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Full Length Research Paper

Spotting pattern features in the brown trout (*Salmo trutta macrostigma,* T., 1954) population

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This study aimed to define spotting pattern features useful to discriminate wild from stocked brown trout (*Salmo trutta macrostigma* T., 1954) in Turkey. 136 trout captured from Munzur Stream in Tunceli, Turkey. Captured fish were measured 20.49±6.31 cm, as a standard length. It characterized the number of red spots, above and below the lateral line, the number of black spots on operculum and the number of black spots on adipose fin and the diameters of spots were measured on the trout population. It also investigated changes of these spotting pattern characters depending on male or female. The relationship of fish size with number of red spots was found to be statistically significant ($p<0.05$). Statistically significant differences between female and male fish were not observed with respect to different characters.

Key words: *Salmo trutta macrostigma*, brown trout, spotting patterns, number of spot.

INTRODUCTION

Salmonids develop some morphological and coloration traits in response to environmental factors such as water quality and bottom structure (Bourke et al., 1997) and studies, related with morphometric and meristic characters of trout are very scarce. In brown trout, several phenotypic characteristics related to spotting and body coloration have shown a genetic basis (Blanc et al., 1982, 1994; Skaala and Jørstad, 1988; Mezzera et al., 1997) and therefore, could be potentially useful to identify individuals belonging to different strains within a population. Some studies have examined phenotypic traits of native brown trout. Aparicio et al. (2005) examined five qualitative and seven quantitative coloration and spotting pattern features in brown trout *Salmo trutta* populations and two hatchery stocks and it was determined that the three genotypes showed significant differences in the coloration and spotting features. Bud et al. (2009) observed significant differences in the number of spotting and coloration characteristics among populations. Keeley et al. (2005) described the genetic basis to the phenotypic variation and was important to assess and help understand the relative roles of deterministic (for example, natural selection) or random effects (for example drift) in explaining variation in morphology. Keeley et al. (2006) compared the morphology of six rainbow trout (*Oncorhynchus mykiss*) populations from different ecotypic categories. Qadri (1959) observed that two subspecies of cutthroat trout have been distinct differences in the number and distribution pattern of spots below the lateral line. Islam et al. (1973) studied the number and distribution pattern of the black spots below the lateral line of rainbow trout inhabiting different hatcheries in Japan. Agapova et al. (2002) studied intra-population variation and inter-population phenotypic differentiation of chum salmon (*Oncorhynchus keta*) populations. The present investigation has carried out number and distribution pattern of the red and black spots, above and below the lateral line, the number of black spots on operculum and the number of black spots on adipose fin in *S. trutta macrostigma*. It was also aimed to investigate the relationship between the number of spots and sex.

MATERIALS AND METHODS

A total of 136 individuals of *S. trutta macrostigma* (Figure 1) were captured from Munzur Stream in Tunceli using by electro-fishing. Sex was determined by gonad examination. Trout were

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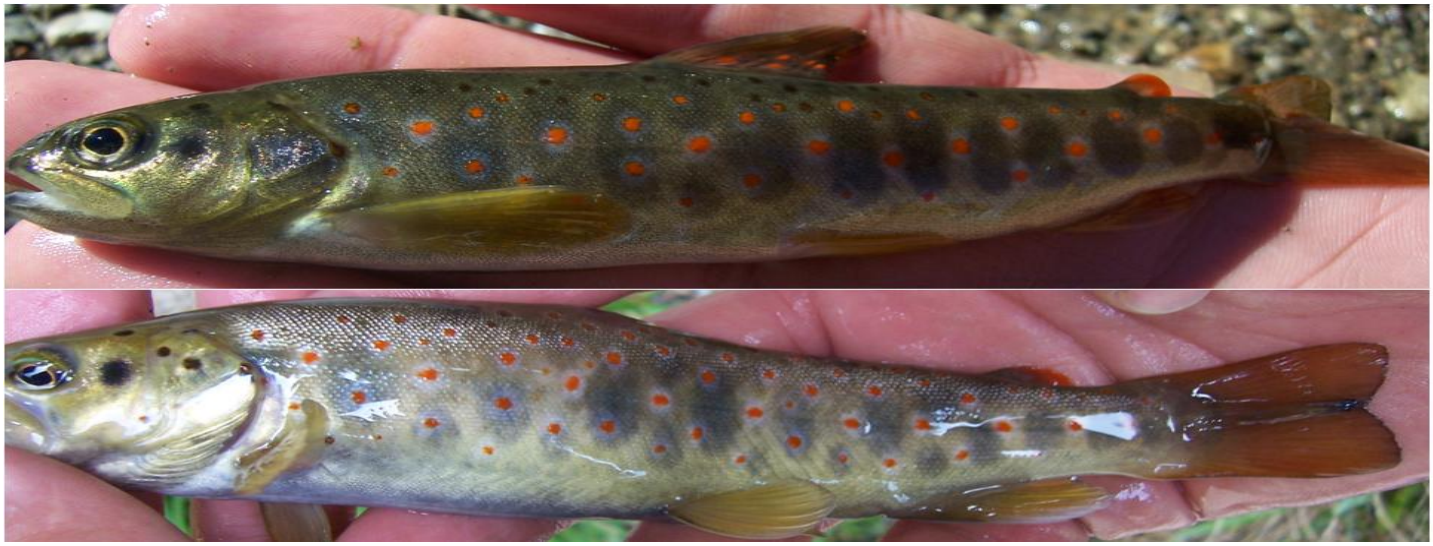

Figure 1. Typical morphotypes of brown trout *S. t. macrostigma.*

photographed with a digital camera (Sony DSC-W350). Length was measured as standard length and total weight was determined. Nine quantitative variables were used. The quantitative variables were: diameters of the (1) spot (2) the number of red spots located on the lateral line; (3) number of red black spots on operculum; number of (4) black and (5) red spots above the lateral line; number of (6) black and (7) red spots below the lateral line; number of (8) black spot and (9) red spot on the adipose fin (Aparicio et al., 2005).The diameters of spots were measured in the field with calipers on the left side of the specimens and rounded to the nearest ±0.1 mm.

Statistical analysis

The red spots and black spots were counted from the both sides of the body and were processed per total body and not per separate sides. The differences number of red and black spots between males and females were tested with one-way analysis of variance (ANOVA). Regression analysis was performed to test significance differences in relationship of fish size with number of spots. Statistical analyses were performed with SPSS 14.0 software package and a significant level of 0.05 was accepted.

RESULTS

It was centered on emphasizing of red spots number and distribution on body surface and on dorsal fin, as well the black spots number on the operculum and pre-operculum surface, features that we consider important and insignificant influenced by the environmental factors.

The number of red spots located at lateral line was determined 12.81±2.10. The number of black spots is 7.10±0.64. Their majority being on half of the anterior body and with a diameter comprised between 1.50 and 6.67 cm. When analyzed the number of red spots located above lateral line, it was observed that the number was determined 4.11±6.69. In case of red spots located under lateral line, it was observed that these have more high density, comparatively with region situated above lateral line. The number of red spots from the adipose fin was determined 3.47±3.71.

The number of black spots is 24.21±1.56. Most of them situated anterior half of the body and their sizes were determined between 1.55 and 3.79. When analyzed the number of black spots located above lateral line, it was observed the number reaches to 31.09±1.70. In case of black spots located above lateral line, it was observed that these have more high density, comparatively with region situated under lateral line. The number of black spots on the adipose fin and the operculum were determined 1.14±1.10, 5.53±3.42, respectively.

Number of spots and body size

Relationship between the number of black and red spots and body length exhibited by the specimens is shown in Figure 2. Number of spots showed a definite increasing tendency with less variation among specimens. The relationship of fish size with number of red spots was found to be statistically significant ($p = 0.001$, $p < 0.05$), but significant differences were not obtained from fish size with number of black spots ($p = 0.786$, $p > 0.05$).

Phenotypic differences related to sex

In the studied population, female and male proved to differ significantly in the frequencies of some characters.

Statistically significant differences between female and male fish were not observed with respect to different phenotypic characters (Table 1).

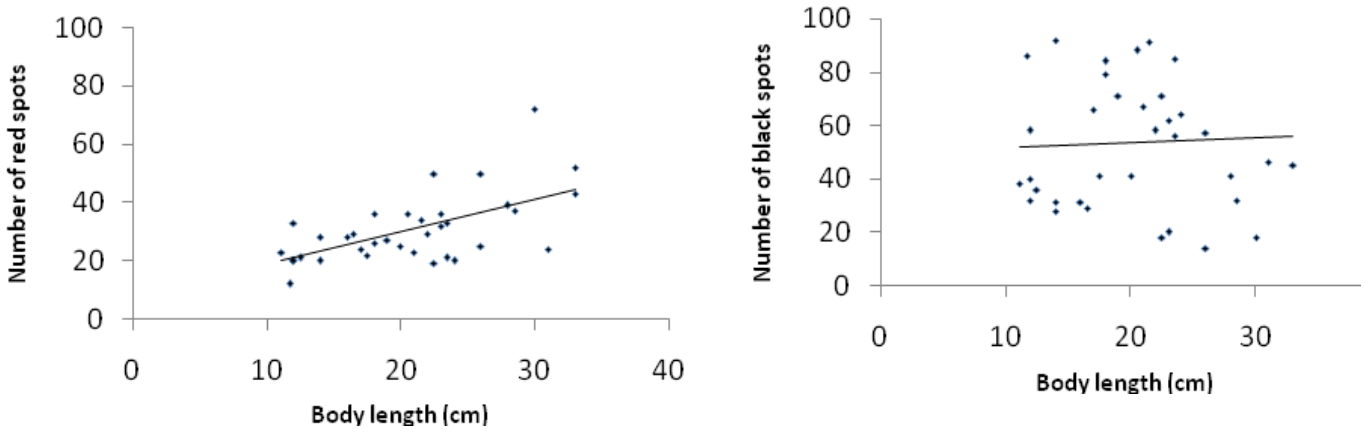

Figure 2. Relationship between the total number of black and red spots on body.

Table 1. Variability of total number of red and black spots on body surface in brown trout depending on sex.

Specification	Mean±SE	p values
diameters of spots (mm)	2.25±0.08	p>0.05
red spots along lateral line	12.81±2.10	p>0.05
red spots located above lateral line	4.11±0.66	p>0.05
red spots located under lateral line	10.10±0.77	p>0.05
red spot number on adipose fin	3.47±3.71	p>0.05
black spot number on operculum	5.53±3.42	p>0.05
black spots on body	24.21±1.56	p>0.05
black spots located above lateral line	31.09±1.70	p>0.05
black spots located under lateral line	17.72±1.75	p>0.05
black spot number on adipose fin	1.14±1.10	p>0.05

DISCUSSION

Populations of the same fish species often differ in phenotypic characters (Sandlund et al., 1992; Schluter and McPhail, 1992; Elliott, 1994). Morphological differences in principle result from two causes, genetic differences or environmental factors, or their interaction. Genetic differences and reproductive isolation between populations can lead to local adaptation, which is reflected in morphology, behavior, physiology and life history traits (Taylor, 1991). Environmental factors, on the other hand, can produce phenotypic plasticity, which is the capacity of a genotype to produce different phenotypes in different environmental conditions (Stearns, 1989; Scheiner, 1993). The factors can produce a rapid change in the skin color that can be controlled physiologically, where hormonal and neural signals participate, regulating the dispersion or aggregation of pigments in the chromatophores; or morphologically, where the number of melanophores in the skin increases or decreases (Colihueque, 2010). To our present knowledge, no other researcher has conducted relation with spotting patterns of *S. trutta macrostigma.* However, some studies have examined phenotypic traits of salmonids (Islam et al., 1973; Qadri, 1959; Blanc et al., 1982; Skaala and Jørstad, 1988; Mezzera et al., 1997; Dyness et al., 1999; Agapova et al., 2002; Alexander and Adams, 2004; Aparicio et al., 2005; Keeley et al., 2005; Keeley et al., 2006; Bronte and Moore, 2007; Bud et al., 2009). In some studies, it was reported that spotting pattern changed depending on sex. Contrary to findings by Agapova et al. (2002) and Lin et al. (2008), in our study, it was determined that differences were not observed in spotting patterns on body between sexes. It was observed that body color of captured female fish was less dark than male. Murta (2000) reported that meristic characters are independent of fish size and the absence of correlations between meristic characters and total length in *Trachurus trachurus*. Interestingly, the results showed that number of red spot changed with fish size while difference was not observed in the number of black spot with fish size. In conclusion, the detailed spotting

patterns presented in this study were about the brown trout *S. trutta macrostigma*. It was found that there is a relationship of fish size with number of red spots but neither black spots nor spotting pattern exhibited any relationship with sex.

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