Thalassia Salentina
Thalassia Sal. 43 (2021), 43-52
ISSN 0563-3745, e-ISSN 1591-0725

DOI 10.1285/i15910725v43p43
http: siba-ese.unisalento.it - © 2021 Università del Salento

DAWOOD S. AL-MAMARI[1], SAEED R. ALSHAJIBI[2], LAITH A. JAWAD[3]

[1] Department of Fisheries Biology, Marine Science and Fisheries Centre, Muscat, Sultanate of Oman.
[2] Department of Fisheries Biology, Fisheries Research Centre, Salalah, Sultanate of Oman.
[3] School of Environmental and Animal Sciences, Unitec Institute of Technology, 139 Carrington Road, Mt Albert, Auckland 1025, New Zealand
Corresponding author: laith_jawad@hotmail.com

THE RELATIONSHIPS BETWEEN BODY AND OTOLITH SIZE OF THE BLUELINE SNAPPER *LUTJANUS COERULEOLINEATUS* (RÜPPELL, 1838) COLLECTED FROM THE COASTS OF OMAN, ARABIAN SEA

SUMMARY

Relationships between fish length and otolith length and width were examined in the blueline snapper *Lutjanus coeruleolineatus* (Lutjanidae) collected from the coasts of Oman, Arabian Sea. The values of exponent *b* from the relationships between fish total length and otolith length and total length and otolith width were estimated representing the close fitness of otolith size with fish size. Both relationships were statistically significant, which means both otolith length and width can be used to retrieve the fish original size. The analysis of covariance (ANCOVA) was used to test the effect of the categorical factor of species in the fish length and otolith length relationship. This study represents the first reference available on the relationship of fish size and otolith size for *L. coeruleolineatus* in the Arabian Sea area. Results from this study will offer original data on quantitative biometric relationships between body and otolith measurements of fish species in Arabian Sea region. By obtaining the mathematical model showing the relationship of the otolith size and fish length will enable fisheries biologists to know the size of the fish that has been eaten an information which important for fish biologists.

INTRODUCTION

Several applications of the relationships between fish size and otolith size have been used by fisheries biologists such as those related to predation studies and

growth of fish (Templeman and Squires, 1956; Park *et al*., 2018). The length of a fish can be inferred from otolith size since somatic growth has a noteworthy effect and is positively linked with otolith mass (Munk, 2012). In the instance when the prey found in the fish diets are undamaged and being possible to identify satisfactorily to the genus or species level, recreating prey size and biomass from otoliths obtained from stomach subjects of fish is possible if correlations between specific morphological features of the prey (e.g. otolith length) and actual prey size, and weight-length relationships of prey species are known (Battaglia *et al*., 2010; Granadeiro and Silva, 2000; Jawad *et al*., 2011). Moreover, otolith length and width features, and their relationships are broadly used in keys and identification guides on fish otolith morphology consequently turning them into a consistent taxonomic tools (Lombarte *et al*., 2006).

Relationships between fish size and otolith size have been done globally in several fish species (e.g. Battaglia *et al*., 2010; Jawad *et al*., 2017) including the Omani waters (Al-Busaidi *et al*., 2017), but there are still inadequate information on these relationships in many fish species of Oman as such relationship is important to know the original size of the prey.

In the present study, otolith information were given for the blueline snapper *Lutjanus coeruleolineatus* collected from the coasts of Oman, Arabian Sea. This species is considered one of the commercially important species in the Indian Ocean as a whole. It is a marine and reef-associated species living at depth range 10 - 20 m (Lieske and Myers, 1994). It distributed in the Indian Ocean surrounding the Arabian Peninsula except the northern Red Sea and the Arabian Gulf. It reaches a maximum total length of 40.0 cm, with a common length of 200 mm TL (Randall, 1995). Adults individuals of this species inhabit clear coastal coral reefs and they occur singly or in small groups. The age structure of male fishes is between 1 and 14 years for males while the age of females ranged from 1 to 18 years. Growth rate (K) was 0.21 y–1 and 0.16 y–1 for males and females, respectively. The natural mortality is 0.296, total mortality is 0.372, fishing mortality is 0.076, and exploitation rate is estimated as 0.2 (Almamari *et al*., 2021). Also, this study characterizes an additional step in gathering of biometric data and parameters in support of the future studies on food habits for Omani teleosts to decide the size of fishes from the length of recovered otoliths. The information provided in this study will assist in gaining information about the size of fish being eaten as prey, which in turn be a valuable data for fish biologists.

MATERIAL AND METHODS

Fish specimens and sampling

A total of 195 otoliths were obtained from 195 fish specimens originated from a commercial catch at Salalah fish market, Dhofar Governorate between March

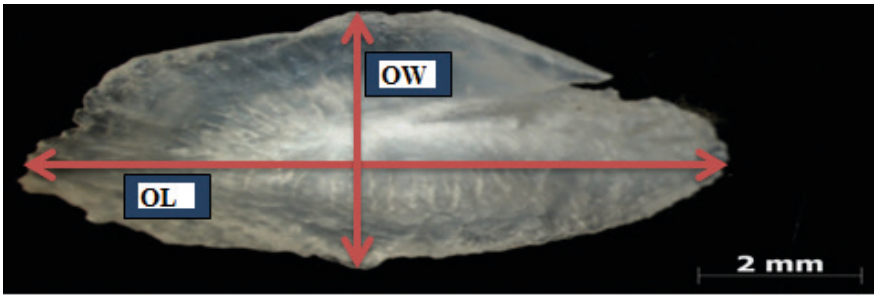
2015 and February 2016. The fish specimens were kept frozen immediately after attaining and taken directly to the laboratory for identification to the species level based on Randal (1995). To decrease shrinkage in body length during the frozen-thawing process, all fishes attained were packed in plastic bags before freezing, and analyses were conducted within 2 weeks after obtaining fish.

Fish processing

For each specimen, total length (TL) and standard length (SL) were measured to the nearest 0.1 cm from the anterior tip of the snout to the end of the pinched caudal fin. Sex was decided by means of macroscopic examination of the gonads (Jawad *et al.*, 2017). Otoliths (sagittae) were extracted through an incision in the cranium, then washed clean with 70% ethanol and stored dry in glass vials.

Otolith measurements and statistical analysis

Preceding to storage, each otolith was positioned with the sulcus acusticus oriented towards the observer and its length (OL) and width (Ow) was measured to the nearest 0.001 mm using electronic digital calipers (Fig. 1). To keep measuring accuracy, measurements were taken by the same person. As no significant differences were observed between left and right otoliths in terms of length and width (student's *t* test, all $p > .05$ for all species). All subsequent analyses were done on randomly selected on right or left otolith from each individual. The relationships between fish TL and both otolith length OL and width Ow were analysed using a linear regression equation of $Y = a + bX$, where *a* and *b* are the intercept and allometric coefficient, respectively (Harvey *et al.*, 2000). The standard error (*SE*) of parameters *a* and *b*, and the statistical significance level of r^2 were estimated. Outermost outliers were deleted before fitting the linear regression (Froese *et al.*, 2011). Full factorial analyses of covariance (ANCOVA) was used to test the effect of the categorical factor of sex in the all relationships between fish body and otolith measurements. In addition, ANCOVA with Bonferroni correction for multiple comparison were used to determine significant differences in TL–OL regressions.



Lutjanus coeruleolineatus. Light microscopy image of otolith placed with the sulcus acusticus oriented through the observer and showing the otolith length and width.

RESULTS

The range of the total length of the specimens used in this study was 214-400 mm with a mean of 296 mm (± SD 4.68). The fish lengths available for the species in question were those available in commercial fisheries and research surveys but the extremes of length ranges were under sampled. The ranges and means (± standard deviation) of otolith length and width were respectively: 7.56-13.53, 10.63 mm (± 1.38), and 4.37-6.96, 5.58 (±0.66) (table 1).

Table 1. *Lutjanus coeruleolineatus*. Data analysis of individuals collected from the coasts of Oman, Arabian Sea showing results of regression analysis between otolith dimensions (length and width) with fish total length.

Parameter	Number of specimens	Slope (*m*)	Intercept (*b*)	Linear equation	Correlation
Otolith length	195	3.1243	3.621	*Otolith length* = 3.1243 *TL* – 3.621	0.84
Otolith width	195	6.4705	6.511	*Otolith width* = 6.4705 *TL* – 6.511	0.83

The otolith length (OL) was about 3.6% of total fish length (2.9-4.8%), and width (OW) of the otolith was about 52.5% of its length. The relationships between TL and OL, and between TL and OW width were also significantly correlated ($p < .05$), with the highest coefficient of correlations of $r^2 = 0.83$ and $r^2 = 0.84$ for TL-OL and TL-Ow relationships respectively (Table 1; Figs. 2, 3). ANOVA tests revealed statistically significant linear relationships between fish size and otolith dimensions ($P< 0.05$). The t-test on the relationship between fish total length (TL) and OL and OW did not show significant differences between right and left sagittae, thus a single linear regression was used for each equation. As no significant differences in the total length of fish and otolith measurements between male and female were detected by the ANCOVA ($p > .05$), the parameters were estimated and summarized by sex combined.

DISCUSSION

Otoliths play an important role in taxonomic studies. With their distinctive and species specific surface morphology, fish species can be identified from otolith retrieved from food of several aquatic animals and from sediments at archaeological sites. In addition, otolith dimensions and characteristics such

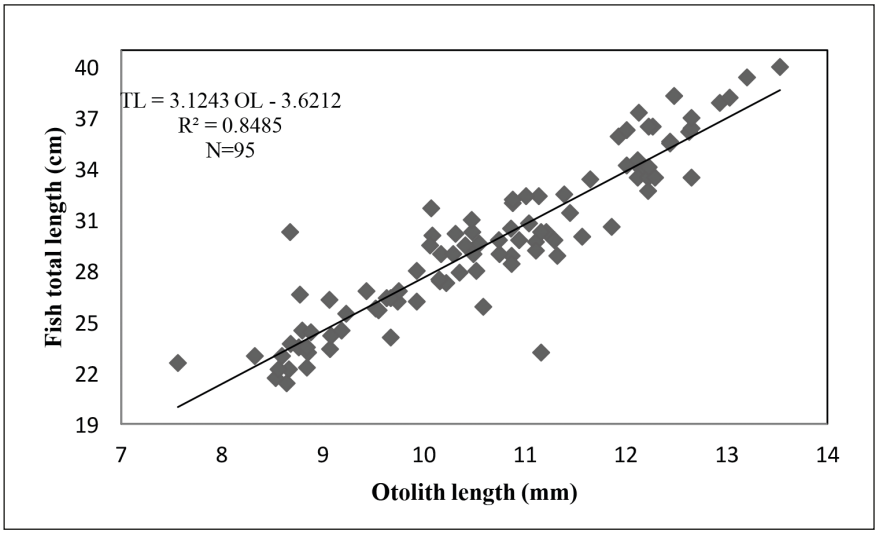


Fig. 2 - Fish Total length (cm) - Otolith length (mm) relationship of *Lutjanus coeruleolineatus*. Regression equation, Regression value (R2), and the number of specimens (N) are written on the figure.

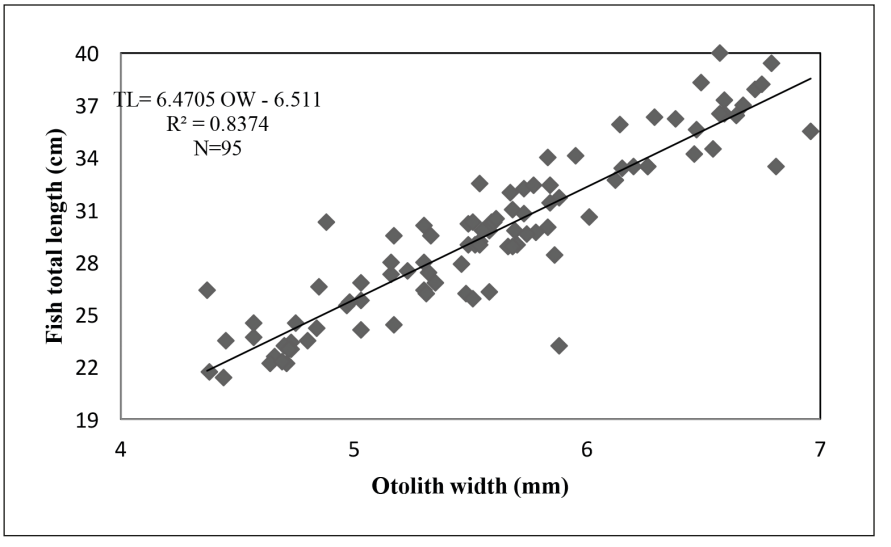


Fig. 3 - Fish Total length (cm) - Otolith width (mm) relationship of *Lutjanus coeruleolineatus*. Regression equation, Regression value (R2), and the number of specimens (N) are written on the figure.

as the length and width are also vital to evaluate the size and mass of the fish being preyed upon. The good example on such a case is that of Battaglia *et al*. (2010), who studied the relationships between otolith size and fish size in some mesopelagic and bathypelagic species from the Mediterranean Sea (Strait of Messina, Italy). The importance of otolith in feeding ecology studies as in most of the instances they represent the only item remaining parts of the prey in the stomach of a predator (Jawad *et al*., 2011). This condition was considered in the present study and delivered the Total length-Otolith length and Total length-Otolith width for both the otolith of *L. coeruleolineatus*. The data can be used in the back-calculation examination to attain fish size from recovered otoliths found in the stomachs of predator fish, which in turn is a prime information for fish stock assessment and feeding biology of the species.

Studies on the relationship between fish and otolith size have focused on the relationship between fish length and otolith length (Granadeiro and Silva, 2000) because it is easily described using a simple linear regression. Recently, however, investigations are also offering additional data on otolith length and width relationships for four demersal fishes from western Korean waters (Jawad *et al*., 2017), and a simple linear relationship between fish size and otolith width of Bengal snapper (Jawad *et al*., 2011), but no such studies were performed on fish species from the coasts of Oman, Arabian Sea that the studies on the fish population management, predator-prey studies, and archaeological research are may be benefited of the results of this study. The use of both measurements is more reliable for evaluating and computing biometric data since the tips of either the otolith rostrum or post-rostrum can often be damaged, making it difficult to assess fish size from the otolith length alone. Such problem solved by considering the otolith width for the calculation.

The results herein are comparable with earlier studies on otolith shapes and morphometric data for fishes from the Arabian Gulf and Sea of Oman. Qasim *et al*. (2019) investigated the relationship between fish length and both otolith sizes and weight in the fish species *Otolithes rube* collected from the marine waters of Iraq, while Al - Busaidi *et al*. (2017) studied the relationship between the fish length and the otolith size of the species *Lutjanus ehrenbergii* collected from the coast of Muscat City, Sea of Oman. The strong correlation between the otolith size and somatic size proposes that somatic growth have important impact on the otolith mass as reported by Munk (2012).

There is no noteworthy variance between the right and left otolith, which shows that these are mirror images of each other (Hunt 1979). Preceding studies by Harvey *et al*. (2000) and Waessle *et al*. (2003) confirmed the similarity of right and left otolith in *Lutjanus benghalensis*. Linear relationship between otolith length and fish length could be influenced by the growth

rate of the fish (Mugiya and Tanaka, 1992) and these relationships became curvilinear in some larval or juvenile fishes (West and Larkin, 1987). The relationship reported to be changed at intervals relative to fish size (FROST and LOWRY, 1981) and ontogenetic changes in the life history (Hare and Cowen, 1995). Therefore, there is a chance of getting mistakes in the conclusion owing to these errors.

Different relationship formulae might obtain for the fish size and otolith size of fish specimens of *L. coeruleolineatus* collected from the neighbouring areas to the coasts of Oman, Arabian Sea. Such changes may disclose geographical disparity owing to the influence of water physical and chemical characteristics (e.g., environmental variables, such as salinity; variation in pollutants) or food obtainability on fish growth (Mommsen, 1998; Adandédjan *et al*., 2012). However, a further inclusive sampling system encompasses the whole year shall be indispensable in order to gather suitable data and companion biological parameters to environmental and anthropogenic factors, while the present study is based on data collected in a single sampling investigation. Certainly, seasonal disparities in relative growth and condition are identified in several fish species (Safran, 1992; Richter *et al*., 2000; Bolognini *et al*., 2013).

REFERENCES

Adandédjan D., P. Lalèyè Gourène G., 2012. Macroinvertebrates communities of coastal lagoon in southern Benin, West Africa. *International Journal of Biological and Chemical Sciences*, **6**: 1233-1252.

Al-Busaidi H. K., L. A. Jawad, Al -Balushi A. H., 2017. Relationships between fish and otolith size of the blackspot snapper Lutjanus ehrenbergii (Peters, 1869) collected from the coast of Muscat City, Sea of Oman. *International Journal of Marine Science*, ***7***.

Almamari D., Rabia S., Myun Park J., Jawad L. A., 2021. Age, growth, mortality, and exploitation rate of blueline snapper, Lutjanus coeruleolineatus (Actinopterygii: Perciformes: Lutjanidae), from Dhofar Governorate, Sultanate of Oman. *Acta Ichthyologica et Piscatoria*, **51**: 159–166

Battaglia P., Malara, D., Romeo T., Andaloro F., 2010. Relationships between otolith size and fish size in some mesopelagic and bathypelagic species from the Mediterranean Sea (Strait of Messina, Italy). *Scientia Marina*, **74**: 605-612.

Bolognini L., Domenichetti, T., Grati F., Polidori P., Scarcella G., Fabi G., 2013. Weight-length relationships for 20 fish species in the Adriatic Sea. *Turkish Journal of Fisheries and Aquatic Sciences*, **13**: 555-560.

Froese R., Tsikliras A. C., Stergiou K. I., 2011. Editorial note on weight– length relations of fishes. *Acta Ichthyologica et Piscatoria*, **41**: 261–263.

Frost K. J., Lowry L. F., 1981. Trophic importance of some marine gaddids in northern Alaska and their body-otolith size relationships. *Fishery Bulletin*, **79**: 187-192.

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.

Hare J. A., Cowen R. K., 1995. Effects of age, growth rate, and ontogeny on the otolith size-fish size relationships in bluefish Pomatomus saltatrix, and the implications for the back calculation of size in early life history stages. *Canadian Journal of Fisheries and Aquatic Sciences*, **52**: 1909-1922.

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 Tech Rep NMFS 150.

Hunt J. J., 1979. Back-calculation of length at age from otoliths for silver hake of the Scotia shelf. *ICNAF Selected Papers*, **5**: 11-17.

Jawad L., 2013. Otolith mass asymmetry in Carangoides caerulepinnatus (Rüppell, 1830) (family: Carangidae) collected from the sea of Oman. Croatian Journal of Fisheries: *Ribarstvo*, **71**: 37-41.

Jawad L., Al-Mamry J. M., Al - Busaidi H. K., 2010. Otolith mass asymmetry in the teleost Beryx splendens Lowe, 1834 (Family: Bercidae) collected from the Arabian Sea coasts of Sultanate of Oman. *Thalassas*, **26**: 43-47.

Jawad L., Al-Mamry J. M., Al - Busaidi H. K., 2011a. Relationship between fish length and otolith length and width in the lutjanid fish, *Lutjanus bengalensis* (Lutjanidae) collected from Muscat City coast on the Sea of Oman. *Journal of Black Sea/Mediterranean Environment*, **17**: 116–126.

Jawad L., Ambuali A., Al-Mamry J. M., Al - Busaidi H. K., 2011b. Relationships between fish length and otolith length, width and weight of the Indian mackerel Rastrelliger kanagurta (Cuvier, 1817) collected from the Sea of Oman. *Croatian Journal of Fisheries*, **69**: 51-61.

Jawad L., Al-Mamry J. M., Al-Mamry D., Al -Hasani L., 2012. Study on the otolith mass asymmetry in Lutjanus bengalensis (Family: Lutjanidae) collected from Muscat City on the Sea of Oman. *Journal of FisheriesSciences. Com*, **6**: 74.

Jawad L., Park J. M., Kwak S. N., Ligas A., 2017. Study of the relationship between fish size and otolith size in four demersal species from the south-eastern Yellow Sea. *Cahier de Biologia Marine*, **58**: 9–15.

Jawad L., Al-Mamry J. M., Al -Mamari H., Al -Yarubi M., Al -Busaidi H., 2011c. Relationship between fish size and otolith size and weight in the pelagic species *Rhynchorhamphus georgi* (Valenciennes, 1846) (Family Hemiramphidae) collected from the sea of Oman. *Romanian Journal of Biology*, **56**: 189-200.

Kontaş S., Bostanci D., Yedier S., Kurucu G., Polat N., 2018. Investigation of fluctuating asymmetry in the four otolith characters of Merlangius merlangus collected from Middle Black Sea. *Türk Denizcilik ve Deniz Bilimleri Dergisi*, **4**: 128-138.

Lieske E., Myers R., 1994. Collins Pocket Guide. Coral reef fishes. Indo-Pacific & Caribbean including the Red Sea. Haper Collins Publishers, 400 p.

Lombarte A., Chic O. , Parisi-Baradad V. , Olivella R., Piera J. , García-Ladona E., 2006. A web-based environment from shape analysis of fish otoliths. The AFORO database. *Scientia Marina*, **70**: 147–152.

Mommsen T. P., 1998. Growth and metabolism. In: *The physiology of fishes* (D. H. Evans ed.), pp. 65-97. CRC Press: New York.

Mugiya Y., Tanaka S., 1992. Otolith development, increment formation, and an uncoupling of otolith to somatic growth rates in the larval and juvenile goldfish. *Nippon*

Suisan Gakkaishi, **58**: 845-851.

Munk M. K., 2012. Somatic-Otolith Size Correlations for 18 Marine Fish Species and Their Importance to Age Determination. *Regional Information Report*, No. 5J12-13. Alaska Department of Fish and Game.

Park J. M., Gaston T. F., Riedel R., Williamson J. E., 2018. Biometric relationships between body and otolith measurements in nine demersal fishes from north-eastern Tasmanian waters, Australia. *Journal of Applied Ichthyology*, **34**: 801-805.

Qasim A. M., Jawad L. A., Abdullah A. H. J., 2019. Fish length-otolith size and weight relationships of the Otolithes ruber (Bloch & Schneider, 1801) collected from the marine waters of Iraq, Persian Gulf. *Cahier du Biologia Marine*, **60**: 439-443.

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

Richter H. C., Luckstadt C., Focken U., BECKER K., 2000. An improved procedure to assess fish condition on the basis of length-weight relationships. *Achieves of Fisheries and Marine Research*, **48**: 255-264.

Safran P., 1992. Theoretical analysis of the weight-length relationships in the juveniles. *Marine Biology*, **12**: 545-551.

Valentine D. W., Soule M. E., Samollow P., 1973. Asymmetry in fishes: a possible statistical indicator of environmental stress. *Fishery Bulletin*, **71**: 357-370.

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.

West C. J., Larkin P. A., 1987. Evidence of size selective mortality of juvenile sockeye salmon (Oncorhynchus nerka) in Babine Lake, British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences*, **44**: 712-721.

Yedier S., Bostanci D., Kontaş S., Kurucu G., Polat N., 2018. Comparison of otolith mass asymmetry in two different *Solea solea* populations in Mediterranean Sea. *Ordu Üniversitesi Bilim ve Teknoloji Dergisi*, **8**: 125-133.