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Comparison of some morphological characteristics of three sparid fishes (Perciformes: Sparidae) otoliths (Sagitta) from Shatt Al-Arab River, Basrah (southern Iraq)

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Abstract:

The otoliths (ear stones) of sparid species (*Acanthopagrus berda* (Forsskal,1775), *A. latus* (Houttuyn, 1782) and *Sparidentex hasta* (Valenciennes,1830)) sagittae were studied. Fifty specimens of each species with different sizes were collected from local markets since December 2014 to March 2015. The largest otolith pair of each specimen (sagitta) was extracted and used to differentiate among the three species. The results revealed that the sagittae of these three species differ from each other, especially from posterior, that it is almost straight in *A. latus*, whereas there is a notch in *A. berda*, in *S. hasta* the posterior of sagitta regularly pointed. A linear relationship between total length-otolith length and body weight-otolith weight are found for the three-studied species. The otolith weight correlated with fish body weight was stronger than the correlation of otolith length with fish total length. The form factor of *A. latus* is higher than the other two species so as to roundness, but *S. hasta* has the highest aspect ratio. The results suggest that otolith (sagitta) morphology of the three sparid species differs from each other, thus, sagitta can be adopted to discriminate among these species, because it is species specific.

Keywords: Sparidae, Otolith, Sagitta, Basrah, Shatt Al-arab, *Acanthopagrus*, *Sparidentex*.

Introduction

The sea breams or porgies (Sparidae) are found in the Atlantic, Indian and Pacific oceans and comprise about 33 genera with about 115 species. This family is characterized by a groove in the distal end of the premaxilla which accommodates the maxilla [1]. There are thirty-seven genera belong to this family in the world [2], whereas three species belong to this family in Iraqi inland waters (*Acanthopagrus berda*, *A. latus* and *Sparidentex hasta*) [1].

In general, there are two basic groups of fishes, firstly the ostariophysian (otophysan) which includes the catfishes, minnows and suckers, secondly the non-ostariophysan (non-otophysan) group which includes the perch, pike, crappie and sunfishes, the otophysans have a structure called the Weberian ossicles that are located at the rear of the skull and are believed to make contact with the swim bladder and enhance hearing [3]. The largest group of hearing specialists is the otophysan fishes, which dominate the fresh waters of the world (over 60% of all freshwater species), because of the Weberian ossicles and gas bladder, the otophysans have the highest sensitivity and greatest frequency range of hearing among fishes [4].

The auditory-equilibrium organ or "labyrinth" of fishes comprises three fluid-filled semicircular canals that are connected with three sac-like chambers, the sacculus, utriculus and lagena, each chamber contains a hard bone-like otolith (ear-stone): the sagitta, lapillus and astericus, respectively, the labyrinths are located in the bony auditory capsules at the back of the cranium. However, in most teleosts the sacculus is the largest of the three chambers, hence the sagitta is usually the largest of the three otoliths [5]. In fact, otoliths which are present in all bony fishes, consist of a calcium carbonate (usually aragonite) crystal that grows continuously by accretion over the life of the fish [6], otolith growth begins with the initial "focus" and thereafter by incremental concretions of calcium carbonate in the form of aragonite. Otolith size increases with increasing size and age of the fish [7].

Otoliths have been proved valuable beyond the studies of feeding, age and growth alone. Studies of populations-stock assessment and stock discrimination, together with fish migration and movement were done by [6]. The otoliths have been used traditionally to obtain information about the taxon, age and size of fishes which is very important because age, growth rate, and mortality rate are three of the most influential life history characteristics controlling the productivity of fish populations. Besides age and growth determination, otoliths have been the object of study in many different fields, such as fish biology (hearing and balance in fishes), larval fish ecology, species identification, fish stock identification and environmental reconstruction of the fish habitat [8]. More importantly for scientists and resource managers, otoliths are natural data loggers that record information in their microstructure and chemistry at different temporal scales related to their growth and environment, this information, which includes age and growth, movement patterns and habitat interactions, can be interpreted at the population level in terms of the ecology, demography and life history of the species, which has become fundamental to the management of fisheries and protected species around the world [9].

Knacigil *et al.* [10] studied the otolith morphologies of 13 species belong to the Sparidae family collected from the Bay of Izmir (Aegean Sea) and found that it is possible to identify the species from the Sparidae family by the otolith characters. After studying 185 sagitta otoliths from 18 species belong to four coastal perciform families of the north-west Mediterranean (Sparidae was one of them). Cruz & Lombarte [11] deduced that species with relatively large otoliths belonged to groups considered specialists in sound production (Sciaenids and Haemulids), while those with small otoliths belonged to groups that rely on bright or contrasted color patterns for visual communication (Labrids) and they noticed that in Sparids, species with clear body marks had smaller otoliths than species without dark stripes or dots. Their findings support the hypothesis that otolith size is related to hearing ability in the inner ear [11].

In Iraq, Al-nusear [12] compared otoliths of two species belong to Mugilidae and found that there are many features in them sagitta could be useful to discriminate *Liza abu* and *L. subviridus*. AL-Jumaily and Dauod [13] studied the morphological description of the inner ear of *Silurus triostegus,* then AL-Jumaily [14] described morphologically inner ear in *Barbus luteus* the results revealed that this species had a pair of inner ears which are embedded in two otic capsules of the skull and the inner ear contains two main structures, the first is the Osseous Labyrinth and the second is the Membranous Labyrinth.

The purpose of this study is to discover the morphological differences among the otoliths (sagitta) of the three-studied species, to provide another tool which can be used to discriminate among them, especially in systematic and biological studies.

Materials and methods

A 50 of fishes for each of three species (*A. berda*, *A. latus* and *S. hasta*) from different sizes were collected in fresh condition from the local fish market at Basrah city (Figure 1).

In the laboratory, the method used by [15] was employed to get the otoliths (sagitta) of the fish under investigation, photographs were taken using a digital camera type SONY DSC w690 after mounting on dissecting microscope. The diagram in Figure 2 was adopted to name the different parts of sagitta [16]. Both of the fish and the left otolith were weighed then the relationship between the otolith (weight and length (y)) and fish body (weight and length (x)) was found by using of linear regression (y = ax + b), (a) and (b) are constants.
In order to describe the shape of the otolith, three dimensionless shape factors were calculated according to [17]:

FF=4.π.A.P-2, RD=4.A.(π.LO2)-1, AR=LO.W-1

Where FF is a form factor, RD roundness, AR aspect ratio, A otolith area (mm^2), P otolith perimeter (mm), LO otolith length (mm) and W otolith width (mm). The form factor (FF) is the inverse ratio of the squared perimeter of an object to the squared perimeter of a circle of the same surface. The smaller it is, the lacier is the outline of the otolith. The roundness (RD) is the ratio between the actual area and the area of a circle of the same length. Namely, this factor is larger if and when the shape of otolith is more circular. The aspect ratio (AR) is the ratio between the otolith length and otolith width. This factor expresses the shape tendency of the otolith; the more elongated the otolith of the fish, the larger the aspect ratio is. The area and perimeter of otolith was measured by using of Imagej© software (free download from https://imagej.nih.gov/ij/).

Results and Discussion

Results revealed that otoliths of the three studied sparids differ from each other (species specific). The excisura in *A. berda* (Figure 3) is obvious whereas it is not found in *A. latus* (Figure 4) and very small in *S. hasta* (Figure 5). The sagitta of *S. hasta* is oblong when compared with those of the two-other species. Cauda (the posterior part of the sulcus) is pending down to the ventral side in *S. hasta* more than the same part does in the other two species. *A. latus* has dorsal depression unlike *A. berda* and *S. hasta*. The posterioventrally descending part of cauda in *A. berda* sagitta is the smallest one among the three studied otoliths.

The ventral margin of *A. latus* sagitta is aciculate, while in *A. berda* and *S. hasta* it is rounded. From posterior, the three sparid species are different from each other, that it is almost straight in *A. latus*, whereas there is a notch in *A. berda*, in *S. hasta* the posterior of sagitta regularly pointed.
Sagittal otolith morphology key to identify three studied sparid species (depending on this study results):

1a) Dorsal depression above sulcus absent …………………… 2

1b) Dorsal depression above sulcus present ………… *Acanthopagrus latus* (Figure 4)

2a) Posterior margin has notch ………….…….…. *Acanthopagrus berda* (Figure 3)

2b) Posterior margin has no notch…………………..…. *Sparidentex hasta* (Figure 5)

A positive linear relationship between total length-otolith length and body weight-otolith weight were found for the three-studied species are given in Table 1. The otolith weight correlated with fish body weight stronger than the correlation of otolith length with fish total length (Table 1), *A. latus* has the strongest correlation among the three species in both relationships.

The form factor in *A. latus* is higher than the other two species (Table 2) so as to roundness, but for aspect ratio *S. hasta* has the highest ratio.

The sagitta otoliths are the most widely used in comparative taxonomy studies because their form, weight, growth, consistency and chemical composition have a distinctive degree of interspecific variation; they are easily accessible structures as well [18]. Our results reveal that otolith (sagitta) morphology of the three sparid species differs from each other as they have a different otolith shape, sulcus, posterior margin and excisura. *A. latus* has dorsal depression unlike *A. berda* and *S. hasta*. Thus, sagitta can be adopted to differentiate among these species, as it is species specific (Figure 3, 4 & 5).

As seen from otolith weight-body weight relationship (Table 1), for the same body weight *A. berda* sagitta is the heaviest and *S. hasta* sagitta is the lighter one. This is because of slow-growing fish tend to have heavier and larger otoliths than fast growing fish of the same length, because otoliths continue to grow even when somatic growth has slowed or stopped [19], and the second reason is otolith is a non-cellular tissue since the elements once deposited undergo almost no change throughout the fish's life [20].

The correlation (R^2) of otolith weight-body weight is stronger than that of otolith length-total length in all three species. This indicates that otolith weight would be a more accurate indicator of somatic growth (Table 1), this is may be due to the pelagic tendency of these species. Parmentier *et al.* [21] referred that fish occupying the same ecological niche show resemblances in otolith shape; pelagic fish species are known as fast swimmers and the shape of their otolith could be an element contributing to make the neurocranium lighter in order to reduce energy expenditure during swimming; on the contrary, in benthic, commensal and parasitic species, the swimming constraint is obviously weaker and does not act as a restricting factor on the otolith development which is reinforced by their thicker otoliths. Campana *et al.* [22] stated that as the chemical composition, can be distinct for different water masses, trace elements incorporated into the surface of the otolith reflect the physical and chemical characteristics of the ambient water, and can be used to discriminate between groups of fish that have spent part of their lives in different environments.

Because of *S. hasta* sagitta has the smallest form factor among the three species, it is the laciest outline of the three sparids, but sagittae of *A. latus* and *A. berda* are more circular than *S. hasta* this is why they have higher roundness indices than it, aspect factor of sagittae says that these sparids otolith can be arranged from more to less elongated as *S. hasta*, *A. latus* and *A. berda* respectively.

Conclusions

(1) The otoliths of studied species are unique for each species and can be used to differentiate among them.

(2) Sagittae are useable in systematics studies to identify specimens downward to species taxon and stomach content analysis of piscivorous.

Table 1. Linear regression of Otolith length (y)- Total length (x) and Otolith weight (y)-Body weight (x) for the three species, R^2 is square of correlation coefficient

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Species	Form Factor	Roundness	Aspect Ratio
S. hasta	0.36065	0.49601	1.66
A. berda	0.37763	0.62583	1.31
A. latus	0.41392	0.62686	1.4

Table 2. Form Factor, Roundness and Aspect Ratio for sagitta of the three species

Species	**Otolith Length-Total Length**		**Otolith Weight-Body Weight**	
	Regression	**R^2**	**Regression**	**R^2**
S. hasta	y = 0.0058x + 6.0851	0.0074	y = ٠.0024x + 0.0084	0.1612
A. berda	y = 0.0353x + 1.3427	0.1957	y = 0.0002x + 0.013	0.4477
A. latus	y = 0.0108x + 5.2951	0.3913	y = 0.0002x + 0.0109	0.689

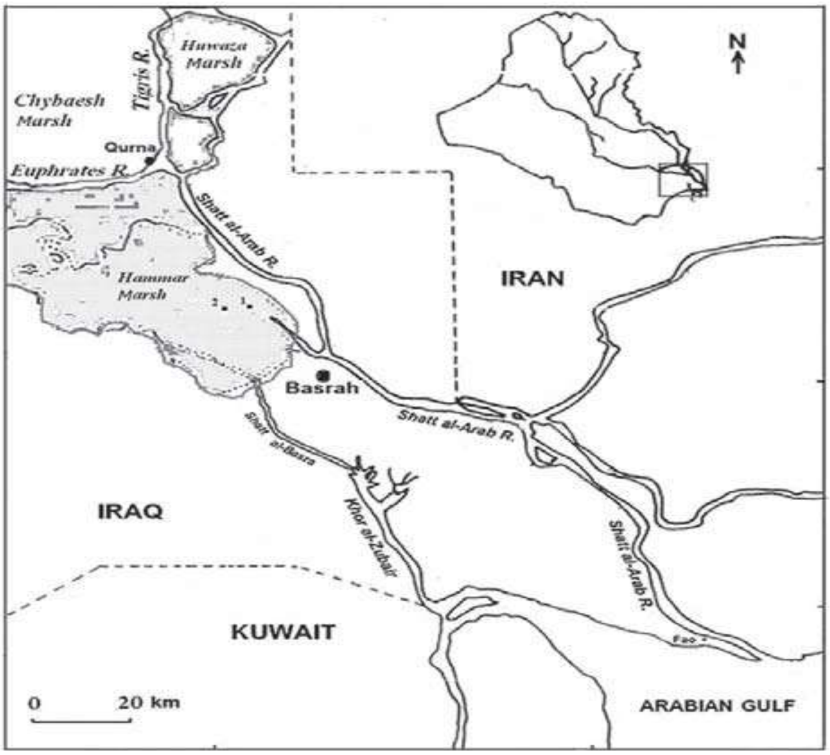

Figure 1. Shatt Al-Arab river in Basrah (southern Iraq)

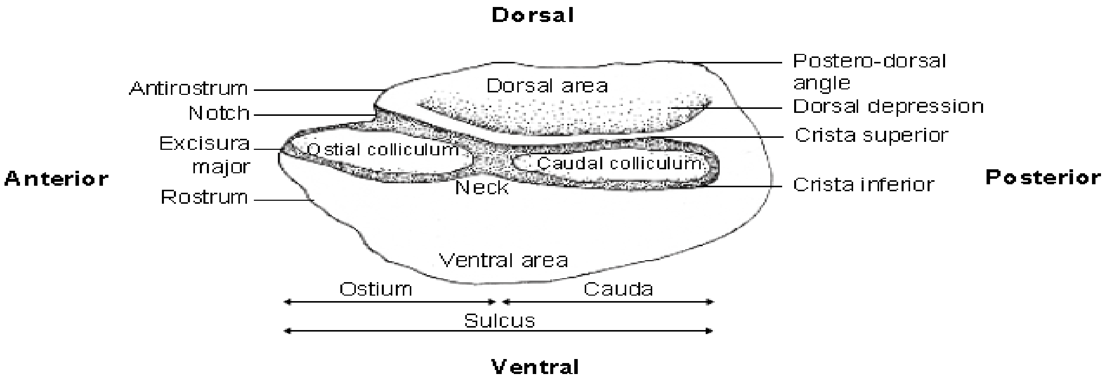

Figure 2. Diagram of Proximal surface of left sagitta showing important characters from [16].

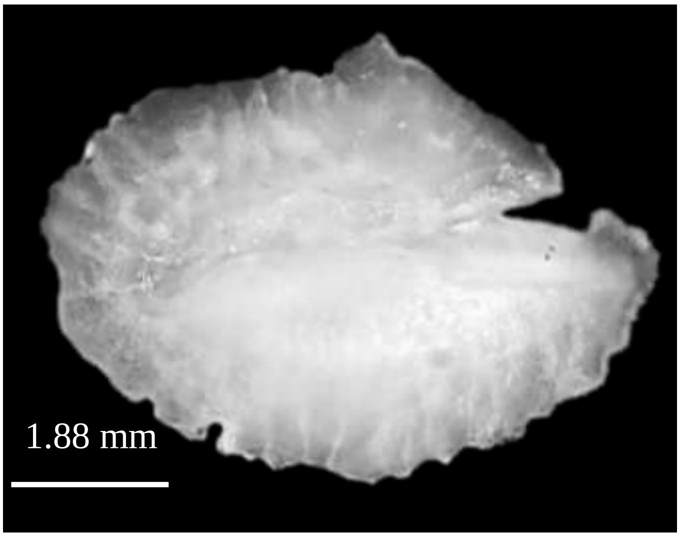

Figure 3. Proximal surface of otolith (Sagitta) of *Acanthopagrus berda* (Total body length 170 mm, Otolith length 7.6 mm).

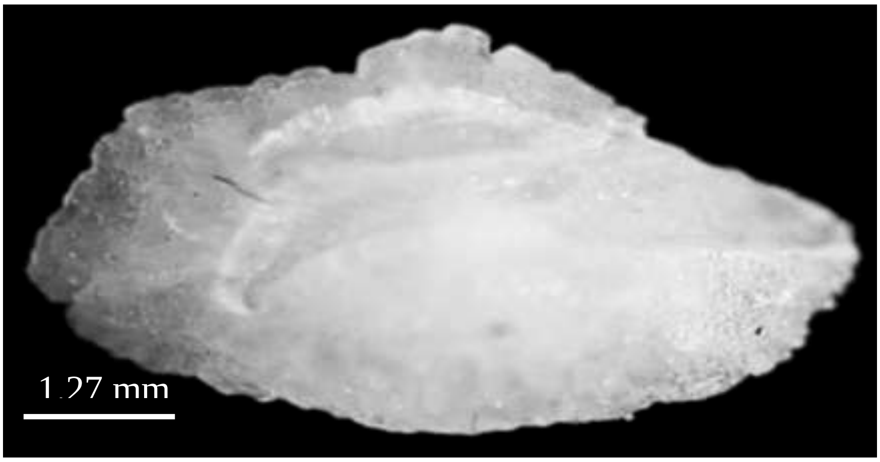

Figure 4. Proximal surface of otolith (Sagitta) of *Acanthopagrus latus* (Total body length 101 mm, Otolith length 7 mm).

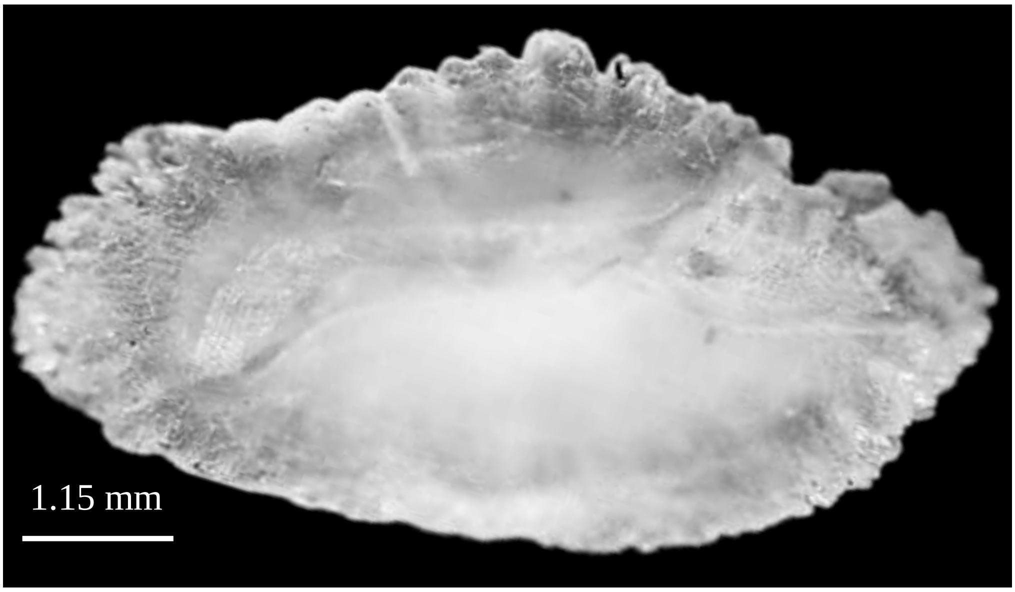

Figure 5. Proximal surface of otolith (Sagitta) of *Sparidentex hasta* (Total body length 210 mm, Otolith length 7.5 mm).

References

[1] Norrocky, Michael James. A technique for extracting all six otoliths from fishes and a list of fishes from Lake Erie, Sandusky Bay and their tributaries located in North-Central Ohio, U.S.A. from which otoliths were collected. http://jimnorrocky.weebly.com/extracting-otholiths-from-fishes.html. (Downloaded at 9/10/2016). 2013.

[2] Bingel, F. Growth of a cod otolith on the crystal level. Meeresforschung, 28:212-215.1981.

[3] Mendoza, R. R. Otoliths and their applications in fishery science. Ribarstvo, 64(3), 89-102.2006.

[4] Begg, G. A.; Campana, S. E.; Fowler, A. J. & Suthers, I. M. Otolith research and application: current directions in innovation and implementation. Marine and Freshwater Research, 56(5), 477-483. 2005.

[5] Knacigil, H. T.; Akyol, O.; Metin, G. & Saygi, H. A Systematic study on the otolith characters of Sparidae (Pisces) in the Bay of Izmir (Aegean Sea). Turkish Journal of Zoology, 24(4): 357-364.2000.

[6] Cruz, A. & Lombarte, A. Otolith size and its relationship with colour patterns and sound production. Journal of Fish Biology, 65(6): 1512-1525. 2004.

[7] Al-nusear, Azal Naser Bader. Morphological study of otolith in two mugilid species *Liza subviridus* (Valenciennes, 1863) & *L. abu* (Heckel, 1843). Bas. J. Vet. Res.; 10(2): 67-71. 2011.

[8] AL-Jumaily, I. S. & Dauod, H. A. M. A study on the inner ear of *Silurus triostegus*: 1. Morphological description. J. AL-Mustansyria Science, 12(7): 805- 816. 2001.

[9] AL-Jumaily, I. S. Morphological description of inner ear in *Barbus luteus* Heckel (Teleostei: Cyprinidae). Ibn Al-Haitham Journal for Pure and Applied Science, 3 (25): 104-112. 2012.

[10] Ponton, D. Is geometric morphometrics efficient for comparing otolith shape of different fish species?. Journal of Morphology, 267(6), 750-757. 2006.

[11] Francis, M. P.; Williams, M. W.; Pryce, A. C.; Pollard, S. & Scott, S. G. Uncoupling of otolith and somatic growth in *Pagrus auratus* (Sparidae). fishery bulletin-national oceanic and atmospheric administration, 91, 159-164. 1993.

[12] Parmentier, E.; P. Vandewalle & Lagardère, F. Morpho-anatomy of the otic region in Carapid fishes: eco-morphological study of their otoliths. J. Fish. Biol., 58(4), 1046-1061. 2001.

[13] Campana, S. E., Chouinard, G. A., Hanson, J. M., Frechet, A., & Brattey, J. Otolith elemental fingerprints as biological tracers of fish stocks. Fisheries Research, 46(1), 343-357. 2000.

[14] Coad, B. W. Freshwater fishes of Iraq. Pensoft. 295pp. 2010.

[15] Nelson, J. S.; Grande, T. C. & Wilson, M. V. Fishes of the World. John Wiley & Sons. 752pp. 2016.

[16] Helfman, G.; Collette, B. B.; Facey, D. E. & Bowen, B. W. The diversity of fishes: biology, evolution, and ecology. John Wiley & Sons. 2009.

[17] Smale, M. J.; Watsony, G. & Hecht, T. Otolith atlas of Southern African marine fishes, monograph 1. Grahamstown (South Africa): JLB Smith Institute of Ichthyological Research. 1995.

[18] Furlani, D., Gales, R., & Pemberton, D. (Eds.). Otoliths of common Australian temperate fish: a photographic guide. CSIRO publishing.216 pp. 2007.

[19] Secor, D. H., Dean, J. M., & Laban, E. H. Otolith removal and preparation for microstructural examination: a user’s manual. Technical Publ. 1991-01, 85 p. The Electronic Power Research Institute and the Bell W. Baruch Institute for Marine and Coastal Sciences, Columbia, SC. 1991.

[20] Lin, C. H. & Chang, C. W. Otolith atlas of Taiwan fishes. National Museum of Marine Biology & Aquarium. 415 pp. 2012.

[21] Nolf, D. Otolith Piscium. In: H. P. Schultze (Editor). Handbook of Palaeoichthyology, Vol. X, Stuttgart and New York, Fisher, pp.1–145. 1985.

[22] Kitagawa, T. & Kimura, S. (Eds.). Biology and ecology of Bluefin tuna. CRC Press. 424 pp. 2016.