Comparative Morphology of the Otolith of Carangids species in the Persian Gulf and Oman Sea

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The otolith morphology of 10 species belonging to the Carangidae family collected from the Persian Gulf and Oman Sea (coast of Iran). Were examined separately and the characteristics were drawn. The morphomttric parameters determined were total length (TL, mm), weight (W, gr), otolith length (OL, mm), weight of right otolith(WRO, mm), weight of left otolith(WLO, mm), height of right otolith (HRO, mm), height of left otolith (HLO, mm),. The values obtained from measurements are given in the 90% confidence interval in most spesies. The observation of this family three shape of sagittal, Sagitiform, Fusiform and Lanceolated. As a result of this analysis, it is possible to identify the species from the Carangidae family by the otolith characters.

Key words: Otolith, Morphology, Sagitta, Carangidae, Persian Gulf, Oman Sea.

Otoliths are acellular concretions of calcium carbonate and other inorganic salts, witch develop over a protein matrix in the inner ear of vertebrates, in close association with the sensitive maculae of labyrinthic compartments (Weichert and Prech 1981; Hildebrand, 1988; Jobling, 1995). Otoliths are enclosed in three compartments linked with the ear in teleost fishes (Popper et al, 2005). The labyrinth includes three semicircular canals oriented in different planes and three compartments: the utriculus, sacculus and lagena. Each compartment contains otoliths (earbones or earstones), the lapillus, sagitta,and asteriscus (Berra &Aday,2004).The sacular otolith (sagitta) is the largest and the utricular otolith (lapillus) is the smallest among the three (Paxton, 2000) at least in most teleost families (Schulzmirbach and Reichenbacher, 2006). Although the morphological features of otoliths are highly variable between species, ranging from the relatively simple disc shape of some flat fishes (Pleuronectidae) to the irregular shape of others, a high level of species specificity has, for along time, been used to achieve various taxonomic objective (Hecth, 1987; Hunt, 1992).

Otoliths have an important biological function because they enable the inner ear to mediate the senses of hearing and balance (Popper et al, 2005). Otoliths growth is related to increase in size of the fish and generally follows and allometric increase in dimensions (Chilton and Beanish, 1982).

In addation to the use of otoliths for estimating age of fish, they may also be used to characterize stock specific differences or to interpolate size at age based on some relation between otolith and fish dimension (Hunt, 1992).Numerous studies have been undertaken to estimate size at some earlier age (back-calculation) based on relationships between otolith dimension and fish size.

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Otoliths of each species of fish have characteristic shapes and features and given adequate comparative material or appropriate keys, identification to species can usually be done provided that the otoliths are not broken or badly digested. The fact that otoliths persist in the stomach, intestines, or feces after after soft parts and bones have disappeared increases their utility.

In the present work, an attempt was made to describe the otolith morphological characters of the family Carangidae collected mainly from Persian Gulf and Oman Sea. There is no work or record that deals solely with the otoliths of carangidae in Persian Gulf and Oman Sea. The aim of this study was to provide new information regarding otolith morphology and body size relationships of 10 species of carangidae.

MATERIAL AND METHODS

The otolith of 10 species of Persian Gulf and Oman Sea carangidae were examined. The number of observations on each species and range in fish lengths is given in table 1. The total length and body weight in fishes were measured.

Table 1. Sample sizes of 10 carangid species in the Persian Gulf and Oman Sea

Species	N	Standard length range (mm)	Mean Standard length (mm)	Weight range (gr)	Mean weight (gr)
Parastromateus niger	59	130-370	173.02±64.67	98-2051	320.14±507.54
Alectis indicus	30	155-490	319.67±79.14	147.24-2000	819.53±383.73
Uraspis helvola	30	145-290	185.43±36.62	109.67-287.67	194.40±50.37
Atropus atropus	42	140-200	160.14±16.14	94.46-260.4	153.32±45.29
Megalaspis cordyla	26	260-380	292.50±39.93	263.12-673.07	359.99±146.28
Scomberoides commersonnianus	29	292-425	334.10±28.84	205.73-777.27	518.20±127.84
Caranx papuensis	27	152-245	176.33±17.11	95.57-388.14	167.68±52.58
Aleps djedaba	64	155-190	169.56±9.49	76.2-165.35	112.05±18.61
Carangoides chrysophrys	32	153-362	195.69±42.13	97.27-544.45	214.98±111.00
Carangoides armatus	30	143-235	186.93±18.23	126.76-555.26	282.15±78.91

Table 2. Shape of otolith and different mode opening and kinds of denticulate

Species	Sagittal forms	Mode oppening	Mode position	Kinds of Ventral margin denticulate	Kkinds of Dorsal margin denticulate
Parastromateus niger	Fusiform	Ostial	Supramedian	Crenate	Irregular
Alectis indicus	Sagitiform	Ostial	Supramedian	Irregular, Dentate,Crenate	Irregular, Dentate, Crenate
Uraspis helvola	Sagitiform	Ostial	Median	Crenate, Entire	Entire,Crenate, Irregular
Atropus atropus	Fusiform	Ostial	Supramedian	Crenate	Irregular, Crenate
Megalaspis cordyla	Lanceolated	Ostial	Median	Crenate	Dentate
Scomberoides commersonnianus	Sagitiform	Ostial	Median	Crenate, Dentate	Irregular, Dentate
Caranx papuensis	Fusiform	Ostial	Supramedian	Crenate	Sinuate
Aleps djedaba	Fusiform	Ostial	Median	Sinuate,Crenate	Sinuate,Crenate
Carangoides chrysophrys	Fusiform	Ostial	Median	Crenate	Crenate, Sinuate
Carangoides armatus	Fusiform	Ostial	Median	Crenate	Sinuate, Crenate

Fish were caught in the Persian Gulf and Oman Sea by trawling ship. The total length and weight, for each fish were determined. Only sagittal otoliths were extracted from fresh specimens. These otoliths are located on the two sides of basioccipital bone and are separated by a thin septum arising from the mid ventral ridge of the occipital (Ruck, 1976). The otoliths were removed by turning the ventral side of the fish upward to allow removal of the lower jaw, the gills and the hypobranchial apparatus and to expose the base of skull. With a sharp scalpel, the optic capsules were separated and the otoliths gently removed with a pair of fine tweezers. Later, the otoliths were cleaned with 70% ethanol and stored dry in small glass tube.

Length (OL), defined as the longest dimension between the anterior and posterior edges of the otolith, and Otolith Height (OH) as the dimension from the dorsal to ventral edge, and Antirostrum Length of Otolith (LARO), and Antirostrum Height of Otolith (HARO), and Rostrum Length of Otolith(LRO),and Rostrum Height of Otolith(HRO)(Fig. 1).

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Table 3. Differences between right and left otolith of 10 carangid species from the Persian Gulf and Oman Sea. (OL) otolith length, (OW) otolith weight, (OH) otolith height (N=number of right otolith + left otolith)

Species	N	Parameter	t	Df	P (a=0.05)
Parastromateus niger	118	OL	4.05	117	0.31
		OW	1.005		0.02
		OH	1.564		0.29
Alectis indicus	58	OL	2.564	57	0.16
		OW	0.458		0.21
		OH	0.254		0.02
Uraspis helvola	52	OL	4.564	51	0.32
		OW	0.564		0.32
		OH	0.458		0.01
Atropus atropus	62	OL	3.154	61	0.14
		OW	0.642		0.12
		OH	0.304		0.10
Megalaspis cordyla	54	OL	3.256	53	0.26
		OW	0.986		0.01
		OH	1.542		0.10
Scomberoides commersonnianus	60	OL	4.293	59	0.26
		OW	0.237		0.25
		OH	1.569		0.14
Caranx papuensis	60	OL	3.045	59	0.00
		OW	1.084		0.10
		OH	0.987		0.25
Aleps djedaba	84	OL	6.254	83	0.14
		OW	2.356		0.10
		OH	0.897		0.14
Carangoides chrysophrys	128	OL	2.564	127	0.02
		OW	0.804		0.16
		OH	3.042		0.12
Carangoides armatus	60	OL	2.609	59	0.29
		OW	1.015		0.04
		OH	0.458		0.21

Table 4. Relationship between otolith morphometric parameters and Total length (TL). Coefficient of determination (R). OL: otolith length, OW: otolith height and O width. All regressions were statistically significant at P< 0.05

Species	N	OL(R). TL	R	O Weight(R). TL	R	O height(R). TL	R
Parastromateus niger	59	TL=0.1213OL + 2.8803	0.8032	$W=0.00000005\ TL^{1.4096}$	0.9158	TL = 0.042 W + 1.4562	0.759
Alectis indicus	29	TL =0.0804OL+ 3.0699	0.3122	$W = 0.00005\ TL^{1.654}$	0.9643	TL=0.0309 W + 0.8184	0.3475
Uraspis helvola	26	TL=0.1739OL+ 0.2737	0.8716	$W = 0.00016\ TL^{1.554}$	0.9784	TL=0.0708 W + 0.8474	0.4586
Atropus atropus	31	TL=0.0872OL + 3.2685	0.519	$W = 0.000042\ TL^{1.454}$	0.9452	TL=0.0658 W + 0.8478	0.658
Megalaspis cordyla	27	TL=0.1302OL + 2.2424	0.3793	$W = 0.000047\ TL^{1.524}$	0.9684	TL=0.0356 W + 0.8564	0.7458
Scomberoides commersonnianus	30	TL=0.1934OL + 0.8034	0.6513	$W = 0.00034\ TL^{1.425}$	0.9584	TL=0.0547 W + 0.8147	0.458
Caranx papuensis	30	TL=0.167 OL + 0.6618	0.8788	$W = 0.000095\ TL^{1.475}$	0.8874	TL=0.0987 W + 0.8478	0.652
Aleps djedaba	42	TL=0.1327OL + 1.1423	0.5646	$W = 0.00042\ TL^{1.356}$	0.9025	TL=0.0487 W + 0.8256	0.485
Carangoides chrysophrys	64	TL = 0.112OL+ 2.3253	0.3684	$W = 0.00036\ TL^{1.428}$	0.9741	TL=0.0358 W + 0.8745	0.6857
Carangoides armatus	30	TL=0.1228 OL+ 1.5073	0.8538	$W = 0.000084\ TL^{1.358}$	0.9857	TL=0.0458 W + 0.8658	0.3284
Parastromateus niger	59	TL=0.1233OL + 2.8608	0.8188	$W = 0.0000008\ TL^{1.3046}$	0.9058	TL = 0.061 W + 1.2652	0.8171
Alectis indicus	29	TL=0.0824OL + 3.0879	0.3022	$W = 0.00018\ TL^{1.589}$	0.9433	TL=0.0819 W + 0.8354	0.3547
Uraspis helvola	26	TL=0.1439 OL+ 0.2537	0.8416	$W = 0.00016\ TL^{1.487}$	0.9844	TL=0.0678 W + 0.8474	0.4458
Atropus atropus	31	TL=0.1042OL + 3.2245	0.6014	$W = 0.000027\ TL^{1.467}$	0.9012	TL=0.0988 W + 0.8475	0.6141
Megalaspis cordyla	27	TL=0.1812 OL+ 2.1725	0.3283	$W = 0.000057\ TL^{1.547}$	0.9648	TL=0.0428 W + 0.8624	0.7464
Scomberoides commersonnianus	30	TL =0.2134OL+ 0.9434	0.6054	$W = 0.00041\ TL^{1.414}$	0.9628	TL=0.0604 W + 0.8247	0.4628
Caranx papuensis	30	TL=0.185 OL + 0.6485	0.8958	$W = 0.000091\ TL^{1.423}$	0.8947	TL=0.0969 W + 0.8592	0.7014
Aleps djedaba	42	TL=0.1542OL + 1.1628	0.5847	$W = 0.00043\ TL^{1.361}$	0.9104	TL =0.04684W+ 0.8256	0.4924
Carangoides chrysophrys	64	TL =0.1042OL+ 2.3451	0.3617	$W = 0.00034\ TL^{1.431}$	0.9801	TL = 0.0406W+ 0.8799	0.6918
Carangoides armatus	30	TL=0.1087OL + 1.5847	0.8478	$W = 0.000087\ TL^{1.362}$	0.9804	TL=0.04628W + 0.9014	0.3452

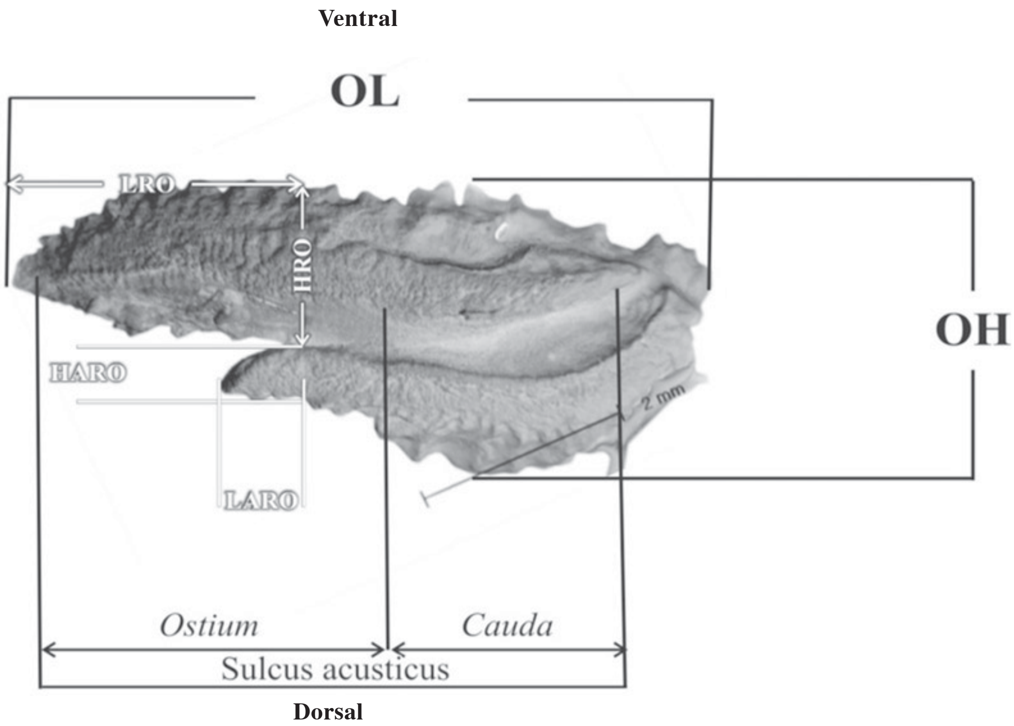

Fig. 1: Otolith morphometric viewed on a sagittal otolith in *Parastromateus niger*

The sagittal otolith of each species, both left and right, photographs taken by scaning electron microscope (Philips XL30). The significance of the variance one way (ANOVA) relationships between otolith and fish length and fish weight. Difference between right and left sagittae were tested using a paired t-test. The following morphometric relationships were analyzed.

RESULTS

All parameter measured show significant morphometric between left and right otolith, (Table 2). The shape of the otolith in carangidae was different and can be classified into three types: fusiform, sagitiform, lanceolate and variable of margin in otolith were determined (Table 2).

The relationships of otolith length and otolith weight with fish length and fish weight in all species was observed. Generally, standard length of fishes is linearly related to otolith length. Otolith length typically is linearly related to length of fish until the fish reaches maximum size; thereafter, the otolith increase only in thickness.

Analyses of otolith morphometric parameters vs.TL in the some species were showed high correlation and the some species were showed less correlation (Table 4). The relationship between fish OW and total length, the coefficient of determination being higher than 0.88 in all species (Table 4).

DISCUSSION

The present investigation has shown that the specific morphology of the otolith can used the taxonomy and identification in carangidae. All equations relating otolith length with fish size proportion of the variance in the all species.

Otoliths of each species of fish have characteristic shapes and features and given adequate comparative material or appropriate keys, identification to species can usually be done provided that the otoliths are not broken or badly digested(Frost, 1981).

Relationship between otolith morphometric parameters and fish total length and weight for carangidae species studied were observed. Generally, total length of ûshes is linearly related to otolith length. Otolith length typically is linearly related to length of the all species examined (Table 4). Newman (2002) and Mosegaard & Reeves (2001) have recorded a linear relationship for both the total body length and weight and otolith weight. Al Dubakel in 2006 reported the relationships between both fish body size versus weight of the oto lith, eye lens and liver were studied in *Acanthopagrus latus Therapon theraps*, and *Pelates quadrilineatus* collected from the Khor Al-Zubair area, Iraq

Otolith lengths of larval and juvenile ûshes may increase in a curvilinear fashion relative to ûsh length for some species, such as sockeye salmon (*Oncorhynchus nerka* ; West and Larkin, 1987) . The relationship between otolith length and ûsh length may be dependent on the growth rate of the ûsh, as was reported for striped bass (*Morone saxatilis*; Secor and Dean, 1989).Similar results have been reported for many fish species(Jawad, 2007; Hunt, 1992; Volpedo et al, 2006).

Studies of sagitta otolith morphometric parameter in all species of carangidae in research significantly between right and left otolith and different in size, similar to in a rockfish species left and right sagitta also may differ in size (Wyllie, 1987).Although in 8 species of Atlantic Ocean fishes were carried out and were not significantly different between left and right otolith (Hunt, 1992). Investigation of sagitta otolith morphometric parameter in 4 species of sciaenidae did not show significant morphometric differences between left and right otoliths, only otolith width in white mouth croaker and otolith length in king weakfish showed significant differences between left and right otoliths (Waessle et al., 2003).

Analyzing the morphometric relationships, we concluded that otolith length and otolith weight are indicators of fish total length and fish weight in all species. In most species otolith length and fish length the potential regression explained more than 90% variation and in most species otolith weight and fish weight 90% variation. Baldas et al (1997) described the relationship between otolith length and fish total length by using potential models in stripped weakfish (50-600mmTL) and linear models in Whitemouth croaker (140-370mm TL). Also Waessle et al (2003) observed similar to results in juvenile sciaenidae.

Otolith growth is generally thought to uncouple from somatic growth at a very early age (Munk and smikrud, 2001). A variety of factors influence the degree or timing of this uncoupling (Moksness et al, 1995).

In this study has shown that the specific morphology of the otoliths examined can be used for taxonomic identification of carangidae species. The observation of this family three shape of sagittal, Sagitiform, Fusiform and Lanceolated (Table 2).

The analysis between left and right otolith showed morphometric difference. Sagitta is the best otolith to recognize in carangidae.

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