Global Journal of Science Frontier Research: C
Biological Science
Volume 17 Issue 1 Version 1.0 Year 2017
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Communities of Helminth Parasites in five Carangidae Species from the Coast of Veracruz, Mexico, Southern Gulf of Mexico

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Abstract- In 140 specimens of five carangid species were captured in Playa Las Barrancas and El Cabezo Reef, Veracruz Reef System National Park, Veracruz State, Southern Gulf of Mexico:*Caranx crysos* (n=51), *Caranx hippos* (n=18), *Chloroscombrus chrysurus* (n=28), *Oligoplites saurus* (n=24) and *Trachinotus carolinus* (n=19), a total of 44 helminth species were recovered, distributed as follows: 18 digeneans (17 adults, and 1 metacercaria), 12 monogeneans, 9 nematodes (6 adults, and 3 larvae), 4 cestodes (all larvae), and 1 acanthocephalan (juvenile). Parasite of helminths species with the highest prevalence in five communities were *Pseudobicotylophora atlantica* and *Amphipolycotyle chloroscombrus*, while species with mean intensity were *Hurleytrema catarinensis*; and the nematode *Hysterothylacium* sp., was registered in all five communities.

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GJSFR-C Classification: *FOR Code: 279999p*

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Abstract- In 140 specimens of five carangid species were captured in Playa Las Barrancas and El Cabezo Reef, Veracruz Reef System National Park, Veracruz State, Southern Gulf of Mexico: *Caranx crysos* (n=51), *Caranx hippos* (n=18), *Chloroscombrus chrysurus* (n=28), *Oligoplites saurus* (n=24) and *Trachinotus carolinus* (n=19), a total of 44 helminth species were recovered, distributed as follows: 18 digeneans (17 adults, and 1 metacercaria), 12 monogeneans, 9 nematodes (6 adults, and 3 larvae), 4 cestodes (all larvae), and 1 acanthocephalan (juvenile).Parasite of helminths species with the highest prevalence in five communities were *Pseudobicotylophora atlantica* and *Amphipolycotyle chloroscombrus*, while species with mean intensity were *Hurleytrema catarinensis*;and the nematode *Hysterothylacium* sp., was registered in all five communities. The component community with highest richness and diversity was for *C. crysos* (*S*=21, Shannon index *H'*= 2.19), atinfracommunitylevel highest richness was for *T. carolinus* (*S* = 4.5 ± 2.1) and *C. hipos* (*S* = 4.1 ± 2.8, while the highest diversity was for *C. chrysurus*(Brillouin index*H* = 1.03 ± 0.32)and*C. crysos* (Brillouin indexH = 1.01 ± 0.44).The highest Similarity Index of was between the communities of*C. crysos*and *C. hippos* (Jaccard index=60%). Results suggestthat compositions, richness and diversity are similar to other founded marine fishfromtropical and temperate latitudes.

Keywords: communities, helminth parasites, c. crysos, c. hippos, c. chrysurus, o. saurus, t. carolinus, mexico.

I. Introduction

Taxonomic studies of parasitic helminths in marine fish families, including Carangidaespecies, are numerous in Mexico and different areas(Lamothe-Argumedo et al. 1997; Konh et al. 2006; García-Prieto et al. 2006; Pérez-Ponce de León et al. 2007; Overstreet et al. 2009; Jensen 2009).However, These studies were concern to species with commercial interest, such as *Trachinotuscarolinus* (Sánchez-Ramírez & Vidal-Martínez 2002), *Eugerresplumieri*, *Hexanematichthysassimilis*, *Oligoplitessaurus* and *Scomberomorusmaculatus* (Aguirre-Macedo et al. 2007), *Symphurusplagiusa* (Rodríguez-González & Vidal-Martínez 2008), *Centropomusnigrescens* (Violante-González et al. 2010), *Lutjanuscampechanus* and *L. synagris*(Montoya-Mendoza et al. 2014; 2016). In respect to carangid fish species, in Mexico, have records of parasite communities of *T. carolinus* (Sánchez-Ramírez & Vidal-Martínez 2002) and *O. saurus*(Aguirre-Macedo et al. 2007), only, unlike other areas from Brazil, e.g. *O.palometa, O. saurus*, and *O. saliens* (Takemoto et al. 1995), *Caranxhippos* and *C. latus* (Luque & Alves 2001), *C. hippos*(Boada et al. 2012), *Selene setapinnis* (Cordeiro & Luque 2004), and *T.goodei* (Luque & Cezar 2004).

These authors have indicated that communities of helminth parasites of marine fish are rich, abundant and diverse, particularly in tropical latitudes(Rohde & Heap 1998; Alves & Luque 2006; Luque&Poulin 2007), in this paper, its assumed than the community parasites obtained from five carangid fish species are similar in richness species and diversity compared to the parasite communities reported in marine fish species from other temperate and tropical latitudes. Moreover, the helminth communities are described in terms of species composition, species richness, diversity and similitude.

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II. Material and Methods

a) Sampling Procedures

A total of 140organisms from five species of the Carangidae Family were examined between August, 2004 and February, 2007. Specimens were caught in Playa Las Barrancas (18º59'31''N,95º57'83''W), of Alvarado Municipality, Veracruz, Mexico. With a beach seine net (500m long x 4–5 m high; ¼–1 in mesh). Larger fish were caught by hook-and-line at El Cabezo Reef (19º03'07''N, 95º52'05''W), 11.7 km east of Playa Las Barrancas. All fish collected were transported alive to the laboratory and placed in 1,000 L tanks, while dead organisms were kept in plastic containers with ice, and transported to the lab for examination within 24 hours post-capture. Taxonomic designations of fish were done according to Frose & Pauly (2016).

Tissues and organs were reviewed using a stereomicroscope. The external examination included skin, scales, fins, gills, eyes, nostrils, mouth, and anus. Gills were removed and analyzed separately in Petri dishes with seawater. Internal examination included mesenteries, liver, kidney, and gonads, and the whole digestive system was placed in Petri dishes with 0.75% saline for examination. Helminths were fixed with hot 4% formalin and preserved in 70% ethyl alcohol.

For taxa identification, monogeneans, digeneans, cestodes, and acanthocephalans were stained using either Mayer's paracarmine, Gomori's triple stain or Erlich's hematoxylin, and then dehydrated in a graded alcohol series, cleared with clove oil, and mounted whole in Canada balsam. Nematodes were studied on temporary slides and cleared in glycerin, and then preserved in 70% alcohol. In order to study sclerotized structures, some specimens of monogeneans were fixed with ammonium picrate (Vidal-Martínez et al. 2001). Voucher specimens were deposited at the National Helminths Collection *(Colección Nacional de Helmintos)* (CNHE), Institute of Biology of the National Autonomous University, Mexico City.

b) Sample Size

Helminth communitiesin the five species of carangidswere analyzed at the component community (all helminths in all individuals of species examined), and infra-community (helminths in each fish examined) levels (Holmes & Price 1986). Helminth species richness observed was one measure of the adopted community structure. Sampling adequacy for the component community was evaluated with procedure similar to the one used for helminth parasites communities of *L.campechanus* (Montoya-Mendoza et al. 2014), and *L. synagris* (Montoya-Mendoza et al. 2016), using a randomized (100x) sample-based species accumulation curve computed in Estimate S (version 8.5 RK Colwell, http://viceroy.eeb.unconn.edu/estimates) (Moreno & Halffter 2001). For the component community, we examined the asymptotic richness based on the Clench's model equation (Soberon & Llorente, 1993),besides the final slope of the randomized species accumulation curve (Jiménez-Valverde & Hortal 2003). Clench's model is described by the following function: $V2 = (a \times V1)/ [1+ (b \times V1)]$,where *V2* is the observed richness, *V1* is the number of hosts examined, and *a* and *b* are curve parameters; *a* equals the new species adding rate, and *b* is a parameter related to the curve shape. These values were calculated using the Estimate S and Statistica software (Stat Soft, Inc., Tulsa, Oklahoma) as in Jiménez-Valverde & Hortal (2003). The slope of the cumulative species curve was calculated as $a/(1+b \times n)^2$, where *a* and *b* are parameters cited above and *n* is the number of hosts examined for a given component. The Clench's model equation allows estimating the total number of species in a component as *a*/*b*. To calculate the number of rare species missing at the component community level, the nonparametric species-richness estimator bootstrap was calculated from data observed, as recommended by Poulin (1998).

c) Data analysis

The prevalence (percentage of infected hosts) and mean intensity (mean number of parasites per infected fish) were calculated following Bush et al. (1997); as well as the correlation between the total number of species with the total number of helminths, and compared with the host size and weight. Were analyzed the distribution of helminth species abundance for community components by rank-abundance curves and data were adjusted to predictive distribution models (x^2, p = 0.05) recording the dominant species in each community. These values were calculated using thePAST version 3.14 (Hammer et al. 2001).The Shannon index of diversity (*H'*), was calculated for the component community as in Magurran (2004). Infra-community descriptors included the mean number of helminth species per fish, the mean number of helminth individuals per fish, and the mean value of the Brillouin's diversity index per fish (*H*).Similarity among all five parasite communities was estimated with a cluster analysis using theJaccard similarity index (Magurran 2004).

III. Results

A total of 140 specimens from five carangids species were collected: 51 blue runners, *Caranxcrysos*; 23 Crevalle jacks, *Caranxhippos*; 28 Atlantic bumpers, *Chloroscombrus chrysurus*; 24 Leather jackets, *Oligoplites saurus*; and 19 Florida pampanos, *Trachinotuscarolinus*.Size and weight aredisplayed in Table 1.

a) Parasite parameters

The 44 species of parasites collected, belonged to 18 trematodes species (17 adults and 1 metacercaria); 12 monogeneans; 9 nematodes (6 adults and 3 larva); 4cestodes (all larvae); and 1 acanthocephalan (juvenile) (see Table 2).Hosts fish species with the highest proportion of trematodes were*T. carolinus* (9 species, 50%) and *C. crysos* (8 species, 38%), and the highest proportion of monogeneans wasfound in *C. hippos*(6 species, 33%).

Hysterothylacium sp., nematode larvae were recorded in all five host species, whilethe cestodelarva of *Scolexpolimorphus*, thetrematode*Gonocerca* sp., and the nematode *Hysterothylaciumfortalezae* were recorded in four host species.The other parasites were recorded in one, two or threehost species, According to inventory of parasites of this study, are reported 12 new locality records and 17 new host records(Table 2).

Table 1: Total Length (Lt, cm) and Weight (W, g) of the five Carangid Species from Alvarado, Veracruz, Mexico.

Host	n	*Lt*(± ES)	Range	*W*(± ES)	Range
C. crysos	51	24.5 ± 11.6	13.4-43.5	262.1 ± 290.1	25.3-885
C. hippos	18	30.1 ± 33.2	11.6-116	1077.1 ± 2670	25-8250
C. chrysurus	28	15.9 ± 1.6	10.5-19.5	41.12 ± 8.2	30-63.1
O. saurus	24	20.6 ± 4.1	13.6-27.3	70.7 ± 36.6	17.3-155
T. carolinus	19	32.8 ± 9.3	13.6-45.9	491.1 ± 280.7	40-1072

Parasites with the highest prevalence were the monogenean *Pseudobicotylophoraatlantica* (89.5%) and the trematode *Huerleytremacatarinensis* (73.7%) for the host *T. carolinus*; the monogenean *Amphipolycotylechloroscombrus* (82.1%) for the host *C. chrysurus*; and the monogenean *Probursataveraecrucis* (66.6 %) for the host *Amphipolycotyle chloroscombrus* (82.1 %). Trematodes with the highest abundance were *H. catarinensis* (7033, *Pi* = 0.98) for the host *T. carolinus*, and *Manteriabrachydera* (198, *Pi* = 0.51) for*C. hippos*. Most abundant monogeneans were *Cemocotylecarangis* (414, Pi = 0.367) for*C. hippos* and *Amphipolycotyle chloroscombrus* (112, *Pi* = 0.25) for the host *C. chrysurus* (see Table 2).

b) Sample Size

The cumulative species curves developed with the Clench model, showed that our species inventories are almost complete, considering that the slope value of the last point of the curve was less or close to 0.1 (*bxi*≤ 0.1), and that we collected between 80% and 95% of the species that make up each community. Also, the Clench model showed that there are some species needing to be collected, based on the a/b value (*Se*, richness expected), and corroborated by the Bootstrap richness estimator (Table 3).

Table 3: Richness of component communities of helminthes parasites of five species of Carangids from Alvarado, Veracruz, Mexico. Data include: n, number of hosts examined; #th, total number of helminths; So, number of observed helminth species; Se, number of helminth species estimated with the Clench model; R^2, correlation coefficient between date and Clench model; b_{xi}, date of the condition species curve as calculated from Clench model; % sp Cle, proportion of species by the Clench model; S_{Boot}, richness estimated by Bootstrap.

Host	*n*	*#th*	*So*	*Se*	R^2	b_{xi}	*% sp Cle*	S_{Boot}
C. crysos	51	1126	21	23	0.9981	0.03	89	22
C. hippos	23	1620	18	22	0.9992	0.13	80	19
C. chrysurus	28	455	12	14	0.9996	0.04	89	14
O. saurus	24	388	7	8	0.9739	0.02	95	8
T. carolinus	19	10184	18	22	0.9991	0.18	80	20

c) Correlations of richness and abundance

Significant correlation (α = 0.05) was found between the total number of species (S) or the total number of helminths (N), when compared to the host size was to *C. crysos* (total host length vs. *S*, r = 0.76; vs. *N*, r = 0.56), and *C. hippos* (total host length vs. *S*, r = 0.82; vs. *N*, r = 0.86), but no significant correlation to *C. chrysurus* (total host length vs. *S*, r = 0.34; vs. *N*, r = 0.01), *O. saurus* (total host length vs. *S*, r = 0.41; vs. *N*, r = 0.39), and *T. carolinus* (total host length vs. *S*, r = 0.37; vs. *N*, r = 0.21).

Table 2: Helminth parasites of 5 carangid species from Alvarado, Veracruz, Mexico. Data include: nhp, number of hosts parasitized; tnhl, total number of helminthes; mnt, mean intensity; % prev, prevalence; in, intestine; ic, intestinal ceca; s, spleen; m, mesentery; bv, biliary vesicle; g, gill; h, head; un, under skin; l, larve; mt, metacercaria, *new locality record, **new host record.

		Caranx crysos (n = 51)			*Caranx hippos* (n = 23)			*Chloroscombruscrysurus* (n = 28)			*Oligoplites saurus* (n = 24)			*Trachinotus carolinus* (n = 19)		
Helminth	site	nhp (% prev)	tnhl (Pi)	mnt (range)	nhp (% prev)	tnhl (Pi)	mnt (range)	nhp (% prev)	tnhl (Pi)	mnt (range)	nhp (% prev)	tnhl (Pi)	mnt (range)	nhp (% prev)	tnhl (Pi)	mnt (range)
TREMATODA																
*Lobatostomakermostoma*MacCallum &MacCallum, 1913	i													1 (5.3)	7 (0.0007)	7 ± - (7)
Lobatostomaringens(Linton, 1907)	i													10 (52.6)	75 (0.0074)	7.5 ± 10.4 (1-36)
Manteriabrachydera (Manter, 1940)	i										18 (75)	198 (0.51)	11 ± 16.3 (1-63)			
Stephanostomumditrematis(Yamaguti, 1939)*	i	12 (23.5)	64 (0.057)	5.3 ± 5.25 (1-17)	2 (8.7)	12 (0.007)	6 ± 5.7 (2-10)									
*Stephanustomumghanensis*Fischthal & Thomas, 1968														8 (42.1)	74 (0.0073)	9.3 ± 13.9 (1-35)
*Stephanostomum megacephalum*Manter, 1940*	i	6 (11.8)	28 (0.025)	4.7 ± 4.8 (1-13)	3 (13.4)	17 (0.01)	5.6 ± 8.1 (1-15)							3** (15.8)	28 (0.0028)	9.3 ± 13.6 (1-25)
Ectenurosyamaguti Nahhas& Powell, 1971*	i	3 (5.8)	10 (0.009)	3.3 ± 3.2 (1-7)												
*Bucephalus margaritae*Ozaki & Ishibashi, 1934*	i, ic	14 (27.5)	72 (0.064)	5.1 ± 4.5 (1-14)	14 (61)	709 (0.44)	50.6 ± 97 (1-282)	5 (17.8)	13 (0.029)	2.6 ± 2 (1-6)						
Tergestiapectinata(Linton, 1905)*	i	5 (9.8)	10 (0.009)	2 ± 1.2 (1-4)	3 (13.04)	9 (0.006)	3 ± 3.5 (1-7)				3 (12.5)	4 (0.01)	1.3 ± 0.6 (1-2)			
*Huerleytremacatarinensis*Amato, 1982*	i, ic													14 (73.7)	7033 (0.69)	502 ± 1023 (1-3931)
*Opechonachloroscombri*Nahhas& Cable, 1964*	i							10 (35.7)	36 (0.079)	3.6 ± 3.4 (1-13)						
*Huerleytremasp.**	i													5 (26.3)	1020 (0.1)	204 ± 389 (2-899)
Neolepidapedonsp.	i							1** (3.6)	1 (0.002)	1 ± - (1)						
Stephanostomumsp.	i	3 (5.9)	11 (0.01)	3.7 ± 0.6 (3-4)										4 (21)	13 (0.0013)	3.2 ± 3.3 (1-8)
Gonocercellasp.	i													2 (10.5)	2 (0.0002)	1 ± 0 (1-1)
*Gonocercasp.**	g	2** (3.9)	2 (0.002)	1 ± 0 (1-1)	3** (13.04)	4 (0.002)	1.3 ± 0.6 (1-2)	1** (3.6)	1 (0.002)	1 ± - (1)	1** (4.1)	1 (0.003)	1 ± - (1)			
*Macrorchytremasp.**	i													1 (5.3)	1 (0.0001)	1 ± - (1)
Didymozoidae[(mt)]*	s	16** (31.4)	83 (0.074)	5.21 ± 0 (1-1)												

MONOGENEA																
Hargicolaoligoplites (Hargis, 1957)	g										14 (58.3)	70 (0.18)	5 ± 4.8 (1-15)			
Allopyragraphorus hippos (Hargis, 1956)	g	3 (13.04)	95 (0.059)	31.7 ± 13 (29-46)												
Amphipolycotyle chloroscombrus Hargis, 1957	g							23 (82.1)	112 (0.246)	4.8 ± 2.3 (2-10)						
Table 2 (Cont.)																
Cemocotylecarangis(MacCallum, 1913)	g	27 (52.9)	414 (0.367)	15 ± 13.2 (1-45)	9** (39.1)	58 (0.036)	6.4 ± 8.9 (1-28)									
Cemocotylenovebo racensis(MacCallum, 1919)	g	3 (5.9)	11 (0.01)	3.7 ± 1.5 (2-5)	3 (13.04)	3 (0.002)	1 ± 0 (1-1)									
Cemocotylellaelongata(Meserve, 1938)	g				1 (4.4)	2 (0.01)	2 ± - (2)									
Probursataveraecrucis Bravo-Hollis, 1983	g										16 (66.6)	49 (0.126)	3 ± 1.8 (1-6)			
Pseudobicotylophora atlantica Amato, 1994	g													17 (89.5)	680 (0.068)	40 ± 54.7 (2-207)
Protomicrocotyle mirabilis (MacCallum, 1918)	g	15 (29.4)	4 5 (0.04)	3 ± 4.1 (1-15)	6 (26.1)	187 (0.015)	31.2 ± 40 (1-108)									
Pseudomazocraes selene Hargis, 1957	g	6 (11.8)	10 (0.009)	1.7 ± 0.8 (1-3)	10 47.8)	371 (0.229)	33.7 ± 89 (1-301)	2 (7.1)	2 (0.004)	1 ± 0 (1-1)						
Pyragraphoruspyragraphorus(MacCallum&MacCallum, 1913)	g													2 (10.6)	2 (0.0002)	1 ± 0 (1-1)
*Engraulicola*sp.	g							13 (46.4)	17 (0.037)	1.3 ± 0.7 (1-3)						
CESTODA																
*Dasyrhynchusgiganteus*Diesing, 1850(l)*	h				3 (13.04)	30 (0.019)	10 ± 9.6 (3-21)									
*Callitetrarhynchus*sp. (l)*	i, m	18 (35.3)	40 (0.035)	2.2 ± 1.7 (1-6)	6 (26.1)	22 (0.014)	3.7 ± 3.6 (1-10)	12 (42.8)	81 (0.178)	6.7 ± 5.6 (1-22)						
*Nybelinia*sp. (l)*	i	7** (13.7)	11 (0.01)	1.6 ± 0.5 (1-2)										3 (15.8)	34 (0.003)	11.3 ± 9.1 (1-18)
Scolexpolymorphus(l)* Muller, 1788	i	5 (9.8)	200 (0.177)	40 ± 86.6 (1-195)	6 (26.1)	22 (0.014)	5.5 ± 4.8 (1-11)	3** (10.7)	24 (0.053)	8 ± 10 (1-20)				1** (5.3)	10 (0.001)	10 ± - (10)
NEMATODA																
*Anisakis*sp. (l)	i	10 (19.6)	51 (0.045)	5.1 ± 6.3 (1-20)										1** (5.3)	1 (0.0001)	1 ± - (1)
Contracaecum sp. (l)	i, ic													4** (21)	1156 (0.113)	289 ± 564 (1-1135)

*Hysterothylaciumfortalezae*Deardoff& Overstreet, 1980*	i	5** (9.8)	6 (0.005)	1.2 ± 0.4 (1-2)	2** (8.7)	9 (0.006)	4.5 ± 2.1 (2-6)	11** (39.3)	56 (0.126)	5 ± 7.3 (1-7)	1 (4.1)	3 (0.008)	3 ± - (3)			
*Hysterothylaciumreliquens*Norris & Overstreet, 1975	i							9** (32.1)	89 (0.196)	9.8 ± 9.8 (1-26)						
Hysterothylacium sp. [I]	i, ic, m	11** (21.6)	27 (0.024)	2.5 ± 1.9 (1-7)	6** (26.1)	12 (0.007)	2 ± 1.3 (1-4)	8** (28.6)	23 (0.051)	2.8 ± 1.9 (1-7)	12** (50)	63 (0.162)	5.2 ± 9.6 (1-35)	4 (21)	30 (0.003)	7.5 ± 6.9 (1-14)
Cucullanuscarangis(MacCallum, 1921)*	i	11** (21.6)	22 (0.02)	2 ± 1.2 (1-5)	3** (13.04)	4 (0.002)	1.3 ± 0.6 (1-2)									
*Cucullanustrachinoti*Pette &Sey, 1997*	i													4 (21)	14 (0.0014)	3.5 ± 2.9 (1-6)
*Caranginemaamericanum*Moravec, Montoya-Mendoza & Salgado-Maldonado, 2008	us				3 (13.04)	54 (0.033)	18 ± 8.2 (11-27)									
Capillaridae	bv	5** (9.8)	9 (0.008)	1.8 ± 1.1 (1-3)												
ACANTOCEPHALA																
Gorgorhynchoides sp. [I]	m	1 (1.9)	1 (0.001)	1 ± - (1)										2 (10.6)	4 (0.0004)	2 ± 1.4 (1-3)

d) Distribution of abundance

Distribution of abundances of helminth parasites in component communities was analyzed with rank-abundance curves and plotted graphs of the share of individuals of each species of parasite on the total of helminths collected for every community (see Figure 1), and data were adjusted to predictive distribution log-normal for*C. hippos* and *T. carolinus*, and broken-stick to *C. crysos*, *C. chrysurus* and *O. saurus*.

In all communities, some parasiteswere more abundantly recorded, but these species were dominant only in a particular host community. The three most abundant species were *H. catarinensis* (*pi* = 0.69) for *T. carolinus*, *M. brachydera* (*pi* = 0.51) for *O. saurus* and *B. margaritae* (*pi* = 0.44) for *C. hippos* (Table 2, Fig. 1). Most abundant species did not exceeded the others, therefore, dominance of these species had no effect on the type of distribution of abundance, because the different communities adapted to the log-normal and broken-stick model, showing that in all community components they have a high proportion of species of median and low abundance, conditions that have effects on the richness of community components.

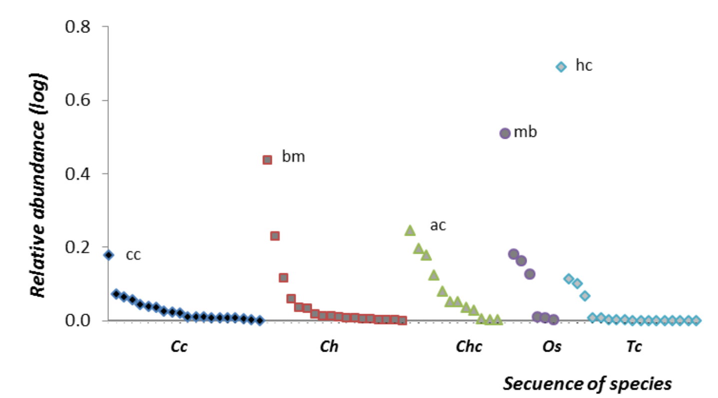

Fig. 1: Dominance-species plot of component communities of five species of Carangids from Alvarado, Veracruz, Mexico. Host: Cc, C.crysos; Ch, C. hippos. Chc, C. hrysurus; Os, O.saurus; Tc, T. carolinus; Parasites: cc, C.carangis; bm, B.margaritae; ac, A.chloroscombrus; mb, M.brachydera; hc, H. catarinensis

e) Component communities and infracommunities

In the component communities, 388 to 10,184 individual helminths and 7 to 23 parasite species (*S*) were collected. The Shannon diversity index (*H*') was of 0.07-2.19, and the Berger-Parker dominance index (I_{B-P}) was of 0.24-0.69 (see Table 4).

The infra-communities richness ranged from 1 to 12 species of helminths per fish. Out of all hosts,only sevenhad no parasites, and all others had from one to 12 species but most often one, two or three species of parasites were found (Table 5).The most frequent co-occurrences between two species of parasites were,*Cucullanuscarangis* and *Anisakis*sp., in *C. crysos* (7/51hosts);*Cemocotylecarangis* and *Pseudomazocraesselene* in *C. hippos* (6/23 hosts); *Amphipolycotylechloroscombrus* and *Engraulicola*sp., in *C. chrysurus* (13/28 hosts); *Hargicolaoligoplites* and *Probursataveraecrucisin* *O. saurus*(11/24 hosts); *Huerleytremashorti* and *Lobatostomaringens* in *T. carolinus* (8/19 hosts).The average number of parasites species per individual host was 2.7±1.5 to 4.5±2.1, while the average number of helminth individuals per host was 16.2 ±19.4 to 536±1106. The value of the Brillouin's index for each infracommunity ranged from 0.1-1.54to 0.54-1.73 with average values of 0.66±0.44 to 1.03±0.32, for indexes such as evenness and dominance see Table 6.

Table 4: Descriptive parameters of component communities of five carangid species from Alvarado, Veracruz, Mexico.#th, no total helminth; S, richness; H´, Shannon diversity index; J´, Equitativity index; I_{B-P}, Berger-Parker dominance index; spd, specie dominante. cc, C. carangis; bm, B. margaritae; ac, A. chloroscombrus; hc, H. catarinensis.

Host	*n*	*#th*	*S*	*H´*	*J´*	I_{B-P}	*spd*
C. crysos	51	1126	21	2.19	0.71	0.36	cc
C. hippos	23	1620	18	1.76	0.61	0.43	bm
C. chrysurus	28	455	12	2.01	0.8	0.24	ac
O. saurus	24	388	7	1.31	0.67	0.5	mb
T. carolinus	19	10184	18	1.07	0.37	0.69	hc

Table 5: Frequency of parasites species per host in five species of carangids from Alvarado, Veracruz, Mexico.

Host	Number of parasite species per host												
	0	1	2	3	4	5	6	7	8	9	10	11	12
C. crysos	3	10	10	9	2	5	3	1	4	2	2		
C. hippos	2	2	5	5	2	3	1		1	1			1
C. chrysurus	2	2	5	5	2	3	1		1	1			
O. saurus		8	4	2	7	3							
T. carolinus		2	1	3	3	5	1	3		1			

Table 6: Infracommunities of five species of carangids from Alvarado, Veracruz, Mexico. Data include.S, Richness helminth species; $\bar{x}$S, average helminth species; $\bar{x}$n, average number of helminth; $\bar{x}$H, average Brillouin index; $\bar{x}$J´, average evenness index; $\bar{x}J_{B-P}$, average Berger-Parker index.

	C. crysos	*C. hippos*	*C. chrysurus*	*O. saurus*	*T. carolinus*
S	21	18	12	7	19
$\bar{x}S \pm ES$	3.8±2.7	4.1±2.8	3.6±1.5	2.7±1.5	4.5±2.1
Range	1-10	1-12	1-7	1-5	1-9
n	1127	1620	455	388	10184
$\bar{x}n \pm ES$	23.5±35.5	77.1±158	17±13	16.2±19.4	536±1106
Range	1-224	1-640	2-54	1-84	10-4883
$\bar{x}H \pm ES$	1.01±0.44	0.85±0.4	1.03±0.32	0.86±0.32	0.66±0.44
Range	0.27-2.1	0.1-1.54	0.54-1.73	0.28-1	0.14-1.41
$\bar{x}J' \pm ES$	0.75±0.2	0.67±0.25	0.83±0.1	0.7±0.2	0.43±0.27
Range	0.27-1	0.1-1	0.63-1	0.29-1	0.11-0.88
$\bar{x}J_{B-P} \pm ES$	0.7 ± 0.2	0.67 ± 0.2	0.6 ± 0.2	0.8 ± 0.2	0.7 ± 0.2
Range	0.2-1	0.3-1	0.2-1	0.3-1	0.3-1

f) Similarity among component communities

Among component communities, the highest similarity record was for communities of *C. crysos* and *C. hippos*, a rate near 60% (I_J = 0.56).Among community components, the highest similarity was observed for communities of *C. crysos* and *C. hippos*, with an index near to 60% (I_J = 0.56), because they have 14 species of parasites in common, but for other communities this value was below 25% (see Figure 2),where they only have some larvae of parasites roundworms and tapeworms in common (see Table 2).

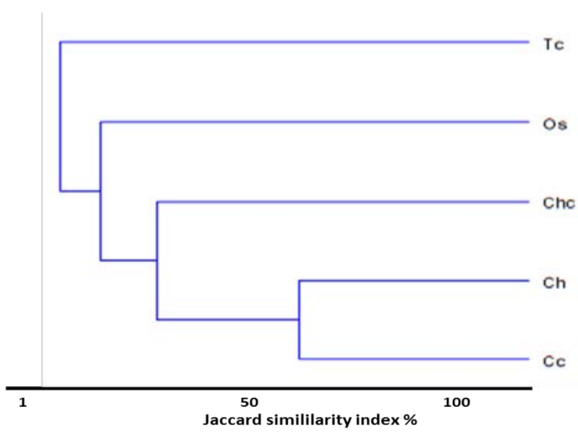

Fig. 2: Cluster of similarity of taxonomic composition of component communities of five species of carangids from Veracruz. Data include. Host: Cc, C. crysos; Ch, C. hippos. Chc, C. hrysurus; Os, O.saurus; Tc, T. carolinus

IV. Discussion and Conclusions

Parasite helminths of Carangidae fish have been widely studied in the Gulf of Mexico and the Caribbean Sea (Nahhas & Powell 1971; Hendrix 1994; Pérez-Ponce de León et al. 2007; Overstreet et al. 2009), with registers for all five helminth groups. However, this study adds new host and location records (Table 2). Groups with the highest number of species were trematodes and nematodes in four host species, excepting *C. hippos* that included monogeneans. As related to the range of species per helminth group, these results are similar to records in other carangids in Mexico (Sánchez-Ramírez & Vidal-Martínez 2002;

Aguirre-Macedo et al. 2007) and Brazil(Takemoto et al. 1995; 1996; Luque & Alves 2001). It has been stated, generalizing, that trematodes and nematodes are the most numerous species in marine fish (Rohde & Heap 1998; Zander et al. 1999), including those from tropical (Moravec et al. 1997; Sabas & Luque, 2003; Luque & Poulin, 2007), and temperate latitudes (Campos & Carbonell 1994; Zander et al. 1999; Madhavi & Sai Ram, 2000). This condition was also observed in hosts included in this study.

On the other hand, records of cestodes, nematodes and some digeneans larvae suggest the importance of carangids as intermediate hosts of these parasites, highlighting their relevance in the food chain of studied hosts that can be infected by parasites, including ichthyophagousfish, birds or mammals, which participate as final hosts (Chaves & Luque 1999; Luque& Alves 2001; Sánchez-Ramírez & Vidal-Martínez 2002), i. e., sharks, completing life-cycles e.g., *Callitetrarhynchus* sp., *Contracaecum* sp., and *Dasyrhynchus* sp., strengthening the relevance of carangids in the transmission mechanisms of these helminths (Overstreet, 1978; Deardoff & Overstreet 1981; Sánchez-Ramírez and Vidal-Martínez 2002; Aguirre-Macedo et al. 2007).

As related to the correlation among the parasites size, richness and abundance, it is generally considered that larger hosts have higher richness and abundance (Kennedy et al. 1986; Holmes 1990; Bush et al. 1990), as we found in larger hosts, such as *C. crysos* and *C. hippos*, associated to a higher possibility of infection, higher vagility and contact with intermediate infected hosts (Poulin et al. 2003; Poulin & Mouillot 2003), enhancing the parasites' life-cycle(Luque 6 Poulin, 2008; Muñoz et al. 2006).

As related to the abundance distribution types, log-normal and broken-stick models were adjusted, frequent distribution types for helminth communities parasitizing marine fish(Poulin & Justice, 2008), with parasite species with relative abundances from low to medium, without significant dominance. It was observed, in both distribution types, that parasites with the highest abundance never exceeded one half of the total abundance (relative abundance < 0.5), excepting *H. catarinensis,* with prevalence of 70% and abundance of 7033 worms in the *T. carolinus* community. The similitude analysis revealed that carangids have and share typical helminth fauna, as the highest similitude was observed among sympatric species living in this area, such as *C. crysos* and *C. hippos*, as described for lutjanids in the same zone(Montoya-Mendoza et al. 2014; 2016).

Finally, it has to be noted that parasitic relations of hosts in wild populations, with biological, commercial and food relevance, and high farming potential, as those of carangids (Hutson et al. 2007), pose no zootic risk, excepting *Anisakis* larvae, and that richness and diversity found for parasite helminth community components and infracommunities in hosts studied, are similar to those reported for carangids on the West Atlantic coast, such as *T. carolinus* (S =18, $\overline{X}S = 6 \pm 2$, $\overline{X}H = 0.33 \pm 0.28$) (Sánchez-Ramírez & Vidal-Martínez 2002); *C. hippos* (S =16, $\overline{X}S = 3 \pm 2$, $\overline{X}H = 0.55 \pm 0.4$) and *C. latus* ($S$ =14, $\overline{X}S = 2.9 \pm 1.6$, $\overline{X}H = 0.6 \pm 0.35$) (Luque & Alves 2001); *O. palometa* (S =13, $\overline{X}H' = 0.79 \pm 0.38$), *O. saurus* ($S$ =11 $\overline{X}H' = 0.9 \pm 0.38$) and *O. saliens* ($S$ =9 $\overline{X}H' = 0.81 \pm 0.42$) (Takemoto et al. 1996); *Selene setapinnis* (S =18, $\overline{X}S = 3.2 \pm 2.2$, $\overline{X}H = 0.32 \pm 0.15$) (Cordeiro & Luque 2004), including that parasite communities in five carangids are as rich and diverse as those of marine hosts in temperate (Châari et al. 2015) and tropical zones (Luque & Poulin 2007; Madhavi & Triveni Lakshmi, 2012).

V. Acknowledgments

This research forms part of the Ph.D. dissertation of Jesús Montoya Mendoza, who received scholarship No. 188620 from the CONACyT. Thanks to the Postgraduate Scholarships Program, DGEP, and the Postgraduate in Biological Sciences of the National Autonomous University of Mexico. Our deep gratitude to Carlos Mendoza Palmero, Mirza P. Ortega Olivares and María Guadalupe Lara Figueroa, for their fieldwork support.

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