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ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

PARASITES OF ELASMOBRANCHS FROM THE SOUTHERN GULF OF MEXICO: THE BULL SHARK *CARCHARHINUS LEUCAS* (MÜLLER & HENLE, 1839) AND THE SOUTHERN STINGRAY *HYPANUS AMERICANUS* (HILDEBRAND & SCHROEDER, 1928)

PARÁSITOS DE ELASMOBRANQUIOS DEL SUR DEL GOLFO DE MÉXICO: EL TIBURÓN TORO *CARCHARHINUS LEUCAS* (MÜLLER & HENLE, 1839) Y LA RAYA LÁTIGO *HYPANUS AMERICANUS* (HILDEBRAND & SCHROEDER, 1928)

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Running Head**:** Elasmobranch Parasites from Southern Gulf of Mexico

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ABSTRACT

Elasmobranchs play an essential ecological role as top predators in marine ecosystems, and parasitological studies allow the assessment of both host health and the environmental conditions they inhabit. This study analyzed the parasitic diversity of two representative species from the southern coast of the Gulf of Mexico: the bull shark *Carcharhinus leucas* (Müller & Henle, 1839), captured at several fishing localities in the states of Campeche and Tabasco (Seybaplaya, Champotón, Ciudad del Carmen, and Barra de San Pedro), and the southern stingray *Hypanus americanus* (Hildebrand & Schroeder, 1928), collected in Seybaplaya, Campeche. In *C. leucas*, all ten examined specimens showed a 100% prevalence of parasitic infection, with a total of 175 individuals belonging to the groups Monogenea, Cestoda, Nematoda, and Copepoda. The identified taxa were *Nesippus orientalis* (Heller, 1865), *Nemesis* sp. (Risso, 1826), *Paralebion elongatus* (Wilson, 1911), *Erpocotyle carcharhini* (Watson & Thorson, 1976), *Granulinema carcharhini* (Moravec & Little, 1988), and *Nybelinia* sp. (Poche, 1926), with cestodes being the most abundant group (64.57%). In 14 examined specimens of *H. americanus*, a total of 1,775 endoparasites were recorded (953 in males and 822 in females), belonging to the groups Cestoda and Nematoda. In this species, the genera *Acanthobothrium* (Van Beneden, 1849), *Nybelinia* (Poche, 1926), *Oncomegas* (Dollfus, 1929), *Pterobothrium* (Diesing, 1850), *Phyllobothrium* (Van Beneden, 1850), *Grillotia* (Guiart, 1927), and *Anisakis* (Dujardin, 1845) were identified. *Oncomegas* showed the highest prevalence (100%) and *Phyllobothrium* the lowest (7.14%), and *Grillotia* is reported for the first time in *H. americanus* from the Gulf of Mexico. Overall, the results reveal a high parasitic diversity dominated by cestodes, which may reflect alterations in coastal habitats. This study provides new parasite records and reinforces the value of parasitology as a tool for understanding biodiversity and assessing the ecological status of elasmobranchs from the southern Gulf of Mexico.

Keywords: Elasmobranchs – *Carcharhinus leucas* – *Hypanus americanus* – Parasitic diversity – Cestodes – Nematodes – Monogeneans – Copepods – Gulf of Mexico

RESUMEN

Los elasmobranquios desempeñan un papel ecológico esencial como depredadores tope en los ecosistemas marinos, y los estudios parasitológicos permiten evaluar tanto la salud de los hospederos como las condiciones ambientales que habitan. En este estudio se analizó la diversidad parasitaria de dos especies representativas de la costa sur del Golfo de México: el tiburón toro *Carcharhinus leucas* (Müller & Henle, 1839), capturado en diversas localidades pesqueras de los estados de Campeche y Tabasco (Seybaplaya, Champotón, Ciudad del Carmen y Barra de San Pedro), y la raya látigo *Hypanus americanus* (Hildebrand & Schroeder, 1928), colectada en Seybaplaya, Campeche. En *C. leucas*, los diez ejemplares examinados presentaron una prevalencia del 100% de infección parasitaria, con un total de 175 individuos pertenecientes a los grupos Monogenea, Cestoda, Nematoda y Copepoda. Los taxones identificados fueron *Nesippus orientalis* (Heller, 1865), *Nemesis* sp. (Risso, 1826), *Paralebion elongatus* (Wilson, 1911), *Erpocotyle carcharhini* (Watson & Thorson, 1976), *Granulinema carcharhini* (Moravec & Little, 1988) y *Nybelinia* sp. (Poche, 1926), siendo los cestodos el grupo más abundante (64.57%). En 14 ejemplares examinados de *H. americanus* se registraron un total de 1,775 endoparásitos (953 en machos y 822 en hembras), pertenecientes a los grupos Cestoda y Nematoda. En esta especie se identificaron los géneros *Acanthobothrium* (Van Beneden, 1849), *Nybelinia* (Poche, 1926), *Oncomegas* (Dollfus, 1929), *Pterobothrium* (Diesing, 1850), *Phyllobothrium* (Van Beneden, 1850), *Grillotia* (Guiart, 1927) y *Anisakis* (Dujardin, 1845). *Oncomegas* presentó la mayor prevalencia (100%) y *Phyllobothrium* la menor (7.14%); además, *Grillotia* se reporta por primera vez en *H. americanus* para el Golfo de México. En conjunto, los resultados evidencian una alta diversidad parasitaria dominada por cestodos, lo cual podría reflejar alteraciones en los hábitats costeros. Este estudio aporta nuevos registros de parásitos y refuerza el valor de la parasitología como herramienta para comprender la biodiversidad y evaluar el estado ecológico de los elasmobranquios del sur del Golfo de México.

Palabras clave: *Carcharhinus leucas* – Céstodos – Copépodos – Diversidad parasitaria – Elasmobranquios – Golfo de México – *Hypanus americanus* – Monogéneos – Nemátodos.

INTRODUCTION

Elasmobranchs have a wide distribution in tropical and subtropical seas worldwide. In coastal environments they can be found in estuaries, shallow freshwater streams, and coastal lagoon systems (Compagno, 1984). In the Mexican region of the Gulf of Mexico, there is a high diversity of sharks and rays, with more than 80 species recorded, of which approximately 20 have commercial importance. Along the coast of Campeche (Mexico), artisanal fisheries report elasmobranchs among the most abundant resources, particularly shark species such as *Rhizoprionodon terraenovae* (Richardson, 1836) and *Sphyrna tiburo* (Linnaeus 1758), which together represent 88% of shark landings in the state (Martínez-Cruz *et al.*, 2011, 2012).

Within this group, the bull shark *Carcharhinus leucas* (Müller & Henle, 1839) and the southern stingray *Hypanus americanus* (Hildebrand & Schroeder, 1928) are species of ecological and economic relevance. The bull shark is a diadromous fish with a broad distribution in tropical and subtropical continental coasts worldwide, including coastal areas, estuaries, and lacustrine systems. It is commercially exploited along the Gulf of Mexico coastline, where it contributes approximately 2% of total shark landings (Bravo-Zavala *et al.*, 2022). *H. americanus* is distributed in the western Atlantic Ocean, from New Jersey (USA) to southern Brazil, and is one of the most abundant ray species in the elasmobranch fisheries of the southern Gulf of Mexico. This species primarily inhabits shallow coastal waters, bays, and seagrass meadows (FishBase, 2022). In recent years, its population has shown an estimated decline of 20–29% over the last three generations and is currently considered "Near Threatened" (Carlson *et al.*, 2020).

Over recent decades, coastal fisheries of the Gulf of Mexico have been affected by overexploitation, pollution, habitat modification, and other factors that compromise population health (Vidal-Martínez *et al*., 2015; Morales-Serna *et al*., 2019). In this context, the study of parasites associated with elasmobranchs represents a useful tool for assessing the ecological status of marine ecosystems, as parasites can act as bioindicators of environmental disturbances (Sures *et al*., 2017). Sharks and rays, by occupying high trophic levels, provide an exceptional habitat for a wide diversity of parasitic fauna, particularly intestinal helminths such as cestodes (Rodríguez-Santiago *et al*., 2019, Kleinertz et al., 2022).

In the case of *C. leucas*, more than 50 parasite species have been recorded worldwide (Rodríguez-Santiago *et al*., 2019, Solano-Barquero *et al*., 2023). However, local studies are scarce, and most have focused on endoparasites, leaving the ectoparasitic fauna poorly documented despite recent reports of parasitic copepods in sharks from the Gulf of Mexico (Rodríguez-Santiago *et al.*, 2015; Rodríguez-Santiago *et al.*, 2016). Similarly, for *H. americanus*, parasitological knowledge remains limited despite its ecological and fishery relevance (Méndez & Galván-Magaña, 2016; Merlo-Serna & García-Prieto, 2016; Pozos-Carré *et al.*, 2020; Rodríguez-Santiago *et al.*, 2019).

Given this scenario, the aim of the present study is to report the parasitic fauna recorded in two elasmobranch species commonly captured along the southern coast of the Gulf of Mexico: the bull shark (*C. leucas*), sampled in localities of Campeche and Tabasco (Seybaplaya, Champotón, Ciudad del Carmen, and Barra de San Pedro), and the southern stingray (*H. americanus*), collected in

Seybaplaya, Campeche. This study contributes to the knowledge of parasitological biodiversity in the region, as well as to the ecological understanding of the host species and their marine environment.

MATERIALS AND METHODS

Study area

The habitats of the southern Gulf of Mexico encompass a wide variety of coastal ecosystems, including lagoons, estuaries, dunes, mangroves, seagrass beds, and coral reefs, which support more than one thousand fish species. This region is part of the marine ecoregion known as the Southern Gulf of Mexico, a semi-enclosed basin influenced by tropical currents that includes the waters off the states of Veracruz, Tabasco, Campeche, and Yucatán (Wilkinson *et al.*, 2009). The economy of this zone depends largely on three main activities: oil and gas extraction, fisheries, and tourism.

Figure 1. Geographic location of the four sampling sites along the southern coast of the Gulf of Mexico: Seybaplaya, Champotón, Ciudad del Carmen, and Barra de San Pedro. The inset shows the position of the study area within the Mexican Republic.

For the present study, four representative localities along the southern coast of the Gulf of Mexico were selected: Seybaplaya (19° 38′ 02″ N, 90° 41′ 02″ W), Champotón (19° 21′ N, 90° 43′ W), and Ciudad del Carmen (18° 38′ 32″ N, 91° 50′ 29″ W) in the state of Campeche, and Barra de San Pedro (18° 39′ 30″ N, 92° 28′ 12″ W) in the state of Tabasco (Fig. 1). Sampling of *C. leucas* was conducted in all four localities, whereas specimens of *H. americanus* were collected exclusively in the fishing zone of Seybaplaya, Campeche.

Host collection

***Carcharhinus leucas* (bull shark)**

Two sampling campaigns were conducted during two collection periods: the first between February and April, and the second between September and November of 2014. A total of 10 specimens were obtained from four localities in the states of Campeche and Tabasco, with the support of local fishing cooperatives and fish vendors from the municipal market of Ciudad del Carmen. Specimens were identified using the field guides of SAGARPA (2008), recording both males and females of different sizes.

For each individual, morphometric data—including total length (cm) and body weight (kg)—were recorded. Dissections were performed to remove the gills and spiral valve for parasitological examination. These organs were placed in properly labeled plastic bags and preserved in 70% ethanol for storage and transport to the Environmental Parasitology Laboratory at the Environmental Sciences Research Center of the Universidad Autónoma del Carmen (UNACAR) in Ciudad del Carmen, Campeche, Mexico.

***Hypanus americanus* (southern stingray)**

Specimens were obtained from the locality of Seybaplaya, Campeche, during two sampling events conducted in August 2020 and April 2021. Individuals were identified using the key of Mejía-Falla *et al.* (2011). For each specimen, morphometric data such as disk length and width (cm) were recorded (Fig. 2), and dissections were performed to remove the gills and spiral valve for parasitological examination. These organs were placed in properly labeled plastic bags, fixed in 70% ethanol, and kept under cold conditions in a portable cooler for transport to the Environmental Parasitology Laboratory.

Processing of biological samples

Parasitological analyses were conducted following the procedures described by Guzmán-Cornejo *et al.* (2012).

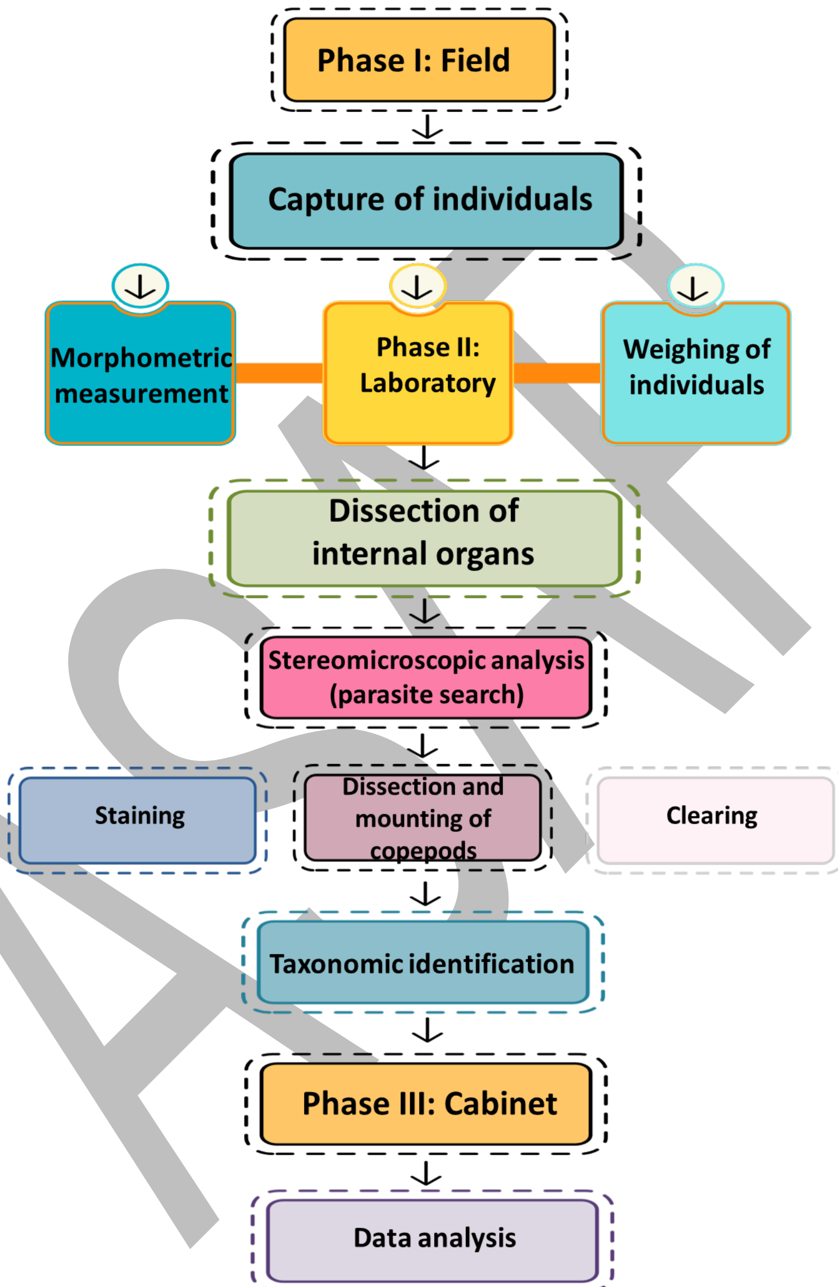

Figure 2. Flowchart illustrating the parasitological procedure divided into three phases. Phase I (Field) includes the capture of individuals, morphometric measurements, and weighing. Phase II (Laboratory) involves the dissection of internal organs, stereomicroscopic examination for parasite

detection, staining and clearing procedures, and the dissection and mounting of copepods, followed by taxonomic identification. Phase III (Cabinet) corresponds to data analysis and final processing.

Parasite identification

Parasite identification was conducted through detailed observation of the characteristic morphological structures of each specimen, with emphasis on diagnostic features. Taxonomic determination was carried out to the levels of family, genus, and species through comparison with previously published morphological descriptions, the use of specialized taxonomic keys, and relevant scientific literature for each metazoan parasite group (Yamaguti, 1959, 1961, 1963, 1971; Anderson *et al.* 1974-1983; Khalil *et al.*, 1994; Walter & Boxshall, 2008, among others). Graphic illustrations of each identified genus were produced using CorelDraw X8, once the helminths had been identified. Two observation techniques were employed: (1) staining using Meyer's paracarmine method (Salgado-Maldonado, 1979) for monogeneans and cestodes, and (2) the technique proposed by Moravec *et al.* (1993) for nematodes and copepods, which involves gradual glycerine solutions to clear the cuticle and allow visualization of internal taxonomic structures of interest (Fig. 2).

Scanning Electron Microscopy (SEM)

For ultrastructural analysis, selected representative specimens of the recovered parasites were processed for scanning electron microscopy. Samples were fixed in 2.5% glutaraldehyde in phosphate buffer, dehydrated through a graded ethanol series, subjected to critical point drying, and subsequently coated with a gold–palladium layer. Observations were carried out using a scanning electron microscope at the facilities of CINVESTAV, Mérida, México.

Data analysis

The characterization of the parasitic communities of *C. leucas* and *H. americanus* was performed following the quantitative ecological descriptors proposed by Bush *et al.* (1997), including prevalence, mean abundance, and mean intensity.

Ethical aspects

All specimens analyzed in this study were obtained from artisanal fisheries and local markets, and no organisms were captured or sacrificed exclusively for research purposes. The collection and handling of hosts complied with national regulations and ethical guidelines for the use of animals in scientific research. Parasitological examinations were conducted following established protocols to minimize unnecessary handling of biological material.

RESULTS

A total of 10 specimens of bull shark (*C. leucas*) were examined: six individuals from Champotón, one from Seybaplaya, one from Ciudad del Carmen, and two from Barra de San Pedro. The mean (± standard deviation) total length of these individuals was 132.37 ± 55.67 cm, and mean body weight was 69.6 ± 30.32 kg. A total of 175 parasites were recorded, corresponding to six parasitic species: one cestode (*Nybelinia* sp.; Fig. 2. A1), one monogenean (*Erpocotyle carcharhini* (Watson & Thorson, 1976) (Fig. 2. A2), one nematode (*Granulinema carcharhini* (Moravec & Little, 1988)) Fig. 3. B1), and three copepods (*Nemesis* sp., (Fig. 2. A3) *Nesippus orientalis* (Heller, 1865) (Fig. 3. B3), and *Paralebion elongates* (Wilson, 1911)) (Fig. 3, B5). The organs with the highest levels of infection were the stomach and spiral valve, primarily due to cestodes.

In the case of the southern stingray (*H. americanus*), a total of 14 specimens from Seybaplaya, Campeche, were examined. Disk length and width (cm) were recorded or estimated for each individual. The mean (± standard deviation) disk width was 56.71 ± 8.91 cm, and the disk length was estimated at approximately 42.5 ± 6.7 cm, based on the proportional relationship between disk width and disk length reported for dasyatid rays. A total of 1,775 parasites were recorded, representing seven parasitic species: six cestodes (*Oncomegas* sp., (Fig. 4, C1), *Pterobothrium* sp., (Fig. 4, C2), *Grillotia* sp., (Fig. 4, C3, *Phyllobothrium* sp., (Fig. 4, C1), *Nybelinia* sp., *Acanthobothrium* sp.) and one nematode (*Anisakis* sp.) (Fig. 2, 3 y 4). Cestodes were the predominant helminth group during both sampling periods, occurring in all fourteen spiral valves.

Information regarding prevalence, mean intensity, and mean abundance of the parasites found in both elasmobranch species is presented in Table 1.

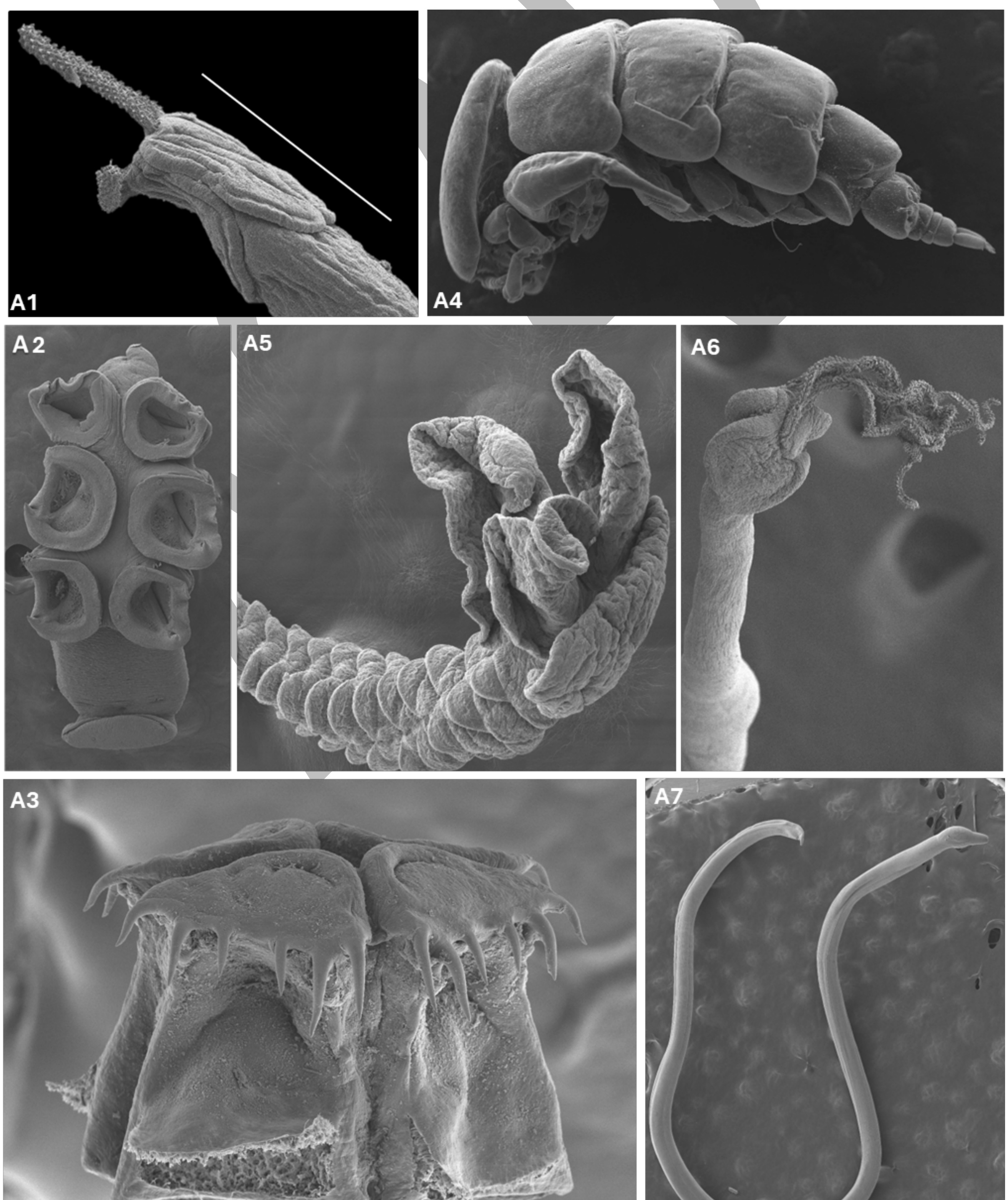

Figure 3. Imágenes obtenidas mediante microscopía electrónica de barrido (MEB). (A1) *Nybelinia* sp. de *C. leucas*, mostrando el escólex en vista lateral con los tentáculos en las regiones basal y metabasal. (A2) *Erpocotyle carcharhini* de *C. leucas*, apreciándose el organismo completo. (A3) *Acanthobothrium* sp. procedente de la válvula espiral de *H. americanus*. (A4) *Nemesis* sp. de *C. leucas*. (A5) *Phyllobothrium* sp. obtenido de la válvula espiral de *H. americanus*. (B6) *Nybelinia* sp. de *H. americanus*. (B7) Representación morfológica de *Anisakis* sp. procedente de la válvula espiral de *H. americanus*.

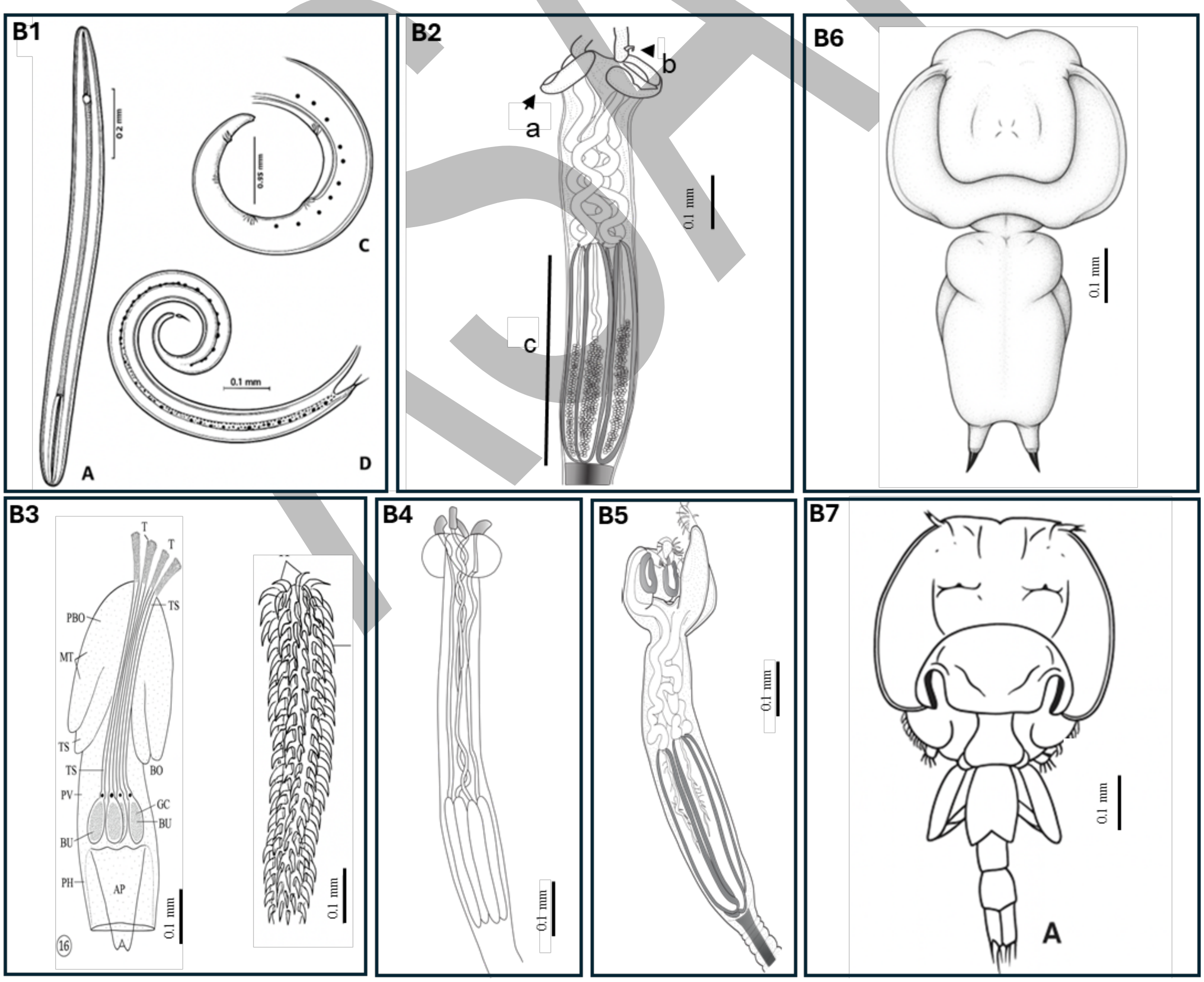

Figure 4. (B1) *Granulinema carcharhini* (male): A) esophageal region; B) anterior part of the body; C) tail; D) posterior part of the body (modified from Moravec & Little, 1988). (B2) Morphological representation of *Oncomegas* sp. obtained from the spiral valve of *H. americanus*. (B3) *Nybelinia* sp. from *H. americanus*. (B4) Morphological representation of *Grillotia* sp. from the spiral valve of *H. americanus*. (B5) Morphological representation of *Pterobothrium* sp. obtained from the spiral valve of *H. americanus*. (B6) Dorsal view of *Nesippus orientalis* observed under the microscope. (B7) *Paralebion elongatus*: male specimen in dorsal view. Morphological drawings were digitally prepared using CorelDRAW 2024 based on microscopic observations.

Table 1. Infection parameters for each parasite species recorded in *Carcharhinus leucas* and *Hypanus americanus*.

Parasite group	Parasite species	Total number of parasites	Prevalence (%)	Mean abundance ± Standard deviation	Mean intensity ± Standard deviation
Bull shark (*Carcharhinus leucas*)					
Monogenea	*Erpocotyle carcharhini*	25	30	2.5±1.5	11.3 ± 5.4
Cestoda	*Nybelinia* sp.	113	100	11.3±3.36	2 ± 0
Nematoda	*Granulinema carcharhini*	2	10	0.2±0.45	8.3 ± 4.9
Copepoda	*Nemesis* sp.	6	10	0.6±0.77	6 ± 0
	Nesippus orientalis	12	30	1.2±1	4 ± 2.1
	Paralebion elongatus	17	30	1.7±1.3	5.6 ± 0.9
Southern stingray (*Hypanus americanus*)					
Cestoda	*Oncomegas* sp.	956	100	68.28 ± 66.98	68.28 ± 66.98
	Pterobothrium sp.	620	92.85	44.28 ± 41.17	47.69 ± 40.75
	Phyllobothrium sp.	2	7.14	0.14 ± 0.53	2 ± 0
	Nybelinia sp.	2	14.28	0.14 ± 0.36	1 ± 0
	Acanthobothrium sp.	47	35.71	3.35 ± 6.87	9.4 ± 9.09
	Grillotia sp.	144	71.42	10.28 ± 9.44	14.4 ± 7.93
Nematoda	*Anisakis* sp.	4	21.42	0.28 ± 0.61	1.33 ± 0.57

DISCUSSION

This study represents a significant contribution to the parasitological knowledge of elasmobranchs along the southern coast of the Gulf of Mexico, constituting the first record of parasites in *C. leucas* from the localities of Seybaplaya, Champotón, and Ciudad del Carmen in Campeche, and Barra de San Pedro in Tabasco, as well as a new parasitological record for *H. americanus* captured in Seybaplaya, Campeche. These results expand the understanding of the geographic distribution of parasitic species in the Gulf of Mexico and suggest the presence of environmental and ecological conditions that favor their establishment in this region, without implying that they are exclusive to these areas.

In *C. leucas*, the ecto- and endoparasite species recorded had not been previously reported for this shark along the coasts of Mexico, allowing it to be considered a new host for several taxa. When compared with studies from other regions of the Gulf, such as that of Méndez & Dorantes-González (2013) in Veracruz, where eight cestode species were reported, only one cestode species (*Nybelinia* sp.) was identified in the present study. This may be attributed to differences in feeding habits, availability of intermediate hosts, or local environmental variations. *C. leucas* is an opportunistic predator (Compagno, 1984) whose diet includes bony fishes potential intermediate hosts of cestodes which explains the presence of helminths such as *Granulinema carcharhini*, a species previously reported in the Gulf of Mexico but with limited taxonomic information (Moravec & Little, 1988). Likewise, the absence of *Erpocotyle carcharhini* in *C. leucas* captured in low-salinity environments such as Laguna de Términos and the San Pedro River aligns with Watson & Thorson (1976), who suggested low tolerance of this parasite to freshwater conditions.

Regarding copepods, genera such as *Nemesis* and *Nesippus* are common gill parasites of sharks, and their presence in this region represents the first record for Mexico, although they have been previously documented in the western Atlantic and African waters (Cressey, 1970; Oldewage, 1993). These observations reinforce the hypothesis that *C. leucas*, by moving between marine and estuarine environments, may act as a vector of interoceanic parasite dispersal.

In *H. americanus*, seven helminth genera were identified, with a prevalence of 100% for the Class Cestoda and 21.42% for the Phylum Nematoda. The high frequency of cestodes is consistent with reports from other elasmobranchs in the Gulf of Mexico (Méndez & Dorantes-González, 2017; Dorantes-González & Méndez, 2018; Pozos-Carré *et al.*, 2020), where this group constitutes the dominant fraction of the parasitic fauna. This high prevalence is associated with the benthic diet of the ray, which includes mollusks, crustaceans, and small fishes (FishBase, 2022), making it a suitable host for larval stages of numerous cestodes (Palm, 2011).

The genera *Oncomegas* and *Pterobothrium* were the most abundant, with prevalences of 100% and 92.85%, respectively—results comparable to those observed in Veracruz (Pozos-Carré *et al.*, 2020). *Oncomegas wageneri*, in particular, has been associated with areas containing aromatic hydrocarbons (Vidal-Martínez *et al.*, 2015), which may indicate exposure to contaminants in Seybaplaya. Other genera, such as *Phyllobothrium* and *Acanthobothrium*, exhibited lower prevalences, although their presence reaffirms their role as typical parasites of Gulf elasmobranchs (Méndez *et al.*, 2018). Also noteworthy is the first record of *Grillotia* in *H. americanus* for the Gulf of Mexico, expanding the known distribution of this genus, previously reported in other rays from the Atlantic and southern Africa (Álvarez *et al.*, 2006; Oosthuizen *et al.*, 2021).

The low representation of nematodes in both species agrees with observations from other studies and may be attributed to the high concentrations of urea present in elasmobranchs, which hinder the development of these helminths (Modzelesky, 2018; Solano-Barquero *et al.*, 2025).

Overall, the results obtained for both species represent only a portion of the parasitic diversity known in chondrichthyans from the Gulf of Mexico, where at least 47 cestode species have been recorded in 27 of the 128 described species (Chandler, 1954; McEachran, 2009; Adán-Torres *et al*., 2025). Nonetheless, the findings of this study suggest the existence of ecological barriers or limiting factors that shape the distribution of certain parasites within the Gulf, potentially influenced by salinity, habitat type, feeding habits, and anthropogenic disturbance. Therefore, expanding sampling areas and increasing sample sizes in future studies will provide a better understanding of the biogeographic patterns and parasite-host relationships in elasmobranchs from the southern (Gulf of Mexico) (Solano-Barquero *et al*., 2025).

This study provides a valuable contribution to the parasitological knowledge of elasmobranchs along the southern coast of the Gulf of Mexico, documenting for the first time the parasitic composition of the bull shark in Campeche and Tabasco, and of the southern stingray in the fishing port of Seybaplaya, Campeche. Six parasite species were recorded in the bull shark, two of which were endoparasites (*Nybelinia* sp. and *G. carcharhini*) and four ectoparasites (*E. carcharhini*, *Nemesis* sp., *N. orientalis*, and *P. elongatus*). In the southern stingray, seven parasite species were recorded six belonging to the Class Cestoda (*Oncomegas*, *Pterobothrium*, *Phyllobothrium*, *Nybelinia*, *Grillotia*, and *Acanthobothrium*) and one to the Phylum Nematoda (*Anisakis*).

The record of *Grillotia* sp. represents the first report of this genus in the southern stingray and in the Gulf of Mexico, extending its known distribution. Overall, the results of this study reveal a high parasitic diversity in the elasmobranchs of the region and highlight the ecological importance of these species as definitive hosts within the trophic networks of the Gulf of Mexico. This work provides a foundation for future research on parasite biogeography, environmental factors influencing helminth distribution, and the potential role of coastal conditions such as salinity and anthropogenic activity in structuring parasitic communities.

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