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The Comparison of Sardinella sindensis Stock in Persian Gulf and Oman Sea through Form Analysis of Otoliths

Simin Safa[1*], Ehsan Kamrani[2], Alireza Salarzadeh[3] and Ali Salaripuri[4]

1- Simin Safa is a Graduate from Hormozgan University, Hormozgan, Iran
2- Kamrani, E is now a Lecturer at Department of Ecology, Hormozgan University, Iran
3- Alireza Salarzadeh is now an Assistant Professor in Department of Ecology, Hormozgan, Iran
4- Ali Salarpuri is now a Faculty Member in Persian Gulf and Oman Sea Ecological Research Institute, Hormozgan, Iran

***Corresponding author*:** Simin Safa

ABSTRACT: Sind sardinella *(Sardinella sindensis*) is one of the most important small pelagic species exploited by the Iranian fisheries from east (Jask) to West (Gorzeh). In order to study the discrimination of sind sardinella populations in three fishing grounds (Gorzeh, Qeshm and Jask) 360 specimens were collected during April-May 2011. After collecting otolith specimens, size and weight parameters including overall length, standard length,fork length, area and primeter were measured and registered. Otolith shape parameters such as roundness, elasticity, circularity and rectangularity were described and determined by using otolith size. The results of the present study indicated that size and weight parameters of left and right otolith showed no significant difference. Also, no significant differences were found between otolith shape parameters in both male and female samples. Discriminant function analysis was performed to examine the segregation of stocks as well as grouping /classification of similar locations / stations. The results demonstrated that the population of sind sardinella was not significantly different in three fishing grounds. Therefore, can be considered as the same stock However, the results of otolith analyses indicated that there was a significant difference in roundness indices in Qeshm and Gorzeh according to T-test. Besides.the ellipticity of otolith shape in Gorzeh is significantly different that from that of Qeshm and Jask(P<0/05). Also, discriminant function analysis among indices of otolith shape demonstrated that no difference was found between otolith indices in mentioned fishing grounds. It can be stated that sind sardinella population in Jask, Qeshm and Gorzeh belong to the same stock.

***Keywords*:** Sardinella sindensis, Otolith shape analysis, Oman Sea, Persian Gulf.

INTRODUCTION

The Comparison of Sardinella sindensis Stock in Persian Gulf and Oman Sea through Form Analysis of Otoliths Sardines are a large group of small fishes living near surface of the water. Annually, more than 20.000 tons of sardine is taken from different fisheries of Hormozgan Province (Salarpur, 2006). In this case, Sardinella sindensis is the most abundant specie of sardines in the province. This type of sardine constitutes 10 thousand of total 20.000 tons of sardines fished from the region (Eftekharnia, 2009). Developing the extent of fishing from current stock of fishes, especially in offshore waters, is one of the significant future projects for the region. The objective of present study is identification and differentiation of stocks of Sardinella sindensis in different areas and fisheries of Jask, Qeshm and Gorzeh.

Identification and differentiation of stock of each fish is one of the most significant principles of managing fish stocks. Because Sardinella sindensis is a surface-living and immigrating specie and it covers a wide expanse of eastern regions (in Jask) and western area (in Garzeh) of Hormozgan Province (Salarpur, 2006), identification and differentiation of stocks of this type of fish could contribute to management of fishing such stocks. Analysis of form

of otoliths is a significant means of studying the population of fishes (Burke, 2008). The otoliths register growth patterns of fishes. The age groups, population, age and growth of fishes could be daily and annually estimated through study of otoliths (Campana & Thorrod, 2001). Variation in the form of otoliths is a strong measure for differentiation between stocks and it could also be used for classification of fishes (Burke et al, 2008).
The objective of present study is differentiation between different stocks of Sardinella sindensis in different areas and fisheries of Jask, Gorzeh and Qeshm. Up to now, few studies on analysis of form of otoliths have been conducted worldwide.

Materials and Methods:

In the present study, three major fishers of sardines located in Hormozgan Province were selected as sampling stations. The fisheries are located in Jask Port (in Sea of Oman), Qeshm Island (in Hormuz Strait) and Garzeh (in Persian Gulf, figure 1). They are located in a longitudinal range of 52°56′ in West to 57°46′ in East of Hormozgan Province. In these regions, fishing is done through two-boat vessels of Persiner and Gelsardine.

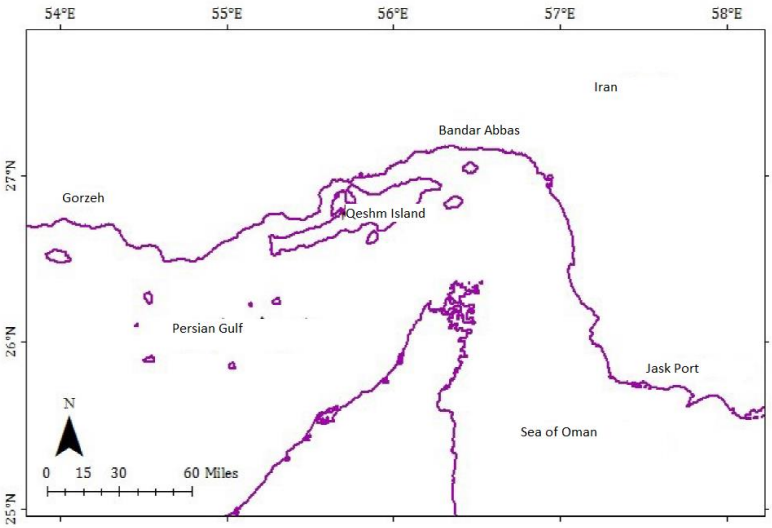

Figure 1. Sampling stations in waters of Hormozgan Province

In each station, 120 Sardinella sindensis fishes with mature lengths and sizes (with already formed otoliths) were selected and transferred to laboratory in frozen form. In laboratory, morphometric characteristics of each sample such as its weight (accuracy of 0.01g) and lengths of body parts (accuracy of 1mm) were measured. Then, sagittal otoliths of left and right sides of each fish should be removed precisely. After washing with distilled water, the samples should be dried and maintained in plastic tubes. Then, each otolith is weighted with accuracy of 0.00001 and its width and length were measured through an ocular micrometer with 1*u*m accuracy. In order to use the otolith in analysis of the form, the first step is placing the fissured part of each otolith downward or placing snout or rostrum of fish to the left. Then, a microscope connected to computer with 4x magnification imaged the samples (Bruke et al, 2008). Then, length, width, perimeter and area of each otolith were measured through Motic Software. On the other hand, the measures of form of otolith (i.e. round, rectangular, oval, and circular) and factor of form was calculated through equations represented in table 1 (Bruke et al, 2008).

Table 1. Calculation of Size and Form of Otolith of Sardinella Sindensis in Waters of Hormozgan Province (2011)

Size Parameters	Form Measures
Perimeter (A)	P/A^2 =(Circularity)
Area (P)	A/(FL*FW)=(Rectangularity)
Length of Otolith (FL)	$(4A)/(\pi FL^2)$ =(Roundness)
Weight of Otolith (FW)	(FL-FW)/(FL+FW) =(Ellipticity)
	$(4\pi A)/P^2$= (Form – Factor)

In the present study, study of length and weight associations such as fish length-otolith length, otolith length-otolith width, and otolith weight-fish weight are done through the linear expression y=ax+b. In the expression, y refers

to length and weight of otolith and x refers to length and weight of the body. In the present study, Kolmogorov-Smirnov test was used for normality test. In addition, t-test is used to determine the difference between factors of form and parameters of otolith size between different sexes and regions. In addition, differentiation analytical test was used to differentiate between existing populations of Jask, Qeshm and Gorzeh. In the present study, data processing was done through Excel Software. In addition, SPSS Software (version 16) was used to conduct statistical analysis.

Results:

In the present study, 362 fishes from three sampling regions (Qeshm: 119; Gorzeh: 120; Jask: 123) were biometrically measured and their otoliths were removed. The length of fishes in Gorzeh, Qeshm and Jask were 13.13±0.8, 14.01±0.6, and 14.41±1.8cm respectively. Since no significant differences were found between length and width of right and left otolith as well as weights of fishes ($P<0.05$), the right-side otolith was used in consequent calculations. The mean length of otolith recorded in Gorzeh, Qeshm, and Jask regions were 2.6125, 2.7265, and 2.809mm. In addition, the mean width of otolith recorded in Gorzeh, Qeshm, and Jask regions were 1.203, 1.228, and 1.266mm. On the other hand, the mean weights of otolith recorded in Gorzeh, Qeshm, and Jask regions were 0.00125, 0.00134, and 0.00150g (table 2). The normality test suggested that obtained data follow a normal curve. Therefore, the collected data could be used in discrimination test. In discrimination test, initial probabilities for the groups were determined through SPSS Software (table 3). On the other hand, classification of study groups through discrimination test suggested that 52.6 percent of all of the data is categorized into three groups of Gorzeh, Qeshm, and Jask (table 4) which is 25 percent higher than the values shown in table 3. Therefore, one may conclude that stocks are not significantly different from each other.

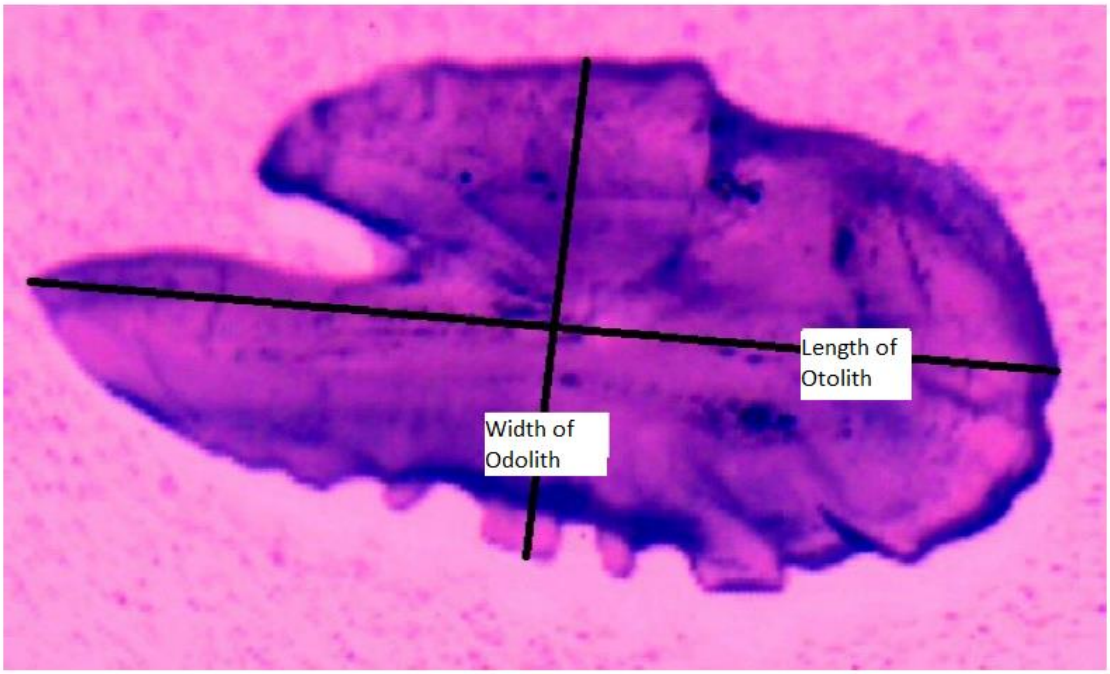

Figure 2. Length and width of odolith of Sardinella sindensis (determined through Motic Software)

Table 2. Statistical Specifications of Right-side Otolith of Sardinella sindensis in Sampling Areas (2010)

	Region	Number	Mean	SD	Standard Error
Length of Otolith (mm)	Gorzeh	73	2.6125	0.155	0.0115
	Qeshm	95	2.7265	0.143	0.014
	Jask	88	2.809	0.269	0.028
Width of Otolith (mm)	Gorzeh	73	1.203	0.080	0.090
	Qeshm	95	1.228	0.068	0.007
	Jask	88	1.266	0.122	0.013
Weight of Otolith (mm)	Gorzeh	74	0.00125	0.000291	0.000033
	Qeshm	98	0.00134	0.000206	0.000022
	Jask	90	0.00150	0.000407	0.000042

Table 3. Output of Discriminate Function Analysis Model for Representation of Initial Probabilities for Nodes

Region	Prior	Cases Used in Analysis	
		Unweighted	Weighted
Qeshm	.333	94	94.000
Gorzeh	.333	73	73.000
Jask	.333	86	86.000
Total	1.000	253	253.000

Table 4. Output of Discriminate Function Analysis Model for Classification of Study Regions

		CASE	Predicted Group Membership			Total
			Qeshm	Gorzeh	Jask	
Original	Count	Qeshm	41	24	29	94
		Gorzeh	12	48	13	73
		JASK	17	25	44	86
	%	Qeshm	43.6	25.5	30.9	100.0
		Gorzeh	16.4	65.8	17.8	100.0
		Jask	19.8	29.1	51.2	100.0

a. 52.6% of original grouped cases correctly classified

Discussion and Conclusion:

Changes in the form of otolith in different fishes might be due to effect of environmental conditions such as nutrition, temperature and genetic factors. For instance, Gauldie and Nelson (1990) concluded that fishes growing at a higher rate (due to any reason such as environmental or genetic factors) have thinner and longer crystals for development of otolith than fishes with less growth. The factor affects form of otolith. A logical reason of the effect is difference in form of otolith of wild and farmed population of cod which itself represents the effect of temperature and type of nutrition (Cardinale et al, 2004). Scientists concluded that difference in form of otolith could approximate genetic differences more closely than environmental differences because fishes that do not belong to a stock but are grown under identical environmental conditions such as temperature and type of food have different forms of otolith (Cardinale et al, 2004). In the case of using the analysis of form of otolith for decimation between populations, some factors that disrupt the analysis should be considered. For instance, certain factors such as sex, age and even size of fishes that affect form of otolith might change the interpretation of difference of otolith-related parameters in different regions (Cardinale et al, 2004). In the present study, no significant difference between left and right otolith in terms of weight and length was found ($P>0.05$). Homayoni (2009) studied the otolith of certain species of Clupeidae fish found in Persian Gulf and Sea of Oman. However, he found insignificant difference between parameters used for measurement of left and right otolith of S. sindensis. However, he found a significant difference between A. chacunda and N. nasus in terms of length of left and right otolith. Hunt (1992) studied morphometric characteristics of right and left sagittal otoliths in 8 species of Atlantic fishes and reported no significant difference between them. As Harvey et al (2000) suggested, the association between of right otolith and length of the fish with length of left otolith and length of fish in 63 species of Atlantic fishes was statistically insignificant. Waessle et al (2003) did not find a significant difference between width and length of left and right sagittal otolith, except for one specie. Burke et al (2008) conducted a study on discrimination of Clupeaharengus stock but found insignificant difference between left and right otolith. When significant difference between left and right otolith is not observed, one could use of these otoliths for analysis. In the present study, the right-side otolith was used. In regard to species that show a significant association between growth of otolith and growth of the fish, one could determine length and weight of fish based on length, width and/or weight of otolith as well as intensity of the association (Homayoni, 2009). Therefore, weight of otolith could a proper measure for determining the length of the fish. Homayoni (2009) conducted a study on morphological properties of fishes of Persian Gulf and Sea of Oman and found a significant correlation between parameters of length of otolith and length and weight of the fishes. As Homayoni suggested, length of otolith of S. sindensis is a proper indicator of standard length and weight of the fish. This is while weight of otolith is a more desirable indicator for S. gibbosa.

Waessle et al (2003) also observed a significant correlation between otolith-related parameters and length and weight of 6 species of Otolithes ruber. In different studies on the association of parameters of length and weight of otolith with length and weight of the fish, exponential, logarithmic and linear associations were used too. For instance, Casteel (1974) reported a significant logarithmic association between length of otolith and length of the fish for 4 species of Salmonidae. Mckren et al (1974) also suggested a linear and significant association between length of otolith and length of Engraulidae. Based on results of present study and similar studies, one may conclude that for most species there is a significant between length and/or weight of otolith and length and weight of the fish. This data could be used for determining weight and length of the fish as well as studies on nutritional habit of mammals and

seabirds (i.e. determining size and weight of caught fishes). In addition, it could be used for estimation of size of fishes the otolith fossils are available (Harvey et al, 2000).

It seems that although sizes of otoliths of a specie living in different study areas might be significantly different but size of otolith is not a proper factor for discrimination of the stock. This is due to two reasons. First, size of otolith is properly affected by type of sampling and its error (Dos Reis et al, 1990). Second, it seems that factors that draw upon multiple parameters concurrently show higher accuracy (Burke et al, 2008). In the present study, form-based indicators were used for differentiation of Sardinella sindensis stock found in three regions of Gorzeh, Qeshm and Jask. Based on results of present study, none of the form indicators determined for the three regions showed a significant difference. Therefore, one may conclude that Sardinella sindensis populations found in the three regions belong to a single stock. Petursdottir et al (2006) studied growth and shape of otolith for discrimination of egg-laying groups of adjacent Gadusmorhua specie. In the study, analysis of form of otolith is based on Fourier analysis. Their findings suggested that the groups found near the coast are significantly different from the groups caught in continental shelf.

Based on results of present study, it is hypothesized that the group living in continental shelf is a distinct stock. In the present study, the form-related indicators were used for discrimination of Sardinella sindensis stocks found in three regions of Gorzeh, Qeshm and Jask. Based on results of present study, none of the form-related indicators determined for the three regions showed significant difference. Therefore, one may conclude that Sardinella sindensis populations found in the three regions belong to an identical stock.

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