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Marine debris ingestion by sea turtles (Testudines) on the Brazilian coast: an underestimated threat?

Robson Henrique de Carvalho [a,*], Pedro Dutra Lacerda [b], Sarah da Silva Mendes [c], Bruno Corrêa Barbosa [c], Mariana Paschoalini [c], Fabio Prezoto [a,c], Bernadete Maria de Sousa [a,c]

[a] Programa de Pós-Graduação em Ciências Biológicas: Comportamento e Biologia Animal da UFJF, Rua José Lourenço Kelmer, s/n — Campus Universitário, Bairro São Pedro, Juiz de Fora, MG CEP: 36.036-900, Brazil
[b] Instituto Ecológico Búzios de Mata Atlântica, Armação de Búzios, RJ, Brazil
[c] Programa de Pós-Graduação em Ecologia — UFJF, Rua José Lourenço Kelmer, s/n — Campus Universitário, Bairro São Pedro, Juiz de Fora, MG CEP: 36.036-900, Brazil

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ABSTRACT

Assessment of marine debris ingestion by sea turtles is important, especially to ensure their survival. From January to December 2011, 23 specimens of five species of sea turtles were found dead or dying after being rehabilitated, along the coast of the municipality of Rio de Janeiro, Brazil. To detect the presence of marine debris in the digestive tract of these turtles, we conducted a postmortem examination from the esophagus until the distal portion of the large intestine for each specimen. Of the total number of turtles, 39% had ingested marine debris such as soft plastic, hard plastic, metal, polyethylene terephthalate (PET) bottle caps, human hair, tampons, and latex condoms. Five of the seven sea turtles species are found along the Brazilian coast, where they feed and breed. A large number of animals are exposed to various kinds of threats, including debris ingestion.

1. Introduction

Five species of sea turtles are found in Brazil: *Caretta caretta* (Linnaeus, 1758), *Chelonia mydas* (Linnaeus, 1758), and *Lepidochelys olivacea* (Eschscholtz, 1829), which are considered threatened species by the International Union for Conservation of Nature and Natural Resources (IUCN) (IUCN, 2015), and *Dermochelys coriacea* (Linnaeus, 1766) and *Eretmochelys imbricata* (Linnaeus, 1766), which are classified as critically endangered species by the IUCN (IUCN, 2015). Other species found outside of Brazil include *Natator depressus* (Garman, 1880), which is endemic to Australia, and *Lepidochelys kempii* (Garman, 1880), which is found in the Gulf of Mexico, with both being classified as threatened species (IUCN, 2015).

The presence of marine debris in the oceans has led to the death of many marine animals (Balazs, 1985; Gall and Thompson, 2015), such as birds (Wilcox et al., 2015), aquatic mammals (Di Beneditto and Awabdi, 2014), and turtles (Mendes et al., 2015). Ingestion of debris poses significant risks to sea turtles, as it can remain in their intestines for months. This causes intestinal disturbances such as blockage of the intestinal tract or entanglement (Derraik, 2002), as well as dysfunction in lipid metabolism resulting in excessive accumulation of gases, which changes the buoyancy of turtles and makes them more vulnerable to predators (Schulman and Lutz, 1995). The marine debris ingested obstructs their digestive tract, resulting in their death even in small quantities (Bjorndal et al., 1994; Bugoni et al., 2001). Some studies conducted off the Brazilian coast found large amounts of marine debris in the stomach of sea turtles, with >50% (Bugoni et al., 2001; Macedo et al., 2011; Mendes et al., 2015), which sometimes reached 100% (Tourinho et al., 2010). Marine debris can also be produced by fishing activities, as pieces of nets, hooks, and tackles, as well as tourist activities on the beach (Bugoni et al., 2001; Gall and Thompson, 2015). Some authors emphasize the importance of assessing the ingestion of marine debris by sea turtles in feeding areas, which is considered crucial for ensuring their survival (Bjorndal, 2000; Plot and Georges, 2010).

The aim of this study was to analyze data on the ingestion of debris by sea turtles in Brazil. Another aim involved discussing the risks of debris ingestion for these species, which are currently ranked as almost threatened species by the IUCN (2015).

2. Material and methods

From January to December 2011, 23 specimens of sea turtles were found dead or dying after being rehabilitated, along the coast of Búzios and Cabo Frio, state of Rio de Janeiro, Brazil (22° 44′ 49″ S to 41° 52′ 55″ W) (Fig. 1).

* Corresponding author.
E-mail address: robsonhc1000@yahoo.com.br (R.H. de Carvalho).

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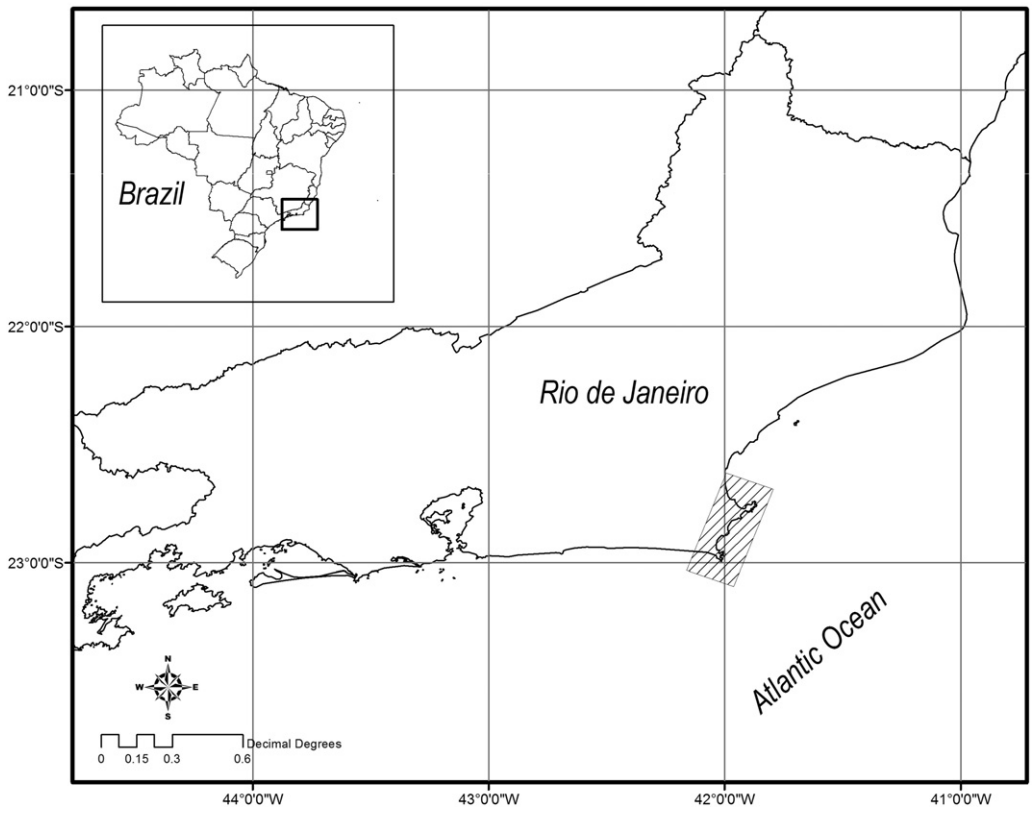

Fig. 1. The study area, located in Búzios, Rio de Janeiro, Brazil.

After identification, the turtles were classified by their body condition as good, regular, bad, and cachectic, according to Wyneken (2001). To detect the presence of marine debris in their digestive tracts, we conducted a postmortem examination from the esophagus until the distal portion of the large intestine for each specimen. The anthropogenic material found in the turtles was categorized into one of three main categories, based on possible origin (fisheries, sewage, and urban waste).

3. Results

We examined 23 specimens of five different species: *C. mydas*, *L. olivacea*, *D. coriacea*, *C. caretta*, and *E. imbricata* (Table 1). Of the total number of specimens analyzed, 39% (eight specimens of *C. mydas* and one of *C. caretta*) were found to have ingested marine debris. Four of these nine turtles recovered during rehabilitation, whereas three showed debilitated bodies (dehydration, exhaustion, and apathy) and died during treatment.

In the present study, we found marine debris such as soft plastic, hard plastic, metal, polyethylene terephthalate (PET) bottle caps, human hair, tampons, and latex condoms. We also observed some cases of ingestion of fishing equipment such as nylon threads, which are used for both fishing and making gillnets, and sisal ropes, which are used for mooring fishing nets.

Table 1
Number of animals analyzed by species, detailing how many of these had ingested some kind of debris.

Species of sea turtles	*N*	NTD	Ingested debris (%)
Chelonia mydas	15	8	53.3
Lepidochelys olivacea	1	0	0
Dermochelys coriacea	4	0	0
Caretta caretta	2	1	50
Eretmochelys imbricata	1	0	0

N = total number of turtles; NTD = number of turtles that had ingested debris.

4. Discussion

Ingestion was confirmed in all seven species of sea turtle, although this was less frequent in flatback turtles (*N. depressus*). Geography, species, year, and life stage appear to affect the frequency of debris ingestion by turtles (NOAA, 2014). Of all specimens that ingested marine debris, 89% belonged to the species *C. mydas*. This finding corroborates other studies conducted on the Brazilian coast, which found 60–100% of green turtles with marine debris in their digestive tract (Bugoni et al., 2001; Tourinho et al., 2010; Macedo et al., 2011).

4.1. Marine debris ingestion by C. mydas

Lutz (1990) suggested that green turtles increasingly ingest marine debris as they cannot distinguish debris from food, which corroborates other studies worldwide, such as in New Zealand, Australia, Mexico, USA, and the Mediterranean (Laist, 1987; Plotkin and Amos, 1990; Van Meter and Weiger, 1992; Tomás et al., 2002; Reinhold, 2015). In Brazil, Mascarenhas et al. (2004) and Awabdi et al. (2013) showed that debris ingestion was an important cause of death in sea turtles, due to the overlap of feeding areas and urban centers (Table 2).

4.2. Marine debris ingestion by C. caretta

Debris ingestion by *C. caretta* is still poorly studied in Brazil (Table 3). This species can be found along the Brazilian coast, with the main nest areas in the northeast and southeast parts. Most cases of stranding occur on the southern coast, which indicates its importance as a feeding area for *C. caretta* (Marcovaldi and Marcovaldi, 1999; Marcovaldi and Chaloupka, 2007; Santos et al., 2011). Lazar and Gracan (2011) studied the data of debris ingestion in the Pacific and Atlantic Oceans and the

Table 2
Studies on the Brazilian coast about ingestion of debris by *Chelonia mydas*.

N	NTD	%	Period	Localities	References
56	38	60.5	1997–1998	Rio Grande do Sul	Bugoni et al. (2001)
1	1	100	2003	Paraiba	Mascarenhas et al. (2004)
45	27	60	2006–2007	Bahia	Macedo et al. (2011)
34	34	100	2006–2007	Rio Grande do Sul	Tourinho et al. (2010)
20	9	45	2008–2009	Ubatuba	Mendes et al. (2015)
49	29	59.2	2009–2010	Rio de Janeiro	Awabdi et al. (2013)
49	29	59.2	2009–2010	Rio de Janeiro	Di Beneditto and Awabdi (2014)
265	185	70	2009–2013	Sergipe, Linhares, Fundão and Aracruz, Vitória,Vila Velha, Ubatuba and Florianópolis	Santos et al. (2015)
15	8	53	2011	Rio de Janeiro	Our study

N = number of turtles studied; NTD = number of turtles that had ingested debris.

Mediterranean Sea, with soft plastic being most commonly found in the digestive tract of *C. caretta*, probably due to the neritic feeding habitat of this species (Casale et al., 2008). Lazar and Gracan (2011) also observed that the turtles are equally susceptible to marine litter ingestion, regardless of size or gender.

Loggerheads were found to ingest debris less frequently than green turtles, possibly due to the wider alimentary tract of adult and sub-adult loggerheads, which promotes a shorter residence time of the debris in the esophagus and stomach (Bugoni et al., 2001). These authors examined the digestive tract of 10 specimens of *C. caretta*, and only one individual was found to have ingested a transparent plastic bag, weighing 0.2 g (Bugoni et al., 2001).

Lazar and Gracan (2011) suggest that the presence of marine debris in about one-third of the foraging habitat of loggerheads in the Adriatic Sea is additionally concerning, as even small amounts of debris can kill a sea turtle, which cannot be predicted easily.

In Brazil, studies on debris consumption are not adequate for finding a solution to this problem. However, Widmer and Hennemann (2010) quantified the amount and type of debris found in Santa Catarina Island, located off the southern coast of Brazil, and found a prevalence of 90% of plastic among the analyzed items.

4.3. Marine debris ingestion by L. olivacea

Mascarenhas et al. (2004) analyzed the stomach content of a male specimen of *L. olivacea*, and they found nine pieces of hard plastic resembling parts of a bottleneck thread and a piece of a plastic bag (Table 4). They also found several external wounds made with a sharp blade (probably of a boat propeller) on the dorsal surface of the head, neck, and carapace.

Schuyler et al. (2014) reviewed the debris ingestion by sea turtles worldwide. They did not find any specific information about this species; thus, the data of debris ingestion by *L. olivacea* may be underestimated.

4.4. Marine debris ingestion by D. coriacea

Barreiros and Barcelos (2001) examined an adult female specimen of *D. coriacea*, a bycatch victim of a swordfish longline, and they found six pieces of soft plastic, a hard plastic belt, and a small plastic cap in the intestine. This type of material, especially hard plastic, can cause ulcers and necrosis. The authors state that debris ingestion is still greatly underestimated in the Azores, Portugal.

In Brazil, the rate of debris ingestion for leatherback turtles has not been studied in depth. Bugoni et al. (2001) examined two leatherback turtles and found consumer waste in one, which had ingested a rigid piece of plastic (Table 5). Although they did not find soft plastic (as floating dendrites), it is most frequently found in this species due to the neritic feeding habitat (Casale et al., 2008).

While monitoring a beach in French Guiana, Plot and Georges (2010) found a female leatherback turtle laying eggs with difficulty. The female exuded a greenish liquid with a strong odor from the cloaca. The researchers removed all of the debris from cloaca, which enabled the animal to lay its eggs. They analyzed the collected material and found 2.6 kg of uncleaned plastic, including 14 pieces of plastic bag fragments, domestic garbage bags commonly used in the area, as well as woven nylon rice bags. Some eggs were laid with copious amounts of white-colored liquid and some fresh blood, which indicated a possible injury to the digestive tract from either the pressure exerted to expel the debris or the researchers' intervention. This study suggests that the ingestion of significant quantities of plastic debris may not be lethal for sea turtles in general, provided the debris is expelled.

4.5. Marine debris ingestion by E. imbricata

Macedo et al. (2011) performed necropsies on nine specimens of *E. imbricata*, seven of which were found to have ingested some kind of debris (Table 6). The debris found in seven samples was predominantly plastic, and anthropogenic materials from fishing activities, such as nylon yarn, nylon ropes, and moorings for boats, were found in three animals. The remaining specimens had debris of different origins such as plastic bags, pieces of hard plastic, styrofoam, sisal rope, cigarette filters, and pieces of plastic straws. Anthropogenic debris was found in all four compartments of the digestive tract (large intestine, stomach, small intestine, and esophagus), not necessarily in the same animal.

Gramentz (1988) suggested that these animals ingest the debris because they confuse them with natural food such as jellyfish and fish. Schulman and Lutz (1995) confirmed that sea turtles ingest debris when hungry, and Tomás et al. (2002) stated that sea turtles have a low selectivity while feeding.

Although other studies have suggested plastic to be the main anthropogenic debris ingested by marine turtles (Bjorndal et al., 1994; Bugoni et al., 2001; Tomás et al., 2002), Macedo et al. (2011) observed fishing debris such as nylon lines and nylon ropes in the majority of samples (62.9%).

Schuyler et al. (2014) analyzed the literature published since 1985 to compile a global assessment of the prevalence of marine debris

Table 3
Studies on the Brazilian coast about ingestion of debris by *Caretta caretta*.

N	NTD	%	Period	Localities	References
10	1	10	1997–1998	Rio Grande do Sul	Bugoni et al. (2001)
2	1	50	2011	Rio de Janeiro	Our study

N = number of turtles studied; NTD = number of turtles that had ingested debris.

Table 4
Studies on the Brazilian coast about ingestion of debris by *Lepidochelys olivacea*.

N	NTD	%	Period	Locality	References
1	1	100	2003	Paraiba	Mascarenhas et al. (2004)

N = number of turtles studied; NTD = number of turtles that had ingested debris.

Table 5
Studies on the Brazilian coast about ingestion of debris by *Dermochelys coriacea*.

N	NTD	%	Period	Locality	References
2	1	50	1997–1998	Rio Grande do Sul	Bugoni et al. (2001)

N = number of turtles studied; NTD = number of turtles that had ingested debris.

Table 6
Studies on the Brazilian coast about ingestion of debris by *E. imbricata*.

N	NTD	%	Period	Locality	References
9	7	78	2006–2007	Bahia	Macedo et al. (2011)

N = number of turtles studied; NTD = number of turtles that had ingested debris.

ingestion by sea turtles. They noted that the probability of debris ingestion by *E. imbricata* decreased from 1985 to 2012. This decrease may have been caused by the small sample size, with only two studies being conducted on hawksbill gut contents, which were conducted at the beginning and at the end of the literature review period (Plotkin and Amos, 1990; Schuyler et al., 2014).

5. Conclusions

A large number of animals are exposed to various kinds of threats, including ingestion of debris, due to the discharge of waste into the sea annually as well as the lack of public policies and studies on this issue. We believe that debris ingestion is the main cause of mortality of a large population of sea turtles in Brazil.

Further insights into this issue are urgently required, to encourage future research on measures for the conservation of sea turtles.

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