Age, growth and reproduction of tub gurnard *Chelidonichthys lucernus* Linnaeus, 1758 (Osteichthtyes: Triglidae) from İzmir Bay, Aegean Sea, Eastern Mediterranean

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*A total of 546 tub gurnard (*Chelidonichthys lucernus *L., 1758) were caught monthly by trawl surveys carried out between September 1999 and August 2000 in İzmir Bay (Aegean Sea). Fork lengths of females ranged from 12.7 to 34.4 cm, and of males from 14.1 to 29.9 cm. The female: male ratio was 1:0.52. The maximum age observed was 5 for females and 3 for males and the length-weight relationships were estimated as $W=0.0051*L^{3.245}$ and $W=0.0053*L^{3.237}$, respectively; the von Bertalanffy growth equations were $L_t=49.09(1-e^{-0.186(t+1.484)})$; $L_t=31.44(1-e^{-0.886(t+0.886)})$ and $L_t=52.12(1-e^{-0.163(t+1.609)})$ for females, males and both sexes, respectively. The growth performance index value (Φ) was computed as 2.646 for all specimens. The gonadosomatic index (GSI) values indicated that spawning occurred from late December (2.268) to the end of March (6.158). Males matured at a fork length of 17.7 cm, while females matured at 19.0 cm.*

Key words: Osteichthyes, Triglidae, *Chelidonichthys lucernus,* age, growth, reproduction, İzmir Bay, Aegean Sea, Mediterranean

INTRODUCTION

The tub gurnard, *Chelidonichthys lucernus* (Linnaeus, 1758) is a demersal marine fish that is distributed in the Mediterranean Sea, the Black Sea and the Atlantic Ocean from Norway to Senegal (TORTONESE, 1975). The biology of gurnards was investigated by PRIOL (1932); MOUNEIMNE, 1970 (c.f. PAPACONSTANTINOU, 1983) and KARTAS, 1970 (in PAPACONSTANTINOU, 1983) off the Mediterranean French coast. Recent studies such as PAPACONSTANTINOU (1984) investigated the age, growth and reproduction in the Ther-

maikos Gulf (Greece); growth and reproduction in Douarnenez Bay (France) (BARON, 1985a, b); biology in Yumurtalık (Adana) Bay (Mediterranean Sea) (ALTUN et al., 1997); FALTAS & ABDALLAH (1997), ABDALLAH & FALTAS (1998) reported growth, mortality and reproductive biology off the Mediterranean coast of Egypt; SERENA et al. (1998) gave some information about nursery areas and biology off the Tuscany Coast (Italy); İŞMEN & İŞMEN (2004) studied its age, growth and reproduction in the Bay of İskenderun (Mediterranean); ERYILMAZ & MERİÇ (2005) and UÇKUN (2005) examined some biological characteristics

of the species in the Sea of Marmara and Edremit Bay (Aegean Sea), respectively.

The aims of the present study are to examine the age, growth, sex ratio and reproduction of *Chelidonichthys lucernus,* which is the commercially important species of Triglidae in İzmir Bay (Aegean Sea), mainly to address areas lacking in knowledge for the management of this species.

MATERIAL AND METHODS

A total of 546 tub gurnard specimens were caught by trawl surveys carried out monthly between July 1999 and August 2000 in İzmir Bay (Fig. 1).

A traditional, commercially used bottom trawl, with 600 meshes around the mouth, was operated onboard R/V EGESÜF. The towing duration was 30 minutes for all hauls and the average towing speed was 2.4 knots (ranging between 2.0 and 2.8). A nominal 400 mm diamond mesh cod-end of about 5 m in streched

length was used. Collected fish samples were kept in ice. After landing, specimens were measured in mm (fork length, FL), and weighed to the nearest 0.01 g (total weight, W) and dissected in the laboratory. Their otoliths were removed and stored dry in properly labeled envelopes. All otoliths were cleaned in 4% NaOH and then became transparent in 70% alcohol.

Age was read from whole sagittal otoliths as suggested by HOLDEN & RAITT (1974). Otoliths were removed immediately and stored dry in labelled envelopes. All otoliths were cleaned in 4% NaOH and then thick ones were made thin with wetted sandpaper, while small ones become transparent in 70% alcohol. They were immersed in glycerin (25%) and alcohol (75%) and viewed with a binocular microscope at a magnification of 10x, under reflected light against a black background. One light (hyaline) and one dark (opaque) zone were collectively interpreted as one year's growth. The age estimates were obtained by reading each otolith at least twice. If the two age estimates did not coincide, a third reading was taken. When the three
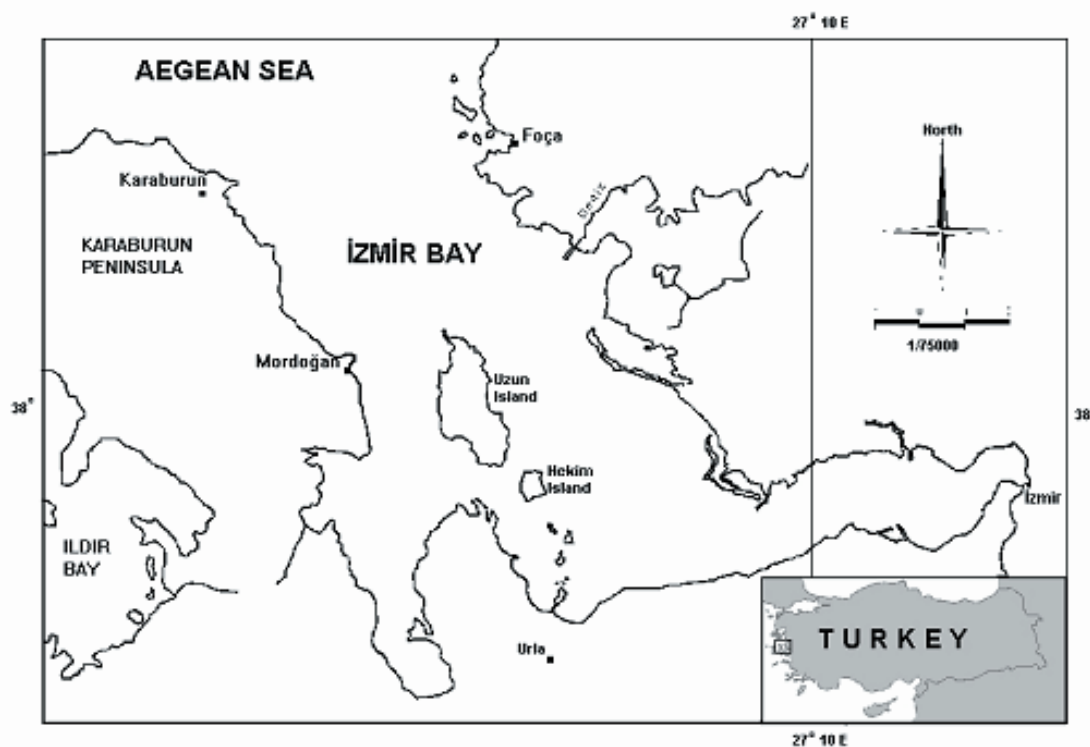

Fig. 1. Map of sampling areas in Izmir Bay (Aegean Sea)

readings differed by one year, the median age of the three readings was used. However, when all three readings differed by more than one year, that otolith was discarded.

The sex and maturity stages were determined by the macroscopic and microscopic examination of the gonads. The stages of maturation were classified according to HOLDEN & RAITT (1974).

The generalized von Bertallanfy growth equations were used to describe the growth of these species (SPARRE *et al.*, 1989):

$$L_t = L_\infty (1 - e^{-k(t-t_0)}) \quad \text{and} \quad W_t = W_\infty (1 - e^{-k(t-t_0)})^b$$

where L_t and W_t are the fish length and weight at age t; L_∞ and W_∞ represent the asymptotic length, k is a relative growth coefficient and t_0 the theoretical age when the fish length is zero.

The allometric growth equation, $W = a * L^b$, was used to examine length-weight relations (RICKER, 1979), where W is the total weight (g), L is the fork length (cm) and a and b are the regression constants. Growth performance index ($\Phi = \log k + 2 \log_\infty$) values were computed in FISAT 1.01. The condition factor was estimated by $K = W * 100 / L^3$ (BAGENAL, 1978). Gonadosomatic index values (GSI = Gonad weight/Total weight*100) were calculated according to the formula given by KING (1995). For the estimation of the mean lengths at 50% maturity, a logistic function was fitted to the proportion of the mature individuals by size class using a nonlinear regresion. The function used was (KING, 1995): $P = 1/(1 + exp[-r(L-Lm)]$ where P is the proportion mature in each size class, r is the slope of the curve and Lm is the mean length at sexual maturity (50%).

RESULTS

Age and Sex Composition

In the research area, the female and male tub gurnard specimens were distributed among the age groups 0-V and 0-III, respectively (Table 1).

The age group I was the most abundant (64.5%) in the samples. Females significantly outnumbered males with a female: male ratio of 1:0.52. Statistical analysis using the Chi-square test (X^2) is significant for the species (p <0.05).

Age-length relationship

Average total length values per age group are given in Table 2. Growth in length was determined as rapid during the first year and slow thereafter. Utilizing the total length values of the specimens in all age groups, the von Bertalanffy growth equations' parameters were computed as indicated in Table 3. These parameters sufficiently reveal the growth performance for the first years of life, while the older specimens in the samples are inadequate and do not give good enough information.

Table 1. Age and sex composition of C. lucernus *from Izmir Bay (Aegean Sea)*

Age Groups	♀ N	♀ %N	♂ N	♂ %N	♀+♂ N	♀+♂ %N	♀:♂
0+	5	0.92	2	0.37	7	1.29	1:0.40
I	223	40.84	130	23.81	353	64.65	1:0.58
II	94	17.22	50	9.15	144	26.37	1:0.53
III	33	6.04	4	0.73	37	6.77	1:0.12
IV	3	0.55	-	-	3	0.55	-
V	2	0.37	-	-	2	0.37	-
Total	360	65.94	186	34.06	546	100.00	1:0.52

N=number of specimens

Table 2. Fork length at age values (cm) of C. lucernus, (*N=number of specimens, Min=minimum fork length, Max=maximum fork length, Ave=mean fork length, SE=standard error*)

	Age Groups	N	Min. (cm)	Max. (cm)	Ave. ±C.I. (cm)	SE
♀	0	5	12.7	14.2	13.7±0.680	0.245
	1	223	13.7	23.1	18.15±0.280	0.142
	2	94	20.8	27.8	23.62±0.336	0.169
	3	33	24.1	31.3	27.50±0.609	0.298
	4	3	13.7	17.7	31.27±4.564	1.061
	5	2	34.4	34.4	34.4	-
♂	0	2	14.1	14.2	14.15±0.449	0.035
	1	130	14.3	24.1	17.93±0.352	0.178
	2	50	20.1	27.7	22.81±0.510	0.253
	3	4	22.4	29.9	25.93±4.235	1.331
♀+♂	0	7	12	14.2	13.83±0.453	0.191
	1	353	13.7	24.1	18.07±0.220	0.111
	2	144	20.1	27.8	23.34±0.287	0.142
	3	37	22.4	31.3	27.33±0.635	0.313
	4	3	29.5	33.8	31.27±4.564	1.061
	5	2	34.4	34.4	34.4	-

Table 3. Parameters of the von Bertalanffy growth equation and Φ values of C. lucernus *(N=number of specimens, L_∞=the asymptotic length, k=a relative growth coefficient, t_0=theoretical age, Φ=growth performance index)*

	N	K	t_0	L_∞	W_∞	Φ
♀	360	0.186	-1.484	49.09	1566.18	2.651
♂	186	0.447	-0.886	31.44	372.93	2.645
♀+♂	546	0.163	-1.609	52.12	1901.51	2.646

Length-weight relationship

The fork length of females ranged from 12.7 to 34.4 cm in size and from 20.58 to 439.37 g in weight. Males ranged from 14.1 to 29.9 cm in length and from 28.52 to 290.60 g. The most abundantly captured specimens ranged from 18.0 to 20.0 cm and 16.0-18.0 cm for females and males, respectively (Fig. 2). Positive allometric growth was observed for both females and males (Fig. 3). Also, for all fish, weight increased allometrically with length.

Condition factor

Condition factors were calculated for months and ages and the results are given in Fig. 4 and Table 4. Minimum and maximum values were found as 0.992 (August) and 1.163 (December) for females, and 1.023
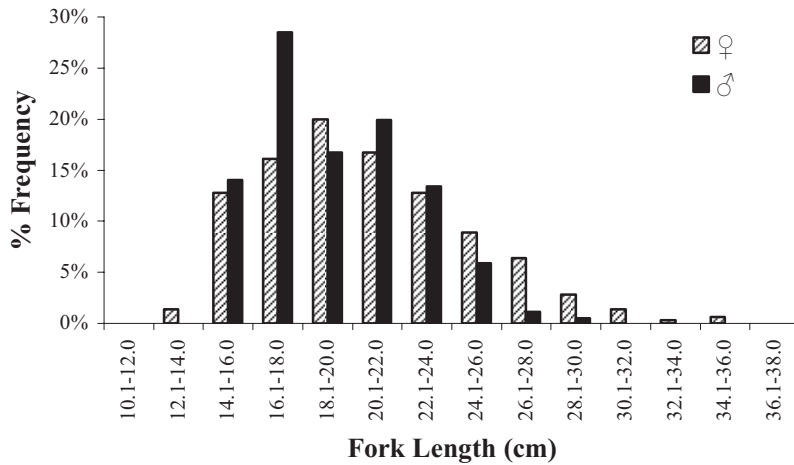
Fig. 2. *Length distributions of tub gurnard females and males caught in İzmir Bay*
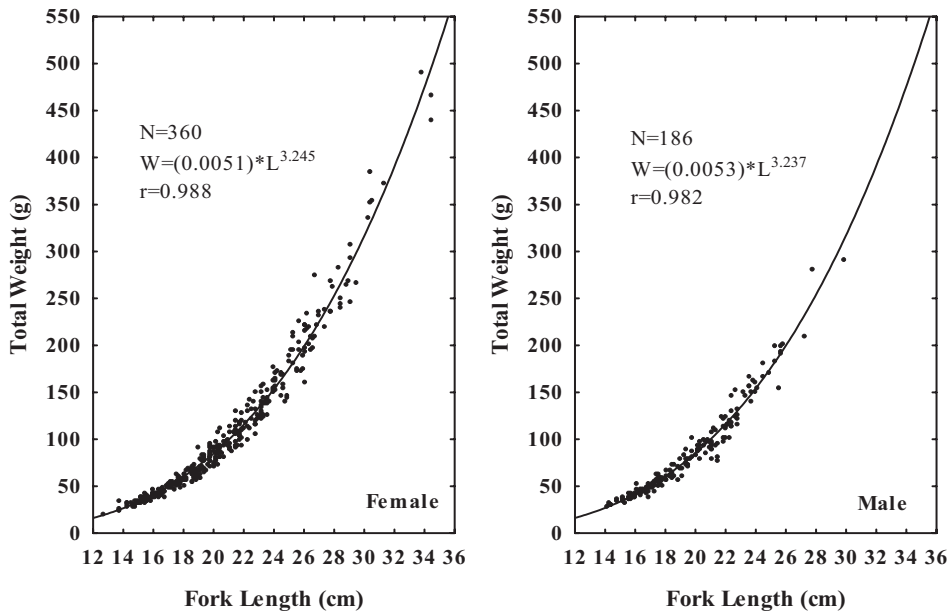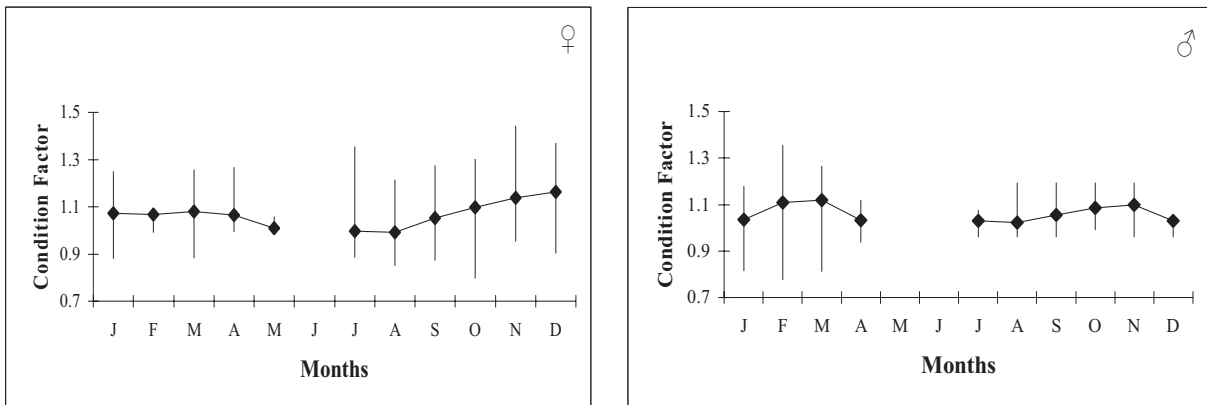

Fig. 3. *Relationship between fork length and total weight of tub gurnards for females and males*

♦: means; |: range

Fig. 4. *Monthly variation of condition factors of female and male* C. lucernus *samples from İzmir Bay*

(August) and 1.119 (March) for males. Condition factors increased directly proportional to ages for both sexes.

Gonadosomatic index

A total of 360 female tub gurnards were investigated to determine the spawning period. Gonadosomatic index (GSI) values increased from October to the end of March. Minimum and maximum GSI values were calculated as being 0.334 and 6.158 for July and March, respectively (Fig. 5). The lengths at first maturity of females and males were found to be 19.0 cm and 17.7 cm (L_T), respectively (Fig. 6).

DISCUSSION

The sex ratio was unbalanced in favor of females for a total of 546 tub gurnard specimens from İzmir Bay. The number of females was more than the number of males in all age groups and in the older age groups (IV-V), there were no males. The predominancy of females has also been observed in other study areas (Table 5). This situation may be attributed to the shorter life span of males which is associated with their earlier attainment of sexual maturity and their beginning to migrate to greater depths for reproduction (HASHEM, 1981).

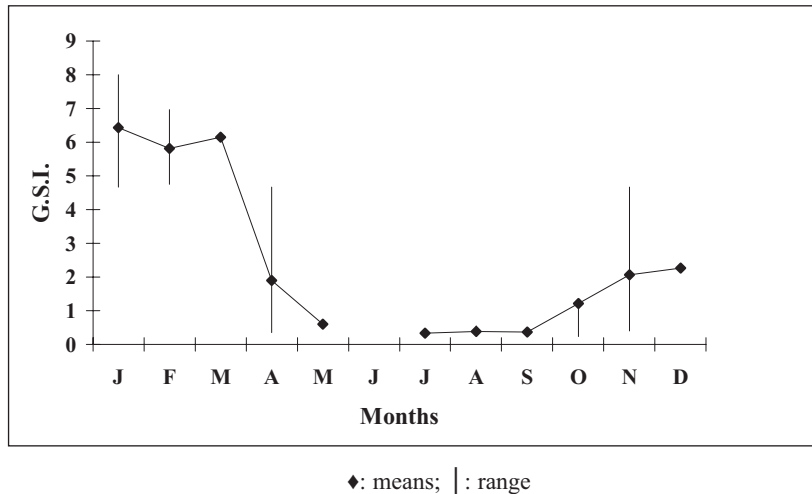According to the studies carried out in different areas, it was determined that *C. lucernus*

♦: means; │: range
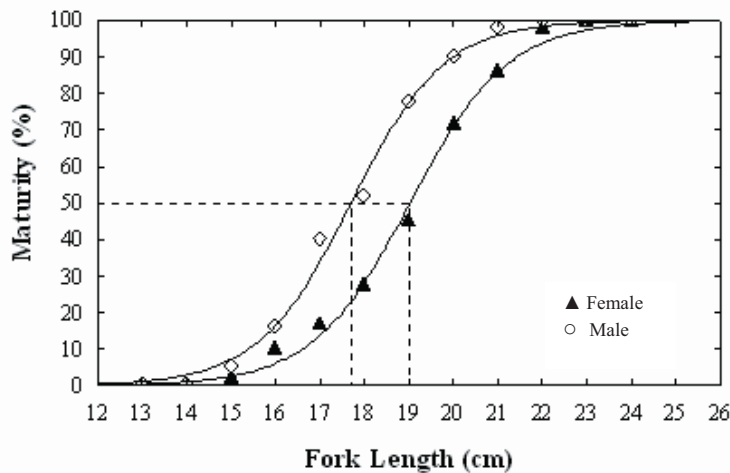*Fig. 5. Gonadosomatic index (GSI) values of female tub gurnards*

Fig. 6. Length at first maturity of females and males of C. lucernus

Table 4. Condition factors versus ages for C. lucernus *females and males*

Age Groups		N	Min.	Max.	Ave. ±CI	SE
♀	0+	5	0.933	1.133	1.026±0.680	0.245
	I	223	0.851	1.353	1.026±0.280	0.142
	II	94	0.594	1.443	1.099±0.336	0.169.
	III	33	0.901	1.369	1.161±0.609	0.298
	IV	3	1.041	1.273	1.188±4.564	1.061
	V	2	1.079	1.145	1.112±	-
♂	0+	2	1.017	1.099	1.058±0.367	0.029
	I	130	0.776	1.325	1.039±0.015	0.008
	II	50	0.863	1.330	1.107±0.036	0.015
	III	4	1.009	1.193	1.116±0.117	0.037

Table 5. Sex ratio of C. lucernus *in different areas by various authors*

Sex ratio (♀:♂)	N	Area	Reference
1:1.1	275	Thermaikos Gulf	PAPACONSTANTINOU, 1984
1.28:1	264	Egyptian Mediterranean Coast	ABDALLAH & FALTAS, 1998
1.4:1.0	342	İskenderun Bay (Eastern Mediterranean)	İŞMEN & İŞMEN, 2004
1:0.5	224	Sea of Marmara	ERYILMAZ & MERİÇ, 2005
1:0.80	262	Edremit Bay (Aegean Sea)	UÇKUN, 2005
1:0.52	546	İzmir Bay (Aegean Sea)	This study, 2006

is mostly distributed between the age groups I-V. Resembling our data presented here, the majority of these populations are formed by these age groups. PAPACONSTANTINOU (1984) and TSIMENIDES *et al.* (1992) stated that the larger fish migrate to greater depths and that this is more evident among females, mainly because of their greater length and life-span.

Comparison of mean length values per age group and von Bertallanfy growth parameters are also given in Table 6.

The asymptotic length value (L_∞) is related to the size of the largest individual sampled in the area. These values are in agreement with FALTAS & ABDALLAH (1997), UÇKUN (2005), and İŞMEN & İŞMEN (2004). However, they differ from those reported by BARON (1985a), SERENA *et al.* (1998) and ERYILMAZ & MERİÇ (2005) from Douarnenez Bay (France), the Tuscany coast (Italy) and the Bay of İskenderun (Mediterranean), respectively. The differences in growth rates between areas were probably related to different bio-ecological conditions, methodologi-

cal differences in the age determinations and sampling depths and also fishing mortality.

In the present study, the growth coefficient (k) was found to be in the mid-range of those calculated by several authors for various tub gurnard stocks inhabiting the Mediterranean Sea (Table 3). In addition, we have found that the male tub gurnards grow faster (k = 0.447) than the females (k = 0.186) as reported by PAPACONSTANTINOU (1984) in the Thermaikos Gulf (Greece).

Our data concerning the growth performance index (Φ) values were compared with those observed by other studies (Table 6). Munro's phi prime test showed that there is no significant difference (p >0.05) between the overall growth performances of the tub gurnard sampled from the other areas.

The correlation coefficients (0.982-0.988) of the tub gurnard computed for İzmir Bay agree with those given by other researchers (Table 7). According to Bagenal and Tesch (in BAGENAL, 1978), the parameter b generally does not vary

Table 6. *Average length values versus age groups and von Bertallanffy growth parameters of tub gurnard populations in various seas*

Author	Location	N	Age Groups											Growth Parameters			
			0+	I	II	III	IV	V	VI	VII	VIII	IX	X	L_∞	k	t_0	Φ
PAPCONSTANTINOU (1984)* ♀	Thermaikos Gulf (Greece)	111	14.57	18.19	22.60	26.39	31.70	35.66	38.40	43.27	-	-	61.10	-	-	-	-
♂		130	15.24	18.26	21.84	26.05	30.33	-	-	-	-	-	-	-	-	-	-
BARON (1985a)** ♀	Douarnenez Bay	239	-	23.0	35.0	44.0	50.0	55.0	-	-	-	-	-	66.8	0.32	-0.46	3.155
♂	(France)	217	-	21.0	31.0	37.0	41.5	44.0	-	-	-	-	-	48.4	0.46	-0.41	3.032
FALTAS & ABDALLAH (1997)**	Egyptian	-	-	11.79	18.84	24.33	28.23							40.3	0.287	-	2.668
SERENA *et al.* (1998)**	Tuscany (Italy)	538	11.7	21.3	35.7	45.5	-	-	-	-	-	-	-	65.9	0.39	-	3.229
İŞMEN & İŞMEN (2004)** ♀	İskenderun Bay	199	-	13.4	19.7	24.8	30.3	-	-	-	-	-	-	45.6	0.223	-0.602	2.583
♂	(Mediterranean)	143	-	13.2	19.1	24.0	-	-	-	-	-	-	-	36.0	0.309	-0.478	2.469
♀+♂		342	-	13.2	19.6	24.6	30.3	-	-	-	-	-	-	45.0	0.221	-0.581	2.566
UÇKUN (2005)* ♀	Edremit Bay	146	14.17	18.07	22.49	26.48	30.13	32.55	-	-	-	-	-	47.45	0.170	-1.826	2.666
♂	(Aegean Sea)	116	12.70	18.82	22.06	25.04	-	-	-	-	-	-	-	59.22	0.084	-3.574	2.603
♀+♂		262	14.02	18.54	22.27	26.20	30.13	32.55	-	-	-	-	-	58.95	0.106	-2.545	2.651
ERYILMAZ & MERİÇ (2005)** ♀	Sea of Marmara	149	-	15.20	17.31	24.97	31.93	39.93	41.50	-	-	-	-	-	-	-	-
♂		75	-	14.27	17.48	22.80	33.50	-	-	-	-	-	-	-	-	-	-
♀+♂		224	-	-	-	-	-	-	-	-	-	-	-	61.3	0.17	-0.04	2.81
This study (2006)* ♀	İzmir Bay	360	13.70	18.15	23.62	27.50	31.27	34.4	-	-	-	-	-	49.09	0.186	-1.484	2.651
♂	(Aegean Sea)	186	14.15	17.93	22.80	25.92	-	-	-	-	-	-	-	31.44	0.447	-0.886	2.645
♀+♂		546	13.83	18.07	23.34	27.33	31.27	34.4	-	-	-	-	-	52.12	0.163	-1.608	2.646

*FL,=fork length, **TL=total length, N=number of specimens, L_∞=the asymptotic length, k=a relative growth coefficient, t_0= theoretical age, Φ=growth performance index

significantly throughout the year, unlike the parameter which may vary seasonally, daily, and between habitats.

The annual means of condition factor values were calculated as 1.060 for females and 1.058 for males. These values increased directly proportional to ages for both sexes. ALTUN *et al.* (1997) and ERYILMAZ & MERİÇ (2005) reported the condition factors of tub gurnard as 0.8634 and 0.990 in Yumurtalık (Adana) Bay (northeastern

Table 7. The growth parameters of C. lucernus *in different localities as reported by various authors (N=number of specimens, a=intercept of the relationship, b=slope of the relationship, r=corelation coefficient)*

		Location	N	a	b	r
PAPACONSTANTINOU	♀	Thermaikos Gulf	122	0.000006	3.110	0.997
(1984)	♂		153	0.000005	3.147	0.992
SERENA *et al.* (1998)		Tuscany (Italy)	538	0.0139	2.859	0.997
ABDALLAH (2002)		Egyptian	196	0.029	2.63	0.973
UÇKUN (2005)	♀	Edremit Bay	146	0.0058	3.181	0.992
	♂	(Aegean Sea)	116	0.0034	3.358	0.971
	♀ + ♂		262	0.0054	3.206	0.989
İŞMEN & İŞMEN	♀	İskenderun Bay	199	0.0095	2.99	0.98
(2004)	♂	(Mediterranean)	143	0.0089	3.01	0.99
ERYILMAZ & MERİÇ (2005)		Sea of Marmara	224	0.0092	3.019	0.989
OLIM & BORGES	♀	South coast of Portugal	13	0.021	2.72	0.99
(2006)	♀ + ♂		21	0.011	2.93	0.99
This study (2006)	♀	İzmir Bay	360	0.0051	3.245	0.988
	♂	(Aegean Sea)	186	0.0053	3.237	0.982
	♀ + ♂		546	0.0052	3.240	0.987

Table 8. Spawning period of C. lucernus *in different areas as reported by various authors*

Spawning Period	Location	Reference
Spring	Mediterranean	FAGE, 1918**
March-April	Adriatic	GRUBIŠIĆ, 1962*
Spring	Mediterranean	MARINARO, 1968**
Winter season	Adriatic	FROGLIA, 1976
Dec-Feb	Adriatic	TORTONESE, 1975*
Spring	Mediterranean	TORTONESE, 1975 *
Dec-March	Izmir Bay (Aegean Sea)	MATER, 1981
Autumn-spring	Greek Seas	PAPACONSTANTINOU, 1983
Jan-May	Thermaikos Gulf	PAPACONSTANTINOU, 1984
April-Sept	Duarnenez Bay (France)	BARON, 1985b
May-July	NE Atlantik-Mediterranean	WHITEHEAD *et al.*, 1986
Dec-April	Mediterranean	FISCHER *et al.*, 1987
end of July	Black Sea	FISCHER *et al.*, 1987
Dec-Feb	Adriatic	JARDAS, 1996*
Dec-April	Egyptian Mediterranean Coast	ABDALLAH & FALTAS, 1998
Dec-April	Edremit Bay (Aegean Sea)	UÇKUN, 2005
Dec-April	İskenderun Bay (East. Medit.)	İŞMEN & İŞMEN, 2004
All year	Sea of Marmara	ERYILMAZ & MERİÇ, 2005
Dec-March	Izmir Bay (Aegean Sea)	This study, 2006

*in DULČIĆ *et al.*, 2001 **in PAPACONSTANTINOU, 1983

Table 9. First sexual maturity length of C. lucernus *in different areas*

First maturity length (cm)			Location	Reference
♀	♂	N		
31.7	26.0	275	Thermaikos Gulf	PAPACONSTANTINOU (1984)
40.1	35.5	556	Douarnenez Bay (France)	BARON (1985b)
17.0	15.6	264	Egyptian (Mediterranean Coast)	ABDALLAH & FALTAS (1998)
20.0	18.0	342	İskenderun Bay (Eastern Mediterranean)	İŞMEN & İŞMEN (2004)
19.0	18.5	224	Sea of Marmara	ERYILMAZ & MERİÇ (2005)
19.0	17.7	546	İzmir Bay (Aegean Sea)	This study (2006)

N=number of specimens

Mediterranean Sea) and the Sea of Marmara, respectively.

According to the gonadosomatic index values computed in the present study, the reproduction of this species took place after December and continued to the end of March (Table 8). SERENA *et al.* (1998) reported that there is a clear shift of timing for the reproductive processes of *C. lucernus* between the Mediterranean and North Atlantic waters. These differences in spawning season may reflect different temperature regimes among these areas (KASHIWAGI *et al.,* 1987).

Lengths at first maturity of *C. lucernus* from several areas are summarized in Table 9. For many fish species, males attain their sexual maturity at smaller sizes than females (HOAR, 1957) as in our findings for *C. lucernus*. Those values given by PAPACONSTANTINOU (1984) and BARON (1985b) are slightly larger than the data reported here. This can be attributed to the average size of maturation being directly related to the population density and ecological conditions, particularly temperature, that stimulate sexual maturation (NIKOLSKY, 1963; KASHIWAGI *et al.,* 1987).

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Starost, rast i reprodukcija lastavice balavice *Chelidonichthys lucernus* Linnaeus, 1758 (Osteichthtyes:Triglidae) u izmirskom zaljevu, Egejsko more, istočni Mediteran

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SAŽETAK

Ukupno je ulovljeno 546 primjeraka lastavice balavice (*Chelidonichthys lucernus* L., 1758) na temelju mjesečnog sakupljanja koćom tijekom rujna 1999. i kolovoza 2000. u izmirskom zaljevu (Egejsko more). Vilična duljina tijela kod ženki kretala se od 12.7 do 34.4 cm, a mužjaka od 14.1 do 29.9 cm. Odnos spolova mužjaka i ženki iznosio je 1:0.52. Najveća starosna dob ustanovljena za ženke bila je 5, a za mužjake 3, dok je dužinsko-maseni iznosio za ženke $W=0.0051*L^{3.245}$ i za mužjake $W=0.0053*L^{3.237}$. Vrijednosti dobivene von Bertalanffy-ijevom jednadžbom iznosile su $L_t=49.09(1-e^{-0.186(t+1.484)})$ za ženke, $L_t=31.44(1-e^{-0.886(t+0.886)})$ za mužjake, te $L_t=52.12(1-e^{-0.163(t+1.609)})$ za oba spola. Vrijednost indeksa rasta (Φ) je iznosio 2.646 za sve primjerke. Gonadosomatski indeks ukazuje da se vrijeme mriješćenja odvijalo tijekom prosinca (2.268) sve do kraja ožujka (6.158). Vilična duljina tijela zrelih mužjaka iznosila je 17.7 cm, a ženki 19.0 cm.

Ključne riječi: Osteichthyes, Triglidae, *Chelidonichthys lucernus,* starost, rast, reprodukcija, izmirski zaljev, Egejsko more, Sredozemlje