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Occurrence and clinical conditions of sea turtles from the Pará coast, Amazon, Brazil

Ocorrência e condições clínicas de tartarugas marinhas do litoral do Pará, Amazônia, Brasil

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The coastline of Pará State plays an important role as a feeding, resting, and nesting area for marine turtles occurring along the Brazilian coast. This study investigated the occurrence and clinical afflictions of turtles admitted to the Wildlife Rehabilitation Center of the Federal Rural University of the Amazon (CETRAS-UFRA) between January 2021 and December 2022. Medical records from 20 individuals were examined to obtain data on species, clinical conditions, and rescue history. The data were analyzed using descriptive statistics, chi-square tests, Cramér's V coefficient ($p < 0.05$), and graphical interpretation performed in RStudio. The species recorded at CETRAS were *Eretmochelys imbricata* (50%), *Chelonia mydas* (40%), and *Caretta caretta* (10%), while the main species occurring along the Pará coast include *C. mydas*, *E. imbricata*, *C. caretta*, *D. coriacea*, and *L. olivacea*. Most individuals were hatchlings (50%) and juveniles (40%), primarily from the municipality of Salinópolis (55%), whereas Curuçá presented the highest number of secondary records. The distribution of animals was not random, showing strong associations with species, location, and rescue history (Cramér's V = 0.95 and 0.89). The most frequent disorders were respiratory (47.06%), mainly pneumonia, and integumentary (44.12%), including dermatitis, abrasive skin lesions, and fibropapillomatosis, as observed in three *C. mydas*. Body condition ranged from regular (60%) to thin (20%), and 65% of the turtles showed mild dehydration. This study contributes to the understanding of the occurrence and health status of marine turtles along the Pará coastline, emphasizing the need for strengthened conservation strategies and more effective monitoring programs.
Keywords: testudines, stranding, fibropapillomatosis.

O litoral paraense é importante para a alimentação, repouso e reprodução das tartarugas marinhas que ocorrem no Brasil. Este estudo investigou a ocorrência e as afecções clínicas dos animais atendidos no CETRAS-UFRA entre janeiro de 2021 e dezembro de 2022. Para isso, os prontuários médicos de 20 tartarugas foram utilizados para a coleta de dados sobre os animais e sua afecções, os quais foram analisados por estatística descritiva, teste do qui-quadrado, coeficiente de Cramér's V ($p < 0,05$) e interpretação gráfica no software RStudio. As espécies registradas no CETRAS foram *Eretmochelys imbricata* (50%), *Chelonia mydas* (40%) e *Caretta caretta* (10%), mas as principais espécies que ocorrem no litoral paraense são *C. mydas, E. imbricata, C. caretta, D. coriacea e L. olivacea.* A maioria dos animais atendidos eram filhotes (50%) e juvenis (40%), oriundos de Salinópolis (55%), sendo o município de Curuçá o que tem maior quantidade de registros secundários. A distribuição dos animais não é aleatória, estando associada à espécie, ao local e ao histórico de resgate (Cramér's V = 0,95 e 0,89). As afecções mais frequentes foram respiratórias (47,06%), por pneumonia, e tegumentares (44,12%), por dermatites, lesões abrasivas e fibropapilomatose, esta última observada em três *C. mydas*. As condições corporais variaram de regulares (60%) a delgadas (20%), e 65% dos animais apresentaram leve desidratação. O estudo contribui para o conhecimento da ocorrência e das condições de saúde das tartarugas marinhas encontradas no litoral paraense, destacando a necessidade de estratégias de conservação e de programas de monitoramento mais eficazes.
Palavras-chave: testudines, encalhe, fibropapilomatose.

1. INTRODUCTION

Marine turtles, long-lived oviparous animals, undertake extensive migrations along the Brazilian coastline, playing a crucial role in nutrient cycling and in maintaining the health and balance of ecosystems [1, 2]. Of the seven existing species distributed across the world, five occur

in Brazil, all of which are threatened with extinction [3, 4]. According to Ordinance No. 148 of June 7, 2022, issued by the Ministry of the Environment (MMA), the threats vary in severity, with *Dermochelys coriacea* classified as critically endangered, *Eretmochelys imbricata* as endangered, *Caretta caretta* and *Lepidochelys olivacea* as vulnerable, and *Chelonia mydas* as nearly threatened.

These threats include incidental capture, human consumption, coastal development, urbanization, and climate change [5, 6]. Additionally, turtles suffer from various afflictions of the integumentary, respiratory, and digestive systems, as well as viral infections [7] as pneumonia, injuries, and fibropapillomatosis [8-10]. These conditions contribute to frequent strandings of these animals [6], particularly along the coast of Pará, which is crucial for feeding, resting, and reproduction [3], but is also subjected to the same predatory human activities, exacerbated by uncontrolled mangrove exploitation, water pollution, rampant tourism, and the practices of zootherapy and zoocraft [11].

There is evidence of the occurrence of all five species of marine turtles in the state of Pará, yet documentation of these occurrences remains sparse compared to other states and regions [2, 11-14]. Most stranded animals are found dead, but survivors are taken to rehabilitation centers [15], where they receive specific treatments, including clinical evaluation, laboratory tests, and radiological examinations, along with daily care by a team of veterinarians. This is exemplified by the Center for the Screening and Rehabilitation of Wild Animals at the Federal Rural University of the Amazon (CETRAS-UFRA), located in Belém, Pará.

Given the lack of sufficient information on marine turtles found along the coast of Pará, this study aims to provide an overview of the occurrence records of these species and the afflictions observed in individuals treated at CETRAS-UFRA, thereby enhancing and making available the literature on sea turtles with a specific focus on the northern region.

2. MATERIAL AND METHODS

The data for this retrospective observational study were obtained through the analysis of medical records files for animals originating from the coast of Pará, which were referred to CETRAS-UFRA between January 2021 and December 2022. The center's facility, located in the capital city of Belém (latitude -1.447464 and longitude -48.468167), is licensed by the State Secretariat for Environment and Sustainability of Pará as a Wildlife Screening and Rehabilitation Center, in accordance with Article 4, Section II of CONAMA Resolution No. 489, dated October 26, 2018.

The data were organized into spreadsheets using Microsoft® Office Excel 2019. To analyze the profile of the clinical afflictions in the animals, the following variables were considered: place of origin, month, history (conditions under which the animal was found), species, sex, age class, carapace length (CL), body condition score (BCS), degree of hydration, behavior upon admission, and diagnosed afflictions. These variables were obtained through clinical and complementary examinations, such as radiographs and blood tests, aimed at elucidating the diagnosis and informing appropriate treatment with antibiotics, anti-inflammatories, hydration, wound care, and feeding, until the animals were stabilized and ready for reintroduction into the wild.

Since the animals are wild, their age class was estimated based on morphometric data, considering carapace length (CL) and the following criteria: 5 to 20 cm for hatchlings, 21 to 80 cm for juveniles, and over 80 cm for adults (15). The BCS was categorized as regular, thin or cachectic.

However, to complement the information on the occurrence and distribution of species along the coast of Pará, a literature survey citing records of sea turtle species found in the study area was conducted. The information obtained was combined with the data from the medical records in order to develop a general map of sea turtle occurrences along the coast of the state of Pará.

The data analysis included variable reduction using descriptive statistics and graphical interpretation, performed with RStudio software, version 4.2.2 desktop, utilizing the packages ggplot, dplyr, readxl, and DescTools. The chi-square test was employed to test the association between non-numerical variables, with a significance level of 5%, and Cramér's V was used to assess the strength of these associations.

3. RESULTS

3.1 Occurrence Analysis

In the study, 20 marine turtles originating from the coast of Pará were treated at CETRAS-UFRA. The most frequently treated species was *Eretmochelys imbricata*, representing 50% (n=10), followed by *Chelonia mydas* with 40% (n=8), and *Caretta caretta* with 10% (n=2).
The distribution map of occurrence records indicated that *Chelonia mydas* was the most frequently reported species along the Pará coast (48.05%, n = 74), succeeded by *Eretmochelys imbricata* (16.23%, n = 25) and *Lepidochelys olivacea* (16.23%, n = 25). *Caretta caretta* accounted for 13.64% (n = 21), while *Dermochelys coriacea* represented 5.84% (n = 9) of the records, totaling 154 occurrences (Figure 1, supplementary data).

These species are concentrated in the northeastern region, with approximately 47% recorded in the municipality of Curuçá, 19% in Maracanã (particularly on Algodoal Island), followed by São João de Pirabas (9%) and Bragança and Salinópolis (8%).

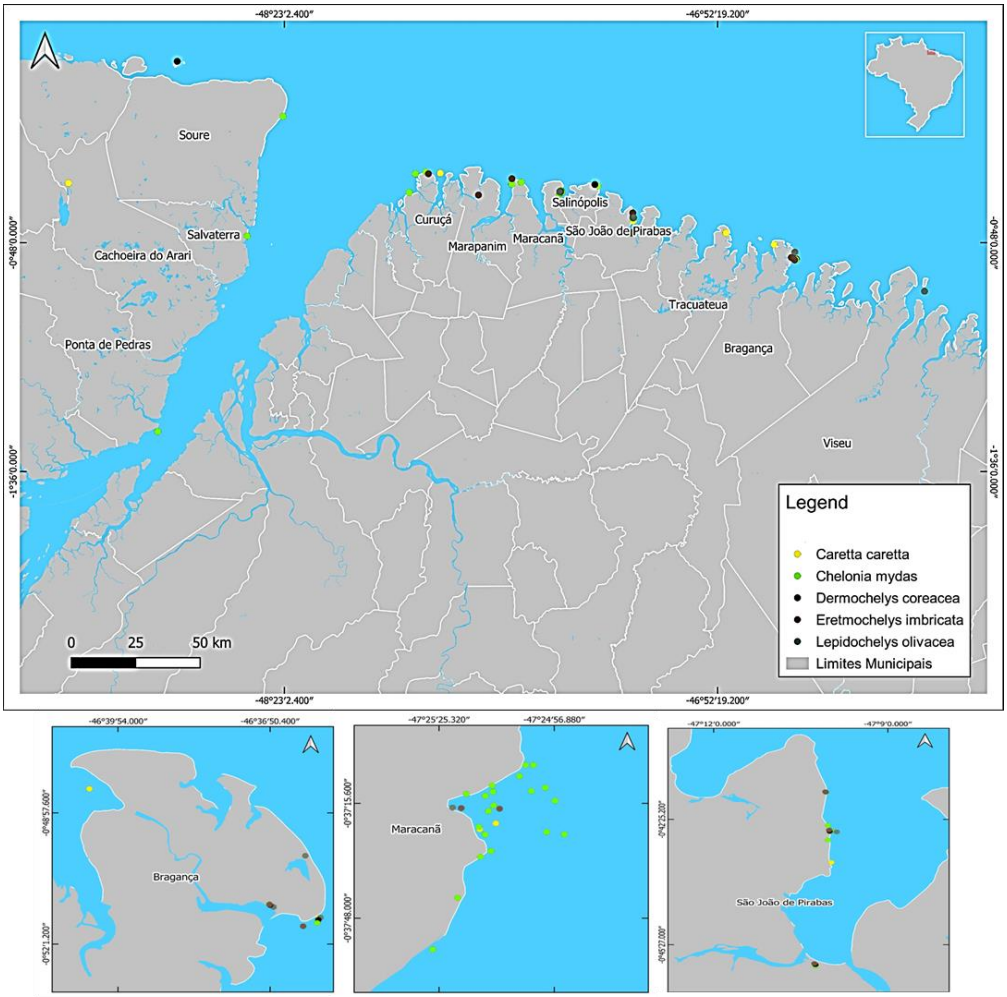

Figure 1: Occurrence records of sea turtles along Pará coastline, Amazon, Brazil.
Source: Data compiled from this research and Cunha (1975) [16], Marcovaldi et al. (2010) [17], Santos et al. (2011) [18], Silva et al. (2011) [19], Peabiru (2012) [12], Marcovaldi et al. (2012) [20], Baudouin et al. (2015) [21], Brito et al. (2015) [13], Chambault et al. (2015) [22], Cintra et al. (2016) [23], Dias et al. (2019) [14], Santos (2021) [11], Santos et al. (2022) [24], Correia et al. (2022) [25], Guimarães and Azevedo (2023) [26].

The majority of the animals received at CETRAS were hatchlings, accounting for 50% (n=10) of the records, with a mean carapace length (CL) of 8.0 cm (6.4 – 9.6, sd = 0.84 cm), all belonging

to the species *Eretmochelys imbricata*. Juvenile turtles represented 40% (n=8), with a mean CL of 53.35 cm (28 - 77, sd = 23.34), predominantly *Chelonia mydas* (n=7), with a species-specific mean of 48.82 cm (28 – 77, sd = 20.15), and one *Caretta caretta*. The latter represented the largest animals, with a mean CL of 82 cm (76 - 88, sd = 0.8), including the only adult in the group (5%), with a CL of 88 cm (Figures 2A and B). One individual (5%) was not classified due to the absence of age data in the clinical records.

In terms of sex determination, 75% (n=15) were categorized as undetermined, corresponding to hatchlings and juveniles. The remaining five specimens (25%) were identified as females, including three *Chelonia mydas* and two *Caretta caretta*.

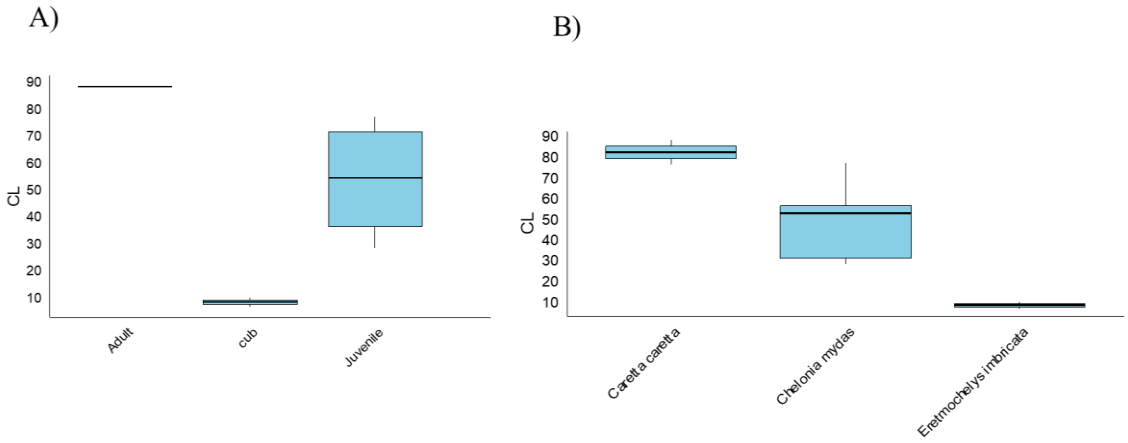

Figure 2: Age range of sea turtles treated at CETRAS-UFRA from 2021 to December 2022, originating from the coast of Pará, Amazon, Brazil. In A) the age range of the animals, in B) by species.

According to the historical data, 70% (n=14) of the animals were found stranded on the beach, including ten specimens of *Eretmochelys imbricata*, followed by three *Chelonia mydas* and one *Caretta caretta*. It was observed that 10% (n=2) were adrift due to buoyancy issues, both of which were *Chelonia mydas*. One *Chelonia mydas* was voluntarily delivered to the environmental authority in the metropolitan region of Belém, Pará. Another individual of the same species was accidentally captured in a fishing net, and a *Caretta caretta* specimen was found hooked in a freshwater river. However, in both cases, the historical records were vague and did not provide clear information (Figure 3).

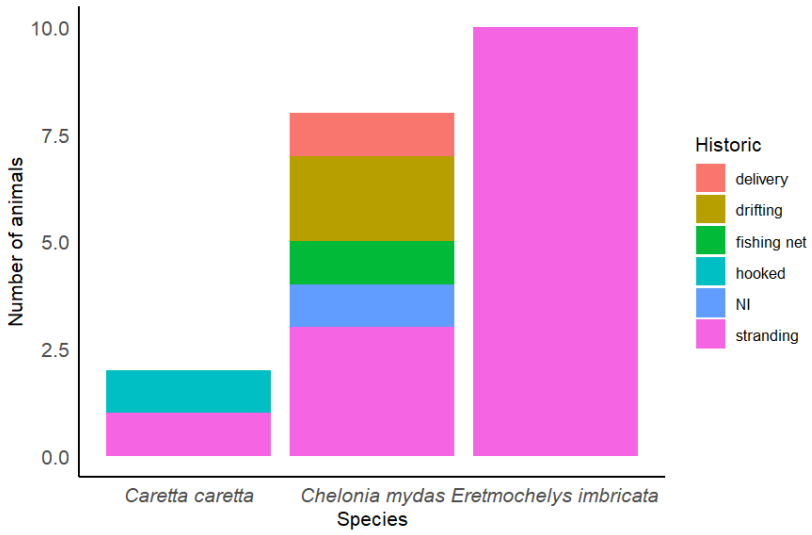

Figure 3: Detailed history of sea turtles before being brought to CETRAS-UFRA, from 2021 to December 2022, by species.

Analysis of the seasonal variation over the two-year data collection period revealed that the animals were admitted in March (n=1), April (n=1), June (n=10), September (n=2), November (n=2), and December (n=3), with one record lacking this information. Salinópolis was the primary site of origin of the animals treated at CETRAS. The spatial distribution of species indicated that 75% of the cases (n=15) occurred in the northeastern region of Pará, followed by Marajó in the north with 20% (n=4). One location (5%, n=1) was unidentified due to incomplete records. Salinópolis had the highest number of individuals (55%, n=11), mainly *Eretmochelys imbricata* (n=10) and one *Chelonia mydas*. Curuçá recorded two *Chelonia mydas*, while other northeastern Pará municipalities each recorded one individual. In Marajó, three records were made: one *Caretta caretta* in Santa Cruz do Arari, and two *Chelonia mydas* in Soure and Salvaterra (Figure 4).

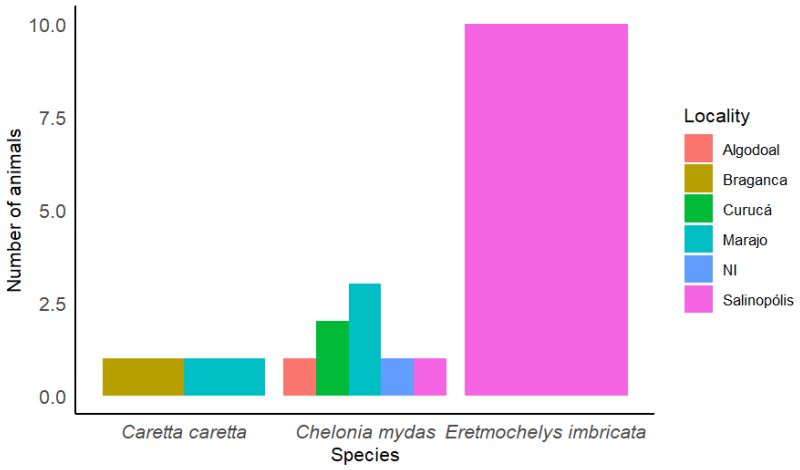

Figure 4: Spatial distribution of sea turtle species by location where they were found before being treated at CETRAS-UFRA from 2021 to December 2022.

The chi-square test revealed a significant association between the variables at a 5% significance level, with a $p < 0.001$. Cramér's V test indicated a strong association between the species and the location where it was found (Cramér's V coefficient = 0.95) as well as between the location and the historical context of how these animals were found (Cramér's V coefficient = 0.89), respectively (Figure 5).

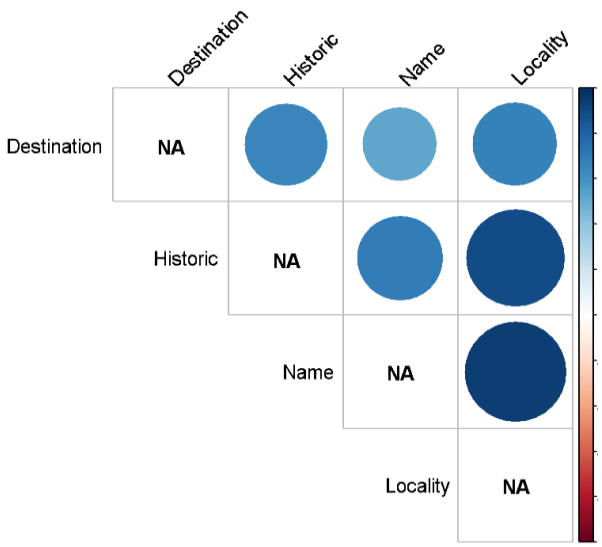

Figure 5: Correlation plot showing strong associations between species, location, and capture circumstances.

3.2 Clinical aspects of the animals

As described in methods, clinical evaluation and complementary examinations revealed 47.06% of cases associated with respiratory problems (n=16), followed by integumentary problems at 44.12% (n=15). Gastrointestinal and ocular alterations were recorded in 2.94% (n=1) and 5.88% of the cases. These percentages indicate that the animals exhibited multisystem involvement, since some animals presented more than one condition. Pneumonia as the most prevalent diagnosis, observed in 75% of the cases (n=16), as shown in Table 1 and Figure 6.

Table 1: Absolute frequency of diagnosed afflictions in sea turtles received at CETRAS-UFRA in 2021 and 2022.

Afflictions by system	**(%)**	**Affliction**	**Diagnosed affliction by species**			
			N=34	***C. caretta***	***C. mydas***	***E. imbricata***
Respiratory	47.06	Pneumonia	16	1	5	10
Integumentary	44.12	Fibropapillomatosis	3	0	3	0
		Dermatitis	6	1	3	2
		Cutaneous abrasions	4	1	3	0
		Demineralization	2	1	1	0
Gastrointestinal	2.94	Timpanism	1	1	0	0
Ocular	5.88	Not informed	2	1	1	0

Among the 20 marine turtles received, 60% (n=12) had a regular body condition score, 20% (n=4) were classified as thin, 10% (n=2) as cachectic, and 10% (n=2) had no information recorded in the clinical files. The cachexia's cases were identified in a *Caretta caretta* and *Chelonia mydas*.

At the time of admission, 75% (n=15) of the animals were apathetic, 5% (n=1) were agitated, and 5% (n=1) were responsive. In 15% (n=3), no behavioral description was provided in the clinical records.

Regarding the degree of hydration, 65% (n=13) of the turtles showed mild dehydration, 25% (n=5) had no data recorded, and 10% (n=2) were severely dehydrated.

Figure 6: Fibropapillomatosis in Chelonia mydas specimens treated at CETRAS-UFRA, Belém-Pa, in 2021 and 2022. In A, fibropapillomas above the anterior flippers; in B, in the inguinal region, tail, and below the posterior flippers; in C, fibropapillomas around the eyes; and in D, on the ventral portion of the animal.

4. DISCUSSION

In this study, we recorded three of the five species of sea turtles that occur along the Brazilian coast: *Eretmochelys imbricata*, *Chelonia mydas*, and *Caretta caretta*. However, the existing literature (supplementary data) confirms the presence of *Lepidochelys olivacea* and *Dermochelys coriacea*, making this the first study to compile various state references confirming the presence, spatial distribution, and afflictions affecting these turtles along the coast of Pará.

Eretmochelys imbricata had the highest absolute number of cases in CETRAS, but it is likely that the most attended species was *Chelonia mydas*, as this result derives from the rescue of hatchlings on the same day, while green turtles were attended from six different locations. The findings of Correia et al. (2022) [25], Dias et al. (2019) [14] and Chambault et al. (2015) [22] corroborate this information, due to the wide distribution [27] and extensive migration of *C. mydas* along the coastal zone of Brazil [21, 22] , which is why this species has the highest number of strandings in the country [2]. The species distribution map confirms that the occurrence in the state follows the sequence of *C. mydas*, *E. imbricata*, *C. caretta*, *D. coriacea*, and *L. olivacea*.

The estimated age class of the animals indicated that most were hatchlings and juveniles, with a history of stranding post-hatching, which can be attributed to the vulnerability of this life stage. Fuentes et al. (2010) [28] explain that these strandings occur when the animals become trapped in sand or vegetation, are affected by erosion, or suffer climate impacts. According to Jardim et al. (2016) [29], the prevalence of non-adult animals is expected, as the simultaneous presence of multiple age classes is rare in the Atlantic, where juveniles and adults usually occupy different areas. This further underscores the importance of the region as a feeding and breeding area for sea turtles.

June had the highest concentration of animal records, similar to the results of Brito et al. (2015) [13], who justified the relationship with the region's rainy season. Nevertheless, we consider that animals appear throughout the year, as the June peak explains the finding of newly hatched *E. imbricata* in Salinópolis, while from September to December, there was a second peak in the number of animals brought in for treatment. During this period, the dry season begins, and seawater tends to penetrate further inland due to lower river levels. Asp et al. (2013) [31] confirmed this movement, even though they indicated substantial differences between the localities of the coastal estuary of Pará, despite their proximity and similar morphology. Additionally, it is worth mentioning that fishing activities and other anthropogenic activities also increase during this period.

Nesting of *E. imbricata* appears to have become common along the coast of Pará, as, in addition to our records from Salinópolis, most reports in the literature cite occurrences in Curuçá and on Algodoal/Maiandeua Island (Maracanã) [12, 14]. According to Moura et al. (2012) [32], the choice of nesting beach for this species is influenced by areas covered with or located near vegetation, but preferably by open beaches. The Atalaia Natural Monument, which comprises surrounding lakes, fixed and mobile dunes, and restinga and mangrove vegetation [33], provides all the environmental conditions that explain the species' nesting in the area.

The fact that most animals were found stranded on beaches in the northeastern region of Pará confirms that this area is particularly important both for these species and for the local population. This is corroborated by the association test results, which were close to 1 in the analysis of the variables species, location, and history, indicating that the species are not randomly distributed along the coastline. A possible explanation is the constant movement of people in this region, which facilitates sightings and rescue efforts, as the logistics of reaching CETRAS-UFRA are favored by proximity and better road conditions. Moreover, most municipalities in this region are popular tourist destinations in the state of Pará. Jardim et al. (2016) [29] demonstrated that shallow coastal waters are key areas for both foraging and resting, supporting juvenile as well as adult individuals.

Another point to consider is a possible increase in public awareness, resulting from some government actions to restrict vehicle access to Atalaia Beach in Salinópolis from February to September 2023 to protect turtle nesting sites. Furthermore, informative reports, participatory monitoring actions of incidental turtle capture by fishing corrals in a nearby Extractive Reserve [25], and enforcement actions by environmental agencies may be reflecting greater social

awareness and efforts to save the animals. On the other hand, other areas with less logistical infrastructure may be going unnoticed or underreported, leading us to suggest that the recorded species occurrences may not yet reflect the state's true reality.

Both the strandings and other historical data that motivated the animals' treatment may be associated with anthropogenic environmental degradation, as Marcovaldi et al. (2011) [2] identified this as one of the main factors affecting sea turtles. This is further evidenced by the fact that more than ten years ago, Vidal and Mascarenhas (2012) [34] already reported pollution and sanitation issues along Pará's tourist coast. Another factor pointing to this understanding was the *C. mydas* found adrift with buoyancy issues, indicating that they may have ingested pollution debris or suffered from nutritional deficiencies [35], as turtles often mistake plastic and other objects for food, which can cause intestinal obstructions and gas accumulation, making them float and leaving them vulnerable Guebert-Bartholo et al. (2011) [36]. Although our results do not indicate many records of animals in fishing gear, we recognize that they pose a risk to the animals, as one *C. caretta* specimen was found hooked and one *C. mydas* was caught in a fishing net in Curuçá (PA). This is consistent with previous studies by Brito et al. (2015) [13], Brito et al. (2016) [30], and Santos (2021) [11], which have already addressed this issue in the studied region.

These historical data were crucial to understanding why pneumonia and dermatitis were the most prevalent afflictions. According to Pough et al. (2003) [37], pulmonary diseases are linked to pollution. Similarly, George (1997) [38] and NOAA (2013) [39] detail that the inhalation of contaminated water, caused by accidental captures, is one of the causes of bacterial and fungal pneumonia in turtles that escape fatal drownings. Additionally, Ciccarelli et al. (2020) [40] emphasizes that the disease can progress from lesions affecting the airways or secondary infections. Based on this, we believe that sun exposure and the debilitating conditions of stranding also contributed to the pneumonia cases in hawksbill turtle hatchlings.

These same reasons may explain the high percentage of dermatitis and abrasive lesions, often caused by interactions with fishing nets Guebert-Bartholo (2011) [36]. These lesions can allow the entry of pathogenic bacteria, resulting in fatal septicemia Escobedo-Bonilla et al. (2022) [10].

Among the recorded afflictions, the cases of fibropapillomatosis in the three *C. mydas* individuals indicate a reasonable prevalence of the disease in the local population. Cutaneous fibropapillomatosis manifests as tumor-like lesions that can impair swimming, vision, feeding, and breathing in turtles Santos et al. (2010) [35]. Environmental pollutants are also relevant to the emergence of the disease, but genetic susceptibility and immunosuppression are also factors related to this disease [8]. The occurrence of the disease in municipalities such as Curuçá, Algodoal Island, and Salinópolis suggests pollution and the presence of marine debris [35, 41]. This is an infectious disease with increasing prevalence [35], and its occurrence in different municipalities suggests possible transmission in the region, as these records in Pará's coastal areas are still scarce [26], highlighting the importance of this study in identifying the geographic distribution and characteristics of the disease along the coast of Pará.

5. CONCLUSION

This study confirms the presence of all five species of sea turtles along the coast of Pará, suggesting its use as a habitat, particularly during the juvenile stage. The prevalence of *Eretmochelys imbricata* hatchlings indicates that these beaches are important nesting sites. Most of the animals received were from the northeastern region of the state and were apathetic, with predominant respiratory and integumentary lesions, particularly pneumonia and fibropapillomatosis, suggesting pollution.

This work contributes to the literature on sea turtles with a specific focus on the northern region, highlighting the need for more in-depth studies on nesting, seasonality, periodicity, and stranding mechanisms. The increase in the number of cases in recent years may reflect greater monitoring and assistance on the beaches, but also an increase in the threats to these animals' survival. Nevertheless, the records still seem underreported.

The CETRAS-UFRA dataset provides valuable insights to support new research and guide management decisions for marine fauna conservation in Pará State

6. ACKNOWLEDGMENTS

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