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Original Article
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Causes of mortality of seabirds stranded at the Northeastern coast of Brazil[1]

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ABSTRACT.- Mariani D.B., Almeida B.J.M., Febrônio A.D.M., Vergara-Parente J.E., Souza F.A.L. & Mendonça F.S. 2019. **Causes of mortality of seabirds stranded at the Northeastern coast of Brazil.** *Pesquisa Veterinária Brasileira 39(7):523-529.* Laboratório de Diagnóstico Animal, Departamento de Morfologia e Fisiologia Animal, Universidade Federal Rural de Pernambuco, Rua Dom Manuel de Medeiros s/n, Dois Irmãos, Recife, PE 52171-900, Brazil. E-mail: fabio.mendonca@pq.cnpq.br

The aim of this work was to determine the main species of stranded seabirds at the Northeastern coast of Brazil in addition to the most frequent causes of stranding and mortality. The study was conducted in a monitored area for three years (2012-2014), from the coastline of south Alagoas through north coast of Bahia encompassing 254km of coast. The seabirds found alive during the monitoring were sent to rehabilitation, clinically examined and the carcasses were removed, necropsied and histopathologically analyzed. A total of 1.347 seabirds were found stranded. Of these, 378 were found alive and sent to rehabilitation. From the 969 dead seabirds 806 were unsuitable for necropsy, being only 163 submitted to necropsy and histopathological analysis. *Calonectris borealis, Puffinus gravis* and *Puffinus puffinus* were the main seabirds stranded in the studied area. Most stranding occurred from March to June with an increase during April and May for the most species of seabirds. The main clinical signs of stranded seabirds consisted of inappetence, apathy, low body score, hypothermia, flying or movement difficulty and prolonged recumbency. Natural causes followed by infectious diseases and anthropogenic environmental factors were the main causes of death of seabirds stranded on the Northeastern coast of Brazil.

INDEX TERMS: Seabirds stranded, wild avian diseases, wildlife conservation, mortality, Brazil.

RESUMO.- [**Causas de mortalidade de aves marinhas encalhadas na costa do Nordeste do Brasil.**] O objetivo deste trabalho foi determinar as principais espécies de aves marinhas encalhadas na costa do Nordeste do Brasil, bem como as mais frequentes causas de encalhe e mortalidade. O estudo foi desenvolvido em área monitorada durante três anos (2012-2014), entre o litoral sul de Alagoas e o litoral norte da Bahia, perfazendo um total de 254km de extensão da costa. As aves encontradas vivas foram encaminhadas para reabilitação e examinadas clinicamente; as carcaças foram removidas, necropsiadas e os órgãos foram analisados por meio da histopatologia. Um total de 1.347 aves foi encontrado, encalhadas. Dessas, 378 estavam vivas e foram encaminhadas para a reabilitação. Das 969 aves marinhas mortas, 806 estavam impróprias para realização de necropsia, sendo apenas 163 submetidas à necropsia e análise histopatológica. *Calonectris borealis*, *Puffinus gravis* e *Puffinus puffinus* foram as principais espécies encontradas na área estudada. A maioria dos encalhes para grande parte das aves marinhas ocorreram de março a junho, com um aumento durante abril e maio. Os principais sinais clínicos das aves marinhas consistiram em inapetência, apatia, baixo escore corporal, hipotermia, dificuldade de voo ou movimento e decúbito prolongado. Causas naturais, seguidas de doenças infecciosas e fatores antropogênicos, foram as principais causas de mortes de aves marinhas encalhadas na costa do Nordeste do Brasil.

TERMOS DE INDEXAÇÃO: Aves marinhas, encalhe, doenças de aves selvagens, conservação da vida selvagem, mortalidade, animais selvagens.

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INTRODUCTION

The extensive Brazilian coast composes a variety of environments with different resource conditions and habitats, covering areas of high environmental relevance and priority for conservation (Brasil 2010). Coastal wetlands and marine environments constitute one of the main routes in the Atlantic corridor for the migration of seabirds (Sick 1983). The seasonal displacement of many of these birds is accompanied by records of dead individuals found on beaches (Vooren & Brusque 1999).

The large interannually variations in the number of dead or debilitated seabirds found on the beaches is a common phenomenon in many parts of the world. Food resources restrictions, intra and interspecific competition between species, predation, weather adversities, climatic events, and anthropogenic environmental changes are the main causes of stranded seabirds (Bodkin & Jameson 1991, Schrag & Wiener 1995, Daszak et al. 2001, Hamer et al. 2002, Bell 2008). In Brazil, massive mortality of seabirds has been reported on the coastal areas of Bahia (Lima et al. 2004), Southeast (Olmos et al. 1995, Martuscelli at al. 1997) and Southern (Petry et al. 2004, Bugoni et al. 2007, Faria et al. 2014).

In Bahia, there is an indication of poor body condition as an explanation, in the Southeast is reported a mortality event of young seabirds, with low weight and potential relationships with climatic aspects and in the Southern there are also evidences of climatic conditions as potential factors of the stranding. Except for Bahia, in the Northeastern coast, there are no reports about individual causes or mortalities of seabirds.

The aim of this work was to determine the main species of stranded seabirds at the Northeastern coast of Brazil in addition to the most frequent causes of stranding and mortality.

MATERIALS AND METHODS

The present work was based on the availability of samples and data for the period from April 2012 to September 2014, coming from the Regional Program for Monitoring Strandings and Anomalies (PRMEA), carried out by Petrobras and executed by the "Fundação Mamíferos Aquáticos" (FMA). Measurement of environmental impacts required by federal environmental licensing conducted by IBAMA.

All the animal procedures were approved by the conservational and regulatory Brazilian agency IBAMA (SISBIO license number 21570-3).

The study was developed along 254Km of the coastline, from Piaçabuçu, Alagoas State (-10.34455 S/-36.30185 W) to Conde, Bahia State (-12.09639 S/37.68624W) (Fig.1). This area was segmented into relatively equidistant subareas, corresponding to 7 stretches of beaches and monitored daily through the first low tide of the day. The coastline location was georeferenced, and the stranded seabirds were identified (Harrison 1983, Narosky & Yzurieta 2003, Mata et al. 2006).

The seabirds found dead were recorded and photographed. Those found alive were rescued and taken to the rehabilitation unit. The age range was determined by the beak and plumage staining patterns of young and adults (Harrison 1983, Prince & Rodwell 1994, Mata et al. 2006, Onley & Scofield 2007, Bugoni & Furness 2009); detailed clinical examination consisted of weighting, physical inspection, measurement of body temperature, evaluation of ocular

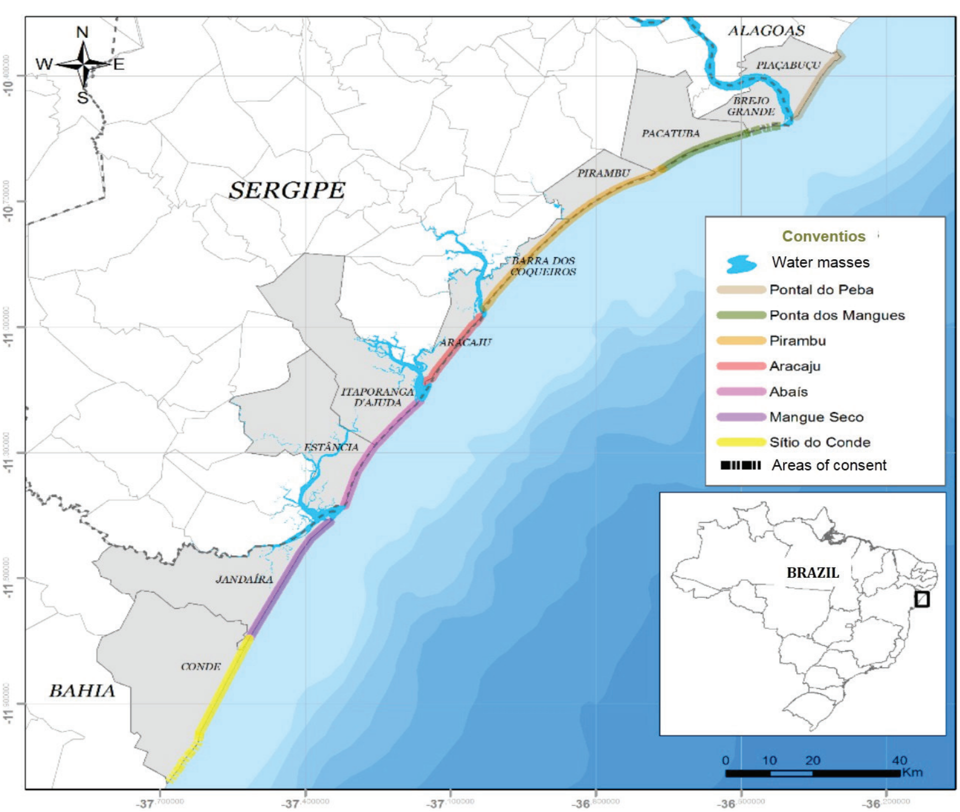

Fig.1. Brazilian northeastern coast between Piaçabuçu, Alagoas State (-10.34455 S/-36.30185 W) and Conde, Bahia State (-12.09639 S/37.68624 W).

and oral mucosa, as well as respiratory pattern, behavior and attitude. The carcasses were-classified as "very fresh", "fresh" and "moderately fresh" according to Van Franeker (2004) and examined according to Work (2000) and Munson (1999). The seabirds that died during rehabilitation were necropsied, and samples of vital organs were collected, fixed in 10% neutral buffered formalin and processed routinely for histopathology and identification of parasites in tissues samples.

RESULTS

A total of 1.347 seabirds belonging to five orders (Procellariiformes, Sphenisciformes Charadriiformes, Suliformes and Pelecaniformes) and nine families (Diomedeidae, Procellariidae, Spheniscidae, Stercorariidae, Sternidae, Scolopacidae Fragatidae, Sulidae and Ardeidae) were identified along the monitoring area (Table 1) and from these, 378 seabirds found alive were sent to rehabilitation.

Table 1. Identification, number and ages of seabirds species rescued on the coast of Northeast Brazil

Taxon	Commom name	Adult	Underadult	Juvenile	Undetermined	Total
Order Procellariiformes						
Family Diomedeidae						
Phoebetria fusca	Sooty albatross				1	1
Thalassarche chlororhynchos	Atlantic yellow-nosed albatross		1	2	5	8
Thalassarche melanophris	Black-browed albatross				2	2
Thalassarche sp.					2	2
Family Procellariidae						
Calonectris sp.					1	1
Calonectris borealis	Cory's shearwater	3	57	89	561	710
Calonectris edwardsii	Cape Verde shearwater				1	1
Pachytila sp.					1	1
Pachyptila desolata	Antarctic Prion				1	1
Procellaria aequinoctialis	White-chinned petrel	1		3	1	5
Procellaria conspicillata	Spectacled petrel	2		1	1	4
Puffinus gravis	Great shearwater	8	6	73	357	444
Puffinus griseus	Sooty shearwater		1	6	7	14
Puffinus puffinus	Manx shearwater	3	2	19	40	64
Procellariidae					2	2
Order Sphenisciformes						
Family Spheniscidae						
Spheniscus magellanicus	Magellanic penguin			8	39	47
Order Charadriiformes						
Suborder Lari						
Family Stercorariidae						
Stercorarius longicaudus	Long-tailed Jaeger	1				1
Stercorarius maccormicki	South polar skua	1			1	2
Stercorarius parasiticus	Parasitic jaeger				1	1
Stercorarius skua	Great skua			2		2
Stercorarius sp.					3	3
Family Sternidae						
Anous stolidus	Brown nody	1	1	1	4	7
Sterna hirundinacea	South American Tern				1	1
Sterna hirundo	Common tern	3	1	1		5
Suborder Scolopaci						
Family Scolopacidae						
Arenaria interpres	Ruddy turnstone	1				1
Order Suliformes						
Family Fregatidae						
Fregata magnificens	Magnificent Frigatebird				1	1
Family Sulidae						
Sula dactylatra	Maskeg booby			4	5	9
Sula leucogaster	Brown booby			1	1	2
Sula sula	Red-footed Booby			1		1
Sula sp.					3	3
Order Pelecaniformes						
Family Ardeidae						
Egretta thula	Snowy egret				1	1

Calonectris borealis (710 individuals, 52.71%), *Puffinus gravis* (444 individuals, 32.96%) and *Puffinus puffinus* (64 individuals, 4.75%) were the main seabirds stranded in this area of Northeastern coast of Brazil considering all species identified. Most seabirds (88.94%, 1.198/1.347) were of undetermined age. From the total of 969 seabirds found dead, 806 were unsuitable for necropsy due to the advanced stage of autolysis, being only 163 necropsied and sent to histopathological analysis. Of these, juveniles were 55.21% (90/163), underadult 26.99% (44/163), adults 11.04% (18/163), and 6.74% (11/163) remained undetermined. Most stranding occurred from March to June with an increase during April and June for the most species of seabirds, mainly *C. borealis*, *P. gravis* and *P. puffinus*. Stranding of *Spheniscus magellanicus* occurred only from August to September (Fig.2).

The areas with the highest rescued number of seabirds were Aracaju/Sergipe, 37.42% (504/1.347), Pirambu/Sergipe, 14.85% (200/1.347), Abaís/Sergipe, 14.62% (197/1.347) and Mangue-Seco/Bahia, 10.84% (146/1.347). The highest density of stranding occurred in Aracaju (20.16 birds/km), Abaís (5.47 birds/km), Mangue-Seco (3.95 birds/km) and Pirambu (3.77 birds/km). The average stranding across the monitored coastline was 6.09±6.27 birds/km (Fig.3).

On the seabirds clinically analyzed at rehabilitation, the main clinical signs consisted of inappetence, apathy, low body score, hypothermia, flying or moving difficulty and prolonged recumbency. Juvenile in first migration and weakened birds, followed by infectious causes, were the most important mortality events, accounting 85.8% of the cases (139/163). The seabirds generally had more than one etiological agent responsible for the weakness and consequent stranding.

Gastroenteric diseases accounted for 71.78% (117/163) of the cases. Main gross lesions were associated to the presence of parasites in the proventriculus (Fig.4A) and/or intestines in 80.34% (94/117), and plastic or others anthropogenic residues in 23.93% (28/117). From 61.70% (58/94) of samples analyzed for endoparasites, the main identified helminths were *Seuratia shipleyi*, 86.21% (50/58), *Contracaecum* sp., 12.07% (7/58), *Contracaecum pelagicum*, 3.45% (2/58) and the genus *Tetrabothrius*, 22.41% (13/58).

In most cases of moderate to severe gastric diseases there was hyperemia of the mucosa 20.51% (24/117) with hemorrhages 15.38% (18/117) and ulceration 11.96% (14/117). Moderate enteritis had similar pattern and severe enteritis were associated to mucosal congestion, 5.98% (7/117), intestinal adhesions, 2.56% (3/117), and necrosis, 2.56% (3/117). Histologically, parasitic gastroenteritis was associated to the presence of different species of helminths (Fig.4B) and heterophils infiltrations in the mucosa and submucosa, with damage to the gastric or intestines' epithelium.

Parasitic infestations were identified during inspection in 50.31% (82/163) of the seabirds, contributing to the debilitation of the birds and subsequent stranding. Of the collected samples of ectoparasites, 29.26% (24/82) were analyzed and the main species identified were *Trabeculus aviator*, 45.83% (11/24), *Halipeurus diversus*, 33.33% (8/24), *Halipeurus* sp., 12.50% (3/24) and *Naubates* sp., 8.33% (2/24).

Respiratory diseases were responsible for 26.99% (44/163) of the cases. Main clinical signs consisted of inappetence, difficult breathing, gasping and anorexia. Most diseases consisted of bacterial pneumonia and were associated to edema, congestion, opacity of air sacs and the presence of caseous material at the pleural surface. Hemorrhages 11.36% (6/44), emphysema 4.54% (2/44), pleural adhesions 4.54% (2/44) and air sacs rupture 2.27% (1/44) were present in severe cases. Histologically, 22 seabirds were analyzed.

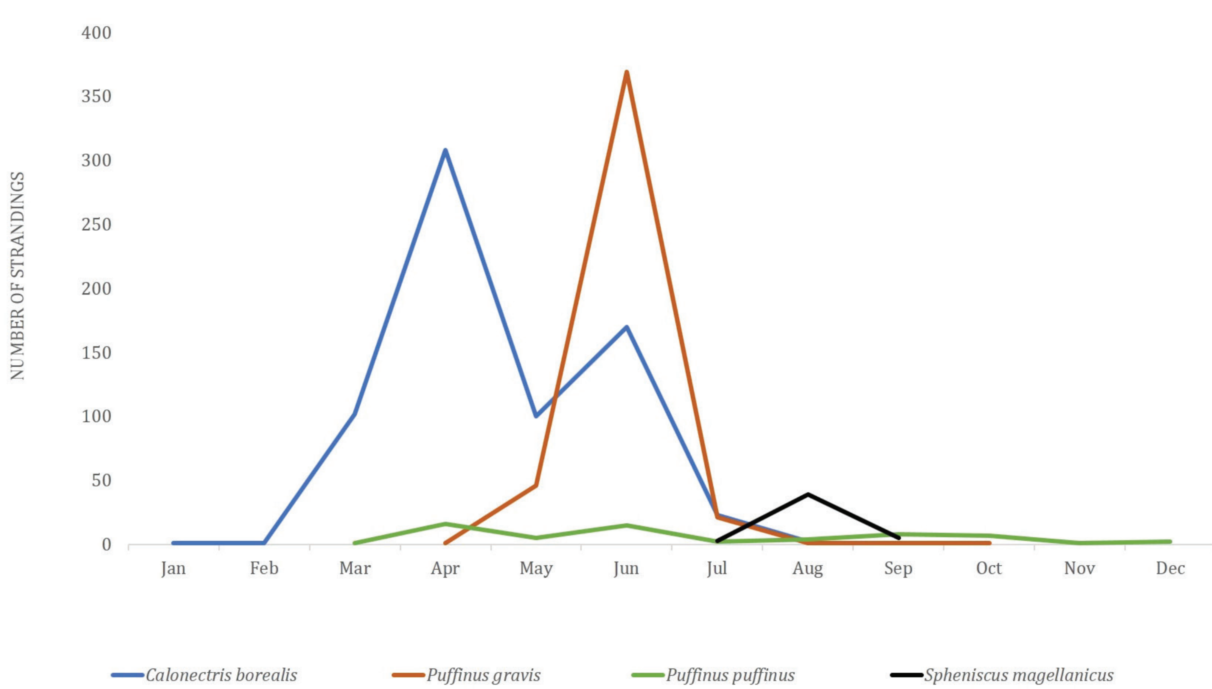

Fig.2. Seasonal distribution of stranding according to species at the studied area.

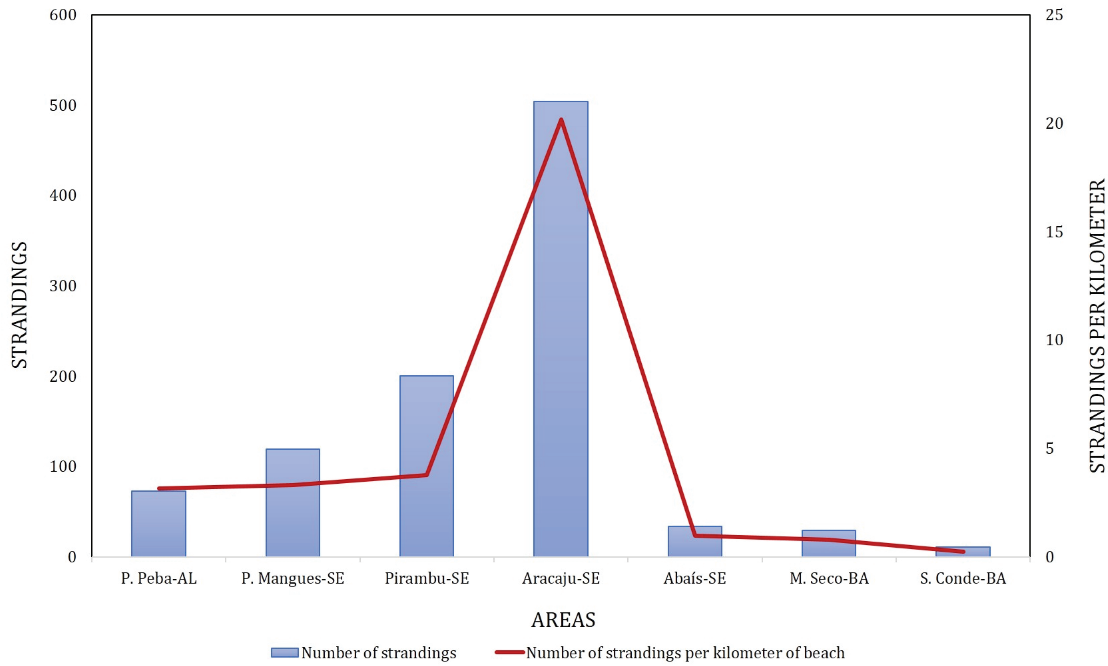

Fig.3. Numbers of seabirds per stretch of beach at the studied area.

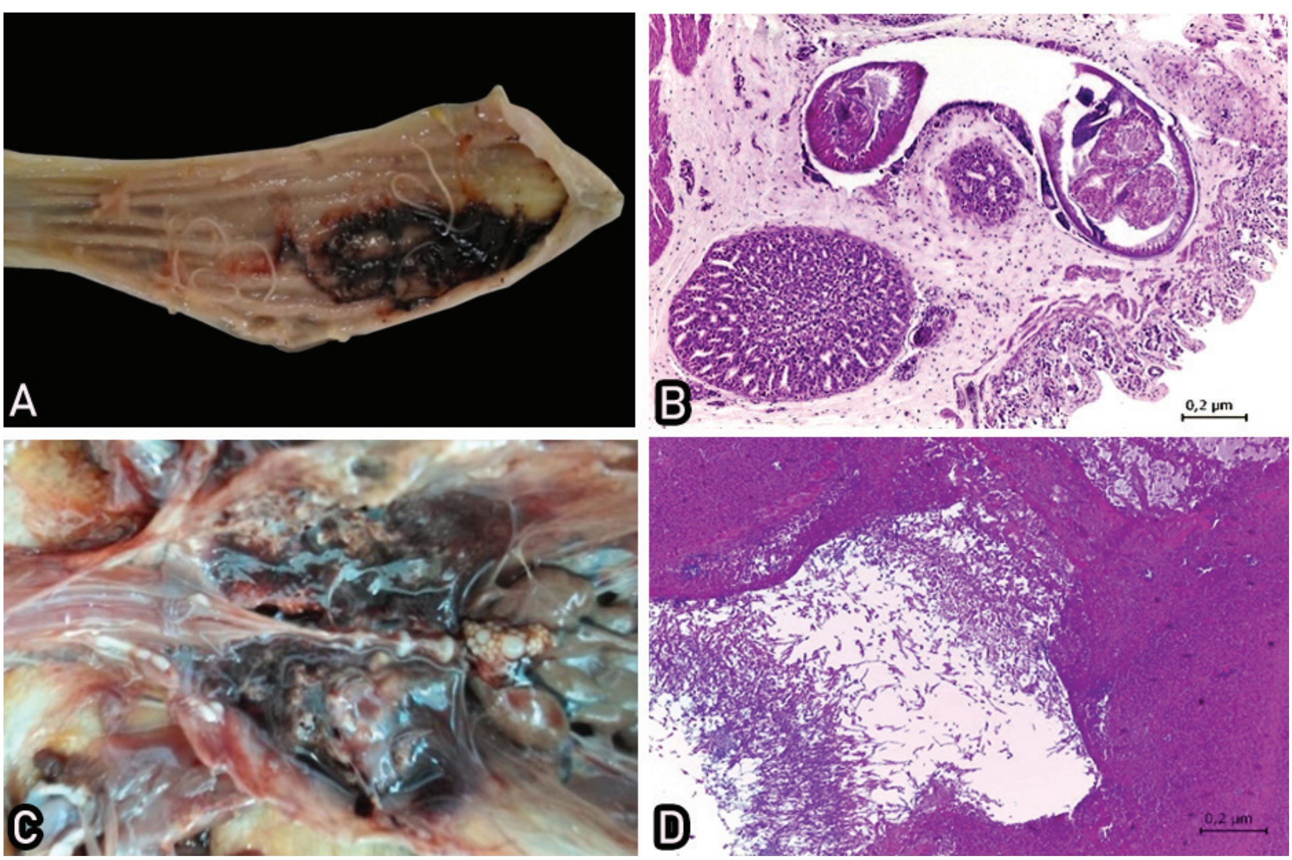

Fig.4. Macroscopic and histopathological aspects of gastric and pulmonary lesions of stranded seabirds. (**A**) Proventriculus mucosa of *Calonectris borealis* presenting areas of haemorrhage and bloody mucus, in addition to endoparasites compatible with nematodes. (**B**) Proventriculitis in *C. borealis*, characterized by discrete eosinophilic infiltrate in the submucosa with presence of cavitation containing oval structure, with external cuticle, muscular layer and internal structures such as ovary and intestine, compatible with nematode larvae. HE, obj.40x. (**C**) Granulomatous pneumonia in *Sterna hirundo* with firm and diffuse white nodules, bilateral and irregular. (**D**) Severe granulomatous pneumonia in *C. borealis* characterized by intense pulmonary consolidation and intense amount of intralesional septate hyphae. HE, obj.40x.

In acute pneumonia, there were infiltration of heterophils, monocytes, lymphocytes and the presence of cellular debris. In chronic cases, generally forming granulomatous lesions, 9.09% (2/22), there were caseous necrosis and infiltration of macrophages and giant cells.

Two cases of respiratory disease were diagnosed as fungal pneumonia. In both cases, gross lesions in the lungs were marked congestion with milliary yellow nodules (Fig.4C); air sacs were thickened with small whitish-yellow plaque-like lesions. Histologically, lungs and air sacs were replaced by disseminated granulomatous foci of caseous necrosis and cellular debris surrounded by heterophils, lymphocytes, macrophages and multinucleated giant cells with hyphal branches (Fig.4D). Also, there was pulmonary edema.

Anthropogenic interactions accounted 22.69% (37/163) of all cases and consisted mainly of ingestion of plastic/trash 54.05% (20/37). Less important cases were different kinds of traumas such as hematomas, fractures and lacerations caused by fishing tackle, 24.33% (9/37), and intoxication by oil 21.62% (8/37).

DISCUSSION

The mean of stranding along the coastline monitored was 6.09±6.27 birds/km. This data could be considered higher in comparison with other studies (Burger 2002, Harris et al. 2006). The main stranded seabird species in northeastern coast of Brazil were *Calonectris borealis*, *Puffinus gravis* and *Puffinus puffinus*. The fall (March to June) was the season with the highest number of seabirds stranding (n=1,191).

Calonectris borealis is a transatlantic migrant from the Oceanic Islands along the Iberian Peninsula (Dias 2011, Howell 2012). It occurs in Brazil throughout the year, mainly from April to August, when they return to the colonies in north Atlantic under the influence of the subtropical convergence in southern Brazil, Argentina and Uruguay (Pacheco & Maciel 1995, Sick 1997). This period also corresponds to the migration of *Puffinus gravis* to north Atlantic during the months of May to July for feeding, and to spend the non-breeding period for molting the plumage (Harrison 1983, Howell 2012).

Puffinus puffinus is a transatlantic migrant species from the northern hemisphere (Onley & Scofield 2007) which reproduces in Great Britain (Scotland, Wales), Ireland and migrates to the south Atlantic, Argentina, Uruguay and southern Brazil during the non-reproductive period (Guilford et al. 2009, Freeman et al. 2013). They stranded throughout the year, but increased between March and June and also September and November. These months corresponds to the end of the winter and spring, after the arrival of these seabirds from British islands, where they reproduce.

The predominance of stranding of these three species in northeastern coast of Brazil are also seen in southwestern and northwestern coast of the United States (Haman et al. 2013) in which most stranded birds are juveniles, probably untrained and weak to their first migration to the northern hemisphere (Vooren & Brusque 1999, Lima et al. 2004, Lee 2009).

Spheniscus magellanicus is the penguin species more frequent in Brazil, found along the coast of Rio Grande do Sul, with some wandering individuals reaching Rio de Janeiro during the winter (Sick 1997, Pinto et al. 2004). The occurrence of this species in the Brazilian Northeast is somewhat intriguing despite the historical records of carcasses found (Farias et al. 2002, Lima et al. 2004, Tavares & Nascimento 2009). In 2008, many penguins were recorded for the Northeast states, including Sergipe (Roos 2008). Other two stranded species, *Procellaria aequinoctiallis* and *Procellaria conspicillata*, deserve special attention since they are considered vulnerable.

The clinical and pathologic data indicates that environmental factors are the major cause of individual mortality of stranded seabirds in northeastern coast of Brazil. The exact causes of deaths are difficult to determine, but in most cases, it is suggested that food deprivation and severe climatic conditions leads to debilitating conditions, such as apathy, inappetence, malnutrition, dehydration, stranding, hypothermia and death (Harvell et al. 1999, 2002).

Infectious diseases were also an important cause of mortality of stranded seabirds. The number of dead seabirds was greater due to gastric or enteric parasitism and bacterial diseases. According to Brown et al. (1992) in a lot of cases, more than one etiology agent is responsible for these deaths. However, parasitic infections and bacterial pathogens in nearshore seabirds are poorly understood because these pathogens are not often documented (Muzaffar & Jones 2004), and it is unclear whether they have played a role in mortality events (Newman et al. 2007).

Several kinds of anthropogenic environmental factors were responsible for seabird's deaths and included mainly ingestion of plastic, fishing lines and hooks, fishing line entanglement and different kinds of traumas. These mortalities should be considered as an additional significant impact to seabirds, mainly due to its severities leading to death (Tasker et al. 2000, Newman et al. 2007). It is worth mentioning that no studies were conducted about the impact of light pollution on seabirds with traumas and organic pollutants on all seabirds. These results could increase the knowledge on animals affected by anthropic alterations.

CONCLUSIONS

Natural causes were the main reasons for stranding of seabirds.

The results of this study provide an important first attempt to use continuous monitoring and necropsies to understand the causes of seabird's mortality in the coast of northeastern Brazil and serves as an indicator of ocean health.

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Conflict of interest statement.- The authors have no competing interests.

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