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A SYSTEMATIC STUDY ON SPARIDAE (PISCES) EMPLOYING OTOLITH CHARACTERS IN THE EASTERN MEDITERRANEAN

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Abstract. The seventeen species of the family Sparidae were investigated in the systematics point of view employing the otolith characters along the southeastern coast of Anatolia. The otolith of each species was described in detail and description was supplemented with its figure, morphometric characters and 95 % confidence limits of these characters. It was observed that the general appearance of the otoliths belonging to family Sparidae were similar to each others in a varying degree, therefore identification of the species employing their otoliths are with some difficulties, yet possible.

List of symbols

OB : Otolith breadth

OD : Otolith depth

OL : Otolith length

n : Sample size

TL : Total length of fish

I. INTRODUCTION

The otolith of each species have characteristic shapes and features [2], therefore these are widely used in the systematic studies of both fossil and recent teleost fishes. Gaemers [4] stated that otoliths are the best remains in the systematic studies of fossil Teleostei, because the other remains found more seldomly. In the other hand, fishes eaten by predators can be identified from otoliths even after soft parts and bones have been digested [3]. Due to the mentioned reasons, description of the otoliths of the fishes are useful not only for the identifieation of the species, but also for the systematic studies of the fossil fishes and the stomach analysis of the fish predators.

II. MATERIALS AND METHODS

Fish samples were obtained by gill net, entangling net and deep trawling in the eastern Mediterranean. Species were identified and total length of the fish was measured. Some authors had reported that sagittal otoliths of the same individual can vary greately in size [1, 5] . There are no records on such differences for the northeastern region of the Mediterranean, therefore without differentiating either right or left otolith from each centimeter group of fish was removed and kept in a paper envelope. The otolith of each species were drawn as using 45° drawing prism and described as employing external morphologic and morphometric characters. Morphometric characters were given as proportions. Additionally 95 % confidence limits of these proportions were also given if sample sizes were more than five.

III. DESCRIPTIONS OF OTOLITHS

I. Boops boops (LINNAEUS, 1758)

Otolith oval. Rostrum prominent and pointed. Antirostrum pointed or flat. In some otoliths excisura ostii defined. Sulcus acusticus rather deep. Ostium like a pit at ostium cauda interface. Posterior section of cauda well bent to ventral side. Cristae well developed. Dorsal area deep and long. Lateral surface slightly concave. Medial surface convex. Edge lobed on dorsal side and denticulated on other sides.

Morphometric characters

n = 10
OL : TL = 1 : 26.69 1.62
OL : OB : OD = 1 : 0.57 ± 0.02 : 0.17 ± 0.01

2. Dentex dentex (LINNAEUS, 1758)

Otolith irregularly pentagonal. Rostrum and antirostrum prominent and pointed. Excisura ostii sharp. Sulcus acusticus not very deep. Cristae well defined. Dorsal area broad and shallow and extending from base of antirostrum to bending point of cauda. Medial surface well convex. Lateral surface well concave, and deeply striated dorsally. Edge highly denticulated.

Morphometric characters

n = 7
OL : TL = 1 : 31.32 ± 1.81
OL : OB : OD = 1 : 0.57 ± 0.03 : 0.15 ± 0.01

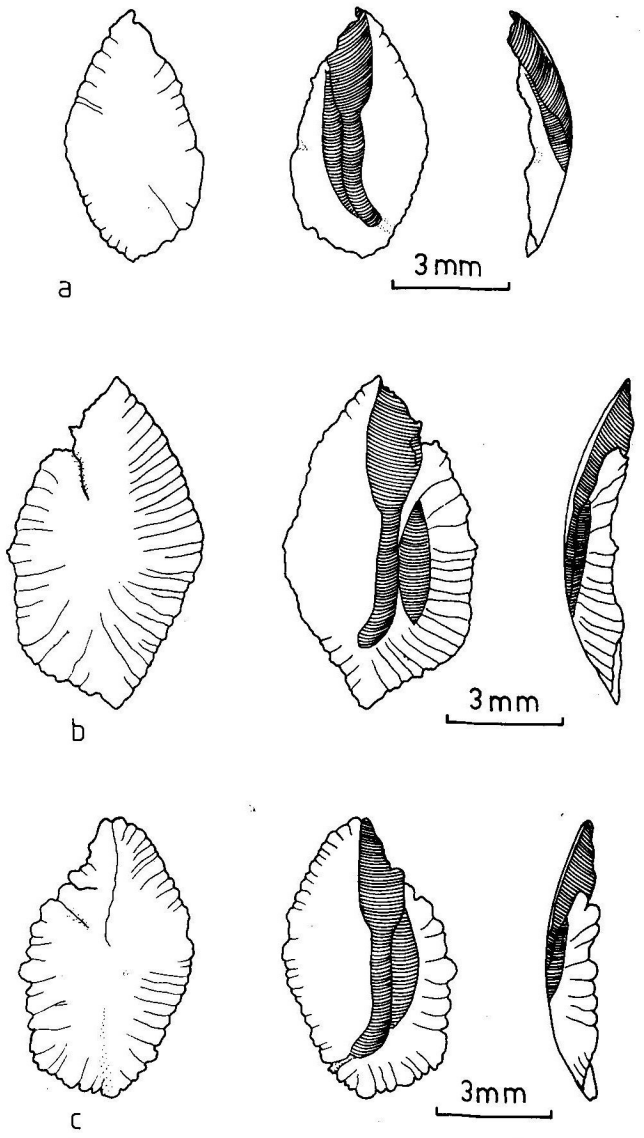

Figure 1. a. Left sagitta of Boops boops
b. Right sagitta of Dentex dentex
c. Right sagitta of Dentex gibbosus

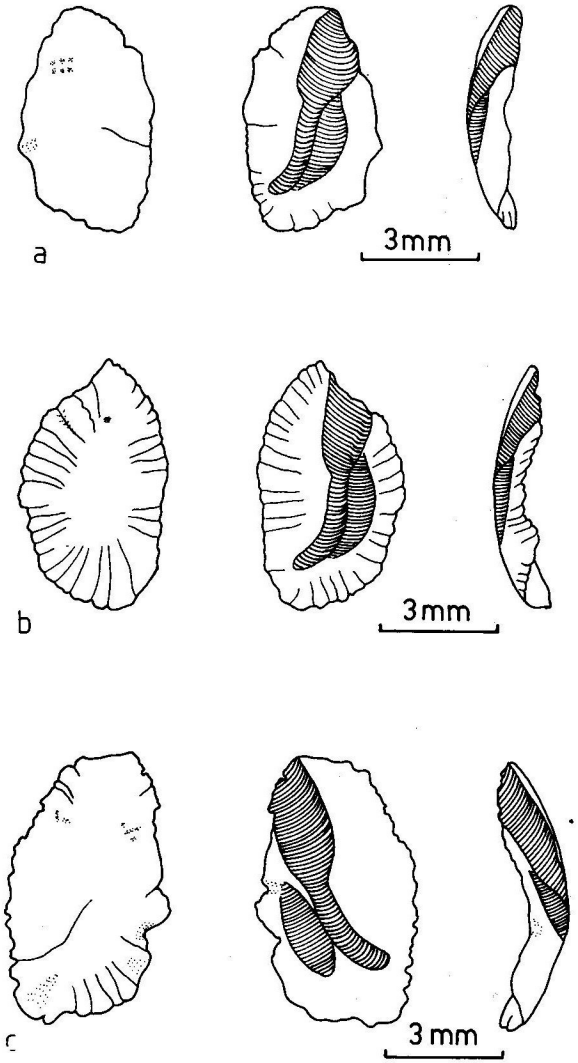

Figure 2. a. Right sagitta of Diplodus annularis
b. Right sagitta of Diplodus cervinus
c. Left sagitta of Diplodus puntazzo

3. Dentex gibbosus (RAFINESOUE, 1810)

Otolith irregularly pentagonal. Rostrum and antirostrum prominent, rostrum pointed while antirostrum nearly rounded. Excisure ostii present and sharp. Sulcus acusticus deep. Cristae well defined. Dorsal area broad and shallow and extending from base of rostrum to bending point of cauda. Medial surface well convex. A ridge vertically extending on midline of lateral surface, therefore surface inclining on dorsal and ventral sides. Inclination on dorsal side more than other. Dorsal side deeply striated. Edge highly denticulated.

Morphometric characters

n = 3
OL : TL = 1 : 24.99
OL : OB : OD = 1 : 0.63 : 0.18

General remarks on genus Dentex The otolith is irregularly pentagonal shaped. The medial surface is convex. The lateral surface is concave in D. dentex and with a ridge where the surface inclines on both the dorsal and the ventral sides in D. gibbosus. In the both species the lateral surface is deeply striated. The edge is serrated in D. dentex and denticulated in D. gibbosus.

4. Diplodus annularis (LINNAEUS, 1758)

Otolith rounded to elongated and thick. Rostrum prominent. Antirostrum flat. Excisura ostii absent. Sulcus acusticus deep and devided into ostium and cauda by V-shaped intrusion of ostium. Cristae well defined. Dorsal area broad and deep. Lateral surface flat. Medial surface well convex. Edge nearly smooth but on dorsal side lobed.

Morphometric characters

n = 5
OL : TL = 1 : 24.64 ± 1.76
OL : OB : OD = 1 : 0.61 ± 0.04 : 0.36 ± 0.06

5. Diplodus cervinus LOWE, 1841

Otolith oval. Rostrum defined. Antirostrum flat. Excisura ostii absent. Sulcus acusticus rather deep and edged by well defined cristae. A groove present on dorsal

side of ostium. Dorsal area deep. Lateral surface well concave and granulated on anterior part. Medial surface well convex. Otolith slightly protruding on dorsal side. Edge with small lobes.

Morphometric characters

n = 7
OL : TL = 1 : 31.78 ± 2.06
OL : OB : OD = 1 : 0.57 ± 0.02 : 0.18 ± 0.03

6. Diplodus puntazzo (GMELIN, 1789)

Otolith oval to oblong. Rostrum strong. Antirostrum flat. Excisura ostii absent. Sulcus acusticus rather deep. Pit like formation present at ostium cauda interface. Crista well defined. Dorsal area deep and connected to edge with a furrow. Medial surface well convex. Lateral surface well concave and covered by granules forming a wall on anteriodorsal side. Otolith protruding on mid dorsal.

Morphometric characters

n = 4
OL : TL = 1 : 34.49
OL : OB : OD = 1 : 0.58 : 0.19

7. Diplodus sargus (LINNAEUS, 1758)

Otolith elongated and rather thick. Dorsal side protruding in two dimensions. First protrusion at nucleus level and upwards in head. Other protrusion below preceding one and in third dimension. Rostrum prominent. Antirostrum flat or absent. Excisura ostii also absent. Sulcus acusticus rather deep and devided by V-shaped intrusion of ostium into cauda. Cauda slightly bending on posterior side. Dorsal area deep and broad.

Morphometric characters

n = 8
OL : TL = 1 : 30.73 ± 1.78
OL : OB : OD = 1 : 0.51 ± 0.01 : 0.22 ± 0.01

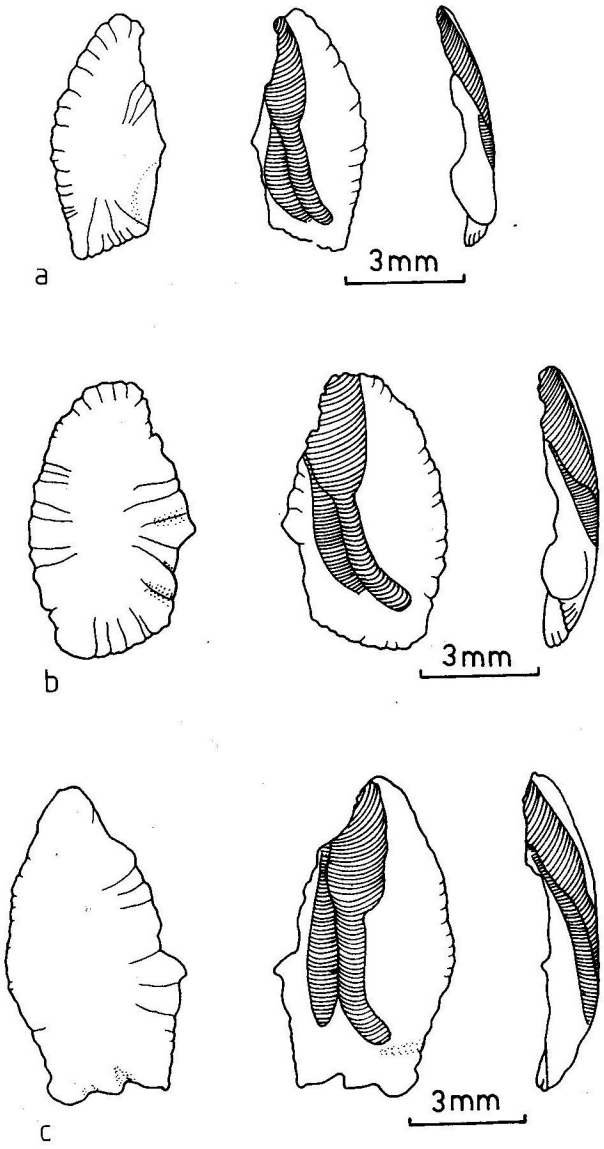

Figure 3. a. Left sagitta of Diplodus sargus
b. Left sagitta of Diplodus vulgaris
c. Left sagitta of Lithognathus mormyrus

8. Diplodus vulgaris (E. GEOFFROY SAINT–HILAIRE, 1817)

Otolith slightly elongated and irregularly pentagonal. Dorsal side protruding at nucleus level. Other protrusion outwards in third timension and below preceeding one. Rostrum prominent. Antirostrum flat or absent. Excisura ostii also absent. Sulcus acusticus very deep and edged by well defined cristae. Pit like formation present at ostium cauda interface. Dorsal area deep and broad and connected to dorsal edge with narrow groove. Otolith well convex medially and well concave laterally. Anterior part of lateral surface covered by granulation forming thick and high wall. Edge denticulated, on dorsal side lobed.

Morphometric characters

n = 9
OL : TL = 1 : 30.23 ± 1.87
OL : OB : OD = 1 : 0.60 ± 0.01 : 0.20 ± 0.01

General remarks on genus Diplodus: The shaped of the otolith is rounded to elongated. In D. annularis rounded, in D. sargus elongated and in the other three species oval in varying degree. Sulcus acusticus is generally deep and in D. annularis and D. sargus the ostium has the V-shaped intrusion into the cauda. In D. puntazzo and D. vulgaris the ostium has the pit like formation at ostium cauda interface. The otoliths of the last two species can be distinguished from the shape of dorsal area. In D. puntazzo it is connected to the edge above the protrusion at nucleus level of the otolith. In D. vulgaris it is connected to the edge close to the base of the rostrum on the dorsal side. The granulation on the lateral surface is characteristic for genus Diplodus, but it develops as the fish grows up.

9. Lithognathus mormyrus (LINNAEUS, 1758)

Otolith oval to slighly elongated, especially on posterioventral side. Rostrum prominent and pointed or rounded. Antirostrum flat or rarely rounded. Excisura ostii absent or very small. Sulcus acusticus deep. Ostium like a pit and separated from cauda by V-shaped intrusion. Cauda connected to edge with a furrow. Cristae well developed. Dorsal area deep and extending along entire length of cauda and beyond ostium cauda interface. Lateral surface well concave and medial surface well convex. Edge lobed on dorsal and posterior sides. Generally lobe on mid dorsal side protruded.

Morphometric characters

n = 11
OL : TL = 1 : 26.89 ± 0.96
OL : OB : OD = 1 : 053 ± 0.01 : 0.17 ± 0.01

10. Oblada melanura (LINNAEUS, 1758)

Otolith oval shaped. Rostrum rounded. Antirostrum flat. Excisura ostii present or absent. Sulcus acusticus deep. especially in ostium. V-shaped intrusion of ostium into cauda clearly devided sulcus acusticus. Cauda connected to edge with a furrow. Dorsal area extending from bending point of cauda to over ostium cauda interface. Lateral surface well concave and medial surface well convex. Edge lobed on dorsal side and denticulated on other sides. Cristae well defined.

Morphometric characters

n = 5
OL : TL = 1 : 30.85 ± 1.26
OL : OB : OD = 1 : 0.58 ± 0.02 : 0.17 ± 0.01

11. Pagellus acarne (RISSO, 1826)

Otolith oval. Rostrum prominent, its tip rounded. Antirostrum small and either pointed or rounded. Excisura ostii present and sharp. Sulcus acusticus deep and devided by V-shaped intrusion of ostium into the cauda. Posterior section of cauda almost straight. Cristae well defined. Dorsal area deep and extending almost along entire length of sulcus acusticus. Otolith well convex medially, nearly flat laterally. Lateral surface striated and enteriorly folded. Edge lobed.

Morphometric characters

n = 6
OL : TL = 1 : 27.43 ± 1.58
OL : OB : OD = 1 : 0.57 ± 0.02 : 0.17 ± 0.01

12. Pagellus erythrinus (LINNAEUS, 1758)

Otolith irregularly pentagonal. Rostrum short, rounded and large based. Antirostrum small and pointed. Excisure ostii short. Sulcus acusticus deep and devided by V-shaped intrusion of ostium into cauda, Posterior section of cauda strongly bent

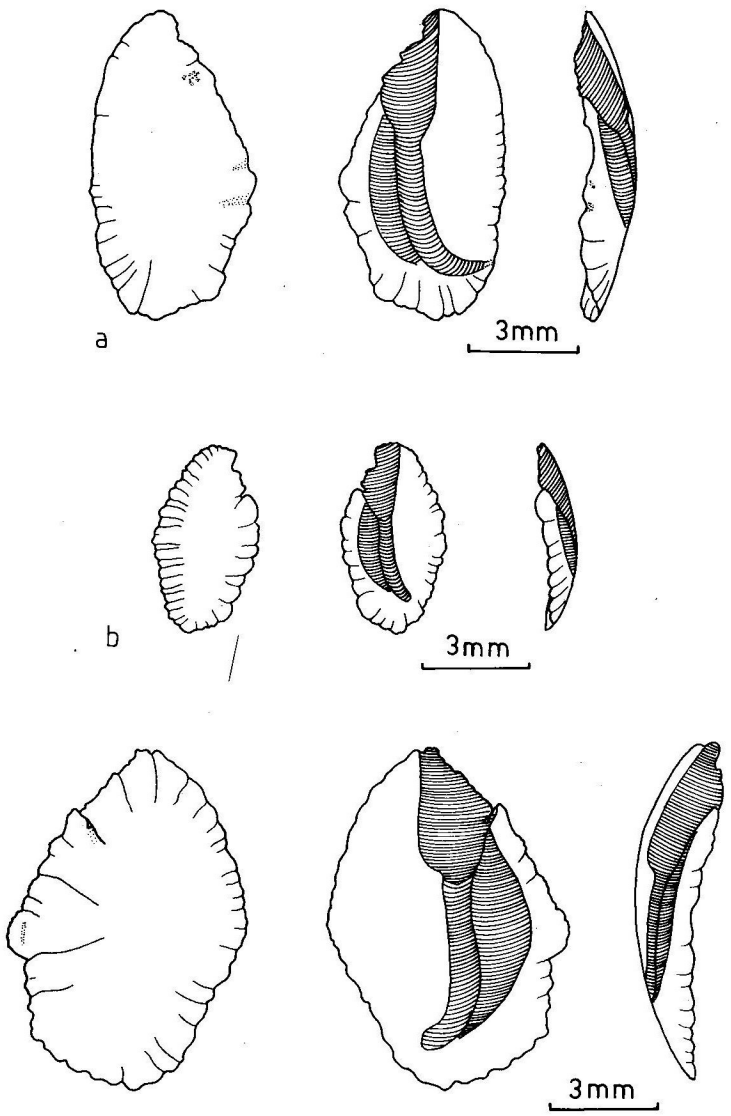

Figure 4. *a. Left sagitta of Oblada melanura*
b. Left sagitta of Pagellus acarne
c. Right sagitta of Pagellus erythrinus

towards ventral edge of otolith. Cristae well defined. Dorsal area deep and very large, extending almost entire length of sulcus acusticus. Medial surface well convex. Lateral surface striated and nearly concave on dorsal side, flat on ventral side. Edge lobed.

Morphometric characters

n = 10
OL : TL = 1 : 23.74 ± 0.63
OL : OB : OD = 1 : 0.72 ± 0.02 : 0.22 ± 0.01

General remarks on genus Pagellus: The shape of the otolith is oval in P. acarne and irregularly pentagonal in P. ertytrinus. The rostrum is rounded, the antirostrum is small and pointed. The excisura ostii is present. The sulcus acusticus is deep and edged by the well defined cristae. The ostium has the V-shaped intrusion into the cauda. In P. acarne the posterior section of the cauda is almost straight or slightly bent, in P. erythrinus strongly bent towards the ventral edge. The medial surface is well convex, the lateral surface is slightly concave or flat. Edge is covered with lobes.

13. Sarfa salpa (LINNAEUS, 1758)

General otolith shape oval, but on posterioventral side slightly elongated. Elongated part laterally twisted and terminating pith rounded or pointed end. Rostrum prominent. Antirostrum and excisura ostii present or absent. If antirostrum present, either pointed or rounded. Sulcus acusticus deep. Rounded or slightly V-shaped intrusion of ostium into cauda present. Cristae well defined. Dorsal area rather deep and terminating before reaching edge on anteriodorsal side. Otolith convex medially, concave laterally. Granular formation present on anterioventral side of lateral surface and ridge extending on posterioventral projection from edge to nucleus. Edge lobed on dorsal and posterior sides and denticulated on rest.

Morphometric characters

n = 6
OL : TL = 1 : 39.03 ± 2.60
OL : OB : OD = 1 : 0.49 ± 0.02 : 0.16 ± 0.02

14. Sparus aurata (LINNAEUS, 1758)

Otolith irregularly pentagonal and slightly elongated. Rostrum prominent and broad. Antirostrum generally connected to rostrum along its entire length, sometimes

small and pointed. In latter case excisure ostii present and small. Sulcus acusticus deep and broad. Cauda strongly bent towards ventral side and connected to edge with weakly defined furrow. Cristae well defined. Dorsal area broad and deep and extending between bending point of cauda and ostium cauda interface. Otolith medially convex, laterally concave. On lateral surface groove extending from base of rostrum towards nucleus. In some otolith granular formation covering lateral surface. Edge denticulated, on posterior side serrated.

Morphometric characters

n = 9
OL : TL = 1 : 28.81 ± 2.95
OL : OB : OD = 1 : 0.60 ± 0.02 : 0.16 ± 0.01

15. Sparus caeruleostictus (VALENCIENNES, 1830)

Otolith irregularly pentagonal. Rostrum broad, its tip rounded. Antirostrum small and pointed. Excisura ostii small. Sulcus acusticus rather shallow. V-shaped intrusion of ostium into cauda present. Cristae poorly developed; cristae superior more defined than crista inferior. Dorsal area deep and broad, and extending beyond bending point of cauda and ostium cauda interface. Medial surface well convex, lateral surface concave. On lateral surface groove extending from base of rostrum towards nucleus. Edge highly denticulated.

Morphometric characters

n = 4
OL : TL = 1 : 26.84
OL : OB : OD = 1 : 0.65 : 0.16

16. Sparus ehrenbergi (VALENCIENNES, 1830)

Otolith irregularly pentagonal, even rounded. Rostrum short and broad. Antirostrum connected to rostrum either along its entire length or just at its tip. In latter case, hollow present between bases of rostrum and antirostrum. Sulcus acusticus deep. V-shaped intrusion of ostium into cauda visible. Cauda strongly bent to posterioventral side. Cristae well defined. Dorsal area deep and extending from bending point of cauda to over ostium canda interface. Medial surface well convex, lateral surface well concave and deply striated. Groove present on anteriodorsal side of lateral surface. Entire edge highly denticulated.

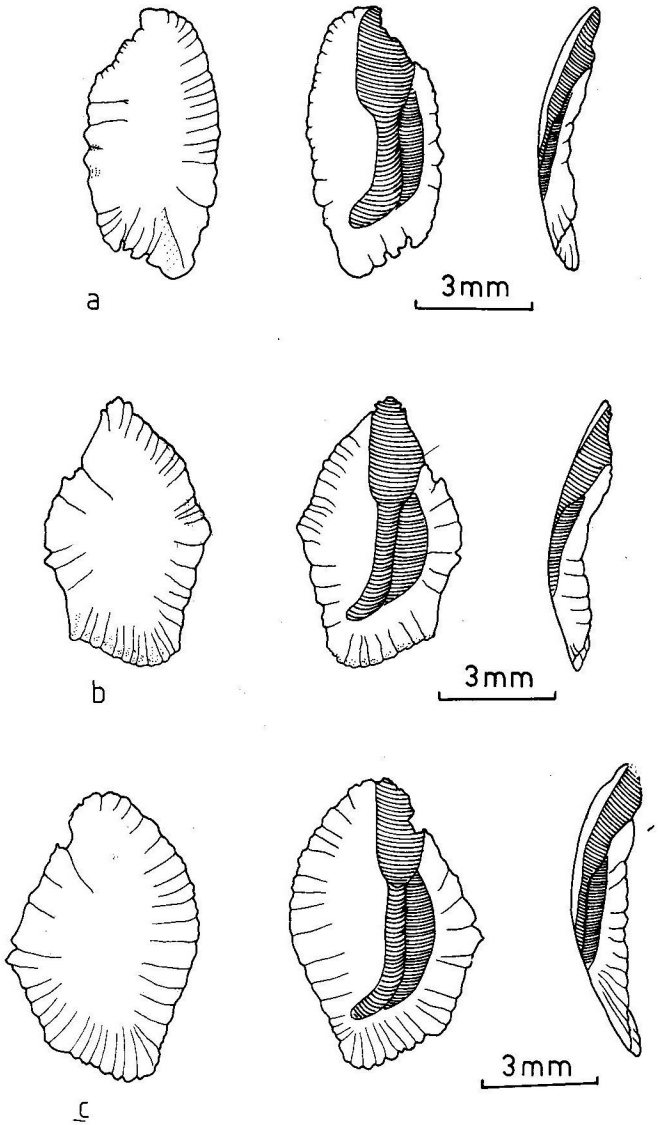

Figure 5. a. Right sagitta of Sarpa salpa
b. Right sagitta of Sparus aurata
c. Right sagitta of Sparus caeruleostictus

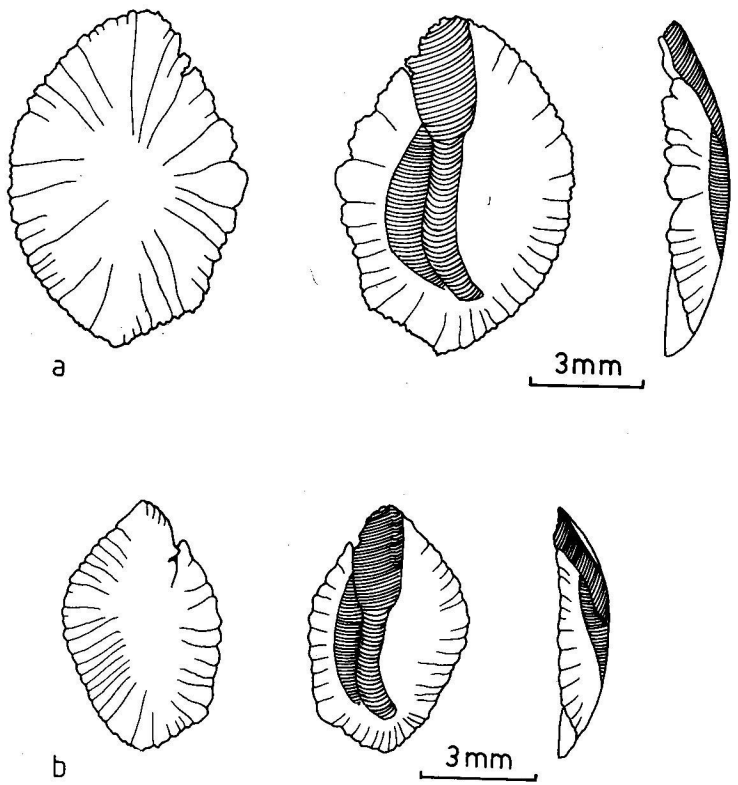

Figure 6. a. Left sagitta of Sparus ehrenbergi
b. Left sagitta of Sparus pagrus

Morphometric characters

n = 10
OL : TL = 1 : 25.39 ± 1.65
OL : OB : OD = 1 : 0.74 ± 0.01 : 0.19 ± 0.01

17. Sparus pagrus (LINNAEUS, 1758)

Otolith irregularly pentagonal. Rostrum prominent, its tip rounded. Antirostrum connected to rostrum but sometimes pointed. Excisure ostii short or absent. In some otoliths antirostrum well separated from rostrum and excisura ostii long and sharp.

Sulcus acusticus rather deep. V-shaped intrusion of ostium into cauda present. Cristae well defined; especially crista superior more defined than crista inferior. Deep dorsal area extending beyond bending point of cauda and ostium cauda interface. Otolith convex medially and concave laterally, Ridge ewtending on striated lateral surface from posterioventral side to nucleus. Edge highly denticulated.

Morphometric characters

n = 5
OL : TL = 1 : 25.13 ± 76
OL : OB : OD = 1 : 0.70 ± 0.04 : 0.15 ± 0.01

General remarks on genus Sparus: The shape of the otolith is irregularly pentagonal, however in S. aurata slightly elongated, in S ehrenbergi even rounded. The rostrum and the antirostrum are present and generally separated, but in some otoliths these are connected to each others. In the latter case the excisura ostii is absent. In S aurata posterior part of the cauda is connected to the edge with a weakly defined furrow. In the other three species the ostium has the V-shaped intrusion into the cauda. In S. ehrenbergi, one of the three species, this intrusion is more defined than that in the other two. The sulcus acusticus is generally deep, but in S. caeruleostictus rather shallow and edged by poorly defined cristae. In the other three species cristae are well developed. The dorsal area is generally broad and deep. The edge is highly denticulated or lobed. The medial surface is convex, the lateral surface is concave. In S. pagrus a ridge extends from posterioventral side to the nucleus on the lateral surface.

IV. CONCLUSION

The characters of the otoliths in the family Sparidae are not generally specialized among the species, therefore it is rather difficult to distinguish the otoliths in this family. The highest similarity is observed between Pagellus erythrinus and the three species of genus Sparus, namely Sparus caeruleostictus, Sparus ehrenbergi and Sparus pagrus. The otoliths of all mentioned species, are irregularly pentagonal in shape. In Pagellus erythrinus the ventral side of the lateral surface is thickned, therefore this part is flat and the dorsal area is very large. The V-shaped intrusion of ostium into the cauda is clearly defined and the edge is lobed. In the other three species the lateral surface is concave and the dorsal area is not so large. In Sparus caeruleostictus and Sparus pagrus the V-shaped intrusion of the ostium into the cauda is present, but weakly developed, and in Sparus ehrenbergi the edge is highly denticulated.

The other two similar otoliths belong to Boops boops and Pagellus acarne. Both species have oval shaped otoliths. In spite of the similarity in the general shape, there are some conspicuous differences between the otoliths. In Boops boops the rostrum is pointed, the ostium has the pit like formation at the ostium cauda interface and the posterior section of the cauda is well bent to the ventral side. In Pagellus acarne the rostrum is rounded at the tip, the ostium has the V-shaped intrusion into the cauda and the cauda is nearly straight or slightly bent.

In Lithognathus mormyrus and Sarpa salpa, the otoliths are rather similar with their elongated forms, but some differences are noticeable. In Lithognathus mormyrus the mid of the dorsal side is generally protruded into a lobe. The posterior part of the cauda is connected to the ventral edge with a furrow and the dorsal area extends to the edge on the antirostrum. In Sarpa salpa there is no protrusion on the dorsal side, and also no furrow between the end of the cauda and ventral edge of the otolith. The dorsal area terminates before the edge on the anteriodorsal side. In this species the ridge and the granular formation on the lateral surface, which are absent in Lithognathus mormyrus, are noticeable.

The otolith of Oblada melanura is similar to the otoliths of Diplodus cervinus, Diplodus puntazzo and Diplodus vulgaris in the general shape. The most noticeable differences, in Oblada melanura, are the V-shaped intrusion of the ostium into the cauda and the furrow which connects the end of the cauda to the ventral edge of the otolith. These two caharcters are absent in the three Diplodus species mentioned above.

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ÖZET

DOĞU AKDENİZ'DE OTOLİT ÖZELLİKLERİNİ KULLANARAK SPARIDAE (PISCES) ÜZERİNE SİSTEMATİK BİR ÇALIŞMA

Anadolu'nun güney-doğu kıyılarında yaşayan onyedi Sparidae türü otolit özellikleri kullanılarak sistematik açıdan incelenmiştir. Her tür için otolit çizimleri, morfometrik özellikler ve bu özelliklerin % 95 lik güvenilirlik sınırlarını kapsayan ayrıntılı bir tanımlama verilmiştir. Sparidae familyasında otolitlerin birbirlerine benzerlik gösterdiği, bu nedenle incelenen familya türlerinin otolit özellikleri kullanılarak tanımlanmasının oldukça zor olduğu, bununla birlikte olanaksız olmadığı gözlenmiştir.

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