

Investigation of otolith's characteristics in *Rachycentron canadum* in the Persian Gulf and Oman Sea

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Abstract

This study aimed to investigate otolith in *Rachycentron canadum* in the Persian Gulf and Oman Sea. Sampling lasted from March 2014 to April 2015 in Khuzestan to Sistan and Baloochestan waters. During this period 30 specimens of *R. canadum* were caught and studied. Trawling time was 2-2½ hours and trawling depth was considered as 10-100 m daily. All the fish were identified and their otolith was extracted for verification. Investigation of otolith morphometric characteristics (length, breadth, weight, perimeter and area) were conducted. Otolith in *R. canadum* was small, with average stretch and low thickness. We conclude that the otolith appearance and morphometry can be used as a key to identify the species.

Keywords: Otolith, *Rachycentron canadum*, Persian Gulf, Oman Sea

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Introduction

Inner ear of bony fish is made up of bony and vestibular labyrinth. Vestibular labyrinth distinctively consists of three more or less separated chambers (utricle, saccule, and lagena) and three semicircular canals or ducts. Utricle and ducts form the upper extremities and saccule and lagena form the lower ones. Saccule is connected to utricle from ventral surface and lagena which is attached to the posterior part of saccule is well recognized, but in some species it is not possible to identify it. In all three sectors mentioned above, there are beds of neuromast cells on which otoliths are placed. Otoliths which are available in utricle, saccule, and lagena chambers are called Lapillus, Sagitta, and Asteriscus respectively (Sattari, 2002). Otoliths are small calcified structures found in the heads of fish, which assist in detecting sound and are used for balance and orientation. All bony fish have three pairs of otoliths (Campana and Neilson 1985) Among the bony fish with three pairs of otoliths, Sagitta is the biggest one in most species and has the most morphological changes among the species which is basically used in determining age and size, classification, migration, and paleontology studies (Harvey *et al.*, 2000; Kinacigi *et al.*, 2000). Morphological characteristics of Sagitta are species-specific and most species can be identified by certain sagitta morphology (Hunt, 1992; Harvey *et al.*, 2000). Thus, the otoliths found by paleontologists from past geological

periods suggest that they are the best documents for systematic research on teleost fish (Harvey *et al.*, 2000; Kinacigi *et al.*, 2000). Moreover, the growth pattern of sagitta otoliths is used for species identification and recognition of different populations of a species because their growth is influenced not only by genetic factors but also by environmental factors such as seasonal changes, temperature, habitat, and food habits and thus investigating the effect of environmental factors on similar species by means of otolith is highly important in eco-morphological studies (Bermejo, 2007). For the fisheries biologist, the otolith is one of the most important tools for understanding the life of fish and fish populations. Today, different methods are used in identification and classification of fish. For example, in identifying the family, genus, species, and subspecies, the size and shape of otoliths are used as one of the safest classification methods. Considering the fact that no measures are taken in this regard so far by academic and scientific research centers, this research aimed to study otolith differences in *R. canadum*.

Materials and methods

In the present study, 30 specimens of *R. canadum* were provided covering March 2014 to April 2015. The samples were caught by F/V Kavian as a bottom trawler. Trawling period was 2-2½ hours and trawling depth was considered as 10-100 m. The study area included Khuzestan to Sistan and

Baloochestan Provinces. The area was classified into 17 strata respectively from west to east (A, B, C... Q). In each stratum, four depth layers as 10-20, 20-30, 30-50, and 50-100 m were identified and isolated, respectively (Fig. 1).

Biometry was done after choosing the species and each specimen was measured for total length (m), fork length (m), body weight (g), otolith length (mm) and otolith weight (g) and classified by the taxonomic classification according to Nelson (2006). Sagittal otoliths were removed from the skulls by the vertical cut method, cutting the back of the heads. Sagittal otoliths of these fish species are large so that they can be removed in a short time with a sharp fish knife. The thumb and forefinger were used to force the head of fish in the eye sockets. The knife blade forced down the skull directly over the operculum, the plane of cutting was a curved line $\frac{3}{4}$ of the way back on the gill flap. The blade was pushed down from the top through the skull. The left and right thumbs were used to separate the anterior part and posterior part of head, the skull and optic capsules were broken open and separated. The large pairs otolith (sagittal otoliths) then lay exposed inside the otic capsules. This area is well supplied with blood vessels so that they were removed with absorbent paper before extracting the sagittal otolith. The forceps were used to remove the largest pairs from the otic capsules, below the rear of the brain. After that, the sagittal otoliths were washed in

clean water to remove the otic fluid, gelatin, tissue and blood. Otoliths were allowed to air dry for 12-24 hours (Jitpukdee, 2009). Then, the turbid otoliths were washed by sodium 1% for two minutes and in order to prevent oxidation, the otoliths, based on their size, were placed in the small frames of solid paraffin which had earlier been thawed by heat until they got cold and solid. Finally, the otoliths were classified based on their shapes and their photographs were taken. Also, investigation of otolith morphometric characteristics (length, breadth, weight, perimeter and area) were conducted.

Results

Rachycentridae: Marine; Atlantic and Indo-Pacific. Body elongate, head depressed; 6-9 short free spines ahead of the long dorsal fin (1-3 spines and 26-33 soft rays); anal fin long, with two or three spines and 22-28 soft rays; three dark stripes on side of body; 25 vertebrae. Maximum length up to 1.5 m. One species, *R. canadum* (Nelson, 2006).

Class: Actinopterygii

Subclass: Neopterygii

Division: Teleostei

Order: Perciformes

Family: Rachycentridae

Genus: *Rachycentron*

Species: *R. canadum*

Thirty samples of *R. canadum* were studied; Fig. 2 and 3 illustrate each sample and its otolith.

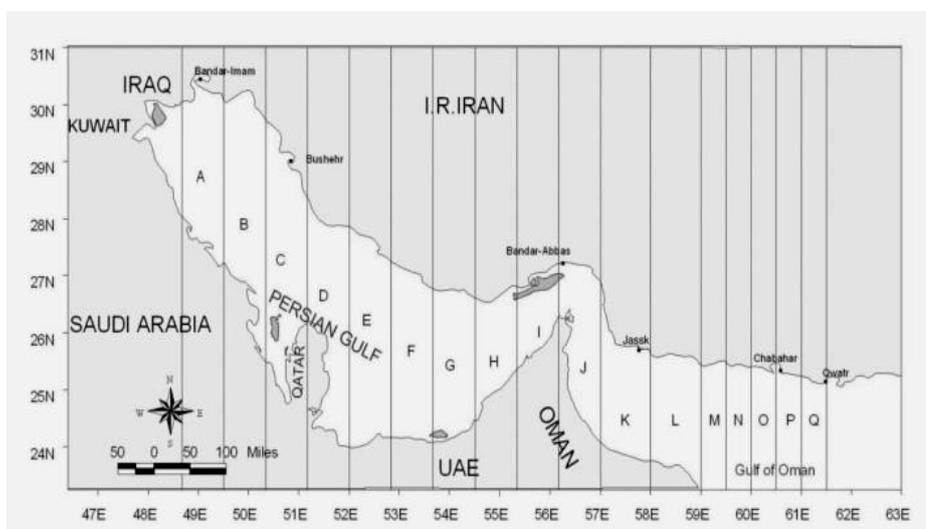


Figure 1: Study area in the Persian Gulf and Oman Sea.



Figure 2: *Rachycentron canadum*

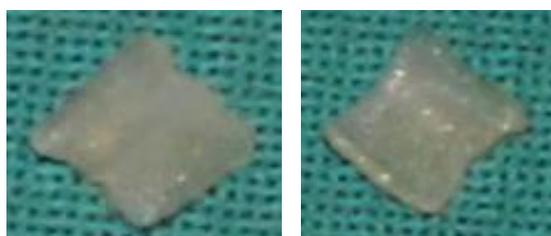


Figure 3: Proximal and distal surface of otoliths in *Rachycentron canadum*.

The samples characteristics such as the relationship between otolith length and weight, the relationship between fork length and otolith length, the relationship between fish length and weight and also the length range of the caught fish (cm) are shown in Table 1. Morphometric characteristics of *R. canadum* and otolith's parameters (such as: TL: Total Length, SL: Standard

Length, TW: Total Weight, ROL: Right Otolith Length, ROB: Right Otolith Breadth, ROD: Right Otolith Depth, ROW: Right Otolith Weight, LOL: Left Otolith Length, LOB: Left Otolith Breadth, LOD: Left Otolith Depth, LOW: Left Otolith Weight, OP: Perimeter and OS: Area) are shown in Table 2.

Table 1: The relationship between biometric characteristics of *R. canadum* and its otolith.

Relationship between otolith length and weight	$OW=8254*10^{-11}OL^{0.0245}$ ($R^2=0.8892$)
Relationship between fork length and otolith length	$FL= 4055x - 1.275$ ($R^2=0.8900$)
Relationship between fish length and weight	$W= 0.158 L^{1.5748}$ ($R^2=0.9304$)
length range of the caught fish (cm)	25-76

Table 2: Morphometric characteristics of *R. canadum* and its otolith.

Parameter	TL (cm)	SL (cm)	TW (g)	ROL (mm)	ROB (mm)	ROD (mm)	ROW (g)	LOL (mm)	LOB (mm)	LOD (mm)	LOW (g)	OP	OS
Max	76	73	2843	1.71	1.59	0.235	0.0016	1.63	1.61	0.241	0.0018	5.826528	3.53E-06
Min	25	23	950	0.56	0.52	0.077	0.0005	0.54	0.53	0.08	0.00059	5.826225	2.73E-07
Mean	58	52	1850	0.95	0.85	0.094	0.0008	0.76	0.85	0.186	0.00093	5.826276	8.14E-07
S.D.	7.2	6.5	153	0.05	0.02	0.006	0.00005	0.04	0.062	0.046	0.00006		

S.D: Standard deviation, Min: minimum, Max: maximum.

Discussion

Otoliths in fish have the same function as the inner ear in human beings. They contribute to both hearing sense and balance; therefore, aquatic animals that are skilful swimmers or those that float in water and swim very slowly or those that creep on the sea floor are expected to have different forms of otolith. For example, otoliths in pelagic bony fish such as Scombridae, Carangidae, and Istiophoridae which are fast swimmers are small while they are bigger in the fish which swim slowly or which are benthic like Sciaenidae, Serranidae, etc. (Parafkande Haghghi, 2008). As mentioned before, otolith in the fish is like otoconia in other vertebrae. Otoliths are bigger than otoconias and are very complicated and different in various species of fish in terms of form and size. Like otoliths, otoconias function to keep the balance. Usually, three pairs of otoliths are all different in the fish in place, size, shape, and structure. Otolith size is slightly bigger in the species

whose body structure is round such as Cod or Haddock. Flying fish also have big otoliths which are probably associated with their adaptation to maintain their balance when they come out of water. Pleuronechtiiformes have thinner otoliths. Generally, bigger sagittas in species and populations which have low somatic growth are called uncoupling. In this case, sagitta otolith's growth is independent of body's somatic growth. It should be noted that in some researches, the results were different from what was mentioned, that is individuals have been seen who grow more slowly but their Sagitta otolith is bigger than those who grow more quickly (Parafkande Haghghi, 2008). Of course, there are some reports about the impressive effect of growth rate on the shape of sagitta (Wilson, 1985). Most of the reports even those about some deep species indicate that faster growth could somewhat affect the otolith shape (Botha, 1971; Lombarte, 1992;

Lombarte and Lieonart, 1993;). *R. canadum* is a large epipelagic fish and the size of otolith is small, otolith's longitude is wide and otolith's thickness is thin. The shape of otolith was rectangular-lanceolated; margins: crenate, Sadighzadeh *et al.*(2012) obtained similar results on the otolith of *R. canadum*. However, in this study the results showed that variation in otoliths shape and size indicated their species features, All the epipelagic fish have very small otoliths in comparison to their bodies. The small otolith of epipelagic fish might be the result of one or several of the following factors. As mentioned before, otolith performance is in relation to hearing and contribution to keep the balance or perception; it seems like that smaller size of otoliths in this fish is related to their lack of need or their failure to recognize the sounds accurately due to high intensity of acoustic waves in the surface of the seas and the oceans. On the other hand, fish in rough seas might get the heavy otoliths to move in the saccule too much and cause problems for the fish. In fact, living in turbulent seas is a certain limiting factor for the fish with big otoliths. Another issue is that the detailed vision of the color of surface waters which are bright enough (lots of pelagic fish have big eyes) might be so important that would be preferred to the advantage of accurate hearing of the sound in calm waters. In addition, studies showed that the otoliths of most benthic fish are big or medium and some of them are very

thick (Sadighzadeh *et al.*, 2007), as mentioned in Campana and Neilson (1985) Large sagitta occur in non-ostariophysean fishes which have well developed hearing or in which communication is important such as Gadidae, Batrachoidida and Sciaenidae. Although speculative, the large size of saggita in deep sea fishes (e.g., Macrouridae and Ophidiidae) might be important in hearing. Since otoliths function in equilibrium and acceleration, it might be expected that different otolith morphologies should be expected for fish which drift, crawl and swim with varying speeds. Fast swimming pelagic fish (e.g., Istiophoridae, Scombridae, Carangidae) have otoliths greatly reduced in dimension and fish which are slower moving or benthic have larger otoliths (e.g., Megalopsidae, Serranidae, Sciaenidae, Gadidae, Centrarchidae). Otolith shape and dimension can also be related to geographic location, ocean depth and chemical and physical qualities of the environment (Campana and Neilson, 1985).

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References

Bermejo S., 2007. Fish age classification based on length,

- weight, sex and otolith morphological features. *Fisheries Research*, 84, 270-274.
- Botha L., 1971.** Growth and otolith morphology of the Cape Hakes *Merluccius capensis* Cast and *M. paradoxus* Franca. Investigation report division of sea fisheries of South Africa No. 97. Capetown. 32P.
- Campana S.E., and Neilson J.D., 1985.** Micro structure of fish otoliths. *Canadian Journal of fisheries and aquatic science*, 42, 1014-1032.
- Harvey T.J, Loughlin R.T, Perez A.M. and Oxman S.D., 2000.** Relationship between fish size and otolith length for 63 species of fishes from the Eastern North Pacific Ocean. NOAA Technical Report NMFS 150.
- Hunt J.J., 1992.** Morphological characteristics of otoliths for selected fish in the Northwest Atlantic. *Journal of Northwest Atlantic Fisheries Sciences*, 13, 63-75.
- Jitpukdee S., 2009.** Crystalline Structure of sagittal otoliths from 8 fish species in different habitats. *Journal of Microscopy Society of Thailand*, 23(1), 57-61.
- Kinacigil H.T, Akyol O., Metun G., and Saygl H., 2000.** A systematic study on the otolith characters of Sparidae (pisces) in the Bay of Izmir (Aegean Sea). *Turkish Journal Zoology*, 24, 357-364.
- Lombarte A., 1992.** Changes in otolith area: sensory area ratio with body size and depth. *Environmental Biology of Fishes*, 33, 405-410.
- Lombarte A. and Leonart J., 1993.** Otolith size changes related with body growth, habitat depth and body temperature. *Environmental Biology of Fishes*, 37, 297-306.
- Nelson, J.S., 2006.** Fishes of the world, 4th edn. John Wiley and Sons, Inc., Hoboken, NJ, 601P.
- Parafkandeh Haghghi, F., 2008.** Age determination in aquatic animals. Fisheries Research Organization Publications, Tehran. 139P.
- Sadighzadeh Z., Vosoghi G.h, Valinasab T. and Fatemi M.R., 2007.** Introduction to study of morphologic characters of otoliths of some economic pelagic fishes of Persian Gulf. *Journal of veterinary medicine (Sanandaj)*, 1(3), 1-10.
- Sadighzadeh Z., Tuset V.M., Dadpour M.R., Otero-Ferrer J.L. and Lombarte A., 2012.** Otolith atlas from the Persian Gulf and the Oman Sea fishes. Lap Lambert academic publishing, Deutschland, Germany.
- Sattari M., 2002.** Fish biology, anatomy, and physiology. Naghshe Mehr Publications, Tehran.
- Wilson RRJr., 1985.** Depth related changes in sagitta morphology in sex macrourid fishes of the Pacific and Atlantic Oceans. *Copeia* (4), 1011-1017.