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Research Article

Length-weight relationship and condition factor of fish species in shallow freshwater habitats from Khuzestan Province, Iran

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Abstract

This study evaluated Length-Weight Relationships (LWRs) and condition factor (K) of the juvenile and young adult fish from shallow littoral zones in some aquatic ecosystems located in Khuzestan province, Iran. In June 2015, the specimens were sampled using a seine net from the Shadegan Wetland, the Dez, and the Karkheh Rivers in the time period of increased juvenile recruitment. The LWRs of fish were calculated using linear regression log formula as log W=log*a*+*b*logTL, and the K estimated using $K=W/L_3$. A total of 18 species belong to 5 families collected in the stations. Exotic species comprised 33.33% of the total ichthyofauna. The variation of *b*-value ranges between 2.65 and 3.26, and the growth pattern is isometric in all species except *Acanthobrama marmid*. Since the amount of K was higher than one in all species, it can be concluded that the sampling stations are favorable for the growth of the fish. As a consequence of the decreased floodplain habitats in the surrounding of the water bodies, the shallow waters of littoral zones that have suitable features for the juvenile fish can play an essential role in the survival of the native fish fauna.

Keywords: Abundance, Allometry, Fish species, Growth, Khuzestan province

Introduction

The littoral zones provide various areas with varying degrees of structural complexity (Chick and Mclvor 1994), which give small fish a refuge against predators and feeding areas (Lewin *et al.* 2004). Early life stages constitute critical periods in the fish life cycle and exhibit narrow and specific habitat requirements, which are essential for the recruitment of a species (Schiemer *et al.* 1991). Therefore, biological parameters such as diversity, abundance, length-weight relationships (LWRs), and condition factor (K) play an essential role in assessing fisheries, appropriate utilization, and ecosystem management in such habitats. The prediction of weight from the length, assessment of fish stocks, determination of age structure, growth studies, morphological comparisons among species and different communities, and contrast of life history between areas are the objectives of determining LWRs (Froese 2006, Loureiro *et al.* 2017). The K also is one of the essential ecological factors for assessing and evaluating the desirability of aquatic ecosystems and is an index for the weighted mean of biota (Anene 2005).

Khuzestan province has rich fish biodiversity with valuable native species but is threatened by invasive alien species such as tilapia species. Some of the species have a high reproductive ability, so that causes a massive threat for the native species. Therefore, the aims of this study were the understanding of the presence ratio and the evaluating of LWR and K of the juveniles and young adult of the exotic and native fish species in shallow-water habitats of littoral zones in the important water bodies, including the Shadegan Wetland, and Dez and Karkheh Rivers, Iran. Since this province is faced with many environmental problems (Akhani 2015), especially in aquatic ecosystems, the results of this study can be used in species management and conservation objectives.

Material and methods

Case Study

The fish were sampled during daylight hours from the Shadegan Wetland, the Dez, and the Karkheh rivers In June 2015 (Fig. 1). The sampling stations were selected based on habitat conditions, including low depth (up to 140 cm), slow velocity (approximately zero), and different densities of aquatic vegetation that are usually considered desirable by juvenile and small fish. The sampling areas were 210, 400, and 440 m^2 at the Shadegan, Dez, and Karkheh stations, respectively, based on the conditions of the stations (Table 1). Therefore, the sampling stations were entirely selected based on selective fishing of juveniles where nursery grounds were probably. In the rivers, the sampling operations carried out in channels adjacent to the main channel.

Field Sampling

One effort was made using a seine net with 5 mm mesh size, 2 m deep, and 25 m long at each station. The sampling coincided with the period of increased juvenile recruitment, which is already well-documented (Abdoli 2016, Coad 2017). The specimens were preserved in 4% formalin solution (Abdoli 2016) and transferred to the lab. All fish were identified to species level using standard taxonomic keys (Abdoli 2000, Coad 2015). The total length and weight were measured to the nearest 0.1 mm and 0.01 g, respectively.

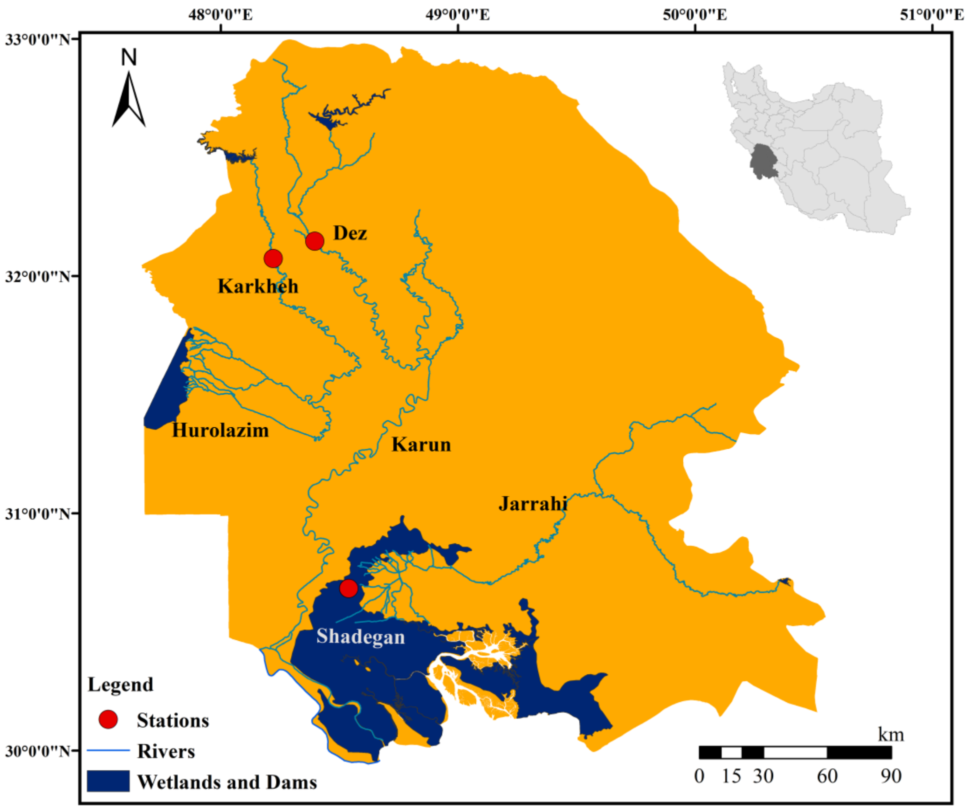

Figure 1. Location of the sampling stations in Khuzestan province, Iran.

Table 1. Habitat variables of the sampling stations.

Station	Sampling Area (m2)	Depth (cm)	Dominant vegetation	Bed	Land use
Shadegan	210	0-120	*Phragmites sp., Najas sp.*	Mud-Sludge	Rural
Dez	400	0-140	*Polygonum sp., Typha sp., Phragmites sp., Ceratophyllum sp.*	Sludge	Urban
Karkheh	440	0-100	*Ceratophyllum sp.*	Sandy	Protection

Statistical Analysis

The LWRs were established using linear regression (least-squares method) log formula as log W=log*a*+*b* logTL; W is the weight of the fish in grams, and TL is the total length in cm, *a* is the intercept of the regression curve (coefficient related to body form), and *b* is the regression coefficient, indicating isometric growth (Froese 2006, Aazami *et al.* 2015, Loureiro *et al.* 2017). The degree of correlation between the variables was computed by the determination coefficient r^2. The Student's t-test was used to determine whether the parameter *b* is significantly different from the expected or theoretical value of 3 (i.e., b = 3, $P<0.05$). The K was estimated according to Asadi *et al.* (2017) using $K=W/L^3$, where K is condition factor, W is the weight of fish (g), and L is the length of fish (cm). All statistical analyses were considered at a significant level of 5% with R statistical software. The fish biomass (wet mass, gm^{-2}) was obtained by summing the biomass of all fish species and dividing it by the sampled area at each station. The area of sampling stations was variable; therefore, the abundances were transformed to hectare before diversity analysis. Three species diversity indices, including Margalef, Shannon-Wiener, Simpson, and also evenness index, were applied by PAST version 3.25 (Hammer *et al.* 2001).

Results

A total of 3268 individuals, comprising 18 fish species including 8 in Shadegan, 8 in Dez, and 13 species from Karkheh stations belong to 5 families were collected (Table 2). Cyprinid fish were dominated with 14 species, and other families (Mugilidae, Cyprinodontidae, Poecilidae, and Cichlidae) were each comprised of one species. Exotic species were consisting of 33.33% of the total ichthyofauna. Six alien species were observed among 18 caught fish, including *G. holbrooki*, *P. parva*, *C. zillii*, *C. auratus*, *H. leucisculus*, and *C. carpio*. The dominated fish of Shadegan, Dez and Karkheh were *Aphanius dispar*, *Acanthobrama marmid*, and *Chondrostoma regium*, respectively. In terms of size, when considering the species that contributed over 90% of the total catch at each station, 87.76%, 82.26% and 98.45% of the individuals were less than 100 mm (TL) at Shadegan, Dez and Karkheh, respectively. Except for *Alburnus caeruleus* that covered both juvenile and adult specimens, all specimens were juvenile and young adult. Exotic species of *Cyprinus carpio* and native *Garra ruffa* were not included in both the LWR and K analysis, due to the lack of at least three individuals for each species. The linear regressions were significant for all species ($P<0.001$) except *Luciobarbus barbulus* ($P=0.028$), with ten species that their r^2 values are greater than or equal to 0.95. In the other six species, r^2 values were between 0.79 and 0.94. The estimates of the parameter *b* ranged from 2.65 to 3.266 (Table 3).

The fish biomass (wet mass) had different values at the stations so that its value was higher at Shadegan (11.7 gm^{-2}) than Karkheh (5.84 gm^{-2}) and Dez (4.23 gm^{-2}), respectively (Fig. 2). The biomass value was dominated by *P. abu* comprising 43.22% at Shadegan and *C. trutta* comprising 42.89% and 41.1% at

Karkheh and Dez, respectively. The results of species diversity indices showed that Karkheh had the highest value, followed by Dez and Shadegan, respectively. In contrast, the highest amount of evenness index was recorded at Dez station (Table 4).

Table 2. The list of fish species caught at Shadegan (Sh), Dez (D), and Karkheh (K) stations. *Exotic fish ** Based on Abdoli (2016) and Coad (2017).

Family	Species		N (N %)	TL (mm)	TW (g)	Max. TL** (mm)
Cyprinidae	*Alburnus caeruleus* (Heckel, 1843)	Sh	55(3.66)	61.87(32-85) ± 19.72	2(0.19-3.86) ± 1.42	86***
	Acanthobrama marmid (Heckel, 1843)	D	175(44.87)	46.04(27-87) ± 12.30	0.94(0.17-5.29) ± 1.06	208
		K	167(12.15)	39.6(31-67) ± 6.66	0.62(0.27-3.08) ± 0.4	
	Alburnus mossulensis (Heckel, 1843)	Sh	62(4.12)	109.59(63-138) ± 19.12	8.24(1.55-14.38) ± 3.56	220
	Arabibarbus grypus (Heckel 1843)	K	4(0.29)	98.75(76-131) ± 23.13	8.82(3.43-18.69) ± 6.75	1200
	Capoeta trutta (Heckel 1843)	D	33(8.46)	125.18(85-179) ± 27.1	21.1(6.01-53.15) ± 14.58	527
		K	334(24.3)	58.63(34-117) ± 24.88	3.3(0.38-18.8) ± 4.42	
	Carasobarbus luteus (Heckel 1843)	Sh	3(0.2)	72(51-90) ± 19.67	4.45(1.66-6.31) ± 2.46	380
		D	104(26.67)	60.64(42-100) ±15.29	2.95(0.66-11.08) ± 2.8	
		K	221(16.08)	42.13(33-119) ± 8.94	1.12(0.41-21.45) ± 1.81	
	*Carassius auratus** (Linnaeus, 1758)	D	3(0.77)	106.33(84-150) ± 37.82	22.1(9.3-47) ± 21.56	350
		K	3(0.22)	119(111-132) ± 11.36	26.49(21.2-36.3) ± 8.5	
	Chondrostoma regium (Heckel, 1843)	D	14(3.59)	91(70-135) ± 21.19	5.9(2.45-15.93) ± 4.35	440
		K	392(28.53)	54.58(34-90) ± 19.26	1.58(0.38-5.01) ± 1.49	
	Cyprinion macrostomum (Heckel 1843)	D	15(3.85)	81.47(50-165) ± 27.34	7.73(1.4-45.08) ± 10.85	193***
		K	166(12.08)	47.62(40-64) ± 7.19	1.25(0.63-3.28) ± 0.69	
	*Cyprinus carpio** (Linnaeus, 1758)	K	1(0.07)	115	17.03	1280
	Garra rufa (Heckel 1843)	K	2(0.14)	47.5(45-50) ± 3.54	1.13(0.89-1.37) ± 0.34	185
	*Hemiculter leucisculus** (Basilewski, 1855)	Sh	1(0.07)	140	20.64	250
		K	5(0.36)	115(95-125) ± 11.55	10.79(5.68-12.4) ± 2.87	
	Luciobarbus barbulus (Heckel, 1847)	D	1(0.26)	253	201.83	940
		K	2(0.14)	77.5(41-114) ± 51.62	6.7(0.62-12.78) ± 8.6	
	*Pseudorasbora parva** (Temminck & Schlegel, 1846)	D	45(11.54)	48.83(29-72) ± 15.41	1.33(0.28-3.23) ± 1.07	120
Mugilidae	*Planiliza abu* (Heckel, 1843)	Sh	306(20.34)	60.47(31-125) ± 23.25	3.47(0.42-22.96) ± 4.02	260
		K	2(0.14)	132(130-134) ± 2.83	24.66(18.64-30.69) ±8.52	
Cyprinodontidae	*Aphanius dispar* (Rüppell, 1829)	Sh	10^3(66.5)	34.23(17-43) ± 4.7	0.69(0.09-1.34) ± 0.29	80
Poecilidae	*Gambusia holbrooki** (Girard, 1859)	Sh	42(2.79)	32.75(23-47) ± 8.27	0.53(0.15-1.35) ± 0.44	60
		K	75(5.46)	35.8(29-40) ± 3.71	0.52(0.17-0.79) ± 0.21	
Cichlidae	*Coptodon zillii** (Gervais, 1848)	Sh	35(2.33)	36.47(23-50) ± 7.74	0.8(0.15-1.98) ± 0.52	190

***Standard Length (SL), N: Number of fish, N%: Relative abundance at each station, Total length (TL), and total weight (TW) are based on Mean (Range) ± SD.

Table 3. The LWRs for 16 fish species from Shadegan, Dez and Karkheh stations (TL: total length range, TW: total weight range, SL: Standard Length, SF: Duan's Smearing Factor; P: p-value or Significant difference, K: Condition Factor, SE: Standard Errors of Mean, G: Growth; A^-: Negative Allometric Growth; A^+: Positive Allometric Growth; I: Isometric).

Family	Species	N	TL (mm)	Max. TL** (mm)	TW (g)	*a*	Ln *a* ± SE	b ± SE	r^2	SF	P	G	K ± SE
Cyprinidae	*Acanthobrama marmid* (Heckel 1843)	342	27-87	208	0.17-5.29	6.51	1.87 ± 0.09	2.65 ± 0.09	0.79	1.0317	0.000	A^-	1.54 ± 0.05
	Alburnus caeruleus (Heckel 1843)	55	32-85	86 SL	0.19-3.86	2.25	1.83 ± 0.10	2.84 ± 0.15	0.95	1.0216	0.257	I	2.81 ± 0.40
	Alburnus mossulensis (Heckel 1843)	62	63-138	220	1.55-14.38	5.73	1.57 ± 0.06	3.01 ± 0.12	0.97	1.0056	0.911	I	7.15 ± 0.51
	Arabibarbus grypus (Heckel 1843)	4	76-131	1200	3.43-18.69	8.01	2.08 ± 0.01	3.11 ± 0.02	0.99	1.0001	0.763	I	8.19 ± 2.11
	Capoeta trutta (Heckel 1843)	367	34-179	527	0.38-53.15	9.81	2.28 ± 0.02	3.05 ± 0.04	0.98	1.0143	0.639	I	5.49 ± 0.63
	Carasobarbus luteus (Heckel 1843)	328	33-119	380	0.41-21.45	11.06	2.45 ± 0.04	2.93 ± 0.04	0.97	1.0073	0.728	I	2.50 ± 0.11
	*Carassius auratus** (Linnaeus 1758)	6	84-150	350	9.3-47	15.58	2.74 ± 0.02	2.82 ± 0.11	0.99	1.0010	0.739	I	2.01 ± 0.34
	Chondrostoma regium (Heckel 1843)	406	34-135	440	0.38-15.93	6.19	1.82 ± 0.05	2.65 ± 0.07	0.94	1.0267	0.349	I	3.05 ± 0.25
	Cyprinion macrostomum (Heckel 1843)	181	40-165	193 SL	0.63-45.08	10.69	2.36 ± 0.04	3.02 ± 0.06	0.97	1.0090	0.937	I	3.55 ± 0.41
	*Hemiculter leucisculus** (Basilewski 1855)	6	95-140	250	5.68-20.64	6.79	1.91 ± 0.07	3.19 ± 0.35	0.94	1.0032	0.538	I	1.17 ± 1.15
	Luciobarbus barbulus (Heckel 1847)	3	41-253	940	0.62-201.83	9.79	2.28 ± 0.10	3.16 ± 0.14	0.99	1.0054	0.717	I	3.83 ± 2.63
	*Pseudorasbora parva** (Temminck and Schlegel 1846)	45	29-72	120	0.28-3.23	7.98	2.07 ± 0.13	2.79 ± 0.16	0.96	1.0114	0.609	I	2.36 ± 0.37
Mugilidae	*Planiliza abu* (Heckel 1843)	308	31-134	260	0.42-30.69	9.88	2.29 ± 0.02	2.69 ± 0.05	0.98	1.0011	0.410	I	4.99 ± 0.49
Cyprinodontidae	*Aphanius dispar* (Rüppell 1829)	1000	17-43	80	0.09-1.34	14.77	2.69 ± 0.15	2.91 ± 0.13	0.82	1.0170	0.783	I	1.97 ± 0.06
Poecilidae	*Gambusia holbrooki** (Girard 1859)	117	23-47	60	0.15-1.35	15.86	2.76 ± 0.19	3.21 ± 0.26	0.88	1.0255	0.367	I	1.42 ± 0.15
Cichlidae	*Coptodon zillii** (Gervais 1848)	35	23-50	190	0.15-1.98	18.55	2.92 ± 0.07	3.26 ± 0.06	0.94	1.0031	0.428	I	2.01 ± 0.14

* Exotic species, ** based on Abdoli (2016) and Coad (2017).

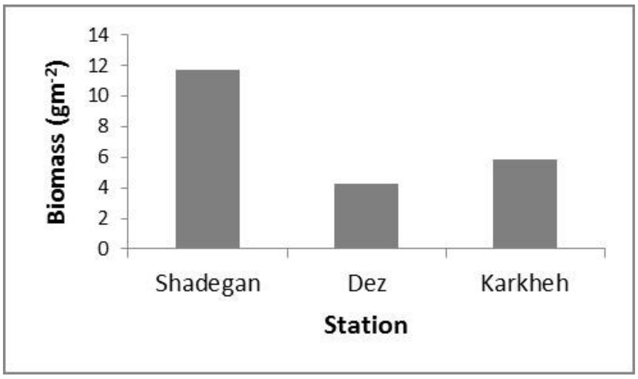

Fig. 2. The fish biomass (wet mass, gm^{-2}) at different stations.

Table 4. The diversity of fish species at the sampling stations.

Station	Margalef	Shannon-Weinner	Simpson	Evenness
Shadegan	0.63	1.05	0.51	0.36
Dez	0.76	1.47	0.70	0.54
Karkheh	1.16	1.75	0.80	0.44

Discussion

Regulation of flow regime often leads to habitat degradation and species loss in floodplains (Poff 1997, Bunn and Arthington 2002, Bowen *et al.* 2003). Since 1980, the construction of dams in southwest Iran has altered the hydrological regime dramatically (Hashemi and Ansary 2012), and thus the floodplain habitats caused in water bodies such as the Dez and Karkheh Rivers and the Shadegan Wetland have significantly decreased. In these conditions, the shallow waters of littoral zones that have suitable features for the juvenile fish can play an essential role in the survival of the native fish fauna.

The fish biomass at Shadegan was higher than the others. Wetlands are well known for their high productivity and their ability to purify water by retaining potentially polluting nutrients (Wilson and Carpenter 1999, Mitsch *et al.* 1995). Despite the high biomass, the values of diversity indices relatively were low at the station. Most likely, one of the reasons could be the presence of exotic species, especially *C. zillii*. Although *C. zillii* had a meager quantity in Shadegan station, the species have been the most abundant among fish caught in the wetland in the local fish markets (Valikhani *et al.* 2018). The fish abundance was relatively low at Dez. One of the reasons could be associated with proximity to residential areas. On the other hand, probably due to protective measures, Karkheh had the highest diversity.

SF index indicates the high efficiency of the used model so that the value is less than 1.032 in all species. The numerical value of P indicates the presence or absence of significant difference statistically between mean *b* with a standard numerical value of 3 for assessing how the species are grown. Lack of significant difference ($p>0.05$) reflects isometric growth, and significant difference implies allometric growth. The growth pattern will be positive allometric if there is a significant difference, and the mean value of *b* is more than the numerical value of 3; otherwise, it will be negative allometric. In the case of LWRs of the species, although the t-test does not show a significant difference between the *b*-value of the species and the standard number of 3, it seems that the higher value of the mentioned number indicates appropriate growth and ecological adaptation of these species. According to the results, only *A. marmid* has negative allometric growth. Başusta and Çiçek (2006) have presented a positive allometric growth for this species in the Atatürk Dam Lake that may be attributed by the size-frequency of the specimens (92-286 mm) collected from the Dam. Among the species caught, *A. caeruleus* only had specimens in different sizes. The linear

LWR (r) of *A. caeruleus* was previously performed (Mohammadi *et al.* 2012), which is consistent with the results of this study. There are a few studies on LWR of the species. Therefore, the results can provide appropriate information to determine the biological status of the species. The value of b for exotic species *H. leucisculus* has been reported in China between 2.87 and 3.37, which is consistent with the results of the present study (Li *et al.* 2014). Because of the invasive features of *H. leucisculus*, it seems that this species requires special attention to control in the wetland to protect the native species. In this study, *H. leucisculus* and *A. caeruleus* were caught at Shadegan. Therefore, the distribution range of the two species increased in Iran. The introduced species *H. leucisculus* had been recorded from the Hurolazim Wetland (Coad and Hussain 2007), the Marun River (Zareian *et al.* 2015), and the Karun River (Abdoli 2016) in Khuzestan province, Iran. The fish can cause destructive impacts on the native species of the Shadegan ecosystem. *A. caeruleus*, as a native species, had been recorded previously from the Karkheh basin (Coad 2017) and the Marun River (Zareian *et al.* 2015) in Iran.

In the studied aquatic ecosystems, the value of K is higher than one in all 11 native species. It can be predicted based on this index that the condition of the ecosystems is favorable for the growth of the fish at the sampling time; however, necessary care should be taken to protect the ecosystems from pollution, habitat degradation, and exotic species.

Finally, we would have suggested that the research subject can be followed by managers and organizations with an accurate and complete study of the biological and non-biological conditions affecting the life of the juvenile and young adults and used the results for ecosystem management. Unfortunately, the habitats are threatened by reduced water volume, degradation of water quality and exotic species. These habitats are important in the survival of the juveniles to produce future adults; therefore, it is necessary to pay special attention to the conservation and management of these parts of the water bodies.

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References

Aazami J., Esmaili-Sari A., Abdoli A., Sohrabi H., Van den brink P.J. 2015. Length-weight relationships of 14 fish species from Tajan River, Southern Caspian Sea basin, Iran. Iranian Journal of Ichthyology 2(4): 299-301.

Abdoli A. 2000. The Inland Water Fishes of Iran. Iranian Museum of Nature and Wildlife. Tehran. [In Persian with English abstract]

Abdoli A. 2016. The field guide of the inland water fishes of Iran. Iran-shenasi. Tehran. [In Persian]

Akhani H. 2015. Iran's environment under sieg. Science 350(6259): 392-392.

Anene A. 2005. Condition factor of four cichlid species of a man-made lake in Imo State, Southeastern Nigeria. Turkish Journal of Fisheries and Aquatic Sciences 5(1): 43-47.

Asadi H., Sattari M., Motalebi Y., Zamani-Faradonbeh M., Gheytasi A. 2017. Length-weight relationship and condition factor of seven fish species from Shahrbijar River, southern Caspian Sea basin, Iran. Iranian Journal of Fisheries Sciences 16(2): 733-741.

Başusta N., Çiçek E. 2006. Length-weight relationships for some teleost fishes caught in Ataturk Dam Lake on southeastern Anatolia, Turkey. Journal of Applied Ichthyology 22(4): 279-280.

Bowen Z.H., Bovee K.D., Waddle T.J. 2003. Effects of flow regulation on shallow-water habitat dynamics and floodplain connectivity. Transactions of the American Fisheries Society 132(4): 809-823.

Bunn S.E., Arthington A.H. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental management 30(4): 492-507.

Chick J.H., Mclvor C.C. 1994. Patterns in the abundance and composition of fishes among beds of different macrophytes: viewing a littoral zone as a landscape. Canadian Journal of Fisheries and Aquatic Sciences 51(12): 2873-2882.

Coad B.W. 2015. Freshwater Fishes of Iran. Available from: www.briancoad.com. Retrieved on 19 November 2015.

Coad B.W. 2017. Freshwater Fishes of Iran. Available from: www.briancoad.com. Retrieved on 20 March 2017.

Coad B.W., Hussain N.A. 2007. First record of the exotic species *Hemiculter leucisculus* (Actinopterygii: Cyprinidae) in Iraq. Zoology in the Middle East 40(1): 107-109.

Froese R. 2006. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology 22(4): 241-253.

Hammer Ø., Harper, D.A.T., Ryan, P.D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4(1): 9pp.

Hashemi S.A.R., Ansary H. 2012. Biomass and production of fish species in the Shadegan wetland, Iran. Global Veterinaria 9(2): 123-128.

Lewin W.C., Okun N., Mehner T. 2004. Determinants of the distribution of juvenile fish in the littoral area of a shallow lake. Freshwater Biology 49(4): 410-424.

Li Q., Xu X., Huang J. 2014. Length–weight relationships of 16 fish species from the Liuxihe national aquatic germplasm resources conservation area, Guangdong, China. Journal of Applied Ichthyology 30(2): 434-435.

Loureiro S., Mourão Júnior M., Giarrizzo T. 2017. Length-weight relationships for seven fish species from Marajó Bay, Amazon estuary, northern Brazil. Journal of Applied Ichthyology 33(3): 620-622.

Mitsch W.J., Cronk J.K., Wu X., Nairn R.W., Hey D.L. 1995. Phosphorus retention in constructed freshwater riparian marshes. Ecological Applications 5(3): 830-845.

Mohammadi M., Askary Sary A., Khodadadi M. 2012. Accumulation Variations of selected heavy metals in *Barbus xanthopterus* in Karoon and Dez Rivers of Khuzestan, Iran. Iranian Journal of Fisheries Sciences 11(2): 372-382.

Poff N.L., Allan J.D., Bain M.B., Karr J.R., Prestegaard K.L., Richter B.D., Sparks, R.E., Stromberg J.C. 1997. The natural flow regime. BioScience 47(11): 769-784.

Schiemer F., Spindler T., Wintersberger H., Schneider A., Chovanec A. 1991. Fish fry associations: important indicators for the ecological status of large rivers. Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen 24(4): 2497-2500.

Valikhani H., Abdoli A., Kiabi B.H., Nejat F., Sadeghsaba M., Khosravi M. 2018. A study on the status of invasive tilapia species (*Coptodon zillii* Gervais, 1848 and *Oreochromis aureus* Steindachner, 1864) in the aquatic ecosystems of Khuzestan province, Iran. Environmental Sciences 15: 29-44. [In Persian with English abstract]

Wilson M.A., Carpenter S.R. 1999. Economic valuation of freshwater ecosystem services in the United States: 1971-997. Ecological Applications 9(3): 772-783.

Zareian H., Esmaeili H.R., Zamanian Nejad R., Vatandoust S. 2015. *Hemiculter leucisculus* (Basilewsky, 1855) and *Alburnus caeruleus* (Heckel, 1843): new data on their distributions in Iran. Caspian Journal of Environmental Sciences 13(1): 11-20.