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Short communication

Relationships between fish size and otolith measurements for *Chlorurus sordidus* (Forsskål, 1775) and *Hipposcarus harid* (Forsskål, 1775) from the Red Sea coast of Egypt

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Introduction

Among the several scarid fish species living along the Red Sea coasts of Egypt are *Chlorurus sordidus* (Daisy parrotfish) and *Hipposcarus harid* (Candelamoa parrotfish). These two species of commercial importance are reef inhabitants in the Egyptian waters of the Red Sea (Reigl, 2001).

Due to their large size the sagittae otoliths offer clear, distinct growth rings in most bony fishes, and have been widely used for age determination, tracking life histories and stock identification (Boehlert, 1985; Summerfelt and Hall, 1987).

The relationship between the fish size and otolith dimensions is of great importance (Echeveria, 1987; Jawad et al., 2011a,b,c; Jawad and Al-Mamry, 2012; Zan et al., 2015) in studying prey-predator relationships; often in a stomach analysis the only remains of many prey species are the otoliths, which can help identify as well as determine the size of the prey (Aydin et al., 2004).

The simple linear regression is used conventionally to determine the relationship between the fish size and the otolith dimensions (Morat et al., 2008; Zan et al., 2015). In the present study a useful tool for dietary studies is provided by analysing relationships between fish length and otolith size (length and width) for *C. sordidus* and *H. harid* from the Egyptian coasts of the Red Sea.

Materials and methods

Hurghada, the main Egyptian port on the Red Sea, lies at the northern part of the Red Sea between lat. 270 10′N–270 33′N and long. 330 70′E–330 85′E. Located on the western coast of the Red Sea, Hurghada is 500 km south-east of Cairo and stretches for about 36 km along the seashore, not reaching far into the surrounding desert. The vicinity of Hurghada was chosen as it represents one of the main fishing grounds for the two species in question; understanding their asymmetry is important to show the effect of this phenomenon on the settlement of the larvae of these species in this important fishing grounds, as has been shown for other fish species (Battaglia et al., 2010).

Specimens of both parrotfish were obtained during the 2012–2013 fishing season through monthly sampling from the commercial landings. The fishes were caught using 60–100 m long gill nets with a mesh size of 2–¼ mm. Standard length (SL) was measured to the nearest 0.1 cm using a digital caliper. Both left and right sagittae were removed through a cut in the cranium for exposure, cleansing and storing dry in glass vials. Sagittae were collected from 58 (160–325 mm SL) *C. sordidus* and 54 (161–303 mm SL) *H. harid* specimens of different length groups. Specimens with obvious evidence of calcite crystallization or other aberrant formations were not considered for this study. Sagittae were each placed systematically with the sulcus acusticus oriented towards the observer; the was length determined using an ordinary light microscope. The maximum length (OL) and maximum height (OW) were measured to an accuracy of 0.01 mm, recording the greatest distance from the anterior tip to the posterior edge (OL) and the greatest distance between the otolith dorsal and ventral margins (OW), according to Harvey et al. (2000) and Battaglia et al. (2010). Linear regression was used to relate fish standard length (SL) to otolith length (OL) and otolith width (OW). For each specimen, these equations were first calculated for both left and right otoliths and the *t*-test was used to compare regression coefficients; when significant differences ($P < 0.05$) were not found, the H_0 hypothesis (*b*right = *b*left) was accepted. Where these equations did not differ statistically, a single linear regression was reported for each variable (OL and OW) and species.

Results

The range of fish lengths covered those known in commercial fisheries and research surveys; however, the smaller and larger size classes (160–325 mm SL) of *C. sordidus* and (161–303 mm SL) of *H. harid* were under-sampled due to season availability and restrictions on the capture of small specimens.

The *t*-test on the relationship between fish standard length (SL) and OL and OW did not show significant differences between right and left sagittae, thus a single linear regression was used for each equation. Regression (SL-OL, SL-OW) of the left and right otolith dimensions on fish length indicated that the slopes were not significantly different from zero (Table 1). In both scarid fish species, the relationship between otolith measurements and fish standard length was having a correlation coefficient value of a maximum 0.996; the regression models adequately described this relationship (Table 1).

Discussion

Otoliths are considered a profound taxonomic tool in fish species identification due to their inter-specific variability (Battaglia et al., 2010). Therefore, many researchers around the world have worked on the morphology of otoliths (Smale et al., 1995; Campana, 2004; Lombarte et al., 2006; Tuset et al., 2008; Sadigzadeh and Tuset, 2012; Jones and Morales, 2014). In addition to taxonomic purposes, otolith measurements such as the length and width are also important to estimate the size and mass of the fish being preyed upon, as often 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 need was addressed in the present study and provided the SL-OL, SL-OW for both the left and right otolith of *C. sordidus* and *H. harid*. The data can be used to back-calculate fish size from recovered otoliths found in the stomachs of predator fish.

Despite the importance role of these two scarid species in the coral reef environment, their biology and ecology have not been well studied on the Red Sea coasts of Egypt (Mehanna et al., 2014). The relationship of fish size – otolith measurements for both species were examined for the first time in Hurghada, at the Red Sea coast of Egypt. This research therefore adds information for these species and for the region, which will be useful in understanding the marine trophodynamics in the area (Zan et al., 2015).

It is more convenient to calculate more than two equations since there is the risk of damaging the tip or the dorsal edge of the otolith. Similarly, this is the reason for using standard length rather than total length of the fish.

Harvey et al. (2000) and Waessel et al. (2003) found a significant difference in size of the left and right sagittae. Their results are in contrast to the results in the present study, which are in agreement 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 and another for adult fish (Nishimura and Yamada, 1988; Linkowski, 1991). The length range for *C. sordidus* and *H. harid* is 161–303 and 160–325 mm, respectively; the regressions of SL-OL and SL-OW for the left and right otolith calculated herein are acceptable.

There are some restrictions as to the use of fish weight reconstruction from otolith measurements. Such limitations arise from the variation in the growth of individuals belonging

Table 1
Sample size, fish size, linear regression relationships between fish standard length (SL) and otolith length and width for *Chlorurus sordidus* and *Hipposcarus harid*

Species	N	Fish length SL (Range) mm	Left side				Right side			
			L-OL equation	R^2	L-OW equation	R^2	L-OL equation	R^2	L-OW equation	R^2
Chlorurus sordidus	58	160–325	L = 10.605OL + 109.90	0.982	L = 11.398OW + 126.19	0.987	L = 10.598OL + 110.62	0.981	L = 11.337OW + 126.89	0.987
Hipposcarus harid	54	161–303	L = 11.780OL + 112.05	0.962	L = 13.814OW + 125.32	0.969	L = 11.711OL + 113.18	0.962	L = 13.716OW + 126.36	0.996

to the same species but of different stocks or that inhabit different areas (Campana and Casselman, 1993; Reichenbacher et al., 2009) or differences between sexes (Echeveria, 1987). Exposure to chemicals and mechanical abrasions might affect the shape of the otolith, which in turn would reduce the usefulness for size reconstruction (Jobling and Breiby, 1986; Granadeiro and Silva, 2000).

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