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Short Communication

Meristic and morphometric characteristics of the Black Sea salmon, *Salmo labrax* Pallas, 1814 culture line: an endemic species for Eastern Black Sea

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Abstract
The Black Sea salmon *Salmo labrax* Pallas, 1814 is an essential species for the Turkish aquaculture sector, given increasing trends of the annual productions. To date, there are few studies on meristic and morphometric characteristics of this species. In this study, the fifth filial generation of the species was specified and studied for meristic and morphometric characteristics. The results obtained in this study were compared with available literature and a similarity was found between the study specimens and wild individuals. The morphological characteristics of any cultured species is valuable especially when a new culture generation is formed and therefore this study outcomes may provide important information to the literature.

Keywords: aquaculture; endemic; morphology; *Salmo trutta labrax*; threatened fish.

1 | INTRODUCTION

Salmonids are one of the most preferred fish families in the world aquaculture (Liu *et al.* 2016). The Black Sea salmon *Salmo labrax* Pallas, 1814 (Figure 1a–b) belongs to Salmonidae is an endemic and anadromous fish species for the eastern Black Sea. Although Black Sea salmon is not listed as threatened species in the IUCN Red List database, it was considered an endangered species in some areas (e.g. Georgia and Russia; GRID 1999) which constitute the natural habitat of Black Sea salmon along with Turkey (Okumuş *et al.* 2004). Besides, Black Sea salmon was listed among vulnerable species by the Black Sea Biodiversity and Landscape Conservation Protocol to the Convention on the Protection of the Black Sea against Pollution in 2002 (Oanta 2015). Because of such information, Black Sea salmon was adapted to culture conditions for the first time in 1998 by the Ministry of Agriculture and Forestry, Central Fisheries Research Institute in Turkey, with the aim of ex-situ conservation of the species.

In 2015, the fifth filial generation (F5) of the Black Sea salmon was achieved (Çakmak *et al.* 2018). In the last 20 years, with the contribution of the research projects, the Black Sea salmon has become an important species for the aquaculture sector (Çankırılıgil *et al.* 2017; Çakmak *et al.* 2019). The production amount of this species reached up to 2070 tons in 2018 in Turkey (TSI 2018). Nowadays, Turkish stocks were overexploited in nature due to severe hunting pressure (Çakmak *et al.* 2019), and the only stock is the culture line breed throughout the years. This research aims to define meristic and morphometric characteristics of the 5th generation of genetically confirmed Black Sea salmon to constitute a basis for culture line registration. Identification of particular fish stocks is crucial for fishery science. Morphometric and meristic differences among stocks are accepted as an important tool to evaluate the population structure and identification (Rawat *et al.* 2017), and they are commonly used for identification of aquatic animals. This research also aims to create a fundamental study for future studies and to contribute to the lacks in literature.

2 | METHODOLOGY

All Black Sea salmon individuals were obtained from the Central Fisheries Research Institute, Trabzon-Turkey (Figure 1b). Sampling was carried out with ARRIVE ethical guidelines (Kilkenny *et al.* 2010) and the European Union Directive (2010/63/EU) (European Commission 2010). Also, all experiments were carried out with the approval coded as ETIK-2017/1 by the Ethical Committee of Animal Experiments of Central Fisheries Research Institute. Morphometric and meristic characteristics were measured for 60 specimens including 30 male and 30 female belonging to the fifth filial generation of the Black Sea salmon. All measurements were based on Figure 1a, modified from Fischer *et al.* (1987) and described as; TL, total length; SL, standard length; PPL, pre-pelvic Length; PDL, pre-dorsal length; PAL, pre-anal length; BHd, dorsal fin based body Height; BHa, anal fin based body height; DFL, dorsal fin length; DFW, dorsal fin width; PcFL, pectoral fin length; PvFL, pelvic fin length; AFW, anal fin width; AFL, anal fin length; AdFL, adipose fin length; AdFW, adipose fin width; CFL, caudal fin length; HL, head length; SL, snout length; OL, orbital length; BHh, head based body height; BHe, eye based head height; DN, the distance between nostrils; DE, the distance between eyes; ML, mouth length; MW, mouth width. Head-related measurements were made by proportioning to head length, and body-related measurements were made by proportion to the total length. Obtained data were analysed with independent *t*-test by IBM SPSS 21 software. The vertebral bones and fin rays were counted from the radiograms, which were taken by x-rays (Vatech, Pax400) to determine the exact number of meristic characters after fish being anaesthetised with clove oil. Otoliths were dissected from each individual (Figure 1c) and they were photographed by binocular microscope (Leica, MZ75) with a digital camera and Leica Application Suite software®.

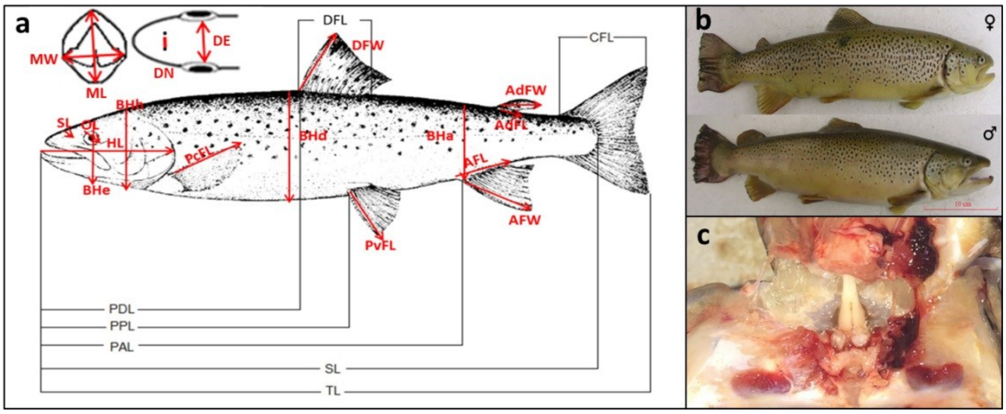

FIGURE 1 Black Sea salmon *Salmo labrax*. *a*, the measurement scheme; *b*, female and male individuals of Black Sea salmon; *c*, otoliths extraction.

3 | RESULTS AND DISCUSSION

The Black Sea salmon has three ecotypes in the Eastern Black Sea region of Turkey *viz*. the lake, river, and sea ecotypes (Tabak *et al.* 2001). In this research, the fifth filial generation of Black Sea salmon, which was formed from individuals belonging to sea ecotypes, was used. The morphometric and meristic characters were counted and calculated for female and male samples shown in Table 1. The otoliths of the samples had a lot of false annulus rings (Figure 2). According to the results, Black Sea salmon has 14 fin rays in the dorsal fin, ten fin rays in pectoral fins, 14 fin rays in pelvic fins and 12 fin rays in the anal fin. Meristic radiograms measurements of Black Sea salmon's fifth generations are shown in Figure 3. Scale numbers in the lateral line were counted between 112 and 125, vertebral bones were counted as 57-58, and gill rakers were counted as 16–18.

Based on statistical analyses, the ratio of the standard length, pre-dorsal length, pre-anal length, dorsal fin based body height, dorsal fin width, anal fin width, head length, snout, length, orbital length, head based body height, eye-based head height, the distance between nostrils, the distance between eyes and mouth width of the females were greater or bigger than males. However, in males, dorsal fin length, pectoral fin length, pelvic fin length, anal fin width, and adipose fin width were found higher than females (*t*-test; $P < 0.05$). However, there were no significant differences between other characteristics of males and females (*t*-test; all $P > 0.05$). Black Sea salmon as an anadromous species migrates between streams and pelagic seawater (Okumuş *et al.*, 2004; Islam and Joadder 2005). Also, in the aquaculture of Black Sea salmon, when the fish individuals reached the smolt size, are transported to marine cages to complete their life-cycle (Kasapoglu *et al.* 2016; Çakmak *et al.* 2018). However, the characteristic red spots can be lost in the marine environment (Slastenenko 1956; Svetovidov 1984). The appearance of the fifth filial generation observed as similar to sea ecotype with brown-green body colour and black spots on the ventral sides of the body (Figure 1b).

TABLE 1 Measurements of the Black Sea salmon *Salmo labrax* individuals according to gender.

Body	Female ♀ (*n* = 30)			Male ♂ (*n* = 30)			*P*-values
	Range (mm)	Mean (mm)	TL (%)	Range (mm)	Mean (mm)	TL (%)	
TL	377.3 – 440.1	413.3 ± 8.90	-	320.2 – 400.3	359.3 ± 16.62	-	-
SL	353.5 – 412.1	383.8 ± 8.72	92.8 ± 0.20	287.1 – 374.3	328.8 ± 18.25	91.4 ± 0.32	**0.016**
PPL	181.3 – 208.5	195.9 ± 4.37	47.5 ± 0.59	154.3 – 180.4	167.5 ± 7.34	46.7 ± 0.65	0.760
PDL	152.1 – 183.0	170.2 ± 4.21	41.1 ± 0.10	129.3 – 161.0	145.2 ± 6.96	40.4 ± 0.14	**0.011**
PAL	251.7 – 289.7	270.0 ± 5.50	65.4 ± 0.56	199.7 – 252.7	225.8 ± 11.76	63.0 ± 0.79	**0.005**
BHd	83.1 – 101.9	93.5 ± 2.81	22.7 ± 0.30	70.8 – 86.6	79.2 ± 3.98	22.1 ± 0.26	**0.016**
BHa	56.6 – 65.6	62.1 ± 1.47	15.0 ± 0.18	51.7 – 56.2	54.3 ± 0.98	15.2 ± 0.30	0.069
DFL	41.5 – 55.4	46.5 ± 2.07	10.6 ± 0.29	42.1 – 49.4	45.1 ± 1.76	12.6 ± 0.28	**0.004**
DFW	35.4 – 49.0	43.8 ± 2.07	11.3 ± 0.21	34.2 – 45.5	38.9 ± 2.38	10.9 ± 0.07	**0.045**
PcFL	31.0 – 47.9	35.7 ± 2.61	8.7 ± 0.35	30.9 – 42.3	37.2 ± 2.36	10.5 ± 0.35	**0.012**
PvFL	24.7 – 40.2	31.2 ± 2.44	7.6 ± 0.29	28.7 – 31.7	30.0 ± 0.79	8.4 ± 0.18	**0.021**
AFW	29.1 – 40.6	34.3 ± 1.76	7.3 ± 0.23	29.2 – 37.4	34.4 ± 2.36	9.6 ± 0.24	**0.008**
AFL	25.8 – 32.6	29.1 ± 0.93	8.3 ± 0.10	24.0 – 27.7	26.4 ± 0.87	7.3 ± 0.05	**0.015**
AdFL	8.3 – 17.0	12.5 ± 1.22	3.0 ± 0.35	10.0 – 11.5	10.5 ± 0.34	3.0 ± 0.07	0.068
AdFW	27.0 – 47.2	34.1 ± 2.79	8.3 ± 0.14	33.2 – 53.7	37.0 ± 5.83	10.6 ± 0.42	**0.017**
CFL	20.6 – 28.0	24.9 ± 1.04	6.0 ± 0.15	26.4 – 37.4	30.6 ± 2.37	8.6 ± 0.32	**0.025**
HL	78.0 – 127.0	93.4 ±7.08	22.7 ± 0.89	55.2 – 86.6	75.7 ± 7.00	20.0 ± 0.53	**0.036**
SL	12.0 – 25.8	17.0 ± 2.07	18.0 ± 0.71	13.6 – 16.1	14.7 ± 0.54	19.8 ± 0.62	**0.005**
OL	11.4 – 13.7	12.4 ± 0.34	13.6 ± 0.42	9.7 – 11.6	10.9 ± 0.44	14.9 ± 0.65	**0.002**
BHh	61.5 – 78.8	72.0 ± 2.40	78.4 ± 2.24	46.6 – 57.0	63.4 ± 2.35	71.8 ± 1.59	**0.015**
BHe	41.4 – 51.6	48.0 ± 1.79	52.2 ± 1.12	39.0 – 51.2	46.3 ± 2.61	62.0 ± 1.19	**0.008**
DN	15.6 – 21.4	19.5 ± 0.85	21.3 ± 0.73	15.3 – 20.3	16.4 ± 1.49	21.9 ± 0.60	**0.021**
DE	36.0 – 41.3	39.4 ± 0.79	43.1 ± 1.12	31.5 – 39.4	35.9 ± 1.74	48.3 ± 1.08	**0.030**
ML	35.1 – 56.6	45.5 ± 2.84	49.0 ± 0.74	42.5 – 57.1	47.3 ± 3.34	63.8 ± 1.10	**0.017**
MW	25.0 – 34.0	30.4 ± 1.38	33.2 ± 1.02	26.7 – 36.7	31.5 ± 2.05	42.4 ± 1.06	**0.009**

P-values showing significant statistical differences are in boldface. *TL*, total length; *SL*, standard length; *PPL*, pre-pelvic length; *PDL*, pre-dorsal length; *PAL*, pre-anal length; *BHd*, dorsal fin based body height; *BHa*, anal fin based body height; *DFL*, dorsal fin length; *DFW*, dorsal fin width; *PcFL*, pectoral fin length; *PvFL*, pelvic fin length; *AFW*, anal fin width; *AFL*, anal fin length; *AdFL*, adipose fin length; *AdFW*, adipose fin width; *CFL*, caudal fin length; *HL*, head length; *SL*, snout length; *OL*, orbital length; *BHh*, head based body height; *BHe*, eye based head height; *DN*, the distance between nostrils; *DE*, the distance between eyes; *ML*, mouth length; *MW*, mouth width.

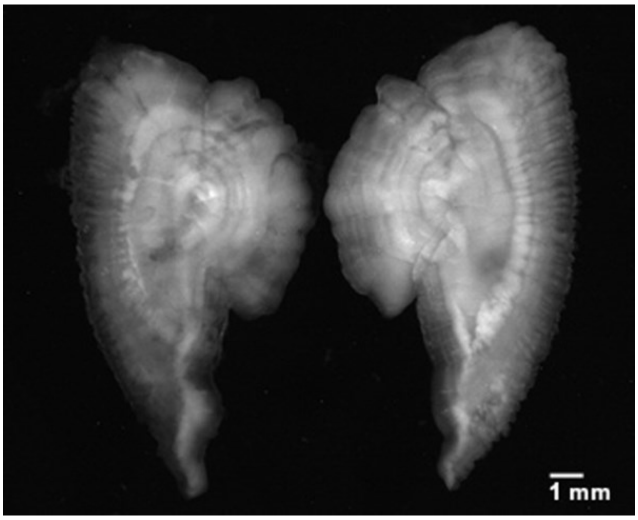

FIGURE 2 Otoliths of the Black Sea salmon *Salmo labrax*.

The lack of information exists on morphometric and meristic features of this species on the reputed databases including fishbase. However, some measurements are available on Fishbas which includes standard length (88.3% TL), fork length (95.8% TL), pre-anal length (65.1% TL), pre-dorsal length (38.1% TL), pre-pelvic length (49.0% TL), pre-pectoral length (18.1% TL), body depth (21.8% TL), head length (18.3% TL), eye diameter (25.7% TL) and pre-orbital length (16.5% TL) of wild ones of this species (Froese and Pauly 2020). These are the only morphometric measurements available for the Black Sea salmon and our study results will be an important addition to this. Our results also showed similarity between the fifth filial generation and wild individuals for this species in terms of morphometric features. Similarly, according to the study of Kottelat and Freyhof (2007) which have the only meristic definition of the species, wild Black Sea salmon have 16–18 gill rakers, one adipose fin, one elongated dorsal fin, and one pair of anal, pelvic and pectoral fins having both spines and soft rays. The otoliths were shown false ring as usual and Kasapoglu *et al.* (2016) have reported that the cultured Black Sea salmon otoliths have irregular annulus starting from the first ring because of the transporting between sea and freshwater conditions.

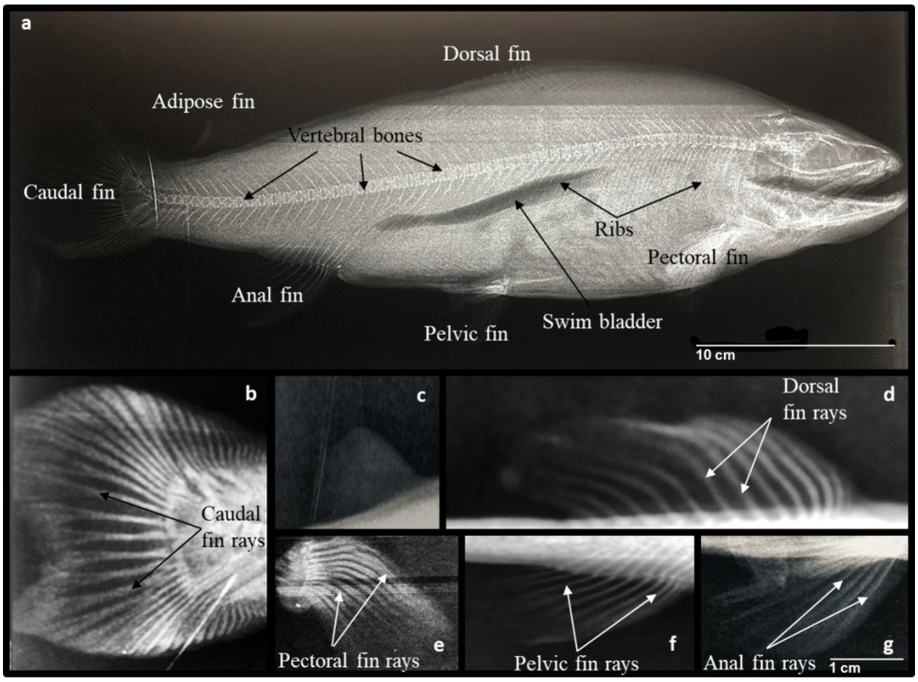

FIGURE 3 Meristic measurements of Black Sea salmon *Salmo labrax*. *a*, vertebral bones; *b*, caudal fin; *c*, adipose fin; *d*, dorsal fin; *e*, pectoral fin; *f*, pelvic fin; *g*, anal fin. *b – g* were visualised on 1 cm scale.

In conclusion, it is essential to know the measurements of these features for this species due to the economic importance of Black Sea salmon for the Turkish aquaculture sector and shed light on future studies. The primary motivation for conducting this study was a lack of information about the species in renowned databases including Fishbase and miscalling based on phenotype researches.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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NK, ECÇ, EÇ, & **OTÖ** data collection and analysis;
NK & **ECÇ** prepared the manuscript.

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