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"REPRODUCTIVE BIOLOGY OF *Boops boops* (Linnaeus, 1758) OFF GRAN CANARIA (Canary Islands): A PRELIMINARY STUDY"

Tutor:
Dr. JOSÉ J. CASTRO HERNÁNDEZ
Dr. JOSÉ M. GONZÁLEZ PAJUELO

Candidate:
ANDREA MASSARO

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Reproductive biology of *Boops boops* (Linnaeus, 1758) off Gran Canaria (Canary Islands): a preliminary study

Andrea Massaro*

Phd in Sustainable Management of Fisheries Resources
Faculty of Marine Science
University of Las Palmas de Gran Canaria

*e-mail: andreamassaro@live.it

Abstract

Preliminary data of the length-weight relationship and reproduction of the bogue *Boops boops* off Gran Canaria (Canary Islands, Central-east Atlantic) are provided. Two thousand and twenty-one individuals of bogue, ranging from 4 to 34 cm TL, were obtained from purse seine commercial landing. Reproduction parameters as sex determination, duration of spawning season, size at first maturity and GSI variation along time were determinated based on macroscopic evaluation of gonads. The results obtained suggest that bogue is a total spawner, with a long spawning season extending from January to May. Size at first maturity was 16.7 and 17.9 cm TL for males and females, respectively. The length-weight relationship obtained showed a positive allometry in both sexes.

Keywords: *Boops boops*, Canary Islands, reproduction, length-weight relationship, size at first maturity, spawning season, Gonadosomatic index.

Biología reproductiva de *Boops boops* (Linnaeus, 1758) en aguas de Gran Canaria (Islas Canarias): un estudio preliminar

Andrea Massaro*

Doctorado en Gestión Sostenible de Recursos Pesqueros
Facultad de Ciencias del Mar.
Universidad de Las Palmas de Gran Canaria.

*e-mail: andreamassaro@live.it

Resumen

Se presentan datos preliminares sobre la relación talla-peso y reproducción de la boga *Boops boops* en aguas de Gran Canaria (Islas Canarias, Atlántico Centro-Oriental). Los 2012 ejemplares examinados, obtenidos de capturas comerciales con cerco, presentaron tallas entre 4 y 34 cm TL. Se determinaron los parámetros reproductivos, como la determinación del sexo, la duración del periodo de desove, talla de primera madurez y variaciones del GSI a lo largo del tiempo, a través del análisis macroscópicamiente las gónadas. Los resultados sugieren que la boga es un desovador total con un largo periodo de puesta, que se extiende desde enero a mayo, y cuya talla de primera madurez es 16.7 y 17.9 cm TL para machos y hembras, respectivamente.
La relación talla-peso obtenida muestra una alometría positiva en ambos los sexos.

Palabras clave: *Boops boops*, Islas Canarias, reproducción, relación talla-peso, de primera madurez, periodo de puesta, índice gonadosomático

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1. - INTRODUCTION

In Gran Canaria *Boops boops* (Linnaeus, 1758) has limited commercial value and it lack of attractiveness for the recreational fishing sector. This is due to the fact that, despite its acceptable morphological and nutritional characteristics that make it suitable for commercialization, is erroneously considered undesirable and unpalatable for most consumers and, consequently, from the point of view of fishermen, their marketing is not economically viable despite it is relatively abundant.

Generally it is discarded at sea after being capture in the purse-seine fishery which targeted species are other middle-size pelagic fish (pilchard, chub mackerel, horse mackerel), and it represents the main discarded species of the artisanal fishery developed off the island together with some benthic sharks and rays, and species of low commercial value (box-fishes, damselfishes, etc.). Its capture also takes place as by-catch in gillnet, longline, and handline operations. On the other hand, its juveniles are the target species for the live-bait fishery addressed to tuna (mainly *Katsuwonus pelamis*) that is a seasonal and high economic value fishery.

To get the most out of the bogue is necessary a comprehensive study of its biology, in order to determine its ecological role in bento-pelagic communities, and to determinate the real situation and fishing potential of the population.

Despite that there are no to many previous information about *Boops boops* in the Canary Islands, there are some studies of its biology and ecology in other parts of world, particularly in the Mediterranean. In this sense, Anato & Katari (1986) described the feeding habits and reproduction of *B. boops* in waters of Tunisian, while Livadas (1988) studied its growth and maturity off Cyprus. Hassan (1990) undertook an study on *B. boops* from Alexandria (Egypt), especially boarding aspects related with growth, feeding habits and reproduction as well as fishery statistics. Ezzat *et al.* (1991) studied the sex reversal in this sparid from the Alexandria coast. Gordo (1995) studied the reproduction of *B. boops* off the Portuguese coast.

Studies of reproduction in fishes, such as duration of spawning season, size at maturity and fecundity, require knowledge of the stage of gonad development in individual fish. The methods used in such studies are generally based on the visual external appearance of the gonad (West, 1990). In this way, the aim of this document is to contribute to the knowledge of the biology of *Boops boops* in the Canary Islands, giving preliminary data of several reproductive parameters that are important for the adequate management of its fishery in neritic waters of Gran Canaria.

2. - SYSTEMATIC

The bogue, *Boops boops*, belongs to the order Perciformes which includes about 160 families for a total of over 10,000 species found in almost all aquatic environments. It belongs to the Sparidae family, where the genus *Boops* is represented by 2 species (*B. boops* and *B. lineatus*). It is distributed in the from Norway to Angola, including the archipelagos of Azores, Madeira, Canary Islands, and Cabo Verde. It is also present in the Mediterranean and Black Seas (FIG. 2.1).

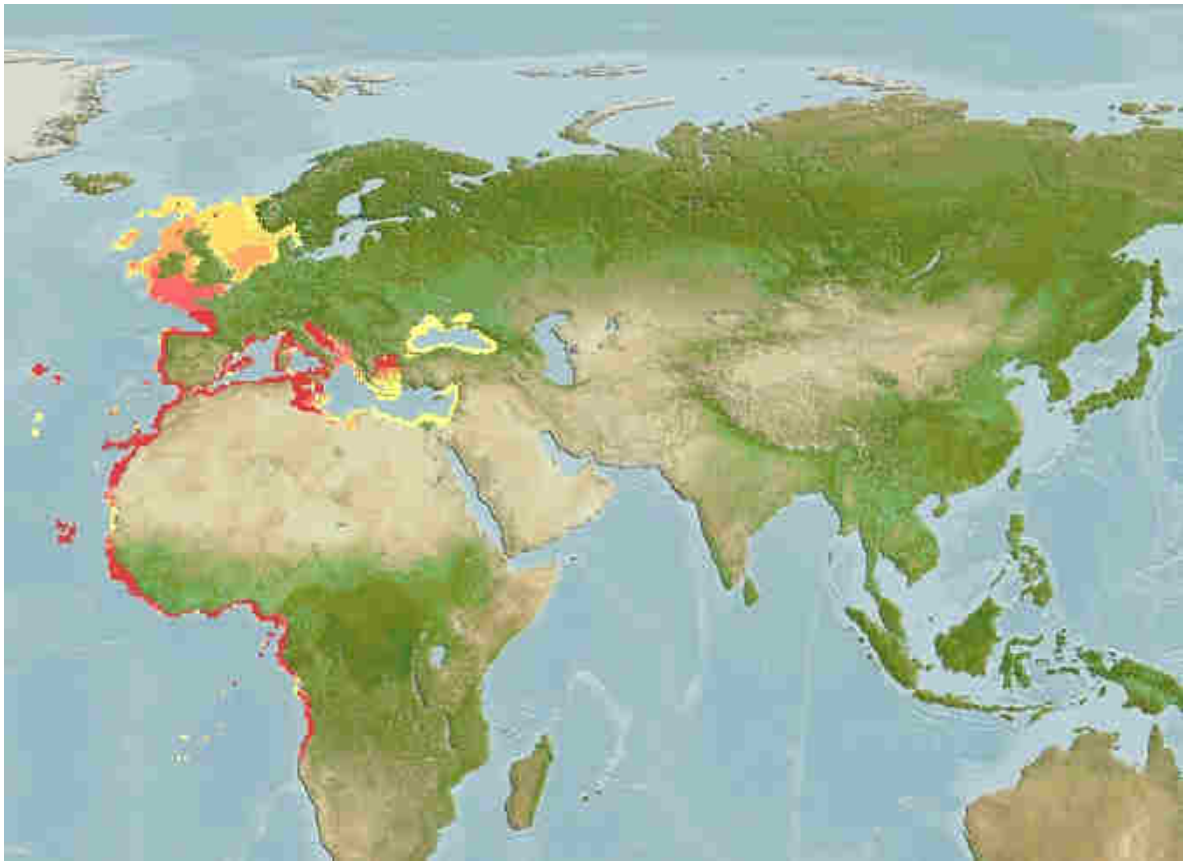


FIGURE 2.1. - Spatial distribution of *Boops boops*: red areas represent the greatest abundance and yellow areas are of lower abundance (from www.fishbase.org).

Boops boops presents a fusiform body, rather low and very slightly compressed, with its anterior part sub-cylindrical in cross section. Eyes are large, with its diameter greater than the snout length. The scales on top of head reaching forward just beyond level of posterior eye margins. Mouth is small, oblique and lips are very thin. All teeth are incisor-like, settled in a single row in both jaws. The

cutting edges of upper teeth with 4, of lower teeth with 5 points (the central point largest) (FIG. 2.2).

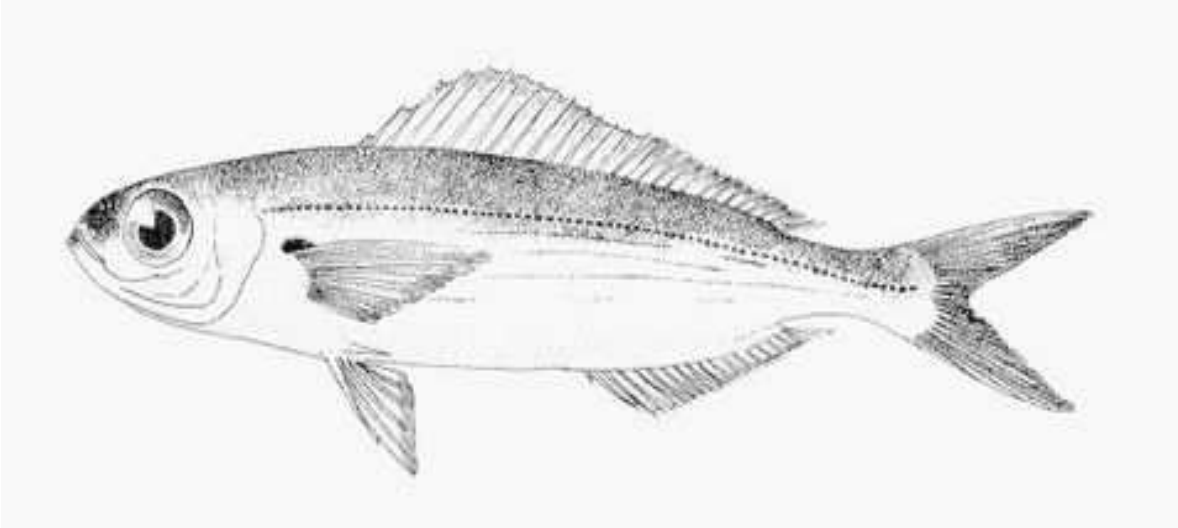


FIGURE 2.2 - Graphical representation of *Boops boops* (source: FAO).

Gill rakers on first arch are 16 to 20 lower and 7 or 8 upper. Dorsal fin has 13-15 spines and 12-16 soft rays. Anal fin has 3 spines and 14-16 soft rays. Pectoral fins are short, not reaching to anus. Caudal fin is forked. Scales along lateral line are 69 to 80. The body colour of the back is bluish or greenish, with sides with silvery or golden reflections and with 3 to 5 golden longitudinal lines. It presents a small brown spot restricted to the pectoral fin axils. The lateral line is dark and fins are light (FIG. 2.3).

FIGURE 2.3 - Speciment of *Boops boops*

The bogue is a gregarious, demersal and semi-pelagic feeder, that can generally be found down to 100 m, and infrequently down to 350 m. It feeds on seaweed, crustaceans, and zooplankton, and rise to the surface at night to feed. Individuals can reach 36 cm TL, but average is about 20 cm. In this species has been reported hermaphroditic behavior (D'Ancona, 1949; Reinboth, 1962; Lissia-Frau, 1966), being a sequential hermaphroditism in the basic form of protoginy. Males may develop directly from the juvenile state (primary males) or may develop from adult females by sex change (secondary males).

3. - MATERIAL AND METHODS

3.1. - SAMPLING

All specimens for this study were collected monthly, from January to September 2012, in purse seine captures at south of Gran Canaria (port of Arguineguín). *Boops boops* captured were generally discarded from the commercial catches of a canarian artisanal fleet. The analyses on the samples were completed immediately after landing.

3.2. - METHODS

Total length (TL) and fork length (FL) of each fish was measured to the lower 0.5 cm, and weighed to the nearest 0.1 g (WT). After the gonads were removed and weighed (WG) to the nearest 0.001 g, the eviscerated weight (WE) was taken to the nearest 0.1 g. Female and male gonads were fixed and preserved in 4% buffered formaldehyde.

The sex of males and females were assessed visually. Ovaries were classified according to their appearance, using the 8 stage-maturity scale (TAB. 3.1) The characteristics considered by Abella *et al.* (2002) in order to establish this scale were size, grade of opacity, colour and oocyte appearance.

The sex ratio was expressed as the feminility rate: ratio between total number of females and total number of females and males. Sex ratios were tested statistically for significant deviations from the expected 0.5 ratio with a Pearson chi-square goodness-of-fit test (α=0.05).

The length at first maturity (length at which fifty percent of individuals attain maturity, Lm) was determined by fitting a logistic ogive:

$$P = \frac{100}{1 + e^{-r(Lt - Lm)}}$$

to the proportion of reproductively active fish in each size class (stages 2B to 4B), where P is the percentage of fish mature at total length Lt; and r the model parameter (Saila *et al.,* 1988). The function was fitted to data by means of the Levenberg-Marquardt's algorithm for non-linear least squares parameter estimation (Draper & Smith, 2000).

The spawning season was estimated by monitoring the monthly changes in the frequency of the maturity stages. The spawning season was also established from the monthly evolution of the gonadosomatic index (GSI) of males and females which was calculated by expressing gonad weight as a percentage of eviscerate weight (Anderson & Gutreuter, 1983).

TABLE 3.1 - Codes of sexual maturity for bony fish (Abella *et al.*, 2002).

SEX	GONAD ASPECT	MATURATION STATE	STAGE	MEDITS
U	Sex not distinguished by naked eye. Gonads very small and translucid, almost trasparent. Sex undetermined.	UNDETERMINED	0	0
F	Small pinkish and translucent ovary shorter than 1/3 of the body cavity. Eggs not visible by naked eye.	IMMATURE = VIRGIN	1	1
M	Thin and withish testis shorter than 1/3 of the body cavity.			
F	Small pinkish/reddish ovary shorter than 1/2 of the body cavity. Eggs not visible by naked eye.	VIRGIN-DEVELOPING *	2a	2
M	Thin withish testis shorter than 1/2 of the body cavity.			
F	Pinkish-reddish/reddish- orange and translucent ovary long about 1/2 of the body cavity. Blood vessels visible. Eggs not visible by naked eye.	RECOVERING *	2b	
M	Whitish/pinkish testis, more or less simmetrical, long about 1/2 of the body cavity.			
F	Ovary pinkish-yellow in colour with granular appearance, long about 2/3 of the body cavity. Eggs are visible by naked eye through the ovaric tunica, which is not yet translucent. Under light pressure, eggs are not expelled.	MATURING	2c	
M	Whitish to creamy testis long about 2/3 of the body cavity. Under light pressure, sperm is not expelled.			
F	Ovary orange-pink in colour, with conspicious superficial blood vessels, long from 2/3 to full length of the body cavity. Large transparent, ripe eggs are cleary visible and could be expelled under light pressure. In more advanced conditions, eggs escape freely.	MATURE/SPAWNER	3	3
M	Whitish-creamy soft testis long from 2/3 to full length of the body cavity. Under light pressure, sperm could be expelled. In more advanced conditions, sperm escapes freely.			
F	Reddish ovary shrunked to about 1/2 length of the body cavity. Flaccid ovaric walls; ovary may contain remanants of disintegrating opaque and/or translucent eggs.	SPENT	4a	4
M	Bloodshot and flabby testis shrunken to about 1/2 length of the body cavity.			
F	Pinkish and translucent ovary long about 1/3 of the body cavity. Eggs not visible by naked eye.	RESTING *	4b	
M	Whitish/pinkish testis, more or less simmetrical, long about 1/3 of the body cavity.			

3.3. - LENGTH-WEIGHT RELATIONSHIP

Length-weight relationship describes body growth in marine organisms. In fact, it makes possible to evaluate the relative growth of the animal throughout his life, highlighting any morphological changes.

Length-weight relationship, also, is a useful tool to convert the equation size-age by weight-age, in order to estimate the biomass of a population starting from size distributions (Wootton, 1990; Pauly, 1993; Petrakis & Stergiou, 1995; Gonçalves *et al*., 1996; Binohlan & Pauly, 1998).

The model that best expresses this relationship in fish is the potential one

$$P = a\, L^{b}$$

where a and b represent two curve parameters.

For teleosts fishes with isometric growth the value of b does not differ significantly from 3; for values greater than 3 growth is allometry positive that explains the greater increase in weight with respect to size, otherwise the allometry is negative type.

To test allometry ($b \neq 3$) was applied *t*-Student test (Pauly, 1984) with n-2 degrees of freedom and null hypothesis $b = 3$. The same test was used to check for any significant differences between the value of b within males and females.

4. - RESULTS

4.1. - DEMOGRAPHIC STRUCTURE

Macroscopically, the gonads were present as elongated testes or ovaries in the functional males and females, respectively, lying in a caudocranial direction. Of the 2021 macroscopically examined specimens, 560 (27.7 %) were males and 593 (29.9%) females. Fish varied in size from 4.0 to 34.0 cm total length. Males varied from 8.5 to 34.0 cm and females from 10.0 and 30.5 cm. Indeterminate individual were 860 (42% of the total). A small number among the adults, 8 specimens (0,4%), were intersexual, varied from 17.0 cm and 21.0 cm. The indeterminate individuals range from 1.0 cm to 8.5 cm (TAB. 4.1) (FIG. 4.1).

Males and females predominated from 13 to 30 cm LT. All individuals larger then 30 cm were males (FIG. 4.2). A significant difference in mean total length between males (20.7 cm) and females (20.0 cm) (t-test, $p<0.01$, $t=3.03$) was observed.

TABLE 4.1 - Number of fishes sampled

MONTH	FEMALE	MALE	INDETERMINATE	INTERSEXUAL	TOTAL
January	121	74	60		255
February	56	58	3		117
March	194	84	7		285
April	26	145	3		174
May	41	82	1		124
June	4	7	754		765
July	116	76	26	2	220
August					
September	35	34	6	6	81
TOTAL	593	560	860	8	2021

4.2. - SEX RATIO

The sex ratio was expressed as the rate of femininity: the sex ratio values was not significantly deviated from the ratio 1:1 (chi-square test $\chi^2 < 0.001$).

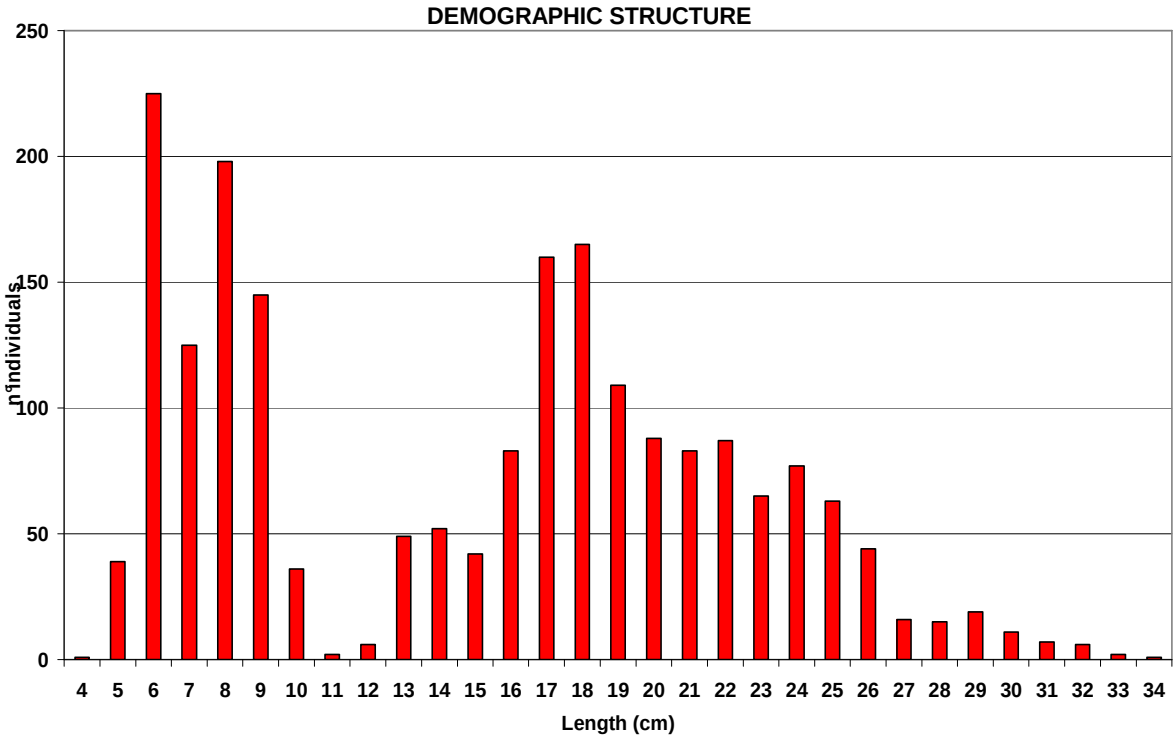


FIGURE 4.1 - Length frequency distribution of *Boops boops* caught off Gran Canaria

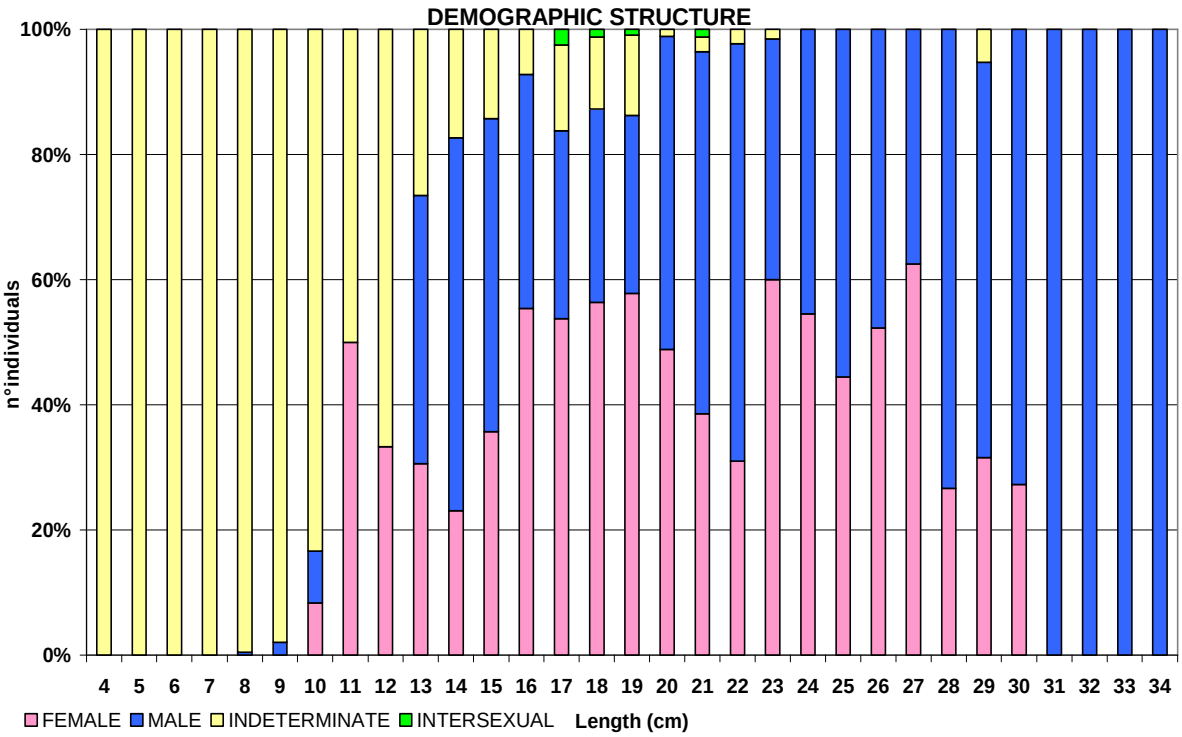


FIGURE 4.2 - Demographic structure of *Boops boops*

4.3. - SIZE AT FIRST SEXUAL MATURITY

Table 4.2 shows female and male individual divided into maturity stage by size classes. Also, is reported the percentage of mature individuals with respect to the total.

The smallest mature male and female analysed were 12.0 and 14.0 cm total length, respectively. The average length at first maturity for males and females was 16.7 and 17.9 cm total length, respectively. No significant difference in length at first maturity was found between sexes (t-test, $X<0.05$). The R^2 values were 0.991 for females (FIG. 4.4) and 0.996 for males (FIG. 4.5)

Table 4.3 shows the main logistic curve parameters; in addition to value of the correlation coefficient R^2, the strength of the linear relationship between the values, was high for both sexes, confirming that the model was good for experimental data.

TABLE 4.2 - Number of female, males, and immature fish per length class.

	MATURITY STAGE									
LENGTH	1	2A	2B	2C	3	4A	4B	TOTAL	MATURE	% MATURE
9	0	0	0	0	0	0	0	0	0	0
10	3	0	0	0	0	0	0	3	0	0
11	1	0	0	0	0	0	0	1	0	0
12	2	0	0	0	0	0	0	2	0	0
13	15	0	0	0	0	0	0	15	0	0
14	8	3	1	0	0	0	0	12	1	8.3
15	1	10	4	0	0	0	0	15	4	26.7
16	8	24	11	2	0	1	0	46	14	30.4
17	5	51	32	0	0	0	0	88	32	36.4
18	3	53	34	2	0	1	0	93	37	39.8
19	2	24	35	2	0	0	0	63	37	58.7
20	0	5	33	4	0	1	0	43	38	88.4
21	0	2	15	10	0	5	0	32	30	93.8
22	0	0	6	14	1	5	1	27	27	100
23	0	0	0	26	9	3	1	39	39	100
24	0	0	1	28	3	10	0	42	42	100
25	0	0	1	17	6	4	0	28	28	100
26	0	0	0	13	5	5	0	23	23	100
27	0	0	0	7	1	2	0	10	10	100
28	0	0	0	0	3	1	0	4	4	100
29	0	0	0	2	3	1	0	6	6	100
30	0	0	0	2	1	0	0	3	3	100

	MATURITY STAGE									
LENGTH	1	2A	2B	2C	3	4A	4B	TOTAL	MATURE	% MATURE
8	1	0	0	0	0	0	0	1	0	0
9	3	0	0	0	0	0	0	3	0	0
10	3	0	0	0	0	0	0	3	0	0
11	0	0	0	0	0	0	0	0	0	0
12	8	1	1	0	0	0	0	10	1	1.2
13	18	3	1	0	0	0	0	22	1	2.2
14	19	8	4	0	0	0	0	31	4	12.9
15	3	14	4	0	0	0	0	21	4	19.0
16	9	14	8	0	0	0	0	31	8	25.8
17	10	16	20	2	0	0	0	48	22	58.3
18	3	8	28	1	0	2	0	42	31	88.2
19	2	1	24	0	0	3	1	31	28	90.3
20	0	9	19	1	0	21	0	50	41	91.8
21	0	3	8	2	0	28	7	48	45	93.8
22	0	0	15	4	0	33	6	58	58	100
23	0	0	2	5	0	15	3	25	25	100
24	0	0	3	1	3	26	2	35	35	100
25	0	0	0	1	4	28	2	35	35	100
26	0	0	1	3	1	15	1	21	21	100
27	0	0	0	2	1	3	0	6	6	100
28	0	0	0	11	0	0	0	11	11	100
29	0	0	0	8	4	0	0	12	12	100
30	0	0	0	6	2	0	0	8	8	100
31	0	0	0	5	2	0	0	7	7	100
32	0	0	0	3	3	0	0	6	6	100
33	0	0	0	1	1	0	0	2	2	100
34	0	0	0	0	1	0	0	1	1	100

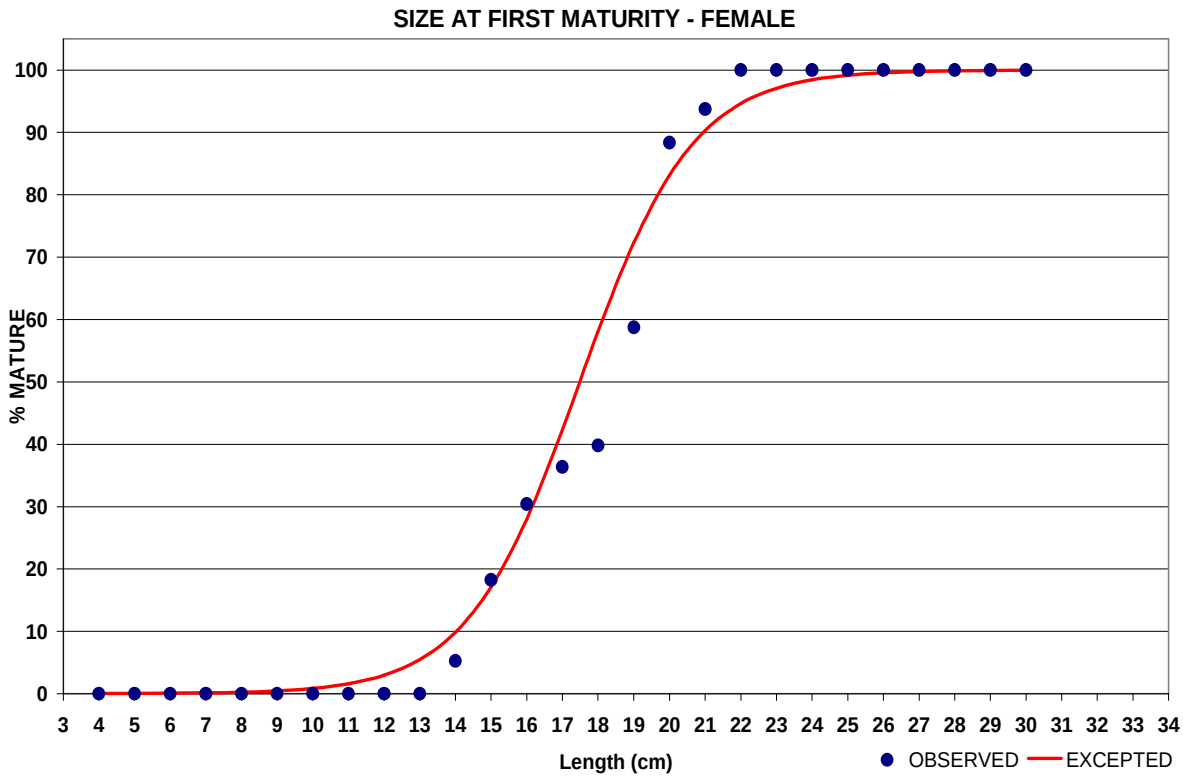


FIGURE 4.3 - Size at first sexual maturity FEMALE

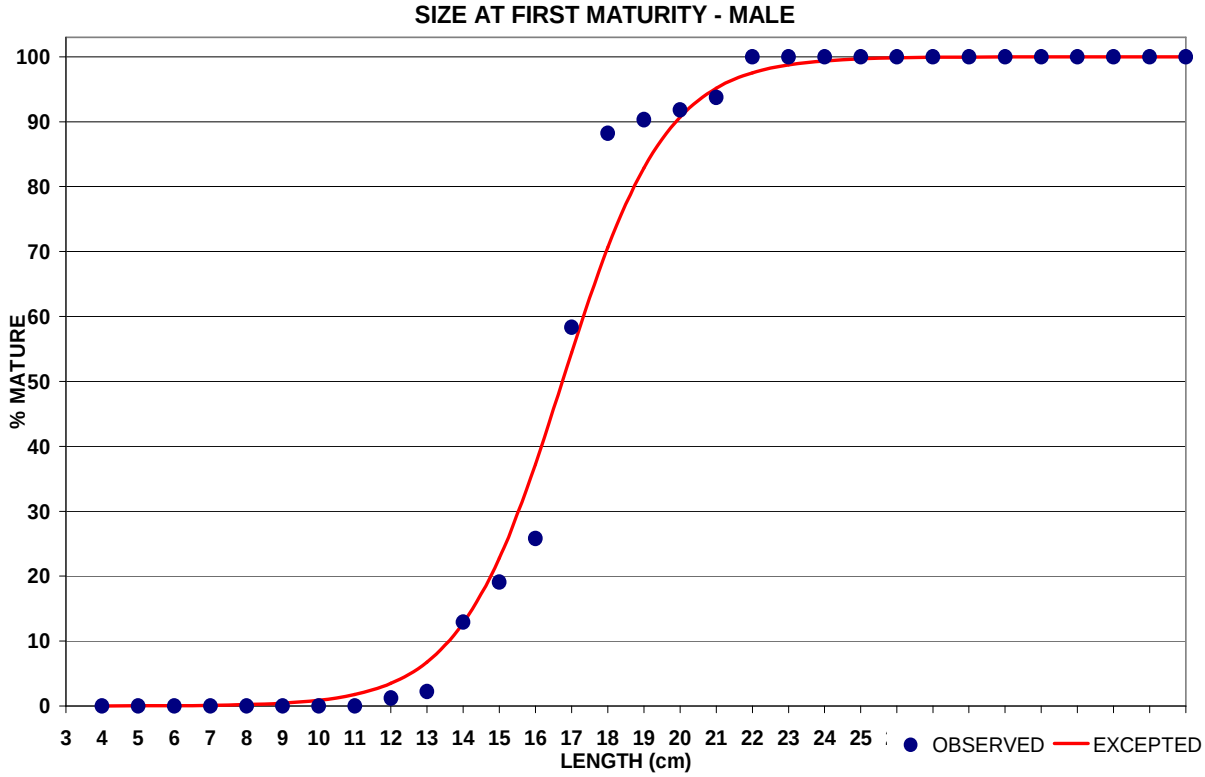


FIGURE 4.4 - Size at first sexual maturity MALE

TABLE 4.3 - Maturity ogive parameters.

	FEMALE	MALE
R^2	0.991	0.996
L_m (cm)	17.9	16.7

4.4. - GONADOSOMATIC INDEX (GSI)

The gonads of this species present a well marked difference between sexes in individuals larger than 10 cm LT. Testes mean weight increase from 0.009 g in stage 1 to 19.180 g in stage 2C whilst in females, the ovary reaches a large size with maturity, with mean ovarian weight increasing from 0.008 g in stage 1 to 9.940 g in stage 3.

The monthly mean value of the gonadosomatic index for females was usually higher than that of males (FIG. 4.5). However, both indices followed the same pattern. The highest values of the GSI for both sexes occurred on February. From March to September the values were low.

All macroscopic stages of female gonad development were observed during the sampling period. Individuals with running ripe gonads (stage 3) were dominant in February. Ripe fish (stage 2C) appeared in January and became dominant in February. Ovaries and testes were spent/resting stage (stage 4A/4B) in April and May. Fishes in immature/developing/recovering stage (stage 1/2A/2B) were always present during the reporting period with dominant values from June to September (FIG. 4.6).

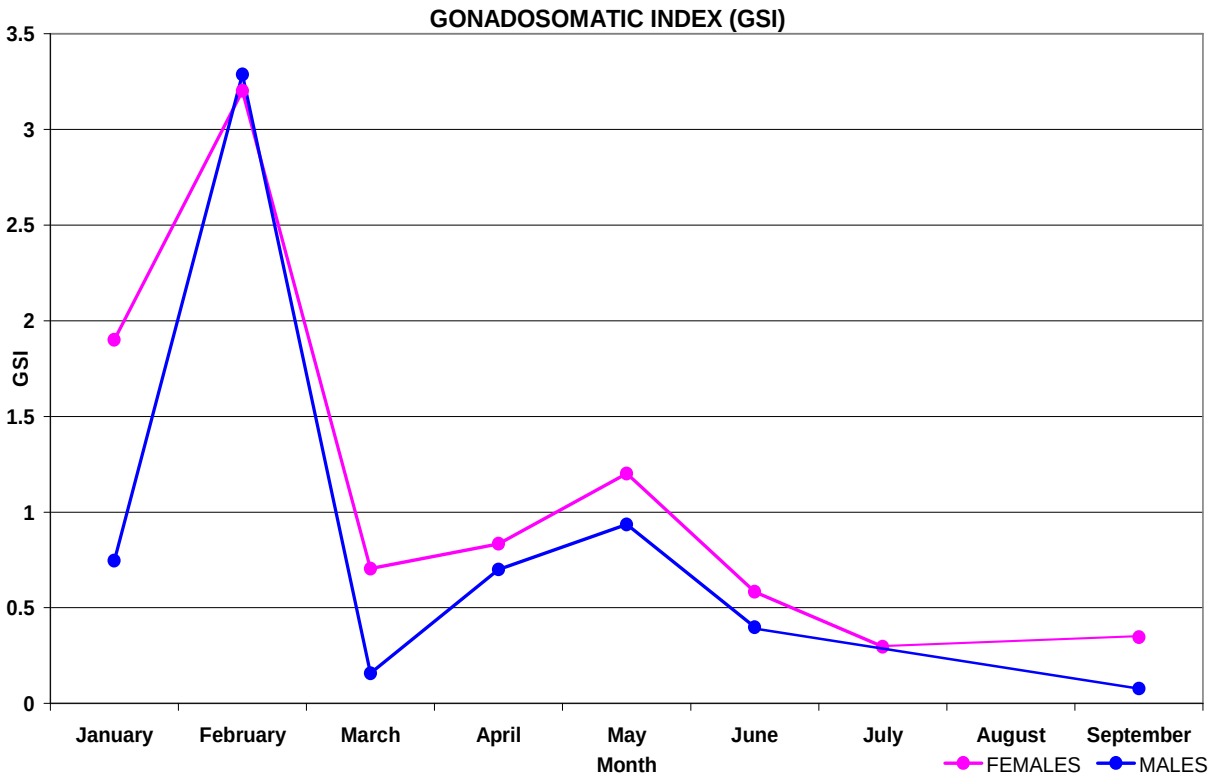


FIGURE 4.5 - Monthly evolution of the GSI for females and males of *Boops boops*.

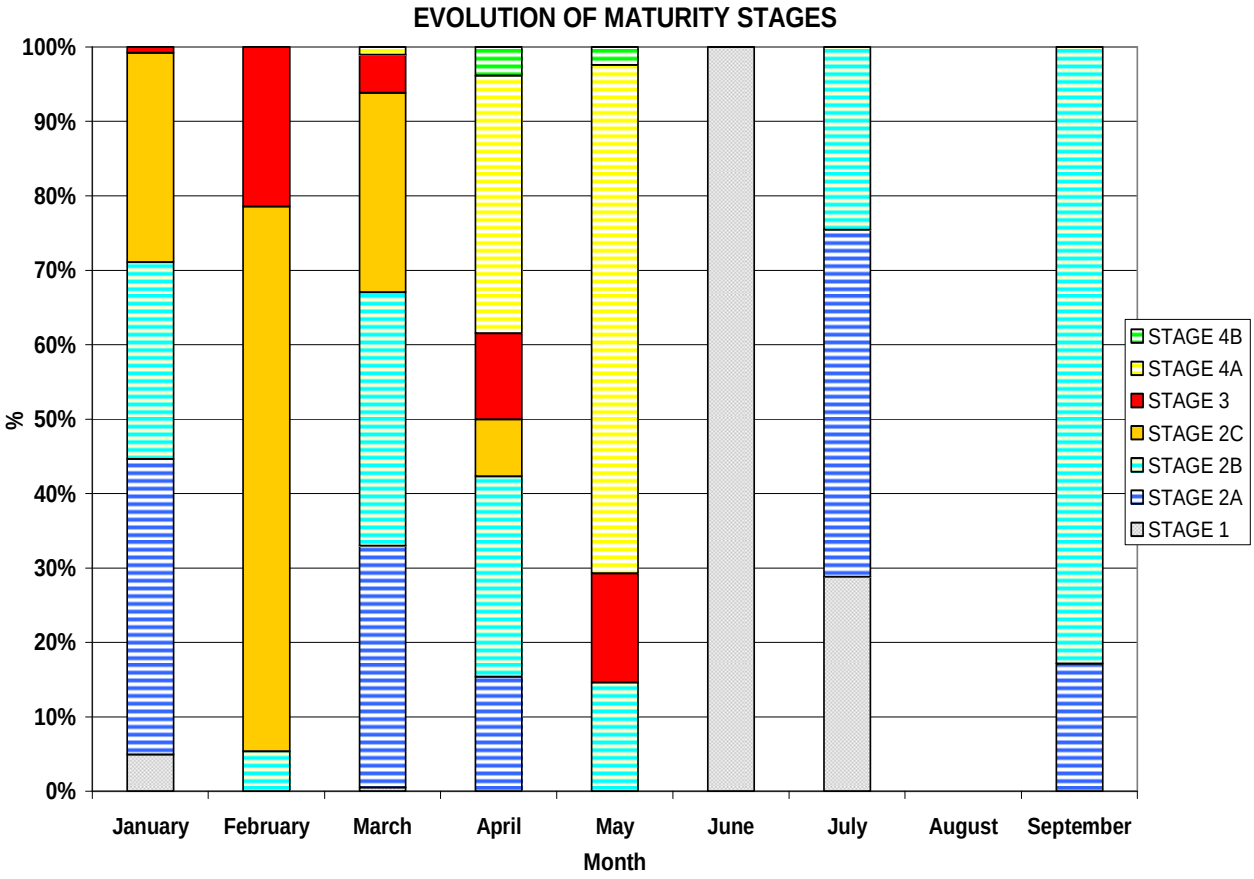


FIGURE 4.6 - Monthly changes in the percent frequency of the maturity stages for all fish of *Boops boops*

4.5 - LENGTH - WEIGHT RELATIONSHIP

The length - weight relationship of *B. boops* was calculated for the total population and for separate sex (FIG. 4.7). On the entire population and for both sex, b parameter was significantly different from 3, expressing positive allometry with a accretion by weight proportionally greater than animal length.

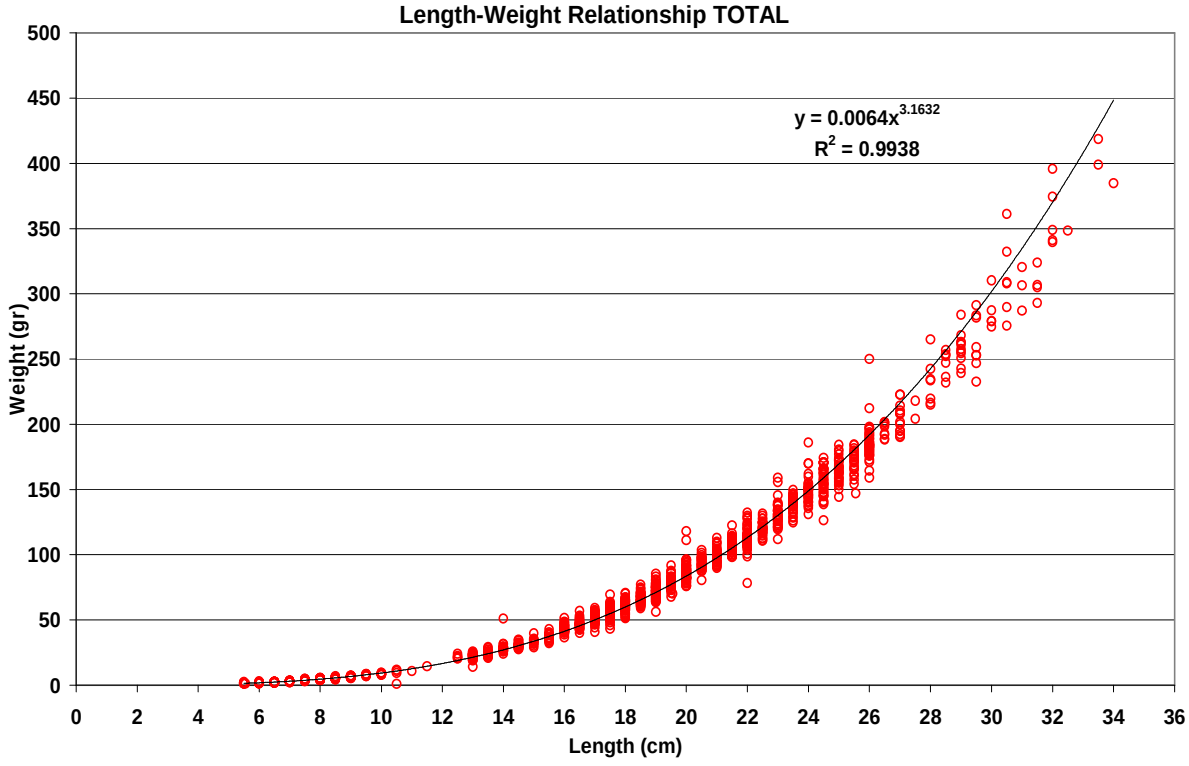
Curve parameters and R^2 value are in Table 4.4.

TABLE 4.4 - Length-Weight relationship parameters for the total population, males and females

	a	b	R^2
TOTAL	0.0064	3.1632*	0.9938
FEMALE	0.0073	3.1204*	0.9544
MALE	0.0064	3.1640*	0.9939

*($t>t_{1,0.05;}$ $p>0.05$)

Test-t showed that there were no statistically significant differences in the value of b between males and females ($p < 0.05$), demonstrating that at the same size there were no differences in weight between individuals of different sex.



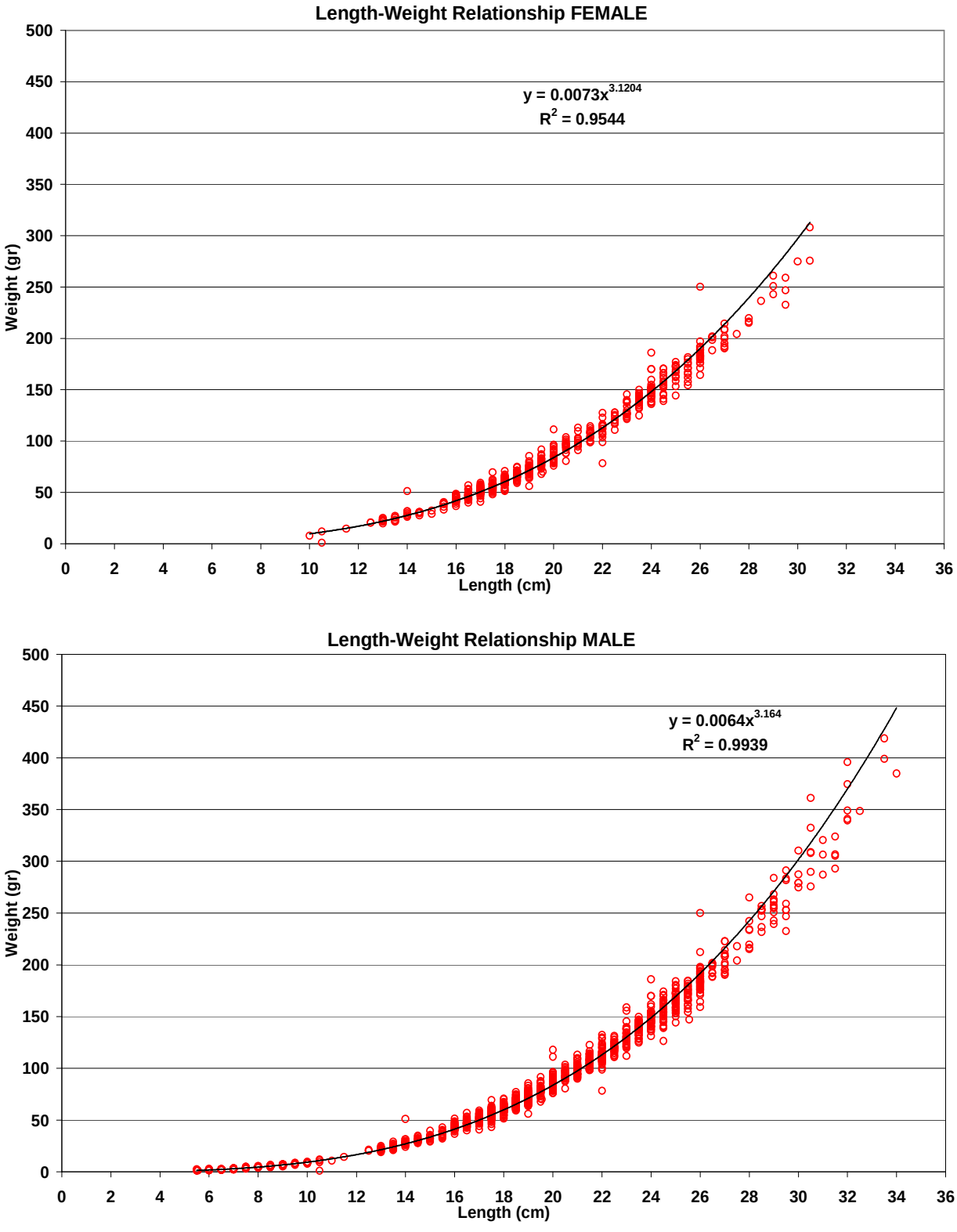


FIGURE 4.7 - Length-weight relationship of the total population, female and male sampled

5. - DISCUSSION

The study on demographic structure of *Boops boops* off Gran Canaria showed a polimodal distribution with a high percentage of immature. The high number of indeterminate individual is due to a sampling distortion, due to the fact that in June catch of bogue was composed mainly from small individuals (LT <10 cm) used as baits for fishing tuna; the macroscopic sex detection was very difficult because gonads were not developed. Medium and large size indeterminate individuals are exclusively due to the gonads degradation. In general, previous studies have analyzed demographic structure of bogue population from different localities and results showed a similar length frequency distribution (TAB 5.1).

The predominance of females at smaller sizes and the high number of males at largest sizes indicated that the bogue could be displays protogynous hermaphroditism. Hermaphroditism in bogue has been found by D'Ancona (1949), Reinboth (1962) and Gordo (1995): they considered this species as a rudimentary hermaphrodite; another authos like Lissia-Frau (1966a; 1968; 1976) consider that the bogue as a protogynous hermaphrodite and that only a minority has a direct development toward males or females from bisexual initial state. Related with this, the proportion of the sexes, as the size at first maturity too, is a intrinsic biological species parameter, whose variations are often due to effects environment, not least due to fishing effort. These two parameters contribute to maintaining, within certain limits, the reproductive ability of the species and its continuity through the diversity of adaptation mechanisms and of the responses to the variability of environmental conditions.

The monthly distribution of the different sexual maturity stages for *Boops boops* revealed that this species is a total spawning: it has a long spawning season extending from January to May, with maximum peaks during February and March. From June to September, the specimens studied were all at non-mature stages, (e.g. recovering stages). However, in June, all fish were in immature stage because all the samples analyzed were individuals less than 11 cm. In February, the majority of the fish were mature (stage 3), and the resting stage begins to appear after March.

In the present study, the monthly distribution of gonadosomatic index values indicated that its values were elevated in January and February (i.e. during the spawning season). The maximum values were attained in February for both sexes (3.20 for females and 3.29 for males).

The spawning season of bogue in the Canary Islands water is almost coincident with those reported for this species in other close areas, althoug it seems to be very variable probably due to the effect of local environmental characteristics. In this way, Moneium (1978), in Libanon waters, mentioned that the spawning season of *Boops boops* extended from February to April, Anato & Ktari (1983), in their study of this species in Tunisian coasts found that the spawning period started from January and ends in June. Hassan (1990), study this species in the Egyptian water and determine that spawning season start in February and end in April. However, Girardin (1981), in the Gulf of Lion, reported that it was from March to June.. These results showed that the present preliminary results in this work are within the limits for the spawning season given by other authors. However, the onset of the sexual maturity varies within the same species under different ecological conditions. Kashiwagi *et al*., (1987) reported that the differences in the spawning season may reflect different temperature regimes or feeding dominance among the areas.

The reproductive process is initiated when the water temperature increases from its lowest values (17ºC, February) to its highest (20-21ºC, June). A prolonged spawning period suggests the existence of favorable environmental conditions for spawning and the development of the larvae

The size at first maturity determined was 16.6 cm TL for males and 17.9 cm TL for females. Other studies showed that size at first maturity range between 13.2 cm LT (in Gulf of Lion (Girardin, 1978), in Libanon waters (Moneium, 1978) and Adriatic Sea (Alegría-Hernández, 1990) and 15.7 cm LT in Portuguese waters (Monteiro *et al.*, 2006).

Boops boops reaches maturity at a large size -approximately 50% of its maximum size as observed- which is characteristic of specialist species.

The determination of the length at first sexual maturity is not just a fundamental parameter to understanding biology of this species, but is also an important parameter for a correct exploitation of fishery resource. A proper resource management, in fact, is achieved when the specimens captured were spawned at least once. This fact determines an important implication on the identification of the minimum sizes and on gear selectivity.

The protogynous hemaphroditism described for the species results in an imbalance towards females, with males less abundant and restricted to those of older age and larger size. This inequality in distribution produces, as a result, differentiated death-rates due to fishing between the sexes (Alonzo *et al.*, 2008).

The weight relative growth with respect to the length showed a positive allometry with a weight growth proportionally greater than length, which determines a morphology change of fish throughout its life.

According to Hile (1936) and Martin (1949) the value of 'b' usually remains constant at 3 for an ideal fish. However, Beverton and Holt (1957) suggested the departure of the 'b' value from 3 is rare in adult fishes. In the present study the males and females showed significant deviations from the ideal value (3.1632 and 3.1204). Similar results can be observed in studies from different localities (TAB. 5.1). The parameter b of the fishes studied in other localities ranged from a minimum of 2.812 to a maximum of 3.130. According to Pauly and Gayanilo (1997), b values may range from 2.500 to 3.500.

The parameters are affected by a series of factors including season, habitat, gonad maturity, sex, diet, stomach fullness, health and preservation techniques (Tesch, 1971; Bagenal & Tesch, 1978; Hossain *et al*., 2006).

In this study, efficient sampling was carried out to include the widest possible range of lengths: the least minimum fish TL of 4.0 cm recorded in the samples is due to the selectivity of the mesh size of net used in June (10mm).

TABLE 5.1 - Length-weight relationships of *Boops boops* from different localities.

AUTHOR(S)	AREA	SEX	LENGTH RANGE (cm)	a	b
Mennes, 1995	Western Sahara, Morocco	unsexed		0.0145	3.000
Alegria-Hernández, 1989	Central Adriatic Sea	female	13.50-23.00	0.0056	3.088
		male	18.80-22.30	0.0087	3.000
Diabali *et al*, 1993	Bou-Ismail, Algeria	unsexed		0.0097	3.000
Merella *et al*., 1997	Balearic Island, Spain	unsexed	12.40-26.60	0.0082	3.000
Abdallah, 2002	Alexandria, Egypt	unsexed	3.70-14.60	0.0070	3.130
Valle *et al*., 2003	East Coast, Spain	unsexed	9.70-16.60	0.0161	2.812

6. - REFERENCES

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CURRICULUM VITAE

ANDREA MASSARO

EDUCATION AND TRAINING

• Dates (from – to)	September 2011 - onward
• Name and type of organisation providing education and training	Univesitad Las Palmas de Gran Canaria **PhD student "Sustainable Management of Fisheries Resources"** Project: Biology, ecology and population dynamics of an exploited seabream, *Boops boops* (Linneo, 1758), in Gran Canaria
• Dates (from – to)	September 2008 - October 2010
• Name and type of organisation providing education and training	Università di Pisa
• Title of qualification awarded	**Master degree cum laude (with honour) in Marine Biology**
• Principal subjects/occupational skills covered	Marine ecology, zoology, physiology, oceanography, fishery biology, biostatistics, genetics.
• Thesis	"Population dynamics of hake, *Merluccius merluccius*, in the Northwest Mediterranean"
• Dates (from – to)	September 2004 - April 2008
• Name and type of organisation providing education and training	Università degli Studi di Milano - Bicocca
• Title of qualification awarded	**Bachelor degree with honours in Biology**
• Principal subjects/occupational skills covered	Chemistry, microbiology, human anatomy, human physiology, ecology, zoology, statistics, genetics, botany.
• Thesis	"Morphology and morphometry of three species of diplectanids (Monogenoidea:Monopisthocotylea) parasites of *Diplodus vulgaris*"
• Dates	September 2002 - June 2003
• Name and type of organisation providing education and training	C.P.F. Vigorelli - Milan
• Title of qualification awarded	**Certification of merit with honours in " Water Depuration Techniques"**

• Dates	September 1997 – September 2002
• Name and type of organisation providing education and training	I.T.C.S "A. Greppi" - Monticello B.za -LC-
• Title of qualification awarded	**Chemical high school qualification**

WORK EXPERIENCE

• Dates (from – to)	January 2010 – September 2011
• Name and address of employer	**CIBM - Livorno**
• Type of business or sector	Marine Institute Research
• Occupation or position held	Fishery biologist, field and laboratory assistant
• Main activities and responsibilities	- Fishery studies, bottom trawl surveys (MEDITS), age and growth studies, population dynamics, stock assessment, set nets selectivity, bottom trawl net selectivity, impact of fishing gears, statistics on landing and discard data;

• Dates (from – to)	May 2010 – September 2011
• Name and address of employer	**Acquario di Livorno**
• Type of business or sector	Aquarium
• Occupation or position held	Tourist Guide
• Main activities and responsibilities	Tourist Guide

• Dates (from – to)	May 2009
• Name and address of employer	**Hydra Institute for Marine Science, Island of Elba, Italy**
• Type of business or sector	Marine Institute Research
• Occupation or position held	Internship
• Main activities and responsibilities	- Fish identification and capture during diving activities; - Laboratory activities on plankton morphology and ecology; - Evolution, systematic, and taxonomy of the Mediterranean fauna; - Functional morphology and special adaptations; - Ecology of marine fauna: defense, nutrition, sensory systems and reproduction; - The way of living of the organisms in their natural environment - Larval development of selected groups.

• Dates (from – to)	May 2007
• Name and address of employer	**Training Center of the Egyptian Environmental Affairs Agency** Sharm El Sheikh - Egypt
• Type of business or sector	Tropical Marine Biology
• Occupation or position held	Internship
• Main activities and responsibilities	- Attendance of marine biology; - Coral reef ecology and biodiversity; - Human impact on reef; - Zoology workshops.

• Dates (from – to)	April 2003 – September 2004
• Name and address of employer	**Ambiente Energia Brianza**
• Type of business or sector	Drinking water laboratory
• Occupation or position held	Laboratory technician
• Main activities and responsibilities	Chemical (HPLC, GM, GS) and microbiological analysis

• Dates (from – to)	April 2003 – September 2004
• Name and address of employer	**S.I.R.**
• Type of business or sector	Chemical industry
• Occupation or position held	Laboratory technician
• Main activities and responsibilities	Quality control on raw material

PARTECIPATION IN RESEARCH PROJECTS

Involved in research projects funded by the European Commission and Italian Ministries;
Involved in the MEDITS (2010/2011/2012) trawl survey, and in the activities of the Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy (Council Regulation (EC) n. 1543/2000, n. 1639/2001, n. 199/2008).

• Project Title: **MEDITS 2012 (Mediterranean Trawl Survey) - DCF (EU Reg 199/2008)**

• Funded by: **EU DG MARE - Italian Ministry of Agricoltura and Food MIPAAF**

• Participants: **CIBM, Univesità di Genova, Università di Roma, Livorno Arpat**

• Duration: from June 2012 to: July 2012

• Amount of grant: 285,000 Euros

• Research Head: **Prof. Stefano Ranieri**

• Number of researchers: **25**

• Project Title: **MEDITS 2011 (Mediterranean Trawl Survey) - DCF (EU Reg 199/2008)**

• Funded by: **EU DG MARE - Italian Ministry of Agricoltura and Food MIPAAF**

• Participants: **CIBM, Univesità di Genova, Università di Roma, Livorno Arpat**

• Duration: from may 2011 to: July 2011

• Amount of grant: 235,000 Euros

• Research Head: **Prof. Stefano Ranieri**

• Number of researchers: **25**

• Project Title: **CAMPBIOL 2011 - DCF (EU Reg 199/2008)**
• Funded by: **EU DG MARE - Italian Ministry of Agricoltura and Food MIPAAF**
• Participants: **CIBM, Univesità di Genova, Università di Roma, Livorno Arpat**
• Duration: from January 2011 to September 2011
• Amount of grant: 420,000 Euros
• Research Head: **Prof. Stefano Ranieri**
• Number of researchers: **22**

• Project Title: **MEDITS 2010 (Mediterranean Trawl Survey) - DCF (EU Reg 199/2008)**
• Funded by: **EU DG MARE - Italian Ministry of Agricoltura and Food MIPAAF**
• Participants: **CIBM, Univesità di Genova, Università di Roma, Livorno Arpat**
• Duration: from May 2010 to: July 2010
• Amount of grant: 220,000 Euros
• Research Head: **Prof. Stefano Ranieri**
• Number of researchers: **25**

• Project Title: **CAMPBIOL 2010 - DCF (EU Reg 199/2008)**
• Funded by: **EU DG MARE - Italian Ministry of Agricoltura and Food MIPAAF**
• Participants: **CIBM, Univesità di Genova, Università di Roma, Livorno Arpat**
• Duration: from January 2010 to December 2010
• Amount of grant: 390,000 Euros
• Research Head: **Prof. Stefano Ranieri**
• Number of researchers: **22**

PUBLICATIONS

Massaro A., 2010. Population dynamics of hake, *Merluccius merluccius*, in the Northwest Mediterranean. *Master Degree Thesis*, 135 pp

Massaro A., 2008. Morphology and morphometry of three species of diplectanids (Monogenoidea:Monopisthocotylea) parasites of *Diplodus vulgaris*. *Bachelor Degree Thesis*, 56 pp.