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GONADAL DEVELOPMENT OF BOGUES, *BOOPS BOOPS* (LINNAEUS, 1758), FROM ORAN BAY (TELEOSTEI, SPARIDAE)

Fatiha DALOUCHE, Lotfi BENSAHLA-TALET, Sidi Mohamed El Amine ABI AYAD & Ahmed BENSAHLA-TALET
Laboratoire Aquaculture et Bioremediation (*AquaBior*). University Oran1 Ahmed Benbella. Faculty of Natural Sciences and Life. Department of Biology. Oran-Algeria
e-mail: btlotfi1977@gmail.com

ABSTRACT

Our study aims to investigate the reproductive cycle of Boops boops *caught in Oran Bay. The samples were received monthly from commercial catches of coastal trawlers operating in this area from January 2016 to December 2017. The overall sex ratio was in favor of females and the length frequency distribution according to sex revealed that females were predominant beyond 14 cm of total length, presuming the beginning of the sexual inversion already described for this Sparidae species. The spawning period was established based on the follow-up of the gonado-somatic index, and appeared to last from February to late June with a peak in the March-April period. Our findings can contribute to a better understanding of the reproductive cycle of this species and help adopt measures toward a more adequate stock management of the most abundant sparid that is landed daily in many Mediterranean and Algerian fisheries.*

Key words: *Boops boops*, reproductive cycle, spawning season, size at first maturity, Oran, Algeria

SVILUPPO GONADALE DELLA BOGA, *BOOPS BOOPS* (LINNAEUS, 1758) NELLA BAIA DI ORANO (TELEOSTEI, SPARIDAE)

SINTESI

Lo studio si propone di indagare il ciclo riproduttivo degli esemplari di Boops boops *catturati nella baia di Orano. I campioni mensili provenivano dalle catture commerciali dei pescherecci costieri operanti in quest'area, da gennaio 2016 a dicembre 2017. Il rapporto tra i sessi è risultato a favore delle femmine e la distribuzione della frequenza della lunghezza in base al sesso ha rivelato che le femmine erano predominanti oltre i 14 cm di lunghezza totale, presumendo l'inizio dell'inversione sessuale già descritta per questa specie di sparidi. Il periodo di riproduzione è stato stabilito sulla base del follow-up dell'indice gonado-somatico e sembra durare da febbraio a fine giugno, con un picco nel periodo marzo-aprile. Tali risultati possono contribuire a una migliore comprensione del ciclo riproduttivo di questa specie e aiutare ad adottare misure per una gestione più adeguata dello stock dello sparide più abbondante, che viene sbarcato quotidianamente in molte zone di pesca del Mediterraneo e dell'Algeria.*

Parole chiave: *Boops boops*, ciclo riproduttivo, stagione di deposizione delle uova, taglia alla prima maturità, Orano, Algeria

INTRODUCTION

The bogue is a widespread species in the eastern Atlantic, found from Norway to Angola, including the Canary, Cape Verde, and Sao Tome-Principe Islands. It is common between the Bay of Biscay and Gibraltar, and in the Mediterranean and Black Seas (Bauchot & Hureau, 1986). This sparid can be found in the shelf or coastal pelagic zone on various bottoms (sand, mud, rocks and seaweeds). Gregarious and ascending to the surface mainly at night, the species is omnivorous, feeding mainly on crustaceans, as well as planktonophagous (Frimodt, 1995).

In Algeria, the Sparidae family is of high commercial importance, with the bogue representing ~ 20 % of all demersal fish landed and 45 % of all sparid catches (D.P.R.H, 2016). *B. boops* is a demersal and semi-pelagic species typifying the daily landed fish in Oran Bay. It moves in aggregations, ascending to the surface mainly at night (Campillo,1992); in Oran Bay it is fished at depths ranging between 100 and 250 m (*pers. obs.*) and captured by line gear, with bottom trawls and purse seines.

There is some published data on the biology of this species, focusing mainly on the weight-length relationship (Gonçalves *et al.,* 1997; Moutopoulos & Stergiou *et al.,* 2002; Özaydin & Taskavak, 2006; Kara & Bayhan, 2008; Karachle & Stergiou, 2008; Crec'hriou *et al.,* 2013; Özvarol, 2014; Crec'hriou *et al.,* 2015), fishing gear selectivity (Ayaz *et al.,* 2009; Cengiz *et al.,* 2013; Kumova *et al.,* 2015; Eryaşar, 2017; Ilkyaz *et al.,* 2017), feeding habits (Sánchez-Velasco & Norbis, 1997; El-Maremie & El-Mor, 2015), and biology and population dynamics (Anato & Ktari, 1983; Alegria Hernandez, 1989; Gordo, 1996; Allam, 2003; Khemiri *et al.,* 2005; Manaşirli *et al.,* 2006; Monteiro *et al.,* 2006; El-Okda, 2008; Kara & Bayhan, 2008).

Several biological studies on its reproductive cycle have also been conducted (Frau, 1966; Gordo 1995,1996; Cano Fortuna & Lizaso, 1996; El-Agamy *et al.,* 2004; Monteiro *et al.,* 2006; Kasalica *et al.,* 2011; Bottari *et al.,* 2014; Layachi *et al.,* 2015; Taylan & Bayhan, 2015; Mobilia *et al.,* 2016; Dobroslavić *et al.,* 2017), but in relation to Algerian waters, the works are limited to Derbal & Kara, 2008 on feeding habits; Boubaiou, 2014 (morphometrics); Benina, 2015; Kherraz *et al.,* 2016 (population dynamics), Ider *et al.,* 2017 (otolithometry), and only works of Chali-Chabane (1988) in Algiers Bay, and Bensahla-Talet *et al.* (1990) and Kherraz (2011) in Oran Bay dealt with the reproductive cycle of this species. Therefore, the present study aims to estimate more precisely the reproduction parameters of this species to help comparative studies in the Mediterranean and propose measures to allow a renewal of the resources and improved management.

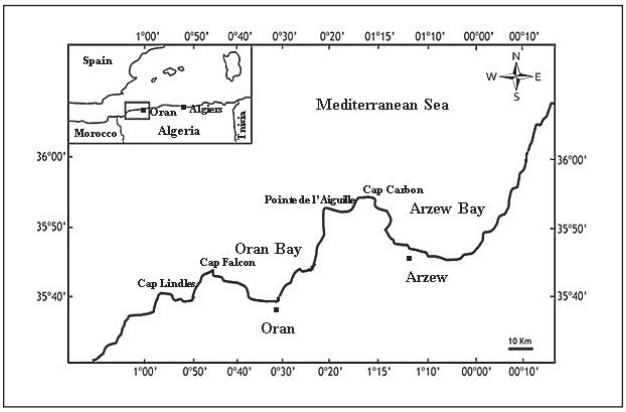

Fig. 1: Map of the study area (Oran Bay).
Sl. 1: Zemljevid obravnavanega območja (Oranski zaliv).

MATERIAL AND METHODS

Specimens of *B. boops* (n=7153; 3317 in 2016, and 3836 in 2017) were caught by trawlers operating in Oran Bay, located in northwestern Algerian coast (western Mediterranean Sea), between Pointe de l'Aiguille and Cape Falcon (35.95 °N-0.65 °E) (Fig. 1) at depths ranging between 100 and 250 m between January 2016 and December 2017. Samples were randomly collected from daily landed fish at the Oran fishery.

At the laboratory, total length (TL), measured to the nearest millimeter with an ichthyometer (± 1 mm), total weight (TW), and gonad weight (GW), using a digital precision balance (± 0.01 g), were recorded for each individual.

Sex ratio

The sex ratio was calculated monthly throughout the study period according to individual sizes (1 cm class interval) and seasons using the formula below, while sexually indeterminate and immature individuals were not taken into account:

$$SR = \frac{nF}{nM+nF} \times 100$$

where:
nF = number of females,
nM = number of males.

To detect statistically significant deviations from the expected 1:1 ratio, the chi-square (χ^2, $P < 0.05$) test was used (Sokal & Rohlf, 1987).

Spawning period

For the description of the sexual cycle of *B. boops* several approaches were used:

Tab. 1: Sexual maturity scale (macro- and microscopic) of the Sparidae modified and used in this study to classify** B. boops **gonads, with a focus on female gonads (Bensahla-Talet** et al.**, 2017).
Tab. 1: Spolna zrelost (makro- in mikroskopska) predstavnikov iz družine Sparidae, prirejena za potrebe te študije za opredelitev gonad vrste** B. boops**, s posebnim poudarkom na samičjih gonadah (Bensahla-Talet** et al.**, 2017).

	Level name	Macroscopic	Microscopic
I	**Immature**	Very small and translucent ovaries. Very small testes; no signs of development.	Oocytes are small arranged on ovigerous lamellae. The nucleus is relatively clear.
II	**Resting**	Ovaries in recovering condition; Testes in recovering condition.	Oocytes are small spherical (about 60 µm), no vitellus is found in their cytoplasm. The nucleus is relatively dense and large with a NPR at its maximum attaining 0.6.
III	**Vitellogenesis (Maturing)**	Larger ovaries and eggs visible. Larger testes, not running.	Vitellogensis initiate characterized by massive entry of small vitelline and lipidic vesicles. Zona radiata begin to thicken and appearance of granulosa formed of single cell layer.
IV	**Ripening and Spawning**	Large transparent eggs that are released under moderate pressure. Sperm released by a light press on the abdomen.	Oocytes attainted their maximal size (~500 µm). The nucleus migrates to the animal pole. The follicle includes a thick zona radiata. The cytoplasm is overload with vitellus and lipid vesicles conferring to the egg a hyaline aspect.
V	**Post spawning**	Ovaries shrunken with few residual eggs, much slime and often redish. Testes small, slack testes and often redish; resting condition.	Many atretic follicles are encountered corresponding to oocytes that have not attained their maturation or mature ones that were not emitted and which will degenerate. The cytoplasm is disorganized and cells undergo pycnosis.

1 - The maturation scale was established following the Holden & Raitt (1974) macroscopic scale, while microscopic description was based on the Aboussouan & Lahaye (1979) scale with a slight modification to fit *B. boops* gonad development (Tab. 1). Both are based on the macroscopic aspect, relative dimensions and microscopic characteristics of the gonads (I: immature, II: resting, III: ripe, IV: ripe and running, V: spent).

2 - Between 10 and 30 specimens of *B. boops* were selected each month for histological examination of the sexual organs, which were placed in Bouin's fixative solution for 48 h, dehydration was carried out by increasing concentrations of acetone/toluene, then fragments were embedded in paraffin wax. Gonads were sectioned with a microtome into 5-6 µm sections and stained with hematoxylin-eosin.

3 - Monthly evolution of the gonado-somatic (GSI) index was calculated as follows:

$$GSI = \frac{GW}{TW} \times 100$$

where:
GSI = gonado-somatic index,
GW = gonad weight (g),
TW = total weight (g).

The nucleoplasmic ratio is considered to be closely related to the mitotic cellular cycle and to the functional phase of cells. It is also a good indicator of dynamic changes in cells (Bensahla-Talet *et al.*, 2017). The nucleoplasmic ratio (NPR) is expressed mathematically as:

$$NPR = \frac{Nd}{Cd - Nd}$$

where:
Nd = nucleus diameter,
Cd = total cell diameter.

Size at first sexual maturity

Size at first sexual maturity (L_m) was defined as the size class at which 50 % of the individuals are mature. Specimens were grouped into 1 cm size classes, and the proportion of mature and immature individuals was recorded. The total length at which 50 % of the specimens were mature was estimated by a logistic non-linear least-squares regression (King, 1995):

$$P = 1 / [1 + e^{-a(L - L_m)}]$$

where:
P = percentage of mature individuals,
a = slope of the curve or rate of increase in maturity,
L_m = length at 50 % maturity,
L = 1 cm length class.

RESULTS

In total, 3317 specimens of *B. boops* were collected in 2016, 1319 of which were males (39.76 %)

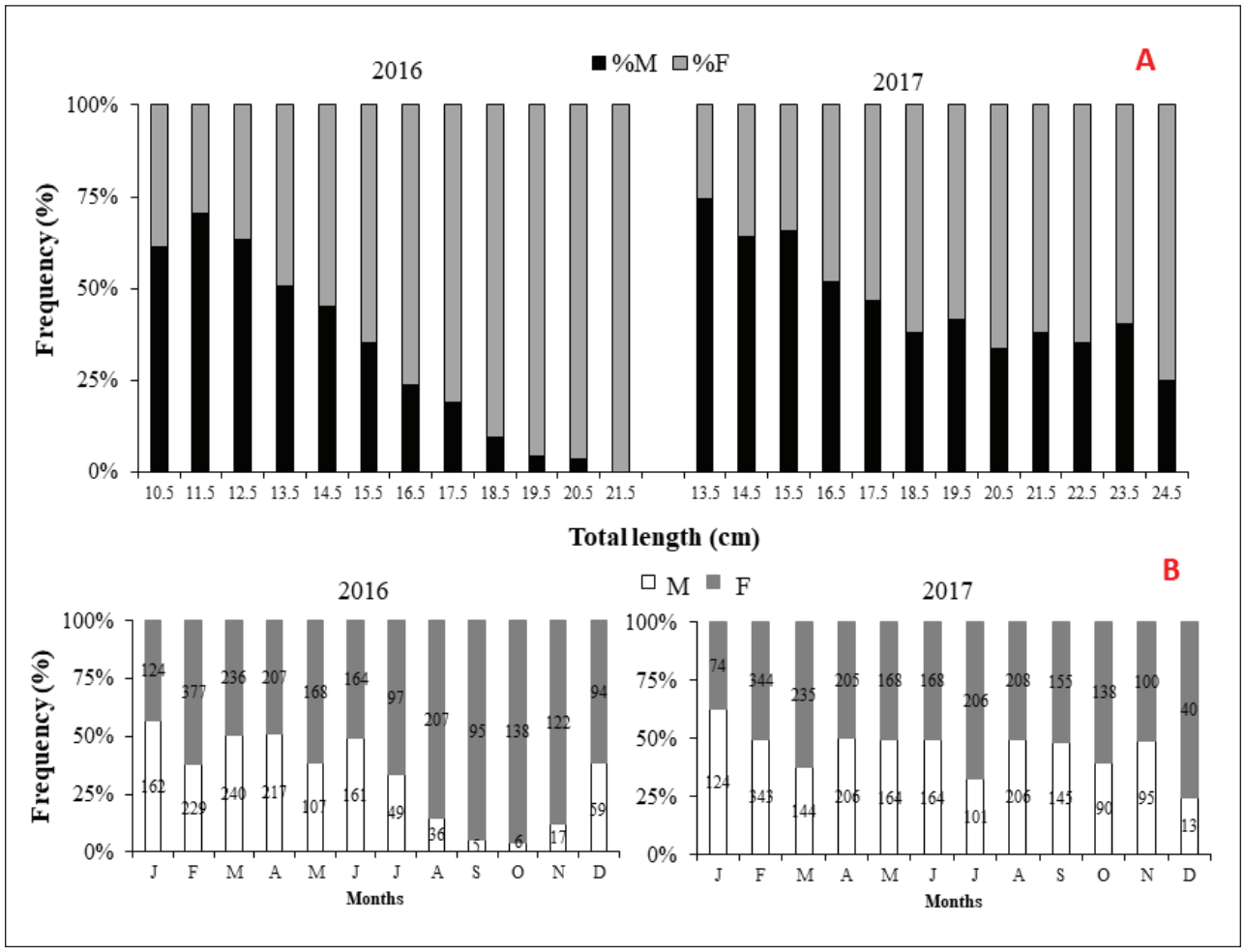

Fig. 2: A. Length frequency distribution of males and females of** B. boops **caught in Oran Bay. B. Monthly length frequency distribution of males and females of** B. boops **caught in Oran Bay.
Sl. 2: A. Frekvenčna porazdelitev velikosti samcev in samic bukve** (B. boops)**, ujete v Oranskem zalivu. B. Frekvenčna porazdelitev velikosti samcev in samic bukve** (B. boops) **po različnih mesecih, ujetih v Oranskem zalivu.

and 1998 were females (60.23 %), while in 2017, 3836 specimens were collected, 1798 males (46.87 %) and 2038 females (53.12 %). The length frequency distribution of the entire population is shown in Fig. 2a, b; the male length range was between 10 and 22.9 cm, the female between 12 and 24.9 cm.

The overall female-male ratio was in favor of females (F:M 1:1.51 in 2016 and F:M 1:1.13 in 2017) and was significantly different from the 1:1 ratio ($\chi 2$=138.99 and $\chi 2$ = 15.02 respectively > $\chi^2_{t\ 1,0.05\ =\ 3.84}$). Sex ratios between males and females by size class were also significantly different from the 1:1 ratio ($\chi^2_{observed} > \chi^2_{t\ 1,\ 0.05\ =\ 3.84}$) for most size classes, the difference was significant beyond the 14 cm length class in 2016, while in 2017, this difference was distinguished beyond the 17 cm of total length, where females predominated. Males predominated in smaller size classes and females in larger ones (Fig. 2).

Maturity stages

Females with ripe gonads (stage III) and those with ripe and running gonads (stage IV) were observed (Fig. 3) in early winter and were dominant in the March-July period, thus highlighting the spawning period of *B. boops* in Oran Bay. Spent fish (stage V) were recorded from June to November with a maximum in August, while the remaining period of the year gonads in stage II were dominant, marking the sexual rest period of this Sparidae species.

Nucleoplasmic ratio (NPR)

The variation of the nucleoplasmic ratio according to maturity stages is presented in Fig. 3b, reflecting the changes that affect the oocytes. It appears that high values of this ratio are encountered in early oogenesis

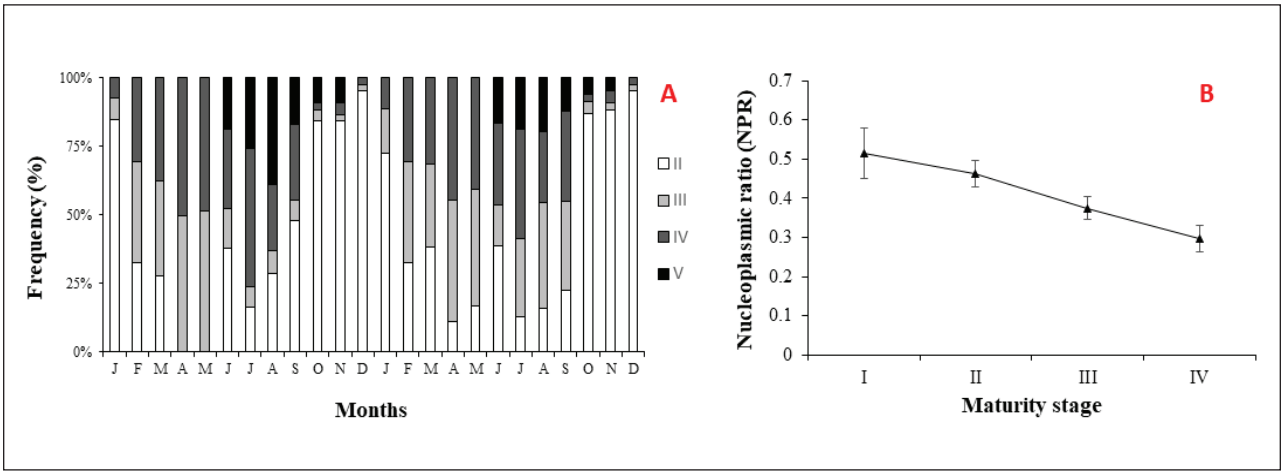

Fig. 3: A. Maturity stages of** B. boops **females caught in Oran Bay (II: resting, III: maturing, IV: ripe and running, V: spent). B. Variation of the nucleoplasmic ratio (NPR) in relation to maturity stages of** B. boops **females.
Sl. 3: A. Zrelostni stadiji samic bukev** (B. boops) **ujetih v Oranskem zalivu (II: počivajoči stadiji, III: dozorevajoči, IV: zreli, V: dokončani). B. Variacije v nukleoplazmičnem deležu (NPR) v odnosu na zrelostne stadije samic bukve** (B. boops)**.

stages, attaining 0.51, and as the oocyte develops, this ratio tends to decrease, attaining its lowest value of 0.29 in stage IV, when the oocytes are ready to be emitted.

Microscopic analysis

As with the majority of teleost fish and especially sparids, the microscopic analysis of the gonads allowed us to describe the following stages in *B. boops*:

Ovaries

Immature period

The oogonia representing the reserve batch are small round cells with a clear nucleus (Fig. 4a), varying in size between 36 and 169 µm, and the NPR is at its maximum value of 0.51.

Resting period

At this stage (Fig. 4b) the oocytes are spherical (169-260 µm), some of them have already began their first cellular division and the cells are arranged as ovarian lamellae with a homogenous and transparent cytoplasm, having numerous nucleoli mixed to a large nucleus containing dense chromatin, the NPR is at 0.46.

Maturing period

Previtellogenesis

Oogonia undergo progressive increase in size reaching 205-390 µm (Fig. 4c, d) with an average NPR of 0.37. The maturation period is mainly characterized by:

A- A clear central nucleus containing some supernumerary nucleoli distributed at the periphery.

B- Thousands of cortical alveoli appearing to mark the beginning of the endogenous lipidic vitellogenesis.

C- The granulosa and zona radiata becoming visible.

The vitellogenesis period (pre-spawning)

A rapid increase in the size of the oocytes is observed at this stage (416 µm), resulting from an intense entry of the protein yolk, also the vitelline globules are rounded and colored red with a mean diameter of 9.5 µm marking the exogenous vitellogenesis (Fig. 4e, f).

Lipid (colorless) inclusions move massively around the nucleus (Fig. 4g, h) forming a central vacuole. The central cytoplasmic zone is filled and repels the cytoplasm at the periphery. The NPR decreases to 0.38.

The oocyte membrane is enveloped by a protective thick membrane, zona radiata, measuring 10.16 µm. The whole is enveloped by the granulosa, formed by one layer of ovarian cells, and the fibrous theca (Fig. 4i).

Ripening and spawning period

The nucleus moves to the animal pole to initiate the first meiotic division (Fig. 4j). Egg release is imminent, cytoplasmic structures merge and give the mature egg a translucent appearance, hence the name hyaline oocyte (Fig. 4k, l); their diameter is max 500 µm (390-542 µm) with an average NPR of 0.29.

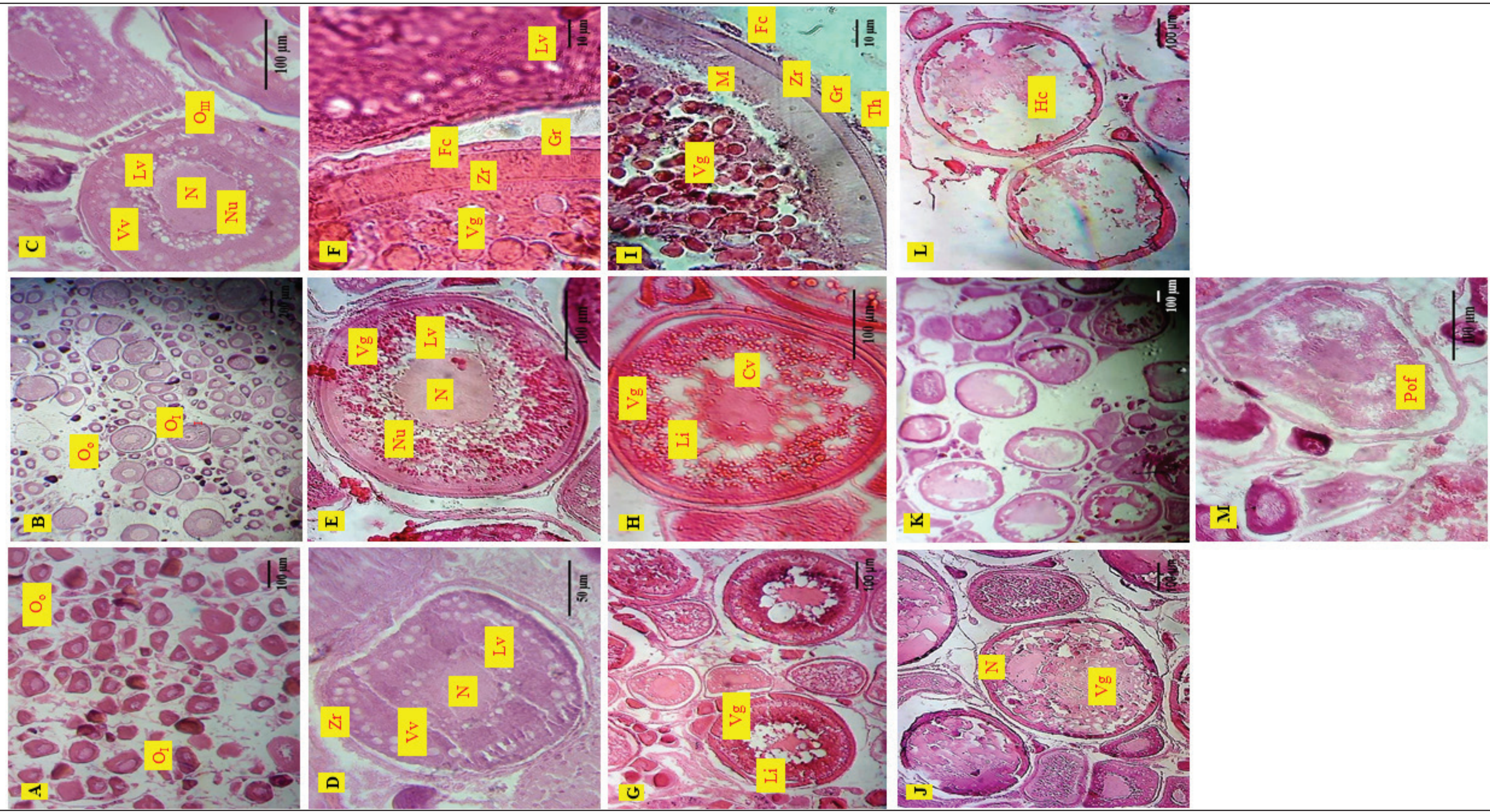

Fig. 4: Ovarian histological slides of B. boops female gonads (a-m) stained by hematoxylin-eosin: (a) general view of an immature ovary × 100; (b) resting ovary with: advanced peri nucleolar oocytes (OII), a large nucleus and homogenous cytoplasm × 40; (c) previtellogenic ovogonia (OIII) presenting a large nucleus surrounded by several lipoprotein vesicles × 250; (d) previtellogenic oogonia (OIII) × 400; (e) early maturing large oocytes with large translucent vitelline vesicles and a thin zona radiata (OIII) × 250; (f) OIII with a thick zona radiata and apparition of granulosa × 1000; (g) hydrated large oocytes (mature) OIV with numerous vitelline globules and important lipid inclusions forming a central vacuole × 100; (h) hydrated large oocytes (mature) × 250; (i) mature oocyte with a thick zona radiata, granulosa and fibrous theca × 1000; (j) hyaline oocyte with nucleus in the animal pole × 100; (k) general view of ovary in spawning phase x 40; (l) hyaline oocyte ready to be released ×100; (m) post-ovulatory follicle × 250. Fc: follicular cells; Gr: granulosa; Hc: hyaline cytoplasm; Li: lipid inclusion; Lv: lipid vesicle; M: oocyte membrane; N: nucleus; Nu: nucleoli; O: oocyte; Oo: oogonia; Vg: vitelline globules; Zr: zona radiata of chorion; Pof: post-ovulatory follicle; Th: theca; Vv: vitelline vesicule; Zr: zona radiata.

Sl. 4: Histološki rezi ovarija samic bukve (B. boops) (a-m), obarvani z hematoksilinom-eozinom: (a) pogled na nezrel ovarij × 100; (b) počivajoči ovarij z: razvitimi perinuklearnimi oocitami (OII), veliko jedro in homogeno citoplazmo × 40; (c) previteligenska ovogonia (OIII) z velikim jedrom, obdan s številnimi lipoproteinski vezikli × 250; (d) previteligenska ovogonia (OIII) × 400; (e) zgodnje dozorevajoče velike oocite z velikimi prozornimi vitelinskimi vezikli in tanko "zona radiata"(OIII) × 250; (f) OIII z debelo "zona radiata" in pojavom "granulosa" × 1000; (g) hidratirane velike oocite (zrele) OIV s številnimi vitelinskimi globuli in pomembni lipidni vključki, ki tvorijo centralno vakuolo × 100; (h) hidratirane velike oocite (zrele) × 250; (i) zrele oocite z debelima "zona radiata" in "granulosa" ter fibrozna teka × 1000; (j) hialina oocita z jedrom v animalnem polu × 100; (k) pogled na ovarij v fazi drstenja x 40; (l) hialina oocita tik pred sprostitvijo ×100; (m) post-ovulatorni folikel × 250. Fc: folikularne celice; Gr: granulosa; Hc: hialina citoplazma; Li: lipidni vključek; Lv: lipidni vezikel; M: membrane oocite; N: jedro; Nu: nukleoli; O: oocita; Oo: oogonija; Vg: vitelinski globuli; Zr: zona radiata pri horionu; Pof: post-ovulatorni folikel; Th: teka; Vv: vitelinski vezikel; Zr: zona radiata.

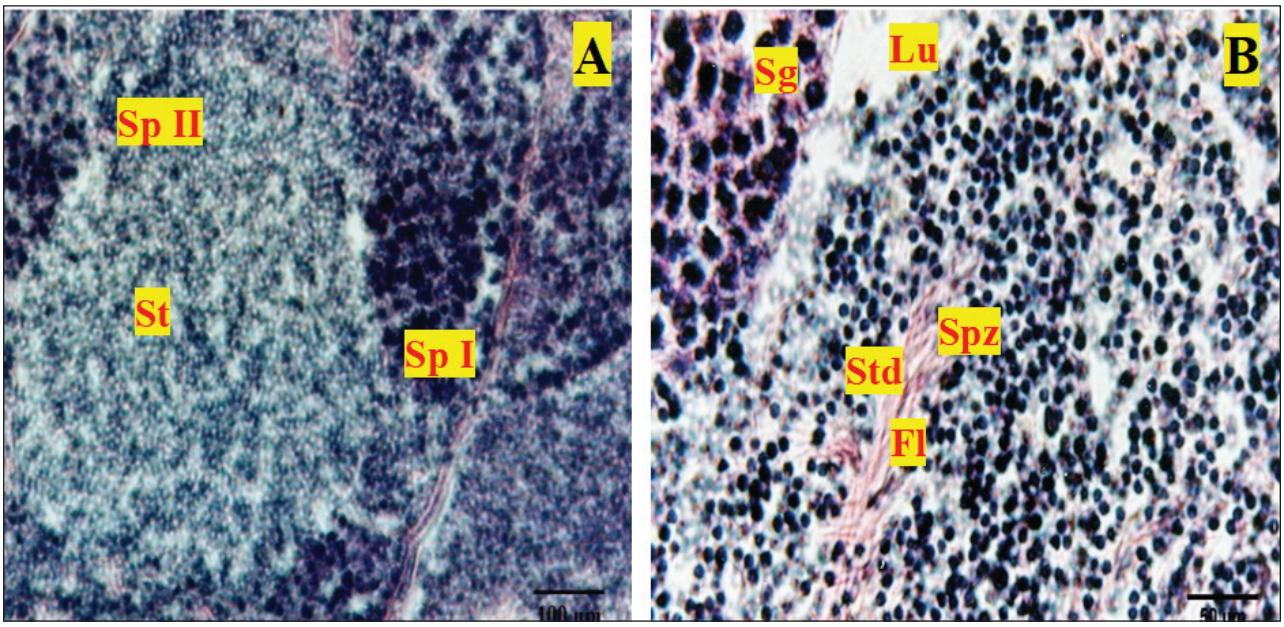

Fig. 5: Spermatogenetic stages; (a) seminiferous tubule with isogenic cysts at different stages of maturation × 100; (b): mature testicle showing seminiferous tubules with lumen full of spermatozoa with their flagella × 1000. Fl: flagella; Lu: central lumen; Sp I: spermatocyte I; Sp II: spermatocyte II; Spz: spermatozoa; Std: spermatids; St: seminiferous tubule.
Sl. 5: Stadiji spermatogeneze; (a) seminiferni tubuli z izogenimi cistami pri različnih zrelostnih stadijih × 100; (b): zreli testikli z vidnimi seminifornimi tubuli z lumnom, napolnjeni s semenčicami z bički × 1000. Fl: bički; Lu: centralni lumen; Sp I: spermatocita I; Sp II: spermatocita II; Spz: spermatozoj; Std: spermatide; St: seminiferni tubul.

Post spawning

In the ovary, a fraction of unemitted mature oocytes enter atresia marking the end of the spawning season; the nucleus enters pycnosis and the yolk disintegrates into a compact cluster; the cytoplasm becomes disorganized; remaining in the ovary is only the reserve oogonia that will be used during the next spawning season (Fig. 4m). At the end of the spawning period, the fish enters the resting phase and the ovary reverts to its initial appearance, which can be recognized by the presence of ovigerous lamellae (Fig. 4a, b).

Testes

With regard to the spermatogenesis in male gonads, the testes studied were mature at the same time as the ovaries. The testicles are formed of a multitude of oval ampoules separated by a connective tissue (Fig. 5). Seminiferous tubules are composed of isogenic cysts at different stages of maturation (Fig. 5a, b). At maturity, spermatids are transformed to spermatozoids, which move into the central lumen and from there into deferent ducts to be released via the genital opening.

Hermaphrodite gonads

B. boops exhibits a protogynous hermaphroditism already described (D'Ancona, 1949; Reinboth, 1962; Frau,1966; Girardin, 1981; Gordo, 1992; Massaro, 2012). During our sampling period, 90 individuals were hermaphrodites presenting the two sexes in the same gonad, the ovotestis. The histological analysis of ovotestis (Fig. 6) allowed us to examine germinal tissues for males and females, which co-exist (Fig. 6a, b, c). The female part is functional and represented by ovogonous cells and some oocytes I (O_I) arranged in ovigerous lamellae. The male part is not yet active and is made up of spermatogonia arranged in isogenic cysts at the beginning of spermatogenesis.

Sexual cycle and spawning period

To determine the reproductive period of *B. boops*, the gonado-somatic index (GSI) was used, which was calculated from samples taken monthly. The GSI value began to rise from January and remained high until May, with a peak in April (3.75 in 2016, and 3.66 in 2017). The GSI then decreased from June and remained low until November, confirming the sexual rest period (Fig. 7), which is in accordance with our macroscopic observation on maturity stages of *B. boops*.

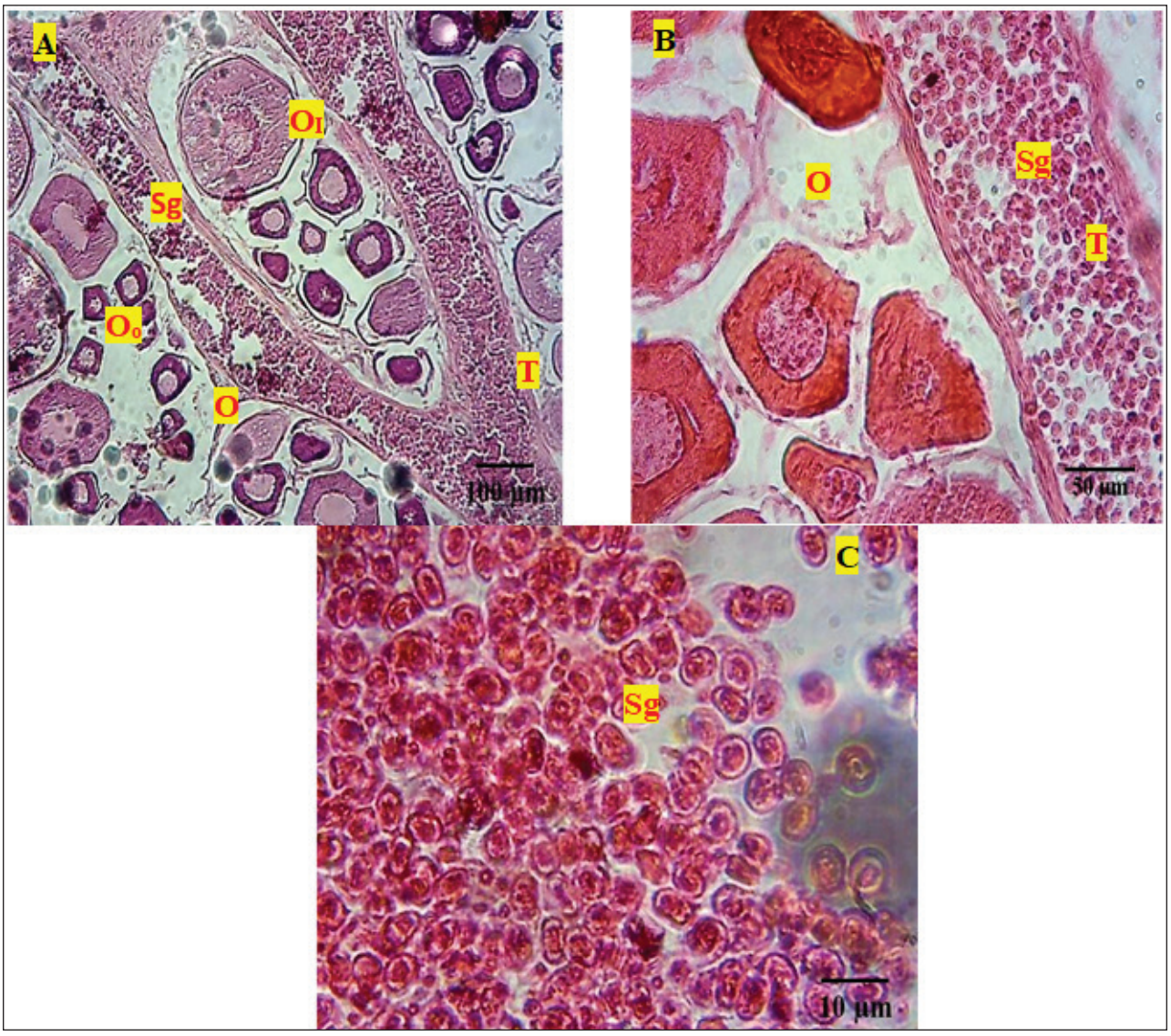

Fig. 6: Section of hermaphrodite gonad of** B. boops**; (a) section of ovotestis × 100; (b) section of hermaphrodite gonad showing a functioning female part and early development of a male part × 250; (c) spermatogonia × 1000. O: ovary; OI: oocyte I; Oo: oogonia; Sg: spermatogonia; T: testis.
Sl. 6: Sekcija hermafroditske gonade pri bukvi** (B. boops)**; (a) sekcija ovotestisa × 100; (b) sekcija hermafroditske gonade, ki kaže funkcionalni del samice in zgodnji razvoj moškega dela × 250; (c) spermatogonija × 1000. O: ovarij; OI: oocita I; Oo: oogonija; Sg: spermatogonija; T: testis.

Size at first sexual maturity

An analysis of shares of mature specimens (Fig. 8) showed that in Oran Bay, 50 % of *B. boops* females were mature at 14 cm of total length.

DISCUSSION

In Oran Bay, the overall female-male ratio was found in favor of females, an observation already made by Lamrini, 1998; Monteiro *et al.*, 2006; Kherraz, 2011; Kasalika *et al.*, 2012; and Dobroslavić *et al.*, 2017, while Bottari *et al.*, 2014 found this ratio equally distributed in the southern Tyrrhenian Sea.

The predominance of males in smaller length classes and females in larger classes is probably due to protogynic hermaphroditism already described for this species by D'Ancona, 1949; Reinboth, 1962; Frau, 1966; Gordo, 1995; Cano Fortuna & Sánchez Lizaso, 1996; Lamrini, 1998; Bottari *et al.*, 2014. Specimens are first female and became progressively male, which is characterized by the development of

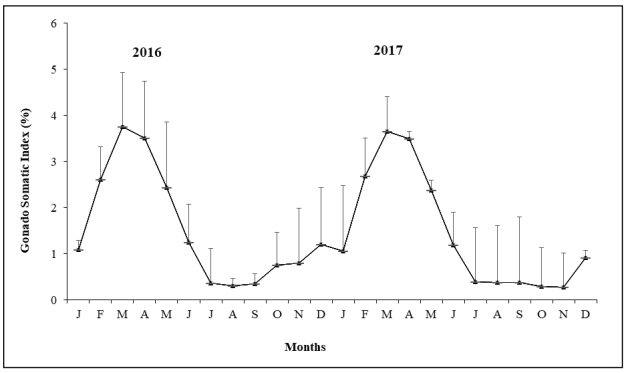

Fig. 7: Monthly changes in the gonado-somatic index of** B. boops **females caught in Oran Bay.
Sl. 7: Mesečne spremembe v gonadosomatičnem indeksu pri samicah bukve** (B. boops)**, ujete v Oranskem zalivu.

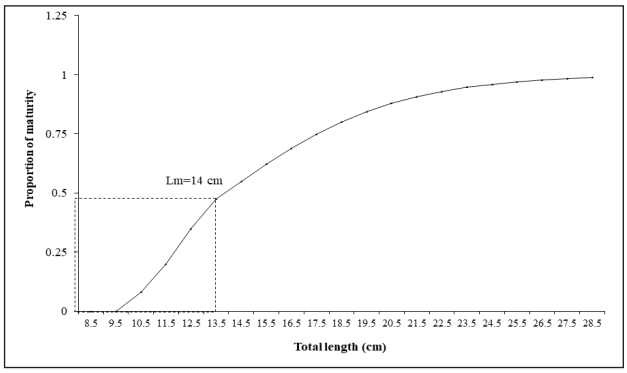

Fig. 8: Sexual maturity for females of** B. boops **caught in Oran Bay.
Sl. 8: Spolna zrelost pri samicah bukve** (B. boops)**, ujete v Oranskem zalivu.

female organs or maturation of their products before the appearance of the corresponding male product.

Evolution of the sex ratio in relation to length classes led us to establish that sexual inversion for this sparid occurs between 13 and 17 cm of total length, which is in accordance with observations made by other authors who studied the same species (Lamrini, 1998) (16 cm).

Investigation of the reproduction period of *B. boops* following a longitudinal evolution showed that (Tab. 2), generally, this species has one long spawning season that extends from January to July. Our findings in western Algerian coasts showed that the spawning period of this Sparidae species extends from January to July, peaking in spring period, which was already reported for this same bay by Bensahla-Talet *et al*. (1990), and Kherraz (2011), and for the Gulf of Annaba by Derbal & Kara (2008).

In central Algerian waters, this period seems to be shortened to 3 or 4 months, as reported for Algiers Bay (Chali-Chabane, 1988) and Bousmail Bay (Dieuzeide *et al*., 1955; Benina, 2015). The same finding was previously observed in the Gulf of Lion (Girardin, 1981), the Thyrrhenian Sea (Bottari *et al.,* 2014), in the Gulf of Tunis (Anato & Ktari, 1983), in Egyptian waters (Hassan, 1990), and in the Lebanese coasts (Mouneimne, 1978). The differences in the spawning period duration could be due to the inflow of Atlantic water through the Strait of Gibraltar, namely, regional differences in the time and duration of the spawning act of species in the Mediterranean basin can be related to biotic and abiotic factors, such as climate, hydro dynamism, temperatures, salinity, and food availability (Wootton, 1979; Pajuelo and Lorenzo, 2000; Mouine *et al.,* 2007; Tsikliras *et al.,* 2010). Gonçalves & Erzini, 2000, stated that the reproduction period is correspondingly much longer when environmental conditions are favorable. The upwellings and related zooplankton abundance can also affect many species reproduction (Parrish *et al*., 1981).

With regard to the length at first sexual maturity (Tab. 2) in Algerian waters, Derbal *et al*. (2007) found females to be mature at 13.5 cm; in Algiers Bay this length was reported at 13.5 cm (Chali-Chabane, 1988) and 14.6 cm (Benina, 2015), in Oran Bay between 12 and 14 cm, like in some other studies in the Mediterranean. Gordo (1995) and Monteiro *et al.*, (2006) reported that length to be between 13 and 15.22 cm in Portuguese waters, while in Spanish waters Cano Fortuna & Sanchez Lizaso (1996) found it equal to 10.2 cm. In Italian coasts, Bottari *et al*. (2014) recorded it at 13.8 cm. In the Adriatic (Kasalica *et al*., 2011) this size was reported to be 11.5 cm TL. In Tunisian waters, the first sexual maturity was reached, by most of the population, at sizes between 14 and 18 cm. In Egyptian and Lebanese waters, this maturity was attained at 13 cm.

Most studies found this length to be comprised between 12 and 14 cm in the Mediterranean, except Bounhiol & Pron (1916) and Kherraz (2011), while in Atlantic waters the bogue seems to reach maturity later, at 17 cm (Lamrini, 1998; Monteiro *et al*., 2006; Massaro, 2012), probably due to environmental conditions, which differ from one habitat to another.

Environmental factors, such as temperature, salinity and food (Gonçalves & Erzini, 2000; Moutopoulos & Stergiou, 2002; Karakulak *et al*., 2006; Bottari *et al.,* 2014) are at the origin of the difference in size at first sexual maturity and in the spawning period between individuals of the same species from different geographic locations.

Mortier (1992), Taupier-Letage & Millot (1998), Salas *et al*. (2001) consider the Algerian current as the most energetic in the Mediterranean basin, conferring to Algerian waters their relative richness.

Tab. 2: Spawning season of** B. boops **in different areas.
Tab. 2: Obdobje drstenja pri bukvi** (B. boops) **v različnih predelih.

Region		J	F	M	A	M	J	J	A	S	O	N	D	Lm50%	Author
Portugal	Algarve		■	■	■	■								13-15	Gordo, 1995
	Peniche			■	■	■	■								
	Algarve		■	■	■	■								15.22	Monteiro *et al.*, 2006
Morocco	Gibraltar strait				■	■	■	■						15.40	Lamrini, 1998
	Beni Ensar Port		■	■	■	■	■	■	■					13.30	Layachi *et al.*, 2015
Spain	Port of Castellon				■	■								-	Zuniga, 1967
	Western Mediterranean			■	■	■								10.20	Cano Fortuna & Sanchez Lizaso, 1996
	Canary island	■	■	■	■	■								17.90	Massaro, 2012
France	Gulf of lion			■	■	■	■							10-20	Girardin, 1981
Algeria	Algerian coasts				■	■								17.20	Bounhiol & Pron, 1916
	Annaba Bay	■	■	■	■	■								13.50	Derbal *et al.*, 2007
	Algiers Bay			■	■	■	■							13.50	Chali-chabane, 1988
	Bousmail Bay		■	■	■									14.60	Benina, 2015
				■	■	■	■							-	Dieuzeide *et al.*, 1955
	Oran Bay	■	■	■	■	■	■	■						17.10	Kherraz, 2011
				■	■	■	■							11.70	Bensahla-Talet *et al.*, 1990
			■	■	■	■								13.30	Aoudjit, 2001
		■	■	■	■	■	■	■						14.00	Present study
Italy	Gulf of Naples			■	■	■								-	Lo Bianco, 1909
	Tyrrhenian Sea				■	■								-	Bini, 1968
			■	■	■									13.80	Bottari *et al.*, 2014
Tunisia	Gulf of Tunis			■	■	■	■							14-18	Anato & Ktari, 1983
Croatia	Adriatic Sea	■	■	■	■	■								-	Dobroslavić *et al.*, 2017
Montenegro		■	■	■	■	■								11.50	Kasalica *et al.*, 2011
Greece	Central Mediterranean		■	■	■	■								-	Vidalis, 1950
Egypt	Alexandria Bay		■	■	■									-	Hassan, 1990
		■	■	■	■	■								13.00	El Agamy *et al.*, 2004
Lebanon	Libanian coasts		■	■	■									13.00	Mouneimne, 1978

Important upwellings, which enhance the development of plankton, the first link of the aquatic food web, are generated by the entrance of Atlantic waters via the Strait of Gibraltar.

The MLS (Minimum Landing Size) set for *B. boops* at 15 cm of TL according to Algerian legislation (Executive Decree no. 2004-86 of 26 Muharram 1425, corresponding to 18 March 2004) (J.O.R.A.D.P, 2004), seems to be inadequate, given that it is too close to the length at first sexual maturity, as has been established during our study (14 cm). It would be recommendable to increase this length and set it at 18 cm, thus giving the opportunity to young females to contribute to and ensure the renewal of the resource.

CONCLUSIONS

The results obtained in the present study shed light on the reproductive biology of *B. boops* in the western Algerian coast. The bogue is of commercial importance to local and national fisheries. The

ban on trawl fishery from 1 May to the 1 August as per Algerian legislation (Executive Decree no. 03-481a of 4 Rabi' al-Awwal 1425, corresponding to 24 April 2004), aiming to protect the renewal of the resources, is from our viewpoint insufficient to insure the set objective. We suggest an increase of the minimum landing size and the establishment of two closed fishing seasons per year to allow the renewal of multiple spawning species in Oran Bay and protect juvenile and adult spawners from overfishing.

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RAZVOJ GONAD PRI BUKVI, *BOOPS BOOPS* (LINNAEUS, 1758), IZ ORANSKEGA ZALIVA (TELEOSTEI, SPARIDAE)

Fatiha DALOUCHE, Lotfi BENSAHLA-TALET, Sidi Mohamed El Amine ABI AYAD & Ahmed BENSAHLA-TALET
Laboratoire Aquaculture et Bioremediation (*AquaBior*). University Oran1 Ahmed Benbella. Faculty of Natural Sciences and Life. Department of Biology. Oran-Algeria
e-mail: btlotfi1977@gmail.com

POVZETEK

Avtorji poročajo o reproduktivnem ciklu primerkov bukve Boops boops*, ujetih v Oranskem zalivu. Vzorce so z obravnavanega območja enkrat mesečno dostavili ribiči od januarja 2016 do decembra 2017. Spolni delež je bil v korist samic. Frekvenčna porazdelitev dolžine je pokazala, da so samice prevladovale pri dolžinah, večjih od 14 cm celotne dolžine, kar verjetno odraža začetek spolne inverzije, sicer že opisane pri tej vrsti špara. Obdobje drstenja, ki je bilo določeno na podlagi gonadosomatičnega indeksa, je bilo od februarja do poznega junija z vrhom v marcu in aprilu. Izsledki avtorjev prispevajo k boljšemu poznavanju razmnoževalnega cikla te vrste in bodo pomagali k pripravi ukrepov za primernejše upravljanje s staležem najbolj pogoste vrste špara, ki ga dnevno ribiči ulovijo v mnogih Sredozemskih državah in Alžiriji.*

Ključne besede: *Boops boops*, razmnoževalni cikel, sezone drstenja, velikost pri zrelosti, Oran, Alžirija

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