

Length-Weight Relations and Monthly Occurrence of Juvenile Fish Species from the Donji Molunat Bay, Croatia (South-East Adriatic Sea)

Dužinsko-maseni odnosi i mjesečno pojavljivanje juvenilnih riba iz zaljeva Donji Molunat, Hrvatska (jugoistočni Jadran)

Antonia Kurtela

University of Dubrovnik
Institute for Marine and Coastal Research
e-mail: antonia.kurtela@gmail.com

Nenad Antolović

University of Dubrovnik
Institute for Marine and Coastal Research
e-mail: nenad.antolovic@unidu.hr

Nikša Glavić

University of Dubrovnik
Institute for Marine and Coastal Research
e-mail: niksa.glavic@unidu.hr

Valter Kožul

University of Dubrovnik
Institute for Marine and Coastal Research
e-mail: valter.kozul@unidu.hr

DOI 10.17818/NM/2019/3.7

UDK 639.2.053(497.5 Molunat)

Professional paper / *Stručni rad*

Rukopis primljen / *Paper accepted*: 8. 3. 2019.

Summary

Length-weight relations (LWR) and monthly occurrence are presented for juvenile fish, sampled from April to December 2018. in the of Donji Molunat bay, Croatia. From total number of 1448 caught fish of 30 fish species, 699 individuals of 16 fish species: *Atherina hepsetus*, *Chromis chromis*, *Coris julis*, *Diplodus annularis*, *Gobius bucchichii*, *Microlipophrys canevae*, *Oblada melanura*, *Oedalechilus labeo*, *Pagellus acarne*, *Sarpa salpa*, *Serranus scriba*, *Siganus luridus*, *Symphodus cinereus*, *Symphodus doderleini*, *Symphodus ocellatus* and *Symphodus rostratus* were analysed. Two parameters were measured: total length (TL) using precision ruler to the nearest 0.1 cm, and weight (W) using digital balance to the nearest 0.1 g. The b values ranged from 2.731 to 3.427, with median 3.0305. This study provides the first LWRs for juvenile fish species in the Donji Molunat bay, as that it can serve as a tool used for future reference.

KEY WORDS

LWR
beach seine net
nursery
Adriatic Sea

Sažetak

Dužinsko-maseni odnosi (LWR) i pojavljivanje vrsta po mjesecima predstavljeni su za juvenilne riblje vrste, uzorkovane od travnja do prosinca 2018. godine u zaljevu Donji Molunat, Hrvatska. Od ukupno 1.448 ulovljenih jedinki mlađih od 30 ribljih vrsta, analizi je podvrgnuto 699 jedinki koje spadaju u 16 ribljih vrsta: Atherina hepsetus, Chromis chromis, Coris julis, Diplodus annularis, Gobius bucchichii, Microlipophrys canevae, Oblada melanura, Oedalechilus labeo, Pagellus acarne, Sarpa salpa, Serranus scriba, Siganus luridus, Symphodus cinereus, Symphodus doderleini, Symphodus ocellatus i Symphodus rostratus. Mjerila su se dva parametra: totalna dužina (TL), koristeći se ravnalom s preciznošću 0,1 cm, i masa (W), koristeći se digitalnom vagom preciznosti 0,1 g. Raspon za parametar b kretao se od 2.731 do 3.427, sa srednjom vrijednosti 3.0305. Ovaj rad pruža prve podatke dužinsko-masениh odnosa juvenilnih vrsta riba u zaljevu Donji Molunat te se kao takav može koristiti kao podloga budućim autorima.

KLJUČNE RIJEČI

LWR
obalna mreža potegača
rastilište
Jadransko more

1. INTRODUCTION / Uvod

Length-weight relation (LWR) has been used widely for fisheries management and conservation. Since stock assessment models and management for fisheries require information about body weight for estimation of biomass and regulation of catches, weight can be predicted from length using a weight-length relation (Froese et al. 2014.) It provides information on the condition factor and somatic growth type (isometric or allometric) of fish species and therefore it is used for the determination of the biomass, enabling the conversion of length to weight (Froese 2006, Froese et al. 2011). The exponent b from WLR can be used as a fundamental parameter to understand the

structure of a fish population (Le Cren 1951, Froese 2006). LWR of a species depends on many factors: habitat, growth phase, season, size range, sex, health, fish condition, fishing pressure... (Froese 2006, Karachle and Stergiou 2008, Liouisia et al. 2012).

The areas of shallow bays are important habitats in which a variety of species of fish and other marine organisms live. Particularly important areas for juvenile fish are areas covered with macrophytic algae and sea grass meadows (Blaber and Blaber, 1980.; Allen, 1982.; Guidetti, 1999.) That is a case in Donji Molunat bay, whose sea bed is covered by *Posidonia oceanica*, endemic sea grass of the Mediterranean Sea, while the bottom

in shallow parts is pebbly (Dobrosravić et al. 2010). Because of its high structural complexity, this bay is nursery and feeding place for a large number of fish species (Tutman, 2002). It is important to determine the number and monthly occurrence of juvenile fish species in this area, and their length-weight relations since they show fish growth patterns, which in turn are essential for developing of ecosystem based models for fisheries.

2. MATERIAL AND METHODS / Materijali i metode

Fish samples were collected monthly from April to December 2018. In the Donji Molunat bay (N 42° 27' 27, 5"; E 18° 25' 34, 5") (Figure 1). The fish samples were collected using small beach seine net, 25 meters long, 70 cm high at the beginning of the net wings, and 500 cm in the central part of the sac. The mesh size of net wings was 8 mm, and of the sac 4 mm. The average surface covered by this net at one pull is about 500 m². After collection the fish samples were frozen and brought to the laboratory, where the measurements were made.

The length-weight relations were calculated on fish species with 5 and more individuals, and some fish species were excluded because of the errors in weighting. The fish were measured randomly for each species without sampling site and sex. Two parameters were measured: total length (TL) using precision ruler to the nearest 0.1 cm, and weight (W) using digital balance to the nearest 0.1 g.

Length- weight relations were estimated using the equation:

$$W = aTL^b$$

where a and b are the equation parameters calculated by the least squares method using the logarithmic form of the equation:

$$\log(W) = \log(a) + b \cdot \log(TL)$$

Intercept a , slope b , and their standard errors (SE_a and SE_b), 95% confidence interval of a and b (95% of a and 95% of b) coefficient of determination (r^2) were estimated using IBM SPSS statistics program (version 2018.). The range 95% confidence interval of b (Range of b) from the FishBase is placed in the table 3 in order to compare the results (Froese and Pauly 2018)

3. RESULTS / Rezultati

During the sampling period, a total of 1467 juvenile individuals were caught from the Donji Molunat bay, representing the following families: Labridae (8 species), Sparidae (7 species), Blenniidae (3 species), Serranidae (3 species), Atherinidae (2 species), Gobiidae, Mugilidae, Mullidae, Pomacentridae, Scorpaenidae, Siganidae, Sphyrinae (1 species each) (Table 1). In total catch *Coris julis*, *Symphodus ocellatus*, *Boops boops*, *Chromis chromis* and *Sphyrina sphyrina* were the most dominant species. From total number of caught fish, 699 individuals of 16 fish species *Atherina hepsetus*, *Chromis chromis*, *Coris julis*, *Diplodus annularis*, *Gobius bucchichii*, *Microlophrys caneavae*, *Oblada melanura*, *Oedalechilus labeo*, *Pagellus acarne*, *Sarpa salpa*, *Serranus scriba*, *Siganus luridus*, *Symphodus cinereus*, *Symphodus doderleini*, *Symphodus ocellatus* and *Symphodus rostratus* were analysed (Table 2). The estimated parameters a and b for the WLRs, along with the descriptive statistics by species, are given in Table 2. The r^2 value ranged from 0.695 (*Oblada melanura*), to 0.996 (*Symphodus rostratus*), with the median value 0.972. For four species (*Symphodus rostratus*, *Serranus scriba*, *Siganus luridus*, *Oblada melanura*) the estimated r^2 were higher than 0.991. Three fish species *Atherina hepsetus*, *Microlophrys caneavae*, *Oblada melanura* had r^2 lower than 0.9. The a values obtained ranged from 0.004 (*Atherina hepsetus*) to 0.025 (*Siganus luridus*), the median value of a was 0.0115. The values of b ranged from 2.731 (*Sarpa salpa*) to 3.427 (*Atherina hepsetus*). The median of b was 3.0305. Of 16 fish species that were measured, for 5 of them *Chromis chromis*, *Diplodus annularis*, *Oedalechilus labeo*, *Sarpa salpa*, *Serranus scriba* the estimated b values were lower than the lowest 95% CI of b values cited in FishBase (Froese and Pauly, 2018) while for 6 species *Atherina hepsetus*, *Microlophrys caneavae*, *Oblada melanura*, *Pagellus acarne*, *Symphodus cinereus*, *Symphodus rostratus* were higher than the upper limit of 95% CI of estimated b . In the other 5 species *Coris julis*, *Gobius bucchichii*, *Siganus luridus*, *Symphodus doderleini*, *Symphodus ocellatus* estimate b values were in the range of b values cited in FishBase. In Table 3 it is



Figure 1 Molunat Donji bay
Slika 1. Zaljev Donji Molunat

Table 1. List of juvenile fish species sampled from Donji Molunat, Croatia
 Tablica 1. Popis juvenilnih ribljih vrsta uzorkovanih iz zaljeva Donji Molunat, Hrvatska

Family	Species	Number
Atherinidae	<i>Atherina boyeri</i> (Risso, 1810)	3
	<i>Atherina hepsetus</i> (Linnaeus, 1758)	69
Blenniidae	<i>Microlipophrys canevae</i> (Vinciguerra, 1880)	19
	<i>Salaria pavo</i> (Risso, 1810)	5
	<i>Parablennius sanguinolentus</i> (Pallas, 1814)	3
Gobiidae	<i>Gobius bucchichii</i> (Steindachner, 1870)	11
Labridae	<i>Coris julis</i> (Linnaeus, 1758)	316
	<i>Ctenolabrus rupestris</i> (Linnaeus, 1758)	1
	<i>Lappanella fasciata</i> (Cocco, 1833)	1
	<i>Symphodus cinereus</i> (Bonnaterre, 1788)	14
	<i>Symphodus doderleini</i> (Jordan, 1890)	23
	<i>Symphodus melops</i> (Linnaeus, 1758)	1
	<i>Symphodus rostratus</i> (Bloch, 1791)	12
	<i>Symphodus ocellatus</i> (Forsskål, 1775)	288
	Mugilidae	<i>Oedalechilus labeo</i> (Cuvier, 1829)
Mullidae	<i>Mullus surmuletus</i> (Linnaeus, 1758)	8
Pomacentridae	<i>Chromis chromis</i> (Linnaeus, 1758)	131
Scorpaenidae	<i>Scorpaena porcus</i> (Linnaeus, 1758)	1
Serranidae	<i>Epinephelus marginatus</i> (Lowe, 1834)	1
	<i>Serranus cabrilla</i> (Linnaeus, 1758)	1
	<i>Serranus scriba</i> (Linnaeus, 1758)	5
Siganidae	<i>Siganus luridus</i> (Rüppell, 1829)	7
Sparidae	<i>Boops boops</i> (Linnaeus, 1758)	216
	<i>Diplodus annularis</i> (Linnaeus, 1758)	63
	<i>Diplodus vulgaris</i> (Geoffroy Saint-Hilaire, 1817)	2
	<i>Oblada melanura</i> (Linnaeus, 1758)	55
	<i>Pagellus acarne</i> (Risso, 1827)	34
	<i>Pagrus pagrus</i> (Linnaeus, 1758)	4
	<i>Sarpa salpa</i> (Linnaeus, 1758)	30
Sphyraenidae	<i>Sphyraena sphyraena</i> (Linnaeus, 1758)	112

Table 2. Parameters of the length-weight relations for 16 juvenile fish species from Molunat Donji bay, Croatia
 Tablica 2. Parametri dužinsko masenih odnosa za 16 juvenilnih ribljih vrsta iz zaljeva Donji Molunat, Hrvatska

Species	n	TL (cm) range	W (g) range	a	95% CI of a	SE of a	b	95% CI of b	SE of b	r ²	Range of b FishBase ¹
<i>Atherina hepsetus</i>	30	4.8-8.2	0.9-7.5	0.004	0.002-0.006	0.002	3.427	3.090-3.764	0.337	0.787	2.94 - 3.20
<i>Chromis chromis</i>	58	1.7-5.0	0.1-1.8	0.021	0.019-0.023	0.002	2.825	2.737-2.913	0.088	0.948	2.86 - 2.98
<i>Coris julis</i>	235	2.9-11.8	0.2-17.4	0.008	0.008-0.008	0.000	3.049	3.016-3.082	0.033	0.974	3.01 - 3.11
<i>Diplodus annularis</i>	37	2.6-6.1	0.3-4.2	0.019	0.016-0.022	0.003	2.922	2.792-3.052	0.130	0.935	3.05 - 3.09
<i>Gobius bucchichii</i>	11	2.6-4.0	0.3-1.0	0.015	0.010-0.020	0.005	2.929	2.641-3.217	0.288	0.920	2.90 - 3.28
<i>Microlipophrys canevae</i>	19	2.4-3.5	0.1-0.6	0.010	0.005-0.015	0.005	3.347	2.872-3.822	0.475	0.745	2.80 - 3.20
<i>Oblada melanura</i>	54	1.6-8.2	0.1-7.5	0.010	0.009-0.011	0.001	3.241	3.155-3.327	0.086	0.695	3.00 - 3.06
<i>Oedalechilus labeo</i>	12	3.5-11.1	0.6-15.3	0.016	0.013-0.019	0.003	2.803	2.697-2.909	0.106	0.986	2.86 - 3.12
<i>Pagellus acarne</i>	34	2.4-7.3	0.2-6.5	0.011	0.010-0.012	0.001	3.184	3.096-3.272	0.088	0.976	3.02 - 3.08
<i>Sarpa salpa</i>	30	3.2-6.3	0.6-3.8	0.023	0.019-0.027	0.004	2.731	2.623-2.839	0.108	0.958	3.00 - 3.06
<i>Serranus scriba</i>	5	4.2-7.5	1.1-5.7	0.015	0.012-0.018	0.003	2.953	2.833-3.073	0.120	0.995	3.01 - 3.09
<i>Siganus luridus</i>	7	4.0-7.0	1.3-6.6	0.025	0.021-0.029	0.004	2.883	2.783-2.983	0.100	0.994	2.92 - 3.02
<i>Symphodus cinereus</i>	14	3.2-7.4	0.3-5.2	0.008	0.006-0.010	0.002	3.323	3.201-3.445	0.122	0.983	3.01 - 3.11
<i>Symphodus doderleini</i>	23	2.6-6.5	0.2-3.7	0.010	0.008-0.012	0.002	3.120	3.013-3.227	0.107	0.976	2.80 - 3.08
<i>Symphodus ocellatus</i>	118	2.2-7.8	0.1-7.0	0.012	0.011-0.013	0.001	3.012	2.963-3.061	0.049	0.970	3.01 - 3.25
<i>Symphodus rostratus</i>	12	0.6-10.3	0.6-14.9	0.006	0.005-0.007	0.001	3.297	3.230-3.364	0.067	0.996	2.88 - 3.14
Min	5			0.004			2.731			0.695	
Max	235			0.025			3.427			0.996	
Median	26.5			0.0115			3.0305			0.972	

Species name, n- sample size, TL (cm)- total length, W (g)- body weight, a and b: parameters of the relation, 95% CI: confidence intervals (significance level 0.95) for two parameters a and b, SE standard errors (SE_a and SE_b), r²: coefficient of determination, Range of b: confidence intervals 95% of b (Froese and Pauly. 2018).

Ime vrste, n- veličina uzorka, TL (cm)- totalna dužina, W (g) masa. a i b: parametri, 95% CI: interval pouzdanosti za dva parametra a i b (nivo značajnosti 0.95), SE njihove standardne pogreške (SE_a i SE_b), r²: koeficijent determinacije, raspon za b: 95% interval pouzdanosti za b (Froese and Pauly. 2018).

Table 3 Monthly occurrence of juvenile fish species from the Donji Molunat bay, Croatia (South-East Adriatic Sea)
 Tablica 3: Mjesečno pojavljivanje juvenilnih riba iz zaljeva Donji Molunat, Hrvatska (Jugoistočni Jadran)

Species	April	May	June	July	August	September	October	November	December
<i>Atherina boyeri</i>	*								
<i>Atherina hepsetus</i>			*		*				
<i>Boops boops</i>	*								
<i>Chromis chromis</i>						*	*		
<i>Coris julis</i>	*	*	*	*	*		*	*	*
<i>Ctenolabrus rupestris</i>									*
<i>Diplodus anularis</i>		*	*	*				*	
<i>Diplodus vulgaris</i>		*							
<i>Epinephelus marginatus</i>							*		
<i>Gobius bucchichii</i>	*	*							
<i>Lappanella fasciata</i>								*	
<i>Microlipophrys canevae</i>			*						
<i>Salaria pavo</i>					*				
<i>Mullus surmuletus</i>			*	*					
<i>Oblada melanura</i>			*		*		*		
<i>Oedalechilus labeo</i>		*	*	*	*				
<i>Pagellus acarne</i>			*	*		*			
<i>Pagrus pagrus</i>		*							
<i>Parablennius sanguinolentus</i>									*
<i>Sarpa salpa</i>		*	*						
<i>Scorpaena porcus</i>			*						
<i>Serranus cabrilla</i>							*		
<i>Serranus scriba</i>							*	*	
<i>Siganus luridus</i>							*		
<i>Sphyaena sphyraena</i>			*						
<i>Symphodius ocellatus</i>	*	*	*	*			*	*	*
<i>Symphodus cinereus</i>	*			*			*	*	*
<i>Symphodus dodderlini</i>	*		*	*	*				
<i>Symphodus melops</i>					*				
<i>Symphodus rostratus</i>			*	*	*		*	*	

shown monthly occurrence of juvenile fish, which depends of the species spawning. The ichthyofauna was most diverse in June and July. *Coris julis* and *Symphodius ocellatus* were two species with biggest individual caught number, and also most occurrence per month.

4. DISCUSSION / Rasprava

Comparison of our data to the other work on the population of juvenile fish from Molunat Donji bay (Tutman, 2002), shows similar results. The most common fish species caught are *Atherina hepsetus*, *Oedalechilus labeo*, *Sarpa salpa*, *Pagellus acarne* and *Coris julis*. All of these species appear in present work with over 30 individuals, except one species, *Oedalechilus labeo*. In particular, for the three above-mentioned species (*Gobius bucchichii*, *Oedalechilus labeo* and *Siganus luridus*), the *b* values could be considered overestimated due to that the small number of sample (11, 12, and 7 individuals) and to that they cover a narrow range of length (Froese 2006). Three juvenile fish species *Atherina hepsetus*, *Microlipophrys canevae*, *Oblada melanura* have shown lower r^2 than 0.9, which could be due to the sampling procedure, namely sample size and length range. LWR of a species depends on many factors: habitat, growth phase, season, size range, sex, health, fish condition, fishing pressure... (Froese 2006, Karachle and Stergiou 2008, Liousia

et al. 2012), all of which were not considered in the present study, and that is why values for certain fish species does not match with the values of the same species from the FishBase. This study provides the first LWRs from the Donji Molunat bay for all the reported species and it can serve as a tool used for future reference. Our findings may well assist on monitoring and conservation of the natural nursery and feeding place for large number of juvenile fish species.

ACKNOWLEDGEMENTS / Zahvala

We would like to thank Prof. Tomislav Treer, PhD and Prof. Marina Piria, PhD for their help with statistical analysis.

REFERENCES / Literatura

- [1] Allen, L. G. (1982). "Seasonal abundance, composition and productivity of fish assemblage in upper Newport Bay, California". *Fishery Bulletin*, Vol. 80, pp. 769-790.
- [2] Blaber, S. J. M., Blaber, T. G. (1980). "Factors affecting the distribution of juvenile estuarine and inshore fish". *Journal of Fish Biology*, Vol. 17, pp. 143-162. <https://doi.org/10.1111/j.1095-8649.1980.tb02749.x>
- [3] Dobroslović, T., Bartulović, V., Lučić, D., Tomšić, S., Glamuzina, B. (2010). "Recruitment Characteristics of Juvenile Salema, *Sarpa Salpa* (Linnaeus, 1758), in Donji Molunat Bay, Southeastern Adriatic Coast, Croatia". *Naše more: znanstveni časopis za more i pomorstvo*, Vol. 57, No. 3-4, pp. 146-152. <https://doi.org/10.1111/j.1439-0426.2012.02046.x>
- [4] Froese, R. (2006). "Cube law, condition factor and weigh-length relationships: History, meta-analysis and recommendations". *Journal of Applied Ichthyology*, Vol. 22, No. 4, pp. 241-253. <https://doi.org/10.1111/j.1439-0426.2006.00805.x>

- [5] Froese, R., Thorson, J. T., Reyes R. B., Jr. (2014). "A Bayesian approach for estimating length-weight relationships in fishes". *Journal of Applied Ichthyology*, Vol. 30, No. 1, pp. 78-85. <https://doi.org/10.1111/jai.12299>
- [6] Froese, R., Pauly, D. (eds.) (2018). *FishBase, World Wide Web electronic publication*. www.fishbase.org
- [7] Froese, R., Tsikliras, A. C., Stergiou, K. I. (2011). "Editorial note on weight-length relations of fishes". *Acta Ichthyologica et Piscatoria*, Vol. 41, No. 4, pp. 261-263. <https://doi.org/10.3750/aip2011.41.4.01>
- [8] Guidetti, P. (1999). "Differences among fish assemblages associated with nearshore *Posidonia oceanica* seagrass beds, rocky-algal reefs and unvegetated sand habitats in Adriatic sea". *Estuarine, Coastal and Shelf Science*, Vol. 50, No. 4, pp. 515-529. <https://doi.org/10.1006/ecss.1999.0584>
- [9] Karachle, P. K., Stergiou, K. I. (2008). „Length-length and length-weight relationships of several fish species from the North Aegean Sea (Greece)". *Journal of Biological Research*, Vol. 10, pp. 149-157. <https://doi.org/10.1046/j.1439-0426.2002.00281.x>
- [10] Le Cren, E. D. (1951). "The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*)". *Journal of Animal Ecology*, Vol. 20, No. 2, pp. 201-219. <https://doi.org/10.2307/1540>
- [11] Lioucia, V., Batziakas, S., Panagiotou, N., Daouti I., Koutrakis, E., Leonardos, I. D. (2012). "Length-weight relations of 22 fish species from the littoral zone of the eastern Ionian Sea, Greece". *Acta Ichthyologica et Piscatoria*, Vol. 42, No. 1, pp. 69-72. <https://doi.org/10.3750/aip2011.42.1.09>
- [12] Petrakis, G., Stergiou, K. I. (1995). „Weight-length relationships for 33 fish species in Greek waters". *Fisheries Research*, Vol. 21, No. 3-4, pp. 465-469. [https://doi.org/10.1016/0165-7836\(94\)00294-7](https://doi.org/10.1016/0165-7836(94)00294-7)
- [13] Tutman, P. (2002). *The juvenile fish in the shallow water of the Donji and Gornji Molunat bays*. Master's thesis, Zagreb: University of Zagreb.