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Determination of regional changes in morphological characteristics of perch (*Perca fluviatilis*) caught in different lakes of Türkiye

Original Article

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Abstract:

This study investigated the morphological traits, growth performance, and organosomatic parameters of perch (*Perca fluviatilis*) populations collected from twelve lakes and reservoirs in Türkiye. The morphometric measurements, growth indicators, and condition factors of the specimens were analysed in detail. The results revealed significant differences in morphometric and growth characteristics among populations. These variations are closely linked to environmental factors, including water temperature, habitat structure, food availability, and trophic interactions. Populations from Konya (Altınapa), Afyon (Şeyitler), and İzmir-Tahtalı exhibited superior growth performance and higher morphometric values, while individuals from Adana (Seyhan), Ankara (Çamlıdere), and Kırşehir (Hirfanlı) exhibited lower values. These results suggest that freshwater perch populations exhibit significant morphological and physiological plasticity in response to varying habitat conditions. These differences highlight the importance of considering regional environmental factors when developing stock management and conservation strategies for this species.

Key words:
pearch, morphometric variation, growth performance, environmental factors, population differences

Apstrakt:

Određivanje regionalnih promena morfoloških karakteristika smuđa (*Perca fluviatilis*) ulovljenog u različitim jezerima Turske

Ova studija je ispitivala morfološke osobine, performanse rasta i organosomatske parametre populacija štuke (*Perca fluviatilis*) prikupljenih iz dvanaest jezera i akumulacija u Turskoj. Morfometrijska merenja, pokazatelji rasta i faktori kondicije ispitanih jedinki detaljno su analizirani. Rezultati su pokazali značajne razlike u morfometrijskim i karakteristikama rasta između populacija. Ove varijacije su usko povezane sa faktorima životne sredine, uključujući temperaturu vode, strukturu staništa, dostupnost hrane i trofičke interakcije. Populacije iz Konje (Altınapa), Afjona (Şeyitler) i Izmira-Tahtalı pokazale su bolje performanse rasta i veće morfometrijske vrednosti, dok su jedinke iz Adane (Seyhan), Ankare (Çamlıdere) i Kırşehira (Hirfanlı) imale niže vrednosti. Ovi rezultati sugerišu da populacije slatkovodne štuke pokazuju značajnu morfološku i fiziološku plastičnost kao odgovor na različite uslove staništa. Ove razlike naglašavaju značaj uzimanja u obzir regionalnih faktora životne sredine pri razvoju strategija upravljanja populacijom i zaštite ove vrste.

Ključne reči:
štuka, morfometrijske varijacije, performanse rasta, faktori životne sredine, razlike između populacija

Introduction

The perch (*Perca fluviatilis* L.) is a medium-sized fish that belongs to the *Percidae* family (McDowall, 1996). It was first described from Swedish lakes in 1730 by Peter Artedi, and later formally classified by Carl Linnaeus in 1758, based on Artedi's studies (Thorpe, 1977; Pimakhin et al., 2015). The *Percidae* family comprises 10 genera and 195 species (Berra, 2001). According to fossil records, the genus *Perca* is estimated to have emerged approximately 19.8 million years ago, during the Early Miocene epoch (Stepien et al., 2015). This genus includes three recognized species:

- *Perca fluviatilis* (Linnaeus, 1758),
- *Perca flavescens* (Mitchill, 1814; commonly known as the yellow perch, widely distributed in North America),
- *Perca schrenckii* (Kessler, 1874; commonly known as the Balkhash perch, with a restricted distribution in lakes of Central Asia).

The body of the perch is laterally compressed and covered with oval-shaped ctenoid scales. The lateral line arches upward, terminating before reaching the caudal fin. The anterior dorsal region appears hump-backed. The preoperculum exhibits a series of serrations, while the postoperculum terminates in a pronounced spine-like projection. The mouth is large, bearing sharp teeth on both the palatine and vomer bones. The head length is approximately one-fourth of the total body length. Although the interorbital region of the skull is scaleless, the cheeks are covered with ctenoid scales. The dorsal fins are located close together. The eyes are relatively large, positioned near the top of the head, and their diameter is about one-fifth to one-sixth of the head length. The first dorsal fin gradually decreases in height from anterior to posterior. The anal fin originates slightly behind the second dorsal fin. The caudal fin is slightly emarginate, with rounded lobes. The general body coloration is brownish-green, with 6–8 dark green vertical bars along the flanks. A distinct black blotch is present on the posterior part of the first dorsal fin. The ventral, anal, and caudal fins are typically orange-red, while the other fins are colorless. The body length may reach up to 50 cm. Local and regional environmental conditions influence both the body size and morphology of perch populations (Persson, 1987; Olsson et al., 2007; Kerstin & Petersson, 2023). Temperature, in particular, is a significant factor affecting the size of the perch. In warmer lakes, where perch populations tend to be denser, the average individual size is usually smaller due to increased competition for limited resources (Kerstin & Petersson, 2023).

In this study, the morphological characteristics, growth performance, and organosomatic parameters of perch individuals captured from natural water bodies in different regions of Türkiye were thoroughly investigated. The primary aim of the research was to identify the morphological variations of perch populations inhabiting distinct geographical regions, compare their growth performance, and evaluate their physiological status based on organosomatic indices.

Materials and Methods

Materials

The fish specimens used in this study were collected from the following water bodies: Darıderesi Dam (Isparta), Yedikır Dam Lake (Amasya), Ürkmez Dam (İzmir), Tahtalı Dam (İzmir), Seyhan Dam (Adana), Şeyitler Dam (Afyon), Denizli Pond (Kocaeli), Karaağaç Pond (Uşak), Hirfanlı Dam (Kırşehir), Çamlıdere Dam (Ankara), Altınapa Dam (Konya), and Ladik Lake (Samsun). The fish were captured using gillnets with a mesh size of 4 mm. A total of 300 specimens were analyzed, with 25 fish collected from each sampling location. All specimens were obtained utilizing gillnet fishing.

Methods

Determination of morphological characteristics

The morphological characteristics of the perch were measured according to the method described by Pravdin et al. (1966) (**Fig. 1**).

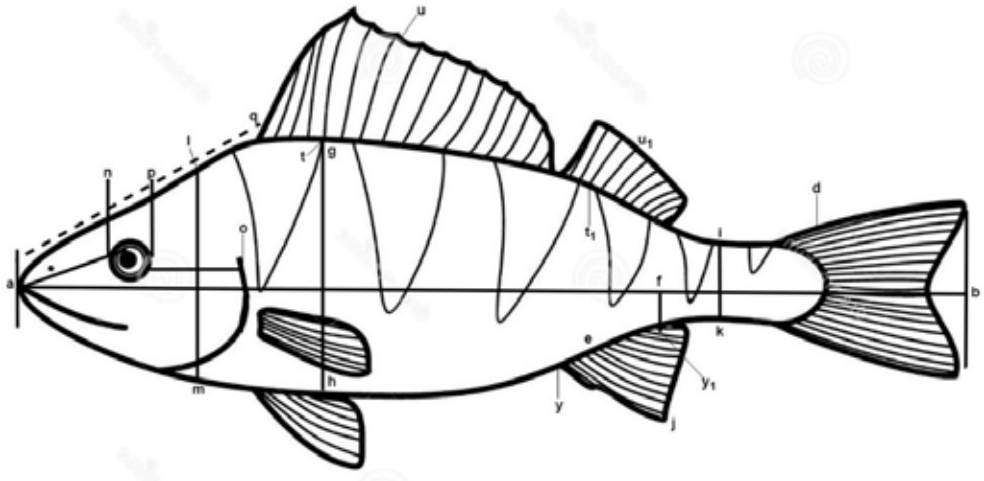

Fig. 1. Measurement diagram of the perch: **ab**–total body length, **an**–snout length, **np**–horizontal eye diameter, **po**–postorbital head length, **ao**–head length, **lm**–head height, **gh**–maximum body height, **ik**–minimum body height, **aq**–distance to the first dorsal fin, **fd**–caudal peduncle length, **tu**–first dorsal fin height, $\mathbf{t_1u_1}$–second dorsal fin height, $\mathbf{yy_1}$–anal fin base length, **ej**–anal fin height

Growth performance and organosomatic parameters

The perch specimens used in this study were captured during their natural spawning season, from December to February. It was determined that approximately 95% of the captured individuals were females, and all biometric and biochemical parameters analyzed in the study were evaluated based on the females. This approach minimized the gender-related variations, especially when assessing reproductive-related biometric data.

Hepatosomatic Index (HSI): The hepatosomatic index (HSI) value was calculated as the percentage of the fish's liver weight (g) to its body weight (g), using the following formula (Hoşsu et al., 2001):

HSI=(Liver weight (g)/Total body weight (g))×100

Renosomatic Index (RSI): The renosomatic index (RSI) value was calculated as the percentage ratio of the fish's kidney weight (g) to its body weight (g), using the following formula (Silva & Anderson, 1995; Hoşsu et al., 2001):

RSI=(Kidney weight (g)/Total body weight (g))×100

Viscerosomatic Index (VSI): The viscerosomatic index (VSI) value was calculated as the percentage ratio of the fish's internal organ weight (g) to its body weight (g), using the following formula (Hoşsu et al., 2001):

VSI=(Internal organ weight (g)/Total body weight (g))×100

Carcass Yield: Carcass yield was calculated as the weight of the fish after removing its internal organs divided by its total body weight, expressed as a percentage:

Carcass Yield=(Weight of fish after removing internal organs/Total body weight)×100

Gonadosomatic Index (GSI): The gonadosomatic index (GSI) value was calculated as the percentage ratio of the gonad weight (g) to the total body weight (g), using the following formula:

GSI=(Gonad weight (g)/Total body weight (g))×100

Statistical analyses

A total of 300 fish were used to determine the morphological and growth parameters, with five repetitions and five fish per repetition. The obtained data were subjected to analysis of variance using the Minitab software. Significant differences among the means were determined using Tukey's multiple comparison test ($p \leq 0.05$) and are presented with different letters.

Results and discussion

Morphological characteristics

The morphological characteristics of perch specimens collected from various dams and lakes located in different geographical regions of Türkiye are presented in **Tab. 1**. Statistical evaluations revealed that all morphometric characters differed significantly among the studied populations ($p<0.05$). These findings highlight the influence of environmental conditions and habitat differences on the morphological variations of the species.

Regarding total length (ab), the highest mean value was recorded in specimens collected from Tahtalı Dam (İzmir) with 263.92 mm, while the lowest mean total length was observed in specimens from Darıderesi Dam (Isparta) with 113.32 mm. For head morphology measurements, including head length (ao), postorbital length (po), and anterior snout length (an), the specimens collected from İzmir and Konya exhibited the highest values, whereas those from Isparta and Uşak had notably lower measurements.

In terms of maximum body depth (gh), a significant similarity was observed among the specimens from İzmir Tahtalı Dam (83.96 mm), Konya Altınapa Dam (81.52 mm), and Afyon Şeyitler Dam (80.64 mm). The lowest value was found in the specimens from Isparta Darıderesi Dam (35.44 mm).

Measurements related to fin morphology - such as first dorsal fin height (tu), second dorsal fin height (t_1u_1), anal fin base length (yy_1), and anal fin height (ej) - also showed distinct variations among different localities. Specimens from İzmir and Konya had longer dorsal and anal fins, while those from Isparta and Uşak displayed the lowest values.

For horizontal eye diameter (np), the maximum value of 11.00 mm was recorded in specimens from Afyon, İzmir, and Konya. In contrast, the lowest measurement of 4.76 mm was observed in the specimens from Isparta.

Growth performance and organosomatic parameters

The growth parameters of the perch specimens collected from various dams and lakes across different geographical regions of Türkiye are presented in **Tab. 2**. Significant differences were observed among individuals in terms of live body weight. The highest mean body weight was recorded in the Konya population (264.20 g), followed by Afyon (220.20 g), İzmir-Tahtalı (212.10 g), and Samsun (197.20 g) populations. The lowest mean body weights were

Table 1. Morphological characteristics of perch collected from different locations

Dams and Lakes	ab	an	np	po	ao	lm	gh
ADANA (Seyhan Dam)	147.12±6.55^{e}	9.96±1.02^{f}	6.00±0.00^{e}	18.68±0.69^{e}	30.40±2.76^{e}	32.84±0.37^{g}	46.60±3.75^{e}
AFYON (Şeyitler Dam)	254.44±11.03^{a}	17.36±0.70^{b}	11.00±0.00^{a}	31.96±1.02^{a}	52.20±3.90^{a}	54.84±0.37^{b}	80.64±6.36^{a}
AMASYA (Yedikır Dam Lake)	215.40±9.70^{c}	14.48±0.51^{d}	9.00±0.00^{c}	26.96±1.02^{c}	44.48±3.29^{bc}	46.84±0.37^{d}	68.48±5.38^{b}c
ANKARA (Çamlıdere Dam)	140.04±6.41^{ef}	9.48±0.51^{fg}	6.00±00^{e}	17.68±0.69^{ef}	29.00±2.32^{e}	30.84±0.37^{h}	44.48±3.52^{e}
ISPARTA (Darıderesi Dam)	113.32±5.98^{g}	7.40±0.50^{h}	4.76±0.52^{f}	13.76±1.30^{g}	22.88±2.60^{f}	24.04±1.64^{j}	35.44±4.06^{f}
İZMİR (Tahtalı Dam)	263.92±11.75^{a}	18.36±0.70^{a}	11.00±0.00^{a}	32.96±1.02^{a}	54.24±4.00^{a}	56.84±0.37^{a}	83.96±6.75^{a}
İZMİR (Ürkmez Dam)	228.52±10.21^{b}	15.44±0.82^{c}	10.00±0.00^{b}	28.80±1.08^{b}	46.96±3.48^{b}	49.36±0.75^{c}	72.80±5.94^{b}
KIRŞEHİR (Hirfanlı Dam)	146±15.16^{e}	9.52±1.08^{fg}	6.00±0.57^{e}	17.92±1.90^{ef}	29.32±3.81^{e}	30.88±3.16^{h}	45.72±6.37^{e}
KOCAELİ (Denizli Pond)	168.16±17.34^{d}	11.12±1.09^{e}	6.84±0.68^{d}	20.72±2.28^{d}	34.00±4.31^{d}	35.80±3.61^{f}	52.56±7.45^{d}
KONYA (Altınapa Dam)	260.68±13.93^{a}	17.32±0.90^{b}	10.72±0.67^{a}	32.04±2.82^{a}	52.60±6.04^{a}	55.40±4.01^{ab}	81.52±9.18^{a}
SAMSUN (Ladik Pond)	207.76±9.3^{c}	14.36±0.70^{d}	9.00±0.00^{c}	25.92±0.90^{c}	42.68±3.11^{c}	44.84±0.37^{e}	66.20±5.29^{c}
UŞAK (Karaağaç Pond)	135.16±13.97^{f}	9.08±0.90^{g}	5.84±0.68^{e}	16.56±1.80^{f}	27.32±3.55^{e}	28.80±2.88^{i}	42.08±5.82^{e}

Continuation of the Table 1

Dams and Lakes	ik	aq	fd	tu	t_1u_1	yy_1	ej
ADANA (Seyhan Dam)	15.44±0.82^{e}	32.24±2.04^{e}	18.16±0.98^{e}	26.36±2.48^{de}	14.44±1.41^{cd}	21.76±1.20^{e}	13.52±1.29^{de}
AFYON (Şeyitler Dam)	26.32±1.06^{a}	54.72±2.92^{a}	30.92±1.68^{a}	45.60±4.10^{a}	24.48±2.38^{a}	37.68±2.21^{a}	22.76±2.58^{a}

observed in the Ankara (109.20 g), Adana (121.50 g), and Uşak (119.39 g) populations.

Regarding liver weight, the highest values were found in Konya specimens (3.36 g), followed by Afyon specimens (2.83 g) and İzmir-Tahtalı specimens (2.61 g). The lowest liver weights were recorded in the populations of Ankara (1.47 g), Adana (1.63 g), and Isparta (1.50 g). These

AMASYA (Yedikır Dam Lake)	22.32±1.06^{bc}	46.68±2.44^{bc}	26.20±1.32^{bc}	38.80±3.52^{bc}	20.84±1.99^{b}	32.08±1.82^{bc}	19.36±2.19^{bc}
ANKARA (Çamlıdere Dam)	14.44±0.82^{ef}	30.48±1.66^{ef}	17.16±0.98^{ef}	25.32±2.376^{e}	13.44±1.41^{d}	20.76±1.20^{ef}	12.52±1.29^{e}
ISPARTA (Darıderesi Dam)	11.28±1.02^{g}	24.32±2.35^{g}	13.44±1.29^{g}	19.80±2.88^{f}	10.84±1.40^{e}	16.88±1.42^{g}	10.28±1.17^{f}
İZMİR (Tahtalı Dam)	27.32±1.06^{a}	56.72±2.92^{a}	31.92±1.68^{a}	47.60±4.10^{a}	25.48±2.38^{a}	39.32±2.61^{a}	23.76±2.58^{a}
İZMİR (Ürkmez Dam)	23.44±0.82^{b}	49.24±2.77^{b}	27.72±1.62^{b}	41.16±3.61^{b}	22.04±1.85^{b}	33.92±2.08^{b}	20.64±2.03^{b}
KIRŞEHİR (Hirfanlı Dam)	14.48±1.91^{ef}	31.32±3.95e^{f}	17.56±1.75^{ef}	25.60±3.90^{e}	13.96±2.40^{d}	21.60±2.19^{ef}	13.24±1.60^{e}
KOCAELİ (Denizli Pond)	17.24±2.20^{d}	36.00±4.48^{d}	20.12±2.18^{d}	29.40±4.44^{d}	16.20±2.73^{c}	24.96±2.45^{d}	15.36±2.03^{d}
KONYA (Altınapa Dam)	26.32±2.28^{a}	55.76±5.33^{a}	31.24±2.77^{a}	45.6±6.56^{a}	25.00±3.24^{a}	38.60±3.16^{a}	23.64±2.70^{a}
SAMSUN (Ladik Pond)	21.44±0.82^{c}	44.72±2.39^{c}	25.16±1.21^{c}	37.44±3.15^{c}	20.04±1.85^{b}	30.92±2.08^{c}	18.64±2.03^{c}
UŞAK (Karaağaç Pond)	13.44±1.75^{f}	29±3.61^{f}	16.08±1.70^{f}	23.60±3.70^{e}	12.96±2.20^{d}	19.80±1.97^{f}	12.28±1.51^{e}

*differences between means indicated by separate letters are significant ($p \leq 0.05$)
ab–total body length, **an**–snout length, **np**–horizontal eye diameter, **po**–postorbital head length, **ao**–head length, **lm**–head height, **gh**–maximum body height, **ik**–minimum body height, **aq**–distance to the first dorsal fin, **fd**–caudal peduncle length, **tu**–first dorsal fin height, t_1u_1–second dorsal fin height, yy_1–anal fin base length, **ej**–anal fin height

differences reflect variations in energy reserves and metabolic conditions among the populations.

The gonad weight, an important indicator of reproductive capacity, was highest in Konya (30.78 g), İzmir-Tahtalı (26.45 g), and Afyon (26.41 g) specimens. The lowest values were recorded in the populations of Adana (3.51 g), Ankara (3.66 g), and Kırşehir (3.76 g). These findings suggest that reproductive timing and maturation stages may vary among populations.

For kidney weight, the highest averages were noted in Konya (1.07 g), followed by Afyon (0.96 g) and İzmir-Tahtalı (0.87 g), while the lowest value was observed in the Kırşehir population (0.42 g).

The highest visceral weight was recorded in the Konya population (35.70 g), followed by the Afyon population (30.43 g) and the İzmir-Tahtalı population (29.45 g). The lowest visceral weight was found in specimens from Ankara (17.10 g).

In terms of carcass weight, the highest value was observed in Konya (228.50 g), with Afyon (189.80 g) and İzmir-Tahtalı (182.60 g) populations also showing relatively high carcass weights. The lowest carcass weights were recorded in Ankara (92.09 g) and Adana (102.90 g) specimens.

The Hepatosomatic Index (HSI) showed limited variation among populations. The highest HSI values were found in Amasya (1.47%), followed by Adana and Ankara (both 1.35%), while the lowest values were recorded in the İzmir-Tahtalı and Ürkmez populations (1.26%).

The Renosomatic Index (RSI) showed relatively low intraspecific variation. The highest RSI was

Table 2. Growth performance and organosomatic parameters of perchs collected from different locations

Dams and Lakes	WEIGHT (g)	LIVER (g)	GONAD WEIGHT (g)	KIDNEY WEIGHT (g)	WEIGHT OF INTERNAL ORGANS (g)	CARCASE WEIGHT (g)	HSİ (%)
ADANA (Seyhan Dam)	121.50±40.20^{de}	1.63±0.49^{cde}	3.51±0.77^{c}	0.50±0.055^{de}	18.58±4.82^{de}	102.90±35.40^{de}	1.35±0.03
AFYON (Şeyitler Dam)	220.20±23.40^{ab}	2.83±0.28^{ab}	26.41±2.76^{ab}	0.96±0.02^{ab}	30.43±2.81^{ab}	189.80±20.60^{ab}	1.28±0.00
AMASYA (Yedikır Dam Lake)	166.70±26.90^{bcde}	2.42±0.20^{abcde}	20.10±3.13^{b}	0.72±0.09^{bcd}	24.01±3.22^{bcde}	142.70±23.60^{bcde}	1.47±0.21
ANKARA (Çamlıdere Dam)	109.20±12.94^{e}	1.47±0.15^{e}	3.66±0.60^{c}	0.47±0.05^{de}	17.10±1.55^{e}	92.09±11.39^{e}	1.35±0.01
ISPARTA (Darıderesi Dam)	117.76±5.40^{de}	1.50±0.22^{de}	5.84±0.96^{c}	0.61±0.18^{cde}	18.13±0.64^{de}	99.63±4.75^{de}	1.27±0.13
İZMİR (Tahtalı Dam)	212.10±42.50^{ab}	2.61±0.13^{abc}	26.45±4.48^{ab}	0.87±0.04^{abc}	29.45±5.10^{ab}	182.60±37.40^{ab}	1.26±0.2
İZMİR (Ürkmez Dam)	176.87±16.43^{bcd}	2.278±0.79^{bcde}	18.84±5.36^{b}	0.72±0.07^{bcd}	25.22±1.97^{bcd}	151.64±14.46^{bcd}	1.26±0.36
KIRŞEHİR (Hirfanlı Dam)	135.51±7.47^{cde}	1.8±0.09^{bcde}	3.76±0.548^{c}	0.42±0.05^{e}	20.26±0.89^{cde}	115.25±6.57^{cde}	1.32±0.00
KOCAELİ (Denizli Lake)	180.69±9.95^{bcd}	2.35±0.12^{abcde}	21.75±1.17^{b}	0.70±0.18^{bcde}	25.68±1.19^{bcd}	155±8.76^{bcd}	1.30±0.00
KONYA (Altınapa Dam)	264.20±24.30^{a}	3.36±0.29^{a}	30.78±30^{a}	1.07±0.12^{a}	35.70±2.92^{a}	228.50±21.40^{a}	1.27±0.00
SAMSUN (Ladik Lake)	197.20±17.60^{abc}	2.548±0.21^{abcd}	22.38±2.26^{b}	0.76±0.04^{bcd}	27.66±2.12^{abc}	169.51±15.51^{abc}	1.29±0.00
UŞAK (Karaağaç Lake)	119.39±11.0^{de}	1.58±0.53^{cde}	4.40±0.34^{c}	0.51±0.11^{de}	18.32±1.33^{de}	101.06±9.76^{de}	1.31±0.35

Continuation of the Table 2

Dams and Lakes	RSİ (%)	VSİ (%)	CARCASS YIELD (%)	GSI (%)
ADANA (Seyhan Dam)	0.43±0.12	15.51 ± 1.00^{ab}	84.48 ± 1.00^{ef}	3.02 ± 0.88^{b}
AFYON (Şeyitler Dam)	0.44±0.03	13.83 ± 0.20^{ef}	86.16 ± 0.20^{ab}	11.99 ± 0.02^{a}
AMASYA (Yedikır Dam Lake)	0.44±0.12	14.44 ± 0.42^{bcdef}	85.55 ± 0.42^{abcde}	12.09 ± 1.01^{a}
ANKARA (Çamlıdere Dam)	0.43±0.05	15.69 ± 0.41^{a}	84.30 ± 0.41^{f}	3.36 ± 0.55^{b}
ISPARTA (Darıderesi Dam)	0.52±0.17	15.40 ± 0.16^{abc}	84.59 ± 0.16^{def}	4.98 ± 0.98^{b}
İZMİR (Tahtalı Dam)	0.42±0.10	13.94 ± 0.44^{ef}	86.05 ± 0.44^{ab}	12.57 ± 1.18^{a}
İZMİR (Ürkmez Dam)	0.40±0.02	14.27 ± 0.22^{cdef}	85.72 ± 0.22^{abcd}	10.52 ± 2.160^{a}
KIRŞEHİR (Hirfanlı Dam)	0.31±0.03	14.9579 ± 0.16^{abcde}	85.04 ± 0.16^{bcdef}	2.77 ± 0.32^{b}
KOCAELİ (Denizli Lake)	0.39±0.11	14.21 ± 0.12^{def}	85.78 ± 0.12^{abc}	12.04 ± 0.01^{a}
KONYA (Altınapa Dam)	0.40±0.03	13.52 ± 0.138^{f}	86.47 ± 0.13^{a}	11.77 ± 2.10^{a}
SAMSUN (Ladik Lake)	0.38±0.02	14.04 ± 0.19^{ef}	85.96 ± 0.19^{ab}	11.38 ± 1.19^{a}
UŞAK (Karaağaç Lake)	0.42±0.05	15.37 ± 0.32^{abcd}	84.62 ± 0.32^{cdef}	3.69 ± 0.22^{b}

*differences between means indicated by separate letters are significant ($p \leq 0.05$). Hepatosomatic Index (**HSI**), Renosomatic Index (**RSI**), Viscerosomatic Index (**VSI**), Gonadosomatic Index (**GSI**)

observed in Isparta (0.52%), and the lowest in Kırşehir (0.31%).

The highest Viscerosomatic Index (VSI) was recorded in the Ankara population (15.69%), followed by Adana (15.51%) and Isparta (15.40%), while the lowest VSI was observed in Konya (13.52%).

Regarding carcass yield, the highest values were recorded in the Konya population (86.47%), followed by the Afyon (86.16%) and İzmir-Tahtalı (86.05%) populations. The lowest carcass yield was observed in Adana (84.48%) specimens.

For the Gonadosomatic Index (GSI), the highest values were observed in İzmir-Tahtalı (12.57%), Amasya (12.09%), Afyon (11.99%), and Konya (11.77%) populations, while the lowest values were recorded in Kırşehir (2.77%), Adana (3.02%), and Ankara (3.36%) populations.

In this study, the morphological, genetic, and physiological characteristics of freshwater perch (*Perca fluviatilis*) populations collected from lakes and reservoirs located in various geographical regions of Türkiye were compared. The morphometric features of freshwater perch are closely related to the environmental conditions of their habitats. Poulet et al. (2004) investigated the morphometric and genetic variations among zander (*Sander lucioperca*) populations inhabiting different sub-basins of the Rhône Delta. They reported significant morphometric differences between populations collected from distinct deltaic regions, particularly in traits such as body depth, head length, and caudal peduncle measurements. The authors suggested that such morphological variations, shaped by environmental adaptations, may lead to adaptive divergence among populations in conjunction with genetic differentiation.

In the present study, our findings confirm that the morphometric characteristics of freshwater perch individuals are directly influenced by the environmental conditions of their habitats, consistent with previous literature. Specifically, individuals

collected from Konya, Afyon, and İzmir-Tahtalı exhibited superior growth indicators, including body weight, liver and gonad weights, and carcass yield, whereas those from Adana, Ankara, and Kırşehir displayed lower values. These differences offer significant insights into how environmental factors, including food availability, water quality, temperature, and pollution, impact growth performance.

Couture and Rajotte (2003) examined parameters like length-weight relationships, liver and gonadosomatic indices (LSI and GSI), and condition factors (K) in *Perca flavescens* collected from three lakes in the Sudbury region with varying levels of metal contamination. They observed that individuals from highly polluted lakes exhibited notably lower condition factors, higher liver somatic indices, lower gonadosomatic indices, and deviations in length-weight relationships. The authors reported growth retardation in some individuals from polluted environments, which they attributed to environmental stress.

Mairesse et al. (2005) noted that cultured fish tend to have shorter and deeper bodies compared to wild individuals, which display longer and slimmer body shapes. Overton et al. (2008) emphasized the direct influence of environmental factors on fish growth. In this context, the statistically significant differences observed in head morphology parameters such as head length, postorbital length, and anterior snout length among individuals from different locations in our study further highlight the role of habitat heterogeneity in shaping growth performance.

Our findings are also supported by Kocovsky et al. (2013), who examined morphometric traits such as standard length, total length, head length, body depth, and caudal peduncle thickness in *P. flavescens* populations from the Great Lakes region of North America and found that these characteristics varied significantly according to geographic origin. They suggested that these differences could be linked to adaptations to environmental factors such as food sources, water flow, and predation pressure. These observations align with the variations detected among freshwater perch populations from different regions of Türkiye in our study.

Rowinski et al. (2015) investigated the potential effects of climate change on fish morphology by examining the impact of elevated water temperatures on the body shape of freshwater perch. They compared populations from long-term thermal discharge areas (nuclear power plant effluents) with those from natural thermal conditions in Sweden. Their findings indicated that individuals from warmer environments had shorter bodies, larger heads, and shorter caudal peduncles compared to those from natural habitats. These results offer important evidence on how temperature regimes and thus metabolic activity can influence morphological traits, especially in ecologically diverse countries like Türkiye, supporting the differences observed in our study.

Baranov (2021) explored the effects of different habitats (river vs. lake) on the morphology of freshwater perch in the Loz'va River and surrounding mountainous and semi-mountainous regions in Russia. He reported distinct morphometric profiles among individuals from flowing river environments characterized by slimmer and longer bodies compared to those from stagnant lake environments, which exhibited shorter body shapes.

Terentjev and Berezina (2022) conducted a comparative study on the ecological characteristics, morphological structure, and feeding habits of freshwater perch in dystrophic and oligotrophic lakes in Northern Karelia during the autumn and winter periods. They found that individuals from dystrophic lakes exhibited smaller body sizes and slower growth rates, whereas those from oligotrophic lakes had larger body morphologies and higher condition factors.

Faulks et al. (2015) examined the genetic and morphological differentiation of freshwater perch and *Rutilus rutilus* populations inhabiting littoral (shoreline) and pelagic (open-water) habitats. They observed that pelagic individuals had longer, narrower bodies and larger eyes, features advantageous for swimming speed and prey detection in open water. In contrast, littoral individuals exhibited deeper body shapes and shorter head-to-body ratios. The authors emphasized that these morphological differences could result from ecological factors, phenotypic plasticity, and possible adaptive evolutionary processes.

In the present study, disparities in parameters such as total length, head length, and body proportions among individuals further substantiate the impact of environmental factors, including water temperature, trophic structure, and oxygen levels, on morphological traits. These findings corroborate previously reported evidence of habitat-driven morphological plasticity. The highest morphometric values were generally recorded in individuals from reservoirs in Western and Central Anatolia, particularly İzmir-Tahtalı, Konya-Altınapa, and Afyon-Şeyitler. These results clearly indicate that regional environmental factors and habitat characteristics significantly influence the morphological traits of freshwater perch.

Evaluation of growth parameters revealed distinct biometric and physiological differences among populations. Konya (Altınapa), Afyon (Şeyitler), and İzmir-Tahtalı populations stood out

with higher live and carcass weights, well-developed gonads, and high carcass yields, suggesting superior growth performance and reproductive potential. In contrast, individuals from Adana (Seyhan) and Ankara (Çamlıdere) exhibited lower growth and reproductive parameters, further highlighting the influence of environmental conditions on physiological development.

Overall, the findings demonstrate significant differences in biological productivity among freshwater perch populations from different regions, emphasizing the need to consider these variations in management and conservation strategies.

Conclusion

In this study, detailed analyses were conducted on the morphological measurements, growth parameters, and condition factors of *Perca fluviatilis* specimens collected from twelve different lakes and reservoirs located in various geographical regions of Türkiye. The evaluation revealed distinct morphometric differences among populations, indicating that these variations are shaped by the environmental conditions of their respective habitats. Specifically, factors such as water temperature, food availability and quality, habitat structure, trophic interactions, and competition intensity were found to exert dominant and directional effects on morphology and growth performance.

Specimens obtained from the Altınapa Dam (Konya), Şeyitler Dam (Afyon), and Tahtalı Dam (İzmir) displayed superior performance in both morphometric traits and growth parameters, exhibiting higher body weight, liver and gonad weights, and increased live and carcass yield. Conversely, individuals from locations such as the Seyhan Dam (Adana), Çamlıdere Dam (Ankara), and Seyfe Lake (Kırşehir) demonstrated lower morphometric values and growth performance. These findings suggest that environmental stressors such as temperature fluctuations, poor water quality, pollutants, or limited food resources may adversely affect the physiological development and biological productivity of populations.

Furthermore, head morphology traits (head length, postorbital length, and anterior snout length) and body ratios varied significantly in relation to habitat heterogeneity, with differences likely driven by factors such as trophic level, water temperature, and oxygen regimes.

Overall, the results demonstrated that freshwater perch populations in Türkiye exhibit a high degree of morphological and physiological plasticity in response to environmental conditions. This plasticity represents a critical factor for understanding natural population dynamics and should be carefully considered in the development of management and conservation strategies. In conclusion, this study revealed significant differences in growth performance, morphological structure, and condition factors among freshwater perch populations from different habitats, highlighting the complex and multifaceted influence of environmental factors on these traits.

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