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Reproduction and growth of Axillary seabream *Pagellus acarne* (Risso, 1827) (Perciformes Sparidae) from the western Algerian coasts

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ABSTRACT *Pagellus acarne* (Risso, 1827) (Perciformes Sparidae) represents an important component of Algerian fishery catch. Reproduction and growth parameter of this species are studied during 13 months, from fish catched from western Algerian coasts from December 2015 to December 2016. The sex-ratio (F:M) of the population studied is 1:1.56 and is in favor of male. The reproductive season extends between late spring and autumn. The resting period occurs in winter. Length at first maturity is estimated at 18.63 cm and 16.95 cm for females and males respectively. The length-weight relationship obtained is $TW=0.009TL^{3.086}$ ($R^2=0.983$). The Von Bertalanffy growth equation parameters are K=0.41, $L\infty=29.97$, $t_0=-0.34$ and the $\Phi'=2.57$.

KEY WORDS Algerian; growth; maturity; *Pagellus acarne*; reproduction; Western Mediterranean Sea.

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INTRODUCTION

Axillary seabream, *Pagellus acarne* (Risso, 1827) (Perciformes Sparidae), is a demersal Sparid fish, widely distributed in Mediterranean Sea and Black Sea. It is occurring in eastern Atlantic coasts from Senegal to Denmark and around the Madeira, Azores, Canary and Cape Verde Islands (Fischer et al., 1987). This species inhabits different type of sea bottom up to 500 m depth. However, it is more common between 40 to 100 m depth and is fished by trawling and artisanal fishing.

Pagellus acarne was studied for his biological feature in the Atlantic coast of Morocco and western Sahara, (Mennes, 1985; Lamrini, 1986), in the Canary Islands (Pajuelo & Lorenzo, 2000), in Portugal (Santos et al., 1995; Coelho et al., 2005) and in Atlantic coast of Spain (Velasco et al., 2011). The species was studied, also, in Mediterranean coasts (Andaloro, 1982), in Greece (Stergiou et al., 1997), in Turkish (Ozaydın et al., 2007; Soykan et al., 2015), in Mediterranean coasts of Spain (Dominguez, 2000; Valesco et al., 2011), in Mediterranean coasts of Morocco (Zoubi, 2001) and in Algerian water (Bensahla, 2014; Boufersaoui & Harchouche, 2015).

Sparid fish are one of the important components of fishery in Algeria. Species of this family have a great commercial value and are largely exploited. Moreover, *P. acarne* is listed by the International Union for Conservation of Nature (Russell et al., 2014). The aim of this paper is to give more information about parameters useful to assess biological feature of *P. acarne* (reproduction period, maturity, growth and age) from western Algerian waters.

MATERIAL AND METHODS

Sampling

Sampling was performed in western Algerian Sea (Fig. 1), off Bouzedjar port (35°34'57.83''N, 1°09'04.97''W) as this fishing port is one of the most important fishery of Algerian coasts

Pagellus acarne were sampled monthly between December 2015 and December 2016, from commercial trawling. All fish were measured for total length (TL, cm) to nearest 1 mm. Total weight (TW, g), eviscerate weight (EW, g), gonad weight (GW, g), to nearest 0.01g.

Sex and gonads maturation stages determination

Gonads were observed macroscopically. Sex was recorded for each fish sampled. Fish having only male gonads were determined to be male, fish having only female gonads were determinate to be female; and fish having both gonads (gonotestis) were determinate to be hermaphrodites and classified depending on the functional gonad in male or female for the estimation of parameters below (Valesco et al., 2011). Individuals with unidentifiable gonads were classified to be indeterminate (I). Four gonadal maturation stages were identified for male and female: (II) developing, (III) mature, (IV) spawning, (V) post spawning (Brown-Peterson et al., 2011).

The sex-ratio (F:M) was calculated and the chi-square test ($\chi 2$) was applied for determining the significance of the female to male ratio compared to the expected 1:1.

Figure 1. The study area: Bouzedjar port in western Algerian coasts.

Reproduction

The spawning period was determined by the monthly variation of the mean gonadosomatic index (GSI) (Pajuelo & Lorenzo, 2000; Velasco et al., 2011, Soykan et al., 2015), calculated as:

$$GSI=100*GW/EW.$$

Size at first maturity (L_{50}) was defined as the size at which 50% of invidious become mature (Batts, 1972), during the reproductive period. It is calculated according to ICES (2008) as:

$$P= 1/1+e^{(a+bTL)}$$

Where P is the proportion of mature individuals in size class of TL (cm), a and b are constants of non linear regression, and L_{50} is the size where 50% of the individuals are mature.

Growth

The length-weight relationship was estimated as:

$$WT = aLT^b$$

Where a and b are coefficients of the equation (Ricker, 1973). When the value is b=3, growth is isometric. Weight increase exhibits positive allometry if b>3 and negative allometry if b<3. The degree of association between variables Weight and length was calculated by the determination coefficient (R^2).

The Von Bertalanffy growth function was applied to size-at age data. The function is:

$$Lt = L\infty[1 - e^{-k(t - to)}]$$

In this equation, Lt is the mean fish length at age t (year), k ($year^{-1}$) is the growth coefficient; L∞ (cm) is the asymptomatic length; and t_0 (year) is the hypothetic age at which length is equal to zero. All the parameters were calculated using ELEFAN method (electronic length-frequency analysis) integrating in LFDA program (Pitcher, 2002). Growth parameters were compared with other studies using the phi-prime test (Φ') (Munro & Pauly, 1983), where

$$\Phi' = \log(k) + 2\log(L\infty)$$

RESULTS

A total of 795 *P. acarne* were collected and examined. Morphometric characteristics are summarized in Table 1 and the frequency distribution of TL of all sample are illustrated in figure 2.

The sex-ratio (F:M) of the sample is 1:1.56. The proportion of female and male grouped among interval size of 1cm is significantly different ($\chi 2$ test, $P < 0.05$) for most size groups except for sizes ranged between 18 and 20 cm (Fig. 3). Significant differences are registered in monthly frequency distribution of males and females ($\chi 2$ test, $P < 0.001$) (Fig. 4).

Results on monthly frequency of the gonads maturation stages for males and females are demonstrated in figure 5. Monthly variations of mean GSI for both sexes are illustrated in figure 6. The higher values of GSI occur between May and July for females and one month earlier for male (between April and July) and between October and November for the two sexes, these coincide with presence of gonads at spawning stage. The first Peak of GSI occurs in June for female and in May for male and the second peak in October for the two sexes. Between the two peaks, a collapse of mean GSI is recorded in August. That coincides with presence of developing and post spawning gonads stages.

Size at first sexual maturity L_{50} is estimate at 18.63 cm for female and 16.95 cm for male.

Length-weight relationship parameters are consigned in Table 2. Isometric growth is observed for males and all sample, when slightly negative allometry is observed for females.

The Von Bertalanffy growth parameters are summarized in Table 3 and the curve of length at age is illustrated on figure 7.

DISCUSSION

The sex-ratio in this study is in favor of male. The same results were observed by Arculeo et al. (2000) and Valesco et al. (2011). In contrast and in all the other distribution area of *P. acarne* sex-ratio is in favor of females (Santos et al., 1995; Pajuelo & Lorenzo, 2000; Coelho et al., 2005; Bensahla, 2014; Soykan et al., 2015; Boufersaoui & Harchouche, 2015). The sex-ratio registers a seasonal variations, as it appears that in spawning season

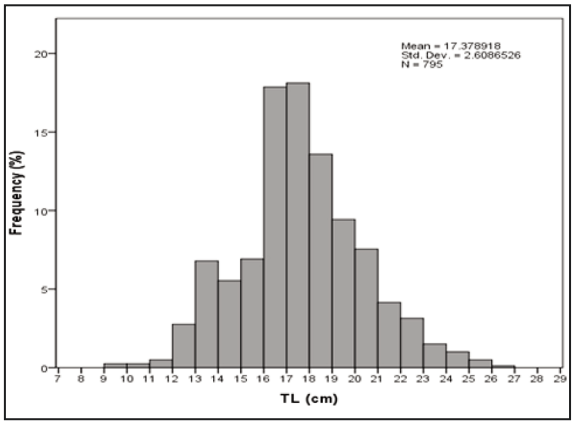

Figure 2. Length frequency diagram of *P. acarne* sampled from western Algerian coasts.

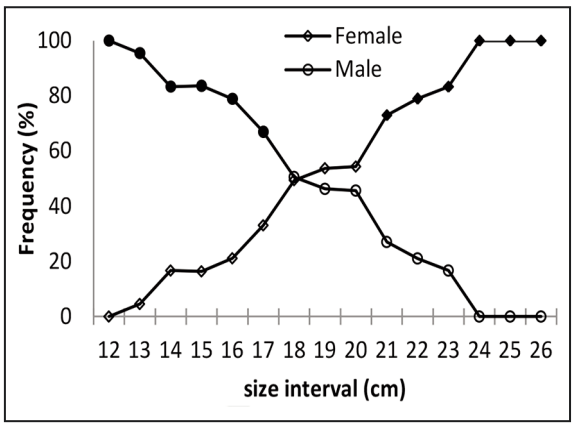

Figure 3. Frequency of females and male among intervals size (full marker: significant difference in frequency of males and females; dominant gender).

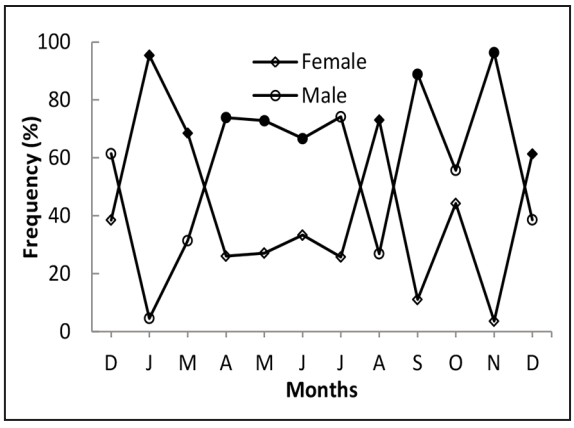

Figure 4. Monthly frequency of females and males of *P. acarne* (full marker: significant difference in frequency of males and females; dominant gender).

	TL		TW		N
	M±SD	Rang	M±SD	Rang	
Female	19.24±2.43	13.5-26.2	90.05±35.53	26.6-223	230
Male	16.81±1.81	12.9-22	58.21±19.99	22.98-148	280
Indeterminate	15.27±2.23	9.8-21	44.10±19.87	10.34-112	178
Hermaphrodite	18.39±2.11	13.8-24	77.74±27.71	28.29-169.32	107

Table 1. Morphometric characteristics of *P. acarne* sampled. M: mean; SD: standard deviation of the mean; N: number.

	a	b	R^2	N
female	0.0131	2.9716	0.9681	241
male	0.0095	3.0756	0.974	377
all	0.0092	3.0868	0.9835	795

Table 2. Parameters of length-weight relationship of *P. acarne* from western Algerian coasts.

	$L\infty$	k	t_0	Φ'	Equation de Von Bertalanffy
Female	29.79	0.5	-0.04	2.64	$Lt = 29.79(1 - e^{-0.5(t+0.04)})$
Male	28.43	0.42	-0.13	2.54	$Lt = 28.43(1 - e^{-0.42(t+0.13)})$
Combined	29.97	0.41	-0.34	2.57	$Lt = 29.97(1 - e^{0.41(t+0.34)})$

Table 3. Von Bertalanffy growth parameters of *P. acarne* from western Algerian coast.

males are dominant and in resting season females are dominant. According to TL, males are dominant in smallest size and female in great size. This is a characteristic of protandric species; the fish are first male and became female.

Reproductive season of *P. acarne* shows two spawning periods. The first, between spring and early summer, with a peak of spawn in later spring and the second, in autumn, with a peak of spawn in October; between the two there is an interruption of spawning in August. The resting period occurs in winter. These results are in agreement with Bensahla (2014) and Boufersaoui & Harchouche (2015) along Algerian coasts. In higher latitudes spawning period occurs between end of spring and early autumn

Authors	Area	Male	Female
Andaloro (1982)	Tyrrhenian and Ionian Sea	16.5	
Lamrini (1986)	Atlantic	20.9	
Santos et al. (1995)	Atlantic	20.9	19.7
Pajuelo & Lorenzo (2000)	Atlantic	15.8	19.4
Coelho et al. (2005)	Atlantic	17.6	18.1
Valesco et al. (2011)	Atlantic	18.4	21.5
	Alboran Sea	17.7	20.1
Bensahla (2014)	W-Mediterranean	15.99	12.75
Boufersaoui et al. (2015)	W-Mediterranean	16.8	16.45
Soykan et al. (2015)	C-Aegean Sea	13.91	14.45
Present study	W-Mediterranean	16.95	18.63

Table 4. Size at first maturity (cm) from different distribution areas of *P. acarne*.

(Lamrini, 1986; Santos et al., 1995; Coelho et al., 2005; Valesco et al., 2011; Soykan et al., 2015). In contrast, in lower latitudes it is occurs between winter and spring (Pajuelo & Lorenzo, 2000). These geographical differences in reproductive season of *P. acarne* could be due to the environmental conditions influencing gonads maturation.

In this study, males attain sexual maturity at a smaller size than female. The same result is observed by Santos et al. (1995); Pajuelo & Lorenzo (2000); Valesco et al. (2011) and Soykan et al. (2015). It appears to be a characteristic of protandric hermaphrodite species. Table 4 summarizes size at first maturity of *P. acarne* registered by different authors. In the present study, first sexual maturity occurs at 16.95 cm for male and 18.63 cm for female (2 years for both sexes). This result agrees with size at first maturity reported in Mediterranean sea by Andaloro (1982) and Boufersaoui & Harchouche (2015) for males only. Even in Mediterranean Sea, smaller sizes at first maturity were obtained in Algerian coasts by Bensahla (2014) and in central Aegean Sea by Soykan et al. (2015). In contrast, Lamrini (1986) in Atlantic Ocean, Santos et al. (1995) in southern Portuguese coasts, Valesco

et al. (2011) in Atlantic Ocean and Alboran Sea, report higher sizes at first maturity comparing to results obtained in this study. Water temperature is an important factor that influences metabolic activity; it is known that Mediterranean water is warmer than Atlantic water. That could explain that fish reach sexual maturity in Mediterranean at smaller size than fish in Atlantic. In addition, the effect of sampling biases cannot be excluded (Tsikliras & Stergiou, 2014).

Length-weight relationship shows an isometric growth for all individuals of *P. acarne*. Positive allometry is reported for axillary seabream in other distribution area in Mediterranean Sea (Valesco et al., 2011; Bensahla, 2014; Soykan et al., 2015) and in Atlantic (Santos et al., 1995; Pajuelo & Lorenzo, 2000; Coelho et al., 2005) (see Table 5). In this study there is a difference in the length-weight relationship between males and females which register slightly negative allometry. This observation is described by Pajuelo & Lorenzo (2000) and Valesco et al. (2011) for the same species. They explain it by the difference in the size distribution of the two sexes due to the protandric hermaphroditism.

The Von Bertalanffy growth parameters allow converting length of *P. acarne* to age. It appears that the younger fish sampled are under 1 year old and the oldest are between 4 and 4.5 years old. The most frequent age reported in the sample is approximately two years.

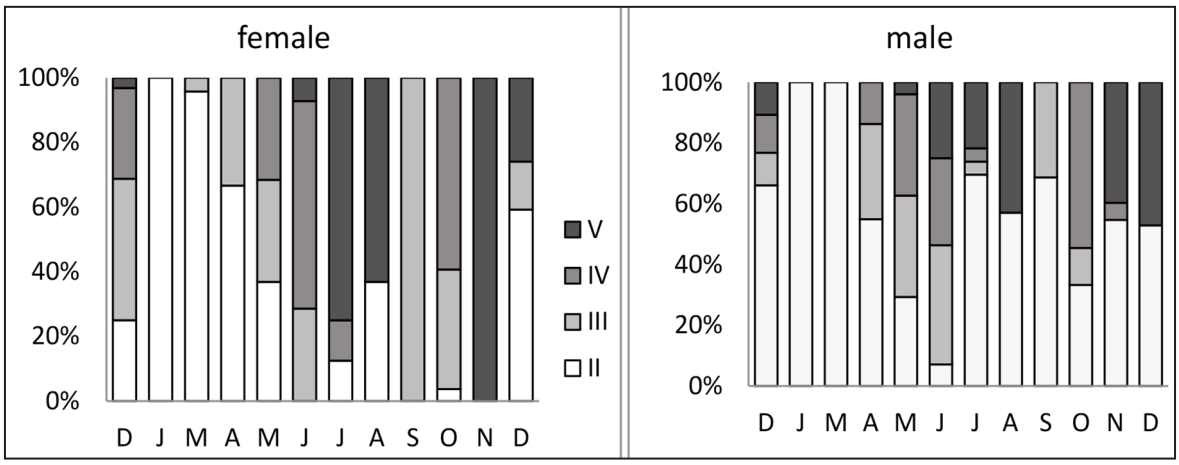

Figure 5. Monthly variation of the frequency of gonads development stages of *P. acarne*.

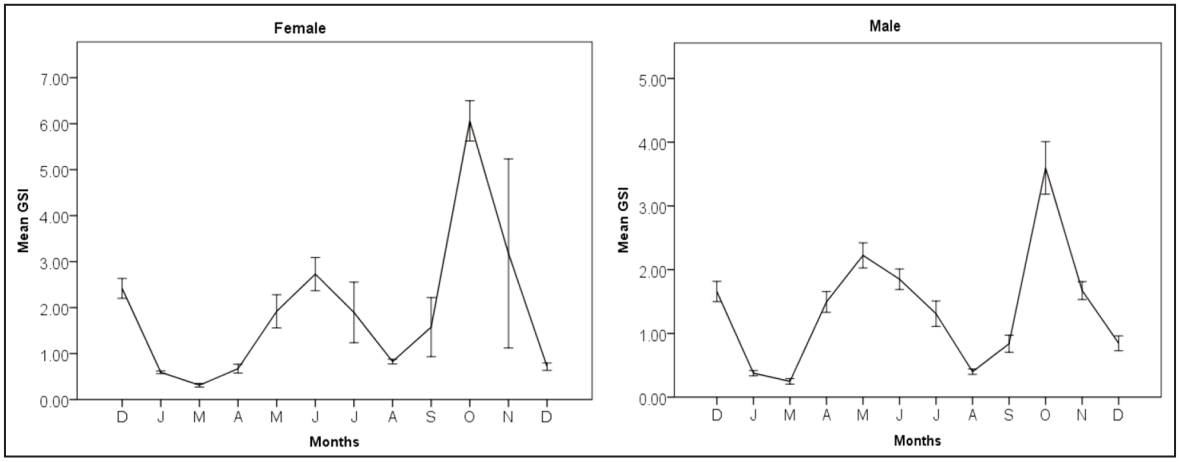

Figure 6. Monthly variation in the mean GSI with standard errors of *P. acarne*.

References	Sex	Rang (cm)	Growth L_∞	K	t_0	Φ'	LWR a	b	Area
Andeloro (1982)	F	8-28	29.78	0.32	-0.26				Italy, Tyrrhenian and Ionian Sea
	M		26.23	0.42	-0.22				
Mennes (1985)	C		31	0.21		2.3	0.02	3	Morocco, Atlantic
Djabali (1990)	C		24.4	0.3		2.46			Algeria, Mediterranean
Santos et al. (1995)	C						0.085	3.153	Portugal, Atlantic
Dominguez (2000)	C		29.62	0.27	-1.36				Spain, Alboran Sea
Pajuelo & Lorenzo (2000)	C	11-31	32.98	0.22	-0.87				Canary Islands
	F	16-31	33.9	0.21	-0.99	2.38	0.006	3.281	
	M	14-24	30	0.27	-0.67	2.39	0.007	3.242	
Zoubi (2001)	C		24	0.43	-0.21	2.39			Morocco, Mediterranean
Coelho et al. (2005)	C	12.4-36.5	32.05	0.18	-2.91		0.012	3.048	Portugal, Atlantic
	F	16.7-36.5	32.3	0.18	-2.56				
	M	15.9-30.0	28.2	0.29	-1.47				
Valesco et al. (2011)	C	11.3-30.9	31.7	0.21	-1.76	2.32	0.005	3.321	Spain, Golf of Cadiz
	C	10.7-29.4	32.1	0.17	-2.69	2.24	0.009	3.113	Spain, Alboran Sea
Bensahla (2014)	C		27.3	0.56	-0.155	4.621	0.008	3.1	Algeria, Western Mediterranean
	F	13-26.3	27.3	0.58	-1.49	4.636	0.11	3.053	
	M	13-23	27.3	0.56	-0.155	4.621	0.009	3.088	
Soykan et al. (2015)	C	8.5-20.2	22.6	0.31	-1.202	2.21	0.009	3.138	Turkey, Aegean Sea
	F	12.5-20.2					0.011	3.055	
	M	12.2-16.6					0.008	3.155	
Present study	C		29.97	0.41	-0.34	2.57	0.0092	3.0868	Algeria, Western Mediterranean Sea
	F	13.5-26.2	29.79	0.5	-0.04	2.64	0.0131	2.9716	
	M	12.9-24	28.43	0.42	-0.13	2.54	0.0095	3.0756	

Table 5. Von Bertalanffy growth parameters, length-weight relationship (LWR) of *P. acarne*, recorded from publications and present study.

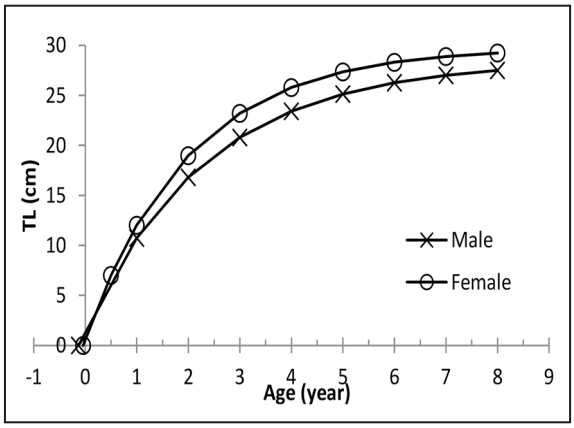

Figure 7. Length at age data from *Pagellus acarne* according to Von Bertalanffy growth equation.

Table 5 shows the growth parameters of *P. acarne* from different distributions areas. The k value in this study is estimated at 0.5 for female, 0.42 for male and 0.41 for the two sexes combinated. These K values indicate a rapid growth of the species in western Mediterranean water of Algeria. These values are close to the one obtained by Andeloro (1982) from Tyrrhenian and Ionian Seas, Zoubi (2001) in Mediterranean coast of Morocco, Bensahla (2014) in Bay of Oran in western Algerian coasts. However, they are higher than those reported by Djabali et al. (1990), Pajuelo & Lorenzo (2000), Coelho et al. (2005), Valesco et al. (2011), and Soykan et al. (2015). The asymptomatic length $L\infty$ reported in this study is 29.79 for female, 28.43

for male and 29.97 cm for all samples. These values are reasonable regarding maximum TL registered from sampled fish. The L∞ values obtained are higher than those observed in Mediterranean Sea by Djabali et al. (1990), Zoubi (2001), Bensahla (2014), and Soykan et al. (2015). However, they are lower than those obtained in Atlantic Ocean by Pajuelo & Lorenzo (2000), Coelho et al. (2005), and Valesco et al. (2011). These differences in K and L∞ values could be attributable to size range of sampled fish and the fitted growth model. The phi prime values calculated in this study are slightly higher than the ones obtained by majority of works on *P. acarne* from his different distribution area (Table 5), but they are comparable to those obtained by Bensahla (2014) in the same geographic area.

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