

Length-Weight Relationship of *Knipowitschia ephesi* Ahnelt, 1995 (Actinopterygii: Gobiidae) from the Kocagöz Lake, Izmir, Turkey

Deniz Innal^{1*}, Salim Serkan Güçlü² & Daniela Giannetto³

¹ Department of Biology, Mehmet Akif Ersoy University, Istiklal Campus, Burdur, Turkey

² Eğirdir Fisheries Faculty, Isparta University of Applied Science, East Campus, Isparta, Turkey

³ Department of Biology, Faculty of Science, Muğla Sıtkı Koçman University, Muğla, Turkey

Abstract: This study reports the first data on length-weight relationship for the Ephesus dwarf goby *Knipowitschia ephesi* Ahnelt, 1995, an endemic species of the Aegean Region of Turkey. Fish sampling was carried on from January to November 2015 in the Kocagöz Lake. A total of 61 specimens of *K. ephesi* were collected: 23 females and 38 males, with an overall M : F sex ratio of 1.6 : 1.0. Their size ranged from 1.73 to 3.40 cm and a new maximum total length of 3.4 cm was reported for the species. The overall length-weight relationship was: $W = 0.0122 TL^{2.7517}$. It was $W = 0.0141 TL^{2.5683}$ for males and $W = 0.0064 TL^{3.3873}$ for females.

Key words: *Knipowitschia ephesi*, ephesus dwarf goby, Küçük Menderes wetlands, endemic species

Introduction

The genus *Knipowitschia* Iljin, 1927 (Gobiidae) is native to Eurasia, from the Black and Caspian Sea to the Aegean, Adriatic and Ionian Sea drainages. These species are eurytopic or freshwater, mostly endemic to a restricted area (MILLER 2004, KOVAČIĆ 2005, OZCAN 2009). South-Western Anatolia represents an important biodiversity hotspot for this genus, with five recorded species, four of which are endemic to the area: *K. byblisia* Ahnelt, 2011, *K. caunos* Ahnelt, 2011, *K. ephesi* Ahnelt, 1995 and *K. mermere* Ahnelt, 1995. These species deserve particular attention because they occur only in isolated habitats (AHNELT et al. 1995, AHNELT 1995, 2011, 2016, GÜÇLÜ & KÜÇÜK 2015, ÇIÇEK et al. 2015, 2016).

The Ephesus dwarf goby *K. ephesi* is a freshwater goby restricted to the Küçük Menderes wetlands and delta lakes in the Aegean Region of Turkey (FREYHOF 2014). The species is well distinguishable by the reduction in squamation and body-size as well as by additional longitudinal interorbital

and oculo-scapular series of sensory papillae rows (AHNELT 1995). However, a recent study by GEIGER et al. (2014) reported *K. ephesi* as genetically identical to some populations of *K. caucasica*, a congeneric species with a wide distribution and rather well studied, also from parasitological point of view (STOYANOV et al. 2015, 2016). *Knipowitschia ephesi* is reported to be seriously threatened by several pressures, mainly water extraction, habitat destruction and pollution (CRIVELLI 1996). For all these reasons currently affecting the small distribution area of the species, it is believed to have declined and is listed as Critically Endangered (FREYHOF 2014). Despite this, there is very little information on the biology and ecology of this species. The deficiency of data, together with the lack of proper conservation actions, represents a severe threat for the survival of this endemic species and could lead to the loss of this important biodiversity heritage (GIANNETTO et al. 2013). Detailed studies focusing on biology and ecology of these species are strongly required. To

*Corresponding author: innald@gmail.com

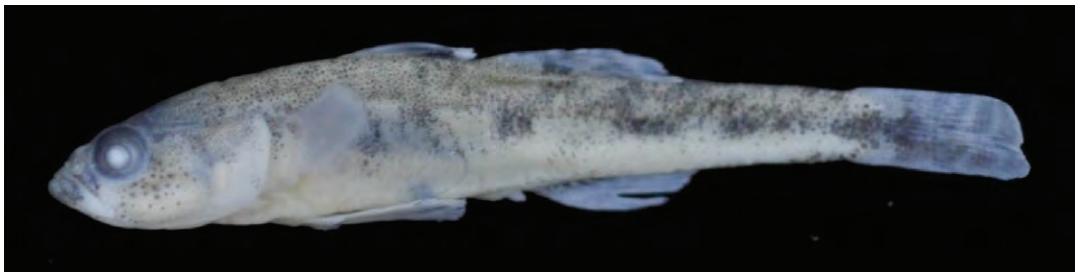


Fig. 1. A specimen of *Knipowitschia ephesi* collected from Kocagöz Lake.



Fig. 2. Kocagöz Lake – the water body where the present study was carried out.

date, no studies reporting data on population structure and length-weight relationships for this species have been carried out.

The aim of the present article is to report the first data on the length-weight relationship for *K. ephesi* (Fig. 1) from the Kocagöz Lake.

Materials and Methods

Data were collected from the Kocagöz Lake (Selçuk-İzmir, South-Western Turkey), one of the lakes of the Küçük Menderes drainage. This lake (Fig. 2) has an area of about 3 ha and it is severely impacted by channelisation, water extraction for agricultural purposes, riparian degradation, drying up during summer and the presence of alien species (D. Innal, personal observations).

The fish sampling was carried out from January to November 2015 by means of shore seine nets. Together with *K. ephesi* other seven fish species were found: *Alburnus demiri*, *Anguilla anguilla*, *Carassius gibelio*, *Cyprinus carpio*, *Cobitis kurui*, *Gambusia holbrooki* and *Petroleuciscus smyrnaeus*. Among all, the alien *G. holbrooki* was the most abundant.

The collected specimens of *K. ephesi* (Fig. 1) were measured for total length (TL, in cm) to the nearest millimeter and total weight (W, in g) using a digital balance with an accuracy of 0.01 g. Sex was firstly recognised by a macroscope observation of the gonads. The overall sex ratio was assessed by X^2 test. Total length (TL)-weight (W) relationships for

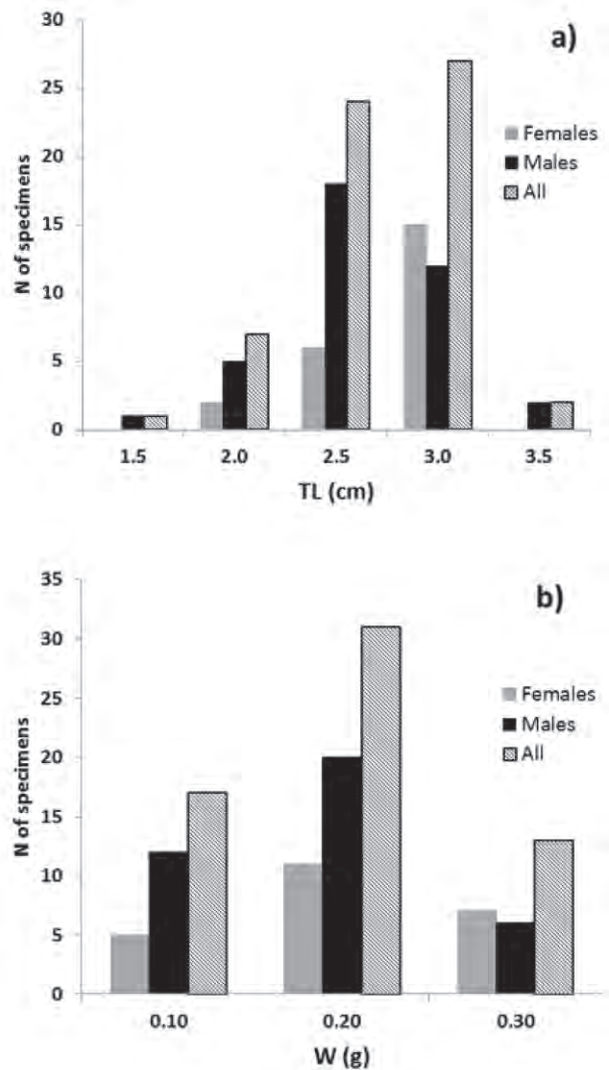


Fig. 3. Total length in cm (a) and weight in g (b) frequency distributions for males (black), females (grey) and all specimens (grid) for *Knipowitschia ephesi* from the Kocagöz Lake.

the total sample and separated for males and females were estimated using the equation $W = aTL^b$, where a was the intercept on the Y-axis of the regression curve and b was the regression coefficient (RICKER 1975). In order to test probable differences between sexes, these regressions were then compared using Analysis of Covariance (ANCOVA) with TL as the covariate variable.

Table 1. Descriptive statistics and estimated parameters of total length (TL)-weight (W) regression for different populations of *Knipowitschia* spp.

Species	Sex	N	TL (cm)		a	b	r	Locality	Reference
			mMin	mMax					
<i>K. caucasica</i>	All	397	1.3	4.1	0.003	3.46	0.91	Evros River Delta, Greece	KLEANTHIDIS et al. (1999)
	M	230	-	2.9	0.004	3.25	0.86		
	F	158	-	4.1	0.003	3.43	0.93		
	I	9	1.3	1.7	0.003	2.79	0.67		
<i>K. caucasica</i>	All	6	2.2	3.4	0.007	3.22	0.98	Büyükçekmece Dam Lake, Turkey	TARKAN et al. (2006)
<i>K. caucasica</i>	All	234	3.5	4.3	0.018	2.51	0.98	Caspian Sea Basin, Iran	ABDOLI et al. (2009)
	M	79	3.7	4.3	0.013	2.73	0.98		
	F	81	3.5	4.3	0.038	1.97	0.97		
<i>K. caucasica</i>	All	400	2.3	4.6	0.012	2.84	0.8	Eğirdir Lake, Turkey	GÜÇLÜ & ERDOĞAN (2017)
	M	183	2.5	4.6	0.011	2.94	0.82		
	F	202	2.4	4.0	0.014	2.76	0.74		
	I	15	2.3	3.6	-	-	-		
<i>K. mermere</i>	All	39	2.0	2.7	0.007	3.43	0.85	Marmara Lake, Turkey	İLHAN & SARI (2015)
<i>K. byblisia</i>	All	310	1.2	3.8	0.005	3.38	0.92	Köyceğiz Lagoon, Turkey	İNNAL & GIANNETTO (2017)
	M	166	1.2	3.6	0.006	3.19	0.9		
	F	144	1.7	3.8	0.004	3.63	0.94		
<i>K. caunosi</i>	All	33	1.9	3.6	0.006	3.42	0.92	Köyceğiz Lagoon, Turkey	İNNAL & GIANNETTO (2017)
	M	13	1.9	3.6	0.007	3.2	0.94		
	F	20	2.6	3.6	0.006	3.34	0.9		
<i>K. ephesi</i>	All	61	1.7	3.4	0.012	2.75	0.96	Kocagöz Lake, Turkey	Present study
	M	38	1.7	3.4	0.014	2.57	0.97		
	F	23	2.2	3.2	0.006	3.39	0.95		

Results

The examined material comprised 61 specimens of *K. ephesi* ranging in size between 1.73 and 3.40 cm (mean \pm SD = 2.67 \pm 0.37 cm; Fig. 3a) and in weight between 0.06 and 0.348 g (mean \pm SD = 0.19 \pm 0.07 g; Fig. 3b). The sample consisted of 23 females (37.7%) and 38 males (62.3%) and the overall M : F sex ratio of 1.6 : 1.0 was not significantly different from 1 : 1 ($X^2 = 3.23$; $df = 1$; $p > 0.05$).

The length-weight relationship for the total sample was calculated as:

$$W = 0.0122 TL^{2.7517} (R^2 = 0.96, n=61)$$

For males it was:

$$W = 0.0141 TL^{2.5683} (R^2 = 0.97, n=38)$$

For females it was:

$$W = 0.0064 TL^{3.3873} (R^2 = 0.95, n=23)$$

No differences between sexes were found with ANCOVA in the estimated regressions (covariate mean: TL = 2.668 cm, F = 2.942, $p=0.092$).

Discussion

The Aegean Region of Turkey represents an extremely important area for the diversity of the genus *Knipowitschia*. Several endemic species of this genus live in isolated freshwater habitats, all they being vulnerable to human threats (FREYHOF 2014). The information on their biology and ecology is still scarce. Knowledge and attention on these species is then compulsory for their conservation and to prevent their extinction. AHNELT (2011) reported that *K. ephesi* shares

with *K. mermere* and *K. byblisia* many characteristics, such as a reduced body size and other similar paedomorphic features. This reduction of body size, together with the reduction of head canals and squamation in the species of *Knipowitschia* of the Mediterranean can be explained as a result of selection pressure in small and restricted habitats (AHNELT 1995, KOVAČIĆ 2005).

The maximum total length known for *K. ephesi* was 2.3 cm (AHNELT 1995), which makes this species as the smallest known vertebrate of Turkey and the Mediterranean area (AHNELT 1995). We found that 87% of the collected specimens were bigger than the known maximum total length of 2.3 cm and a new maximum total length of 3.4 cm was found for a male specimen.

The estimated values of b of the length-weight relationship for the total sample suggested a negative allometric growth for this species and the sample studied fits within the range of 2.5-3.5 (see CARLANDER 1969). The estimated parameters for *K. ephesi* were compared with those reported for populations of other congeneric species (Table 1): the values of b for *K. ephesi* resulted lower than those reported for other populations of congeneric species except for a population of *K. caucasica* from the Caspian Sea Basin (ABDOLI et al. 2009). A further comparison was done with the Bayesian LWR predictions based on LWR estimates published in Fishbase for species of this genus and with similar body shape (FROESE et al. 2014, FROESE & PAULY 2016). The values of a fell within the 95% range confidence limits reported in FishBase ($a = 0.0100$; range = 0.00244 – 0.04107). On the other hand, the estimated parameters of b for *K. ephesi* were outside the estimated range in

FishBase – the values for the total and the male sample of *K. ephesi* were lower and that for females, i.e. higher than those predicted in FishBase ($b = 3.04$; range = 2.81 – 3.27). Differences between the measured and predicted values can be due to several factors such as the number of sampled specimens, gonad maturity, sex and growth phase (FROESE 2006). The higher b value for females is likely due to the narrow size range of the examined sample – only specimens from 2.2 to 3.2 cm have been studied.

Endemic species are very sensitive because they have a small distribution area and are the most exposed to human impacts (GIANNETTO et al. 2015). Currently, no information on biology and ecology of *K. ephesi* is available and the species is known only by museum specimens (AHNELT 1995). Further detailed studies to increase knowledge on this species and better understand its current distribution and status are needed.

References

- ABDOLI A. S., ALLAHYARI S., KIABI B. H., PATIMAR R., GHELICHI A., MOSTAFAVI H., AGHILI S. M. & RASOOLI P. 2009. Length-weight relationships for seven gobiid fish species in the southeastern Caspian Sea basin, Iran. *Journal of Applied Ichthyology* 25: 785-786.
- AHNELT H. 1995. Two new species of *Knipowitschia* from Western Anatolia (Turkey). *Mitteilungen des hamburgers zoologischen Museums und Instituts* 92: 155-167.
- AHNELT H. 2011. Two new sympatric *Knipowitschia* species (Teleostei: Gobiidae) from an eastern Mediterranean coastal lake – examples of different dispersal patterns? *Zootaxa* 3114: 22-30.
- AHNELT H. 2016. A second record of *Knipowitschia byblisia* Ahnelt, 2011 (Teleostei: Perciformes: Gobiidae) from southwestern Anatolia, Turkey. *Journal of Threatened Taxa* 8 (9): 9195-9197.
- AHNELT H., BIANCO P. G. & SCHWAMMER H. 1995. Systematics and zoogeography of *Knipowitschia caucasica* (Teleostei: Gobiidae) based on new records from the Aegean Anatolian area. *Ichthyological Explorations of Freshwaters* 6: 49–60.
- CARLANDER K. D. 1969. *Handbook of freshwater fishery biology*. Vol. 1. Ames, IA: Iowa State University Press. 752 p.
- CRIVELLI A. J. 1996. The freshwater fish endemic to the Mediterranean region. An action plan for their conservation. *Tour du Valat Publication*, 171 p.
- ÇIÇEK E., SUNGUR BIRECIKLIGİL S. & FRICKE R. 2015. Freshwater fishes of Turkey: a revised and updated annotated checklist. *Biharean Biologist* 9 (2): 141-157.
- ÇIÇEK E. & SUNGUR BIRECIKLIGİL S. & FRICKE R. 2016. Addenda and errata of: Freshwater fishes of Turkey: a revised and updated annotated checklist. *FishTaxa* 1(2): 116-117.
- FREYHOF J. 2014. *Knipowitschia ephesi*. The IUCN Red List of Threatened Species 2014: e.T61238A19009499. Downloaded on 27 December 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., THORSON J. & REYES R. B. J. 2014. A Bayesian approach for estimating length-weight relationships in fishes. *Journal of Applied Ichthyology* 30: 78-85.
- FROESE R. & PAULY D. 2016. FishBase. World Wide Web Electronic Publication. www.fishbase.org, version (01/2016).
- 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., ÖZULUG M., PERDICES A., PEREA S., PERSAT H., PORCELOTTI S., PUZZI C., ROBALO J., ŠANDA R., SCHNEIDER M., ŠLECHTOVÁ V., STUMBOUDI M., WALTER S. & FREYHOF J. 2014. Spatial heterogeneity in the Mediterranean Biodiversity Hotspot affects barcoding accuracy of its freshwater fishes. *Molecular Ecology Resources* 14 (6): 1210-1221.
- GIANNETTO D., CAROSI A., GHETTI L., PEDICILLO L., POMPEI L. & LORENZONI M. 2013. Ecological traits of *Squalius lucumonis* (Actinopterygii, Cyprinidae) and main differences with those of *Squalius squalus* in the Tiber River Basin (Italy). *Knowledge and Management of Aquatic Ecosystems* 409: 04.
- GIANNETTO D., TARKAN A.S., AKBAŞ F., TOP N., AĞDAMAR S., KARAKUŞ U., POMPEI L. & LORENZONI M. 2015. Proposed empirical standard weight, length-weight and length-length equations for three endemic cyprinid species of Aegean Region (Turkey): *Barbus pergamonensis*, *Capoeta bergamae* and *Ladigesocypris irideus*. *Turkish Journal of Zoology* 39: 925-932.
- GÜÇLÜ S. S. & KÜÇÜK F. 2015. The ichthyofauna of Gediz River (Turkey): taxonomic and zoogeographic features. *Annual Research and Review in Biology* 6 (3): 202-214.
- GÜÇLÜ S. S. & ERDOĞAN Ö. 2017. Age, growth, sex ratio and feeding of *Knipowitschia caucasica* (Berg, 1916) (Actinopterygii, Gobiidae) a non-native species of Eğirdir Lake (Turkey). *Acta Biologica Turcica* 30 (1): 1-6.
- İLHAN A. & SARI H. M. 2015. Length-weight relationships of fish species in Marmara Lake, West Anatolia, Turkey. *Croatian Journal of Fisheries* 73: 30-32.
- İNNAL D. & GIANNETTO D. 2017. Length-weight relationships of two sympatric species from Köyceğiz Lake, Turkey. *Journal of Applied Ichthyology* 33 (4): 855-857.
- KLEANTHIDIS P. K., SINIS A. I. & STERGIOV K. I. 1999. Length-weight relationships of freshwater fishes in Greece. *The ICLARM Quarterly* 22 (4): 37-40.
- KOVAČIĆ M. 2005. A new species of *Knipowitschia* (Gobiidae) from Dalmatia, Croatia. *Cybium* 29 (3): 275-280.
- MILLER P. J. 2004. *Knipowitschia* Iljin, 1927. Pp. 331-337. In: Miller, P. J. (ed.): *The Freshwater Fishes Of Europe*. Vol. 8: Gobiidae. Wiesbaden: AULA-Verlag.
- OZCAN G. 2009. The status of the Freshwater Gobiid, *Knipowitschia mermere* Ahnelt, 1995: distribution ecology and threats. *Biharean Biologist* 3 (2): 139-141.
- RICKER W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board Canada* 191, 382 p.
- STOYANOV B., NEOV B., PANKOV P., RADOSLAVOV G., HRISTOV P. & GEORGIEV B. B. 2015. Redescription of *Aphalloides coelomicola* Dollfus, Chabaud & Golvan, 1957 (Digenea, Opisthorchioidea) based on specimens from *Knipowitschia caucasica* (Berg) (Actinopterygii, Gobiionellidae) from a Black Sea lagoon, with comments on the systematic position of the genus. *Systematic Parasitology* 91: 1–12.
- STOYANOV B., HUYSE T., PANKOV P. & GEORGIEV B. B. 2016. Morphological and molecular identification of *Gyrodactylus bubyri* Osmanov, 1965 (Monogenea: Gyrodactylidae) from Caucasian dwarf goby, *Knipowitschia caucasica* (Berg) (Actinopterygii: Gobiionellidae) from a Black Sea lagoon. *Parasitology Research* 115: 1617–1625.
- TARKAN A. S., GAYGUSUZ Ö., ACIPINAR H., GÜRSOY Ç. & ÖZULUG M. 2006. Length-weight relationship of fishes from the Marmara Region (NW-Turkey). *Journal of Applied Ichthyology* 22: 271-273.

Received: 03.04.2017

Accepted: 30.09.2017