage represents a critically vital stage of the life cycle of aquatic animals which can affect fish health, growth performance and survival. Transition to artificial feeds after the consumption of the yolk sac is an extremely sensitive period for culture operations that defines a successful production. Failure of this transition period results in starvation and low survival rates which hinders culture operations considerably (Skalski et al. 2005).

The aim of the present study was to evaluate the effects of monoculture and duo-culture during the artificial feed transition period on Black Sea trout larvae cultured with rainbow trout larvae with respect to survival rates and growth performance parameters in hatchery conditions

Materials and Methods

The author declares that this study complies with research and publication ethic.

Rainbow trout (RT) and Black Sea trout (BT) pre-larvae were obtained from the Istanbul University, Faculty of Fisheries, Sapanca Inland Fisheries Production Research and Application Unit, located in Sakarya, Turkey. The larvae of two species were randomly allocated to two monoculture groups (only RT or BT) and tree duo-culture groups (50% RT + 50% BT; %75 RT + %25 BT; %25 RT + %75 BT).

The experiment was conducted for 50 days. Fish were kept in 15 rearing baskets with each group having three replicates. Rearing baskets were supplied with freshwater at flow rates 1-2 l/min depending on fish size. The water temperature, pH and dissolved oxygen were measured with multiparameter device (YSI 560) twice a day between 08:00-09:00 and 16:00-17:00 hours. The fish were exposed to natural photoperiod in hatchery conditions. Ad libitum feeding was preferred for the duration of the experiment. Commercial trout feed 300-500 μm; 500-800 μm and 800-1200 μm were used and feed size changed parallel to fish growth. Larvae were hand-fed five times a day at 09:00, 11:00, 13.00, 15:00, and 17:00 hours.

The dead fish count was recorded daily during the experiment. Fish larval survival was determined based on the difference between the initial and final number of larvae in each basket. Due to the small size of fish, growth performance parameters were calculated by using the initial-last weight of fish. Each tank was sampled (n=200) in order to measure the weight (BW; to 0.01 g) at the start and end of the study. Specific growth rate (SGR) was calculated as [(logeW2 −

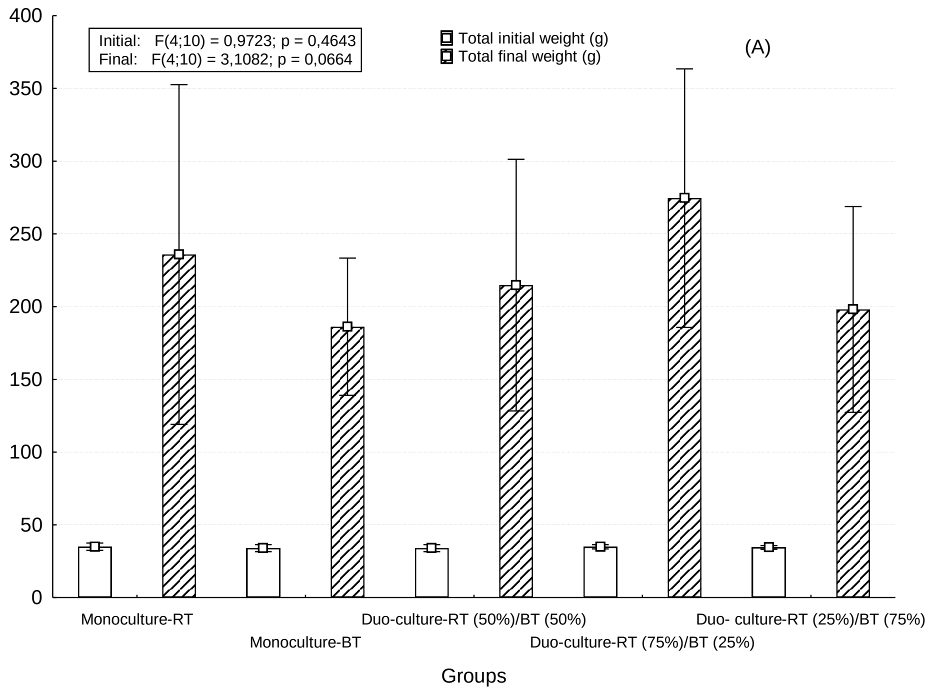
logeW1) / (t2 − t1) × 100], where W1 and W2 represent BW at times t1 and t2, respectively. Feed conversion rate (FCR) was calculated as biomass (B) gain per weight unit of consumed feed (C): i.e., FCR = (B2 − B1)/C (Çelikkale 2002). Statistical analyses were performed using STATISTICA software (StatSoft Inc. v.8). Data were first analyzed with ANOVA; when any differences were found, analyzed separately by Tukey's HSD. Results were considered statistically significant at a level of 0.05. The results are shown as mean ± SD.

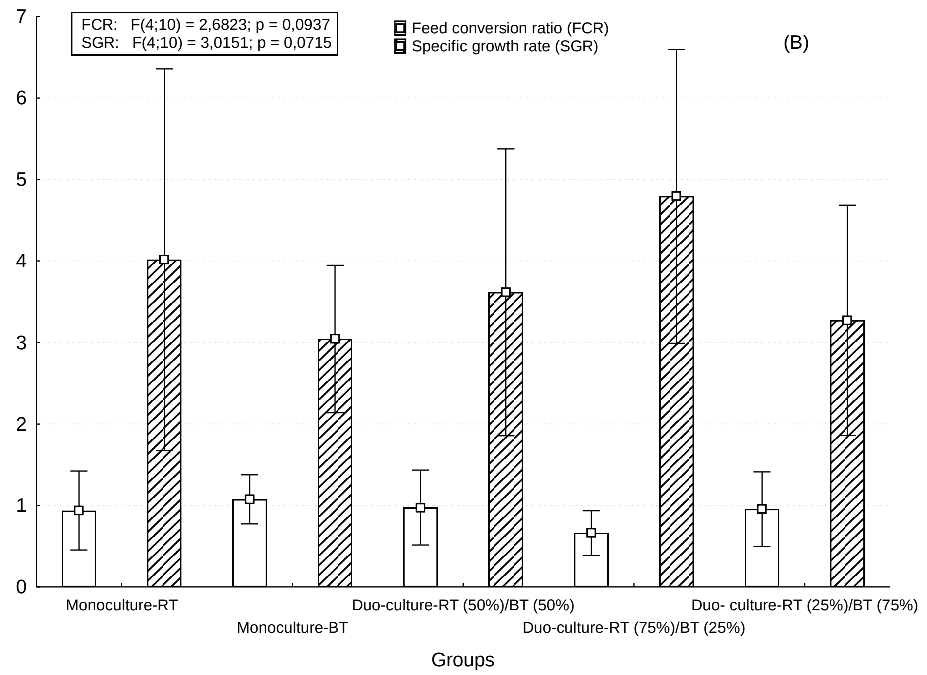
Results

The temperature of the intake water was 12.07±1.1°C. The pH and dissolved oxygen levels in the tanks were 7.93±0.12 and 8.5±1.3 respectively during the study. The initial total mean weight of monoculture groups were 35±1g and 34±1g and the duo-culture groups of RT/BT; RT>BT and RT<BT were 34±1; 34.9±0.6 and 34.5±0.5 respectively. At the end of the study, the mean final weight of monoculture RT and BT groups increased to 235.8±47 g and 186.18±19 g respectively. The mean final weight of duo culture groups RT/BT; RT>BT and RT<BT were measured as 214.81±34 g; 274.6±35 g and 198±28 g respectively. The highest weight gain was measured in RT monoculture group as 200.8±47 g. Between the duo-culture groups, the highest gain was recorded for the RT>BT group with 239.7±36 g. The RT>BT duo-culture group showed the highest specific growth rate (4.7±0.7) while lowest was recorded for BT monoculture group (3.04±0.3). The calculated feed conversion rate (FCR) of RT>BT was lower (0.6±0.1%) than the other duo-culture groups whereas; the FCR was higher in BT (1) monoculture group than the RT group (Table 1). The comparison of growth parameters showed no significant difference between the groups (p>.05). However, survival rate of the RT<BT duo-culture treatment was significantly lower 44.8±3.7 compared to the others groups (p<.05) (Figure 1).

Table 1: Mean (±SD) growth (initial and final weights; weights gain; SGR: specific growth rate; FCR: feed conversion rate) and survival rate values of the mono and duo-culture groups.

	Monoculture Groups		**Duo-Culture Groups**		
Parameters	Rainbow trout (% 100)	Black Sea trout (% 100)	Rainbow trout (%50) + Black Sea trout(%50)	Rainbow trout (%75) + Black Sea trout(%25)	Rainbow trout (%25) + Black Sea trout(%75)
Initial weights (g)	35±1	34±1	34±1	34.9±0.6	34.5±0.5
Final weights (g)	235.8±47	186.18±19	214.81±34	274.6±35	198±28
Weight gain (g)	200.8±47	152.18±18	180.81±35.4	239.7±36	163.5±28
SGR (%)	4.01±0.9	3.04±0.3	3.6±0.7	4.7±0.7	3.2±0.5
FCR (%)	0.9±0.19	1.07±0.12	0.97±0.18	0.9±0.1	0.95±0.18
Survival rate	69±1.8	63±9.3	64.5±9.9	53.3±1.04	44.8±3.7


Initial: F(4;10) = 0,9723; p = 0,4643
Final: F(4;10) = 3,1082; p = 0,0664
Total initial weight (g)
Total final weight (g)
(A)
0
50
100
150
200
250
300
350
400
Monoculture-RT
Monoculture-BT
Duo-culture-RT (50%)/BT (50%)
Duo-culture-RT (75%)/BT (25%)
Duo- culture-RT (25%)/BT (75%)
Groups


FCR: F(4;10) = 2,6823; p = 0,0937
SGR: F(4;10) = 3,0151; p = 0,0715
Feed conversion ratio (FCR)
Specific growth rate (SGR)
(B)
0
1
2
3
4
5
6
7
Monoculture-RT
Monoculture-BT
Duo-culture-RT (50%)/BT (50%)
Duo-culture-RT (75%)/BT (25%)
Duo- culture-RT (25%)/BT (75%)
Groups

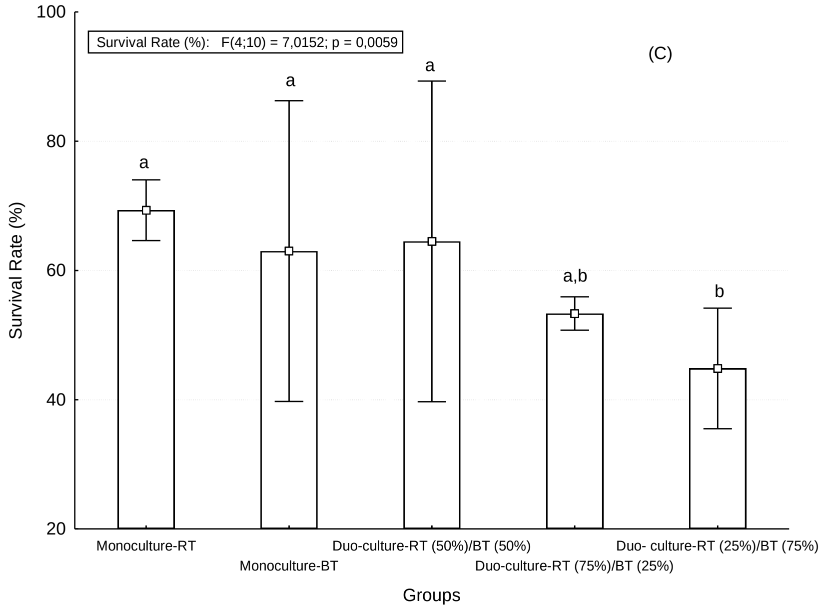


Figure 1: Initial and final weights (A); feed conversion rate (FCR), specific growht rate (SGR) (B) and survival rate (C) of mono and duo-culture groups. Values with different letters are significantly different (p<.05).

Discussion

The BT showed low weight gain in comparison to RT during the artificial feeding transition period in the monoculture groups. Although the survival rate was low in some cases, duo-culture groups with RT and the BT performed well in terms of growth parameters with similar or better rates (Table 1). The similar growth rates were most likely due to the competitive nature of RT, resulting in the consumption of the majority of the feed offered to the fish. This competitive nature resulted in lowered survival rates of the duo-culture groups where the BT failed to consume enough feed. It was possible for the trained eye to differentiate the feeding behavior of the two different trout species. Contrary to our results, Nortvedt and Holm (1991) reported that duo-culture of Atlantic salmon (*Salmo salar*) and Arctic charr (*Salvelinus alpinus*) did not affect the growth performance of Arctic charr but the Atlantic salmon had better growth performance in duo-culture condition compared to monoculture. We can derive that the BT may perform better with a less competitive counterpart in a duo-culture environment than RT.

Başçınar has been stated that rearing Brook trout and Black Sea trout in monoculture have slightly better growth result compared to duo-culture (Başçinar et.al., 2009). In the experimental study designed by Khan and Hossain (2018), BT and Abanticus trout (*Salmo trutta abanticus*) were reared in monoculture and duo-culture tanks where Brook trout performed poorly in terms of growth rate. We can derive that the behavior of one species is significantly involved in the success of duo-culture designs and a competitive or dominant counterpart will likely result in a failed rearing environment. Contrary to this study, RT was dominant in our experimental design and the BT failed to compete for the offered feed for a successful growth. When we compare the growth performance of duo-culture groups; best weight gain was achieved with rainbow trout majority (75% RT-25%BT) group. This was most likely because of the feed rivalry amongst species where rainbow trout had better performance. The recorded least live weight gain was calculated in BT majority (75%BT-%25 RT) group between duo-culture groups. There is no statistically important difference between the experimental groups in terms of growth performance. However; live weight gain data from the duo culture group where a balanced population was set (%50-%50) and black sea trout majority group is better. In this study, it was found out that each group had suitable food conversion ratio and it was similar for each group which can be interpreted as no feed was wasted regardless of the population design. The adlibitum feeding strategy shows that there is no need to overfeed in case of mono and duo-culture conditions of RT and BT.

Larval developmental rates, growth, and mortality are highly influenced by available food during the artificial feed transition period. Salmonid species have zone defense and dominant hierarchy characteristics when individuals are kept in small groups. In this study, the survival rate was affected by the presence of the other species. The higher mortality observed in the duo-culture groups with one species being the majority is probably because of the dominant hierarchy characteristic of this family.

Conclusions

As a conclusion, this study has shown that the duo-culture of rainbow trout and the Black Sea trout is disadvantageous for the Black Sea trout when rainbow trout is the dominant species in the culture condition. Duo-culture will work with a balanced population design during larval first feeding period where failing to do so will result in aggression between species with high mortality for these two Salmonid species.

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Data availability statement

The authors declare that data are available from authors upon reasonable request.

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