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Determination of the age and growth by Otolithometry of *Brachydeuterus auritus* off Togolese waters

Détermination par otolithométrie de l'âge et de la croissance de *Brachydeuterus auritus* des eaux togolaises

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KEY WORDS
Brachydeuterus auritus, age, growth, Togolese marine waters.

Abstract The present study aims to estimate the age and the growth of *Brachydeuterus auritus,* off Togo waters, in order to stock assessment. The otoliths were extracted from commercial landings by Togolese marine fisheries and analyzed in the Spanish Institute of Oceanography laboratories in Tenerife. The results showed that Total Length of the fish (T_L) is linked to the otoliths weight (OW): TL = 5.171*ln (Ow) + 28.805 (R^2=0.9227).
The mean length by age-class from the Age-Length key for the age-classes 1 to 4 were 10.6, 13.2, 15.1 and 16.8 cm, respectively. Length and age data were fitted to von Bertalanffy equation, and the growth parameters estimated were $L\infty$ = 23.15 cm; K= 0.225 year^{-1} and t_0 = -1.722 year.
The current results, comparable globally to those obtained, in Gulf of Guinea, such as in Togo waters with the marking and recapture method. Therefore, these results could be useful for the stock assessment of this species off Togo waters.

MOTS CLES
Brachydeuterus auritus, âge, croissance, eaux marines togolaises.

Résumé La présente étude a pour objectif l'estimation de l'âge et la croissance de *Brachydeuterus auritus* (Val, 1832) des eaux togolaises en vue de l'évaluation du stock de l'espèce. Les échantillons d'otolithes ont été collectés à partir des individus débarqués par les pêcheries artisanales maritimes togolaises et analysés dans les laboratoires de l'Institut Espagnol de l'Océanographie à Santa Cruz de Tenerife. Les données de taille et de l'âge ont été ajustées à l'équation de Von Bertalanffy avec le logiciel *GraphPad Prism* v.4.03 à partir de la longueur totale du poisson (LT).
Les résultats obtenus montrent que la longueur totale (LT) est liée au poids de l'otolithe par la relation LT = 5,171*ln (poids de l'otolithe) + 28,805 (R^2=0.9227) et

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qu'il a été déterminé 4 classes d'âges différentes.
Les tailles moyennes par classe d'âge obtenues à travers la clé Taille-Âge sur les classes d'âge 1 à 4 ont été de 10,6; 13,2; 15,1 et 16,8 cm et les paramètres de croissance sont pour L∞ de 23,15 cm ; K de 0,225 an^{-1} et t_0 de -1,722 an. Les présents résultats, comparables globalement à ceux obtenus, dans le golfe de Guinée notamment au Togo, par la méthode de marquage et recapture. Aussi peuvent-ils être utilisés pour l'évaluation de l'état de stock de l'espèce dans les eaux togolaises.

1. Introduction

The subject approached here relates to the determination by otolithometry, of the age and the growth parameters of Brachydeuterus auritus (Val, [60]). The situation of fisheries resources exploited in the world, particularly in the Gulf of Guinea, is currently worrying. In order to be ensured about the exploitation status of the fish populations in the region and in each of its countries, it is necessary to conduct stock assessments using different scientific methods or techniques giving different outcomes which can be compared [39]. Most methods, including the use of hard parts (otoliths, scales, etc.), are poorly applied in the Gulf of Guinea region [1], [11], [20], [26], [31], [56], because of the very low thermal amplitude comparing to temperate countries [15]. In order to know about the exploitation status of B. auritus, one of the main species most caught in Togolese waters, for the sustainable management, its stock should be evaluated [29], [30], [38]. This activity is very rarely conducted and singularly in the waters of this country, because of the lack of information on the age and growth patterns of the species exploited, the present study proposes to determine these parameters using the otoliths by studying the *Sagitta* otoliths [9]. Specifically, it is a question of: (i) the collection and the "reading" otoliths of *B. auritus*; (ii) the determination of age and (iii) the estimation of growth from the ages obtained.

2. Material and méthod

Otoliths of *B. auritus* were collected at the fishing port of Lomé (Togo) by random sampling from June to September 2016 on landings of artisanal marine fisheries (purse seines, gillnets and bottom gillnets).

This fishing harbor is the main landings site of marine catches and more than 80% of catches are in landed annually [57], [58].

The marine artisanal segment is only one which is more active, specially in this period corresponding to upwelling season, landing more than 99% of Togolese marine catches region [57], [58] and operate in coastal zone where adults and juveniles are living usually region [59].

Table 1 shows the characteristics of the samples. The size of the sample (334 otoliths) collected is more than the minimum (150 otoliths) requested for this the reading ([30].

Tab. 1 : Periodicity, number and range of sample sizes LT: total length (cm) of *Brachydeuterus auritus* individuals cached in Togolese waters in 2016

Month	Nº individuals	Size class (LT, cm)
June	21	8,1 - 16,5
July	26	8,4 - 15,3
August	135	8,2 - 17,0
September	152	8,6 - 21,3
Total	**334 (185 ♂, 149 ♀)**	**8,1 - 21,3**

Source: Results of this study

After extraction, the otoliths were washed, dried and stored in labeled tubes. A electronic scale branded "*© Mettler Toledo AG204*", accuracy 0.0001g was used for weighing.

For otoliths recording photography, images were obtained using an integrated microscope system brand *Nikon AZ 100* connected to a computer via a Nikon digital image capture card. Digital Sight DS-U2 with Niss Elements F © software at a resolution of 2560x1920 pixels (Cf. Photo 1).

Photo 1: Photographic equipment of the Spanish Oceanographic Institute (IEO) Laboratories, used for reading of otoliths samples collected in Togolese waters
Source: Results of this study (Photo taken during this study)

Regarding reading (interpretation of age), the otoliths were placed whole in black plates, immersed in distilled water and were observed through a binocular microscope Nikon SMZ-10 (full magnification 10X) under the light exterior provided by an illuminator placed laterally.

For the interpretation of growth structures, the criteria used are those described by [30] and presented below:

- It was considered normal birth date, January 1st for species distributed in the northern hemisphere ([38]);

- For the formation of an annual cycle: it is considered that an annual ring composed of 2 seasonal rings (an opaque - of rapid growth - which forms during the most favorable season for example the summer, and a hyaline - of slow growth - which forms in the most unfavorable time, for example in winter). Therefore, an annual ring corresponds to an opaque ring followed by a hyaline ring ;

- The width of the otoliths rings gradually decreases as the growth of the individual is more intense in the first years of his life; which is reflected in the relative width of the opaque and hyaline band. The opaque band of the first rings is considerably larger than the hyaline band, and then gradually decreases and the two become similar [44], [52], [53], [55].

- Regarding the nature of the border, the distribution of the age of a fish depends not only on the number of rings, but also on the nature of the edge of the otoliths in relation to the date of capture and the birth date adopted [12].

In addition, it takes into account existence and interpretation of several false rings (or pseudo-rings), particularly present in the first *annulus*. These pseudo-rings are formed in otoliths following changes in fish metabolism and break the normal pattern of growth marks. They may be due to internal factors (diseases, reproduction, diet, etc.) and external factors (time, temperature changes, etc.) [22], [30], [41], [42], [43], [44], [51], [52].

On the basis of the above criteria, the age class was assigned to each individual for future analysis.

For reading, a degree of reliability between 4 (maximum) and 1 (minimum) was assigned to each otoliths during its analysis.

Due to the lack of samples collected monthly during the study period, it was impossible to determine the periodicity of formation of a band or ring area. However, since most of the scientific community agrees that annulus formation occurs annually [9], [25], it is possible to consider that the rings of the otoliths of this species in Togolese waters are formed each year.

Obtaining pairs of values for size classes and age classes made it possible to develop the Size-Age Key for all analyzed individuals (males and females). Then average size and standard error for each age class as calculate.

The data obtained from the readings were adjusted to the von Bertalanffy model according to two different approaches:

- Adjustment of the obtained size-age class value pairs, which we call "direct reading" of the values;

- Adjustment of the mid-age-class value pairs obtained from the Key Age-Age, which we call "average size".

It is used to estimate growth parameters, the GraphPad Prism software v.4.03 from the total fish length (LT) according to its age (t) [50]: $\mathbf{L_t = L\infty\ (1-e^{(-k\ (t-t_0))})}$

L_∞ is the maximum theoretical (or asymptotic) size that an individual of the species would reach if he was alive indefinitely; K is the growth coefficient and represents the speed at which the curve approaches the asymptote, and t_0 is the theoretical age at which the fish size would be zero.

The von Bertalanffy growth parameters are used in order to compare our results to those found by other authors.

3. Results and discussion

3.1. Brief presentation of *Brachydeuterus auritus* ([60])

3.1.1. Taxonomic characteristics of *Brachydeuterus auritus*

Brachydeuterus auritus, belonging to the Haemulidae family with 11 genders, occupies zoological classification for the position presented in table 2.

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Tab. 2: Classification of *Brachydeuterus auritus*

Kingdom	Animal	Super class	Gnat-hostom	Class	Ray-finned fishes	Family	*Haemu-lidae*
Sub-kingdom	Meta-zoan	**Super class**	Fish	**Super order**	Teleos-teans	**Genus**	*Brachydeuterus*
Sub-phylum	Verte-brate	**Class**	Osteic-hthyes	**Order**	Perci-forms	**Species**	*auritus*

Source: ([60])

3.1.2. Morphology of Brachydeuterus auritus

According to [59], *Brachydeuterus auritus* is characterized by an elongated and compressed body with a height of 2.6 to 3 times the standard length. The eyes are big; the mouth is large and protractile; the muzzle is smaller than the diameter of the eye. The dorsal fin has 12 spines of moderate form and 11 to 13 soft rays; the third, and sometimes the fourth, is longer than the others. The anal fin has 3 spines with 9 to 10 soft rays.

The caudal fin is deeply indented. The lateral line has 48 to 52 scales with 4 or 5 rows below. The back is olive-colored, the sides and belly are silver-white. There is a dark spot on the upper edge of the operculum and on the base of the dorsal fin there are sometimes small dark spots (Cf. Photo 2).

Photo 2: de *Brachydeuterus auritus* ([60])
Source: Photo taken during this study

3.1.3. Area of distribution, habitats and reproduction

B. auritus is one of the species whose biology is poorly studied. Relatively large work on the species in Côte d'Ivoire, Ghana, Nigeria, Togo and Congo has addressed the species distribution ([7] and [53]). *B. auritus* is a semi-pelagic and eurybenthic species. It has a tropical and subtropical distribution, and occurs along the coasts of Mauritania to Angola in coastal waters 10 to 100 m deep [49]; and in Togo, on soft beds from 0 to 100 m depth [8], [14], [32].

According to [13] and [48], *B. auritus* is abundant in Ghana from 55 to 90 m depth. [34] estimates that the species evolves in schools and is on both sides of the thermocline; young people meeting only in the coastal fringe; adults are found further offshore, but are approaching the coast probably during the nesting season.

Brachydeuterus auritus polyphagia is limited to microscopic zooplankton, shrimp, juvenile fish, cephalopods, benthic crustaceans and, if necessary, polychaetes [5]. Planktonic crustaceans are constituted of majority of the diet, mainly large copepods that are numerous in the vicinity of the deep seabed. *B. auritus* feeds off the bottom during the day and, if necessary, in mid-water layers at night.

The author indicates that feeding would be important in the cold season when zooplanktons are very abundant. The diet would have seasonal variations between the long cold season and warm seasons; the small cold season does not have a diet distinctly different from the hot seasons. If planktonic crustaceans are scarce (in summer) the species varies its diet. [1] and [33] seem to confirm [6] and points out that in the case of small crustaceans, polychaetes and fishes, the species has a preference for the two latest.
The works of [7] are the only conducted on the biology *of B. auritus* in Togolese waters and interests include growth. These works are the one conducted on the biology of *B. auritus* in Togolese waters and deals, among other things, on growth. In these works, data on the size at first sexual maturity are available. But in Ghana, these sizes are 14.8 cm for the male and 15.1 cm for the female [3]; in Côte d'Ivoire they are 13.8 cm and 14.5 cm (TL) [5] then 12.25 and 11.96 cm (FL) respectively [56]; in Congo, they are 12 cm (LF) for the female [21] and in Senegal for 14.4 and 14.8 cm [49] for male and female respectively.

The nutrition regime of *B. auritus* shows that this species is opportunist and this can influence it growth in zone where it lives.

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3.2. Relationship between total length of individual and its otoliths weights

The equation of relationship between the total length of individuals and the weight of their respective otoliths is presented in Figure 1. The coefficient of determination R^2 very close to 1 (R^2 = 0.9227) shows a strong positive correlation between the two parameters and indicates that the otoliths weight increases with the fish size; which allows their use in studies of the predator-prey system [28], [36].

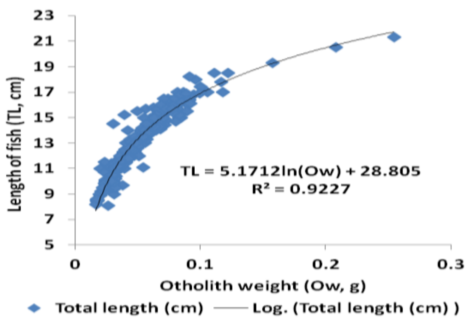
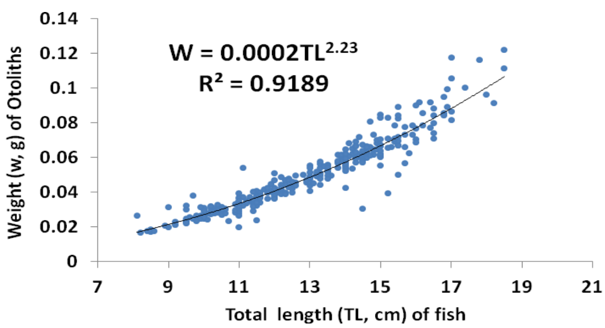


Fig. 1: Individuals total length relation and otoliths weight of *Brachydeuterus auritus* samples collected in Togolese waters
Source: Results of this study

Figure 1 also shows that the weight of otoliths increases rapidly at the beginning with individual size, slows down after, then reaches the asymptote at a certain size; this seems to reveal the growth that should be observed at the level of the height-age relationship of individuals (Fig. 5). Figure 2 shows the allometric relationship between the length of individuals and the weight of otoliths of *B. auritus*. The value of the parameter b of the relation is less than 3, even if mathematically the difference is not significant (W, p> 0.05).



Fig; 2: Allometric relationship between length of individuals and weight of *B. auritus* otoliths samples collected in Togolese waters
Source: Results of this study

Allometry relatively minor seems showing that the growth of fish length is faster than the weight of the otoliths. This situation in the growth of calcified parts seemed to be a fairly general case for teleosts [40], [46].

3.3. Estimation of age by reading otoliths

A total of 334 otoliths were read. In general, It can note on (Cf. Fig. 3) that:

- Otoliths have a well-defined nucleus, sometimes surrounded by very marked pseudo-rings that make up the first ring. In some cases, the nucleus presents itself with a small raised formation, in the form of a dome;

- There are no otoliths area exclusively reserved for ring identification; it depends on their number and how they present themselves;

- Otoliths have good visibility with regard to the identification of the first 3 rings (opaque and hyaline). In most cases, pseudo-rings do not facilitate the interpretation of their reading, but their presence does not prevent the use of otoliths for age determination;

- From the 3rd ring, there is a decalcification in the otoliths and the rings become less obvious;

- It was not possible to analyze the monthly evolution of the last otoliths ring because our samples are not collected during the whole one or two years. However, it was found that the percentage of hyaline edges of otoliths sampled from June to September 2016 increased steadily to 100% translucent in September.

During the interpretation of the age, 12% otoliths were rejected due to the presence of pseudo-rings and / or broken; and 293 individuals were taken into account for the analysis (very reliable 25% and less reliable 75%). The age classes shown in Figure 5 ranged from 1 to 4 years.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Tab. 3: Size-Age Key (cm / yr), in %, of *Brachydeuterus auritus* of Togo. SE: standard error

Age class Size (LT cm)	1	2	3	4
8	100			
9	93	7		
10	68	32		
11	37	63		
12	32	63	5	
13		64	33	3
14		47	51	2
15		37	52	11
16		35	59	6
17		17	67	16
18			50	50
19				100
20			100	
21				100
N	75	130	76	12
Average size (cm)	10,6	13,2	15,1	16,8
SE	0,80	0,68	0,94	2,63

Source: Results of this study

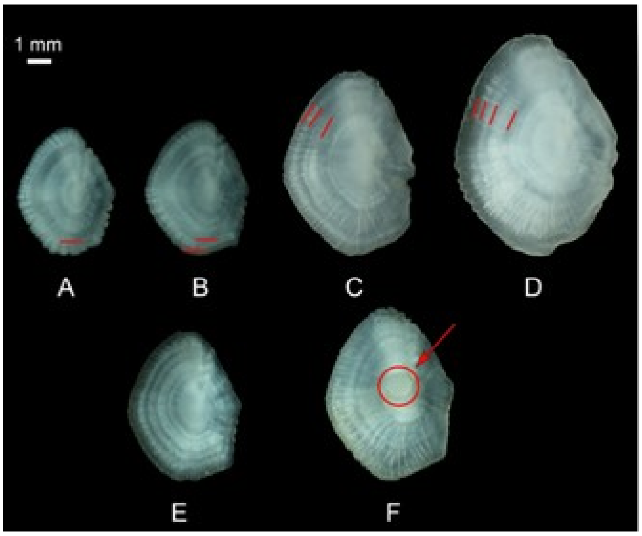

Fig. 3: Photos of Otoliths of *Brachydeuterus auritus* sample collected in Togolese waters
Source: Results of this study

TL: Total length. M: male. F: female A: Age Class 1 (9.8 cm TL, F), B: Age Class 2 (11.2 cm TL, F), C: Age Class 3 (14.1 cm TL, M), D: Age Class 4 (17.8 cm TL, F), E: Otoliths with false rings (11.5 cm TL), F: Otoliths with a calcified form in the nucleus

The age class 2 was the most represented (44%) in the sample followed by those of 1 and 3 (26%).

The age class 4 is represented at 4% in the sample studied (Cf. Fig. 4).

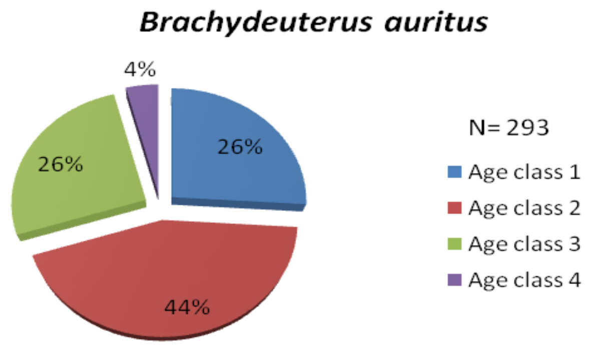

Fig. 4: Percentage plot of age classes of *Brachydeuterus auritus* samples from Togo waters
Source: Results of this study

3.4. Key Size-Age

The Size-Age Key of the total number of individuals analyzed (males and females) is presented in Table 3. The sizes are between 8.2 and 21.3 cm with the dominant size class 14 cm in the sample. Different size classes exist from age group 1 and overlap across several age groups; this could be explained by a high variability in the individual growth rates of the species in the same area. The individual class age 1 are 75 and covering range size from 08 to 13 cm. There are 75 individuals of class age 1 covering size classes ranging from 8 to 12 cm; 130 individuals belong to class age 2 covering range class size from 9 to 17 cm; while the 76 individuals of class age 3 covering size class 12 to 20 cm and 12 in age class 4 are in the 13 to 21 cm size classes.

The average size of the individuals was estimated at 10.6 cm; 13.2 cm; 15.1 cm and 16.8 cm for age groups 1, 2, 3 and 4 respectively. From these values, it indicates that during their life, individuals have the size that grows faster the first years; then as a result, the growth rate decreases.

Our results are compared with those of [4] obtained in Ghanaian waters close to those of Togo; one of the few results of growth work on the species in the waters of the western central Gulf of Guinea (Ghana and Togo).

Indeed, the average sizes obtained from the 4 age classes are generally found within the age class limits obtained by [4] with the length frequencies applied to the Modal Progression Analysis models (average length), from FiSat II Length Prediction, and von Bertalanffy Growth Equation (average length).

Also, the values of the age classes 1 to 4 obtained using these three models are respectively between 7.83 and 12.01 cm; 11.79 and 17.74 cm; 15.68 and 21.52 cm; 18.56 and 23.19 cm; and for age class 5; the average length is 22.41cm obtained using the von Bertalanffy equation alone. The growth parameters thus obtained by the size frequency being L∞ equal to 23.1 cm; K equal 0.73 yr^{-1} and t_0 equal to 0 yr, it is obvious that at age 4, the difference between the average length we found and that of [2] seemed more visible; even if it is not mathematically significant (W, p = 0.5); because growth seems to be faster.

The difference between our results and those of [4] may be due to the influence of the environment or the methods used. However, considering the theory of [2] and the conclusions of [7], [8], [19], [23], [24] and [47] that the coastal marine ecosystem of the countries from Liberia to Nigeria would be the same, the environmental influence hypothesis could be ruled out in favor of the method used for the determination of age and growth parameters.

3.5. Determination of growth according to the von Bertalanffy model

Table 4 presents the growth parameters estimated from age-size-pair pairs, and the average age-class size from the von Bertalanffy Age-Aged Key.

The results obtained from the Key Age-Age showed a very high coefficient of determination, probably because of the characteristics of the method itself (4 values having been determined previously).

Tab. 4: Growth parameters estimated according to von Bertalanffy model and from the direct otoliths readings and the mean size of the Key Age-Age

	Method	N	L∞ (cm)	K (years-1)	t_0 (years)	R^2
Total (♂ + ♀)	Value pairs	293	23.31	0.221	-1.704	0.59
	Average size key	293 (4)	23.15	0.225	-1.722	0.99

Source: Results of this study

N: number of individuals; L∞: theoretical maximum size; K: growth rate; t_0: age at which length would be zero

The size growth curve is shown in Fig. 5.

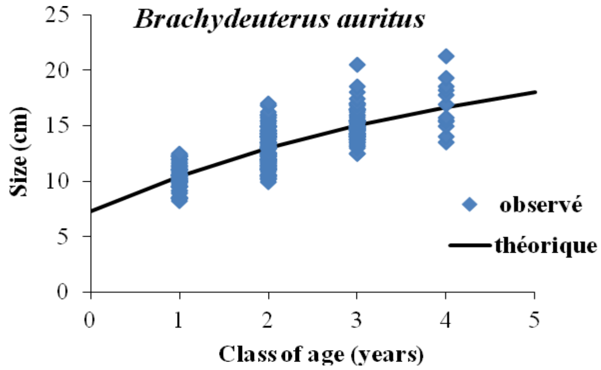

Fig. 5: Graph of estimated growth curve for *B. Auritus* (♂ + ♀) of Togo waters with direct reading
Source: Results of this study

The present study allowed us to determine the age of *B. auritus* by otolithometry with *Sagitta* otoliths. It could contribute to the revival of the debates according to which the age determination of tropical species, particularly those of the Gulf of Guinea by reading otoliths, would be very problematic [1], [11], [20], [26], [31], [35], [39], [56].

It is true that the reading of the otoliths rings of the 334 individuals of *B. auritus* led us to confront the false rings or the poor clarity of the opaque and hyaline rings and to reject the otoliths of 41 individuals representing 12% of the sample submitted to the examination.

But, our results are similar to those obtained by the few studies carried out in the Gulf of Guinea using length frequency and recapture tagging methods (Cf. Tab. 5).

Indeed, our results are comparable to those of [45] and [56] concerning L∞. They are more comparable to those of [7] and [8] at the level of L∞ and K obtained in Togo waters and those of [21] concerning L∞, K and t_o which were obtained in Congo waters (p> 0. 05).

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Tab. 5: ***Brachydeuterus auritus*** **growth parameters off Togo waters and other areas of the Gulf of Guinea**

Zone	Source	Method	Sex	N	Size Rang (cm)	L∞ (cm)	K (yrs^{-1})	t_0 (years)
Côte d'Ivoire	Barro (1968)	FT	T			25.3	0.40	0
Nigeria	Raitt et Sagua (1972)	FT	T			20.6	0.40	0
Togo	Beck (1974)	MR	M			23.1	0.29	0
Togo	Beck (1974)	MR	F			22.1	0.32	0
Congo	Fontana et Bouchereau (1976)	FT	T	56		23.46	0.061	-1.082
Ghana	Bannerman et Cowx (2001)	FT	T		5 - 22	23.1	0.73	0
Côte d'Ivoire	Zan-Bi (2014)	FT	T	255	10.1 – 18.1	23.03	0.58	0
Côte d'Ivoire	Konan *et al.* (2015)	FT	T	3.7	6 - 24	25.2	0.58	0

Source: [59]

MR: recapture marking. FT: Frequency of sizes. M: Male. F: Female. T: Total (♂ + ♀)

However, our outcomes concerning the same growth parameters are very less similar to those of [4] and [5]. The difference, especially about K, can be explained by the fact that the samples of the works of [4] were collected from both artisanal and industrial fisheries and [5] and [40] collected from industrial fisheries (seiners and trawlers). Also, the food availability in the working area of [4] and [5] seemed more important than in Togolese waters [14].

In addition, the consequences of fishing pressure could explain the differences observed at K level in the sub-region. Also, it is accepted that Togo shares the same *B. auritus* stocks with Benin, Côte d'Ivoire and Ghana ([7], [20], [26]). However, the level of fishing pressure on the stocks is not the same. In fact the industrial fishing activities are less in Togolese marine waters than those of the other three countries. The only 24 m long fishing vessel operating since 1998 does not target *B. auritus*.

According to [4], [16] and [29], the level of fishing pressure affects the size and especially the fish longevity which decreases creating many kind of disruption. This situation led to the K increasing in order to the species adaptation to the disruption of their growth and reproductive capacity in the ecosystem.

4. Conclusion

The present study allowed us to determine the age of *B. auritus* by otolithometry with *Sagitta* otoliths, a first in Togolese waters. It has shown that the individuals in the sample have an age ranging from 1 to 4 years (sizes between 8.1 and 21.3 cm, total length).

The results led to obtaining the Key Age-Size for the two sexes (♂ + ♀) and to estimate the growth parameters through pairs of values as well as the average sizes from the Key (Cf. Tab. 6).

Tab. 6: Size key obtained from the reading of ***Brachydeuterus auritus*** **otoliths collected in Togolese waters en 2016**

	Method	N	L∞ (cm)	K (yrs^{-1})	t_0 (yrs)	R^2
Total (♂+♀)	Values	293	23,31	0,221	-	0,59
	Average size key	293 (4)	23,15	0,225	-1,72	0,99

Source: Results of this study

These results, in both cases, are similar to those of other authors like [7] and [8] and are acceptable. However, they can not be taken, in any case as objective references; but, as hypotheses that must be verified by other studies.

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References

[1] F.A. Adebiyi, Growth pattern of the big eye grunt *Brachydeuterus auritus* (Valenciennes, 1832) off Lagos, Nigeria. Department of Marine Sciences, Faculty of Science, University of Lagos, Akoka, Yaba, Lagos, Nigeria. *Indian J. Fish*., 60 (3): 2013, pp 9-12.

[2] P. Agger, O. Bagge, O. Hansen, E. Hoffman, M. J. Holden, G. L. Kensteven, H. Knudsen, D. F. S. Rait, A. Saville and T. Williams, “Manual of Fisheries Science Part 2: Methods of Resource Investigation and their Application”. FAO Fisheries Technical Paper - 115 Rev. 1. 1974.

[3] A. Asabere-Ameyaw. “Observations on the reproductive biology and recruitment of the big eye grunt *Brachydeuterus auritus* (Pisces: Haemulidae), in Ghana”. J. *Ghana. Sci. Assoc.* 2001; 3: pp 14-21.

[4] P.O. Bannerman, and I.G. Cowx, “Stock assessment ok big eye grunt (*Brachydeurerus auritus* Val. 1831) fishery in Ghanaian coastal waters”. *Fish. Res*. 59: 2001, pp197-207.

[5] M. Barro, "Première estimation sur la croissance des *Brachydeuterus auritus* (Val. 1834) en Côte d'Ivoire". *Document scientifique provisoire* N° 031, ORSTOM - Novembre 1968. Tirage: 200 exemplaires.

[6] M. Barro, "Contribution à l'étude de la biologie et de la dynamique des populations de *Brachydeuterus auritus* (Val. 1831) (Téléostéens. *Pomadasyidae*) au large de la Côte d'Ivoire (sous presse)", 1976.

[7] U. Beck. Bestandskundliche Untersuchungen an einigen Fischarten der Grundschleppnetzfischerei auf dem Schelf von Togo (West Afrika). *MSc. Thesis, Hamburg University*, 1974, p 126.

[8] VU. Beck. “Die Zuammentzung der Eträge aus der küstenfischerei Togos. 25, Institut fur hydrobiologie und fischerei wissenschaft der Universität Hamburg, Hamburg. [Composition of the landings of the coastal fisheries of Togo”; in German with English abstracts] 1976, pp. 37-45.

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

[10] T. Boëly. "Biologie des deux espèces de sardinelles (*Sardinella aurita* Valenciennes 1847 et *Sardinella maderensis* Lowe 1841) des côtes sénégalaises". *Thèse Doc. D’état. Université de Paris VI. Travaux et documents de l’ORSTOM microéditor. TDM 7*: 1981, p. 286.

[11] T. Boëly, P. Fréon et B. Stequert. "La croissance de *Sardinella aurita* (Val.1847) au Sénégal". *Cah. ORSTOM, sér.Océanogr.*, 17 (2). 1982, pp. 103-119.

[12] S.E. Campana “Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods”. *Journal of Fish Biology.* Vol. 59. 2001, pp. 197-242.

[13] F. Chrzan, “Characteristics of the stock composition of fish in West African shallow waters as observed in 1961”. ICES C.M 1961/Atlantic Comm. Pap. 10 p.

[14] A. Crosnier, G. R. Berrit et J. Marteau, "Fonds de pêche le long des côtes des républiques du Dahomey et du Togo". Cah. ORSTOM, ser, Oceanogr,, suppl,vol, IV, 1, 1966, p. 144.

[15] J. Daget and J.C Le Guen. (1975). Les critères d'âge chez les poissons In: Lamotte M. and Bourlinière F. (eds.) Problèmes d'écologie : la démographie des populations de vertébrés. Masson et Cie, Paris. pp253-289

[16] F. Duponchelle, et J. Panfili, “Variations in age and size at maturity of female tilapia, *O.niloticus*, populations from man-made lakes of Côte d’Ivoire”. *Environ. Biol. Fish*., 52. 1998, pp. 453-465.

[17] FAO "Les Ressources Halieutiques de la ZEE Mauritanienne: Description, Evaluation et Aménagement. Rapport du deuxième Groupe de travail CNROP/FAO/ORSTOM. Nouadhibou, Mauritanie, 15–22 novembre 1988". E. Josse (Ed.). *COPACE/PACE SERIES* 89/49: p. 199.

[18] FAO "Rapport d’évaluation du Groupe de travail des ressources halieutiques dans la région sud du COPACE", FAO, 2009. Rome, Italie. http://www.journalissues.org/IJAPR/ http://dx.doi.org/10.15739/IJAPR.043

[19] FAO "Rapport du Groupe de Travail de la FAO sur l’évaluation des petits pélagiques au large de l’Afrique nord occidentale". Gambie, 19-24 May 2014. *FAO Rapport sur les pêches et l’aquaculture*. No. 1116 Rome: 2015, p. 241.

[20] A. Fontana, "Étude de la maturité sexuelle des sardinelles *Sardinella eba* et *Sardinella aurita* C. et V. de la région de Pointe-Noire". *Cah. O.R.S.T.O.M., s*ér. Océanogr., vol. VII, nº 2. 1969, p. 13.

[21] A. Fontana, et T.J. Bouchereau, "Croissance de *Brachydeuterus auritus* au Congo". *Doc. Sci. O.R.S.T.O.M. (Pointe Noire) N.S*., 47. 1976, p. 8.

[22] R.W. Gauldie, “The Morphology and Periodic Structures of the Otoliths of the Chinook Salmon (*Oncorhynchus tshawytscha*), and Temperature-dependent Variation in

Otoliths Microscopic Growth Increment Width". *Acta Zoologica.* Vol. 72 (3): 1991, pp. 159-179.

[23] A. Gbaguidi, K. M. Sedzro, S. N. K. Quaatey, P. Bannermann, T. Joanny, S. Mehl, O. Alvheim, M. A. Caramelo and M. Tandstad, "Distribution and abundance of the main pelagic fish stocks in the western gulf of Guinea (Benin, Togo, Ghana and Côte d'Ivoire)". Summary of results from the R/V Dr. Fridtjof Nansen surveys 1981- 2006. Global Information System on Fishes. 2008. http://www.fishbase.org

[24] GCLME Project, "Productivity Patterns in the Guinea Current Large Marine Ecosystem with regard to its Carrying Capacity for Living Resources". Experts workshop Accra, 24 – 26 November, 2010. GUINEA CURRENT LARGE MARINE ECOSYSTEM PROJECT. Accra-Ghana. 2008, p. 151.

[25] A.J. Geffen, "Validation of Otolith Increment Deposition Rate": pp. 101-113. *In:* Stevenson, D.K. and S.E. Campana (eds.). Otolith microstructure examination and analysis*. Can. Spec. Publ. Fish. Aquat. Sci*, Otawa, Canada.

[26] Y. Ghéno et J.C. Le Guen, "Détermination de l'âge et de la croissance de *Sardinella aurita* (Val.) dans la région de Pointe-Noire". *Cah. O.R.S.T.O.M.,* sér. Océanogr., vol. VI, no 2: 1968, pp. 70-82.

[27] Groupe de Travail de FAO/COPACE, "Rapport d'évaluation du Groupe de travail des ressources halieutiques dans la région sud du COPACE", FAO, Rome, Italie, 2011.

[28] J.P. Granadeiro & M.A. Silva, "The use of otoliths and vertebrae in the identification and size-estimation of fish in predator-prey studies. *Cybium,* 24(4)", pp. 383-393.

[29] Gulland, J.A., The fish resources of the oceans. West Byfleet, Surrey, Fishing News (Books), Ltd., for FAO, 1971, p. 255.

[30] A. Jurado-Ruzafa, "Parámetros poblacionales del chicharro *Trachurus picturatus* (Bowdich, 1825) en aguas de Tenerife (Islas Canarias)". *Tesis Doctoral, Universidad de La Laguna*: p. 204.

[31] K.J. Konan, T.G.T. Joanny, S. Sylla, L. Lianthuam and K.L. Kumar, "Stock assessment of the bigeye grunt *Brachydeuterus auritus* (Valenciennes, 1832) in the coastal water of Ivory Coast". *International Journal of Agricultural Policy and Research* Vol. 3 (5): 2015, pp. 222-230.

[32] F. Lhomme, "Estimation par chalutage des ressources halieutiques du plateau continental togolais". Lomé, Togo. ORSTOM, 1985.

[33] A.R. Longhurst, "A summary survey of the food of West African demersal fish. *Bull. IFAN, sér. A*, 22 (1): 1960, pp. 276-282.

[34] A.R. Longhurst, "Bionomics of the Sciaenidae of tropical west Africa". *J. Cons. Inter. Explor. Mer*, 1 : 1964, pp. 93-114.

[35] E. Marchal, "Biologie et écologie des poissons pélagiques côtiers du littoral ivoirien". *In*: Environnement et ressources aquatiques de Côte d'ivoire. Éditions O.R.S.T.O.M.Tome I: Le Milieu marin: 1993, pp. 277-286.

[36] O. Martucci, L. Pietrelli & C. Consiglio, "Fish otoliths as indicators of the cormorant *Phalacrocorax carbo* diet (Aves, Pelecaniformes)". *Boll. Zool.*, 60(4): 1993, pp. 393-396.

[37] S. Mehl, M. Olsen, and P. Bannerman, "Surveys of the fish resources of the Western Gulf of Guinea (Benin, Togo, Ghana & Côte d'Ivoire). Survey of the pelagic and demersal resources 19 May - 7 June 2006". FAO/NORAD-EAF-NANSEN Project//GCLME. Cruise Dr Fridtjof Nansen, 1999, 2000, 2002, 2004, 2005 et 2006 reports. Mer. C.M. 1966/J:6.

[38] B. Morales-Nin, "Determinación del crecimiento de peces óseos en base a la microestructura de los otolitos". *FAO Documento Técnico de Pesca.* No. 322*,* Roma: 1991, p. 58.

[39] J.-C. N'Jock, "Les ressources démersales côtières du Cameroun: Biologie et exploitation des principales espèces ichtyologiques". *Thèse de doctorat, Université d'Aix-Marseille 2 Centre d'Océanologie de Marseille Observatoire des Sciences de l'Univers*: 1990, p. 187.

[40] J. Panfili, de Pontual H., Troadec J.-P., Wright P. J. (eds.) (2002). Manual of fish sclerochronology. Brest, France: IFREMER-IRD co-edition. 464pp.

[41] G. Pannella, "Fish Otoliths: Daily Growth Layers and Periodical Patterns. *Science.* Vol. 173 (4002). 1971, pp. 1124-1127.

[42] G. Pannella, "Growth patterns of fish *sagittae*." *In:* Rhoads, D.C. and K.A. Lutz (eds.). Skeletal growth of aquatic orpanisms. Plenum Press, New York: 1980, pp. 519-560.

[43] A. I. L. Payne, and R. Sacks (eds.), "ICSEAF otolith interpretation guide. No. 2, Cape horse mackerel.

International Commission for the Southeast Atlantic Fisheries. Madrid" 1986, p. 24.

[44] M.E. Pereira, "Aspectos da Biologia do chicharro, *Trachurus picturatus* (Bowdich, 1825)", da Madeira. Faculdade de Ciencias da Universidades de Lisboa: 1993, p. 153.

[45] D. S. F. Raitt and V.O. Sagua. "Preliminary investigations on the biology of *Brachydeuterus auritus* (Val. 1831), in Nigerian waters". *In*: Proceedings of the Symposium on the oceanography and Fisheries resources of the tropical Atlantic. Results of the ICITA and the GTS 1972..

[46] B. Sallami, Béarez, P. et B. S. Mohamed, "Relations allométriques entre la longueur du poisson et la taille de l'otolithe chez trois anguilliformes des côtes du nord de la Tunisie (Méditerranée centrale). *Cybium" 2013, 37(3): pp. 159-163.*

[47] B. P. Satia, "Arrangements institutionnels éventuels pour la coopération sous régionale en matière de pêcheries dans le Centre Ouest du Golfe de Guinée". Rapport d'expertise FAO/COPACE. Mars 2006, p. 50.

[48] E. A. Salzen, "A trawling survey off the Gold Coast*". J. Con. C.1.E.M* , 1957, 23(1): pp. 72 -82.

[49] B. Samb, "Biology of *Brachydeuterus auritus*. Fish Biodivity : local studies as basis for global inferences". ACP-EU Fisheries Research Report N°14. ISS N 1025-3971.

[50] P. Sparre, E. Ursin and S.C. Venema, "Introduction to tropical fish stock assessment". Part 1, Manual. *FAO Fisheries Technical Paper*. No. 306.1 Rev. 2, Rome: p. 407.

[51] S. Sponaugle, "Otolith microstructure reveals ecological and oceanographic processes important to ecosystem-based management". *Environmental Biology of Fishes.* Vol. 89 (3): 2010, pp. 221-238.

[52] J. Vasconcelos, A. Alves, E. Gouveia and G. Faria, "Age and growth of the blue jack mackerel, *Trachurus picturatus* Bowdich, 1825 (Pisces: Teleostei) off Madeira archipelago". *Arquipelago. Life and Earth Sciences.* Vol. 23 (A): 2006, pp. 47-57.

[53] F. Williams, "Report on the Guinean trawling survey". *Publ. org. Afr. Unity* Sci. *Tech. Res. Corn.,* 99(1): 1968, p. 827.

[54] T. Williams and B.C. Bedford, "The use of otoliths for age determination: 1974, pp. 114-123. *In:* Bagenal, T.B. (ed.). The ageing of fish. Proceedimgs of an International Symposium. Unwin Brothers, LM. Surrey.

[55] T.T. Zan-Bi, "Biologie de reproduction et Dynamique d'exploitation du Pelon *Brachydeuterus auritus (*Valenciennes, 1831) à Grand-Bassam (Côte d'Ivoire)". Mémoire de Master Recherche. Université Polytechnique de Bobo-Dioulasso, p. 63.

[56] K. M. Sedzro, E. D. Fiogbe, E. B. Guerra and C. Stamatopoulos, "Analyse de la fiabilité des statistiques des pêcheries maritimes artisanales togolaises générées par ARTFISH de la FAO". *Journal of Applied Biosciences.* 2016. 97:9227– 9239.

[57] K. M. Sedzro, E. D. Fiogbe and E. B. Guerra, "Pêcheries maritimes artisanales togolaises : analyse des débarquements et de la valeur commerciale des captures marines artisanales". International Journal of Science Social Studies Humanities and Management (IJSSHM). April-May 2016. J. Rech. Sci. Univ. Lomé (Togo), 2017, 19(2) : 47-69. Journal ResearchGate.

[58] Y. Desaunay, J.B. Perddou and P. Beillois, "Etude des nurseries de poissons du littoral de la Loire-Atlantique". Science et Pêche, Bull. fllst. Pêches marit., n° 319, décembre 1981. http://archimer.ifremer.fr/ consulté le 5 sept 2012

[59] FishBase, 2012, http://www.fishbase.org/search.php consulted from 14 to 20 December 2015 and February the 1st 2016

[60] W. Fischer, M.L. Bauchot and M. Schneider, Fiches FAO d'identification des espèces pour les besoins de la pêche. (Révision 1). Méditerranée et mer Noire. Zone de pêche 37. Volume II. Vertébrés. Publication préparée par la FAO, résultat d'un accord entre la FAO et la Commission des Communautés Européennes (Projet GCP/INT/422/EEC) financée conjointement par ces deux organisations. 1987. *Rome, FAO, Vo1.2: P 1061*