



RESEARCH ARTICLE

Reproductive Characteristics of Dusky Grouper (*Epinephelus guaza*, Linnaeus, 1758) in Antalya Bay of Eastern Mediterranean

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ABSTRACT

This study aimed to investigate sexual cycles and reproductive characteristics of dusky grouper (*Epinephelus guaza* L. 1758) in Antalya Bay of Eastern Mediterranean, Turkey. A total of 104 dusky groupers were collected during a year by spear-fishing. Their 13 developmental stages of reproduction were determined. The first step was named as juvenile; the gonads were ovo-testes. The female characters started to begin after the juvenile form. All the fishes had different six female stages (F₁ to F₆) according to gonad ripening. The first sexual maturity of the females was observed in F₃ stage with 1-3 years old and 39.1cm (L_S). Three transitional periods (T₁, T₂, T₃) were seen beyond of the female period (4-6 years old). Intersexual periods were followed by testicular phases. The fishes underwent to male sex which included three stages (M₁, M₂, M₃). The first sexual maturity of the males (M₂; 7-8 years old) was started at 83.5cm (L_S). According to data, gonado-somatic index (GSI) peaked in between July and September in females while it was peaked in between May and July in males. Furthermore, mating time started in May as assessed on the basis of GSI and I_{RG} which were parallel in males and females.

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INTRODUCTION

The dusky grouper, *Epinephelus marginatus* (Lowe), more widely known by its synonym, *Epinephelus guaza* (Linnaeus, 1758) is highly valued throughout the Mediterranean. The fish is one of the members of Epinephelidae sub-family belonging to Serranidae family (Spedicato *et al.*, 1994; Glamuzina *et al.*, 1998a,b).

It is a prime species for Mediterranean mariculture and for restocking fished-out ecosystems (Glamuzina *et al.*, 1998c; Zhou and Gui, 2008). This species preferentially inhabits hard substrata on the continental shelf or rocky bottoms of the shallow waters up from 50 to 80 m depth (Irigoyen *et al.*, 2005; Renones *et al.*, 2007). Demographic data and gonad histology confirmed that the dusky grouper is protogynous hermaphrodite that follows a monandric pathway to sexual development (Zabala *et al.*, 1997; Marino *et al.*, 2001). The determination of reproductive characteristics and fecundity of wild or farming fish will give more information regarding their prospective population. The bio-ecological features of the fish are known well; the

confirmation of spawning season and fecundity will provide more suitable fishing and more productive farming (Özen, 1998). Thereby, the main aims of the present study were to investigate sexual cycles and reproductive characteristics of dusky grouper (*E. guaza* L. 1758) in Antalya Bay of Eastern Mediterranean in Turkey.

MATERIALS AND METHODS

This study was carried out in Kemer, Lara and side of Antalya Bay of Eastern Mediterranean, Turkey (Fig. 1). We dived by scuba in 30m deep in all of fishing grounds. Dusky groupers were seen amongst rocky places of the area. A total of 104 groupers were collected by along fishing-line and harpoons from three sampling points throughout the year. Age of the fish was determined by yearling scale rings (Avşar, 2005; Türkmen *et al.*, 2010). All of the sexual developing stages of the fish were confirmed and grouped according to histological examination of the gonads under light microscope (Balcı, 2003).

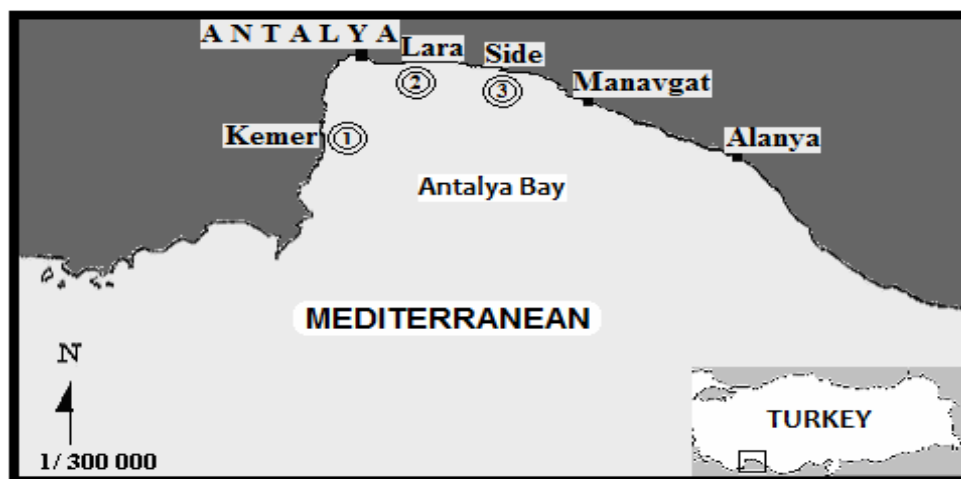


Fig. 1: Capture locations (⊙) for dusky grouper (*Epinephelus guaza* L. 1758)

Total body weight and gonad weights were measured for the calculation of gonado-somatic index ($GSI = \text{gonad weight (g)} / \text{body weight (g)} \times 100\%$) (De Vlaming *et al.*, 1982; Ntiba and Jaccarini, 1990; Avşar, 2005). The data of relative gonadal index (I_{RG}) were used for the determination of reproductive period of hermaphrodite fishes alternatively to GSI's. Because the maturity stages of this kind of fishes has different period, hence, GSI data can't provide homogeneity among different ovarian maturation. During each growing period, individual body weight of male and female fish was calculated along with individual gonadal weight which subjected to regression I_{RG} data. The I_{RG} of the fish in this study was calculated according to the formula: $I_{RG} = W_G \times S^{-b_j}$; Where W_G : Gonadal weight, S : body size, b_j : parameters of gonadal stages (De Vlaming *et al.*, 1982; Ericson *et al.*, 1985; Marino *et al.*, 2001). The eggs were cleaned from connective tissue; dried, counted and gonads were weighed. Fecundity was computed in such fishes by applying common formula ($F = \text{gonad weight} \times \text{egg number} / \text{egg weight}$) (Avşar, 2005). Statistical analyses were performed using SPSS v.9.0 for Windows. Analysis of variance (ANOVA) was used and statistical significance was set at $P < 0.05$ (Özdamar, 2001).

RESULTS

Dusky groupers more often found during the spring while rare in the winter (Water Temperature: $WT = 11.3^\circ\text{C}$). The fish started their mating activities in spring (May, $WT = 16.5^\circ\text{C}$) to summer (June, $WT = 27.6^\circ\text{C}$) in each of three sampling points. Hence, the bigger ones of the fishes were come out from their caverns.

Fecundity and Gonado-somatic Index

The egg diameters ranged from 725 to 965 μm and the number of eggs found were from 66304 to 651654. On an average, 37 female fish had 358979 eggs. Large oocytes started to develop when sea water temperature reached up to 20°C after July. The fishes of three stations have age from 0^+ to 11; body weight from 300 to 20000g and body length measured from 24 to 111cm.

GSI reached maximum level in the summer when water temperature exceeded 20°C . The mating of dusky grouper (*Epinephelus guaza* L. 1758) occurred in between May and July (Fig. 2).

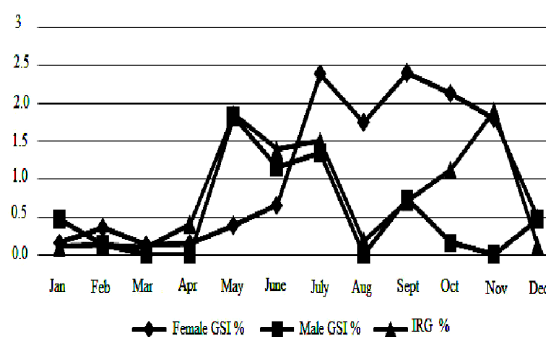


Fig. 2: Monthly changes of GSI and I_{RG} data in female and male dusky grouper in Antalya Bay

Relative Gonad Index

The peak of I_{RG} was seen in May and November (Fig. 2). I_{RG} data ranged from 0.30 to 5.71. A comparison with I_{RG} data and GSI according to months and water temperature has been given in Table 1. Sexual life of the fish was identified mainly into four sexual developmental stages according to their histological features. These were: Juvenile (J) stage (immature female), mature female (F_{1-6}), transitional phases (T_{1-3}) and male stages (M_{1-3}).

DISCUSSION

In the leopard grouper adults formed spawning aggregation of 150 – 700 individuals at specific sites from late April through early June (Erisman *et al.*, 2007). Reñones *et al.* (2007) reported that some study area in the Mediterranean and age of the captured fish, accordingly were 1-7 years in Egypt and East Algeria and in East and North Tunisian grouper were 1-16 and 0-36 years old, respectively while Balearic Island's grouper (Western Mediterranean) were 0-61 years old. In the present study, captured fish age ranged from 0 to 11 years ($n = 104$).

Table 1: Monthly frequency of maturity stages of female, transitional and males of dusky grouper (*Epinephelus guaza*) in Antalya Bay, Turkey

Month	Age (Years)												
	0-I*	I-II*	I*-III*	II-III*	II*-IV	III*-IV*	III-V	IV-V*	IV*-VI	V*-VII	VI*-VII*	VII* IX	VIII*-XI
	J	F ₁	F ₂	F ₃	F ₄	F ₅	F ₆	T ₁	T ₂	T ₃	M ₁	M ₂	M ₃
Jan.	n=17(80.9)	n=2(9.5)						n=1(4.8)			n=1(4.8)		
Feb.	n=3(37.5)	n=3(37.5)	n=1(12.5)								n=1(12.5)		
Mar.	n=3(60)	n=1(20)	n=1(20)										
Apr.		n=1(25)	n=2(50)		n=1(25)								
May	n=6(27.2)	n=1(4.54)	n=3(13.6)	n=1(4.5)	n=3(13.6)	n=1(4.5)		n=1(4.5)	n=1(4.5)	n=1(4.54)		n=2(9.1)	n=2(9.1)
Jun.	n=2(12.5)			n=2(12.5)	n=5(31.2)	n=2(12.5)		n=1(6.25)	n=1(6.25)		n=2(12.5)	n=1(6.3)	
Jul.					n=1(14.3)						n=2(28.5)	n=2(28.5)	n=2(28.5)
Aug.				n=1(100)									
Sep.							n=1(20)			n=1(20)		n=2(40)	n=1(20)
Oct.							n=4(100)						
Nov.	n=2(40)						n=2(40)			n=1(20)			
Dec.	n=5(83.3)										n=1(16.6)		
n	38	8	7	4	10	3	7	3	2	3	7	7	5

Figure in parenthesis indicate percentage.

It has been reported the dusky grouper *E. guaza* L. 1758 were a protogynous hermaphrodite that follow a monandric pathway to sexual development (Marino *et al.*, 2001). Gonadal indices commonly are used to quantify reproductive condition of fishes (Ericson *et al.*, 1985; Avşar, 2005). But, allometric gonadal growth data might be inappropriate. Hence, Ericson *et al.* (1985) applied relative gonadal index (I_{RG}) as a new model which was developed to quantify the reproductive condition of fishes independent of body sizes. Marino *et al.* (2001) used also the same model (I_{RG}) in the identification of reproductive stages of dusky grouper. In the present study, it was observed a protogynous hermaphroditism that follows a monandric pathway to sexual development in the southern Mediterranean grouper, *E. guaza* L. 1758 too. Bertoncini *et al.* (2003) noted that age and sexual inversion rates of hermaphrodite fishes are characteristics according to specific geographic region. As evident from literature on sexual characteristics of the grouper, it was also seen that they mature as female but transform into male after a sex reversal (Marino *et al.*, 2001; Zhou and Gui, 2008). Ericson *et al.* (1985) claimed that relative gonadal index is independent of fish size. This index is capable of removing the dependence on gonadal size on fish size. So it was found to be more appropriate than the GSI. In other studies, the examination of monthly changes in periodicity of reproduction of grouper was also utilized relative gonad index (I_{RG}) instead of GSI (Marino *et al.*, 2001).

Not only sexual developmental stages of the trial fish according to relative gonadal index (I_{RG}) method (Ericson *et al.*, 1985) were determined, but GSI model to quantify reproductive condition was also used in the present study. Marino *et al.* (2001) reported that females of the dusky groupers from the Southern Mediterranean reached first sexual maturity have length 43.8cm L_S (Smallest length) for females, 81.3cm L_S for males. Adult sex ratio during the reproductive period was 3.5:1 females to males. Gonads were ripe from early May and spawning occurred from June until early September. Transitional individuals accounted for 9% of sampled of adult population. Sex change occurred in fish at weight of 5-6kg and 69-93cm of the L_S range (Glamuzina *et al.*, 1998c; Marino *et al.*, 2001). The

reproductive characteristics of other hermaphrodite grouper species showed that may affect stock sustainability. Now-a-days it is known that some protogynous stocks may be vulnerable to fishing than are comparable gonochoristic stocks in Brazilian waters (Bertoncini *et al.*, 2003).

In the present work, body length in the first sexual maturity (F_3) were measured 39.1cm [L_S] in female and 83.5cm [L_S] in male and body weight in the first sexual maturity (F_3) was 1692.5g in female, and 9943.3g in male (M_2). Adult sex ratio during the reproductive period was determined 2:1 female to male. It was accounted 19.2% for females and 18.2% males while transitional individual was 4.8% part of the whole adult population.

From the results of the present study, it can be concluded that propagation of the dusky grouper (*E. guaza*) has annual cycle and monandric protogynous hermaphroditic characteristics. Reproductive season occur at 20°C in summer time (from June to August) in Easter Mediterranean of Antalya Bay in Turkey. Published information on the biology and ecology of the grouper is very scarce except for information that one commercial producer keep brood stock (Glamuzina *et al.*, 2000). Further studies on the growth of this grouper species are needed in order to establish a clear picture of the growth performances at ambient conditions (i.e. cages) and recirculation systems.

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