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Impacts of climate change on breeding success of Green Turtles *Chelonia mydas* (Linnaeus, 1758) (Testudines: Cheloniidae) in Brazilian Islands

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Tese apresentada ao Programa de Pós-Graduação em Biodiversidade e Conservação da Natureza da Universidade Federal de Juiz de Fora como requisito parcial para obtenção do título de Doutor em Biodiversidade e Conservação da Natureza.

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Robson Henrique de Carvalho

Orientadora: Profa. Dra. Bernadete Maria de Souza

Tese apresentada ao Instituto de Ciências Biológicas, da Universidade Federal de Juiz de Fora, como parte dos requisitos para obtenção do Título de Doutor em Ecologia Aplicada ao Manejo e Conservação de Recursos Naturais.

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“Your eyes can deceive you. Don’t trust them.”

Obi-Wan Kenobi

Star Wars

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Summary

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Abbreviations

MMA - Ministério do Meio Ambiente.

IUCN - International Union for Conservation of Nature.

UFJF- Universidade Federal de Juiz de Fora.

INPE – Instituto Nacional de Pesquisas Espaciais.

General Introduction

Green Turtles - *Chelonia mydas* (Linnaeus, 1758) are distributed in tropical and subtropical regions in feeding and breeding areas (Lutz & Musick, 1996). Among the species of sea turtles in Brazil the Green Turtles are the only one that use oceanic islands for nesting (Almeida et al., 2011). They are in the Endangered (ED) category according to IUCN (Seminoff, 2004). The population of Green Turtle of brazil are from RMU Atlantic, Southwest and Atlantic, Southcentral population (Wallace et al., 2010).

In Brazil the nesting season is from December to June, in other countries the months of the nesting season may be different (Almeida et al., 2011; Bellini et al., 2013). Females lay 122 eggs on average (Bellini et al., 2013) and sex of hatchlings is determined by temperature (Yntema and Mrosovsky, 1982).

Fig. 1 Female of Green Turtle nesting at Atol das Rocas in February 2017.
Source: Personal archive.

Sea turtle populations are vulnerable to the effects of climate change at different levels (Witt et al., 2020). Rising air temperatures have caused the increase in the number of females, a process called feminization that is already registered in different parts of the world (Allen et al., 2015).

Green Turtles, like other turtle species, may have ability to respond to climate changes, for example changing the period of their nesting season, as has already been observed in Florida (Weishampel et al., 2010). It is extremely urgent to study the reproductive characteristics of sea turtles, especially at regional levels, because each rookery there must be some variation in this temperature in order to maintain phenotypic diversity (Booth & Freeman, 2006). Sea turtles are important indicators of the impacts of climate change. To measure the impacts of climate change on the reproduction of Green Turtles we need to better understand the reproductive characteristics. Only then can we understand these impacts and study the adaptability of populations (Godley, 2009; King et al., 2012).

This further increases the gap between our knowledge and the measures that must be taken to mitigate the impacts of climate change. In addition, other information about the biology of these animals, such as copulation behavior and predation of hatchlings is still poorly reported on oceanic islands, these characteristics are examples of knowledge that we can acquire during field research activities. Therefore, the general objective of this work is to study biological characteristics of the reproduction of Green Turtles in Brazilian oceanic islands, especially linked to sand temperatures and breeding.

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Chapter 1

Thermal profile of Green Turtle nesting beaches in Brazilian islands and their vulnerability to climate change

Abstract

Sea turtles are vulnerable to effects of climate change, the increase in temperature leads to a higher production of female turtles, the increase in the frequency of extreme weather events increases the impact of nest loss in the affected areas, moreover, projections indicate that the rising sea levels will lead to a potential loss of current nesting areas. In view of this, the goals of the study are: (1) Access sand and air temperature data in two Green Turtle nesting areas (2) Study the relationship of climatic characteristics and the possible impacts on the reproduction of Green Turtles. To achieve these objectives, we access the temperature of sand and turtle nests in Atol das Rocas and in Trindade Island. Dataloggers were buried in Atol das Rocas during the 2017 and 2018 season and in Trindade Island in 2011, historical data on air temperature were also accessed at both locations. The data show current and historical temperature averages below 29.2 ° C in the Atol das Rocas, this is important as pivotal temperatures for Green Turtles are close to that temperature. Green Turtles' nest in the hottest months of the year. which can lead to sex ratio biased and high mortality rates. This work is a first access to thermal profiles and the impacts that climate change may have on the reproduction of Green Turtles in Brazil.

Keywords: climate change, temperature, hatchlings, reproductive biology.

1. Introduction

The sex of sea turtle's hatchlings is determined by nest temperature, where higher temperatures producing more females and lower temperatures more males (Pieau & Mrosovsky,1991). Sea turtles are vulnerable to effects of climate change (Fuentes et al., 2012; Reneker et al., 2016; Montero et al., 2018). Accessing this knowledge about temperature of the sand in islands is extremely important because it allows us to realize the importance of South America in relation to the reproduction of Green Turtles. Accessing the profile temperatures of sea turtle nesting areas is essential to understanding how climate change is affecting the reproduction of all species of sea turtles (Kaska et al., 2006).

Other studies at local levels and for each species of sea turtle are important for understanding characteristics and threats at global levels (Tomillo et al., 2018). In addition, accessing the thermal profiles is the first step to better understanding the importance of each breeding site for turtle conservation (Montero et al., 2018, Patricio et al., 2018).

The impacts of climate change on sea turtles are related to different levels, such as increased temperature, sea level rise and cyclonic activity (Fuentes et al., 2011). Green Turtles nest in tropical and subtropical areas. Green Turtles in Brazil nesting especially on Oceanic islands (Almeida et al., 2011; Bellini et al., 2012).

In Brazil, there are already studies related to the relationship between the environment and the sexual proportion of hatchlings for the species *Caretta caretta*, which demonstrate that there is a tendency to produce more females in northeast and males in southeast (Baptistotte et al., 1999, Marcovaldi et al., 2016), this study is very important due to the problem the increase in the number of birth of female turtles due to the increase in temperature.

Other studies (Monsinjon et al., 2019), demonstrate the vulnerability of *Caretta caretta* nesting areas in Brazil, demonstrating that they are vulnerable to different impacts at regional levels, being that in the northeast they will be more significant than in the southeast. However, studies for Green Turtles in Brazil are still poor. In other parts of the world, several studies demonstrate the trend towards the feminization of the Green Turtle population in Africa and Australia over the next 100 years according to IPCC projections (Fuentes et al., 2010a, Patrício et al., 2018). Changes in phenology have been observed in other sea turtles in response to changes in sea surface temperature (SST), with a tendency to nest earlier (Weishampel et al., 2010).

Registering the variation in sand and nest temperatures within a rookery is the first step toward a detailed understanding of how incubation temperature influences sea turtle populations (Booth & Freeman, 2006). Discovering Brazil's role in the reproduction of these animals is extremely necessary to understand the global dynamics of Green Turtle populations. Studies on oceanic islands are also rare, as these environments are often difficult to access, in addition they require a higher financial cost than studies done on the continent, all of these difficulties are reflected in the smaller number of studies carried out on oceanic islands in Brazil. Climate change is happening fast and questions of how it affects wildlife are still unanswered. In this way, sea turtles can be good indicators of the effects of climate change on coastal and marine habitats (Godley, 2009).

In order to propose solutions to these problems, it is necessary first to know the vulnerability of the Green Turtle nest in the Atol das Rocas. These data bring the importance of controlling the emission of greenhouse gases in the atmosphere in relation to their effects on biodiversity. In a specific case in the Brazilian islands can be taken measures of management of the nests, aiming at a greater effectiveness in the reproduction if indicated significant impacts in some specific area of the island.

The goals of the study are: (1) Report the thermal profiles of the sand of two Brazilian Islands where Green Turtles reproduce (2) Study preferences regarding the environmental characteristics associated with the choice of the nest location and the relationship of these characteristics with the distribution of the nests.

2. Methods

2.1 Study areas

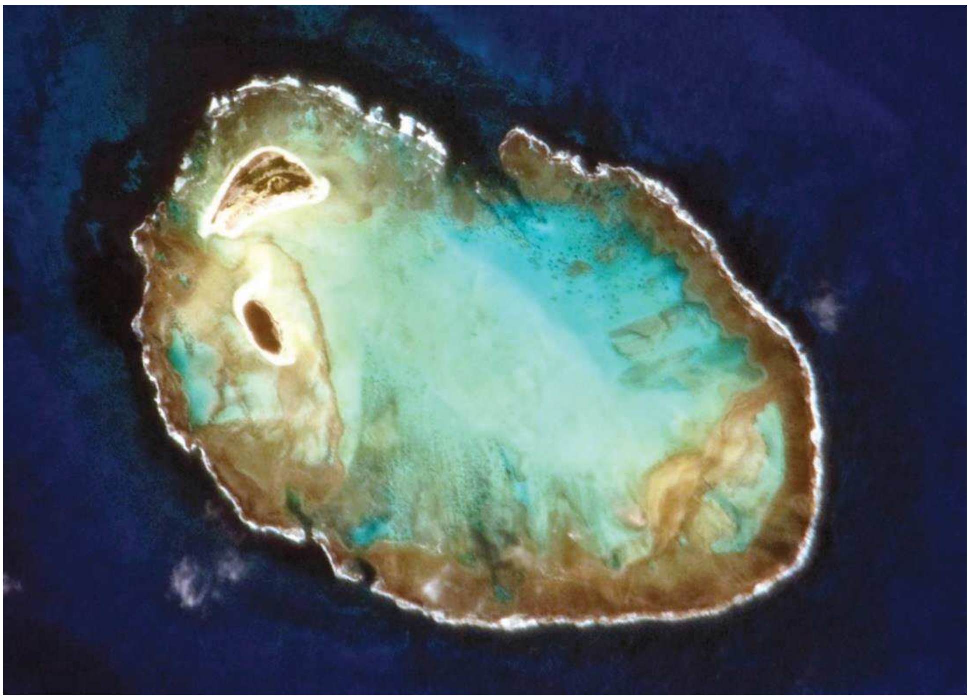
Data were collected in two nesting areas of Green Turtles in Brazil, Atol das Rocas (Northeastern Brazil) and Trindade Island (Southeastern Brazil) (Lutz & Musick, 1996; Almeida et al., 2011).

Fig. 2 Map of nesting grounds used by the Green Turtles in Brazil (Bellini et al, 2012).

2.1.1 Atol das Rocas

The Atol das Rocas (3°51′50″S 33°48′40″W) is located at 260 km of the state capital of the Rio Grande do Norte and at 150 km of the Fernando de Noronha archipelago, in Northeastern of Brazil. The Atol das Rocas is a Federal Reserve since 1979, but it was only in 1990 that sea turtle conservation activities began. The nesting peaks occur between February and April, with an annual average of 335 (±139) nests, with 120 (±28) eggs on average and emergence success ranging from 70.1% to 78%, the incubation period varies between 54.6 and 62.4 days (Bellini et al., 2012).

Fig. 3 Picture of the Atol das Rocas taken from the international space station. Source: Image Science and Analysis Laboratory, NASA-Johnson Space Center.



2.1.2 Trindade Island

Trindade Island is part of Trindade and Martin Vaz archipelago (20º30'S and 29º20'W), that is located 1,160 km off the coast of the state of Espirito Santo state. The archipelago consists of five islands and form the island group furthest from the Brazilian coast. Trindade is the largest island, with an area of 10.1 square kilometers. It has nine beaches where *C. mydas* nesting (Almeida et al., 2011). Given the importance of the island for the conservation of sea turtles, the Tamar Project (Brazilian Sea Turtle Conservation Project) has been monitoring the island since 1982, sending teams of researchers and trainees to follow the nests of *C. mydas* and to capture and mark the *Eretmochelys imbricate* (Linnaeus, 1766) juveniles that use Trindade as feeding area.

The islands are of volcanic origin and have rugged terrain (Santos et al., 2015). The climate of this island complex is the tropical Atlantic tempered by east and southeast trade winds, and its average annual temperature of 27ºC (Serafini et al., 2010).

Fig. 4 Image of Ilha de Trindade. Source: Simone Marinho.

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2.2 Data collect

2.2.1 Atol das Rocas

Data collection on nest characteristics was mensured between 18 January and 22 February of Year 2017. The collections were always carried out at night, only in Ilha do Farol, two hours before high tide and ended when the tide was low and the turtles could not access the beach to nest. There is another smaller island within the Atol das Rocas, called Ilha do cemitério, due to logistical difficulties we only carried out this study on the Ilha do Farol.

To measure sand temperature, we buried nine dataloggers (HOBO Water Temp Pro v2, Onset computer corp, with a precision sensor for ±0.2°C accuracy), around Ilha do Farol (randomly and not systematically) all at a depth of 70cm. The devices were buried on the beach, in line with the vegetation, locations were chosen where other nearby turtle nests were observed.

To measure nest temperature, we buried one datalogger per month in the 2017 nesting season (Jan to June) in the central portion of the nest, totaling 6 dataloggers, the dataloggers were removed when the eggs hatched. At this time, the number of hatched eggs and the number of stillborn turtles were also recorded. There were 6 nests in different areas of the island, chosen by the field team during the monitoring.

To better understand the characteristics of the micro-habitat, during the nesting, the temperature and humidity of the air and sand were measured. For this, a thermo hygrometer (Standart model from Thermo, ±1°C/5% accuracy), was used with an external probe, to measure the temperature in the air and humidity of the air, we held the device approximately 1 meter above the surface of the nest, to measure the temperature and humidity of the sand we buried the external probe at approximately 3 cm in sand, on the surface at the edge of the nest.

It was also measured the distance from the nest to water and the distance from the nest to the vegetation, the depth of the nest and the beach area where the nest was placed (under vegetation, between vegetation and beach or open beach), using a measuring tape (30 meters). Data on female size and nest location was accessed from the Rebio - Atol das Rocas Report.

Fig. 5 Atol das Rocas data collection activities in nesting season 2017. (A) Dataloggers and datalogger data reader, (B) dataloggers stuck to pvc pipe, (C) Researcher digging a hole in the sand near vegetation, to bury the dataloggers.

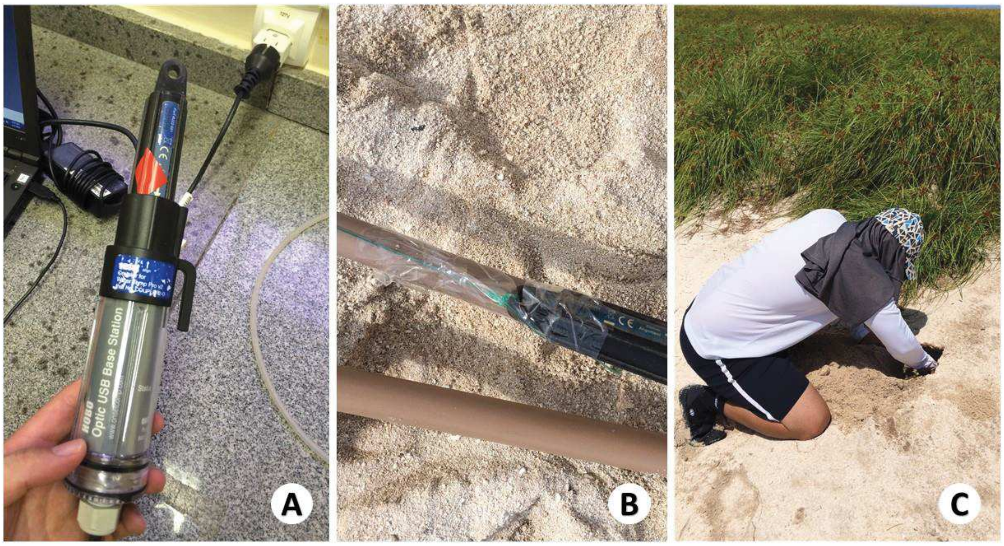
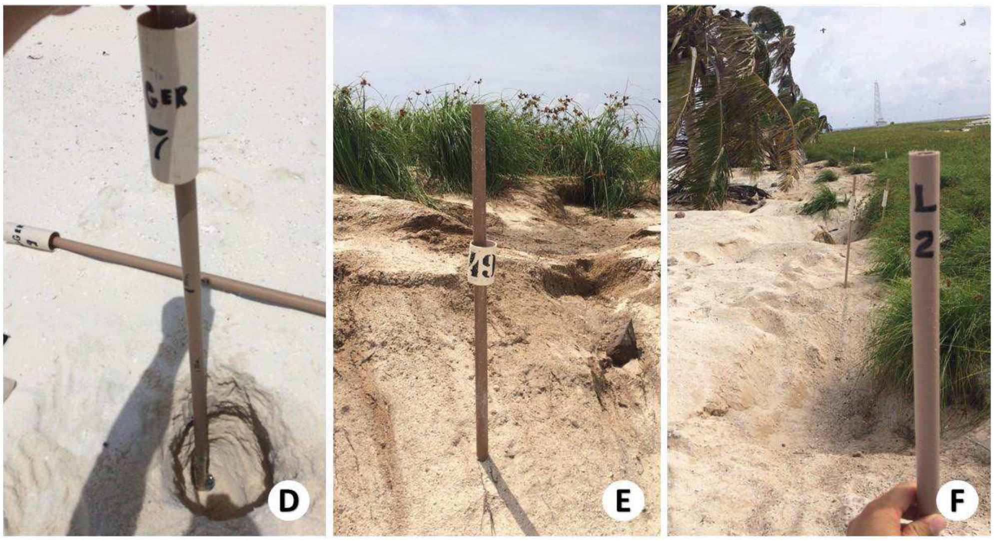


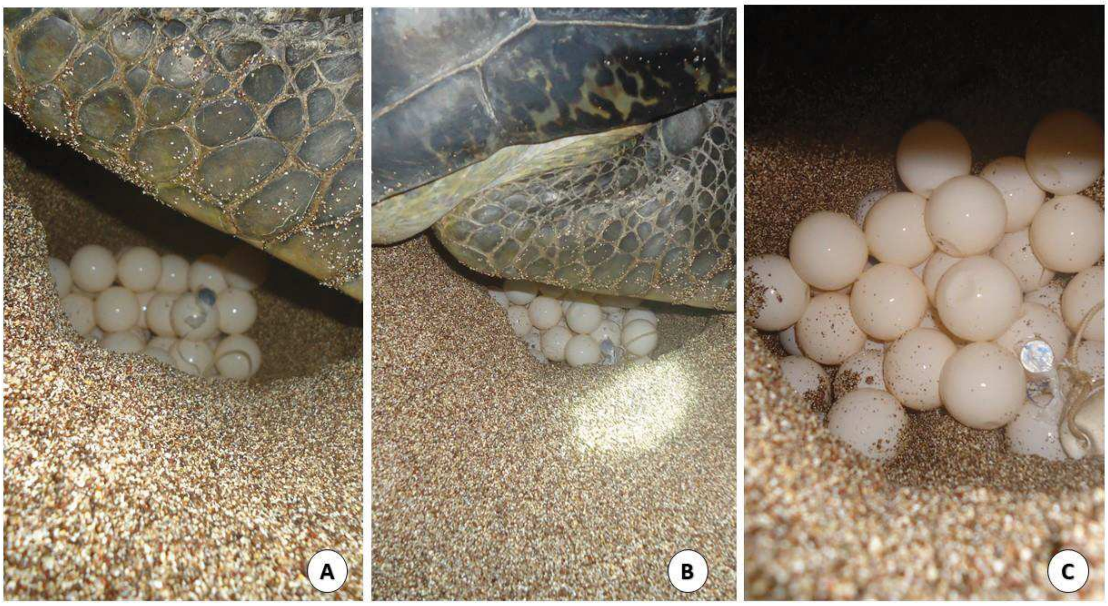
Fig. 6 Atol das Rocas data collection activities in nesting season 2017. (D) Location where datalogger 7 was buried, (E) Nest 49, (F) Location where datalogger 2 was buried.



2.2.2 Trindade Island

Data collection was performed from December 2011 to April 2012, Maxim Ibutton thermographs were used to measure the incubation temperature of Green Turtle nests in Trindade, in 21 nests. The thermographs were positioned in the middle of the egg chamber, recording the temperature at 60 min intervals throughout the incubation period. Thermographs were collected after hatching, when data were collected on the number of live hatchlings, dead hatchlings and unviable eggs. The collection of data from the Trindade Island was carried out by biologist Paulo Roberto de Jesus Filho and were provided for this project.

Fig. 7 (A, B and C) images of Green Turtle nests, taken during nesting, with ibutton placement. Ilha de Trindade, 2011. Source: Paulo Roberto de Jesus Filho.



2.3 Analysis

2.3.1 Sand and nests temperatures

The graphs with the thermal profiles of the Atol das Rocas were made using the daily temperature averages of the dataloggers measured during the nesting season (December to July). For reference, a line was drawn at the pivotal temperature for the species (29.2° C) (Godfrey & Mrosovsky, 2006). Graphs of nest temperatures were made with daily temperature averages measured by the nested datalogger during the egg incubation period.

2.3.2 Spatial distribution of nests

To make the maps, the Shapes files were built from satellite images (Datum WGS84). Free access images via Google Earth Pro. made by (Longo et al., 2015) for geomorphological characterization of Atol das Rocas. We excluded 215 nests for presenting geographic coordinate errors (latitude and longitude).

For the nest distribution map of the same female, we consider females with at least four nesting episodes in the same season of 2017 (fourteen females, sixty-three points). The females were identified by the number of the washer present in their fin.

3. Results

We recorded data from January 22 to February 24, 2017 from 78. Females always nesting at night, during high tide, average air temperatures during spawning were 26.76 ° C ± 0.58 (N = 76) and sand 26.07 ° C ± 0.65 (N = 77), the main nesting site was between sand and vegetation (67%) (N = 24), the average nest depth was 73.38cm ± 7.25cm (N = 21) (Table 1).

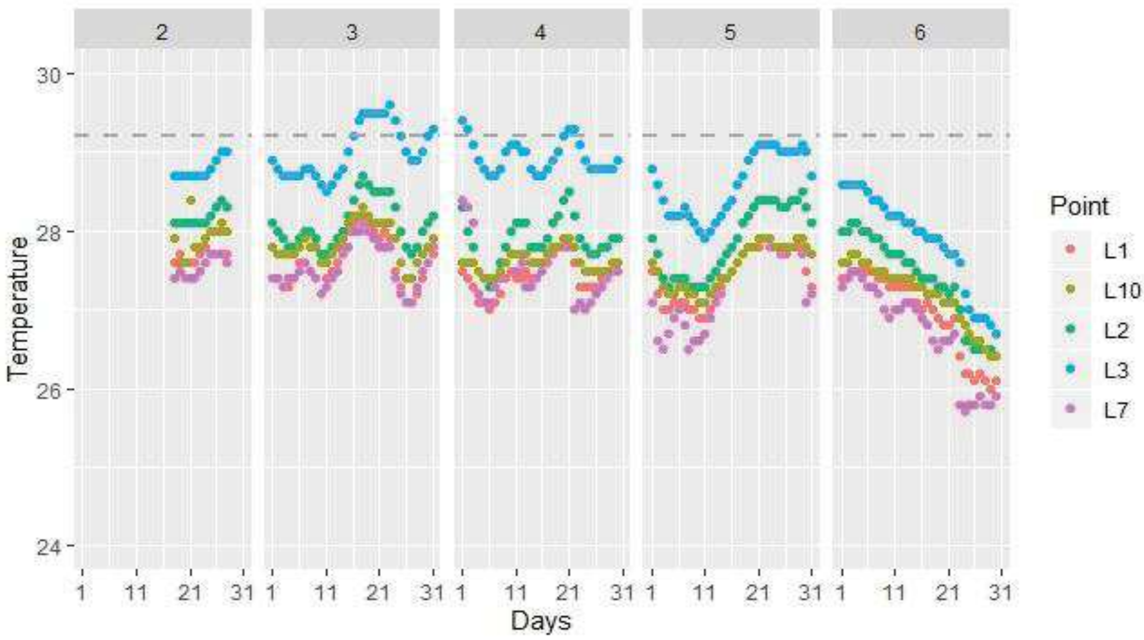
Table 1 Characteristics of Green Turtle nesting microhabitat in Atol das Rocas, Rio Grande do Norte State, Brazil.

Parameters	Results	Number of nests
Air temperature	26,76°C ± 0,58	N=76
Air humidity	83,17% ± 3,13	N=78
Sand temperature	26,07°C ± 0,65	N=77
Sand Humidity	83,18% ± 3,09	N=76
Distance from the sea	15,46m ± 5,3	N=51
Distance from vegetation	6,57m ± 5,35	N=28*

* 50 nests were under vegetation and were not in this and were not in this analysis.

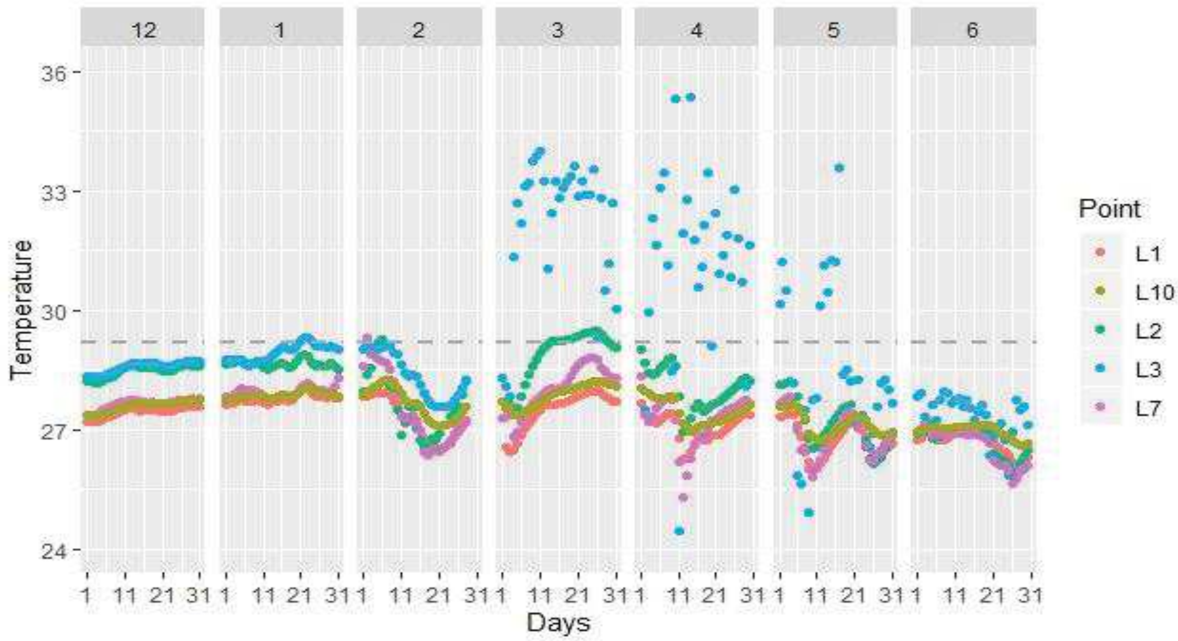
Daily temperatures of sand temperatures during 2017 nesting season can be seen in Fig 8. The five dataloggers have different temperatures, with the L7 (datalogger 7) presenting the lowest daily averages and the L3 (datalogger 3) datalogger presenting the highest daily sand temperature averages.

Fig. 8 Daily average sand temperatures for the 2017 Nesting season (Feb-Jun) in Atol das Rocas. Sand temperatures were recorded every 1 h and these averaged over a 24-h period to give the daily means. The column numbers represent the months, February is 2, March 3, April 4 etc. The letter L represents the dataloggers, L1 represents the Datalogger 1, l2 the datalogger 2 and etc. For reference, a dotted line was drawn at the pivotal temperature for the species (29.2 ° C) (Godfrey & Mrosovsky, 2006).



Daily temperatures of sand temperatures during 2018 nesting season can be seen in Fig. 9. The five dataloggers have different temperatures, with the L10 (datalogger 10), L7 (datalogger 7) and L1 (datalogger 1) dataloggers presenting the lowest daily averages and the L3 (datalogger 3) presenting the highest daily sand temperature averages. Regarding the differences in temperature averages between the dataloggers, even considering that they were buried at the same depth (70 cm), different points on the island were chosen, it should be considered that other physical characteristics of the place interfere with the temperature of the soil, such as color of the sand, granulometry and humidity. The sharp drops in the temperature of the sand, when registered by only one datalogger, may indicate that this was touched by other turtles during the excavation of new nests. Therefore, they should be disregarded.

Fig. 9 Daily average sand temperatures for the 2018 Nesting season (Dec-Jun) in Atol das Rocas. Sand temperatures were recorded every 1 h and these averaged over a 24-h period to give the daily means. The column numbers represent the months, February is 2, March 3, April 4 etc. The letter L represents the dataloggers, L1 represents the Datalogger 1, l2 the datalogger 2 and etc. For reference, a dotted line was drawn at the pivotal temperature for the species (29.2 ° C) (Godfrey & Mrosovsky, 2006).



The average nest temperatures in the second third of incubation of monitored nests in Atol das Rocas during the 2017 nesting season was 29.69°C (Fig. 10), unfortunately the other five dataloggers buried in the nests in 2017 were lost during thunderstorms or showed failures.

Fig. 10 Nest temperatures for the incubation period (01/24/2017 – 03/26/2017) on Nest 75 in Atol das Rocas. Sand temperatures were recorded every 1h and these averaged over a 24h period to give the daily means. The column numbers represent the months, February is 2, March 3, April 4 etc. For reference, a dotted line was drawn at the pivotal temperature for the species (29.2 ° C) (Godfrey & Mrosovsky, 2006).

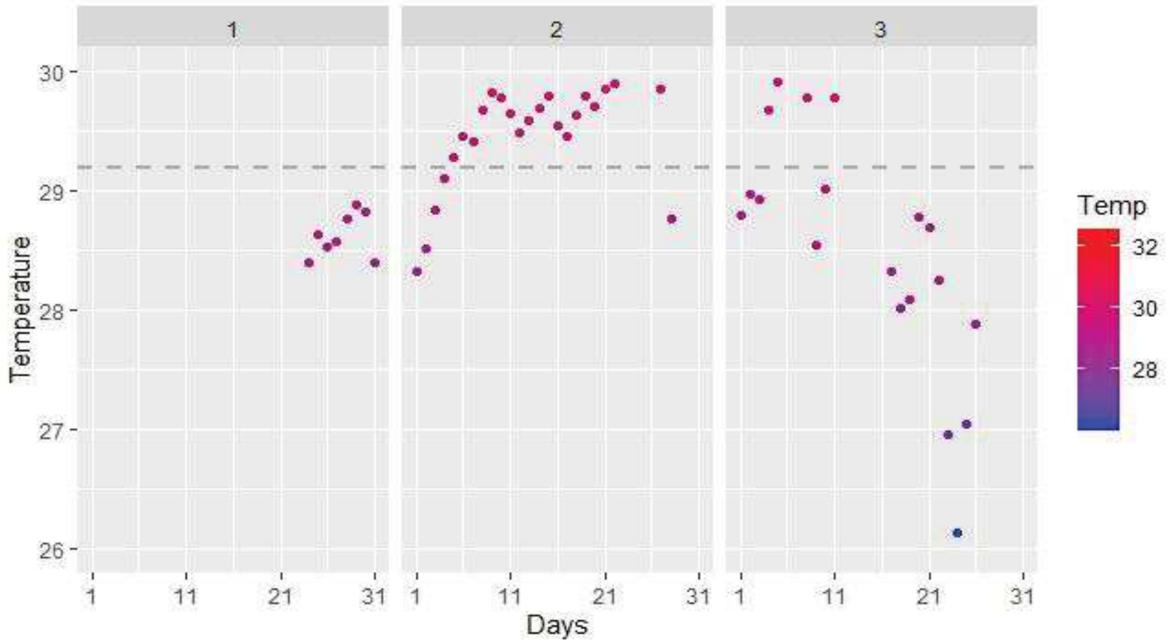
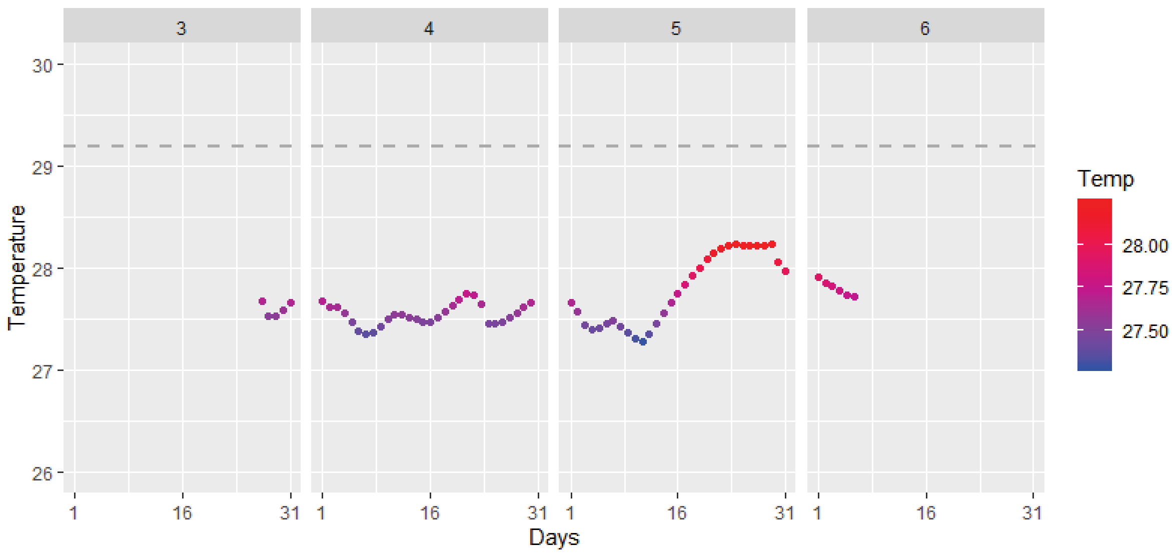


Fig. 11 Nest temperatures for the incubation period (03/27/2017 – 06/06/2017) on Nest 469 in Atol das Rocas. Sand temperatures were recorded every 1h and these averaged over a 24h period to give the daily means. For reference, a dotted line was drawn at the pivotal temperature for the species (29.2 ° C) (Godfrey & Mrosovsky, 2006).



The average nest temperatures in the second third of incubation of monitored nests in Trindade Island during the 2011 nesting season were variable. The nests with the lowest temperature averages were those placed in December and the nests with the highest temperature averages were those placed in February. Sixteen nests had average temperatures higher than 29.2°C (Pivotal temperature), indicating that they produced more females than males.

The average depth of trinity island nests was 101.9cm (N = 21), the average emergence success was 85.74% and the incubation period was 57.15 days on average (Table 2).

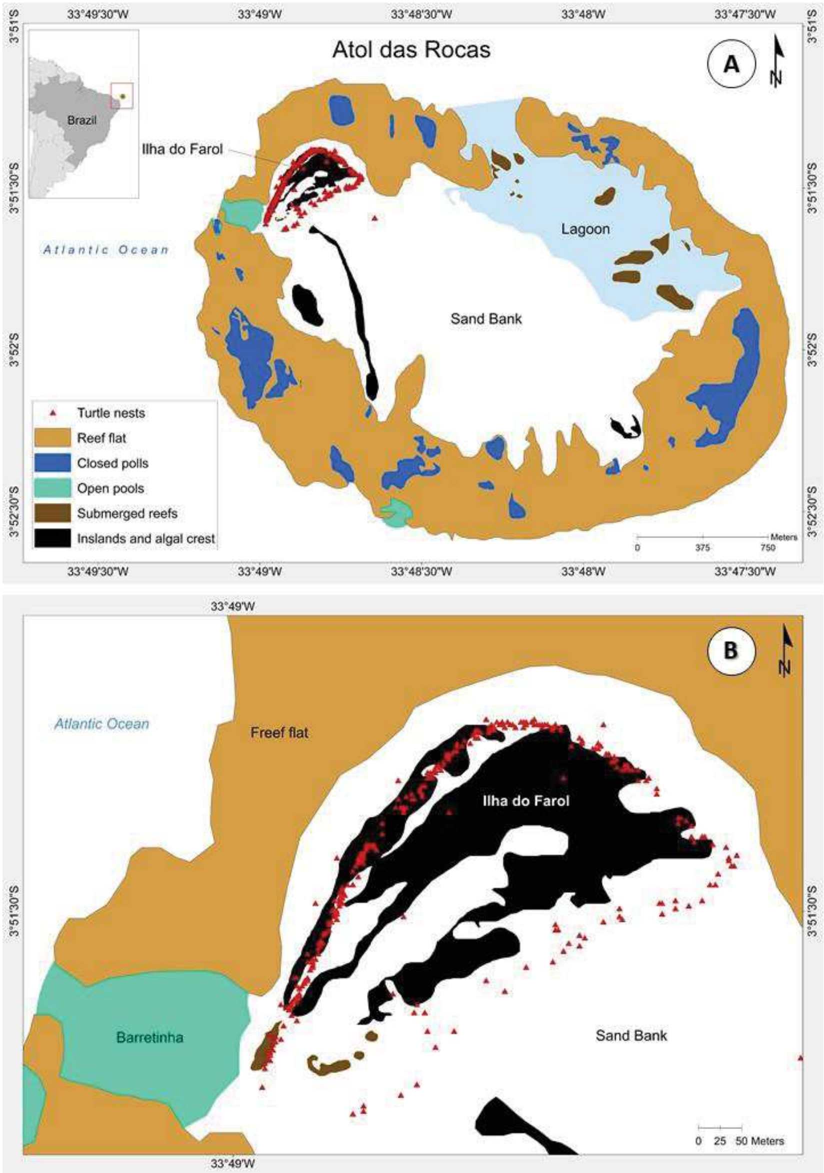
Table 2: Laying date, incubation periods, Depht, Emergence success and temperature data (C°) for the 21 clutches (one of Atol das Rocas and twenty for Trindade) in wich temperature was monitored.

Nest	Lay date	Incubation Period (days)	Depht (cm)	Emergence success (%)	Middle third IP Mean	±SD	Min	Max
Atol das Rocas								
75	01/24/2017	62	-	88.7	29.69	-	28.76	30.88
Trindade								
1	12/09/2011	65	117	98.9	27.66	1.09	26.50	30.50
2	12/10/2011	72	80	90.3	31.41	1.17	29.50	33.00
3	12/13/2011	63	122	97.0	28.50	0.81	27.50	30.13
4	12/15/2011	56	152	47.6	29.12	0.68	28.20	30.63
A	12/16/2011	107	103	70.0	29.59	0.71	28.50	31.00
9	12/18/2011	68	104	82.0	28.04	0.81	26.50	29.50
15	12/27/2011	50	109	96.4	29.20	0.70	28.50	31.00
18	12/29/2011	52	87	95.8	31.56	0.80	30.00	33.00
19	12/30/2011	55	-	93.0	29.52	0.25	29.00	30.00
20	01/01/2011	51	107	91.8	29.96	0.21	29.50	30.50
22	01/02/2011	55	110	83.3	30.61	0.34	30.00	31.50
30	01/12/2011	44	90	87.4	30.35	0.44	30.00	31.50
34	01/14/2011	54	108	94.6	29.98	0.44	29.50	31.00
35	01/16/2011	55	90	93.6	30.37	0.44	30.00	32.00
37	01/23/2011	55	92	93.2	30.83	0.86	30.00	32.50
59	02/04/2011	47	80	85.5	30.63	0.51	30.00	32.00
61	02/07/2011	47	91	87.8	31.13	0.57	30.50	32.50
62	02/04/2011	54	107	95.6	31.52	0.88	30.50	33.00
67	02/08/2011	44	112	94.8	31.35	0.34	31.00	32.00
68	02/08/2011	52	68	58.8	31.74	1.05	30.50	33.50
69	02/08/2011	52	109	70.4	31.40	1.07	30.00	34.00

3.1 Spatial distribution of nests

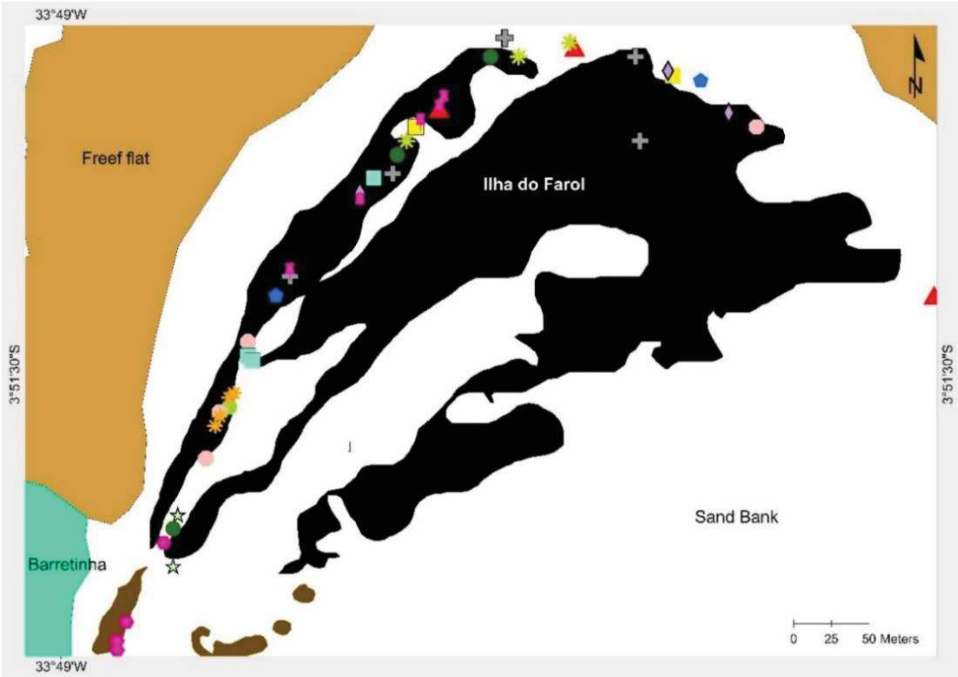
The nests are distributed over the entire length of the Ilha do Farol and are concentrated on the North face of the Island. Most of them are in the highest part, where they have more vegetation than the south side of the Island (Fig. 12).

Fig. 12 A and B, distribution of Green Turtle nests in Atol das Rocas, nesting season 2017. Each red triangle represents a nest.



The points present a difference between the shaded area of the map because, due to the currents on the island, the shape of the island changes due to the internal currents of the Atol das Rocas.

Fig. 13 Nest distribution map of female Green Turtles that performed at least four nests in the 2017 season. Each symbol represents the same females in different time periods.



Nest site preferences was observed in some females, it was observed that in the 2017 nesting season some turtles placed the four nests in the same area of the Island (pink circles, dark yellow asterisks), others showed preference for a certain area by placing 3 some nests nearby and only one distant (light pink circles), one the female placed two nests in the same location (light blue square) and other females did not show preference for areas of the island, placing the nests in different locations (blue pentagon). Each symbol represents a nest of a certain female (Fig. 13).

4. Discussion

The Green Turtles nest at night and during high tide hours, because at that moment they can approach the nesting beach. Bustard & Greenham (1969) described the nesting behavior of Green Turtles in Australia in nine stages, the first stage when they approached the nesting area during sunset, but they had to wait for the tide to rise to access the beaches, even if it happens in Atol das Rocas, it also says that Green Turtles rarely nest in daylight. The average depth of the nests was 73.38 cm ± 7.25 cm (N = 21). The depth of the nest depends on several factors, including the size of the female (Bustard & Greenham, 1969). Regarding the clutch size, they can vary from 3 to 209 eggs in Costa Rica for example, and the age of the females is related, the older the female the larger the clutch size (Bjorndal & Carr, 1989).

Most nests were close to vegetation, between the middle zone and vegetated zone, studies indicate that vegetation has a strong influence on the choice of nesting sites for Green Turtles, due to the presence of roots that increase the sand compaction, allowing the nest is dug without collapsing (Chen et al., 2007). Knowing the basic characteristics of the nests and the influence of environmental factors is essential for a better understanding of how climate change may affect the reproduction of sea turtles (Fuentes et al., 2010b), factors such as albedo and the presence of silt can significantly change rates hatching, dark sand have higher temperatures (Hays et al., 2001, Marco et al., 2017). Temperature is directly related to reproductive success, but other studies show that it is not always the main fact that affects sexual rates, in the study by Santidrián Tomillo et al., (2015) it was shown that for leatherback turtles, the humidity of the sand demonstrated a more direct relationship with the reproductive success than the temperatures.

The sands of Atol das Rocas have high surface moisture, but sand moisture at other depths was not analyzed, Patino-Martinez et al., (2014) Analyzed the ratio of moisture in the sand under the sand and surface and it was found that the success of emergence of leatherback turtles, it was observed that the nests where the sand was more humid the success of emergence was greater. When analyzing the relationship with the moisture of the sand surface, no relationship with other reproduction parameters was found, so it has no direct relationship with the size and speed of hatchlings. The relationship between hatching rates and drier or wetter nests may differ between species (Mortimer et al., 1990).

Nesting takes place in the hottest months of the year in Atol das Rocas and Trindade, with the highest number of nests in March and April. These data corroborate the work of Bellini et al., (2011), which can demonstrate that there is still no temporal variation in the months of preference for nesting activity. Air temperature averages of 26.76 ° C in Atol das Rocas may indicate good conditions in the region for the production of male turtles.

However, it is not only the air temperature that influences the temperature of the nest, studies related to environmental characteristics such as depth of the nest and distribution show different correlations of each of these factors with the temperature of the nest, among them. There was correlation between mean nest depht and mean nest temperatures (Booth 2006, Kiliç and Candan, 2014), in addition beach orientation influenced sand temperatures. Other studies have shown that there are differences between nests deposited on different sides of the same island, such as what happens on Heron Island for example, sand temperatures demonstrate complexity and variability, they vary even in the same nesting areas, the same island may have different thermal profiles in its territory, as well as areas close geographically (Fuentes et al., 2010a). There is a positive relationship in relation to nest temperature and distance from the sea and a negative relationship between nest temperature and incubation duration. (Kiliç and Candan, 2014). The lower temperatures of the sand of the Atol das Rocas can also be linked to the specific heat of the sediments. The sediments of Rocas are represented, practically in 100%, by bioclasts, in which, among the organisms that constitute the sediment, the calcareous algae is the most notable bioclast. The size of the Atoll is variable (Pereira et al., 2008).

In addition to the sex ratio, temperature is related to other factors related to turtle reproduction. For example, the incubation temperature has an effect on the locomotion and size of the leatherback turtles hatchlings, according Patino-Martinez et al., (2014) turtles incubated at 27˚C showed decreased locomotor ability. Turtles incubated at 31˚C took longer to right themselves but showed high locomotor ability in other tests. Turtles incubated at both 27˚C and 31˚C were also the smallest in curved carapace length (Patino-Martinez et al., 2014).

The observations of the spatial distribution of the nests demonstrate that they are distributed throughout the area of the Ilha do Farol, and are concentrated on the north face of the Island, in that part of the island we can find a greater amount of vegetation, some trees, a higher concentration of mixed organic matter with sand (darker sand) and higher elevation, which may explain this preference for these areas.

The female sea turtles are philopathic, that is, they nest on the beaches that were born, in the Atol we test the female loyalty to the beach regions, trying to reveal if there is a tendency to choose the nest location, some females presented nests in only one area of the island, having even nesting in the same location in the same region of the island, others did not show this trend, spawning each nest in a region of the beach, these data demonstrate the plasticity of the nesting choice behavior, which can be revealed as different reproductive strategies, such as the careful choice of a preferred location and egg deposits in the same area or the choice of different locations to ensure variability in the chances of success.

The comparison of the differences between the Green Turtles that nest in the Oceanic Islands of Brazil goes beyond the environment, since according to (Bjorndal et al., 2006) the populations of Trindade present genetic difference in relation to the populations of Atol das Rocas and Fernando de Noronha.

The solutions to mitigate the effects of high temperatures can be made in different ways, the nests can be shaded for example, in an experiment made by Esteban et al., (2018) demonstrate that semi-shaded nests can be up to 0.6 ° C more cooler than not shaded. In this experiment tree leaves were used, another study evaluated the presence of Casuarina equisetifolia trees in 50 turtle nesting sites in Asia, observed that the trees help to contain erosion, but can bring other problems, such as being an obstacle to females for example (De vos et al., 2019).

In the past, sea turtles changed their phenology during climate variations, the work of Weishampel et al., (2010) reveals that Green Turtles and loggerhead turtles in Florida are changing their reproductive behavior in recent decades, where Green Turtles are laying more nests in the warmer months. Santidrián Tomillo et al., (2015) He observed that the months in which nests do not occur have better environmental characteristics for the development of hatclings, demonstrating that the phenology of changing nesting months could mitigate the effects of future climate changes.

We also have to discuss the ecological factors that are characteristic of oceanic islands, which are also linked to the conservation of sea turtles, as well as the vulnerability of species that live on the islands, because they generally have fewer numbers, and their declines that lead to imbalance in the ecological chain. location (King et al., 2013). Along with the presence of invasive species, which can become pests, in the Atoll there are many cockroaches, rats and scorpions, originating from ships that have docked on the Island since the time in great sailing, due to these factors island environments are fragile and require conservation efforts different from that practiced in continental environments (King et al., 2013).

Regarding the distribution of nests, studies suggest that the choice of nest location may differ between species, noted that for loggerhead turtles the distribution of nests may seem more random when compared to Green Turtles, also noted that the topography of the beach had a relationship with the choice of Green Turtle nesting sites in Ascension Islands (Hays et al., 1995).

The phenomenon of feminization is already predicted in some populations of sea turtles. This imbalance in the population is caused by the increasingly high temperatures (Hawkes et al., 2007). Some populations of Green Turtles already naturally present a greater presence of female individuals, as in Australia for example, where the sex ratio can be 2: 1 Females per male (Hamann et al., 2007) . Another problem associated with the increase in temperature is the increase in mortality and malformation rates, a fact that is already observed in regions with higher temperatures (Montero et al., 2018b).

The increase in temperature also leads to the melting of the polar ice caps, and as a consequence the increase in sea levels (Rahmstorf, 2007). In some studies simulating the increase in sea levels in nesting areas and sea turtles estimate losses of up to 50% of current nesting areas, how these animals will react to such a big change is still poorly studied (Fish et al., 2008).

Some scientists also point to the hypothesis that sporadic nesting events in different areas from where the females were born, for example in foraging areas during their development can be a mechanism used in warmer environments and that can thus increase dispersion capacities. and the adaptability of sea turtles in the changing scenario. Temperature. (Carreiras et al., 2018).

5. Conclusions

This work is a first access to the temperatures of the sand and nests of the Atol das Rocas and Trindade Island, and brings a limited view in the temporal sense, however it is of great importance to understand the role of the Green Turtle populations of the South Atlantic in the global dynamics. This work provides information on the reproductive biology of Green Turtles in poorly studied areas in Brazil, we observe that the thermal profiles indicate the Atol das Rocas as a possible production area for male turtles, an important fact in the face of the challenges of rising temperatures. Projections of future temperatures demonstrate high impacts on the reproduction of Green Turtles in Brazil in a pessimistic scenario. Our results reinforce the urgent need to discuss and carry out measures to control gas emissions and promote more effective debates regarding the impacts of climate change. A better understanding of the reproductive biology of Green Turtles is essential to understand the current and future impacts of climate change. Especially in South America, where the knowledge regarding thermal ecology and thermal profiles of the beaches is still little known, especially in oceanic islands.

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Chapter 2

Field observations during monitoring activities of the Green Turtle nesting season on Brazilian oceanic islands

Abstract

Information about mating behavior of sea turtles is hard to find, especially if dealing with Green Turtles. Thus, the observations of mating events between individuals of the *Chelonia mydas* in the two islands in Brazil were report. In Atol das Rocas, a female of Green Turtles was observed, after nesting and returning to the ocean, when she was intercepted by three males. In Trindade Island three mating attempts were observed with a variety of individuals in each case. Some of observed behaviors such as males would rub the gular region of receptive females and the use of flipper's claw to grab the female shell corroborates previous studies. Therefore, the male's competition and the multiple paternity have consequences for the development of male/female choice strategies. These selection strategies in mating acts are usually more important for females, given the higher cost of producing offspring by them. These reports is important because bring more information about Green Turtles' courtship, twinning and predation in oceanic islands, something rare to see in nature.

Keywords: predation, Islands, Green Turtle

1. Introduction

There is a lack of information on the mating behavior of Green Turtles in oceanic islands in Brazil, which are the main nesting grounds for Green Turtles in the region. There have been several previous reports on sex discrimination of chelonians in general (Miller and Dinkelacker 2008) but not for sea turtles. For those animals, however, it remains unknown how a male searches for and discriminates between an adult female in differing maturity status.

In sea turtle populations, varying levels of competition for females have been observed, including male-male contests and polygamy (Jessop et al., 1999; Howe et al., 2018), with most females copulating with several males. Finding potential mates is an essential component of the reproductive success of animals, and this success is, in most cases, limited by finding receptive females (Okuyama et al., 2014). However, variable rates of multiple paternities have been observed for different sea turtle species (Lee et al., 2018; Crim et al., 2002), which suggests that encounter rates drive the intensity of competition (Schofield et al., 2017).

Although courtship behaviors of adult females by adult males have been observed (Alvarado and Figueroa 1989; Schofield et al., 2006), direct observation of courtship is often difficult due to underwater visibility and natural light availability, that make it difficult to access the study animal.

Female turtles benefit from indirect gains from multiple mating (genetic contributions) which play a more singular role in mate choice and paternity distributions in turtles than has been found in most bird, fish, and mammal studied species (Pearse and Avise 2001). In addition questions about turtle mating systems are related to: number or quality of female's mates, female's choice and capacity for sperm storage (Galbraith et al., 1993; Pearse and Avise 2001).

In Brazil, Green Turtles nest predominantly in the oceanic islands, Trindade Island (Espirito Santo State), Atol das Rocas (Rio Grande do Norte State) and Fernando de Noronha archipelago (Pernambuco State) (Almeida et al., 2011). The main breeding site of Green Turtles in Brazil is the Trindade Island, where it is estimated that between 1333 and 6402 eggs in average were laid during the 2007/2008 nesting seasons, which places Trindade Island as the seventh largest nesting colony of Green Turtles in the Atlantic (Almeida et al., 2011), with up to 335 (± 139) nests per breeding season. Atol das Rocas is the second most important nesting site of Green Turtles in Brazil (Bellini et al., 2012).

Recording the reproductive behavior this behavior is the first step to understand how male choose females, polyandry and reproductive success. Thus, the objective of this study was to report the observations of a copula event between individuals of the *Chelonia mydas* in the Trindade Island and Atol das Rocas.

Sea turtles hatchlings are preyed by different animals, such as birds (Burger & Gochfeld. 2014), reptiles (Mora & Robinson, 1983.) and mammals (Yerli et al., 1996). In spite of being rare, several observations have been reported regarding normally-formed twins in reptiles, including sea turtles (Hewavisenthi, 1989; Piovano et al., 2011).

2. Material and methods

2.1 Mating Behavior

2.1.1 Atol das Rocas observations

These results are a report based on observations made from January 2017 in Atol das Rocas, Brazil. The Atol das Rocas (3°51′50″S 33°48′40″W) is located at 260 km of the state capital of the Rio Grande do Norte and at 150 km of the Fernando de Noronha archipelago, in Northwest of Brazil. The Atol das Rocas is a Federal Reserve since 1979, but it was only in 1990 that sea turtle conservation activities began. The nesting peaks occur between February and April, with an annual average of 335 (±139) nests, with 120 (±28) eggs on average and hatching rate ranging from 70.1% to 78%, the incubation period varies between 54.6 and 62.4 days (Bellini et al., 2012). The mating behavior was observed by a team of four researchers and videos of short duration were made to a certain distance of at least 4 meters to not influence or impact the copula activity of the animals. The observations of the researchers and the videos were used for this report (License number 54987), issued by Instituto Chico Mendes, Brazilian Government.

2.1.2 Trindade Island Observations

Trindade Island belongs to Trindade and Martin Vaz Archipelago. The area of the Island is 13,5 km², located approximately 1200 km from the mainland (20º 30 '54' 'S and 29º 18' 20 '' W). There are nine beaches where *C. mydas* nest Almeida et al., 2011). Given the importance of the island for the conservation of sea turtles, the Tamar Project (Brazilian Sea Turtle Conservation Project) has been monitoring the island since 1982, sending teams of researchers and trainees to follow the nests of *C. mydas* and to capture and mark the *Eretmochelys imbricata* juveniles that use Trindade as feeding area. For two periods June until October of 2009, and November of 2011 until February of 2012, dives by snorkel were taken four times a week around the island, accompanying fishermen and sailors on patrols of the island.

In Trindade is common to spot juveniles of *Eretmochelys imbricata*. Some were captured and recorded by the Tamar Project. In the first expedition, only from the second half of September was observed the first adult individuals of *Chelonia mydas* around of the Island. The behavior was observed still in 2009, but the photographic register was possible just in December 2011.

2.2 Predation

This work is based on observations made in January 2017 in Atol das Rocas (Fig. 1) and observations made from June 2009 in Trindade Island (Fig. 2), both Islands are important nesting areas for Green Turtles in Brazil. The Atol das Rocas is located at 150 km from Fernando de Noronha archipelago, in Northwest of Brazil. Trindade Island is located in the Southwest of Brazil, with a size of 13.5 km², located approximately 1200 km from the mainland.

2.3 Twins

This data was based on observations made in March 2017 in Atol das Rocas, an important nesting area for Green Turtles in Brazilian territory. The Atol das Rocas is located at 150 km from Fernando de Noronha archipelago, in Northwest of Brazil.

3. Results

3.1 Mating Behavior

Green Turtle mating behavior in Atol das Rocas

On 26th January 2017 at 0700 hrs a female of *C. mydas* was observed, after nesting and coming back to the sea, when she was intercepted by three males (first by two males and shortly after a third) (Figure 1). The males were smaller than the female and the sequence of events is described in Figure 1 and Table 1.

Table 1: Description of behaviors (Figures 1 and 2) during mating behavior of Green Turtles (*Chelonia mydas*) in Atol das Rocas, Brazil.

Sequence	Description of behaviors
A	The female is on the beach with half of her body submerged, and two other males, smaller than the female, are in the water about two meters away, immersed and in physical contact.
B	One male holds the female by the head, facing it, the other male places the female's right without contact.
C	The male on the right intercepts the pair and removes the other male from the top of the female.
D	The female moves a little away and the males continue to contact.
E	A third male approaches to the right.
F	The four animals come in contact.
G,H,I and J	One male individual immobilizes the female and they stay on one side due to the waves and the contact of the other male. The other male circulates the couple and tries to remove the male from the top of the female, without success. The couple stays together until the end of the filming.

Fig. 1 Sequence of mating behavior of Green Turtles, Atol das Rocas. The description of observed behaviors in A, B, C, D, E, F is in Table 1.

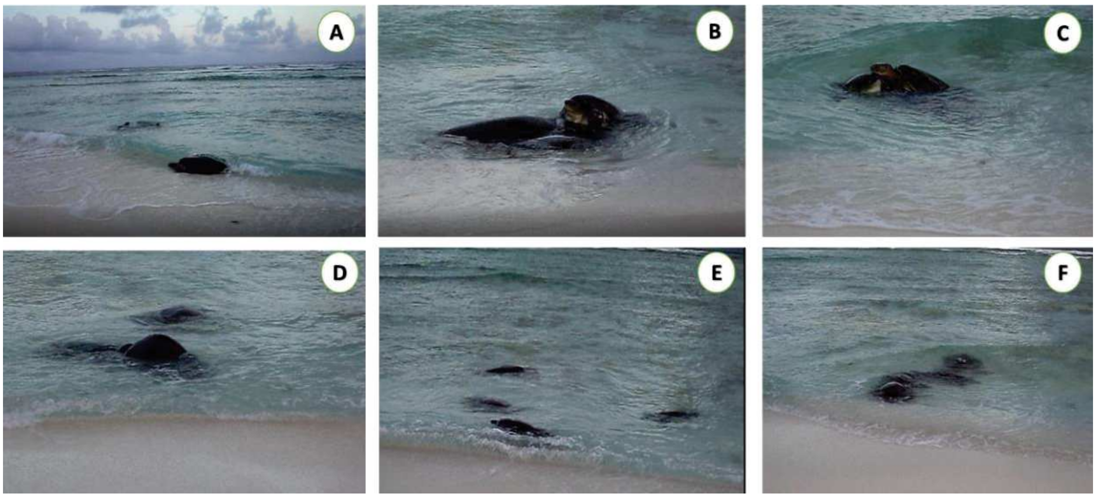
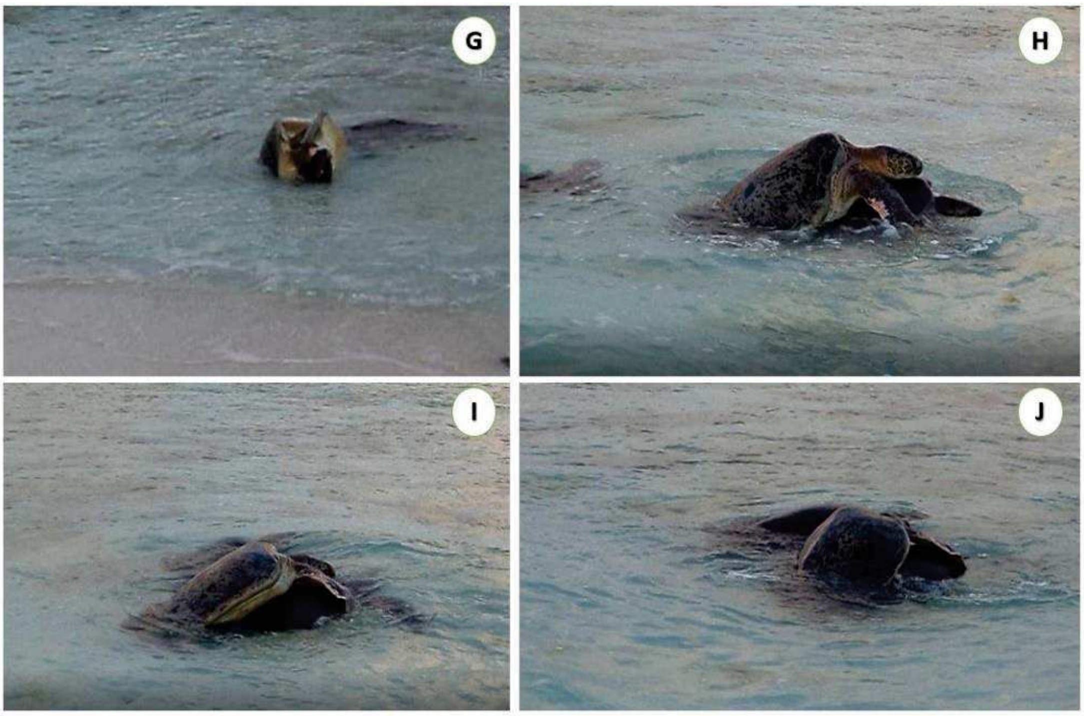


Fig. 2 Sequence of mating behavior of Green Turtles, Atol das Rocas. The description of observed behaviors in G, H, I, J is in Table 1.



Green Turtle mating behavior in Trindade Island

During the monitoring activities of the nesting season of 2009, two adult individuals of Green Turtles were observed near the island from the middle of September. The first couples in reproductive activities were registered in the month of October, where three observations were made. The first record was about 400 meters from the Island. On board a Brazilian Navy vessel, two turtles were observed on the surface of the water, which dived with the approach of the vessel, not allowing the observation of the reproductive behavior.

The First observation was made 300 meters from the Island. The couple was on the surface, with the shells emerging, making it possible to still observe from the vessel. During underwater observation, it was possible to register the male biting the female in the neck and attempting to attach the claw of the front flippers to the female shell. The couple stayed together for about 7 minutes, until the male detached from the female and submerged. We have no images of these first two observations.

The second observation was made approximately 700 meters from Tartarugas Island, the main spawning beach in Trindade Island. This time, four turtles were seen, a couple who were already in mating behavior and two other males at a distance of 10 to 15 meters to the right and left of the couple. The observation was made approximately 15 meters of the couple, allowing the register of the behavior of the individuals (Table 2). Two males were observed, submerged and close to the couple. The pair was together, with the male trapped under the female using the front flippers with the rear flippers not attached. This process lasted between 10 and 15 minutes, with only one of the assisting males approaching, but not disturbing the mating behavior. The observation ended when the male and female separated and went to the bottom, followed by the other two male assistants.

Table 2: Description of behaviors (Figures 3 and 4) during mating behavior of Green Turtles (*Chelonia mydas*) in Trindade Island, Brazil.

Sequence	Description of behaviors
A, B and C	At the first moment the male approaches, the pair comes in contact near the surface, the male tries to bite the female's neck and put one of the fore flipper on the female's shell.
D	The male tries unsuccessfully to hold the female with the claw of the left fore flipper and continues to bite the female's neck.
E, F and G	The male continues to bite the neck and tries to grab the female with the nail. The female tries to emerge to breathe. The couple remains on the surface turning counterclockwise.

Fig. 3 Sequence of mating behavior of Green Turtles, Trindade Island. The description of observed behaviors in A,B,C,D is in Table 2.

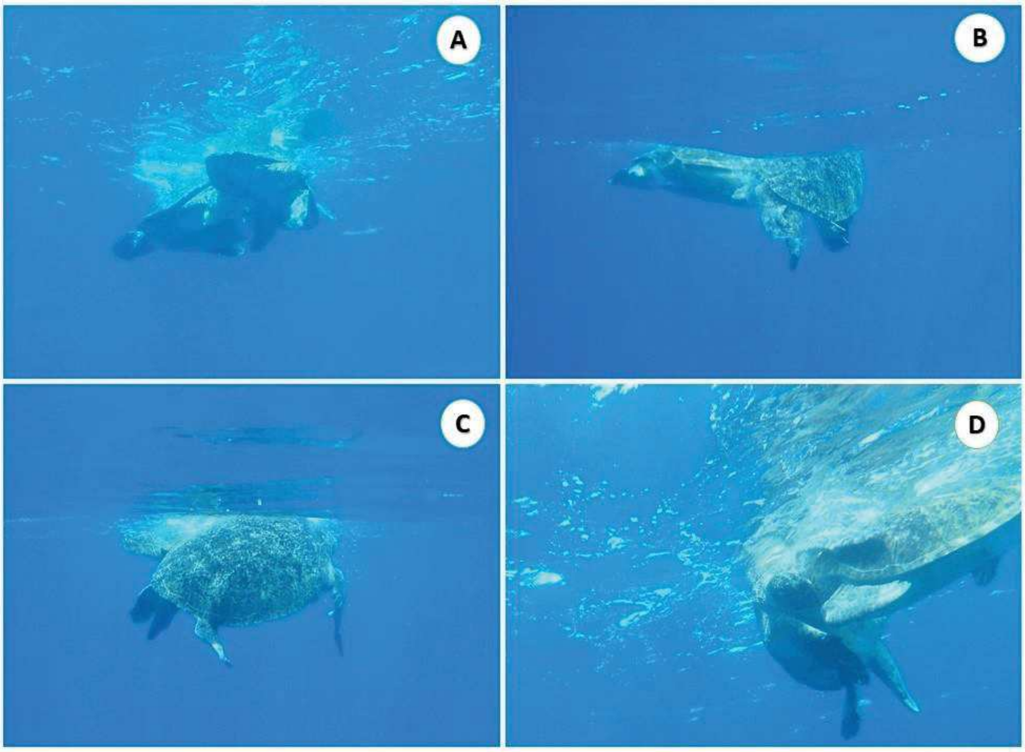
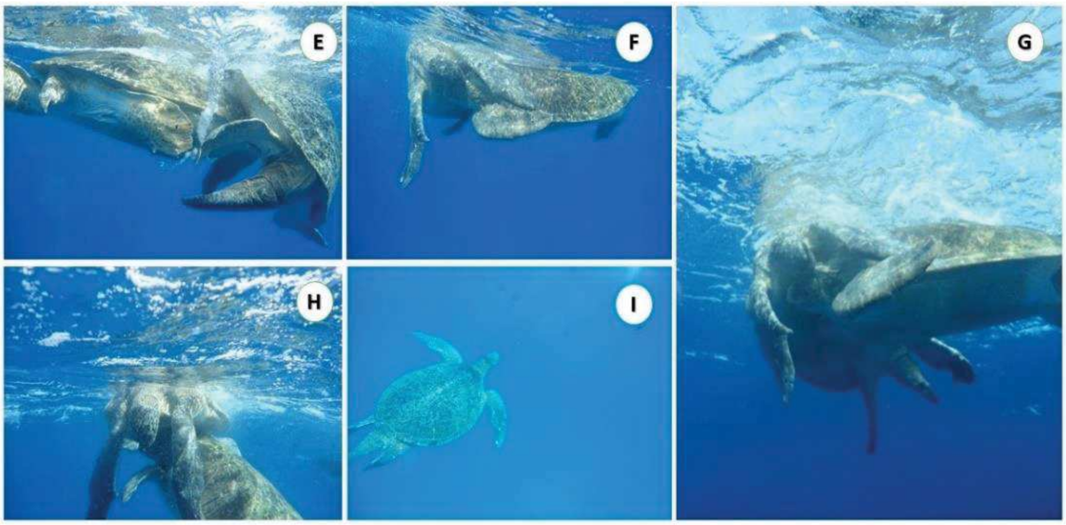


Fig. 4 Sequence of mating behavior of Green Turtles, Trindade Island. The description of observed behaviors in E,F,G,H,I is in Table 2.



Predation

The hatchlings of Green Turtles were predated by the crab *Johngarthia lagostoma*. that inhabits the islands of the South Atlantic. Another crab found in Atol das Rocas was *Percnon gibbesii* although the predation of hatchlings by individuals of this species has not been detected in this study.

Fig. 5 A. Individual of crab *Johngarthia lagostoma*; B. Dead Green Turtle hatchling. C. Dead Green Turtle hatchling with a typical injury cause by crab predation in Atol das Rocas, Brazil.

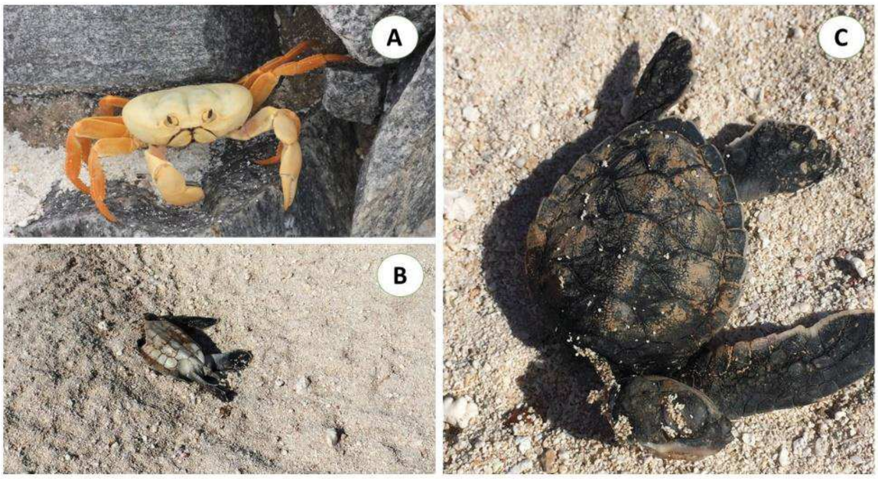
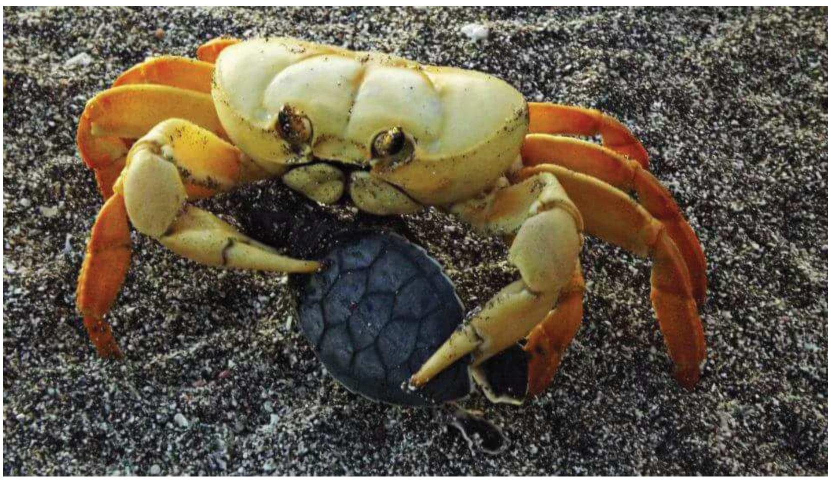


Fig. 6 Green Turtle hatchlings predation by crabs *Johngarthia lagostoma* in Trindade island, Brazil.



4. Discussion

Previous studies in Atol das Rocas have shown that males exhibit fidelity to a breeding area, and some males may return in consecutive years, unlike females, which present intervals ranging from two to three years (Longo and Grossman 2010). It was also verified the presence of the same male at intervals of seven to ten years, demonstrating even more the fidelity of these males in this area of reproduction (Longo and Grossman 2010). The potential for multiple paternity and associated fitness and benefits may have consequences for the development of male/female choice strategies. Selection strategies in mating acts are usually larger for females, given the higher cost of producing offspring by them (Howe et al., 2018). However, it is increasingly recognized that the energy costs of sperm production cannot be disregarded (Olsson et al., 1997; Wedell et al., 2002).

Merino-Zavala et al., (2018) observed copula behaviors performed by *Caretta caretta*, indicated by the observation of the male circling the female, followed by a successful attempt and assembly on the surface. And just as in our work, the researchers' approach has shown to have an influence on the mating behaviors of these animals.

Comazzie and Owens (1990) were the first to systematically evaluate and quantify the copula behaviors presented by *Chelonia mydas*. According to their observations, the sequence of acts would be: males would rub the gular region of receptive females, followed by biting or pinching along the body, especially in soft regions. Then occurred cloacal verification, males surrounding females, and nibbling their neck, followed by females escaping the males, who swam behind them, and tried again to mount them until they are successful and the mating behavior actually happened. As we observed other males accompanying the couple copulating, swimming next to it, Comazzie and Owens (1990) also verified this behavior, since in the same enclosure that couples were copulating there were several other males and females not receptive to mating behavior.

Not all steps described by Comazzie and Owens (1990) were observed in the present study. This can be explained by the difference between the sites of observation of such behaviors, since our study was conducted in loco, being at the mercy of all kinds of events that could interrupt the copula, as the presence of the researchers themselves and the fact that the animals dive and make it impossible to observe them on the surface. On the other hand, the work of Comazzie and Owens (1990) was conducted in a tank prepared in order to allow observations of animals from all angles and depths.

Behaviors similar to those described by Comazzie and Owens (1990) were observed by Okuyama et al., (2014), in which these acts were performed by an adult male of *C. mydas* in relation to an immature individual of the same species, who attempted to escape from the adult male. After about five minutes of interaction, the behaviors ceased and the male adult released the immature. Thus, this work suggests that males cannot distinguish mature females from immature turtles, which indicates the possibility that the partner search strategy is completely different between sea turtles and other chelonians, which make use of olfactory stimuli mainly (Miller and Dinkelacker 2008).

Booth and Peters (1972) reported that males occasionally attempted to mate with other males, just as Green (1999) observed an assisting male mating to form a trio on a couple who was already copulating. Furthermore, extended this discussion by reporting an event in which a male of *C. mydas* approached him exhibiting typical copulation behaviors, which may indicate that males cannot distinguish between females and other males (Bowen 2007).

Aggressive behaviors by other males in relation to a couple, such as biting the tail of the copulating male, were observed in other studies (Alvarado and Figueroa 1989; Schofield et al., 2006) but were not verified in the present study. Observations of copula behavior in nature are rare and their records are important to increase our knowledge about these animals that spend much of their life at sea where they cannot be observed.

Crabs are responsible for predation of sea turtle hatchlings of different species (Marco et al., 2015). Environmental factors such as the moon phase may influence the rates of predation of turtle hatchlings by crabs, as anthropogenic factors, like beach lighting, may also increase the success of this predator (Silva et al., 2017). Registering predation and factors influencing their rates is important for the conservation of the Green Turtle, especially if it is oceanic island, which are especially vulnerable ecosystems.

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Anexos A – Publication

Chico Mendes de Conservação da Biodiversidade (ICMBio) for providing collection permits (SISBIO 48102-2).

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TESTUDINES — TURTLES

CHELONIA MYDAS (Green Sea Turtle). **PREDATION.** Sea turtle hatchlings are preyed upon by many different animals, including birds (Burger and Gochfeld 2014. Copeia 2014:109–122), reptiles (Mora and Robinson 1983. Rev. Biol. Trop. 32:161–162), mammals (Stoll et al. 1996. Biol. Conserv. 82:109–111), and invertebrates such as crabs (Marco et al. 2015. J. Exp. Mar. Biol. Ecol. 468:74–82). This report of crab predation is based on observations made in January 2017 in Rocas Atoll (3.86389°S, 33.81111°W; WGS 84) (Fig. 1) and in June 2009 in Trindade Island (20.5157°S, 29.30555°W; WGS 84) (Fig. 2); both islands are important nesting areas for *Chelonia mydas* in Brazil. Rocas Atoll is located 150 km from Fernando de Noronha archipelago, in northeastern Brazil. Trindade Island (with a size of 13.5 km²) is located in southeastern Brazil, approximately 1200 km from the mainland. The hatchlings of *C. mydas* were predated by *Johngarthia lagostoma*, a crab that inhabits the islands of the South Atlantic. Another crab found in Rocas Atoll was *Percnon gibbesi*, but predation of hatchlings by this species were not detected in this study. Environmental factors such as moon phase might influence predation rates of turtle hatchlings by crabs, and anthropogenic factors such as beach lighting might also increase the success of this predator (Silva et al. 2017. J. Photochem. Photobiol. B 173:240–249). Recording turtle predators and factors influencing predation rates is important for the conservation of *C. mydas*, especially on oceanic islands, which are especially vulnerable ecosystems.

FIG. 1. A) Individual of the crab *Johngarthia lagostoma*; B) dead *Chelonia mydas* hatchling; C) dead *C. mydas* hatchling with a typical injury caused by crab predation in Rocas Atoll, Brazil.

FIG. 2. *Chelonia mydas* hatchling captured by *Johngarthia lagostoma* in Trindade Island, Brazil.

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CHRYSEMYS PICTA MARGINATA (Midland Painted Turtle). **PREDATION.** Here we present an observation of likely predation by *Microtus pennsylvanicus* (Eastern Meadow Vole) on a hatchling *Chrysemys picta marginata*. At ca. 1500 h on 5 May 2015, we observed two *M. pennsylvanicus* consuming a hatchling *C. p. marginata* in a wet meadow (41.6752°N, 80.8626°W; WGS 84) in Ashtabula County, Ohio, USA. The meadow voles were observed consuming the hatchling turtle as we conducted artificial cover surveys. Upon lifting a 2.4 × 0.7 m piece of corrugated metal roofing, the two meadow voles ceased consuming the hatchling and rapidly retreated into the surrounding herbaceous vegetation, leaving the deceased hatchling turtle in what appeared to be a vole nest linked to other such depressions via tunnels. It appeared that the meadow voles had chewed a hole through the carapace and were beginning to consume the viscera prior to our observation (Fig. 1). Although predation on Painted Turtle hatchlings has been noted for other rodents, including Rice Rats (*Oryzomys palustris*) and Muskrats (*Ondatra zibethicus*), predation by *M. pennsylvanicus* has apparently not been reported (Ernst and Lovich 2009. Turtles of the United States and Canada. 2nd ed. The Johns Hopkins University Press, Baltimore, Maryland. 827 pp.). Predation of vertebrates by meadow voles has not been described, but scavenging of deceased vertebrates has been

FIG. 1. Remains of a hatchling *Chrysemys picta marginata* partially consumed by two meadow voles (*Microtus pennsylvanicus*).

Anexos B – SISBIO Licence

Ministério do Meio Ambiente - MMA
Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio
Sistema de Autorização e Informação em Biodiversidade - SISBIO

Autorização para atividades com finalidade científica

Número: 54587-4	Data da Emissão: 27/03/2018 10:44	Data para Revalidação*: 26/04/2019

* De acordo com o art. 28 da IN 03/2014, esta autorização tem prazo de validade equivalente ao previsto no cronograma de atividades do projeto, mas deverá ser revalidada anualmente mediante a apresentação do relatório de atividades a ser enviado por meio do Sisbio no prazo de até 30 dias a contar da data do aniversário de sua emissão.

Dados do titular

Nome: Robson Henrique de Carvalho	CPF: 082.635.536-30
Título do Projeto: Influência das mudanças climáticas na reprodução de tartarugas verdes Chelonia mydas (testudines: Cheloniidae) em ilhas oceânicas Brasileiras	
Nome da Instituição : Universidade Federal de Juiz de Fora	CNPJ: 21.195.755/0001-69

Cronograma de atividades

#	Descrição da atividade	Início (mês/ano)	Fim (mês/ano)
1	Submissão do projeto a editais de financiamento	08/2016	12/2016
2	Revisão Bibliográfica	08/2016	03/2020
3	Coleta dos dados - temporada 2017	10/2016	06/2017
4	Divulgação em eventos científicos nacionais e internacionais	03/2017	03/2020
5	Coleta dos dados - temporada 2018	10/2017	06/2018
6	Coleta de dados - temporada 2019	12/2018	06/2019
7	Elaboração e submissão de artigos	01/2019	12/2019
8	Elaboração da tese de doutorado	01/2019	12/2019
9	Análise dos dados	01/2019	12/2019
10	Defesa da tese	02/2020	02/2020

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Outras ressalvas

1	O pesquisador titular desta autorização deverá enviar para o Centro TAMAR-ICMBio, ao final do desenvolvimento do projeto, cópia integral dos relatórios e publicações científicas oriundos da pesquisa em questão.
2	Tendo em vista as limitações logísticas à ReBIO Atol das rocas, solicitar com antecedência, as vagas para a equipe.

Equipe

Este documento (Autorização para atividades com finalidade científica) foi expedido com base na Instrução Normativa nº 03/2014. Através do código de autenticação abaixo, qualquer cidadão poderá verificar a autenticidade ou regularidade deste documento, por meio da página do Sisbio/ICMBio na Internet (www.icmbio.gov.br/sisbio).

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Autorização para atividades com finalidade científica

Número: 54087-4	Data da Emissão: 27/03/2018 10:44	Data para Revalidação*: 26/04/2019

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Dados do titular

Nome: Roberson Henrique de Carvalho	CPF: 062.836.936-30
Título do Projeto: Influência das mudanças climáticas na reprodução de tartarugas verdes Chelonia mydas (testudines: Cheloniidae) em ilhas oceânicas Brasileiras	
Nome da Instituição : Universidade Federal de Juiz de Fora	CNPJ: 21.195.755/0001-69

#	Nome	Função	CPF	Doc. Identidade	Nacionalidade
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3	Jaqueline Cerqueira de Araujo	Estagiário	[illegible]	[illegible]	Brasileira
4	Patrícia Cristal Nunes Rocha	Estagiário	[illegible]	[illegible] SSP-MG	Brasileira
5	Alessandra Resende Pessoa	Estagiário	[illegible]	[illegible] PC-MG	Brasileira
6	André Yves Barbosa Martins	Estagiário	[illegible]	[illegible] SSP-MG	Brasileira

Locais onde as atividades de campo serão executadas

#	Município	UF	Descrição do local	Tipo
1		RN	RESERVA BIOLÓGICA DO ATOL DAS ROCAS	UC Federal

Atividades X Táxons

#	Atividade	Táxons
1	Coleta/transporte de amostras biológicas in situ	Blattodea, Chelonia mydas, Thysanura, Hemiptera, Diptera, Thysanoptera, Orthoptera, Coleoptera, Hymenoptera, Lepidoptera
2	Coleta/transporte de espécimes da fauna silvestre in situ	Diptera (*Qtde: 30), Orthoptera (*Qtde: 30), Lepidoptera (*Qtde: 30), Hemiptera (*Qtde: 30), Coleoptera (*Qtde: 30), Chelonia mydas (*Qtde: 300), Blattodea (*Qtde: 30), Thysanura (*Qtde: 30), Thysanoptera (*Qtde: 30), Hymenoptera (*Qtde: 30)
3	Observação e gravação de imagem ou som de táxon em UC federal	Chelonia mydas

* Quantidade de indivíduos por espécie, por localidade ou unidade de conservação, a serem coletados durante um ano.

Material e métodos

1	Amostras biológicas (Invertebrados Terrestres)	Secreção
2	Amostras biológicas (Tartarugas marinhas)	Animal encontrado morto ou partes (carcaça)/osso/pele
3	Método de captura/coleta (Himenópteros)	Captura manual
4	Método de captura/coleta (Invertebrados Terrestres)	Coleta manual
5	Método de captura/coleta (Lepidópteros)	Captura manual
6	Método de captura/coleta (Tartarugas marinhas)	Outros métodos de captura/coleta(Coleta dos filhotes natimortos)

Destino do material biológico coletado

#	Nome local destino	Tipo Destino
1	Universidade Federal de Juiz de Fora	

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Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio
Sistema de Autorização e Informação em Biodiversidade - SISBIO

Autorização para atividades com finalidade científica

Número: 54987-4	Data da Emissão: 27/03/2018 10:44	Data para Revalidação*: 26/04/2019

* De acordo com o art. 28 da IN 03/2014, esta autorização tem prazo de validade equivalente ao previsto no cronograma de atividades do projeto, mas deverá ser revalidada anualmente mediante a apresentação do relatório de atividades a ser enviado por meio do Sisbio no prazo de até 30 dias a contar da data do aniversário de sua emissão.

Dados do titular

Nome: Robson Henrique de Carvalho	CPF: 062.836.836-30
Título do Projeto: Influência das mudanças climáticas na reprodução de tartarugas verdes Chelonia mydas (testudines: Cheloniidae) em ilhas oceânicas Brasileiras	
Nome da Instituição : Universidade Federal de Juiz de Fora	CNPJ: 21.195.755/0001-69

* Identificar o espécime no nível taxonômico possível.

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Autorização para atividades com finalidade científica

Número: 54987-4	Data da Emissão: 27/03/2018 10:44	Data para Revalidação*: 26/04/2019

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Dados do titular

Nome: Robson Henrique de Carvalho	CPF: 062.636.936-38
Título do Projeto: Influência das mudanças climáticas na reprodução de tartarugas verdes Chelonia mydas (testudines: Cheloniidae) em ilhas oceânicas Brasileiras	
Nome da Instituição : Universidade Federal de Juiz de Fora	CNPJ: 21.195.755/0001-69

Registro de coleta imprevista de material biológico

De acordo com a Instrução Normativa nº 03/2014, a coleta imprevista de material biológico ou de substrato não contemplado na autorização ou na licença permanente deverá ser anotada na mesma, em campo específico, por ocasião da coleta, devendo esta coleta imprevista ser comunicada por meio do relatório de atividades. O transporte do material biológico ou do substrato deverá ser acompanhado da autorização ou da licença permanente com a devida anotação. O material biológico coletado de forma imprevista, deverá ser destinado à instituição científica e, depositado, preferencialmente, em coleção biológica científica registrada no Cadastro Nacional de Coleções Biológicas (CCBIO).

Táxon*	Qtde.	Tipo de amostra	Qtde.	Data

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