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A review of length–weight relationships of fish from the Segura River basin (SE Iberian Peninsula)

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Summary

We present the relationships between fork length and total weight for 14 fish species from the Segura River basin (southeastern Spain): *Barbus sclateri*, *Chondrostoma polylepis*, *Gobio lozanoi*, *Aphanius iberus*, *Micropterus salmoides*, *Lepomis gibbosus*, *Carassius auratus auratus*, *Cyprinus carpio carpio*, *Sander lucioperca*, *Gambusia holbrooki*, *Liza ramado*, *Mugil cephalus*, *Atherina boyeri* and *Pomatoschistus marmoratus*. Significant length–weight relationships were found for all species. The values of the exponent *b* of the length–weight relationships ranged from 3.82 for *Sander lucioperca* to 2.59 for *Micropterus salmoides*.

Introduction

Length–weight relationships have been extensively used for the conversion of growth-in-length equations to growth-in-weight for use in stock assessment models, to estimate stock biomass from limited sample sizes, as indicators of fish condition, to compare the life histories of certain species between regions and other aspects of fish population dynamics (Kolher et al., 1995; Petrakis and Stergiou, 1995; Gonçalves et al., 1997; Binohlan and Pauly, 1998; Moutopoulos and Stergiou, 2002). These relationships are an important component of FishBase (Froese and Pauly, 2005).

In this study, we report the length–weight relationships for 14 fish species collected from the Segura River basin (main watercourse, tributaries and reservoirs), one of the most arid zones in the southeastern Iberian Peninsula (Vidal-Abarca et al., 1987) and probably in Europe (Geiger, 1973). In Spain, only two regions exist with semi-arid climate characteristics, one in the central region of the Ebro depression and the other in the south-east, the location of the analysed populations. Of the 14 species presented here, the length–weight relationships for the Segura River basin have only been presented previously for two species: *Barbus sclateri* (Torralva et al., 1997; Oliva-Paterna et al., 2003a,b), and *Gobio gobio* (Miñano et al., 2003), which is actually assigned to a new species (*Gobio lozanoi*) based on genetic and morphological characters (Doadrio and Madeira, 2004). The results therefore constitute the first information for 12 of the 14 species in the Segura River basin.

Materials and methods

All length–weight relationships presented here are the product of field studies conducted during the period 2000–2004 in the Segura River basin. Fish were caught with different types of sampling gear and measured in the field for fork length (FL) to the nearest 0.1 cm using a measuring board, and weighed (TW, total weight) to the nearest 0.01 g using a digital balance. The relationship was established using linear regression analysis, TW vs FL (log-transformed): $TW = \log(a) + b \log(FL)$, where a is the intercept of the regression line and b the regression coefficient. The significance of the regression was assessed by analysis of variance (ANOVA), and the b-value for each species was tested by t-test to verify if it was significantly different from the isometric growth ($b = 3$) (Sokal and Rohlf, 1981). Additionally, the slopes of the length–weight regressions were compared for between-body of water differences using analysis of covariance (ANCOVA).

Results and discussion

Overall, 8849 specimens of 14 different fish species belonging to eight families were sampled: *Barbus sclateri* Günther, 1868; *Chondrostoma polylepis* Steindachner, 1864; *Gobio lozanoi* Doadrio and Madeira, 2004; *Aphanius iberus* (Valenciennes, 1846); *Micropterus salmoides* (Lacépède, 1802); *Lepomis gibbosus* (Linnaeus, 1758); *Carassius auratus auratus* (Linnaeus, 1758); *Cyprinus carpio carpio* Linnaeus, 1758; *Sander lucioperca* (Linnaeus, 1758); *Gambusia holbrooki* Girard, 1859; *Liza ramado* (Risso, 1810); *Mugil cephalus* Linnaeus, 1758; *Atherina boyeri* Risso, 1810 and *Pomatoschistus marmoratus* (Risso, 1810). Cyprinidae (64.3%) was the most abundant family, while barbel (*B. sclateri*), an endemic fish of the mid-south Iberian Peninsula (Doadrio, 2002), was the dominant species (38.4% of the total captures). The length–weight relationships are summarized in Table 1. Linear regressions were significant for all species ($P < 0.001$), with 15 $r^2 > 0.95$ and the lowest being 0.83. The sample size ranged from 3699 for *Barbus sclateri* to seven for *Sander lucioperca*.

The exponent b often has a value close to three, but varies between two and four (Tesch, 1971). A value close to three indicates that the fish grows isometrically and other values indicate allometric growth. The value of the slope b in the plot of log W against log L ranged from 3.82 for *Sander lucioperca*, for which only seven specimens were available, to 2.59 for *Micropterus salmoides*, where small juveniles were included (Table 1). Eight species showed isometric growth ($b = 3$): *L. ramado*, *M. cephalus*, *A. iberus* (in reservoirs), *C. carpio carpio*, *G. lozanoi*, *C. auratus auratus*, *M. salmoides* and *L. gibbosus*; seven species showed positive allometric growth ($b > 3$): *G. holbrooki*, *A. iberus* (in tributaries), *A. boyeri*, *P. marmoratus*, *B. sclateri* (in tributaries), *Ch. polylepis* and *S. lucioperca*; and only *B. sclateri* (in the main watercourse and reservoirs) showed negative allometric growth ($b < 3$). Differences in b-values can be attributed to the combination of one or more of the following factors: (i) differences in the number

Table 1
Length–weight relationships of fishes collected from Segura river basin (southeastern Spain)

Family	Species	Body of water	n	Min	Max	a	b	SE (b)	r^2	P-value
Mugilidae	*Liza ramado*	2	9	24.9	39.0	5.73×10^{-3}	3.23	0.2059	0.9724	0.2957
	Mugil cephalus	2	38	33.9	78.0	1.81×10^{-2}	2.96	0.1002	0.9605	0.7283
Poeciliidae	*Gambusia holbrooki*	1	57	2.0	5.7	5.23×10^{-3}	3.59	0.1226	0.9397	< 0.05
		2	119	2.2	5.7	4.40×10^{-3}	3.81	0.0838	0.9465	< 0.05
		3	60	1.9	4.9	7.79×10^{-3}	3.37	0.1773	0.8614	< 0.05
Cyprinodontidae	*Aphanius iberus*	2	753	1.3	4.2	1.61×10^{-2}	3.02	0.0203	0.9752	0.5191
		3	49	1.5	4.1	8.07×10^{-3}	3.53	0.1419	0.9294	< 0.05
Atherinidae	*Atherina boyeri*	2	1936	3.9	9.4	5.58×10^{-3}	3.26	0.0129	0.9706	< 0.05
Gobiidae	*Pomastoschistus marmoratus*	2	56	2.0	3.7	5.11×10^{-3}	3.54	0.1641	0.8961	< 0.05
Cyprinidae	*Cyprinus carpio carpio*	1	25	10.0	23.8	2.27×10^{-3}	3.68	0.1036	0.9992	0.0956
		2	614	1.7	56.0	1.84×10^{-2}	3.01	0.0082	0.9955	0.0530
Cyprinidae	*Barbus sclateri*	1	891	2.4	44.9	2.78×10^{-2}	2.72	0.0296	0.9048	< 0.05
		2	2019	4.0	49.5	1.94×10^{-2}	2.89	0.0059	0.9915	< 0.05
		3	1289	2.7	40.8	1.16×10^{-2}	3.04	0.0129	0.9775	< 0.05
Cyprinidae	*Chondrostoma polylepis*	1	64	5.2	23.2	5.40×10^{-3}	3.29	0.0616	0.9787	< 0.05
		2	590	5.1	35.3	9.60×10^{-3}	3.08	0.0139	0.9882	< 0.05
Cyprinidae	*Gobio lozanoi*	1	104	3.7	14.0	1.73×10^{-2}	2.88	0.1143	0.8615	0.2967
Cyprinidae	*Carassius auratus auratus*	2	92	2.6	18.0	1.93×10^{-2}	3.04	0.0206	0.9959	0.0798
Centrarchidae	*Micropterus salmoides*	1	20	9.0	37.0	6.87×10^{-2}	2.59	0.2744	0.8323	0.1557
		2	26	5.5	46.5	1.04×10^{-2}	3.11	0.0475	0.9944	0.1318
Centrarchidae	*Lepomis gibbosus*	1	41	4.8	8.8	1.56×10^{-2}	2.98	0.0356	0.9945	0.5985
Percidae	*Sander lucioperca*	1	7	39.0	75.0	3.60×10^{-4}	3.82	0.2596	0.9687	< 0.05

n, sample size; body of water :1, main watercourse; 2, reservoirs; 3, tributaries; min and max, minimum and maximum fork lengths in centimeter; a and b, parameters of the relationship; SE (b), standard error of the slope b; r^2, coefficient of determination ($P < 0.001$); P-value for Student's t-test.

of specimens examined; (ii) area/season effect; (iii) habitat; (iv) degree of stomach fullness; (v) gonad maturity; (vi) sex; (vii) health and general fish condition; (viii) preservation techniques; and (ix) differences in the observed length ranges of the specimens caught (Tesch, 1971; Wootton, 1998). Nevertheless, only habitat effect was taken into account in the present study. Thus, the slope b differs significantly (ANCOVA; $P < 0.05$) with the body of water for *G. holbrooki*, *A. iberus*, *C. carpio carpio*, *B. sclateri*, *Ch. polylepis* and *M. salmoides*. For *G. holbrooki* and *M. salmoides*, the highest b-values were recorded in reservoirs, for *A. iberus* and *B. sclateri* in tributaries, and for *C. carpio carpio* and *Ch. polylepis* in the main watercourse. The length–weight results obtained could well be considered when fish populations are subjected to sports fishing regulations, recovery programmes or any other management activity.

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References

Binohlan, C.; Pauly, D., 1998: The length–weight table. In: Fishbase 1998: concepts, design and data sources. R. Froese and D. Pauly (Eds). ICLARM, Manila, pp. 121–123.

Doadrio, I., (Ed.), 2002: Atlas y Libro Rojo de los Peces Continentales de España. CSIC y Ministerio de Medio Ambiente, Madrid (in Spanish).

Doadrio, I.; Madeira, M. J., 2004: A new species of the genus *Gobio* Cuvier, 1816 (Actynopterigii, Cyprinidae) from the Iberian Peninsula and southwestern France. Graellsia **60,** 107–116.

Froese, R.; Pauly, D.(Eds), 2005: FishBase. World Wide Web electronic publication. http://www.fishbase.org, version (02/2005).

Geiger, F., 1973: El sureste español y los problemas de la aridez. Rev. Geogr. **7,** 166–209 (in Spanish).

Gonçalves, J. M. S.; Bentes, L.; Lino, P. G.; Ribeiro, J.; Canario, A. V. M.; Erzini, K., 1997: Weight–length relationships for selected fish species of the small-scale demersal fisheries of the southwest coast of Portugal. Fish. Res. **30,** 253–256.

Kolher, N.; Casey, J.; Turner, P., 1995: Length–weight relationships for 13 species of sharks from the western North Atlantic. Fish. Bull. **93,** 412–418.

Miñano, P. A.; García-Mellado, A.; Oliva-Paterna, F. J.; Torralva, M., 2003: Edad, crecimiento y reproducción de *Gobio gobio* L. (Pisces, Cyprinidae) en un tramo regulado del río Segura (SE España). Anim. Biodivers. Cons. **26,** 67–76 (in Spanish).

Moutopoulos, D. K.; Stergiou, K. I., 2002: Length-weight and length-length relationship of fish species from the Aegean Sea (Greece). J. Appl. Ichthyol. **18,** 200–203.

Oliva-Paterna, F. J.; Miñano, P. A.; Torralva, M., 2003a: Habitat quality affects the condition of *Barbus sclateri* in Mediterranean semi-arid streams. Environ. Biol. Fishes **67,** 13–22.

Oliva-Paterna, F. J.; Vila-Gispert, A.; Torralva, M., 2003b: Condition of *Barbus sclateri* from semi-arid aquatic systems: effects of habitat quality disturbances. J. Fish Biol. **63,** 699–709.

Petrakis, G.; Stergiou, K. I., 1995: Weight–length relationships for 33 fish species in Greek waters. Fish. Res. **21,** 465–469.

Sokal, R. R.; Rohlf, F. J., 1981: Biometry. W. H. Freeman and Co., San Francisco, CA.

Tesch, F. W., 1971: Age and growth. In: Methods for assessment of fish production in fresh waters. W. E. Ricker (Ed.). Blackwell Scientific Publications, Oxford, pp. 99–130.

Torralva, M.; Puig, M. A.; Fernández-Delgado, C., 1997: Effect of river regulation on the life-history patterns of *Barbus sclateri* in the Segura River basin (southeast Spain). J. Fish Biol. **51,** 300–311.

Vidal-Abarca, M. R.; Montes, C.; Ramírez-Díaz, L.; Suárez, M. L., 1987: El clima de la cuenca del río Segura (SE de España): Factores que lo controlan. An. Biol. **12,** 11–28 (in Spanish).

Wootton, R. J., 1998: Ecology of teleost fishes. Kluwer Academic Publishers, Dordrecht, The Netherlands.

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