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DOI 10.2478/helm-2022-0003

HELMINTHOLOGIA, 59, 1: 94 – 103, 2022

Parasite community analysis of the gray snapper *Lutjanus griseus* (Perciformes, Lutjanidae) in a tropical region of the Southern Gulf of Mexico

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Article info

Received October 13, 2020
Accepted December 9, 2021

Summary

The gray snapper *Lutjanus griseus* is a commercially important fish species along its distribution range in the western Atlantic Ocean. However, despite its importance, there is still little knowledge about its parasitic fauna for the Mexican coasts of the Gulf of Mexico. The aims of this research were to generate a list of the parasitic fauna present in juvenile gray snapper *L. griseus* from a coastal lagoon located in southeastern Mexico, to evaluate the infection levels of parasites and to determine the relationship between the abundance of parasites and the fish size and condition factor. Samples of *L. griseus* (12 – 29.2 mm) were obtained in two periods of the year (dry and rainy seasons) to examine the intra-annual variability of its parasitic fauna. A total of 17 parasite species were recorded belonging to six taxonomic groups (Myxozoa, Monogenea, Digenea, Cestoda, Nematoda and Acanthocephala). The highest levels of infection (abundance, prevalence and intensity of infection) were found for the monogeneans *Euryhaliotrema griseus* and *Euryhaliotrema fastigatum*. There were no significant correlations between the total abundance of parasites and the fish condition and size (total length) in not any of the two seasons studied, suggesting that the body size and the biological condition index of the host did not directly influence the abundance of parasites in early life stages of *L. griseus*. Moreover, the species of parasites found that could be zoonotic for humans through the consumption of raw or inadequately cooked fish were the nematodes *Contracaecum* sp. type 1, *Contracaecum* sp. type 2, *Cucullanus pargi* and *Pseudoterranova* sp. The presence of the monogeneans *E. griseus* and *E. fastigatum* was also highlighted because these ectoparasite species are known to cause harm to fish under culture systems. All the parasite species found in this study, except nematodes, were new records of geographic distribution.

Keywords: coastal lagoon; intra annual variability; *Lutjanus griseus*; parasites; southeast of Mexico

Introduction

Parasites can play a fundamental role in the life of fish, as they can alter their biological effectiveness, affect their behavior, growth, fecundity, migratory patterns, and mortality (Barber & Poulin, 2002; Marcogliese 2004; Luque & Poulin 2007; Raissy & Ansari, 2012).

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In the case of the snappers (Family Lutjanidae), this fish group is commonly associated with the seabed where feed mainly on benthic organisms such as nocturnal fish, crustaceans (crabs, shrimp, stomatopods), molluscs (gastropods and cephalopods) and plankton from shallow waters to bottoms located between 400 and 500 m deep (Anderson, 2002; Brulé, 2004; Guevara *et al.*, 2007). These organisms on which they feed can include intermediate hosts of helminths, which in addition to infecting the snapper, can cause negative impacts on their commercialization, on the farming of the species and generate public health problems (e.g., in the case of have nematode species that cause anisakiasis or gnathostomiasis) (Emmel *et al*., 2006; Shamsi *et al*., 2013; Alda *et al*., 2015; Mattiucci *et al*., 2017; Drietrich *et al*., 2018; Ikuno *et al*., 2018; Yuan *et al*., 2018; Juárez-Camargo *et al*., 2020).

In the case of the commercially important snapper species on the coasts of the Mexican Atlantic (Gulf of Mexico and Caribbean), there is relatively little knowledge about their parasitic fauna (González-Solís *et al*., 2002; González-Solís *et al*., 2007a, b; Argáez-García *et al*., 2010; Montoya-Mendoza *et al*., 2014; Mendoza-Franco *et al*., 2018). This may be because marine fish from this region (southeast of Mexico) have been relatively less studied (from a parasitological point of view) than freshwater fish (Salgado-Maldonado, 2006).

The gray snapper, *Lutjanus griseus* (Linnaeus, 1758), is a commercial important fish that distributes from Massachusetts USA to Brazil, including the Gulf of Mexico and Caribbean, and characterize by feeds on fish and large invertebrates (Guevara *et al.,* 2007; Juárez-Camargo *et al*. 2020), which, as mentioned above,

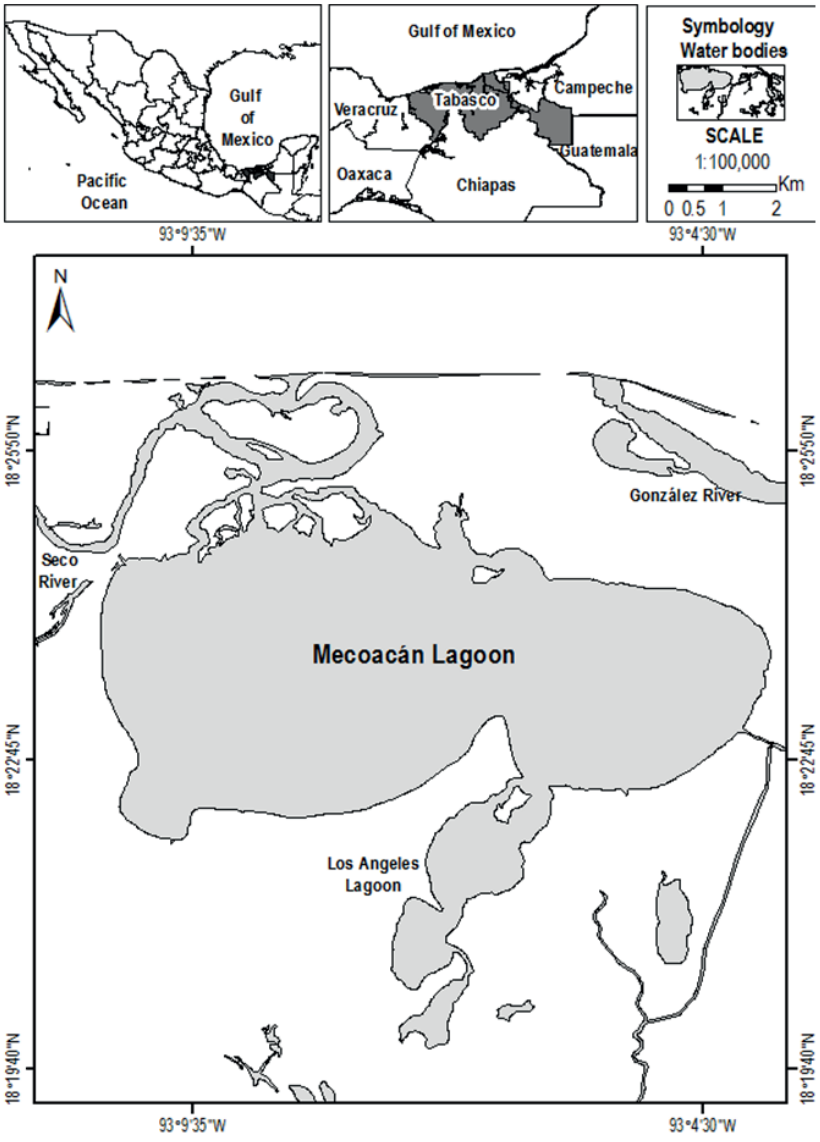

Fig. 1. Location of the study. The Mecoacán Lagoon system is located in Tabasco, southeastern Mexico.

are possible intermediate hosts and / or vectors of parasitic helminths and crustaceans. However, despite the high commercial value of this fish in the Mexican coasts and that has been considerate a good candidate for aquaculture in this region (Riley *et al*., 2008), there are still few parasitological studies on this species (e.g., Salgado-Maldonado, 1979; Lamothe-Argumedo *et al*., 1997; Argáez-García *et al*., 2010). Therefore, knowing the diversity of species of parasites that infect this fish species as well as their prevalence and intensities is relevant, since these organisms can negatively affect the host populations. For example, recent helminthological examinations of specimens of the grey snapper in the northern Gulf of Mexico (Florida, USA) described a myxozoan infection causing high mortalities in juvenile of this fish species, which was associated with increases in seawater temperature (Holzer *et al.,* 2013).

In the Mecoacán lagoon system in the southern Gulf of Mexico (Tabasco, Mexico) the gray snapper *L. griseus* is a highly consumed fish notable for its size and abundant catch by artisanal fishing throughout the year (Hernández-Ojendi *et al*., 2020). However, for this region there are no parasitological records on this fish species. Therefore, the aims of this research were: (1) to generate a taxonomic list of the parasitic fauna present in *L. griseus* in the Mecoacán lagoon system, (2) to evaluate infection levels (prevalence, intensity and abundance) for each parasite species found, (3) to determine the relationship between the fish size and condition factor with the abundance of parasites in two periods of the year and (4) to determine whether any of the parasite species found can be pathogenic for human or cause negative effects to aquaculture rearing systems.

Materials and Methods

The Mecoacán lagoon system is in the Tabasco state in southeastern Mexico (between 18° 16' N and 18° 26' N - 93° 04' W and 93° 14' W) (Fig. 1). Through commercial catches the specimens were collected in two seasons of the year (dry and rain seasons). Thirty fish were collected for each season. The fish were kept in coolers with ice and transported to the Laboratory which conducted a parasitological examination. For each fish general measurements were taken; total length (cm) and weight (g). Examination of eyes, fins, skin, gill cavity and internal organs; intestinal caeca and coelomic cavity, stomach wall, stomach, intestine, spleen, gall bladder, liver, kidneys and heart were carefully examined for ectoparasites and endoparasites under a stereoscopic microscope (LEICA-DMBL 10), and all parasites were removed. Monogeneans and digeneans were fixed in AFA (acetic acid-formaldehyde-alcohol) solution for 24 h, then preserved in ethylic alcohol (70 %), and stained with Gomori's trichromic stain (Lamothe-Argumedo, 1997; Eiras *et al.,* 2003; Guzman-Cornejo *et al*., 2012). Nematodes were fixed in Berland's liquid, preserved in ethylic alcohol (70 %), cleared with a solution of phenol-ethanol (Lent's solution), and mounted on slides covered with glycerin-gelatin (Moravec, 1992). For the generic and specific description of the parasites, the keys proposed by the following authors were used (Amin, 1985; Anderson *et al*., 1974 – 1983; Blend & Dronen, 1997; Gibson, 2002; Fuentes *et al.,* 2003; Gibbons, 2010; Kritsky, 2012; Al-Zubaidy & Mhaisen, 2012). The parasitological material was deposited in the Helminthological Collection in the Academic Division of Biological Sciences of the Universidad Juárez Autónoma de Tabasco (Mexico). Species richness, prevalence (%), abundance (parasite

Table 1. Parasite species found in *Lutjanus griseus* (n = 60).
Parasites Species, Organ preference, Location in the body of the host: GC- gill cavity, IC- intestinal cecum, Me- mesentery, CC- coelomic cavity, Stw- stomach wall, S- stomach, I- intestine, L- liver. Levels of infection in prevalence (%P), mean abundance (MA) (± standard deviation), intensity (M) in dry and rain seasons.

		Dry season			Wet season		
	Site of Infection	I	%P	MA	I	%P	MA
Myxozoo sp.	I, R	0	0	0	17	33.33	5.7 ± 3.4
Euryhaliotrema griseus	S, GC, D, R	10.65	96.66	10.3 ± 2.1	15.46	100	15.46 ± 1.2
Euryhaliotrema fastigatum	S, CG, R	7.21	93.33	6.73 ± 1.6	19.63	100	19.63 ± 1.9
Helicometra sp.	I, D	1.16	20	0.23 ± 0.09	1	3.33	0.033 ± 0.33
Siphodera vinaledwardsii	IC, D, R	1	3.33	0.03 ± 0.03	0	0	0
Pseudophyllidea gen. sp.	IC, D	3	3.33	0.1 ± 0.07	0	0	0
Tetraphyllidea gen. sp.	IC, D	10	3.33	0.33 ± 0.33	0	0	0
Contracaecum sp. type 1*	I, Me, CC, D, R	1	3.33	0.03 ± 0.18	0.2	16.66	0.03 ± 0.18
Contracaecum sp. type 2*	I, Me, CC D, R	3	3.33	0.1 ± 0.1	3	23.33	0.7 ± 0.3
Cucullanus pargi .*	I, Me, CC D, R	1.5	6.66	0.1 ± 0.74	1	3.33	0.03 ± 0.18
Pseudoterranova sp.*	Me, R	0	0	0	1	3.33	0.03 ± 0.18
Rhadinorhynchus sp.	M, D	1	3.33	0.03 ± 0.03	0	0	0
Gorgorhynchoides sp.	Me, S, D	1	3.33	0.03 ± 0.18	1	3.33	0.1 ± 0.5
Cysthacanth sp.1	I, Me, CC D, R	1	3.33	0.03 ± 0.03	0	0	0
Cysthacanth sp. 2	I, Me, CC D, R	1	3.33	0.03 ± 0.033	0	0	0
Gorgorhynchus sp.	L y Me, Stw, R	1.16	20	0.23 ± 0.093	1	6.66	0.01 ± 0.25
Neoechinorhynchus sp.	L y Me, Stw	0	0	0	4.28	23.33	1 ± 2.6

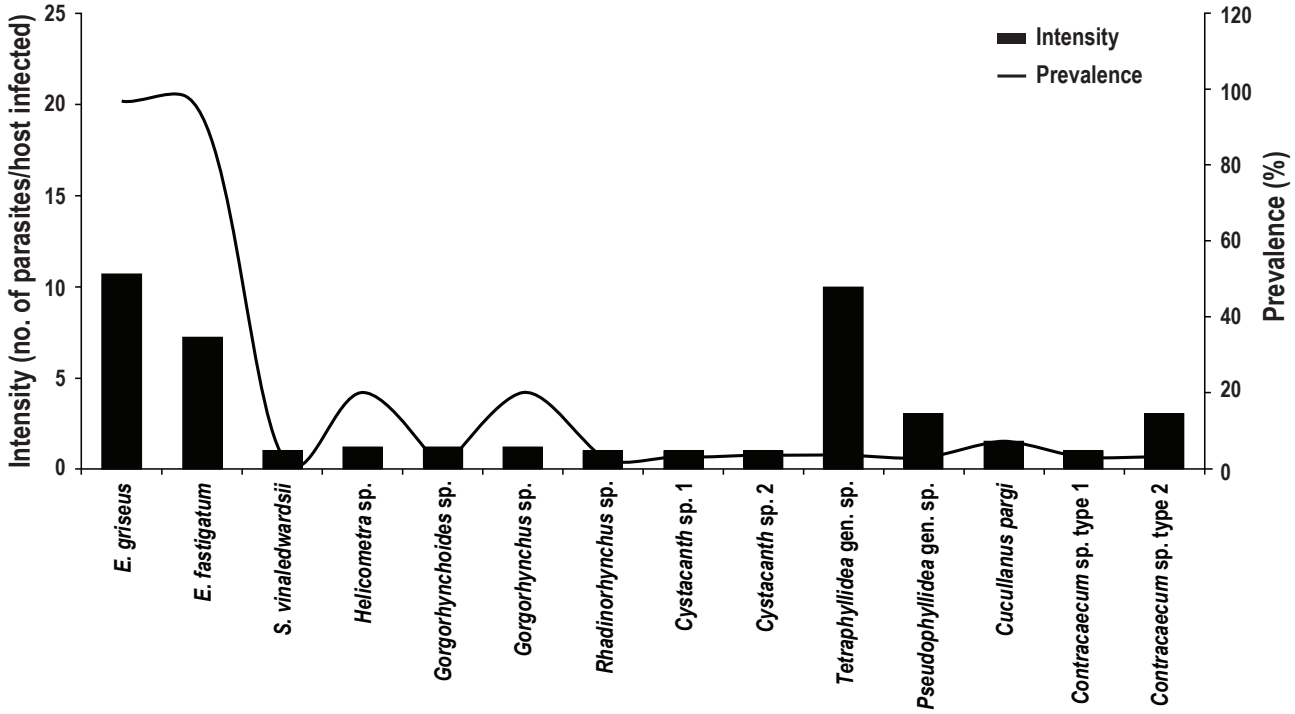

Fig. 2. Intensity (no. of parasites/host infected) and prevalence (%) of parasite species of gray snapper *Lutjanus griseus* in the dry season in the Mecoacán Lagoon system, Tabasco. Number of hosts (n = 30).

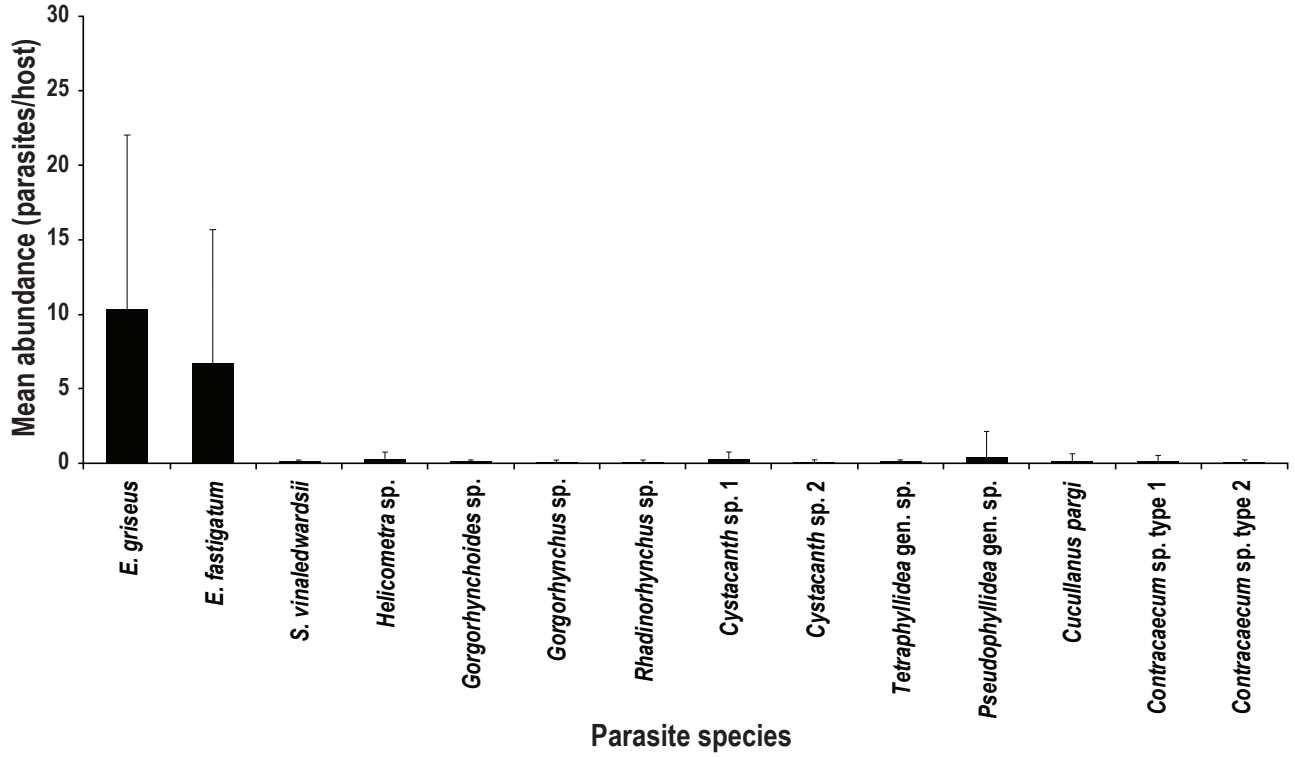

Fig. 3. Mean abundance (individuals per host ± standard deviation) of parasite species of gray snapper *Lutjanus griseus* in the dry season in the Mecoacán Lagoon system, Tabasco. Number of hosts (n = 30).

number / host), and intensity (parasite number / infected hosts) of parasites were determined according to Bush *et al*. (1997). The status of parasite species as core, secondary, satellite or rare species, was described by abundance: > 2 individuals / host = core species; 0.6 – 2 = secondary species; 0.2 – 0.6 = satellite species; < 0.2 = rare species (Zander *et al*., 2000; Zander, 2003).

For the seasons sampled (dry and rainy seasons) a Spearman correlation analysis was made between the total length of the fish and the abundance of parasites, and for the condition of the fish and the abundance of parasites. The condition of the fish was determined by means of the Fulton Condition Factor Index (Fulton, 2002).

Ethical Approval and/or Informed Consent

For this study formal consent is not required

Results

Species composition and organ specificity on *Lutjanus griseus*

A total of 60 specimens of *L. griseus* were examined, for the dry season, 30 fish were examined (TL sizes 12 – 29.2 mm, weight 201.9 – 356 g) and in the rain season, 30 other fish were examined (TL sizes 23.5 – 28 mm, weight 201.9 – 356 g). A total number of 1,831 parasites, belonging to 17 species were identified (Table 1). The digestive tract was the most infested organ with 15 species (Table 1).

The species of monogenean *Euryhaliotrema fastigatum* (Zhukov, 1976) Kritsky & Boeger, 2002 and *Euryhaliotrema griseus* Fuentes-Zambrano & Silva Rojas, 2006 showed the highest prevalence (dry season = 96.66 % and 93.33 %, respectively and 100 % during the rainy season in both cases). The species *Cucullanus pargi* González-Solís, Tuz-Paredes and Quintal-Loria (6 %) and *Siphodera vinaledwardsii* Linton (1901), *Pseudophyllidea* (Cestoda), *Tetraphyllidea* (Cestoda), *Contracaecum* sp. type 1, *Contracaecum* sp. type 2, *Rhadinorhynchus* sp., *Gorgorhynchoides* sp., *Cystocanth* sp. 1, *Cystocanth* sp. 2 had the lowest prevalences (<10 %) (Table 1).

The greatest infections were for the monogeneans for the two climatic seasons, followed by the acanthocephala and nematodes but only for the rainy season. Table 1 shows the levels of infection for each of the parasite species, for the dry and rain seasons. The monogenean species *E. fastigatum* and *E. griseus* had the highest abundances (Figs. 2 and 3), prevalences and intensities (Figs. 4 and 5) for both the dry season and the rainy season and were considered as core species. Likewise, based on the abundance data, the species *Contracaecum* sp. type 2 and *Neoechinorhynchus* sp. were considered as secondary species, *Helicometra* sp., Tetraphyllidea and *Gorgorhynchus* sp. as satellite species and the rest of them as rare species. Satellite species are found in few infracommunities and with low abundances. Bush and Holmes (1986a) called "secondary species" those species with intermediate characteristics in the community

The average condition factor of *L. griseus* was 1.34 for the dry season and 1.55 for the rainy season. The average size of specimens in the dry season was 19.29 mm and 25.62 mm in the rainy season. There were no significant correlations between the total abundance of parasites and the fish condition and size (total length) in not any of the two seasons studied. In all cases, the resulting value was $p > 0.5$.

As for the number of species and parasites per season (Table 2), we found an average for the dry season of 2.7 ± 1.23 species/host with an average of 18.33 ± 16.53 parasites/host. For the rainy season an average of 3.16 ± 0.74 species/host examined was recorded with an average of 42.7 ± 23.47 parasites/host. For the rainy season it increases the average number of parasites and species per host.

Table 3 shows the parameters of the *L. griseus* parasite communities in the component community. There was a greater number of individuals of parasites in the rainy season than in the dry season, with a greater species richness in the dry season. Also, the diversity of species tended to be greater during the rainy season, however, it was not statistically different from that recorded in the dry season. The dominant species for the dry season was *E. griseus* and for the rainy season was *E. fastigatum*.

Moreover, some parasite species registered in this study may

Table 2. Characterization of the *Lutjanus griseus* parasite structure in the Mecoacán Lagoon system for the rainy and dry season.

	Dry season	Wet season
Examined hosts	n=30	n=30
Average number of species ± SD	2.7 ± 1.23	3.16 ± 0.74
Average number of parasites ± SD	18.33 ± 16.53	42.7 ± 23.47
Range	2 – 61	13 – 139
Average Simpson's Index (1/D) ± SD	0.47 ± 0.21	0.54 ± 0.065
Range	0 – 0.84	0.41 – 69
Average Brillouin's Index ± SD	0.53 ± 0.27	0.74 ± 0.142
Range	0 – 1.14	0.57 – 1.21

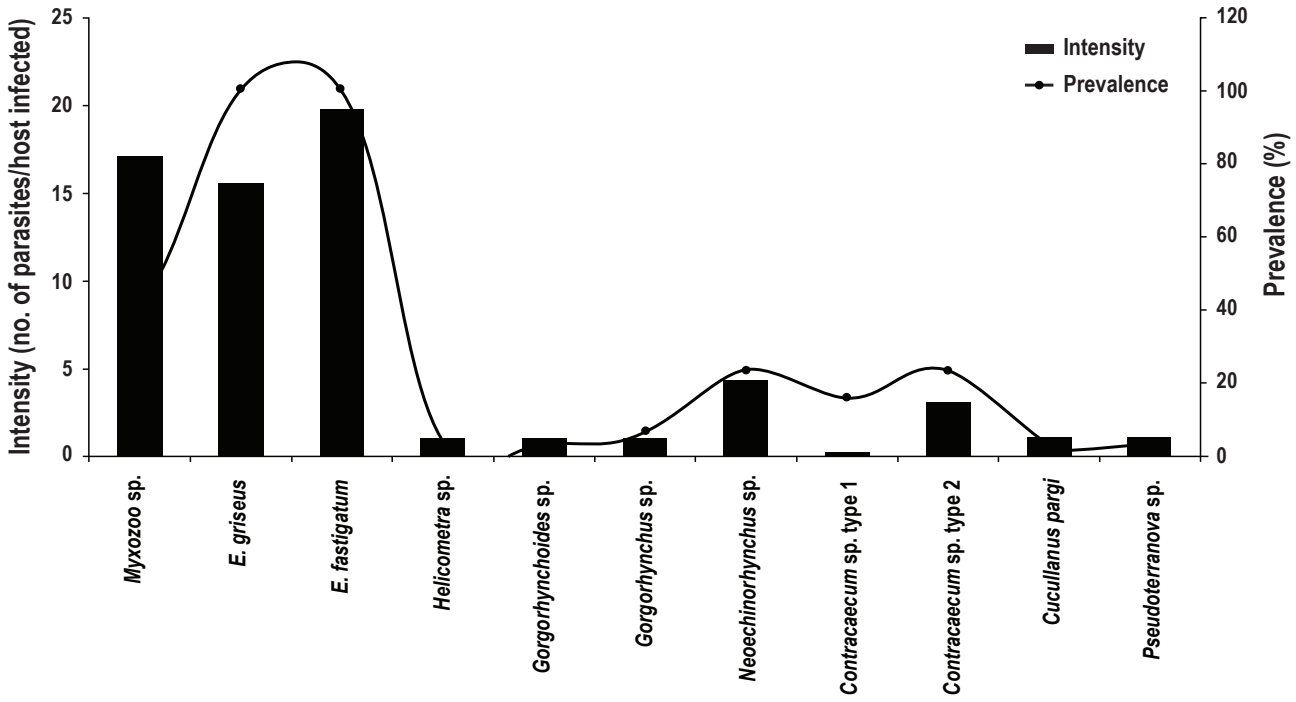

Fig. 4. Intensity (number of parasites / infected host) and prevalence (%) of parasite species of gray snapper *Lutjanus griseus* in the rainy season in the Mecoacán Lagoon system, Tabasco. Number of hosts (n = 30).

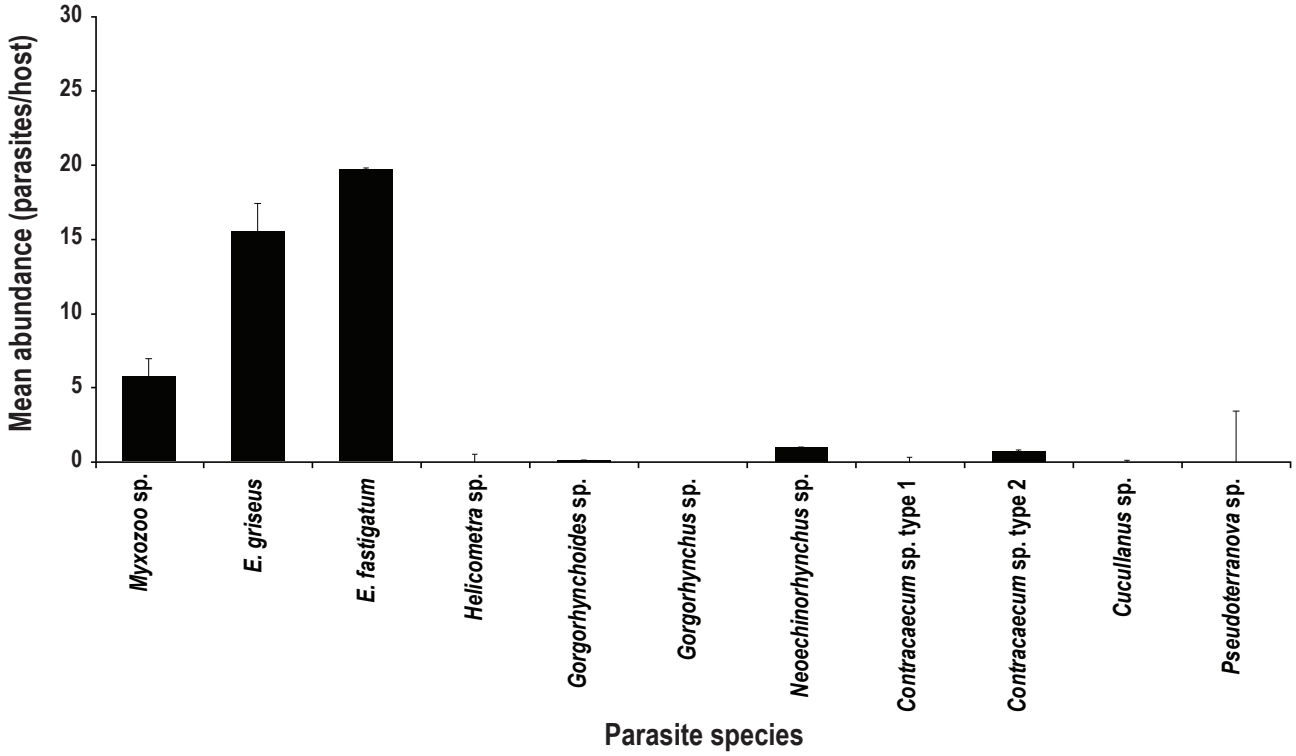

Fig. 5. Mean abundance (individuals per host ± standard deviation) of parasite species of gray snapper Lutjanus griseus in the rainy season in the Mecoacán Lagoon system, Tabasco. Number of hosts (n = 30).

Table 3. Characterization of the diversity of the component community of the *Lutjanus griseus* parasites in the Mecoacan Lagoon system for the dry and rainy season.

	Dry season	Wet season
Examined hosts	30	30
N° of species	14	11
N° of individuals	550	1281
Shannon Index	1.03	1.18
Margalef's Index	2.06	1.39
Berger-Parker Index	0.56	0.45
Numerical dominance 1/D	0.45	0.34
Dominant species	*Euryhaliotrema griseus*	*Euryhaliotrema fastigatum*

cause health risks for humans. These parasites belong to the group of nematodes and were the following: *Contracaecum* sp. type 1, *Contracaecum* type sp. 2, *C. pargi* and *Pseudoterranova* sp. Two species of the genus *Euryhaliotrema* (*E. griseus* and *E. fastigatum*) were also identified, which, according to previous reports, could represent a potential risk for juvenile of *L. griseus* under farming conditions.

Discussion

This is the first study of parasite communities in the gray snapper (*L. griseus*) in the lagoon of Mecoacán Tabasco, Mexico. Therefore, the 17 recorded parasite species comprise new records of geographic distribution. The most diverse groups of parasites were that of the acanthocephalans (six species) and nematodes (four species). A factor that can influence the presence of these species are the host's eating habits (Shamsi, 2013). Guevara *et al*. (2007) conducted a study on feeding habits and trophic ecology of *L. griseus* where they mention that they have preference for areas of submerged vegetation, as well as an increase in their abundance during the night. They also found that macrocrustaceans are the main component in the diet of this fish species (Guevara *et al*., 2007). This could explain that a greater number of acanthocephalan and nematode species are present and, since these groups present an indirect life cycle where their first intermediate host is generally a crustacean or other invertebrate.

It's important to recognized valuable research concerning helminthological examinations of specimens of the grey snapper in the Gulf of Mexico (González-Solís *et al*., 2002; González-Solís & Tuz-Paredes, 2007), earlier Argáez-García *et al*. (2010) elaborated a detailed contribution list of just internal (intestinal) parasites of *Lutjanus griseus* at the Yucatán region. In our study 17 parasite species were found and Argáez-García *et al*. (2010) reported 20 helminth species at the Yucatán Peninsula, therefore both of the community parasite composition are similar, nevertheless, our present study in Mecocacan, Tabasco reports new taxonomical groups, such as: Myxozan in the wet season (33.3 %), and ectoparasites *Euryhaliotrema griseus* and *E. fastigatum* in both seasons both with the highest prevalence in the wet seasons (100 %). Our study has increased the knowledge of parasites presence with new records for *Lutjanus griseus* in the the Gulf of Mexico.

The monogenean species *E. fastigatum* and *E. griseus* showed high levels of infection and are dominant, both for the dry season and the rainy season. This is because monogeneans are highly host-specific and have a direct life cycle where one free swimming larva called oncomiracidium must infect a host to complete its life-cycle. It is so that when the fish move in the middle, it can acquire a large quantity of these parasites, as they have specialized hooks that they use to adhere and survive in their host. It is worth mentioning that temperature is considered as the main abiotic factor that regulates the dynamics of monogeneans (Tinsley & Jackson, 2002; Soler-Jiménez & Fajer-Ávila, 2012; Ogawa, 2014). In the lagoon, warm waters are maintained (24 ° to 32 ° C) with an average of 26 ° C (García-Cubas *et al*., 1990). In the present study, the average condition factors were 1.34 in dry and 1.55 in rain season, which indicate that, on average, they presented healthy condition. Bashirullah (1975) determined that the average condition factor of *L. griseus* is 1.51 in males and 1.48 in females. In this study the fish presented good condition, it is a factor that statistically had no relationship with the parasitic load. Muñoz and Delorme (2011) pointed out that there is a relationship between the size of the fish and the parasite load, and that larger fish provide a greater contact surface for the parasites, and this is how the probability of encounter between the parasites increases. However, in the present study there was no correlation between the total length of the fish and the abundance of parasites. One factor that could influence these results are the total length of the fish that were reviewed in this study (12 – 29.2 mm) and that they can reach sizes greater than 40 cm (Castro-Aguirre *et al*., 1999). On the other hand, Samano-Zapata *et al.* (1998) studied that snappers increase in size, and also increasing diversity and volume of food in the coastal lagoons. This condition may explain the similarity in prevalence and mean abundance values for parasite species in specimens from other previous report in coastal lagoons (González-Solís *et al*., 2007; Argáez-García *et al.,* 2010) as well as the increase in parasite species richness for specimens.

In the Acanthocephala group, the adults of *Neoechinorhynchus* are usually found in the intestine of freshwater and brackish water

fish (Pinacho-Pinacho *et al*., 2014). These authors also reported low prevalence indicating probably an accidental infection of the specimens from eleotrif fishes in coastal lagoons across the Gulf of Mexico. In the comparison with intestinal parasites the prevalence is similar with our results and in the particular case of the acanthocephala and cestoda group the prevalence was very low (3 %) in the dry season and non-existing in the wet season. Argáez-García *et al*. (2010) also reported the presence of only of Tetraphyllidae organisms, in our study we reported the presence also the Pseudophyllidea individuals (3 %). The low prevalence may be an indicator of an accidental infection; these results justify further research.

Although, the latest authors mentioned that the helminth fauna of the gray snapper is replaced by new species after fish leave coastal lagoons, in our results show an addition of species for specimens from this lagoon in the same way, nematodes species found in fish from the Mecoacán lagoon system in Tabasco, Mexico were also present in specimens from others coastal lagoon in Quintana Roo according with Argáez-García *et al.* (2010). Perhaps the most reasonable hypothesis according these authors is that the gray snapper specimens sampled offshore are subject to rather slow replacement process of parasite species.

The parasite transmitted to humans by animals is known as zoonosis (Beaver *et al.,* 1984). In particular, those infected by the intake of raw fish meat are called ichthyozoonosis. In the present work, it was found that species representing the group of nematodes may generate public health problems, particularly the species: *Contracaecum* sp. type 1 and 2, and *Pseudoterranova* sp., which belong to the Anisakidae family, among these parasites are known to have zoonotic importance. Rojas-Sánchez *et al.* (2014) point out that of the almost 100 known ichthyozoonosis worldwide, 12 have been recorded in Mexico that could affect humans. Anisakiasis, caused by members of the Anisakidae family to which *Contracaecum* sp type 1 and 2 reported in this study and gnathostomiasis, caused by members of the genus *Gnathostoma* sp, are the two most frequent cases. Therefore, the habit of eating raw fish, such as ceviche and sushi, or insufficiently cooked fish should be avoided. Monogeneans are ectoparasites that cause problems in aquaculture (Whittington, 2005). This study recorded two species of genus *Euryhaliotrema* (*E. griseus* and *E. fastigatum*), with the highest values of intensity, prevalence, and mean abundance, which is consistent with that previously reported for this fish species from the Venezuela coasts (Zambrano *et al.,* 2003). In that study, a species of *Euryhaliotrema* with relatively high values of prevalence, intensity, and mean intensity was also reported, and it was suggested that due to the fragility of the parasitized organ (gills) these ectoparasites could eventually represent a serious problem for *L. griseus* in captivity (Zambrano *et al.,* 2003).

Conflict of Interest

Authors declare no conflict of interest.

Acknowledgments

The authors thank the fishermen of the Mecoacán Lagoon system who offered their support to obtain fishes. Also to Nicolás Álvarez Pliego of the UJAT for his support for the identification of *L. griseus*. In the same way, Belén Rodríguez Guadarrama of the UJAT is thanked for the support she gave us for the preparation of the map of the study area. As well as CONACyT for financing the postgraduate scholarship during this project. Special thanks to Amy Kathryn Lowe to provide editorial comments. Special thanks to the anonymous reviewers for their comments to improve this article.

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