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Research Article

Study of the Age of *Centropomus robalito* by Otoliths Analysis of Sagitta, Asteriscus and Lapillus in Mexican Central Pacific

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Abstract

Morphology, morphometry and growth rings of the otoliths: Sagitta, asteriscus and lapillus of *Centropomus robalito* Jordan and Gilbert 1882 in Cuyutlan lagoon, Colima, Mexico were studied. Samples were taken from October 2015 to September 2016. Differences between sexes, as right and left of the three pairs of otoliths were analyzed. In all cases the growth of the otoliths was eccentric to the core. The relationship between total length of the fish and length of the sagitta showed that this structure is suitable to determine the age of this species. Nine growth rings were identified on sagittae. The identification of growth rings was carried out only in sagittae. Data on lengths obtained by polymodal curves of *C. robalito* were compared to the present results.

Keywords: Age determination; Asteriscus; *Centropomus robalito*; Lapillus; Otolith; Sagitta

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Introduction

Most species of the Centropomidae family are demersal euryhaline semi-catadromous. Their distribution is determined by salinity and temperature, they can inhabit in water colder than 20°C for short periods, they also tolerate a wide spectrum of salinities: From 0.07 ppm to 58.29 ppm, but they prefer fresh or brackish waters with a tendency to remain in estuaries, rivers or coastal lagoons. This makes them more prone to the effects of pollution [1]. They are carnivores that feed on smaller fish and crustaceans [2].

With regard to the yellowfin snook *Centropomus robalito* Jordan and Gilbert 1882 (Figure 1), its distribution is from Sinaloa state Mexico to northern Colombia [3,4].

Figure 1: Yellowfin snook *Centropomus robalito* Jordan & Gilbert 1882.

Its fishery importance is medium in a local scale, it is delivered complete in ice and its commercial classification is of third category. Its price is of $40.00 Mexican pesos ($2.00 US dollars). It is fished with hand line and fish hook, cast net, and gill nets. Annual commercial captures go from 1.4 tons to 26.7 tons with an average of 12.8 tons in Colima during the last years (from 2013 to 2017) [5].

Studies have been carried out to determine age through the analysis of length frequency and growth lines on scales by Tovilla-Hernández and Castro-Aguirre [6], in the coast of Chiapas, Mexico. Gil-López et al. [7], studied the life cycle of *C. robalito* in the Mar Muerto lagoon system, Oaxaca and Chiapas. Analysis of length structures and biomass was done in Sinaloa and Nayarit, Mexico by Madrid-Vera et al. [8]. Analysis of feeding habits in juvenile in Barra de Navidad lagoon, Jalisco, Mexico was carried out by Flores-Ortega et al. [9].

We did not find studies on the age determination of *C. robalito* using otoliths. The following objectives of this study are: a) Description and analysis of the labyrinth system. b) Morphologic analysis of the sagittae, asterisci and lapilli. c) Morphometric study of the otoliths and its variation regarding age and sex. d) Identification of growth marks. e) Comparison with results by other authors.

Studies on the growth ring identification are necessary to determine the species growth and the assessment of the von Bertalanffy growth constants, necessary to calculate age groups of the population and analyze the population dynamics of the species, such as reproduction, feeding, maximum sustainable yield models, prediction and capture simulation. This information is important to achieve a rational management and prevent overexploitation of resources.

Material and Methods

From October 2015 to September 2016, 335 organisms of *Centropomus robalito* were obtained from the commercial captures in Cuyutlan lagoon, Colima, Mexico and brought to the laboratory of the National Institute of Fisheries in Manzanillo (INAPESCA). Organisms were captured with gill nets, hand lines and cast net, to obtain a stratified sample which includes all the age groups and size classes.

In the laboratory, data were taken from each organism: Total Length (TL, cm), Standard Length (SL, cm), Total Weight (TW, g), Eviscerated Weight (EW, g) and sex.

Sagittae, asterisci and lapilli were obtained by doing a transversal cut in the organism's skull, removing the brain, and extracting the semi-circular canals (left and right). Otoliths were liberated from the otic capsules, cleaned in water and dried. Samples were then preserved dry in Eppendorf tubes, and labeled accordingly.

Otoliths were analyzed with a dissecting microscope. The glossary terminology of Secor et al. [10], was used to describe the labyrinth system and the sagittae of this species. In the case of the asterisci and lapilli, similar concepts were used for description as in Gallardo-Cabello et al. [11-17], and Espino-Barr et al. [18-21].

Photographs from each otolith (internal and external aspect, and close ups) were taken with the scanning electronic microscope JEOL model JSM6360LV. Samples of otoliths were prior mounted on aluminum sample holder, on a two faced carbon tape and coated with a layer of gold of 20 Å for two minutes, in a vaporizer.

Measurements of the length and width of the three pairs of otoliths (right and left) were registered, with the help of a graduated measuring ocular in the microscope. Sample size was corroborated [22].

Regressions by least squares were used to calculate the relationship constants of the Sagitta rostrum Length (SL) vs. Width (SW). In the case of the asterisci and lapilli the regression indexes were only used for Length vs. Width (AL-AW, LL-LW). The allometric relationships between total length of the fish and the length and width of each otolith were also obtained by least square regression.

A one way variance analysis (ANOVA, α=0.05) [23] was used to determine if there were morphometric differences between male and female otoliths, and between right and left otolith.

Growth ring identification was carried out on sagittae, observing rings by transparency in a stereoscopic microscope, using transmitted light. Average length for each growth ring was calculated.

Results

This is the first time that data on otoliths of *Centropomus robalito* is published considering, either the sagittae or the three pairs of the otoliths: Sagittae, asterisci and lapilli, therefore this study is completely original and we could not find other researches to compare and discuss our findings.

Morphometrics of *Centropomus robalito*

General data of the fish are shown in table 1. All specimens had an average of 20.78 cm TL (±4.69 standard deviation) when separated by sex, the indefinite or juvenile were 16.07 cm (±5.91 sd), males 18.69 cm (±2.8 sd) and females 23.04 cm (±3.04 sd).

	StL (cm)	TL (cm)	Hi (cm)	TW (g)	EW (g)
n	335	335	335	334	335
Average	15.90	20.78	4.78	91.30	82.67
Maximum	27.0	34.0	8.0	390.0	353.0
Minimum	5.0	6.5	1.6	2.7	2.5
SD	3.70	4.69	1.16	59.22	53.73

Table 1: Morphometric of *Centropomus robalito* used in the present study.

Note: StL=Standard Length (cm), TL=Total Length (cm), Hi=Maximum Hight (cm), TW=Total Weight (g), EW=Eviscerated Weight (g), SD=Standard deviation, n=Number of individuals.

Table 2 describes the measurements of the otoliths. The big structures are sagittae, 2.43 times bigger than the asterisci and 2.45 bigger than the lapillus. Compared sizes can be observed in figure 2.

	TL (cm)	SL (mm)	SW (mm)	AL (mm)	AW (mm)	LL (mm)	LW (mm)
n	366	362	363	350	348	348	347
Average	21.23	8.52	5.18	1.38	2.06	1.56	1.01
Maximum	32.0	13.1	7.4	2.1	3.4	2.1	1.7
Minimum	8.5	3.5	2.4	0.7	0.8	0.8	0.5
SD	3.945	1.519	0.797	0.238	0.355	0.219	0.139

Table 2: Morphometrics of *Centropomus robalito* otoliths.

Note: TL=Total Length (cm), SL=Sagitta Length (mm), SW=Sagitta Width (mm), AL=Asteriscus Length (mm), AW=Asteriscus Width (mm), LL=Lapillus Length (mm), LW=Lapillus Width (mm), SD=Standard deviation, n=Number of individuals.

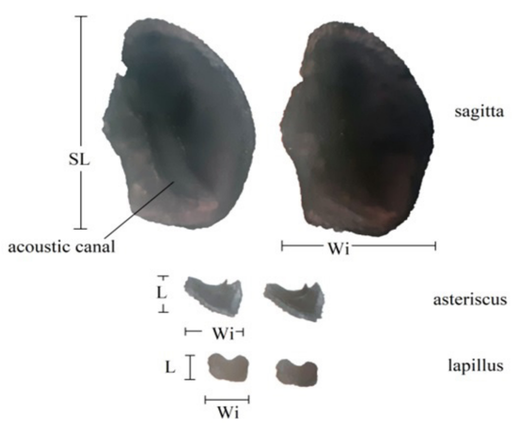

Figure 2: Relationship between the three pairs of otoliths in *Centropomus robalito*: Left side internal aspect, right side external aspect. SL=rostrum length, WI=Width, L=Length.

Labyrinth system of *Centropomus robalito*

The membranous labyrinth is formed by the canals: Anterior vertical canal, posterior vertical canal and horizontal canal (Figure 3). These canals form chambers that contain otoliths: The sagitta is contained in the sacculus, the asteriscus is contained in the lagena and the lapillus is contained in the utriculus (Figures 3 and 4). The otoliths are immersed in a liquid called endolymph [24].

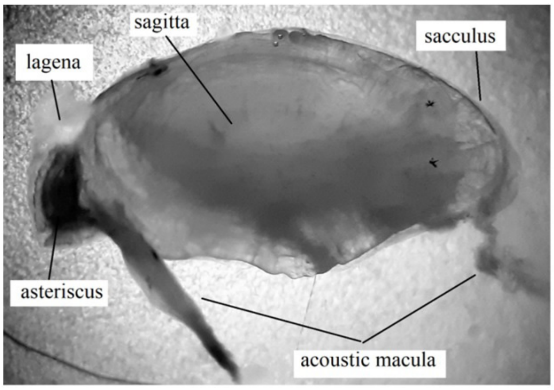

Figure 3: Section of the membranous labyrinth of *Centropomus robalito* (22 cm total length) (enlarged 14 times) showing the sacculus, which includes the sagitta, the lagena with the asteriscus; also the acoustic macula is shown penetrating the acoustic canal of each of these otoliths.

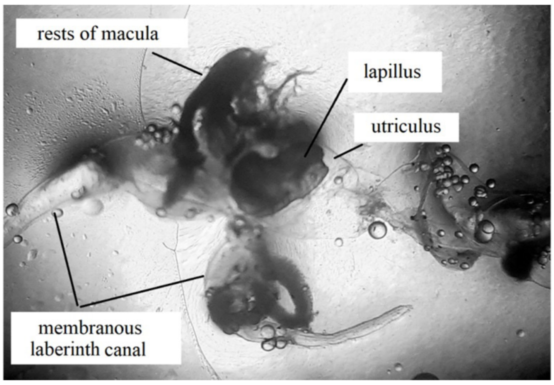

Figure 4: Section of the membranous labyrinth of *Centropomus robalito* (22 cm total length) (enlarged 14 times) showing the utriculus with lapillus, the membranous labyrinth canal and rests of macula.

The acoustic macula (inside each chamber) penetrates the otoliths at the level of the acoustic canal through the neuromas, which are nerve cells (Figures 3 and 4). Deposition of the calcium carbonate and protein takes place through the macula, leading the otoliths to grow and enlarge their size. Ramifications of the eighth cranial nerve can be observed in the macula, through which impulse transmission to the brain is carried out, by means of vibration of the otolith suspended in the endolymph [25-27]. Sagittae and asterisci are related with the sound perception, gravity and angular acceleration, while the lapilli are more related to the fishes' equilibrium [28,29].

The protein of which otoliths are made was denominated otoline by Degens et al. [30], and presents a high molecular weight. Other component that forms the otoliths is calcium carbonate in its form of aragonite [24,31-34].

Description of the sagitta

Rostrum is elongate, with no excisura major to divide the otolith in rostrum and antirostrum (Figures 5a and 5b). The dorsal border is serrated with multiples dentitions from the rostrum till the postrostrum. The ventral border presents a groove tending to be continuous to the medium part of the sagitta, after it descends towards the postrostrum showing serrated edges.

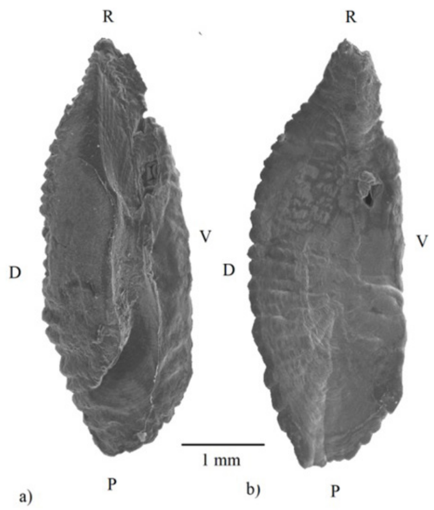

Figure 5: Scanning photograph of: a) Left internal aspect with acoustic canal, b) The right sagitta external aspect of *Centropomus robalito*. R=Rostrum, P=Postrostrum, D=Dorsal margin, V=Ventral margin.

The interior aspect is convex and is covered lengthwise by the acoustic canal, which is very developed and deep, with a notorious differentiation between ostium and cauda (Figure 5a). At the base of the acoustic canal, calcium carbonate crystals are observed, showing different orientations possibly related to a greater transmission of the impulse to the eighth cranial nerve through the acoustic macula. In figures 6a and 6b these calcium carbonate crystals are observed in the part of the acoustic canal that corresponds to the ostium and in figures 7a and 7b, the crystals in the acoustic canal of the cauda.

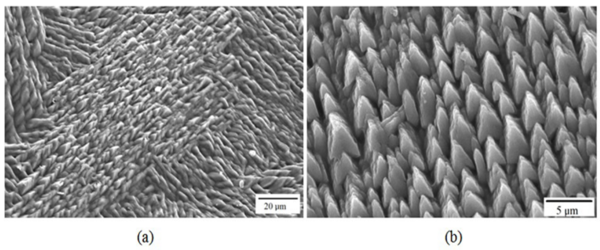

Figure 6: Details in a) and b) of crystals in the acoustic canal corresponding to the ostium of the sagitta of *Centropomus robalito*.

The external aspect is concave; as the organism grows and its age increments, the otolith tends to be more curved and tends to thicken. On the surface of the external aspect growth rings can be observed of a smaller periodicity than seasonal (Figures 8a and 8b).

Growth rings are more clearly observed in the postrostrum, towards the ventral border in the internal aspect and they are seen as dark lines that run the length of the otolith. Average width of the sagitta is 1.65 times its average length. No statistical difference was observed between right and left otoliths ($F'_{0.05(2,361=3.867)}=0.032$). Statistical significant difference was observed between sagitta lengths

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of females and males ($F'_{0.05(2,300=3.873)}=22.258$), and widths ($F'_{0.05(2,338=3.869)}=129.003$).

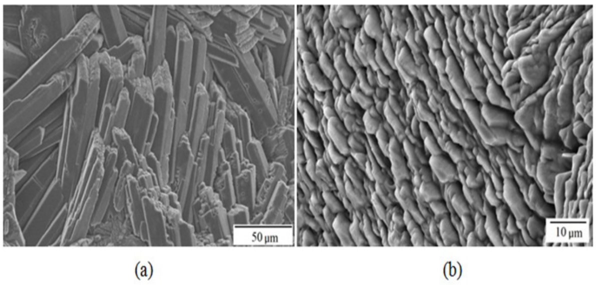

Figure 7: Details in a) and b) of crystals in the acoustic canal corresponding to the cauda of the sagitta of *Centropomus robalito*.

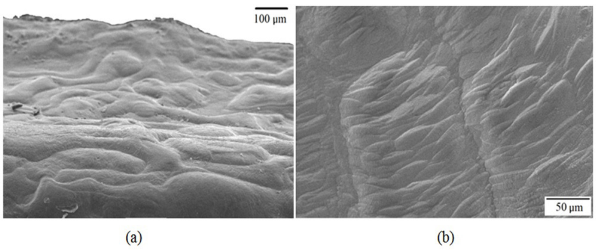

Figure 8: Details in a) and b) of growth rings corresponding to a lower periodicity than seasonal on the external aspect of the sagitta of *Centropomus robalito*.

Description of the asteriscus

The form of the asteriscus can present high variations in the same individual, nevertheless no difference was found between right and left asteriscus ($F'_{0.05(2,349=3.868)}=0.018$), although there was statistical significant difference between sexes ($F'_{0.05(2,283=0.875)}=55.985$).

The anterior margin of the asteriscus consists of two parts divided by a blunt projection, nominated as the dorsal area that exhibits a smaller surface and a ventral area of bigger surface (Figure 9). The dorsal and ventral margins exhibit sections that can be rounded or rectilinear.

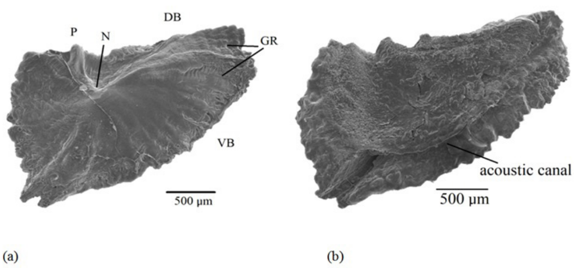

Figure 9: Scanning photograph of the right and left asteriscus, a) External and b) Internal aspect of *Centropomus robalito*: P=Projection, N=Core or primordia, DB=Dorsal Border, VB=Ventral Border, GR=Growth Rings of lower periodicity than seasonal, and acoustic canal.

The asteriscus presents in its inner aspect an acoustic canal (Figures 9b and 10), where the acoustic macula captures impulse transmission of this otolith in the lagena and takes it through the eighth cranial nerve to the brain. Also, it is through this acoustic macula that the calcium carbonate and otolin are deposited in this structure, which nurture the asteriscus and allows that it develops and grows as the organism ages.

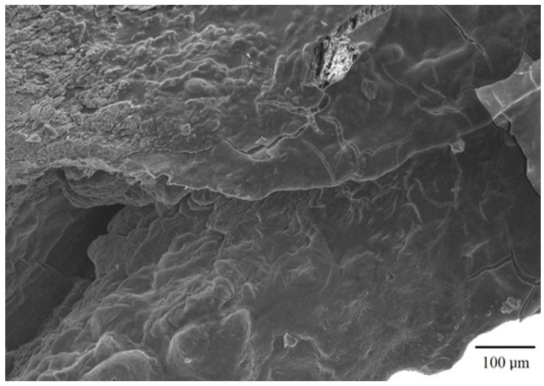

Figure 10: Details of the acoustic canal of the asteriscus of *Centropomus robalito*.

The internal aspect of the asteriscus is concave, while the external aspect is convex; this curvature is accentuated as the fish ages. The asteriscus' borders have numerous indentations. Its average width is 1.49 times its average length.

Description of the lapillus

The anterior margin of the lapillus is a rounded structure oriented to the front side of the fish (Figure 11a). The dorsal and ventral margins extend toward the rear, forming a broad structure, divided into several lobes by radios (Figure 11b).

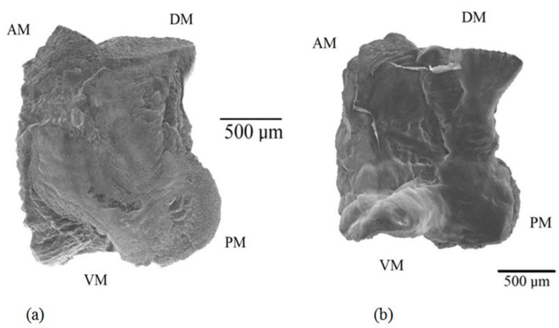

Figure 11: Scanning photograph of the right and left lapillus, a) External and b) Internal aspect of *Centropomus robalito*: AM=Anterior Margin, PM=Posterior Margin, DM=Dorsal Margin and VM=Ventral Margin.

The dorsal margin is significantly longer than the ventral and mostly rectilinear, while the ventral border shows dentitions. The inner aspect of the lapillus is concave and its curvature increments with age. The acoustic canal can be observed in the anterior border, this structure comes into contact with the acoustic macula. The external aspect of the lapillus is convex. The surfaces of the external and inner face are smooth.

On the surface of the external aspect, calcic carbonate crystals are observed in which otoline is disposed (Figures 12a and 12b). In the posterior border of the internal aspect, growth rings can be observed with a smaller periodicity than seasonal (Figures 13a and 13b).

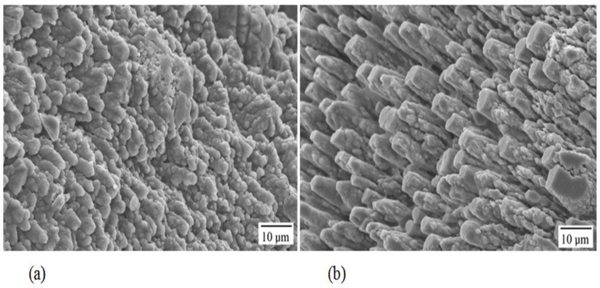

Figure 12: Details in a) and b) of crystals in the external aspect of the lapillus of *Centropomus robalito*.

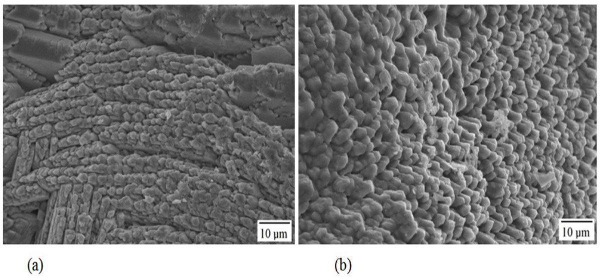

Figure 13: Details in a) and b) of crystals in the internal aspect of the lapillus of *Centropomus robalito*.

Average length of the lapillus is 1.55 times its average width. No statistical differences were found between the right and left lapillus ($F'_{0.05(2,\ 347\ =\ 3.868)} = 0.078$), but it was found between sexes ($F'_{0.05(2,\ 300\ =\ 3.873)} = 22.258$).

Growth of the sagitta

The relationship between size classes, rostrum length and width of the sagitta, for the species as for sexes is observed in table 3. The rostrum growth of the sagitta is higher in females than males from 5 to 17 cm TL, but from 20 cm on, it is higher in males than females.

Table 4 shows the relationship between the rostrum length vs. width of the sagitta, both for species as a whole and for each sex. The relationship between the rostrum length and width of the sagitta is expressed by the value of the exponent b=0.802 which corresponds to a negative allometric growth, where the sagitta grows more lengthwise than widthwise. The determination index for these two series of data is R^2=0.886, with an ANOVA result of F=2817. The relationships for sexes were b=0.609 for females, and b=0.801 for males, which is closer to an isometric index.

The relationship between total fish length, length of the rostrum and width of the sagitta is shown in table 5. In the case of males, values were closer to an isometric growth, with b=0.930, data for the species was b=0.873, and for females b=0.781. Values of the fish length vs. width of sagitta showed values of the allometric index: For all specimens b=0.757 (R^2=0.872, F=2450), by sex the values were b=0.673 (females) and b=0.684 (males). These results show that as the organisms grow in length, sagittae decrease in size (length and width).

	All		Females		Males	
Classes (cm)	SL (mm)	SW (mm)	SL (mm)	SW (mm)	SL (mm)	SW (mm)
5	2.41	1.73	2.73	1.97	2.24	1.92
8	3.63	2.48	3.94	2.71	3.47	2.65
11	4.80	3.15	5.06	3.36	4.66	3.30
14	5.92	3.78	6.10	3.95	5.83	3.89
17	7.01	4.38	7.10	4.50	6.98	4.44
20	8.08	4.95	8.06	5.02	8.12	4.96
23	9.13	5.51	8.99	5.51	9.25	5.46
26	10.16	6.04	9.90	5.99	10.37	5.94
29	11.18	6.56	10.78	6.44	11.48	6.40
32	12.19	7.07	11.64	6.89	12.58	6.85
35	13.18	7.57	12.48	7.31	13.67	7.28
38	14.16	8.06	13.31	7.73	14.76	7.70

Table 3: Calculated measures of rostrum (SL) and width (SW) of sagitta at different size classes of *Centropomus robalito*.

SL vs. SW	a	b	R^2	F'	n
All	0.929	0.802	0.886	2817	362
Females	1.439	0.609	0.633	355	206
Males	0.919	0.800	0.872	596	88

Table 4: Relationships between the rostrum length and width of the sagitta of *Centropomus robalito*.

Total length (cm)		a	b	R^2	F'	n
SL (mm)	Both	0.591	0.873	0.842	1919	360
	Females	0.777	0.781	0.527	225	202
	Males	0.501	0.930	0.970	2783	87
SW (mm)	Both	0.513	0.757	0.872	2450	361
	Females	0.668	0.673	0.580	285	207
	Males	0.640	0.684	0.743	253	88

Table 5: Relationship between total fish length and rostrum length and width of sagitta of *Centropomus robalito*.

Growth of the asteriscus

Table 6 shows the values of length classes related to the length and width of the asteriscus by all individuals and sexes. In all cases the length of the asteriscus is bigger in males than in females in size classes ranging from 5 to 38 cm TL of the fish.

Table 7 shows the relationships of the allometric indexes between length and width of the asteriscus; for all individuals a value of b=0.838 (R^2=0.621 and F=569) was obtained, which corresponds to a negative allometric growth, that is, the asteriscus grows more in width than in length as the fish ages. In the case of males the value of b=0.998 is very close to an isometric index, that is, the asteriscus grows in length and width in the same proportion. For females the b=0.525 corresponding a negative allometric index.

Classes (cm)	All		Females		Males	
	AL (mm)	AW (mm)	AL (mm)	AW (mm)	AL (mm)	AW (mm)
5	0.48	0.66	0.42	0.74	0.45	0.57
8	0.68	0.96	0.61	1.03	0.65	0.88
11	0.85	1.23	0.79	1.29	0.83	1.17
14	1.02	1.48	0.97	1.54	1.01	1.46
17	1.17	1.73	1.13	1.76	1.18	1.74
20	1.32	1.96	1.29	1.98	1.34	2.02
23	1.46	2.19	1.45	2.18	1.50	2.29
26	1.60	2.41	1.60	2.38	1.65	2.57
29	1.73	2.63	1.75	2.57	1.80	2.83
32	1.86	2.84	1.90	2.76	1.95	3.10
35	1.98	3.05	2.04	2.94	2.09	3.36
38	2.10	3.25	2.18	3.11	2.23	3.62

Table 6: Calculated measures of length (AL) and width (AW) of the asteriscus at different size classes of *Centropomus robalito*.

AL vs. AW	a	b	R^2	F'	n
All	1.568	0.838	0.621	569	348
Females	1.796	0.525	0.411	138	198
Males	1.495	0.998	0.616	136	85

Table 7: Relationships between the length (AL) and width (AW) of the asteriscus of *Centropomus robalito*.

The relationships between total length of the fish and length and width of the asteriscus for all the individuals as for sexes are shown in table 8.

Total length (mm)		a	b	R^2	F'	n
AL (mm)	All	0.149	0.728	0.702	821	349
	Females	0.112	0.817	0.443	158	199
	Males	0.124	0.795	0.647	155	85
AW (mm)	All	0.186	0.786	0.726	919	347
	Females	0.237	0.708	0.502	199	198
	Males	0.133	0.909	0.524	94	85

Table 8: Relationship between total fish length and asteriscus length (AL) and width (AW) of *Centropomus robalito*.

The allometric index value between the fish length and the length of the asteriscus for all individuals is b=0.728 (R^2=0.702 and F'=821), which represents a negative allometric index, where the asteriscus' length grows less than the fish length. Similarly data were obtained for sexes where b=0.817 in females and b=0.795 in males.

The allometric index value between the fish length and the width of the asteriscus for all individuals is b=0.786 (R^2=0.726 and F'=919), which corresponds to a negative allometric index, where the asteriscus' width grows less than the fish length. Similarly, this relationship in females shows low values, that is, a negative allometric index: b=0.708. Nevertheless, in the case of the males there is a strong tendency to isometry represented by the value of the index b=0.909, where growth of the width of the asteriscus is proportional to the fish growth.

Growth of the lapillus

The relationships between length and width of the lapillus for the species (all individuals) and each sex, for each age class are shown in table 9. The lapilli of males are of bigger size than those of females in length classes from 5 to 29 cm TL, while bigger in size those of females than of males with lengths from 35 to 38 cm TL.

Classes (cm)	All		Females		Males	
	LL (mm)	LW (mm)	LL (mm)	LW (mm)	LL (mm)	LW (mm)
5	0.65	0.50	0.62	0.54	0.71	0.52
8	0.86	0.63	0.84	0.66	0.92	0.65
11	1.05	0.73	1.02	0.76	1.10	0.76
14	1.21	0.83	1.19	0.84	1.26	0.85
17	1.36	0.91	1.35	0.92	1.41	0.93
20	1.50	0.98	1.49	0.98	1.54	1.01
23	1.64	1.05	1.63	1.04	1.67	1.08
26	1.76	1.12	1.76	1.10	1.79	1.14
29	1.88	1.18	1.89	1.15	1.90	1.20
32	2.00	1.23	2.01	1.20	2.01	1.26
35	2.11	1.29	2.12	1.25	2.11	1.31
38	2.22	1.34	2.24	1.29	2.21	1.37

Table 9: Calculated measures of length (LL) and width (LW) of the lapillus at different size classes of *Centropomus robalito*.

Table 10 shows the values of the allometric indexes for length and width of lapilli of the species and by sex. The value of b=0.661 shows a negative allometric growth index for all the individuals (R^2=0.516 and F=370), which means that the lapillus grows more lengthwise than in thickness as the fish grows old. Similar data were obtained for females: b=0.587 and males b=0.773.

LL vs. LW	a	b	R^2	F'	n
All	0.753	0.661	0.516	370	347
Females	0.783	0.587	0.342	103	196
Males	0.718	0.773	0.797	326	84

Table 10: Relationships between the length (LL) and width (LW) of the lapillus of *Centropomus robalito*.

Relationships between total length of the fish and length and width of the lapillus are observed in table 11. Data represent negative allometric indexes that show that growth of lapillus in length as in width is much smaller than the growth of the fish.

Identification of the growth rings

The analysis of the growth rings in sagittae made it possible to identify nine groups, the results being as follows: Ring 0=7.95 cm TL of the fish, ring 1=14.36 cm, ring 2=19.35 cm , ring 3=22.42 cm, ring 4=25.49 cm, ring 5=27.54 cm, ring 6=29.30 cm, ring 7=31.90 cm, ring 8 = no data found, ring 9=34 cm. There was only one organism with a total length of 34 cm and 9 growth rings, and no organism with

8 growth rings. The percentage of the sagittae that showed growth rings perfectly defined were 100%. Growth rings were observed with best clarity in the postrostrum of the sagitta. These observations were made with a stereoscopic microscope with transmitted light.

Total length (mm)		a	b	R^2	F'	n
LL (mm)	All	0.244	0.607	0.736	964	346
	Females	0.226	0.630	0.535	225	196
	Males	0.287	0.561	0.577	116	85
LW (mm)	All	0.229	0.487	0.560	439	345
	Females	0.272	0.429	0.246	65	196
		0.245	0.472	0.546	101	84

Table 11: Relationship between total fish length and lapillus length (LL) and width (LW) of *Centropomus nigrescens*.

No growth rings could be clearly observed on asterisci, because the dorsal area of the otolith is too narrow, which makes it difficult to observe the continuity of the growth marks on the dorsal and ventral areas, as in the case of the asterisci of other members of the Centropomidae family as happens with *C. nigrescens*.

Due to its thickness, growth rings in the lapillus could not be observed.

Discussion

Regarding the relation between sagitta length and fish length, data were close to the unit, showing a tendency to an isometric relation, which means that the growth of the otolith is proportional to the fish. Unlike the values found for *Centropomus nigrescens*, in which the tendency towards a negative allometry was very noticeable in this relation (sagitta and fish lengths) [16].

In the asterisci it was not possible to appreciate clearly the growth rings because the dorsal area is too narrow, this makes the continuity of the growth marks between the dorsal and ventral areas difficult to observe. In the case of *C. nigrescens*, it was possible to observe growth rings in the asterisci [16]. Due to its thickness, growth rings in the lapillus could not be observed.

As in other members of the Centropomidae family, growth rings identification on scales is very unreliable because the formation of rings has a very irregular pattern, also ring formation is not continuous, that is, the growth rings do not cover the entire scale, but consist of fragments of marks such as *C. robalito* [6] and *Centropomus undecimalis* [35]. Tovilla-Hernández & Castro-Aguirre [6] reported a maximum length of 32 cm or more. Average length determined by polymodal curve analysis are shown in table 12 (data from Zacapulco, coast of Chiapas, Mexico). Their average sizes considered for each polymodal curve are higher than those found by us, probably because of difference in feeding of a higher fishing pressure of this species and consequently a reduction in the commercial size.

Conclusion

The identification of growth rings was carried out only in sagittae. Growth rings could not be observed in asterisci because the dorsal area is too short.

In the case of lapilli, marks were not recognized due to the thickness of the otolith.

No statistically significant morphometric differences were observed between the right and left otolith, but between sexes there were differences in the case of the sagittae, asterisci and lapilli.

Growthrings	TL (cm) (a)	TL (cm) (b)
0	7.95	
1	14.36	17
2	19.35	23
3	22.42	25
4	25.49	29.5
5	27.54	32
6	29.30	33.5
7	31.90	
8		
9	34.00	

Table 12: Mean lengths of *Centropomus robalito* for growth rings and polymodal curves.

Note: a) Present study, b) Tovilla y Castro-Aguirre.

The growth of the three pairs of otoliths is eccentric to the core; a larger quantity of material is deposited in the dorsal areas and borders, in relation to the borders and ventral areas.

The relationship between total length of the fish and sagitta length showed that this structure is suitable to determine the age of this species.

Nine growth rings were identified on sagittae, nevertheless the time of formation of these rings will have to be evaluated.

Recommendations

Studies to identify growth rings in this species should continue, in order to detect changes in the average size for each growth ring which may represent overfishing and reduce the size of first capture.

The time of growth ring formation has to be evaluated to consider them as annual age groups and conduct studies on the growth of this species, calculating the von Bertalanffy growth constants and compare these results with those obtained by other authors.

Analysis of the reproduction of *C. robalito* has to be carried out in order to determine the sex proportion of sexes, hermaphroditism, fecundity, and lengths and season at which the phenomena of sexual inversion might take place, as well as reproduction zones for the species.

Also the analysis of feeding, hepatosomatic index, condition factor, relationships of length weight per sex, by season, months and different year are important. These studies will help have a better comprehension of the age and growth phenomena.

Finally, once this information is obtained, an analysis of the fishery should be carried out, to evaluate the captures, indexes and exploitation rates and suggest improvements in the fishery.

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