Int. J. Aquat. Biol. (2018) 6(5): 274-280
ISSN: 2322-5270; P-ISSN: 2383-0956
Journal homepage: www.ij-aquaticbiology.com
© 2018 Iranian Society of Ichthyology

Original Article

How did dams affect length-weight and length-length relationships of *Capoeta razii* (Cyprinidae) in Sefid River, the southern Caspian Sea basin?

Hamed Mousavi-Sabet*[1,2], Adeleh Heidari[1], Meysam Salehi[3]

[1]Department of Fisheries Sciences, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Guilan, Iran.
[2]The Caspian Sea Basin Research Center, University of Guilan, Rasht, Iran.
[3]Abzi-Exir Aquaculture Co., Agriculture Section, Kowsar Economic Organization, Tehran, Iran.

Abstract: Fish populations are affected by dams in terms of morphology, reproduction, migration, growth rate and etc. To examine the hypothesis; how dams can affect the length-weight and length-length relationships in cyprinids, four *Capoeta razii* segregated populations (by dams) were studied. The length-weight (LWR) and length-length (LLRs) relationships were calculated for three populations from upstream, dam lakes and downstream of Manjil and Tarik dams in Sefid River, in the southern Caspian Sea basin. Also, one independent population from the damming impacts was considered as the control, to examine other possible annual effects on LWR. The *b* values in the LWR ranged from 2.893 to 3.586 in downstream and dam lakes populations, respectively. The r^2 value ranged from 0.966 to 0.988. The averages of recorded length and weight in dam lake population were up to two and six times (respectively) more than the ranges in up and downstream populations. Monthly LWR is presented for the control population. The sex and maturity were found as effective factors on LWR in the control population. No significant differences were observed in LWR by seasons. All LLRs were highly significant (r^2> 0.95). This study presents that the dams and the sex and maturity can be considered as effective non-biological and biological factors (respectively) affecting growth patterns as expressed by length and weight relationships in cyprinid (*C. razii*) populations. The results may be helpful in future fisheries studies and conservation programs.

Article history:
Received 11 July 2018
Accepted 14 October 2018
Available online 25 October 2018

Keywords:
Sefid River
Caspian Sea
Population
Dam

Introduction

Knowledge of length-weight relationship (LWR) and length-length (LLRs) relationships is an important tool for the adequate management of fish stocks and populations (King, 2007; Ndome et al., 2012; Qiang et al., 2013; Mousavi-Sabet et al., 2013, 2014, 2015a; Zamani Faradonbeh et al., 2015). The LWR is useful in local and interregional morphological and life-history comparisons across species and populations, also represent an important fishery management tool. LLRs also have great importance for comparative growth studies (Moutopoulos and Stergiou, 2002; Heidari et al., 2018, Mousavi-Sabet et al., 2015b, c).

Sefid River is one of the most important rivers in the southern Caspian Sea basin with 765 km in length. The Manjil and Tarik dams were constructed on Sefid River in 1962 and 1968, respectively (Najmaii, 2004), which have effectively fragmented the river into upstream and downstream and have probably blocked the migration of the fish among up and downstream. The Manjil Dam (also known as the Sefidroud Dam) is a buttress dam on the Sefid River near Manjil (Guilan Province, Iran). It was constructed as a water reservoir for irrigation and produce hydroelectric power. It is 106 m high and forms a reservoir with a capacity of 1.82 km^3. The Tarik Dam is located 35 km downstream from Manjil Dam and diverts releases from Manjil Dam for irrigation (Najmaii, 2004). Heidari et al. (2013, 2014) showed that the dams could affect morphological traits of fish populations in the river.

The genus *Capoeta* contains potamodromous cyprinid fishes, which *Capoeta razii* being an important native species in Sefid River (Zareian et al.,

*Correspondence: Hamed Mousavi-Sabet
E-mail: mousavi-sabet@guilan.ac.ir
DOI: https://doi.org/10.22034/ijab.v6i5.534

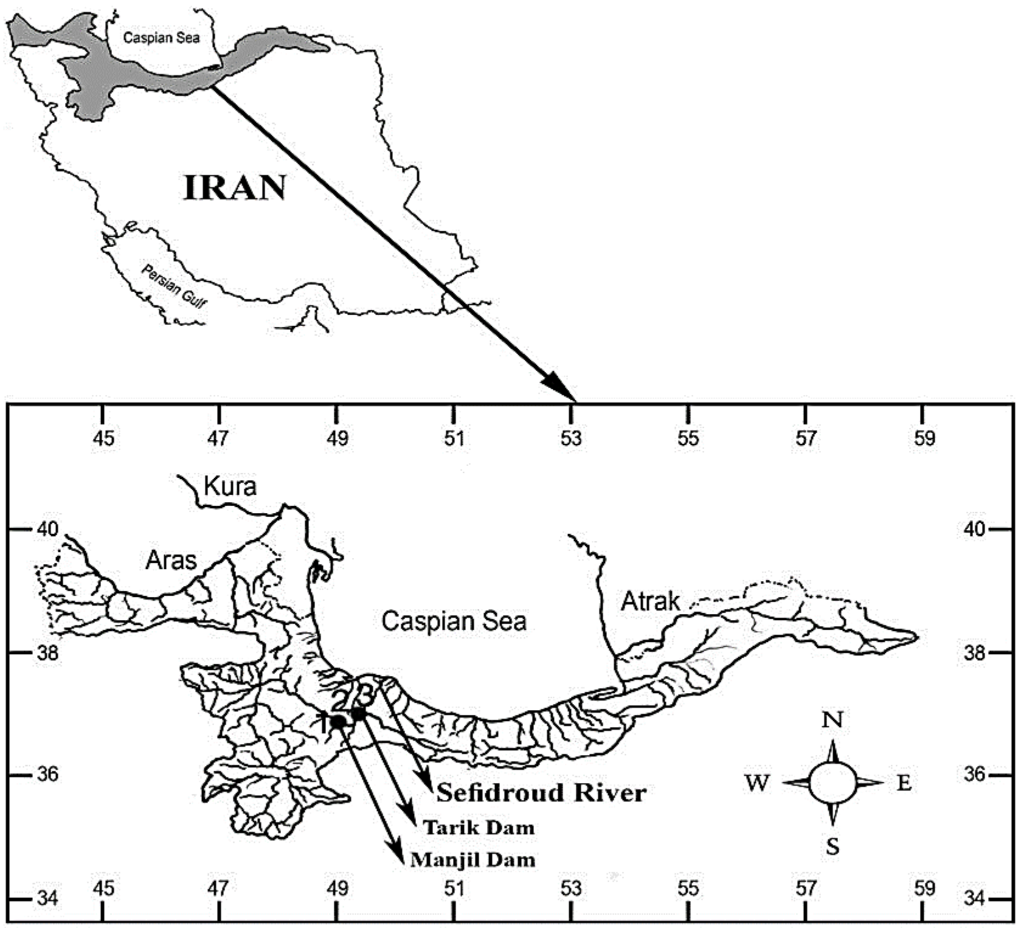

Figure 1. Location of sampling sites. Upstream and downstream of Manjil and Tarik dams on the Sefid River, southern Caspian Sea Basin, Iran

2016; Esmaeili et al., 2018) and for this species LWR studies are still poorly known from the southern Caspian Sea basin. Also, there is currently no report about the impact of dams on LWR and LLRs for any fish species, inhabiting the Caspian Sea basin.

According to litterateurs (Jageret al., 2001; Heidari et al., 2013, 2014; Mousavi-Sabet et al., 2015a, 2016a, b): (1) the LWR can be affected by biological and non-biological factors, and (2) dam separate fish populations and make different habitats in upstream and downstream which impacts on fish morphology and growth parameters; therefore, the present study aimed to assess the impact of dams on length-weight and length-length relationships of *C. razii* as the case species here.

Materials and Methods

Fish were collected from upstream, dam lake and downstream of dams and a population as control, specimen's measurements, analysing and estimating possible relations of the studied parameters with different habitats caused by dam constructor. For this purpose, a total of 439 individuals of *C. razii* were collected by electrofishing (energy level: 200-300 V; distance between electrodes: 10-50 meters; area covered each time: 100 meters; water depth covered: 40-120 cm; substrate of the fishing areas: with diverse structures, including pools, riffles, gravel bed, sandy shore, etc.) from Sefid River in the southern Caspian Sea basin, northern Iran. Of the total samples, 108 adult specimens (sex ratio 1:1) were caught in November 2014 from three sampling sites according to dams locations in the river, including upstream of Manjil Dam (37°18′29″N, 49°15′25″E; n = 44), dam lake (36°46′52.86″N, 50°1′18″E; n = 30) and downstream of Tarik Dam (37°39′15″N, 49°58′11″E; n = 33) (Fig. 1). Also, to estimate the effects of biological factors on LWR, 331 specimens were

Table 1. Descriptive statistics and estimated parameters of length-weight relationship for *Capoeta razii* in up and downstream of Manjil and Tarik dams in Sefid River, Iran.

Locality	*n*	Total length (cm)		Total weight (g)		Relationship parameters					*t* value	Growth
		Range	Mean ± SD	Range	Mean ± SD	log *a*	*b*	r^2	SE*b*	±95% CI of *b*		
Upstream	40	5.8-15.3	9.99±3.41	4.7-44.6	13.76±11.93	-1.9303	2.939	0.988	0.052	2.835-3.43	-1.1731	-A
Dam Lake	30	11.3-21.7	17.51±2.91	15.4-162.6	79.66±43.64	-2.6089	3.586	0.966	0.172	3.218-3.953	3.4011	+A
Downstream	34	6.9-16.2	9.24±2.02	4.1-57.3	11.50±9.88	-1.7937	2.893	0.983	0.067	2.758-3.029	-1.5970	-A
Tutkabon Stream (control population)	331	3.9-23.5	11.26±3.30	2.3-126.7	21.38±20.57	-4.8735	2.735	0.903	0.025	2.67-2.83	-1.5825	-A

SD = standard deviation, *n* = sample size; *a* and *b*, the parameters of the length-weight relation, SE*b* = standard errorof the slope, r^2 = the coefficient of determination, *t* value (difference of *b* from 3), CI = confidence interval, +A = allometric (+), -A = allometric (-)

collected monthly (during September 2013 to August 2014) from Tutkabon stream in the river drainage, as an independent and protected stream from the damming impacts (37°01′16.82″ to 36°50′44.71″N, 49°37′56.86″ to 49°35′01.23″E), which considered as control population. The sampled fish were fixed in 10% formaldehyde upon capture and transported to the laboratory for further analysis.

In the laboratory for each individual, total length (TL), standard length (SL) and fork length (FL) (cm) were measured and whole-body weight (W) was taken using a digital balance to the nearest 0.1 g. The LWR of the fishes was calculated by using the formula $W = a\, L^b$ (Le Cren, 1951; Froese, 2006; Froese et al., 2011), where W is the total body weight in grams and L is the total length (TL) in cm. Regression parameters *a* and *b* of the LWR were estimated by linear regression equation Log TW = log *a* + *b* log TL. For LWR with $r^2 < 0.95$, the regression was repeated after removing outliers (Froese, 2006). Additionally, 95% confidence limits (CL) of *b* were estimated. The model fit to the data was measured by the coefficient of the Pearson r-squared (r^2) test. The null hypothesis that $b = 3$ was tested using two tailed t-test as described by Zar (1999). TL vs FL, TL vs SL and SL vs FL relationships were also estimated by linear regression (Zar, 1999). All statistical tests were at $\alpha = 0.05$.

Results

The mean (±SD) and range of total length, sample size, weight range, length-weight parameters *a* and *b*, the standard error of the slope, and the coefficient of determination (r^2) for the studied populations of *C. razii* are given in Table 1. Monthly LWR for the control population is given in Table 2. Maximum recorded total length and body weight were 23.5 cm and 162.60 g respectively. Also, LLRs were found to be highly correlated (in all cases: $r^2>0.95$, $P<0.001$) (Table 3).

The average recorded TL in dam lake population was 17.51±2.91 cm (vs. 9.99±3.41 and 9.24±2.02 in up and downstream populations) and average recorded weight was 79.66±43.64 g (vs. 13.76±11.93 and 11.50±9.88 in up and downstream populations). The values of coefficient of determination 'r^2' calculated for all relationships *viz*., TL-Wt, TL-SL, TL-SL and SL-FL for the studied populations of *C. razii* are shown in Tables 1 and 3 which are highly significant ($P<0.001$).

Discussion

This study presents new records of maximum total length for *C. razii* in Sefid River from the southern Caspian Sea basin. Maximum recorded total length for *Capoeta gracilis* (now is *C. razii* in the southern Caspian Sea basin) was reported to be 41 cm from Turkey in FishBase database (Froese and Pauly, 2015).

The *b* values in the LWR ranged from 2.893 in downstream to 3.586 in dam lake populations, which

Table 2. Descriptive statistics and estimated monthly LWRs for both sexes of *Capoeta razii* in Sefid River from the southern Caspian Sea basin (Sep 2013 to Aug 2014).

Month	Sex	*n*	Total length (cm)		Weight (g)		Regression parameters		
			Min	Max	Min	Max	*a*	*b*	r^2
Sep	M	18	7.1	13.1	4.45	23.97	0.0170	2.827	0.975
	F	12	7.5	14.2	5.11	32.10	0.0159	2.863	0.983
Oct	M	13	7.0	13.4	3.16	19.77	0.0127	2.874	0.986
	F	5	6.7	9.3	2.74	8.010	0.0054	3.262	0.971
Nov	M	17	7.7	14.5	5.80	37.30	0.0161	2.864	0.990
	F	14	6.2	17.5	3.03	53.07	0.0194	2.769	0.989
Dec	M	30	7.3	14.2	4.40	41.00	0.0087	3.121	0.982
	F	16	5.6	15.3	2.30	36.50	0.0161	2.836	0.992
Jan	M	9	7.5	19.5	4.21	96.42	0.0080	3.141	0.996
	F	10	6.0	14.8	2.77	32.42	0.0195	2.738	0.997
Feb	M	41	7.2	17.8	4.10	55.88	0.0114	2.978	0.968
	F	8	9.2	20.0	8.13	109.93	0.0050	3.331	0.991
Mar	M	27	8.5	15.3	7.63	37.92	0.0255	2.694	0.974
	F	4	14.5	20.7	34.65	99.00	0.0136	2.943	0.992
Apr	M	25	10.2	15.3	13.20	42.40	0.0202	2.800	0.968
	F	5	14.7	21.13	43.30	126.00	0.0200	2.848	0.979
May	M	4	13.0	18.5	21.90	65.00	0.0071	3.112	0.988
	F	5	12.0	15.0	18.10	33.00	0.0403	2.478	0.970
Jun	M	12	9.5	15.0	11.39	35.29	0.0433	2.465	0.973
	F	8	7.0	23.5	3.74	124.66	0.0124	2.929	0.998
Jul	M	34	7.5	16.5	6.20	62.70	0.0209	2.819	0.984
	F	3	15.0	18.5	40.90	70.00	0.0308	2.644	0.981
Aug	M	14	7.0	16.0	4.24	44.12	0.0108	3.034	0.991
	F	3	14.0	15.5	35.10	48.01	0.0085	3.158	0.985
Over all	M	244	7.0	19.5	3.16	96.42	0.0151	2.894	0.966
	F	83	5.3	23.5	2.30	126	0.0105	3.036	0.990
	Immature	4	7.0	9.5	4.35	10.95	0.0139	2.946	0.989

Table 2. Length-length relationships between total length, fork length and standard length of *Capoeta razii* in Sefid River, Iran.

Locality	Equation	*n*	*a*	*b*	r^2
Upstream	TL = *a* + *b*FL	44	0.057	1.010	0.994
	FL = *a* + *b*SL		0.014	0.057	0.994
	SL = *a* + *b*TL		0.968	0.119	0.994
Dam Lake	TL = *a* + *b*FL	30	1.073	0.130	0.974
	FL = *a* + *b*SL		1.090	0.146	0.990
	SL = *a* + *b*TL		0.820	0.285	0.957
Downstream	TL = *a* + *b*FL	34	0.018	0.056	0.989
	FL = *a* + *b*SL		1.042	0.083	0.983
	SL = *a* + *b*TL		0.918	0.153	0.979
Tutkabon Stream (control population)	TL = *a* + *b*FL	331	0.986	0.062	0.992
	FL = *a* + *b*SL		0.972	0.099	0.989
	SL = *a* + *b*TL		1.029	0.137	0.991

n = sample size, *a* = intercept, *b* = slope, r^2= coefficient of determination

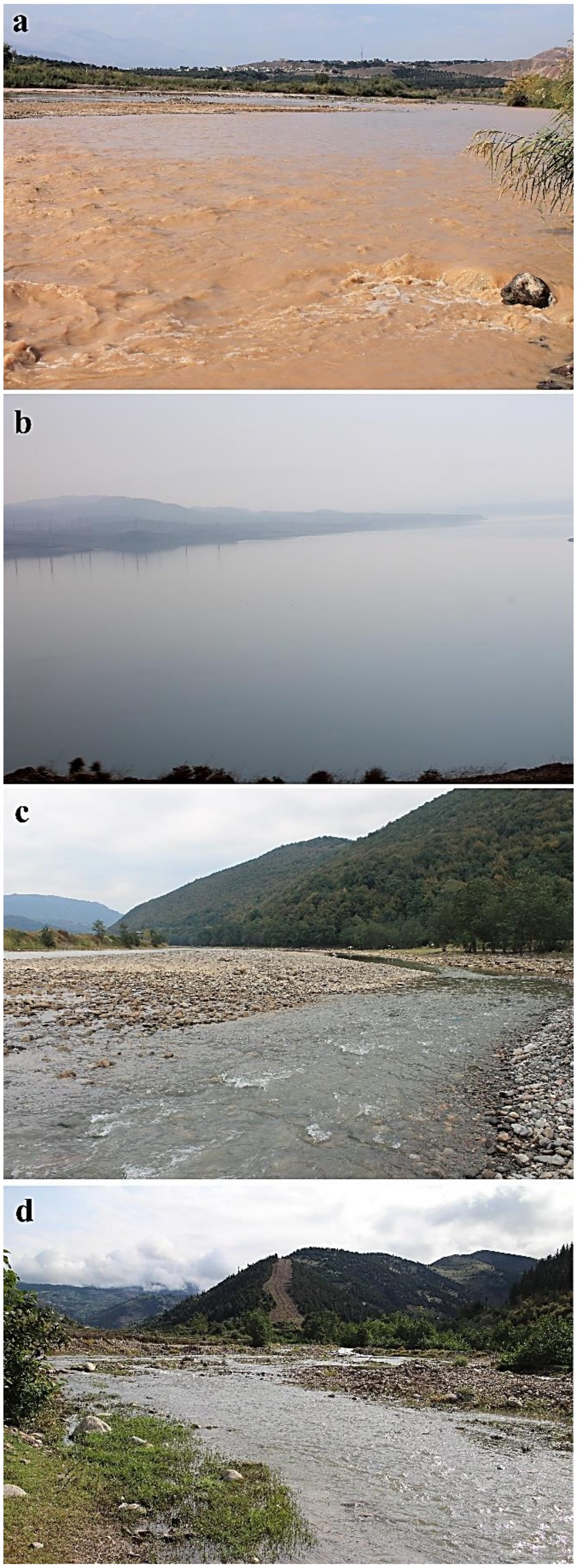

Figure 2. Habitats in the sampling sites: (a) upstream of Manjil dam, (b) Manjil Dam Lake, (c) downstream of Tarik Dam, (d) Stream Tutkabon.

was 2.735 in the control population. Overall, the values of parameter *b*, which varies between 2 and 4, mostly remained within the expected range of 2.5-3.5 (Froese, 2006), with extreme values of 2.893 in downstream and 2.939 in upstream populations. In terms of growth type, the results showed that upstream, downstream and control populations had negative allometric growth pattern while the dam lake population had positive allometric growth. The differences between growth patterns can be explained by the differences between the different habitats and food availability, which up and downstream habitats are shallow and free flowing river with low primary production in compare with the dam lake (Fig. 2). In addition, water flow and quality in the up and downstream are affected by the damming, which are normally fast and muddy (Fig. 2).

The present study has revealed that the Manjil and Tarik dams on the Sefid River have created differences in length and weight relationship of *C. razii* in upstream and downstream. The LWR in fishes can be affected by a number of factors, including season, habitat, gonad maturity, sex, diet, health and preservation techniques of the captured specimens (Jager et al., 2001; Mousavi-Sabet et al., 2017a, b; Alavi-Yeganeh et al., 2018), which were considered for the control population in the present study. Thus, differences in LWR among different studied populations could be potentially attributed to differentiation of habitats caused by the dams construction. It was also previously suggested that these dams separated *Capoeta* populations morphologically (Heidariet al., 2013, 2014), which could be cause by the differences in growth parameters. Dams influence on upward migration of fish especially that of the migratory species and prevent of migration them resulting in an ecological trap for fishes that ascend the fish passages (Pelicice and Agostinho, 2008). Fragmentation of the river converts a free-flowing river into reservoir habitat, affecting the ecosystem and this in turn affects the migration patterns of fish populations (Jageret al., 2001; Mohadasi et al., 2013; Jalili et al., 2015).

In conclusion, the present study indicates that there exist different length-weight and length-length relationships in populations of *C. razii* in upstream, Dam Lake and downstream of the Manjil and Tarik dams on the Sefid River, and the probable reason for the differentiation of these populations are the construction of the dams. This study provides basic information and suggests that biological variations observed in *C. razii* should be considered in fisheries management and commercial exploitation of this species and any stock enhancement program.

Acknowledgements
The authors are grateful to H. Bagherpour, A. Habibi, M. Mohammadi-Darestani, M. Mansuro-Chorehi and K. Ghasemzadeh for their help in fish collections.

References
Alavi-Yeganeh M.S., Sharifiniya M., Ghasemzadeh J., Amoeii M., Mousavi-Sabet S.H. (2018). Length–weight and length–length relationships of three Blenny species from the Persian Gulf and the Gulf of Oman. Journal of Applied Ichthyology, 34: 1238–1240.

Esmaeili H.R., Sayyadzadeh G., Eagderi S., Abbasi K. (2018). Checklist of freshwater fishes of Iran. FishTaxa, 3(3): 1-95.

Froese R., Pauly D., (2016). FishBase. World Wide Web Electronic Publication. Available at: http://www.fishbase.org. (Accessed on 29 February 2016).

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

Froese R., Tsikliras A.C., Stergiou K.I., (2011). Editorial note on weight-length relations of fishes. Acta Ichthyologica et Piscatoria, 41 (4): 261-263.

Heidari A., Mousavi-Sabet H., Khoshkholgh M., Esmaeili H.R., Eagderi S. (2013). The impact of Manjil and Tarik dams (Sefidroud River, southern Caspian Sea basin) on morphological traits of Siah Mahi *Capoeta gracilis* (Pisces: Cyprinidae). International Journal of Aquatic Biology, 1 (4): 195-201.

Heidari A., Mousavi-Sabet H., Sattari M., Alavi-Yeganeh M.S., Abbasi K. (2018). Length–weight and length–length relationships for two gobiids from the Anzali Wetland, in the southern Caspian Sea basin. Journal of Applied Ichthyology, 34: 1042-1044.

Heidari A., Khoshkholgh M., Mousavi-Sabet H. (2014). Tracing the effects of Sefidroud dams on *Capoeta gracilis* (Cyprinidae) populations using Truss distances in southern Caspian Sea basin. Iranian Journal of Ichthyology, 1 (2): 106-113.

Jager H.I., Chandler J.A., Lepla K.B., Winkle W.V. (2001). A theoretical study of river fragmentation by dams and its effect on white sturgeon populations. Environmental Biology of Fishes, 60: 347-361.

Jalili P., Eagderi S., Keivany Y. (2015). Body Shape Comparison of Kura Bleak (*Alburnus filippii*) in Aras and Ahar-Chai Rivers Using Geometric Morphometric Approach. Research in Zoology, 5(1): 20-24.

King M. (2007). Fisheries biology, assessment and management. Wiley-Blackwell, 400 pp.

Le Cren E.D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology, 20 (2): 201-219.

Li Q., X.u R., Huang J. (2013). Length-weight relations for 20 fish species from the Pearl River, China. Acta Ichthyologica et Piscatoria, 43 (1): 65-69.

Mohadasi M., Shabanipour N., Eagderi S. (2013). Habitat-associated morphological divergence in four Shemaya, *Alburnus chalcoides* (Actinopterygii: Cyprinidae) populations in the southern Caspian Sea using geometric morphometrics analysis. International Journal of Aquatic Biology, 1(2): 82-92

Mousavi-Sabet H., Habibi A., Bagherpur O. (2013). Studies on Length-weight and Length-length Relationships, Relative Condition Factor and Fulton's Condition Factor of *Hemiculter leucisculus* (Pisces: Cyprinidae) from the Southwestern Caspian Sea Basin. Our Nature, 11 (1): 25-30

Mousavi-Sabet H., Heidari A., Fekrandish H. (2015c). Population structure, length-weight and length-length relationships of six populations of the Bartail Flathead *Platycephalus indicus* (Scorpaeniformes: Platycephalidae) along the Persian Gulf coastal waters. Journal of Threatened Taxa, 7(1): 6810-6814.

Mousavi-Sabet H., Heidari A., Paknejad S. (2015b). Length-weight and length-length relationships of the genus *Alosa* (Clupeoidei: Clupeiformes: Clupeidae) along the southern Caspian Sea coast. Journal of Applied Ichthyology, 32: 129-130.

Mousavi-Sabet H., Heidari A., Vatandoust S. (2017a). Length–weight and length–length relationships for 11 species of the genus *Alburnoides* Jeiteles, 1861 (Cyprinidae) from Iran. Journal of Applied Ichthyology, 33: 609-612.

Mousavi-Sabet H., Heidari A., Vatandoust S. (2017b). Length–weight and length–length relationships for nine species of the genus *Paracobits* (Nemacheiliidae) in Iran. Journal of Applied Ichthyology, 33(3): 617-619

Mousavi-Sabet H., Heidari A., Mohamadi-Darestani M., Mansouri-Chorehi M., Ghasemzadeh K. (2016a). Length-weight relation-ships and condition factors of two fish species from the southern Caspian Sea basin: *Alburnoides samiii* Mousavi-Sabet, Vatandoust & Doadrio, 2015 and *Ponticola iranicus* Vasil′eva, Mousavi-Sabet & Vasil′ev, 2015. Journal of Applied Ichthyology, 32: 751-752.

Mousavi-Sabet H., Heidari K., Abbasi S., Vatandoust S. (2016b). Length-weight relationships of six species of the genera *Cobits* and *Sabanejewia* (Cobitdae) in Iranian river systems. Journal of Applied Ichthyology, 32: 1310-1312.

Mousavi-Sabet H., Homayouni H., Marjani M., Heidari A. (2015a). Length-weight relationships for 5 Clupeiformes species from the Persian Gulf and Oman Sea. Journal of Applied Ichthyology, 32: 169-170.

Mousavi-Sabet H., Khataminejad S., Vatandoust S. (2014). Length–weight and length–length relations of the seven endemic *Alburnus* species (Actinopterygii: Cypriniformes: Cyprinidae) in Iran. Acta Ichthyologica et Piscatoria, 44(2): 157–158.

Moutopoulos D.K., Stergiou K.I. (2002). Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). Journal of Applied Ichthyology, 18: 200-203.

Najmaii M. (2004). Dam and Environment. Department of Energy-Iranian Large Dams National Committee. 385 p. (In Persian)

Ndome C.B., Eteng A.O., Ekanem A.P. (2012). Length-weight relationship and condition factor of the smoothmouth marine catfish (*Carlarius heudelotii*) in the Gulf of Guinea, Niger delta, Nigeria. AACL Bioflux, 5(3): 163-167.

Pelicice F.M., Agostinho A.A. (2008). Fish-passage facilities as ecological traps in large Neotropical rivers. Conservation Biology, 22: 180-188.

Zar J.H, (1999). Biostatistical analysis. Fourth Edition. Pearson Education India. 663 p.

Zareian H., Esmaeili H.R., Heidari A., Khoshkholgh M., Mousavi-Sabet H. (2016). Contribution to the molecular systematics of the genus *Capoeta* from the south Caspian Sea basin using mitochondrial cytochrome *b* sequences (Teleostei: Cyprinidae). Molecular Biology Research Communications, 5(2): 65-75.

Zamani Faradonbeh M., Eagderi S., Ghojoghi F. (2015). Length-weight relationship and condition factor of seven fish species of Totkabon River (southern Caspian Sea basin), Guilan, Iran. International Journal of Aquatic Biology, 3(3): 172-176.