

Otolith morphometry and population parameters of red porgy, *Pagrus pagrus* (Linnaeus, 1758) in Saros Bay (North Aegean Sea)

Saroz Körfezi'nde fangri [*Pagrus pagrus* (Linnaeus, 1758)] 'nin otolit morfometrisi ve populasyon parametreleri

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Özet: Bu çalışmada, Kuzey Ege Denizi'nde (Saroz Körfezi) Fangri balığının toplam boy (TL) ile toplam ağırlık (TW) arasındaki ilişki, yaş, büyüme ve otolit boyu (OL) - otolit ağırlığı (OW), balık boyu (TL) - otolit boyu (OL), balık ağırlığı (TW) - otolit boyu (OL), otolit boyu (OL) - otolit genişliği (OWi) arasındaki morfometrik ilişkiler incelenmiştir. Toplam 100 adet balık üzerinde yapılan ölçümlerde minimum boy 9,6 cm, maksimum boy 44,4 cm; minimum ağırlık 17,1 g, maksimum ağırlık 1372,5 g olarak tespit edilmiştir. Otolit ağırlığı minimum 0,0181 g, maksimum 0,1456 g; otolit boyu minimum 0,52 cm, maksimum 1,17 cm olarak ölçülmüştür. Boy-ağırlık ilişkisi $TW=0,021*TL^{2,885}$ ($r^2=0,98$), otolit boyu - otolit ağırlığı $OW=0,105*OL^{2,609}$ ($r^2=0,92$), toplam boy - otolit boyu $OL=0,024*TL+0,249$ ($r^2=0,83$) otolit boyu - toplam ağırlık $OL=0,235*TW^{0,237}$ ($r^2=0,81$) otolit boyu - otolit genişliği $OWi=0,501*OL+0,116$ ($r^2=0,832$) ilişkileri tespit edilmiştir. En büyük yaş 9 olarak belirlenmiş, von Bertalanffy büyüme parametreleri $L_{\infty}=51,59$ cm, $K=0,12$ yıl⁻¹ ve $t_0=-1,13$ yıl olarak hesaplanmıştır.

Anahtar kelimeler: *Pagrus pagrus*, yaş, büyüme, otolit, boy-ağırlık ilişkisi

Abstract: In this study, total length (TL) – total weight (TW) relationship, age, growth, and the morphometric relationships of otolith between otolith length (OL) and otolith weight (OW), total length (TL) and otolith length (OL), total weight (TW) and otolith length (OL), otolith width (OWi) and otolith length (OL) of *Pagrus pagrus* were investigated in Saros Bay (North Aegean Sea). A total of 100 specimens were measured as minimum TL 9.6 cm, maximum TL 44.4 cm, and minimum TW 17.1 g and maximum TW 1372.5 g. A total of 55 otoliths were measured as minimum OL 0.52 cm, maximum OL 1.17 cm, minimum OW 0.0181 g, and maximum OW 0.1456 g. The relationships between TL and TW, OL and OW, TL and OL, OL and TW, OL and OWi were determined as $TW=0.021*TL^{2.885}$ ($r^2=0.98$), $OW=0.105*OL^{2.609}$ ($r^2=0.92$), $OL=0.024*TL+0.249$ ($r^2=0.839$), $TW=0.235*OL^{0.237}$ ($r^2=0.814$), and $OWi=0.501*OL+0.116$ ($r^2=0.832$), respectively. Maximum age was 9 years for *P. pagrus* and von Bertalanffy growth parameters were estimated as $L_{\infty}=51.59$ cm, $K=0.12$ year⁻¹ and $t_0=-1.13$ year.

Keywords: *Pagrus pagrus*, age growth, otoliths, length-weight relationship

INTRODUCTION

The red porgy is sublittoral (at depths ranging from 18 – 185 m) demersal species that commonly found over rock or sandy and hard bottom (young frequently found on seagrass beds and the continental shelf) and a variety of temperate to subtropical habitats in the Atlantic and Mediterranean Sea (Manooch and Hassler, 1978; Vaughan et al. 1992, Labropoulou et al. 1999). *Pagrus pagrus* commonly feeds on crustaceans, fishes, and mollusca. This species is widely distributed in the Atlantic Ocean including Strait of Gibraltar, Medarie and Canary islands, Mediterranean and northward to the British Isles and northern Gulf of Mexico to Argentina (Froese and Pauly, 2012).

In the Mediterranean *Pagrus pagrus* is frequently caught by bottom trawls and long lines. Total landings of *Pagrus pagrus* was reported as 1221 tonnes in 2010 in the Mediterranean (Turkey and Greece) (FAO, 2012). Red Porgy is an endangered species in Red List (IUCN, 2012). However its importance and commercial value, the life history and distribution of *P. pagrus* poorly known in Aegean Sea but it is

mentioned in numerous papers about it around the Atlantic, that have reported on population structure (Afonso et al. 2008; Vaughan et al. 1992; Ball et al. 2007), and the other studies about on habitat selection (Labropoulou et al. 1999), length weight relationship of *P. pagrus* (Dulcic and Kraljevic, 1996; Gonçalves et al. 1997; Moutopoulos and Stergiou 2002; Santos et al. 2002; Morey et al. 2003; Rosa et al. 2006). In addition, age, growth, life history and otolith morphometry of *Pagrus pagrus* were examined in the Atlantic and Mediterranean (Potts and Manooch, 2002; Harris and McGovern, 1997; Manooch and Huntsman, 1977; Pajuelo and Lorenzo, 1996; Hood and Johnson, 2000; Machias et al. 1998).

There are a few studies about this species in the Aegean Sea that refer to aspects of length-weight relationships and otolith characters (Moutopoulos and Stergiou, 2002; Ozaydin et al. 2007, Kinacigil et al. 2000). In addition, biology, age, growth parameters and otolith morphometry of *P. pagrus* is unknown in the Turkish Aegean Sea.

The main purpose of this study was to estimation of growth parameters, length weight relationship and otolith morphometry of red porgy in Saros Bay. Consequently, this study is important of the fisheries assesment of *P. pagrus* in the study area.

MATERIALS AND METHOD

A total of 100 *P. pagrus* were collected between October 2006 to July 2008 from monthly samplings at depths ranging from 0 to 500 m (0-50, 50-100, 100-200, 200-500 m depth contour) in Saros Bay, Aegean Sea, using a commercial bottom trawl net (Figure 1). The bottom trawl net with a 44 mm stretched mesh size at the cod-end was towed for 30 min at approximately 2.5 knots h⁻¹.

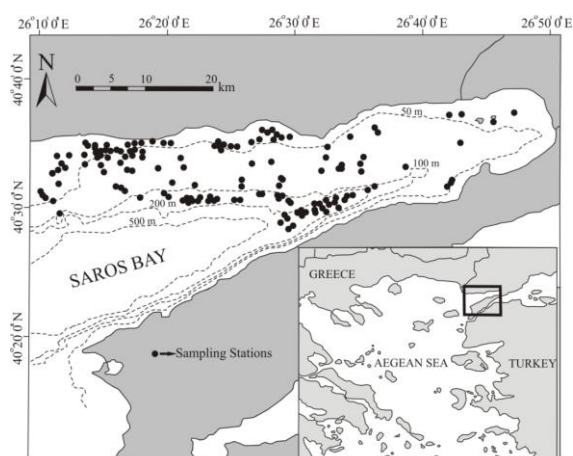


Figure 1. Trawl sampling stations in Saros Bay, the North Aegean Sea.

Total lengths (TL) and total weight (TW) were determined to the nearest 1 mm and 0,01g respectively. The length-weight relationships were determined according to the allometric equation (Sparre et al., 1989): $W = aL^b$, where W is the total body weight (g), L is the total length (cm) while a and b are constants.

The age was determined using the otoliths. Sagittal otoliths from each fish were removed, cleaned and stored in small, labelled plastic tubes. Size of the otoliths was measured by stereomicroscope with camera sensitive to 0.01 mm (Figure 2) and weighed with the precision of 0.0001 g by balance. Annual rings on the whole otolith were counted in glycerin under a stereomicroscope. Estimation of age was based almost exclusively on interpretation of otolith structures for the presence of hyaline and opaque zones which are assumed to represent winter and summer growth periods.

Growth parameters were determined using von Bertalanffy equation (Beverton and Holt, 1957): $L_t = L_\infty (1 - e^{-K(t-t_0)})$, where L_∞ is the asymptotic total length, L_t the total length at age t, K the growth curvature parameter and t_0 is the theoretical age when fish would have been at zero total length. Growth parameters were estimated according to the non-linear method by using the FISAT program package (Sparre et al.,

1989). For the sake of comparison, the index of overall growth performance ϕ' , proposed by Pauly and Munro (1984). This test provided an indication of the reliability of age estimates since it had been suggested that phi-prime test values were similar for the same species and genera. The test was based on $\phi' = \log K + 2 \cdot \log L_\infty$ (Pineiro and Sainza, 2003).

RESULTS

The length and weight of the *P. pagrus* ranged from 9.6 cm to 44.0 cm in total length (TL) and from 17.1 g to 1372.5 g in weight, respectively. Most of the fishes were between 15 and 20 cm TL, accounting for 62%. Otolith length, weight and width measurements are given in Table 1.

Table 1. Length- weight and otoliths measurements of *P. pagrus* in Saros Bay

	N	Min. (cm)	Max (cm)	Mean (cm)
Fish length	100	9.6	44.4	18.23±0.53
Fish weight	100	17.1	1372.5	121.0±17.0
Otolith length	55	0.52	1.17	0.70±0.01
Otolith weight	55	0.0181	0.1456	0.0533±0.005
Otolith width	55	0.34	0.68	0.47±0.01

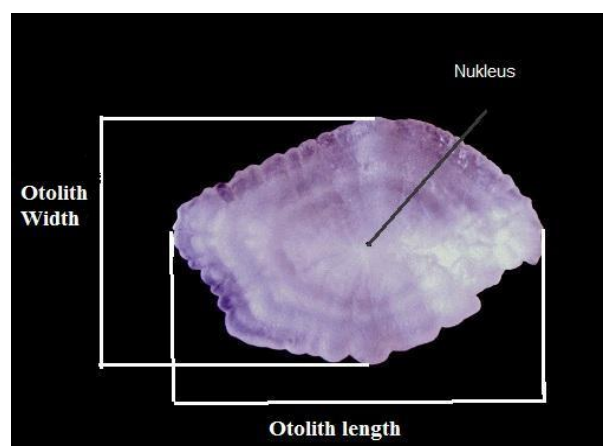


Figure 2. Otolith measurements of *P. pagrus*

Length-weight relationships were estimated of $TW = 0.021 \cdot TL^{2.885}$, $r^2 = 0.985$, $n = 100$ (Figure 3). Value of the exponent b was 2.885 ($r^2 = 0.984$) which indicated a negative allometric growth. Otolith length - otolith weight, total length - otolith length, otolith length - total weight, otolith length - otolith width relationships were found $OW = 0.105 \cdot OL^{2.609}$ ($r^2 = 0.929$), $OL = 0.024 \cdot TL + 0.249$ ($r^2 = 0.839$), $TW = 0.235 \cdot OL^{0.237}$ ($r^2 = 0.814$), $OW_i = 0.501 \cdot OL + 0.116$ ($r^2 = 0.832$) on the total of 55 specimens, respectively (Figure 4).

The age was determined by counting the annual ring marks on the surface of the otoliths in 55 specimens. The von Bertalanffy population growth parameters for *P. pagrus* were estimated as $L_\infty = 51.59$ cm, $K = 0.12$ year⁻¹ and $t_0 = -1.13$ year (Figure 5).

The maximum age of fish calculated was 9 years. The age group 2 (60 %) were dominant and it was followed by age groups 3 (25 %) and age group 1, 4 and 9 have two specimen (Table 2).

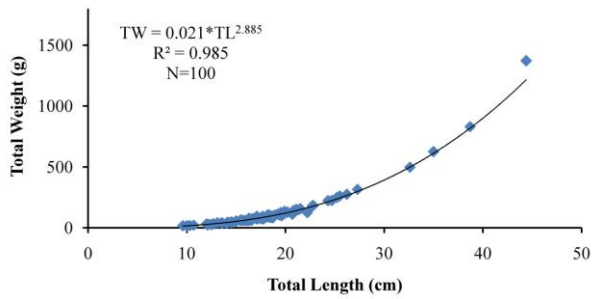


Figure 3. Length-weight relationships of *P. pagrus*

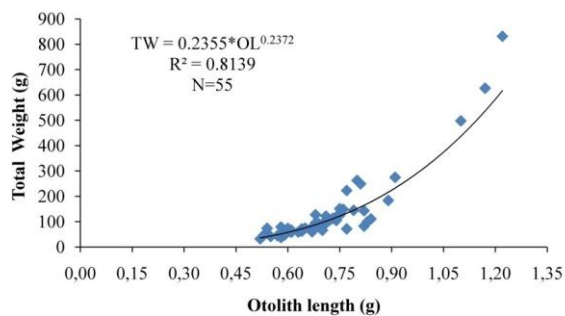
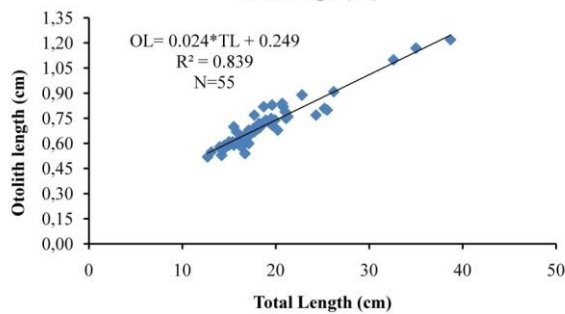
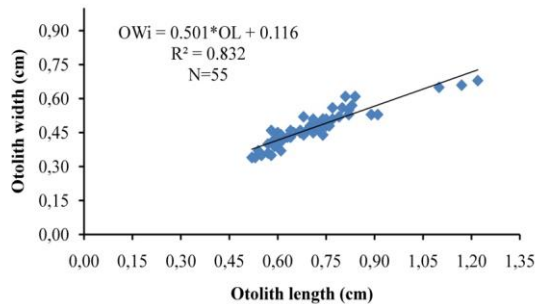
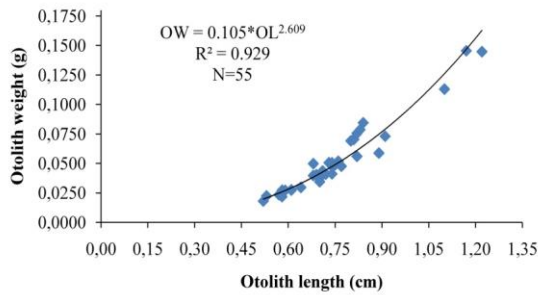


Figure 4. OL-OW (a), OL-OWi (b), TL-OL (c), OL-TW (d) relationships of *P. pagrus*.

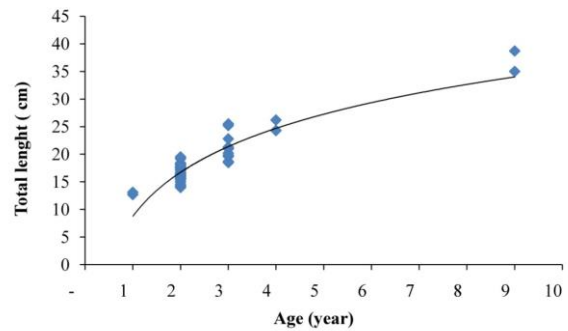


Figure 5. The von Bertalanffy growth curve of *P. pagrus*

Table 2. The mean lengths by ages of *P. pagrus*

Age	N	Length (cm)	Mean Length(cm)
1	2	12.7-13.1	12.9
2	35	14.0-18.4	16.4
3	14	18.5-25.5	20.7
4	2	24.3-26.2	25.2
5	-	-	-
6	-	-	-
7	-	-	-
8	-	-	-
9	2	35-38.7	36.8

DISCUSSION

The red porgy is rather long-lived and shows a slow, steady rate of growth, reflecting not only its genetic capabilities but also the type of environment in which it occurs. *P. pagrus*, which are relatively sedentary and live in a stable environment, therefore are able to expend more energy on growth than species which migrate extensively and must compensate for physiological stresses produced by salinity and temperature changes or seasonal availability of food. In order to compare the growth of the red porgy population with others, all available literature data of von Bertalanffy growth parameters and ϕ values, including results from the present study are reported in Table 3.

In this paper, theoretical growth as described by the von Bertalanffy equation predicts an asymptotic length of 51.59 cm and a growth coefficient, K, of 0.12 y^{-1} . Φ -test indicated that there was not significant differences between other studies ($t_s < t_i$).

Previous studies providing length-weight relationships for *P. pagrus* are given in Table 4 for comparative purposes. The length ranges covered for red porgy should be considered when using parameters of weight-length relationships, as to some extent the smallest specimens may change the parameters. The differences between b values are due to one or more factors: the season and effects of areas of origin, sex, and the food availability. Differences in the sampling design may also affect the relationships, as the numbers of specimens and length ranges of the species were distinct among localities (Tesch, 1971; Sparre et al. 1989; Moutopoulos and Stergiou, 2002).

Table 3. Parameters of von Bertalanffy growth equation (K , L_{∞} , t_0) obtained by different authors

Author	L_{∞}	K	t_0	ϕ	Region
Manooch <i>et al.</i> (1977)	76.3	0.1	-1.88	2.75	North and South Carolina
Nelson (1988)	55.4	0.28	0.06	2.93	Western Gulf of Mexico
Haimovici (1991)	44.6	0.24	-0.55	2.67	Southeastern region
Vassilopoulou and Papaconstantinou (1992)	45.1	0.24	-	-	Greece
Serafim and Krug (1995)	118	0.07	-1.20	2.96	Azores Island
Avila-da-silva (1996)	54.6	0.20	-0.24	2.77	Sao Paulo
Pajuelo and Lorenzo (1996)	59.6	0.17	-0.74	2.77	Canary island
Harris and McGovern (1997)	35.6	0.28	-	2.55	Cape Fear, NC to Cape Canaveral
Cotrina and Raimondo (1997)	47.3	0.15	-2.89	2.53	Buenos Aires
Costa <i>et al.</i> (1997)	52.9	0.11	-2.78	2.48	Cabo Frio, Rio de Janeiro
Machias <i>et al.</i> (1998)	43.9	0.30	-0.54	2.77	Greece
Hood and Johnson (2000)	45.9	0.11	-6.6	2.37	Eastern Gulf of Mexico
Potts and Manooch (2002)	64.5	0.15	-0.76	2.80	North Carolina to Southeast Florida
This study	51.6	0.12	-1.13	2.52	Saros Bay

Table 4. Total length – total weight relationships of *P. pagrus* obtained by different authors.

Author	N	a	b	R ²	Region
Vassilopoulou and Papaconstantinou (1992)	1142	0.02796	3.105	0.98	Crete
Vassilopoulou and Papaconstantinou (1992)	-	0.02796	2.993	0.98	Kastelloriza Island
Dulcic and Kraljevic (1996)	15	0.000053	3.343	0.98	Adriatic
Pajuelo and Lorenzo (1996)	758	0.0133	3.030	0.98	Canary Island
Gonçalves <i>et al.</i> (1997)	23	0.000035	2.860	0.98	Portugal
Moutopoulos and Stergiou (2002)	35	0.0152	3.005	0.98	Kyklades
Moutopoulos and Stergiou (2002)	-	0.0152	3.005	0.98	Aegean Sea
Santos <i>et al.</i> (2002)	75	0.025	2.855	0.99	Portugal
Morey <i>et al.</i> (2003)	127	0.282	2.803	0.95	Mediterranean
Rosa <i>et al.</i> (2006)	884	0.0388	2.850	0.99	Portugal
Ozaydin <i>et al.</i> (2007)	60	0.0605	2.570	0.96	Mediterranean
This study	100	0.028	2.885	0.98	Saros Bay

The description of otolith morphometry provided in this study for *P. pagrus* is given for the first time in this study area. The results suggest that the relationships between OL-OW and OL-OWi are interspecific characteristics that could be related the structure of the species. Therefore, their incorporation in the description of sagitta otolith is suggested. The results of the study indicated that the age composition of *P. pagrus* ranged between 1 to 9 years. The oldest age class reported in the literature was 18 and 17 years old (Potts and Monooch III, 2002; Jarzhombek, 2007).

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