

Length-weight and length-length relationships of an established exotic mosquitofish population (*Gambusia holbrooki*), from Namak Lake basin in central Iran

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Abstract. Length–weight (LWR) and length–length (LLR) relationships were estimated for 119 specimens of mosquitofish, *Gambusia holbrooki*, from Qom River, in the Namak Lake basin. The maximum total length and weight of the studied population were 5.8 cm and 3.4 g, respectively. The length-weight parameter b for this species was 3.05 with regression coefficients (r^2) 0.85. The LLR were highly significant ($r^2 > 0.99$).

Key Words: Poeciliidae, livebearer, population structure, exotic fish, Qom River.

Introduction. The family Poeciliidae (37 genera and about 304 species) includes live-bearing fishes of small size (< 200 mm length) having diverse morphology and coloration, with distribution in the freshwater and brackish environments of the eastern United States, South America, and Africa, including Madagascar (Moyle 2002; Nelson 2006). A myriad of poeciliids have been widely and deliberately introduced worldwide for mosquito control (Fuller et al 1999) or the aquarium trade (Crossman & Cudmore 1999) due to their short generation time, colorfulness, hardiness, and readiness to breed in captivity (Moyle 2002). One of the exotic species which is introduced almost in whole Iran is the mosquitofish, *Gambusia holbrooki* (Esmaeili et al 2010; Mousavi-Sabet & Eagderi 2014; Jouladeh-Roudbar et al 2015; Mousavi-Sabet 2018). Introduction of the fish into Iranian water bodies dates back a long time but were most prominent in the 1920s when the fish was introduced as an anti-malarial Agent (Esmaeili et al 2010; Jouladeh-Roudbar et al 2015; Radkhah et al 2016). However, later other poeciliids were introduced into the country due to ornamental fish trade (Mousavi-Sabet & Eagderi 2014; Mousavi-Sabet & Eagderi 2016; Mousavi-Sabet 2018), as these are popular fish species for hobbyist and interesting models for researchers in the country (Faghani-Langroudi et al 2014a; Moshayedi et al 2015a; Moshayedi et al 2015b).

Information on length-weight relationship (LWR) of fishes are a useful tool for biologist in fisheries for their assessment and proper management due to providing the estimation of biomass from length observation (Mousavi-Sabet et al 2016a; Heidari et al 2018; Alavi-Yeganeh et al 2018). Fish LWRs are useful for converting length observations into weight estimates to provide some measure of biomass (Froese 1998; Froese 2006; Mousavi-Sabet et al 2015; Mousavi-Sabet et al 2016b). This information is necessary for fisheries management in the area as well as for estimation of the biomass of the fish species (Froese 2006; Mousavi-Sabet et al 2016c). The length-length relationships (LLRs) are used to convert length measurements from one length-type into another (Froese 1998, 2006; Faghani-Langroudi et al 2014b; Mousavi-Sabet et al 2016d). The general

biology including LWR and LLR for exotic/invasive fish species in Iranian inland waters is barely known (Mousavi-Sabet et al 2013a; Mousavi-Sabet et al 2013b; Heidari et al 2018). The specific objectives of this study were to determine LWR and LLRs of the exotic mosquitofish, *G. holbrooki*, from Qom River in the Namak Lake basin, central Iran.

Material and Method. The *G. holbrooki* specimens were collected by hand-net during fieldwork in the Namak Lake basin, central Iran on 10 August 2012. Our collecting site was Qom River near Qom City (34°18'49.20"N, 50°32'12.37"E), Qom Province, Iran. The specimens were preserved in 10% formalin after anesthetizing with 1% clove solution and transferred to laboratory for further processing. Species *Capoeta aculeata* and *Paracobitis malapterura* were also collected during sampling. Total (TL) and standard (SL) lengths (± 1.0 mm) and body weight (± 0.1 g) were recorded for each fish specimen. Length-weight relationships were calculated using the formula $W = aL^b$, where W is the total weight (g), L is the total length (cm) and a and b are regression coefficients (Ricker 1973). For LWR with $r^2 < 0.95$ the regression was repeated after removing outliers (Froese 2006). Additionally, 95% confidence limits (CL) of a and b were estimated. The model fit to the data was measured by the coefficients of the Pearson r-squared (r^2) test. Outliers observed in the log-log plots of all species were excluded from the regression. The parameters a and b were estimated by linear regression: $\log(W) = \log(a) + b \log(L)$ (Froese 1998, 2006).

Results and Discussion. A total of 119 individuals (102 females and 17 males) of *G. holbrooki* were included in this LWR and LLR study. Sample descriptive statistics and estimated parameters of LWR are given in Table 1. Sample size, TL, W, LWR with 95% confidence intervals of a and b with the respective confidence intervals, and the coefficient of correlation (r^2) are given. The value of parameter b was 3.05 with r^2 value 0.85. LLRs and the coefficient of determination r^2 are given in Table 2. In this study LLR was found to be highly correlated ($r^2 > 0.99$, $p < 0.001$).

Table 1
Descriptive statistics and parameters of LWR for *G. holbrooki* determined from samples obtained in Qom River, Namak Lake basin, Iran

Species	n	Length (cm)	Weight (g)	a	b	95% CI a	95% CI b	r ²
<i>G. holbrooki</i>	119	2.4-5.8	0.16-3.4	0.0008	3.05	0.0012-0.0215	2.90-3.65	0.85

n, sample size; a, intercept; b, slope; CL, confidence limits; r², coefficient of determination.

Table 2
Length-length relationship for *G. holbrooki* determined from samples obtained in Qom River, Namak Lake basin, Iran

Species	TL (cm)	SL (cm)	n	Equation	r ²
<i>G. holbrooki</i>	2.4-5.8	1.9-5.1	119	TL = 0.220+0.907SL	0.99

n, sample size; r², coefficient of determination.

The parameter b of the studied species was 3.05. According to Bagenal & Tesch (1978), the range of b could be from 2 to 4 and $b = 3$ in fish with isometric growth. This study is the first report on LWR and LLR for *G. holbrooki* from the Namak Lake basin and can serve as a baseline for future studies. A new maximum length is reported for the fish from Iran. According to Esmaeili & Ebrahimi (2006) and Eagderi & Radkhah (2015) the maximum lengths of *G. holbrooki* were 4.1 and 5.5 cm from Iran.

There are some differences in the functional regression b value in available data on LWR for *G. holbrooki* from different countries (Table 3). It is well known that the functional regression b value represents the body form of fish (Ricker 1973; Kalayci et al 2007; Mousavi-Sabet et al 2014; Mousavi-Sabet et al 2017a; Mousavi-Sabet et al

2017b), and is affected by a number of factors such as gonad maturity, sex, diet, stomach fullness, health, age, fishing time as well as the area and fishing vessels (Wootton 1998); however, these factors were not considered in the present study.

Table 3

Length-weight relationships (LWRs) for different populations of *G. holbrooki*

<i>n</i>	<i>Sex</i>	<i>Length (cm) /Length type</i>	<i>a</i>	<i>b</i>	<i>r</i> ²	<i>Country</i>	<i>Reference</i>
35	mixed	2.4-4.1 TL	0.0114	3.05	0.876	Iran	Esmaeili & Ebrahimi (2006)
50	mixed	2.3-3.7 TL	0.000008	3.09	0.96	Iran	Eagderi & Radkhah (2015)
25	mixed	1.6-3.1 TL	0.00001	2.99	0.98	Iran	Eagderi & Radkhah (2015)
43	mixed	2.6-5.5 TL	0.000007	3.76	0.96	Iran	Eagderi & Radkhah (2015)
119	mixed	2.4-5.8 TL	0.0008	3.05	0.85	Iran	Present study
2338	female	1.8-5.9 TL	0.007	3.27	0.966	Spain	Moreno-Valcárcel et al (2012)
1172	male	1.8-4.1 TL	0.007	3.12	0.887	Spain	Moreno-Valcárcel et al (2012)
119	unsexed	2.2-5.7 FL	0.0044	3.81	0.945	Spain	Andreu-Soler et al (2006)
57	unsexed	2-5.7 FL	0.00523	3.59	0.939	Spain	Andreu-Soler et al (2006)
60	unsexed	1.9-4.9 FL	0.00779	3.37	0.861	Spain	Andreu-Soler et al (2006)
19	unsexed	2-4.4 TL	0.0064	3.49	0.948	Turkey	Tarkan et al (2006)
15	unsexed	3.2-4.7 TL	0.0087	3.42	0.97	Turkey	Tarkan et al (2006)
6799	female	0.7-3.9 SL	0.0195	3.02	0.806	USA	Klassen et al (2014)
1181	male	0.9-3.1 SL	0.0145	3.22	0.809	USA	Klassen et al (2014)
18951	mixed	0.7-4.7 SL	0.0172	3.02	0.894	USA	Klassen et al (2014)

Conclusions. The present study presented basic information on LWR and LLR for an established population of the exotic fish *G. holbrooki* in central Iran, which would be useful for fish biologists to control exotic species in the region. The narrow sample size or the length range possibly affected the b value of the study. Thus, differences in LWRs between this and other studies could be potentially attributed to the combination of one or more of the factors given above.

Acknowledgements. We would like to thank Saber Vatandoust for helping with the fish collection in the Namak Lake basin in 2012, and the University of Guilan for financial support.

References

Alavi-Yeganeh M. S., Sharifiniya M., Ghasemzadeh J., Amoeii M., Mousavi-Sabet 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.

- Andreu-Soler A., Oliva-Paterna F. J., Torralva M., 2006 A review of length-weight relationships of fish from the Segura River basin (SE Iberian Peninsula). *Journal of Applied Ichthyology* 22:295-296.
- Bagenal T. B., Tesch F. W., 1978 Age and growth. In: *Methods for assessment of fish production in fresh waters*. 3rd edition, IBP Handbook No. 3, Blackwell Science Publications, Oxford.
- Crosmann E. J., Cudmore B. C., 1999 Summary of North American fish introductions through the aquarium/horticulture trade. In: *Nonindigenous freshwater organisms: vectors, biology and impacts*. Claudi R., Leach J. H. (eds), Lewis Publishers, Boca Raton, Florida, USA, pp. 129-133.
- Eagderi S., Radkhah A., 2015 Length-weight relationship and condition factor of Mosquitofish (*Gambusia holbrooki*) in three inland basins of Iran. *Poec Res* 5(1):39-43.
- Esmaeili H. R., Ebrahimi M., 2006 Length-weight relationships of some freshwater fishes of Iran. *Journal of Applied Ichthyology* 22:328-329.
- Esmaeili H. R., Gholamifard A., Teimori A., Baghbani S., Coad B. W., 2010 *Xiphophorus hellerii* Heckel, 1848 (Cyprinodontiformes, Poeciliidae), a newly introduced fish recorded from natural freshwaters of Iran. *Journal of Applied Ichthyology* 26:937-939.
- Faghani-Langroudi H., Esmailpour-Chokami H., Rohani-Rad M., Mousavi-Sabet H., 2014a Sex reversal, mortality rate and growth performance of platy *Xiphophorus variatus* (Poeciliidae) treated by methyltestosterone. *Poec Res* 4(1):6-12.
- Faghani-Langroudi H. F., Esmailpour-Chokami H., Eslamkhah-Taghizad M. M., Rohani-Rad M., Mousavi-Sabet H., 2014b Length-weight and length-length relationships of *Cyprinion macrostomum* from the Tigris River drainage. *AAFL Bioflux* 7(4):235-240.
- Froese R., 1998 Length-weight relationships for 18 less-studied species. *Journal of Applied Ichthyology* 14:117-118.
- Froese R., 2006 Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology* 22:241-253.
- Fuller P. L., Nico L. G., Williams J. D., 1999 *Nonindigenous fishes introduced into inland waters of the United States*. American Fisheries Society, Bethesda, Maryland, USA.
- 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.
- Jouladeh-Roudbar A., Vatandoust S., Eagderi S., Jafari-Kenari S., Mousavi-Sabet H., 2015 Freshwater fishes of Iran; an updated checklist. *AAFL Bioflux* 8(6):855-909.
- Kalayci F., Samsun N., Bilgin S., Samsun O., 2007 Length-weight relationship of 10 fish species caught by bottom trawl and midwater trawl from the Middle Black Sea, Turkey. *Turkish Journal of Fisheries and Aquatic Science* 7:33-36.
- Klassen J. A., Gawlik D. E., Botson B. A., 2014 Length-weight and length-length relationships for common fish and crayfish species in the Everglades, Florida, USA. *Journal of Applied Ichthyology* 30(3):564-566.
- Moreno-Valcárcel R., Oliva-Paterna F. J., Arribas C., Fernández-Delgado C., 2012 Length-weight relationships for 13 fish species collected in the Doñana marshlands (Guadalquivir estuary, SW Spain). *Journal of Applied Ichthyology* 28:663-664.
- Moshayedi F., Eagderi S., Jalili P., Mousavi-Sabet H., 2015a Allometric growth pattern and morphological development of sailfin molly *Poecilia latipinna* (Cyprinodontiformes, Poeciliidae) during early development. *Poec Res* 5(1):1-7.
- Moshayedi F., Eagderi S., Parsazade F., Azimi H., Mousavi-Sabet H., 2015b Allometric growth pattern of the swordtail - *Xiphophorus helleri* (Cyprinodontiformes, Poeciliidae) during early development. *Poec Res* 5(1):18-23.
- Mousavi-Sabet H., 2018 Range extension of an exotic sailfin molly *Poecilia latipinna* (Lesueur, 1821) in Iran. *Poec Res* 8(1):18-23.
- Mousavi-Sabet H., Eagderi S., 2014 First record of *Poecilia reticulata* Peters, 1859 (Cyprinodontiformes, Poeciliidae) from natural freshwaters of Iran. *Poec Res* 4(1):19-23.

- Mousavi-Sabet H., Eagderi S., 2016 First record of the convict cichlid, *Amatitlania nigrofasciata* (Günther, 1867) (Teleostei: Cichlidae) from the Namak Lake basin, Iran. *Iranian Journal of Ichthyology* 3(1):25-30.
- Mousavi-Sabet H., Habibi A., Bagherpur O., 2013a 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., Abdollahpour S., Salehi-Farsani A., Vatandoust S., Langroudi H. F., Jamalzade H. R., Nasrollahzadeh A., 2013b Length-weight and length-length relationships and condition factor of *Alburnus mossulensis* from the Persian Gulf basin. *AACL Bioflux* 6(4):297-302.
- 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.
- Mousavi-Sabet H., Heidari A., Fekrandish H., 2015 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 K., Abbasi S., Vatandoust S., 2016a Length-weight relationships of six species of the genera *Cobitis* and *Sabanejewia* (Cobitidae) in Iranian river systems. *Journal of Applied Ichthyology* 32:1310-1312.
- Mousavi-Sabet H., Heidari A., Mohamadi-Darestani M., Mansouri-Chorehi M., Ghasemzadeh K., 2016b Length-weight relationships and condition factors of two fish species from the southern Caspian Sea basin: *Alburnoides samiii* Mousavi-Sabet, Vatandoust & Doadrio, 2015 and *Ponticola iranica* Vasil'eva, Mousavi-Sabet & Vasil'ev, 2015. *Journal of Applied Ichthyology* 32:751-752.
- Mousavi-Sabet H., Homayouni H., Marjani M., Heidari A., 2016c Length-weight relationships for 5 Clupeiformes species from the Persian Gulf and Oman Sea. *Journal of Applied Ichthyology* 32:169-170.
- Mousavi-Sabet H., Heidari A., Paknejad S., 2016d 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 nine species of the genus *Paracobitis* (Nemacheilidae) in Iran. *Journal of Applied Ichthyology* 33:617-619.
- Mousavi-Sabet H., Heidari A., Vatandoust S., 2017b Length-weight and length-length relationships for 11 species of the genus *Alburnoides* Jenteles, 1861 (Cyprinidae) from Iran. *Journal of Applied Ichthyology* 33:609-612.
- Moyle P. B., 2002 *Inland fishes of California*. University of California Press, Berkeley, USA.
- Nelson J. S., 2006 *Fishes of the world*. 4th edition, John Wiley and Sons, Inc., New Jersey, USA, 624 pp.
- Radkhah A., Eagderi S., Mousavi-Sabet H., 2016 First record of the exotic species *Hemiculter leucisculus* (Pisces: Cyprinidae) in southern Iran. *Limnetica* 35(1):175-178.
- Ricker W. E., 1973 Linear regressions in fishery research. *Journal of Fisheries Research Board of Canada* 30:409-434.
- Tarkan A. S., Gaygusuz O., Acipinar H., Gürsoy C., Ozulug M., 2006 Length-weight relationship of fishes from the Marmara region (NW-Turkey). *Journal of Applied Ichthyology* 22:271-273.
- Wootton R. J., 1998 *Ecology of teleost fishes*. Kluwer Academic Publishers, Dordrecht, 396 pp.

Received: 25 October 2018. Accepted: 25 November 2018. Published online: 11 December 2018.

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How to cite this article:

Mousavi-Sabet H., Salehi M., 2018 Length-weight and length-length relationships of an established exotic Mosquitofish population (*Gambusia holbrooki*), from Namak Lake basin in central Iran. *Poeciliid Research* 8(1):27-32.