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Short Note

Parasites of Pygmy Sperm Whales (*Kogia breviceps*) Stranded in the Southern Gulf of Mexico

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Mexico contains a high diversity of marine mammals, with 34 species of whales, dolphins, and manatees reported in the Gulf of Mexico (Würsig et al., 2000). Of these, 27 species are recorded for the State of Yucatan, including the pygmy sperm whale (*Kogia breviceps* [Blainville, 1838]; Sosa-Escalante et al., 2014). The pygmy sperm whale inhabits tropical and temperate oceanic waters (Iñiguez et al., 2011), and sightings are common in the Gulf of Mexico (Würsig, 2017). Stranding events are less common and have been documented in the Gulf of Mexico along the coasts of Veracruz, Tabasco, Quintana Roo, and Yucatan (Heckel et al., 2018).

Strandings provide a good opportunity to obtain scientific information, including parasitic forms on the stranded individual and species. Parasites play an important role in regulating wild populations and are key in the biodiversity of ecosystems (Luque, 2008). In addition, parasites have proven useful as biological tags for host social structure, movements, and other ecological aspects (Mignucci-Giannoni et al., 1998; Colón-Llavina et al., 2009). Some parasites of marine mammals also have public health and economic importance (Oshima & Kliks, 1987; Balbuena et al., 1995). Furthermore, they can significantly affect individuals and populations of marine mammals (Geraci & Lounsbury, 1993). Therefore, studying the parasites of marine mammals such as pygmy sperm whales can contribute to understanding the causes of stranding and mortality and provide biological and ecological information on its hosts (Carvalho et al., 2010), thereby supporting the conservation of these protected species (Colón-Llavina et al., 2009).

On the Atlantic coast of the Americas, there are parasitological reports from pygmy sperm whales in the waters of Brazil, Canada, Florida, Mexico, and Puerto Rico (Zam et al., 1971; McAlpine et al., 1997; Mignucci-Giannoni et al., 1998; Santos & Lodi, 1998; Mattiucci et al., 2005; González-Solís et al., 2006; Colón-Llavina et al., 2009; Carvalho et al., 2010; Iñiguez et al., 2011; Di Azevedo et al., 2017). In Mexico, there are parasitological studies for only six species of cetaceans (Lamothe, 1988; Morales-Vela & Olivera-Gómez, 1993; Aguilar-Aguilar et al., 2001, 2010; Aguilar-Aguilar & Moreno-Navarrete, 2002), including a report of anisakid nematodes from the digestive tract of *K. breviceps* on the coast of the Yucatan Peninsula (González-Solís et al., 2006). In the present work, we report helminths of the stomach, fat, and subcutaneous area of the neck of pygmy sperm whales stranded in the southern Gulf of Mexico.

Five individuals of *K. breviceps* were found stranded in four locations on the coast of Yucatan, southern Gulf of Mexico, including one individual in 2009 and four individuals in 2016 (Table 1). Stranding management and the corresponding necropsies were carried out following the Protocol for Management to Stranding of Marine Mammals (Diario Oficial de la Federación [DOF], 2014). Before necropsy, sex was determined, and standardized measurements of the individuals were taken. During the necropsies, nematodes were collected from the stomach, cestodes from the fat, and nematodes from the subcutaneous area of the neck. The samples were preserved in 70% ethanol. For morphological identification, the nematodes were rinsed with a mixture of glycerin and distilled water at different concentrations, and then in lactophenol. The cestodes were prepared with hydrochloric carmine and mounted in permanent preparations with Canada balsam (Vidal-Martínez et al., 2001). Finally, the parasites were taxonomically identified using specialized keys (Deardorff & Overstreet, 1981; Khalil et al., 1994; Failla & Le, 2003; Mattiucci et al., 2005; Jabbar et al., 2015). Infection parameters were measured as

Table 1. Stranding records of the pygmy sperm whale (*Kogia breviceps*) from 2009 to 2016 in the southern Gulf of Mexico. Ab = *Anisakis brevispiculata*, Ap = *Anisakis paggiae*, Pc = *Pseudoterranova ceticola*, Cm = *Crassicauda magna*, and Cd = *Clistobothrium delphini*.

Date	Stranding code	Sex	Stage	Total length (cm)	Helminths	Locality
13 Sept. 2009	3	Female	Adult	296	Ab, Pc, Cd	El Cuyo, Yucatan
6 Jan. 2016	1	Male	Adult	336	Cm, Cd	Sisal, Yucatan
27 May 2016	1	Female	Juvenile	217	Ab, Ap, Pc	Telchac Puerto, Yucatan
28 May 2016	1	Female	Adult	285	Cm, Cd	Telchac Puerto, Yucatan
30 June 2016	1	Female	Adult	300	Cm	Chuburna Puerto, Yucatan

prevalence, mean intensity, and mean abundance as proposed by Bush et al. (1997). Prevalence was expressed as a probability (range: 0 to 1) using Sterne's method (Reiczigel, 2003), and confidence intervals were established for mean intensity and mean abundance using bias-corrected accelerated bootstrap with 10,000 replicates (Rózsa et al., 2000). The free software *Quantitative Parasitology* (*QPweb*), Version 1.0.15 (Reiczigel et al., 2019), was used to calculate infection parameters.

All individuals of *K. breviceps* presented at least one species of helminth. A total of 2,513 worms belonging to five taxa of parasitic helminths were obtained. In the stomach, we identified 2,190 individuals of *Pseudoterranova ceticola*, 294 individuals of *Anisakis brevispiculata*, and nine individuals of *Anisakis paggiae*. In addition, several fragments of *Crassicauda magna*, including portions of three individuals, were obtained from the subcutaneous area behind the head (Figure 1), and 17 cestodes of *Clistobothrium* (=*Phyllobothrium*) *delphini* were extracted from the fat (Figure 2). The highest prevalence was observed in *C. magna* and *C. delphini*, with mean intensity and abundance in *P. ceticola* and *A. brevispiculata* (Table 2).

The nematodes were the most varied parasites of the pygmy sperm whales stranded in the southern Gulf of Mexico, mainly anisakids, which are commonly found in *K. breviceps* and were present in large quantities in the digestive tract of this cetacean. *P. ceticola* (small nematodes, with a wider middle part of the body and the presence of an intestinal cecum; Figure 3a) have previously been reported in *K. breviceps* from the Atlantic coast of Canada (McAlpine et al., 1997), Galician coasts (Abollo & Pascual, 2002), Florida (Cavallero et al., 2011), and the Yucatan Peninsula (González-Solís et al., 2006). *A. brevispiculata* (long-bodied nematodes, with a short and simple ventricle; Figure 3b) has been reported from specimens on the Galician coast (Abollo & Pascual, 2002), the Yucatan Peninsula (González-Solís et al., 2006), the Philippines (Quiazon, 2016), Brazil (Di Azevedo

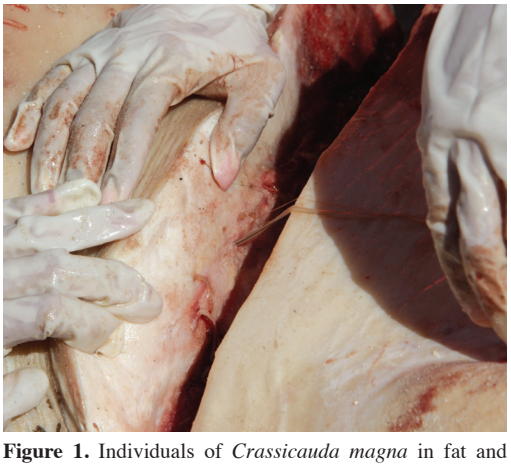

Figure 1. Individuals of *Crassicauda magna* in fat and muscle of the pygmy sperm whale (*Kogia breviceps*)

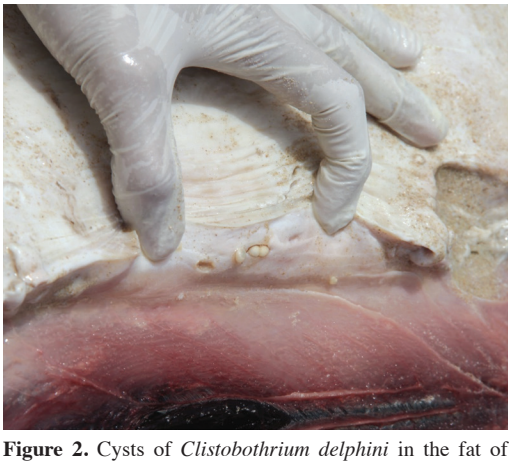

Figure 2. Cysts of *Clistobothrium delphini* in the fat of *K. breviceps*

Table 2. Infection parameters of the helminths in *K. breviceps* from the southern Gulf of Mexico

Helminth	Prevalence (CI 95%)	Mean intensity (CI 95%)	Mean abundance (CI 95%)
Nematoda			
Anisakis brevispiculata	0.40 (0.076-0.811)	147 (56-147)	58.8 (0-154)
Anisakis paggiae	0.20 (0.010- 0.657)	9	1.8 (0-36)
Pseudoterranova ceticola	0.40 (0.076-0.811)	1,100 (246-1,100)	438 (0-1,220)
Crassicauda magna	0.60 (0.189-0.924)	1.7 (1-2.3)	1 (0.2-2)
Cestoda			
Clistobothrium delphini	0.60 (0.189-0.924)	6.3 (1-11.7)	3.8 (0.2-10.6)

et al., 2017), and Australia (Shamsi et al., 2019). *A. paggiae* (characterized by a short, violin-shaped ventricle; Figure 3c) is reported from *K. breviceps* throughout the coasts of Florida (Mattiucci et al., 2005), the Philippines (Quiazon, 2016), Brazil (Di Azevedo et al., 2017), New Caledonia (Shamsi et al., 2018), and Australia (Shamsi et al., 2019).

Some studies report only the genus *Anisakis* of *K. breviceps* in Brazil, Puerto Rico, and New Zealand (Mignucci-Giannoni et al., 1998; Carvalho et al., 2010; Lehnert et al., 2019). In Mexican waters, the presence of anisakids in cetaceans has been reported in three species: (1) the spinner dolphin (*Stenella longirostris*) with *Anisakis typica* in Baja California Sur, (2) the pygmy killer whale (*Feresa attenuata*) with *Anisakis* sp. in Veracruz, and (3) *K. breviceps* with *Anisakis simplex*, *A. brevispiculata*, and *P. ceticola* in the Yucatan Peninsula (Aguilar-Aguilar et al., 2001; Aguilar-Aguilar & Moreno-Navarrete, 2002; González-Solís et al., 2006). González-Solís et al. (2006) reported that *P. ceticola* was the most abundant species in *K. breviceps* as was also found in the present study. Anisakids have been associated with gastric lesions in cetaceans and can cause ulcers and granulomatous dermatitis (Iñiguez et al., 2011; Van Beurden et al., 2015). In *K. breviceps*, anisakids have an adverse impact on the intestines, which can cause malnutrition and stress (Shamsi et al., 2019). It has been mentioned that anisakids can cause serious infections in marine mammals; however, their pathogenicity is under discussion (Shamsi et al., 2012). The presence of adult anisakids in cetaceans is not a direct risk to public health. Indirectly, the dispersion of larval stages could infect cephalopods and marine fish and accidentally be consumed by humans (Quiazon, 2016).

Fragments of *C. magna* (large and long nematodes; males with five pairs of papillae and cuticular ornamentation; Figure 3d) were also obtained from our samples, including a portion with a length of 107 cm on the tail of a male individual. This nematode infects the connective tissues and subcutaneous musculature of the neck region of *K. breviceps* (Keenan-Bateman et al., 2018). *C. magna* has been previously reported on *K. breviceps* in Australia (Jabbar et al., 2015), the United States (Keenan-Bateman et al., 2018), and New Zealand (Lehnert et al., 2019). In Mexico, there is only one report of *Crassicauda* sp. in short-finned pilot whales (*Globicephala macrorhynchus*) in Cozumel, Quintana Roo (Morales-Vela & Olivera-Gómez, 1993). The cestode *C. delphini* (Figure 3e) is frequently observed in the fat of these cetaceans and has been reported in *K. breviceps* off the coast of Florida (Zam et al., 1971), Canada (McAlpine et al., 1997), Spain (Abollo et al., 1998), Puerto Rico (Colón-Llavina et al., 2009), Brazil (Carvalho et al., 2010), and New Zealand (Lehnert et al., 2019). No damage has been reported from *C. delphini* infection, even at high intensities (McAlpine et al., 1997; Dailey, 2001). Its definitive hosts are elasmobranchs, and cetaceans act as intermediate hosts (Dailey, 2001).

The diversity of parasitic helminths observed in individuals of *K. breviceps* stranded in the southern Gulf of Mexico is most probably due to their feeding habits. Their basic diet consists of cephalopods, mainly from the families Cranchiidae, Enoploteuthidae, Histioteuthidae, Lycoteuthidae, and Ommastrephidae (Bloodworth & Odell, 2008). In southeastern Brazil, their main cephalopod prey has been reported to be from the families Lycoteuthidae, Histioteuthidae, and Ommastrephidae (Aguiar dos Santos & Haimovici, 2001); while in New Zealand, it has been reported that the diet of this host consists mainly of cephalopods (94%), which are almost exclusively pelagic, representing 23 species and 13 families (Beatson, 2007). It is common for cephalopods to act as reservoir hosts or even second or third intermediate hosts for the larval stages of helminths (e.g., digeneans, cestodes, acanthocephalans, and nematodes), transferring these parasites through the diet to their final hosts (e.g., marine mammals) (Hochberg, 1990).

In Mexico, there are few cetacean species with any parasitological record, with reports for the pygmy killer whale, the spinner dolphin, the pygmy

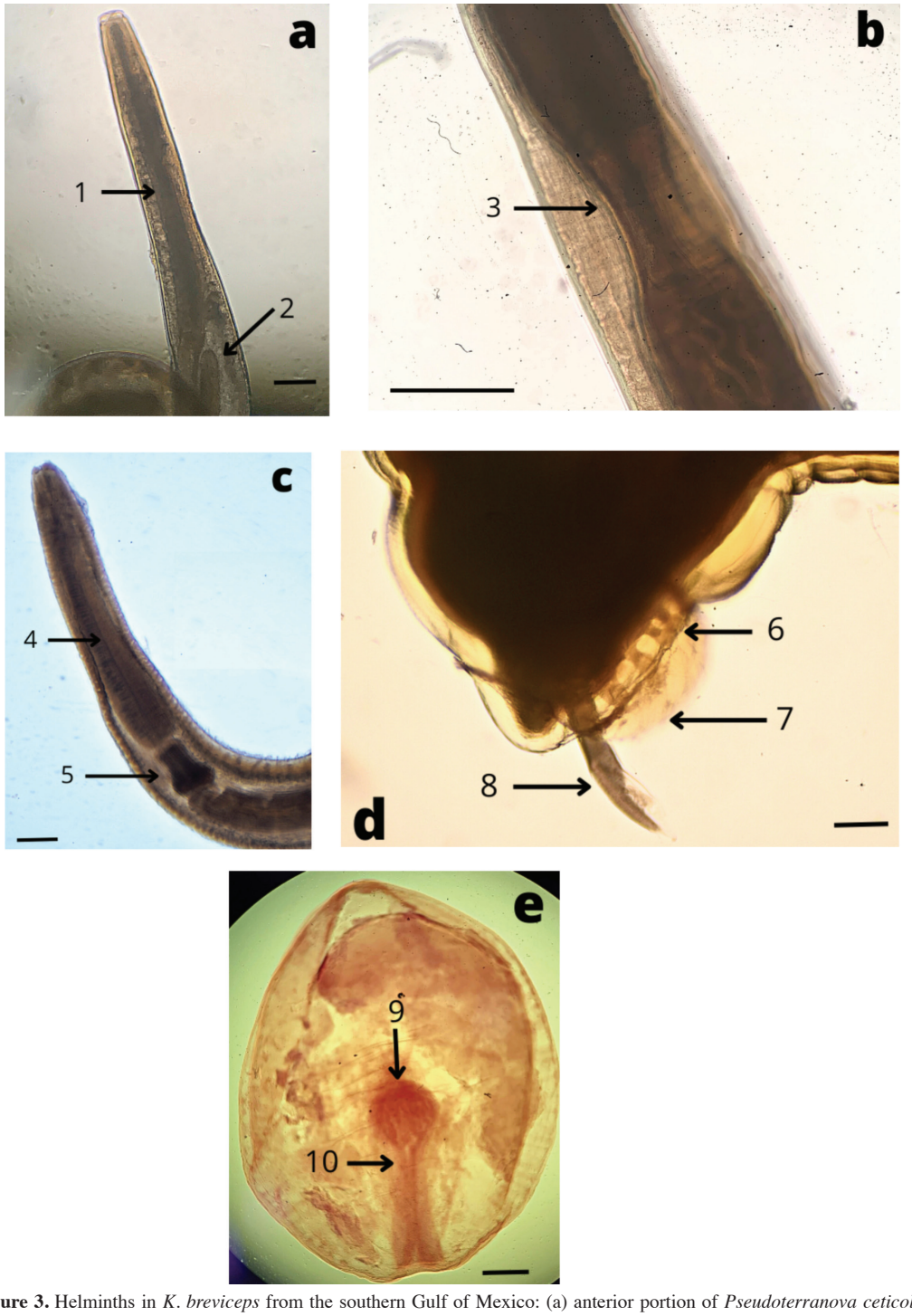

Figure 3. Helminths in *K. breviceps* from the southern Gulf of Mexico: (a) anterior portion of *Pseudoterranova ceticola*, esophagus (1) and intestinal cecum (2); (b) anterior portion of *Anisakis brevispiculata*, simple ventricle (3); (c) anterior portion of *Anisakis paggiae*, esophagus (4) and violin-shaped ventricle (5); (d) posterior portion of *Crassicauda magna*, papillae (6), cuticular ornamentation (7), and spicules (8); and (e) *Clistobothrium delphini*, scolex (9) and neck (10). Scaling bars = 0.5 mm (a, b, c, e) and 1 mm (d).

sperm whale, the short-finned pilot whale, the vaquita (*Phocoena sinus*), and the Clymene dolphin (*Stenella clymene*) (Lamothe, 1988; Morales-Vela & Olivera-Gómez, 1993; Aguilar-Aguilar et al., 2001, 2010; Aguilar-Aguilar & Moreno-Navarrete, 2002; González-Solís et al., 2006). However, with the present study, the number of parasitic helminths reported in *K. breviceps* of the region increases, including the first record of the nematodes *A. paggiae* and *C. magna*, and the cestode *C. delphini* in Mexican waters.

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Literature Cited

Abollo, E., & Pascual, S. (2002). SEM study of *Anisakis brevispiculata* Dollfus, 1966 and *Pseudoterranova ceticola* (Deardoff and Overstreet, 1981) (Nematoda: Anisakidae), parasites of the pygmy sperm whale *Kogia breviceps*. *Scientia Marina*, *66*(3), 249-255. https://doi.org/10.3989/scimar.2002.66n3249

Abollo, E., López, A., Gestal, C., Benavente, P., & Pascual, S. (1998). Macroparasites in cetaceans stranded on the northwestern Spanish Atlantic coast. *Diseases of Aquatic Organisms*, *32*(3), 227-231. https://doi.org/10.3354/dao032227

Aguiar dos Santos, R., & Haimovici, M. (2001). Cephalopods in the diet of marine mammals stranded or incidentally caught along southeastern and southern Brazil (21-34°S). *Fisheries Research*, *52*(1-2), 99-112. https://doi.org/10.1016/S0165-7836(01)00234-X

Aguilar-Aguilar, R., & Moreno-Navarrete, R. G. (2002). Presencia de nemátodos del género *Anisakis* en una orca pigmea *Feresa attenuata* (Cetacea: Delphinidae) varada en costas de Veracruz, México [Presence of nematodes of the genus *Anisakis* in a pygmy killer whale *Feresa attenuata* (Cetacea: Delphinidae) stranded on the coast of Veracruz, Mexico]. *Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoología*, *73*(2), 239-240.

Aguilar-Aguilar, R., Delgado-Estrella, A., & Moreno-Navarrete, R. G. (2010). New host report for nematodes in a stranded short-snouted spinner dolphin *Stenella clymene* (Cetacea: Delphinidae) from the Mexican Caribbean coast. *Helminthologia*, *47*(2), 136-138. https://doi.org/10.2478/s11687-010-0020-0

Aguilar-Aguilar, R., Moreno-Navarrete, R. G., Salgado-Maldonaldo, G., & Villa-Ramírez, B. (2001). Gastrointestinal helminths of spinner dolphins *Stenella longirostris* (Gray, 1828) (Cetacea: Delphinidae) stranded in La Paz Bay, Baja California Sur, Mexico. *Comparative Parasitology*, *68*(2), 272-274.

Balbuena, J. A., Aznar, F. J., Fernández, M., & Raga, J. A. (1995). Parasites as indicators of social structure and stock identity of marine mammals. *Developments in Marine Biology*, *4*, 133-139. https://doi.org/10.1016/S0163-6995(06)80017-X

Beatson, E. (2007). The diet of pygmy sperm whales, *Kogia breviceps*, stranded in New Zealand: Implications for conservation. *Reviews in Fish Biology and Fisheries*, *17*(2-3), 295-303. https://doi.org/10.1007/s11160-007-9039-9

Bloodworth, B. E., & Odell, D. K. (2008). *Kogia breviceps* (Cetacea: Kogiidae). *Mammalian Species*, *819*, 1-12. https://doi.org/10.1644/819.1

Bush, A. O., Lafferty, K. D., Lotz, J. M., & Shostak, A. W. (1997). Parasitology meets ecology on its own terms: Margolis et al. revisited. *Journal of Parasitology*, *84*(4), 575-583. https://doi.org/10.2307/3284227

Carvalho, V. L., Bevilaqua, C. M. L., Iñiguez, A. M., Mathews-Cascon, H., Ribeiro, F. B., Pessoa, L. M. B., de Meirelles, A. C. O., Borges, J. C. G., Marigo, J., Soares, L., & Silva, F. J. (2010). Metazoan parasites of cetaceans off the northeastern coast of Brazil. *Veterinary Parasitology*, *173*(1-2), 116-122. https://doi.org/10.1016/j.vetpar.2010.06.023

Cavallero, S., Nadler, S. A., & Paggi, L. (2011). Molecular characterization and phylogeny of anisakid nematodes from cetaceans from southeastern Atlantic coasts of the USA, Gulf of Mexico, and the Caribbean Sea. *Parasitology Research*, *108*, 781-792. https://doi.org/10.1007/s00436-010-2226-y

Colón-Llavina, M. M., Mignucci-Giannoni, A. A., Mattiucci, S., Paoletti, M., Nascetti, G., & Williams, E. H. (2009). Additional records of metazoan parasites from Caribbean marine mammals, including genetically identified anisakid nematodes. *Parasitology Research*, *105*(5), 1239-1252. https://doi.org/10.1007/s00436-009-1544-4

Dailey, M. D. (2001). Parasitic diseases. In L. A. Dierauf & F. M. D. Gulland (Eds.), *CRC handbook of marine mammal medicine* (2nd ed., pp. 357-379). CRC Press. https://doi.org/10.1201/9781420041637.ch18

Deardorff, T. L., & Overstreet, R. M. (1981). *Terranova ceticola* n. sp. (Nematoda: Anisakidae) from the dwarf sperm whale; *Kogia simus* (Owen), in the Gulf of Mexico. *Systematic Parasitology*, *3*(1), 25-28. https://doi.org/10.1007/BF00012236

Di Azevedo, M. I. N., Carvalho, V. L., & Iñiguez, A. M. (2017). Integrative taxonomy of anisakid nematodes in stranded cetaceans from Brazilian waters: An update on parasite's hosts and geographical records. *Parasitology Research*, *116*(11), 3105-3116. https://doi.org/10.1007/s00436-017-5622-8

Diario Oficial de la Federación (DOF). (2014). *Acuerdo mediante el cual se expide el protocolo de atención para varamiento de mamíferos marinos* [Issuance agreement of the care protocol for the stranding of marine mammals] (17/06/2014). Secretaría de Medio Ambiente y Recursos Naturales. 28 pp.

Failla, G. S., & Le, A. E. B. (2003). Morphometrical categorization of *Phyllobothrium delphini* (Cestoidea, Tetraphyllidea) cysts from Fraser's dolphin, *Lagenodelphis hosei* (Cetacea, Delphinidae). *Latin American Journal of Aquatic Mammals*, *2*(2), 95-100. https://doi.org/10.5597/lajam00037

Geraci, J. R., & Lounsbury, V. J. (1993). *Marine mammals ashore: A field guide for strandings*. Texas A&M University.

González-Solís, D., Vidal-Martínez, V. M., Antochiw-Alonso, D. M., & Ortega-Argueta, A. (2006). Anisakid nematodes from stranded pygmy sperm whales, *Kogia breviceps* (Kogiidae), in three localities of the Yucatan Peninsula, Mexico. *Journal of Parasitology*, *92*(5), 1120-1122. https://doi.org/10.1645/GE-3553RN.1

Heckel, G., Ruiz, M. G. M., Schramm, Y., & Gorter, U. (2018). *Atlas de distribución y abundancia de mamíferos marinos en México* [Atlas of distribution and abundance of marine mammals in Mexico]. Universidad Autónoma de Campeche. https://doi.org/10.26359/epomex.cemie022018

Hochberg, F. G. (1990). Diseases caused by protistans and metazoans. In O. Kinne (Ed.), *Diseases of marine animals: Vol. III. Introduction, Cephalopoda, Annelida, Crustacea, Chaetognatha, Echinodermata, Urochordata* (pp. 47-202, 205-227). Biologische Anstalt Helgoland.

Iñiguez, A. M., Carvalho, V. L., Motta, M. R. A., Pinheiro, D. C. S. N., & Vicente, A. C. P. (2011). Genetic analysis of *Anisakis typica* (Nematoda: Anisakidae) from cetaceans of the northeast coast of Brazil: New data on its definitive hosts. *Veterinary Parasitology*, *178*(3-4), 293-299. https://doi.org/10.1016/j.vetpar.2011.01.001

Jabbar, A., Beveridge, I., & Bryant, M. S. (2015). Morphological and molecular observations on the status of *Crassicauda magna*, a parasite of the subcutaneous tissues of the pygmy sperm whale, with a re-evaluation of the systematic relationships of the genus *Crassicauda*. *Parasitology Research*, *114*, 835-841. https://doi.org/10.1007/s00436-014-4245-6

Keenan-Bateman, T. F., McLellan, W. A., Costidis, A. M., Harms, C. A., Gay, D. M., Rotstein, D. S., Rommel, S. A., Potter, C. W., & Pabst, D. A. (2018). Habitat use pattern of the giant parasitic nematode *Crassicauda magna* within the pygmy sperm whale *Kogia breviceps*. *Diseases of Aquatic Organisms*, *127*(3), 163-175. https://doi.org/10.3354/dao03205

Khalil, L. F., Jones, A., & Bray, R. A. (1994). *Keys to the cestode parasites of vertebrates*. CAB International.

Lamothe, R. A. (1988). Tremátodos de mamíferos 3. Hallazgo de *Synthesium tursionis* (Marchi, 1873) Stunkard & Alvey, 1930 en *Phocoena sinus* (Phocoenidae) en el Golfo de California, México [Mammalian flukes 3. Finding of *Synthesium tursionis* (Marchi, 1873) Stunkard & Alvey, 1930 in *Phocoena sinus* (Phocoenidae) in the Gulf of California, Mexico]. *Anales del Instituto de Biología, UNAM, Serie Zoología*, *58,* 11-20.

Lehnert, K., Poulin, R., & Presswell, B. (2019). Checklist of marine mammal parasites in New Zealand and Australian waters. *Journal of Helminthology*, *93*, 649-676. https://doi.org/10.1017/S0022149X19000361

Luque, J. L. (2008). Parásitos: ¿Componentes ocultos de la biodiversidad? [Parasites: Hidden components of biodiversity?]. *Biologist*, *6*(1), 5-7. https://doi.org/10.24039/rtb200861519

Mattiucci, S., Nascetti, G., Dailey, M., Webb, S. C., Barros, N. B., Cianchi, R., & Bullini, L. (2005). Evidence for a new species of *Anisakis* Dujardin, 1845: Morphological description and genetic relationships between congeners (Nematoda: Anisakidae). *Systematic Parasitology*, *61*(3), 157-171. https://doi.org/10.1007/s11230-005-3158-2

McAlpine, D. F., Murison, L. D., & Hoberg, E. P. (1997). New records for the pygmy sperm whale, *Kogia breviceps* (Physeteridae) from Atlantic Canada with notes on diet and parasites. *Marine Mammal Science*, *13*(4), 701-704. https://doi.org/10.1111/j.1748-7692.1997.tb00093.x

Mignucci-Giannoni, A. A., Hoberg, E. P., Siegel-Causey, D., & Williams, E. H., Jr. (1998). Metazoan parasites and other symbionts of cetaceans in the Caribbean. *Journal of Parasitology*, *84*(5), 939-946.

Morales-Vela, B., & Olivera-Gómez, L. D. (1993). Varamiento de calderones *Globicephala macrorhynchus* (Cetacea: Delphinidae) en la isla de Cozumel, Quintana Roo, México [Stranding of pilot whales *Globicephala macrorhynchus* (Cetacea: Delphinidae) on the island of Cozumel, Quintana Roo, Mexico]. *Anales del Instituto de Biología, Universidad Nacional Autónoma de México*, *Serie Zoología*, *64*(2), 177-180.

Oshima, T., & Kliks, M. M. (1987). Effects of marine mammal parasites on human health. *International Journal for Parasitology*, *17*(2), 415-421. https://doi.org/10.1016/0020-7519(87)90117-2

Quiazon, K. M. A. (2016). *Anisakis* Dujardin, 1845 infection (Nematoda: Anisakidae) in pygmy sperm whale *Kogia breviceps* Blainville, 1838 from west Pacific region off the coast of Philippine archipelago. *Parasitology Research*, *115*, 3663-3668. https://doi.org/10.1007/s00436-016-5169-0

Reiczigel, J. (2003). Confidence intervals for the binomial parameter: Some new considerations. *Statistics in Medicine*, *22*(4), 611-621. https://doi.org/10.1002/sim.1320

Reiczigel, J., Marozzi, M., Fabian, I., & Rózsa, L. (2019). Biostatistics for parasitologists: A primer to quantitative parasitology. *Trends in Parasitology*, *35*(4), 277-281. https://doi.org/10.1016/j.pt.2019.01.003

Rózsa, L., Reiczigel, J., & Majoros, G. (2000). Quantifying parasites in samples of hosts. *Journal of Parasitology*, *86*(862), 228-232. https://doi.org/10.1645/0022-3395(2000)086[0228:QPISOH]2.0.CO;2

Santos, C. P., & Lodi, L. (1998). Occurrence of *Anisakis physeteris* Baylis, 1923 and *Pseudoterranova* sp. (Nematoda) in pygmy sperm whale *Kogia breviceps* (De Blainvillei,

1838) (Physeteridae) in northeastern coast of Brazil. *Memorias Instituto Oswaldo Cruz*, *93*(2), 187-188. https://doi.org/10.1590/S0074-02761998000200009

Shamsi, S., Gasser, R., & Beveridge, I. (2012). Genetic characterization and taxonomy of species of *Anisakis* (Nematoda:Anisakidae) parasitic in Australian marine mammals. *Invertebrate Systematics*, *26*(2), 204-212. https://doi.org/10.1071/IS11019

Shamsi, S., Spröhnle-Barrera, C., & Hossen, S. (2019). Occurrence of *Anisakis* spp. (Nematoda: Anisakidae) in a pygmy sperm whale *Kogia breviceps* (Cetacea: Kogiidae) in Australian waters. *Diseases of Aquatic Organisms*, *134*, 65-74. https://doi.org/10.3354/dao03360

Shamsi, S., Chen, Y., Poupa, A., Ghadam, M., & Justine, J. L. (2018). Occurrence of anisakid parasites in marine fishes and whales off New Caledonia. *Parasitology Research*, *117*(10), 3195-3204. https://doi.org/10.1007/s00436-018-6018-0

Sosa-Escalante, J. E., Hernández-Betancourt, S., Pech-Canche, J. M., MacSwiney, M. C. G., & Díaz-Gamboa, R. (2014). Los mamíferos del estado de Yucatán [The mammals of the State of Yucatán]. *Revista Mexicana de Mastozoología*, *4*(1), 40-59. https://doi.org/10.22201/ie.20074484e.2014.4.1.190

Van Beurden, S. J., IJsseldijk, L. L., Cremers, H. J. W. M., Gröne, A., Verheije, M. H., & Begeman, L. (2015). *Anisakis* spp. induced granulomatous dermatitis in a harbour porpoise *Phocoena phocoena* and a bottlenose dolphin *Tursiops truncatus*. *Diseases of Aquatic Organisms*, *112*(3), 257-263. https://doi.org/10.3354/dao02818

Vidal-Martínez, V. M., Aguirre-Macedo, M. L., Scholz, T., González-Solís, D., & Mendoza-Franco, E. (2001). *Atlas of the helminth parasites of cichlid fish of Mexico*. Academia.

Würsig, B. (2017). Marine mammals of the Gulf of Mexico. In C. W. Herb (Ed.), *Habitats and biota of the Gulf of Mexico: Before the Deepwater Horizon oil spill: Vol. 2. Fish resources, fisheries, sea turtles, avian resources, marine mammals, diseases, and mortalities* (pp. 1489-1588). Springer. https://doi.org/10.1007/978-1-4939-3456-0_5

Würsig, B., Jefferson, T. A., & Schmidly, D. J. (2000). *The marine mammals of the Gulf of Mexico*. Texas A&M University Press.

Zam, S. G., Caldwell, D. K., & Caldwell, M. C. (1971). Some endoparasites from small odontocete cetaceans collected in Florida and Georgia. *Cetology*, *2*, 1-11.