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A systematic study on *Carangidae* (Pisces) employing the otolith characters in the eastern Mediterranean

Sistematski pristup izučavanju porodice *Carangidae* (Pisces) iz istočnog Mediterana na osnovu karakteristika otolita

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Nine species belonging to seven different genera in the family *Carangidae* were investigated from the systematics point of view employing the otolith characters along the south eastern coast of Anatolia. The otolith of each species was described in detail and its figure was given. The morphometric characters were measured and their 95% confidence limits were given if the sample size was more than three. It was observed that the otolith characters in the family *Carangidae* were species specific therefore identification of the species from the otolith was rather easy.

INTRODUCTION

Due to its characteristic shape and features for each species, otolith is commonly used in the systematic studies of both fossil and recent teleost fishes. Especially in the paleontological studies it is the best remain from the fossil teleost, because the other remains are found more seldomly Gaemers (1968). Additionally the specific shape of the otolith is used in the stomach analysis of the fish predators. Fishes eaten by predators can be identified from otoliths even after soft parts and bones have been digested Frost and Lowry (1981).

MATERIALS AND METHODS

Fish samples were collected by the gill net and the entangling net, however some species were also caught by the deep trawling. The captured species were identified and the total length was measured individually. Some authors had reported that sagittal otoliths of the same individual can vary

greately in size Reinsch (1968) and Bingel (1972). There are no records on such differences for the north eastern region of the Mediterranean therefore without differentiating, either the right or the left otolith from the each centimeter group of the fish obtained was removed, and kept in a paper envelope. The otolith of each species were drawn using the 45° drawing prism and described employing the morphologic and the morphometric characters. The morphometric characters were given as ratios as applied by Hecht and Hecht (1979). If the sample size is more than three, 95% confidence limits of the morphometric characters were also given.

The abbreviations used for the morphometric characters are as follows:

OB : Otolith breadth

OD : Otolith depth

OL : Otolith length

n : Sample size

TL : Total length of fish

RESULTS

Caranx crysos (MITCHILL, 1815), (Figure 1a)

Otolith very delicate and elongated. Rostrum prominent and sharply pointed. In the fish larger than 22.4 cm in total length separated and pointed antirostrum observed. In the smaller individuals antirostrum connected to rostrum and blunt. When antirostrum present, excisura ostii present and sharp. Sulcus acusticus deep. V-shape intrusion of ostium extending into cauda. Cauda slightly bent posteriorly to edge of otolith. Both cristae poorly developed, especially at posterior part of cauda. Dorsal area narrow and extending to edge of antirostrum on dorsal side. Entire edge highly denticulated. Lateral surface well concave and deeply striated; Its anterior and posterior sides twisted laterally. Medial surface convex along entire length of otolith.

Morphometric characters:

$n = 6$

$OL : TL = 1 : 42.25 \pm 5.45$

$OL : OB : OD = 1 : 0.33 \pm 0.02 : 0.11 \pm 0.1$

Caranx dentex (SCHNEIDER, 1801), (Figure 1b)

Otolith's shape elongated parallelogram. Rostrum and antirostrum prominent and pointed. Sulcus acusticus deep. Ostium slightly expanding on rostrum and cauda slightly bending posteriorly to otolith edge. A large slope inclining from dorsal to ventral in posterior part of cauda. Cristae well defined. Dorsal area deep, and undulated on dorsal side. Its posterior and anterior ends unclosed. Edge denticulated. Lateral surface slightly concave on its ventral side and almost flat on rest. Medial surface slightly convex.

Morphometric characters:
n = 3
OL : TL = 1 : 52.17
OL : OB : OD = 1 : 0.39 : 0.14

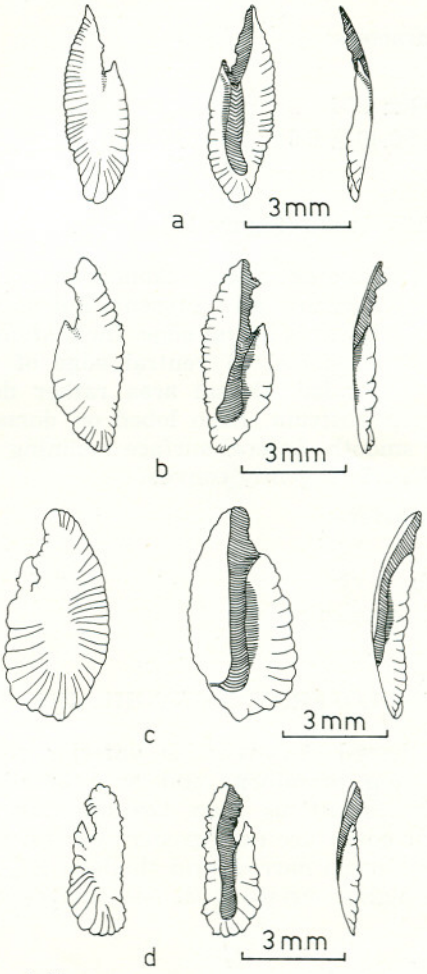

Figure 1: a. Left sagitta of *Caranx crysos*
b. Right sagitta of *Caranx dentex*
c. Right sagitta of *Caranx rhonchus*
d. Right sagitta of *Lichia amia*

Caranx rhonchus (E. GEOFFROY SAINT-HILAIRE, 1817), (Figure 1c)

Otolith oval and rather thick, especially on ventral side. Rostrum prominent and often pointed. If antirostrum present, excisura ostii defined. In some otoliths antirostrum connected to base of rostrum. In such a case a

groove extending between them or antirostrum fused into rostrum. Sulcus acusticus deep. Ostium-cauda interface with pit like formation. Cauda strongly bent on its posterior part to otolith edge. Cristae well defined. Dorsal area terminating before reaching dorsal edge of antirostrum. Edge lobed. Lateral surface deeply striated and concave dorsally and flat ventrally. Medial surface clearly convex.

Morphometric characters:

$n = 7$

$OL : TL = 1 : 33.99 \pm 1.94$

$OL : OB : OD = 1 : 0.49 \pm 0.01 : 0.14 \pm 0.01$

Lichia amia (LINNAEUS, 1758), (Figure 1d)

Otolith small and elongated, and thickened on dorsal side. Rostrum and antirostrum prominent. Excisura ostii present. Sulcus acusticus rather deep. Ostium inclining slightly towards dorsal edge. Inclination extending into cauda, but a contrast slope from dorsal to ventral edge of cauda present. Cauda straight and slightly expanded. Dorsal area rather deep and narrow, and extending to base of antirostrum. Edge lobed on dorsal and posterior sides, on other sides nearly smooth. Lateral surface inclining to edge on dorsal and posterior sides. Medial surface gently convex.

Morphometric characters:

$n = 1$

$OL : TL = 1 : 86.00$

$OL : OB : OD = 1 : 0.35 : 0.12$

Scyris alexandrina (E. GEOFFROY SAINT-HILAIRE, 1817), (Figure 2a)

Otolith oval in shaped, however its anterior part slightly expanded. Rostrum and antirostrum prominent and with broad bases. Excisura ostii short and sharp. Sulcus acusticus deep. Ostium narrow on rostrum. Cauda terminating with slight curvature near posterioventral edge of otolith. Cristae poorly developed. Dorsal area narrow and shallow. Edge thinly lobed. Lateral surface concave and highly striated. Medial surface convex and relatively smooth.

Morphometric characters:

$n = 7$

$OL : TL = 1 : 55.42 \pm 3.57$

$OL : OB : OD = 1 : 054 \pm 0.03 : 0.16 \pm 0.02$

Selar djeddaba (FORSSKÅL, 1775), (Figure 2b)

The unique sagitta was broken at its anterior tip when removing. Otolith slightly elongated. Rostrum and antirostrum prominent. Antirostrum pointed. Excisura octii short. Sulcus acusticus deep. Cauda strongly bent towards edge

of otolith. Cristae poorly developed especially at the end of cauda. Cristae inferior connected to edge with a stria. Dorsal area small and shallow, and extending to edge between rostrum and antirostrum. Edge lobed on dorsal side. Lateral surface deeply striated. Deep groove extending from excisura ostii to center of otolith on lateral surface. Otolith slightly concave to flat laterally and convex medially.

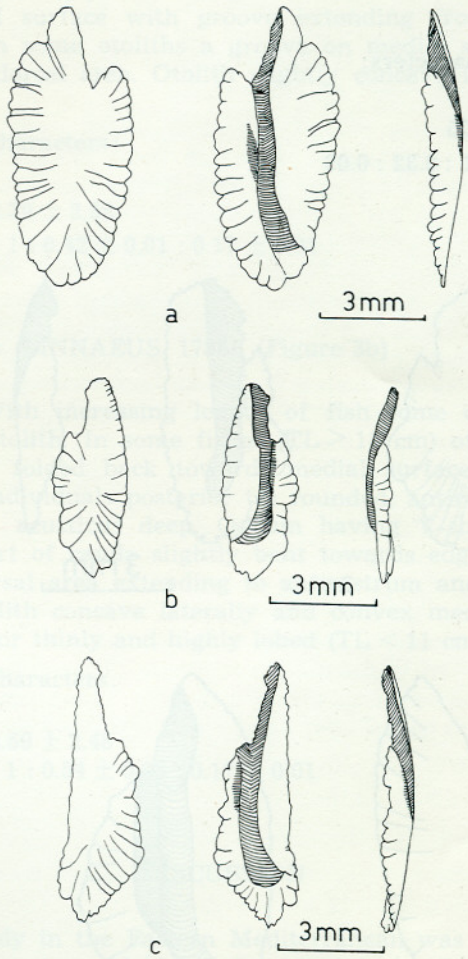

Figure 2: a. Left sagitta of *Scyris alexandrina*
b. Right sagitta of *Selar djeddaba*
c. Left sagitta of *Seriola dumerili*

Due to broken anterior tip of the otolith, it is impossible to give the morphometric characters.

Seriola dumerili (RISSO, 1810), (Figure 2c)

Otolith elongated and thin. Rostrum prominent and pointed. Antirostrum very small and nearly flat. Excisura ostii very short. Sulcus acusticus deep V-shaped intrusion of ostium extending into cauda. Ostium narrow, cauda expanded and bent posteriorly. Cristae well developed. Dorsal area deep and terminating before reaching edge on antirostrum. Edge lobed on dorsal and posterioventral sides. Lateral surface well concave and deeply striated. Medial surface well convex.

Morphometric characters:

n = 1

OL : TL = 1 : 62.25

OL : OB : OD = 1 : 0.32 : 0.09

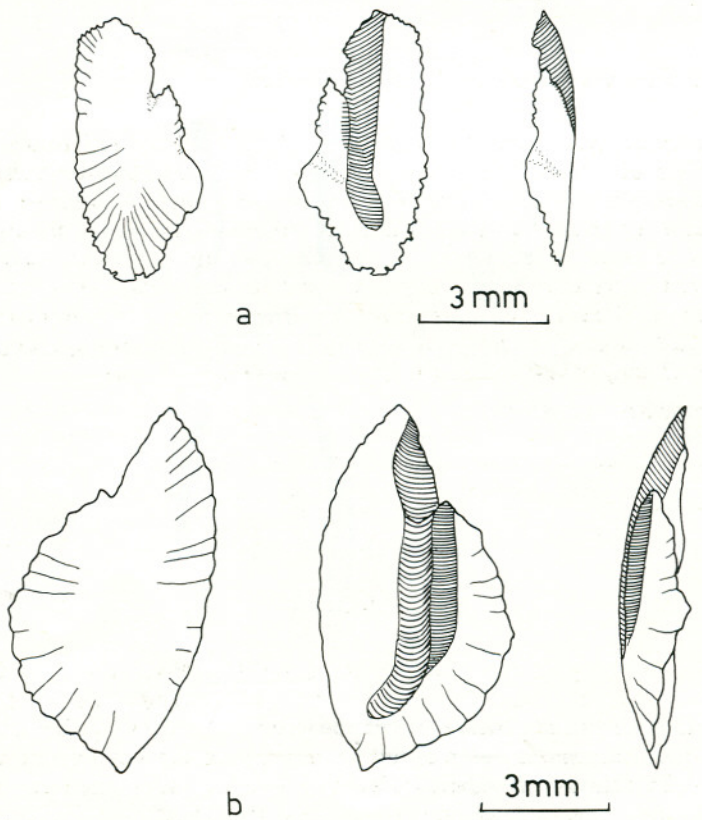

Figure 3: a. Left sagitta of *Trachynotus ovatus*
b. Right sagitta of *Trachurus trachurus*

Trachynotus ovatus (LINNAEUS, 1758), (Figure 3a)

Otolith oval to elongated. Rostrum prominent, its anterior tip rounded. In some otoliths rostrum protruding on dorsal side. Antirostrum rather long and pointed. Excisura ostii sharp. Ostium not expanding on rostrum, but having V-shaped intrusion into cauda. Cristae poorly developed, especially crista superior weakly defined. Dorsal area shallow and extending to base of antirostrum. Edge generally lobed on dorsal side and serrated to smooth on other sides. Lateral surface with groove extending from excisura ostii to center of otolith. In some otoliths a groove on medial surface connected to dorsal edge below dorsal area. Otolith slightly concave laterally and convex medially.

Morphometric characters:

$n = 7$

$OL : TL = 1 : 48.39 \pm 2.38$

$OL : OB : OD = 1 : 0.42 \pm 0.01 : 0.17 \pm 0.01$

Trachurus trachurus (LINNAEUS, 1758), (Figure 3b)

Otolith oval. With increasing length of fish some differences observed on appearance of otolith. In some fishes ($TL > 11$ cm) otolith pointed posteriorly. Antirostrum folded back towards medial surface and excisura ostii sharp. In smaller individuals posterior tip rounded, antirostrum and excisura ostii absent. Sulcus acusticus deep. Ostium having V-shaped intrusion into cauda. Posterior part of cauda slightly bent towards edge of otolith. Cristae well developed. Dorsal area extending to antirostrum and connected to edge on dorsal side. Otolith concave laterally and convex medially. Edge roughly lobed ($TL > 11$ cm) or thinly and highly lobed ($TL < 11$ cm).

Morphometric characters:

$n = 12$

$OL : TL = 1 : 32.59 \pm 2.48$

$OL : OB : OD = 1 : 0.54 \pm 0.03 : 0.17 \pm 0.01$

DISCUSSION

The similar study in the Eastern Mediterranean was done on the family *Sparidae* Akkiran (unpubl. data). In this fish family the general appearances of the otoliths are similar to each others in a varying degree therefore identification of the species employing their otoliths are with some difficulties, yet possible. In the family *Carangidae* the otoliths have specific shapes and features, so the investigated species are easyly identified from the otolith characters.

In *Carangidae*, the differences in the otolith characters in the same genus are even very noticeable. In the genus *Caranx*, the most noticeable difference

between the otoliths is observed in the general shape; It is elongated in *Caranx cryses*, parallelogram in *Caranx dentex* and oval in *Caranx rhonchus*. The shape and the structure of the sulcus acusticus are important characters in the distinguishing of the otoliths; In *Caranx crysos* the ostium has the V-shape intrusion into the cauda, in *Carnax dentex* the anterior section of the sulcus acusticus is slightly expanded and the cauda has the cave like formation on its ventral side. In *Caranx rhonchus* the ostium-cauda interface has the pit like formation. It is also neccessary to consider the shape of the dorsal area; In *Caranx crysos* it extends to the base of the antirostrum. In *Caranx dentex* it is undulated and both its anterior and posterior parts are unclosed. In *Caranx rhonchus* the dorsal area is rather broad and it terminates before reaching the edge near the antirostrum.

The otoliths of *Caranx rhonchus* and *Trachurus trachurus* are the most similar ones in the general shape, although these belong to different genera. As stated by Jurkschat (1977) for the freshwater fishes of the Northern Germany, the otoliths of the young individual expose more or less uncertain characters and as the fishes grow up some of the structures undergo variations. *Trachurus trachurus* exposse most variations with the increasing the total length of the fish between the examined species. In spite of the variations, the general shape of the otolith resembles that of *Caranx rhonchus*. In both species the otolith is oval in shape, but there are certain differences between them. In *Caranx rhonchus* the dorsal area terminates before reaching the edge on the antirostrum. In *Trachurus trachurus* it extends to the antirostrum and is connected to the edge on the dorsal side of the otolith. The sulcus acusticus exposes different characters in the both species; The posterior section of the cauda is slightly bent towards the posterioventral side of the otolith and the ostium has the V-shape intrusion into the cauda in *Trachurus trachurus*. In *Caranx rhonchus* the curvature of the cauda is stronger than that of the preceding species. The ostium is like a pit on the ostium-cauda interface. In the otoliths of the large individuals of *Trachurus trachurus* the antirostrum is folded back towards the medial surface. This character is not observed in the otolith of *Caranx rhonchus*. The morphometric characters are also different in the two species. These characters were given by Schmidth (1968) as follows: for *Caranx rhonchus* from Gulf of Guinea:

OL : TL = 1 : 37.00

OL : OB : OD = 1 : 0.51 : 0.15

for *Trachurus trachurus* from North sea:

OL : TL = 1 : 30.00

OL : OB : OD = 1 : 0.45 : 0.15

CONCLUSION

The otolith characters of the nine species belonging to seven genera in the family *Carangidae* were employed in the systematics point of view. The detailed descriptions and the figures of the otoliths were given. These are supplemented with the morphometric characters of the otoliths. To provide the reliability of the morphometric characters the large number of the otoliths

should be used. In this research it was attempted to collect the otoliths from the each centimeter group of the fishes, however for some species only one otolith was obtained.

In summary, it is possible to identify the species of the family *Carangidae* from the otolith characters easily.

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SISTEMATSKI PRISTUP IZUČAVANJU PORODICE *CARANGIDAE* IZ ISTOČNOG MEDITERANA NA OSNOVU KARAKTERISTIKA OTOLITA

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KRATKI SADRŽAJ

Devet vrsta sedam različitih rodova porodice *Carangidae* iz južnoistočnog obalnog područja Anatolije, izučavane su sa stajališta sistematike na osnovu karakteristika otolita. Otoliti svake pojedine vrste detaljno su opasni i prikazani na slikama. Mjerene su morfometrijske karakteristike za koje su određene granice pouzdanosti od 95% ukoliko je riba potjecala iz uzorka s najmanje tri primjerka. Determinacija pojedinih vrsta bila je u mnogome olakšana činjenicom da svaka vrsta pokazuje određene specifičnosti otolita.

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