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Length-weight relationships for the fifty littoral and coastal marine fish species from the Eastern Adriatic sea

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The length–weight relationship parameters are reported for the fifty littoral and coastal marine fish species from the Eastern Adriatic. Captures were made between the years 2004 and 2017 during sport fishing competitions. The parameters a and b of the equation $W = aL^b$ *were estimated. The b values ranged from 2.1972 for* Spicara smaris *(Linnaeus, 1758) to 3.7044 for* Salaria *pavo (Risso, 1810). The L-W relation for* Scyliorhinus stellaris *(Linnaeus, 1758),* Gobius bucchichi *Steindachner 1870,* Gobius geniporus *Valenciennes 1837 and* Lipophrys trigloides *(Valenciennes, 1836) are not available in FishBase and presents new data for these species. For some other species, such as* Labrus mixtus *Linnaeus 1758, there are only two relationships, but none from the Mediterranean, for* Gobius paganellus *Linnaeus 1758 only four relationships and none from Central and Eastern Mediterranean, while for* Labrus merula *Linnaeus 1758,* Symphodus mediterraneus *(Linnaeus, 1758),* Symphodus roissali *(Risso, 1810),* Gobius cobitis *Pallas 1814,* Gobius cruentatus *Gmelin 1789*, Gobius niger *Linnaeus 1758,* Parablennius *gatorugine (Linnaeus, 1758),* Parablennius sanguinolentus *(Pallas, 1814),* Salaria pavo *(*Risso, 1810), and Bothus podas *(Delaroche, 1809) very low number of relationships are presented and none from the Adriatic Sea.*

Key words: length-weight relationship, parameters, fish, littoral and coastal, Adriatic

INTRODUCTION

The length–weight relationship (LWR) is useful in fishery assessments (ÇALIK &, ERDOĞAN SAĞLAM, 2017) for predicting weights from the more easily measured lengths (RICKER, 1975), yield assessment (GARCIA *et al*., 1998) and when calculating biomass (MARTIN-SMITH, 1996). During various sampling programs, it is usually easier to measure only length (e.g., because of the bobbing motion of the boat), or weight cannot be measured at all (e.g., underwater visual censuses). The LWR of a particular species allows the inter-conversion of these parameters. The relationship between the length (L) and weight (W) of a fish is usually expressed by the equation $W = aL^b$. The exponent b provides information on growth (MOREY *et al*., 2003); being isometric when $b = 3$ and allometric when this is not the case (positive if $b > 3$, negative if $b < 3$). The present study provides information on the length–weight relationships of fifty littoral and coastal marine fish species from the littoral and coastal waters of the Eastern Adriatic Sea.

MATERIAL AND METHODS

Data were collected between 2004 and 2017 from the Eastern Adriatic sea during the study of sport fishing competitions, using various fishing

gears, from the different hook lines to spear fishing. Competitions are held from the shore, and boats, while spear fishermen were fishing near shore or further offshore on underwater reefs. Thus, most of the fishes have been caught up to 40 m of depth. Due to the common period of the sport fishing competitions all fishes were collected from May until the end of October. Data on total length (TL, cm) to the nearest millimeter and total weight (TW, g) to the nearest gram were recorded for each fish. The length–weight relationship was calculated using the expression: $W= aL^b$, where the W is the weight (g), L the length (cm), *a* the intercept of the regression and *b* is the regression coefficient (HAYES *et al*., 1995). Parameters *a* and *b* of the length–weight relationship were estimated by linear regression analysis based on logarithms: $\log(W) = \log(a) + b \log(L)$.

RESULTS AND DISCUSSION

A total of 16373 fish specimens representing 20 families and 50 different fish species were analyzed. For each species, the sample size, the minimum and maximum total length, the minimum and maximum weight measured, the LWR parameters *a* and *b*, and the coefficient of determination r^2 are presented in Table 1. The L-W relationship for *Scyliorhinus stellaris* (Linnaeus, 1758), *Gobius bucchichi* Steindachner 1870, *Gobius geniporus* Valenciennes 1837 and *Lipophrys trigloides* (Valenciennes, 1836) are not available in FishBase (FROESE & PAULY, 2019). For some other species, such *as Labrus mixtus* Linnaeus 1758, there are only 2 relationships, none from the Mediterranean, for *Gobius paganellus* Linnaeus 1758 only 4 relationships and none from Central and Eastern Mediterranean, while for *Labrus merula* Linnaeus 1758, *Symphodus mediterraneus* (Linnaeus, 1758), *Symphodus roissali* (Risso, 1810), *Gobius cobitis* Pallas 1814, *Gobius cruentatus* Gmelin 1789, *Gobius niger* Linnaeus 1758, *Parablennius gatorugine* (Linnaeus, 1758), *Parablennius sanguinolentus* (Pallas, 1814), *Salaria pavo* (Risso, 1810), *Trachinus radiatus* Cuvier 1829 and *Bothus podas* (Delaroche, 1809) very low number of relationships are presented and none from the Adriatic Sea, except for *T. radiates* (FROESE & PAULY, 2019). Comparing maximum lengths of fishes indicated in FishBase (FROESE & PAULY, 2019) with those obtained during this study, the new maximum lengths can be reported for a range of gobies, particularly *G. cobitis* (30.0 cm), *G. bucchichi* (12.1 cm), *G. geniporus* (17.8 cm), *G. paganellus* (16.0 cm) and for a blenny *S. pavo* (13.4 cm). The sample size ranged from 61 specimens for *Muraena helena* Linnaeus 1758 to 1472 for *Coris julis* (Linnaeus, 1758). The r^2 values ranged from 0.5644 for *Spicara smaris* (Linnaeus, 1758) to 0.9980 for *Chelidonichthys lastoviza* (Bonnaterre, 1788), 0,9953 for *T. radiatus* and 0.9917 for *Sarpa salpa* (Linnaeus, 1758). Twenty seven species, out of 50, showed r^2 values higher than 0.95, while only four of them had r^2 values less than 0.75. The *b* values ranged from 2.1972 for *S. smaris* to 3.7044 for *S. pavo*. Three species had *b* values less than 2.5 while only one had higher than 3.5. The mean value of *b* was 2.975, while the median was 2.9804. 50 % of the *b* values ranged between 2.8473 and 3.1434.

BAGENAL & TESCH (1978) reported that the parameters of weight–length relationships, particularly *a*, may vary daily, seasonally, and/or between habitats, unlike the parameter *b*, which does not vary significantly throughout the year. However, the comparison of *b* values for the same species appearing in different studies in the Mediterranean Sea suggested inter-regional differences (MOREY *et al*., 2003). In order to test differences on a regional level, *b* values for similar habitat and species obtained previously from the Adriatic (DULČIĆ & KRALJEVIĆ, 1996) were compared to results of this study (Table 2). Comparison showed that for most of the species *b* values were indeed similar, but for *Mullus surmuletus* Linnaeus 1758 (3.512 vs 3,0901), *Pagellus acarne* (Risso, 1827) (3,499 vs 2,746) and *Scorpaena scrofa* Linnaeus 1758 (3,298 vs 2,8162) were significantly different. Therefore, it can be concluded that even *b* values, although less than *a* values, can vary due to a combination of different reasons, such as period of the year, spatial variation, influence of water qual-

ity, food availability, population differences and the ontogenetic stage of the individuals studied (SPARRE *et al.,* 1989, MOMMSEN, 1998, DULČIĆ & GLAMUZINA, 2006) or differences in sampling (the number of specimens and length ranges).

Thus, when LWR parameters are used for some species it would be appropriate, for obtaining more precise weight estimations, to use local/regional values calculated within suitable length ranges.

Table 1. Length – weight relationship parameters for the fifty species from the Eastern Adriatic

Family/Species	N	Weight range (g)	Length range (cm)	a	b	r^2
Scyliorhinidae						
Scyliorhinus stellaris	86	998-3820	58,1-96,2	0,0705	2,3769	0,8161
Sparidae						
Boops boops	1144	12-236	11,0-27,5	0,0147	2,8608	0,9515
Dentex dentex	92	442-6695	32,7-82,1	0,0095	3,0855	0,9884
Diplodus annularis	1325	8-195	8,3-22,5	0,017	2,9796	0,9511
Diplodus puntazzo	101	61-795	15,6-39,0	0,0243	2,8477	0,9772
Diplodus sargus	415	58-1525	15,3-42,0	0,0251	2,9003	0,9322
Diplodus vulgaris	740	8-570	8,5-32,0	0,0118	3,0926	0,9789
Lithognathus mormyrus	74	41-488	15,0-32,7	0,008	3,1393	0,9849
Pagellus erythrinus	1235	12-744	10,0-39,2	0,0163	2,8942	0,9786
Pagellus acarne	288	12-110	10,0-21,1	0,0253	2,746	0,8847
Sarpa salpa	171	16-885	10,7-39,0	0,015	2,9636	0,9917
Sparus aurata	202	124-1460	21,0-49,1	0,0106	3,064	0,9542
Labridae						
Coris julis	1472	4-116	8,5-23,0	0,0035	3,3611	0,967
Labrus merula	299	59-1102	16,6-42,0	0,0183	2,947	0,9457
Labrus mixtus	63	60-536	18,1-34,6	0,0042	3,3251	0,9786
Symphodus mediterraneus	301	10-64	8,0-16,1	0,0247	2,7591	0,8226
Symphodus roissali	93	10-41	8,4-13,4	0,0109	3,1801	0,867
Symphodus tinca	876	14-565	9,6-34,8	0,0212	2,8351	0,9636
Gobiidae						
Gobius bucchichi	62	8-18	9,1-12,1	0,0071	3,1548	0,7205
Gobius cobitis	141	12-332	10,3-30,0	0,0134	2,9844	0,9609
Gobius cruentatus	504	8-78	9,6-17,8	0,0078	3,1435	0,9002
Gobius geniporus	472	4-58	7,2-17,2	0,0546	2,36	0,7784
Gobius niger	91	5-31	7,8-14,0	0,0092	3,0831	0,8622
Gobius paganellus	277	8-38	9,8-16,0	0,028	2,6675	0,7496
Serranidae						
Serranus cabrilla	457	12-226	10,8-26,2	0,0123	2,9636	0,9561
Serranus hepatus	169	3-32	5,3-12,0	0,0364	2,6475	0,8977
Serranus scriba	923	10-154	9,8-22,1	0,0092	3,1433	0,9621
Centracanthidae						

Spicara flexuosa	504	17-92	12,0-19,8	0,0093	3,0367	0,8639
Spicara maena	182	32-340	14,2-27,1	0,0052	3,2846	0,9526
Spicara smaris	179	22-52	12,3-19,2	0,0716	2,1972	0,5644
Scorpaenidae						
Scorpaena porcus	173	21-770	10,5-32,7	0,0099	3,2133	0,9841
Scorpaena scrofa	225	20-2060	10,6-50,2	0,034	2,8162	0,9542
Carangidae						
Trachurus trachurus	377	20-564	13,4-44,5	0,0115	2,8637	0,9746
Blenniidae						
Lipophrys trigloides	77	9-26	8,9-13,0	0,0341	2,5688	0,7557
Parablennius gatorugine	155	6-198	7,4-22,0	0,0064	3,2741	0,9667
Parablennius sanguinolentus	316	9-89	9,7-19,4	0,0051	3,343	0,9261
Salaria pavo	83	4-16	8,3-13,4	0,0015	3,7044	0,9215
Mugilidae						
Chelon auratus	83	205-875	27,6-47,5	0,0158	2,8472	0,9029
Chelon ramada	65	278-1311	35,5-56,8	0,0243	2,7089	0,9707
Triglidae						
Chelidonichthys lastoviza	64	40-214	15,8-27,7	0,0133	2,9109	0,998
Trachinidae						
Trachinus draco	447	7-192	10,4-32,2	0,0082	2,9063	0,9784
Trachinus radiatus	85	24-399	13,8-33,5	0,0085	3,0285	0,9953
Congridae						
Conger conger	391	735-11775	70,9-165,4	0,0006	3,2754	0,9057
Phycidae						
Phycis phycis	127	210-2720	26,6-58,3	0,0048	3,2499	0,9594
Mullidae						
Mullus surmuletus	157	14-330	9,9-30,3	0,0099	3,0901	0,9797
Sciaenidae						
Sciaena umbra	118	328-1995	29,0-52,2	0,0095	3,1053	0,9664
Pomacenthridae						
Chromis chromis	235	11-48	9,2-13,2	0,0181	2,979	0,6425
Moronidae						
Dicentrarchus labrax	119	230-2963	27,8-64,1	0,0104	2,9812	0,9095
Muraenidae						
Muraena helena	61	1115-4310	79,0-120,2	0,0116	2,6477	0,8212
Bothidae						
Bothus podas	77	16-58	12,6-18,1	0,0058	3,2125	0,8998

n – sample size, weight range, total length range, a and b parameters, r2 – coefficient of determination

Table 2. Number of specimens (n), total length ranges (TL range) and b values for species compared between previous study from the Adriatic (DULČIĆ & KRALJEVIĆ, 1996) and present study

species	DULČIĆ & KRALJEVIĆ, 1996			present study		
	n	TL range (cm)	b	n	TL range (cm)	b
Chromis chromis	1230	5,9-13,9	3,102	235	9,2-13,2	2,979
Coris julis	94	4,3-15,3	3,238	1472	8,5-23,0	3,3611
Dentex dentex	250	18,3-85,9	3,172	92	32,7-82,1	3,0855
Dicentrarchus labrax	417	24,5-88,0	3,146	119	27,8-64,1	2,9812
Diplodus annularis	100	8,9-23,5	2,928	1325	8,3-22,5	2,9796
Diplodus puntazzo	289	5,9-45,0	2,951	101	15,6-39,0	2,8477
Diplodus sargus	214	14,3-39,9	3,038	415	15,3-42,0	2,9003
Diplodus vulgaris	601	14,3-39,9	3,028	740	8,5-32,0	3,0926
Mullus surmuletus	127	15,4-30,9	3,512	157	9,9-30,3	3,0901
Pagellus acarne	74	10,0-23,7	3,499	288	10,0-21,1	2,746
Pagellus erythrinus	193	10,9-46,0	2,944	1235	10,0-39,2	2,8942
Phycis phycis	58	26,2-56,4	3,502	127	26,6-58,3	3,2499
Sciaena umbra	26	18,1-41,2	3,048	118	29,0-52,2	3,1053
Scorpaena porcus	351	9,7-26,6	3,243	173	10,5-32,7	3,2133
Scorpaena scrofa	125	19,7-53,6	3,298	225	10,6-50,2	2,8162
Spicara maena	220	14,2-27,5	3,037	182	14,2-27,1	3,2846
Symphodus tinca	100	12,7-30,2	2,726	876	9,6-34,8	2,8351
Trachinus draco	22	9,2-26,8	2,934	447	10,4-32,2	2,9063
Trigloporus lastoviza	52	7,4-35,0	3,003	64	15,8-27,7	2,9109

REFERENCES

BAGENAL, T.B. & P.W. TESCH, 1978. Age and growth. In: Methods for Assessment of Fish in Fresh Waters. 3rd Edition (Edittor T. Benegal), IBP Handbook No. 3. Blackwell Scientific Publications, Oxford, pp. 101–136.

ÇALIK, S. & N. ERDOĞAN SAĞLAM. 2017. Length-weight relationships of demersal fish species caught by bottom trawl from Eastern Black Sea (Turkey). Cahiers de Biologie Marine, 58: 485 - 490 DOI: 10.21411/CBM.A.AA0D91E6

DULČIĆ, J. & B. GLAMUZINA. 2006. Length–weight relationships for selected fish species from three eastern Adriatic estuarine systems (Croatia). J. Appl. Ichthyol. 22: 254–256

DULČIĆ, J. & M. KRALJEVIĆ 1996. Weight–length relationships for fish species in the eastern Adriatic (Croatian waters). Fisheries Research, 28: 243–251. DOI: 10.1016/0165-7836(96)00513-9

FROESE, R. & D. PAULY. (Editors) 2019. FishBase. World Wide Web electronic publication. www.fishbase.org, (10/2019)

GARCIA, C.B., DUARTE, J.O., SANDOVAL, N., VON SCHILLER, D., MELO, G. & P. NAVAJAS 1998. Length–weight relationships of demersal fishes from the Gulf of Salamanca, Colombia, Naga. ICLARM Quart., 21 (3): 30–32.

HAYES, D.B., BRODZIAK, J.K.T. & J.B. O'GORMAN 1995. Efficiency and bias of estimators and sampling designs for determining length–weight relationships of fish. Canadian Jour-

nal of Fisheries and Aquatic Science, 52: 84–92. DOI: 10.1139/f95-008

MARTIN-SMITH, K.H. 1996. Length/weight relationships of fishes in a diverse tropical freshwater community, Sabah, Malaysia. Journal of Fish Biology, 49: 731–734. DOI: 10.1111/j.1095-8649.1996.tb00069.x

MOMMSEN, T.P. 1998. Growth and metabolism. In: The Physiology of Fishes (Evans D.H. ed), pp. 65–97. CRC Press, New York.

MOREY, G., MORANTA, J., MASSUTI, E., GRAU, A., LINDE, M., RIERA, F. & B. MORALES-NIN. 2003. Weight–length relationships of littoral to lower slope fishes from the western Mediterranean. Fisheries Research, 62: 89–96. DOI: 10.1016/S0165-7836(02)00250-3

RICKER, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, 191: 382 p.

SPARRE, P., URSIN, E. & S.C. VENEMA. 1989. Introduction to tropical fish stock assessment. Part I. Manual. FAO Fisheries Technical Paper No. 306. 337 pp.

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Dužinsko-maseni odnos pedeset litoralnih i obalnih riba u istočnom Jadranu

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SAŽETAK

Parametri dužinsko-masenog odnosa su prijavljeni za 50 litoralnih i obalnih rba iz istočnog Jadrana. Svi primjerci su ulovljeni u periodu 2004-2017 za vrijeme natjecanja u sportskom ribolovu.

Parameteri *a i b* od jednadžbe $W = aL^b$ su prezentirani. Vrijednosti *b* parametra su varirale od 2.1972 za *Spicara smaris (Linnaeus, 1758)* do 3.7044 za *Salaria pavo (Risso, 1810)*. Dužinsko-maseni odnosi za *Scyliorhinus stellaris (Linnaeus, 1758), Gobius bucchichi Steindachner 1870, Gobius geniporus Valenciennes 1837 i Lipophrys trigloides (Valenciennes, 1836)* dosad nisu bili dostupni u *FishBase.*

Za neke druge vrste, primjerice *Labrus mixtus Linnaeus 1758,* postoje samo dva prijavljena odnosa, pri čemu niti jedan nije iz Mediterana, za *Gobius paganellus Linnaeus 1758* postoje samo 4 odnosa i nijedan iz središnjeg i istočnog Mediterana, dok za *Labrus merula Linnaeus 1758, Symphodus mediterraneus (Linnaeus, 1758), Symphodus roissali (Risso, 1810), Gobius cobitis Pallas 1814, Gobius cruentatus Gmelin 1789, Gobius niger Linnaeus 1758, Parablennius gatorugine (Linnaeus, 1758), Parablennius sanguinolentus (Pallas, 1814), Salaria pavo (Risso, 1810)* i *Bothus podas (Delaroche, 1809*) postoji veoma mali broj dužinsko-masenih odnosa, pri čemu niti jedan nije prijavljen za Jadransko more, osim za *T. radiates.*

Ključne riječi: dužinsko-maseni odnos, parametri, riba, primorje i priobalje, Jadran