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# Length-Weight Relationships for Four Threatened Fish Species in Asi (Orontes) River Basin, Turkey

Sibel Alagöz Ergüden*

Çukurova University, Vocational School of Imamoglu, Department of Fisheries 01700, Imamoglu, Adana, Turkey

## Abstract

The length-weight relationships (LWRs) are one of the most useful parameters for fishery management and have importance in fisheries science. The present study describes the length-weight relationships for four freshwater fish species from the Asi River system (Hatay, Turkey), namely *Cobitis anabelae* Freyhof, Bayçelebi & Geiger, 2018, *Cobitis levantina* Krupp & Moubayed, 1992, *Oxynamecheilus hamvii* (Krupp & Schneider, 1991) and *Oxynamecheilus namiri* (Krupp & Schneider, 1991). A total of 154 specimens collected for this study was caught by fishing gears from June 2017 and March 2018. This study presented the first reference on LWRs for C. anabelae, *C. levantina*, and *O. namiri* from inland waters of Turkey. Besides, this data also will be helpful in FishBase.

**Keywords:**
Length-weight parameters, Freshwater, Threatened fishes, Southeastern Anatolia
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## Introduction

Anatolia (Turkey) is known as an important biodiversity region in terms of species diversity of freshwater fish (Geiger et al., 2014). Freyhof et al. (2014) stated that the Middle East has a very rich diversity in terms of freshwater fish, and new species have been frequently described in the last two decades.

The spined loaches, *Cobitis* is a genus of small freshwater fishes in the family Cobitidae commonly found in Asia and Europe (Fricke et al., 2007). Especially, new species of spined loaches, belonging to the genus *Cobitis* in Anatolia, Turkey has been described by researchers for decades (Freyhof et al., 2018). In the light of the recent revision studies, the existence of two *Cobitis* species namely as Anabel's spined loach *Cobitis anabelae* Freyhof, Bayçelebi & Geiger (2018)

* *Corresponding Author: Sibel ALAGÖZ ERGÜDEN, E-mail: alagozs@cu.edu.tr*

and Orontes spined loach, *Cobitis levantina* Krupp & Moubayed (1992) has been confirmed from the Asi River basin (Freyhof et al., 2018).

*Oxynoemacheilus* is a genus belonging to the Nemacheilidae family and this fish species is known from Albania eastwards to Central Iran (Krupp & Schneider, 1991; Freyhof et al., 2011). Also recently, most nemacheilid loaches from Eastern Europe and the Middle East including the genus *Oxynoemacheilus*, many new species from inland water of Turkey have been reconsidered by various researchers (Geiger et al., 2014; Bayçelebi, 2020). According to the revision studies (Çicek et. al., 2020) carried out in recent years, two *Oxynoemacheilus* species; loach, *Oxynoemacheilus hamwii* (Krupp & Schneider, 1991) and levantine roach, *Oxynoemacheilus namiri* (Krupp & Schneider, 1991) have been reported as valid species in the Asi (Orontes) River system.

Length-weight relationships (LWRs) are very important in fish biology. These parameters can provide information on the stock condition and growth studies. LWRs are essential to recognize the ecology and life cycle of fish species and very useful to predict weights from easier measures of lengths (Froese, 2006; Santos et al., 2002).

In this study, present data report the length-weight relationships (LWRs) for four threatened freshwater fish species from Asi River, Turkey (south-eastern Anatolia, Hatay, Turkey). Besides, length-weight relationships were estimated for the first time for these three species (*C. anabelae, C. levantina, O. namiri*) except for *O. hamwii* from inland waters of Turkey.

**Materials and Method**

Fish samples were collected scoop net and tulle net at 0-1 m depths between June 2017 and March 2018 in the Asi River Basin, Turkey (Figure 1). After collected all samples were preserved in the icebox and transported to the laboratory. Total lengths (TL) of the specimens were measured to the nearest 0.1 cm and total weights (TW) were scaled to the nearest 0.01 g.

Fish species were identified in the laboratory according to Freyhof et al. (2018) and Baycelebi (2020), and four species were checked in Freshwater Checklist (Çicek et. al., 2020) and FishBase (Froese & Pauly, 2021). Sampling locations, sampling time, and coordinate information are given in detail in Table 1.

The LWRs were established using linear regression analysis with the equation $W= axL^b$. Logarithmic transformation was used for the data. TW and TL were log-transformed: logTW = log(a) + blog(TL), where a is the intercept of the regression curve and b is the slope (Bagenal & Tesch, 1978).

The determination coefficient ($r^2$) was used as an indicator of the quality of the linear regression. Whether the growth of fish was isometric (b =3) or allometric (b >3, b <3) was estimated by the student's t-test. Analysis of variance (ANOVA) was used to test the difference of the b values of the length-weight relationship between sexes (Zar, 1999).

All data were statistically analyzed by using Microsoft Excel 2017 and SPSS Version 22.0 package programs.

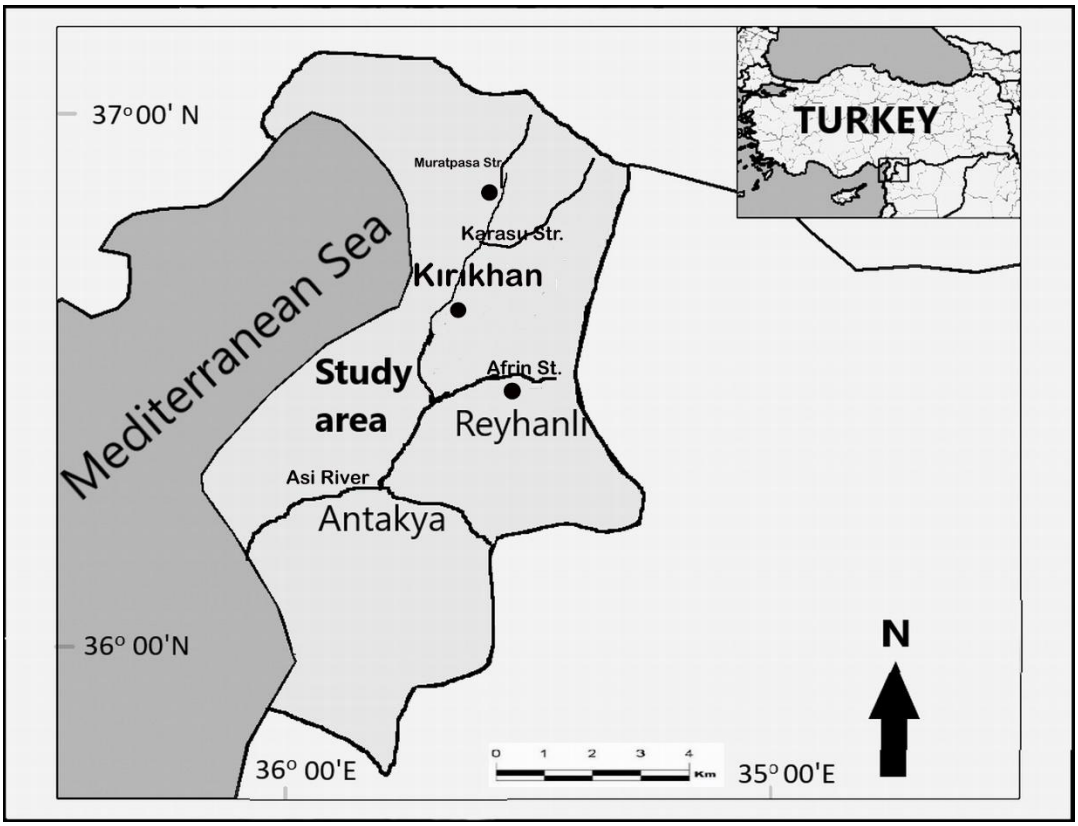


Figure 1. Sampling locations in the Asi River basin

Table 1. Sampling locations, sampling time, and coordinates for four fish species in the Asi River basin

| Local Name | Locality | Date | Coordinates | Native/Endemic |
|---|---|---|---|---|
| Loach/Çöpçü baligi | Afrin Stream | June 2017 | 36º 19.012 N<br>036º 36.112 E | Native |
| Levantine loach/Çöpçü baligi | Muratpaşa Stream | March 2018 | 36º 25.812 N<br>036º 23.098 E | Native |
| Orontes spined loach/Tasyiyen baligi/ | Afrin Stream | June 2017 | 36º 18.781 N<br>036º 24.644 E | Native |
| Anabel's spined loach/Tasyiyen baligi/ | Karasu Stream | March 2018 | 36º 34.039 N<br>036º 25.644 E | Endemic |

## Results

A total of 154 fish specimens were sampled. Descriptive statistics for each species the sample size, minimum and maximum total length and LWRs parameters a and b, standard error of b, coefficient of determination, $r^{2,}$ and growth type for four freshwater fish species caught in the Asi River are given in Table 2. Linear regressions were significant in all species ($P < 0.001$).

Samples size ranged from 32 for *C. levantina*, to 45 for *O. hamvii*. The $r^2$ values ranged from 0.950 for *O. hamvii* to 0.972 for *C. anabelae*. The values of the b LWRs ranged from 3.105 to 3.881 for the four fish species (Table 2). The values of b were found that an allometric growth for all fish species.

Table 2. Descriptive statistics and estimated parameters of length-weight relationships four threatened fish species from Asi River (Southeastern Anatolia)

| **Species** | **n** | **$L_{min}$-$L_{max}$ (TL, cm)** | **a** | **b** | **±S.E(b)** | **95% CI of b** | **$r^2$** | **Growth** |
|---|---|---|---|---|---|---|---|---|
| *Oxynamecheilus hamwii* | 48 | 3.5-6.2 | 0.0055 | 3.121 | 0.104 | 2.911-3.331 | 0.950 | A+ |
| *Oxynamecheilus namiri* | 41 | 3.2-5.3 | 0.0061 | 3.105 | 0.112 | 2.879-3.330 | 0.951 | A+ |
| *Cobitis anabelae* | 33 | 3.5-7.2 | 0.0027 | 3.762 | 0.113 | 3.532-3.993 | 0.972 | A+ |
| *Cobitis levantina* | 32 | 4.0-7.3 | 0.0019 | 3.881 | 0.159 | 3.556-4.206 | 0.952 | A+ |

n: Sample size; TL: Total length; a: Intercept of the relationship; b: Slope of the relationship; S.E.(b): Standard Error of b; $r^2$: Coefficient of determination; CI: Confidence Interval

Length-weight relationships of *C. anabelae C. levantina O. hamvii* and *O. namiri*, are found $W= 0.0055xL^{3.121}$, $W= 0.0061xL^{3.105}$, $W= 0.0027xL^{3.762}$ and $W= 0.0019xL^{3.881}$ respectively (Figure 2). The length-weight regressions were significant ($P < 0.001$) for all species, with all $r^2$ values greater than 0.95. A comparison of published length-weight relationship parameters in different areas for *O. hamvii* is given in Table 3.

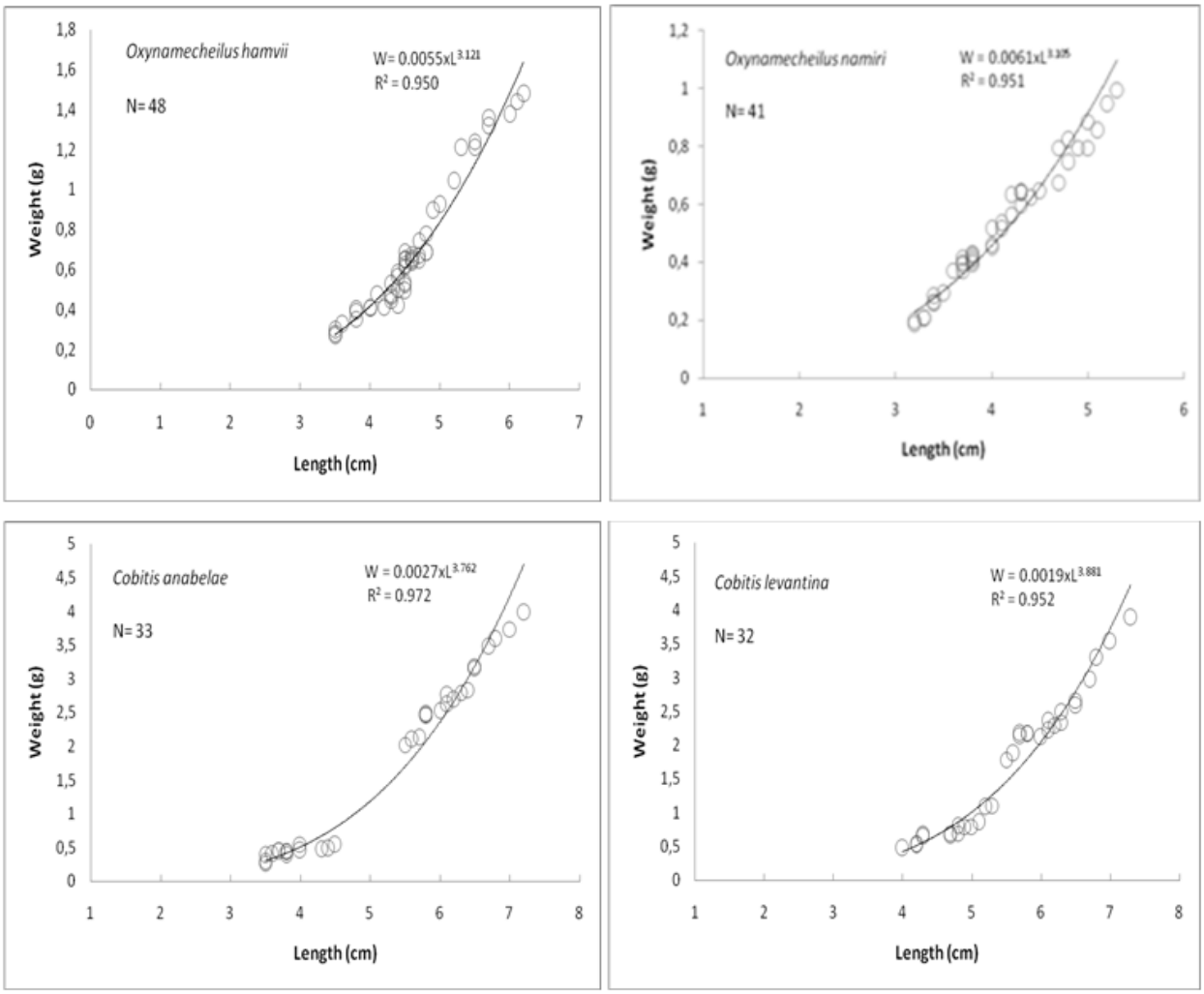


Figure 2. Length–weight relationships for *O. hamvii*, *O. namiri*, *C. anabelae* and *C. levantina* from the Asi River (Hatay, Turkey)

Table 3. Length-weight relationships of *Oxynamecheilus hamwii* from different areas for Turkey

| **Species** | **Study** | **Location** | **Country** | **n** | **Sex** | **Length (TL, cm) Min- Max** | **a** | **b** | **$r^2$** |
|---|---|---|---|---|---|---|---|---|---|
| *Oxynamecheilus hamwii* | Birecikligil and Ciçek, (2011) | Euphrates and Orontes Rivers | Turkey | 20 | Mixed | 4.3-6.3 | 0.0099 | 2.660 | 0.921 |
| *Oxynamecheilus hamwii* | Özcan and Altun (2016) | Gölbaşı Lake (Hatay) | Turkey | 28 | Mixed | 5.0-8.8 | 0.0021 | 3.520 | 0.955 |
| *Oxynamecheilus hamwii* | This study | Asi River | Turkey | 48 | Mixed | 3.5-6.2 | 0.0055 | 3.121 | 0.950 |

**Discussion**

In the present study, 154 specimens of 4 fish species (*C. anabelae C. levantina O. hamvii* and *O. namiri*) representing 2 families were investigated from the Asi River Basin. The estimated parameters of the LWRs are given in Table 2. R-square values ranged from 0.95 for *O. hamvii* to 0.97 for *C. anabelae*.

The b values for four fish species fall between 2.5-3.5, which agrees with the suggestion of Froese (2006). A value of three indicates that fish grows symmetrically or isometrically: values other than 3 indicate allometric growth. The values of b were 3.121, 3.105, 3.762, 3.881 for overall samples of *O. hamvii*, *O. namiri*, *C. anabelae*, and *C. levantina*, respectively, and the growth of these species was allometric (b>3) (Table 2).

To date, no references dealing with length-weight relationships for the three species (*O. namiri*, *C. anabelae*, and *C. levantina*) are available, thus it was not possible to compare the present results with previous references. However, there are a few studies on the length-weight relationship of *O. hamvii* only in inland waters of Turkey. In addition, the comparison of length-weight relationship parameters obtained by various researchers from different regions for other fish species belonging to the genus *Cobitis* and *Oxynamecheilus* are given in Table 4 and Table 5.

Based on previously reported studies, positive allometry (+) and negative allometry (-) were observed in *O. hamvii* from Turkey (Table 3). Positive allometric growth (b= 3.520) determined in this study was in accordance with results reported in the previous study (Özcan & Altun, 2016). On the contrary, Birecikligil & Çiçek (2011) from Euphrates and Orontes Rivers of Turkey has reported negative allometric growth (b= 2.660). These differences could be the result of environmental factors, food, sex, reproductive period, seasonal variation fishing time, and area (Bagenal & Tesch, 1978; Ricker, 1973).

The parameters of b generally do not vary significantly throughout the year, unlike parameter *a*, which may vary seasonally, daily, and between habitats (Bagenal & Tesch, 1978; Goncalves et al., 1997). Besides, several factors are known to influence the LWRs in fish, including habitat, general fish condition, gonad maturity, season, and preservation of fish (Tesch, 1971; Bagenal & Tesch, 1978; Wootton, 1990), these factors were not accounted in the present study.

Table 4. Comparison of length-weight relationships parameters for *Cobitis* fish species from different regions

| Species | Reference | Area | Length Type (cm) | n | Sex | Length Min-Max | a | b | $r^2$ |
|---|---|---|---|---|---|---|---|---|---|
| *Cobitis taenia* | Robotham (1981) | River Great Ouse, UK | TL | 425 | F | 5.5-8.3 | 0.0052 | 2.08 | - |
| | | | TL | 326 | M | 4.6-7.2 | 0.0076 | 1.81 | - |
| *Cobitis taenia* | Marconato & Rasotto (1989) | Timonchio Stream, Italy | TL | 94 | F+M | 4.6-11.0 | 0.878 | 3.19 | 0.994 |
| *Cobitis simplicispina* | Ekmekci & Erkakan (2003) | Darıözü Creek, Turkey | SL | 67 | F+M | 9.1-9.8 | 0.00567 | 3.00 | 0.920 |
| *Cobitis turcica* | Erk'akan et al. (2013) | Saz Lake, Turkey | TL | | F+M | 3.8-7.3 | 0.044 | 3.33 | 0.956 |
| *Cobitis paludica* | Sanchez-Carmona et al. (2008) | Portil Lagoon, Iberian Peninsula | TL | 855 | F+M | 3.2-10.2 | 0.00497 | 3.07 | 0.927 |
| *Cobitis paludica* | Sanchez-Carmona et al. (2008) | Rivera de Cala River, Iberian Peninsula | TL | 236 | F+M | 3.1-11.5 | 0.00281 | 3.39 | 0.966 |
| *Cobitis cf. satunini* | Patimar et al. (2011) | Southern Caspian basin (northern Iran) | TL | | F | 7.6-8.0 | 0.0037 | 3.34 | - |
| | | | TL | | M | 5.6-6.0 | 0.0047 | 3.25 | - |
| *Cobitis turcica* | Kırankaya & Ekmekçi (2014) | Pınarbaşı-Gök Lake, Turkey | TL | | F | 12.6 | 0.00001 | 2.83 | 0.920 |
| | | | TL | | M | 10.3 | 0.000008 | 2.91 | 0.810 |
| *Cobitis turcica* | Koca & Ölmez (2015) | Aksu Stream-Köprüçay River, Turkey | TL | 258 | F+M | 4.8-12.3 | 0.14 | 2.95 | 0.940 |
| *Cobitis taenia* | Zencir & Korkmaz (2016) | Kirmir Stream, Turkey | SL | 21 | F+M | 6.0-11.8 | 0.113 | 1.94 | 0.550 |

n: Sample size; TL: Total length; SL; Standard length; F: Female; M: Male; a: Intercept of the relationship; b: Slope of the relationship; $r^2$: Coefficient of determination

Table 5. Comparison of length-weight relationships parameters for other *Oxynamecheilus* fish species from different regions

n: Sample size; a: Intercept of the relationship; b: Slope of the relationship; $r^2$: Coefficient of determination

| Species | Reference | Area | n | Sex | Length Min-Max | a | b | $r^2$ |
|---|---|---|---|---|---|---|---|---|
| *Oxynamecheilus angorae* | Gaygusuz et al. (2013) | Balıklı Stream (western part of Anatolia), Turkey | 30 | Mixed | 4.7-7.3 | 0.006 | 3.23 | 0.882 |
| *Oxynamecheilus eregliensis* | Erk'akan et al. (2013) | Melendiz Creek, Turkey | 76 | Mixed | 1.65-10.3 | 0.005 | 3.19 | 0.979 |
| *Oxynamecheilus angorae* | Erk'akan et al. (2014) | Sögütözü Beynam, Turkey | 24 | Mixed | 4.4-8.3 | 0.00622 | 3.22 | 0.992 |
| *Oxynamecheilus simavicus* | Erk'akan et al. (2014) | Karaçaltı Creek, Turkey | 17 | Mixed | 4.6-7.1 | 0.0044 | 3.26 | 0.953 |
| *Oxynamecheilus mesudae* | Erk'akan et al. (2014) | Küfe Creek, Turkey | 14 | Mixed | 6.6-8.9 | 0.0161 | 2.62 | 0.951 |
| *Oxynamecheilus evreni* | Erk'akan et al. (2014) | Çayır Creek,Turkey | 27 | Mixed | 5.4-9.4 | 0.0128 | 2.78 | 0.921 |
| *Oxynamecheilus samanticus* | Erk'akan et al. (2014) | Karaboğaz Creek, Turkey | 40 | Mixed | 4.5-8.6 | 0.00851 | 2.91 | 0.919 |
| *Oxynamecheilus theophilii* | Innal et al. (2015) | Bozcay Creek, Turkey | 10 | Mixed | 3.1-5.6 | 0.01 | 2.89 | 0.94 |
| *Oxynamecheilus theophilii* | Innal et al. (2015) | Dalaman Stream, Turkey | 10 | M ixed | 6.4-7.9 | 0.011 | 2.98 | 0.93 |
| *Oxynamecheilus theophilii* | Innal et al. (2015) | Cüneyt Creek, Turkey | 17 | M ixed | 6.6-10.5 | 0.007 | 3.07 | 0.96 |
| *Oxynamecheilus theophilii* | Innal et al. (2015) | Duger Spring, Turkey | 13 | M ixed | 3.9-5.8 | 0.007 | 3.18 | 0.94 |
| *Oxynamecheilus theophilii* | Innal et al. (2015) | Yiğitler Creek, Turkey | 9 | M ixed | 5.5-8.9 | 0.004 | 3.29 | 0.98 |
| *Oxynamecheilus angorae* | Birekcikliğil et al. (2016) | Kızılırmak River Basin, Turkey | 127 | M ixed | 2.8-8.6 | 0.008 | 3.10 | 0.84 |
| *Oxynamecheilus angorae* | Yazıcıoğlu &Yazıcı (2016) | Kılıçözü Stream, Turkey | 103 | M ixed | 3.5-9.8 | 0.0098 | 2.92 | 0.963 |
| *Oxynamecheilus veyseli* | Özdemir et al. (2019) | Bozkuş Creek, Turkey | 46 | M ixed | 3.9-10.0 | 0.0111 | 2.82 | 0.965 |

n: Sample size; a: Intercept of the relationship; b: Slope of the relationship; $r^2$: Coefficient of determination

Today, three freshwater fish species (*C. anabelae*, *C. levantina* and *O. hamvii*) are considered locally Endangered (EN) and Near Threatened (NT) species listed by the IUCN Red

List (Freyhof, 2014a, b; Freyhof et al., 2018; IUCN, 2021). In recent years, these species living in the Asi River have been affected by water pollution, habitat destruction, and water abstraction. Besides, low rainfall due to climate change as well as increased exploitation of the water resources in the Asi River very seriously threatens these fish species (IUCN, 2021). Therefore, conservation action needs to be taken as a high priority for these threatened fish species in the Asi River basin.

The present study provides the first reference on LWRs are useful scientists and fishery management, and conservation. Besides, length-weight estimates for *C. anabelae*, *C. levantina*, and *O. namiri* were not available in the Fishbase database for Orontes River. Thus, this data also will be helpful in FishBase.

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**Author Contributions**

The author contribution is equal for the preparation research in the manuscript.

**Conflict of Interest**

Author declares that no conflict of interest pertaining to the publication of this manuscript.

**References**

Bagenal, T. B., & Tesch, F. W. (1978). *Age and growth*. pp. 101-136. In: T. Bagenal (Ed.). *Methods for assessment of fish production in fresh waters*. 3 rd edition, IBP Handbook No. 3, UK: Blackwell Scientific Publications, Oxford.

Bayçelebi, E. (2020). Distribution and Diversity of Fish from Seyhan, Ceyhan and Orontes River Systems. *Zoosystematics and Evolution*, 96(2), 747-767. http://dx.doi.org/10.3897/zse.96.55837

Birecikligil, S., & Çiçek. E. (2011). Length-Weight Relationships for 16 Freshwater Fishes Caught in Tributaries of Euphrates and Orontes Rivers in Gaziantep (southeastern Anatolia, Turkey. *Journal of Applied Ichthyology*, 27, 1131-1132. https://doi.org/10.1111/j.1439-0426.2011.01760.x

Birecikligil, S. S., Çiçek, E., Öztürk, S., Seçer, B., & Celepoğlu, Y. (2016). Length-Length, Length-Weight Relationship and Condition Factor of Fishes in Nevşehir Province, Kızılırmak River Basin (Turkey). *Acta Biologica Turcica*, 29, 72-77.

Çiçek, E., Sungur, S., & Fricke, R. (2020). Freshwater Lampreys and Fishes of Turkey; A Revised and Updated Annotated Checklist 2020. *Zootax*a, 4809(2), 241-270. https://doi.org/10.11646/zootaxa.4809.2.2

Ekmekçi, F.G., & Erk'akan, F. (2003). Preliminary Data on Growth and Reproduction of *Cobitis simplicispina* from Turkey. *Folia Biologica (Kraków)*, 51, 183-186.

Erk'akan, F., Innal, D., & Özdemir, F. (2013). Length–Weight Relationships for Ten Endemic Fish Species of Anatolia. *Journal of Applied Ichthyology*, 29, 683-684. https://doi.org/10.1111/jai.12140

Erk'akan, F., Innal, D., & Özdemir, F. (2014). Length-Weight Relationships for Some Endemic Stone and Spine loach Species in Anatolia. *Journal of Applied Ichthyology*, 30, 244-245. https://doi.org/10.1111/jai.12260

Fricke, R., Bilecenoglu, M., & Sari, H. M. (2007). Annotated Checklist of Fish and Lamprey Species (*Gnathostoma* and *Petromyzontomorphi*) of Turkey, Including a Red List of Threatened and Declining Species. *Stuttgarter Beitr. Naturk. Sea A,* (706), 1-172.

Freyhof, J., Erk'akan, F., Cevher Özeren, C., & Anabel Perdices, A. (2011). An Overview of the Western Palaearctic Loach Genus *Oxynoemacheilus (*Teleostei: Nemacheilidae). *Ichthyological Exploration of Freshwater*, 22(4), 301-312.

Freyhof, J. (2014a). *Oxynoemacheilus hamwii*. The IUCN Red List of Threatened Species 2014: e.T19414192A19849096. https://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T19414192A19849096.en. Downloaded on 25 August 2021.

Freyhof, J. (2014b). *Cobitis levantina*. The IUCN Red List of Threatened Species 2014: e.T61390A19010687. https://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T61390A19010687.en. Downloaded on 25 August 2021.

Freyhof, J., Bayçelebi, E., & Geiger, M. (2018). Review of the Genus *Cobitis* in the Middle East, with the Description of Eight New Species (Teleostei: Cobitidae). *Zootaxa*, 4535(1), 001-075. https://doi.org/10.11646/zootaxa.4535.1.1

Froese, R. (2006). Cube Law, Condition Factor and Weight Length Relationships: History, Meta-Analysis and Recommendations. *Journal of Applied Ichthyology*, 22, 241-253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Froese, R., & Pauly, D. (2021). Fishbase. Worldwide Web Electronic Publication. www.fishbase.org, Version (06/2021).

Gaygusuz, O., Aydın, H., Emiroglu, O., Top, N., Dorak, Z., Gaygusuz, C. G., Baskurt, S., & Tarkan, A. S. (2013). Length-Weight Relationships of Freshwater Fishes from the western Part of Anatolia, Turkey. *Journal of Applied Ichthyology*, 29(1), 285-287. https://doi.org/10.1111/jai.12015

Geiger, M. F., Herder, F., Monaghan, M. T., Almada, V., Barbieri, R., Bariche, M., Berrebi, P., Bohlen, J., Casal-Lopez, M., Delmastro, G.B., Denys, G. P. J., Dettai, A., Doadrio, I., Kalogianni, E., Kärst, H., Kottelat, M., Kovačić, M., Laporte, M., Lorenzoni, M., Marčić, Z., Özuluğ, M., Perdices, A., Perea, S., Persat, H., Porcelotti, S., Puzzi, C., Robalo, J., Šanda, R., Schneider, M., Šlechtová, V., Stoumboudi, M., Walter, S. & Freyhof, J. (2014). Spatial Heterogeneity in the Mediterranean Biodiversity Hotspot Affects Barcoding

Accuracy of Its Freshwater Fishes. *Molecular Ecology Resources*, 14, 1210-1221. https://doi.org/10.1111/1755-0998.12257

Goncalves, J. M. S., Bentes, L., Lino, P. G., Ribeiro, J., Canario, A. V. M., & Erzini, K. (1997). Weight-Length Relationships for Selective Fish Species of the Small Scale Demersal Fisheries off the South and Southwest Coast of Portugal. *Fisheries Research*, 30, 253-256. https://doi.org/10.1016/S0165-7836(96)00569-3

Innal, D., Özdemir, F., & Dogangil, B. (2015). Length-Weight Relationships of *Oxynoemacheilus theophilii* (Teleostei: Nemacheilidae) from Turkey. *International Journal of Fisheries and Aquatic Studies*, 2, 249-250.

IUCN, (2021). The IUCN Red List of Threatened Species. Version 2021-1. Retrieved on August 25, 2021 https://www.iucnredlist.org

Kırankaya, Ş. G., & Ekmekçi, F. G. (2014). Growth and Reproduction of a Stream Population of *Cobitis turcica* in Central Anatolia (Turkey). *Journal of Applied Ichthyology*, 30(2), 322-328.

Koca, H. U., & Ölmez, M. (2015). Age, Growth and Mortality of the *Cobitis turcica* (Hanko, 1925) Population from Aksu Stream-Köprüçay River (Isparta-Turkey). *LimnoFish*, 1(3), 113-121. https://doi.org/10.17216/LimnoFish-5000128870

Krupp, F., & Schneider, W. (1991). Two New species of *Nemacheilus* Bleeker, 1863 from the Orontes River Drainage Basin of Lebanon, Syria and Turkey. (Pisces, Osteichthyes: Balitoridae). *Senckenbergiana Biologica.* 71, 23-34.

Özcan, G., & Altun, A. (2016). Length–Weight and Length-Length Relationships for Four Freshwater Fish Species from Gölbaşı Lake (Hatay), Turkey. *Journal of Applied Ichthyology*, 32(6), 1350-1352. https://doi.org/10.1111/jai.13215

Özdemir F., & İnnal, D., Erk'akan, F. (2019). Length and Weight Parameters of the Loach, *Oxynoemacheilus veyseli* (Nemacheilidae) in Bozkuş Creek (Kars-Turkey). *Menba Su Ürünleri Dergisi*, 5(1), 1-5.

Marconato, A., & Rasotto, M. B. (1989). The Biology of a Population of Spined Loach, *Cobitis taenia* L., *Bolletino di Zoologia*, 56(1), 73-80. https://doi.org/10.1080/11250008909355624

Patimar, R., Amouei, M,, & Mir-Ashrafi Langroudi, S. M. (2011). New Data on the Biology of *Cobitis cf. satunini* from the Southern Caspian Basin (northern Iran). *Folia Zoologica*, 60(4), 308-314.

Ricker, W. E. (1973). Linear Regressions in Fishery Research. *Journal of Fisheries Research Board of Canada*, 30, 409-434.

Robotham, P. W. J. (1981). Age, Growth and Reproduction of a Population of Spined Loach, *Cobitis taenia* (L.). *Hydrobiologia*, 85, 129-136. https://doi.org/10.1007/BF00006622

Sanchez-Carmona, R., Encina, L., Rodriguez-Ruiz, A., Rodriguez-Sanchez, V. (2008). Age, Growth and Diet of the Iberian loach, *Cobitis paludica* in Two Different Environments. *Folia Zoologica*, 57(4), 420-434.

Santos, M. N., Gaspar, M. B., Vasconcelos, P., & Monteiro, C. C. (2002). Weight-Lenght Relationships for 50 Selected Fish Species of the Algarve coast (Southern Portugal). *Fisheries Research*, 59, 289-295. https://doi.org/10.1016/S0165-7836(01)00401-5

Tesch, F. W. (1971). *Age and growth.* pp. 99-130. In: W. E. Ricker (Ed.). Methods for Assesment of Fish Production in Freshwaters. UK: Blackwell Scientific Publications, Oxford.

Yazıcıoğlu, O., & Yazıcı, R. (2016). The Length-Weight, Length-Length Relationship and Condition Factor of Angora Loach, *Oxynoemacheilus angorae* (Steindachner, 1897) Inhabiting Kılıçözü Stream in Kızılırmak River Basin (Central AnatoliaTurkey). *Turkish Journal of Agriculture - Food Science and Technology*, 4, 1165- 1168. https://doi.org/10.24925/turjaf.v4i12.1165-1168.973

Zar J. H. (1999). *Biostatistical Analysis*. 4th edition. PrenticeHall, Englewood Cliffs, New Jersey.

Zencir, Ö., & Korkmaz, A. Ş. (2016). Length-Weight and Length-Length Relationships of Fish Species in Kirmir Stream and Its Tributaries (Suveri and Ilhan Stream) of Sakarya River, Turkey. *Journal of Applied Biological Sciences*, 10(1), 55-60.