6(3): 203-208 (2012) DOI: 10.3153/jfscom.2012023

Journal of FisheriesSciences.com

E-ISSN 1307-234X

© 2012 www.fisheriessciences.com

RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

RELATIONSHIP BETWEEN FISH LENGTH AND OTOLITH DIMENSIONS IN THE CARANGID FISH (*Carangoides coeruleopinnatus* (Rüppell, 1830)) COLLECTED FROM THE SEA OF OMAN

Laith A. Jawad*, **Juma Al-Mamry**

Marine Science and Fisheries Centre, Ministry of Agriculture and Fisheries Wealth, Sultanate of Oman

Abstract: The regressions between otolith size (length and width) and fish length of the carangid fish, *Carangoides coeruleopinnatus* living along the coasts of the Sea of Oman were provided. ANCOVA test showed no differences in length and width of the right and left otolith of fish specimens obtained. Similarly, no significant difference was observed between regressions of fish length on width and length of otolith length, so a single linear regression was plotted against total length (TL) for otolith length (OL) and otolith width (OW).

Keywords: Otolith dimensions, Fish length, Sea of Oman, Muscat

Özet: **Umman Denizinden Toplanan Carangit Balığının (Carangoides coeruleopunctatus (Rüppell, 1830)) Boyu ile Otolit Boyutları Arasındaki İlişki**

Umman Denizi kıyılarında yaşayan Carangid türü bir balık olan Carangoides coeruleopinnatus'in otolit boyutları (uzunluk ve genişlik) ve balık boyu arasındaki regresyonlar incelenmiştir. ANCOVA testi ile elde edilen balık örneklerinin sağ ve sol otolitinde uzunluk ve genişlik açısından herhangi bir farklılık göstermemiştir. Benzer şekilde, balık uzunluğu ve otolit uzunluğu arasındaki regresyonda da belirgin bir fark gözlenmemiştir. Bu nedenle otolit uzunluğu ve otolit genişliği için toplam uzunluğa karşı tek bir lineer regresyon alınmıştır.

Anahtar Kelimeler: Otolit boyutu, Balık boyu, Umman Denizi, Muscat

* **Correspondence to:** **Laith JAWAD**, Marine Science and Fisheries Centre, Ministry of Agriculture and Fisheries, P.O.Box 427, Postal Code 100, Muscat-SULTANATE OF OMAN

Tel: 00968 99610015

E-mail: laith_jawad@hotmail.com

Introduction

The Carangidae family known popularly with their members called Jacks is among the large families of the order Perciformes and it is important in both tropical and subtropical waters.

The carangid species are large, strong swimming, open-water and carnivorous fishes (Randall 1995). In Oman, this family is composed of 48 species belonging to 24 genera (Randall 1995), and they are considered among the most important commercial commodities.

Among the three pairs of otoliths in bony fishes, sagittae have the largest pair (Harvey *et al*. 2000). Due to their large size and their distinct growth rings in most bony fishes, sagittae have been widely used by fisheries biologists (Boehlert 1985, Summerfelt and Hall 1987).

Paleontologists, oceanographers and marine biologists have used the species specific distinctive morphology of the sagittae and their dense structure that can resist certain degree of disintegration to determine the identity of fish species found in middens, sediments and stomach content of marine birds and mammals (Fitch 1964, 1969, Tripple and Beamish 1987, Ainley *et al*. 1981, Treacy and Crawford 1981). In the early years of the second half of the twentieth century the importance of the positive relationship between otolith size and fish size was demonstrated by Trout (1954) and Templemann and Squires (1956).

Researches in fish biology and population dynamics get huge usage of the otolith length-total length relationship (Echeverria 1987). Furthermore, the identity of the eaten fish species and their size can be estimated from their otolith retrieved from the digestive tract of the piscivorous fishes (Aydin *et al*. 2004).

The relationship between fish length and otolith length and width has not been investigated in the fish fauna of Oman. Therefore, the aim of the present study is to find out the relationship between fish length and otolith length and width in the carangid fish species *C. coeruleopinnatus*. These data may be used by researchers studying archaeology and food habits of piscivores to determine the size of fishes from the length of recovered otolith.

Materials and Methods

Fish specimens were collected during the period March-May 2010 from waters around Muscat City at the Oman Sea coasts using long lines. The specimens were identified according to Randall (1995). Total length (TL; most anterior point to the posterior tip of the caudal fin) was considered and measured to the nearest millimeter. Sagittae were (total of 57 individuals, *i.e.*, 114 otolith) removed through a cut in the cranium to expose them, then cleaned and stored dry in glass vials and the left and right otolith were considered 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 was determined using hand-held vernier callipers and defined as the longest dimension between the rostrum and postrostrum axis (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. The relationship between otolith size (length and width) and fish length (TL) were determined using least squares linear regression for the following parameters: otolith length (OL)-fish length (TL) and otolith width (OW)-fish length (TL). These equations were first calculated for both left and right otoliths and ANCOVA test (Fowler and Cohen 1992) was used to check any differences between regressions. Similarly, the sex-linked changes in fish length and otolith length were examined statistically with the ANCOVA test. The regression coefficients were compared and when significant differences ($P<0.05$) were not found, the H_0 hypothesis ($b_{right} = b_{left}$) was accepted. When the equations did not differ statistically, a single linear regression was reported for each parameter (OL and OW). The significance of the linear regressions was verified using the ANCOVA test.

Results and Discussion

One population of *C. coeruleopinnatus* was used in the analysis presented in the work at hand. The linear regressions of otolith length and width against fish length for male, female and combined sexes were calculated and are given in Figures 1&2.

Table 1. Result of regression analyses between otolith dimension on fish length of *Carangoides coeru leopinnatus*.

Parameter	Intercept	Intercept	Correlation
Length	3.184	6.7895	0.4659
Width	6.3503	6.9675	0.5279

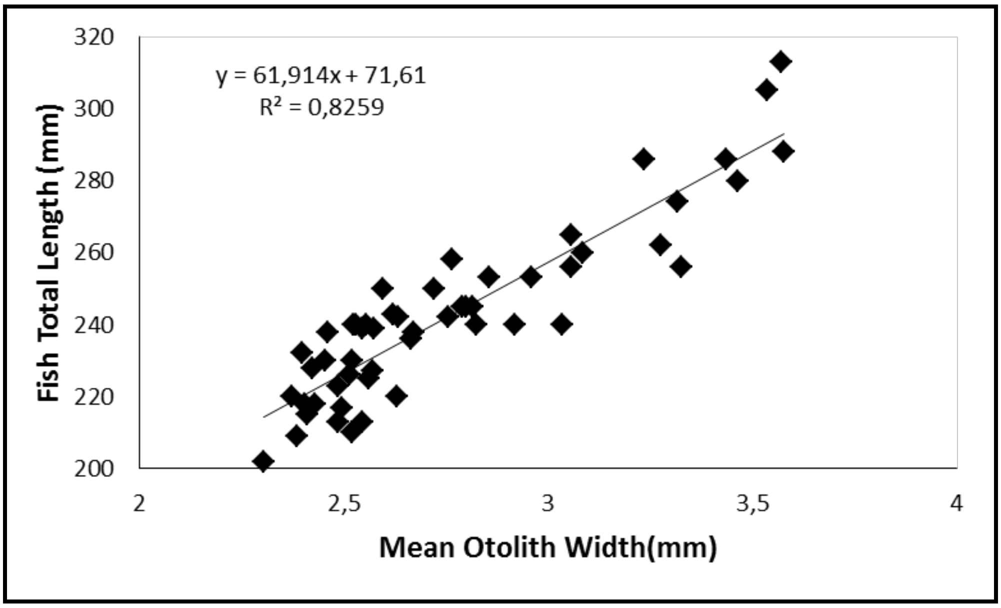

Figure1. Total length otolith length relationship.

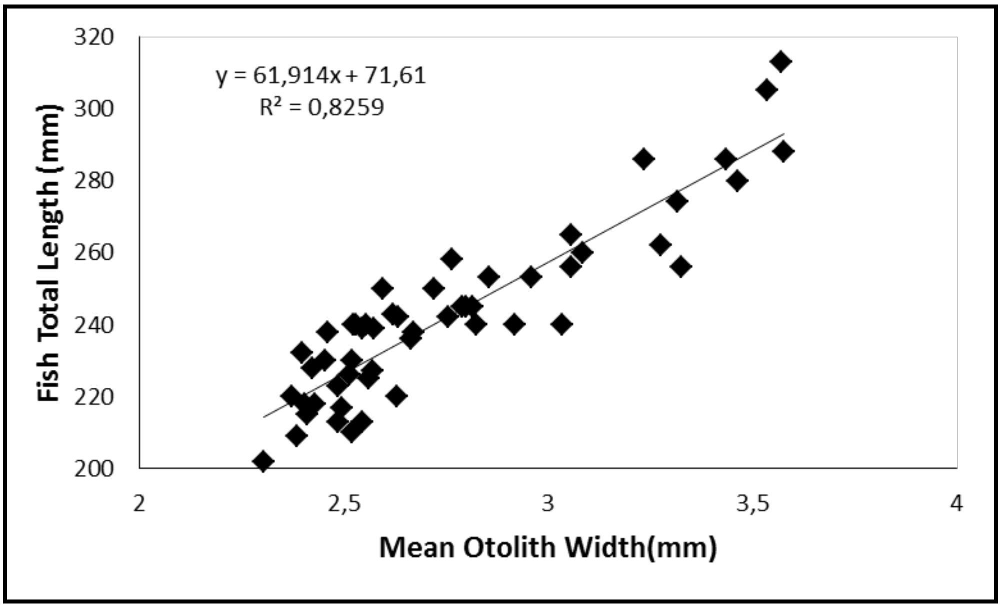

Figure 2. Total length otolith width relationship.

The result of the analyses has revealed no statistical significant differences (P>0.05) between; (1) the regressions of the fish length on the left and right otolith sizes; (2) the regressions of the otolith length and width of two sexes; (3) the combined (male & female) regression of the left and right otolith length.

Among the protocols of fish identification, shape of the otolith stands as one of the main tool to separate fish species due to their high interspecific variability (Battaglia *et al*. 2010). Therefore several reference works on the morphology of the fish otolith are in use specially in the field of identification of fish preys, to identify fish species depending on the shape of their otolith (Smale *et al*. 1995, Campana 2004, Lombarte *et al*. 2006, Tuset *et al*. 2008), however, only certain geographical areas are covered and the access to reference material remains requisite (Santos *et al*. 2001). Thus, it is essential to estimate specific equations which are useful to calculate the size and mass of the preys.

The results of the present paper address to this need, providing TL-OL and TL-OW relationships for the carangid fish *C. coeruleopinnatus*. Despite the commercial importance role of this species in the Omani waters, its biology and ecology had not been well investigated until today in Oman.

There are some limitations to the use of biomass reconstruction from otolith size. Several authors have shown that individuals of the same species inhabiting different areas or individuals of different stocks of the same species have different growth rate. Such difference in the growth rate will affect the morphology of the otolith (Campana and Casselman 1993, Reichenbacher *et al*. 2009). The increased or reduced otolith growth rates most often are the result of changes in water temperature, water depth and diet (e.g., Lombarte and Lleonart 1993, Tuset *et al*. 2003, Katayama and Isshiki 2007, Mérigot *et al*. 2007). Elongated otolith are usually produced during increased growth rates, while more rounded otolith contours occur if growth is reduced (Reichenbacher *et al*. 2009). Such situation was not observed in the results of the present study as only one population has been studied.

The effect of chemical and mechanical abrasion in the digestive track of predators on the otolith traits might become factor to underestimate otolith size (Jobling and Breiby 1986, Granadeiro and Silva 2000). Similar results were obtained for some otolith of the species in question retrieved from the stomach of fishes collected from Sea of Oman. In these otoliths, the ornaments usually found on the mesial side of the otolith have been severely abrassed and the anterior and posterior edges of the otolith have been deteriorated and the size of the otolith looks much smaller than that of the otolith recovered directly from the fish body of the same species (Sulaiman *et al*. 2007, Saad 2005, Khalid 2007).

Unlike the previous studies that focused on the relationship between fish and sagitta sizes (Wyllie 1987, Gamboa 1991, Granadeiro, Silva 2000, Harvey *et al*. 2000, Waessle *et al*. 2003, Battaglia *et al*. 2010), this paper supplies additional information by considering both the otolith length (OL) and otolith width (OW). It is more suitable to calculate more than one equation (TL-OL and TL-OW) since the tip of the otolith rostrum or the dorsal or ventral edges of the otolith may be damaged, making it impossible to measure the OL or OW.

In contrast with the findings of Harvey *et al*. (2000) and Waessle et al. (2003) the otolith of the species in question did not show significant differences in size between left and right sagittae. This finding is in agreement with the results of Battaglia *et al*. (2010).

In spite of all data fitted well with the linear regressions obtained in the present study, it is advisable to use these equations within the fish size range limit reported for this species in the results section. Authors who studied wide range of fish length and include larvae in their sample, have supplied two different TL- OL regressions, one for the small sized fish and another for the adult specimens (Nishimura and Yamada 1988, Linkowski 1991). Such situation is not applicable to the results obtained in the present study as no larvae were present in the sample as the individuals of *C. coeruleopinnatus* collected in the present paper belong to the 202- 313 mm TL range, the regressions TL-OL and TL- OW calculated here in can be accepted.

Conclusions

There are no differences in length and width of the right and left otolith of fish specimens obtained. This is also true for the regressions between fish length on the length and width of otolith, so a single linear regression was plotted against total length (TL) for otolith length (OL) and otolith width (OW). These relationships provide a reliable tool in feeding studies and also provide support to palaeontologists in their research on fish fossils.

Acknowledgements

Our sincere thank goes to the Ministry of Agriculture and Fisheries Wealth, Marine Science and Fisheries Centre and the directorate of Agriculture and Fisheries Developmental Fund for giving us the opportunity to work on the fish samples within the qualitative and quantitative distribution of marine organisms in Sultanate of Oman and to provide the appropriate financial support.

References

Ainley, D. G., Anderson, D.W., Kelly, P. R., (1981). Feeding ecology of marine cormorants in southwestern North America, *Condor*, **83**: 120-131.
doi: 10.2307/1367418

Aydin, R., Calta, M., Sen, D., Coban, M. Z., (2004). Relationships between fish lengths and otolith length in the population of *Chondrostoma regium* (Heckel, 1843) inhabiting Keban Dam Lake, *Pakistan Journal of Biological Sciences*, **7**: 1550-1553.
doi: 10.3923/pjbs.2004.1550.1553

Battaglia, P., Malara, D., Romeo, T., Aadaloro, F., (2010). Relationship between otolith size and fish size in some mesopelagic and bathypelagic species from the Mediterranean Sea (Strait of Messina), *Scientia Marina*, **74**: 605-612.
doi: 10.3989/scimar.2010.74n3605

Boehlert, G. W., (1985). Using objective criteria and multiple regression models for age determination in fishes, *Fishery Bulletin*, **83**: 103-117.

Campana, S. E., Casselman, J. M., (1993). Stock discrimination using otolith shape analysis, *Canadian Journal of Fisheries and Aquatic Sciences*, **50**: 1062-1083.
doi: 10.1139/f93-123

Campana, S. E., (2004). Photographic atlas of fish otoliths of the Northwest Atlantic Ocean, pp. 284.Ottawa, Ontario: NRC Research Press.

Eecheverria, T. W., (1987). Relationship of otolith length to total length in rockfishes from northern and central California, *Fishery Bulletin*, **85**: 383-387.

Fitch, J. E., (1964). The fish fauna of the Playa del Rey Locality, a southern California marine Pleistocene deposit, *Los Angeles City Museum of Contemporary Science*, **82**: 3-35.

Fitch, J. E., (1969). Fossil records of certain schooling fishes of the California current system, *CALCOFI Report*, **13**: 71-80.

Fowler, J., Cohen, L., (1992). Practical statistics for field biology. John Wiley and Sons, Chichester, New York, Brisbane, Toronto, 227pp.

Gamboa, D. A., (1991). Otolith size versus weight and body-length relationships for eleven fish species of Baja California, Mexico, *Fishery Bulletin*, **89**: 701-706.

Granadeiro, J. P., Silva, M. A., (2000). The use of otoliths and vertebrae in the identification and size-estimation of fish in predator-prey studies, *Cybium*, **24**: 383-393.

Harvey, J. T., Loughlin, T. R., Perez, M. A., Oxman, D. S., (2000). Relationship between fish size and otolith length for 63 species of fishes from the eastern North Pacific Ocean. *NOAA Technical Report NMFS*, 150: pp. 35.

Jobling, M., Breiby, A., (1986). The use and abuse of fish otoliths in studies of feeding habits of marine piscivores, *Sarsia*, **71**: 265-274.

Katayama, S., Isshiki, T., (2007). Variation in otolith macrostructure of Japanese flounder (*Paralichthys olivaceus*): a method to discriminate between wild and released fish, *Journal of Sea Research*, **57**:180–186.
doi: 10.1016/j.seares.2006.09.006

Khalid, M. H., (2007). Food items of some piscivorous fishes obtained from the Sea of Oman. Quarterly Report, Ministry of Environment, Iran 345pp.

Linkowski, T. B., (1991). Otolith microstructure and growth patterns during the early life history of lanternfishes (family Myctophidae), *Canadian Journal of Zoology*, **69**: 1777-1792.
doi: 10.1139/z91-247

Lombarte, A., Lleonardti, J., (1993). Otolith size changes related with body growth, habitat

depth and body temperature, *Environmental Biology of Fishes*, **37**: 297–306.
doi: 10.1007/BF00004637

Lombarte, A., Chico, Ò., Parisi-Baradad, V., Olivellaii, R., Piera, J., Garcia-Ladona, E., (2006). A web-based environment from shape analysis of fish otoliths. The AFORO database (http://www.cmima.csic.es/aforo/), *Scientia Marina*, **70**: 147-152.

Mérigot, B., Letourneur, Y., Lecomte-Finiger, R., (2007). Characterization of localpopulations of the common sole *Solea solea* (Pisces: Soleidae) in the NW Mediterranean through otolith morphometrics and shape analysis, *Marine Biology*, **151**: 997-1008.
doi: 10.1007/s00227-006-0549-0

Nishimura, A., Yamada, J., (1988). Geographical differences in early growth of walleye Pollock *Theragra chalcogramma*, estimated by back-calculation of otolith daily growth increments, *Marine Biology*, **97**: 459-465.
doi: 10.1007/BF00391041

Randall, J. E., (1995). Coastal fishes of Oman. Bathurst, Australia: Crawford House Publishing Pty Ltd. 439pp.

Reichenbacher, B., Kamrani, E., Esmaeili, H. R., Teimori, A., (2009). The endangered cyprinodont *Aphanius ginaonis* (Holly, 1929) from southern Iran is a valid species: evidence from otolith morphology, *Environmental Biology of Fishes*, **86**: 504-521.

Saad, S. Y., (2005). On the food items of some piscivorous fishes collected from the Sea of Oman, Annual Report, Ministry of Environment, 456pp.

Santos, M. B., Clarkeii, M. R., Pierce, G. J., (2001). Assessing the importance of cephalopods in the diets of marine mammals and other top predators: problems and solutions, *Fisheries Research*, **2**: 121-129.
doi: 10.1016/S0165-7836(01)00236-3

Strong, M. B., Neilson, J., Hunt, J., (1986). Aberrant crystallization of Pollock otoliths, *Canadian Journal of Fisheries and Aquatic Sciences*, **43**: 1457-1463.
doi: 10.1139/f86-180

Sulaiman, D. F., Hameedi, N. B., Ilahii, U. K., (2007). Food and feeding habits of some piscivorous fishes collected from the Sea of Oman. Scientific Report No. 5, Ministry of Fisheries, Iran, 98pp.

Summerfelt, R.C., Hall, G. E., (Eds.) (1987). The age and growth of fish. Iowa State University Press, Ames, 544p.

Templemann, W., Squires, H. J., (1956). Relationship of otolith lengths and weights in the haddock, *Melanogrammus aeglefinus* (L.), to the growth of the fish, *Journal of Fisheries Research Board of Canada*, 13: 467-487.
doi: 10.1139/f56-029

Treacy, S. D., Crawford, T.W., (1981). Retrieval of otoliths and statoliths from gastrointestinal contents and scats of marine mammals, *Journal of Wildlife Management*, **45**: 990-993.
doi: 10.2307/3808110

Tripple, E. A., Beamish, F.W. H., (1987). Characterizing piscivory from ingested remains, *Transaction of the American Fisheries Society*, **116**: 773-776.
doi: 10.1577/1548-8659(1987)116<773:CPFIR>2.0.CO;2

Trout, G. C., (1954). Otolith growth of the Barents Sea cod. *Rapp P -V Réun Cons Int Explor Mer*, **150**: 297-299.

Tuset, V. M., Lombarte, A., Assis, C. A., (2008). Otolith atlas for the western Mediterranean, north and central eastern Atlantic, *Scientia Marina*, **72S1**: 7-198.

Waessle, J. A., Lasta, C. A., Bavero, M., (2003). Otolith morphology and body size relationships for juvenile Sciaenidae in the Río de la Plata estuary (35-36°S), *Scientia Marina*, **67**: 233-240.

Wyllie, E. T., (1987). Relationship of otolith length to total length in rockfishes from northern and central California, *Fishery Bulletin*, **85**: 383-387.