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Fish length-otolith size and weight relationships of the *Otolithes ruber* (Bloch & Schneider, 1801) collected from the marine waters of Iraq, Persian Gulf

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Abstract: Relationships between fish length and otolith length, width and weight were analysed in the tigertooth croaker *Otolithes ruber* (Sciaenidae) collected in the marine waters of Iraq, Persian Gulf. The relationships between otolith length-fish total length (TL), otolith weight-TL, and otolith width-TL were analysed by means of non-linear models. This study represents the first reference available on the relationship of fish size and otolith size and weight for *O. ruber* in the investigated area.

Résumé : *Relations entre la taille et le poids des otolithes et la longueur chez* Otolithes ruber *(Bloch & Schneider, 1801) récolté en Irak, Golfe Persique.* Les relations entre, d'une part la taille et le poids des otolithes, et d'autre part la longueur totale des individus ont été analysées au moyen de modèles non linéaires. Cette étude constitue la première référence disponible sur les relations entre la longueur totale et la taille et le poids de l'otolithe chez *O. ruber* dans cette région.

Keywords: Otolith weight ● Otolith sizes ● Relationship ● Iraq ● Persian Gulf ● Sciaenidae

Introduction

Among the marine fish species found in brackish water is the tigertooth croaker *Otolithes ruber* (Bloch & Schneider, 1801) (Family: Sciaenidae) (Riede, 2004). This species prefers to live at depth range 10-40 m (Sasaki, 2001) and is distributed in several localities in the Indo-West Pacific region (Sommer et al., 1996). Individuals of this species feed on fishes, crustaceans and other invertebrates (Sasaki, 2001).

The investigation of morphometric relationships is used in fisheries valuation and administration, as they can be used to make judgements between species, populations, and stocks (King, 1995). The association between fish size and otolith length and weight may have relevance in feeding studies, as the rebuilding of body size and prey biomass from otolith measurement can be conceivable involving correlations between specific morphological features of the

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prey (such as otolith length, width or weight) and prey size (length) (Jobling & Breiby, 1986; Battaglia et al., 2010). For instance, rebuilding prey biomass from measurement of otoliths found in stomach contents of predator species is likely by means of the use of a back-calculation formula connecting prey size and otolith size or weight (Granadeiro & Silva, 2000; Waessle et al., 2003; Battaglia et al., 2010). Although enormous work has been completed (Froese et al., 2014), data on weight-length relationship and fish size and otolith size relationships is still uncommon for some tropical and sub-tropical fish species (Harrison, 2001).

In Iraqi marine waters, the relationship between fish size and otolith length, width and weight has not been explored. In the view of these considerations, this paper aims at providing information on morphometric parameters by means of analysing body size and otolith size and weight data relationships in *O. ruber* a marine demersal species in the north-western part of the Persian Gulf. These data may be useful for future researchers studying archaeology and food habits of piscivores to determine the size of fishes from the length of recovered otoliths. Also, the first-hand information assembled by the present study will offer original visions on the population dynamics of the sciaenid species examined and symbolize the first step in get-together data and parameters supportive for the design and application of valuation modes for the assessment of the status of those stocks.

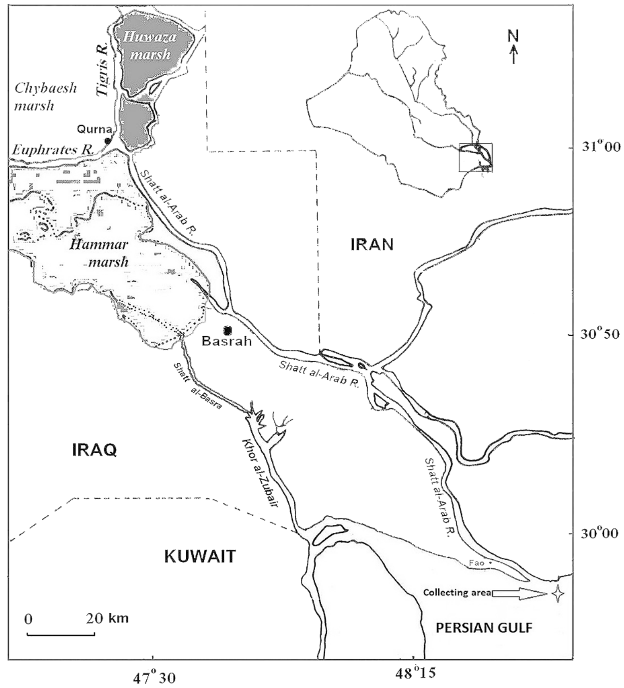

Figure 1. *Otolithes ruber*. Map showing the collection area of from the Iraqi marine waters, Persian Gulf.

Materials and Methods

Description of sampling area

There are four main areas that form the Iraqi marine coastal area, these are: the estuary of the Shatt AlArab River at the city of Fao, Khor Abdulla, Khor alZubair and Um Qasar regions (Fig. 1). The Shatt al-Arab delta is a contribution of the Karun River and the two major Mesopotamian Rivers (Purser et al., 1982; Baltzer & Purser, 1990). The western side of the Iraqi coastal area has become a navigational area, with a length of 40 km, a width of 600-800 m, and a depth of up to 22 m. It has a semidiurnal tidal rhythm with amplitude ranging within 5 m. This region contains a group of important Iraqi ports. The climate and hydrology of the lower Mesopotamian plain, which includes the coastal area were fully described by Purser et al. (1982) and AlAzzawi (1986).

Fish sample collection

Fish samples (120) of *O. ruber* were collected during fishing activities using small trawler (21 m length x 3.5 m width) equipped with net of mesh size 2.5 cm operating at from Khor Abdullah at the south extent of the marine waters of Iraq. Collection was made in the period February-September 2017 and at depth of 10-25 m. Total length (TL) was measured to the nearest 1 mm from the tip of the snout to the posterior edge of the caudal fin. Otoliths (sagittae) were removed through a cut in the cranium to expose them and then cleaned and stored dry in glass vials. Sagittae from both sides of the fish head were dissected out from the sacculus part of the fish inner ear. Sagittae were collected from different fish length groups to ensure that the attained sample is more demonstrative and the assessed factors are more vigorous. Each otolith was placed with the sulcus acusticus oriented through the observer and its length was measured using hand-held Vernier callipers on the axis between the rostrum and post-rostrum axis (Fig 2). Otolith weight was measured to the nearest 0.001 g. The measurements used following Jawad et al. (2017).

Statistical analysis

Linear regression investigation was used to designate the relationships between otolith length and fish TL, and otolith weight and length. The otolith weight-TL relationships were analysed by means of the power equation:

$$w = a \times TL^{b} \quad (1)$$

where w is weight (g) and TL is length (TL in cm, otolith weight in g). Parameters *a* and *b* were estimated from log-transformed data (Ricker, 1973):

$$\text{Log}(w) = \log(a) + b \log \quad (2)$$

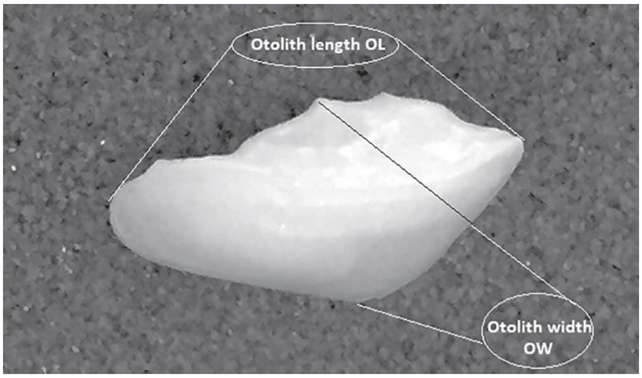

Figure 2. *Otolithes ruber*. Light microscopy image of otolith placed with the sulcus acusticus oriented through the observer and showing the otolith length and width.

Data exploration and analyses were carried out with the package R, vers. 3.2.2 (R Core Team, 2015). An assumed significance level of 5% was used in all statistical analyses.

The *b* values of the fish weight-length relationships were tested using a Student's t-test (confidence level of 95%) in order to verify the null hypothesis of isometric growth (H_0: $b = 3$).

Results

The range of the total length of the specimens used in this study is 150-466 mm with a mean of 309 mm. The fish lengths available for the species in question were those observed in commercial fisheries and research surveys but the extremes of length ranges were under sampled. The ranges and means (± standard deviation) of otolith length, width and weight were respectively: 6.50-15.44 mm and 10.9 ± 2.2 mm; 3.8-8.2 mm and 6.2 ± 3.1 mm; 0.05-0.82 g and 0.43 ± 1.20 g.

The different relationships between fish length and otolith length, width and weight are shown in table 1. In the analysis of morphometric parameters (otolith length and width) and weight against fish total length, no considerable differences between right and left otoliths were detected by ANCOVA test. Thus, single linear regression was plotted for each parameter. Data fitted well to the regression model for three parameters to TL as demonstrated by the high values of the coefficient of determination (Table 1).

Discussion

Otoliths are deliberated a thorough taxonomic means in fish species identification owing to their inter-specific inconsistency (Battaglia et al., 2010). Consequently, several researchers have worked on the morphology of otoliths (Smale et al., 1995; Campana, 2004; Lombarte et al., 2006; Sadigzadeh & Tuset, 2012; Jawad et al., 2018a & b). Further to taxonomic purposes, otolith dimensions and characters such as the length, width and weight are also vital to assess the size and mass of the fish being preyed upon, as frequently in studies on feeding ecology the only item remaining in the stomach of a predator is the otolith (Jawad et al., 2011a, b & c). This prerequisite was attended in the present study and delivered the Total length-Otolith length, Total length-Otolith width and Total length-Otolith weight for both the otolith of *O. ruber*. The data can be treated in the back-calculation analysis to obtain fish size from recovered otoliths exist in the stomachs of predator fish.

Even though the significance commercial part of the tigertooth croaker *O. ruber* in the marine environment, its biology and ecology have not been well studied in the Iraqi waters (Mohamed & Hussain, 1993). The relationship of fish size-otolith measurements of *O. ruber* were studied for the first time in the Iraqi marine waters, Persian Gulf. This research consequently supplements information for this species and for the region, which will be useful in appreciating the marine trophodynamics in the area (Zan et al., 2015).

It is more suitable to compute more than two equations since there is the possibility of damaging the tip or the dorsal edge of the otolith. Harvey et al. (2000) and Waessel et al. (2003) found a noteworthy difference in size of the left and right sagittae. Their results are in dissimilarity to the results in the present study, which are in accord with those of Battaglia et al. (2010) and Jawad et al. (2011a & b). Some authors have included larvae in addition to adult fish in their studies. Therefore, they present two different fish size-otolith measurements, one for the small-sized fish

Table 1. *Otolithes ruber.* Data analysis of individuals collected from the marine waters of Iraq, Persian Gulf, showing results of regression analysis between otolith dimensions (length & width) and weight with fish total length.

Parameter	Slope (*m*)	Intercept (*b*)	Linear equation	Correlation
Otolith length	16.872	0.5321	*Otolith length* = 16.872 *TL* + 0.5321	0.725
Otolith width	7.6099	4.3995	Otolith width = 7.6099 *TL* + 4.3995	0.881
Otolith weight	2.188	26.205	Otolith weight = 2.188 *TL* + 26.205	0.983

and another for adult fish (Nishimura & Yamada, 1988; Linkowski, 1991). In the present study, only adult specimens were used for the otolith analysis.

There are some limitations as to the use of fish weight re-establishment from otolith sizes. These restrictions appear from the disparity in the growth of individuals belonging to the same species but of different stocks or that live in diverse areas (Campana & Casselman, 1993, Reichenbacher et al., 2009) or dissimilarities between sexes (Echeveria, 1987). Introduction to chemicals and mechanical scrapes might distress the shape of the otolith, which consecutively would decrease the practicality for size rebuilding (Jobling & Breiby, 1986; Granadeiro & Silva, 2000).

Different relationship formulae might obtain for the fish size and otolith size and weight of fish specimens of *O. ruber* collected from the neighbouring areas to the Iraqi marine waters. Such differences may reveal spatial variation due to the effect of water physical and chemical characteristics (e.g., environmental variables, such as salinity; variation in pollutants) or food availability on fish growth (Mommsen, 1998, Adandédjan et al., 2011 & 2012). Nevertheless, an additional comprehensive sampling system covering the whole year shall be essential in order to gather adequate data and associate biological parameters to environmental and anthropogenic factors, while the present study is based on data collected in a single sampling investigation. Indeed, seasonal variations in relative growth and condition are known in several fish species (Safran, 1992; Richter et al., 2000; Bolognini et al., 2013). Even though additional data and information on the structure of the populations of *O. ruber* needed to be performed in the Iraqi marine waters, it is to be expected that the outcomes of the present report will offer a introductory input to future population dynamics and stock assessment studies in such heavily environmentally polluted area as the Iraqi marine waters at the head of the most busy giant oil tankers route in the world.

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