Short Scientific Article
Received: 2011-06-13

UDK 591.1:597.5(267.35)

THE RELATIONSHIP BETWEEN FISH LENGTH AND OTOLITH DIMENTIONS OF MUGILID FISH, *LIZA KLUZINGERI* (DAY, 1888) COLLECTED FROM THE PERSIAN GULF NEAR BANDAR ABBAS

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ABSTRACT

The relationships between otolith dimensions and fish size (total length and fork lengths) for the teleost species, Liza klunzingeri *(Day, 1888) collected from the vicinity of Bandar Abbas, Persian Gulf were examined and found to be linear. Otolith morphometric observations including length, width and weight were correlated with the total and fork lengths of the fish. The length, width and weight of the otolith appeared to be good criteria to estimate total and fork length of fish as well as the easiest parameters to measure.*

Keywords: otolith dimensions, fish length, *Liza klunzingeri*, Persian Gulf, Iran

RELAZIONE FRA LUNGHEZZA TOTALE E DIMENSIONI DELL'OTOLITE NEL MUGILIDE *LIZA KLUZINGERI* (DAY, 1888) CATTURATO NEL GOLFO PERSICO VICINO A BANDAR ABBAS

SINTESI

Le relazioni tra dimensioni di otoliti e taglia (lunghezza totale e lunghezza alla biforcazione) per la specie Liza klunzingeri *(Day, 1888), raccolta nelle vicinanze di Bandar Abbas, nel Golfo Persico, sono state esaminate e ritenute lineari. Le misurazioni morfometriche degli otoliti, inclusi lunghezza, larghezza e peso, sono state correlate con le lunghezze totali e le lunghezze alla biforcazione dei pesci. Lunghezza, larghezza e peso dell'otolite risultano essere buoni criteri di stima per la lunghezza totale e la lunghezza alla biforcazione, nonché i parametri più facili da misurare.*

Parole chiave: dimensioni otoliti, lunghezza totale del pesce, *Liza klunzingeri*, Golfo Persico, Iran

INTRODUCTION

In all bony fishes (Osteichthyes) there are three pairs of otoliths, or ear stones: the sagittae, asteriscus, and lapillus. Otoliths are mineral inert components made of calcium carbonate in the form of aragonite, in a protein matrix. They are located within the inner ear where they contribute to several physiological processes such as audition, mecano-reception and equilibration (Popper & Coombs, 1980) which allow fishes to achieve a better perception of their own environment. Except in Cypriniformes and Siluriformes, the sagittae are the largest pair of otoliths in most bony fishes (Paxton, 2000). Ichthyologists have used otoliths and in particular sagittae in registering the information of age, reproduction and migration (Morat *et al*., 2008). Otoliths are also involved in ecological studies (Campana, 2005), stock assessments (Tracey *et al*., 2006, Gonzalez-Salas & Lenfant, 2007), and determination of the diet of predatory fishes (Lilliendahl & Solmundsson, 2006).

The demonstration of the significant positive relationship between otolith size and fish size could go back seventy years ago with Trout (1954) and Templemann & Squires (1956), who attempted to study this relationship in the cod species *Borreogadus saida* and haddock *Melanogrammus aeglefinus*.

For most species, the relationship between otolith dimensions and fish length can be described by a simple linear regression. Otolith weight also has been correlated with fish length (Hunt, 1979; Lychakov *et al*., 2006).

Otolith dimensions and weight-fish length relationship studies have not been conducted for Iranian fishes. Thus, this information is needed for research on resources used by an early Iranian dietary analysis of fish eaters, and a reconstruction of ancient marine environments.

The aim of the present study is to provide data about the relationship between otolith size (length and width) and weight and fish length of the teleost fish, *Liza klunzingeri* collected from the vicinity of Bandar Abbas, Persian Gulf. The data offers a helpful tool for feeding studies and also gives support to palaeontologists in their investigation on fossils.

MATERIALS AND METHODS

Adult fish specimens were collected on 3rd July 2007 from the coastal waters of Bandar Abbas, Persian Gulf. All specimens were identified according to Randall (1995) and then they were examined for total length (TL) and fork length (FL) to the nearest millimetre. The total number of sagittae used in this research was 92 with three replicates for each length size. Sagittae were removed through a cut in the cranium to expose them and then cleaned and stored dry in glass vials. The left and right otoliths were measured using digital callipers and recorded separately. Specimens with obvious evidence of calcite crystallization (Strong *et al*., 1986) or other aberrant formations were rejected. Each sagittae, systematically placed with the sulcus acusticus oriented through the observer and its length and width were determined using digital callipers and defined as the longest and widest dimensions between the rostrum and postrostrum axis respectively (nomenclature of Smale *et al*., 1995) and width as the dimensions from the dorsal to ventral edge taken at right angles to the length through the focus of the otolith. Individual otolith mass was determined to the nearest milligram using an electronic weigh scale. The relationship between otolith length, width, weight and fish lengths (TL and FL) were determined using least squares regression analysis.

RESULTS

The range of the total and fork lengths of the specimens used in this study was 121-178 mm, and 111-167 mm respectively with a mean of 152.1, 117.6 mm respectively. The fish lengths available for the species in question were those observed in commercial fisheries

Tab. 1: Results of the regression analysis of the difference between left and right otolith dimension on total length and fork lengths of *L. klunzingeri*.
Tab. 1: Regresija razlike med merami levega in desnega otolita ter celotno dolžino in dolžino do repne zajede pri vrsti *L. klunzingeri*.

Parameter	Intercept	Slope	Correlation	Significance
Total length				
Otolith Length	15.215	0.228	0.001	not significant
Otolith Width	15.208	0.881	0.005	not significant
Otolith Weight	15.167	141.72	0.008	not significant
Fork Length				
Otolith Length	13.996	0.342	0.004	not significant
Otolith Width	14.019	0.884	0.006	not significant
Otolith Weight	13.965	126.99	0.007	not significant

and research surveys but the extremes of length ranges were under-sampled.

Regression of the difference between left and right otolith on fish total length indicated slopes not significantly different from zero with 0.001, 0.005, 0.008 correlations for length, width and weight respectively. Correlations not significantly different from zero were also obtained for the regression of the difference between the left and right otolith on fork length with 0.001, 0.006, 0.007 correlation for otolith length, width and weight respectively. Results of regression analysis are given in Table 1. The range in observed values for otolith length, width and weight of the species in question are 4.5-6.7 mm, 2.1-3.30 mm and 0.007-0.013g respectively.

A linear regression model was used to determine the relationship between the fish total and fork lengths and the sagittae dimensions used in the present study. For both fish total length and fork length, the otolith weight regression model appeared to adequately describe this relationship with both high correlation and significant estimates for slopes and intercepts (Tab. 2).

DISCUSSION

Paxton (2000) recognised an arbitrarily otolith size range. In this range, he suggested that a small to moderate otolith has a range of 2-5 % SL. The results of the present study showed that the otolith of *Liza klunzingeri* has a size ranging between 4.9-5.0 of % SL which falls near the top upper limit of the small to moderate otolith category from Paxton (2000). The species in question is a benthic species, living in shallow areas (Froese & Pauly, 2010). It has moderate sized eyes as well as moderate sized otoliths with a strong sense of hearing. Lombarte & Cruz (2007) suggested that the importance of acoustic communication is correlated with a moderate to large otolith size in a benthic environment in order to compensate for the reduction of light with depth. Therefore, it might not possible to separate the evolutionary history completely from the habitat (Paxton, 2000), as evidenced from the taxonomic grouping of the species of the fish families.

Results indicated that otolith linear dimensions and weight were related to fish length by a linear regression model and the increases in linear dimensions and weight appeared to keep pace with increases in fish length. These results agree with those of Hunt (1979) on several species collected from Northwest Atlantic Ocean and several other authors (Harvey *et al.*, 2000; Morat *et al.*, 2008). This linear relationship will continue until the fish reaches a maximum size; thereafter the otolith increases only in thickness (Aydin *et al.*, 2004). However, the level of this correlation also depends on some other factors such as feeding and habitat conditions (Beamish & McFarlen, 1987; Geldiay & Balik, 1996).

The lack of significant difference between the left and right otolith is consistent with the observation that the otolith pair are mirror images of each other (Hunt, 1979).

A relationship between otolith dimension and fish length has been used in identifying prey size from stomach content samples (Ross, 2005). Harkonen (1986) discusses some of the problems associated with this technique. Unlike other authors (*e.g.*, Hunt, 1979), results of this study suggested that otolith dimensions and weight are considered the most appropriate for this task.

Ross (2005) has stated some sources of error in the estimation of fish size from otolith size and has suggested they should be recognized. The linear otolith-length

***Tab. 2: Results of the regression analysis of total length, fork and standard length** vs. **otolith dimensions of** L. klunzingeri.*
***Tab. 2: Regresija med celotno dolžino, dolžino do repne zajede in standardne dolžine in merami otolitov pri vrsti** L. klunzingeri.*

Parameter	Intercept	Slope	Correlation
Total length			
Otolith length	5.363	1.728	0.453
Otolith width	6.411	3.353	0.418
Otolith weight	12.976	156.07	0.506
Fork length			
Otolith length	4.349	1.694	0.456
Otolith width	5.206	3.352	0.437
Otolith weight	11.724	159.2	0.551
Standard length			
Otolith length	4.979	1.189	0.386
Otolith width	5.776	2.280	0.347
Otolith weight	10.281	103.310	0.399

to fish-length relationship may depend on the growth rate in some species (Secor & Dean, 1989; Mugiua & Tanaka, 1992) or become curvilinear in some larval or juvenile fishes (West & Larkin, 1987). Alternatively, the linear relation may change at intervals relative to fish size (Frost & Lowry, 1981) or ontogenetic stage (Hare & Cowen, 1995) in some species. Thus, extrapolation may lead to significant error in the estimation of fish size, although most of these error sources were identified from larval or early juvenile fishes. Erosion of the otolith recovered from faeces or regurgitated digestive pellets might add additional biases to the process of fish length estimation (Ross & Johnson, 2000).

Fish size versus otolith size relationships will be useful for researchers examining food habits of fish eaters and size of fish in archaeological samples. Many more species and sizes of fish should be sampled to cover the full ranges of fishes involved in these studies.

RAZMERJE MED DOLŽINO RIBE IN MERAMI OTOLITOV PRI CIPLJU VRSTE *LIZA KLUZINGERI* (DAY, 1888), ULOVLJENEM V PERZIJSKEM ZALIVU BLIZU BANDAR ABBASA

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POVZETEK

V članku smo preučili razmerje med merami otolitov in velikostjo ribe (celotno dolžino in dolžino do repne zajede) pri ribi kostnici Liza klunzingeri *(Day, 1888), ulovljeni v bližini Bandar Abbasa v Perzijskem zalivu, in ugotovili, da je linearno. Rezultati morfometričnih meritev dolžine, širine in teže otolitov so v korelaciji s celotno dolžino in z dolžino do repne zajede. Ugotovili smo, da so dolžina, širina in teža otolitov dobri kriteriji za oceno celotne dolžine in dolžine do repne zajede ter da so to parametri, ki jih je najlaže izmeriti.*

Ključne besede: mere otolitov, dolžina ribe, *Liza klunzingeri*, Perzijski zaliv, Iran

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