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Body size, sexual maturity and diet in *Chelidonichthys lucerna* (Osteichthyes: Triglidae) from the Adriatic Sea, north eastern Mediterranean

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*A total of 1,114 tub gurnard (*Chelidonichthys lucerna L.*, 1758) were caught by trawl surveys carried out between May 2005 and March 2007 in the Adriatic Sea (north eastern Mediterranean). Females ranged from 113 to 415 mm TL and males from 128 to 299 mm TL. At 50% maturity, females matured at a fork length of 270 mm, while males matured at 220 mm. The tub gurnards prey mainly crustaceans and fishes. Molluscs are also consumed. A length around 180 mm is a critical size that coincides with the slope to great depths, the migration along the Italian coast towards the Croatian coast, the start of sexual maturity and the change of their main food, from crustaceans to fish.*

Key words: body size, sexual maturity, feeding habits, *C. lucerna,* Adriatic Sea

INTRODUCTION

ICES has identified the tub gurnard, *Chelidonichthys lucerna* (Linnaeus, 1758) as a potential commercial species and a new MOU (Memorandum Of Understanding) species and has recommended that monitoring programmes should be conducted to derive information on biological parameters for stock assessment purposes (ICES, 2006). The tub gurnard lives in the Mediterranean Sea, Black Sea and eastern Atlantic from Norway to Senegal. Along the Italian coast the species generally occurs at up to 200 m depth and it is the most important gurnard species for Italian fisheries. Many researchers during recent years investigated its growth and reproduction in the eastern Mediterranean (PAPACONSTANTINOU, 1984-Greece; ABDALLAH & FALTAS, 1998-Egypt; ISMEN *et al*., 2004-Turkey; ERYILMAZ & MERIC, 2005-Turkey; UCKUN ILHAN & TOGULGA, 2007-Turkey; CICEK *et al*., 2008-Turkey; BOUDAYA *et al*., 2008-Tunisia).

Concerning length-frequency distribution, generally tub gurnard females reach a length greater than males, for example: males 8.3- 21.2 cm, females 8.0-30.3 cm (ISMEN *et al.* 2004); males 12.0-37.9 cm, females 12.0-41.9 cm (ERYILMAZ & MERIC, 2005); males 14.1-29.9 cm, females 12.7-34.4 cm (UCKUN ILHAN & TOGULGA, 2007) and males 6.5-29.3 cm, females 6.1-30.3 cm (CICEK *et al.,* 2008).

Concerning reproduction, generally (at 50% maturity) tub gurnard males mature at a smaller size than females, for example males 18.0 cm,

females 20.0 cm (ISMEN *et al*., 2004); males 18.50 cm, females 18.97 (ERYILMAZ & MERIC, 2005); males 17.7 cm, females 19.0 (UCKUN ILHAN & TOGULGA, 2007).

However, there is a lack of knowledge on the life cycle of this species and its ecological characteristics along the Italian coast of the north eastern Mediterranean. Most of the studies provided information on nursery areas and the distribution of juveniles concentrating in shallow waters, mainly in estuarine waters, where food is abundant (COLLOCA *et al*.1994 - Tyrrenian Sea; SERENA *et al*., 1998 -Tyrrenian Sea).

A few studies examined some of its biological characteristics in the Adriatic Sea. Regarding feeding habits, tub gurnard changes diet during growth with the capture of bigger-sized prey and the replacement of food categories or bathymetric migration (FROGLIA, 1976 - middle Adriatic Sea). Early larval development in the laboratory was described by DULČIĆ *et al*., (2001). The length–weight relationships varied significantly according to juvenile and adult specimens (CERIOLA *et al*., 2004 -southern Adriatic Sea; VALLISNERI *et al*., 2010 - northern-middle Adriatic Sea).

The aim of the present study is to contribute to knowledge of the tub gurnard, that is a reference species of the Mediterranean Sea, regarding its size distribution, size at maturity and diet in the coastal waters of the Adriatic Sea.

MATERIAL AND METHODS

A total of 1,114 specimens of tub gurnard (*Chelidonichthys lucerna* L., 1758) were collected from May 2005 until March 2007 in the Adriatic Sea (north eastern Mediterranean) from the Gulf of Trieste (45°40’ N 13°37’ E) to the Tremiti Islands (42°0,8’ N 15°16’ E) (Fig.1) at depths ranging from 11 to 257 m. Samples were collected during seasonal oceanographic bottom trawl surveys (winter survey: GRUND project,

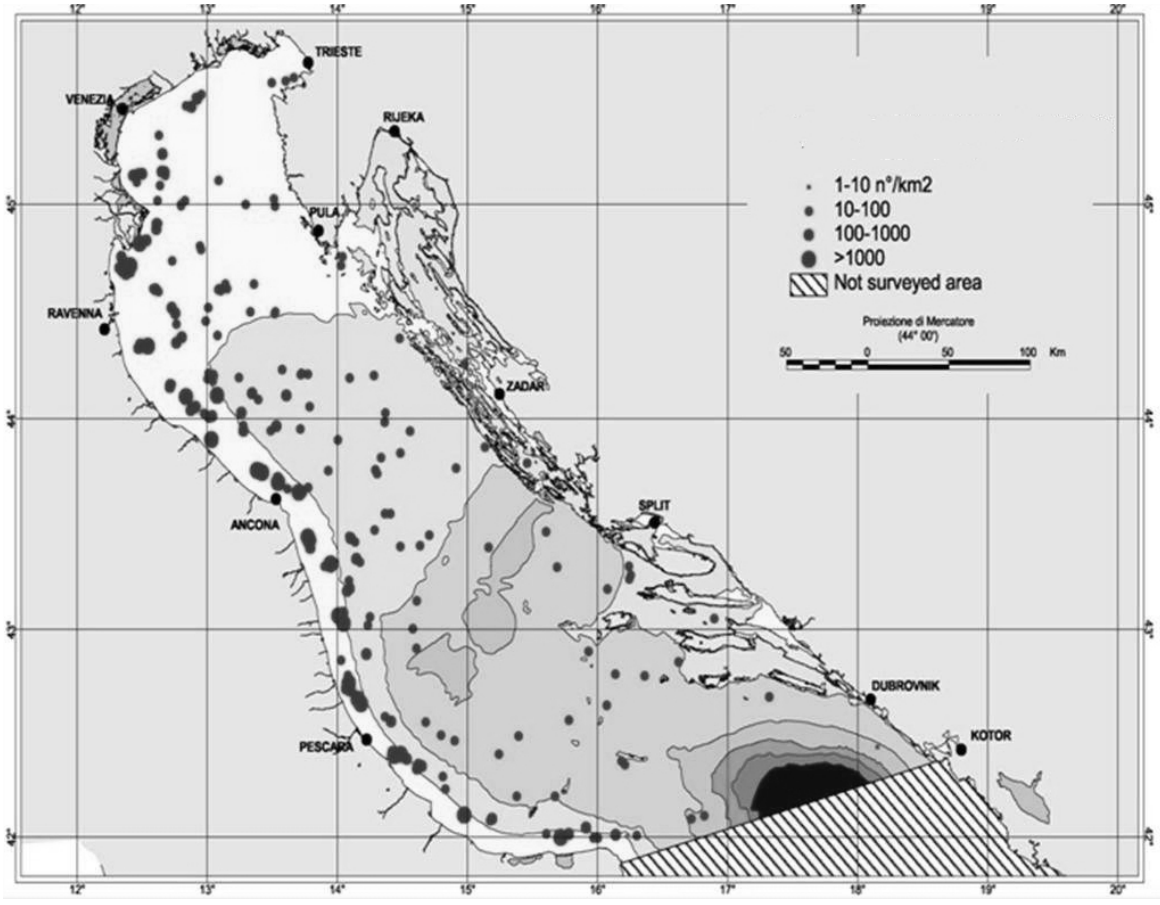

Fig. 1. Map of sampling areas in the Adriatic Sea

GRUppo Nazionale Demersali; summer survey: MEDITS project, MEDiterranean International Trawl Survey) using a special bottom trawl (GOC 73) designed for experimental fishing for scientific purposes (RELINI *et al*., 2008). To increase the catch of demersal species, the gear was characterized by a high vertical opening (about 2.5 m), greater than the most common professional gear used in this area, and a mesh codend size of 20 mm (stretched mesh) (FIORENTINI *et al.*, 1999). Catches were frozen to prevent digestion of their stomach contents, and subsequently taken to the laboratory.

All specimens were measured (total length, TL, to the nearest 1 mm) and weighed with 0.1 g precision. The length-weight relationship was determined by the equation: $W = aL^b$, where *W* is the total weight of the fish (g), L is the total length (mm), *a* is the intercept on the Y-axis of the regression curve and *b* is the regression coefficient.

The sex and maturity stages were determined by macroscopic examination of the gonads following a scale according to RELINI *et al*. (2008). The specimens were classified as juveniles (J) and adults: females (F) or males (M). The percentage of mature individuals in 5 cm intervals was calculated for both sexes. A logistic ogive was fitted to the data in order to estimate the size at which 50% of individuals were sexually mature.

Stomachs were preserved in 70% ethanol solution, while prey were identified to the lowest possible taxonomic level, counted and weighed to the nearest 0.1 mg after removal of surface water by blotting paper. The importance of prey was evaluated using the percentage frequency of occurrence (%O), the percentage by number (%N) and the percentage by weight (%W). We used these values to calculate the index of relative importance (IRI) of PINKAS *et al.,* (1971) expressed as IRI=%O(%N+%W) and modified by HACUNDA (1981) expressed as IRI%=(IRI/∑IRI)x100.

Diet pattern according to tub gurnard size classes was evaluated by cluster analysis (cluster methods: complete) of square root transformed numeric prey abundance at species level, using the Bray-Curtis similarity index (CLARKE & WARWICK, 1994). This method was computed to test the correlation between predator length and number of ingested food categories.

Multivariate analyses by PCA (Principal Component Analysis) plot were performed between predator size ranges and prey classes in order to evaluate environmental and ontogenetic patterns. All data analyses were performed with R software ver. 2.9.2 base and Vegan package (R DEVELOPMENT CORE TEAM, 2009).

RESULTS

The length–frequency distribution of all samples ranged from 63 to 415 mm (mean 208.8±58.9 mm) and articulates on two principal cohorts: the first includes small samples more frequent in the summer and next to the coast, while the second includes individuals of average and large size, more frequent in winter and to great depths (Pearson's Chi-squared test: X-squared = 226.061, df = 4, p-value < 2.2e-16) (Fig. 2; Table 1). Total body weight ranged from 2.2 to 650.9 g (mean 110.9±79.1).

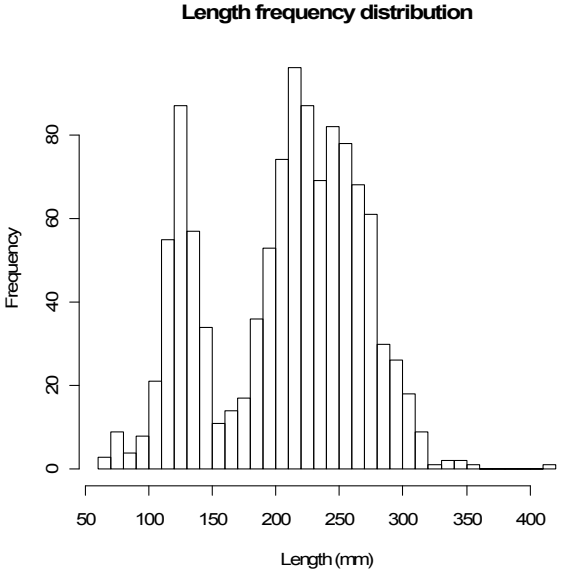

Fig. 2. Length-frequency distribution for C. lucerna *juveniles (n=234) and adults (n=880)*

TL of females (n=484) ranged from 113 to 415 mm (mean 237.1±47.5 mm) and W from 15.6 to 650.9 g (mean 147±81.1 g).

Table 1. Distribution by depth

Depth classes	Juveniles	Females	Males
(10,25) m	199	167	113
(25,50) m	29	144	104
(50,250) m	6	173	179

TL of males (n=396) ranged from 128 to 342 mm (mean 225.9±32.5 mm) and W from 32.7 to 321.8 g (mean 120.9±53.9 g).

TL of juveniles (n=234) ranged from 63 to 180 mm (mean 121.6±17.6 mm) and W from 2.2 to 54.3 g (mean 19.3±7.1 g).

The regression of total wet body weight (W) as a function of total length (TL) was statistically significance ($p<0.001$). For all size range (juveniles and adults: females and males), weight increased proportionally to length (Fig. 3).

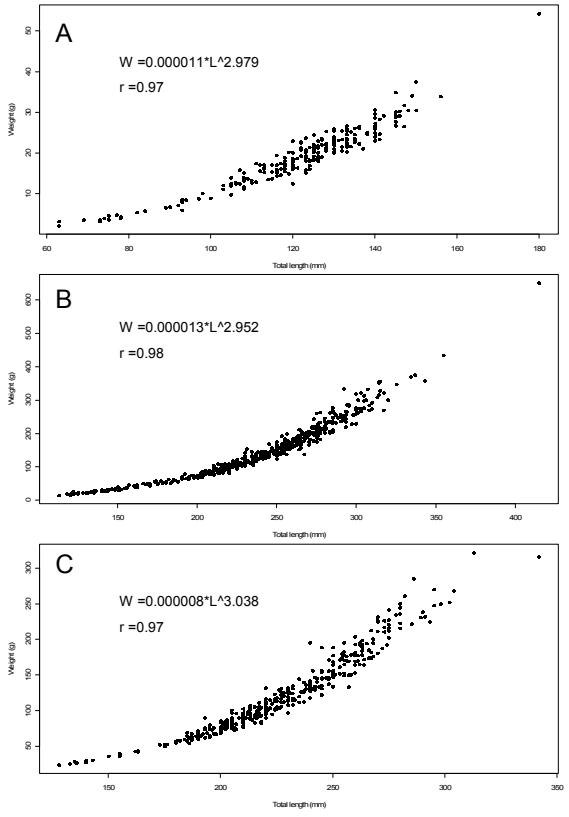

Fig. 3. Length-weight relationship between juveniles (n=234), females (n=484) and males (n=396) for C. lucerna

The smallest mature males and female measured around 180 mm. 50% of males were mature at 238 mm TL and 50% of females were mature at 255 mm TL respectively (Fig. 4).

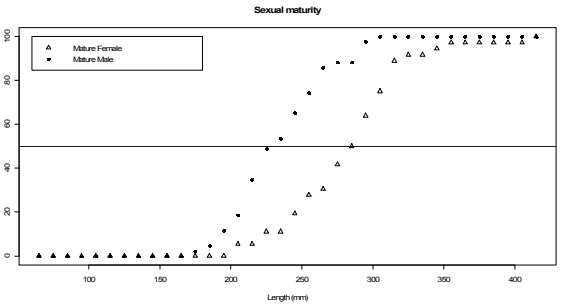

Fig. 4. Relationship between the percentage of mature C. lucerna *and total length for females and males*

With respect to diet, crustaceans had the highest index of relative importance as the main prey items (%IRI=92) and occurred in 58% of stomachs with food. These were followed by fish (%IRI=7), which were the other important prey group, while molluscs and polychaetes were minor components (Table 2). Cluster analysis of %N (numeric prey abundance percent) values according to class size showed tub gurnard to be mostly associated with fish and crustacean preys. Substantial differences in the diet were observed between juveniles (≤180 mm) and adults (>180 mm) when crustaceans decreased and fish increased (Fig. 5).

Taxa	N(%)	W(%)	O(%)	IRI(%)
Crustacea	89.69	58.01	7.47	92.24
Teleostei	6.72	39.74	1.92	7.45
Bivalvia	1.13	0.23	0.25	0.003
Gastropoda	0.3	0.22	0.12	0.001
Cephalopoda	0.14	0.1	0.04	0
Polychaeta	0.03	0.01	0.01	0

Table 2. Trophic spectrum. N(%): numeric prey abundance percent, W(%): wet weight prey abundance percent, O (%): frequency of occurrence, IRI(%): percentual index of relative importance

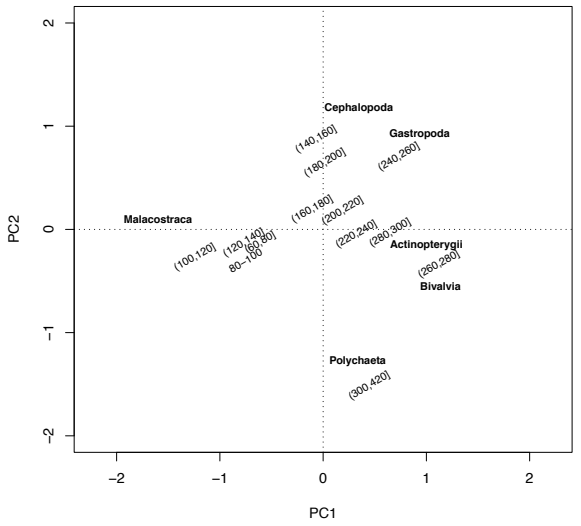

Fig. 5. Multivariate analyses plot of numeric prey abundance by predator size classes

DISCUSSION

The length–frequency distribution for the southern Adriatic Sea ranged on two principal cohorts, according to CERIOLA *et al*., (2004).

A relationship between size and depth has been shown; in fact juveniles are concentrated in shallow waters probably because food is abundant, according to the literature (FROGLIA, 1976; PAPACONSTANTINOU, 1984; BARON, 1985; SERANGELI *et al*., 1985; COLLOCA *et al*., 1994; BOUDAYA *et al*., 2008). *C. lucerna* females reach greater lengths than males, according to the literature on other areas (SERENA *et al*., 1998 - Tuscany coast; ISMEN *et al*., 2004 - Iskenderun Bay; ERYILMAZ & MERIC, 2005 - Sea of Marmara; BOUDAYA *et al*., 2008 - Gulf of Gabès).

Tub gurnard mature at a smaller size for males than females according to some authors (PAPACONSTANTINOU, 1984; BOUDAYA *et al*., 2008). This phenomenon is attributed to the fact that body size is a less important factor for male fitness, while for females a large size at maturity probably implies less fitness costs, as large eggs, large fecundity and access to the best spawning sites (BOUDAYA *et al.,* 2008). Regarding size at maturity, our data are comparable to those reported in the literature as being related to area. The differences can be attributed to ecological conditions, particularly temperature, that stimulate sexual maturation (UCKUN ILHAN & TOGULGA, 2007) and the methods used.

Mediterranean gurnards share a common feeding pattern based on crustaceans and other epibenthic infauna (COLLOCA *et al*., 1994; MORTE *et al*., 1997; LABROPOULOU & MACHIAS, 1998; BOUDAYA *et al*., 2008). According to COLLOCA *et al*. (1994) and BOUDAYA *et al.* (2008), tub gurnards change their diet with size. Smaller individuals feed upon benthic crustaceans. Tub gurnards prey increasingly on Decapoda Reptantia and small fish as their body sizes increase.

A length of around 180 mm represents a critical size for *Chelidonichthys lucerna* in this area, and coincides with the slope to great depths, the migration from the Italian coast towards the Croatian coast, the start of sexual maturity and the change of their main food from crustaceans to fish. A rapid change in the feeding strategy of Mediterranean gurnard species generally coincides with the size of first maturity (COLLOCA *et al*., 1994).

Control of fishing activity is achieved by enforcement of the current system and covers restrictions on species, fish sizes, mesh sizes, locations, etc. The available data suggest that the minimum fishing size should be limited for the Mediterranean tub gurnard, according to ISMEN *et al*. (2004).

In conclusion, updated biological parameters should be produced in order to define stock characteristics and assist in the development of management strategies for sustainable exploitation. The results of this study help to provide such information for tub gurnard in the Adriatic Sea.

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Veličina, spolna zrelost i ishrana lastavice balavice, *Chelidonichthys lucerna* (Osteichthyes: Triglidae), u Jadranskom moru,

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SAŽETAK

Uhvaćeno je ukupno 1.114 primjeraka lastavice balavice *(Chelidonichthys lucerna L., 1758)* tijekom kočarenja provedenih između svibnja 2005. i ožujka 2007. u Jadranskom moru (sjeverno istočni Mediteran). Veličina ženki je bila u rasponu od 13 do 415 mm ukupne duljine (TL), dok je ukupna veličina mužjaka iznosila od 128 do 299 mm (TL). Dužina pri kojoj 50% populacije dosiže spolnu zrelost, kod ženki iznosi 270 mm, a kod mužjaka 220 mm. Plijen lastavice se pretežito sastoji od rakova i riba. Također su konzumirani i mekušci.

Dužina jedinki od oko 180 mm jest kritična u tom smislu jer se podudara sa prelaskom jedinki na život u većim dubinama, početkom migracije uzduž talijanske obale pa prema hrvatskoj obali, početkom spolne zrelosti te sa promjenom u njihovoj glavnoj hrani koja prelazi sa rakova na ribe.

Ključne riječi: veličina, spolna zrelost, hranidbene navike, *C. lucerna,* Jadransko more