© by PSP Volume 30– No. 12/2021 pages 13339-13342 Fresenius Environmental Bulletin

LENGTH-WEIGHT RELATIONSHIPS FOR 57 FISH SPECIES OF BAKIRCAY RIVER ESTUARY IN CANDARLI BAY

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ABSTRACT

Known as the fourth longest river in the Aegean sea with its 129 km length, the Bakırçay River flows into Çandarlı Bay in the north of Aegean sea. This study was conducted to measure length weight relationships (LWRs) of fishes captured with different fishing gears in the estuary of Bakırçay River. This is the first study on this subject. The fishes that caught by each gear and carried in boxes to the lab were measured for total length (TL) as cm and wet weighed (W) as g. The length-weight (LW) relationships were estimated by $W=aL^b$. The level of statistical significance for r^2 was determined with $LogW=loga +b.logTL$. LW relationships were calculated in 57 fish species of 27 families from Bakırçay River Estuary in Çandarlı Bay. 3487 fish samples were caught with beach seines, handlines, longlines, fyke nets, scoop nets, cast net and trammel net between November 2012 and December 2015. The number of the samples ranged from 9 individuals for *Gasterosteus aculeatus* to 133 ones for *Solea solea*. r^2 values varied from 0.84 to 0.99. All regressions were highly significant ($p<0.01$). The value *b* of the LW regression changed between 2.371 in *Engraulis encrasicolus* and 3.490 in *Syngnathus acus* with a median of 3.134 where 25-75% of the values changed from 3.010 and 3.170. Species of Sparidae, Mugilidae and Gobiidae families were captured more than others, which can be accepted as a typical feature for Mediterranean estuarine areas.

KEYWORDS:
Length-weight relationship, fishes, Bakırçay estuary, Çandarlı Bay, Aegean Sea

INTRODUCTION

Although the Turkish Aegean Sea is rich in bays and gulfs, its narrow continental shelf, broken and rough bottom structure restrict fisheries activities. Because of this, catching processes mostly focus on daily and coastal fisheries [1]. In the middle of Turkish Aegean Sea, Çandarlı Bay is located between Izmir and Dikili Bays. It covers about 325 km^2 area and the distance between north and south side of the Bay is 20 km [2]. As an important and large river in the Bay area, Bakırçay River flows into Çandarlı Bay and there is another important one known as Güzelhisar that located in the south of the bay.

Vital habitats for aquatic living organisms and estuarine environments have great importance in terms of biodiversity and they influence commercial fisheries as well. LWRs are generally used in fisheries, especially in fisheries management and biology practices as well as being an important element in FishBase.

This study was made to discover and report the LW relationships of 57 fish species that collected by using a variety of fishing gears across the estuary (Bakırçay has two inlets into the sea which were both included in the study).

MATERIALS AND METHODS

Bakırçay River where the study was performed is geographically located between 39°57′. 21. 8″ North and 27°00′. 40. 8″ East coordinates. Bakırçay River comes out of Ömer mountains in Balıkesir province and finally flows into Izmir Bay between Dikili and Foça. It goes through the Çandarlı town into the Bay. For the reason that located in a region under the influence of the Mediterranean climate, the waters of Bakırçay decrease in summer. In winter and early spring, it overflows with precipitation. The Bakırçay River is the second largest river after the Gediz River in the province of Izmir and flows into Çandarlı Bay [3].

Samplings were made in Çandarlı Estuary from November 2012 to December 2015 by using a variety of fishing gears which are cast net with pockets, beach seines, handlines, longlines, fyke nets, scoop nets and trammel net. We employed with cast net with pockets having mesh size (bar length) of 10.5 mm, the two beach seines with codends of 6.5 mm and 12 mm in mesh size, handlines and longlines of various hook sizes, fyke nets with mesh size of 12 mm, scoop nets 6.5 mm in mesh size and trammel net of 18 mm in inner and 120 mm in outer net in bar length during daytime and overnight. Fresh specimens that captured by each gear were measured

TABLE 1
Length-weight relationships of 57 fish species captured from Bakırçay (Çandarlı Bay), Turkey

Classis/Family Species	N	Length Characteristics		Weight Characteristics		Relationship Parameters					
		TL Range (cm)	Mean TL (±SD)	W Range (g)	Mean W (±SD)	*a*	*b*	SE of *b*	95% Cl of *b*	r^2	*FG*
Chondrichthyes											
Rajidae											
Raja clavata (Linnaeus, 1758)	21	22.0-32.4	26.34±2.78	47.0-160.0	86.08±28.90	0.0024	3.200	0.055	3.089-3.311	0.994	HL, LL
Osteichthyes											
Clupeidae											
Alosa fallax (Lacepède, 1803)	29	27.4-42.4	33.79±3.77	205.0-745.0	391.72±132.51	0.0115	2.954	0.016	2.922-2.986	0.999	TN
Sardina pilchardus (Walbaum, 1792)	101	5.0-11.4	7.87±1.62	0.96-12.0	4.39±2.77	0.0070	3.057	0.006	3.045-3.069	0.999	BS
Sardinella aurita (Valenciennes, 1847)	53	9.4-12.5	10.08±1.90	5.5-13.7	7.60±4.27	0.0063	3.027	0.020	2.987-3.067	0.998	TN
Engraulidae											
Engraulis encrasicolus (Linnaeus, 1758)	129	6.0-8.9	7.30±0.79	1.63-4.7	2.86±0.77	0.0025	2.371	0.034	2.987-3.067	0.974	TN, BS
Anguillidae											
Anguilla anguilla (Linnaeus, 1758)	113	39.7-63.0	49.23±4.86	96.1-434.5	200.68±67.54	0.0006	3.270	0.013	3.245-3.295	0.998	HL, FN
Congridae											
Conger conger (Linnaeus, 1758)	61	42.5-80.0	61.25±9.04	97.0-770.0	347.64±165.04	0.0005	3.263	0.011	3.240-3.286	0.999	LL, HL, FN
Belonidae											
Belone belone (Linnaeus, 1760)	93	15.2-27.7	21.37±3.42	3.8-23.5	11.41±5.30	0.0008	3.115	0.005	3.104-3.126	0.999	TN, HL
Cyprinodontidae											
Aphanius fasciatus (Valenciennes, 1821)	57	2.6-3.2	2.90±0.17	0.2-0.5	2.90±0.66	0.0085	3.348	0.195	2.959-3.737	0.843	BS
Syngnathidae											
Syngnathus abaster (Risso, 1827)	17	9.4-12.5	10.86±0.92	0.4-1.0	0.62±0.17	0.0003	3.171	0.074	3.024-3.313	0.992	BS
Syngnathus acus (Linnaeus, 1758)	81	9.5-21.6	14.71±3.43	0.5-8.3	2.78±2.22	0.0002	3.490	0.011	3.469-3.511	0.999	BS
Syngnathus typhle (Linnaeus, 1758)	33	9.0-14.6	11.32±1.76	0.2-0.8	0.38±0.19	0.0001	3.212	0.040	3.133-3.291	0.995	BS
Gasterosteidae											
Gasterosteus aculeatus (Linnaeus, 1758)	9	4.7-7.7	6.29±1.00	0.95-4.8	2.69±1.29	0.0062	3.256	0.039	3.178-3.334	0.999	BS
Serranidae											
Serranus cabrilla (Linnaeus, 1758)	37	14.2-27.8	18.25±3.18	36.0-277.0	84.78±50.08	0.0115	3.036	0.020	2.995-3.077	0.998	LL, HL, TN
Serranus hepatus (Linnaeus, 1758)	93	5.0-13.1	8.71±2.25	1.9-39.8	13.17±10.19	0.0124	3.124	0.010	3.104-3.144	0.999	LL, HL, TN
Serranus scriba (Linnaeus, 1758)	55	11.5-15.0	13.13±0.99	17.9-42.0	27.07±6.37	0.0115	3.161	0.078	3.091-3.231	0.994	TN
Moronidae											
Dicentrarchus labrax (Linnaeus, 1758)	105	9.7-34.7	19.15±6.87	11.8-510.0	120.73±116.43	0.0150	2.938	0.008	2.922-2.954	0.999	LL, HL, TN
Carangidae											
Trachurus mediterraneus (Steindachner, 1868)	53	7.6-12.3	10.01±1.25	3.7-15.4	8.81±3.10	0.0099	2.928	0.015	2.899-2.957	0.999	TN
Sciaenidae											
Argyrosomus regius (Asso, 1801)	41	24.2-60.7	42.51±9.35	148.0-2290.0	903.35±562.85	0.0112	3.036	0.003	2.972-2.984	0.999	LL, HL
Umbrina cirrosa (Linnaeus,1758)	17	15.3-35.3	21.14±5.05	45.3-570.0	143.14±125.70	0.0119	3.095	0.036	2.953-3.095	0.998	LL, HL
Mullidae											
Mullus barbatus barbatus (Linnaeus, 1758)	121	5.0-12.2	8.61±2.17	1.05-18.1	7.29±5.22	0.0063	3.182	0.011	3.159-3.205	0.999	BS
Mullus surmuletus (Linnaeus, 1758)	75	5.9-9.6	7.30±1.10	1.7-8.5	11.07±1.95	0.0051	3.280	0.017	3.247-3.313	0.998	BS
Sparidae											
Boops boops (Linnaeus, 1758)	65	6.8-13.8	10.22±1.84	3.05-25.7	11.39±6.03	0.0094	3.015	0.008	3.035-3.067	0.999	TN
Diplodus annularis (Linnaeus, 1758)	85	6.8-14.9	11.18±1.61	4.1-50.0	23.26±10.08	0.0070	3.327	0.048	3.232-3.422	0.983	TN, HL
Diplodus puntazzo (Walbaum, 1792)	77	3.9-13.5	9.25±11.75	1.05-41.3	16.51±11.75	0.0184	2.958	0.008	2.941-2.975	0.999	TN, LL
Diplodus sargus (Linnaeus, 1758)	75	4.8-11.7	8.07±1.93	1.7-26.5	9.97±6.59	0.0135	3.085	0.009	3.066-3.104	0.999	TN, LL
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	103	4.9-14.1	8.97±2.57	1.4-39.7	12.36±10.33	0.0089	3.181	0.007	3.168-3.196	0.999	TN, LL, HL, CN
Lithognathus mormyrus (Linnaeus, 1758)	85	8.4-14.4	11.54±1.72	6.2-34.0	17.59±7.75	0.0078	3.125	0.025	3.075-3.175	0.995	TN, LL
Sarpa salpa (Linnaeus, 1758)	101	4.8-14.6	8.93±2.16	0.9-31.2	7.95±6.11	0.0073	3.114	0.012	3.089-3.139	0.999	BS, CN, TN
Sparus aurata (Linnaeus, 1758)	77	7.8-16.3	13.16±2.31	5.8-60.0	33.65±14.83	0.0083	3.188	0.014	3.159-3.217	0.999	TN, LL, HL, FN
Centracanthidae											
Spicara smaris (Linnaeus, 1758)	41	7.8-12.9	10.60±1.49	4.3-20.0	11.96±4.7	0.0076	3.091	0.022	3.047-3.135	0.998	TN

Labridae											
Symphodus cinereus (Bonnaterre, 1788)	31	7.4-11.1	9.32±1.03	5.4-19.0	11.45±3.82	0.0112	3.090	0.021	3.047-3.133	0.999	TN
Trachinidae											
Trachinus araneus (Cuvier, 1829)	21	8.2-14.4	11.25±1.74	5.2-25.5	13.66±5.81	0.0134	2.837	0.038	2.761-2.913	0.997	BS
Uranoscopidae											
Uranoscopus scaber (Linnaeus, 1758)	31	20.6-31.8	25.95±3.12	145.0-572.0	315.50±117.63	0.0109	3.142	0.015	3.111-3.173	0.999	TN
Gobiidae											
Gobius cobitis (Pallas, 1814)	23	8.5-13.5	11.24±1.35	8.9-39.0	23.26±8.08	0.0107	3.159	0.039	3.082-3.236	0.997	FN
Gobius niger (Linnaeus, 1758)	57	5.0-11.7	8.35±1.75	1.35-19.2	6.60±4.68	0.0085	3.136	0.021	3.115-3.157	0.998	FN
Gobius paganellus (Linnaeus, 1758)	45	7.1-11.5	8.81±1.23	4.2-21.4	9.35±4.70	0.0055	3.383	0.026	3.330-3.436	0.997	FN
Pomatoschistus bathi (Miller, 1982)	33	2.2-3.1	2.65±0.26	0.10-0.31	0.19±0.06	0.0088	3.120	0.108	2.905-3.335	0.965	BS
Pomatoschistus marmoratus (Risso, 1810)	45	3.5-6.0	4.73±0.57	0.35-2.20	0.89±0.35	0.0064	3.141	0.071	3.000-3.282	0.979	BS
Pomatoschistus minutus (Pallas, 1770)	73	5.7-8.8	7.29±0.69	2.6-9.75	5.65±1.60	0.0120	3.083	0.015	3.053-3.113	0.998	BS
Zosterisessor ophiocephalus (Pallas, 1814)	33	5.7-9.9	7.81±1.20	1.9-10.0	5.17±2.21	0.0111	2.957	0.016	2.926-2.988	0.999	FN
Blennidae											
Parablennius gattorugine (Linnaeus, 1758)	21	7.0-10.0	9.01±1.11	4.7-19.0	11.11±4.15	0.0090	3.217	0.039	3.139-3.295	0.997	BS
Parablennius incognitus (Bath, 1968)	11	4.3-6.4	5.46±0.64	0.8-2.75	1.76±0.59	0.0096	3.046	0.056	2.935-3.157	0.997	BS
Parablennius sanguinolentus (Pallas, 1814)	37	9.7-15.4	12.34±1.57	12.0-53.2	27.39±10.97	0.0095	3.147	0.027	3.092-3.202	0.997	BS
Parablennius tentacularis (Brünnich, 1768)	23	9.0-13.7	11.31±1.29	5.3-19.5	11.20±3.91	0.0063	3.067	0.138	2.792-3.342	0.960	BS
Mugilidae											
Chelon labrosus (Risso, 1827)	71	4.8-17.6	10.90±3.12	1.1-58.5	16.90±13.34	0.0087	3.073	0.006	3.061-3.085	0.999	CN, TN
Chelon auratus (Risso, 1810)	77	4.7-13.3	8.89±2.63	1.1-23.5	8.83±6.53	0.0099	3.002	0.012	2.979-3.025	0.999	CN, TN
Chelon ramada (Risso, 1827)	103	3.8-12.2	8.30±2.36	0.6-18.2	7.04±5.08	0.0098	3.008	0.004	2.999-3.017	0.999	CN, TN
Chelon saliens (Risso, 1810)	66	6.0-15.5	11.12±2.56	1.6-44.0	15.44±10.30	0.0070	3.125	0.057	3.011-3.239	0.979	CN, TN
Mugil cephalus (Linnaeus, 1758)	115	5.0-15.9	10.26±3.04	1.5-41.0	13.95±10.74	0.0102	3.000	0.011	2.979-3.021	0.999	CN, TN
Atherinidae											
Atherina hepsetus (Linnaeus, 1758)	65	5.5-10.2	7.36±1.26	1.1-7.35	2.97±1.62	0.0056	3.099	0.016	3.067-3.131	0.998	BS, SN
Atherina boyeri (Risso, 1810)	105	4.0-11.2	6.72±2.09	0.5-10.0	17.79±6.13	0.0056	3.099	0.056	2.987-3.211	0.987	BS, SN
Citharidae											
Citharus linguatula (Linnaeus, 1758)	43	10.1-15.9	13.29±1.56	7.0-29.0	13.95±10.74	0.0102	3.000	0.011	2.979-3.021	0.999	FN
Bothidae											
Arnoglossus laterna (Walbaum, 1792)	62	5.9-10.9	8.36±1.36	1.5-9.35	4.53±2.07	0.0076	2.975	0.019	2.938-3.012	0.998	FN
Pleuronectidae											
Platichthys flesus (Linnaeus, 1758)	39	9.3-1509	12.23±1.59	6.9-29.5	16.47±6.43	0.0066	3.101	0.019	3.062-3.140	0.999	FN, TN, HL
Soleidae											
Buglossidium luteum (Risso, 1810)	21	8.0-11.7	9.56±0.98	5.7-18.6	10.53±3.29	0.0118	2.996	0.046	2.903-3.089	0.996	FN
Solea solea (Linnaeus, 1758)	133	6.7-16.9	11.98±2.42	2.8-46.1	18.15±10.57	0.0065	3.143	0.013	3.118-3.168	0.998	FN, TN

N: number of individuals, *a*: intercept, *b*: slope, CI: confidence limits, r^2: coefficient of determination, *FG*: Fishing Gear (BS: Beach seine, TN: Trammel net, LL: Longline, HL: Handline, FN: Fyke net, CN: Cast net, SN: Scoop net)

and weighed in cm and gram, respectively.

The length-weight measurement was made with the equation of $W=aL^b$ [4]. r^2 and the statistical significance were estimated by linear regressions on the transformed equation, $LogW=loga+b.logTL$.

RESULTS

Sample size of 3487 captured fish specimens ranged from 9 individuals for *Gasterosteus aculeatus* to 133 for *Solea solea* with r^2 values between 0.843 and 0.999. Median of *b* was 3.14 and its 50% was between 3.010 and 3.170. Except from Rajidae family of Chondrichthyes classis, the other families belonged to Osteichthyes in the study. The highest number of species was 8 in Sparidae family, followed by Gobiidae with 7, Mugilidae with 5, Blennidae with 4, Clupeidae with 3, Syngnathidae with 3 and Serranidae with 3 species. All the other families are represented by one or two species. Table 1 shows sample size, types of catching gears that used for fishing, length range, length-weight relationship parameters (intercept and slope) for each species and related statistical values (95% confidence limits of *a* and *b*, and coefficient of determination). All regressions were highly significant ($p < 0.01$). Fifteen species showed isometric growth ($b = 3$), seven species had negative allometric growth ($b < 3$) and all remaining species

(35 species) had positive allometric growth ($b > 3$) (Table 1).

DISCUSSION

The study did not examine the effects of daytime and overnight catches on species diversity. The total number of species in catch was taken into account. Individuals had been collected by catching activities for a long period of time. Therefore, calculated parameters were regarded as mean annual values. As various researchers stated, there are many abiotic and biotic factors which influence parameters for length-weight relationships. These factors are not considered in this study. As reported previously, this study was the first research that tried to determine which species were captured and what sorts of fishing gears used for catching them in the Bakırçay estuary. Moreover, we attempted to determine their length-weight relationships.

Similar studies were made in terms of length-weight relationships in fishes caught from the estuary areas. Length-weight relationships of 43 species from 19 families, 59 from 32, 54 from 22 and 48 from 24 were measured by Koutrakis and Tsikliras [5], Dulcic and Glamuzina [6], Veiga et al. [7] and Kara et al. [8], in three Estuaries in northern Aegean Sea, in three Estuaries along Croatian Adriatic Sea, in Arade Estuary in Southern Portugal and in Gediz Estuary of Izmir Bay, respectively. This study measured LWRs of 57 species from 27 families in Bakırçay River Estuary. Sparidae, Gobiidae and Mugilidae were most abundantly seen families in all estuaries including Bakırçay. Most abundant ones across all Mediterranean estuaries could generally be regarded as the typical feature of estuary regions.

The above four studies including ours used almost the same fishing gears to capture the species. However, we employed trammel net instead of gill net to catch much more species in more various lengths. Gill nets were not preferred because they are more selective and they catch less species.

ACKNOWLEDGEMENTS

We appreciate local fishermen for their precious contributions to sampling and measuring of specimens.

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Received: **28.06.2021**
Accepted: **24.08.2021**

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