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journal homepage: www.elsevier.com/locate/marpolbulDebris ingestion by the Antillean Manatee (*Trichechus manatus manatus*)Fernanda Loffler Niemeyer Attademo^{a,b,*}, Deisi Cristiane Balensiefer^a, Augusto Carlos da Bôaviagem Freire^b, Glucia Pereira de Sousa^a, Fábio Adonis Gouveia Carneiro da Cunha^a, Fábria de Oliveira Luna^a^a National Center for Research and Conservation of Aquatic Mammals (Centro Nacional de Pesquisa e Conservação de Mamíferos Aquáticos - CMA), Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio), Estrada do Forte Orange, s/n., Itamaracá, PE 53900-000, Brazil^b Department of Veterinary Medicine (Departamento de Medicina Veterinária), Federal Rural University of Pernambuco (Universidade Federal Rural de Pernambuco - UFRPE), R. Dom Manoel de Medeiros, s/n, Recife, PE 52171-900, Brazil

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ABSTRACT

The Antillean manatee inhabits coastal regions of North and Northeastern Brazil and currently is considered an endangered species in the country. Aiming to gather information for the development of public policies focusing on the conservation of manatees, the National Center for Research and Conservation of Aquatic Mammals of the Chico Mendes Institute for Biodiversity has been rescuing, rehabilitating and releasing these mammals since the 1980s. Over the last 36 years, 40 manatees were released by the CMA/ICMBio and four of them were rescued again due to debris ingestion. Two of these manatees died and the other two were taken back into captivity for a new rehabilitation process. The four mammals had confirmed diagnosis of plastic debris ingestion. These findings demonstrate that the environment where the manatees live after being released had a significant amount of garbage which may hinder the success of the species conservation in Brazil.

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1. Introduction

Human activities have been largely responsible for the decline of biological diversity and the increased extinction rate of several species, often due to pollution and disposal of waste into estuaries, rivers and oceans (Derraik, 2002; Simmonds, 2012). The rescue of aquatic animals of different taxa including birds, mammals and turtles, affected by debris ingestion has increased recently (Tarpley and Marwitz, 1993; Bjorndal et al., 1994; Walker et al., 1997; Bugoni et al., 2001; Stamper et al., 2006; Meirelles and Barros, 2007; Jacobsen et al., 2010; Denuncio et al., 2011; Lazar and Gracan, 2011; Hong et al., 2013; Mendes et al., 2015). Besides ingestion, the entanglement encounters in marine debris have also increased over time (Gall and Thompson, 2015).

The Antillean manatee, *Trichechus manatus manatus*, inhabits the coast of Central and South America. This mammal is considered one of the most endangered aquatic mammals in Brazil and has discontinuous occurrence in the North and Northeast coast of the country (da Silva et al., 2008; Luna et al., 2008a, 2011). Changes in habitats, human activities, low genetic variability and high number of stranding of manatee calves have been the major problems for the conservation of the

Antillean manatee in Brazil (Parente et al., 2004; Luna et al., 2008b, 2012; Meirelles, 2008; Luna, 2013).

Debris ingestion by manatees has been sparsely documented (Laist, 1987; Beck and Barros, 1991; Silva and Marmontel, 2009; Guterres-Pazin et al., 2012). This is the first report of debris ingestion by debilitated or dead specimens of *T. m. manatus* in Brazil.

2. Materials and methods

The National Center for Research and Conservation of Aquatic Mammals (Centro Nacional de Pesquisa e Conservação de Mamíferos Aquáticos - CMA), of the Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio) conducts the rehabilitation and reintroduction of Antillean manatees in Brazil (Normande et al., 2014). All the data reported in the present study are from animals from this reintroduction and monitoring program.

Debris ingestion was diagnosed by clinical monitoring of physically debilitated animals and by necropsy of animals found dead in the wild. The debilitated manatees with suspected debris ingestion were rescued by the research center staff and clinically monitored in individual enclosures, where they were treated for reversal of the symptoms. The recommended treatment consisted of feeding animals with fibrous vegetables (carrots and beets), lettuce and fresh water *ad libitum*. Mineral oil and multivitamins were provided as support medications. Clinical signs presented individually were treated in a timely manner.

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Necropsies were performed according to the protocols adopted by the CMA/ICMBio (Bonde et al., 1983; Vergara-Parente, 2005). The animals' stomach content was analyzed to identify the ingested items.

3. Results

The CMA manatee reintroduction program has released 40 animals from 1994 to 2015. Of these animals, four (10%) had confirmed diagnosis of debris ingestion (Fig. 1). However, the occurrence of this type of

interaction in the other manatees released by CMA/ICMBio, or in wild manatees, cannot be ruled out.

In the cases reported in the present study, two manatees died and the other two were found in the wild debilitated, necessitating rescue by the research center staff. All four specimens were males, between 8 to 15 years old. These animals were calves, younger than 30 days old, when first rescued due to stranding on the coast of the states of Paraíba and Ceará, Brazil. The manatees went through a rehabilitation process in artificial enclosures of the CMA/ICMBio.

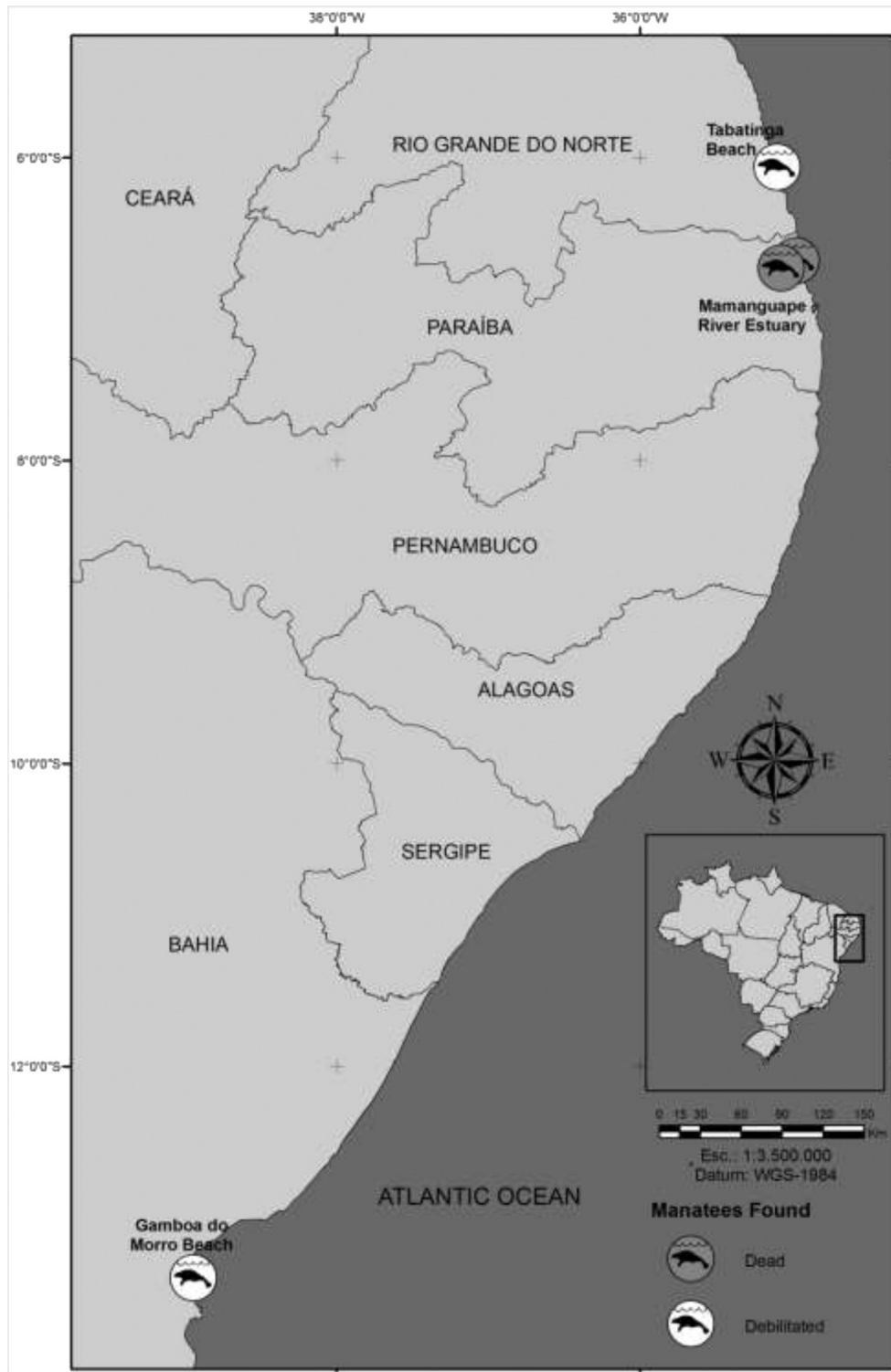


Fig. 1. Places where the Antillean manatees were found dead or physically debilitated.

The first record of debris ingestion is from a 2.4 m long manatee. After 48 months in the rehabilitation program at CMA, this specimen was kept in an acclimatization enclosure in the estuary of the Mamanguape River, located in the Environmental Protection Area (Área de Proteção Ambiental - APA, in Portuguese) of the Barra do Rio Mamanguape, state of Paraíba, Brazil for 88 months, until his escape to the wild. Three months later, the manatee was found dead with great weight loss and advanced state of putrefaction (code 3; Geraci and Lounsbury, 2005) in a mangrove area within the APA. At necropsy, a large amount of plastic bags and raschel knit fabric was found in the animal's stomach. We believe that the manatee was physically debilitated due to the amount of debris ingested, which impaired its digestion process, preventing the consumption of other foods. In addition, the manatee probably had limited mobility and was not able to release itself from the mangrove vegetation because part of the radio telemetry equipment was caught on the vegetation, resulting in drowning.

The second case of debris ingestion reported in the present study was from a 2.6 m long male. The animal's life history from rescue to release is similar to that described for the first animal. However, after reintroduction at the APA of Barra do Rio Mamanguape, this manatee moved to the coast of the state of Rio Grande do Norte, Brazil. Six months later the animal was found with great physical debilitation in Tabatinga beach, state of Rio Grande do Norte (approximately 90 km from the release site). Therefore, he was rescued and brought back into captivity at the CMA/ICMBIO. The manatee had lost 66% of body weight, had injuries in the lip region and body, especially at the peduncle level, as well as respiratory dysfunction and loss of appetite. One week after the recommended treatment had started; the animal began to eliminate a large amount of plastic debris along with feces which persisted over the next three months. During this period, the animal gained weight and after four months of treatment, the manatee recovered. The specimen was taken back into the acclimatization enclosure where it died 54 months later. The cause of death was not related to debris ingestion; however, at necropsy, fragments of plastic bags were found in the animal's stomach, indicating recent ingestion.

The third case was a 2.5 m long male released twice at the APA of the Barra do Rio Mamanguape. On the first attempt, after to remained five years in the CMA/ICMBio, the animal was rescued after being hit by a boat on the coast of state of Rio Grande do Norte. After more 103 months of rehabilitation, the manatee was released again and three months later the specimen was found dead at the estuary of the Mamanguape River (code 2; Geraci and Lounsbury, 2005). At necropsy, it was verified that the end portion of the stomach and the first third of the duodenum, especially the pyloric region where the intestinal lumen is narrower, were clogged by debris. The medial portion of the duodenum was ruptured, which may have occurred due to increased peristalsis in an attempt to eliminate the debris (plastic bags, raschel knit fabric and condoms). In this case, debris ingestion was confirmed as the cause of death.

The fourth case was of a 15 year old, 2.8 m long manatee. This specimen went through three release attempts, all in very different conditions. In the third and final attempt, the animal remained in the wild for approximately 24 months, and was being considered a successful release. However, in February 2015, the animal was found in Gamboa do Morro beach, state of Bahia, Brazil, about 600 km from the release site. A large amount of debris was observed in the local and the manatee was seen ingesting ice cream and sanitary napkin packaging. In an attempt to interact with the animal, the residents provided ship's ballast water of poor quality. The manatee was physically debilitated which was confirmed by significant weight loss and little reaction to stimuli. For this reason, the animal was removed to a swimming pool at the National Center for Research and Conservation of Sea Turtles in the state of Bahia (Centro Nacional de Pesquisa e Conservação de Tartarugas Marinhas - TAMAR/ICMBio). After the recommended treatment, the animal eliminated a small amount of plastic debris and feces with the appearance and odor of vessel oil.

4. Discussion

Plastic was the most common debris ingested by the manatees evaluated in the present study, being ingested by all four specimens. The direct effect of plastic ingestion is the obstruction of the digestive tract and even small amounts can kill the animal (Bjørndal et al., 1994). Plastic ingestion can cause loss of appetite, constipation, ulcers in the stomach and in the intestine mucosa, intestinal perforation, starvation and general debilitation in animals (Beck and Barros, 1991; Tarpley and Marwitz, 1993; Bjørndal et al., 1994; Gregory, 2009). When a large amount of plastic is ingested, it can block the intestine causing satiety and reduction of energy reserves (Day et al., 1985; Azzarello and Van-Vleet, 1987). These alterations were verified in all animals evaluated in the present study. The two manatees that were rescued would likely have died if they had remained in their natural habitat without proper clinical monitoring due to gradual evolution of the symptoms.

Plastic pollution is a threat to marine biodiversity (Derraik, 2002) and many species consume it intentionally or accidentally (Allsopp et al., 2006; Gregory, 2009). Plastic ingestion has been reported as cause of death of marine mammals, especially cetaceans, since the last century (Tarpley and Marwitz, 1993; Gorzelany, 1998; Secchi and Zarzur, 1999; Baird and Hooker, 2000; Stephanis et al., 2013). However, it is very difficult to distinguish the effects of debris ingestion from those caused by other natural or human-related sources in a population (Laist, 1987). Frequently cases of debris ingestion are only confirmed by necropsy (Jacobsen et al., 2010).

Aquatic mammals ingest different types of debris because usually they cannot differentiate waste from food (Allsopp et al., 2006). The debris ingested by the manatees evaluated in the present study came from the local crab fisheries or domestic waste disposal, which accumulates in estuaries, rivers and seas. The estuary of the Mamanguape River where two manatees were found dead consists of a large extension of mangrove habitats (Alves and Nishida, 2004). The APA of Barra do Rio Mamanguape was created to ensure the conservation of the Antillean manatee's habitats in the 90's. Despite being a Conservation Unit, the mangrove areas can be used for harvesting crabs, which is a legal activity in the area. The crab harvesters set up small traps made of raschel knit fabric during the low tide and these traps remain during the high tide if not removed. The manatees likely interact with the nets, while foraging because they resemble needle grass (*Halodule* sp.) and red algae filaments, which are relevant species of the Antillean manatee diet in Northeastern Brazil (Borges et al., 2008). Remnants of these traps can also remain in the vegetation and be accidentally ingested by manatees. The APA is inhabited by local communities what unfortunately may also contribute for waste accumulation in this habitat.

It is difficult to evaluate the importance of debris ingestion for the Antillean manatee population in Brazil. This a cryptic problem caused by the low probability of finding intact manatee carcasses with evidence of debris ingestion (Williams et al., 2011). However, a study of the Florida manatee (*T. m. latirostris*) performed in Florida showed that 14.4% of the necropsied animals ingested one or more debris types (Beck and Barros, 1991). In the present study, debris ingestion was confirmed in 10% of the specimens reintroduced. The fact that manatees typically inhabit shallow waters near the coast (Hartman, 1979) that historically accumulate waste may facilitate debris ingestion. In Brazil, reintroduced specimens often live close to beaches and riverbanks where they interact with humans (Lima and Passavante, 2013). In these habitats, the manatees are attracted by improper food and water eliminated by motorized boats, and are exposed to waste accumulated at the nearshore areas. It is noteworthy that the animals evaluated in the present study did not consume any type of debris while in captivity; however, the close contact with humans may have favored debris ingestion after they were released. In case of oil ingestion, problems such as contamination, irritation of the digestive tract, damage to the intestinal flora and even the animal's death may occur. For this reason, the manatee

that was seen ingesting oil (fourth case) remained under observation, even after the clinical symptoms had stabilized.

The present data represent the first evidence of the potential impact of debris ingestion on the Antillean manatee population in Brazil. We cannot state that debris ingestion is a problem faced only by reintroduced manatees in Brazil. Studies on the feeding biology of *T. m. manatus* are needed and necropsied specimens are an important source of information. The adoption of public policies focused on environmental quality as well as on the development of awareness work in the communities where manatees occur is extremely important for the conservation of the species in Brazil.

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