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Effects of Live Feeds and Compounded Diet on Growth Parameters of Brown Trout Fry (*Salmo trutta abanticus* T. 1954) in the Context of Habitat Restoration

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ABSTRACT

Three diets were tested to feed triplicate groups of *Salmo trutta abanticus* fry with initial average body weight of 0.091 g in fiberglass tank. Two diets consisted of live guppy fry (*Lebistes* sp.), tubifex (*Tubifex tubifex*) and third diet was compound diet made up from commercial trout feed. At the end of 12 week of feeding, the best results for average daily growth, specific growth rate, feed conversion ratio, protein efficiency ratio, daily growth index, feed efficiency, plasma total protein, weight increase, mean weight gain and survival rate were observed for the group fed with guppy fry ($P<0.05$) whereas the poorest results were obtained for the group fed with compound diet.

Keywords: Brown trout; *Salmo trutta abanticus*; Growth; Habitat; Restoration; Feeding

Canlı ve Karma Yemin Habitat Restorasyonunda Kullanılacak Kahverengi Alabalık Larvalarının Büyüme Parametrelerine Etkisi

ESER BİLGİSİ

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ÖZET

Başlangıç ağırlıkları ortalama 0.091 g olan *Salmo trutta abanticus* larvaları üç tekerrürlü olarak üç farklı rasyonla beslenerek denemeler yürütüldü. Rasyonların iki grubu canlı yem (*lebistes* yavrusu ve *tubifex*), üçüncüsü karma yemden (ticari alabalık yemi) oluşmuştur. 12 haftalık besleme sonucunda ortalama günlük büyüme, spesifik büyüme oranı, yem dönüşüm oranı, protein etkinlik oranı, günlük büyüme indeksi, yem etkinliği, plazma toplam proteini, ağırlık artışı, ortalama ağırlık kazanımı ve yaşama oranı için en iyi sonuçlar *lebistes* yavrusu ile beslenen grupta gözlenmiştir ($P<0.05$). En düşük sonuçlar ise karma yemle beslenen grupta elde edilmiştir.

Anahtar Kelimeler: Kahverengi alabalık; *Salmo trutta abanticus*; Büyüme; Habitat; Restorasyon; Besleme

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1. Introduction

Brown trout (*Salmo trutta abanticus*), as per taxonomic considerations by Linnaeus in 1758, belongs to family *Salmonidae* and is closely related to brook trout (*Salvelinus fontinalis*) and the sea trout (*Salmo trutta labrax*). Brown trout (*S. trutta abanticus*), like most of

natural resources, is threatened due to natural factors and human activities such as pollution, acidification, habitat modifications, damming and over-fishing.

To decrease losses and protect wild life, some measures such as efficient sewage systems, habitat restorations, elimination of migration barriers,

limitations in the fishery and building fishladders are being taken (Martinez et al 1993; Jonsson 2001). Stocking fish is a common method for recreational purposes and rearing brown trout has gained more importance in recent years (Jonsson 2001; Hunter 1991; Graff 1991).

Although brown trout (*S. trutta*) is native to Mediterranean region of Europe-North Africa, its original distribution has changed and it was successfully began to rear in 24 countries outside these areas from 1852 to 1938 (Jonsson 2001).

One genus (*Salmo*), one species (*S. trutta*) and four subspecies (*S. trutta macrostigma*, *S. trutta abanticus*, *S. trutta labrax*, *S. trutta caspius*) of this family have been recorded in Turkish waters. Nevertheless this classification in respect of subspecies is controversial, since individuals defined as different subspecies can be found in the same environment (Geldiay 1999).

Undoubtedly, achievement of a rearing method requires a successful nutritional program. Over the past 15 to 20 years, the nutrient composition of the diets for farmed fish has significantly changed in respect of protein, lipid and carbohydrate contents (Azevedo et al 2004). Yet it is obvious that further investigations are needed for better definition of feed formulation for different fish species and fish sizes.

These researches especially have great importance for fish, like trout, unable to utilize artificial feed adequately. An argument in this field is whether optimal feed for trout may be fish. This view is based on that high-energy content and composition of proteins, lipids, minerals and vitamins of fish are suitable, since brown trout is piscivorous, in other words prey and predator have similar body components (Jonsson et al 1999).

As a live feed, guppy fry (*Lebistes sp.* fry) and red tubifex (*Tubifex tubifex*) have great opportunity. There are some reasons for the guppy fry using as a live feed in fish nutrition. First of all, guppies can be reared easily and they are very cheap, so it is widely used as feeder fish among aquarium fish. Female guppies mature in about 3 months, males mature sooner. A female's gestation period last approximately 4 weeks. Since females can store sperm one mating can produce 4 to 8 sets of fry. One female may have as many as 200 fry; the average is 40 to 50. It is theoretically possible to gain about 300 000 fry in a year from only one female and one male (Alpbaz 1984). Therefore they are called as "millionsfish".

Red tubifex is a common favorite diet for many fish, especially aquarium fish. Although the amino acid profile of the proteins in tubifex is satisfactory, the fatty acid profile is pretty poor. Another drawback is that tubifex generally lives in polluted streams and can

carry parasites, which may cause many contagious diseases in fish. For this reason, it should be used carefully.

Tortonese (1954) reported first the existence of brown trout (*S. trutta abanticus*) in Turkish waters. This species is an endemic to Abant Lake in Bolu, province of Turkey. Although it is similar to *S. trutta macrostigma* and *S. trutta labrax*, it can be discerned via its red spots on lateral body (Geldiay 1999).

Similar factors to those mentioned above in the context of the decrease in wild fish population have also affected population of brown trout (*S. trutta abanticus*) in the Abant Lake adversely. Considering as a source of gene in nature, there is needed to rehabilitate population on urgent basis. Stocking the fry reared artificially to the Lake and restoring habitat physically can be mentioned among the measures to be taken. However, to solve the problem of successful stocking is very important. One of the most noticeable answers for this question is to improve rearing models that facilitate the adaptation of fry to the natural environment in a short period. In fact, such models have played major roles in the success of fry stocking.

The aim of this study was to determine the most appropriate feeds which were carried out in a few critical months after spawning. Within this framework, it was tried to make some suggestions about rearing fry which were capable of feeding themselves and adapting to natural waters easily as well as having high survival rate.

2. Material and Methods

2.1. Experimental diets

The total duration of the experiment was 12 weeks. During this period, three diets were tested, two of them were live and one was compound diet shown in Table 1.

One of live feed (A) consisted of guppy fries (mean body 4-6 mm long and 0.6-0.8 mm wide). Guppy fries were obtained from Laboratory of Aquaculture Department, Faculty of Agriculture, Ankara University. Before starting the experiment, the guppy fries were acclimated to the experimental conditions. The other live feed (B) used in the experiment is red tubifex (mean body 10-23 mm long, 0.4-0.6 mm wide). This feed were obtained from a pet shop. Third feed is commercial trout starter diet (C) (size of pellets: 0.6-0.8 mm)

Table 1- Type of diets tested

Çizelge 1- Test diyetleri

Diet	Type	
A	Live	<i>Lebistes</i> sp. fry
B	Live	<i>Tubifex</i> sp
C	Compounded	Commercial trout feed

Before starting the experiment, trout fry were acclimated to the experimental conditions for a period of 2 weeks during which time *S. trutta abanticus* were fed with 3 test diets and rainbow trout were fed only with compounded diets.

Following this treatment, *S. trutta abanticus* larvae were fed *ad libitum* with three diets and rainbow trout were fed *ad libitum* with compound diet. Thus this made it possible to compare the effects of feeding artificial diet on growth parameters of rainbow trouts and brown trout.

In order to remove the remains, a black feeding table (30 cm x 30 cm) was put in every tank and each tank was cleaned every morning prior to feeding by siphoning excess food. The excess food was considered in calculating feed consumption.

All foodstuffs can be evaluated according to their water contents (Solberg 1979). In order to get uniformity, the calculations in this experiment are considered as percentage of dry weight of the diet.

2.2. Experimental system and animals

S. trutta abanticus larvae were obtained from the Ministry of Forest, General Directorate of Protection of Wildlife and the study was carried out under the laboratory conditions of the Department of Aquaculture, Faculty of Agriculture, Ankara University, Ankara, Turkey.

The study was conducted in 150 l conical bottom fiberglass tank containing 100 l of water. Each tank was provided with aerated recirculation water and water pumps were used to supply water to each tank at a flow rate of 1.5-2 l/min. The sand-filtered water was maintained at 10 ± 0.5 °C.

As the metabolic rate and food intake change depending on the temperature increase, temperature can be accepted as a paramount parameter for the survival and growth of brown trout. Therefore, in present study the water temperature requirements for *S. trutta abanticus* in natural environment were considered.

Three replicate of 15 fish in each tank were placed for each dietary treatment. The length (cm) and weight (sensitive to 0.01 gram balance) of all fish were measured every 4 weeks. Dead fish were removed from tank and registered daily.

At the end of the experiment, growth rate performance, body composition and food utilization were calculated using the following parameters.

- The growth rate (average daily growth, ADG) %
ADG= $100 \times (\text{weight at time } t - \text{weight at time } t_0) / \text{weight at time } t_0 \times (t - t_0)$;
- Specific growth rate, SGR= $100 \times [\ln \text{ final weight} - \ln \text{ initial weight} / \text{duration}]$;

- Daily growth index (DGI= $100 \times (\text{Final body weight, g}^{1/3} - \text{Initial body weight, g}^{1/3}) / \text{duration}$);
- Feed efficiency (FE=Weight gain/Feed fed);
- Protein efficiency ratio (PER=Weight gain/protein fed);
- Feed conversion ratio [FCR = Food intake (dry weight)/Body weight gain (wet weight)];
- The condition factors of fish were calculated as
- $K=100 \times (\text{wet fish weight, g}) / (\text{total length, cm})^3$

Unconsumed feed was removed and dried in a hot air oven at 105 °C. Feed consumption was estimated by subtracting the amount of unconsumed dry feed from the dry weight of the feed offered.

2.3. Blood sampling and biochemical assays of plasma

Fish blood was collected by caudal vein puncture from five fish using heparinised syringes. Afterwards the total plasma protein was determined using Biuret reaction and the data were expressed in g/dl. (Siwicki & Anderson 1993).

Heamatocrit (Hct) measurements were made immediately by drawing blood samples into heparinized capillary tubes and centrifuging at 12.5000 r.p.m. for 4 min (Siwicki & Anderson 1993).

2.4. Chemical analysis of experimental diets

Analysis of dry matter was performed by drying in an oven at 105 °C over 24 h. Crude protein (%N 6.25) was determined according to Kjeldahl method by using a Kjeltec apparatus, crude fat by dichloromethane extraction using a Soxlet apparatus and ash by combustion in an oven at 550 °C for 18 h. All analyses were performed in triplicate.

2.5. Statistical analysis

Data were analysed by analysis of variance (ANOVA) with the SAS package. Duncan's multiple-range test was used to compare differences among individual means. Treatment effects were considered significant at $P < 0.05$. All percentage and ratio data were transformed to arcsin values prior to analysis (Zar 1984). Statistical significances of the differences of means were determined by Student's t test, using paired data (Düzgüneş et al 1987).

3. Results and Discussion

The values of the indices for each foodstuff and water quality parameters are shown in Table 2 and 3. According to the statistical analysis shown in Table 4, there was no significant difference ($P > 0.05$) in average weights among experimental groups at the beginning.

Table 2- Composition and proximate analyses of test diets

Çizelge 2- Deneme yemlerinin analizi ve bileşimi

	<i>Lebistes sp. fry meal (A)</i>	<i>Tubifex sp. Meal (B)</i>	<i>Compound diet (C)</i>
Protein	61.7	67.5	61.6
Lipid	18.5	11.7	16.8
Ash	13.7	5.0	12.2

Guppy fry (*Lebistes sp.*) meal and *Tubifex sp.* meal are based on dry weight.

However significant differences ($P<0.05$) were observed for mean final weight, mean weight gain, specific growth rate (SGR) and daily growth index (DGI) among brown trout (*S. trutta abanticus*) fed with live feeds A, B and diet C at the end of the experiment (Figure 1). The best results among these values were found for feeding on live feed A, whereas the poorest results were determined for feeding on diet C. On the other hand these results are lower when comparing to the values for rainbow trout (*Oncorhynchus mykiss*) fed on diet C.

The protein efficiency ratio (PER) is defined as weight gain/protein fed. In the case the best and the poorest results in brown trout (*S. trutta abanticus*) fed on live feed A and C, and were 1.617 ± 0.010 and 0.436 ± 0.002 , respectively. The feed conversion ratio (FCR) is defined as food intake (dry weight/body weight gain (wet weight)). In the case the best and the poorest results were in brown trout (*S. trutta abanticus*) fed on A and C, and were 1.005 ± 0.005 and 3.725 ± 0.015 , respectively. The index of feed efficiency (FE) relates weight gain/feed fed and its maximum value is 1 when all feed is transformed into body weight. The best result was found for brown trout (*S. trutta abanticus*) fed on A (0.998 ± 0.006) whereas the worst result was for brown trout (*S. trutta abanticus*) fed on C (0.268 ± 0.001). When three diets were compared with each other, in respect of PER, FCR and FE, significant differences ($P<0.05$) were found.

On the other side, the PER, FCR and FE values for rainbow trout (*O. mykiss*) fed on only diet C were 1.088 ± 0.026 , 1.495 ± 0.005 and 0.670 ± 0.016 , respectively. These results were better than those for brown trout (*S. trutta abanticus*) fed on diet C.

Table 3- Water quality parameters in the main system during the experimental period

Çizelge 3- Deneme periyodunda sistemdeki su kalite parametreleri

Parameter	Level range
Total ammonia (NH ₃ -N)	0.039-0.219 ppm
Nitrite (NO ₂ -N)	0.008-0.154 ppm
Nitrate (NO ₃ -N)	0.23-0.315 ppm
pH	8.15-8.25
Oxygen (mg/l)	10.53-11.32

In respect of the average daily growth (ADG %), the best and the poorest results were found for brown trout (*S. trutta abanticus*) fed on live feed A (16.915 ± 0.102) and diet C (11.232 ± 0.188). There was no significant difference ($P>0.05$) between the groups fed live feed B and diet C. Nevertheless these results were lower than the value (28.328 ± 0.573) for rainbow trout (*O. mykiss*) fed on diet C.

Total plasma protein levels were significantly higher ($P<0.05$) for brown trout (*S. trutta abanticus*) fed on live feed A compared to other groups.

The haematocrit value of brown trout (*S. trutta abanticus*) fed on live feed A was significantly lower ($P<0.05$) compared to those fed on live feed B; but higher than those fed on diet C. However it was similar to the result for rainbow trout (*O. mykiss*) fed diet C.

In respect of survival rates, the best result were observed for brown trout fed on live feed A, significant differences ($P<0.05$) was found between brown trout (*S. trutta abanticus*) fed on live feeds A, B and diet C.



Figure 1- Experimental groups [a.b.c are brown trout (*S. trutta abanticus*); d is rainbow trout (*O. mykiss*)]

Şekil 1- Deneme grupları [a.b.c. kahverengi alabalık (*abant alası*) (*S. trutta abanticus*); d. gökkuşağı alabalığı (*O. mykiss*)]

Table 4- Growth performance, feed conversion and protein efficiency by *S. trutta abanticus* and *O. mykiss* at 10 °C over the 12 week (moisture-free basis*)

Çizelge 4- 12 hafta boyunca 10 °C'de *S. trutta abanticus* ve *O. mykiss*'in büyüme performansı, yem dönüşümü ve protein etkinliği (Kuru madde temel alınmıştır. *)

Parameter	<i>S. trutta abanticus</i>			<i>O. mykiss</i>	P values	
	live feed		compounded diet		<i>S. trutta</i>	<i>S. trutta</i> and <i>O.</i> <i>mykiss</i>
	A	B	C	C	Feed effect	C Feed effect
Mean initial weight (g) (W ₁)	0.092±0.002 ^a	0.091±0.002 ^a	0.091±0.002 ^a _A	0.090±0.002 _A	0.940	0.353
Mean final weight (g) (W ₂)	1.394±0.064 ^a	1.118±0.038 ^b	0.946±0.038 ^c _B	2.240±0.156 _A	0.000	0.000
Mean weight gain (g) (W ₂ -W ₁)	1.302±0.006 ^a	1.027±0.040 ^b	0.855±0.008 ^c _B	2.150±0.070 _A	0.002	0.003
Mean initial length (mm)	2.217±0.013 ^a	2.213±0.013 ^a	2.210±0.014 ^a _A	2.173±0.001 _A	0.939	0.071
Mean final length (cm)	5.427±0.088 ^a	4.883±0.055 ^b	4.783±0.056 ^b _B	6.077±0.154 _A	0.000	0.000
Mean initial condition factor (K)	0.842±0.018 ^a	0.839±0.016 ^a	0.840±0.018 ^a _A	0.884±0.019 _A	0.995	0.446
Mean final condition factor (K)	0.856±0.012 ^b	0.952±0.012 ^a	0.852±0.013 ^b _B	0.956±0.014 _A	0.090	0.000
Food consumption (0-12 weeks) (g/fish)	1.305±0.015 ^b	1.247±0.014 ^b	3.187±0.014 ^a _A	3.208±0.025 _A	0.000	0.525
ADG (%/day)*	16.915±0.102 ^a	13.436±0.376 ^b	11.232±0.188 ^c _B	28.328±0.573 _A	0.001	0.001
SGR (%/day)*	3.240±0.007 ^a	2.986±0.031 ^b	2.792±0.018 ^c _B	3.822±0.023 _A	0.001	0.001
FCR	1.005±0.005 ^c	1.215±0.035 ^b	3.725±0.015 ^a _A	1.495±0.035 _B	0.000	0.000
PER	1.617±0.010 ^a	1.221±0.035 ^b	0.436±0.002 ^c _B	1.088±0.026 _A	0.000	0.002
DGI	0.793±0.004 ^a	0.700±0.013 ^b	0.634±0.004 ^c _B	1.023±0.014 _A	0.002	0.001
FE	0.998±0.006 ^a	0.824±0.023 ^b	0.268±0.001 ^c _B	0.670±0.016 _A	0.000	0.002
Survival rate (%)*	91.111± 2.220 ^{ab}	82.222±4.440 ^b	77.780±5.880 ^b _B	95.560±2.220 _A	0.134	0.050
Haematocrit. Hct (%)*	30.500±0.677 ^{ab}	33.000±0.707 ^a	29.714±1.293 ^b _A	31.333±1.153 _A	0.050	0.358
Plasma total protein (g/dl)	3.620±0.008 ^a	2.700±0.004 ^c	2.923±0.013 ^b _B	3.2850±0.007 _A	0.000	0.000

^{a-b} Different superscript letters of means in the same row indicate statistical significant differences (P<0.05)

^{A-B} Different superscript letters of means in the same row indicate statistical significant differences (P<0.05)

^{A-B} Statistical analysis between *S. trutta* and *O. mykiss* fed by compounded diet

* P values in all percentage data were used by arcsin transformation

4. Conclusion

Although there exists various researches about the types of food consumption, weight gain and body composition of brown trout in their natural habitat (Armstrong et al 2003; Kreivi et al 1999), little is known about these subjects under the conditions of controlled culturing (Arzel et al 1995 & 1992 and Gabaudan et al 1989) for protein requirement; Azevedo

et al 2004 and Turchini et al 2003 for energy utilization and lipid sources). Even according to our knowledge, there is no publication concerning a study implemented under the conditions of controlled feeding brown trout (*S. trutta*) fry and especially *S. trutta abanticus* to increase its population for its restoration in natural waters.

Controlled culturing of brown trout requires that foods consumed have an acceptable form and suitable nutrient composition. In other words they should not be deprived of the choice of nutrition that they have in their natural environment. As mentioned above, brown trout is piscivorous and whereas rainbow trout picks up pellet at the water surface, brown trout ingests pellet under the water surface (Lagardere et al 2004). For that reason, it is very important that the diets meet the requirements of fish. In our study, food consumption was 3.187 g in brown trout fries and 3.208 g in rainbow trout fries fed with diet C. There was no significant difference statistically between these figures. However brown trout fries consumed pellets after pellets dropped on feeding table while rainbow trout fries consumed the pellets on water surface. For this reason, it is estimated that brown trout fries could consumed remains after the most usefull part of pellets dissolved in water. Therefore remains might contribute to growth parameters limitedly. It is predicted that unconsumed diet C could not be sifoned exactly, since some part of pellets mixed with water. Shortly, these factors may affected the determination of quantity of unconsumed diet C.

The values of FE closest to 1 were obtained for the group fed with live feed A and this result indicated a greater digestibility of live feed compared with compound diet.

Essential amino acids and non-essential nitrogen in protein of a diet should meet the requirements of fish. Therefore, detailed analyses for each fish species are necessary. However, there is little knowledge about the determination of protein or amino acid requirements of brown trout. According to the study by Arzel et al (1995), the requirement of this species was between 48 and 53% of crude protein i.e. 46 and 51% of the digestible protein in respect of specific growth rate. Feed/gain ratio indicated a minimal value for a higher dietary protein level, i.e. 57%. In present study, protein value was 56.1- 63.5%.

It is commonly considered that the PER and FE values in brown trout fed on compound diet are lower compared to optimum values, due to the food wastage. However in present study, protein levels in all diets were similar, the best and the poorest results of PER were in brown trout (*S. trutta abanticus*) fed on A and C and were 1.617 ± 0.010 and 0.436 ± 0.002 , respectively. It is estimated that this situation stemmed from being piscivorous characteristic of brown trout and their preference for live feed as well as food wastage. The fact that brown trout fry was benefited insufficiently from diet C confirmed this estimation. Although protein nutrition covered the requirements for

essential amino acids plus non-essential nitrogen, the results did not change.

The factor of condition (K) is an index giving information on the physiological state of fish and it reflects whether food resources are utilized well (Lizama & Ambrosio 2002). In present study, values were close to 1 and similar in all groups except the group fed with compound diet, which indicated that the fish were in good condition and fed well.

According to a study on brown trout (Arzel et al 1995), SGR was affected by protein level and ranged 2.4 to 2.9%. In another experiment (Arzel et al 1998), SGR values were observed as 2.55, 2.61 and 2.64 at 53, 58 and 63% protein level respectively. In present study, the similar result to these values were obtained as 2.79 in brown trout group fed with C, whereas SGR values were higher in groups fed with A and B. They were 3.24 and 2.98 respectively. There was significant difference ($P < 0.05$) among all groups for SGR. In addition Uysal & Albaz (2002) reported *S. trutta abanticus* that SGR varied from 1.07 to 1.11 at 56% protein level. These results were lower than those in present study.

According to the study conducted by Turchini et al (2003) on brown trout (initial weight approximately 58.4 g) fed with different lipid sources including about 46% crude protein, the best value for FCR was 1.05 and the poorest value was 1.32. In present study, FCR was observed as 1.00, 1.22, 3.73 and 1.49 for brown trout fed with live feed A, B, diet C and rainbow trout fed with diet C respectively. First reason for the poorest value in brown trout group fed with diet C was estimated that the ability of fry to take compound diet could not developed and that diet were wasted because of melting. Another reason was the difference between feeding habits of big and small fish. Live feed has great importance to rear even omnivore and herbivore fish. Therefore it is thought that the best result for group fed with live feed A is an indicator for this.

As shown, the best results for K, ADG, SGR, FCR, PER, DGI, FE and survival rate were observed in groups fed with live feeds A and B. On the other side, since tubifex generally lives in polluted streams, they can carry parasites, which may cause many contagious diseases in fish. In present study, it can be said that fish was healthy, according to haematocrit values. The highest haematocrit value was observed in fry fed with red tubifex. This depended on the feature of tubifex. In addition the best result for plasma protein appeared in the group fed with live feed A. This was indicator that this group was fed well. Another parameter is gross efficiency. In the study conducted by Elliott & Hurley (2000), gross efficiency of trout fed on invertebrates were compared with trout fed on fish at 10 °C and

found as 31.3% for trout fed on invertebrates and much higher 41.7% for piscivorous trout. These results support the advantages of live feed A used in present study.

In addition, tubifex protein is a rich source of amino acids compared to compound diets. However, its content of the sulphur amino acid, methionine may become limiting in respect of the fish requirements (Dabrowski et al 1987). In present study, poor results were obtained for group fed on tubifex compared to group fed on fish. It is estimated that two factors caused this situation. One of them was low lipid content of tubifex. Second reason was that fish spent more energy to feed since tubifex formed a big ball.

One of general features of salmonids is to be aggressive against other fish and protective towards their fields. Therefore many researchers conducted various studies on the relationship between their growth rates and behavioural traits. Some of these studies are summarized below:

Lahti et al (2001) reported that there was a positive correlation between aggression and growth rate of brown trout and high aggressiveness which encouraged high growth rate owing to prior access to food resources at the individual level. Metcalfe et al (1995) showed a positive correlation between standard metabolic rate and being dominant position in Atlantic salmon. Also Lahti et al (2002) emphasized that significant positive correlation between aggressiveness and standard metabolic rate between the populations was found in brown trout. Another study was on the connection between having dominant position and environmental factors. Kestemont & Baras (2001) and Mambrini et al (2004) explained that environmental factors and dominant individuals affected fish performances. In addition the relationship between unusual objects and the familiarity with environment was observed (Misslin & Ropartz 1981). Armstrong et al (1997) indicated that in Atlantic salmon the exploratory behaviour was related to the size of the fish. Huntingford et al (1990) and Johnsson (1993) also claimed that large size stemmed from bold behaviour and dominance; however it was always not true that bold behaviour and dominance were due to large size. We observed in our study that brown trout fries fed with live feed also behaved aggressively. Therefore our results support this assumption.

All these researches may make useful contribution to studies concerning the period after stocking fish to natural habitat. Because the most important problem faced with in this stage is low survival rate. In fact, Ersbak & Haase (1983) expressed that hatchery trout did not respond to the new conditions such as seeking cover, recognizing natural food and that these

inappropriate reactions might cause low survival rate. Stone (1872) emphasized that hatchery trout could not live in natural environment because of being used to hatchery conditions. There are also some studies on relationship between size of fish and their adjustment to new environment. Johnsen & Ugedal (1986, 1989, 1990) and L'Abée-Lund & Saegrov (1991) observed that small-size stocked brown trout could adapt to new conditions in a short time, whereas Hesthagen et al (1989) reported that takeable-sized brown trout adjusted slower to new conditions and it took a long time to learn how to use natural food. In our study, brown trout fries had the opportunity to consume live feed similar natural food resources. In taking into consideration that small size stocked brown trout can easily adapted to new conditions, we expect that our findings will contribute to the researches on juvenile recruitment after stocking stage.

In the research carried out by Kahilainen & Lehtonen (2001), stocked trout were larger than native trout during their first year in the lake whereas average lengths were the same during the second season. In addition brown trout were piscivorous at a length of about 20 cm in that study. However in our study, brown trout in fry period were already piscivorous.

Furthermore, there is growing evidence that fish can learn to recognize and avoid predators and learning plays a key role in predator avoidance (Alvarez & Nicieza, 2003). We hope that our study will shed a light on the researches on which fish reared under conditions similar to natural environment can achieve to adapt to the natural habitat easily in comparison with fish fed on compound diet.

As a conclusion, in this study, the best results for many parameters were observed in brown trout (*S. trutta abanticus*) fed on live feed A. These results show that feed A is the most suitable among others for brown trout (*S. trutta abanticus*). Considering the explanations mentioned above, it is concluded that feeding brown trout (*S. trutta abanticus*) on live feed A will make it possible to develop their ability of being aggressive, with the result that they will achieve high growth rate during post-stocking period and adapt to natural habitat easily. Therefore we estimate that the subjects such as giving importance to produce feeder fish (Guppy, Goldfish, Cichlids), producing attractive food in respect of colour, scent etc., giving importance to use safe sources of invertebrate like white worm, studying to improve quality of live feed will benefit later researches.

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References

- Alpbaz A (1984). Akvaryum Tekniği ve Balıkları. Acargil Matbaası. 863 Sok. No:58, 1-384, Kemeraltı-İZMİR
- Alvarez D & Nieceza A G (2003). Predator avoidance behaviour in wild and hatchery-reared brown trout: The Role of Experience and Domestication. *Journal of Fish Biology* **63**: 1565-1577
- Armstrong J D, Braithwaite V A & Huntingford F A (1997). Spatial strategies of wild atlantic salmon parr: exploration and settlement in unfamiliar areas. *Journal of Fish Biology* **48**: 242-254
- Armstrong J D, Kemp P S, Kennedy G J A, Ladle M & Milner N J (2003). Habitat requirements of atlantic salmon and brown trout in rivers and streams. *Fisheries Research* **62**: 143-170
- Arzel J, Metailler R, Kerleguer C, Delliou H & Guillaume J (1995). The protein requirement of brown trout (*Salmo trutta*) fry. *Aquaculture* **130**: 67-78
- Arzel J, Metailler R, Le Gall P & Guillaume J (1998). Relationship between ration size and dietary protein level varying at the expense of carbohydrate and lipid in triploid brown trout fry. *Salmo trutta. Aquaculture* **162**: 259-268
- Arzel J, Metailler R, Huelvan C, Faure A & Guillaume J (1992). The specific nutritional requirements of brown trout (*Salmo trutta*). *Buvisindi (Icel. Agr. Sci)*, **6**: 77-92
- Azevedo P, Leeson A S, Cho C Y & Bureau D P (2004). Growth nitrogen and energy utilization of juveniles from four salmonid species: diet, species and size effects. *Aquaculture* **234**: 393-414
- Dabrowski K, Kaushik S J & Fauconneau B (1987). Rearing of sturgeon (*Acipenser baeri* Brandt) larvae iii. nitrogen and energy metabolism and amino acid absorption. *Aquaculture* **65**: 31-41
- Düzgüneş O, Kesici T, Kavuncu O & Gürbüz F (1987). Araştırma ve Deneme Metodları (İstatistik Metodları II), Ankara Üniv. Ziraat Fak. Yayınları:1021, Ders Kitabı, 295. Ankara
- Elliott J M & Hurley M A (2000). Optimum energy intake and gross efficiency of energy conversion for brown trout. *Salmo trutta*. feeding on invertebrates or fish. *Freshwater Biology* **44**: 605-615
- Ersbak K & Haase B L (1983). Nutritional deprivation after stocking as a possible mechanism leading to mortality in stream-stocked brook trout. *North American Journal of Fisheries Management* **3**: 142-151
- Gabaudan J, Metailler R & Guillaume J (1989). Nutrition comparee de la truite arc en ciel (*Oncorhynchus mykiss*) la truite fario (*Salmo trutta*) et le saumon coho (*Oncorhynchus kisutch*). Effet des taux de proteines totales et de lipides ICES **5**: 1-13
- Geldiay R, & Balık S (1999). Türkiye Tatlısu Balıkları. Ege Üniversitesi Su Ürünleri Fakültesi Yayınları No: 46, Ders Kitabı Dizini No:16, 1-532, Ege Üniversitesi Basımevi, Bornova-İzmir, 1999
- Graff D R (1991). Why stock? (Editor: stoltz J & schnell J, *wildlife series: trout*) Stackpole Book, Harrisburg, pp. 341-345
- Hesthagen T, Jonsson B & Skurdal J (1989). Survival, exploitation and movement of takeable size brown trout, *Salmo trutta* L., in a norwegian river. *Aquaculture and Fisheries Management* **20**: 475-484
- Hunter C J (1991). Better trout habitat: a guide to stream restoration and management. 320 pp, Washington: Island press
- Huntingford F, Metcalfe N B, Thorpe J E, Graham W D & Adams C E (1990). Social dominance and body size in atlantic salmon parr. *Salmo salar* L. *Journal of Fish Biology* **36**: 877-881
- Johnsen B & Ugedal O (1986). Feeding by hatchery-reared and wild brown trout. *Salmo trutta* L. in a norwegian stream. *Aquaculture and Fisheries Management* **17**: 281-287
- Johnsen B & Ugedal O (1989). Feeding by hatchery-reared brown trout, *Salmo trutta* L. released in lakes. *Aquaculture and Fisheries Management* **20**: 97-104
- Johnsen B & Ugedal O (1990). Feeding by hatchery- and pond-reared brown trout, *Salmo trutta* L., fingerlings released in a lake and in a small stream. *Aquaculture and Fisheries Management* **21**: 253-258
- Johnsson J I (1993). Big and brave: selection affects foraging under risk of predation in juvenile rainbow trout, *Oncorhynchus mykiss*. *Animal Behaviour* **45**: 1219-1225
- Jonsson N, Nesje T F, Jonsson B, Saksgard R & Sandlund O T (1999). The influence of piscivory on life history traits of brown trout. *Journal of Fish Biology* **55**: 1129-1141
- Jonsson S (2001). Stocking of Brown Trout (*Salmo trutta* L.) Factors affecting survival and growth. Doctoral thesis, Swedish University of Agricultural Sciences Department of Aquaculture 1-25, Umea, 2001
- Kahilainen K & Lehtonen H (2001). Resource use of native and stocked brown trout *Salmo trutta* L. in a subarctic lake. *Fisheries Management and Ecology* **8**: 83-94
- Kestemont P & Baras E (2001). Environmental factors and feed intake: mechanisms and interactions. (Editors: Houlihan D, Boujard T & Jobling M *Food Intake In Fish*) Blackwell Science, Oxford, 131-156
- Kreivi P, Muotka T, Huusko A, Maki-Petays A, Huhta A & Meissner K (1999). Diel feeding periodicity, daily ration and prey selectivity in juvenile brown trout in a subarctic river. *Journal of Fish Biology* **55**: 553-571
- L'Abée-Lund J A & Saegrov H (1991). Resource use, growth and effects of stocking in alpine brown trout, *Salmo trutta* L. *Aquaculture and Fisheries Management* **22**: 519-526
- Lagardere J P, Mallekh R & Mariani A (2004). Acoustic characteristics of two feedings modes used by brown

- trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and turbot (*Scophthalmus maximus*). *Aquaculture* **240**: 607-616
- Lahti K, Laurila A, Enberg K & Piironen J (2001). Variation in aggressive behaviour and growth rate between populations and migratory forms in the brown trout, *Salmo trutta*. *Animal Behaviour* **62**: 935-944
- Lahti K, Huuskonen H, Laurila A & Piironen J (2002). Metabolic Rate and Aggressiveness Between Brown Trout Populations. *Functional Ecology* **16**: 167-174
- Lizam M, De Los A P & Ambrósio A M (2002). Condition Factor In Nine Species Of Fish Of The Characidae Family In The Upper Paraná River Floodplain, Brazil. *Brazilian Journal of Biology* **62(1)**: 113-124
- Mambrini, M., Sanchez, M.-P., Chevassus, B., Labbe, L., Quillet, E. and T. Boujard. 2004. Selection for growth increases feed intake and affects feeding behaviour of brown trout. *Livestock Production Science* **88**: 85-98
- Martinez P, Arias J, Castro J & Sanchez L (1993). Differential stocking incidence in brown trout (*Salmo trutta*) populations from northwestern Spain. *Aquaculture* **114**: 203-216
- Metcalf N B, Taylor A C & Thorpe J E (1995). Metabolic Rate, Social Status and Life-History Strategies in Atlantic Salmon. *Animal Behaviour* **49**: 431-436
- Misslin R & Ropartz P (1981). Responses in mice to a novel object. *Behaviour* **78**: 169-177
- Siwicki A K & Anderson D P (1993). Immunostimulation in fish: measuring the effects of stimulants by serological and immunological methods. Abstract Symposium on Fish Immunology, Lysekil, Sweden
- Solberg S O (1979). Formulation and technology of moist feed - moist pellets. (Editors: J E Halver & K Tiews *Finfish Nutrition and Fishfeed Technology*), Schriften der Bunders-forschungsanstalt für Fischerie, Berlin, pp. 41-50
- Stone L (1872). Trout culture, Proceedings of the American Fish Culturists' Association **1**: 46-56
- Turchini G M, Mentati T, Caprino F, Panseri S, Moretti V M & Valr'e F (2003). Effects of dietary lipid sources on flavour volatile compounds of brown trout (*Salmo trutta* L.) fillet. *Journal of Applied Ichthyology* **20**: 71-75
- Uysal İ & Albaz A (2002). Comparison of the growth performance and mortality in Abant trout (*Salmotrutta abanticus* Tortonese, 1954) and rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) under farming conditions. *Turkish Journal of Zoology* **26**: 399-403
- Zar J H (1984). Biostatistical analysis. Prentice Hall Englewood Cliffs, N J. 718