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A preliminary study of length-weight relationship (LWR) and condition factor of *Pagellus erythrinus* from Gökçeada Island, northern Aegean Sea (Turkey)

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Abstract

The aim of the present study was to estimate the length-weight relationship and to determine the condition factors of the common pandora (*Pagellus erythrinus* Linnaeus, 1758) from Gökçeada Island, the northern Aegean Sea in Turkish coasts. Totally 30 specimens of *P. erythrinus* which are considered as bycatch were sampled by a commercial trawl in the northern Aegean Sea. Total length values of the sampled individuals ranged between 13.60 cm and 18.70 cm in total length and weight values ranged between 28.58 g and 90.04 g. The length-weight relationship of *P. erythrinus* was estimated as $W=0.0062L^{3.2581}$ (R^2=0.94). The length-weight relationship was highly significant ($p<0.0001$). Fulton's condition factor ranged between 1.08 and 1.56 with a mean of 1.26 (SE: ±0.02). The relative condition factor ranged between 0.86 and 1.26 with a mean of 1.01 (SE: ±0.02). *P. erythrinus* exhibited a positive allometric growth and the results of Fulton's condition factor and the relative condition factor indicate the well-being of specimens in the study area. Knowledge of the distribution of exploited stocks is important for the appropriate management of fisheries resources. Therefore, the relationships between the length and weight of fish populations should be investigated and updated regularly. This study provides significant information on the length-weigh relationship and condition factors of *P. erythrinus* for fisheries managers and policymakers. Responsible authorities should consider the findings of the present study for sustainable fisheries management.

Keywords: LWR, Trawl, Bycatch, Condition factor, Common pandora

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1. Introduction

The relationship of length and weight of fish species has been investigated by several researchers (Karakulak et al., 2006; Acarli et al., 2014; Kara et al., 2018; Fassatoui et al., 2019; Berber et al., 2020; Kara et al., 2020; Cengiz & Paruğ, 2021; Babaoğlu et al., 2021; Cengiz, 2021a; Cengiz, 2021b). Understanding the relationship between the length and weight of fishes is of great importance for determining the structure of any population. Many authors well documented the significance of the length-weight relationships (LWRs) in fisheries science (Pauly, 1993; Petrakis & Stergiou, 1995; Froese, 2006). The relationships between length and weight of fish species should be regularly studied due to possible variations in the spatial or temporal status of the population. Therefore, LWR data of fish populations is needed for fisheries managers and policymakers.

Pagellus erythrinus, the common pandora, distributes along the coasts of the Mediterranean Sea, the Black Sea, and Atlantic Ocean coasts between Cape Verde and Norway (Bauchot & Hureau, 1986; Whitehead et al., 1986; Fisher et al., 1987). The common pandora generally lives in sandy-muddy, gravelly, and rocky habitats in shallow waters till 120 m (Jukic & Arneri, 1984; Papaconstantinou et al., 1988). *P. erythrinus* is a benthic feeder and a generalist predator (D'Iglio et al., 2021). It has been reported that the spawning period of the common pandora takes place between spring and early autumn, based upon hydrological conditions and the location (Pajuelo & Lorenzo, 1998; Coelho et al., 2010; Metin et al., 2011). *P. erythrinus* is a protogynous hermaphrodite species (Girardin, 1981), and individuals are female firstly, then become male in the third or fourth year of life (Ayyildiz & Altin, 2018). The sex reversal of *P. erythrinus* varied in the different parts of the Mediterranean Sea (Zei & Županovic, 1961; Klaoudatos & Klaoudatos, 2004; Zarrad et al., 2010; Saoudi et al., 2017). It is an important demersal species along the coasts of the Black Sea and Mediterranean Sea (Ayyildiz & Altin, 2018). This species has a high economic value among other Sparid species (Coelho et al., 2010). Trawls, bottom longlines, trammel nets, and gill nets are used to catch *P. erythrinus* (Metin et al., 2011).

Numerous scientists have already investigated the length-weight relationships of different fish species from the northern Aegean Sea (Lamprakis et al., 2003; Filiz & Bilge, 2004; Karakulak et al., 2006; Gurkan et al., 2010; Gurkan et al., 2013; Cengiz, 2013; Altın et al., 2015; Gönülal, 2017; Ayyildiz & Altin, 2018; Ayyildiz et al., 2019; Adamidou et al., 2020; Cengiz & Paruğ, 2021; Cengiz, 2021a). The age and growth of *P. erythrinus* were investigated by several authors (Al-Zahaby et al., 1994; Coelho et al., 2010; Ayyildiz et al., 2019). Ayyildiz and Altin (2018) also studied daily age and growth at early life stages of the common pandora. Kale et al. (2015) modeled the spatial distribution of *P. erythrinus* in the shallow waters of Gökçeada Island. Limited research has been conducted for bycatch and discarded species in the commercial trawl fishery at the same location (Soykan et al., 2016; Soykan et al., 2019). Soykan and Kınacıgil (2021) also studied the LWR of some discarded fish species from the central Aegean Sea.

This paper aimed to determine the length-weight relationship and condition factor of *Pagellus erythrinus* as bycatch species in the commercial trawl fishery in the northern Aegean Sea, Turkey.

2. Material and Methods

Samples were collected by the commercial trawl in the coasts of the Gökçeada Island, northern Aegean Sea (Figure 1) between March 2015 and April 2017 during the commercial trawl fishery season in the study area. The commercial trawl nets with a 22 mm codend mesh size were used in the study. Bottom trawl surveys were carried out between 109.7 m and 332.8 m water depth. The trawl hauls were completely towed during the daytime hours by way of the recommendation of the MEDITS program survey handbook (Bertrand et al., 1997).

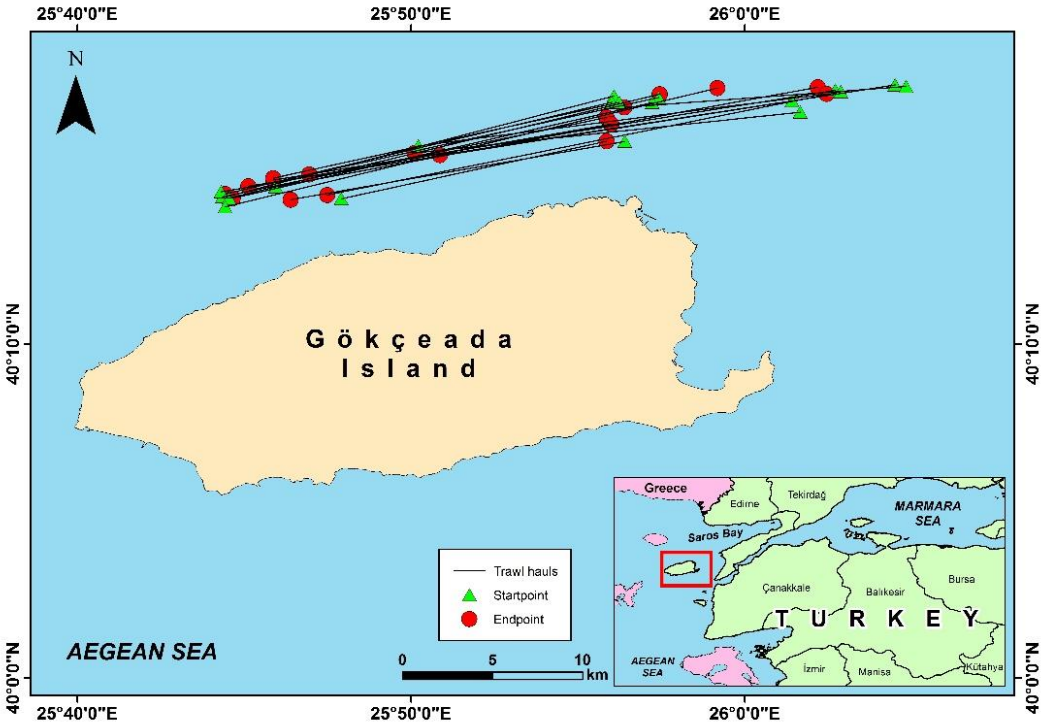

Figure 1. Sampling location

The total length (*TL*) of fish species was measured to the nearest 0.1 cm and the total weight (*W*) was measured to the nearest 0.01 g. LWR was estimated according to Eq. 1 (Ricker, 1975):

$$W = aL^b \quad (1)$$

In this equation, *L* is the total length, *W* is the total weight (g) of individuals, *a* is the intercept and *b* is the slope. Moreover, Fulton (1904)'s condition factor (*K*) was used to compare the conditions of species and was calculated using Eq. 2:

$$K = 100\frac{W}{L^3} \quad (2)$$

In this equation, *K* is the condition factor, *L* is the total length (cm) and *W* is the total weight (g). The relative condition factor (K_n) of Le Cren (1951) was calculated using Eq. 3:

$$K_n = \frac{W}{aL^b} \quad (3)$$

In this equation, K_n is the relative condition factor, *L* is the length (cm) and *W* is the total weight (g) of individuals, *a* is the intercept and *b* is the slope obtained from the LWR estimation.

The growth type of sampled individuals was identified using *t*-test (Zar, 1984). The growth is isometric while the *b* value is equal to 3, however, the growth is positive allometric while the *b* value is greater than 3, and the growth is negative allometric while the *b* value is less than 3 (Froese, 2006).

3. Results

Totally 30 specimens of *P. erythrinus* which are considered as bycatch were sampled by a commercial trawl in the northern Aegean Sea. The descriptive statistics (mean, standard error, skewness, kurtosis, minimum, maximum, range) of the dataset for the total length, weight, Fulton's condition factor (*K*) and Le Cren's relative condition factor (K_n) were given in Table 1.

Table 1. Descriptive statistics for *Pagellus erythrinus* from Gökçeada Island, northern Aegean Sea (sample size: 30)

Values	Total Length (cm)	Weight (g)	*K* (Fulton)	K_n (Le Cren)
Mean	14.83	42.05	1.26	1.01
Standard Error	0.22	2.55	0.02	0.02
Skewness	1.63	2.26	0.79	0.84
Kurtosis	2.67	5.08	0.53	1.17
Minimum	13.60	28.58	1.08	0.86
Maximum	18.70	90.04	1.56	1.26
Range	5.10	61.46	0.48	0.40

Length values of the sampled individuals ranged between 4.16 cm and 70.30 cm in total length and weight values ranged between 0.87 g and 565.91 g. The slope (*b*) of the length-weight relationship was 3.2581. The length-weight relationship of *Pagellus erythrinus* is presented in Figure 2. The length-weight relationship was highly significant ($p<0.0001$).

Fulton's condition factor (*K*) ranged between 1.08 and 1.56 with a mean of 1.26 (SE: ±0.02). The relative condition factor (K_n) ranged between 0.86 and 1.26 with a mean of 1.01 (SE: ±0.02). The growth type was determined as positive allometric for the common pandora.

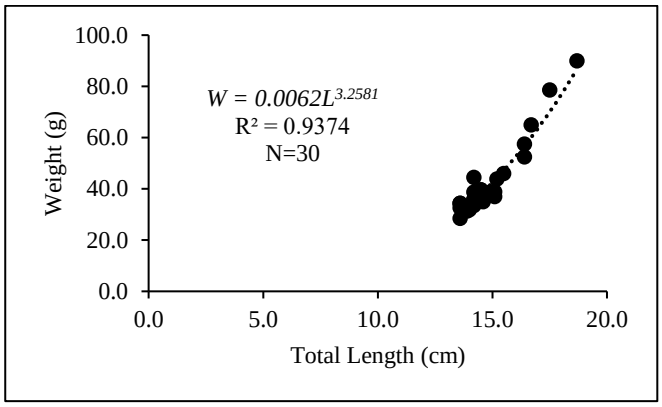

Figure 2. The length-weight relationship of *P. erythrinus*

4. Discussion

The exponent (*b*) value was 3.2581 for the common pandora in the coasts of Gökçeada Island, northern Aegean Sea. Froese (1998) advised that the slope (*b*) of the LWR is expected between 2.5 and 3.5. The b value found in the study supports this expectation and ranged between the expected values. Positive allometric growth was found for *P. erythrinus* in the northern Aegean Sea. Similar growth was also observed by Altin et al. (2015) in the same region and the curve of the LWR is relatively close to those obtained by Altin et al. (2015). Similar results have also been reported from other areas (Girardin & Quignard, 1985; Andaloro & Giarritta, 1985; Livadas, 1989; Santos et al., 1995; Özaydın, 1997; Joksimovich, 2001; Stergiou & Moutopoulos, 2001; Mehanna & Fattouh, 2009; Bilge et al., 2014; Altin et al., 2015; Gülşahin & Soykan, 2017).

Comparison of LWR results with previously published papers was presented in Table 2. The differences in LWRs between the present study and other studies may be involved with one or more factors such as fishing gears (Kapiris & Klaoudaos, 2011), sample size, season, sampling period (Moutopoulos & Stergiou, 2002), diet, stomach content/fullness, sex, gonadal maturity (Wootton, 1990), gonadal development (Hossain et al., 2006), changes in the physiology of fish (Le Cren, 1951), behavior (Muclisin et al., 2010), and feeding rate (Tarkan et al., 2006). In addition, bathymetric and spatiotemporal distribution are also thought to be effective on the LWR results. The effect of overfishing on *P. erythrinus* stocks could be more destructive than thought and overexploiting might disrupt the sex reversal in the stock of the hermaphrodite species and this may resulted in a fall both in the population and in the sustainability of reproduction.

Table 2. Length-weight relationships of *Pagellus erythrinus* in the literature

N	*a*	*b*	R^2	G	L	Location	References
386	0.0189	2.881	0.954	-A	TL	Mediterranean Sea, Algarve coasts	Neves Santos et al. (1995)
903	0.016	2.950	0.988	*nd*	TL	Mediterranean Sea, Egyptian coasts	Abdallah (2002)
676	0.00007	2.7388	0.839	-A	FL	North Aegean Sea, Edremit Bay	Hoşsucu & Türker-Çakır (2003)
1787	0.0152	2.840	0.973	-A	TL	Mediterranean Sea, Babadıllimanı Bight	Cicek et al. (2006)
169	0.0124	3.012	0.943	I	TL	North Aegean Sea, Gökçeada Island	Karakulak et al. (2006)
226	0.0122	3.034	0.990				Özaydın & Taskavak (2006)
365	0.0176	2.885	0.942	*nd*	TL	Aegean Sea, Gökova Bay	Akyol et al. (2007)
9	0.0076	2.910	0.910	+A	TL	North Aegean Sea, Izmir Bay	Gökçe et al. (2007)
2480	0.0105	3.060	0.980				Ismen et al. (2007)
495	0.0190	3.000	0.972	I	FL	Aegean Sea, Izmir Bay	Özaydın et al. (2007)
222	0.0145	2.910	0.940				Sangun et al. (2007)
1014	0.0134	2.980	0.983	*nd*	TL	Aegean Sea, Izmir Bay	İlkyaz et al. (2008)
59	0.0144	2.9660	0.970	*nd*	TL	North Aegean Sea, Greece	Karachle & Stergiou (2008)
181	0.0011	2.660	0.920				Türker-Çakır et al. (2008)
125	0.0178	2.855	0.942	-A	TL	Aegean Sea, Gökova Bay	Ceyhan et al. (2009)
2670	0.0096	3.1181	0.982	+A	TL	Mediterranean Sea, Egypt	Mehanna & Fattouh (2009)
122	-4.1080	2.929	0.982	*nd*	TL	Mediterranean Sea, southern Portugal	Coelho et al. (2010)
223	-4.071	2.910	0.982	*nd*	TL	Mediterranean Sea, southern Portugal	Coelho et al. (2010)
43	0.0412	2.580	0.950	-A	TL	Mediterranean Sea, İskenderun Bay	Gökçe et al. (2010)
129	0.0109	3.030	0.900	I	TL	Mediterranean Sea, Tunisia	Ghailen et al. (2010)
2033	0.0163	2.920	0.990	*nd*	TL	Mediterranean Sea, Sicily	Giacalone et al. (2010)
587	0.00002	2.860	0.922	-A	TL	Aegean Sea, Argolikos Gulf	Kapiris & Klaoudatos (2011)
2654	0.0143	2.950	0.990	-A	TL	Aegean Sea	Metin et al. (2011)
717	1.799	2.940	0.964	*nd*	TL	Mediterranean Sea, French Catalan coast	Crec'hriou et al. (2012)
32	0.0209	2.840	0.980	-A	TL	North Aegean Sea, Çanakkale Strait and Gallipoli Peninsula	Cengiz (2013)
531	0.0184	3.0128	0.972	+A	TL	Southern Aegean Sea	Bilge et al. (2014)
2166	0.0160	2.905	0.676	-A	TL	Mediterranean Sea, Tyrrhenian Sea	Busalacchi et al. (2014)
87	0.0511	2.513	0.946	-A	TL	Mediterranean Sea, Gulf of Antalya	Özvarol (2014)
50	0.0301	2.691	0.801	-A	FL	North Aegean Sea, Çandarlı Bay	Akalın et al. (2015)
259	0.0090	3.2180	0.981	+A	TL	North Aegean Sea, Gökçeada Island	Altin et al. (2015)
87	0.0117	3.0609	0.932	I	TL	North-eastern Atlantic, Canary Islands	Espino et al. (2016)
336	0.0075	3.150	0.950	+A	TL	Aegean Sea, Gökova Bay	Gülşahin & Soykan (2017)
90	0.0223	2.6207	0.929	-A	TL	North Aegean Sea, Gökçeada Island	Ayyildiz et al. (2019)
60	0.0084	3.128	0.960	I	TL	Mediterranean Sea, Gulf of Tunis	Miled-Fathalli et al. (2019)
945	0.0137	2.9600	0.980	-A	TL	Aegean Sea, Gökova Bay	Yapıcı & Filiz (2019)
346	0.1219	2.1543	0.946	-A	TL	Mediterranean Sea, Iskenderun Bay	Uyan et al. (2020)
310	0.0786	2.3338	0.947	-A	TL	Mediterranean Sea, Mersin Bay	Uyan et al. (2020)
302	0.0693	2.3887	0.954	-A	TL	Mediterranean Sea, Antalya Bay	Uyan et al. (2020)
1235	0.0163	2.8942	0.979	*nd*	TL	Adriatic Sea	Soldo (2020)
2152	0.0170	2.9120	0.970	-A	TL	Mediterranean Sea, Lebanese coast	Lteif et al. (2020)
1326	0.0096	3.118	0.980	I	TL	Mediterranean Sea, Egypt	Mehanna & Farouk (2021)
30	0.0062	3.2581	0.937	+A	TL	North Aegean Sea, Gökçeada Island	Present study

Note: *N*: sample size; *a* and *b*: parameters derived from the LWR; R^2: coefficient of determination; *G*: growth type (+*A*: positive allometric; -*A*: negative allometric; *I*: isometric; *nd*: not determined); *L*: length type (*TL*: total length; *FL*: fork length)

Fulton's condition factor (K) ranged between 1.08 and 1.56 with a mean of 1.26. The relative condition factor (K_n) ranged between 0.86 and 1.26 with a mean of 1.01. Condition factor is used to determine the condition of individuals (Froese, 2006). It is supposed that the growth of fish in ideal conditions keep the balance in length and weight, and it is a convenient index for age and growth ratios, monitoring feeding intensity, and evaluating the state of the aquatic ecosystem of fishes (Zamani-Faradonbe et al., 2015; Radkhah & Eagderi, 2015). As noted by Anene (2005), the condition factor is an index that expresses the interactions between biotic and abiotic factors on the physiological status of fish. Thus, it is a broadly used index to evaluate the status of the aquatic environment where fish lives. Condition factor of greater than one indicates the well-being of fishes fed with different experimental diets (Datta et al., 2013). In the present study, the findings on the condition factors of individuals with a mean of 1.26 (SE: ±0.02) and 1.01 (SE: ±0.02) for K and K_n, respectively, indicate the well-being of specimens in the study area.

Weatherley (1979) indicated that determining the condition factor of fish species is very beneficial for comparing fish populations living under similar or different conditions. Size at first maturity of *P. erythrinus* has been reported to be 17-23 cm in total length (*TL*) in the coasts of the Canary Islands (Pajuelo & Lorenzo, 1998), 17-18 cm *TL* in the coasts of Portugal (Coelho et al., 2010), 14-16 cm *TL* in the central part of the Mediterranean Sea (Zarrad et al., 2010; Ali Ben Smida et al., 2014), and 11-16 cm *TL* in the Aegean Sea (Metin et al., 2011). In the present paper, the range of the total length for sampled specimens was between 13.60-18.70 cm. Although the commercial trawlers consider this species as a bycatch, it can be concluded that the samples were above the size at first maturity given in the literature. Thus, it can be assessed as a target species when a massive catch has been caught. The increase in the mortality of adult individuals and the fishing pressure of fish stocks could lead to earlier maturation in smaller sizes (Beverton & Holt, 1956).

5. Conclusion

In conclusion, this research estimated the length-weight relationship of the common pandora (*P. erythrinus*) from the northern Aegean Sea. The length-weight relationship was found as $W=0.0062L^{3.2581}$ for the common pandora in the northern Aegean Sea during the study period. *P. erythrinus* exhibited a positive allometric growth. The results of Fulton's condition factor and the relative condition factor indicate the well-being of specimens in the study area. Knowledge of the distribution of exploited stocks is important for the appropriate management of fisheries resources. Therefore, the relationships between the length and weight of fish populations should be investigated and updated regularly.

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Conflict of interest

The authors declare that there is no conflict of interest.

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