

## Article

# Helminth Community of the Black Margate *Anisotremus surinamensis* (Teleostei: Haemulidae), from Coral Reefs off the Veracruz Coast, Mexico, Southern Gulf of Mexico

Jesús Montoya-Mendoza <sup>1</sup>, Guillermo Salgado-Maldonado <sup>2,\*</sup>, Carlos Roberto Blanco-Segovia <sup>1</sup>,  
Edgar F. Mendoza-Franco <sup>3</sup> and Fabiola Lango-Reynoso <sup>1</sup>

<sup>1</sup> Laboratorio de Investigación Acuícola Aplicada, Tecnológico Nacional de México, Instituto Tecnológico de Boca del Río, Km 12 Carretera Veracruz-Córdoba, Boca del Río, Veracruz C.P. 94290, Mexico; jesumontoya@bdelrio.tecnm.mx (J.M.-M.); roberttnight@gmail.com (C.R.B.-S.); fabiolalangoitboca@gmail.com (F.L.-R.)

<sup>2</sup> Laboratorio de Helminthología, Instituto de Biología, Universidad Nacional Autónoma de México, Ciudad Universitaria, Ciudad de México 04510, Mexico

<sup>3</sup> Instituto de Ecología, Pesquerías y Oceanografía del Golfo de México (EPOMEX), Universidad Autónoma de Campeche, Avenida Héroe de Nacozari No. 480, CP. 24029, San Francisco de Campeche, Campeche 24039, Mexico; efmendoz@uacam.mx

\* Correspondence: gsalgado@ib.unam.mx



**Citation:** Montoya-Mendoza, J.; Salgado-Maldonado, G.; Blanco-Segovia, C.R.; Mendoza-Franco, E.F.; Lango-Reynoso, F. Helminth Community of the Black Margate *Anisotremus surinamensis* (Teleostei: Haemulidae), from Coral Reefs off the Veracruz Coast, Mexico, Southern Gulf of Mexico. *Diversity* **2022**, *14*, 368. <https://doi.org/10.3390/d14050368>

Academic Editor: Luc Legal

Received: 18 February 2022

Accepted: 15 April 2022

Published: 6 May 2022

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

**Abstract:** We describe the composition and structure of the helminth community of the black margate *Anisotremus surinamensis* in coral reefs from the Parque Nacional Sistema Arrecifal Veracruzano (PNSAV) off the Veracruz coast. We examined a total of 78 specimens (total length TL range 21.7–77.9, mean 33.7 cm) (28 males, TL range 22.5–51.5, mean 32.7 cm; 50 females, TL range 21.7–77.9, mean 34.3 cm) of *A. surinamensis*. At least nine helminth taxa (seven intestinal) were found, for all of which *A. surinamensis* is a new host. Our inventory includes two new geographic records for the southern Gulf of Mexico: the digeneans *Cainocreadium oscitans* (Linton, 1910) and *Infundiburictus longovatus* (Hopkins, 1941). Observed component community richness ( $S = 9$ ) and infracommunity richness (mean  $\pm$  SD,  $S = 2.8 \pm 1.3$ ) for *A. surinamensis* were lower than previously recorded richness for the sympatric *A. virginicus* and other coral reef fishes from the PNSAV. Numerically dominant taxa were trematodes (four taxa) and monogeneans (two), followed by nematodes (one), acanthocephalans (and) and cestodes (one). The trematode *Monorchis latus* was the more prevalent, more abundant and numerically dominant helminth species in the community of parasites of *A. surinamensis*.

**Keywords:** coral reef; parasites of fish; richness; diversity; southern Gulf of Mexico

## 1. Introduction

The parasite communities of grunts (Teleostei: Haemulidae) are insufficiently documented in Mexican waters, and those that inhabit coral reefs areas are even less known. Haemulids are among the principal components of marine ecosystems; the family includes 133 species in 23 genera distributed worldwide [1]. Along the American Continent, haemulids are found in both the Pacific and Atlantic regions. The known fauna of metazoan parasites of haemulids have been compiled [2]. These authors [2] documented 231 species of metazoan parasites in 48 species of grunts from the Neotropical and Nearctic regions. *Haemulon sciurus* (Shaw, 1803) is the haemulid host species with the most number of parasites recorded ( $S = 54$ ) [2]. Thus, a rich fauna of helminth parasites could be expected when examining other haemulids. However, few works have focused on the composition, richness and diversity of parasite communities of haemulids [3–6], and parasite communities of these fish groups remain poorly known.

Coral reef fishes harbour a remarkable diversity of parasites [7–11]. However, compared to other biotic components, data on parasites of coral reef fishes, especially species

richness, remain scarce [11–14]. Small, platform, bank-reefs occur along the Mexican coast in the southwestern Gulf of Mexico [15–17]. The coral reef system located across the state of Veracruz is the largest reef system in this region and constitutes the Parque Nacional Sistema Arrecifal Veracruzano (PNSAV) (Veracruzano Coral Reef System National Park) [16–18].

The burriquete or black margate, *Anisotremus surinamensis* (Bloch) (Haemulidae), is a demersal reef-associated fish found in the PNSAV area; it is of moderate economic importance, primarily for human consumption and recreational fishing [19,20]. The species is distributed from Florida and the Bahamas through the Gulf of Mexico and the Caribbean to Brazil [21]. It is found down to a 20 m depth and reaches 76 cm in maximum length and 5.8 kg in weight [1]. It feeds on small fishes, urchins, crustaceans, and molluscs [22,23] and is prey mainly of sharks [24]. Data on helminths of *A. surinamensis* are scarce compared to those for other haemulids [25]. Host-parasite records from Brazil report the monogeneans *Mexicana anisotremum* Dias-Cezar, Paschoal and Luque, 2012 and *Encotyllabe spari* Yamaguti, 1934, and the acanthocephalan *Serrasentis* sp. [2,26]. However, the helminth fauna parasitizing the populations of *A. surinamensis* inhabiting the coral reef system of Veracruz is unknown.

The aim of this work is to determine the prevalence and mean intensity and describe the community of helminth parasites associated with the black margate *Anisotremus surinamensis* in coral reefs from the PNSAV in Veracruz, southern Gulf of Mexico.

## 2. Materials and Methods

Local fishermen, using harpoons and scuba at depths of 3 to 10 m, captured 78 black margate, *A. surinamensis*, from coral reefs in the PNSAV (19°02'24"–19°16'00" N, 95°46'19"–96°12'01" W) from May 2017 to April 2018. We placed the fish specimens in plastic containers with ice and transported them fresh to the laboratory for further examination within the next 24 h. For these fish, we recorded the total length (cm from snout to the margin of the caudal fin). The sex of each fish was confirmed by visual inspection of gonads during the dissections. A complete external and internal examination of each fish specimen was conducted. Tissues and organs were examined using a stereoscopic microscope. External examination included skin, scales, fins, gills, nostrils, mouth and anus. Gills were excised and examined in petri dishes with seawater. Internal examination included mesentery, liver, kidneys and gonads. The digestive system was excised and examined in petri dishes with 0.75% saline. The circulatory system and bones were excluded from examination. All specimens were examined to assess species richness of parasite assemblages and abundance distribution of each parasite taxon.

Helminths were fixed in hot 4% formalin and preserved in 70% ethyl alcohol [27–29]. Platyhelminths and acanthocephalans were stained using Mayer's Paracarmine or Gomori's Trichrome stain, dehydrated using a graded alcohol series, cleared with clove oil and mounted whole in Canada balsam. Nematodes were cleared in glycerine, examined in temporary mounts and preserved in 70% ethyl alcohol [27,29]. Identification was made using specialized literature [18,25–27]. Voucher specimens were deposited in the Colección Nacional de Helminths (National Helminth Collection), Universidad Nacional Autónoma de México, Instituto de Biología, Mexico City.

### Data Analysis

We calculated the prevalence (percentage of infected hosts) and mean intensity (mean number of helminths per infected host) for each parasite species according to Bush et al. [30]. The range (minimum–maximum) of the mean intensity was recorded. Data were analysed at the component community level (all helminths in all specimens of *A. surinamensis*) and at the infracommunity level (all helminths in each specimen) [31].

Sampling adequacy was evaluated using randomized species accumulation curves as described in [6]. The curve was developed at 100× randomization using the EstimateS software (version 8.5 Colwell, <http://viceroy.eeb.uconn.edu/estimates>, accessed on

26 November 2019) [32]. We analysed the asymptotic richness based on Clench's model, given that the model equation enables estimation of the total number of species in the component as  $a/b$  [33,34]. Clench's model is described by the equation

$$V2 = (a \times V1) / (1 + (b \times V1))$$

where  $V2$  is the observed richness,  $V1$  is the number of hosts examined, and  $a$  and  $b$  are parameters of the curve calculated iteratively.  $a$  equals the rate of adding new species, and  $b$  is a parameter related to the shape of the curve [35]. Furthermore, the number of rare species likely to have been missed by inadequate sampling was estimated using the Bootstrap non-parametric species richness estimator ( $S_B$ ), calculated as

$$S_B = S_0 + \sum [1 - (h_j/H)^H]$$

where  $S_0$  is the observed species richness,  $H$  is the number of host individuals sampled from the component community and  $h_j$  is the number of host individuals in the sample in which parasite species  $j$  is found [35].

At the component community level, we calculated the Shannon's diversity index ( $H'$ ) and the Berger–Parker dominance index [36]. Descriptors at the infracommunity level included the mean number of helminth species per fish, the mean number of helminths per fish and mean Brillouin's diversity index per fish ( $H$ ). We examined the correlation between species richness and the number of helminths with host size and weight.

### 3. Results

We examined 78 black margate specimens (28 males, total length TL range 22.5–51.5, mean 32.7 cm; 50 females, TL range 21.7–77.9, mean 34.3 cm). We found nine helminth taxa, including two monogeneans, four digeneans, one cestode, one nematode and one acanthocephalan (Table 1). The cumulative species richness curve at the component community level suggests that the helminth species inventory was almost complete. The estimated richness (Clench's model) was 9.2 species ( $a = 3.4$ ,  $b = 0.37$ ;  $a/b = 9.2$ ). Similarly, the non-parametric Bootstrap species richness estimator ( $S_B = 9.4$ ) suggests that we sampled most species from the helminth community.

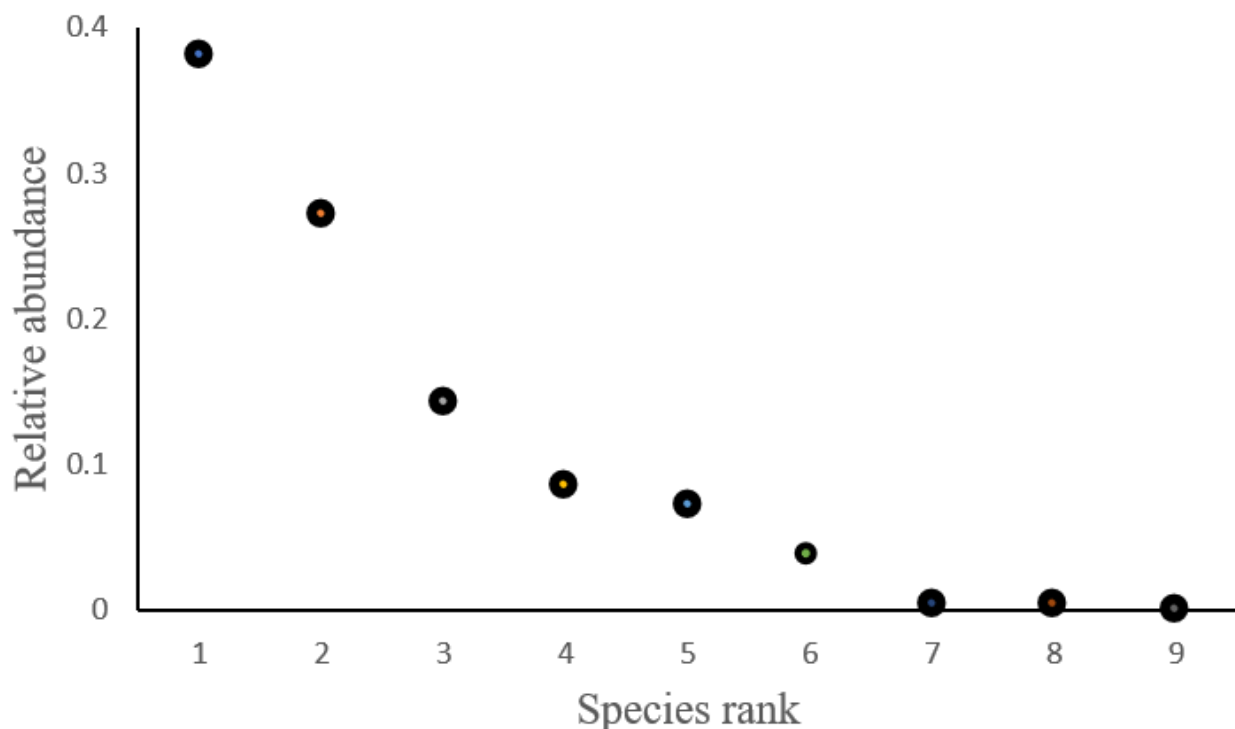
**Table 1.** Prevalence, mean intensity and site of infection of helminth parasites of 78 *Anisotremus surinamensis* from reefs of the PNSAV, Veracruz, Mexico. All nine helminths are new host records for *A. surinamensis*; <sup>†</sup>, new geographic record Southern Gulf of Mexico; CNHE, number of catalog of voucher specimens deposited in the Colección Nacional de Helminths, UNAM. Sites of infection: I, intestine; G, gills.  $N$ , number of hosts infected;  $P$ , plerocercoid.

Parasite Taxa	CNHE	Site of Infection	$N$ (% Prevalence)	Mean Intensity ( $\pm$ SD)	Range
Monogenea					
<i>Encotyllabe pagrosomi</i> MacCallum, 1917	11,518	G	1 (1)	$1 \pm 0$	1
<i>Choricotyle</i> sp.	11,519	G	4 (5)	$2.5 \pm 3$	1–7
Digenea					
<i>Alloinfundiburictus longicaecum</i> (Manter, 1940)	11,520	I	24 (31)	$8 \pm 15$	1–68
<i>Cainocreadium oscitans</i> (Linton, 1910) <sup>†</sup>	11,521	I	53 (68)	$11.5 \pm 15.2$	1–96

Table 1. Cont.

Parasite Taxa	CNHE	Site of Infection	N (% Prevalence)	Mean Intensity ( $\pm$ SD)	Range
<i>Infundiburictus longovatus</i> (Hopkins, 1941) <sup>†</sup>	11,522	I	33 (42)	9.7 $\pm$ 10.3	1–40
<i>Monorchis latus</i> Manter, 1942	11,523	I	36 (46)	23.6 $\pm$ 43	1–208
Cestoda					
Tetraphyllidea gen. sp. <sup>P</sup>	11,524	I	18 (23)	8.9 $\pm$ 19.7	1–79
Nematoda					
<i>Heliconema</i> sp.	11,525	I	8 (10)	1.3 $\pm$ 0.5	1–2
Acanthocephala					
<i>Dollfusentis chandleri</i> Golvan, 1969	11,526	I	24 (31)	3.5 $\pm$ 3.1	1–13

All nine helminths of our inventory are new host records for *A. surinamensis*, of which two are new geographic records for the southern Gulf of Mexico (Table 1). The digeneans *Cainocreadium oscitans* (prevalence 68%) and *Monorchis latus* (46%) exhibited the highest prevalences; *M. latus* also attained the highest mean intensity (23.6) and was the dominant species in the component community (Figure 1). The helminth parasite community of *A. surinamensis* is structured on the basis of at least five frequent (prevalence  $\geq$  18%) and abundant (mean intensities  $\geq$  8 helminth individuals per infected host) (Table 1) taxa.



**Figure 1.** Pattern of relative abundance of nine taxa of helminths in the component of community of *A. surinamensis* from coral reef environments of Veracruz, Mexico. The dominant helminth species is *Monorchis latus*.

We collected a total of 2232 helminths (range 1–208, mean  $\pm$  SD = 31  $\pm$  45 helminths per infected fish). At the component community level, species richness was  $S = 9$  and Shannon's diversity index was  $H' = 1.6$ . At the infracommunity level, the range of observed

richness was 1–7 species (mean  $\pm$  SD =  $2.8 \pm 1.3$ ) of parasites per host. Six fish had no parasites, 11 harboured 1 parasite taxon, 25 harboured 2, 15 harboured 3, 13 harboured 4, 6 harboured 5, 1 harboured 6, and 1 harboured 7 parasite taxa. The mean  $\pm$  SD Brillouin's diversity index ( $H$ ) was  $0.5 \pm 0.4$  (range 0.1–1.5). No significant correlation was observed between the total number of taxa ( $S$ ) ( $r = 0.25$ ) or the total number of helminths ( $N$ ) ( $r = 0.16$ ) with host size (total host length). Similarly, no significant correlation was observed between the total number of taxa ( $S$ ) ( $r = 0.25$ ) or the total number of helminths ( $N$ ) ( $r = 0.2$ ) with host weight. Of the nine helminth taxa identified, seven were intestinal parasites (77.7%) (Table 1). Seventy-one host specimens were infected with intestinal parasites; 11 were infected with 1 taxon, while 60 had concurrent intestinal infections with 2 to 6 helminth taxa. We collected a total of 2221 intestinal helminths. The mean  $\pm$  SD number of helminths per host was  $31.3 \pm 45.6$  (range 1–208). The mean  $\pm$  SD number of species of intestinal helminths was  $2.8 \pm 1.3$  (range 1–6), and the mean Brillouin's diversity index was  $0.5 \pm 0.4$  (range 0.1–1.3).

#### 4. Discussion

This work represents the first analysis of the helminth community in the black margate *A. surinamensis* and new host record for nine helminth taxa. Two of these nine species, the digeneans *Cainocreadium oscitans* and *Infundiburictus longovatus* are recorded for the first time in the southern Gulf of Mexico. *Cainocreadium oscitans* was previously known from the northeastern area of the Gulf of Mexico, recorded from various grunts mainly of the genus *Haemulon* and also from *Anisotremus* [2]. Therefore, our results represent significant range extensions for this species. However, *Infundiburictus longovatus* (= *Genolopa longovatus* Hopkins, 1941), see [37], has been previously reported in grunts from the northern Gulf of Mexico to Brazil, Ecuador and Chile [2]. This study broadens the geographic record of the parasite to the southern Gulf of Mexico.

The only larval taxa recorded in this work were the Tetraphyllidean plerocercoids. The presence of these plerocercoids is explained by the intermediate level of *A. surinamensis* in the marine food web. Tetraphyllideans naturally parasitize sharks, for which the black margate is a common prey. The assemblage of taxa that are here reported under Tetraphyllideae undoubtedly represents hitherto undiscovered diversity [38]. We recognize that by neglecting a precise identification of this larval taxon we are omitting a significant part of parasite biodiversity.

All other helminths recorded here were adults. The two monogenean ectoparasites have direct life cycles. However, the endohelminths, including the four digeneans, the nematode and the acanthocephalan are mostly trophically transmitted to the black margate. The entire sample of hosts examined includes only mature adult fish, most of them of a size close to the common length (~45 cm total length; [1]) and several of which attain the maximum length reported for the black margate (76 cm; [1]). Thus, the composition and richness of the helminth community of *A. surinamensis* in the PNSAV geographical area as reported in this work constitute the typical community for this host species in their adult stage, and correspond to the intermediate level position of *A. surinamensis* in the food web.

Not unexpectedly, the recorded composition of the community of helminth parasites of *A. surinamensis* closely resembles the composition of the sympatric *A. virginicus*, see [6], with which it shares seven helminth taxa, plus the addition of the two digeneans here reported for the first time in the PNSAV. However, the helminth community of *A. virginicus* is richer than that of *A. surinamensis* ( $S = 22$  vs.  $S = 9$ ), and it includes more diversity of taxa, among which the monogenean *Mexicana anisotremum*, the digenean *Monorchis latus* and the acanthocephalan *Dollfusentis chandleri* play important numerically dominant roles [6]. In contrast, the helminth community of *A. surinamensis*, as currently described in this work, is structured mostly on four digenean species and the acanthocephalan. For both hosts, *A. virginicus* and *A. surinamensis* the Tetraphyllid plerocercoids constitute a significant part of their respective diversities.



Parasite communities are influenced by both host biological factors and habitat [39]. Host level factors as processes affecting parasite assembly at a local scale explain variation among parasite communities of host species that co-occur under identical environmental conditions [40]. It is possible to assume the influence of the same environmental components acting upon the two sympatric host populations examined in this work. Therefore, host biological factors such as diet and size may explain the variation in species richness and diversity. Host size and dietary breadth (trophic position) are the two main determinants shaping parasite variation among host species [40,41]. Why does the smaller *A. virginicus* (20–40 cm maximum TL) harbour more parasites than the almost twice as large *A. surinamensis* (76 cm)? Both these haemulids have similar diets. Both host species are found along the reef area and thus have access to the same prey resources. They overlap in prey consumed [42,43]. However, *A. surinamensis* prey primarily on an echinoid sea urchin, mostly *Diadema* spp., while the diet of *A. virginicus* is more varied in prey items, mainly based on small benthic organisms such as isopods, amphipods, tanaidacea, decapods and polychaetes [44,45]. *A. virginicus* also consume echinoid sea urchins but as a smaller proportion of its diet [43]. Furthermore, records of the diet of *A. surinamensis* indicate that smaller individuals (less than 30 cm) consume mainly small crustaceans and small limpets, while larger individuals preferably consume sea urchins [42]. *A. surinamensis* consumes more sea urchins by achieving large body sizes [43]. The richest enteric helminth communities of fishes have been found in carnivorous fishes [2,26,39]. However, the selective feeding of *A. surinamensis* on a specific poorly infected food item, a sea urchin in this case, may have led to the poor communities recorded in this host. Therefore, our data suggest that the variation in parasite infection of sympatric *A. surinamensis* and *A. virginicus* can be explained by the difference in parasite exposure. Most parasites recorded are transmitted via ingestion, and both host species share food resources and use similar habitat types.

## 5. Conclusions

The black margate, *A. surinamensis*, is a new host for the nine helminths reported in this work, including the monogeneans *Encotyllabe pagrosomi* MacCallum, 1917 and *Chorycotyle* sp., the digeneans *Alloinfundiburictus longicaecum* (Manter, 1940), *Cainocreadium oscitans* (Linton, 1910), *Infundiburictus longovatus* (Hopkins, 1941) and *Monorchis latus* Manter, 1942; the plerocercoids of *Tetraphyllidea* gen. sp.; the nematode *Heliconema* sp., and the acanthocephala *Dollfusentis chandleri* Golvan, 1969. Our data show that the community of helminths from *A. surinamensis* in the PNSAV shows a pattern similar in its composition to that of other haemulids, whereby the dominant fauna is made up of digeneans. In addition the community is structured based on the presence of digenean species that had not previously been recorded in the area and now have been recorded in *A. surinamensis* with high prevalences and intensities. This suggests that the diversity of parasites in PNSAV fish may be very high and that the examination of other new hosts may contribute records of other species of helminths preferentially associated with that species.

**Author Contributions:** Conceptualization, J.M.-M. and G.S.-M.; methodology, J.M.-M., G.S.-M., C.R.B.-S., E.F.M.-F. and F.L.-R.; validation, J.M.-M., C.R.B.-S. and E.F.M.-F.; formal analysis, J.M.-M., G.S.-M. and C.R.B.-S.; investigation, J.M.-M., G.S.-M. and C.R.B.-S.; resources, J.M.-M. and G.S.-M.; data curation, J.M.-M., C.R.B.-S., E.F.M.-F. and F.L.-R.; writing—original draft preparation, J.M.-M. and G.S.-M.; writing—review and editing, J.M.-M., G.S.-M., C.R.B.-S., E.F.M.-F. and F.L.-R.; project administration, J.M.-M. and G.S.-M.; funding acquisition, J.M.-M. and G.S.-M. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by Tecnológico Nacional de México/Instituto Tecnológico de Boca del Río, Clave 6400.18-P. GSM was supported by UNAM DGAPA PAPIIT IN200820 and CONACyT A-1-S-19959.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Authors are preparing a manuscript to be submitted to provide data in brief.

**Acknowledgments:** Thanks are due to three anonymous reviewers whose candid revisions very much contribute to the improvement of our work. Special thanks to Julio César Montero Rojas, Instituto de Biología, UNAM for the preparation of the graphical abstracts. We are grateful to Marcia M. Gowing (Seattle, WA, USA) for improving the writing style.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Froese, R.; Pauly, D. (Eds.) FishBase World Wide Web Electronic Publication. Available online: [www.Fishbase.org](http://www.Fishbase.org) (accessed on 4 February 2022).
2. Paschoal, F.; Cezar, A.D.; Luque, J.L. Checklist of metazoan associated with grunts (Perciformes, Haemulidae) from the Nearctic and Neotropical regions. *Check List* **2015**, *11*, 1501. [\[CrossRef\]](#)
3. Chero, J.; Cruces, J.C.; Iannacone, J.; Alvaríño, L. Helminth parasites of *Anisotremus scapularis* (Tschudi, 1846) (Perciformes: Haemulidae) Peruvian grunt acquired at the fishing terminal of Villa María del Refugio, Lima, Perú. *Neotrop. Helminth.* **2014**, *8*, 411–428.
4. Bashirullah, A.K.; Díaz, M.T. Helminth infracommunity of *Haemulon aeorolatus* Cuvier, 1830 (Haemulidae) from the Gulf of Cariaco, Venezuela. *Rev. Cientif. FCV-LUZ* **2015**, *25*, 167–172.
5. Iannacone, J.; Alvaríño, L.; Chero, J.; Sáez, G. Comunidad parasitaria de Cabinza *Isacia conceptionis* (Cuvier & Valenciennes, 1830) (Perciformes: Haemulidae) en la zona de Chorrillos, Lima, Perú. *Rev. Inv. Vet. Perú* **2015**, *26*, 96–110.
6. Montoya-Mendoza, J.; Fernández-Peña, M.L.; Salgado-Maldonado, G.; Castañeda-Chávez, M.R.; Mendoza-Franco, E. Helminth communities of *Anisotremus virginicus* (Perciformes: Haemulidae) in Veracruz, Mexico. *J. Parasit.* **2021**, *107*, 364–368. [\[CrossRef\]](#)
7. Cribb, T.H.; Bray, R.A.; Barker, S.C.; Adlard, R.D.; Anderson, G.R. Ecology and diversity of digenean trematodes of reef and inshore fishes of Queensland. *Int. J. Parasitol.* **1994**, *24*, 851–860. [\[CrossRef\]](#)
8. Cribb, T.H.; Bott, N.J.; Bray, R.A.; McNamara, M.K.A.; Miller, T.L.; Nolan, M.J.; Cutmore, S.C. Trematodes of the Great Barrier Reef, Australia: Emerging patterns of diversity and richness in coral reef fishes. *Int. J. Parasitol.* **2014**, *44*, 929–939. [\[CrossRef\]](#)
9. Justine, J.-L.; Beveridge, I.; Boxshall, G.A.; Bray, R.A.; Moravec, F.; Trilles, J.-P.; Whittington, I.D. An annotated list of parasites (Isopoda, Copepoda, Monogenea, Digenea, Cestoda, and Nematoda) collected in groupers (Serranidae, Epinephelinae) in New Caledonia emphasises parasite biodiversity in coral reef fish. *Folia Parasitol.* **2010**, *57*, 237–262. [\[CrossRef\]](#)
10. Justine, J.-L.; Beveridge, I.; Boxshall, G.A.; Bray, R.A.; Moravec, F.; Whittington, I.D. An annotated list of parasites (Copepoda, Monogenea, Digenea, Cestoda, and Nematoda) collected from Emperors and Emperor bream (Lethrinidae) in New Caledonia further highlights parasite biodiversity estimates on coral reef fish. *Zootaxa* **2010**, *2691*, 237–262. [\[CrossRef\]](#)
11. Justine, J.-L.; Beveridge, I.; Boxshall, G.A.; Bray, R.A.; Miller, T.L.; Moravec, F.; Trilles, J.-P.; Whittington, I.D. An annotated list of fish parasites (Isopoda, Copepoda, Monogenea, Digenea, Cestoda, Nematoda) collected from Snappers and Bream (Lutjanidae, Nemipteridae, Caesionidae) in New Caledonia confirms high parasite biodiversity on coral reef fish. *Aquatic Biosyst.* **2012**, *8*, 22. Available online: <http://www.aquaticbiosystems.org/content/8/1/22> (accessed on 24 November 2021). [\[CrossRef\]](#)
12. Beveridge, I.; Bray, R.A.; Cribb, T.H.; Justine, J.L. Diversity of trypanorhynch metacestodes in teleost fishes from coral reefs off eastern Australia and New Caledonia. *Parasite* **2014**, *21*, 60. [\[CrossRef\]](#) [\[PubMed\]](#)
13. Justine, J.-L. Parasites of coral reef fish: How much do we know? With a bibliography of fish parasites in New Caledonia. *Belgian J. Zool.* **2010**, *140*, 155–190.
14. Rigby, M.C.; Holmes, J.C.; Cribb, T.H.; Morand, S. Patterns of species diversity in the gastrointestinal helminths of coral reef fish, *Epinephelus merra* (Serranidae), from French Polynesia and the South Pacific Ocean. *Can. J. Zool.* **1997**, *75*, 1818–1827. [\[CrossRef\]](#)
15. Spalding, M.D.; Ravilious, C.; Green, E.P. *World Atlas of Coral Reefs*; UNEP World Conservation Monitoring Centre, University of California Press: Berkeley, CA, USA, 2001.
16. Horta-Puga, G.; Tello-Musi, J.L.; Beltrán-Torres, A.; Carricart-Ganivet, J.P.; Carriquiry, J.D.; Villaescusa-Celaya, J. Veracruz Reef System: A hermatypic coral community thriving in a sedimentary terrigenous environment. In *Aportes al conocimiento del Sistema Arrecifal Veracruzano: Hacia el Corredor Arrecifal del Suroeste del Golfo de México*; Granados-Barba, A., Ortiz-Lozano, L.D., Salas-Monreal, D., González-Gándara, C., Eds.; Universidad Autónoma de Campeche: Campeche, Mexico, 2015; pp. 181–208.
17. Jordán-Dahlgren, E.; Rodríguez-Martínez, R.E. The Atlantic coral reefs of Mexico. In *Latin American Coral Reefs*; Cortés, J., Ed.; Elsevier Science: Amsterdam, The Netherlands, 2003.
18. Montoya-Mendoza, J. Ecología de Helminthos Parásitos de Peces Marinos de Alvarado, Veracruz, México. Ph.D. Thesis, Universidad Nacional Autónoma de México, Instituto de Biología, Mexico City, Mexico, 2009; p. 109.
19. Jiménez-Badillo, M.L.; Pérez-España, H.; Vargas-Hernández, J.M.; Cortés-Salinas, J.C.; Flores-Pineda, P.A. *Catálogo de Especies y Artes de Pesca del Parque Nacional Sistema Arrecifal Veracruzano*; CONABIO, Universidad Veracruzana: Ciudad de México, Mexico, 2006; p. 182.
20. Burton, M.L.; Potts, J.C.; Ostrowski, A.D. Preliminary estimates of age, growth and natural mortality of margate, *Haemulon album*, and black margate, *Anisotremus surinamensis*, from the southeastern United States. *Fishes* **2019**, *4*, 44. [\[CrossRef\]](#)
21. McEachran, J.D.; Fechhelm, J.D. *Fishes of the Gulf of Mexico*; University of Texas Press: Austin, TX, USA, 2005; Volume 2, p. 1004.

22. FAO. *Species Identification Sheets for Fishery Purposes. Western Central Atlantic (Fishing Area 31)*; Fischer, W., Ed.; FAO—Food and Agriculture Organization of the United Nations: Rome, Italy, 1978; Volume II, III, IV, V.
23. García, C.B.; Contreras, C.C. Trophic levels of fish species of commercial importance in the Colombian Caribbean. *Rev. Biol. Trop.* **2011**, *59*, 1195–1203. Available online: <https://www.scielo.sa.cr/pdf/rbt/v59n3/a21v59n3.pdf> (accessed on 26 November 2021). [CrossRef]
24. Allen, T.; Jiménez, M.; Villafranca, S. Estructura y categorías tróficas de peces asociados a praderas de *Thalassia testudinum* (Hydrocharitales, Hydrocharitaceae) en el golfo de Cariaco, Estado de Sucre, Venezuela. *Lat. Am. J. Aquatic Res.* **2006**, *34*, 125–136. Available online: <https://www.redalyc.org/pdf/1750/175020522012.pdf> (accessed on 26 November 2021). [CrossRef]
25. Overstreet, R.M.; Cook, J.O.; Heard, R. Trematoda (Platyhelminthes) of the Gulf of Mexico. In *Gulf of Mexico Origins, Waters, and Biota Vol. 1. Biodiversity*; Felder, D.W., Camp, D.K., Eds.; Texas A&M University Press: College Station, TX, USA, 2009; pp. 419–486.
26. Dias-Cezar, A.D.; Paschoal, F.; Luque, J.L. A new species of *Mexicana* (Monogenea: Dactylogyridae) parasitic on two species of *Anisotremus* (Perciformes: Haemulidae) from the Brazilian coastal zone. *Neotrop. Helminthol.* **2012**, *6*, 25–29. [CrossRef]
27. Caspeta-Mandujano, J.M. *Nemátodos Parásitos de Peces de Agua Dulce de México. Clave de Identificación, Descripción y Distribución de Especies*; AGT Editor: Ciudad de México, Mexico, 2010; p. 228.
28. Salgado-Maldonado, G. *Manual de Prácticas de Parasitología con Énfasis en Helmintos Parásitos de Peces de Agua Dulce y Otros Animales Silvestres de México*; Instituto de Biología: Unam Ciudad de México, Mexico, 2009; p. 56.
29. Vidal-Martínez, V.M.; Aguirre-Macedo, M.L.; Scholz, T.; González-Solís, D.; Mendoza-Franco, E.F. *Atlas of the Helminth Parasites of Cichlid Fish of Mexico*; Academia: Praha, Czech Republic, 2001; p. 165.
30. Bush, A.O.; Lafferty, K.D.; Lotz, J.M.; Shostak, A.W. Parasitology meets ecology oits own terms: Margolis et al. Revisited. *J. Parasitol.* **1997**, *83*, 575–583. [CrossRef]
31. Holmes, J.C.; Price, P.W. Communities of Parasites. In *Community Ecology: Patterns and Processes*; Kikkawa, J., Anderson, D.J., Eds.; Blackwell Scientific Publications: London, UK, 1986; pp. 187–213.
32. Moreno, C.E.; Halffter, G. On the measure of sampling effort used in species accumulation curves. *J. Appl. Ecol.* **2001**, *38*, 487–490. [CrossRef]
33. Jiménez-Valverde, A.; Hortal, J. Las curvas de acumulación de especies y la necesidad de evaluar la calidad de los inventarios biológicos. *Rev. Ibér. Aracnol.* **2003**, *8*, 151–161.
34. Soberon, M.J.; Llorente, J.B. The use of species accumulation functions for the prediction of species richness. *Conserv. Biol.* **1993**, *7*, 480–488. Available online: <https://pdfs.semanticscholar.org/979b/1859669ecc4c05f10276bad2015816dd8f95.pdf> (accessed on 26 November 2021). [CrossRef]
35. Poulin, R. Comparison of three estimators of species richness in parasite component communities. *J. Parasitol.* **1998**, *84*, 485–490. [CrossRef] [PubMed]
36. Magurran, A.E. *Measuring Biological Diversity*; Blackwell Publishing: Oxford, UK, 2004; p. 256.
37. Wee, N.Q.-X.; Cutmore, S.C.; Pérez-del-Olmo, A.; Cribb, T.H. First steps to reconstructing the problematic genus *Lasiotocus* Looss, 1907 (Digenea: Monorchiiidae) with the proposal of four new genera. *Parasit. Int.* **2020**, *79*, 102164. [CrossRef]
38. Caira, J.N.; Jensen, K.; Ruhnke, T.R. “Tetraphyllidea” van Beneden, 1850 relics. In *Planetary Biodiversity Inventory (2008–2017): Tapeworms from Vertebrate Bowels of the Earth*; Caira, J.N., Jensen, K., Eds.; The University of Kansas Natural History Museum, Special Publication No. 25; The University of Kansas: Lawrence, KS, USA, 2017; pp. 371–400.
39. Santoro, M.; Iaccarino, D.; Bellisario, B. Host biological factors and geographic locality influence predictors of parasite communities in sympatric sparid fishes off the southern Italian coast. *Sci. Rep.* **2020**, *10*, 13283. [CrossRef] [PubMed]
40. Deflem, I.S.; Van Den Eeckhaut, F.; Vandevoorde, M.; Calboli, F.C.F.; Raeymaekers, J.A.M.; Volckaert, F.A.M. Environmental and spatial determinants of parasite communities in invasive and native freshwater fishes. *Hydrobiologia* **2022**, *849*, 913–928. [CrossRef]
41. Poulin, R. *Evolutionary Ecology of Parasites*; Princeton University Press: Princeton, NJ, USA, 2011; 360p.
42. Randal, J.E. Food habits of reef fishes of the West Indies. *Stud. Trop. Ocean.* **1967**, *5*, 655–847.
43. Grubich, J. Morphological convergence of pharyngeal jaw structure in durophagous perciform fish. *Biol. J. Linn. Soc.* **2003**, *80*, 147–165. [CrossRef]
44. Díaz-Ruiz, S.A.; Yáñez-Arancibia, A.; Amezcua-Linares, F. Taxonomía, diversidad, distribución y abundancia de los pomadásidos de la Laguna de Términos, Campeche (Pisces: Pomadasyidae). *An. Inst. Cien. Mar Limnol.* **1982**, *9*, 251–278.
45. Humann, P.; Deloach, N. *Reef Fish Identification. Florida, Caribbean, Bahamas*; New World Publ. Inc.: Jacksonville, FL, USA, 2002; 481p.