Artículo científico

Reproduction of the yellowfin snook *Centropomus robalito* (Teleostei: Centropomidae) in Cuyutlan Lagoon, Mexican Central Pacific

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Reproduction of *Centropomus robalito* of the Pacific coast, Mexico was studied. Samples of 335 individuals were monthly obtained from October 2015 to September 2016. The proportion of male:female was 1:2.75 with a significant difference ($\chi^2 = 0.0009$, $p>0.05$). Also mean length of females was significantly higher than that of males ($H_{(1, 335)} = 59.539$, $P = 1.191 \cdot 10^{-4}$). Length of first maturity for both sexes was $L_{25} = 20.70$ cm total length (TL), in females $L_{25} = 21.38$ cm TL and in males $L_{25} = 17.93$ cm TL. First reproduction length was $L_{50} = 22.29$ cm TL for both sexes, in females $L_{50} = 22.63$ cm TL, and in males $L_{50} = 18.20$ cm TL, in both cases corresponding to an age between two and three years. The allometric relationship between liver weight and total length obtained in the present study was $LW = 0.00001\ TL^{3.517}$ ($r^2 = 0.735$, $F = 894.076$), with maximum values observed in October, November, January, June, July and September. The gonadosomatic index (GSI) reached its highest value in August. The gastric repletion index (GRI) showed higher values during, July, June, October, January, March and April. The condition factor showed higher values from October to January and April for Fulton's and Clark's, and May with Safran's indexes. Oocytes diameters were 0.25 mm minimum and maximum 0.29 mm, mean 0.27 (± 0.02 SD). Fecundity values ranged from 539 524 to 696 581 oocytes in females of four to ten years of age and lengths of 25.0 cm to 35.37 cm, and 122.53 g to 364.54 g of weight. Relative fecundity (oocytes/gram) was from minimum 438.7 to maximum 3 695.4 and an average of 1 731.4 oocytes (± 749.7 SD). The number of oocytes per gram of gonad was from 42 215 to 85 609, average 57 483 (± 10 144 SD).

Keywords: fecundity, reproduction period, gonadosomatic index, hepatosomatic index, gastric repletion index, condition factor.

Reproducción del constantino *Centropomus robalito* (Teleostei: Centropomidae) en la Laguna de Cuyutlán, en el centro del Pacífico mexicano

Se estudiaron aspectos de la reproducción de *Centropomus robalito* de la costa centro del Pacífico mexicano. Se obtuvieron 335 individuos de octubre 2015 a septiembre 2016. La proporción de machos:hembras fue de 1:2.75 con diferencias significativas ($\chi^2 = 0.0009$, $p<0.05$). También el valor de la longitud media de las hembras fue significativamente mayor que el de machos ($H_{(1, 335)} = 59.539$, $P = 1.191 \cdot 10^{-4}$). La longitud de la primera madurez para ambos sexos fue $L_{25} = 20.70$ cm de longitud total (TL), en hembras fue de $L_{25} = 21.38$ cm TL y en machos de $L_{25} = 17.93$ cm TL. La longitud de la primera reproducción para sexos combinados fue de $L_{50} = 22.29$ cm TL, en hembras de $L_{50} = 22.63$ cm TL y en machos de $L_{50} = 18.20$ cm TL, en ambos casos corresponden a organismos de edades entre dos y tres años. La relación alométrica entre el peso del hígado y la longitud total en el presente estudio fue $LW = 0.00001\ TL^{3.517}$ ($r^2 = 0.735$, $F = 894.076$), y el índice hepatosomático (HSI) presentó valores máximos en octubre, noviembre, enero, junio, julio y septiembre. El índice gonadosomático (GSI) alcanzó su valor más alto en agosto. El índice de repleción gástrica (GRI) mostró sus valores más altos durante julio, junio, octubre, enero, marzo y abril. Los factores de condición según Fulton y Clark mostraron valores más altos de octubre a enero y en abril, y en mayo con el índice de Safran. El diámetro de los ovocitos fue de 0.25 mm a 0.29 mm, con promedio 0.27 mm (± 0.02 DE). Los valores de fecundidad fueron de 539 524 a 696 581 ovocitos en hembras de cuatro a diez años de edad y longitudes de 25.0 cm a 35.37 cm y pesos de 122.53 a 364.54 g. La fecundidad relativa (ovocitos/gramo) fue de mínimo 438.7 a máximo 3 695.4, promedio 1 731.4 ovocitos (± 749.7 DE). El número de ovocitos por gramo de gónada fue de 42 215 a 85 609, en promedio 57 483 (± 10 144 DE).

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Introduction

Fish from the Centropomidae family are demersal euryhaline semi-catadromous (Muhlia-Melo *et al.* 1995). 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 (Muhlia-Melo *et al.* 1995). They are carnivores that feed on smaller fish and crustaceans (Chávez 1963).

The distribution of the yellowfin snook *Centropomus robalito* Jordan & Gilbert 1882is from Sinaloa state Mexico to northern Colombia (Allen & Robertson 1994, Fischer *et al.* 1995).

Its fishery importance is medium in a local scale, it is delivered complete in ice to the market, and its commercial classification is of third category. Its price is of $40.00 Mexican pesos/kg ($2.00 US dollars/kg) to the fisherman, and $60.00 Mexican pesos/kg in Manzanillo's market place ($3.00 US dollars/kg). It is fished with hand line and fish hook, cast net, and gill nets throughout the year. 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) (SIPESCA 2017[1]).

There are no publications on the reproduction of *C. robalito* that allow establishing comparisons with the present work. As for other species of the same family there are a few publications, all of them from the Atlantic Ocean that analyze some parameters as the reproduction season, length and age of first reproduction and values of fecundity (Chávez 1963, Fuentes 1973, Carvajal 1975, Keith *et al.* 2000, Perera-García 2006, Perera-García *et al*. 2008 and Lorán-Núnez *et al.* 2012).

According to this, the objectives of this paper are to determine: the sex ratio, the average length of first maturity (L_{25}) and length of sexual maturity (L_{50}), analysis of the gonadosomatic index, allometric relationship between liver weight and fish length, analysis of the hepatosomatic index, the gastric repletion index and condition factors according to Fulton (1902), Clark (1928) and Safran (1992). Also, the analysis of total fecundity, relative fecundity, and oocytes diameter will be analyzed. Comparisons will be made with results obtained in the present study and those obtained by other authors on members from the Centropomidae family.

Materials and methods

From October 2015 to September 2016 335 organisms of *C. robalito* were taken directly from the commercial captures in Cuyutlan Lagoon, Colima State, México, and taken to the laboratory of the Regional Center for Aquaculture and Fisheries Research (CRIAP). Organisms were captured with gill net, hand line and cast nets, to obtain a sample including all the age groups and size classes.

In the laboratory, data taken from each organism were: total length (TL, cm), standard length (SL, cm), and height (He, cm), total weight (TW, g), eviscerated weight (EW, g) and sex. Gonads (Gi, g), liver (LW, g) and stomach (SW, g) were also weighed, and gonads preserved in 70% alcohol.

Regarding reproduction analysis, gonads were weighed. Sex and gonad maturation were determined *in visu*, on fresh organisms taken to the laboratory the same day they were caught. The stages of sexual maturity were determined using the key described in Espino-Barr *et al*. (2008).

To prove possible statistic differences between sex proportions, a chi-square test (χ^2) was carried out (Daniel 1991). Kolmogorov-Smirnov's statistic test was applied to determine data normality (Zar 1996). These results suggested that total length between sexes have a different distribution than the normal, therefore a Kruskal-Wallis test was made to corroborate possible differences.

The first spawning TL for males and females was determined by 50% of the accumulative frequency (L_{50}) of stages IV and V of sexual maturation (Sparre & Venema 1995), and the minimum TL of first maturity (L_{25}) was also recorded to compare with other authors findings (Rodríguez-Gutiérrez 1992).

1. SIPESCA. 2017. Sistema de información de pesca y acuacultura. Base de datos 2000-2017. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. https://sipesca.conapesca.gob.mx/loginfiel.php

The logistic function was described by the equation (Gaertner & Laloe 1986, Sparre & Venema 1995):

$$Hp = \frac{1}{1 + e^{a+b\cdot TL}}$$

where: Hp = proportion of females or males sexually mature, *a* and *b* are constants. Its logarithmic transformation is: $\ln(1(1/Hp-1)) = a-b \cdot TL$, and the length at which 50% of the population is sexually mature ($L_{0.5}$) corresponds to: $L_{50} = a/b$. The original equation is modified to include $L_{0.5}$: $Y = 1/[1+a(1-TL/L_{50})]$.

The minimum TL of first maturation (L_{25}) was also recorded to compare with other author's findings.

The gonadosomatic index (GSI) was calculated according to Rodríguez-Gutiérrez (1992), where gonad weight (GW) is expressed as a function of body weight: GSI = 100·GW/TW. As a measure of physical fitness of the fish, we obtained the condition factor $K = (We\cdot TL^{3})\cdot 100$ (Clark 1928), $K = (Wt\cdot TL^{-3})\cdot 100$ (Fulton 1902) and $a = Wt\cdot TL^{-b}$ and $a = We\cdot TL^{-b}$ (Safran 1992). The hepatosomatic index (HSI) was expressed as the percentage of liver weight (LW) with respect to the total weight HSI = 100·LW/TW (Rodríguez-Gutiérrez 1992).

Fecundity (F) and relative fecundity were obtained by the gravimetric method using the wet weight of phase V female gonads of *C. robalito*, two subsamples of 0.01 g were obtained of each individual and put in a modified Gilson fluid (Simpson 1951) to preserve. All oocytes were counted with the help of a stereoscopic microscope and measured with a micrometric ocular.

The following expression was used in the calculation: $F = n \cdot GW/g_i$, where F = fecundity of a sample; *n* = number of oocytes in the subsample; GW = gonad weight (g) and g_i = weight of the subsample (g) (Holden & Raitt 1975).

Results

Total sample was of 335 organisms, 198 females, 72 males and 35 undifferentiated. Significant difference was found in between the female:male proportions (M:F = 1:2.75, $\chi^2 = 0.0009$, DF = 1, $p>0.05$). Females length interval was from 15.6 to 34.0 cm (average 23.04 ± 3.04 SD), males from 12.5 to 26.2 (18.7 ± 2.8 SD) and undifferentiated from 6.5 to 21.0 (10.6 ± 4.3). Length distribution was not normal (D = 0.10102, $p<0.05$), and significant difference between sexes was found ($H_{(1, 335)} = 59.539$, $P = 1.191 \cdot 10^{-4}$).

Gonads can be differentiated macroscopically, except for the virgin individuals who have never spawned and are just beginning their development.

Table 1 shows values of the gonad weight (GW, g) for each age group, as well as the length (TL, cm), total weight (TW, g) and eviscerated weight (EW, g), also liver weight (LW, g) and

Table 1

Total length (TL, cm), growth index (GI, cm), total weight (TW, g), eviscerated weight (EW, g), liver (LW, g), testis weight (TeW, g), ovary weight (GW, g) and fecundity (number of oocytes) for each age group (years) of *Centropomus robalito*

Age (years)	*TL (cm)*	*GI (cm)*	*TW (g)*	*EW (g)*	*LW (g)*	*GW (g)*	*TeW (g)*	*F (eggs) TL*	*F (eggs) TW*
0	6.10		1.47	1.48	0.01				
1	12.39	6.28	13.51	13.72	0.07				
2	17.49	5.10	39.91	40.60	0.23		0.94		
3	21.63	4.14	77.81	79.26	0.50		1.01		
4	25.00	3.37	122.53	124.92	0.82	1.01	1.06	539 524	180 794
5	27.73	2.73	169.73	173.15	1.19	1.27	1.09	580 895	208 986
6	29.95	2.22	216.17	220.62	1.56	1.49		614 497	232 714
7	31.75	1.80	259.73	265.17	1.91	1.69		641 788	252 509
8	33.22	1.46	299.23	305.59	2.24	1.87		663 955	268 919
9	34.41	1.19	334.18	341.35	2.54	2.01		681 958	282 461
10	35.37	0.97	364.54	372.43	2.80	2.14		696 581	293 597

Note: Age and growth parameters were obtained from Gallardo-Cabello *et al*. (2018) and Espino-Barr *et al*. (2019).

fecundity (number of oocytes/ organism). Values of the age and growth parameters were obtained from Gallardo-Cabello *et al*. (2018) and Espino-Barr *et al*. (2019).

Testes are elongated and whitish color and smaller than the ovaries. *Table 1* shows that the ovary weight is 1.27g in individuals of five years of age, while testes are 1.09 g in individuals of the same age.

A total of 180 oocytes were measured and diameters were 0.25 mm minimum and maximum 0.29 mm, mean 0.27 (± 0.02 SD, standard deviation). Fecundity values ranged from 539 524 to 696 581 oocytes in females of four to ten years of age and lengths of 25.00 cm to 35.37 cm, and 122.53 g to 364.54 g of weight (Table 1). Relative fecundity was from minimum 438.7 to maximum 3 695.4 and an average of 1 731.4 oocytes (± 749.7 SD). The number of oocytes per gram of gonad was from 42 215 to 85 609, average 57 483 (± 10 144 SD).

Sample size of sexed individuals was of 335 organisms of *C. robalito* of which 198 (59.3%) were females, and 72 (21.6%) males, 29 (8.7%) undetermined (Fig. 1), and the rest were eviscerated. The proportion of male: female was 1:2.75 ($\chi^2 = 0.0009$, $p<0.05$).

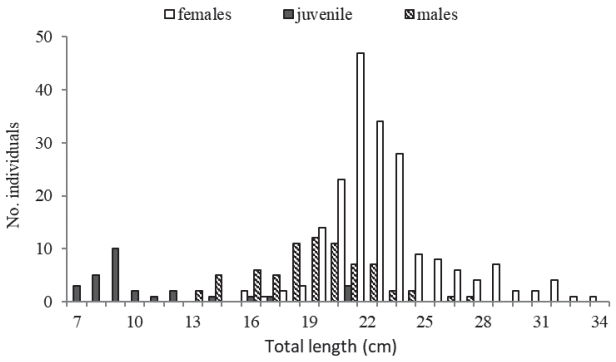

Fig. 1. Length distribution of *Centropomus robalito* in Cuyutlan Lagoon, Colima State, México.

Monthly variations of the relative frequency of gonad maturity stages are shown in *figure 2*. During May no samples were found and in December no males. Stage II or immature females are present 21.05% in October, 90% in November, 96.15% in December, 93.33% in January, 83.33% in February, 87.50% in March, 24.14% in April and 30.43% in September 20%. Males in stage II or immature were observed during the months of October, January, February, March, and April at 100%, November 50%, in August 73%, and in September 15.79%. Stage III was observed in females at 42.11% in October, 3.85% in November, 12.50% in January and February, 44.83% in March, 17.39% in April, and 10.00% in September. Stage III was observed in males at 50% in November, 66.67% in June, 75% in July, 26.92% in August, and 42.11% in September. Stage IV, mature, was observed in females at 10.53% in October, 4.17% in January, 3.45% in March, 8.70% in April, and 5% in June. Stage IV, mature, was observed in males at 25.00% in July, and 36.84% in September. Stage V or spawning stage was observed in females at 26.32% in October, 3.45% in March, 4.35% in April, 95% in June, 100% in July and August, and 70% in September. Males were in stage V at 33.33% in June and 5.26% in September. Stage VI, post-spawning was observed in females at 24.14% in March and 39.13% in April. This stage was not observed in males. It is possible, that due to the small size of males, information on their mature stage is lacking. Nevertheless, mature organisms of both sexes coincide in the second and third trimester of the year.

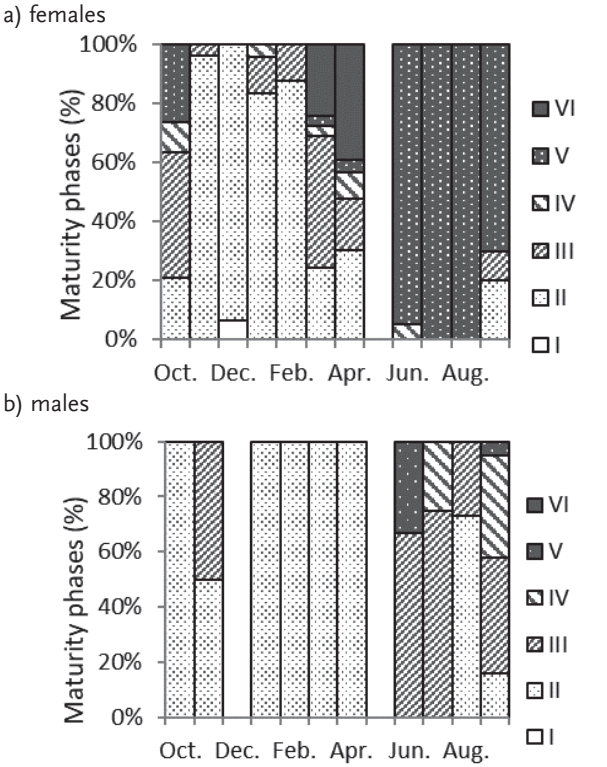

Fig. 2. Monthly relation of sexual maturity in *a)* females and *b)* males of *Centropomus robalito* in Cuyutlan Lagoon, Colima State, México.

Length of first maturity for both sexes was L_{25} = 20.70 cm TL, in females L_{25}= 21.38 TL, and in males L_{25} = 17.93 cm TL. First reproduction length was L_{50} = 22.29 cm TL for both sexes, in females L_{50} = 22.63 cm TL, and in males L_{50} = 18.20 cm TL (Fig. 3), in both cases corresponding to an age between two and three years.

Monthly variations of the relative frequency of gonad maturity showed that phase V or spawning stage was in females at 100% at July and August.

The gonadosomatic index (GSI) reached its highest average value in August. Other months that reached high values were June, July, September, October and March. GSI values decreased during the months of November, December and February (Fig. 4).

The allometric relationship of the hepatosomatic index (HSI) obtained in the present study was LW = 0.00001 $TL^{3.517}$ (r^2 = 0.735, F = 894.076). HSI variations are shown in *figure 5*, maximum values are observed in October, January, June and July.

Variations in the gastric repletion index (GRI) (Fig. 6) show higher values during June, July, October, January, March and April, and maximums also February and September.

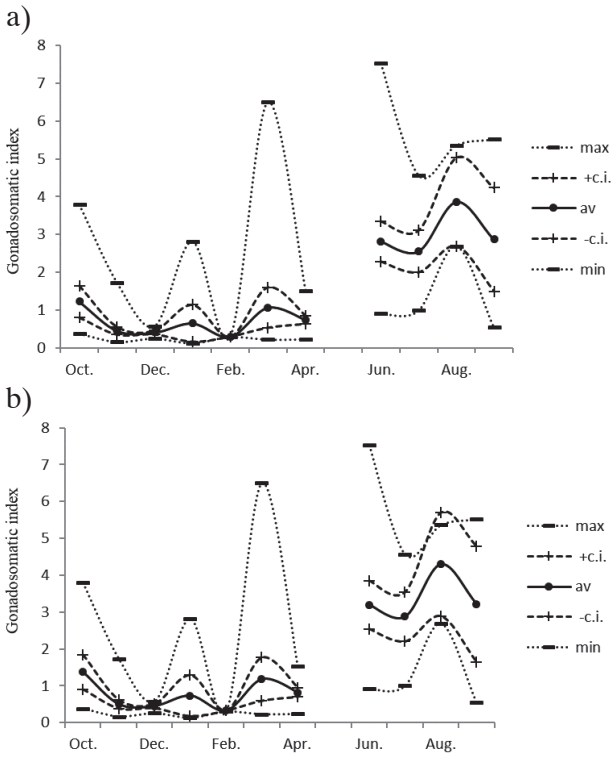

Fig. 4. Monthly variation of the gonadosomatic index (GSI), *a)* calculated with total weight (g), and *b)* calculated with eviscerated weight (g) of *Centropomus robalito* in Cuyutlan Lagoon, Colima State, México. Note: av = average, max = maximum, min = minimum.

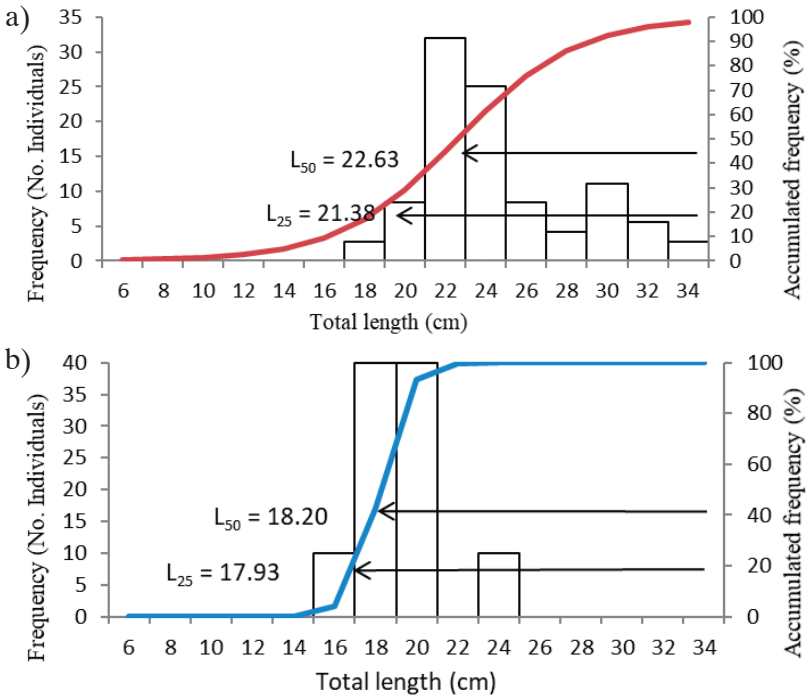

Fig. 3. First maturity length (L_{25}) and first reproduction length (L_{50}) of: *a)* females, *b)* males of *Centropomus robalito* in Cuyutlan Lagoon, Colima State, México.

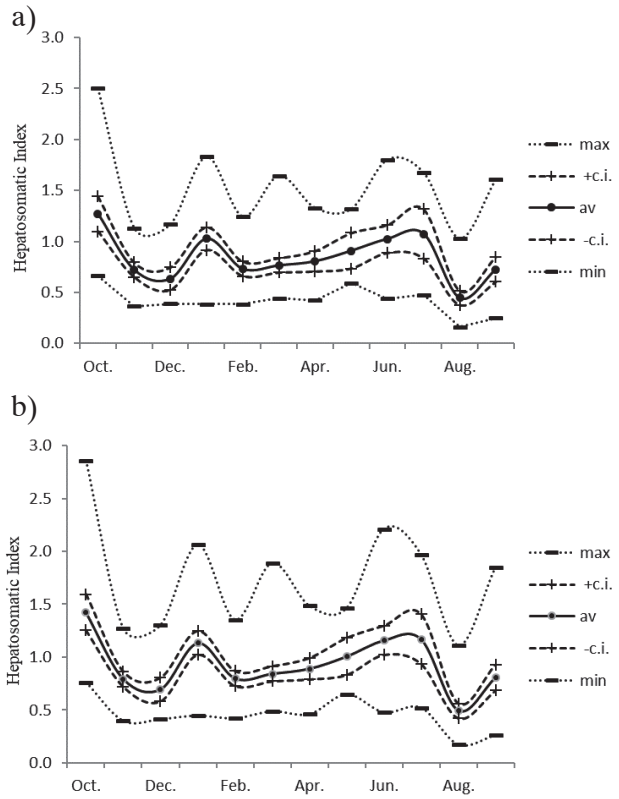

Fig. 5. Monthly variation of the hepatosomatic index (HSI), *a)* calculated with total weight (g), and *b)* calculated with eviscerated weight (g) of *Centropomus robalito* in Cuyutlan Lagoon, Colima State, México.

Figure 7 shows the values of the condition factor; the higher values are obtained in the months of October, November, December, January and April for Fulton and Clark, and May with Safran's indexes.

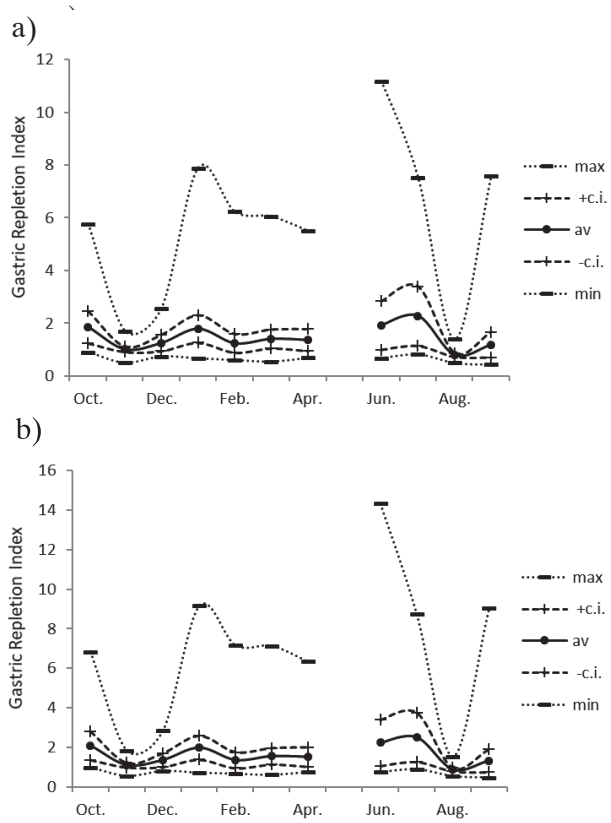

Fig. 6. Monthly variation of the gastric repletion index (GRI), *a)* calculated with total weight (g), and *b)* calculated with eviscerated weight (g) of *Centropomus robalito* in Cuyutlan Lagoon, Colima State, México.

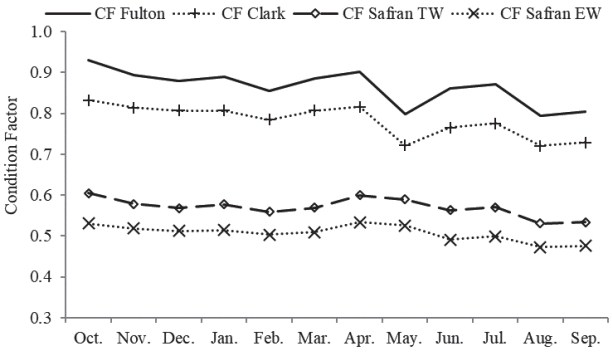

Fig. 7. Monthly values of the relative condition factor of *Centropomus robalito* in Cuyutlan Lagoon, Colima State, México.

Discussion

The highest value of the length growth rate of *Centropomus robalito* occurs in group one, 12.39 cm TL (Gallardo-Cabello *et al*. 2018, Espino-Barr *et al*. 2019), after which it starts to diminish and the total weight and gonad weight start to rise, likewise the fatty reserve index. Therefore, two fundamental periods were considered in the life cycle of *C. robalito*: a first period when most of the energy obtained through food is used to increment in length (to avoid depredation and interspecific competence), a second period, when this energy is oriented to form the sexual products (Table 1, Fig. 8) (Espino-Barr *et al*. 2008, Gallardo-Cabello *et al.* 2010).

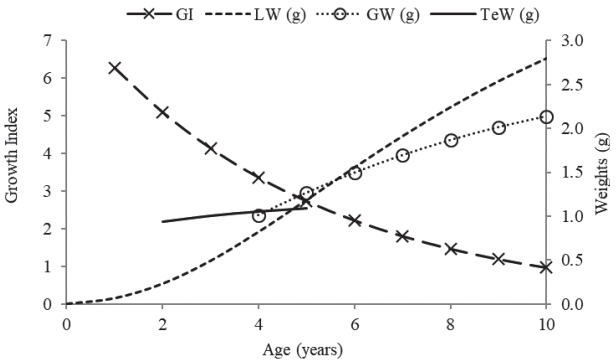

Fig. 8. Relationship between age and growth index (Gi, cm), liver weight (LW, g), gonad weight (GW, g) and testis weight (TeW, g) of *Centropomus robalito* in Cuyutlan Lagoon, Colima State, México.

Length of first reproduction was observed in *C. robalito* males from 17.5 to 21.6 cm TL, during two to three years of age. In the Atlantic Ocean, other members of the family Centropomidae show higher values, of three and four years, as more than *C. ensiferus*, *C. mexicanus*, *C. parallelus* (Keith *et al.* 2000). In the French Guyana *C. undecimales* reaches length of first reproduction between three and five years (Keith *et al.* 2000).

In the case of other species of the Centropomidae family in México, it was observed that the absolute fecundity in the Atlantic Ocean, was of 80 000 to 2 500 000 in *C. ensiferus,* 800 000 to 1 2000 000 for *C. mexicanus*, 900 000 for *C. parallelus* (Keith *et al*. 2000), and 3 000 000 to 4 000 000 for *C. undecimalis* (García-Cagide *et al*. 1994).

In the case of *C. robalito*, there is a massive spawning period during the months of July and August. Very similar values were reported for *C. poeyi* in the Alvarado lagoon in Veracruz, and Términos lagoon in Campeche (Chávez 1963, Fuentes 1973, Carvajal 1975, Lorán-Núñez *et al.* 2012). Also, in the case of *C. undecimalis* similar values were observed in the Alvarado lagoon in Veracruz (Chávez 1963, Lorán-Núñez *et al.* 2012), and Términos lagoon in Campeche (Carvajal 1975), and Barra de San Pedro, Tabasco, México (Perera-García 2006, Perera-García *et al.* 2008). It has been observed that members of the family Centropomidae, either in the Pacific or Atlantic Ocean spawn massively during the months of July and August, which correspond to rainy seasons, when the flow of the rivers increases and therefore the contributions to the estuarine zones is higher and the reproduction of these organisms take place. In the case of *C. robalito*, it is important to note that it is an estuarine species that inhabits most of its life in coastal lagoons, differently from *C. undecimalis* and *C. nigrescens* which can live in estuarine, freshwater and marine environments.

Massive spawning occurs in July and August; therefore the condition factor decreases, because it is a time when the energetic wear of fish is greater than in other months of the year. After the reproductive season passes, values of the condition factor increase, which happens in the months of October to January. Similar values were obtained for the gastric repletion index, which increases during the time when the condition factor increases, from October to January, as during pre-spawning periods, March to July.

The allometric index *b* of HSI indicates that the liver weight (LW) increments in a higher proportion than cubic, in terms of its length, which results in a positive allometric growth of the fish, increasing its fatty reserves as it ages. Fatty reserves increase during the months of October to January (HSI), when the condition factor increase and the organisms are in optimal conditions of "health". Likewise, there is an increase in liver reserves in the months of June, July and September, that is, pre-spawning and spawning season, when the reserve materials are used in the production of sexual products.

Conclusions

The proportion of male: female was 1: 2.75 ($\chi^2 = 0.0009$, $p<0.05$).

Length of first maturity for both sexes was L_{25} = 20.70 cm TL, in females L_{25}= 21.38 cm TL in males and L_{25} = 17.93 cm TL. First reproduction length was L_{50} = 22.29 cm TL for both sexes, in females L_{50} = 22.63 cm TL, and in males L_{50} = 18.20 cm TL, in both cases corresponding to an age between two and three years.

The allometric relationship of the hepatosomatic index (HSI) obtained in the present study was $LW = 0.00001\ TL^{3.517}$ ($r^2 = 0.735$). Maximum values are observed in October, November, January, June, July and September.

The gonadosomatic index (GSI) reached its highest value in August. Other months that reached high values were June, July, September, October and March. GSI values decreased during the months of November, December and February.

The gastric repletion index (GRI) show higher values during, July, June, October, January, March and April.

The condition factor shows the higher values in the months of October, November, December, January and April for Fulton and Clark, and May with Safran's indexes.

Mature oocytes diameters were 0.25 mm minimum and maximum 0.29 mm, mean 0.27 (± 0.02).

Fecundity values ranged from 539 524 to 696 581 oocytes in females of four to ten years of age and lengths of 25.0 cm to 35.37 cm, and 122.53 g to 364.54 g of weight.

Relative fecundity was from minimum 438.7 to maximum 3 695.4 and an average of 1 731.4 oocytes (± 749.7).

The number of oocytes per gram of gonad was from 42 215 to 85 609, average 57 483 (± 10 144).

Recommendations

Studies on the reproduction of the yellowfin snook *Centropomus robalito* should be enlarged by histological analysis of the gonads, to continue with the knowledge of the oogenesis and spermatogenesis of this species, which would allow understanding the phenomena of sexual shift and hermaphroditism, common in the members of this family.

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References

Allen GR, DR Robertson. 1994. *Peces del Pacífico Oriental Tro*pical. CONABIO, Agrupación Sierra Madre y CEMEX, México. 327p.

Carvajal RJ. 1975. Contribución al conocimiento de la biología de los robalos *Centropomus undecimalis* y *C. poeyi* en la Laguna de Términos, Campeche, México. *Boletín del Instituto Oceanográfico de la Universidad de Oriente* 14(1): 51-70.

Chávez H. 1963. Contribución al conocimiento de la biología de los robalos chucumite y constantino (*Centropomus* spp.) del estado de Veracruz (Pisces: Centropomidae). *Ciencia Mexicana* 22: 141-161.

Clark F. 1928. The weight-length relationship of the Californian sardine (*Sardina coerulea*) at San Pedro. *Fishery Bulletin*12: 22-44.

Espino-Barr E, A González Vega, H Santana Hernández, H González Vega. 2008. *Manual de biología pesquera*. Universidad Autónoma de Nayarit, México. 168p.

Espino-Barr E, M Gallardo-Cabello, M Puente-Gómez, A Garcia-Boa. 2019. Study of the age of *Centropomus robalito* by otoliths analysis of *sagitta*, *asteriscus* and *lapillus* in Mexican Central Pacific. HSOA *Journal of Aquaculture & Fisheries* 3:013. DOI: 10.24966/AAF-5523/100013

Fischer W, F Krupp, W Schneides, C Sommer, KE Carpenter, UH Niem (ed.). 1995. *Guía FAO para la identificación de especies para los fines de la pesca. Pacífico Centro Oriental*. Vertebrados Vols. II y III: 644-1813.

Fuentes CDF. 1973. Contribución al conocimiento de la biología del robalo prieto (Pisces, *Centropomus poeyi* Chávez) en el área de Alvarado, Veracruz, México. *Revista de la Sociedad Mexicana de Historia Natural* 34: 369-421.

Fulton TW. 1902. The rate of growth of fishes. *20th Annual Report of the Fishery Board of Scotland* 1902 (3): 326-446.

Gaertner D, F Laloe. 1986. Étude biometrique de la talle a'premier maturité sexualle de Geryonmaritae, Maning et Holthuis, 1981 de Senegal. *Oceanologica Acta* 9(4): 479-487.

Gallardo-Cabello M, M Sarabia-Méndez, E Espino-Barr, V Anislado-Tolentino. 2010. Biological aspects of *Lutjanus peru* in Bufadero Bay, Michoacán, México: growth, reproduction and condition factors. *Revista de Biología Marina y Oceanografía* 45(2): 205-215.

Gallardo-Cabello M, E Espino-Barr, A Garcia-Boa, M Puente-Gómez. 2018. Growth of the yellowfin snook *Centropomus robalito* (Teleostei: Centropomidae) in Cuyutlan Lagoon, Mexican Central Pacific. *International Journal of Scientific Research* 7(12): 28-31. DOI: 10.36106/ijsr

García-Cagide A, R Claro, BV Koshelev. 1994. Reproducción. *In*: R Claro (ed.). *Ecología de los peces marinos de Cuba*. Inst. Oceanol. Acad. Cienc. Cuba/ Centro de Investigaciones de Quintana Roo (CIQRO) México. pp: 187-262.

Holden MJ, DFS Raitt. 1975. *Manual de Ciencia Pesquera*. Parte 2.- Métodos para investigar los recursos y su aplicación. ONU/FAO. Documento Técnico de Pesca, Núm. 115. rev. 1. 207p.

Keith P, P-Y Le Bail, P Planquette. 2000. *Atlas des poissons d'eau douce de Guyane*. Tome 2, Fascicule I: Batrachoidiformes, Mugiliformes, Beloniformes, Cyprinodontiformes, Synbranchiformes, Perciformes,Pleuronectiformes,Tetraodontiformes. Collection Patrimoines Naturels Paris: Publications scientifiques du Muséum National d'Histoire Naturelle. 43(1): 286p.

Lorán-Nuñez RM, FR Martínez-Isunza, AJ Valdez-Guzmán, M Garduño-Dionate, ER Martínez-Lorán. 2012. Reproducción y madurez sexual de robalo prieto (*Centropomus poeyi*) y robalo blanco (*C. undecimalis*) en el Sistema Lagunar de Alvarado, Veracruz (2005-2007). *Ciencia Pesquera* 20(1): 49-64.

Muhlia-Melo A, J Arvizu-Martínez, J Rodríguez-Romero, D Guerrero-Tortolero, FJ Gutiérrez-Sánchez, A Muhlia-Almazán. 1995. *Sinopsis de información biológica, pesquera y acuacultural acerca de los robalos del género Centropomus en México*. Programa de Evaluación de Recursos Naturales del Centro de Investigaciones Biológicas del Noroeste, SC. 51p.

Perera-García MA. 2006. Biología pesquera del robalo blanco *Centropomus undecimalis* (Pisces: Centropomidae), en Barra de San Pedro, Centla, México. Tesis de Maestría. Universidad Juárez Autónoma de Tabasco. México. 81p.

Perera-García MA, M Mendoza-Carranza, S Páramo-Delgadillo. 2008. Dinámica reproductiva y poblacional del robalo, *Centropomus undecimalis* (Perciformes: Centropomidae), en Barra San Pedro, Centla, México. *Universidad y Ciencia* 24(1): 49-59.

Perera-García MA, M Mendoza-Carranza, W Contreras-Sánchez. 2013. Comparative age and growth of common snook *Centropomus undecimalis* (Pisces: Centropomidae) from coastal and riverine areas in Southern Mexico. *Revista de Biología Tropical* 61(2): 807-819.

Rodríguez-Gutiérrez M. 1992. *Técnicas de evaluación cuantitativa de la madurez gonádica en peces*. AGT Ed. México. 79p.

Safran P. 1992. Theoretical analysis of the weight-length relationship in fish juveniles. *Marine Biology* 112: 545-551.

Simpson AC. 1951. The fecundity of the plaice. *Fishery Investigations* 18: 1-27.

Sparre P, SC Venema. 1995. *Introducción a la evaluación de recursos pesqueros tropicales*. Parte 1 - Manual. *FAO Documento Técnico de Pesca* 306/1, Roma, 420p.

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