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# FISH LENGTH AND OTOLITH SIZE OF IN *NEMIPTERUS RANDALLI* RUSSELL, 1986 (ACTINOPTERYGII: PERCIFORMES: NEMIPTERIDAE) COLLECTED FROM GÖKOVA BAY, TURKEY

## SUMMARY

Otoliths have been proved an appropriate tool to identify fish species, and they have been in use in studies of prey-predator relationships, population dynamics and ichthyo-archaeology. In addition, the fish otoliths are frequently used to decide age and size of the teleost fishes. The relationships between otolith measurements (length, width, and weight) and fish length and weight were calculated for Randall's threadfin bream, *Nemipterus randalli* collected from Gökova Bay, Turkey. Otolith length, width and weight were shown to be good indicators of the length of fish, but the best indicator was the otolith length. Sizes of the left and right otoliths were found not be significantly different.

## INTRODUCTION

The rate of consumption in predators, the biomass of the prey consumed, and selectivity of a predator towards a particular size class of prey are groups of biological and ecological information frequently applied in the feeding studies. To achieve such task, the original size of the ingested prey needs to be assessed. The size of the otolith measurements is utilised to rebuild the prey body size by linking the correlation between otolith length and fish size (Battaglia *et al.*, 2015).

The supposed proportionality between the growth in otolith and fish body growth (Maceina and Sammons, 2006) was among the major examination measures for the purpose of reconstructing individual growth history, which is well recognized and has noteworthy prospective for the previous analysis of environmental effects on growth forms in populations (Maceina and Sammons, 2006). Implication on the relationships between ecological causes and past growth in populations can be useful for inferring how populations will respond to the environmental variations in the future. Different computable methods for describing this relationship have been assessed for their back-calculation of length-stage, but the application may be limited in some cases by the non-existence of procedural control for individual species (Maceina and Sammons, 2006).

Randall's threadfin bream (*Nemipterus randalli* Russell 1986) is a marine, demersal and non-migratory fish species living down to 450 m and preferring benthic habitats (Sommer *et al.*, 1996). Maximum length for the species was given inCIESM Atlas of Exotic Species in the Mediterranean as 30 cm (Sommer *et al.*, 1996), but the typical length is 160 mm (Russel, 1990). This species is distributed in the W Indian Ocean from the Red Sea to Arabian Sea.

In the Mediterranean Sea, the first report of the presence of *N. randalli* was the misidentified specimen of the Japanese threadfin bream *Nemipterus japonicus* (Bloch 1791). That specimen was collected off the northern Israeli coast (Golani and Sonin, 2006). Afterward, it was recorded off Lebanon (Lelli *et al.*, 2008), the Mediterranean coast of Syria (Ali *et al.*, 2013). In the Turkish waters of the eastern Mediterranean Sea, this species has been reported from several places, from Iskenderun Bay (Erguden *et al.*, 2009), from Antalya Bay (Gökoglu *et al.* 2009), from the south-eastern Aegean Sea (Gulsahin and Kara, 2013).

The present study aims to estimate the relationship between otolith sizes (length and width) and weight with the total fish length and weight in Randall's threadfin bream collected from Gökova Bay, Turkey. These data are valuable to researchers studying food habits of predator species, to establish the size of prey from the length of regained otoliths.

## MATERIAL AND METHODS

### *Fish and otolith collection and measurements*

A total of 322 *N. randalli* collected between May 2015 and April 2016 by fishnet and longline in addition to samples obtained from Akyaka Fisheries Cooperative located on Gökova Bay. The collected specimens were transported in ice instantly to the laboratory. Fishes were identified according to Russell (1990) and measured to the nearest 0.1 cm total length (TL) using digital callipers sensitive to 0.1 mm and nearest 0.001 g total weight (W). Otoliths (sagittae) were removed from both sides of the fish head, cleaned and stored dry in vials. Otolith major axis (length OL) and minor axis (width OWi) were measured to the nearest 0.1 mm using a dissection microscope provided with a micrometre eyepiece (micrometric ocular, ± 10 µm) with ×1 magnification) (Fig. 1). The weight of otolith (OW) was obtained using Sartorius Quintix 224-1S digital balance (± 0.0001 g).

### Data analyses statistics

The relationships between otolith length, width weight, and total fish length were calculated using the following formula:

Y= *a* X*b* where Y= morphological characters, X= total fish length, *a* and *b*= constants. According to the law of the allometry, "*b*" would take a value close to 1. To test this value, Student test "*t*" was used. The maximum coefficient of determination ($R^2$) was selected to define the concerned mentioned relationships. Alterations among coefficients of regressions created discretely for right and left otoliths were verified by analysis of covariance (ANCOVA) (Zar, 1999). In case of equation coefficients did not agree statistically, a single regression was counted for each factor using the mean of right and left otolith measurements. An ANOVA F-test was used to check the significance of the slope of the regression (testing the null hypothesis H0: *b*=0). The allometry was assessed by checking the significance of the allometric coefficient "*b*" (*b*=1, *b*<1 and *b*>1 for isometry, negative allometry and positive allometry respectively) that used as a ration for the strength of differential increase in the morphological traits comparable to an exact reference length (Van Snik *et al.*, 1997). The regression equations between the total length and otolith length, total length and otolith width, total length and otolith weight were considered with the Excel programme using power equation with best fit trend line and $R^2$.

## RESULTS

The average fish total length was 16.5 ± 0.1 cm (10.6~21.9 cm), and the average fish weight was 66.9 ± 1.5 gr (14.9~150.9 g). The average otolith length OL range was 6.6 ± 0.05 cm (4.3~8.5 cm), otolith width OWi 4.4 ± 0.03 cm (3.0~5.5 cm) and otolith weight W was 0.3 ± 0.001 g (0.013~0.07 g). As no significant differences (*t*-test for paired comparisons, $p<0.05$) were found between left and right otolith length, width and weight data, only the left sagittae measurements and weight were used for determining the relationship between fish size and otolith size and weight.

The relationships between the three parameters of the otolith, length, width, and weight and the two parameters of the fish, total length, and total weight were calculated. The values of *a* and *b* of these formulae are given in Table 1. The highest value of *b* was observed for the fish total weight W vs otolith width Wi (3.3), and the lowest value is observed for fish total weight W vs Otolith wright W (0.01).

Positive allometry was noticed in the TL vs OW, OW vs OL and OW vs OWi relationships, while negative allometry was observed for TL vs OL, TL vs OWi and OWi vs OL, W vs OL, W vs OWi and W vs OW relationships. The values of correlations obtained from the nine relationships were higher than 0.8. The highest correlation values (0.93) was observed in OW vs OL relationship. The lowest correlation value (0.82) was observed in W vs OW relationship (Table 1). Although otolith length, width, and weight gave the best estimations for both fish total length and weight, however, the otolith length was the best.

## DISCUSSION

Among the characters that separate species and populations of fishes are the surface morphology of the otolith and the relationships between size and weight of the fish and otolith length, width and weight. These relationships can be utilised to assess the fish size and biomass in food and feeding studies (Hussy *et al*., 2012). Few studies on these biological features in the fishes of Turkish waters were on record (Bostanci, 2009; Kasapoglu and Duzgunes, 2013). There is no work published for *N. randalli* in the Turkish waters except for that of Innal *et al*. (2015).

It is common in the fisheries studies to use otolith length, width, and weight as variables for evaluating fish size (Battaglia *et al*., 2015). The present study puts forward the equations based on otolith length, width dimensions and otolith weight in relation to the fish total length of Randall's threadfin bream from Gökova Bay for the first time and the Turkish marine waters for the 2nd time. Therefore, the comparison was made in the present study for the values of *b* and $R^2$ with the results of Innal *et al*. (2015) only.

The present study evaluated the somatic relationship with otolith length, width, and weight, which is expected to show more accurate assumptions. The present study indicated a strong correlation between otolith length, width, and weight and fish total length and weight. Many researchers reported similar relationships between otolith and somatic measurements (Metin and Ilkyaz, 2008; Jawad *et al*., 2011).

Otolith length was found to be the best for deducing fish length for *N. randalli*. There is no significant difference between the right and left otolith indicated that these are mirror images of each other (Hunt, 1979). Harvey *et al*. (2000) and Waessle *et al*. (2003) confirmed the similarity of right and left otolith in *Lutjanus benghalensis*. Similarly, Jawad *et al*. (2011) showed the same results on *Lutjanus benghalensis* from Omani waters. The relationships between otolith length, width, and weight with the fish body proportions are related to the growth rate of the fish (Mugiya and Tanaka, 1992), and this relationship became curvilinear in some larval or juvenile fishes (West and Larkin, 1987), such curvilinearity was observed in the present study, but not in the previous similar studies on fishes from Oman (Jawad *et al*. 2011). Harvey *et al*. (2000) and Waessle *et al*. (2003) and Battaglia *et al*. (2015) have suggested that there is a possibility of getting error in the final results of the relationship between otolith dimensions and fish size due to changes in this relationship during the life history of the fish and as the fish length changes (Hare and Cowen, 1995).

The results of Innal *et al*. (2015) have shown that the OL vs TL and OW vs TL relationship of *N. randalli* from Antalya Gulf, Turkey have coefficients of determination $R^2$ values 0.74 and 0.87 respectively. Although the values of $R^2$ obtained by Innal *et al*. (2015) are reasonably high, they are less than those obtained for the same species from Gökova Bay, Turkey given in the present study. Such differences can be ascribed to various factors; among these are differences in measuring due to the personal handling of the specimens performed in both studies and the differences in the living habitats (Kasapoglu and Duzgunes, 2012). Similar differences were detected in studies of Bostanci (2009) and Kasapoglu and Duzgunes (2012). The otolith measurements of the same species occurring in different locations may vary according to habitat and water quality. The formation of the otolith during early development of fish is specific to species and also depends on environmental factors such as temperature and oxygen concentration (Balon, 1981). Investigation of these parameters may assist predictable otolith interpretation processes and propose additional research to accurately document otolith size relationships for these and other species (Munk and Smikrud, 2002). Therefore, the present study reveals that the relationship between otolith length, width, and weight for the same species can vary according to region and practice used.

The other factor that may affect the differences in the otolith size and weight and fish length and weight is the sex of the specimens. Such factor was observed in several studies on several fish species (Mundy *et al*., 2004; Tarkan *et al*., 2007; Bostanci *et al*., 2012). This inconsistency seems to be related to changes in somatic growth between males and females. Vallisneri *et al*. (2008) stated that if otolith and somatic growth were close to each other, the difference in otolith size between females and males, corresponding to differences in somatic size would be expected. But otolith and somatic growth are not always tightly run together coupled as otoliths proceed to grow in the absence or slowing of somatic growth (Mundy *et al.*, 2004). Such an effect will produce larger otoliths for slower growing specimens (Francis *et al.*, 1993). Therefore, different equations should be used for females and males. In spite of all data fitted well with the regression model, it is advisable to use these equations within the fish size range limits given in this study for this species. The regressions from this study can be useful for investigators examining food habits of predators of species in question. In our research, sexes were mixed and also in the samples of Innal *et al.* (2015). Therefore, the differences in the otolith sizes and weight with the fish length and weight can be explained on this bases.

Since *N. randalli* being a dominant species in the benthic environment and feeding on small benthic fishes, the assessment of specific relationships would be very much useful to assess the size of preys during the food and feeding studies. This study expected to give an improved thoughtful in the trophic relationship in the Gökova Bay food web by the rebuilding of the prey size using the otolith dimensions and weight. It also will be valuable in the paleontological studies. Such numerical relations to predict fish size from the otolith size and weight need to be established for more species, to enhance the studies and understand the trophic relationship between the fishes from the Turkish waters, quite renowned for its rich fish diversity.

Otolith may have been subjected to chemical and mechanical abrasion while they are in the stomach of the predator. Such adverse environment could lead to underestimating of otolith size or weight (Granadeiro and Silva, 2000). The strongly correlated relationship of total length of the fish and otolith length was inspected, and the study resolved that this equation can be used to calculate the prey size for trophic dynamics studies. Battaglia *et al.*, (2015) have recommended that such equation is appropriate within the size ranges used in this study for accurate estimations. On the other hand, Hare and Cowen (1995) has given a set of restrictions in envisaging the prey size of even the same species using the regression equations. These limitations are the geographical areas, stocks, populations, sexes, ontogenic changes in the life history.

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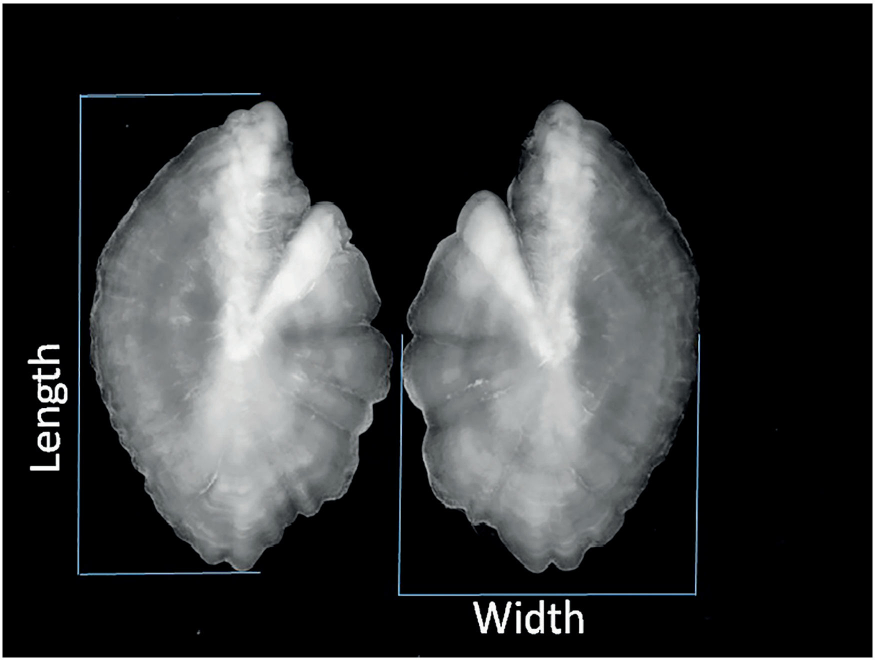


Fig 1. Otolith of *Nemipterus randalli* showing the major axis length (otolith length, OL) and minor axis length.

Table 1. The otolith major axis length (otolith length, OL), minor axis length (otolith width, OWi) and otolith weight-fish total length (TL) and weight (W) relationships of *Nemipterus randalli*. Intercept values (*a*), regression slope (*b*) and coefficients of determination ($R^2$).

| | Relationship | a | b | $R^2$ | Significance |
|---|---|---|---|---|---|
| Fish total length | TL vs. OL | 0.0363 | 0.5945 | 0.90 | $P < 0.001$ |
| | TL vs. OWi | 0.0209 | 0.9263 | 0.85 | $P < 0.001$ |
| | TL vs. OW | 0.0067 | 2.1507 | 0.87 | $P < 0.001$ |
| Fish total Weight | W vs. OL | 0.2242 | 2.9938 | 0.91 | $P < 0.001$ |
| | W vs. OWi | 0.4833 | 3.3012 | 0.87 | $P < 0.001$ |
| | W vs. OW | 0.0004 | 0.0105 | 0.82 | $P < 0.001$ |
| Otolith | OW vs. OL | 0.0004 | 2.3182 | 0.93 | $P < 0.001$ |
| | OWi vs. OL | 0.5604 | 0.6843 | 0.89 | $P < 0.001$ |
| | OW vs. OWi | 0.0008 | 2.5598 | 0.89 | $P < 0.001$ |