



Note

Comparison of number and shape of parr marks in three species of the genus *Salmo* and two ecotypes of cultured brown trout *Salmo trutta* from Turkey

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ABSTRACT

This study focused on the variation in number and shape of parr marks in three fish species of the genus *Salmo* [*S. abanticus* Tortonese, (1954), *S. caspius* Kessler, (1877) and *S. labrax* Pallas, (1814)] and two ecotypes of cultured brown trout [*S. trutta macrostigma* (Dumeril, 1858) and *S. trutta fario* Linnaeus, (1758)]. The brown trouts were collected from 11 streams in Turkey by electrofishing and transferred to the laboratory in an aerated container and then stocked in the adaptation tanks. Artificially fertilized eggs were incubated and larvae were maintained in fiberglass tanks and the variations in number and shape of parr marks in all five groups were studied for one year. The data collected indicated that there were significant differences in the number and size (length and width) of parr marks among the groups ($p < 0.05$). The highest number of parr marks (11-13) was recorded in *S. trutta macrostigma*. Parr marks on the skin of *S. trutta macrostigma* was found to remain stable during development.

Keywords: Brown trout, Ecotypes, Parr marks, *S. abanticus*, *S. caspius*, *S. labrax*, *S. trutta macrostigma*, *S. trutta fario*

Brown trouts (*Salmo trutta* and related species) are important fishes having aquaculture potential, economic value and wide consumer demand. Brown trouts forms resident populations in the upper streams of rivers in North Africa, Europe, West Asia and Anatolia (Kuru, 2004; Kottelat *et al.*, 2007) and are also important species of recreational fishery. Three species of brown trouts namely *Salmo abanticus* Tortonese, (1954), *Salmo caspius* Kessler, (1877) and *Salmo labrax* Pallas, (1814) and two ecotypes of *Salmo trutta* [*S. trutta macrostigma* Dumeril, (1858) and *S. trutta fario* Linnaeus, (1758)] are cultured in Turkey (Kocabas, 2009).

Spots pattern and colouration characteristics are primarily used for identification of species or different strains within a population (Skaala and Jorstad, 1988; Larijader and Scholl, 1996; Lascaux, 1996; Aparicio *et al.*, 2005) and often varies in different populations (Blanc *et al.*, 1982, 1994; Moran *et al.*, 1989; Mezzera *et al.*, 1997).

Parr marks are important phenotypic traits in salmonid species, present as, series of distinctive vertical dark bands along the sides of the body especially in the younger groups. These marks may serve as camouflage in vulnerable young fishes (Venkataraman, 2011). Parr

marks may persist in young adults, but disappear in adults. Visible parr marks are important characteristics in several fishes for identification (Aparicio *et al.*, 2005). Brown trout juveniles normally have visible parr marks on their sides as in many other salmonid species (Mezzera *et al.*, 1997). Parr growth rate, shape and parr mark pigmentation show differences among different populations (Culling *et al.*, 2013).

The objective of this study was to examine duration of the parr marks formation and to determine the differences in parr mark number and size (length and width) in different species/ecotypes of brown trouts from Turkey.

Adult individuals of trouts (*S. abanticus*, *S. trutta macrostigma*, *S. caspius*, *S. trutta fario* and *S. labrax*) were collected by electrofishing from 11 streams in Turkey (after availing permission from Ministry of Agriculture and Rural Affairs, General Directorate of Protection and Control). The fishes were transferred to the laboratory in aerated containers and stocked in adaptation pools at Black Sea Technical University Scientific Research Foundation, Trabzon. For each fish, total weight (g) and fork length (mm) were measured, recorded and tagged using Visible Implant Fluorescent Elastomer tags. The fishes were bred in captivity and the larvae were maintained

in fiberglass tanks (40 x 50 x 50 cm) with recirculation facility. Daily average water exchange was only 20%. Temperature was measured with a digital thermometer two times a day at (8:00-9:00 and 16:00-17:00 hrs). Temperature of the incoming water was $10.2 \pm 1.08^\circ\text{C}$ (7.7 to 14.2°C). All groups were fed daily the same ration of commercial feed with automatic feeders. Number and shape of parr marks were examined in all the five groups when the larvae reached size range of 3.5 to 4.5 cm [*S. abanticus* (n=41), *S. trutta macrostigma* (n=20), *S. aspius* (n=25), *S. t. fario* (n=21) and *S. labrax* (n=16)]. The fishes were anaesthetised using benzocaine solution (30 mg l^{-1}) and measured fork length (LF) to the nearest mm and were photographed with a digital camera (Sony DSC-W350). Visible parr marks were counted in all fishes. Size (width and length) of parrmarks were measured or identified from the photographs.

Differences in parr marks number and size on all the five groups were tested using one-way ANOVA. Statistical analyses were performed with SPSS 14.0 software package. Duncan's multiple range test was used for all *post-hoc* comparisons.

The mean length and weight of all five groups studied (*S. abanticus*, *S. trutta macrostigma*, *S. caspius*, *S. trutta fario* and *S. labrax*) were $51.69 \pm 13.54 \text{ mm}$ and $1.63 \pm 1.53 \text{ g}$; $89.72 \pm 54.97 \text{ mm}$ and $16.98 \pm 23.00 \text{ g}$; $43.72 \pm 25.25 \text{ mm}$ and $2.52 \pm 7.64 \text{ g}$; $52.94 \pm 11.72 \text{ mm}$ and $1.93 \pm 1.46 \text{ g}$; $59.81 \pm 26.58 \text{ mm}$ and $3.79 \pm 5.11 \text{ g}$, respectively.

Table 1. Number (Mean \pm SE) of parr marks in *Salmo* spp. and *S. trutta* ecotypes

| Species/ Ecotype | n | Mean \pm SD (min-max) | F | P |
|------------------------------|----|---------------------------------|--------|-------|
| <i>S. trutta macrostigma</i> | 20 | 11 \pm 1 ^a (10-12) | | |
| <i>S. abanticus</i> | 41 | 6 \pm 1 ^b (4-7) | | |
| <i>S. trutta fario</i> | 25 | 5 \pm 1 ^c (5-7) | 115.23 | 0.000 |
| <i>S. caspius</i> | 21 | 8 \pm 1 ^d (7-9) | | |
| <i>S. labrax</i> | 16 | 8 \pm 1 ^d (7-9) | | |

Table 2. Length and width (Mean \pm SE) of parr marks of *Salmo* spp. and *S. trutta* ecotypes

| Species/Ecotypes | <i>S. abanticus</i> | <i>S. trutta macrostigma</i> | <i>S. caspius</i> | <i>S. trutta fario</i> | <i>S. labrax</i> |
|------------------|---------------------------------|--------------------------------|--------------------------------|---------------------------------|--------------------------------|
| LF | | | | | |
| Mean \pm SD | 51.30 \pm 13.51 ^{bc} | 89.53 \pm 55.11 ^a | 43.27 \pm 25.16 ^c | 52.43 \pm 11.80 ^{bc} | 59.57 \pm 26.52 ^b |
| (min-max) | 31.00-87.00 | 40.00-193.00 | 26.00-150.00 | 37.00-77.00 | 36.00-118.00 |
| PW | | | | | |
| Mean \pm SD | 1.88 \pm 0.48 ^{cd} | 3.45 \pm 2.63 ^a | 1.59 \pm 0.79 ^d | 2.09 \pm 0.73 ^c | 2.69 \pm 1.63 ^b |
| (min-max) | 0.85-2.93 | 1.24-9.23 | 0.63-4.44 | 0.97-3.54 | 1.24-6.48 |
| PL | | | | | |
| Mean \pm SD | 3.77 \pm 0.92 ^b | 6.29 \pm 4.06 ^a | 2.53 \pm 1.25 ^c | 4.28 \pm 1.25 ^b | 4.63 \pm 2.05 ^b |
| (min-max) | 2.32-6.10 | 2.00-14.64 | 1.08-5.79 | 2.74-7.57 | 2.41-9.80 |

LF: Fork length (mm), PL: Parr mark length (mm), PW: Parr mark width (mm)

Skin pigmentation pattern and the numbers of parr marks are presented in Fig. 1 and Table 1. There were significant differences in parr marks number among the five groups of juvenile brown trouts ($p < 0.05$). The highest mean number of parr marks was in *S. trutta macrostigma* population (11 \pm 1) while the lowest number was in the *S. trutta fario* population (5 \pm 1).

Visible parr marks in *S. abanticus*, *S. trutta macrostigma*, *S. caspius*, *S. trutta fario* and *S. labrax* were initially observed from length groups 40 \pm 10 mm, 50 \pm 30 mm, 25 \pm 20 mm, 4 \pm 40 mm and 36 \pm 20 mm, respectively (Table 2). Parr marks were more distinctive in *S. trutta macrostigma*. Parr marks completely formed on each side of *S. trutta fario* on reaching 100 mm length.

The relationships between the length and width of parr marks are given in Table 2. Significant differences were obtained from the statistical comparison in length and width of parr marks between all groups tested ($p < 0.05$). Size of parr marks positively correlated with growth in all the five groups. Largest parr mark was observed in *S. trutta macrostigma* population and the smallest in *S. caspius* population.

Detailed identification and classifications differentiate species into subspecies, sub-population (Wells and Richmond, 1995), distinct population segments (US Fish and Wildlife Service, 1973), evolutionarily significant units (Ryder, 1986), evolutionary units (Committee on scientific issues in the endangered species act, 1995) and designatable units (DUs; COSEWIC, 2010). In recent years, the importance of ecotypes was emphasised by Morrison (2012) to identify the differences in morphology, physiology, behaviour, geographic range separation, phylogenetic divergence, local adaptations for ecological settings, genetics (COSEWIC, 2010) and also to reflect fundamental differences in life history characters (Pond *et al.*, 2016). Particularly, brown trout (*S. trutta*) shows a wide range of diversity in morphological characters.

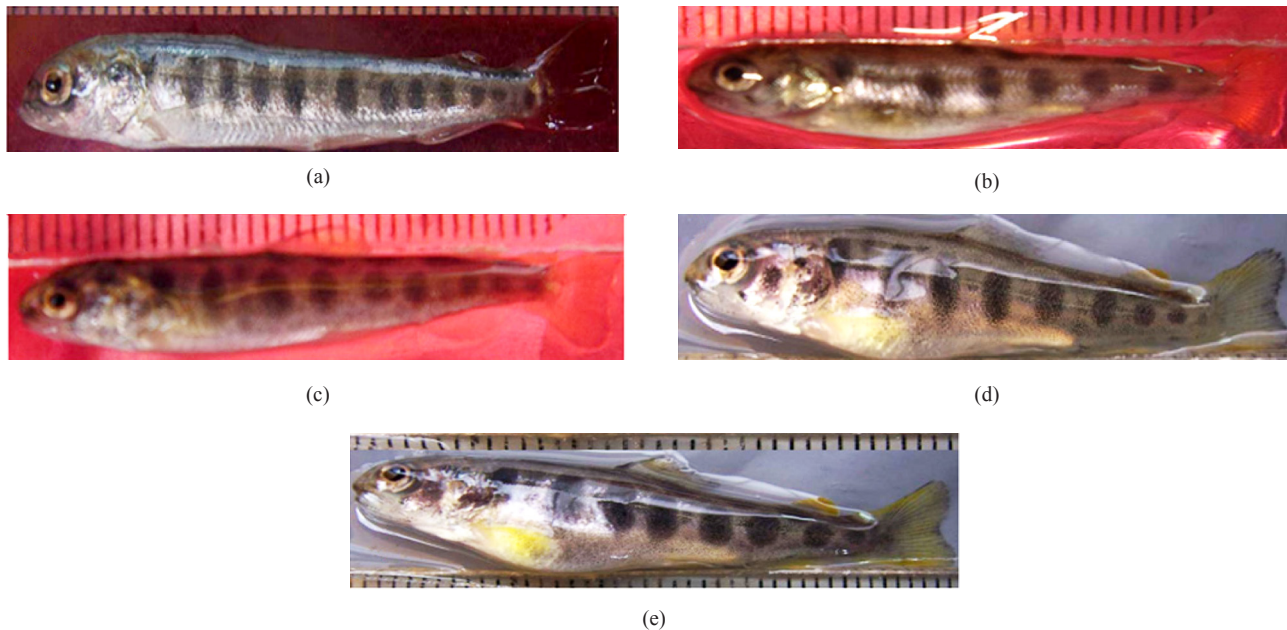


Fig. 1. Skin pigmentation pattern and parr marks of three species of trouts and two ecotypes of *S. trutta*; (a) *S. trutta macrostigma* (L=44.82 mm), (b) *S. caspius* (L= 37.67 mm), (c) *S. abanticus* (L=39.48 mm), (d) *S. trutta fario* (L= 41.89 mm), (e) *S. labrax* (L=36.20 mm)

S. trutta was represented by five ecotypes in Turkey but current consensus on classification and taxonomy retained the species status of three, namely *S. abanticus*, *S. caspius* and *S. labrax*. In the current scenario, the present study analysed characteristics and formation of parr marks in all five groups of brown trout from Turkey. It was confirmed that the number, size, and formation of parr marks differed in all the groups studied. The parr marks were stable in *S. trutta macrostigma* while they diminished in other groups with growth.

Only a few studies concentrated on the relationship of parr marks and spots pattern in salmonids. Venkataraman, (2011) opined that the parr marks of members of the Salmonidae disappear shortly after the juvenile phase and the parr mark development in the river resident form of the red spotted masu trout (*Oncorhynchus masou ishikawae*) was completed relatively early in the life cycle of fish (6 to 7 months after hatching) and remained stable during further development. Aparicio *et al.* (2005) stated that parr marks may persist into young adults, but disappear in large individuals. Kurtoglu (2002) reported that parr marks diminished in *S. trutta fario* and *S. trutta labrax* after smoltification. In the present study, the results indicated that parr marks diminished in *S. abanticus*, *S. caspius*, *S. trutta fario* and *S. labrax* with growth but they were constant in *S. trutta macrostigma*. These morphological differentiations could be due to genetic drift in populations (Karaiskou *et al.*, 2009).

Mezzera *et al.* (1997) reported that the number of parr marks were between 11 and 13 in *S. trutta* but

according to Aparicio *et al.* (2005) it ranged between 8 and 12. The present study recorded 5 to 12 parr marks in all five groups. The noted difference in number of parr marks may be due to differences in physiology or genetic relation with local adaptation and heterogeneous environmental conditions (Pond *et al.*, 2016).

Number of parr marks may increase (Martinez, 1984) or remain unchanged with increasing fork length (Mezzera *et al.*, 1997). The results confirm the observations of Mezzera *et al.* (1997) that the length and width of parr marks increased with length or size of the fish. In conclusion, all five groups of cultured brown trouts showed distinct variation in the morphological traits which can help in identification and segregation even at the juvenile stage. Parr marks can be used as a character to distinguish all the five groups from 30 mm size onwards.

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