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Relationships Between Fish Length Otolith Size of *Diplodus vulgaris* from Boughrara and El Bibane Lagoons (Southeastern Tunisia)

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Research Article

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ABSTRACT

In this study, the relationships between total fish length and otolith biometry parameters (length, width and weight) of *Diplodus vulgaris* (Teleostei, Sparidae), sampled from two Tunisian lagoons (Boughrara and El Bibane), were examined. The individuals of the two samples presented a symmetry in their otolith pairs (no significant differences between left-right: t-test, $P>0.05$), thus, only right otoliths have been used for the statistic analyzes. Fish length-otolith biometry relationships have been represented by linear regressions. The highest correlation was observed between body length and otolith weight ($R^2=0.662$, $R^2=0.56$) following otolith length ($R^2=0.42$, $R^2=0.23$) and the last were otolith width ($R^2=0.33$, $R^2=0.20$), respectively for Boughrara and El Bibane lagoons. This strong relationship between otolith weight and total length of *Diplodus vulgaris*, reflect that sagittal weight could be used as the best predictor of fish length.

INTRODUCTION

The Sparidae family (seabreams) comprises more than 100 species worldwide with a peak of diversity in the Mediterranean Sea and the Northeast Atlantic [1]. The common two-banded seabream, *Diplodus vulgaris* is a demersal species distributed in the Mediterranean and Black Seas, along the eastern Atlantic coast from France to Senegal and from Angola to South Africa [2].

The otoliths are calcified structures found in the inner ear of teleost fish [3]; there are three pairs of calcareous structures: the sagitta, asteriscus, and lapillus [4].

We used the Sagittae because it is the biggest pair of otoliths, it has specific characteristics (shape and size) and it is characterized by a high morphological variability between species [5-7].

By using the relationship between fish-otolith length, it is possible to determine otolith length from fish length or vice versa [8], the analysis of otoliths retrieved from the stomachs or feces of piscivorous predators can be used to provide information on the type, size, mass, and energetic content of their fish prey [9] and specially for the determination of the prey size [10,11]. Otolith biometry–body length relationships have been determined for many fish species by different researchers [12-18].

Under the hypothesis that there is strongly linear regression relationship between fish length and otolith parameters (length, width and weight). The aim of the present research was to determine for the first time in worldwide, the relationship between fish lengths and otolith parameters (length, width and weight) of *Diplodus vulgaris* collected form Boughrara lagoon and El Bibane lagoon, Gulf of Gabes, Tunisia, also which of these three parameters have a strong

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correlation with the length of the fish to be able to determine later the size of the fish or vice versa. The relationships between fish length and otolith parameters were tested by using regression method.

So, the findings will be very useful for the studies on subjects mentioned above and for the corresponding studies which will be carried on for the other species in Sparidae family.

MATERIALS AND METHODS

Lagoons are economically and ecologically important because of intensive recreational and fishing activities [19], in our study fishes were selected, randomly, from Boughrara and El Bibane lagoon - Boughrara lagoon is located in southeastern Tunisia on the Mediterranean Sea and covers an area of 500 km^2 **(Figure 1)**. It is located on latitudes varying between 33° 28′ and 33°45′ N and on longitudes varying between 10°45′ and 10°57′ E. Water exchange between the sea and the lagoon is assured through two areas: The first is a 6-km-wide channel on the eastern side closed by an old Roman road. Only an opening of 150 m allows communication between the sea and the lagoon. The second, located in the northern side, is a 2.5-km-wide channel (known as the Ajim channel) [19].

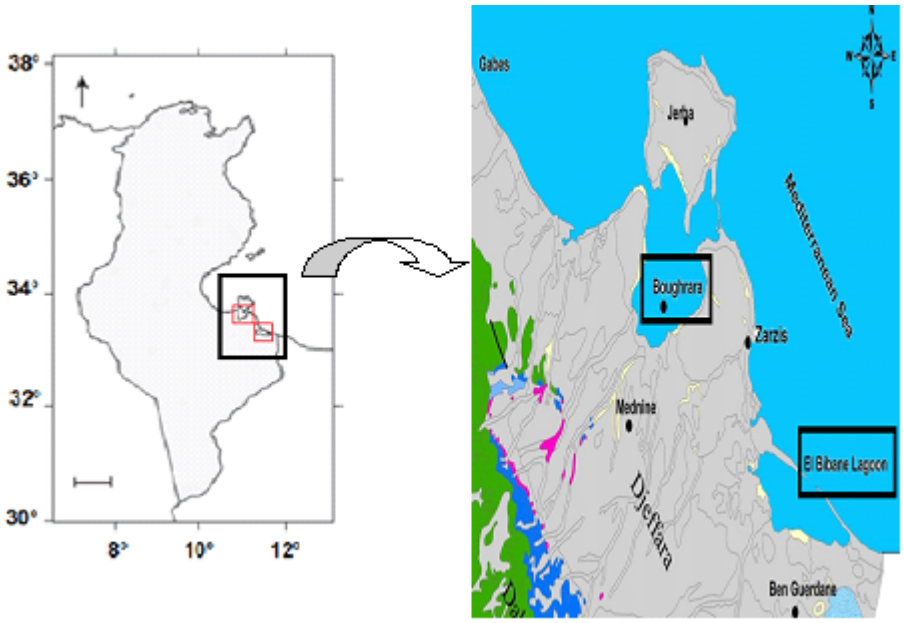

Figure 1. Sampling area of *D. vulgaris*, Boughrara and El Bibane lagoons, Tunisia.

- Bahiret el Bibane is a hyperhaline lagoon located close to the Gulf of Gabиs in southeastern Tunisia on the Mediterranean Sea (33°15 ' North and 11'15 East) [20].

It covers approximately 230 kml; the greatest depth is 6.5 m. The lagoon of El Bibane is separated from the Mediterranean Sea by a narrow belt of well-consolidated Tyrrhenian coastal deposits, which in their middle break up into a series of small islands. Strong tidal currents pass between the islands, but water exchange with the open sea is limited [21].

This study was carried out between May 2015 and May 2016. During this time, 120 specimens of *D. vulgaris* were examined, total lengths of fish samples were measured , sagittae, the largest of the 3 pairs of otoliths, were removed, cleaned with distilled water, air-dried and stored in Eppendorf tubes to photograph.

All the 120 sagittal otolith pairs were observed under binocular microscope (X40) and photographed by a fixed digital camera with a high performance (Sony HD 720p with the resolution of 16.1 megapixels and optical zoom 10X).

The photos of all otoliths were processed by the software Adobe Photoshop CS6 whose role is the transformation of the original image of the otolith into a binary image, afterwards the photos will be analyzed by another program, “Shape”, which will create twenty harmonics for each otolith (each otolith represents an individual).

The Length and Width of otoliths were also obtained automatically by numerical analysis from Shape software ver.1.3 to be able to couple this data with Fourier ellipses. The results were fed into Microsoft Excel so that they are processed by other statistical software (XLSTAT); otolith weight was measured by using digital balance to the nearest 0.0001 g.

Differences between left and right otolith were tested by t-test by paired t-test.

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The results were statistically tested with t-test and the correlation coefficient of these relations was interpreted according to Fowler and Cohen.

The total length-otolith parameters (length, width and weight) relationships were analyzed by linear model using the following equation:

$y=bx+a$

Where, y: otolith size, x: total length, a: intercept value, b: coefficient value.

RESULTS

The present paper describes the relationship between Total Lengths and Otolith size (Length, Width and Weight) in *D. vulgaris* from lagoon of Boughrara and El Bibane (southeastern Tunisia). We could not find any paper dealing with the relationship between fish lengths and otolith size of this species in Tunisia or any other country for comparison.

A total of 120 specimens belonging to the *D. vulgaris* have been examined, total lengths of them were ranged between 131-176 mm for Boughrara lagoon and 101-141 mm for El Bibane lagoon as in **Table 1**.

Table 1. Means and standard deviation of Total Length (TL) of specimens of *Diplodus vulgaris* examined in this study.

TL	N	Min	Max	Mean	SD
Boughrara lagoon	60	131	176	150.577	10.99
El Biben lagoon	60	101	141	115.48	8.092

Al measurements of left and right otoliths were tested and no significant differences were observed between left and right otolith (t-test, P>0.05), therefore, only right otolith used for next analysis. Otolith length, width and weight measurements are recorded in **Table 2**.

Table 2. Measured values of otolith size length (mm), width (mm) and weight (g) of *D. vulgaris* (Boughrara and El Bibane lagoons).

		N	Min	Max	Mean	SD
*Boughrara Lagoon	OL(mm)	60	62.98	155.04	1.04.001	19.1
	OW(mm)	60	11.91	97.10	42.59	11.67
	Owe(g)	60	0.0104	0.201	0.019	0.022
*El Bibane Lagoon	OL(mm)	60	257	427	345.02	37.35
	OW(mm)	60	99	368	222.83	65.35
	Owe(g)	60	0.001	0.107	0.012	0.0125

Sagittal otolith **(Figure 2)** lengths and widths were ranged between 62.98-155.04 mm and 11.91-97.10 mm, respectively for Boughrara lagoon and for El Biben lagoon were ranged between 257-427 mm and 99-368 mm, respectively. Otolith weights were determined between 0.0104-0.201 g for Boughrara lagoon and 0.001-0.107 g for El Biben lagoon **(Table 2)**.

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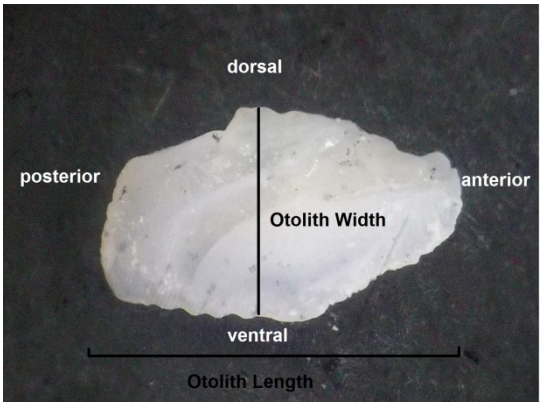

Figure 2. Schematic picture of Otolith of *D. vulgaris* and its biometric parameters.

Relationships between fish length and otolith length, weight and width were described by regression model and linear equation for the two lagoons **(Figures 3-8):**

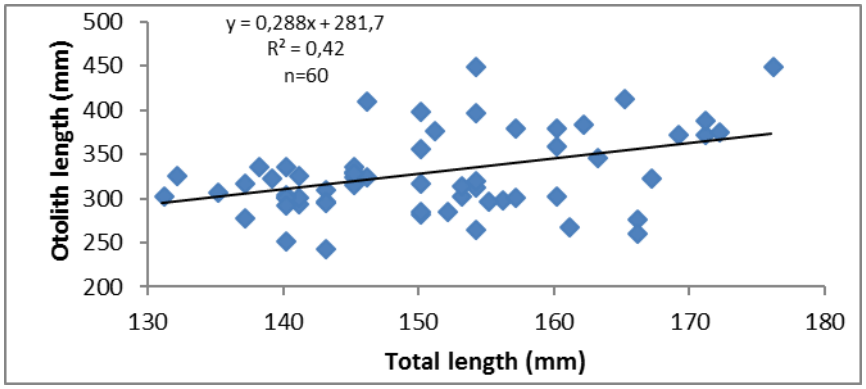

Figure 3. Total length-otolith length relationship of *D. vulgaris* in Boughrara lagoon.

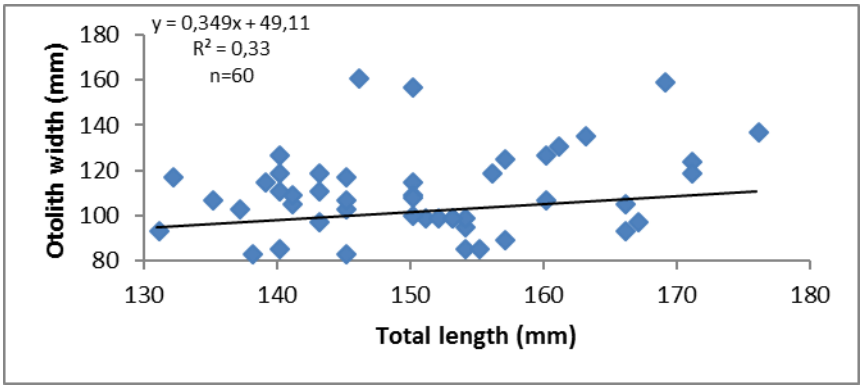

Figure 4. Total length-otolith width relationship of *D. vulgaris* in Boughrara lagoon.

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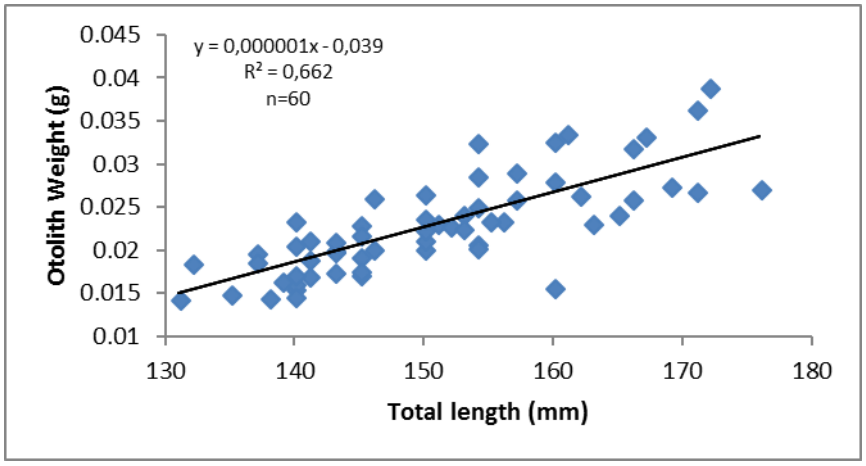

Figure 5. Total length-otolith weight relationship of *D. vulgaris* in Boughrara lagoon.

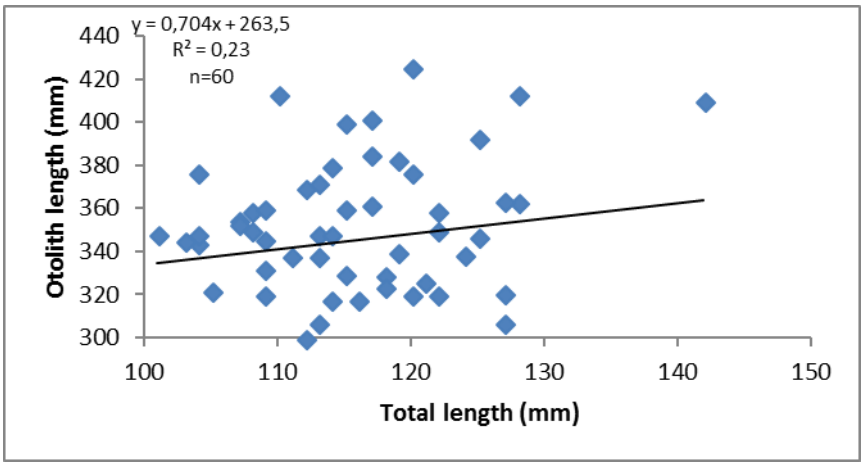

Figure 6. Total length-otolith length relationship of *D. vulgaris* in El Bibane lagoon.

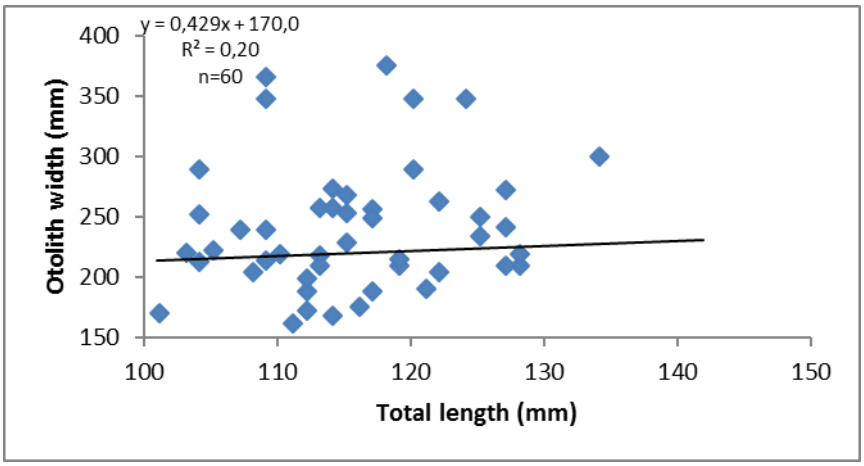

Figure 7. Total length-otolith width relationship of *D. vulgaris* in El Bibane lagoon.

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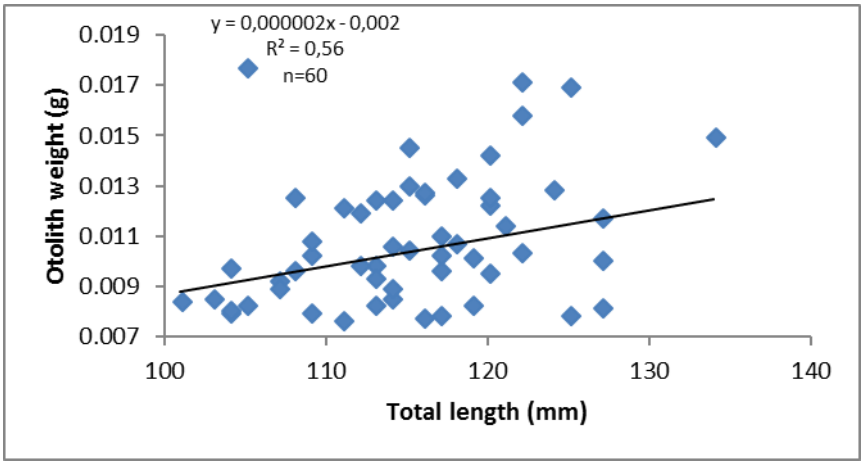

Figure 8. Total length-otolith weight relationship of *D. vulgaris* in El Bibane lagoon.

Boughrara lagoon:

Fish Length <--> Otolith Length: RI=0.42

Fish Length <--> Otolith Width: RI=0.33

Fish Length <--> Otolith Weight: RI=0.66

El Biben lagoon:

Fish Length <--> Otolith Length: RI=0.23

Fish Length <--> Otolith Width: RI=0.20

Fish Length <--> Otolith Weight: RI=0.52

DISCUSSION

The results given by the linear model analyze, showed that otolith dimensions and weight had linearly correlated to total fish length; In addition, for each two lagoons' population (Boughrara and El Bibane) of *Diplodus vulgaris*, this relationships between fish length and otolith parameters showed a high positive correlation, this latter is similar to results found by Black Pomfret from Iranian Coast of Oman Sea [22].

In general, linear functions are often chosen as the preferred to describe the relations between otolith size and fish length [23]. But, according to Campana, the relationship between otolith size (length, width and weight) and fish length is not necessarily linear, moreover, the relationship for adults is often very different from that for larvae.

Our research findings show that otolith parameters (length, width and weight) increase as fish length increase; Thus, otolith growth can be correlated with fish growth for *D. vulgaris*. However, otolith weight is more related to fish length growth, it showed the highest correlation value, but, otolith width has the lowest correlation. Therefore, the results from this study indicate that otolith weight can be power proxy to estimate the size of *D. vulgaris*.

Additionally, Hunt [24], investigated that otolith weight as the best indicator to determine the age and length of the fish and also the most easily measured parameter to be determined. Nevertheless, Harkonen [25], found that there is a high correlation between fish length and otolith length more than width and weight, and that this relationship is usually linear between all these parameters [26].

The major reasons of these differences in relationships' results obtained by various researchers may be due to the differences of fish species, habitat, and food availability in surrounding and water quality [27]. Moreover, one of the most responsible environmental factors acting on fish is the temperature [28]. Certainly, fish were very sensitive to temperature changes and were able to respond to a change of only 0.03°C [29].

Different studies of several researchers [30-32] have determined stronger and positive linear relationships between fish length and otolith size in different fish species with different body forms.

Thus correlation between otolith size and the fish size resulted that the weight, length and width, are basic indicators for the growth measurement. Also, according to Harvey et al, this research studies showed in food habits and food chain

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of predators (fish, Sea birds, marine mammals…), to determine the size of fish that are usually according to weight, length or width of otolith achieved useful.

D. vulgaris is an important fish species with a high commercial value in Tunisia. Due to its economic importance, this study is essential to ameliorate management and stock monitoring, for a sustainable exploitation of this resource.

Also this suggests that for better understanding about otolith growth, in future studies should be used the relationships between otolith age and weight, and survey about otolith factors such as perimeter, area, circularity, rectangularity, and thickness [33-37].

REFERENCES

1. Bauchot ML and Hureau JC. Sparidae. In: Fishes of the north-eastern Atlantic and the Mediterranean. In: Whitehead PJP, et al. (Eds.) 1986; pp: 883-907
2. Bauchot ML and Hureau JC. In: Quero JC, et al. (Eds). Checklist of the fishes of the eastern tropical Atlantic (CLOFETA). JNICT, Lisbon. 1990;2:790-812.
3. Mendoza RPR. Otoliths and their applications in fishery science. Ribarstvo 2006;64:89–102.
4. Das M. Age determination and longevity in fishes. Gerontology 2004;40:70–96.
5. Platt C and Popper AN. Fine structure and function of the ear. In: Tavolga WN (Ed). Hearing and sound communication in fishes. Springer- Verlag, New York 2004; pp: 3–38.
6. Belchier M, et al. Recruitment studies: Manual on precision and accuracy of tools. ICES Techniques in Marine Environmental Sciences.
7. Yilmaz S, et al. Relationships between fish length and otolith size for five cyprinid species from Lake Ladik. Samsun, Turkey. Turk Journal Zool 2015;39:438-446.
8. Eroglu M and Sen D. Otolith size-total length relationship in Spiny eel, Mastacembelus mastacembelus (Banks& Solander, 1794) inhibiting in Karakaya Dam lake (Malatya, Turkey). J Fisheries Sci 2004;3:342-351.
9. Appelbaum S and Hechte T. Otolith length/fish length relationship of leptocephali, elvers, and sub-adult (reared) eels Anguilla Anguilla. Environmental Biology of Fishes 1978;3:245247.
10. Avsar D. Fisheries Biology and Population Dynamic - Baki Publication, Adana, Turkey 1998: p; 303.
11. Aydin R. Relationships between Fish Length and otolith Length in the population of Chondrostoma regium (Heckel, 1843) inhabiting Keban Dam lake. Pakistan Journal of Biological Sciences. 2004;7:1550-1553.
12. Basusta A. Otolith biometry-total length relationships in the population of Hazar Bleak, Alburnus heckeli (Battalgil, 1943) inhabiting Lake Hazar, Elazig, Turkey. Pakistan J Zool 1943;45:1180–1182.
13. Bostancı D and Polat N. Dil balığı, Solea lascaris (Risso, 1810)'te otolit yapısı, otolit 1998.
14. boyutları-balık boyu ilişkileri ve yaş tayini, Fırat Ьniviversitesi Fen ve Mьhendislik Bilimleri Dergisi 2010;19:265-272.
15. Bostancı D and Polat N. Benekli Pisi, Lepidorhombus boscii (Risso, 1810)'nin otolit 2008.
16. Yapisi H. Otolit boyutları-balık boyu ilişkileri ve yaş tayini, Journal of FisheriesScience. Com., 2001;2:375-381.
17. Bostanci, D. Yaşı bilinen balıkların kemiksi yapılarında gerзek yaşı gцstermeyen halka цrneği, Journal of Fisheries Science. com, (baskıda), 2009.
18. Bull HO. An evaluation of our knowledge of fis behavior in relation to hydrography. Rapports et procиs-verbaux des rйunions du Conseil permanent international pour l'exploration de la mer 1952;131:8-23.
19. Campana SE. Photographic Atlas of Fish Otoliths of the Northwest Atlantic Ocean. 1st ed. Ottawa, Canada: NRC Research Press 2004.
20. Fablet R. Reconstructing individual shape histories of fish otoliths: A new image-based tool for otolith growth analysis and modeling. Fisheries Research 2009;96:148-159.
21. Fowler J and Cohen L. Practical Statistics for Field Biology. John Wiley and Sons 2009; p: 227.
22. Gordoa A and Molн B. Age and growth of the sparids Diplodus vulgaris, D. sargus and D. annularis in adult populations and the differences in their juvenile growth patterns in the north-western Mediterranean Sea. Fisheries Research, 1997;33:123–129.

e-ISSN: 2321-6190
p-ISSN: 2347-2294

23. Harkonen T. Guide to the otoliths of the bony fishes of the Northeast Atlantic. Danbiu ApS 1986; p: 251.
24. Harvey TJ, et al. Relationship between fish size and otolith length for 63 species of fishes from the Eastern North Pacific Ocean. National Marine Fisheries Service, USA.
25. Hunt JJ. Morphological characteristics of otoliths for selected fish in the Northwest Atlantic. J Northw Atl Fish Sci 1992;13:63-75.
26. İşmen A, et al. Otolith morphometry and population parameters of red porgy, Pagrus pagrus (Linnaeus, 1758) in Saros Bay (North Aegean Sea). Ege J Fish Aqua Sci 2013;30:31–35.
27. Kharroubi A. Assessment of sediment quality in the Mediterranean Sea–Boughrara lagoon exchange areas (southeastern Tunisia): GIS approach-based chemometric methods. Environ Monit Assess 2011;184:4001–4014.
28. Medhioub K. La Bahiret el Biban: Etude geochimiqueets & limentologique d'une 1998.
29. lagune du Sud-Est tunisien. Ecole Normale Suprrieure, Paris, Trav. Lab. Grol., 13.
30. Metin G, et al. Otolith and age determination from otoliths of the bony fishes - Mediterranean Fisheries Congress, 9-11 April, 1997, Izmir, Turkey:1997; pp: 895-901.
31. Morley S and Belchier M. Otolith and body size relationships in big eye grenadier (Macrourus holotrachys) in CCAMLR subarea 48.3 CCAMLR Science 2002;9:133–143.
32. Tarkan AS, et al. Use of bone and otolith measure for size-estimation of fish in predator-prey studies. Folia Zool 2007;56:328–336.
33. Şen D, et al. Relationships between fish length and otolith length in the population of Capoeta capoeta umbla (Heckel, 1843) inhabiting Hazar Lake, Elazığ, Turkey. Archives of Polish Fisheries 2001;9:267-272.
34. Short JA, et al Using otolith morphometrics to separate small Walleye Pollock, Theragra chalcogramma, from Arctic Cod, Boreogadus saida, in mixed samples. Alaska Fish Res Bull 2006;12:147-152.
35. Strasser A, et al. Carbonate cements in Holocene beachrock: example from Bahiret el Biban, southeastern Tunisia. Sedimentary Geology 1989;62:89100.
36. Yadollahvand R and Rahnama B. The Age Determination of Black Pomfret (Parastromateus niger), based on Otolith Cross Sections in Iranian Coast of Oman Sea. J Aquac Res 2014;5:261.
37. Yaremko ML. Age determination in Pacific sardine, Sardinops sagax. NOAA Technical Memorandum NMFS 1996.