Serum Ionic Content of Endemic *Chalcalburnus tarichi* During Spawning, Prespawning and Postspawning Terms, Living in Highly Alkaline Waters of Lake Van (pH 9.8), Turkey

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Abstract

In this study, serum inorganic ion values of the endemic cyprinid *Chalcalburnus tarichi*, the only fish species living in highly alkaline Lake Van and migrating to freshwater rivers for spawning, were determined during spawning, prespawning, and postspawning terms.

A decrease in serum Na^+, K^+, Cl^-, Ca, Mg^{++}, P_i concentrations were observed in *C. tarichi* migrating to freshwater rivers for spawning. Serum ion composition of *C. tarichi* living in Lake Van resembles that of many marine teleost species except high serum Na^+ value, but it seems likely that osmoregulatic pathways are different. Similarities in the decrease of serum inorganic ion concentrations in spawning migration in *C. tarichi* with anadromous fish were detected, and *C. tarichi* has high osmoreguletory capacity compering to other fishes.

Key Words: *Chalcalburnus tarichi,* spawning migration, serum ionic content

Introduction

The osmoregularity ability of the endemic cyprinid *Chalcalburnus tarichi* enables this fish to live in Lake Van, which has conditions of extreme alkalinity (pH 9.8). Lake Van is the largest soda lake and fourth largest closed lake on earth. It is situated at 1648 m above sea level in eastern Anatolia, Turkey, and has many springs and freshwater rivers inlet to Lake Van. In the summer, the surface water temperature changes between 15-22 °C (Sari *et al.*, 2000). Some physicochemical parameters of Lake Van are given in Table 1.

C. tarichi is an endemic species and is the only fish living in Lake Van. It is a member of the cyprinidae family. It actually lives in lake Van, but during April-June, the reproduction period of the fish, they move to rivers and after laying eggs they return to the lake. Earlier works about this fish are on systematic (Pallas, 1813; Berg, 1964; Deyrolle, 1872; Günther, 1868; Ladiges, 1960; Kuru, 1980), fisheries (Akgül, 1980; Sari, 1997; Sari, 2000), fisheries biology (Akyurt *et al.,* 1985; Cetinkaya *et al.,* 1995; Sari and Arabaci, 1997), life history, nitrogenous waste excretion, accumulation of urea and ammonia (Danulat and Selcuk 1992; Danulat and Kempe 1992).

The aim of this study is to obtain values for serum ionic composition of *C. tarichi* under natural conditions in Lake Van during prespawning and postspawning terms, and in river freshwater (river Karasu) during spawning migration (Table 1).

Table 1. Physicochemical parameters of lake Van and river Karasu (Kempe *et al.*, 1978; Tugrul *et al.*, 1984).

	Lake Van	River Karasu
pH	9.8	7.4
Conductivity	25.5-26.5 mS/cm2*	-
Salinity	%0 22.7	
Osmolarite	551 mosmol/kg*	-
Ion concentrations (meq/l)		
Na^+	336.9	1.32
K^+	13	0.103
Mg^{++}	7.8	2.01
Ca^{++}	0.23	1.01
Li^+	0.22	-
Sr^+	0.016	0.021
Total cation	358.17	4.44
Cl^-	153.7	0.37
Total alkalinity	152.5	-
SO_4^{--}	48.6	-
PO_4^{--}	0.36	0.004
Total anion	354.94	6.03

(*) Danulat and Selcuk (1992)

Materials and Methods

Fish were caught from the edge of Lake Van in prespawning (PrS) and postspawning terms ($PsS_{1,}$ PsS2), and from the freshwater river Karasu during spawning term (DrS). Sampling periods were 9, 13 June, 6 July and 1 August 1995. Water temperature, salinity, and water pH were determined by using pH meter (Hanna HI 8314) and S.C.T. meter (YSI model 33).

Large individuals at the samples were selected for work (Table 2). After anaesthesia in 2-phenoxyethanol (0.3 ml/l), a disposable plastic syringe was used to penetrate the heart and draw blood from the heart. This sampling was normally completed in 1 minute. Blood samples were transferred to ependorf tubes, and then placed on ice and transported to the laboratory where they were immediately centrifuged for analysis of serum ions. Water samples were also taken from sampling areas for determining water ion concentrations.

Na^+, K^+, Cl^- ions in serum and water were measured using Lloyt Na^+, K^+, Cl^- analyser (Ion selective electrot method). Calcium, magnesium, and serum inorganic phosphor in serum and water were measured by using commercial kits (Biotrol A 012821, A 02322U and A 02477U respectively) at Tectnicon RA-XT Otoanalyser.

Results are presented as mean values ± standard deviation. Mann-Whitney U test was used to check statistical differences between means. Five percent was used as the fiducial limit.

Results and Discussion

Water temperature, salinity, water pH at sampling periods, and some metric-meristic measurements in *C. tarichi* used in the study were given in Table 2.

Serum ionic content of *C. tarichi* for each term and water ion composition is shown in Table 3. Serum ion composition of *C. tarichi* living in Lake Van showed some interesting features when compared to other fish, and resembles anadromous fish when migrating to freshwater river for spawning.

In DrS, serum Na^+ concentration of *C. tarichi* caught from river Karasu was lower than that was caught in the Lake Van ones, but higher than the river Karasu water Na^+ concentration (Table 3). This is due to adaptation strategies as in other anadromous fish such as *Onchorynchus tschawytscha* (Love, 1980).

Serum Na^+ concentration increased in individuals returning to Lake Van after spawning. The increasing in serum Na^+ in PsS1 shows that the adaptation response to a higher saline environment lasts (Eddy, 1981; Love, 1980).

Finally, the serum Na^+ value in PsS2 decreased to 212 mmol/l, and the Serum Na^+ in PrS is lower than in PsS2. This is normal because before the *C. tarichi* migrates to freshwater it waits for the rising water temperature at the places where it has lower salinity and freshwater inlets to Lake Van (Sari and Arabaci, 1997). If we accept normal serum Na^+ value of *C. tarichi* in Lake Van as 212 mmol/l (Table 3), it is considerably higher than the values reported for many marine fish (Holmes and Donaldson, 1969). However, it is similar to the determined values for *Oreochromus alcalicus grahami*, living in Lake Magadi, which has conditions of extreme alkalinity (Eddy and Maloiy, 1984; Table 4). The Serum Na^+ value is similar to *O. a. grahami,* but *C. tarichi* is exposed to a higher Na^+ concentration gradient in Lake Van (Table 3-4). This results shows that *C. tarichi* uptakes Na^+ actively in freshwater, while effluxes Na^+ actively in Lake Van.

In Drs, decrease in serum Cl^- concentration was observed. Holmes and Donaldson (1969) attributed to Black, Lysa and Kuba reported that the plasma Cl^- concentration of *O. gorbushka*, *O. nerka,* and *O. mosau* decreased in freshwater during spawning migration. This shows that there is an active Cl^- uptake in freshwater rivers. It is highly interesting that although environmental Cl^- concentration changed in PrS and PsS, serum Cl^- is stable (Table 3). The serum Cl^- concentration of *C. tarichi* is relatively close to Lake Van water Cl^- concentration. This is an advantage for ion regulation and also in acid-base balance. Serum Cl^- concentration is similar to normal values for many teleost fishes and just similar to *O. a. grahami* quantitically (Eddy and Maloiy, 1984). In *O. a. grahami* there is a tendency to lose Cl^- to the environment (Eddy *et al*., 1981), and Lake Magadi has a low Cl^- concentration. However, Lake Van Cl^- concentration is higher (Table 3) than Lake Magadi Cl^- concentration (Eddy and Maloiy, 1984; Table 4).

Hypokalemia was seen in *C. tarichi* migrating to freshwater. Holmes and Donaldson (1969) attributed to Robertson *et al*., and Urist *et al*. reported that hypokalemia (0.7-0.8 mmol/l) was also seen in anadromous *Onchorynchus tschawytscha* migrating to freshwater for spawning. Hypokalemia may also be a result of starvation (Love, 1980). *C. tarichi* takes no food during spawning migration (Sari and Arabaci, 1997). In each term, serum K^+ value profile changing resembles in serum Na^+ changes. These results show that *C. tarichi* effluxes K^+ actively in Lake Van while uptakes actively K^+ in freshwater. Even though O. *a. grahami* has a tendency to lose K^+ to the environment (Table 3-4).

In PrS, serum calcium content was high; in DrS it decreased slightly, although calcium of freshwater increases comparing to calcium of Lake Van. This may be interesting with egg development in the ovaries because vitellogenins are necessary for the development of eggs, which are transported to the ovaries in the form of calcium complex, phosphoprotein, phospholipid, and glikolipoprotein. Thus, at the last stages of egg development (vitellogenesis) serum calcium value highly increases

Table 2. Water temperature, salinity, pH at sampling periods and some metric-meristic measurements in *C. tarichi* used in the study (n=12).

Terms	Water temperature (°C)	Water salinity (%)	Water pH	Length (cm)	Weight (g)	GSI(%)
PrS	20	0.15	9.78	18.65±0.24	61.09±2.28*	28.5±4.5*
DrS	21.9	0.05	8.28	17.98±0.18	50.09±2.28*	9.6±1.8*
PsS_1	21	0.18	9.8	17.10±0.22	36.35±0.85*	2±0.2*
PsS_2	22	0.18	9.8	17.34±0.42	44.33±3.73*	-

(*) Indicates differences statistically from other groups (p<*0.05*)
GSI- Gonadosomatik index

Table 3. Serum ionic content of *C. tarichi* for each term and water ion composition (n=12).

	Na^+ (mM/l)		K^+(mM/l)		Cl^-(mM/l)		Ca(mg/dl)		Mg^{++}(mg/dl)		P_i(mg/dl)
Terms	Serum	Water	Serum	Water	Serum	Water	Serum	Water	Serum	Water	Serum
PrS	181,2±1,03*	239,9±1,2*	5,50±0,88	7,9±0,31	146,58±4,89	145,1±0,9*	16,65 ±0,89*	0,5±0,1	4,41±0,23	6,65±0,25	16,25±0,70
DrS	156,9±11,6*	8,45±0,55*	0,74±0,45*	0,32±0,08*	124,62±7,33*	9,8±0,5*	13,24±0,84*	1,15±0,15*	3,3±0,162#	2,05±0,05*	8,28±0,45#
PsS_1	235,26±2,84*	260±1,2	7,02±0,91*	7,92±0,61	146,54±2,57	156±1,3	6,63±2,03*	0,5±0.1	3,67±0,87#	7,15±0,65	7,90±1,17#
PsS_2	212,05±3,35*	264,1±0,81	5,46±0,54	8,22±0,01	146,33 ±1,88	158±1,2	9,68±0,89*	-	4,3±0,1	-	12,48±1,81

(*) Indicates differences statistically from other groups (p<*0,05*)
(#) Indicates differences between PrS and PsS_2 is statistically important (p<*0,05*).

Table 4. Plasma and water characteristics of *C. tarichi* and *O. a. grahami*. Data collected from previous works (Wood *et al*., 1989; Danulat and Selcuk, 1992; Eddy and Maloiy, 1984; Randall *et al.,* 1989).

Water characteristics;	Lake Van	Lake Magadi
PH	9.8	10*
Temperature °C (max.)	22	40*
Total alkalinity (meq/l)	153&	184*
Osmolarite (mosmol/kg)	551&	525*
Na^+ (mmol/l)	336,9&	328#
K^+ (mmol/l)	13&	2.4#
Cl^- (mmol/l)	153.7&	103#
Plasma;	*C. tarichi*	*O. a. Grahami*
PH	7.89&	7.58#
Osmolarite (mosmol/kg)	483&	351#
Na+ (mmol/l)	(See Table 1-3)	210#
K^+ (mmol/l)	(See Table 1-3)	6.5#
Cl^-(mmol/l)	(See Table 1-3)	144.6#
Urea (mmol/l)	-	23*
Urea-NH_3 excretion rate	% 37 Urea	% 100 Urea$
	% 63 NH_3&	-
Spawning area	Freshwater rivers	Lake Magadi

(*) Wood *et al*. (1989), (&) Danulat and Selcuk (1992), (#) Eddy and Maloiy (1984), ($) Randall *et al.* (1989)

(Heath, 1987; Love, 1980). This is due to higher calcium value in PrS and partially in DrS. Matty (1985), attributed to Watts *et al*. reported that the serum calcium value of *O. nerka* increased during spawning migration.

The calcium concentration of all freshwater rivers, *C. tarichi* migrates for spawning, is higher than Lake Van. This situation seems like an advantage in the adaptation of *C. tarichi* to freshwater, because high calcium concentration in the water prevents loss of Na^+ at the low water pH. Also, because of the effecting gill permeability (Heath, 1987) it is an advantage in adaptation of marine fishes to freshwater (Lagler *et al*., 1977; Rankin and Davenport, 1981).

The serum Pi value profile changing resembles serum calcium changes and may interact with egg development as in calcium. Love (1980) attributed to Mc Cartney, reported that in *Salmo trutta*, serum total lipid phosphor increased during spawning period and decreased after spawning. Serum ionic composition of *C. tarichi* resembles that of many marine teleost species except the high serum Na^+ value. Although serum ionic content is close to *O.a. grahami*, it seems that the osmoregulation processes, acid-base balance, and nitrogenous waste excretion are different. The spawning migration of *C. tarichi* lasts for a short time and releases alternately (Sari and Arabaci, 1997). In this short time, adaptation to extreme life conditions is very interesting. Their fry (1.5-2 cm) migrates and adapts to alkaline in Lake Van (Arabaci 1995). It is necessary for further investigation urgently for clarification of these events.

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