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Collective Article B

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New Fisheries-related data from the Mediterranean Sea (December 2017)

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Abstract

In this collective article we discuss the relationships between the otolith measurements (weight, radius) and total length of *Mullus surmuletus* in the Aegean and Ionian Seas and of *Pagellus erythrinus* samples caught in the Southern Aegean Sea. In addition to the above mentioned studies, the abundance of the rare fish *Echiodon dentatus* in the Kyklades islands and the Saronikos Gulf (Central Greece) is also documented. The first weight-length relationship of the alien northern brown shrimp *Penaeus aztecus* from the Central Aegean Sea is given at the end.

Keywords: Otolith-total length relationships, length-weight relationships, rare fishes, Aegean Sea, E. Mediterranean.

Introduction

Otoliths serve as a permanent record of the life history of an individual fish (Belchier *et al*., 2004); they hold a wealth of information on age, size, growth and ontogeny of fishes (Gerard & Malca, 2011) and they are one of the most reliable tools for determining the age of a fish. The size and shape of otoliths are variable, and depend on the species and size (Eroglou & Sen, 2009). By using the relationship between fish length and otolith dimensions (length, width, area, perimeter, thickness) and weight, it is possible to identify and estimate the size of fish, the prey size from stomach samples and also analyse the digestive tract content of fishes, feeding on others fishes, identify fish stock and determine the age (Granadeiro & Silva, 2000).

The family of Carapidae comprises two subfamilies, 7 genera, about 31 described and several undescribed species. They inhabit the tropical waters of the Atlantic, Indian, and Pacific Oceans at depths down to 2,000 m, along oceanic shelves and slopes. They are slender, elongated fish with no scales, translucent bodies, and dorsal fin rays that are shorter than their anal fin rays. The adults of most species live symbiotically inside various invertebrate hosts. *Echiodon dentatus* (Cuvier, 1829) is a demersal species. In the Mediterranean, this species is distributed at depths range mainly between 100 and 300 m.

The invasion of new regions and territories by alien species is a phenomenon of paramount and global importance. It has been estimated that during the last four centuries invasive alien species have contributed to nearly 40% of animal extinctions with known causes. The unique combination of geological, geophysical and climatic factors in the Mediterranean has led to the development of a characteristic and highly diverse biota. The northern brown shrimp *Penaeus aztecus* (Ives, 1891) is not a Lessepsian species, but is native to the western Atlantic Ocean and has been introduced in Oceania for aquaculture purposes.

The contributors are co-authors in this collective article and their names appear in alphabetical order. The contributing authors are cited at the beginning of each section of the collective article.

1. Otolith radius, weight and fish length relationships for the striped mullet *Mullus surmuletus* (Linnaeus, 1758)

Kousteni V. and Anastasopoulou A.

The size and shape of otoliths vary according to species (Eroglou & Sen, 2009; Anastasopoulou *et al*., 2016). Such information combined with fish size can be a useful tool for population identification, aging, feeding studies and stock assessment (Zan *et al*., 2015 and references therein). In this study, the relationships between otolith radius, weight and fish length were established for the striped mullet *Mullus surmuletus* (Linnaeus, 1758).

A total of 226 specimens were collected using multiple gears (trawlers, driftnets, gillnets and trammel nets) in the Aegean (AEG) and Ionian (ION) Seas within the Data Collection Framework Program in 2013. Total length (TL) ranged from 95 to 291 mm (mean=166±42.2; N=139) in the AEG and from 144 to 264 mm (mean=192±30.0; N=87) in the ION. Both sagittal otoliths were extracted from each specimen, cleaned and dried. The broken otoliths were excluded from the analysis. Left otolith weight and right otolith weight (OW) were recorded, using an electronic balance of 0.0001 g readability, and compared using the Student's t-test. No statistical differences were found (t=0.1953, P_t=0.8453), supporting the view that the left and right otoliths are very similar, but not identical, mirror images of each other (Campana, 2004). Thus, only the left otoliths were used for the analyses. Digital images of the left otoliths were obtained through the stereoscope image analysis system of the HCMR, and the otolith radius (OR) was measured to the nearest 0.001 mm. OR and OW were compared between sexes and areas using the Student's t-test. Regression analysis was used to estimate the OR-OW, OR-TL and OW-TL parameters (Table 1). The slopes of the regressions were compared for between-sex and -area differences using the analysis of covariance (ANCOVA).

OR ranged from 1.25 to 2.26 mm (mean=1.64±0.23; N=170) in females and from 1.21 to 2.16 mm (mean=1.59±0.23; N=31) in males. OW ranged from 0.0013 to 0.0066 g (mean=0.0033±0.0012; N=124) in females and from 0.0018 to 0.0064 g (mean=0.0031±0.0014; N=25) in males. No significant between-sex differences were found in the mean values of OR (t=1.0238, P_t=0.3072) and OW (t=0.7189, P_t=0.4734).

The parameters of the OW-OR relationships were: α=10.83 and b=0.3281 in the AEG (multiplicative model, R^2=0.92, N=96); α=1.085 and b=173.05 in the ION (linear model, R^2=0.84, N=52); α=11.60 and b=0.3394 overall (multiplicative model, R^2=0.91, N=148). In males, otoliths were significantly heavier than those of females of the same OR (P_{ANCOVA}=0.0144, F=6.14). No significant between-sex differences were found in both the OR-TL (P_{ANCOVA}=0.2598, F=1.28) and OW-TL (P_{ANCOVA}=0.6914, F=0.16) relationships.

Considering the sampling location, both OR and OW were significantly higher in the ION than in the AEG (OR: t=-5.0926, P_t=8E-7; OL: t=-4.7361, P_t=5E-6). Otoliths from the AEG were significantly heavier than otoliths from the ION of the same OR (P_{ANCOVA}=0.0426, F=4.18). Similarly, in the red mullet *Mullus barbatus* (Linnaeus, 1758), OW-OR relationships differed significantly between the AEG and the ION (Anastasopoulou *et al*., 2016). No significant difference was found in b values between the AEG and the ION for OR-TL (P_{ANCOVA}=0.2006, F=1.65). On the contrary, individuals from the ION showed significantly heavier left otoliths than individuals from the AEG of the same length (P_{ANCOVA}=0.0195, F=5.57) (Table 1, Figure 1); this may be related either with the existence of a higher number of smaller individuals caught in the AEG or with the existence of different population stocks, as it has been assumed for the red mullet (Anastasopoulou *et al*., 2016). In any case, a strong and positive relationship was observed between OW-OR, OR-TL and OW-TL, confirming previous results for other species (Zan *et al*., 2015; Anastasopoulou *et al*., 2016).

Table 1. Descriptive statistics for OR and OW and parameters of the OR-TL and OW-TL relationships for *Mullus surmuletus* by area (AEG, Aegean Sea; ION, Ionian Sea) and overall.

Area	N	Mean±S.D.	Range	N	α	b	$S.E._{(b)}$	R^2	Description
		OR				**OR-TL**			
AEG	136	1.57±0.22	1.21–2.19	136	0.756	0.0049	0.0001	0.91	Linear
ION	86	1.72±0.18	1.38–2.26	86	7E-2	0.5968	0.0364	0.96	Multiplicative
Total	270	1.61±0.20	1.21–2.26	222	1E-1	0.5400	0.0133	0.88	Multiplicative
		OW				**OW-TL**			
AEG	97	0.0028±0.0012	0.0013–0.0064	97	-0.002	3E-5	7E-7	0.97	Linear
ION	70	0.0036±0.0010	0.0020–0.0066	70	5E-7	1.6995	0.068	0.90	Multiplicative
Total	204	0.0031±0.0011	0.0013–0.0066	167	8E-7	1.5946	0.032	0.94	Multiplicative

Abbreviations: N, number of individuals; TL, total length in mm; OR, otolith radius in mm; OW, otolith weight in g; α, intercept; b, slope; S.D., standard deviation; S.E.(b), standard error of b; R^2, correlation coefficient

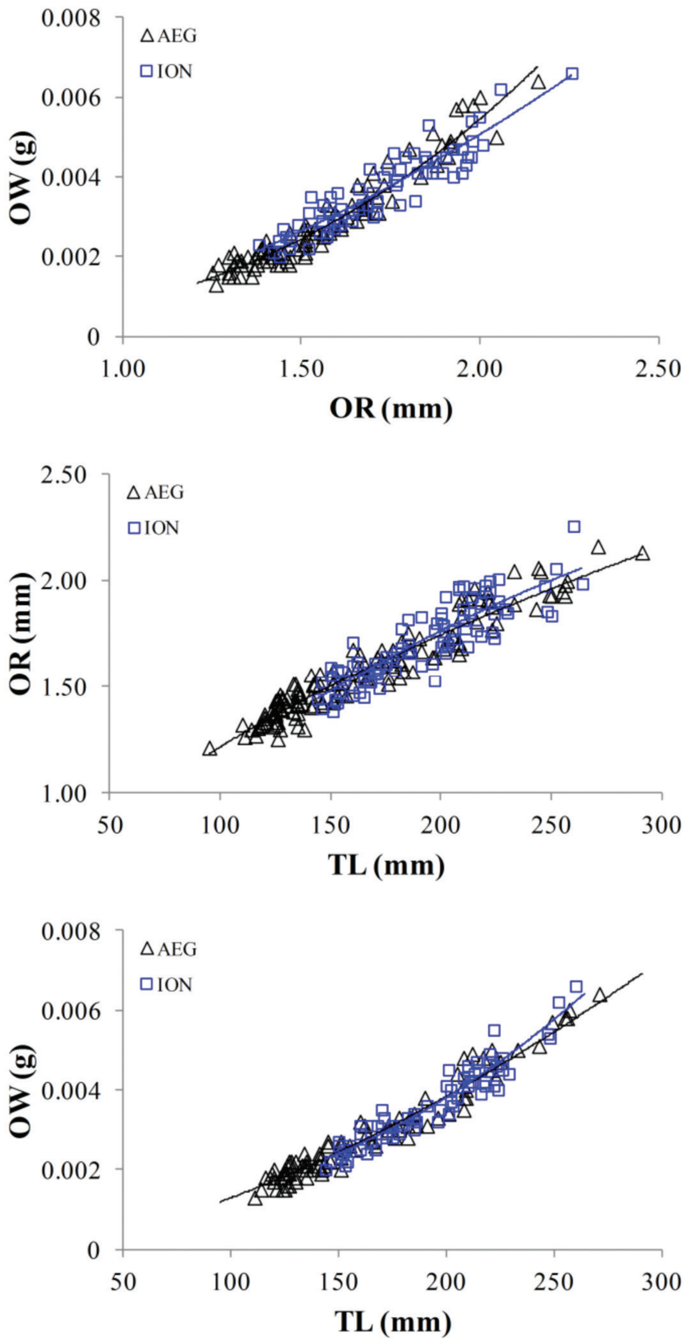

Fig. 1: OW-OR, OR-TL and OW-TL relationships for *Mullus surmuletus* by area (AEG, Aegean Sea; ION, Ionian Sea).

2. Morphometric characteristics of otoliths in the common pandora *Pagellus erythrinus* (Linnaeus 1758) in the Southern Aegean Sea

Lampri P-N and Mytilineou Ch.

Otolith weight (OW) is an important attribute that has been explored for population identification, aging and feeding studies as well as stock assessments for many fish species (Zan *et al*., 2015). This study provides information on the relationships between otolith dimensions – including otolith weight– and fish length in the common pandora (*Pagellus erythrinus*), a demersal fish whose geographic distribution is expanding throughout the Mediterranean Sea and the eastern coasts of the Atlantic Ocean (Fisher *et al.,* 1987). In particular, we investigated the relationships between: i) otolith weight (OW) and total length (TL), ii) OW and otolith radius (OR) and iii) TL and OR in the common Pandora, in the South Aegean Sea.

In total, 181 fish were collected from the Southern Aegean Sea within the Data Collection Framework Program in 2013. Their total length (TL) ranged from 63 to 488 mm.

Both otoliths from each specimen were extracted, cleaned and weighed to the nearest 0.0001g. The otoliths were photographed using the Image analysis Pro-Plus software and their OR was measured from the digital images. The OR was defined as the distance from the otolith core to its margin. ANOVA analysis was performed in order to check for differences between the right and the left otolith weight. Since, no statistical differences were found between the left and right otolith ($p>0.05$), only the left one was used for the analyses. Regression analysis among OW, TL and OR for all specimens was performed using the STATGRAPHICS statistical software. No sex division took place when analyzing the data, since the common pandora is a protogynous hermaphrodite species; the majority of individuals born females with sex inversion later in their life cycle. The power model was the most appropriate for both the OW-TL ($OW= 2x10^{-7} xTL^{2.46}$, R^2= 97.61%, N=181, SE=0.14) and the OW-OR relationships ($OW= 0.0014 x OR^{2.82}$, R^2= 98.1%, N=181, SE=0.125) (Fig. 2 & 3). Negative allometry ($b<3$) was found in otolith growth for both relationships indicating that otolith weight increases slower than fish length and otolith radius. As it concerns the relationship between TL and R, the power model was also the most adequate to fit the data ($TL= 37.52 x OR^{1.1289}$, R^2= 98.06%, N=181, SE=0.051) (Fig. 4); however, since b is close to one, an almost linear relationship can be considered between the two variables.

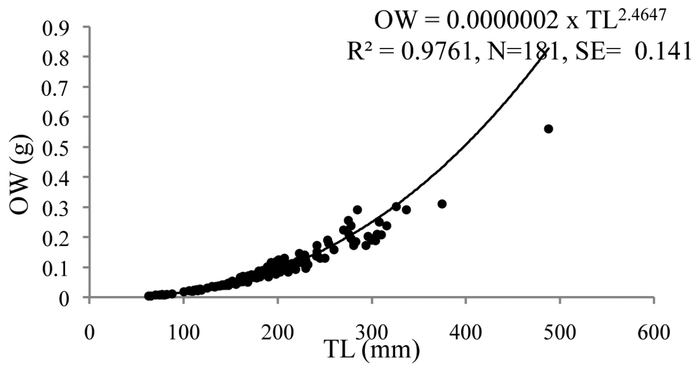

Fig. 2: Relationship between OW and TL of the common pandora in the S. Aegean Sea.

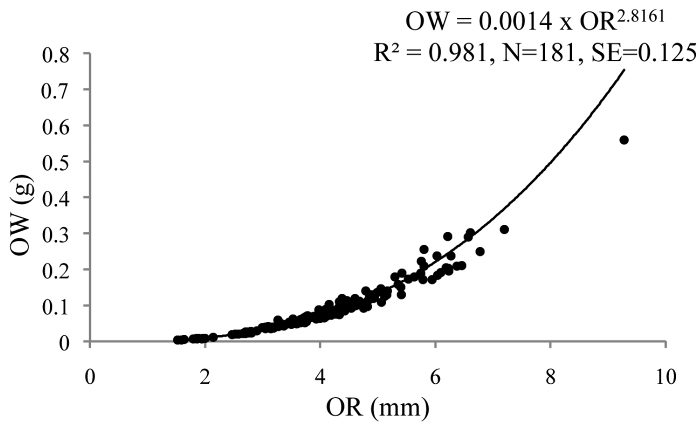

Fig. 3: Relationship between OW and OR in the common pandora in the S. Aegean Sea.

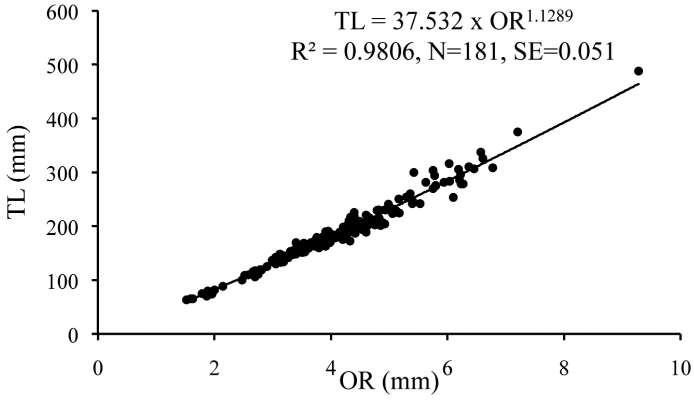

Fig. 4: Relationship between OR and TL in the common pandora in the S. Aegean Sea.

3. Biological data on the uncommon *Echiodon dentatus* (Cuvier 1829) in the Southern Aegean Sea

Oikonomidis G. and Mytilineou Ch.

Echiodon dentatus is an uncommon fish belonging to the family Carapidae. It is characterized by an eel–like cylindrical shape, small size, translucent body and two pairs of long fangs at both jaws. Nielsen *et al*. (1999) mentioned that the species is free-living or facultative commensal inside holothurians. Despite its wide distribution across the Atlantic and Mediterranean Sea, there are few studies about it (Filiz *et al*., 2007; Froese & Pauly, 2013 and references within). In Greek waters, the species has been reported to date in the Ionian Sea, Korinthiakos Gulf, Thermaikos Gulf, Thracian Sea and Kyklades Islands (Papaconstantinou, 2014). The present work aims to increase our knowledge regarding this carapid species.

In September 2014, specimens of *E. dentatus* were collected in the area of the Kyklades and Saronikos Gulf, a new record for the species (Table 2). Samples were caught by trawl experimental fishing during the EPILEXIS program in 4 (out of 168) hauls of 1 hour duration (Table 2). In total, 13 specimens were caught in the net (10 mm mesh size) covering the trawl codend, towed on muddy and sandy bottoms at depths ranging from 90 to 102 m (Table 1). Total length (TL) and weight (W) ranged between 9.3-19.3 cm and 0.4-4.2 g, respectively. In the current work, a larger maximum size for the species than that reported in published literature (17.0 cm; Froese & Pauly, 2013) was found. The W-TL relationship was fitted by the power model: $W=0.0004075TL^{3.09282}$ ($P<0.0001$, $N=13$, $SE=0.27428$, $R^2=92.04\%$). Measurements for 13 morphometric characteristics were recorded (Table 3). Stomach contents in all specimens consisted of remnants of digested unidentified Crustaceans and other digested food. This, in line with the presence of long fangs, may indicate predator behaviour for *E. dentatus*.

This study underlined the rarity of this species as previously mentioned by Froese & Pauly (2013). However, this fact seems to be related with the sampling gear used since in our case all specimens were caught in the small-meshed cover codend net.

Table 2. Longitude, latitude, depth and abundance at the *E. dentatus* sampling sites.

	Saronikos		Kyklades	
Longtitude	28°28.47	24°01.98	25°09.23	25°13.45
Latitude	37°50.78	37°37.90	36°50.76	25°12.75
Depth (m)	90	90	102	102
Abundance	1	4	6	2

Table 3. Morphometric characteristics of E. dentatus (St. Dev.: standard deviation).

Morph. Charact.	1	2	3	4	5	6	7	8	9	10	11	12	13	Mean	St. Dev.
TL	153.64	160.68	126.63	126.96	121.05	93.13	161.82	160.89	98.51	155.51	173.52	192.92	168.07	145.64	29.85
PDL	25.71	26.30	21.37	21.98	19.19	15.89	25.70	26.92	13.04	24.02	27.80	28.39	22.74	23.00	4.67
PECL	1.32	1.36	1.35	1.39	1.12	0.73	1.49	1.29	1.36	1.39	1.71	1.75	1.81	1.39	0.28
PrPecL	16.71	17.42	15.79	15.51	12.97	11.53	16.05	16.22	10.74	17.73	19.36	19.43	18.17	15.97	2.75
PosOrL	10.07	10.27	9.73	9.74	8.45	7.17	10.11	10.80	4.61	8.73	9.22	10.45	9.55	9.15	1.67
PrOrL	2.91	2.45	2.48	2.41	2.24	2.10	3.08	2.98	2.57	2.62	3.87	3.67	3.44	2.83	0.55
S	3.58	2.91	2.73	2.93	2.45	2.16	3.18	3.04	2.31	2.49	2.25	3.23	3.35	2.82	0.46
HL	15.20	16.58	13.71	13.64	12.07	8.97	14.79	15.15	9.80	15.60	17.48	18.89	15.75	14.43	2.83
HHE	6.68	6.09	5.73	5.61	4.65	3.63	6.84	6.94	1.28	1.98	2.01	2.20	1.98	4.28	2.16
ED	4.09	4.22	3.50	2.79	2.53	2.11	3.63	3.86	2.01	3.96	4.64	4.02	2.64	3.38	0.86
EH	3.89	3.71	2.23	2.47	2.16	1.92	3.07	3.29	1.77	2.43	2.82	3.15	3.40	2.79	0.68
IOD	3.68	4.02	3.22	3.56	2.24	2.07	3.41	3.20	2.56	3.60	4.22	3.76	3.43	3.31	0.65
BEW	1.63	2.27	1.65	1.55	1.68	1.17	1.71	1.65	1.85	3.49	3.07	4.45	3.79	2.30	1.04

TL: total length, PDL: pre-dorsal length, PECL: pectoral length, PrPecL: pre-pectoral length, PosOrL: post-orbital length, PrOrL: pre-orbital length, S: snout, HL: head length, HHE: head height in eye axis, ED: eye diameter, EH: eye height, IOD: inter-orbital distance, BEW: between eye width.

4. Weight-length relationship of the northern brown shrimp *Penaeus aztecus* Ives, 1891 (Decapoda: Penaeidae) from the Central Aegean Sea, Greece.

Kapiris K. and G. Minos

The northern brown shrimp, *Penaeus aztecus* (Ives, 1891) (Decapoda: Penaeida) is a very abundant and commercial decapod native in the western Atlantic. It is an estuarine and oceanic littoral shrimp in its West Atlantic natural range and shows a fast growing distribution within the eastern and central part of the Mediterranean Sea, where it was probably introduced via shipping (ballast waters) (Deval *et al*., 2010). In the Mediterranean, it has been reported from several sites, such as Antalya Bay (Deval *et al*., 2010), the western part of France (Galil *et al*., 2017), Montenegro and Israel (for details see Scannella *et al*., 2017).

Penaeus aztecus has been reported from many Greek areas, such as the Northern Aegean (see Minos *et al.*, 2015), Ionian Sea, Dodekanese islands, Lakonikos Gulf, Maliakos Gulf and the Kyklades area (Kapiris & Maina, 2016 and references therein). The study of the invaded species is of crucial importance in the Mediterranean since its biodiversity is influenced.

The samples were caught in Vivari Lagoon, situated in the Argolikos Gulf, Central Aegean Sea) (37.533771^o N, 22.914990^o' E). This lagoon has an area of 0.54 km^2 and its communication with the sea is immediate and continuous. It is considered to be a closed lagoon with a uniform water surface. It receives very little fresh water from a pipeline with intermediate flow. The bottom of the lagoon (0.6-1.8 m) is muddy. The communication channel with the sea is 10 m long, 30 m wide, 1.5 m deep and there are fishing facilities of reinforced concrete. The samples were caught using a hand net having a length of 200 m and height between 1.30-2.30 m.

A total of 300 individuals were caught of which 207 (69%) were females and 93 (31%) males. The sex ratio differed significantly ($P < 0.05$) from the theoretical 1:1. The carapace length was 33.06 ± 2.23 mm (range 25.85-3.22 mm) for females and was significantly (t test, $P < 0.05$) larger than that of males 28.73 ± 1.62 mm (range: 21.67-34.62 mm). The mean weight of females (25.20 ± 3.86 g, range: 15-35 g) was significantly (t test, $P < 0.05$) greater than that of males (17.63 ± 1.93 g range: 14-23 g). The weight-carapace length relationships for combined sexes was $W=0.013*CL^{2.13}$ ($R^2=0.79$), $W=0.028*CL^{1.93}$ ($R^2=0.67$) for females and $W = 0.306*CL^{1.20}$ ($R^2=0.42$) (Fig. 5) for males. The regression analyses, describing the relation of CL and W, showed that *b* values for females (b=1.93: *t*-test, $P<0.05$), males (b=1.20: *t*-test, $P<0.05$), and combined sexes (b=2.13, *t*-test, $P>0.05$) differed from 3.0, which indicates a negative allometric growth pattern. To test for possible significant differences between sexes, Student's t-test was used for the comparison of two slopes. A significant difference (t-test, $P < 0.05$) was found between males and females.

This is the first relationship between the carapace length and body weigh in *P. aztecus* in the Mediterranean. The only estimated *b* values in the bibliography are based on individuals caught in the Gulf of Finike (Özvarol & Gökoğlu, 2014) that, however, related total length and body weight. In this study, the weight-total length relationships for combined sexes was $W=0.029*TL^{2.89}$ ($R^2=0.79$), $W=0.081*CL^{2.47}$ ($R^2=0.73$) for females and $W=0.47*CL^{1.62}$ ($R^2=0.46$) for males. In the Gulf of Finike, the same estimated relationships were $W=0.009*CL^{2.97}$ ($R^2=0.91$) for females and $W= 0.01*CL^{2.73}$ ($R^2=0.88$) for males. In the latter study, the estimated higher values could be attributed to the different environmental conditions in the different habitats.

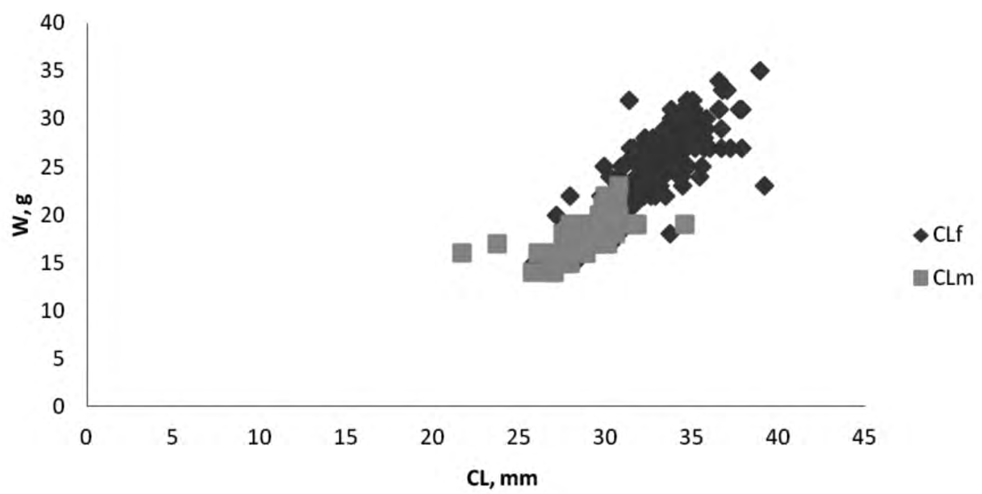

Fig. 5: Weight (W) carapace length relationship for both sexes (f=females, m=males) of *Penaeus aztecus.*

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