Journal of Materials and Environmental Sciences
ISSN : 2028-2508



J. Mater. Environ. Sci.,2017 Volume 8, Issue 12, Page 4467-4474

http://www.jmaterenvironsci.com /

# Study of reproduction of anchovy *Engraulis encrasicolus* (Actinopterygii, Engraulidae) in the central area of the Moroccan Atlantic coast

**A. Baali[1], H. Bourassi[1], S. Falah[1], W. Abderrazik[2], I. El Qoraychy[1], K. Amenzoui[3], A. Yahyaoui[1]**

[1] *Laboratory of Zoology and General Biology, Faculty of Science, Mohammed V University, Ibn Battouta Avenue, B.P. 1014, Rabat, Morocco.*

[2] *Laboratory of Immunology and Biodiversity, Faculty of Science Ain Chock, Hassan II University, Maarif, B.P. 5366, Casablanca, Morocco.*

[3] *National Fisheries Research Institute, Sidi Abderrahmane Road, Equestrian Club Ould Jmel, B.P. 20050, Casablanca, Morocco*

*Received 14 Feb 2017,*
*Revised 08 Jun 2017,*
*Accepted 10 Jun 2017*

*Keywords*
- Condition factor,
- Gonado-somatic index,
- Sex-ratio,
- Sexual maturity,
- *Engraulis encrasicolus*

**A Baali**
**ayoubbaali22@gmail.com** ,
**+212 623 755 804**

## Abstract

A study on the sexual cycle, of the European anchovy, the pelagic fish, *Engraulis encrasicolus* (Clupeiformes, Engraulidae), was carried out in the Central Atlantic Moroccan coast in the period between January 2013 and December 2013. This work represents the first attempt to investigate the reproductive features of the *E. encrasicolus* population in this area. The sex ratio for all fish (1:1.32) was in favour of females. The macroscopic examination of the gonads showed that this specie is mature throughout the year. The gonado-somatic index presented a maximum value (4-7 %) during April- September, and decreased gradually to reach minimum value (1-2 %) in November. The size at first sexual maturity ($L_{50}$) is 9.82 cm for males against 9.96 cm for females.

## 1. Introduction

Morocco is one of the four regions in the world known for the richness of its fish resources in its coasts (through upwelling). The upwelling phenomenon is the origin of high biological productivity of the regions which results in a strong richness of the pelagic resources (sardines, anchovies, mackerel, etc.). These species were defined as fish living in the sea between the surface and 200 meters deep and characterized by significant horizontal and vertical migration in coastal waters [1]. They make up the largest share of global marine catch and they represent quantitatively the main exploited resources, and account for almost 80 % of catches [2,3].

The socioeconomic importance of sea fishing requires managers to strengthen the biological studies necessary for the evaluation of these resources in order to allow fishermen to make the most of natural stands on one hand, and to safeguard stocks by appropriate regulatory measures on the other hand.

The anchovies *Engraulis encrasicolus* Linnaeus, 1758 are an essential element of food chain [4]. Little is known about the biology of this species in the Atlantic waters of Morocco. It is generally admitted the existence of one unique stock for North West Africa, which extends from Morocco to Sierra Leona. Nowadays, the occurrence of different modal classes detected in acoustic surveys carried out in Moroccan and Mauritanian waters raises out the possibility of the existence of different stocks [5].

Most of the research on the ecology of this species was performed in the northern Mediterranean Sea [6-9], the Black Sea and the Azov Sea [10-12], the Adriatic Sea [13,14] or the Bay of Biscay [15-18].

Despite the significant economic importance of this species along the North African Atlantic coast, little information is known either on its ecology or biology. Populations of small pelagic fish, such as sardine and anchovy, show evidence of important natural fluctuations in their abundance [19,20]. These fluctuations seem to be related, among other factors, to climate variability [21] or habitat conditions [9]. Growth and reproduction are two important parameters in fish population dynamics.

Therefore, the present paper is focused on the study of *E. encrasicolus* reproduction and growth; particularly sex-ratio, gonado-somatic index, condition factor and the size at first maturity were studied.

## 2. Materials and methods

The samples of *Engraulis encrasicolus* used in this study come from the Atlantic area between Cape Cantin and Cape Boujdor during one year, from January 2013 to December 2013. The frequency of sampling is based on the availability of anchovies since they are not always available in the fishing zones (Figure 1).

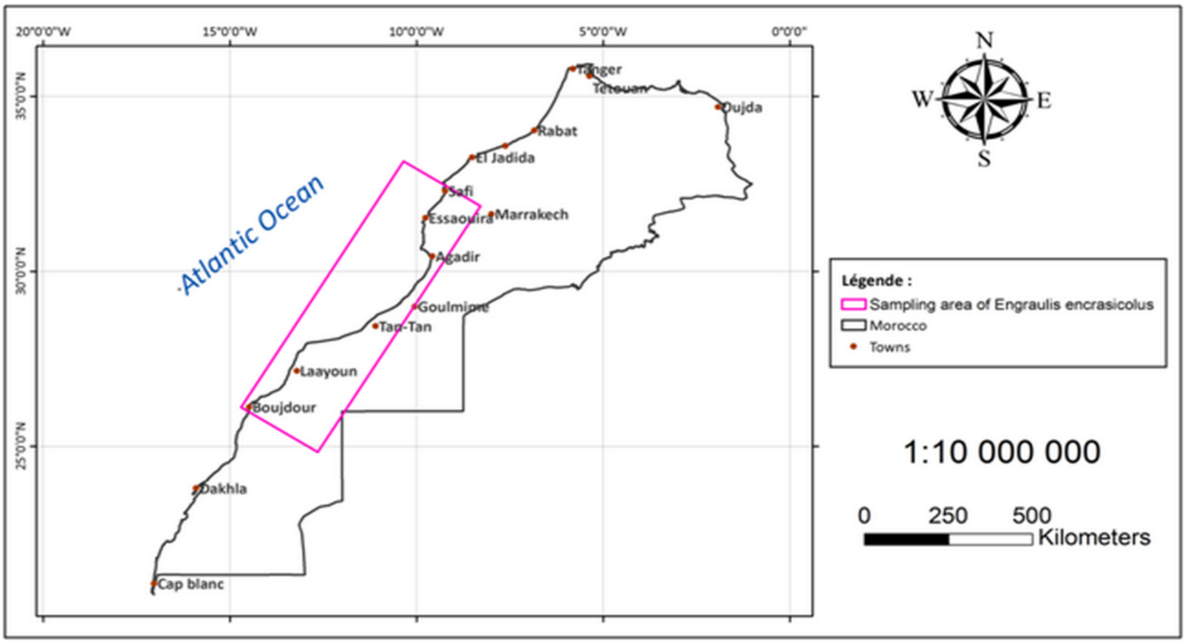


**Figure 1:** Sampling area of *Engraulis encrasicolus* in the Atlantic Centre of Morocco (Cape Cantin-Cape Boujdor)

A total of 1216 specimens of *E. encrasicolus* were collected monthly in the studied area by the sardine seiners. The catches were sorted, identified, inventoried and weighed. In the laboratory, all specimens were measured (Total Length, $L_T$) to the nearest 0.1 cm, and weighed (Total weight, $W_T$) to the nearest 0.1 g. The sex of each fish was determined and the fish gonads were macroscopically classified. The maturity stages of the testes and ovaries were determined with reference to the universal scale, considering five stages in accordance with [22].

### 2.1. *Sex ratio*

The sex ratio is defined as the proportion of each sex, determined by macroscopic observation of gonads in a given population. The principal hypothesis supposes that there is equal sex ratio. This was evaluated with a chi-square test ($\chi^2$). Analysis of variance (ANOVA) was applied to test the differences between males and females using Tukey test ($P < 0.05$).

### 2.2. *Sexual maturity*

The macroscopic sexual maturity includes five stages [22] (Table 1).

### 2.3. *Gonado-somatic index*

Variations in the gonad are almost estimated with respect to the parameters such as the length of the body, the total body weight ($W_T$) or the somatic weight [23]. The expression used in this study is the gonad index ($I_G$). It equals both gonad weight ($W_G$) divided by the total weight of the body and expresses gonad weight as a percentage of body weight [24]: $I_G = 100 \times W_G \times W_T^{-1}$; where $W_G$ is gonad weight and $W_T$ is total body weight.

### 2.4. *Condition factor*

This factor is suitable for comparing the fish of the same species in different locations, between different sexes or seasons. The condition factor, therefore, reflects the ecological and physiological conditions [25]. It is an indicator of the "fitness" of the population according to [26]. In this work, condition factor (K) was calculated using the following formula: $K = (W_T \times L_T^{-3}) \times 100$ [27], where $W_T$ is the total weight and $L_T$ is the total length.

### 2.5. *The size at first sexual maturity*

The total lengths at which 50% of specimens attain maturity (stage three is retained as the point at which the fish is considered mature) was deduced using theoretical maturity curve which corresponds to the regression between P parameter depending on the fish size: $P = (1+e^{-((a+b) \times L_T)})^{-1}$ [28]. Where P is a mature proportion by class size, $L_T$ is a total length, a is an intercept, and b is a slope. The linearization of this formula by introducing the natural logarithm gives: $-\ln((1-P) \times P^{-1}) = (a+b) \times L_T$. The regression between $\ln(P \times (1-P)^{-1})$ and total length ($L_T$) makes finding the parameters a and b, so: $L_{50} = -a \times b^{-1}$.

**Table 1:** Maturity scale for "partial spawners" of *Engraulis encrasicolus*

| **Stages of maturity** | **State** | **Features ovarian** |
|---|---|---|
| Stage 1 | Immature | Ovary and testis about 1/3rd length of body cavity. Ovaries pinkish, translucent; testis whitish. Ova not visible to the naked eye. |
| Stage 2 | Maturing virgin and recovering spent | Ovary and testis about ½ length of body cavity. Ovary pinkish, translucent; testis whitish, more or less symmetrical. Ova not visible to the naked eye. |
| Stage 3 | Ripening | Ovary and testis about 2/3rds length of body cavity. Ovary pinkish yellow colour with granular appearance, testis whitish to creamy. No transparent or translucent ova visible. |
| Stage 4 | Ripe | Ovary and testis from 2/3rds to full length of body cavity. Ovary orange-pink in colour with conspicuous superficial blood vessels. Large transparent, ripe ova visible. Testis whitish-creamy, soft. |
| Stage 5 | Spent | Ovary and testis shrunken to about ½ length of body cavity. Walls loose. Ovary may contain remnants of disintegrating opaque and ripe ova, darkened or translucent. Testis bloodshot (not positive about this adjective because it is always used with the eyes) and flabby. |

## 3. Results

### *3.1. Sex-ratio*

A total of 1216 individuals of *Engraulis encrasicolus* were analyzed; 57 % of them were females, 43 % were males. The difference between the two sexes is significant (Table 2).

**Table 2:** Comparison of males and females proportions of *Engraulis encrasicolus*, and the decision rule

| Number of males | Number of females | $\chi2_{\text{obs}}$ | $\chi2$ (1 ; 0.05) | Rule decision |
|---|---|---|---|---|
| 525 (43 %) | 691 (57 %) | 22.66 | 3.84 | Significant difference between proportions of sexes |

The evolution of the sex-ratio depending on the size shows that the size between 8.5 cm and 13.5 cm is characterized by slight predominance of males ($\chi2 = 0.28$; $P > 0.05$), from the size of 13.5 cm, we observe a significant dominance of females ($\chi2 = 23.19$; $P < 0.001$) (Figure 2).

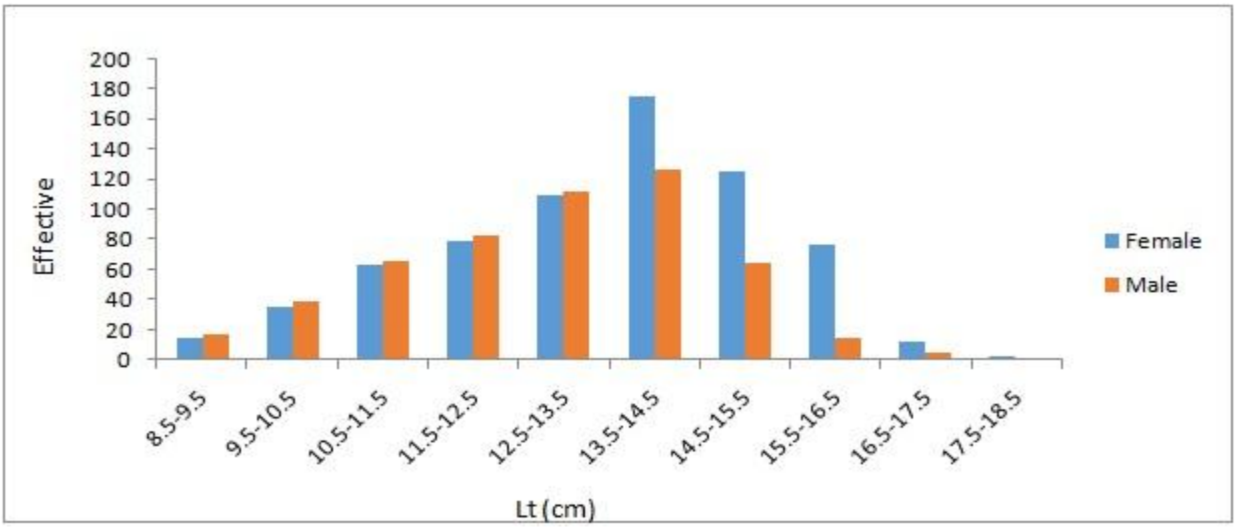


**Figure 2:** Sex-ratio depending on the total length ($L_T$) of *Engraulis encrasicolus* in the central region of Morocco

Monthly variations of sex-ratio are shown in Figure 3. Broadly speaking, the sex-ratio was in favour of females for seven months, particularly during the warmest ones (from May to September); on December we noted an equal value of sex ratio for both sexes.

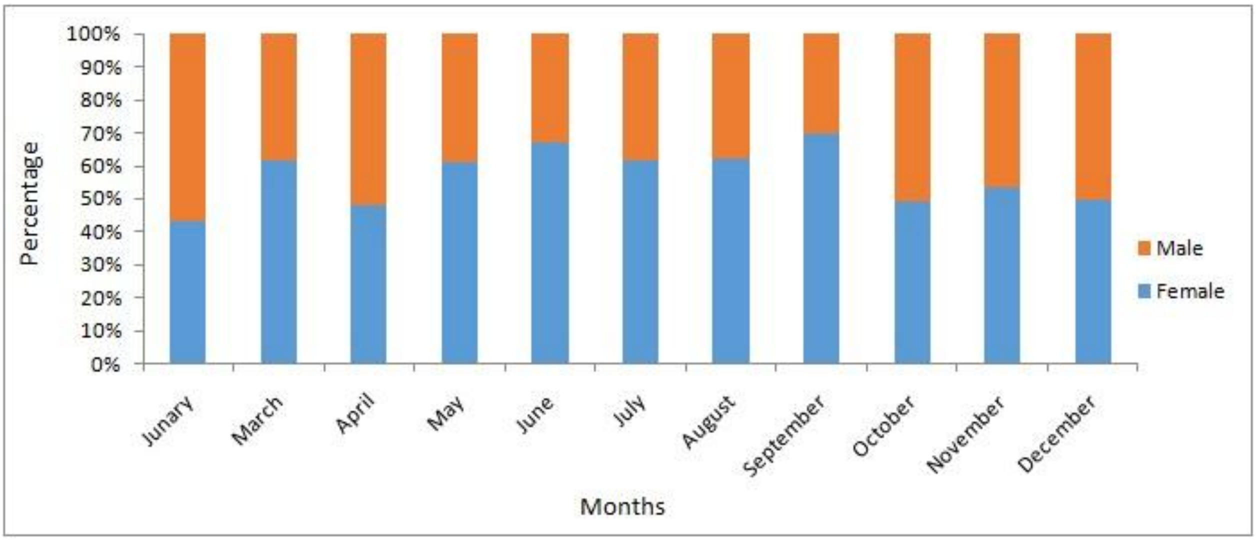


**Figure 3:** Monthly change in the sex ratio of *Engraulis encrasicolus* in the central region of Morocco

The sexual maturity stages are determined by the scale defined by [22]. There are five stages for *E. encrasicolus*. Fish with gonads at stage greater than or equal to three were considered mature [29]. The monthly changes of different maturation stages are shown in Figure 4. Mature fishes were dominant throughout the year; these stages reflect an extensive breeding activity for *E. encrasicolus*.

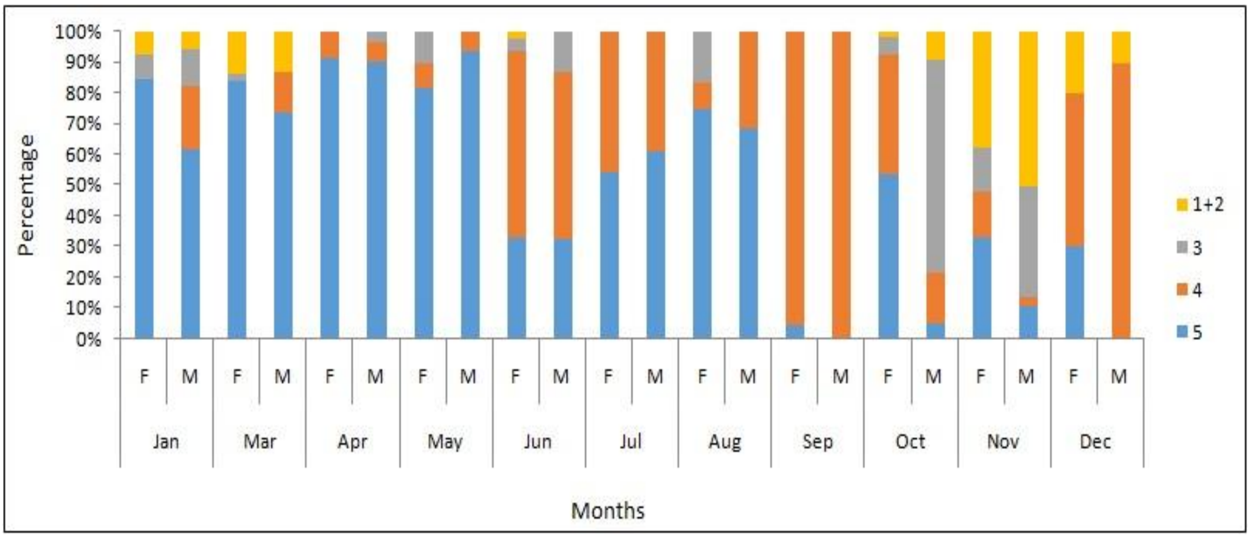


**Figure 4:** Monthly percentage of maturity stages of males (M) and females (F) *Engraulis encrasicolus* in the central region of Morocco

*3.2. Gonado-somatic index*

Graphically, monthly fluctuations of gonado-somatic index ($I_G$) values of *Engraulis encrasicolus* are shown in Figure 5. For both sexes, $I_G$ showed the highest values in summer with a maximum in August ($I_G$ = 5.72 for females and 6.72 for males). They also showed a decrease at the beginning of autumn; the lowest values have been recorded in November (2.04 for females and 1.74 for males).

*3.3. Condition factor (K)*

Both males and females condition factor of *Engraulis encrasicolus* have similar paces (Figure 6). K values are high in August with 0.75 and 0.73 for females and males respectively. For both sexes the low values were observed in November with 0.63 and 0.61 for females and males respectively.

*3.4. Size at first sexual maturity*

The size at the first sexual maturity ($L_{50}$) was 9.82 cm for males and 9.96 cm for females of *Engraulis encrasicolus* (Figure 7).

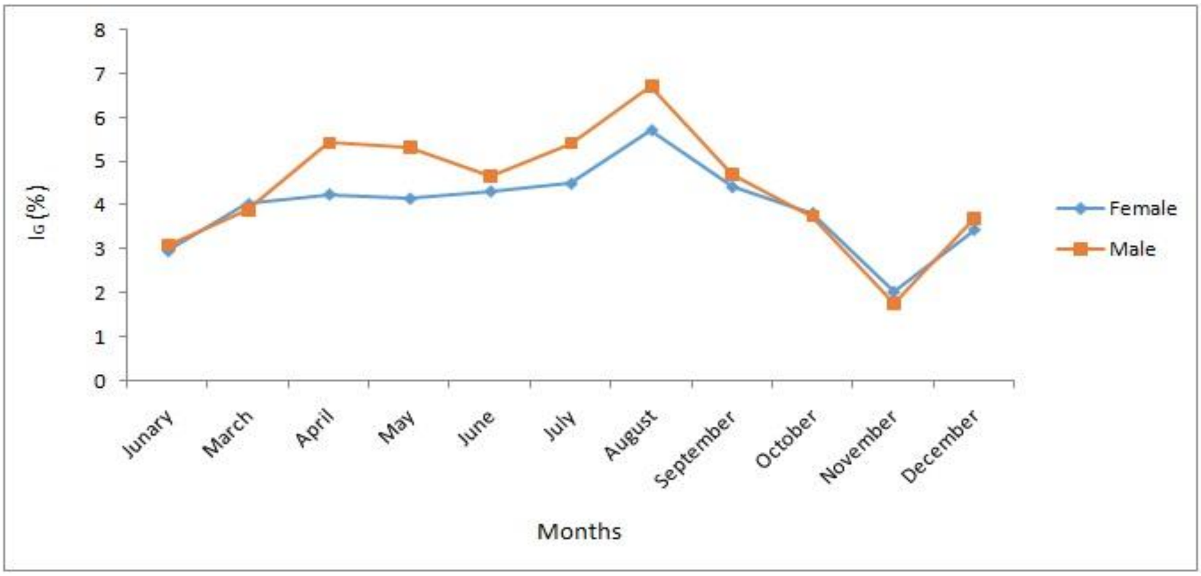


**Figure 5:** Monthly variations of gonado-somatic index $I_G$ in *Engraulis encrasicolus* in the central region of Morocco

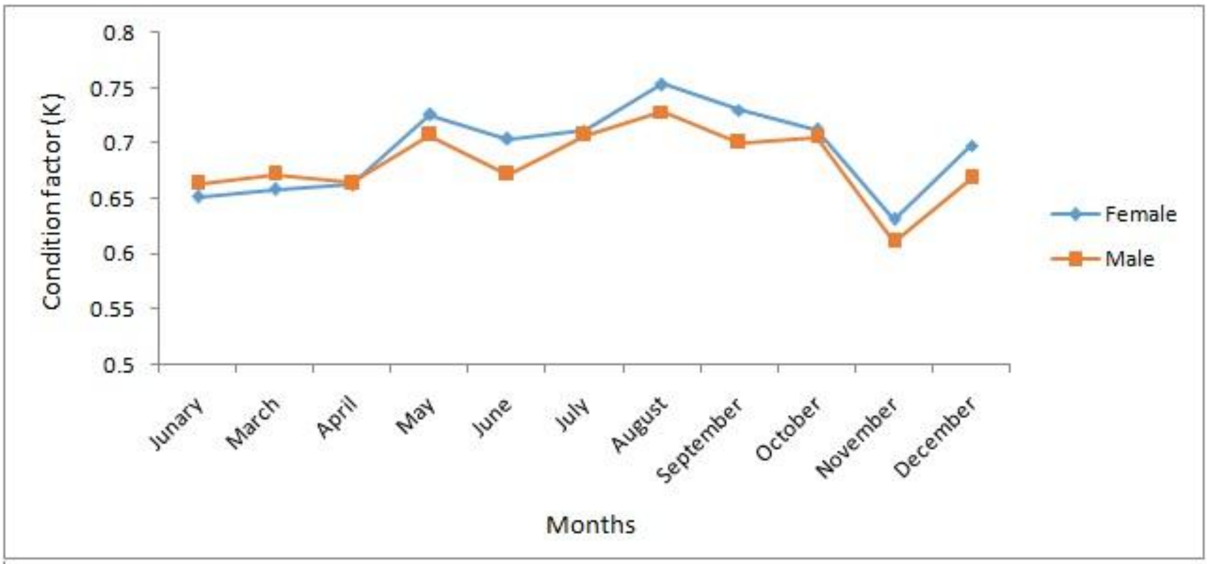


**Figure 6:** Mean monthly changes in condition factor (K) for both sexes of *Engraulis encrasicolus*.

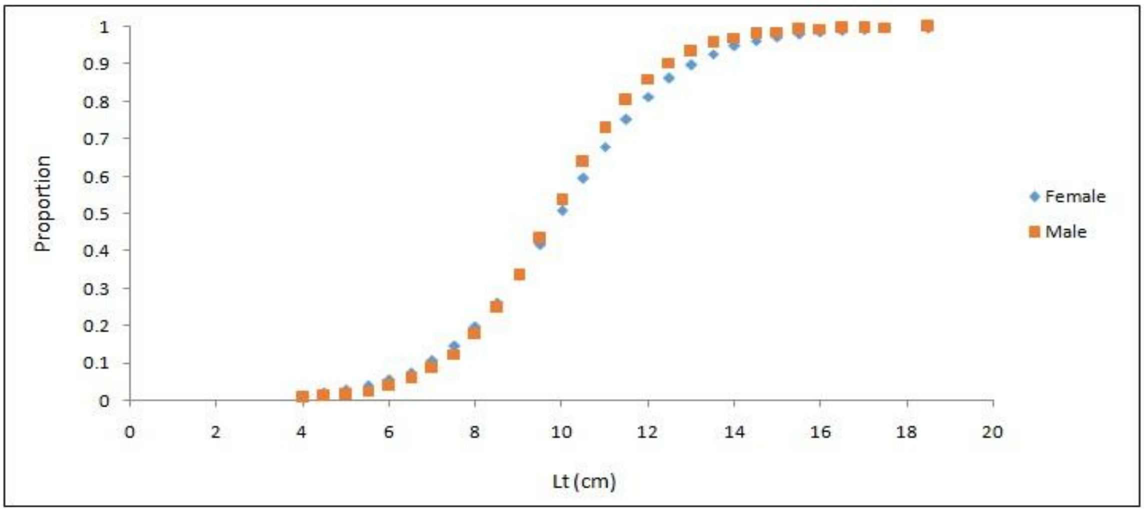


**Figure 7:** The size at first sexual maturity of *Engraulis encrasicolus* (males and females) in the Central Moroccan Atlantic Ocean ($L_T$, total length)

## 4. Discussion

In the present study, *Engraulis encrasicolus* has a separate sex (gonochorism type) in all specimens examined of all different size classes. The ratio of males to females showed more females than males (1:1.32) in the whole of *E. encrasicolus* population. This agrees with [30] and [31] who studied the Western Mediterranean *E. encrasicolus* population and pointed out that the annual sex ratio has a significant dominance of females. The female predominance has been observed by other authors for the *E. encrasicolus* of the Alboran Sea [32-38]. Conversely, with [39] and [40], who found that the annual sex ratios fulfil the hypothesis of a 1:1 ratio. Other results obtained by [41] in the extreme west of Algeria, show a dominance of males (58.36 %). Similarly, in the coast east of Ivory Coast, the results obtained show a dominance of males (1:1.2) on the overall sample [42].

In our study, the sex ratio is in favour of males in the small sizes and of females in the larger sizes. This agrees with the results obtained by [42]. The change in the sex ratio during the fish cycle may be due to differential migration or differential natural mortality by sex [43 - 45]. The most likely hypothesis in the case of this study may be migration. Indeed, the anchovies move in large schools over large distances (hundreds of kilometres) and at depth (200 m). This spatial displacement and time affect all size classes but differentially by sex during the breeding season [46]. [23] indicate that males remain longer on the spawning grounds because of the gradual emission of their sexual products, which would explain the change in the sex ratio observed. Furthermore, no sex reversal in the gonad development has been described to this date in the anchovies.

The highest proportions of sexual maturity stages, more advanced (stages three, four and five) in males and females of *E. encrasicolus,* were recorded throughout the year. In some countries of North Africa, including Senegal, Mauritania and Morocco, reproduction of *E. encrasicolus* is spread throughout the year [47]. This result is different to those obtained by [42] on the coast east of the Ivory Coast, where the only breeding period extended from January to May. [46-48] on the Ivory Coast indicates two periods of reproduction. The first occurs from January to May on the east and west coasts, and the second from August to December, only on the west coast. According to the same author, the western coastline has the most favourable environmental conditions for breeding. On the east coastline of Ivory Coast, [42] found that *E. encrasicolus* essentially reproduced in the rainy season.

The evolution of $I_G$ associated with monthly changes in different stages of sexual maturity indicates that reproduction starts in April and continues beyond September. Indeed, the highest values of the $I_G$ (4-7 %) were observed during this period. In Mauritania, the punters are mostly observed from April to October [49] or December [47] at which time the $I_G$ reaches 5 %. In the Bay of Biscay, the spawning period extends from April to August [50]. A large variation is well noted in the spawning periods in *E. encrasicolus*. Indeed, the waters of North Africa coastal countries, constituting "Ecoregion Sahelian upwelling" [51] have a constant supply of nutrients from rising currents of cold water. These marine areas are favourable for growth and reproduction of fish including anchovies in winter, spring and summer [47]. The factors that influence the process of maturation and spawning would be mainly temperature and salinity [52,53]. Also, migrating *E. encrasicolus* over 40 m to 100 m or 200 m depth during lying period seeking for favourable temperature and trophic environment to trigger spawning, are inaccessible to artisanal machinery fisheries. Favourable temperatures for *E. encrasicolus* reproduction lie indeed within 14 to 24°C in depth [54-56].

The monthly variations in condition factor would be attributable to maturity, spawning, feeding activity as well as environmental factors [57,58] concluded that the monthly variation in condition factor of the fishes is being affected by the feeding activities which may show their reflection on the body condition, either during the same months or later on. In the current work, condition factor of *E. encrasicolus* showed the highest values in summer.

In the present study, for males of *E. encrasicolus*, the size at first maturity was 9.82 cm total length, whereas in females, size at first maturity was 9.96 cm total length. This size is greater than what was observed by [59 - 61] during high-Ivorian sea trawling. On the northern coast of Tunisia, the size at first maturity of *E. encrasicolus* is very small (7.3 cm) [40] and lower than those found in the present study and the Ivory Coast. However, these various values obtained in Ivorian waters are all lower than those observed in Mauritania for females (10.1 cm) and males (10.4 cm) [49] and in the Gulf of Gascoigne (11-12 cm) [50]. In the far west of Algeria, this size is much larger (12.8 cm for females and 12.2 cm in males) [41]. [39] concluded that the maturity is attained at a total length of 11.9 cm in males and 11.2 cm in females in the Bay of Cadiz, Spain. Some authors explain that the variations in sizes are due to environmental conditions. Thus, the growth of fish could be delayed by bad environmental conditions and food resources [62] and by fishing pressure. For [63], changes in the first maturity sizes may be attributable to the different strategies developed by fish in different environments to better adapt to environmental conditions. Indeed, overfishing and low amount of nutrients in water (low upwelling) are factors that might explain the low size of *Engraulis encrasicolus* compared to those that have been observed in other countries.

## Conclusions

The species studied *Engraulis encrasicolus* occupy an important part of the Moroccan fisheries on both the Atlantic and Mediterranean coasts, due to their high commercial value. Thus, this work was devoted to the study of reproduction, needed to understand the population dynamics of this species in order to ensure sustainable and rational exploitation of their stocks in the Moroccan central Atlantic area.

Our results show that the sex ratio was in favor of females (57%) with a significant difference from males. Regarding the sex ratio depending on the size we found that the females were dominant from the large size classes. Concerning the breeding period the Gonado-somatic index showed that the highest values were in summer with a maximum in August for the both sexes.

**Acknowledgement-**This work was conducted at the National Fisheries Research Institute (INRH) in collaboration with the Faculty of Sciences of Rabat, Mohammed V University. We thank the staff of Biology and Ecology laboratory in the INRH of Casablanca-Morocco.

## References

1. Fréon P., Cury P., Shannon L., Roy C., *Bull. Mar. Sci*., 76 (2005) 385-462.
2. Amenzoui K., Doc. Sci. Université Mohammed V, Rabat, Maroc, (2010).
3. Amenzoui K., Ferhan-Tachinante F., Yahyaoui A., Mesfioui A. H., Kifani S., *Bull. Inst. Sci*., 26-27 (2004) 43-50.
4. Palomera I., Olivar M. P., Salat J., Sabatés A., Coll M., García A., Morales-Nin B., *Prog. Oceanogr*., 74 (2007) 377-396.
5. FAO 2007., [www.fao.org/docrep/009/a0773e/ a0773e00.htm](www.fao.org/docrep/009/a0773e/a0773e00.htm) (accessed 14 Nov 2016).
6. Morales-Nin B., Pertierra J. P., *Mar. Biol*., 107 (1990) 349-356.
7. Tudela S., Palomera I., *Mar. Ecol. Prog*. Ser., 160 (1997) 121-134.
8. Bellido J. M., Pierce G. J., Romero J. L., Millan M., *Fish. Res*., 48 (2000) 107–115.
9. Basilone G., Guisande C., Patti B., Mazzola S., Cuttitta A., Bonanno A., Kallianiotis A., *Fish. Res.*, 68 (2004) 9-19.
10. Mikhman A. S., Tomanovich L. V. J., *Ichthyol*., 17 (1977) 240-244.
11. Karacam H., Duzgunes E., *Fish. Res*., 9 (1990) 181-186.
12. Bulgakova Y. U. J., *Ichthyol*., 33 (1993) 78-88.
13. Dulčić J., *Fish. Res*., 31 (1997) 189-195.
14. Coombs S.H., Giovanardi O., Halliday N. C., *Mar. Ecol*. Prog. Ser., 248 (2003) 221-235.
15. Plounevez S., Champalbert G., Estuar. Coast. *Shelf. Sci*., 49 (1999) 177-191.
16. Allain G., Petitgas P., Grellier P., Lazure P., *Fish. Oceanog.,* 12 (2003) 407-418.
17. Díaz E., Txurruka J. M., Villate F., *Mar. Ecol. Prog*. Ser., 361 (2008) 227-238.
18. Díaz E., Txurruka J. M., Villate F., *Mar. Ecol. Prog*. Ser., 382 (2009) 173-183.
19. Lluch-Belda D., Crawford R. J. M., Kawasaki T., Maccall A. D., Parrish R. H., Schwartzlose R., Smith P. E. S., *Afr. J. Mar. Sci*., 8 (1989) 195-205.
20. Martin P., Bahamon N., Sabates A., Maynou F., Sanchez P., Demestre M., *Hydrobiologia*., 162 (2008) 185–199.
21. Sabatès A., Olivar M. P., Salat J., Palomera I., Alemany F., *Prog. Oceanog*., 74 (2007) 355–376.
22. Holden M. J., Raitt D. F. S., *FAO Fisheries Technical Paper* 115 (Rev. 1), Rome, (1974).
23. Kartas F., Quignard J. P., *Masson, Collection de Biologie des Milieux Marins*, Paris, (1984).
24. Bougis P., *Arch. Zool. Exp. Gén*., 89 (1952) 57–174.
25. Belvèze H., Doc. Sci. Université de Bretagne Occidentale, (1984).
26. Bolger T., Connolly P. L., J. *Fish. Biol*., 34 (1989) 171–182.
27. Fréon P., Doc. Sci. Cent. Rech. Océanog. Dakar-Thiaroye., 08 (1979)114–171.
28. Pope J. A., Margettes A. R., Hamley J. M., Akyuz E. F., *FAO Technical Paper*, (1983).
29. Fontana A., Université de Pierre et Marie Curie, Paris, France, (1979).
30. Pertierra J. P., University of Barcelona, Spain, (1992).
31. Giraldez A., Abad R., *Sci. Mar*., 59 (1995) 15–23.
32. Fernandez C. R., Del Val Cordon J. M., *Bol. Inst. Esp. Oceanogr*., 99 (1960) 1–28.
33. Padoan P., Rapport de la Commission Internationale pour la Mer Méditerranée, (1963).
34. Dragesund O., *General Fisheries Council for the Mediterranean*, (1964).
35. Lee J. Y., Juge C., *Bull. Comm. Int. Exploit. Sci. Mer Méditerr*., 18 (1965) 221–224.
36. Arrignon J., *Revue des travaux de l'Institut des pêches maritimes*, (1966).

37. Cort J. L., Cendrero O., de Cárdenas E., *Inst. Esp. Ocean*., 9 (1979) 1–9.
38. Casavola N., Marano G., Saracino C., de Martino L., *Oebalia*., 7 (1981) 24–42.
39. Millán M., *Fish. Res*., 41 (1999) 73–86.
40. Gaamour A., Khemiri S., Mili S., Ben Abdallah L., *Bull. INSTM de Salammbô*., 31 (2004) 17–24.
41. Sennai C. S., Centre National d'Étude et de Documentation pour la Pêche et l'Aquaculture, (2003).
42. Ouattara S., Fantodji A., Ouattara M., *Cybium*., 32 (2008) 201–209.
43. Albaret J. J., Gerlotto F., Doc. Sci. Cent. Rech. Océanog. Abidjan., **7** (1976) 113–133.
44. Garcia S., Albaret J. J., *Cah. ORSTOM*. Sér. Océanog., 15 (1977) 83-87.
45. Fantodji A., Université d'Abidjan, (1987).
46. Marchal E., Tome I : *Le Milieu Marin*, éditions ORSTOM, (1993).
47. Berraho A., Omar Ettahiri Y., Letourneur A., Orbi A., Yahyaoui A., *Cybium*., 29 (2005) 21-31.
48. Marchal E., Doc. Sci. Prov. Cent. Rech. Océanog. Abidjan., 5 (1966) 15.
49. Ba I. S., Cent. Nat. Rech. Océanog. Pèche. Nouadhibou., 18 (1989) 41-66.
50. Duhamel E., Masse J., Divisions VIII ab du CIEM, (2004).
51. Fantodji A., Actes du Premier Séminaire régional sur l'Aménagement et la Gestion des Aires protégées de l'Afrique de l'Ouest. 14-16 avril 2003. Parakou, Bénin, (2003).
52. Domanevsky L. N., Copenhagen Denmark Ices 1968/G 3, (1968).
53. Domain F. 1979. Notes sur les périodes de reproduction de quelques espèces démersales du plateau continental sénégambien. Document Scientifique, Centre de Recherches Oceanographiques de Dakar-Thiaroye 68:111-126.
54. Aldebert Y., Tournier H., *Rev. Trav. Inst. Pêche. Mar*. 35 (1971) 57-75.
55. Sobral M. C., Copenhagen Denmark Ices 1975/J:11, (1975).
56. Re P., Farinha A., Menrses I., *Cybium* **7 (**1983) 29-38.
57. Botros G., El-Sharif R., Huni H., *Bull. Mar. Biol. Res*., 6 (1985) 78–101.
58. Ahmed A. E., Faculty of Science, Suez Canal University, (1992).
59. Marchal E., *Editions de l'ORSTOM*, Paris, (1991).
60. Torstensen E., Alvheim O., Koranteng K. A., Tandstad M., Institut de Recherche Marine, Bergen, Norvège, (2000).
61. Mehl S., Olsen M., Bannerman P., Cruise Reports Dr. Fridtjof Nansen, Institute of Marine Research. Bergen, Norway, (2005).
62. Wootton R. J., Chapman and Hall, London, (1990).
63. Albaret J. J., In: Durand J.R., Dufour P., Guiral D., Zabi S. G. F. (editors). Tome II - *Les milieux Lagunaires*, ORSTOM, (1994).

(2017) ; http://www.jmaterenvironsci.com